Introduction to

Restoration Ecology

Instructor's Manual



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Island Press gratefully acknowledges the support of its work by the Agua Fund, Inc., The Margaret A. Cargill Foundation, Betsy and Jesse Fink Foundation, The William and Flora Hewlett Foundation, The Kresge Foundation, The Forrest and Frances Lattner Foundation, The Andrew W. Mellon Foundation, The Curtis and Edith Munson Foundation, The Overbrook Foundation, The David and Lucile Packard Foundation, The Summit Foundation, Trust for Architectural Easements, The Winslow Foundation, and other generous donors.

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ISLANDPRESS

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Cover design by Mary McKeon

Cover photos by John A. Harrington and Stephen B. Glass. Inset photos from left to right: sediment removal and reconstruction of former stream meanders, Pecatonica Watershed, southwest Wisconsin; volunteers replanting a restoration site disturbed by construction activities; bank restoration and stabilization, Raccoon Creek, Carl and Myrna Nygren Wetland Preserve, Rockton, Illinois. Background: prairie restoration, McHenry County Conservation District, Illinois.

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Introduction

Welcome to the *Instructor's Manual* for *Introduction to Restoration Ecology*. Our goal is to supplement the textbook with additional insights about its structure and the reasoning behind it, as well as to share some of the approaches we have found to be useful in teaching restoration ecology at the college level for thirty years. Altogether we teach five different courses that include restoration ecology as a major focus: a student-led seminar; two combined lecture/discussion/lab courses (one with an enrollment of more than 150, the other with an enrollment of 12 to 25); a field study course; and a hands-on workshop.

Our courses serve intermediate- and advanced-level undergraduates as well as master's and doctoral candidates with biology, geography, environmental studies, soil science, and landscape architecture majors, among others. Many students come from the midwestern United States, but many are from other parts of the Americas, as well as from Europe and Asia.

This diversity of backgrounds (often found in a single course) and formats has led us to create materials that can be modified to fit different learning contexts as well as to take advantage of the opportunity for students to teach their peers by sharing what they know with one another.

We have found that helping students to learn about restoration ecology is as fascinating, intellectually challenging, and rewarding as the practice itself. We hope that you will use the ideas and examples presented in this manual as a jumping-off point to develop and share new creative learning tools that will inspire students to practice restoration ecology, either as a professional or as a volunteer.

About the Textbook: Introduction to Restoration Ecology

Restoration ecology is a complex conservation activity that creates plant and animal communities/ecosystems modeled on historical systems and ecological theory, on sites that have been significantly altered by modern human disturbance.

The focus of *Introduction to Restoration Ecology* is on the process that guides the course of each restoration. The textbook is organized around a generalized problem-solving framework; the principles, theory, and contemporary practices that underlie this framework; the set of questions to be asked at each step in the process—the answers to which will guide the decisions that need to be made; and the different means by which each project can be designed so that it contributes the information needed to advance the field.

Our goal is to provide students with a guide they can adapt to practice restoration on sites with varying degrees of disturbance located anywhere in the world, a guide that will teach them to apply and fit the general restoration framework to the details of each new situation. The textbook includes—in the narrative as well as in case studies and supplementary sidebars—examples illustrating specific applications of the ideas we present.

From our experience, and because restoration ecology is such an interdisciplinary endeavor, we anticipate that this textbook will be useful for students of biology, botany, conservation, environmental studies, and ecology, as well as for students of landscape architecture or planning.

Science students will benefit from learning about the logic of the restoration process and the components of the plans that result; what is involved in putting ecological principles to the test in designing restorations; and how to make choices and take actions in complicated circumstances when outcomes are uncertain. In addition, many science students assume that restoration rests primarily on natural science principles. This textbook will introduce them to importance of the social and economic context of restoration and to the necessity of working with people if a restoration is to be successful.

Students in planning and design will be very familiar with the basic framework of the restoration process and its site, master, and implementation plan components. Although many planning and design students will be familiar with community participation techniques, they will benefit from our emphasis on creating communication networks to share information about projects. Most important, these students will learn about the ecological principles that guide restoration projects. Members of interdisciplinary teams must understand what each member contributes to the whole. One of the goals of this textbook is to help facilitate this understanding.

Organization of the Instructor's Manual

We have divided this manual into chapters that parallel the chapters in the textbook, with the exception of Chapters 14 and 15, which are not discussed here. Our goal is to share some of the teaching and learning approaches that have worked for us over the years, as well as to amplify the ideas we present in the textbook.

We believe that the best way for students to learn about restoration ecology is to use it—in other words, to engage in what has come to be known as "active learning." You will find that many of our examples involve having students solve problems, create plans, or engage in discussions. We include suggestions for how to use these kinds of activities in both large (100 or more) and small (25) classes.

Those of you already familiar with active learning principles will recognize several of the formats we suggest. If you would like to know more about this exciting approach to education, take a look at *Teaching What You Don't Know* (Huston 2009). (Don't worry about the title—this book contains excellent ideas for those of us who are experts in the material that we teach.)

The chapters in the manual begin with a summary of the major concepts and themes around which each is organized (Major Themes). These supplement and expand upon the shorter Key Concepts sections that are found at the end of the textbook chapters.

Next in each chapter of the manual is a section titled Comments on the Food for Thought Questions. Here we discuss the Food for Thought questions found at the end of Chapters 1 to 13 in the textbook. These questions are meant as a tool to help students to review and apply the concepts introduced in the textbook and, in so doing, to check their understanding of the concepts.

The Food for Thought questions are related to the learning objectives given at the beginning of Chapters 1 to 13 in the textbook. In many cases, we have tried to provide questions that integrate or tie together ideas from several sections of a chapter, and even from earlier chapters, to help students build their understanding.

We also use variations of many of the questions in our classes as active learning exercises to help students work with the chapter material. The manual includes several examples of ways to create activities centered around these questions. We also suggest key things to look for in student responses to

help assess their depth of understanding, determine whether they are achieving the learning objectives, and uncover uncertainties and misunderstandings.

The third section of each chapter in the manual, Supplemental Activities and Exercises, includes suggestions for activities and exercises to supplement those in the textbook. These include additional Food for Thought questions as well as links to example problem statements posted on the textbook website (www.introrestorationecology.com).

The fourth section of each chapter, Suggested Learning Objectives Outcomes, suggests outcomes to look for in conjunction with the learning objectives found on the first page of each chapter in the textbook. We place the learning objectives at the beginning of each chapter to serve as a learning guide for students.

This section of the manual provides things for you to look for to see how well students have understood the material. We offer several different assessment outcomes organized around learning levels that we have adapted from the revised Bloom's taxonomy of educational objectives (Anderson et al. 2001):

- Level 1: Remembering and Understanding
- Level 2: Applying and Analyzing
- Level 3: Evaluating and Creating

Each chapter in the manual ends with a discussion of some of the common issues, questions, and misconceptions that may arise surrounding the textbook chapter contents (Potential Issues, Questions, and Misconceptions). Where appropriate, the manual chapters also include a list of references and a list of links to online resources.

Information about the Textbook Website

We have created a textbook website (www.introrestorationecology.com) to accompany *Introduction to Restoration Ecology* that contains several teaching tools to help support both classroom-based and online instruction. These tools include links to (1) a set of images found in the textbook, (2) additional digital images, and (3) short videos (accessed on YouTube) that show practical aspects of implementing, monitoring, and managing a restoration project.

The Supplemental Activities and Exercises section of the website includes example exercises. For instance, we've included a sample problem statement for a semester project in which teams of students work with real clients on planning actual restoration projects. In addition, you will find a list of references and resources to supplement those included in the textbook.

As we're mentioned, our emphasis is on helping students to understand the components of the restoration process and its underlying logic rather than on presenting examples from diverse restoration settings. If you plan to use this textbook in a survey course, it will be helpful to bring in additional examples from around the world to provide breadth. If your course has a field or workshop format, you will want to supplement the textbook with local examples to add depth. One of the goals of this manual is to help you and your students locate such additional resources.

References

Anderson, L. W., D. R. Krathwohl, P. W. Airasian, K. A. Cruikshank, R. E. Mayer, P. R. Pintrich, J. Raths, and M. C. Wittrock. 2001. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Boston: Allyn & Bacon.

Huston, T. 2009. *Teaching What You Don't Know*. Cambridge, MA: Harvard University Press.

Online Resources

Overbaugh, Richard C., and Lynn Schultz, Old Dominion University. Comparison of new and old versions of Bloom's Taxonomy

www.odu.edu/educ/roverbau/Bloom/blooms_taxonomy.htm

Shrock, Kathy. Google Apps to Support Bloom's Revised Taxonomy

www.schrockguide.net/bloomin-apps.html

Wilson, Leslie. Dr. Leslie Owen Wilson's Curriculum Pages: Beyond Bloom—A New Version of the Cognitive Taxonomy

www.uwsp.edu/education/lwilson/curric/newtaxonomy.htm

Chapter 1

Restoration Ecology

Composing the Landscape of the Future

Chapter 1 introduces the restoration process that is the organizational framework for the textbook and provides a historical and contemporary context for restoration ecology.

Major Themes

- Restoration ecology is a complex conservation activity undertaken for many reasons that relate to repairing what we perceive as damage caused by direct or indirect human impact. One key to the process is identifying and articulating the nature of the damage we wish to repair. Regardless of purpose, there are two underlying principles:

    1. The goal of restoration ecology is to establish groups of (usually native) species on a site according to a community/ecosystem model, the composition of which is based on our current understanding of ecological theory and the nature of historical communities. This model is at the heart of every project, whether it is explicitly expressed (the preferred way) or rests in the mind(s) of the restorationist(s).

    2. Restoration is a product of human culture, and the role of people is a central consideration in how a site is to be restored. Every project includes decisions about how people will interact with a site as members of the restoration team and as visitors; what to do about continuing undesirable human impacts coming from offsite or due to onsite use; and how to involve neighbors and policymakers with the project.

- Restoration uses information, practices, and tools coming from the natural and physical sciences, social science, and the humanities and has historical roots and precedents in each of these fields.

- Restoration projects are best undertaken by following an explicit planning process that encourages restorationists to state assumptions; consider several options before making decisions; justify the decisions; routinely assess the restoration during all phases, from establishment to management; and be willing to change course if necessary. The final step is to document the process in written and graphic form. By following such a process, restorationists reduce the likelihood of jumping to conclusions before getting all the relevant facts. By documenting their reasoning and intentions, restorationists provide guidance to future site managers and add to our general understanding of conservation.

- Restoration is no substitute for preservation. Many challenges exist, some of which are legacies of the past, while others are due to competing interests of modern living. Restoration also holds great promise in designing the landscapes of the future to conserve biodiversity and the life-sustaining functions of natural ecosystems, as well as in aiding our understanding of how the world works.

Comments on Food for Thought Questions

Question 1. How do you define restoration? What does it mean to you? Describe your experience with restoration as a student, volunteer, land manager, or restoration ecologist.

How to Use or Expand on This Question

- We like to use variations of this question at the beginning of a semester (even before students have checked out a textbook) to find out what class members already know (or assume) about the theory and practice of restoration. This helps us to tweak the level of the course content to match the backgrounds of the students and, later on in the course, to create interdisciplinary class project teams with diverse experiences. This exercise can also uncover misconceptions. Here are some suggestions on how to proceed:
    1. Have students write the answers to each of the subquestions on a note card at the beginning of class and hand it in. At the same time, you might ask for information about previous classes the students have taken in related fields or about skills they have, such as familiarity with geographic information systems (GIS) software, using herbicides, conducting prescription burns, or using a nominal group method.
    2. Use an online survey tool (or e-mail, Twitter, or other electronic media) to generate the responses.
    3. In either case, summarize the results, looking for common themes and assumptions; incorporate these—especially any misconceptions that may arise—in subsequent classes.
- It is interesting to have the students repeat this exercise after reading Chapter 1 and to compare their responses.
- Modify the question by adding additional parts, and use the responses as the basis for an in-class discussion to talk about the practice of restoration. The goal might be to generate a class definition; to link restoration to conservation, bioengineering, reclamation, natural landscape design, and other practices mentioned in the textbook as restoration roots; or to discuss the kinds of information that underlie the practice. Here are some possible approaches:
    1. Ask each student to take out a piece of paper (or his or her computer) and take a few minutes (5 minutes or so) to write a definition of "restoration"; generate a set of words or phrases that he or she associates with restoration; list areas of knowledge that a restorationist should have; or expand on other concepts related to your goals for the discussion.
    2. Ask each student to read one of his or her responses out loud. Write each response on the classroom board, or post responses using digital media and a computer projection system. Once everyone has had a chance to contribute, go around the room again until all the ideas have been expressed.
    3. Then have the class as a whole discuss the common themes and unique perspectives that have been generated.
    4. If the class is large, divide the students into teams and have them complete steps 1 and 2, then share the resulting summary with the class. After all the teams have reported, go on to step 3.

- You might also want to use this question as a take-home essay assignment and ask students to find additional definitions of restoration or—based on the famous idea that the definition of a field is simply what the practitioners do—to generate a definition based on what people who call themselves restorationists do.
- We also use this question at the end of the semester to see if the students have a different perception of restoration at the end of the course than they did at the beginning.

What to Look for in Student Responses

- It is best if the restoration definitions are accompanied by stated assumptions. Examples might include assumptions about:
    1. Outcomes—for example, the idea that restorations should include only native species and that the definition of "native" is . . . , or that restorations include only those species or communities that can be documented to have been present on a site at a particular point in time
    2. The role of people in shaping "natural communities"
    3. The ability of communities to restore themselves if human disturbance is removed
    4. Whether biological engineering is a type of restoration
- The definitions should be broad enough to include the different examples given in the textbook (e.g., complete restoration, ecological services restoration, experiential restoration), or the student should explain why the definition should be more narrow.
- Responses should also address in some way what is being restored (species, functions, communities) and the purpose or goal of the restoration (the nature of the "target").
- Similarly, when students describe their experiences with restoration, it is most helpful if they are explicit about how these experiences fit in with their definition of restoration. For example:
    1. Is removing an unwanted species always restoration?
    2. Why or why not?

Question 2. Should we restore ecosystems? Why not let nature take its course? How "natural" is a restored community?

How to Use or Expand on This Question

- This question addresses a major concern that is often raised by people who are skeptical about the need for, or the value of, restoration. The question is also a means to explore assumptions about the degree to which humans are part of or separate from nature; how "natural" and "human" disturbances compare; or what might be lost or gained by restoration activities such as the removal or additions of species. The question also can open up a discussion of restoration goals. Here are some possible approaches:

1. To use this question as the focus of an in-class discussion, try asking students to jot down their answers before opening up the discussion. This technique usually generates more thoughtful insights.
2. Choose one of the subquestions, provide students with a set of Post-it notes, and ask them to write down as many answers as they can think of, one answer per Post-it. Next, have the students stick their notes on the wall (or on a poster board on an easel) for all to see. Then ask the class (or a group of volunteers, if the class is larger than 20 students or so) to rearrange the Post-it notes into sets connected by a theme. Once the themes have been identified, discuss the results.
3. It is helpful to also have students address this question later in the course. For example, you might have students take 10 minutes during a class at the beginning of the semester to write down and hand in their answers, and then repeat the process after several weeks have elapsed. Next, return both sets of answers, and have the students discuss how their responses have changed or remained the same over time.
4. Make the question more concrete by asking about a specific situation, ideally one in your region. For example, have students investigate what is "natural" or "not natural" about the restoration and speculate what the site would be like if the restoration had not occurred. If possible, see if the team responsible for the restoration would be willing to meet with the class to join the discussion.

What to Look for in Student Responses

- Because this question is about what motivates people to practice restoration ecology, look for references to the Society for Ecological Restoration (SER) definition of "restoration ecology," as well as at Section 1.6: Assumptions, Challenges, and Opportunities for Restoration.
- Students should attempt to define "nature," "natural," and, by way of contrast, "not nature," and "not natural." It is important that they provide support for their definitions. They should also think about what is meant by "letting nature take its course."

Question 3. What assumptions beyond those mentioned in this chapter do restoration ecologists make about their work?

How to Use or Expand on This Question

- We use this question to start to reinforce a theme that we carry throughout the textbook—namely, that a key component of the restoration process, as well as of most problem-solving approaches, is a statement of the assumptions (ideas that are taken for granted and not questioned) that underlie the situation. Such assumptions are often unstated and can lead to misunderstandings if not everyone is aware of them. We also like to point out that assumptions may prove to be unfounded or even misguided as we learn more about restoration. Here are some possible approaches:

  1. Most of the discussion techniques mentioned for questions 1 and 2 work well with this question. It may helpful to begin by talking about what an "assumption" is, in anticipation of the idea of "adaptive restoration," which is covered in Chapter 3.

2. As an alternative to using the question as the focus for a discussion activity, you might have students read a journal article, visit a website that describes a restoration project or plan, or interview a local restoration practitioner, and then try to identify the assumptions involved. You can identify a set of articles that make good candidates for this kind of exercise or ask the students to make the choice. If you make the selections, you can focus attention on the restoration challenges of your region or use this opportunity to have students learn about the issues faced by restorationists in a completely different part of the world.

What to Look for in Student Responses

- In order to answer this question, students need to begin by listing the assumptions mentioned in Section 1.6.1 (many parts and processes of the Earth are damaged, destroyed, or missing to the detriment of people and other species; it is possible to repair the damaged parts of the Earth; people have the capacity to undertake such repairs; and by interacting with nature in this way, people and our communities benefit).
- Students might also point to other assumptions within the chapter that are stated less directly—for example, that human disturbance is different in magnitude, kind, and or timing from other forms of disturbance (e.g., storms or disease outbreaks) and that therefore people should reverse the effects.
- Additional "global" assumptions made by restorationists that students may uncover include the following:
  1. People are able to recognize damage and understand how to repair it.
  2. We understand the structure and functions of the systems that we want to restore.
  3. If people understand that their actions are harmful to the Earth, they will change their ways.
  4. Most restoration problems can be solved by science.
- Students will also come across both stated and unstated assumptions about techniques, including the following:
  1. Planting seeds ultimately leads to better results, because only the fittest genotypes survive and patterns are natural since microhabitats act as selective forces.
  2. Adding all desired species to a site at once will result in a diverse restoration or the converse.
  3. Species should be added to a restoration in "waves," to create a diverse restoration.
- This kind of detail is discussed later in the textbook.

Question 4. What are the differences between complete restoration, ecological services restoration, and experiential restoration? How are they similar? How would you classify the types of restorations found in your community?

How to Use or Expand on This Question

- This question provides an opportunity for students to think about the variety of projects that are or have been called "restorations," and to identify the themes that unite as well as divide them. It also helps to reinforce the point about the importance of stating assumptions, the focus of the previous

question, and lays groundwork for the discussion of restoration goals and objectives that will come in Chapters 6 (see Section 6.3.2) and 7 (see Section 7.1).

- The textbook classifies restorations according to attributes that we introduce in Chapter 6—the project purpose, use-policy, and goals. By addressing this question, students anticipate the discussion in Chapter 6 (see Section 6.3) and also start to deepen their understanding of the complexity of restoration. In many ways, such categories are artificial, but we have found that they help students clarify their thinking. The categories often break down when discussing a particular project—the focus of the third subquestion. Here are some possible approaches:

  1. For an in-class discussion, have students take a few minutes to list attributes that unite or separate the different types of restorations presented in the textbook. Then have each person in turn name an attribute that the different types of restoration have in common. Record each response on a master list that is visible to all (e.g., write it on the board or type it into a PowerPoint slide).

     When all the common attributes have been named, repeat the process, this time naming the attributes (if any) that are unique to a particular type of restoration. Once all the responses have been recorded, discuss the results.

     Questions that come up may include: "Some of you have listed Attribute A (e.g., aesthetics) as being characteristic of all restorations, while others have listed it as belonging only to experiential restorations. What is your reasoning in each case?"

     Or: "One of the attributes listed as being common to all restorations is X (e.g., native species are used), yet an attribute of ecosystem services restorations is the creation of novel communities. Is this a contradiction? Explain."

  2. Alternatively, prepare a list of attributes and ask students, working alone or in teams, to place them under the proper category—for example, "common to all restorations," "unique to complete restorations," or even "not applicable." Then have the students share their answers with the class and discuss as above.

  3. You could set this activity up by providing a handout with an unsorted or scrambled list of attributes, or you could write each attribute on a separate slip of paper or note card and provide a set to each student or team.

  4. The third subquestion provides an opportunity for students to become more familiar with restorations in your community or region. If possible, have students start with the restoration attributes they identified in their responses to the first two subquestions and set up an interview with the site managers to determine which apply to the project at hand. If an interview isn't possible, information can usually be found on the web.

What to Look for in Student Responses

- Question 4 is similar to Learning Objective 2 in this chapter. For additional comments about expectations, you might also look at Suggested Learning Objectives Outcomes, below.
- Students should be able to identify the following attributes of ecological restorations, as described in the textbook:

1. They repair loss or damage to communities or ecosystems caused by humans.
2. They contain native species.
3. They have a structure similar to that of historical communities.
4. They supply ecological services that satisfy human needs.
5. They may result in novel communities.
6. They are transdisciplinary human creations.
7. They are conducted by private individuals and groups and public agencies at several scales.
8. They have aesthetic value.
9. They bring pleasure to people.
10. They are dynamic.
11. They have recreational, educational, or research value.

Question 5. What additional examples of challenges and opportunities might restoration provide in your community?

How to Use or Expand on This Question

- This question is an opportunity to encourage students to explore the social, technical, and theoretical context of restorations in your region. Here are some possible approaches:
  1. You might want to present case studies about one or several projects in your region and ask students to identify challenges and opportunities that are or were faced by the restoration team,
  2. You could invite site managers to visit the class to talk about their sites and have students ask them about challenges and opportunities,
  3. You could ask students to add to the lists in the textbook by investigating local examples using websites, interviews, or printed media.

Question 6. Restoration has been compared to improvisational theater—someone gathers characters (species) on a stage (site), gives them a sketchy idea of their roles in the cast (community), and lets the play unfold. What are the merits of this analogy? Where might it fall apart (if you think it does)?

Question 7. Think of a community with which you are familiar. Using the improvisational theater analogy, assign the characters and roles for the restoration play of that community.

How to Use or Expand on These Questions (Questions 6 and 7)

- The learning objectives behind these questions include helping students to become more familiar with the logic behind the restoration process; helping them to think about the interactions between the components; and, as is also true for questions 4 and 5, prompting them to investigate the restorations in their regions.

- Educators at all levels use analogies and metaphors to help students understand new concepts. The idea is to link the new idea to something with which the students are already familiar. Students learn by comparing the new with the old—identifying similarities and differences. (Of course this works best if we know what our students already know—but that is another story!) Here are some possible approaches:

    1. The analogy provided in questions 6 and 7 can be helpful to students at the beginning of a restoration course as well as at the end. Hopefully, the detail of the comparisons increases! Question 6 is an exploration of the analogy; Question 7 asks students to cast a particular play—this anticipates the discussion of community composition and structure in Chapter 2 (see Section 2.3). These questions work as brief paper assignments, and Question 7 in particular makes a good in-class discussion.

    2. To begin the discussion or to set up a paper assignment, it is often helpful to ask students to begin by contrasting improvisational theater with more traditional performances with regard to the roles of author, director, producer, and actor, especially with regard to the nature of their interactions. (Most students are familiar with improvisational theater, but if not, a reference to improv comedy usually works.)

What to Look for in Student Responses (Questions 6 and 7)

- Students should think about how creating, producing, and presenting a play is or is not similar to the restoration process. Following are some examples of what to look for in student responses:

    1. How does writing a play compare with designing a restoration? (A play has a plot line; a restoration has goals and objectives.)

    2. How do the results compare? (A play has a conclusion; a restoration may achieve the goals and objectives, but the process continues for the life of the site. The plot and the ending of improv theater are different at every performance as the actors respond to spontaneous decisions; each restoration is also unique.)

    3. Are play actors analogous to species in a restoration? (The actors in a play perform specific roles; species in a community also have roles.)

    4. How does the performance of one actor/species influence that of the other? (Major categories of species interactions include predator-prey relationships, competition, and mutualisms. See Section 2.3.1 and Table 2.1.)

Supplemental Activities and Exercises

See the textbook website (www.introrestorationecology.com) for examples of activities.

Suggested Learning Objectives Outcomes

Learning Objective 1. Discuss the historical roots and current scope of restoration ecology. This objective is related to Food for Thought Question 1 in the chapter.

Learning Level 1 Outcomes

- The textbook emphasizes two major historical threads (roots) in restoration ecology. Students should be able to identify, describe, and give examples of each:
    1. Naturalists and conservationists, garden writers, horticulturalists, landscape architects, and others in the late nineteenth and early twentieth centuries interested in reversing what they perceived as the loss of nature and the consequent harmful effects on the quality of human life (e.g., Muir, Marsh, Olmsted, Jensen)
    2. Educators interested in providing examples of natural areas for students to learn from (e.g., Longenecker, Curtis, Leopold)
- We describe the current scope of restoration ecology in four ways. Students should be able to identify and give examples of each:
    1. Scale: Size, expense
    2. Sponsorship: Individuals on private property, government on public land, volunteers on public land
    3. Expertise: Transdisciplinary, with team members from biological and physical sciences, the design arts, and the humanities
    4. Purpose (types): Conservation of biodiversity and complexity ("complete restoration"); conservation of ecosystem functions important to people ("ecosystems services"); aesthetic and emotional pleasure for people ("experiential") restoration

Learning Level 2 Outcomes

- Students should be able to link past and current projects and to make comparisons such as the following:
    1. The purpose of both historical and current projects is conservation of native species and ecosystem functions and providing pleasure for people.
    2. Both historically and currently, the practitioners of ecological restoration have included scientists (especially botanists) and landscape architects.

Learning Objective 2. Describe the similarities and differences between complete, ecological services, and experiential restorations.

This objective is related to Food for Thought Question 4 in the chapter. Check out the preceding section for additional comments about activities and expectations. The classification of the type of restoration is based on the project purpose and goals.

Learning Level 1 Outcomes

- Students should be able to define each of these terms for types of ecological restorations in their own words and to classify restorations using these categories.

Learning Level 2 Outcomes

- Students should be able to make comparisons between these three types of ecological restoration based on several characteristics of a project purpose and goals. Most important in the comparisons is the reasoning behind the students' decisions. For example:

  1. *Inspiration:* All three types of restorations are based on natural community/ecosystem models:

     Complete restorations model species compositions, community structure, ecosystem processes, and community dynamics.

     Ecological services restorations model those functions that most benefit humans (including protecting habitats of valued species) and may even include non-native species.

     Experiential restorations model those aspects of communities/ecosystems that bring pleasure to people: beautiful species arranged in aesthetic arrangements.

  2. Native species:

     Complete restorations include only native species in natural abundances and patterns.

     The origin of species in ecological services restorations is not very important; the roles they play in providing for human needs are. Ecological services restorations may include non-native as well as native species; they may be less diverse than complete restorations.

     Experiential restorations contain mostly native species, usually with the most aesthetically pleasing being the most abundant. Experiential restorations can be more or less diverse than the natural models.

  3. Human visitors: All three types of restorations often involve the public in the planning process and may welcome visitors, but:

     Experiential restorations actively encourage human interaction; complete restorations may at times discourage human use.

     The highest-priority uses of complete restorations are research and education; the most important uses of experiential restorations are recreation and education.

     Whether or not people are encouraged to interact with an ecological services restoration depends on the degree to which human use interferes with the benefits that the project is meant to provide. In some situations—for example, brownfield restorations—human use may be discouraged because of concerns over coming into contact with the hazards that the projects have been established to mitigate.

Learning Objective 3: Explain the design and planning process used by restoration practitioners.

Learning Level 1 Outcomes

- Students should be able to list the steps of the design and planning process as given in Figure 1.7 (see Section 1.5) and to arrange them in logical order.

Learning Level 2 Outcomes

- Students should be able to explain the reasoning behind each step, explain how each relates to the others, and draw parallels with other problem-solving processes with which they are familiar.

Learning Objective 4. Appreciate the theoretical and practical challenges restorationists face, as well as the many ways in which restoration ecology can contribute to composing the landscape of the future.

Learning Level 1 Outcomes

- Students should be able to list and explain the significance of the major challenges and opportunities presented in Sections 1.6.2 and 1.6.3.

Learning Levels 2 and 3 Outcomes

- By doing their own investigations using the web, published materials, interviews, and their own onsite observations, students should be able to identify the challenges and opportunities faced by specific existing restorations and compare them to those mentioned in the textbook. Food for Thought Question 5 provides such an opportunity.

Potential Issues, Questions, and Misconceptions

- Restoration involves putting things back to replicate the conditions of a site as it was at a particular time in the past. As we discuss in the textbook, the use of the term "restoration" to describe the field can lead to confusion. Many students are familiar with the term "restoration," having used it in other contexts as meaning "bringing back to a former position or condition" (verb) or "a representation or reconstruction of the original form" (noun).

  It is not surprising, then, that students come to the study of restoration ecology with the idea that the purpose is to reproduce exactly the historical vegetation of a site and, most important, to have a static and fixed community image against which they measure "success." These assumptions have led to debates among practitioners or with members of the public about "what time in the past should a restorationist reconstruct?" or about whether "only those species known to have been present on a site at some time in the past can be included in its restoration"—approaches that can severely limit the diversity of a site or even cause projects to fail if conditions have changed.

  Often students cling to a "typal" or static image of restoration targets even though they are aware of the spatial and temporal variation of communities and ecosystems.

- Some people involved in restoration projects contend that creating and reviewing plans is an unnecessary waste of resources, time, and energy. Often they are impatient and want to act now and figure it out later, and/or they are concerned that the consequences of delay will be worse than the consequences of moving ahead without a review. In our experience, especially with regard to working with public projects, exactly the opposite is true. Planning helps to ensure that important ideas and information are not overlooked and helps us learn from small mistakes rather than suffer from large ones.

- Students sometimes expect that learning restoration involves learning and applying a standard set of procedures that will work for most sites in a particular region of the world. To the contrary,

every restoration situation is unique. What can be learned is a framework to help address each new situation as it arises.

Chapter 2

The Community Model

Ecological Theory

As the name of the field implies, familiarity with the science of ecology is essential to the theory and practice of restoration ecology. Chapter 2 is an attempt to review some of the major ideas about the composition, organization, structure, dynamics, and functions of communities and ecosystems that underlie restoration theory and practice. In addition, we introduce the conceptual community/ecosystem model, a device that helps restorationists organize and apply their understanding of ecological theory to specific restoration situations.

Major Themes

- Every restoration is based on community/ecosystem models—descriptions of the restoration target communities and/or ecosystem services. The models guide the entire planning process from site inventory and analysis to design, implementation, and management. Ecological theory underlies the models and, depending on the type of restoration (complete, ecological, or experiential), addresses composition, structure, functions, services, interactions, spatial distributions, and spatial and temporal dynamics.
- Science-based ecological theories are established using an explicit and self-correcting process, the scientific method. A theory can and does change over time as information is discovered that it cannot adequately explain. To design successful restorations, it is important to keep up with recent developments in ecology.
- To ensure the long-term success of a project, it is very important that restoration designers describe the community/ecosystem model they are using to guide the project. That way, future managers can understand why the restoration proceeded as it did and can make adjustments to strategies or goals based on advances in theory.
- The majority of restorations concern the establishment of plant communities. Communities are collections of species; no two communities have identical species compositions. Species are present in a particular community because they are adapted to the environmental conditions of the site, have been able to arrive onsite, and interact favorably with other species that are present. Because these factors differ geographically, communities are variable in space.

  The composition and structure of communities may vary through time, owing to actions of the species within community disturbances coming from the outside or changes in global climate. Conversely, the influence of keystone species or the operation of cyclical disturbance patterns may keep composition and structure unchanged for long periods. The composition and structure of each community is the product of a unique history.

  Implications for restoration include the following considerations:

  1. Achieving a good species-to-environment match is a key to success,

2. Restoration plans should be written to include a range of possible species,
3. The area surrounding a restoration site needs to be evaluated as a source of potential colonists and disturbances,
4. To predict how a restoration may change through time, it is important to understand the interactions that take place within communities as well as predictions of changing global weather and disturbance patterns.

- Ecosystem functions include energy flow and nutrient cycles. Ecosystem services restorations in particular are concerned with ecosystem theory, although ideas such as the existence of energy limitations on the length of food chains and therefore on community diversity have implications for all types of restorations.

  Restorations are planned to serve as nutrient sinks (carbon storage) or nutrient sources (waterlogged wetland soils that harbor denitrifying microorganisms that move nitrogen to the atmosphere and out of the biological cycle).

- According to landscape ecology theory, the spatial distribution, size, and shape of restorations influence processes of colonization, extinction, disease transmissions, and therefore the potential species diversity of communities as well as the extent of "interior" habitat.
- Climate change is occurring, although what the pattern of change will be on any particular site is not yet certain. A major implication for restoration is to adapt a flexible, adaptive approach to restoration. Other considerations include the following:
  1. Use species with broad environmental tolerances.
  2. Include a variety of habitats onsite.
  3. If possible, use restorations to connect existing habitat patches to allow for the movement of species to more favorable habitats as conditions change.

Comments on Food for Thought Questions

Question 1. Community/ecosystem models can be expressed in a variety of ways, including text, diagrams, and sketches. What aspects of a model are best expressed in these different ways?

How to Use or Expand on this Question

- This question works well as a class discussion, or a take-home essay. Here are some possible approaches:
  1. It is helpful to begin by having the class (or student) develop a list of the topics they think should be part of a community/ecosystem model, based on the ideas in this chapter. Then, for each topic, ask if it is best expressed by text, diagrams, or in some other way. Be sure that students give reasons for their decisions.
  2. To make the question more concrete, apply it to a particular community, ideally one in your area. This especially helps students who learn best by applying ideas to concrete examples.

3. Have the students describe how each topic in the list they generated might be expressed using each of the three methods—text, diagrams, sketches. This version of the question helps students think about the strengths and weaknesses of each form of communication, as well as the kinds of information needed to understand the model.

What to Look for in Student Responses

- Model components: The questions posed in the sidebar on page 34 of the textbook and the forest model example in the case study on pages 35 and 36, together with the chapter headings, should help guide students to identify the following components of a community/ecosystem model (information contained in later chapters will add further detail):

  1. Geographic and climate ranges of community type
  2. Composition (possible species, given the environmental conditions; presence of species that play key roles—keystone species, dominant species)
  3. Community structure (vertical layers, species abundance, horizontal patterns, expected number of species)
  4. Landscape structure (found naturally in large expanses or small embedded patches)
  5. Species interactions (flower/pollinator partners, trophic relationships)
  6. Dynamics and stability (annual cycles; disturbance cycles; patterns of succession, including response to disturbance)
  7. Biogeochemical cycle compartments (presence, size)
  8. Hydrologic cycle role (source, conduit, or recipient of water)

  The important thing is that students convey their vision of what a community or ecosystem is. For many students, creating a model for a particular site, as in the alternative Question 2, works best.

- The question as to which form of communication best expresses the different model features will usually yield a variety of opinions because of the variety of ways in which people learn. Visual learners will prefer sketches and diagrams; those who prefer language and narrative will prefer text in most cases. The important message is that the ideal community/ecosystem model will use a combination of techniques (including some not mentioned—e.g., tables and photographs) in order to reach as many people as possible. The following points are often brought up by students:

  1. *Text:* Although an image is sometimes "worth a thousand words," text can be used to describe all the model components and is especially useful in providing explanations and in discussing species interactions and roles.
  2. *Diagrams:* Diagrams are useful to illustrate ecosystem flows and cycles, trophic relationships, and successional pathways, as they depict relationships at a glance.
  3. *Sketches:* Sketches provide excellent summaries of community and landscape structure, as well as geographic ranges. Sketches used in describing structure often distill the features of many individual examples into a composite that expresses the "essence" of a community.

Question 2. Choose a community that would be a candidate for restoration in your region, and create a community model that addresses the questions regarding composition, interactions, structure, and dynamics posed at the beginning of the chapter.

Question 3. Choose an ecosystem process (nutrient cycle, energy flow, hydrologic cycle), and describe the composition of the system compartments and the nature of their interactions in a community typical of your region.

How to Use or Expand on Questions 2 and 3

- The main learning objective for both of these questions is to give students the opportunity to apply the ideas discussed in the chapter to one or more concrete examples. For many students, this exercise helps to clarify concepts and provides them with a deeper understanding of the communities they would like to restore. The questions also anticipate several Food for Thought questions found at the ends of Chapters 4–8 of the textbook, the answers to which rely on information from community/ecosystem models. Examples include questions 1 and 4 in Chapter 4 (pp. 138, 139); questions 2 and 4 in Chapter 6 (p. 196); questions 4 and 7 in Chapter 7 (pp. 226, 227); and questions 2, 3, 4, and 5 in Chapter 8 (p. 275).
- The questions work well either as individual or small-group assignments. Here are some possible approaches:
    1. Rather than having the students choose which community or process to address, you may want to choose the topic for them. In this way, you can ensure that the class covers a variety of communities or processes.
    2. Alternatively, you might limit the assignment to one or two communities to facilitate discussion
    3. You can also assign students specific items to cover. Doing so provides more direction and is particularly valuable to students with minimal previous familiarity with design and planning problems or ecology. For example, instead of asking students to prepare a composition model, ask them to describe composition by listing expected life forms and representative or common species. Or narrow the description of species interactions by asking them to focus on a specific set of organisms in describing interactions.
- If you choose to have students work together in groups, each of which will produce a report, it is helpful to provide guidelines on how to organize the work and how to facilitate collaboration. You can find many examples of such guidelines on the Internet. Here are some approaches we have found to be helpful:
    1. Have the group create a work plan (storyboard) that breaks the assignment into specific tasks, places the tasks in order of completion (A needs to happen before B), and assigns due dates for each (it helps to work backward from the date the assignment is due).
    2. Assign specific roles to each group member. The roles can include responsibility for specific tasks in the work plan and/or serving as convener, report editor, graphic designer, discussion facilitator, recorder of discussions, or timeline facilitator (the official "nudge").

3. Especially if many of your students are new to group work, it is helpful to provide a set of group expectations and protocols. These can include such items as completing assignments on time, participating in group meetings, and showing respect to each member.
4. Give each student the chance to explain what he or she contributed to the final report and to provide constructive comments on the contributions of others.

- These days, technology can greatly facilitate the writing of a group report. There are many document-sharing platforms that allow multiple authors to collaborate. These range from the now old-fashioned sending drafts to one another via e-mail to using online sites such as those developed for managing groups (e.g., http://wiggio.com), to taking advantage of instructional software packages offered by your school.
- An individual essay assignment built around either Question 2 or Question 3 is a good opportunity to introduce a peer review process. Here are some ways you could proceed:

1. Have students share a draft of their community or process model with one or more of their peers to obtain preliminary feedback.
2. After they receive the comments, students then submit both the paper and the drafts with reviewer comments to you.
3. At this point, you could also serve as a reviewer and ask students to submit a final copy after responding to your comments. (If only you had the time, right?)

   Each student serves as a peer reviewer as well as an author. The system works best if you assign the reviewers, as well as provide guidelines for the review. For example, you can ask the peer reviewers to look for clarity of content, missing topics or explanations, and factual errors, as well as spelling a grammar mistakes. You will remain the best person to judge the depth and accuracy of content.

   When it is working well, the peer review process helps you by catching obvious problems before the papers reach you, helps the authors improve their drafts, and gives students an opportunity to provide and receive constructive critiques. It is also good practice for students who plan to be restoration practitioners or researchers. As we discuss in Chapter 3 (see Sections 3.3 and 3.4.7), both peer and client reviews are essential components of restoration ecology.

What to Look for in Student Responses (Questions 2 and 3)

- The detailed content of the models will, of course, vary. Check out the commentary regarding Question 1 above for a listing of typical model components. If you have used the "improvisational theater" Food for Thought questions (questions 6 and 7) in chapter 1, students should link their responses to their models.
- One thing that we remind students to do is to reference and cite the sources of the information used to create the models. It is helpful to make this expectation clear in the assignment statement.

Question 4. What kinds of human impacts occur in your region, and what are the potential effects on the natural communities? How do human-caused impacts differ from so-called natural disturbances?

A discussion of community dynamics and/or stability is an important component of community/ecosystem models. The goal of this question is to have students consider whether the consequences of different kinds of human impacts are similar to or different from the consequences of natural disturbances. In addition, this question serves both as an opportunity to review information presented in Chapter 1 and to set the stage for the information we present in Chapters 11 and 12.

How to Use or Expand on This Question

- This question works well as the basis of an in-class discussion or as an essay.
- You can also ask students to include a consideration of the consequences of potential human impacts as students create the community/ecosystem models in assignments based on questions 2 and 3 above.
- If possible, you can have students interview area restoration practitioners or conservationists and report on their responses to this question.

What to Look for in Student Responses

- Students can find several examples of human impacts and their consequences in both Chapters 1 and 2. In Chapter 2, we mention human impacts primarily in relation to disturbance cycles (see Section 2.3.3) and the creation of patchy landscapes (see Section 2.5) and as instigators of global climate change (see Section 2.6). Chapter 1 lists several kinds of human impacts (removal of natural areas and substitution of artificial habitats of steel and concrete; monoculture crops; control and setting of wildfires; transplanting species to distant areas), as well as ways in which they differ from natural disturbances (global reach, creation of novel chemicals and organisms, capability of rapid global movement and transport). (In particular, see the Chapter 1 introduction as well as Section 1.6.)

  Depending on which version of the question you assign, students' answers will be more or less focused. For example, if students are considering human impact in the context of a particular community/ecosystem model or are summarizing the experiences of a specific group of practitioners or conservationists, their answers will necessarily focus on the human impacts and the natural disturbances that are most likely to affect the specific situations they are investigating.

Question 5. What course is climate change predicted to take in your region over the next 100 years? Select a species or community, and based on what is known about its response to temperature, precipitation, and so on, discuss what changes, if any, there will be in its geographic distribution 100 years from now.

How to Use or Expand on This Question

- One purpose of this question is to make the discussion of climate change more concrete by focusing on the implications of changes in local climate and weather patterns for one aspect of the

community/ecosystem models used in restoration—namely, community composition. It is important that students are aware of the possibility that some species ranges and community compositions may change over the next several decades in response to changes in the physical environment.

- In order to answer this locally focused question, students will need to evaluate material that is supplemental to this textbook. The reports of the Intergovernmental Panel on Climate Change, referenced at the end of Chapter 2, are a start. You can provide a list of resources with which you are familiar and/or ask the students to hone their research skills to locate the needed information.
- A second goal of the question is to help students understand the kinds of information scientists use to study historical and recent climate patterns (and species distributions) and to make predictions of future trends. Here are some ways you might proceed:
    1. To address the first part of the question, provide students with a summary of the current thinking on climate change for your region (or, if you like, any region of the world). Start by summarizing current patterns, and then explain what the climate models predict the future patterns will be. You could give a mini-lecture or assign readings, whatever you think best.
    2. Then have students address the second part of the question, pertaining to species and communities.
        a) Geographic range data are available for many native species, based on herbarium and museum collections. Students can find this information as well as maps of historical vegetation communities online or by contacting natural resource agencies in your area.
        b) With permission from the herbarium or museum, you might even ask students to create their own local species distribution maps by having them map the collection locations reported on the labels of herbarium specimens.
        c) Students can also find information about environmental tolerances for many plant species and for animals that are of special interest—because they are rare, for example.
        d) The next step is for the students to predict if the species or communities will be able to survive the predicted future environmental conditions of their current locations and, if not, to speculate where they might be found.
        e) In a small class, if you would like to create a discussion activity, you might, for example, have each student be responsible for a different community or species and present his or her findings to the class. After the individual presentations, open up the floor for a general discussion.
- As an alternative, have students investigate climate changes that have taken place in your region (if any) in recent times—say the past 50 or 60 years.
    1. For example, students could compare averages using data from 1900 to 1950 with data from 1950 to 2000. Chapter 4 (see Section 4.4.2) provides information about sources of climate data, as well as ideas for the kinds of data to explore—for example, monthly or seasonal maximum, minimum, and average temperatures; annual precipitation totals; or the start and end dates of things like frost-free days or precipitation cycles.

2. Students can use the data to investigate and propose short-and long-term trends and/or compare what seems to be happening in a specific region to global-scale predictions. For more information, check out the suggested resources found at the end of Chapter 2 (p. 64), as well as the chapter references (pp. 401–02).

- You can also have students add an explicit discussion of regional climate change (if they have not already done so) to the community/ecosystem models they have prepared in addressing questions 2 and 3.

  1. For example, they could take any trends they have seen in looking at past data and assume that the patterns will continue into the future, or use available expert predictions.

  2. Then they can consider how any climate changes might influence those portions of their models that discuss species or community distributions.

- Another possibility is to have students consider how any regional climate change trends they discover might influence other community/ecosystem model components—for example, structure, dynamics, or nutrient cycles.

- The Wisconsin Initiative for Climate Change Impacts (http://www.wicci.wisc.edu/climate-map.php), referenced at the end of Chapter 2, has recently developed an interactive map that allows you to see the predicted future climate of different regions of Wisconsin using a simple mouse click. The maps show locations in the United States that currently have the climate features predicted for the Wisconsin location in the future and display the predictions of several different models, based on different parameters. Students can see the range of the model predictions, as well as the convergence of several.

  Even if you and your students are not based in Wisconsin, you might be interested in developing an exercise based on this interactive map.

  1. For example, you could have students investigate the historical natural communities of locations in Wisconsin and compare these with the historical vegetation of the future climate matches.

  2. You could also have students investigate the geographic range of species currently found in Wisconsin and determine if they are, or could be, found in the region of the future climate matches.

What to Look for in Student Responses

- The details of the responses will vary by region as well as according to how you frame the question. You will be the best judge of accuracy and completeness. Here are some points to look for:

  1. Climate parameters important to restoration include the following:

     a) Precipitation and temperature patterns by month, season, or year

     b) Frequency and magnitude of storm events and wildfires

     c) Growing season length (dates of first and last frost or first and last precipitation event)

a) The consequences of climate change will vary across the globe.

b) The geographic distribution of climate parameters influences the geographic distribution of species and communities.

c) There are several climate models using different parameters; all predict future climate change, but the details vary.

d) Climate is not the only factor in the geographic distribution of species and communities.

- It is important that students give reasons for their predictions and that they use evidence, results from their own data analyses, and/or reference citations to support their claims.
- Depending on your location, it is possible that students will find that some aspects of regional climate seem to be changing or are predicted to change more than others, or that patterns are not clear. So long as such findings are evidence based, they are certainly acceptable. You might then ask the students to speculate what might lead to a relatively stable local climate in light of strong evidence in support of climate change at a global scale.

Question 6. We stated in Chapter 1 that one of the opportunities provided by restoration is that of enlarging the size of preserves (see p. 26, Section 1.6.3). Based on the principles of landscape ecology, describe the species, communities, and processes in your area that are most likely to benefit from this restoration application.

How to Use or Expand on This Question

- The goals of this question are to have students apply a landscape perspective to local conservation efforts and to review, or expand on, the ways in which spatial extent influences communities and ecosystems. Here are some suggestions on how to proceed:

1. This question works well as discussion topic. You could begin by having the class create a list of the ways in which size influences communities, species, and ecosystem processes, according to ecological theory. Then focus on one or more types of communities found in your region to discuss how increasing the size of a parcel would influence the items on the list. What, exactly, would a restoration need to accomplish?

   You can expand the question by asking about other ways by which restoration might advance landscape ecology principles—for example, the restoration of corridors or the maintenance of patch isolation; the use of design strategies to increase or decrease colonization rates; or the creation of multiple patches, some of which are remnants, others restorations.

2. You can also use Question 6 to inspire exam questions. For example, you could ask students to list four ways in which community size can affect its composition and structure. Or you could ask students to explain why they agree or disagree with the following statement: "The XYZ Conservancy purchased a 200-ha tract of cropland adjacent to their grassland restoration. They claim that by restoring a sustainable-harvest timber stand on the property, they have increased the size of the preserve, which will enhance and protect the grassland."

3. Another option is to make the situation more concrete. Use an aerial photo to identify patches of natural vegetation in an otherwise developed region, as well as a map showing parcel

ownership boundaries (real or hypothetical). Then ask students, individually or in teams, to propose a "parcel purchase priority list" in order to piece together a large preserve consisting of existing patches and restored areas. To the extent possible, assign purchase prices to the various parcels, conservation values to the natural parcels, and both a purchase and a restoration budget.

What to Look for in Student Responses

- Students should be able to discuss the following concepts, presented in Chapters 1 and 2 of the textbook: "Size influences habitat diversity and biodiversity, edge-to-interior ratio, the ability to maintain disturbance mosaics within a patch, and the ability to sustain animals requiring large territories" (see Sections 1.6.3, 2.5.1, and 2.5.2).

Question 7. What functions besides energy flow and biogeochemical cycles do ecosystems in your region perform? How might restoration influence them?

How to Use or Expand on This Question

- Question 7 is meant to link ecosystem functions with ecosystem services and ecosystem services restorations. One way to proceed is to use this question as the basis of a class discussion:
    1. First, have students generate a list of functions and ecosystem services.
    2. Next, have the class discuss what components of the natural communities in your area are essential to carrying out each one of these functions and ecosystem services.
    3. Finally, ask the students what restorationists would have to do if one or more of the essential components are missing.
- As an alternative, have students investigate an ecosystems services restoration, preferably one in your region, to learn what functions and services it was designed to provide. Then ask them to evaluate how well the restoration is achieving its desired outcomes. This exercise works well as an essay assignment and is particularly effective if students can talk with project managers.
- If there is no restoration in your region that was designed specifically to provide ecosystem services, you can still use it for this question. You can specify which services you want the class to investigate (removing particulates from stormwater runoff, providing habitat for songbirds) or have the class generate a list of possibilities and pick one to investigate. Then ask the students how site managers might influence the site performance.
- Another alternative is to assign students to do a literature search to investigate how restoration has been or is being used to provide ecosystem services. This could be an individual essay assignment, a required class presentation, the basis of a student-led seminar session, or some combination of these approaches.

What to Look for in Student Responses

- There are many possible answers here, such as:
    1. Providing habitat for special species

2. Controlling erosion
3. Protecting water quality
4. Contributing to mental health
5. Providing human food and fuel
6. Influencing climate

- To consider how restoration might influence these services, students should reference specific situations—for example, restoring wetlands around a pond to improve water quality.

Supplemental Activities and Exercises

- Students who have a good understanding of ecology will benefit from exploring the themes in this chapter in more detail. Here are some suggestions:

1. Ask students to predict possible outcomes for plant succession on a specific abandoned agricultural site in your region. Students can use the suggested guidelines presented in the textbook or other criteria; the important thing is that they link theory to their solutions.
2. Ask students to investigate individual species—plant, insect, animal—in terms of their roles within a community. Are they pioneer or climax species? Do they facilitate or inhibit? What symbiotic relationships do they participate in? Where do they fit in the community trophic structure? Are the species found in only one community type or on one site, or are they part of several communities? Are they found in one habitat as juveniles and in a different habitat as adults?
3. Explore the pros and cons of using restorations for assisted migration.
4. Discuss the concept of "assembly rules"; discuss what has been learned about the idea so far and its potential to inform community/ecosystem models.
5. Find an article or website that discusses a restoration case study, and describe the community/ecosystem model that underlies the goals or practices. Is the model explicit or intrinsic? What pieces are missing and/or vague?

Suggested Learning Objectives Outcomes

Learning Objective 1. Describe the purpose, features, and formats of conceptual community/ecosystem models, and explain the role of such models in restoration ecology.

Learning Level 1 Outcomes

- Students should be able to define "purpose" and "community/ecosystem model" in their own words.
- Students should be able to identify the two basic "features" of a model:

1. It describes the vision or image of the restoration target in terms of composition, structure, dynamics, stability, functions, and services.

2. It describes the assumptions about ecological theory that inform the vision.

- Students should be able to identify the following formats for a model:
  1. Text
  2. Diagrams
  3. Flow charts
  4. Equations
  5. Photographs
  6. Tables
  7. Sketches
  8. Other graphics
- Students should be able to describe the following roles of a model:
  1. It avoids misunderstandings and confusion.
  2. It helps organize thinking (which helps prevent inadvertent omissions).
  3. It identifies needed site inventory data.
  4. It predicts the effectiveness of different strategies and techniques.
  5. It guides the restoration plans.

Learning Objective 2. Discuss how ecological theory informs conceptual community/ecosystem models and underlies restoration practice.

Learning Level 2 Outcomes

- Students should be able to link the questions found in the sidebar "Questions Addressed by Community/Ecosystem Models" with the ecological theory topics discussed in Chapter 2. For example, the question "Are some species, organisms, or roles pivotal or essential for the survival of a particular community, and if so, what are they?" is informed by theories about symbiotic relationships, keystone species, and the role of species in creating microclimates.

Learning Objective 3. Differentiate between communities, ecosystems, and landscapes, and discuss how an understanding of each informs restorations.

Learning Level 1 Outcomes

- Students should be able to define "communities," "ecosystems," and "landscapes" in their own words.

Learning Level 2 Outcomes

- Students should be able to compare the concepts by identifying both similarities and differences. For example:
    1. Communities and landscapes comprise a nested hierarchy. Landscapes contain a set of communities.
    2. In the study of communities and landscapes, the focus is on organisms. The focus in studying ecosystems is on the roles that organisms play in carrying out processes. Organisms are one of several interacting components.
    3. It is possible to identify examples of communities and landscapes on a site and to study either type from an ecosystem perspective.
- All three concepts contribute to the community/ecosystem models that underlie restoration purpose, goals, and strategies.

Learning Objective 4. Evaluate the implications of climate change for the long-term future of current restorations.

Learning Level 1 Outcomes

Students should be able to identify the major theme brought out in the textbook—namely, the idea that species that are a good match for the environmental conditions of a restoration site today may not be a good match in future.

Students should also be able to list the implications of this theme:

1. The plan adopted needs to be flexible.
2. Species need to be selected with future conditions in mind,
3. A variety of microclimates needs to be incorporated within a restoration site, and opportunities for future colonization need to be provided.
4. Recent climate data need to be used to determine site conditions.

Learning Level 2 Outcomes

In addition to listing implications for restoration design, students should be able to evaluate the issues surrounding their application. For example, if species are selected with future conditions in mind, what if the predictions are not realized? At what point can we recognize that a restoration will not succeed because of climate change?

Potential Issues, Questions, and Misconceptions

- It is a misconception to think that community/ecosystem models are not used for all restoration projects. It is true that not all restorations contain an explicit description of the restoration team's guiding vision. And in some cases, a restoration team isn't concerned with achieving a specific community type, composition, or structure.

Even so, all restorations have an underlying theoretical framework that guides their implementation. This framework could be simply the idea that native species are disappearing and pest species are found in their place. Based on the theory of competition, it is possible (or likely) that the pest species are outcompeting the natives; therefore, to protect the natives, we should remove the pests.

- We have chosen to define the term "ecosystem" to emphasize an intellectual framework or point of view—the study of interactions between organisms, the atmosphere, the lithosphere, and the hydrosphere—rather than using it to describe a physical entity (all the organisms on a site and the physical environmental factors with which they interact).

  When used in the latter sense, "ecosystem" has a meaning similar to that of the community concept, which also situates organisms within an environment. We have found that when restorationists use the terms "community" and "ecosystem" interchangeably, it often leads to considerations of ecosystem services being overshadowed by discussions of composition and structure. Also, this distinction separates "ecosystem" from the nested hierarchy: population (collection of individuals), community (collection of species populations), and landscape (collection of communities).

  All members of the hierarchy can be found in nature, as well as being theoretical concepts. All can also be studied as ecosystems.

Offline Resources

- Intergovernmental Panel on Climate Change (IPCC), http://www.ipcc.ch
- Wisconsin Initiative on Climate Change Impacts. How is Wisconsin's Climate Changing?, http://www.wicci.wisc.edu/climate-map.php.

Chapter 3

Adaptive Restoration

Documentation and Research

In Chapter 3, we continue the discussion we began in Chapter 2 of background information necessary for restoration planning. Specifically, we describe the importance of using a flexible, adaptive approach to restoration, setting up documentation protocols, and incorporating research into every project.

Major Themes

- The adaptive approach to restoration builds in opportunities to revise goals and implementation strategies and techniques at every stage of a project. It is similar to the midcourse corrections that are part of the scientific method. Using the adaptive approach, we routinely evaluate the progress of a project to see if things are going as predicted and, if not, consider whether to modify either our expectations or our strategies. In addition, if an unexpected disturbance strikes the restoration site or if we learn about a new technique, we are prepared to meet these new challenges.
- Although the process is time consuming, documentation greatly enhances the long-term success, not only of an individual project, but of restoration practice. Project documentation includes recording and storing information about planning, implementation, and management.
- Restoration research informs restoration practice and can contribute to ecological theory. Two methods—directed observation of contemporary remnants and investigations of historical communities—together with the theory discussed in Chapter 2, inform community/ecosystem models. Embedded scientific experiments and field trials are key components of adaptive restoration and provide information that is critical in site design and in choosing restoration implementation and management strategies.

Comments on Food for Thought Questions

Question 1. Which aspects of a restoration project would be best documented using photographs? Written notes? Annotated maps? What are the advantages/disadvantages of each of these media in terms of accuracy, reliability, longevity, and ease of storage?

How to Use or Expand on This Question

- We have used this question as the basis for a class discussion, as a take-home essay, and on exams. Here are some possible approaches:

    1. To make the question more concrete, ask students to apply it to a specific site for which you have documentation and/or access.
    2. Have students interview a restoration practitioner about documentation. They could ask about the use and accuracy of photographs, notes, and annotated maps, in particular, or conduct a more wide-ranging interview. For example, they could ask about priorities—what aspects of

a project (if any) must be documented, what documentation would be useful if time and resources permit, and what information is not worth the trouble to collect and keep. They could ask about formats and storage and whether the information is considered to be private or public.

What to Look for in Student Responses

- The question addresses three common ways in which restorations have been documented. Students should describe each in terms of what information they convey and in terms of the longevity and ease of storage of the data they provide. Students should also address the accuracy and reliability of each type of media in representing the information they are being proposed to document. For example:

  1. *Photographs* provide a visual image; track restorations through time; document the use of implementation and management tools and techniques; and show visual results of implementation and management. How well photographs represent a restoration depends on the representativeness and numbers of their locations, how often they are taken, and the amount of detail they record. The detail in turn is dependent on distance and sharpness. Ease and longevity of storage depend on the type of photograph—digital image, formats, film.
  2. *Written notes* provide a narrative of observations and evaluations and a record of thoughts and ideas; serve as a record of progress for later reflection and digestion; and are an accurate reflection of an individual's immediate impressions but may not represent a complete understanding. Notes are relatively easy to record with pen and paper or digital devices; digital devices are more expensive. Paper notes can last for many years but may take storage space; the longevity of digital records is improving.
  3. *Annotated maps* depict the geographic location of different parts of a restoration site, with the notations conveying observations made at specific locations; are useful to show locations of items of interest—for example, exact locations of plantings or invasions of pest species; coupled with GPS readings, are helpful in pinpointing locations for others to find or for one to return to. Accuracy is variable, depending on the scale of the map. Paper maps are bulky to store; digital maps may not be retrievable if software changes and maps are not updated.

Question 2. Why is it helpful to understand the range of variation of historical and contemporary natural communities before designing a restoration?

Question 3. How might the idea that communities vary in composition over space and time influence the choice of species for a restoration?

- The main learning objective for both of these questions is to reinforce one of the main premises of restoration—that is, because natural communities are dynamic and are spatially heterogeneous, restorations based on these communities will follow suit.

How to Use or Expand on These Questions (Questions 2 and 3)

- These questions work well as the basis for a class discussion.

- To better reach students who like to work with tangible examples, here is an alternative exercise that works well.
    1. Provide students with descriptions, photographs, species lists, or sampling data from several examples of historical and/or contemporary examples of a particular community type.
    2. Then have the students compare and contrast the sites with respect to composition and structure.
    3. Next, ask the students to propose a community model (see Chapter 2) for a complete or experiential restoration.
- If you don't have or can't locate existing sources of information, consider using the exercise described under Supplemental Activities and Exercises below to generate the information.

What to Look for in Student Responses (Questions 2 and 3)

- Students should realize the following:
    1. Because communities are variable in space and time, no two restorations based on the same community/ecosystem model will be identical in composition, structure, or development.
    2. Similarly, this variation means that no two restoration projects will be the same; one cannot use a "cookie cutter approach" to restoration. This makes the field both challenging and interesting.
    3. The species found within a particular community type may vary geographically or depend on the amount of time since disturbance. For example, deciduous forests in Wisconsin contain American beech trees in the eastern portion of the state, but not in the central or western portion.

Question 4. What arguments might you use to convince a funding agency to support embedding one or more research projects in a restoration?

How to Use or Expand on This Question

- We have used this question as the basis for a class discussion and on exams.
- We have also assigned students to compose a "letter of appeal" to a hypothetical funding agency that would not provide funds for an experiment, no reasons given.
- You might try to obtain an application form from one or more funding agencies and have students "apply" for funds for a project that includes an embedded research project.
- If possible, have students interview someone from a public or private agency or an academic colleague who has experience in obtaining funding for restoration. Students could ask about their experience or impressions of the difficulty of embedding research in a restoration project. If the interviewee has been successful in incorporating research into the project, the student could ask about the strategies used.

What to Look for in Student Responses

- Students should be able to bring up the following points:

1. Embedded research projects are an important and integral part of the adaptive restoration process, and although they require time and resources to implement, they usually save time and resources in the long run.
2. The practice of restoration is relatively new. There are often several options for achieving the goals of a restoration, and/or there may be no precedents for a project. Sometimes a technique that works on one site does not work on another. Using mini-experiments to see what strategies/techniques work best onsite often saves effort later.
3. Experimentation is an important avenue for improving restoration practice.

Question 5. Design a field experiment to compare two different techniques for planting herbaceous species in the understory of a forest restoration.

How to Use or Expand on This Question

- You can modify this question to fit restoration situations in your area. The idea is to have students apply the experimental methods discussed in the chapter.

What to Look for in Student Responses

- Be sure that the students consider the principles of replication, randomization, and unknown environmental variation in a field study. Students should also consider the need for controls. For example, if students are addressing the planting method question, the control would be a plot with no planting; such a control plot would be especially important if the species involved might colonize the site on their own.

Sidebar: Quadrat Sampling

- This sidebar (see p. 79 of the textbook) includes several questions about the composition of a prairie remnant that can be answered using the sampling data displayed in Table 3.1 (p. 78). The questions and sample answers follow.

What to Look for in Student Responses

Question 1. What is the minimum number of forbs (non-grasslike flowering plants), grasses/sedges, and shrubs found in Muralt Bluff Prairie?

- To answer this question, students should count the total number of taxa listed in Table 3.1 all of which were present in the sample 39. Students should note that several of the taxa (for example, Physalis sp., Rosa sp., Carex sp., and Panicum sp.) are not identified as to species; this means that there may have been more than 39 species in the sample. Also, the sample likely did not include all of the species on the site.

Question 2. What species are the most and least common (frequently found) at this site?

- Students should find that the species with the highest frequencies (shown in Table 3.1 in the column to the right [freq.]) were: Liatris aspera (14), Sisyrinchium campestre (12), Andropogon gerardii (11), and Poa compressa (11).

Question 3. How many species are found in an area of 1/4 m2 (average number, minimum, maximum, variation by life form)?

- Students should reason as follows: Each quadrat was 1/4 m^2 in size. The totals listed at the bottom of the table show the number of different species found in each quadrat. The average total can be found by finding the sum of the totals and dividing by the number of quadrats sampled: 158/15 = 10.5.
- The minimum number of species per quadrat is 4 (Quadrat 13); the maximum is 17 (Quadrat 5).

  Considering different life form categories:

  1. For shrubs, no quadrat had more than 1 species; most had no species.
  2. For grasses, the average number of species per quadrat is 65/15 = 4.3; the minimum number of grass species per quadrat is 2 (Quadrats 2 and 15); the maximum is 8 (Quadrat 5).
  3. For forbs, the average number of species per quadrat is 91/15 = 6.1; the minimum is 1 (Quadrat 13); the maximum is 9 (Quadrat 5).

Question 4. Are some species found throughout the site? Are others clustered in the north? The south? Explain.

- Students should be able to recognize that frequency can be used to measure spatial distribution, and that species with the highest frequency values (see answer to Question 2) are those that are found throughout the site. A frequency of 11 or more means that they are in almost 75% of the site.
- To see if any species are clustered in the north or south, students should compare their presence in the northern and southern tiers of quadrats with their presence elsewhere. Some species—Erigeron strigosus, Physalis sp., and Ratibida pinnata, Viola pedata—seem to have been found only or primarily in the northernmost quadrats (Quadrats 1–5): Anemone cylindrica, Dodecatheon meadia, Euphorbia corollata, and Monarda fistulosa are found only in the southern quadrats (Quadrats 11–15).

Sidebar: Quadrat Sampling: Food for Thought Questions

Question 1. If you know that there is a physical gradient on a site, running from the top to the bottom of a hill, how would you distribute quadrats? Explain.

What to Look for in Student Responses

- Students should be able to reason as follows: Assuming that the goal is to capture as much species diversity as possible, and assuming that the different parts of the environmental gradient will support different species, one would distribute samples along the gradient, in this case following the slope from top to bottom. To ensure that most portions of the gradient are covered by the quadrats, one might divide the slope into equidistant segments and place the same number of quadrats in each segment.

Question 2. What information is missing from the presence/absence data used in the Muralt Bluff Prairie example?

What to Look for in Student Responses

- Students should be able to explain that the data do not provide information about the abundance of the different species—the number of individuals of each species or the amount of ground covered by each. The data also do not indicate height or three-dimensional structure or provide information about the age structure of the population or whether the species are flowering or producing fruit or seed.

Question 3. Which might change more if you increase the number of sampling points: the list of rare species or the list of common species?

What to Look for in Student Responses

- Students should be able to explain that the answer will depend on the sampling layout and the definition of "rare" and "common" that you are using. Here are some points to look for, assuming you are using a random sampling layout.

    1. One definition of "rare" is that a species is found in small numbers in only one portion of a site as compared to a "common" species that is found throughout a site. Odds are that any one sample will more likely contain a common species than a rare one. The more samples you use, the more area you will cover and the more likely it is that the sampling points will land on the spots with the rare species.

    2. Sometimes species that are rare in a region will be in high abundance on a particular site, and species that are common in a region will not be abundant on your site. In this case, you would need more samples to include the "common" species.

    3. If you know in advance that your site contains microclimates that support regionally rare species, you can design the layout of the sampling points to be sure that some of them will land in the area containing the rare species. This will allow them to be counted by targeting sampling locations rather than increasing the number of samples.

Sidebar: Collecting and Analyzing Tree Rings: Food for Thought Question

Question 1. The increment borer removes a very thin cylinder of wood from the trunk of a tree. What are some of the potential problems with using this technique, in terms of the health of the tree, as well as in using the information to understand the age structure of a forest or patterns of climate?

What to Look for in Student Responses

Student responses should include the following points:

1. The increment borer technique creates a channel to the interior of the trunk, thus potentially creating a means for the invasion by pathogens.
2. The core may be collected at an angle and miss existing rings.
3. 3Trees may produce more than one ring per year or in a poor year may miss a ring, so the number of rings is not a direct correlate of climate.
4. Very thin cores may break.
5. You may miscount or misread a core.
6. As with any form of historical data, information gathered by this technique needs to be cross-referenced with other data to determine trends. For example, the microclimate of the site from which the cores are collected may not represent the general climate of an area.

Supplemental Activities and Exercises

- In this chapter we introduced three techniques for studying remnants that can form the basis for learning activities. The techniques include (1) the site immersion technique, (2) the vegetation quadrat sample, and (3) quadrat mapping. These techniques are discussed in the textbook and in Sidebars 3.1 and 3.2, Table 3.1, and Figure 3.4.
- You can have students use combinations of all three to study one site, or to make comparisons between several different examples of a single community type, or between different types of communities. For example:
    1. Arrange for the class to visit a series of remnants, all of which are classified as the same community. Begin each visit by having each student conduct a site immersion exercise (the full text of the exercise we use can be found on the textbook website, www.introrestorationecology.com). Next, divide the class into teams and conduct a presence/absence quadrat sample. Be sure to use the same size, shape, and number of quadrats at each site. If there is time, have the students map the species in a few of the quadrats. (An example of the exercise we use in a field class is on the textbook website.) Then, using the results of the sample (you can provide summaries or have students create them) and their immersion experiences, have the students:
        a) Use the sampling data to compare and contrast the vegetation of the sites. Be sure to consider the following questions: What is the species richness of each site? Which species are the most and least frequently found on each site? Looking at the sites as a whole, are there any species found at all of the sites? At most sites? At only one site? Are

any species frequently found together (in the same quadrat)? If so, name them. What is the range of site diversity (species richness)?

b) Use the results of their immersion exercises to describe the visual and spatial character of each site.

c) Create a community/ecosystem model using the results of these field data.

2. Instead of visiting a series of remnants of the same community type, visit examples of different communities. Have the students sample the site and use the immersion technique as described in exercise 1 above. Ask them to compare and contrast the vegetation of the sites. Be sure to have them consider the following questions:

a) What is the species richness of each site? What is the range of site diversity (species richness)? What species are the most and the least frequently found on each site? Using the frequency measure to represent relative commonness or rarity (high frequency = common; low frequency = rare), do some communities seem to have more common or more rare species than the others? Looking at the sites as a whole, are there any species found at all of the sites? At most sites? At only one site?

b) What are the similarities and differences between the sites in terms of visual and spatial character?

c) Which sites (communities) seem to be most similar, based on species composition and structure?

- Many students enjoy investigating historical communities. If you are in a region of the United States included in the Public Land Survey, you can have students explore these records to create vegetation maps for specific sites. You can also have students visit your local historical society or natural history museums in search of photographs, artifacts, and narratives. See the textbook website for an example exercise.

Suggested Learning Objectives Outcomes

Learning Objective 1. Appreciate the importance and significance of the adaptive approach to restoration.

Learning Level 1 Outcomes

- Students should be able to define "adaptive restoration" in their own words; give examples of methods (field trials and experiments); and identify situations when the approach is used (determining implementation methods, for example).

Learning Level 2 Outcomes

- Students should be able to describe how adaptive restoration can save time and money and to evaluate the merits of different methods and different situations (flexibility and having a predetermined change procedure arguably allow a quicker response time in an emergency).

Learning Objective 2. Discuss the kinds of documentation and communication networks that inform the practice of restoration.

Learning Level 1 Outcomes

- Students should be able to name the types of documentation and categories of communication networks mentioned in the textbook. For example:

  1. *Documentation:* field notes and observations, photographs, work journals and team reports, records of purchases
  2. *Communication networks:* professional organizations and conferences (talking with colleagues, presenting and listening to talks, publication in peer-reviewed journals, visiting restoration sites)

Learning Levels 2 and 3 Outcomes

- Students should be able to compare and contrast the merits of different documentation and communication techniques in terms of value to the individual and the profession, accuracy, reliability, and costs of time and money.

Learning Objective 3. Discuss the role of research in contributing to adaptive restoration practice and theory.

Learning Level 1 Outcomes

- Students should be able to define "research" in their own words and to identify the different forms of research discussed in the chapter—for example, performing a literature search and evaluating the information; observing remnants using directed techniques; investigating historical communities using maps, photos, and the like; establishing scientific experiments; performing field trials.

Learning Levels 2 and 3 Outcomes

- Students should be able to explain the purpose of each form of research; give specific examples of how the results benefit restoration practice; and discuss their pros and cons in terms of reliability, accuracy, cost, or additional parameters.

Potential Issues, Questions, and Misconceptions

- The use of adaptive restoration and the value of embedded restoration research projects is now widely adopted by practitioners working for public agencies and nonprofit conservation organizations. However, barriers remain for restorationists working in the private sector. One problem is that restoration firms are often hired using short-term contracts with a set budget. Restorations take years to mature, and the need for adaptations may not even be recognized until after the contract is no longer in effect. The budget is based on implementation procedures that are specified in advance. Such contracts often allow limited flexibility for midcourse corrections. In addition, many clients want to pay for "results," not "information."

- The research section of Chapter 3 (see Section 3.4) only scratches the surface of experimental design. Many instructors will want to present more sophisticated examples and information. For best results, it is always good practice for restorationists to consult with a statistician before implementing experiments.

Chapter 4

Site Inventory and Analysis

Chapters 4 and 5 describe site inventory and analysis, one of the most important and central components of the theory and practice of restoration ecology. As we state in Chapter 1 (p. 20), matching species to the environmental conditions of a site is crucial to the success of a project, as is an understanding of its social milieu. Together, Chapters 4 and 5 introduce a procedural framework and a set of strategies, information sources, and tools with which restorationists become informed about a site and its context. The focus in Chapter 4 is on understanding the many ways the information provided by site inventory and analysis informs restorations, and on how to determine which features of a site to study for a particular project, how to locate existing information about those features, and how evaluate the information in order to apply it.

Major Themes

- Restorationists usually repeat the site inventory and analysis step several times during a project. We use the results to determine what community and habitat types a site will support, how the restoration of a community/ecosystem will be implemented, and how the completed restoration will be managed. The inventory describes the current conditions of the site features that are relevant for a specific stage of a particular project; the analysis describes the restoration opportunities that the site resources afford, as well as any constraints that need to be addressed.
- The focus of inventory and analysis does not stop at the boundaries of the project area but includes its physical, biological, and sociological context as well.
- The types of resources that are generally included in an inventory and analysis are topography, hydrology, soils, fauna, vegetation, cultural features, regulations and permits, human use patterns, and human perceptions. Exactly which resource features are involved depends on the project goals and objectives.
- In many cases, restorationists will be able to find existing information about a site from the Internet or in publications. Formats include digital and hard-copy maps, aerial photographs, satellite imagery, databases (some of which are georeferenced), and descriptive narratives. Sources include national, regional, and local governments; academic institutions; and private conservation organizations.
- Once the restoration team has gathered the site inventory data, one of the best ways to organize and communicate the findings is to create a series of maps that show the spatial locations of the site features. During site analysis, the team evaluates the data with respect to the desired project goals and objectives.
- Suitability analysis and opportunities and constraints analysis are the two most prominent approaches to site analysis.
- The results of the initial site inventory and analysis are included in the master plan report (see Section 6.4).

Comments on Food for Thought Questions

Question 1. What site data would you collect in the process of developing a plan for a stream restoration? Explain why you selected these data. How might they be used to determine opportunities and constraints for the restoration?

How to Use or Expand on This Question

- You can use this question as the basis of a class discussion before students have read Chapter 4 or as a means of reviewing and applying the information found in the textbook. In either case, the learning goals are for students to be able to use community/ecosystem models to identify the site features that will most affect the progress and outcomes of a restoration.
- Using the question before students read Chapter 4 is a great way to help them to anticipate the major themes of the chapter and even to formulate the themes for themselves. Using the question as a review helps students to apply what they have learned and to deepen their explanations.
- Here are some possible ways to organize a discussion:
    1. You can divide the class into teams of from two to four students. Then pose the first subquestion and give the groups time to come up with lists of data. Next, ask each group in turn to share an item from their list, and write it on the classroom board or use a projection system to display the answers. Once all the items have been displayed, discuss how each is relevant (or not). Then repeat the process for the second subquestion.
    2. Alternatively, you can have each individual write down items on sticky notes and place them on a board or a sheet of paper at the front of the class. Next, have one or two volunteers organize the individual notes into themes for discussion. Or just open up the classroom for a general discussion
- You can also modify the question for use on a short-answer-format exam. For example:
    1. "Name three types of site information that you would collect in the process of developing a plan for a stream restoration. Explain why you selected these data. For each, explain where you would look to find existing sources of information. How might each be used to determine opportunities and constraints for the restoration?"
- Another way to frame this question for a discussion or an exam is to have students list the goals that would likely be desired for a stream restoration and then list and describe the site data or attributes that would be collected to determine whether the goals are feasible.
- To add specificity to the question, select an actual nearby stream or water body and ask students to focus on it when addressing the question. To make the question even more focused, specify a restoration purpose and/or a set of restoration goals.
- You can also substitute another local community/ecosystem for "stream" as the restoration focus.

What to Look for in Student Responses

- It is important that the students' recommendations about what site information to collect be relevant to stream restoration and to the restoration goals. In other words, students need to explain how each bit of information will help them make their restoration decisions.
- The question as written does not spell out specific goals. Students can begin either by establishing a set of goals or by listing the data that they think would apply to most stream restorations. The important thing is that they understand that every inventory and analysis is organized around the needs of a specific project. You can also supply this information for them.
- Students should consider physical and biological resources as well as cultural features and human use patterns. For example:
    1. Position of stream within watershed
    2. Position of stream in relation to groundwater
    3. Size and land cover types of stream's watershed
    4. Water quality (chemicals, particulates)
    5. Water volume (seasonal, flood frequency)
    6. Water temperature and oxygen levels (seasonal)
    7. Flow rates (total, by season, base flow, storm events)
    8. Channel structure (width, length, depth, slope, bank slope)
    9. Channel substrate (rocks, sediments)
    10. Presence and quantities of aquatic plants and animals
    11. Presence of debris
    12. Microclimate (overhead shade, wind patterns)
    13. Presence and quantities of streambank plants and animals
    14. Soils of streambanks, watershed
    15. Human and animal access—presence of paths, dams, trampled banks
    16. Presence of fishing, trapping activities
    17. Existing applicable policies and regulations
- Once students have developed their lists of features, they should explain how they would use each piece of information to evaluate restoration opportunities and constraints. For example, sedimentation, as discussed in the chapter, has significant impacts on water quality (turbidity, temperature, oxygen levels, etc.), which in turn affect which species can live in the stream. The degree of active sedimentation found during the site inventory when compared with the rates called for in the restoration objectives will determine if this feature is an opportunity or a constraint.

- If you modify the question for use on a short-answer-format exam, as suggested in the What to Look for in Student Responses section above, student responses can be more specific, and students can more directly identify a link between site information and restoration goals.

Question 2. Explore the SSURGO files on the USDA NRCS Soil Data Mart website (http://soildatamart.nrcs.usda.gov). What data can they provide about a site? What is the level of accuracy of these data? What onsite data would you gather to supplement the SSURGO data?

How to Use or Expand on This Question

- This question works well in a classroom setting in which students (or teams of students) each have access to an Internet-connected computer. Here are some possible approaches:

1. Have the students use a web browser to open and explore the SSURGO files for a few minutes, and then lead a discussion to address the subquestions.
2. Alternatively, you can use a projector to display the web pages to the entire class so that you and the students can explore the site and develop answers together.
3. A good way to begin is to explore the "Soil Data Mart—Purpose and Procedures" and "Soil Data Access" links found on the Soil Data Mart home page (http://soildatamart.nrcs.usda.gov). Then choose a specific location (using geographic coordinates) and collect information. Next, return to the Soil Data Mart home page and follow the "Web Soil Survey" link for an alternate presentation of soil survey data.

   For those of you not based in North America, in addition to or instead of exploring the USDA NRCS website, have students explore the online information available on the web for your location.
4. You can also use parts of the question as the basis for a homework assignment. For example, have students design a table that displays the data sets that can be found in the database and the information that each data set contains. This exercise helps students become more familiar with the database.
5. As an alternative, have students use the Soil Data Mart to look up a specific property, generate a map of the soils found onsite, and provide a description of each of the soil units. The directions needed to perform all of these tasks are provided on the Soil Data Mart website (http://soildatamart.nrcs.usda.gov). Students can take this further by describing the community types that might be feasible for the site when considering both soils and topography.
6. Expand the search for soils information relevant to restoration by asking students to find and then explore other Internet sites. Students will enjoy discovering what is available for sites around the world.

d) Begin by having students generate a list of key words or phrases to use in performing the search.

e) Then ask students to document the kinds of information found on each site, and discuss the reliability of the information, in terms of the credentials of the website authors/developers, the source and age of the information on the site, the date the site was last updated, and so on.

7. Substitute another online data source for the SURGGO/Soil Data Mart files, such as the NOAA (http://www.noaa.gov) or the U.S. Water Resources (http://water.usgs.gov) websites.

- This question can also be used to introduce students to metadata—what it is and what information it contains—the answers to which can be found for the SSURGO database by clicking on the "SSURGO metadata" link on the front page of the Soil Data Mart website (http://soildatamart.nrcs.usda.gov).

What to Look for in Student Responses

- In their responses to the first part of the question—"What data can the SSURGO files provide about a site?"—students should include the following points:

1. The information contained in the site comes from the National Cooperative Soil Survey operated by the USDA NRCS. Useful information found within the Soil Data Mart includes the following:

f) Soil map showing the locations of soil mapping units using the Natural Resources Conservation Service soils classification system. The mapping units are based on soil type, and on socioeconomic issues, such as being "prone to flooding." Maps can be viewed online or downloaded into a computerized geographic information system such as ArcGIS.

g) Tables of physical descriptions of each of the soil mapping units (e.g., texture, pH, depth to bedrock, depth to water table) and of the area covered by each soil type. These are the "inventory" data.

h) Tables of assessments provided by the NRCS of the suitability of the soil units for a number of human uses, ranging from growing agricultural crops to siting buildings and paths and trails. This is the "analysis" information. The tables indicate whether or not a particular soil type has limitations for a particular use.

2. The Web Soil Survey, accessible from the Soil Data Mart web page (http://soildatamart.nrcs.usda.gov), presents the National Cooperative Soil Survey and includes links to a number of guidelines to interpreting soils inventory data in order to determine suitability for a number of purposes. These guidelines help in data interpretation. The site also provides links to soil geography and to a number of tools for obtaining specific soils information, including the Soil Data Access and Soil Data Viewer tools.

- There are a couple of ways to respond to the second part of the question—"What is the level of accuracy of these data?"

1. One answer addresses the accuracy of the data found on the site—for example, in terms of its positional accuracy (how accurate the boundaries of the mapping units are) or its temporal accuracy (how long ago the data were collected). This information will be different for each state, because of variations in when and how the soil inventory was conducted. The scales of the maps vary from 1:12,000 (for the newer maps) to 1:63,360 (older maps). Students can

find this information by using the "View Soil Survey Area Metadata" link found at the bottom of the screen, in which the user selects the survey area within the Soil Data Mart.

2. Another way to approach the question is to address the relevance of the information found in the database to a particular restoration situation. For example, are the categories of the suitability ratings relevant to what a restorationist needs to know? For what restoration purposes is the scale of the survey appropriate?

   A possible response might be that the scale of the information available from the soil survey is more useful at the master plan level than for the site plan, and the most relevant suitability ratings concern the siting of cultural features, such as roads and trails, or broad vegetation categories, such as wetlands or communities growing on dry soils.

- To address the third subquestion—"What onsite data would you gather to supplement the SSURGO data?"—students should think about the purpose of a particular restoration and about the issue of site variation and the scale at which maps can present information.

  With regard to the restoration purpose, students should mention that restorationists might need to collect information that is not provided by the online database in order to evaluate the soils of a site. One example they could provide is whether or not mycorrhizal fungi needed for the establishment of a particular plant species are present in the soil. With regard to scale, the soils information provided online varies in the level of detail provided. A particular survey may not reveal the fine-scale variations of texture or soil depth that an onsite inventory can provide. Such variations may matter in selecting species for a restoration.

Question 3. Develop and then defend a list of data sources that can provide information on a potential site for restoration in your area, prior to your visiting it. What value might these sources have for you in learning about the site before actually visiting it? Where might they be inadequate without a site visit?

How to Use or Expand on This Question

- This question helps students organize all the data sources listed in Chapter 4, as well as others that are specific to your area. It works well as a class discussion, as a homework assignment, or, by narrowing it a bit (for example, asking for three data sources), as an exam question.
- One suggestion for addressing the first subquestion—"Develop and then defend a list of data sources that can provide information on a potential site for restoration in your area, prior to your visiting it"—is to break it into several steps:

  1. Have students begin by listing data categories (soils, vegetation, topography) and the specific attribute information needed for restoration (soil texture, soil pH, existing plant communities, presence of native species, presence of steep slopes).
  2. Then have create a table with rows listing needed types of data and columns listing existing available sources (Soil Data Mart, aerial photographs, USGS topographic maps). They can then fill in the cells with information about the format of the data provided by each source. If no existing sources exist for some of the data types, suggest that they leave that portion of the table blank.

3. Once the table is complete, ask students to describe any limitations of the available data—level of detail, age, format, and the like. This analysis will help them in answering the third part of the question: "Where might they be inadequate without a site visit?"
4. Finally, ask how the inventory informs restoration. For example, How can we use the data to determine restoration opportunities and constraints?

- To make this question even more concrete, have students answer it in the context of an actual restoration scenario. Select a nearby site that is appropriate for a restoration, such as a vacant urban lot, a portion of a public park, or a private property that you have permission to access. Propose a restoration purpose and a set of goals. Ask students to consider what they would need to know about the site in order to develop the proposed restoration plans.

What to Look for in Student Responses

SubQuestion 1: "Develop and then defend a list of data sources that can provide information on a potential site for restoration in your area, prior to your visiting it."

- One of the themes of this chapter is that a restoration site inventory and analysis needs to be designed for the specific project at hand. Nevertheless, almost every project includes an inventory of the resources that are represented in the subheadings of Chapter 4 (see Sections 4.4–4.12): climate, topography, hydrology, soils, fauna, vegetation, and cultural features, social uses, and perceptions. Students should address all of these resources in their answer.

1. Sources of available existing site data that students should mention include satellite imagery, aerial photographs, resource maps, and inventory databases maintained by both public and private agencies.
2. Students should indicate that, in most cases, the information is available online or in public libraries.
3. Students should include the information addressed in the "Data Sources" sections of the textbook that appear at the end of each of Sections 4.4 to 4.10, as well as in the "Resources for Further Study" section at the end of the chapter.
4. Student responses should identify the sources that are most appropriate for your region, explain how to access them, and link each to the resource information it can provide. For example, in the United States, the U.S. Geological Survey (USGS) provides maps from which we can derive information on:

    a) The region and context of a site

    b) The types of landforms that are present, slope steepness and aspect, and the shape and extent of watersheds, all of which can be derived from map elevation contours

    c) The presence of surface water bodies

    d) The locations of buildings, roads, and other cultural features

    The National Oceanic and Atmospheric Administration (NOAA) provides annual climate data and presents seasonal weather patterns.

SubQuestion 2: "What value might these sources have for you in learning about the site before actually visiting it?"

- Students should be able to identify the following points:
  1. An important reason to collect and review information prior to a site visit is to help organize and focus the visit. For example, recent aerial photographs can be used to create a preliminary map of the existing plant communities on a site. Then, on the site visit, restorationists spend at least some time in each community they have identified, thereby helping to ensure they have not overlooked something.
  2. Knowing what information is already available also means that restorationists know what information is inadequate (not detailed enough, for example) or missing altogether. They can then be sure to bring the equipment needed to collect the missing information along with you when you visit the site.

SubQuestion 3: "Where might they [these sources] be inadequate without a site visit?"

- Here are some possible answers:
  1. The scale of mapped information may be such that the exact locations of trails or of the boundaries between different soils or vegetation communities may not be accurate enough for purposes of creating a restoration site plan.
  2. The age of the existing data may be old enough to be no longer accurate—for example, development activities have altered the soils or topography, or animals once found on the site are no longer present and new species have moved in.
  3. Some features may not show up on aerial photographs—for example, the canopy can obscure structures or erosion channels in a woods. It is also difficult to differentiate natural grasslands from pasture land and to identify the presence and abundance of specific desired or invasive species
  4. The ability to visualize the three-dimensional form of the landforms of a site or the vertical structure of a community using two-dimensional contour maps is difficult for many of us.

Question 4. We presented a number of categories of potential onsite resource attributes to be collected and analyzed, including climate, topography, soils, hydrology, and socioeconomic factors. Can you think of additional categories? Are there additional attributes within the categories provided that have not been discussed in the textbook?

How to Use or Expand on This Question

- The intent of this question is to have the students review what Chapter 4 does cover, and then to think about topics introduced in Chapters 1 to 3 that that are not covered in detail in Chapter 4. The learning objective is for the students to think about a variety of potential restoration aims and

what a restorationist would need to know about a site to determine how easily the goals for each could be accomplished. Here are some possible approaches:

1. If you use the question to guide a discussion, we have found that a good way to start is to first have the students recall and list the major resource categories discussed in the chapter and then suggest a series of restoration purposes. Then ask what types of helpful site information are missing from the resource list.
2. Although the question makes a distinction between "additional categories" (e.g., vegetation) and "additional attributes within categories" (e.g., list of species present), you can easily combine the two for purposes of discussion simply by asking, "What site information relevant to restoration has not been discussed in this chapter?"
3. This question could also be turned into an assignment for individual students or teams to each select a "missing" data category and either write a brief report or give a brief presentation to the class covering the following topics: (1) description of the category; (2) implications for restoration; and (3) existing data sources.

What to Look for in Student Responses

- The important theme to look for in student responses is that the resource categories or attributes they suggest inform restoration in some way—that they help determine the feasibility of restoring the compositional, structural, or functional target for a particular community; inform choices of implementation and/or management approaches; or identify human use opportunities. Students need to explain the reasons behind their choices.

  Some resource categories/data attributes that are either missing from or mentioned only briefly in Chapter 4 include:

  1. *Ecosystem services:* Ecosystem services include such items as carbon and nitrogen cycles, rates of photosynthesis, or food and fiber production. Identifying the biological and physical components as well as the fluxes and storage times of such processes may be important to accomplishing the purpose of ecosystem services restorations.
  2. *Aesthetics:* The enjoyment of experiential restorations is often enhanced by how humans perceive the space. In the textbook, we mention the beauty of natural landscapes, as well as smoke, noise, and smells. Students should be able to add more detail and to identify additional design elements that heighten people's enjoyment of a restoration. For example, the use of design elements such as colors, textures, and forms to organize the restoration and create balance, symmetry, and focal points helps visitors organize the space and find their way around. Features such as trails that disappear around a bend create curiosity about what lies ahead and provide a sense of adventure.
  3. *Important species interactions:* As discussed in Chapter 2 (see Section 2.3.1 and Table 2.1), the structure and composition of natural communities is due in large part to species interactions—competition, exploitation (predator-prey, food webs), and mutualisms. Understanding the presence and nature of such interactions already present on a site can be crucial in implementing and managing a site, as is identifying keystone species

4. *Evidence of historical disturbance cycles:* We mention several types of disturbances in Chapter 4, including floods, fires, and windstorms, but not how to find evidence of past onsite disturbances.

Question 5. This chapter also listed a number of offsite attributes that influence a proposed restoration site. What additional offsite attributes may influence the prospect of a successful restoration at a particular site? Think of a scenario in which each new attribute would be informative, and how it might influence restoration, implementation, or management plans and activities.

How to Use or Expand on This Question

- Question 5 can make a useful in-class activity. For example:
  1. Divide the class into teams of four or five students each and assign each team to address a different scenario. For example, you might select an upland community (hardwood forest), a lowland community (floodplain forest), an experiential restoration, a site surrounded by cropland, a site surrounded by natural remnants, a small site with a high edge-to-interior ratio, a large site with a low edge-to-interior ratio, and so forth.
  2. Next, have the students review the offsite attributes mentioned in the textbook and describe how each might affect their case.
  3. Then ask the students to go on to identify additional features of the context that could affect their situation.
  4. Finally, ask each team to present their findings to the class.
- You can also focus this question on a specific local example.
  1. Provide the class with a restoration purpose statement and a set of goals. Begin with an assignment to collect existing information about the context of the site. Depending on the size of the class, you can assign this task to individuals or to teams.
  2. The next step is for students to determine what conclusions they can draw with the information at hand and to plan what information they need from a visit to a site and its surroundings, as well as what they need to do to obtain it.
  3. After the students have collected their onsite and offsite information, have them describe how the context will likely interact with the restoration.

What to Look for in Student Responses

- The context features that are mentioned in the textbook include:
  1. The degree of isolation of the restoration site from natural remnants, water bodies, or land uses such as agriculture, urban development, and the like
  2. Landform position relative to the surroundings—for example, is the restoration site part of a regional topographic high or a low point?
  3. Prevailing wind direction

4. The size and shape of the restoration site in relation to its surroundings

Students should come up with a similar summary.

- They can then mention additional items, such as sociological factors, including the age profile of residents in the surrounding area—something that might identify potential site users—or rules and regulations governing the surrounding properties that might be useful in restricting impacts.
- Students could also mention specific instances of the general categories (degree of isolation, landform position, and so forth). For example, they could talk about likely sources of unwanted species invasions or stormwater runoff, or the presence of nearby sources of native colonists or natural firebreaks—all things that provide challenges and benefits for a restoration.

Question 6. When beginning a restoration project, under what circumstances would you use an opportunities and constraints analysis? A suitability analysis? Would you want to use only one of these two approaches, or would both be useful in the analysis of site data?

How to Use or Expand on This Question

- The purpose of this question is to help students understand the logic behind these two approaches to site analysis by thinking about how each is applied. To use the question during a class discussion, it is helpful to guide the students using the following steps:

  1. Begin by providing a purpose statement, as well as some general restoration goals.
  2. Then have the students describe the steps involved in each approach. Be sure to have them consider what data would be collected, how the information would be organized and evaluated, and what form the analysis would take.
  3. Next, have them consider each approach in terms of its advantages and disadvantages and the context within which each might prove most useful. These discussions will set the stage for answering the question.

- To better understand both approaches, create an activity for students to use existing inventory data to actually perform both an opportunities and constraints analysis and a suitability site analysis. It is ideal if students can work with an actual site; however if this is not possible, you can create a credible scenario for a real location using the information that is readily available online, or you can provide a set of mapped or spatially referenced resource information for a hypothetical site.

  If your project concerns an actual site, you can either provide inventory data for the students or have them locate existing information, as in Question 5. Students can also, of course collect their own onsite data—Chapter 5 introduces a number of inventory techniques. In order to conduct either a suitability analysis or an opportunity and constraints analysis, access to computer facilities with geographic information systems and or computer-aided design software is helpful, but not required.

  1. To set up the exercise, provide the class with a restoration purpose statement and a set of goals. The students will also need a base map of the site, as well as a set of inventory

information that is already mapped or that can be easily mapped by the students. A base map is a map on which site inventory information is plotted. At a minimum, a base map shows the site boundaries and elevation contour lines; it is also helpful to include the locations of existing vegetation and cultural features or landmarks.

2. If you are using a hypothetical site, you need to create the base map, as well as maps and descriptions of various resources—soils, vegetation, cultural features, and so forth. These can be hand-drawn paper maps or digital versions created using computer-aided design software. You can find copies of simple hypothetical maps on the textbook website (www.introrestorationecology.com).

3. If you are using a real location, you can provide the students with a base map or assign them to create one. Digital or paper copies of a USGS topographic map of the area and/or a copy of a recent aerial photograph make a good starting point. Using the Internet and a GIS program, you or your students can create a simple base map using a recent orthophoto (an aerial photograph that has been corrected for the distortions caused by camera tilt and/or landscape features) and digital elevation data. Digital elevation models (DEMs) can be obtained from several sources, including, in the United States, from the USGS. Use the DEM within the GIS program to generate elevation contour lines for the map. Chapter 4 includes several examples of student-created base and resource maps.

- As described in the textbook, to create an opportunities and constraints analysis, students identify and locate the site features that will either facilitate or detract from the ability to achieve the restoration objectives.

  For example, an existing patch of mature native trees on a portion of a site might be considered to be an "opportunity" with respect to restoring a forest, but a "constraint" with respect to restoring an open grassland. Or the presence of a native remnant just outside of the boundaries of a site could be an "opportunity" for recruitment of colonists, whereas the restoration of a site that is surrounded by development might be "constrained" by the potential for negative cross-boundary influences.

  The idea is to highlight particular site locations and specific resources and/or resource combinations (e.g., prairie plants on a steep, south-facing hillside) and to describe them as being opportunities or constraints.

  The finished product is an annotated map, a list of opportunities and constraints, and a text describing the reasoning behind the assessment.

- To create a suitability analysis:

  1. Have students begin by creating site maps of all the resources that will figure in the analysis, generally one resource per map.

  2. Next, for each resource, they need to determine which attributes are "suitable," "not suitable," and in some cases "acceptable" with respect to a particular restoration project. For example, the presence of a patch of native trees would likely be rated as being "suitable" for a forest restoration, an open native grassland "not suitable," and bare ground (absence of vegetation) "acceptable." All areas of the site are rated for each resource under consideration.

3. The ratings for all resources are then combined to create a composite analysis that displays the portions of the site (if any) that are most suitable (all resources combined) for the restoration.
    a) The combination can be accomplished physically by creating a series of maps on translucent paper showing the suitability ratings, one per resource.
    b) The ratings can be displayed using a single color ramp—for example, shades of gray—with no color for the "suitable" rating, a dark shade (black) for the "unsuitable" rating, and, if used, an intermediate tone (medium gray) for "acceptable."
    c) They can also be represented using numerical values (see, e.g., Table 4.2 in the textbook).
    d) By overlaying all of the maps, the areas that are the lightest color (or highest sum, as per the example on page 129 of the textbook) represent the portions of the site that are most suitable for achieving a particular goal.

- A similar result can be obtained using GIS, by creating attribute tables to display suitability ratings, assigning color shades to the ratings as described above, creating digital maps to display the ratings, and finally creating a composite map using the individual resource maps as layers and the GIS transparency feature to display the combined ratings. You will find an example exercise on the textbook website.
- Have the students discuss the advantages and disadvantages of the opportunities and constraints analysis. Under what context might this type of analysis prove most useful? Do the same for the suitability analysis.
- Have students describe how they would apply one or the other, or both, to a specific project.
- Provide students with site data for a specific set of restoration goals or objectives. Have students use these data to set up and defend a hypothetical weighted suitability analysis. With this approach, instead of treating each resource as being of equal importance in rating a site, the resources are ranked in order of importance. Table 4.2 in the textbook (p. 130) illustrates one weighting procedure.
- Karen Hanna and R. Brian Culpepper (1998) describe another approach to weighting the contributions of a set of resources in creating a suitability analysis:
    1. Developed for use with digital mapping systems such as GIS, the first step is to rank all the resources in order of their importance for the analysis.
    2. Next, a suitability map is created for each resource using only two categories—"suitable" and "unsuitable." A value of 0.0 is assigned to the "suitable" ratings category of all resources, and a unique value to the "unsuitable" category of each resource, based on their weighted importance. An example can be seen in the following table.

Table. Set of resources in order of importance from most to least in restoring a native grassland

	Suitable	Unsuitable
Presence/absence of native grassland species	0	16
Presence/absence of pest species	0	8
Presence/absence of trees	0	4
Soil type	0	2
Historical vegetation	0	1

The numbers assigned to the "unsuitable" rating category depend on the number of resources being considered; the numbers begin at 1 for the least significant component of the weighted list, and double with each step up. In this way, each possible combination results in a unique number, and we can tell at a glance which resource attributes are potentially most problematic in the different areas of the site.

Using this example, the possible scores range from a total of 0, if all resource values are "suitable," to 31, if all resource values are "unsuitable." A rating of 14 means that pest species, trees, and soils are "unsuitable," but historical vegetation and native grassland species are "suitable." This system allows you to tell at a glance which resources are most problematic over different areas of the site.

What to Look for in Student Responses

- In order to be able to discuss the circumstances under which to use each technique, students first need to be able to explain how to use each technique, and to describe the strengths and weaknesses of each as well as their similarities and differences. Here are some points the students might make:

1. The opportunities and constrains analysis allows you to look for and identify particular site characteristics, the presence or absence of which experience has told you are important to the success of a restoration. You do not spend time describing the rest of the site in any detail. This method also allows you to look for the presence of combinations of resource characteristics, rather than treating each one separately. The opportunities and constraints analysis can be done relatively quickly, and without the use of digital technology. It benefits greatly from an onsite visit. It can be used at either the master plan or site plan stage of a project; it works best with small sites.

   On the other hand, different restorationists can, and often do, interpret a site differently. Interpretations depend on a restorationist's training, level of experience, and degree of familiarity with the specific plants and animals found on the site. It is easy to overlook things with which you are not familiar. This kind of bias can be problematic in the context of public projects.

2. The suitability analysis considers the whole site; each resource is described, wherever it exists onsite. This makes it less likely than the opportunities and constraints analysis to overlook a site feature. The suitability analysis works particularly well in situations for which

existing digital resource maps are available and when you can use a GIS program to run the analysis. In the digital environment, you can change ranking schemes and study the results quickly and easily. It is also easy to make the decisions about a site accessible and transparent. It is possible (though not optimal) to conduct a suitability analysis without actually visiting a site. Because of the scale of existing data maps, the suitability analysis works well for large sites and for creating restoration master plans.

On the other hand, the suitability analysis is only as accurate as the resource maps and rating decisions that make it up. Because it is often done using a GIS program, there is a tendency to rely on the results as being accurate because they are computer generated. It is important to remember "garbage in, garbage out."

3. For large sites for which appropriately-scaled existing mapped data are relatively available, it can be useful to use a suitability analysis approach to make initial decisions as to how to apportion a site and then a suitability analysis to focus on particular areas or features.

Question 7. The Internet has numerous data sources to help a restoration team learn about a site's characteristics. Are there attributes you can solely look to the Internet for? Are there attributes you would still need to visit the site to obtain and fully understand?

How to Use or Expand on This Question

- Provide students with a list of data categories to investigate on the Internet. Have them list and cite the sources they find for each and describe the nature of the information each source provides.
- Have students list the advantages and disadvantages of using the Internet to assist site analysis. You can ask this question in a general sense or have students investigate specific websites.

What to Look for in Student Responses

- A good answer to the original question would be that a site analysis usually works with all relevant available information, and most use a combination of existing resource maps and rating schemes prepared by conservation professionals, many of which can be found on the Internet, plus information gathered by one or more site visits while the project is in process. It is possible to create a preliminary analysis from existing information while at the master planning stage, but to proceed to the next restoration steps, a site visit is almost always required.
- Students should be able to identify the following attributes that can currently be determined from existing data available on the web:

  1. Maps, descriptions, and ratings of general soil types
  2. Maps of elevation contours and digital elevation data sets, from which you can determine landforms, slope steepness, slope aspect, and in combination with maps of streams and ponds, you can map watersheds
  3. Maps of surface water features
  4. Aerial photographs, from which you can identify land use, cultural features, vegetation types
  5. Climate and weather statistics

6. General locations of views

- Attributes that are not easily located on the web, and therefore best found during a site visit include:

1. Soil characteristics that may vary over a short distance—for example, nutrient status, pH, microbial content (although technology is rapidly advancing such that some of this information (such as soil nitrogen levels) can be collected using remote sensing techniques, albeit with sophisticated and expensive equipment)
2. Small changes in elevation, water ponding
3. The presence and abundance of specific plant and animal species
4. Microclimate variation
5. The presence of small human artifacts
6. Processes such as rates of nutrient mineralization and sedimentation
7. The location of specific views
8. The location of existing or potential nesting sites

- In considering the advantages and disadvantages of Internet sources (as referenced in one of the alternative questions suggested above), students should consider such things as the reliability, credibility, and objectivity of the information found on a particular website and how they might evaluate these qualities. In other words, students should describe how to evaluate websites. Students can find several guides to evaluating Internet sources on the Internet, and the campus library system will certainly be able to help. See the Online Resources list at the end of this chapter for two examples.

  In addition, students should think about the scale of the data available in terms of the information detail needed for a restoration implementation or site plan. They should also note that the currency of the information is also an issue. A contour map completed 30 years ago may no longer be relevant, especially if the land use has changed. And, as outlined above, some information is much better obtained onsite.

Sidebar: Deciding on the Attribute Level for Analysis: Food for Thought Questions

1. If you were the project manager for this particular restoration, what attributes under each resource category would you want to inventory and why?
2. What sources would you use for data, and where or how might you acquire them?

What to Look for in Student Responses

- These questions refer to the Cross Plains Ice Age National Scientific Reserve (CPIANSR) case study, and in particular to a set of desired resource attributes listed in Figure 4.22 (p. 134).

1. A good way for students to begin is to use the information given in Figure 4.22 to create a list of the data they will need to determine the extent to which these ideal features are present onsite. Matching the existing conditions of the site to the goals of the restoration is one of the

important reasons to perform a site inventory and analysis at the this stage of the restoration (creating the master plan—see Chapter 6) described in the case study. The list might include:

a) Number of open grown oak trees with diameters at breast height (dbh) of at least 45 cm

b) Presence of sugar maple saplings and seedlings

c) Tree canopy cover

d) Shrub cover

e) Presence of savanna forbs and grasses

f) Presence of shrubs and herbaceous species common to maple forests

g) Soil series map to detect the presence of preferred types

h) Soil drainage

i) Soil texture

j) Slope steepness

k) Slope aspect

l) Presettlement communities of the site

2. Next, students should think about what additional information they need to assess how well the site meets the restoration purpose/goals. For example, one of the purposes given in the case study is to preserve the "geologic . . . and scenic resources" of the site. So an inventory might also include:

   a) Presence of glacial features such as drumlins, moraines, and the like

   b) Location of potential onsite or offsite views

   c) Location and condition of existing trails or roads

   d) Nature of surrounding land uses to locate potential continuing impacts

   e) Presence of endangered plant or animal species

   f) Presence of iconic plants or animals—those that people want to see

   g) Presence of problem species (invasive or harmful species, for example)

3. Next, students should list potential source of existing data, Possible answers include:

   a) The Cross Plains site is in the United States, so you can find information on soil series from the Soil Data Mart in the SSURGO files on the USDA NRCS website (http://soildatamart.nrcs.usda.gov). The descriptions of the soil mapping units provide general information on soil texture and drainage.

   b) You can use an existing USGS topographic map to identify landforms and slope steepness and aspect.

   c) A current aerial photograph will show vegetation cover—particularly the locations of masses of trees, areas of scattered trees, areas where trees are absent, and the locations of

trails. As described in the textbook, looking at aerial photographs taken over a period of time (generally dating to the 1930s) will provide insights into past land uses and vegetation change.

d) You can use some historical land surveys to get an idea of what presettlement communities might have been present on or near the site. (In Wisconsin, the Public Land Survey records are routinely used in this way.)

All these sources provide information on both the site and its context.

4. Students should recognize that to collect information about existing plant and animal species and potential views, a site visit is generally necessary. This is the topic of Chapter 5.

Sidebar: CPIANSR User Issues: Food for Thought Questions

- The Food for Thought question (listed below) in this sidebar concerns the following questions that came up in a discussion concerning the design of a trail system for a restoration:

1. If the trail were to lead down into the gorge, how would people be prevented from traveling along the fragile gorge floor?
2. If trails were taken to overlooks along the gorge, what would prevent people from attempting to climb down the slopes, which are very fragile and have a great potential for erosion?
3. Would fencing take away from the natural beauty of the gorge? Would it obstruct animal movement?
4. Some members proposed building a bridge over the gorge, but that led to several questions: Can the National Park Service or the Wisconsin Department of Natural Resources afford the costs of a bridge spanning 20 m (65 ft.) or more?
5. Would disturbance from the required bridge footings cause extensive damage?
6. Would shade cast from the bridge affect the plant composition and structure?
7. Would people throw items off the bridge?
8. Is the bridge an appropriate aesthetic for the site?

Others questioned whether trails should go to the gorge at all.

- The above questions have no definitive answer but are representative of the types of questions you may face when restoring a landscape in what is also part of a public facility. How would you answer each of these questions? Are there additional questions you can think of relating to how to handle trails in sensitive areas where visitors have the potential to cause damage? How would you go about finding consensus on this issue?

What to Look for in Student Responses

- To answer the questions, students should identify the issues that the managers raise, as well as the pros and cons of several potential solutions. For example, issues reflected in the questions include:

1. Providing (or not) access to all portions of the site

2. Providing trails or not
3. Balancing the benefits of providing access for visitors with preventing or mitigating impacts caused by their visitor presence
4. Identifying the kinds of visitor impacts that might occur (trampling, leaving trash behind, harvesting plants or rocks)
5. Assuming that at least some visitors will not stay on trails if they are provided and identifying the circumstances that might lead to such behavior
6. Building a structure in a natural area (spoiling the experience of nature for some) in order to provide a short route to cross the gorge.

- Potential solutions in addition to fencing and a bridge might include educational signage; requiring guides to accompany visitors; providing and managing trash containers onsite; having a ranger patrolling the site at all times to prevent problems; and, if fences and a bridge are desired, making materials and design choices to enhance the experience. To decide among the alternatives, students should consider the biological and physical site impacts of public access with and without trails; the monetary costs of materials and personnel to construct trails and/or mitigate impacts; the relative desirability of experiencing the site with and without trails or a bridge; and the potential loss of public political and funding support if access becomes difficult or the experience less desirable.

  Addressing this series of questions provides a good opportunity for students to investigate the literature to find case studies or research projects that address the issues raised.

Supplemental Activities and Exercises

See the textbook website for examples of activities related to using existing data in conducting a site inventory and analysis

Suggested Learning Objectives Outcomes

Learning Objective 1. Describe each major step of the site inventory and analysis process.

Learning Level 1 Outcomes

- Students should be able to list each major step as provided in on pages 95 and 96 of the textbook.

Learning Level 2 Outcomes

- Students should be able to analyze a case study of an existing restoration and discuss how the steps were or were not used, including how the data collected were analyzed (or the type of analysis—qualitative, quantitative, opportunity/constraint, suitability—that was used).

Learning Level 3 Outcomes

- Students should be able to create and apply each of these steps to a specific site that is targeted for restoration.

Learning Objective 2. Students should be able to apply site inventory and analysis to decision making within the master, site, implementation, and management plans.

Learning Level 2 Outcomes

- Students should be able to identify the kinds of information needed to create each type of plan and explain how the inventory and analysis informs each type of plan.

Learning Level 3 Outcomes

- Students should be able to perform all the steps of site inventory and analysis in creating a master, site, implementation, and management plan.

Learning Objective 3. List the attributes that are inventoried during the site inventory, identify the sources for each, and discuss how each informs the restoration process and decisions.

Learning Level 1 Outcomes

- Students should be able to define attributes (soil texture, soil pH, etc.) and how they are related to categories of site resources (e.g., soils).
- Students should be able to locate sources to acquire information on each attribute using existing sources.

Learning Level 2 Outcomes

- Students should be able to explain how each of the attributes is important to the restoration planning process. If goals can be provided, students should be able to discuss how different attributes apply to each.
- Students should be able to explain how understanding an attribute leads to the development of objectives.

Learning Level 3 Outcomes

- Students should be able to select resource categories and related attributes that are appropriate to explore for a given restoration project.

Learning Objective 4. Differentiate between two general methods of analyzing the inventory data.

Learning Level 1 Outcomes

- Students should be able to describe both the opportunities and constraints method and the suitability method approaches to site analysis.

Learning Level 2 Outcomes

- Students should be able to compare and contrast the two approaches.

Learning Level 3 Outcomes

- Students should be able to use both approaches to conduct a site analysis for a specific site.

Potential Issues, Questions, and Misconceptions

- It is a misconception that the site inventory needs to be done once (as the master plan is created) so the restorationist can move on with the site design and implementation. As we discuss in the textbook, the site inventory and analysis is repeated to one degree or another at several stages in a restoration, particularly at the beginning of the site planning and implementation phases of a project. Since achieving a good site/species match is fundamental to a good restoration, understanding the site is essential!
- Another issue is the tendency to rely on existing site information rather than taking the time to do more than a cursory site visit. This tendency has been heightened in recent years with the proliferation of digital data on the Internet. There is no doubt that access to such information is very beneficial. However, two of the problems that can arise through relying solely on such data are: (1) the scale and age of the inventory may be inappropriate for the questions you are asking at a particular restoration stage and (2) if you use only existing information, you may overlook important site features not covered by the data sources to the detriment of the project.
- Remember, too, that people familiar with a site through long association can be valuable sources of information, especially regarding the history of human–site interactions, but also for insights into wildlife use patterns, plant and animal population cycles, and disturbance cycles. You can use surveys and interviews (both formal and informal), as well as public hearings and other group techniques. We cover many of these tools in Chapters 5 (see Section 5.10) and 13 (see Section 13.1.4).

  It is important to cross-check the information you are given and also to remember that it is important to ask the right questions. Recently, a colleague who is investigating an exotic plant species control situation was having a difficult time interpreting his data. He had done extensive interviews with the landowners prior to beginning experiments to test the effectiveness of different control methods, so he thought he knew the site history. By accident, in a discussion about a different topic, one of the landowners happened to mention to him an event that had not come up during the formal interviews. When the investigator asked why this had not been mentioned before, the response was: "You didn't ask."

References

Hanna, Karen C., and R. Brian Culpepper. 1998. *GIS in Site Design.* New York: Wiley and Sons.

Online Resources

Georgetown University Library. Evaluating Internet Sources

https://library.georgetown.edu/tutorials/research-guides/evaluating-internet-content

Purdue University. "Why we need to evaluate what we find on the Internet"

http://www.lib.purdue.edu/research/techman/eval.html

USDA NRCS Soil Data Mart

http://soildatamart.nrcs.usda.gov

Chapter 5

Gathering Onsite Resource Information

Chapter 5 continues the discussion of site inventory and analysis that we introduced in Chapter 4. The focus here is on strategies, tools, and techniques for collecting resource information in the field. You will find descriptions of some of the techniques most commonly used to measure microclimate, slope, soils, water, vegetation, wildlife, cultural features, and human experience and perceptions. We also include a framework that you can use to develop onsite inventory protocols.

Major Themes

- As noted in Chapter 4 of the textbook (see pp. 95, 96, and Section 4.1) , restorationists usually repeat the site inventory and analysis step several times during a project, especially during the site planning, implementation, monitoring, and management stages. Usually at least some onsite data collection is involved.
- We conduct the onsite inventory using protocols developed for a particular situation. Based on the relevant plan's purpose or objectives, protocols specify what information to collect, which tools to use where and when, and how to summarize and evaluate the information. Other considerations in protocol development include the needed level of information accuracy and reliability, available time and resources, and skill levels of project personnel.
- Available techniques include systematic observations and the use of instruments ranging from meter sticks to cameras to sophisticated solar-powered meters. New techniques are being developed all the time; it is important to use communication networks and professional contacts and to check supplier catalogs to keep abreast of innovations.
- These same tools and protocols are used in restoration monitoring (see Chapter 9) and in the process of conducting adaptive restoration experiments.

Comments on Food for Thought Questions

Question 1. You work for a conservation organization that has acquired a property in your region for the purpose of creating a nature study preserve. List the steps you would follow to design onsite data collection protocols for the initial site inventory and analysis.

How to Use or Expand on This Question

- The learning objective is to have students articulate the decisions that need to be made in designing site inventory and analysis protocols. Here are some possible approaches:
  1. The question works well as an in-class discussion activity.
  2. You can easily modify the question by specifying a particular restoration target community (e.g., saltwater marsh); designating a real site as being the location of the proposed preserve (e.g., Chesapeake Bay); and/or listing the characteristics that would make a site suitable for

nature study to address the needs of a particular education program (e.g., the presence or absence of particular plants and animals, geological features).

What to Look for in Student Responses

- To address the question as written, students will need to identify what onsite resource information they would need to design a nature preserve; they will also need to specify the components of a protocol.

  1. First, students should define what makes a site "a nature study preserve." For example: Does it need to have a high diversity of native species? Does it contain "iconic species"? Does it have the ability to support trails with signage or experimental study plots?

     Next, they should be able to determine what site features enhance, detract from, or will be harmed by the nature preserve. For example, having several different communities each with a high diversity of native plant and animal species and featuring gentle slopes for easy walking could enhance the use. The presence of abundant biting insects could detract from the nature study experience. Any rare species on the site that would be disrupted by crowds of people could be harmed if a trail were to be placed near them. These (communities, plant and animal species, topography) become the site resources for which protocols would need to be developed.

  2. Students should then be able to develop protocols for collecting the information. Each protocol should specify what to measure, which tools to use, when to collect the information, and how to summarize and interpret the findings To make these decisions, students should consider accuracy and reliability with regard to the resource feature, ease of use, and training required. For this example, they should measure: number of different communities present; diversity of plant and animal species within each; list of species within each (to determine if designated rare species are present); abundance of species present (to determine if there are species that have low site abundance—also a definition of rare species); location of rare species; presence, location, and abundance of biting insects; and slope steepness.

     Once the protocols are developed, students should be able to conduct the inventory and analyze the results.

- The more specific the form of the question, the more detailed the student answers can be. For example, suppose one of the requirements for the preserve will be to have at least 40 native herbaceous species that are found in sufficient abundance to be easily seen and studied by visitors. This means that the restoration plans will need to address the presence and abundance of native species, and the initial site inventory and analysis should collect and evaluate data about the species that currently exist on the site. A detailed answer might look something like this:

  1. Using a recent aerial photograph, divide the site into inventory units, based on having similar land covers/land uses.

  2. Within each unit, use a qualitative walk-through survey method to generate a plant species list that includes abundance categories.

  3. Personnel requirements include plant species identification skills for data collection during the inventory, and data organizing skills for analysis.

- The protocol for generating and evaluating the species lists is as follows:

1. At least once every growing season, walk through each unit, covering as much ground as possible, and record every herbaceous plant species encountered. As you move through the unit, record every time you encounter each species. At the end of the survey, designate each species as being rare, frequent, or common, using the following abundance classes (note that these classes would be chosen based on the size of the units):

   a) *Class 1 (rare):* Found in 1–2 locations within a unit

   b) *Class 2 (frequent):* Found in 3–5 locations within a unit

   c) *Class 3 (common):* Found in > 5 locations within a unit

2. Compile a species list for each unit, divided into two categories, "native" and "exotic," and organize each so that the "common" species are listed first, in alphabetical order, followed by the "frequent" and then the "rare" species.

3. Next, create a searchable species database for the entire site, again divided into two categories, "native" and "exotic." Include:

   a) Species scientific name

   b) Unit name and vegetation type

   c) Abundance designation of each species in each unit (common = 10; frequent = 5; rare = 1; absent = 0)

   An example of such a database can be seen in the following table:

   Table. Abundance of grassland and forest units

	Grassland Unit 1 G-1	Grassland Unit 2 G-2	Forest Unit 1 F-1	Forest Unit 2 F-2
Species A	10	10	0	1
Species B	1	5	0	0
Species C	0	10	10	10

4. Finally, identify those native species that are abundant or frequent in all units and those that are abundant or frequent in all or most units of a specific vegetation type. These species can be considered to be in sufficient abundance to be readily seen and studied by visitors.

Notes

- It is helpful to be more explicit about "covering as much ground as possible" in describing the walk-through survey. For example, the protocol could include directions about walking a series of compass or grid lines. If you are assigning a real location for this exercise, students can propose such a system.
- It is also possible to suggest a more modest protocol, depending on the size of the site. The important point is that students describe the protocol in such a way that others can follow it.

Question 2. For each of the following, name two ways by which you could measure each of the following site features. Which one would you choose, and why?

1. The number of different bird species present
2. Soil texture
3. The areas with the most /least sun exposure
4. The rate of spread of an invasive species
5. The ways in which people interact with a restoration

How to Use or Expand on This Question

- This question is, of course, easily expanded by adding more site features and or specifying a particular site or situation. In fact, in order to answer the question, students need to make some assumptions about needed level of information coverage, accuracy and reliability, available time and resources, and skill levels of project personnel. Depending on what you would like to emphasize, providing guidance as to the context of the inventory would be desirable—focusing on specific decisions rather than covering several eventualities. The sidebar "Designing an Onsite Inventory Protocol" (see below) is an example of a more concrete version of Question 2.

What to Look for in Student Responses

- Here are a few notes on some possible answers, based on the information provided in Chapters 4 and 5 of the textbook :

1. The number of different bird species present (see Sections 4.8 and 5.7)
    a) *Techniques:* Walk-through transects (using sight, sound, traces—nests and tracks); photography; live trapping of individuals (mist nets)
    b) *Choice: Walk-through transects:* take least time and equipment; if done only once, may miss seasonal species, may miss birds not active at time of day or season of the walk-through or those hidden in foliage; personnel require identification skills. Photography: requires more equipment; can help in identification; can use mounted cameras with motion detection to find hidden species. Live traps: help with identification; will miss species not using the flyway of the nets; in rare instances, birds can suffer mortality.
2. Soil texture (see Sections 4.7 and 5.6.1)
    a) *Techniques:* Soil hand test; lab tests of collected samples; soil survey maps.
    b) *Choice: Hand test:* most immediate; works with obvious texture categories; easy to learn; not expensive; yields coarse results. Lab tests: expensive; accurate; have reliable results. Soil survey maps: readily available; accuracy can be a problem if maps out of date and at wrong scale to capture small site variations.

3. The areas with the most /least sun exposure (see Sections 4.5 and 5.2 and the sidebar "Modeling Shadow Patterns" on p. 145 of the textbook).

    a) *Techniques:* Model shadow patterns using landform slope and aspect (digital elevation models) or sun angles and site feature heights; instruments for measuring solar radiation.

    b) *Choice: Models:* take time to run; information is indirect; do not measure sunlight per se. Instruments: are expensive to purchase and run; may provide more detail than is useful.

4. The rate of spread of an invasive species (see Sections 5.7 and 5.8)

    a) *Techniques:* Photographic time series using photo points or aerial photography; placing stake in the ground at edge of patch to measure change of location of edge through time.

    b) *Choice: Time series:* relatively easy to obtain; storage simple; difficult to measure distances on photo point images; aerial photographs, if rectified, can be imported into GIS programs, making for ease of distance measurements; scale can be an issue—hard to measure micro scale. Stakes in ground: provide direct relatively accurate measures; stakes can be lost.

5. The ways in which people interact with a restoration (see Section 5.10)

    a) *Techniques:* Direct observations, notes, photographs, sketches, use of checklists; interviews and questionnaires; feedback at public meetings; participatory photo mapping.

    b) *Choice: Direct observations:* easy to do; presence of observer may influence behavior; may be difficult to get representative sample; easy to note behaviors; not easy to note feelings/experiences. Interviews and questionnaires: vary in ease of use; may be difficult to get representative sample; can be difficult to construct informative questions; can be difficult to find patterns in the data. Feedback at public meetings: may be difficult to get representative sample. Participatory photo mapping: time consuming; requires resources (cameras); can reveal unexpected insights as to experience.

How to Use or Expand on These Questions (Question 3 and 4)

- Questions 3 and 4 are similar in that both concern the situational nature of site inventory and analysis protocols. In both cases the key is that site inventory and analysis protocols are specific to the issues being addressed at each stage of the restoration planning process.

  We have used both of these questions to generate class discussions. They can also work on an exam. Again, you can readily apply them to a specific restoration project to improve the understanding of students who learn best with concrete examples.

Question 3. Would you use the same protocols for an initial site inventory and for checking on the progress of a restoration as it is being implemented? Why or why not?

What to Look for in Student Responses

- Students should begin by recognizing that the initial site inventory takes place at the beginning of the restoration process as the master plan is being created and that therefore general information about the site resources is needed. Students should understand that existing maps, qualitative data,

and general onsite walk-through surveys usually provide enough detail to make decisions at this stage. In contrast, students should explain that the goal in monitoring the implementation of a project is to check to see if explicit project objectives (outcomes) are being met. To do so requires detailed protocols, usually involving the onsite collection of quantitative data (see Section 4.1.1).

An example that students could use is that the initial site inventory might include a walk-through inventory to determine the presence and general location of pest species. At the implementation stage, restorationists might need to do a quantitative sample to see if the restoration is achieving an outcome (objective) of "containing < 5% frequency of pest species."

Question 4. Under what circumstances would the soil maps described in Chapter 4 provide sufficient information for a restoration plan? Under what circumstances would you need to collect additional onsite soils information?

What to Look for in Student Responses

- A good answer to this question should include the following points:

1. The soil maps provide information about the location of different soil mapping units. These are areas that have the same origin, chemistry, and physical structure. However, there is often variation within soils of the same mapping unit that is not expressed in the maps; the location of the boundaries between units may not be precise; the scale of the mapping units may be inappropriate for the scale of the project; and some maps are years old and may not reflect current conditions. In some cases, the smallest mapping units are on the order of hectares in size.
2. Soils maps work best at a regional or large site scale and for purposes of creating master plans. To decide on the exact locations of species or trails during the site plan stage, detailed information about such things as soil texture, soil compaction, and nutrient composition, obtained from specific points, is often required. This level of detail generally requires onsite data inventory and analysis.

Question 5. Do you think it is possible to design a restoration without visiting the site yourself? Why or why not?

How to Use or Expand on This Question

- The purpose of this very open-ended question is to have students think about the information in both Chapters 4 and 5 in terms of what can be learned from secondhand information as compared with what can only be gained from spending time on a site. We have found it to work well in generating a class discussion
- Perhaps the best way for students to understand the implications of this question is for them to go on a site visit, after having first done an inventory using existing data.

What to Look for in Student Responses

- More important than the answer (we would expect students to say no to the first part of the question) is that the students should be able to demonstrate a good understanding of what is gained from a personal visit. See also the discussion of Food for Thought Questions 2, 3, and 4 in Chapter 4 in the manual.

Sidebar: Modeling Shadow Patterns: Food for Thought Question

To test your understanding, try modeling the shadows for May 15 and September 15 to see how the shadows change with the seasons.

What to Look for in Student Responses

- Students will need to create a table similar to Table 5.1 and a drawing similar to that shown in Figure 5.4 of the textbook (both on p. 146. Examples are posted on the textbook website (www.introrestorationecology.com).

Sidebar: Designing an Onsite Inventory Protocol: Food for Thought Question

- The Arboretum managers have several ideas as to why the understory is not doing well. These include concerns that, with regard to the restoration site:
    1. The soils do not match the requirements of the northern species.
    2. The snow cover in winter is too shallow and too uncertain to protect the northern species.
    3. The litter layer is too deep.
    4. The tree the light levels under the trees are too low.
- Assume that you have been hired by the Arboretum to conduct an inventory of the restoration site so that the managers can evaluate whether these concerns are plausible. Describe what information you would like to collect, what techniques you would use, and why.

What to Look for in Student Responses

- To address this question, students need to decide what kinds of data to collect and, for each kind, to create a protocol that specifies what equipment to use, what to measure, where and how often to collect data, how to analyze the information, and who should do the work. Since the idea is to compare a restoration with a model (requirements of northern species), students should do one or more of the following:
    1. Propose that the protocols specify that data need to be collected from not only the Arboretum site, but also at (preferably) several remnant northern communities known to contain the species in question.
    2. In order to make a comparison, state that the data collected at the Arboretum should be comparable to information for which the preferences of the northern species are known.

3. Propose experiments testing the responses of northern species to variations in the factors mentioned by the managers (snow cover patterns, depth of litter, etc.) and then compare the results to the conditions at the restoration site.

- Following are a few notes on some possible measurement techniques, based on the information provided in Chapters 4 and 5 of the textbook (in particular, see Sections 4.7, 5.2 and 5.6).

1. *Soil measures to consider:* texture; nutrient levels (N, P, K); water-holding capacity; pH. Take samples and submit to lab for analysis.
2. *Snow depth:* Use meter sticks to measure snow depth in several plots at least twice a week during winter; place permanent rods with depth markings; record depth at least twice a week during winter; use camera to record images of snow cover two times per week.
3. *Litter depth and biomass:* Use similar strategies to measure litter depth, starting in autumn and during periods with no snow cover. Can also collect and weigh litter biomass.
4. *Light meters:* Use light meters—there are quite a number of types—to record light levels in the understory. Take measurements every two weeks or so all year.

Supplemental Activities and Exercises

- If you have access to a field site and equipment, there is no better way for students to understand onsite data collection than to do it. The resources listed at the end of Chapter 5 in the textbook contain information to help you started. You can often find publicly owned properties whose managers will let your class take small samples or use nondestructive sampling techniques on the sites. It is also worth connecting with a local restoration network to see if they know of inventory projects that would welcome student volunteers.
- As we mention in the textbook , if a potential restoration site is large and diverse, the first step in conducing an initial site inventory and analysis is to divide the site into survey units. Have students locate existing spatial data from sources mentioned in Chapter 4 of the textbook (contour maps, soils maps, rectified aerial photographs), and use these to divide the site into more or less homogeneous units. (This makes a good computer-mapping project if your class has access to GIS or computer-aided design software.) Students can then do an onsite walk-through to adjust the unit boundaries (and go on to conduct an inventory if circumstances permit).
- People are central to restoration projects, as site visitors, on-the-ground volunteers, sources of monetary and political support, and, in some parts of the world, site residents. Here are suggestions for several activities that students can do to learn more about how people interact with restorations. Note: In some cases, you may have to submit these projects to the "human subjects" review committee in your institution, to be sure that the procedures respect privacy and cultural traditions.

1. Assign students to review the literature and report to the class on such topics as:
    a) Visitor impacts on particular community types or landscape settings
    b) Resource impacts on sites with trails as compared with those with no trails
    c) How to attract and retain volunteers

d) Case studies of impacts caused by offsite uses

e) How to attract and maintain community support

2. Create a participatory photo mapping project. Provide GPS-equipped cameras to restoration site visitors and ask them to take pictures of those features they particularly enjoy or dislike. Have the participants describe each of their images. Summarize the results. Alternatively, individual students can walk through the site with the participants and interview them about the photos as they are taking them.

3. Have students walk through a site and observe traces of human impact (trash, soil compaction, soil or trail erosion, etc.). Then have them map the locations using a GPS unit or GPS-linked cameras and discuss any use patterns or impact–environment correlations they observe.

4. Ask students to interview volunteers, site visitors, neighbors, or other groups they think might be interested in speaking about their interactions with a proposed or existing restoration. Have students identify their goals (or research questions), develop the interview questions (in the form of a questionnaire or interview), collect the information, and analyze the results.

Suggested Learning Objectives Outcomes

Learning Objective 1. Describe the stages of the restoration process that are informed by site inventory and analysis.

Learning Level 1 Outcomes

- Students can reproduce Figure 5.1 in the textbook (see p. 142), which shows that site inventory and analysis is linked to every major step in the restoration process: (a) setting the project purpose, goals, objectives; and (b) creating the master, site, implementation and research, monitoring, and management plans.

Learning Levels 2 and 3 Outcomes

- Students can explain the links between site inventory and analysis and each of the other steps. For example, the original purpose of the project might be to restore a historical wetland; therefore the site inventory and analysis is designed to look for site features that can support that community. But the results of the inventory indicate that the site is now too dry to support the historical system, so the purpose is revised to restore a different wetland type more in keeping with current conditions.
- Students can design an onsite inventory to collect the level of detail required at the different stages of the restoration process. For example, at the master plan level, you may need to know if an invasive species is found onsite. At the site implementation stage, you would need to know the exact locations of the species and its abundance at each location.

Learning Objective 2. Identify the physical, biological, and cultural resources for which it is important to collect onsite information, and the features of each that are most relevant to the success of a specified

project. This objective is asking for the same thinking as in Food for Thought Question 1. Check out that narrative for more information.

Learning Level 1 Outcomes:

- Students should be able to list the major resources discussed in this chapter: microclimate, topography, hydrology, soils, fauna, vegetation, cultural features, and people.

Learning Levels 2 and 3 Outcomes

- Students should identify that the site features to be measured by an onsite inventory in order to inform the goals of a specific project.

Learning Objective 3. For each feature, describe several different onsite inventory tools, and explain how to decide which to use for a particular restoration.

- This objective is similar to Food for Thought Question 2. Check out that narrative for more information.

Learning Level 1 Outcomes

- Students should be able to describe the inventory tools that can be used to collect onsite information for the major resource features listed in Learning Objective 1.

Learning Level 2 Outcomes

- Students should be able to compare and contrast the different tools that can be used for each specific resource in terms of what they measure, ease of use, expense of use, and the like.

Learning Level 3 Outcomes

- Students should be able to create an onsite data-gathering plan for a specific project.

Learning Objective 4. Know where to look for information about new inventory tools and methods.

Learning Level 2 Outcomes

- Students should be able to name specific communication networks (e.g., SER) and professional contacts and as well as supplier catalogs and professional and academic journals and websites.

Learning Level 3 Outcomes

- Students can independently use these resources to suggest the use of a new technique for a specific site inventory problem.

Potential Issues, Questions, and Misconceptions

- The protocol that governs how data are to be collected and analyzed is an essential part of the onsite inventory process. It is important to create it before data collection begins and to be sure that the information to be collected is relevant to the question being asked. Determining the link

between taking the measurements and analyzing the results in order to answer a specific question saves many headaches later on!

- Most restoration projects use a combination of the approaches covered in Chapters 4 and 5 of the textbook, often during the same site visit. For example, we take copies of existing maps with us on a site visit and use them to locate and record places from which to collect onsite information.
- The techniques in Chapter 5 are also used to collect data in the course of experiments or field trials.

Chapter 6

The Master Plan

Determining the Project Purpose, Solutions, and Goals

Chapter 6 is the first of five chapters that take readers through the process of planning, designing, and implementing a restoration and ensuring its long-term survival. In Chapter 6, we introduce the basic features of a plan and discuss the importance of a collaborative and documented planning process to achieving a successful restoration outcome. We then describe the master plan, which presents the overall restoration vision and spatial layout together with the assumptions, understanding, and decisions that underlie it.

Major Themes

- The act of restoring a site is essentially solving a problem—that is, How do I take a site from where it is today to how I want it to be once it is restored? Formal restoration plans guide restorationists through a structured, collaborative problem-solving process and provide a record of the decisions that are made.
- The master plan includes text and graphics and describes the overall physical layout and general composition and structure of the proposed communities/ecosystems; explains why this is the best solution for the project; explains how people will or will not interact with the site; and creates procedures for periodic review and modifications. It sets the goals for the site plan to follow.
- The proposed master plan solution is selected only after all restoration team members and project stakeholders have the opportunity to discuss the strengths and weaknesses of several (a minimum of three) realistic alternatives. This procedure helps ensure that the solution is well supported.

Comments on Food for Thought Questions

Question 1. Why is it helpful to include both text and plan graphics in a master plan?

How to Use or Expand on This Question

- You can use this question as written as the basis for an in-class discussion or as an essay assignment.
- One of the best ways to help students learn about restoration ecology is to have them propose restoration plans for an actual site. This question can help students as they write master plan documents for their clients (the instructors or even the actual site owners). Here are some possible approaches:

  1. Have the students list the major ideas that they want to convey in the plan document. For example, such a list might include the project purpose, use-policies, and goals; the results of

the site inventory and analysis; the types and locations of communities/ecosystems; the strengths and weaknesses of different alternatives.

2. Next, ask them to describe how they could express each idea as text or, alternatively, by using different graphics. Discuss the relative merits of each communication tool in conveying the idea.

3. Finally, have the students indicate which tool (and often which combination of tools) they will use for each main component of the report and why.

- Students could hand in this exercise for review, or you could use it as the focus of an in-class discussion. Alternatively, you could provide a master plan solution and the components of step 1 and have the students discuss or hand in answers to steps 2 and 3. Students could work on this in pairs, in groups, or as individuals. For step 2, you can have students actually write a text and/or provide different graphics to illustrate a particular master plan component.

What to Look for in Student Responses

- Be sure students understand that a restoration master plan document presents and explains the assumptions and reasoning behind the results of the master planning process. The document needs to be able to communicate this information to the restoration team and the project's stakeholders at the time it is written as well as in the future.
- Answers should mention the main components of a master plan, as these are the ideas that the text and/or graphics should present (project purpose, use-policies, and goals; the results of the site inventory and analysis; the types and locations of communities/ecosystems; the strengths and weaknesses of different alternatives; a periodic review process).
- Graphics is the use of pictures to convey information. Graphic tools students should consider include plan views (drawings that show an area when seen from above; bird's-eye view); elevation sketches (drawings of the features of an area, such as topography, vegetation, buildings as seen from the front or a horizontal view); flow charts, maps, photographs, and graphs.
- Text is writing, using words to convey information. Students should conclude that text is an excellent means by which to explain assumptions, ideas, and reasoning and to record conversations.
- Answers should recognize that some key components of a master plan—for example, the type of communities to be included in a restoration—are best communicated using both text and graphics. Text provides a clear description of community composition; graphics can clearly illustrate pattern and structure.

Question 2. Assume you are in charge of creating a conservation park, a publicly owned property established to conserve native communities while at the same time providing opportunities for hiking and nature study. Create a use-policy and a set of natural system and user goals for the park, based on the forest ecosystem model presented in Chapter 2 [of the textbook—see pp. 35–36] or a native community of your choice.

Question 3. Design a public participation strategy to encourage understanding and support for the conservation park. Explain who you would invite to participate, how you would pique their interest, and what activities you would plan.

How to Use or Expand on These Questions (Questions 2 and 3)

- We use each of these questions as a take-home assignment, due the week after it is assigned, to give students practice in writing use-policies and restoration goals. This exercise has proved to be very helpful in generating questions and uncovering misconceptions. Because a site is not specified, students will need to base their answers on general information about conservation parks and the native communities involved. For Question 2, it also means that students are more likely to create "restoration goals" rather than "implementation strategies" (see the Potential Misconceptions discussion below).
- With modification, these also make good exam questions. For example, with regard to Question 2, ask for a specific number of goals rather than the more open-ended "set" and/or specify that the use-policy should pertain to a particular set of visitors, such as summer hikers of varied mobility. Similarly, modify Question 3 to ask for a specific number of interest-generating strategies and activities.

What to Look for in Student Responses for Question 2

- Students should state their assumptions/understandings about the role of a conservation park. What might be involved in "conserving native communities"? How does a park provide "opportunities for hiking and nature study"? General themes to look for include:
    1. Protecting the native communities from user impacts (list likely impacts)
    2. Restoring and maintaining the restoration
    3. Providing (or not providing) trails, signage
    4. Separating (or not) the hikers from those engaged in nature study
    5. Providing several different or just a few kinds of experiences (solitary, social, etc.) for hiking and or nature study
- Students will need to begin by describing their understanding of what a "conservation park" is, and then find or create a community/ecosystem model. They can then use this information as the basis of their use-policy and restoration goals.
- If you are addressing a particular location, students should also address:
    1. Site context
    2. Steps needed to conserve specific communities: periodic fire or floods, for example, and how their implementation might affect the site and/or visitors
    3. The identity of potential users
    4. Specific educational themes (natural history, restoration, conservation, etc.)

- The use-policy should probably include several statements, each of which describes an activity and an experience. For example: "The site supports solitary and social hiking"; "Visitors shall remain on the trails"; "The site will provide opportunities for individual visitors to learn about natural history."
- The master plan goals should be time-neutral and describe the desired results of the restoration, not the means of achieving them. If you use the "generic" version of these questions, students can usually write goals in this way with few problems. If you apply these questions to a particular site, students often have more difficulty in writing time-neutral goals—see the Potential Issues, Questions, and Misconceptions section below. Students will need to write both natural community and user goals.
- If you are using the forest community/ecosystem models presented in Chapter 2 of the textbook (see "Case Study: Excerpt from an Ecosystem Model," pp 35–36), the natural system goals might include:
    1. The site contains two communities that are dominated by mature trees: mesic and xeric forest.
    2. The most common trees in the mesic forest are maple and basswood; the most common trees in the xeric forest are oaks.
    3. The mesic forest has a sparse shrub layer; the majority of the understory herbs bloom in spring; spring ephemerals are abundant.
    4. The xeric forest contains several species of shrubs; the understory contains many species that bloom in late spring and summer; many species produce nuts and berries.
- User goals for the forest communities might include:
    1. The site contains a network of trails, the majority of which are designated "pedestrians only"; the remainder are paved and wide enough for emergency vehicles
    2. The trails allow visitors to experience both the mesic and the xeric forests.
    3. Formal opportunities to learn about the natural history of mesic and xeric forests are provided along the trails.
- The quantitative site plan restoration outcomes (objectives) that we discuss in Chapter 7 of the textbook (see Section 7.1) follow from the more general, qualitative master plan restoration goals discussed in Chapter 6.

What to Look for in Student Responses for Question 3

- Students will find the logic model shown in Figure 6.5 (see textbook p. 187) to be a good way to organize their responses to Question 3.
    1. Before describing their public participation strategies (inputs and outputs), students should explain what they want the outcomes to be. For example, do they want to raise funds; establish political support; and recruit volunteers to carry out restoration, management, or educational activities? Or do they want to simply encourage visitation?

2. Next, they can determine who their audience is—in other words, which people will benefit the most from or have the most to contribute to the restoration.
3. Once the outcomes and the people are identified, students can go on to discuss their strategies.

Note: We discuss "working with people" in more detail in Chapter 13.

Question 4. Would the master plan components we listed change depending on where you are conducting your restoration? Or depending on different community types?

Compared with questions 2 and 3, Question 4 is rather less complicated. It is meant to reinforce the idea that restorationists use a problem-solving, planning framework, just as scientists use the scientific method. The idea is to have students consider whether the presence or absence of each of the master plan components is place- and/or community/ecosystem-dependent.

How to Use or Expand on This Question

- You can use this question as an active learning exercise to check that students know and understand the reasons for the various components of a master plan. (The first step in answering the question is to identify the components.) Here are some possible approaches:
  1. Ask students to read the chapter before coming to class, and then use the first 15 minutes of class to have them work in groups to answer the question. You can collect the answers for evaluation and/or have one or more of the groups share their answers with the class. It is also a good idea to be sure that students explain their answers—not just respond yes or no. To be sure that this is clear, it is helpful to reword the question—for example, add the phrase "explain your reasoning" or "why do you think so?"
  2. Another way to address this idea is to have students review existing restoration plans to see how many of the master plan components are explicitly presented and, if any are missing, speculate as to why that might be the case. Have them address the initial question—do place and composition explain the absence—as well as suggest other factors that might be involved. Formal restoration plan documents may be difficult to locate. If this proves to be the case in your region, the descriptions of restorations found on the Internet can serve the same purpose.
  3. You can also modify either of the Question 4 subquestions to focus on how the nature of the individual components do or do not change from one site to another or with different community types.

What to Look for in Student Responses

- The first thing to look for is that students are able to identify the master plan components. For example:
  1. Project overview and purpose
  2. Use-policy
  3. Restoration goals (natural system and user)

4. Description of site inventory and analysis
5. Set of alternative solutions
6. Choice and justification of the desired solution
7. Restoration goals for each community or restoration unit
8. Estimated budget
9. Procedures for plan adoption, review, modifications
10. Text and graphics

- In the case of the first alternative for the question, students should address why or why not site location or composition (target communities/ecosystems) would influence the inclusion of each component in a restoration plan. We expect students to conclude that, since all of the components of a master plan are important to the long- and short-term success of a restoration, location and community type should not change the basic planning framework. On the other hand, a restoration team might decide to knowingly omit a component (skip a step) in some circumstances.
- For the second alternative for the question, students should list which components are or are not mentioned, and speculate as to the reasons. (Of course, if students are interviewing practitioners, they can ask directly.) Factors other than location and target community type that might be involved could be: (1) the nature of the audience (budgets might be shielded from public view); or (2) a privately owned site is so small that the restoration team felt that only one solution was feasible and so did not consider alternatives.
- The point of the third alternative for the question is that the components of the plan will remain the same, but they will differ in detail. Students should list specifics, for example:

1. Use policies for a restoration in a location where people live on or near the restoration and depend on the site resources for survival will likely be very different from those for a site in a part of the world where people are only occasional visitors.
2. Many site inventory procedures will be different on upland and wetland sites.
3. The goals will be different if the purpose is to create an experiential restoration rather than an ecosystems services restoration (goals would likely focus on aesthetics in the former case, and on function—e.g., water quality protection—in the latter).

Question 5. How would you differentiate the project purpose, use-policy, and goals? How does the master plan graphically exemplify each?

The first part of Question 5 helps students understand the role of each component in creating a master plan and that each complements the others. The second part helps students think about the uses of graphic communication. Question 5 covers some of the same ground as previous questions, focusing on three concepts that can be confusing to students.

How to Use or Expand on This Question

- You can use either part as the basis for a class discussion, exam question, or essay assignment. You might also ask students to demonstrate how graphics can illustrate each concept—in other words, have them use graphics to represent a particular project purpose, use-policy, and master plan goal.

What to Look for in Student Responses

- Each of the components plays a particular role in the process leading to a restoration master plan. In their responses, students should provide the following key points:

    1. The project purpose explains what the restoration team hopes to accomplish. The purpose is action oriented and directed at solving a problem. It reflects the situation that exists at the beginning of the project.
    2. The use-policy explains how people will interact with the site once the restoration is completed.
    3. The goals describe the site as it will be when the project is completed.
    4. Both the use-policy and the goals are written in time-neutral language; they are written as outcomes. At the beginning of the restoration process when the master plan is being written, they represent a snapshot of a desired future. The purpose uses action language, addressing what will be accomplished. It presents both the present and future.

- Although in Chapter 6, our examples of project purpose, use-policy, and master plan restoration goals are in the form of text, they can be expressed using graphics as well. Students can be quite creative with their answers here. The main point is that the images represent the concept. For example:

    1. The purpose could be represented by before-and-after images (e.g., students might use a software program such as Adobe Photoshop to illustrate how an actual site would look once restored) and/or action shots of restorationists planting vegetation.
    2. A bird's-eye view of the site after restoration could illustrate the general locations of the proposed community types listed in the plan goals.
    3. The plan could include sketches showing someone walking along a narrow trail to illustrate a "solitary hiking" use-policy.

Sidebar: Choosing the Desired Solution: Food for Thought Questions

The questions in this sidebar refer to the Kishwauketoe Nature Conservancy master plan alternatives presented in Chapter 6 (see textbook pp. 189–191). They are asking the students to think about how they would critique the different alternatives.

1. How would you respond to the following questions?

    a) Which alternative plan would be easiest to implement, given the existing vegetation?

    b) Would alternative 3 result in community patches that are too small to support desirable species?

c) Which alternative would provide the best biodiversity for educational or birdwatching purposes?

d) Is the presence of grassland bird habitat more desirable in this region than the presence of forest bird habitat?

e) Would the more developed amenities of alternative 2 detract from a solitary experience?

f) How difficult will it be to manage each alternative once established? For example, is the difference in the disturbance regimes necessary to maintain the communities more feasible for one alternative than the others?

2. What information would you need to make a decision?
3. What additional questions might be addressed in the selection of one of several alternative master plan solutions?
4. You will want to consider the similarities and differences between each scenario and then evaluate how well each meets the project purpose, use-policy, and objectives.
5. Consider what other criteria you might use to evaluate and select the desired solution.

What to Look for in Student Responses

- The questions all center around the process of choosing among different master plan solutions. They are meant to lead students through the decision process. Students should be able to demonstrate in their answers (especially with regard to sidebar Question 5) why the selection criteria include such things as:
  1. How well each plan achieves the project purpose, use-policy, and each of the master plan goals and outcomes
  2. If each plan serves some goals better than others, which goals are most important
  3. Whether the target communities of each plan match the current site conditions
  4. Whether the proposed extent of each community is sufficient, given the relevant community/ecosystem model
  5. Whether the sites differ in terms of ease/expense of establishment
- In order to address the questions, students should recognize that they would need to know more about the following:
  1. The extent and composition of existing vegetation (they are told that it consists of "disturbed woods and pasture").
  2. The conservation or social value of the native plants and birds that would be in the different community types
  3. The identity and biological habitat requirements of each desired species and physical site features in terms of how well the soils, topography, water systems, microclimate, and the extent of usable habitat of each alternative will support the different desired species

4. The process of restoring the communities mentioned in the different alternatives (oak savanna, marsh, oak forest, and prairie, to name a few), given the current site conditions.
5. More details about the kinds of experiences visitors prefer.

- Students should also mention involving the project's neighbors and other stakeholders in making the decision.

Supplemental Activities and Exercises

- Use the master planning process to create a master plan for an actual site.
- The best way for many students to come to understand the material in Chapter 6 is to use the concepts to design a restoration. We are fortunate to be able to work with public and private agencies, as well as private landowners in and around the Madison, Wisconsin, area to locate actual potential restoration projects. The land managers act as clients and provide information about the site and their desired uses and outcomes. The students are allowed to visit the sites and collect inventory data. Once the students complete their master plan alternatives, they present their ideas to the clients, who provide feedback.

  The agencies and landowners report that they enjoy working with the students, and that they appreciate the ideas that the students advance. In many, but not all, cases, the land managers actually implement the plans. In most cases, they utilize some of the ideas presented.
- You can also create a more hypothetical project if you can locate a site that students can visit and for which site information can be obtained. You can then serve as the client for the restoration.
- Examples of project statements we have used are on the textbook website (www.introrestorationecology.com).

Suggested Learning Objectives Outcomes

Learning Objective 1. Recognize the differences between master, site, implementation, monitoring, and management plans and where they occur in the restoration process.

Learning Level 1 Outcomes

- Students should be able to define/explain the concepts in their own words and list them in a logical order. (The order they appear in the question is the one we present.)

Learning Level 2 Outcomes

- Students should make the following points in their analysis of differences:

  1. The master plan presents restoration goals—general statements of desired outcomes; the site plan presents restoration objectives (written as outcomes), which expand on the goals, providing more detailed, measurable outcomes.
  2. The master plan shows the general locations of desired communities and the site infrastructure; the site plan shows exact locations.

3. The master and site plans describe future outcomes; the implementation plan explains how to achieve the site plan outcomes, given current site conditions.
4. The monitoring plan explains how to collect information to determine if the site plan outcomes are being or have been achieved. Monitoring plans may address the implementation phase of a restoration as well as the management phase.
5. The management plan provides guidance as to how to ensure that a restoration continues to meet the site plan outcomes once they have been achieved.

- With regard to how the concepts fit in the restoration process, students should explain the following:
  1. Site plan outcomes are based on the master plan goals.
  2. Implementation strategies rely on achieving site plan outcomes.
  3. The information that a monitoring plan provides is based on the site and management plans.
  4. The management plan relies on the site plan outcomes.

Learning Objective 2. Explain what a master plan is and the attributes shared by all master plans.

Learning Level 1 Outcomes

- Students should be able to define "master plan" in their own words and to identify the following points included in all such plans:
  1. Collaboration
  2. A report including text and graphics
  3. Flexibility (provisions for midcourse corrections.

Learning Objective 3. Identify the structural components of a master plan and their importance to the restoration planning process.

- Check out the preceding discussion about Food for Thought Question 4.

Learning Level 1 Outcomes

- Students should be able to list the components of a master plan (purpose statement, use-policy, etc.) and explain why each is included.

Learning Level 2 Outcomes

- Students should be able to review an existing master plan and evaluate it for completeness.

Learning Level 3 Outcomes

- Students should be able to create a master plan for a specific site.

Learning Objective 4. Assess when during the restoration process collaboration between interested and affected parties needs to occur.

Learning Level 1 Outcomes

- Students should be able, at minimum, to identify the following stages of master plan development as being important opportunities for collaboration:
  1. The start of a project, when the project purpose and restoration goals are being formulated
  2. The stage when alternative solutions are being reviewed
  3. The point at which the plan is to be adopted.
- Students should also be able to explain why collaboration at these points is useful to the restoration team. For example, in addition to gaining support for the project if community members feel that they are a part of it, knowledgeable neighbors often have information that helps guide the restoration.

Learning Level 2 Outcomes

- Students should be able to review and evaluate an existing master plan in terms of its opportunities for collaboration.

Learning Level 3 Outcomes

- Students should be able to design a collaborative master planning process for a particular site.

Potential Issues, Questions, and Misconceptions

- One of the most common issues we hear from students is the idea that it is a waste of time to consider alternatives before choosing a specific master plan. In our fast-paced world, it often seems easiest to go with the first solutions or responses we consider when resolving a problem or addressing a task. However, this kind of quick response often limits our thinking and may cause us to miss one or more solutions that are much more advantageous than the one we first thought of. It is important to outline or sketch as many alternatives for master plans as can come to mind. We can then evaluate each based on the project goals and outcomes.

  In addition, creating several alternatives is an essential part of involving the public in the master plan process—an essential component of the restoration process. We can present three or more alternatives for review at a public meeting or, even better, invite interested members of the community to help generate alternatives in the first place. We often find that the master plan that is adopted includes ideas from several of the alternatives.
- Students often have difficulty writing time-neutral master plan goals (and site plan outcomes). Their tendency is to confuse these plan components with the kinds of statements included in action plans, such as: "My objective is to reduce the tree canopy to <10% cover." Remember that the restoration goal and outcome statements describe the site vision, not the actions that need to be taken to achieve the vision.

Chapter 7

The Site Plan

Design and Plan Documents

As we discuss in Chapter 6, the master plan presents an overview of the desired outcomes of a restoration together with the assumptions, understandings, and decisions that underlie its creation. In Chapter 7, we describe the next step in the restoration process—the creation of the site plan. The site plan includes detailed written and graphic specifications for the locations of communities and the species within them. The site plan outcomes (objectives) add detail to the master plan goals. This is also the point at which the project team decides on the details of any desired infrastructure and recommends physical landscape alterations. Together, the master and site plans set the stage for the implementation plan (see Chapter 8), the road map that guides the execution of the project.

Major Themes

- The site plan adds sufficient detail to the master plan so that restorationists can implement a project that is true to the vision of the planning team. The site plan describes exactly what is to be accomplished in measurable terms. Whereas the master plan goals are general descriptions of outcomes and therefore provide room for different interpretations, the site plan outcomes remove ambiguity by being much more explicit. Similarly, the spatial layout of the restoration presented in the site plan is more refined than that presented in the master plan.
- The restoration outcomes described by the goals and outcomes address ecosystem processes and community composition, structure, and dynamics (guided by community/ecosystem models [see Chapter 2, Section 2.1, in particular], as well as intended human activities and experiences (if any) and the physical condition of the site. The plan layout shows the locations of plant communities and describes the proposed condition of physical features, including topography, soils, and water. Depending on the project purpose and use-policy, the layout may also show the placement of specific species and infrastructure features.
- Because of the variation found in nature as well as the potential influence of unexpected disturbances, it is important to build flexibility into the plan. One way to build in flexibility is to write outcomes that specify an acceptable range of conditions rather than only one. Another is to recommend community compositions that include species with broad ranges of tolerance able to survive environmental changes. And, once again, the plan includes procedures for periodic review and modifications.
- In developing the site plan it is important to consider the surrounding landscape and address the opportunities and constraints presented by potential cross-boundary interconnections.
- The use-policies of many restorations (and especially experiential restorations) include activities and experiences designed to provide pleasure to people. In such situations, restorationists use design principles, based on aesthetics, to guide the location of trails and other infrastructure features, as well as to choose and locate species within communities.

- In designing the infrastructure of a restoration, in addition to providing features that support and enhance the use-policy, it is important to consider how each supports or harms the surrounding communities/ecosystems. It is also a good idea to have the infrastructure serve multiple purposes—for example, a circulation system that can serve both as trails and firebreaks.

Comments on Food for Thought Questions

Question 1. List several reasons why a wildlife species may not always be able to recolonize a restored community, even if its habitat needs seem to have been restored. What strategies would you add to the site plan to resolve this?

How to Use or Expand on This Question

- You can use this question as written as the basis for an in-class discussion, using one of the approaches discussed earlier in this manual. For example, one way to proceed is to pose each part of the question to the class and wait for individuals to respond. As the discussion continues, add comments as appropriate, and if necessary, ask additional questions to lead the discussion to include the points you wish to cover. In addressing the second part of the question regarding strategies, be sure to have the students examine their solutions to consider if they create conflicts with species that may currently exist onsite. (In fact, such conflicts could be one of the constraints on recolonization.)
- Alternatively, give the students, working as individuals or in teams of two or three, 5 minutes or so to write down their answers. Then ask each student or team to share one of their responses and post it for all members of the class to see. Continue until all of the ideas have been expressed; then have the class as a whole discuss the results. There are many ways to post the answers, ranging from traditional chalkboards to digital technology involving interconnected keyboards and projectors. You can also use online discussion forums, both in the form of live chats and on-going discussion threads.
- Depending on the backgrounds and levels of experience of the students in your class, you may find that they struggle with how to address this question. (This is also the case with a number of the Food for Thought questions, found in earlier chapters—for example, Question 3 in Chapter 4; questions 3 and 4 in Chapter 5; and questions 2 and 3 in Chapter 6.) In introducing students to restoration ecology in courses ranging from a sophomore-level honors biology course to workshops and seminars aimed at first-year graduate students, we have found that many sophomores and also a few of the graduate students come to us with little experience in solving this kind of "story problem." Using this question as an example, here is one of the problem-solving strategies we have used to assist students in analyzing and solving problems centered on such case study situations.
- To help students get started, we have found it helpful to break the discussion into several stages:

    1. First, we have the students identify and define the key words and phrases that are embedded in the question; in this case they might select "restored community," "recolonize," "wildlife species," "habitat needs," and "site plan strategies."

2. Next, we have them identify the information provided by the question and explain any assumptions they make about the situation, based on how the question is phrased, as well as what they have been learning in class. For example:

    a) The question uses the term "recolonize." Based on previous discussions of ecological theory (see Chapter 2 [p. 39 and Section 2.5.1] and Chapter 4, Section 4.8), the use of this term implies that the species once was found onsite, but before restoration started, it was no longer present. It also implies that the goal is for the wildlife species to establish a "resident" *population*, but it is not clear whether this is to be a breeding population, or a population that is present all year, or one seen only during a particular season. For a species to colonize a site, several individuals must arrive on the site and remain there for a specified period of time. If colonization does not occur, it could be because of the failure of a species to reach the site or to remain onsite in sufficient numbers.

    b) The wording of the problem implies that the restoration team identified a set of habitat needs, included relevant restoration outcomes in the site plan, and has determined that these outcomes have been met—the factors are now present onsite.

    c) The wildlife species has not been recorded on the site post-restoration (at least not in sufficient numbers to be said to have colonized the site).

    d) The current site plan "strategies" for having the wildlife onsite are not explicitly stated, but from the use of the verb "recolonize" and the reference to "restoration of habitat," we can infer that the restorationists were assuming that if they created suitable habitat, the wildlife species would return on its own.

3. Then we have the students describe the situation in their own words and rephrase the question, to help them pinpoint what is being asked. Here is an example: "The goal of the restoration project is to provide habitat for a population of a particular, unspecified wildlife species. At the start of the project, the site did not provide the habitat needs of the species. The project team assumes that if the habitat is restored, the species will return on its own and establish a sustainable population. The restoration has proceeded in such a way that the site now appears to contain the appropriate habitat elements, but the species is not yet present, at least not in the form of a sustainable population. What are some possible reasons for the failure of the wildlife species to arrive at and establish a population on the site? How might the site plan address each of these issues?"

4. Finally, taking each of the two Question 1 subquestions in turn, we have the students brainstorm answers, using what they have learned in steps 1 to 3.

- Instead of asking students to discuss wildlife species as a whole, ask them about one or more specific species. If students are likely to be familiar with the species you select, this question can form the basis of a class discussion with minimal advanced preparation required of the students. Depending on the backgrounds of the students, however, they may only be able to answer the question in general terms.

  To create a more sophisticated discussion, consider providing detailed background information or readings about the wildlife species you wish to discuss, and assign the students to become familiar with it before class. Or you can ask the students to find the information on their own (use a class

discussion to help them decide what information they need to collect or specify this yourself). This approach has an added benefit of introducing the students to more wildlife species and giving them practice in finding and organizing information. If you are having the students work in teams, this is also a good opportunity for students to learn how to work together. Assign individual team members to different species, and have each person share her or his findings with the team.

- You can also use this question to combine a class discussion with an essay assignment. First, discuss the general form of the question in class using one of the approaches described above. Then ask students to write a paper in which they apply the ideas generated during the discussion to a specific wildlife species.
- It is also very helpful to apply this question to an actual site and to a species that might occur on the site but does not exist there now. The site could be a property that is easily accessible to the class, a distant location for which they can find site information, or even a hypothetical site that you create. Have students assume that the habitat on the site has been restored, and go on to answer the question in one of the ways described above.
- Substitute "plant species" for "wildlife species" and have students address the question in one of the ways described above.

What to Look for in Student Responses

Responses to SubQuestion 1

- In their answers, students will need to address two major factors that underlie species colonization: (1) the ability to reach a site, and (2) the ability to survive onsite. If either of these general conditions is not met, a population will not survive. These ideas are first introduced in Chapter 2 in the context of plant communities (see p. 39 and Section 2.5.1) and discussed with regard to wildlife in Chapter 4 (see Section 4.8) and again in Chapter 7 (see p. 206). Here are some notes on possible answers:
- Factors that might influence the ability of a species to reach a site include:

1. Its inherent dispersal abilities (the ability to fly, move on the ground, travel in the treetops, swim, drift in the wind or in water, hitch a ride on another species)
2. The nature of the landscape between its current location and the location of the restoration (distance, type of habitat)
3. The presence of perils, such as predators and car traffic, or barriers (e.g., an incompatible habitat) a species might encounter en route.

Students should also mention that constraints to colonization are species-specific and often include a combination of these factors. For example, salamanders may not survive the crossing of a six-lane highway in sufficient numbers to establish a population, whereas many birds can fly over such a barrier.

- If the restoration invites extensive human use, it is possible that the types of activities, the extent of use, or the nature or placement of the infrastructure interfere with the wildlife species' ability to feed or reproduce. Students could use the example that if a trail is located too close to a nesting

site, birds may be disturbed by the presence of people and fail to reproduce, and the population may die out.

- Depending on what the restorationists included in their definition of habitat, it is possible that the site conditions are not suitable for the continuing survival of the population, even though the established restoration outcomes have been met. For example, it is possible that the planners did not recognize the onsite presence of a competitor or predator or the absence of an important mutualistic partner, leading to the eventual local extinction of a species even if individuals are successful in reaching the site. Often this situation is the result of our lack of understanding of the complexities of species–species and species–environment interactions rather than an oversight. Similarly, students could mention that we do not understand the microclimate requirements of every species.
- Sometimes unforeseen cross-boundary influences can play a role in preventing wildlife species establishment by, for example, disrupting a nesting season or a needed food supply. Off-season flooding by stormwater runoff can affect a site in this way. Changes in the use patterns of the surrounding landscape are not always predictable.

  For wildlife species that require several different kinds of communities to meet their habitat needs, unless the restoration site can provide all of these, the failure to establish on a site may be due to the loss of critical habitat elsewhere.

Responses to SubQuestion 2

- Students should take each of the issues they identify in answering subQuestion 1 and discuss how a site plan might be modified to address it. Three strategies students should be able to identify are:

  1. Designing the layout of the communities to include numerous access points
  2. Creating a use-policy and designing the infrastructure so as to avoid negatively impacting wildlife
  3. Modifying the physical and/or biological features of the site to better match habitat requirements
  4. Creating safe travel corridors that link the restoration site with sources of the desired species.

  Students should also recognize that, in order to avoid overlooking vital habitat components in specifying restoration outcomes, it is important to be as detailed and inclusive as possible in creating the community/ecosystem models that provide the foundation of all of the restoration plans.

Question 2. Consider the ways in which wildlife or vegetation that occur outside the physical project area affect your success for restoration. After listing each one, discuss how you might plan for these potential influences when writing the site plan.

How to Use or Expand on This Question

- This question addresses one of the concepts behind the responses to Question 1—the importance to a restoration's success of the connections or interactions between the site and its external

context. In this case, we are asking students to think about how to create a site plan to account for the ways in which plant and animal species located off-site may have both positive and negative effects on restoration outcomes. The approaches discussed with regard to Question 1 also work well with Question 2.

- You can also broaden the question beyond a discussion of plant and animal species by asking about a variety of cross-boundary effects, especially those originating from human activities. Such an activity can serve as background information for Chapter 12, the focus of which is cross-boundary influences. The purpose here is to emphasize that the design of the site plan can and should take off-site conditions into account, with regard to both implementation and long-term management.
- This is also a good opportunity to assign students to use the Internet to locate case studies in which the restoration planners specifically address the site context in specifying the desired outcomes of the project.

What to Look for in Student Responses

- In order to identify the ways in which off-site species might influence a restoration, students should consider the potential for adjacent properties to serve as a source of both desirable and undesirable colonists, as well as the possibility that off-site species might influence the microclimate of a restoration. Also, as discussed earlier in connection with responses to Question 1, the ability of colonists to reach a restoration depends on the biology of the species involved, as well as on the proximity of the source populations and the nature of the landscape they must cross. Students should consider each of these factors in their answers.
- Once on the site, in order to influence restoration outcomes, species need to be able to survive long enough to interact with the site components. For example, they could negatively affect desired species through direct or indirect competition or predation, or by changing the environment (e.g., by uprooting plants or reducing shrub cover). On the other hand, if the species belong to the restoration's community/ecosystem models, they could contribute to the success of the restoration by helping achieve its outcomes.
- Off-site plant species can influence the environment of a restoration by, for example, casting shade onto a restoration site or creating a wind tunnel that directs increased wind velocity onto a site.
- If you decide to ask this question with reference to a specific site or set of species, students will need to collect the relevant information. For example:

    1. They will need to determine the species compositions of sites that surround the restoration and to note the distances migrants would have to travel and the nature of the barriers or conduits they would need to cross or use.
    2. Using this information, they can then identify potential colonists—species present on adjacent properties that have appropriate dispersal abilities—and determine how each might affect the restoration should it arrive onsite.
    3. Students should also pay attention to the locations of species on closely adjacent properties that might influence the restoration microclimate.

- The nature of the wildlife and vegetation found in the landscape surrounding a project site can influence a restoration in a number of ways. With regard to writing both the site and master plans, this information can influence the choice of which community/ecosystem to restore, the project goals and outcomes, and the layout of the communities onsite. Here are some examples students might provide:
    1. If the surrounding area is forested and the restoration site could support either grassland or forest, a restoration team might opt to restore forest in order to enlarge the size of the existing patch.
    2. If desirable native species are found in the surrounding area, assuming they match the environmental conditions of the project site, the team will add them to the list of acceptable species forming the core of the restoration (e.g., "Site includes at least 75 of the species found on the attached list").
    3. Similarly, if potentially undesirable species are located nearby, restorationists will generally create an objective to limit their presence onsite (e.g., "less than 1% cover of each invasive species found on the attached list").
    4. If the context of the site is such that most of the potential colonists are either undesirable or invasive, it may be desirable to protect the restoration by creating a buffer zone to prevent the species from reaching the core of the restoration or by designing the layout to reduce the amount of edge (creating relatively large communities that are as close as possible to being circular in shape, rather then creating long rectangles.
    5. If most of the potential colonists are desirable, restorationists might design the plan layout to be rectangular rather than circular in order to include large amounts of edge to facilitate their arrival onsite. (See the discussion of "patch geometry" in Chapter 2 [pp. 56–57] and in Section 7.2.).
- If you have broadened the question to have students consider additional cross-boundary influences, some of the factors that students might identify, based on information from this as well as earlier chapters, include increased flooding, rates of erosion or amounts of silt deposits due to stormwater runoff, and pesticide drift. The site plan might address these with the use of buffer zones, or through the creation of water detention or treatment facilities.
- Students may also identify cross-boundary issues that are part of the restoration planning process, rather than of the site plan per se. For example, stormwater is a topic that is best addressed in the context of a region or watershed and involves broad social and political issues that are often outside the scope or control of a particular restoration project. Nevertheless, during the public input portion of the restoration planning process, it is possible for restoration stakeholders and neighbors to be made aware of the problem and to take voluntary steps to reduce the flow of stormwater onto a restoration site. It is useful to discuss these kinds of complex solutions with the students.

Question 3. Select a restoration project occurring on public lands in your area. What are the public expectations for it? How are the public expectations and uses incorporated into this landscape? Is the

restoration successful in terms of its use-policy and public satisfaction? How would you determine whether the restoration is successful?

How to Use or Expand on This Question

- The goal of this question is to have students consider the social component of restoration—how people perceive, and the degree to which they accept, a restoration—and to give students experience in evaluating a restoration project from this perspective. The activity works as an individual paper assignment, but is most valuable as a group project.
- To address the question as written, it is ideal if you have access to a public restoration project with readily accessed supporting materials and/or knowledgeable managers willing to share information with you and the class. Students will need information about the project purpose and use-policies and, if possible, any public meeting transcripts or narratives that describe public opinions expressed during the planning stages of the project.
- If the project plan does not include purpose or use-policy statements, you (or the students) can write a project purpose and a set of use-policies based on conversations with the managers, or you can prepare hypothetical versions for purposes of the assignment.
- If there is no official record of initial public expectations, it is sometimes possible to obtain information from articles about the project reported in various media. Such historical information is not essential for completing the assignment but is useful in understanding the site design, especially the type and placements of any infrastructure.
- Note that the members of the "public" who participate in the planning process may be different from those who actually use the site. And people who participate onsite may include visitors (people who come to the site to enjoy outdoor activities or to learn about and experience nature), researchers, and volunteers assisting with the implementation, monitoring, or management of the project.
- We talk more about these different groups of users in Chapter 13 (see Section 13.1). If you have the time, it is helpful to discuss how expectations may differ among these groups, as well as among individuals within each group. For a shorter assignment, you may want to concentrate on only one group in addressing most of the parts of Question 3. Following is an example of what students can do in focusing on the site visitors:

    1. Assuming that information is available, have the students determine how well the implemented use-policies, site layout, and the composition and infrastructure of the restoration address the initial public expectations for the restoration expressed during the planning process.
    2. Next, have the students investigate how well the site supports the current visitors. To do so, students will need to establish evaluation criteria that measure such things as the types of current user activities, visitor and site conflicts, visitation patterns, and visitor expectations and satisfactions. Students can use one of the techniques discussed in Chapter 5 (direct observations, interviews, questionnaires, participant photo mapping) to gather relevant onsite information. For example:

a) Have students observe visitor actions throughout a day or during a weekend, noting behaviors and adherence to the use-policies.

b) Have students set up an interview station at the restoration site and ask users about their satisfaction with the restoration, the purpose for their visit, and what types of activities they engaged in while visiting.

c) After collecting this visitor information, the next step is for the students to use the data they have collected and the criteria they have established to report their findings.

Note

- Depending on the policies of your school and/or the restoration owners/managers, you may need to obtain a permit to conduct onsite observations or interviews. As discussed in Chapter 5(see Section 5.10), most public agencies have established procedures to ensure that the privacy rights and cultural traditions of research subjects are respected. In a project such as this, the site users are considered to be research subjects, so it is important to follow the protocols relevant to your situation. In almost all cases, permission to proceed will be easily granted. Having to design a data collection protocol complete with a "human subjects" review requirement is an important learning opportunity for students. [[[This text aligns with #2 in the numbered list above.]]]
- If you or your colleagues will be teaching restoration ecology on a regular basis, consider using Question 3 to create a multiple-year project. Each year, students can collect data and, as the project continues, compare their findings with those of past years to see if they can identify any trends in visitor use, satisfaction, or impacts to the restoration caused by the users.
- As an alternative, you can create an even shorter version of Question 3 by having students concentrate on how well the site design accommodates current use patterns. In other words, focus on user activities rather than on user experiences or expectations. For example:
    1. If the restoration site includes a trail system, have students observe how many visitors use the designated trails and record any instances of people creating their own routes through the site.
    2. Ask the students to identify any signs of user impact they encounter.
    3. Have them evaluate other features of the design in terms of how well they promote the use-policies.
- Another approach we have used is to have students suggest solutions to situations in which a restoration site plan and user expectations do not match. You can pose hypothetical situations, use the findings of student responses to the original Question 3, or use case studies from the literature. The idea is to have students create "win-win" restoration designs whenever possible. (In fact, we have found that it aids understanding if you add to all versions of this assignment a question about how to modify the restoration to improve user experiences.)
- Consider having students discuss whether they would expect the degree of public satisfaction with a restoration to vary, depending on whether the project was a complete restoration, an ecological services restoration, or an experiential restoration. How might the expectations surrounding these purposes differ?

What to Look for in Student Responses

- The responses to this question will vary depending on the situation and the versions of the question you choose to use. The important thing to look for is that students demonstrate an understanding of how the features of a site plan interact with public expectations and experiences—in particular, the use-policies, the plan outcomes, and the infrastructure design.

Question 4. Select a community type that occurs within 100 miles of where you live. Assume you have the opportunity to develop a restoration project for this community. What specific outcomes would you establish in terms of species composition and structure? Defend each outcome.

Question 5. Establish and defend a set of criteria for selecting specific plant and animal species that meet the outcomes for the restoration in Question 4. In this defense, explain how you would use each criterion to select species.

How to Use or Expand on These Questions (Questions 4 and 5)

- The learning objective for both of these questions is to have students demonstrate their understanding of the components of a site plan by, in the case of Question 4, actually creating a set of restoration outcomes and, in the case of Question 5, proposing a method to choose the species to be included in the desired composition of each community. We use the questions as take-home assignments either separately or in combination, or as the basis of an in-class charrette. In both cases, we usually specify one community or a set of communities from which students can choose one to focus on.

  For those of you who are not familiar with charrettes, here is a brief explanation, and an example, using Question 4. A charrette is a problem-solving method borrowed from several design and planning professions. The idea is to foster creativity by having individuals or teams generate solutions to a problem during a limited period of intense effort. Planning agencies often use charrettes to get public input for a proposed project by having teams of stakeholders and designers/planners generate ideas during a two- or three-hour workshop, at the end of which each team presents their proposals to the entire group.

  We generally have students work in teams during the charrette in order to advance our learning goal of being able to work as members of a productive, collaborative design or research team. We break the assignment into several timed steps, after each of which we discuss the various solutions as a class. (The format of our fall semester class includes one three-hour lab period per week. We spend this period in the field during the first part of the semester and save the charrettes for later on after winter sets in.) For Question 4, the directions for the charrette might be as follows:

  1. Choose a community type from the following list and summarize the main characteristics of the community based on your community/ecosystem models (45 minutes).
  2. Develop a project purpose statement and use-policy for your chosen community. (20 minutes)
  3. Develop a minimum of 6 significant biological outcomes for your chosen community and justify each one. (45 minutes)

4. After each step, be prepared to present your findings to the class as a whole, and participate in the discussion.

We usually set aside two and a half hours to run the entire charrette, and the time is well spent. As students develop their answers, they reveal misconceptions and gaps in their knowledge, which we then go over during the discussion periods. Having to apply the concepts is a great way for students to truly understand them. If you do not have the time to use the full version, one way to shorten the assignment is to specify the community type, then provide the community/ecosystem model summary, the project purpose, and the use-policy, effectively starting the assignment at step 3.

To be able to create the measurable outcome statements needed for a site plan, the community/ecosystem models will need to include specific details and at least some quantitative information. In this example, we are asking students to use their community/ecosystem models from a previous assignment. If students need to create or add detail to their existing models, you can provide students with reference materials during the charrette and/or specify the information categories they will need to include; in this case, more time will likely be needed.

- Consider using the conservation park scenario introduced in Chapter 6 (see Food for Thought Question 2) as the setting for questions 4 and 5. Students can apply the use-policies, target community, and goals they created to this situation and go on to write the community outcomes. (If you did not use this assignment before, just introduce it here.)

  If you choose to have your students use the Wisconsin southern mesic forest model to develop their answers, they can use the information in Tables 7.1–7.3 (pp. 203–205) in the textbook, reproduced from *The Vegetation of Wisconsin* (Curtis 1959), to develop measureable outcomes.

- Another way to get at the points covered in Question 4 is to either assign or ask students to find a published restoration site plan and have the students describe the components of the plan. Then ask them how they would be able to determine, based on the information provided, if a site had achieved its restoration outcomes (met its outcomes).

- As an alternative to Question 5, especially if you do not choose to use Question 4, you could list a series of site plan outcomes and have the students suggest criteria for these in reference to a particular community/ecosystem.

What to Look for in Student Responses to Question 4

- Restoration outcomes describe what a site will be like when the project has been fully implemented. They describe the features of the plan in measurable terms. The outcomes follow from the restoration goals. They depend upon the purpose of the restoration (whether it is an experiential, complete, or ecosystem services restoration, for example); the use-policies of the site (whether particular iconic species are to be highlighted or a stream is to be protected from siltation); and the relevant community/ecosystem model. Students should justify why each objective they write is important and appropriate to the situation they are addressing; they should avoid including extraneous information simply because they have seen it used with regard to other projects. It is important that students recognize that each restoration situation is unique.

The outcomes identify the desired results, not the actions to be taken. Be sure that students phrase the outcomes accordingly—for example, "Chaparral contains a minimum of 30 native species," not "Increase the native species diversity to achieve a minimum of 30 species." As discussed in the textbook, the site plan outcomes are not linked to the status of a restoration site at any particular time. They are time-neutral. Although both statements are quantitative—good—the second one does not make sense once the restoration has been successfully implemented (achieved a minimum of 30 species).

Chapters 2, 3, 4, 5, and 9, as well as Chapter 7, provide suggestions about the kinds of community/ecosystem features that are included in restoration outcomes, as well as ideas about how to set reasonable expectations (see Sections 2.3 and 7.1.1 and Figures 9.4 and 9.5 [p. 281] in particular). Many restoration projects include outcomes concerning species composition—for example, specifying a minimum number of species (as above) or setting standards of abundance for species or life forms and the like. To find information about composition for inclusion in an ecosystem/community model, students should look for existing species lists collected from appropriate remnants, visit remnants to create their own lists, or find community summaries in books, or on conservation agency websites. In our classes, we use species lists and quantitative sampling data gathered by our summer field class in Wisconsin's system of protected natural areas.

If you are using the Wisconsin southern mesic forest as the focus of this question, students might use the quantitative information in Tables 7.1–7.3 (pp. 203–205) to create and defend site outcomes as follows:

1. *Outcome:* Site contains a minimum of 30 native ground layer species.
2. *Reason:* The prevalent species list for this community contains 39 species. This represents the average number of species per site sampled in Curtis's study of this community (Curtis 1959). To provide flexibility, the required outcome is set slightly below the average.
1. *Outcome:* Site contains a minimum of 18 species found on the prevalent species list.
2. *Reason:* The "prevalent species" are those with the highest presence value (percentage of sampled sites in which they were found) and therefore are most representative of the community type. The number is set at half the species density to account for variation.

What to Look for in Student Responses to Question 5

- This question asks students to explain how they would choose from among the many species that meet a restoration objective. As discussed in Chapter 2 (see Sections 2.3.1, 2.3.2, and 2.3.3), one of the important ecological principles is that communities are variable in space and through time. The implication is that no two examples of a community type are identical. So, for example, if an initial inventory of a restoration site indicates that the composition of the vegetation does not meet the outcome of "containing a minimum of 45 species" or the outcome of "contain a minimum of 5 shrub species," you would identify some criteria that could be used to decide which species to add to the site so as to achieve both of these outcomes.

  Criteria mentioned in the textbook and listed in Figure 7.4 (see p. 215) include:

  1. Ability to survive in the environmental conditions of the site

2. Current or past presence onsite or in the vicinity
3. Contributes to community structure
4. Fills an important role in the community
5. Aesthetic qualities such as color, form, texture, or fragrance
6. Belongs to a representative plant family

Other possibilities include availability, cost, ease of establishment, or desirability due to cultural associations. We discuss several of these criteria in Chapter 8.

Question 6. Why do some large landscapes have no more plant species than smaller landscapes? Do you think this would also be true for animal species? Explain how your responses could influence your outcomes for species composition at a particular restoration site.

How to Use or Expand on this Question

- The intent of Question 6 is to have students think about how the size of a restoration site may modify what a particular restoration can accomplish. This topic is related to themes also covered by Food for Thought questions 1 and 2 regarding the effective context of a restoration. We sometimes vary the wording of this question to focus directly on the influence of the size of a restoration site on community/ecosystem composition, structure, or processes. For example, we might ask:

  1. In what ways might site size influence the composition of plant and or animal communities?
  2. How does a process such as fire influence community composition or structure or ecosystem processes, and how does site size affect how the process operates?

  To be most effective, it helps to focus the question on a particular community or ecosystem.

- You might also ask students to focus on a specific species (plant or animal) in terms of how site size might influence the ability of a restoration to support a sustainable population.

What to Look for in Student Responses

- A discussion of how habitat size influences the composition and structure of communities first appears in Chapter 2 (see Section 2.5). In Chapter 4 (see Section 4.8), we continue this discussion with particular attention to wildlife. We discuss site size again in Chapter 7 (see Section 7.2). Some of the points students should be able to discuss include:

  1. In general, the larger the site, the more species it will contain.
  2. The larger the site, the more interior habitat it contains relative to edge habitat.
  3. A larger site can accommodate a greater variety of post-disturbance stages, and therefore a greater total diversity, as it can support both pioneer and climax species.
  4. Minimum site size requirements are included in habitat suitability models for most wildlife species.

5. A larger site can contain a greater diversity of microclimates or, in the case of wildlife, habitat types and therefore can sustain more species. (Many animals move through several habitats in order to meet all of their needs, finding food in some, reproductive sites in others, etc.)
6. Because of the interdependence of plant and animal species, the diversity of a particular restoration often depends on meeting minimum size requirements for both species.

- Students may also suggest additional influences of site size. For example, the intensity of fire often is greater if the burn area is large than on a small area. Intensity influences how fire affects species.
- Since the first part of Question 6 goes against the idea that the larger the site, the more species it contains, students need to think about the reasons that underlie the relationship between species richness and site size. For example, one explanation is that the larger the site, the more microclimates it contains, and the greater the diversity of microclimates, the more species will have ranges of tolerance that fit. So if a small site has as many species as a large one, students might reason that perhaps the range of microclimates is similar. Or students might point out that site size is also related to patterns of human disturbance and is the result of fragmentation. In such a situation, perhaps the small site was once larger, and now contains long-lived plant species that can no longer reproduce by seed because of loss of pollinator species that cannot survive on the small site. Since the plants can survive onsite for many years, their loss has not yet been felt.
- Students should be able to identify a number of ways in which site size can influence restoration plans. Here are some examples of situations students might identify:

1. If the restoration outcomes contain outcomes that are facilitated by larger rather than smaller patches of similar habitat, a restorationist team will design the restoration layout to include large blocks of each community. Because of this consideration the team may need to simplify the site plan by including one or two different communities, rather than three or four.
2. In some cases, a site may be too small to support a particular community type. For example, to create sufficient interior habitat, many temperate forests need to be at least 16 hectares in size. Depending on the geographical region, perhaps an open woodland or a savanna would be a better choice if trees are desired on a smaller site.
3. If restorationists know that a particular keystone predator cannot survive on the restoration site because of its size, they will need to design their desired site plant species list with this in mind and/or include techniques to simulate the effects of the absent keystone in their management plan. For example, if a keystone herbivore functions to reduce competitive exclusion by an aggressive native plant species and the site cannot support the presence of the keystone species, restorationists can either design the species list to specifically exclude the dominant competitor, or institute a mowing or grazing regime to weaken its competitive abilities.

The idea is for students to recognize that the size of a community can affect composition (and also structure and function) in a number of ways, and to be successful, site plans must take these factors into account. [[[This text aligns with last bulleted item above.]]]

Question 7. What other criteria would you use to develop a proposed restoration's species composition, in addition to those listed in Table 7.6 [see pp. 223–224]? How might these criteria change under different outcomes or environmental circumstances?

- Table 7.6 (see pp. 223–224) presents the composition of several planting mixes proposed for the restoration of the Cross Plains Ice Age National Scientific Reserve, located in Dane County, Wisconsin. The idea is that the addition of the species included in the mixes will help the site achieve the restoration outcomes listed in Figure 7.11 (see p. 222). The table presents the species grouped according to the selection criteria used by the site planners. You can readily modify this question by finding or creating site plan outcomes and associated species lists for restoration situations in your area. These could be restoration planting mixes, as in the example, or simply lists of species that, if present onsite, would achieve the restoration outcomes. The question works well as the basis of an in-class discussion, a brief, or a take-home assignment.

What to Look for in Student Responses

- The idea behind Question 7 as written is to have students think about how the species included in the mix might change if additional criteria were added, if the site plan outcomes were changed, or the site conditions were different.

1. The first step is for students to identify the criteria used in Table 7.6 (see pp. 223–224) and discuss why the planners might have included each one. If students are not familiar with the oak savanna community, Chapter 16 in The Vegetation of Wisconsin (Curtis 1959) will provide needed background. Students can discern the criteria used by the planners without being familiar with oak savanna, but it may be more difficult to describe the underlying reasons. Selection criteria are also discussed in Section 7.1.1. Possible answers might include:

    a) *Criterion*: Life form: Species are grouped by life form (trees, shrubs, grasses and sedges, forbs)

    b) *Underlying reason*: The presence of characteristic life forms defines the structure of plant communities. For example, savannas are defined by the presence of scattered trees, providing areas of shade and open sun. In addition, the site plan includes open-sun prairie and The understory is grass/sedges-dominated in the open sun and forb dominated in the shade.

    a) *Criterion*: Within the forb category, species are grouped by plant families.

    b) *Underlying reason*: Plant family presence in different communities is relatively constant, so it is a good way of making sure a restoration is a good reflection of a natural community.

    a) *Criterion*: Species are grouped by shade tolerance.

    b) *Underlying reason*: Species differ in the range of tolerance with respect to light levels; species are selected to match the shade levels found in the restoration plan.

    a) *Criterion*: The composition of the three mixes overlaps, and the abundances of species found in more than one mix changes.

b) *Underlying reason*: To reflect the gradual environmental gradients found in most landscapes, and the fact that species do better in some parts of their tolerance range than in others (see Figures 2.6 [p. 38] and 2.7 [p. 38]).

2. Next, students should discuss how the criteria they identify match the site plan outcomes found in Figure 7.11(see p. 222). There are four community/ecosystem-specific outcomes listed. The criterion that best reflects the outcomes is the one that groups species by shade tolerance. In fact, one of the outcomes uses Table 7.6 (see pp. 223–224) as a reference.

3. Students can use the discussion in Section 7.1.1 to list additional criteria that might be included. You can have them list general criteria—for example, "species function" and/or have them use the discussion of oak savanna in The Vegetation of Wisconsin to compose additional site plan outcomes to match the criteria. One thing to notice: There is one outcome listed with regard to wildlife, but no specifics about which wildlife might be desired. If the physical environment changes, the criteria could stay the same, but the selection of species might differ; or if one of the outcomes is to achieve a specific environment through the actions of the species—for example, to provide large areas of deep shade, then the criteria might change as well.

- If you choose to create a custom version of this question, a good way to go about this would be to list the points you want to make—for example, that criteria for establishing composition outcomes considers not only the appropriateness of the abiotic site conditions and the composition/structure model for the community type, but also the functional roles that various species (including plants and animals) provide to the community—and craft your version of Figure 7.11 and Table 7.6 to reflect these points.

Sidebar: Setting Targets for the CPIANSR: Food for Thought Questions

- How would you address these questions:?

  1. Would fewer larger-size communities or many smaller-size communities be most appropriate as a restoration goal?

  2. How diverse are the soils and topography? What site attributes (soil pH, nutrient levels, elevation, etc.) are most important in contributing to that diversity? At what level of differences in these attributes are distinctions in community types most likely to occur?

  3. Would a single community of larger size be most beneficial to wildlife, or would wildlife be best served by a diversity of habitats regardless of size?

  4. Under which configuration of landscape would visitors be best served with a use-policy focused on landscape interpretation?

- Are there additional questions to ask before making a final decision?

- What would you have recommended in regard to the number of community types, given what you know about the site and ecology?

- What additional information would help you with this decision?

What to Look for in Student Responses

- The sidebar asks students to think about the difficulty of establishing outcomes for a restoration because of the complexity of the issues involved. Restoration outcomes include the spatial layout of communities and infrastructure elements and the written goals and outcomes that describe each. The decision as to how many communities to include is guided by the project purpose and use-policy statements; the relevant community/ecosystem models; and what is possible, given the initial and potential environment of the site and its surroundings. The main points that students should include in their answers are:

    1. Refer to the site inventory to answer the questions posed about the diversity of the soils and topography, and, if necessary, return to the site to collect additional information. To decide what, if any, additional information about these resources would help determine how many community types the site will support, check the community/ecosystem models and anything else that might influence how many communities the site might support.

    2. To address the question about what configuration of community types would be most beneficial to wildlife, students should specify which wildlife species are being considered and whether the restoration goals are to have a variety of species and/or large populations of a few iconic species. Some wildlife species require large territories ranging over one community type; others require habitats (large or small) consisting of many community types. In these situations, an understanding of area needs for a species is a necessity.

    3. To determine how visitors would best be served, students should specify what aspects of the landscape are to be interpreted. The outcomes listed in Figure 7.11 (see p. 222) provide a lot of leeway. Which aspects are more important—glacial history? vegetation? wildlife? Is breadth of information or depth of understanding more important?

    4. In the sidebar, the justification for community inclusion and placement is given primarily in terms of topography, existing vegetation, and soils. Students should suggest additional justifications based on information provided by the community/ecosystem models, including, for example, any minimum size requirements, edge-to-interior habitat ratios, patterns of change, or potential stressors.

Supplemental Activities and Exercises

- Individuals or small groups of students can explore the concepts discussed in this and previous chapters by developing a site plan for an actual restoration site.

    1. If you had students create a master plan exercise as described during the Chapter 6 discussion in this manual, one way to proceed would be to continue the restoration process where that project left off. Ideally, students will have established a project purpose and sets of use-policies and restoration goals, conducted a site inventory and analysis, and created a relevant set of ecosystem models. If students have not yet created a master plan, you can add this step to this exercise, or provide the needed information for students to use.

    2. Next, have students write a series of outcomes for each master plan goal and explain the reason for including each one.

3. Have students develop a graphic plan that shows the specific locations of plant communities, infrastructure elements, and any physical landscape changes as they would occur once the restoration is completed. Have students justify the layout in terms of the community/ecosystem models and existing physical and biotic onsite and offsite features.

Especially if the exercise includes the creation of a master plan as well as a site plan, it may require several in-class sessions and involve considerable discussion among students to complete. You will find examples of project statements we have used on the textbook website (www.introrestorationecology.com).

- We also have students write site plan outcomes or suggest or critique the placement of communities or infrastructure during our short-answer exams. See the textbook website for examples.

Suggested Learning Objectives Outcomes

Learning Objective 1. Describe the various components of the site plan.

Learning Level 1 Outcomes

- Students can list and describe the purpose or role of each of the components of the site plan, including written outcomes (objectives) and a graphic plan showing the distributions of communities and infrastructure relative to physical elements such as landforms, soils, water features, and views. The site plan also includes a number of supporting documents, including species lists, engineering drawings, design specifications, and recommended physical site alterations. Each component is included to describe what the site will be like at the completion of the implementation phase in sufficient detail that (a) the intentions of the planning team are clear to those involved in the implementation stage, and (b) objective criteria are available with which to judge the success of the project and determine when the restoration moves from implementation to management.

Learning Level 2 Outcomes

- Students can review an existing site plan and evaluate how well each component is represented in it.

Learning Level 3 Outcomes

- Students can create all of the components of a site plan.

Learning Objective 2. Define and apply site outcomes for restoration.

Learning Level 1 Outcomes

- Students can define site outcomes (objectives) as statements that explain what a site will be like when the project has been fully implemented. They describe the features of the plan in measurable terms. The outcomes identify the desired results, not the actions to be taken.

Learning Level 2 Outcomes

- Students can critique the objectives of an existing site plan.

Learning Level 3 Outcomes

- Students can take a set of restoration goals and write one or more site plan outcomes per goal that amplify the goal by providing detail using time-neutral language with measurable criteria.

Learning Objective 3. Apply your knowledge and understanding of a community model to the development of site outcomes.

Learning Level 3 Outcomes

- Students can use information about community organization, dynamics, and stability; ecosystem functions and processes; and the spatial and temporal patterns and processes of landscapes to write restoration plan objectives for a specific site.

Learning Objective 4. Create a site plan layout using the site inventory and analysis, reference models, and the site outcomes.

Learning Level 3 Outcomes

- Students can designate the locations and specify the composition and structure of the native plant communities to be restored on a site so as to achieve a good species/environment match. Students can create a graphic site plan layout.

Potential Issues, Questions, and Misconceptions

Misconceptions

- Students often think that there is only one site plan solution meets all of the requirements of a restoration project. The site plan is made up of many components and follows the direction provided by the master plan. However, there are likely to be many ways to meet the master plan directives. Many of these alternatives will be decided onsite or among the members of the restoration team as the site plan develops and opportunities or constraints emerge. For example, the master plan will in most cases call for specific plant community times. As we have discussed, a single community can have many species, not all of which will occur in any single stand. Depending on the detailed microenvironment of a setting the species composition will fluctuate.
- Students sometimes assume that the composition of all examples of the same community type will be identical and that in a restoration ecology course, they should be given a set of design templates that can be applied to every site. On the contrary, no two restorations are ever alike any more than all examples of a tropical forest are exactly alike. As we note in the chapter, for example, the species composition of a site is always a subset of the species that could be found there. Although we can identify species that are widespread, these usually do not make up the majority of species found on a site.

This means that restorationists need to create unique designs for the composition and placement of communities and landscape infrastructure. What a course (or textbook) can do is provide a guide to the questions that need to be asked and the kinds of issues that need to be addressed in creating successful design solutions that are tailored to fit their unique situations.

- It is important to emphasize that a site plan adopted to guide the implementation of a restoration is always subject to alteration as the circumstances of the site change and we gain new information about the theory and practice of restoration ecology. We also often make changes because of things we discover about the site during implementation that we did not know at the time of the site plan (think of the frequent changes to plans during the remodeling of a house). In addition an inability to acquire seeds of specific species, unexpected weather conditions, and changes in funding also often require a change in direction. The key is to always build a review process into the plan, to account for both routine assessment and unforeseen circumstances.

References

Curtis, J. T. 1959. *The Vegetation of Wisconsin.* Madison: University of Wisconsin Press.

Chapter 8

The Implementation Plan

The implementation plan is the road map for moving a site from what it is like at the start of a project to achieving the vision set forth in the site plan. The goal is to guide the site toward achieving the outcomes (objectives) described in Chapter 7 (see Section 7.1). An implementation plan includes both text and graphics. It features a graphic layout of implementation units and a description of the chosen implementation strategies, tools, and techniques as well as a discussion of any alternatives that were considered by the restoration team. The plan also includes a set of performance standards, a budget, an implementation time line, and a review process. Once the restoration meets the site plan outcomes, the restoration team moves into the final phases of the process—monitoring (see Chapter 9) and management (see Chapter 10).

In Chapter 8, we describe these implementation plan components and discuss the decisions and actions required to accomplish the restoration onsite. We present general principles together with specific examples to illustrate how the principles are applied, paying special attention to the techniques used to remove and introduce plant species.

Major Themes

- The implementation stage of the restoration process involves the creation of a written and a graphic plan that explains the steps to be taken, followed by the actual execution of the plan. The implementation actions include the following steps:

  1. Determining the boundaries of the implementation units.
  2. Revisiting the site inventory and analysis to determine how the current site resources do or do not match the site plan outcomes. This information will help determine what actions are needed—additions or subtractions of species, changes in physical characteristics such as soils and topography, additions or subtractions of infrastructure, and discussions with adjacent property owners, for example.
  3. If physical site alterations are needed and/or species need to be removed, carrying out the chosen site preparation strategies.
  4. If species are to be added, carrying out the species introduction strategies.
  5. Resolving logistics—obtaining the resources and permits to execute the plan.

  Steps 1, 2, and 5 generally occur before steps 3 and 4.

- One of the major causes of failure in a restoration is inadequate or inappropriate site preparation. The past, present, and projected future human uses of a site are often important clues to the extent and types of preparation that will needed. Human impacts are one of the most important community stressors and the origins of many current site features.

- If plant species are to be added to a site, information about the species' reproductive strategies, dispersal abilities, and relative competitive abilities in different habitats is crucial to the success of the restoration efforts.
- The text of the implementation plan includes a set of performance standards as well as an implementation time line. The performance standards are site plan outcomes with a time period attached, by the end of which the outcomes are to be achieved. The plan also describes the consequences that will occur if a target is not met—for example, loss of funding, or a requirement for an immediate review and revision of the implementation and/or site plans.

  The implementation time line describes the sequence of actions to be taken in each implementation unit. The time line can be organized by calendar date or by completion of specific action steps.

Comments on Food for Thought Questions

Question 1. Both the Kissimmee River and the Everglades ecosystem in Florida have been undergoing major restoration efforts during the past decade. Using journal articles, Internet sources, and government agency reports, discuss who the interest groups are for each project, the goals for the restorations and their time frames, and any conflicts or problems that have surfaced in the restoration efforts.

How to Use or Expand on this Question

- The projects in question are useful because of the wealth of information readily available on the web. Because this question asks about the two case studies in general terms, it is a good review exercise at this stage, because we have now addressed the steps of the restoration process from creating the master plan through implementation—the point at which a project achieves the restoration objectives, at least initially. The question works as an individual or group written assignment or as the basis for an in-class discussion. It is also a good opportunity for students to demonstrate their abilities to find, organize and use what they are learning to evaluate relevant information in the literature or on the web. They should also use what they have found to uncover new information.
- You can also focus the question to ask specifically about the strategies, techniques, and tools used to implement one or both of the projects—in other words, the topics covered in Chapter 8. Consider having the students address the following questions:

  1. What site modifications were necessary?
  2. What procedures did they use?
  3. Do the restoration plans call for adding plants or wildlife, and, if so, what strategies did they use (are they using)?
  4. Who is carrying out the plantings or wildlife additions?
  5. Does the project include performance standards, and, if so, what are they?
  6. What is the proposed implementation time line?
  7. Has the project met the time line?

8. Has the project achieved any or all of the site plan goals and outcomes?

- Of course, you can always substitute other case studies for the two mentioned in the question. For best results, be sure that the projects are at or past the implementation stage, and that there is sufficient documentation available for the students to review.

What to Look for in Student Responses

- Students should cite references and provide specific examples to illustrate their findings.
- Be sure that the students not only find and use the most recent information available but also examine documents produced at earlier stages in the projects they examine. In this way, they can trace the evolution of the project through time. It is also helpful to have them think about the goals of the authors of the materials they find, and how they might influence the content accuracy of the information. For example:

1. How might a news release from a sponsoring organization differ from an article written by a journalist coming from the outside, or by a researcher?
2. Have the students consider how their conclusions about the project might be affected if they are discussing preliminary rather than final results.

Question 2. Select a possible restoration project from your geographic region, establish goals, and discuss the variety of site preparation needs that would be required.

Question 3. Select a second ecological community found within your region for a hypothetical restoration project. Put together your desired species composition, including the proportions of each species, and defend these. Then consider whether you would keep these same proportions in the actual planting mix, or whether you would adjust the rates for specific species based on establishment considerations. For each species, explain and defend any adjustments.

Question 4. Consider the actual planting of the species in Question 3. Would you plant them all at once or sequence the planting over time? Explain and defend your decision.

Question 5. What ecological measures would you use to judge the success of the restoration?

Question 6. Develop a time line for the implementation, beginning with site plan review.

How to Use or Expand on These Questions (Questions 2 through 6)

- These questions ask students to use the process presented in the textbook to design a restoration implementation plan for situations in which plant species are to be added to the site. The aim is to have them provide the detailed planting lists and step-by-step site preparation and planting directions that would be included in an actual implementation plan.
- For best results, students will need to find, evaluate, gather or refer to the following information:

1. The site master plan and/or site plan; the target restoration communities and their onsite locations; the project purpose and use-policies; and depending on the question, the restoration goals

2. Community/ecosystem models for the target communities, in order to create site outcomes related to species composition and structure
3. Information on the resources of the site and its context that aid in the selection of the species to be planted and understanding site preparation needs—including, for example, topography (slope steepness and aspect); soils (texture, degree of compaction, erosiveness, nutrient status); hydrology; and existing vegetation (species presence, composition of seed bank)

You can provide this information, have students obtain it as part of the assignment, or use the results of previous assignments focused on the site.

- You can use the individual questions as the basis for in-class discussions or short assignments, or put them together to create a project for a real or hypothetical site that includes the creation of master, site, and implementation plans.

What to Look for in Student Responses

- The details of the responses will vary depending on the question and the site, but in most cases, students will need to be specific enough that another person can carry out the steps needed to introduce species to a site and evaluate whether or not a project has achieved the performance standards for the project. Students should give the level of detail presented in the examples and tables provided in the textbook (see Tables 8.1–8.5 [pp. 233–235; 252, 254, 270, 271–273]), and they should be able to justify their proposals in terms of the background information on the master and site plans, and in terms of the site and its context that you have provided. They should address the following topics, if only to decide that no actions are needed:

1. Site preparation
    a) Notifying existing users of a change in use policy
    b) Removing existing structures
    c) Removing or reducing competition from undesired plants and animals
    d) Modifying physical site features such as soil, water, and landforms
    e) Preparing the planting bed—actions needed and equipment used
2. Additions of plants
    a) Selecting form—seedlings, transplants, seeds, sod
    b) Specifying which species to add in what proportions
    c) Specifying origins of plants to be added
    d) Deciding whether to use cover or companion species
    e) Deciding how to locate the plants onsite
    f) Determining whether to add all species at once or in stages
    g) Determining whether to plant with hand tools or mechanized equipment
3. Implementation time line

4. Performance standards

Students should link the choice of site preparation techniques with the choice of planting techniques; the choice of planting techniques with the reproductive and growth characteristics of the species to be added to the site; and the planting logistics (when to plant, whether or not to plant in stages, what equipment to use) with the choice of planting techniques. They should link all of these decisions with the physical and biological conditions of the site and its context, and with the availability of materials (plants, seeds, etc.), equipment, personnel, and money, as well as the social and regulatory arena. In other words, students should demonstrate that their implementation plans have been created for the particular situation at hand. [[[This text should be aligned with last bulleted item above.]]]

Sidebar: Evaluating the Habitat Value of Existing Vegetation: Food for Thought Question

- In order to make this decision, what would you want to know about the existing habitat prior to implementation, the songbirds, and the projected future vegetation cover if these stands of shrubs were to be taken out?

What to Look for in Student Responses

- The context of this question is one common to many restorations—dealing with potentially conflicting restoration (or conservation) goals. In this case, the issue is whether or not to remove a stand of shrubs. Students should begin by stating the situation clearly. For example, the case for removal is that the shrubs do not meet the restoration goal of having the site mimic the "natural vegetation" of the site—no shrubs were present before the site was disturbed by agriculture. The case against removal or alteration is that the shrubs now serve as habitat for songbirds. The information that students indicate they wanting to know should include the following:

    1. Whether or not the songbirds existed onsite before it was disturbed
    2. Whether or not the songbirds require shrubs for habitat or may also use or even prefer the desired vegetation
    3. Whether or not the songbirds are rare and thus in need of protection at any scale (locally, regionally, etc.)
    4. Whether or not the shrubs interfere with other desired vegetation or habitat; Does their presence exclude equally or more desired wildlife species (particularly other songbirds) that would be present if the shrubs were not?
    5. Do the shrubs present a threat of spreading to other areas?

Supplemental Activities and Exercises

- One question we have used on exams as well as for in-class active learning activities is to have students "compare and contrast" sets of concepts. In this way, they begin to understand similarities (e.g., of purpose) and differences (e.g., of degree of environmental impact). We have found that making such comparisons helps students make decisions about which techniques to use in different situations. Some comparisons to consider include the following:

1. Using a disc, plow, herbicide, or smothering technique during site preparation
2. Using a companion crop, a nurse crop, both, or neither
3. Planting by seed, seedlings, or transplants
4. Obtaining seed from a nursery or collecting from a remnant
5. Planting a large site all at once or in stages

Suggested Learning Objectives

Learning Objective 1. Differentiate between the site plan and the implementation plan.

Learning Level 1 Outcomes

- Students should be able to define/describe "site plan" and "implementation plan" in their own words and correctly identify each.

Learning Level 2 Outcomes

- Students should be able to explain the ways in which a site plan leads to an implementation plan.
- Students should be able evaluate existing plans and use them in practice. For example, they should be able to use a site plan as the basis for an implementation plan and apply an implementation plan to a site.

Learning Level 3 Outcomes

- Students should be able to create a site and implementation plan for a specific site

Learning Objective 2. Describe five steps in the development of the implementation plan.

Learning Level 1 Outcomes

- Students should be able to identify and use their own words to explain the five steps described in the textbook concerning: (1) implementation units; (2) the need to revisit/supplement a site inventory and analysis; (3) site preparation; (4) reintroduction of plants and animals; and (5) implementation logistics.

Learning Level 2 Outcomes

- Students should be able to evaluate a project in terms of how and whether the five steps were used.

Learning Level 3 Outcomes

- Students should be able to use the five steps to create an implementation plan for a site.
- Students should be able to evaluate the implementation of an existing restoration in terms of whether and how the restorationists followed the five steps.

Learning Objective 3. Recognize and discuss the various ways a site's physical and biological characteristics, as well as its social and landscape context, influence plans for site preparation and installation.

Learning Level 1 Outcomes

- Students should be able to name and describe site and context characteristics that influence site preparation and site additions.

Learning Level 2 Outcomes

- Students should be able to analyze how each site characteristic can influence a site implementation plan.

Learning Level 3 Outcomes

- Students should be able to create site preparation and installation plans for a specific site.

Learning Objective 4. Differentiate between goals, objectives, and performance standards, and describe where in the restoration process each should be used.

Learning Level 1 Outcomes

- Students should be able to define "goals," "objectives," and "performance standards" using their own words.
- Students should be able to correctly define a statement as being a goal, an objective, or a performance standard.

Learning Level 2 Outcomes

- Students should be able to explain that all three describe the outcomes of a restoration and are linked: one follows another. Goals are general descriptive statements; objectives add detail to a goal and are expressed on measurable terms; performance standards are objectives with a time frame added and are used to help restorationists decide whether or not their implementation strategies are working as expected and/or whether or not to pay a contractor.

Learning Level 3 Outcomes

- Students should be able to write goals, objectives, and performance standards for a restoration project.

Learning Objective 5. Describe the variety of ways that propagules are introduced to a site, and how to evaluate which ones would work best for a particular situation.

- Note: the textbook primarily describes vegetation planting techniques. Similar discussions can occur around wildlife species.

Learning Level 1 Outcomes

- Students should be able to list the planting techniques described in the textbook—for example, introducing seed, seedlings, and transplants using hand-broadcasting or planting techniques; employing seed drills on plowed or disked sites or no-till sites; or relying on colonization from offsite (or even onsite) sources.

Learning Level 2 Outcomes

- Students should be able to compare the techniques in terms of planting success, site impacts, and project resources such as availability of equipment, personnel, and money.

Learning Level 3 Outcomes

- Students should be able to prepare a planting plan for a specific site and justify the plan in terms of planting success and so forth.

Learning Objective 6. Compose a time line of actions that need to occur during the implementation phase of a restoration.

Learning Level 1 and 2 Outcomes

- Students should be able to list and describe the components of an implementation time line and evaluate an existing time line in terms of its completeness.

Learning Level 3 Outcomes

- Students should be able to create an implementation time line for a specific site.

Potential Issues, Questions, and Misconceptions

- Because the implementation of a restoration requires knowledge ranging from an understanding of ecological theory to how to correctly operate a seed drill, restoration is best accomplished by a diverse team covering many kinds of expertise.
- Many restorations are not implemented all at once. Often the site is restored in sections, and lessons learned (through the adaptive restoration process described in Chapter 3) in one section are then applied to the next one. Or the restoration of one unit becomes a source of colonists for the next, so that the implementation plan changes. Also, it is possible to add species to the same site or unit in stages—waiting for a microclimate to develop, for example.
- The success of a restoration is dependent not only on how well we prepare, plant, and manage a project, but also on how well we respond to uncontrolled events such as weather, animal behavior, and the site's accessibility to both wanted and unwanted colonists.

References

Curtis, J. T. 1959. *The Vegetation of Wisconsin.* Madison: University of Wisconsin Press.

Chapter 9

The Monitoring Plan

The focus of this chapter is on monitoring, the process we use to determine if a restoration project has initially achieved and then continues to meet its objectives. In order to illustrate the kinds of decisions involved in creating a management plan, we have chosen to focus on monitoring vegetation, a site resource that is part of all restorations.

Major Themes

- Monitoring is essentially an inventory and analysis process with the added dimension of time. It is a systematic process by which restorationists periodically evaluate the status of a project, starting shortly after the project is initiated and continuing throughout its lifetime. It is an integral component of the adaptive approach to restoration.
- The monitoring plan includes text and graphics (including maps of monitoring units, if needed); a series of inventory and analysis protocols that describe how to evaluate the degree to which the restoration is achieving the site, implementation, or management plan goals and objectives; a budget; and procedures for archiving data and reviewing and modifying the plan.
- Vegetation monitoring can include qualitative and quantitative techniques and include measurements of species populations, plant community composition and structure, and landscape form and structure. The monitoring of ecosystem functions often includes a vegetation component as well.

Comments on Food for Thought Questions

Question 1. Site inventory and monitoring use similar techniques. In what ways do they differ?

- The purpose of this question is to have students pull together materials from several sections of the textbook (see Chapters 4, 5, and 9), and to reinforce the interconnections of the different parts of the restoration planning process.

How to Use or Expand on This Question

- As an alternative, make the question more concrete by applying it to a particular site or resource. For example:

1. The quadrat technique is commonly used to study the vegetation of a site. Describe how the use of quadrats during an initial site inventory might differ from their use in conducting a monitoring survey.

Or modify the question a bit to ask about different measurements of the same resource:

2. Suppose you have been hired by the restoration firm Quadrats, LLC, to inventory a newly acquired property for the purpose of establishing an educational field station with restored

native communities. One of the goals of the project is to minimize soil erosion. Describe how you would address the issue of soil erosion during the initial site inventory and during the monitoring phase of the restoration.

What to Look for in Student Responses

- Here are some points to look for in student responses:

1. The data collection techniques used in an inventory can be the same as those used during monitoring. There is often no difference in the tools used or which resources (soils, vegetation, fauna) are studied. However, there is often a difference in when the tools are employed, and exactly what data are collected.

2. An inventory protocol used to understand site conditions before a restoration is implemented is designed to be a limited time event; the specific protocols of a monitoring plan are used repeatedly for the life of a project. In the site inventory, the data are collected, summarized, and evaluated to provide a reliable and accurate description of the site at a particular moment in time. The information collected during monitoring is used not only to describe the site as it is but also to evaluate whether the site has changed over time and whether it continues to meet the restoration site plan outcomes. (Remember that restorationists do collect site information during all of the steps of the restoration process, generally with specific questions in mind. In a sense, this amounts to an ongoing inventory process.)

3. In many cases, the goals of an inventory are to provide an overall site description and evaluation. Therefore the exact locations of resource boundaries and detailed description of the resources are not usually necessary. In monitoring, it is important to provide detailed information to address measurable site outcomes.

   For example, one answer to alternative 1 for the question might be that quadrats are used to collect information on a representative sample of vegetation, the plants within the quadrats. For a site inventory, it is often sufficient to note the presence of species within each quadrat, thereby generating a species list. Presence data can be used in monitoring as well, if a site objective is to "maintain a particular number of species onsite," or "maintain the presence" of particular species. In other cases, the restoration objectives might call for a particular population density, in which case the number of individuals of each species as well as the species presence would be noted for each quadrat. (Also see possible answers to Food for Thought Question 2 below.)

   A possible response to alternative 2 for the question might be as follows: For an initial inventory, a restorationist might identify the portions of the site that already exhibit or are potentially vulnerable to erosion. She would then walk the site looking for evidence of existing erosion—for example, the presence of erosion rills or gullies, or areas of soil loss (check for exposed roots or top soil loss) and deposition. To evaluate erosion potential, she would look for the presence of soils onsite that are vulnerable to erosion. She would find this information by using existing soil maps (provided by agencies such as the NRCS in the United States—see Chapter 4, Section 4.7 of the textbook) to find the location of different soils and then use the provided evaluations to identify the soils that have high erosion potential.

For the monitoring plan, a restorationist might create a protocol to measure soil loss that is consistent with the relevant site plan outcome. Assuming the site plan outcome is something like "annual soil loss from erosion <15mm per year," he could establish a network of monitoring points at each of which he would place a rod into the soil with the top sticking out a recorded distance from the surface. Then at designated intervals (once or twice a year), he would measure the lengths of the above ground portion of each rod and compare these to the original lengths. This would give an indication of soil loss (if any) at each monitoring station.

Question 2 You are in charge of creating a monitoring plan for a newly restored 40-acre marsh/sedge meadow complex surrounding a shallow pond. The area was protected in part because it contains a population of rare orchids, and because it is an important stopover area for migratory waterfowl and a nesting site for sandhill cranes. The restoration objectives are as follows:

1. Maintain a minimum of 50 native plant species.
2. Maintain <5% cover of exotic species and <20% cover of woody species.
3. Maintain the orchid population such that it is at or above the minimum viable population size.
4. Maintain quality habitat sufficient to support a minimum of 25 species of waterfowl during spring and fall migrations.

Propose a monitoring plan for this site. Explain the reasoning behind your decisions. Is there additional information that you need?

How to Use or Expand on This Question

- You can easily modify this question to reflect the communities or ecosystems of your area, or any part of the world your students are familiar with. The idea is to provide a set of outcomes that might be measured in more than one way, and some that refer to information not provided in the question exposition.

What to Look for in Student Responses

SubQuestion 1: "Propose a monitoring plan for this site. Explain the reasoning behind your decisions."

- There are many possible responses to this first part of the question. Look for a match between the techniques the students propose and the information needed to address each outcome (objective), and be sure that students explain their reasoning. The more practical the suggestions, the better, and the more efficient the plan, the better. Here are some possible student responses:

1. Maintain a minimum of 50 native plant species:

    a) Conduct a walk-through inventory of the site twice each year and list all native plant species you encounter. Specify that the inventory follow a particular route, or discuss the layout in other ways.

    b) Establish permanent sampling points and conduct a presence/absence quadrat inventory. Describe how to position the sampling points—a regular grid or at random—and explain.

    c) Conduct a random quadrat sample. Note species presence/absence.

2. Maintain <5% cover of exotic species and <20% cover of woody species.
    a) Use the permanent sampling points and quadrats described above, and measure the cover of any exotic or woody species found in the quadrat. (Cover is the percent of ground occupied or shaded by a plant.)
    b) For herbaceous species, measure within quadrats by visual estimate. For woody species, set up a line intercept centered on the sampling point (see p. 286 of the textbook and the example in Table 9.3, p. 285).
3. Maintain the orchid population such that it is at or above the minimum viable population size.
    a) Record the location of the existing orchid population by placing permanent markers in the field, plotting it on maps, and/or using a GPS to record its geographical coordinates.
    b) Once a year, count the number of individuals within the population.
    c) Check for flower and seed production.
    d) In addition, walk the entire site in order to identify any new populations.
4. Maintain quality habitat sufficient to support a minimum of 25 species of waterfowl during spring and fall migrations:
    a) Do a walk-through survey at the peak of the spring and fall migrations to identify all species of waterfowl seen or heard onsite.

SubQuestion 2: "Is there additional information that you need?"

- Once again, there are several possible answers. Students should be sure to explain their reasoning. They should be able to bring up the following points:
    1. In order to decide if the size of the orchid population is meeting the restoration objective, we need to know what the minimum viable population size is.
    2. The protocol suggested for the waterfowl objective deals with the presence of species on the site; it does not address habitat. To address habitat, we would need to know what resource parameters are important.
    3. To suggest a specific arrangement of sampling locations or survey routes to ensure that the information we collect represents the site as a whole, we need to know more about the geographic and environmental variation of the site.
    4. We need to know more about personnel and resource availability in order to specify who will do the data collection and how the information will be stored.

Question 3. Given that both ecological theory and data collection and storage technologies continue to advance, what steps can a restorationist take to create a monitoring plan that remains relevant and useful over the life of a project?

What to Look for in Student Responses

- Students should include the following steps:

1. A review procedure should be built into the monitoring program to be sure that the monitoring protocols match current information requirements and current site conditions, as well as budget and personnel constraints. The procedure should describe who does the review, how any resultant recommendations are approved and implemented, and what triggers a review. The procedure should stipulate that a review could be requested at any time in light of technology change or onsite events, plus it should require a routine periodic review (every 5 years?).
2. The review procedure should include a policy that any change in the monitoring protocol needs to include a provision that the restoration team can tie the new information to the locations from which it was collected if boundaries or landmarks are changed.
3. There should also be a policy that information that has previously been stored using what is now outdated technology or nomenclature needs to be converted and updated to a more usable format, as well as archived in its original form.

Question 4. Contact managers of restorations in your area. What kinds of monitoring plans, if any, do they administer? What are the monitoring issues that are of most concern?

How to Use or Expand on This Question

- If opportunities for interacting with area practitioners are limited, another way for students to investigate the scope of modern restoration practice is to have them review published case studies or look in restoration journals, conference proceedings, or books for discussions of monitoring.

What to Look for in Student Responses

- The responses will, of course, depend on the interactions that students have with the practitioners or which case studies or readings the students review. Look for students both to report on what they learn and to reflect on how their findings match, amplify, or deviate from the information in the textbook.

Question 5. Discuss the pros and cons of (a) qualitative and quantitative monitoring approaches and (b) permanent and repeatedly randomized sampling locations.

How to Use or Expand on This Question

- Here are some additional comparisons to add:
  1. Measuring plant species abundance using density versus measuring using cover
  2. Monitoring using volunteers versus monitoring using paid staff
  3. Monitoring vegetation using photographs versus monitoring using a quadrat-based vegetation sample

What to Look for in Student Responses

- In comparing qualitative and quantitative monitoring approaches, students should include the following points:

  1. Qualitative monitoring approaches involve careful observations, impressions, and interpretations; quantitative techniques collect numerical data.

  2. Qualitative techniques can generate some numerical results—for example, lists of species observed while surveying a site. The most common qualitative monitoring technique is the walk-through transect survey, during which a restorationist visits a site and records targeted observations based on the restoration objectives—for example, looking for exotic or rare species, noting ponding of stormwater after a rain, or the presence or absence of plant diseases. Qualitative observations can be rich in detail—the more experienced the observer, the more detailed and relevant the observations. Because the observations are observer-dependent, it is difficult to compare information collected by different people.

  3. Many restoration objectives are expressed in quantitative terms to facilitate evaluation and clear communication among members of the restoration team and its various stakeholders. Therefore many restorationists use quantitative monitoring techniques that collect data to match the information needs of particular objectives. Quantitative techniques often take more time and resources to use on a site than qualitative methods, but it is usually possible for several different users to get the same results.

- In comparing permanent and repeatedly randomized sampling locations, students should include the following points:

  1. Any changes that take place over time in permanent sampling locations are real, so when used in monitoring to track vegetation dynamics, it is relatively easy to determine if a site has changed over time. Assuming the locations are easy to find, there is little setup time in advance of each sampling visit. However, sampling locations can be lost and/or compromised, and the vegetation history lost. Also, if the chosen locations do not represent the site as a whole, the sampling data will not accurately reflect the status of the site. This is a problem when checking to see if a site continues to meet the restoration objectives.

  2. Setting up repeatedly randomized samples is time consuming. Since the locations of the sample will be different with each inventory, change is more difficult to demonstrate than with permanent samples. On the other hand, if the protocol uses a sufficient number of samples, this procedure can reliably represent the site as a whole. (A randomized scheme often requires more samples than does the use of permanent plots.)

Sidebar: Evaluating Vegetation Monitoring Data: Food for Thought Questions

Question 1. Based on the monitoring results, determine whether or not each of the restoration objectives had been achieved as of June 2004. Explain your reasoning, and indicate any assumptions you had to make in arriving at your decisions.

How to Use or Expand on This Question

- This question is asking students to use vegetation sampling results to determine whether the composition of a site matches the following restoration outcomes:
    1. Maintain at least 40 native species, including a minimum of 5 native tree species, 5 native shrub species, and 25 native herbs and vines.
    2. <5% of the species are non-native.
    3. <1% of the species are pest plants.
    4. Some herbaceous species are common; most are relatively rare.
    5. Pest species, if present, are rare.
    6. Total shrub cover is 15%–40%.
    7. Tree density is 240–300 trees per hectare.
    8. The canopy is dominated by oak species.
    9. Oak reproduction is occurring.

What to Look for in Student Responses

- The first step is for students to use the information found in Tables 9.1, 9.2, and 9.3 of the textbook (pp. 284–285) to summarize what the results of the sample tell us about the site in terms of the given objectives. The following table is one way students might organize the information:

Table. Summary of Sampling Results

Measure	Objective	Site
Number of native species	>40	31
Number of native trees	>5	8 species, 6 as mature trees
Number of native shrub species	>5	5
Number of native herbs and vines	>25	18 (including 1 listed separately as a sedge)
% Non-native species	<5%	2 non-native species of a total of 31 species = 2/31 = 6.5%
% Pest plant species	<1%	2 pest plant species of a total of 31 species = 2/31 = 6.5%
Structure of distribution of individuals among herbaceous species	some common, most rare	4 of 19 species noted in the grasses herbs and vines layers have a frequency of 9 or more; the rest are present in 6 or fewer sample points.
Abundance of pest species	rare	Pest species are found in 3 of 20 quadrats (quadrats 4, 15, and 17).
Total shrub cover	10%–40%	27%
Tree density	240–300 trees per ha	390 per ha (78 trees in 2,000 m2) (1 ha =10,000m2)
Canopy dominance	oak species	51% of the trees in the sample are oak (Quercus) species. 91% of the basal area is oak. Minimum of 90% frequency. Highest totals for all species: highest importance value.
Oak reproduction	occurring	2 saplings, but no seedlings are oaks.

- Next, students should decide whether the site meets each of the objectives. The following table provides sample student answers and explanations.

Table. Model answers for Chapter 9 case study

Proposed outcome	Site achieves restoration outcome?
Total number of native species	No, need 40, have 31
Total number of native tree species	Yes, need 5, have 5
Total number of native shrub species	Yes, need 5, have 5
Total number of native herbs, ferns, vines	No, need 25, have 18
% non-native species	No, need ≤5%, have 6.5%
% pest plant species	No, need ≤1%, have 6.5%
Abundance of understory species	Yes, 4 of 19 are common species (>45% frequency)
Abundance of pest species	Yes, found in 3 of 20 quadrats (15% frequency)
Total shrub cover	Yes, need 10%–40%, have 27%
Tree density	No, need 240–300/ha, have 390/ha
Canopy dominance	Yes, need oak dominance; 51% of trees in the sample are oak; oak is found in at least 90% of sample points; > 90% of BA is oak
Oak reproduction	No, found no oak seedlings and only 2 oak saplings

- Students should be able to list the following assumptions:

1. The objective about relative abundance of herbaceous species does not define "common" or "relatively rare." The protocol uses "frequency," the number of samples in which the species occurs, to measure abundance. Use this to measure the objective, and define common as occurring in ≥45% of samples.
2. Similarly, use frequency to measure the objective concerning the abundance of pest species. Define rare as occurring in <20% of samples.

3. Use a combination of frequency (number of points), number of trees, and total basal area to measure canopy dominance (see the sidebar "Comparative and Composite Measures of Vegetation").
4. Oak reproduction is measured by presence of oak saplings and seedlings. Assume that both are needed to indicate that reproduction is occurring.

Question 2. The site and monitoring plans for this restoration are due for a routine review this year. What changes, if any would you make in way the objectives are written and/or in the monitoring protocol? Explain. (Consider for example, whether or not the current objectives are clear and measurable, and whether the current monitoring protocol provides sufficient information to accurately assess the restoration in terms of the objectives.

What to Look for in Student Responses

- There are several issues that students should address in answering this question. For example:
  1. It is best if the protocol specifies which sampling data are to be used to measure each restoration objective. This is clear for some objectives, not for others.
  2. The protocol does not define what is meant by "common" and "rare."
  3. The data summary designates species as being "pests" but gives no definition.
  4. If abundance is important, a density measure could be added to the understory sample. Frequency is an indication of how widespread a species is—this is one dimension of being "common"—but population size is also important.
  5. The objectives do not seem to address all of the objectives listed in Figure 9.7 (p. 286 of the textbook) (number of "target" species, distribution of shrubs and herbs as a whole).

Supplemental Activities and Exercises

- If your students are creating a restoration plan for an actual site (see suggested project protocols on the textbook website, www.introrestorationecology.com), have them include a monitoring plan. This will help the more concrete learners to learn the material. In addition, having students link their desired restoration outcomes as expressed in the site plans to concrete assessment techniques helps them to clarify and articulate their assumptions and understanding. Creating a monitoring plan is also an excellent way to improve the site plan!
- As we discuss in the textbook, restoration monitoring goes on for the life of the site, which ideally could be hundreds of years. Therefore, plans for information storage and retrieval are important components of a monitoring plan. Here are a few ideas for assignments to explore issues surrounding the storage and retrieval of monitoring data, and how the issues might influence the choice of monitoring strategies and therefore the writing of restoration objectives:
  1. Have students interview experts on information management. These could include managers of public lands, natural history museum curators, arboretum managers, and professionals involved with library and information sciences. The goal is to learn how professionals store and manage information, what they believe to be the major issues and questions in the field,

and any insights they might have for restorationists regarding formats, accessibility, and longevity.

2. Have students consider the information presented in Tables 9.1, 9.2, and 9.3 of the textbook (pp. 284–285). The format of Table 9.1 is very similar to the form in which the data were recorded in the field. Tables 9.2 and 9.3 are data summaries. In the field, monitors record tree and shrub data by quadrat. Ask how the sampling data should be stored to be of maximum long-term benefit. Should restorationists include raw data; summaries only; the actual field sheets; or digital records? Should the information be in the form of tables, entries in database programs, or printouts of digital records?

3. Using a local restoration site as an example—perhaps one for which students are writing a monitoring plan—have the students list all of the kinds of monitoring data that should be kept. For each kind, specify a format and the level of detail that should be included, and specify which data should be accessible to the public, if any. Be sure to have students explain their decisions.

Suggested Learning Objectives Outcomes

Learning Objective 1. Describe the purpose, features, and importance of a restoration monitoring plan and the role of monitoring in the restoration process.

Learning Level 1 Outcomes

- Students should be able to describe the purpose of a restoration monitoring plan in their own words.
- Students should be able to list and describe the major features—inventory, measurement, evaluation, and analysis procedures (including a timeline); text and graphics; procedures for regular reviews and updates; procedures for data storage and retrieval.
- Students should be able to place monitoring as being linked to restoration research, implementation, and management (see Figure 9.1, p. 279 of the textbook).

Learning Level 2 Outcomes

- Students should be able to explain why monitoring is important to restoration: it informs us if the implementation plan is working; tells us when the restoration has met the objectives (achieved its purpose); triggers management interventions.
- Students should be able to evaluate and critique the components of an existing monitoring plan.

Learning Objective 2. Discuss the decisions that need to be made in establishing monitoring protocols, with particular reference to vegetation.

Learning Level 1 Outcomes

- Students should be able to list and describe the questions that underlie the protocols of a restoration plan (see Figure 9.2, p. 279 of the textbook): what, how, where, when, who, why.

Learning Level 2 Outcomes

- Students should be able to link site plan objectives (outcomes); vegetation structure and function descriptors (see Figures 9.4, 9.5, and 9.6, pp. 281–282 of the textbook); questions about vegetation listed in Section 9.2 (pp. 282–283); monitoring criteria (see Figure 9.7, p. 286), and monitoring protocols.
- Students should be able to design a vegetation monitoring plan for a site.

Learning Objective 3. Describe the use of common vegetation sampling approaches, measurements, and data collecting tools, and explain how to decide which to include in a monitoring plan. (Note: This objective expects students to recall information from Chapter 5.)

Learning Level 1 Outcomes

- Students should be able to list and describe:
  1. *Qualitative techniques:* walk-through survey, site immersion
  2. *Quantitative techniques:* quadrat survey, line intercept, plotless point-quarter method, point intercept
  3. *Photography:* aerial photography, repeated ground photography using photo points
  4. *Information collected:* presence/absence, counts of individuals, cover, change in population boundaries, others (see Figures 9.4 and 9.5, p. 281 of the textbook)
  5. *Sample and photo point distribution:* number and placement (regular, random, permanent)

Learning Level 2 Outcomes

- Students can evaluate the appropriateness/effectiveness of an existing monitoring plan in terms of the restoration objectives.

Learning Level 3 Outcomes

- Students can create a monitoring plan with respect to vegetation objectives by addressing "what, how, where, when, who, why" for the learning objectives of a specific site.

Potential Issues, Questions, and Misconceptions

- Many restoration practitioners do not stay with a project long enough to be part of the long-term monitoring stage—what we refer to as the management phase. Perhaps it is for this reason that many restoration plans do not include an explicit monitoring plan, and many restorations are not monitored, or the monitoring is not done systematically with an eye toward preserving and communicating the information gained. We have included a separate chapter on monitoring to emphasize that the information gained from restoration monitoring has the potential to advance restoration practice and ecological theory (see also Chapter 3).

Chapter 10

The Management Plan

Management begins after the implementation phase of a restoration is over. It is a set of strategies and techniques focused on ensuring that the ever-changing communities and ecosystems of a restoration continue to meet the site plan outcomes into the future. The focus is on directing, not preventing change. In Chapter 10, we discuss the features of a restoration management plan and five types of the most commonly used vegetation management techniques: hands-off (nonintervention); mechanical approaches; herbicides; fire; and biological controls.

Major Themes

- All restorations require management because human activities continue to impact all parts of the world whether people visit a site or not. In addition, communities/ecosystems are constantly changing, and sometimes these changes move a site away from the restoration objectives.
- You should develop the management plan at the same time as you are creating the site, implementation, and monitoring plans. The management plan is essentially a set of if/then scenarios. The key to developing a management plan is to anticipate and identify future problems, based on your community/ecosystem models and your understanding of the site context.
- The features of a restoration management plan include the following:
    1. A discussion of alternative strategies to deal with potential stressors
    2. A set of specific management prescriptions (protocols)
    3. A description of management units, if applicable
    4. A projected management budget
    5. A set of plan review and updating procedures
- It is important to consider the pros and cons of alternative management strategies for all potential management situations. One of the alternatives is always the nonintervention technique, so you always address whether or not the problem might resolve on its own. After thinking about the pros and cons, if the best choice is not obvious, you can use experiments or field trials to test the alternatives onsite—the adaptive approach.
- A management prescription includes a detailed set of instructions about when (time of year, weather conditions, time of day); how (with which tools, how often); where (which management unit); and by whom management is to be accomplished.
- Mechanical approaches to managing vegetation involve using tools to remove some or all parts of unwanted plants. Major strategies include pulling and cutting, girdling, and mowing.
- Chemical management tools (herbicides) kill plants outright or suppress growth through disrupting physiological processes. You must use herbicides with caution because of the potential of harming nontarget species on- or offsite and of harming human health.

- Restoration managers use fire in vegetation management to harm plants selectively and/or to reestablish natural fire regimes. Management burns have the potential to escape, so you must conduct them only when the site's microclimate and fuel conditions (particularly relative humidity, temperature, wind speed and direction, atmospheric stability, fuel moisture, and fuel load) fall within the management prescription. Burn plans also include directions for the construction and location of firebreaks, the location(s) of the initial ignition spot(s), and the predicted burn path. You also need to include detailed information about the role of each burn participant.
- Biological vegetation control strategies include the use of grazing mammals, such as cattle, sheep, or goats, and herbivorous insects. It is usually possible to confine the activities of mammals to a particular location by using fences, for example, although escapes can occur. A major concern with the use of exotic insects in vegetation control is damage to nontarget species.

Comments on Food for Thought Questions

Question 1. Describe the differences and similarities between the focus of the initial restoration and the focus of subsequent management of a restoration.

How to Use or Expand on This Question

- This question helps students to review the logic of the restoration process. It is an opportunity to focus once again on the "big picture."

What to Look for in Student Responses

- Students should make the following points:

1. By definition, the initial restoration (the "action" steps, including conducting the initial site inventory and analysis and creating and implementing the master and site plans) is focused on moving a site from the condition it is in at the beginning of the project to a status of meeting the project objectives. The focus of management is on ensuring that the restoration continues to meet the objectives into the future.
2. Both the initial restoration and management phases:
    a) Are based on community/ecosystem models
    b) Deal with past and ongoing human impacts
    c) Use an adaptive approach—have built-in reviews and employ experiments and field trials
    d) Require current site and context information, the gathering of which is directed by protocols
    e) May employ similar tools and/or strategies (for example, cutting, pulling, mowing, herbicides, fire, and biocontrols for vegetation)
3. Considerations of future management requirements influence the initial restoration; the objectives of the initial restoration direct management.

Question 2. Choose a restored site in your area to visit. Look for, or inquire of the site's managers about, any natural processes that have over the years been impeded by human activities. As a result, what management issues might need to be addressed? Are these issues that can be addressed right now with available tools? Will new tools have to be developed?

Question 3. Consider another restoration site you are familiar with or have read about. What are a few of its management concerns? Could you write a management prescription for it? What would you need to know? What management tools would you recommend?

How to Use or Expand on These Questions (Questions 2 and 3)

- Each of these questions asks students to apply the management framework presented in Chapter 10 to actual examples. They involve doing some research beyond the information provided in the textbook, and then applying what they have learned to an actual situation.

  It is ideal if students have access to local projects with managers who are willing to spend time with them. If not, many agencies and even private companies involved in restoration now have websites with enough descriptive information to serve the purpose.

- Rather than having students contact restoration managers individually, consider inviting the managers of several local restorations to join one or more class sessions to address the issues raised in the questions. We have done this with good success using a couple of formats:

  1. Some managers prefer to give a lecture followed by a question-and-answer session.
  2. Others are more comfortable joining a panel to field questions from the students—no lecture required!
  3. In either case, we prepare the class ahead of time, having them visit or look up information about the sites. We also ask each student to prepare a set of potential questions and submit them for review. That way, we can encourage a thoughtful and informed discussion.

- If the class is working on a restoration plan for an actual site, you can use these questions, as well as Question 4, to write a management plan for the project.

- As an alternative, consider specifying one or more management situations that are typical of restorations in your area. For example:

  1. You could modify Question 2 by listing natural processes, such as fire or flood cycles, and having students describe how humans have impacted them and the strategies and tools that are or might be available to manage them.
  2. Similarly, you could modify Question 3 by listing impacts, such as vegetation trampling, soil compaction, or water pollution, and having the students address each of these.

What to Look for in Student Responses (Questions 2 and 3)

- The details of the responses will vary according to the kinds of restorations that are being investigated. In general, the answers should set up if/then scenarios concerning potential impacts that are based on relevant community/ecosystem models as well as the individual sites being

studied. For each potential problem they identify, students should discuss the pros and cons of alternative strategies (tools and application protocols), one of which is the hands-off approach.

Question 4. Would it be possible, based upon your site inventory and analysis or the area surrounding your restoration, to anticipate and/or prevent the kinds of impacts that human activities might have on your restoration?

How to Use or Expand on This Question

- This question can be approached either by applying it to an actual restoration project (perhaps one that your class has been developing for a real site) or by considering it in relation to the restoration process in general.

What to Look for in Student Responses

- To the question of whether we can anticipate potential human impacts, the answer is yes. We would expect students to reach this conclusion by discussing current information about the kinds of human activities that affect natural communities. Chapter 1 as well as the beginning of this chapter, reviews such impacts. In addition, the condition of the restoration site before restoration, as well as the past and current situation of the site context can provide information that helps us anticipate future problems. Students can find relevant information to support this response in Chapters 4 and Chapter 12, as well as in Chapter 10. Site conditions before restoration are in part due to offsite influences. Students might offer as an example evidence of erosion caused by stormwater runoff or the presence of pest species coming from offsite. Assuming that the restoration has not changed the relative topographic position of the site or created colonization barriers and that the context has not changed, it is likely that the impacts to continue.

Question 5. What site parameters would you consider prior to conducting a prescribed burn or initiating a grazing program to achieve management goals?

How to Use or Expand on This Question

- You can use this question as written as the basis for a class discussion.
- With a slight rewording, Question 5 can become the basis for one or more exam questions. For example: "Name 5 environmental factors that must be considered in conducting (or alternatively, in creating a prescription for) a prescribed burn."
- You can also create similar questions for discussion or for exams that focus on the use of herbicides, mechanical techniques, or biological controls with respect to vegetation management.
- As an alternative, you could create a literature research assignment to have students investigate strategies for managing animals, insects, storm water, trail erosion, excessive seed collecting, or numerous additional human impacts that are relevant to restoration in your area.

What to Look for in Student Responses

- Students should explain the following steps in conducting any management strategy:

1. You start by comparing the monitoring results with the relevant restoration site plan objectives to determine what is to be achieved—this step essentially defines the management goals.
2. Next, you check to see if the site conditions on the day you plan to initiate a management action fit the management protocol (prescription). Based on the information presented in Chapter 10, for a prescribed fire, the site parameters include such things as:
    a) Relative humidity
    b) Temperature
    c) Wind speed and direction
    d) Atmospheric stability
    e) Fuel moisture
    f) Fuel load
    g) Presence of any firebreaks, hazards, or escape routes
    h) Location of any fire- or smoke-sensitive areas

- With regard to the use of grazing in restoration management, the textbook provides only limited information. However, there is a wealth of global information on range management, and as more restorationists explore this tool, more case study information is available. Parameters students should find include:
    1. Existence of hazards—for example, noxious species
    2. Presence of vegetation types that the grazing animals are likely to consume (including the management targets and others)
    3. Amount of target vegetation species biomass available in relation to the numbers of animals being used (this helps determine stocking numbers and rotation frequency)
    4. Availability of water and shelter for the grazers.
    5. Compaction-sensitivity of soils
    6. Soils and substrate allowing for the construction of fencing.

Question 6. Under what circumstances might a management action cause more harm than good?

How to Use or Expand on This Question

- You can use this question as part of a class discussion about the importance of evaluating management strategies and the difficulties of anticipating all of the consequences of taking (or not taking) action. It also provides a springboard for discussing the importance of considering both long- and short-term consequences of an action and the fact that actions often cascade through the interconnections of community/ecosystem components. You can use the question as written or provide case study examples drawn from your own experience or from the literature.
- This question also makes a good topic for a panel discussion. You could invite area professionals engaged in managing restorations or natural remnants to talk with your class about their experiences in general and also to relate specific instances in which a management action created problems.

What to Look for in Student Responses

- In their answers, students should begin by defining "harm" and "good" in terms of the restoration objectives, the site managers, the site users, the site neighbors, and even the project budget. The idea is that whether an "action causes more harm than good" depends on perspective and priorities.
- Following are some examples of situations that students could address:

1. When the action causes unanticipated and unintended damage to nontarget organisms—for example, when a biocontrol unexpectedly moves from an undesirable target organisms to a desirable nontarget species.
2. When a management tool is used incorrectly. For example, when a fire escapes or when a herbicide applicator sprays the wrong species or fails to wear protective gear and becomes ill.
3. When a community becomes upset over tree removal and withdraws support for the restoration project.
4. When a manager does not consider long-term as well as short-term consequences of a strategy. For example, the removal of pest shrub species in a forest may initially achieve a restoration objective for an open midstory layer, but if no further action occurs, in a few years, seedlings or root resprouts of those same species may grow back and create an even denser shrub layer than before

Sidebar: Pine Forest Management Planning: Food for Thought Questions

- Can you think of other unknowns that need to be answered? Are there opportunities here the team has not mentioned?
- Can you think of other constraints? What would the restoration team need to know to address the constraints? What would you recommend in this situation?

What to Look for in Student Responses

- These questions relate to the "Management of a Pine Forest Restoration" case study in Chapter 10 of the textbook (see p. 299). The case study focuses on managing the impacts from erosion caused by offsite-generated stormwater runoff. Students can draw information from the case study in answering these questions. Some possible issues students might address include:

    1. Is the source of the water generating the erosion onsite or offsite? If from offsite, are there opportunities to stop the water at the source? Who manages the offsite properties, and are they willing to cooperate? If not, are there legislative tools available? Is some of the water coming from Arboretum communities that could be redesigned to reduce runoff?
    2. Can the trails that seem to be a contributing factor to erosion be relocated or removed without serious effects on the users of the site? For example, instead of having trails run straight downslope, can switchback trails be created?
    3. Are there trail surface treatments that may decrease erosion?
    4. Is there evidence of soil compaction, either from use of the site before restoration, or from off-trail uses? If so, can these effects be reduced?
    5. Since the pine forest is not actually a community native to the region, is the best solution to do a midcourse correction and start over with a different community type?

Supplemental Activities and Exercises

See the textbook website (www.introrestorationecology.com) for additional examples.

Suggested Learning Objectives Outcomes

Learning Objective 1. Identify the components of a restoration management plan.

Learning Level 1 Outcomes

- Students should be able to list and describe the components of a restoration plan:

    1. Anticipate and identify potential future problems and management threshold site conditions.
    2. For each problem identified, develop alternative strategies, one of which is nonintervention.
    3. Develop a management prescription (protocol) for each of the chosen strategies.
    4. Identify management units, if appropriate, and link management strategies to each one.
    5. Develop a budget and review and updating procedures.

Learning Level 2 Outcomes

- Students should be able to examine an existing management plan to see whether and how well each component is represented

Learning Objective 2. Explain the underlying logic of a restoration management plan and its place in the restoration process.

Learning Level 1 Outcomes

- Students should be able to place the steps identified in Learning Objective 1 in a logical order (as suggested above).

Learning Level 2 Outcomes

- Students should be able to explain the importance of each step as described for Learning Objective 1 in achieving management success.

Learning Objective 3. Evaluate situations to determine whether management interventions are required.

Learning Levels 2 and 3 Outcomes

- Students should be able to analyze the information collected by a monitoring team in order to compare the results with restoration objectives.
- Students should be able to design a management plan for a specific restoration site.
- Students should be able to then determine whether a restoration is or is not meeting the objectives and if it has or has not therefore passed the management threshold (the state in which management actions are required).

Learning Objective 4. Plan your management actions.

Learning Levels 2 and 3 Outcomes

- Students should be able to propose alternative strategies to address a specific site management issue; describe the pros and cons of each; choose the "best" solution; and create a prescription to guide the implementation of the strategy.

Learning Objective 5. Use some basic vegetation management tools.

Learning Levels 2 and 3 Outcomes

- From reading the textbook, students should be able to describe the issues (environmental and practical) that surround the use of several vegetation management tools: mechanical, chemical, fire, and biocontrols. They should also be able to discuss their application (timing, location) in theory. As to actually using these tools in a real situation, that will need to be evaluated in a field setting.

Potential Issues, Questions, and Misconceptions

- It is important to emphasize that "letting nature take its course" is actually the nonintervention management strategy and should not be employed by default. In other words, the choice of a hands-off strategy is really active management.
- Because of continuing human impacts, the feasibility of management needs to be considered as the master and site plans are being developed. For example, if the long-term survival of a desired community composition depends on annual spring floods and the site cannot be flooded, then it would be better to choose a different target community for the restoration. Similarly, if it is likely that fire management will be needed, the site design can incorporate firebreaks, thus making it easier to conduct a management burn.
- One of the biggest restoration challenges is the difficulty of controlling impacts coming in from neighboring properties. One management strategy worth considering is finding ways to influence surrounding land uses.
- Some of the management issues that may face the restorations of the future are:
    1. The control of pest species
    2. Being able to maintain natural processes such as wildfires and floods
    3. Potential impacts of climate change, including increased frequencies of severe storms in some areas
    4. The continuing introduction of novel chemicals (plastics) and organisms (genetically modified organisms)

Chapter 11

The Role and Impact of Pest Species on Restoration

Pest species are one of the most pervasive community/ecosystem stressors and present a major challenge to the management of restorations. In Chapter 11 we present an overview of the problem and suggest a logical framework for developing strategies to manage pest species.

Major Themes

- Pest species are native or non-native (exotic) organisms that interfere with restoration goals and objectives. They are a feature of the situational nature of restorations; a particular species may be viewed as a pest on one site, but not on another.
- Pest species are a continuing challenge because: (1) rapid and frequent travel allows for widespread global transport of species; (2) land use patterns provide opportunities for invasions; and (3) the direct or indirect impact of human activities often disrupts native communities/ecosystems.
- Pest species management follows a plan developed as part of overall site implementation (see Chapter 8) and management (see Chapter 10) and often involves control or containment of the pests rather than eradication. The goal is to choose tools and strategies that achieve effective control with minimal damage to nontarget organisms within the practical constraints of budget, time, and the skills of available personnel.
- Faced with limited resources and several pest species, managers may have to set action priorities, based on the degree of threat posed by each species and the ease or difficulty of control.

Comments on Food for Thought Questions (Questions 1 through 5)

Questions 1–4 (and potentially also Question 5 if applied to the pest species discussed in Questions 1–4) are linked, meaning that students need to answer the first question to move on to the second, third, and fourth. Taken together, they challenge students to apply the concepts presented in Chapter 11 to contemporary issues in your region. We have organized this section of the manual to present three different approaches to the set of questions rather than addressing each in turn. You will find specific suggestions as to how to use the questions and what answers to expect from students using each approach. Note that questions 2, 3, and 4 can be used out of sequence if you provide the necessary information.

Approach 1

- Provide class time, Internet and library resources, and contact information for willing area professionals; then put your students in charge of their own learning. Help students apply the framework and definitions provided in the textbook to real-world examples and compare the issues raised in the textbook with the results of their investigations. You can also provide more structure by arranging field trips to restoration sites to talk with managers or by inviting local restorationists

or pest species experts (government agencies often employ such folks) to make presentations to your class.

Question 1. Consider a few common pest species that occur in your area. What impacts have they had on a restoration with which you are familiar?

How to Use or Expand on This Question

- Based on their investigations (and/or past experiences), have the class generate a list of the common pest species found in your area (or anywhere in the world). This could be a class, small-group, or individual exercise using any of a number of methods—Post-it notes; round-robin discussion; listing on a whiteboard; turning in individual lists for you to compile (see the discussion of the Food for Thought Questions in Chapter 1 of this manual for examples)—to create a master list of pest species. Then have the class as a whole discuss the list to understand why each species is considered to be a pest and to decide whether any species are missing or should be deleted.
- Ask the students, as a class, small-group, or individual exercise to list impacts from each pest species.
- If applicable, ask students to relate a story of their personal field experience in dealing with these (or other) pest species.

Question 2. Team up with a partner. With each of you taking opposite sides, discuss whether the pest species from Question #1 are drivers or followers of ecosystem change.

How to Use or Expand on This Question

- We use Question 2 with pairs of students in several ways:

1. As an introduction for this question, have the students explain (or you can provide) the types of evidence they could use to describe a pest species as being a driver or follower of change.
2. Have each pair of students select a few species from the list they have generated. (If you plan to share the results from this activity with the class as a whole, it might work best for you to assign species to each student pair to be sure that the entire list is evaluated.) Students will need some time to investigate their assigned species.

Students could contact area professionals to obtain information, or you could arrange to bring experts to class to serve as resources, or students could use Internet and library resources to find the evidence they will need.

3. Next, one option would be to have each pair, after they have discussed the issues involved outside of class, present a summary of their findings to the class, after which you can ask the entire class to decide which species cause or follow change. Or you can have each pair reach a final decision about their species. In either case, you can have each pair submit a report.
4. Another option would be to have each student team turn a report in to you so that you can summarize the results for a class discussion during the next class session. Ask the class for

any patterns they see within the list. For example, are most species "followers"? Do some species cause change as well as follow it? Is the evidence used to support the positions strong in all cases? Are there some species for about which the jury is still out?

What to Look for in Student Responses (Questions 1 and 2)

- Students should be able to define "pest species" in their own words and explain how the label gets applied to specific species. For example, be sure that students consider the following questions:

  1. How do you know a species is a pest?
  2. Is it a pest because it is on a list of troublesome species?
  3. How does a species get placed on a list of troublesome species?
  4. What criteria are used?
  5. Is it a pest because a colleague said it is?

  Perhaps some students have worked at a restoration site and have firsthand experience with the impacts of pest species that they could use in defining the term.

- The key is that, according to how the term is used in the textbook, to be called a pest, there needs to be evidence that a species is interfering with the objectives of a restoration (or conservation reserve). Examples of evidence the students should be able to cite include:

  1. The site plan outcomes of a particular project include a requirement for the community composition and structure to include a limited number of a certain species. For example, if a complete restoration has a goal of "≤5% cover of exotics," then any non-native species likely to exceed that cover percentage would be considered to be a pest.
  2. Observations, anecdotes, or experimental results found in published articles or on conservation agency websites, or provided in interviews of area professionals.

- Students should also recognize that a species might be considered a pest in some circumstances and not in others. [[[This text aligns with the last bulleted item above]]]

- Students should be able to define a "driver" as a species that is a fundamental underlying cause of change, and to define a "follower" as a species the presence of which is a symptom of change. Students may decide that in some cases, not enough is known about cause and effect to be able to make this distinction, or that a species is both a follower and a driver. They will again need to provide evidence. For example:

  1. Documentation that a plant species actively competes for resources and actively excludes other species would be evidence of the species being a driver of change.
  2. Documentation that a species can survive on a site only after a disturbance has altered the habitat would be evidence that the species is a follower of change.

Question 3. Conduct a risk analysis of the pest species in your area, and assign a priority ranking for each. (Alternatively, you could do this together with your partner.)

How to Use or Expand on These Questions

- We have found Question 3 to be very helpful in helping students grapple with the complexities of restoration management in the "real world," where restorationists are faced with limited resources and many, often conflicting, issues to resolve. We have assigned the activity to pairs of students, as specified in the question, or to larger teams, depending on the size of the class. Each pair or team produces a report in the end.

  1. It is helpful to begin, if possible, by providing the opportunity for the students to consult with area professionals. Conversations with practitioners are particularly valuable in gathering information to address this question. You could invite practitioners to come to class and appear on a panel of experts to discuss setting risk priorities. For maximum learning potential, try having your students run the discussions with these guest experts.

     Work with the students ahead of time to be sure that important points are covered. For example, have them ask the local restorationist to explain the steps she uses in prioritizing pest species on her site and to describe her data and information sources.

     After the class presentations, lead a class discussion to summarize the information the guests provided.

  2. Next, have the students assign priority rankings for each species on the class list. (The list could be generated by you, by the guest experts, or be the result of the answers to questions 1 and 2.) Unless the number of species on the list is small (<5 organisms), it is probably best to divide the list so that each student or student team concentrates on only a few species. Have each team prepare a written report, explaining their rankings and the process they used to reach their decisions.

- As an alternative, rather than having teams of students prepare individual reports, following the panel presentation, lead the class as a whole in a nominal group process to create the priority rankings. See a discussion of a version of this process in Chapter 1 of the manual. Then, once the individual rankings are complete, pool the information and have the students discuss the results.

- Another approach would be to provide students with a set of pest species already ranked according to risk potential and to have them justify the rankings.

What to Look for in Student Responses

- In order to conduct a risk analysis, students should first establish some general criteria used in risk assessment. They should include the information found in Figure 11.7 and Section 11.5.3 of the textbook (see p. 339). See also the discussion under alternate Question 3 below.

- The results of this activity will include, at minimum, a ranking of the species on the "pest species" list according to the management risk posed by each species. It is ideal if you also require students to explain the assumptions and reasoning behind their ranking scheme and also the sources they used to obtain the information on which the rankings are based. In other words, they should display critical thinking skills and sophistication and an understanding of the complexities of pest species management.

- The details of the answers will depend on your local situation.

Question 4. What steps would you take to manage these pest species? Are they amenable to control or eradication, or is there an underlying ecosystem disruption that must be corrected before they can be controlled?

Question 5. What factors would you consider in making a choice between a pest species eradication, containment, or control program? What would be the key elements of your management approach? Consider your response if the pest were an animal instead of a plant species.

How to Use or Expand on These Questions

- Follow the approaches outlined for Question 3 above (start with a panel presentation; have students work in pairs or in teams; end with a discussion and/or a report), this time focusing the discussion on developing pest species management strategies and protocols rather than on setting management priorities in the form of a risk assessment. The focus is on investigating alternative control methods for different species as well as on establishing criteria to use to decide whether a species can be eradicated, contained or controlled.
- In their reports (or during the class discussion), have the students not only describe several alternative strategies for managing each species but also provide a cost-benefit evaluation of each strategy and, based on the results of the analysis, specify the circumstances under which each might be preferred and the protocols under which each might be applied. Students should also specify the circumstances under which the goal would be containment, eradication, or control.

What to Look for in Student Responses (Questions 4 and 5)

- The aim of questions 4 and 5 is to expose students to the complexity of the issues involved in creating a management plan for pest species and to get some practice in thinking through the issues. Students should provide evidence (and reference citations) to support the choices and decisions that they make.
- The discussion of alternative strategies should include:
    1. A description of how the technique works (what it does to the pest)
    2. Consideration of how successful each strategy is likely to be
    3. The potential positive or negative effects of each strategy on nontarget species or community/ecosystem components
    4. The costs of the labor, equipment, and supplies involved in using it.
- The protocols should include:
    1. A description of the management threshold—the resource conditions that trigger the response
    2. A discussion of anticipated outcomes (goals)
    3. A detailed set of instructions as to when (time of year, weather conditions, time of day), how, where, and by whom management is to be accomplished

Alternative strategies and management protocols are discussed in Chapter 10 (see Sections 10.2.2 and 10.2.3).

- Items students should consider in determining whether a species might be eradicated, contained, or controlled include:
  1. The ability to identify and act on an invasion early on, before a population grows
  2. The immediate effectiveness of the management technique
  3. The ability to prevent a reinvasion (e.g., by controlling borders, managing an unfavorable environment)

Approach 2

- Use questions 1–5 as a guide for students to follow while working individually or as teams to prepare all or part of a specific pest species management plan for a specific site for which information on the location and extent of the species is either known or can be determined.

How to Use or Expand on These Questions

- Start the students off by assigning a site that contains known pest species. Then provide a set of specific resources (articles, web pages, and the like; site history; site inventory results; the restoration objectives) that will help them evaluate impact, perform a risk assessment, set management priorities, and propose a management approach.
  1. Aside from assigning the species and the site, you can leave the assignment open-ended, leaving the wording as is, and expect that the students will look to the textbook to find guidance for the different sections of the report.
  2. As an alternative, you can be explicit about the steps they should follow, the questions they should address, and the information they will need. For example, provide instructions such as:
     a) In performing a risk assessment, consider the points presented in Figure 11.7 in the textbook (see p. 339)
     b) Base your management priorities on the current extent of the species onsite, the current and potential significance of the impact of the pest species on the restoration objectives, and the ease or difficulty of control.

What to Look for in Student Responses

- The details of the students' responses will, of course, depend on the site and the management scenario that you propose. Student responses should include:
  1. An evaluation of the nature of, and the current and potential extent of, the impacts caused by each pest species
  2. The characteristics of the pests that lead to the impacts
  3. A risk assessment and set of management priorities, including whether the goal is eradication, containment, or control
  4. A discussion of the pros and cons of effective management options
  5. A proposed strategy

For additional guidelines, see the discussion of student responses to alternative Question 1, below.

Approach 3

- Focus on basic principles rather than on specific species, sites, or regions.

How to Use or Expand on These Questions

- Reword the questions, and use these in class discussion to reinforce or deepen understanding and uncover any misconceptions. For example:

  Alternate Question 1. Name some of the major impacts that pest species have on restorations.

  Alternate Question 2. It has been said that pest species can be drivers or followers of ecosystem change. Explain.

  Alternate Question 3. List criteria by which a pest species may be evaluated in terms of the degree of risk it poses to a restoration. Describe how these criteria might be used to rank species according to overall risk potential.

  Alternate Question 4. Name and describe the features of a pest species management plan.

  Alternate Question 5. Compare and contrast "eradication," "containment," and "control" as these terms are applied in pest species management. Under what circumstances might each be employed in restoration?

What to Look for in Student Responses

Alternate Question 1

- Students should be able to identify and discuss several general categories of impacts that change community structure, composition, and ecosystem functions, including:

  1. Killing desired species outright—e.g., outcompeting, causing illness, using as prey
  2. Changing the physical conditions of a site—e.g., in respect to soil fertility, water availability, amount of shade
  3. Altering the operation of disturbance cycles—e.g., increasing fuel load and fire intensity

Alternate Question 2

- Students should explain that a "follower" is a pest species that is a symptom of change and a "driver" is a pest species that causes a change.
- Students should be able to provide examples of both types of pest species.

Alternate Question 3

- Students should begin by defining the term "risk" as it applies to pest species management. "Risk" in this sense refers to the likelihood that a management strategy will be effective, as well as to the magnitude of the consequences of a failure to control—that is, the most probable threats posed to the restoration by the presence of the pest (see Section 11.5.3 of the textbook).
- Risk factors students should be able to identify include:

1. Status of the extent of the presence of a species onsite
2. Significance of current and potential negative impacts on restoration objectives
3. Value of the restoration
4. Ease or difficulty of control

Alternate Question 4

- Students should be able to list and discuss the reasons for the steps shown in Figure 11.6 of the textbook (see p. 336):
  1. Establish goals.
  2. Identify pests, determine the impacts they cause, and set control priorities.
  3. Identify and correct aspects of the site that may be facilitating pest species problems.
  4. Decide on effective control options.
  5. Implement the management plan.
  6. Monitor the effect of management actions.
  7. Based on the monitoring results, refine the plan, if warranted.
- Students may also include information from Chapter 10, Sections 10.2.2 and 10.2.3.

Alternate Question 5

- Students should use their own words to define "eradication," "containment," and "control" as these terms are used in pest species management The basic distinctions that students should make are that, through eradication, the entire population is removed from a site; in containment, a pest population is confined to a specific, generally small portion of a site and prevented from spreading to other portions; and when a pest is controlled, the population density throughout a site is kept below an established threshold level.
- Students should be able to list the following factors to be considered in determining which approach to use in pest species management:
  1. Cost of implementation
  2. Circumstances that contribute to likelihood of success
     a) Species characteristics (see Section 11.4.1)
     b) Nature of site context
        i. Proximity to sources of colonization
        ii. Magnitude of continuing human impacts
        iii. Edge-to-interior ratio (see Chapter 2, Section 2.5.1)
        iv. Current extent and history of species onsite
  3. State of our current understanding of the ecology of the species

- Students should discuss that restorationists often (1) choose the approach that, under the circumstances, is the least costly and has the most chance of success, or alternatively (2) begin with the idea of eradication but settle on control or containment if eradication proves to be impractical.

Question 6. Under what circumstances might a management action cause more harm than good?

How to Use or Expand on These Questions

- This question works well as a class discussion. Because the subject of Chapter 11 is pest species, we focus the question on pest species management, not on restoration management per se.
- By focusing on specific species, we have also used this question as an essay assignment. We assign a different pest species to each student. The goal of the assignment is for them to use the literature (journal articles, management agency websites, etc.) to (1) report on what alternative management actions are generally used and with what effectiveness; (2) examine each of the alternatives with regard to the potential for harm to the environment (including other species and the managers); and (3) report on what would happen to a site if no pest species management actions were taken.
- We have also used the question as the basis of an informal debate. In this case, we sometimes use the general form of the question but more often reword it to focus on a particular situation, a specific pest species, and/or a particular management tool. For example, we might propose a scenario such as: "The Wisconsin State Natural Areas Program shall allow the use of glyphosate herbicide to control garlic mustard (Alliaria petiolata) in Abrahams Woods." When framed as a debate, one side is given the task of arguing that this action should be allowed, the other side that it shouldn't, based on the premise of "doing harm."

  The Abrahams Woods example is real, and we provide students with sources of information about the current composition (including the extent of the garlic mustard invasion) of the site and the policies of the State Natural Areas Program. We expect the students to find information about glyphosate and garlic mustard on their own.

What to Look for in Student Responses

- There are several possible answers to be found in Section 10.4 of the textbook and in the discussions of different management approaches. The general theme is that damage can come from harming nontarget organisms (e.g., pulling the wrong plants, trampling vegetation in general); the site environment (e.g., compacting the soil, disrupting the litter layer); site managers (e.g., inhaling herbicides); or people or areas outside the site boundaries (e.g., herbicide drift or uncontrolled fire).
- Sometimes failure to carry out a management prescription in its entirety can cause more problems than the original management targets. For example, sometimes cutting the stems of undesired shrubs and then failing to carry out a second cut or to apply herbicides can result in a greater density of shrub cover due to resprouts than was present before the treatment.

Sidebar: Implications of Bark Beetle Outbreaks for Restoration: Food for Thought Questions

1. What role(s) does restoration have in dealing with a complex pest species management problem on such a large scale? What about the role for restoration on a more local scale?
2. What does it mean to "manage" a pest species in this situation?
3. Does the fact that a native species is involved change your view or what can or should be done?
4. What are the goals, objectives, and targets of pest management in the case of the bark beetle infestations in the mountain west?
5. What can be done on a local (watershed) or site-specific scale?
6. What are some restoration strategies that are, or could be, used?
7. What would you do if novel communities developed in the wake of a bark beetle tree-killing episode?
8. What factors (biotic and abiotic; social and cultural) would you consider in making judgments about the above questions? Is this strictly an environmental problem? Does the problem have only environmentally based solutions?

What to Look for in Student Responses

- These questions relate to the whitebark pine case study presented in the textbook (see pp. 333–334). As stated in the sidebar, students can use the Internet to find out how professional managers are addressing bark beetle outbreaks and then compare these findings with the principles and strategies discussed in the textbook. The Rocky Mountain National Park website referenced in the sidebar (http://www.nps.gov/romo/naturescience/mtn_pine_beetle_background.htm) is an excellent source of information, as is the website of the Whitebark Pine Ecosystem Foundation (http://www.whitebarkfound.org)
- In addressing the questions, students should make the following points:

1. With regard to Question 1, students should first identify the restoration techniques that are being used on both a regional and a local scale. The approaches that they should be able to locate include:

   a) The restoration of fire regimes

   b) The restoration of conditions favorable to natural pine reproduction by mechanical means

   c) Efforts to protect individual trees from beetles using insecticides

   d) In the case of the whitebark pine, efforts to protect populations from the exotic fungus by encouraging the growth of resistant strains

   With respect to the whitebark pine in particular, students should report that restoration efforts include using fire or cutting to control competing trees species and creating "nutcracker openings" that encourage the birds to cache pine seeds. Many of the cached seeds germinate. The hope is that this will increase the possibility that enough trees with genetic resistance to

the exotic fungus will survive to reproduce. The problem is that all young trees are susceptible to the beetles.

Students should conclude that on a regional scale, restoration can be used to maintain community/ecosystem objectives in some parts of a landscape, even if pest species outbreaks in other locations remove them (for the moment) from compliance. They should also note that on a local scale, restoration efforts can also repair immediate damage but are dependent on the continuing existence of offsite organisms to provide the materials and processes for long-term survival.

Students should also discover that such restoration efforts on a large scale are made possible only if managers of several properties coordinate their efforts. Information sharing such as occurs at professional meeting facilitates coordination, as do sources of resources, such as the Whitebark Pine Foundation.

2. Students should report that with respect to the bark beetles per se (Question 2), pest management could mean containment, control, or eradication. The managers seem to be attempting to control the size and frequency of bark beetle outbreaks through the reintroduction of fire. They also are attempting to protect individual high-value trees through the use of pesticides—a very local form of elimination.

3. Question 3 gets at the fact that the definition of "pest" is tied to restoration/management objectives. Students should conclude that, depending on the situation, the goal might be to control a native pest and eradicate an exotic pest if these actions are feasible. If a restoration objective on a particular site is to protect fungal-resistant whitebark pine trees, the goal might be the local eradication of the beetles.

4. Students should find the general themes of the answers to questions 4–6 in the suggested answer to Question 1 above. You can ask students to find a specific case study to respond in more detail—exactly what has been done at a particular park, for example. An Internet search will provide a number of such case studies.

5. Students should conclude that the answer to the question about novel communities (Question 7) depends on the objectives of the project. For example, if the purpose of a site is to conserve a particular species or an interacting community of a particular species, and the "novel" community does not achieve these goals, then restorationists would probably take some kind of action to discourage the novel species. If the goal is to prevent soil erosion from silting a particular streambed and the novel community offers this service, then site managers would probably not take action.

6. With regard to Question 8, students should respond that, in general, restoration decisions of all types always involve working with people, and management always involves the consideration of how any action or inaction affects nontarget resources, both onsite and offsite. Students should check out the details of specific case studies to provide particulars of how these factors influence the actions managers have been or are taking.

Supplemental Activities and Exercises

- Have students investigate one or more organizations concerned about pest species to find out what actions they are currently pursuing. For example:

  1. What are the goals of the organization?
  2. Do they have an action plan? If so, what is it?
  3. Do they have a public awareness mission? If so, describe it.
  4. Do you think it would be effective? Why or Why not?

  Ask the students to see which of the themes discussed in Chapter 11 are reflected in the information or goals of the organization. [[[This text aligns with the last bulleted item above.]]]

- The organizations listed in the Resources section at the end of Chapter 11 would be a good place to start. In addition, students in the United States could look at the website of the National Invasive Species Council (http://www.invasivespecies.gov/index.html). The Nature Conservancy also has an archived website for its disbanded (as of 2009) Global Invasive Species Team (http://www.invasive.org/gist/index.html). Though no longer current, the structure is still worth looking at.

- Ask the students to check out the origins of the most common pest species in your region (perhaps those from the list they have already generated in pursuing the Food for Thought questions.) Then have them address one or more of the following issues:

  1. How many are non-native?
  2. Which ones were deliberately imported for use in solving a land use problem (e.g., soil conservation, landscape design)?
  3. Which ones were deliberately imported for the pet trade?
  4. Which ones were deliberately imported for agricultural purposes?
  5. Which ones were accidental introductions?
  6. Were any developed by selective breeding?

  It is also useful for students to pick out a few of the plant species and see how well their characteristics match the traits listed in Section 11.4.1 of the textbook.

Suggested Learning Objectives Outcomes

Learning Objective 1. Develop criteria to identify species that are behaving as pests in a restoration.

Learning Level 1 Outcomes

- Students should be able to define what makes a species a pest in their own words, to the effect that "pest species interfere with restoration goals and objectives."

Learning Levels 2 and 3 Outcomes

- Students should be able to explain that pests are species that interfere with the goals and objectives of a restoration; therefore the criteria need to address the kinds of objectives that species might impact. The criteria use information to link cause and effect.

Students should be able to list such criteria. For example:

1. Presence of a species alters community composition.

   Evidence: Objective limits species to natives; presence of an exotic does not match the objective; the species is a pest; introduction of the pest is followed by the loss of one or more species.

2. Presence of a species alters community structure.

   Evidence: Presence of the species increases canopy cover above 50%; objective specifies 20%–40% cover.

Learning Objective 2. Conduct a pest species risk analysis and set priorities for management action.

Learning Level 1 Outcomes

- Students should be able to define "risk analysis" and "management action" using their own words.

  Risk analysis: A technique for identifying the most probable threats to the restoration; in this context, the pest species that poses the greatest threat

  Management action: Taking steps to alleviate a threat to a restoration's ability to continue to meet its goals and objectives

- Students should be able to explain that setting priorities for the management of pest species means determining which species will be acted on first.

Learning Level 2 Outcomes

- Students should be able to describe how risk assessment leads to priorities for management action.
- Students should be able to develop criteria to use to assess risks—for example, to create a risk index using information from Section 11.5.3 and Figure 11.7 of the textbook (see p. 339).
- Students should be able to apply the criteria to an actual site containing several pest species, or to several sites, each of which contains at least one pest species.

Learning Level 3 Outcomes

- Students should be able to add new criteria to Figure 11.7 of the textbook (see p. 339) and/or to create their own risk assessment approach and then apply it to one or more situations.

Learning Objective 3. Specify strategies for eradication, containment, or control of pest species.

Learning Level 1 Outcomes

- Students should be able to define "eradication," "containment," and "control" using their own words.
    1. *Eradication* is the elimination of a species from a site.
    2. *Containment* is limiting a species to a small portion of a site.
    3. *Control* is keeping the population size or the spatial extent of a species below a minimum threshold.

Learning Level 2 Outcomes

- Students should be able to describe the general circumstances that would lead them to choose each of the following strategies:
    1. *Eradication:* The population is small and/or isolated; management actions can be targeted to affect only that species.
    2. *Containment:* The population is large but is slow to spread to new locations; resources are not available to reduce the population at the center of its location, but it is possible to prevent the spread.
    3. *Control:* The population is too large to eradicate with available resources or without damage to nontarget organisms, or it is difficult to locate all individuals; but it is possible to reduce the population.

Learning Level 3 Outcomes

- Students should be able to apply the appropriate strategy to an actual situation.

***Learning Objective 4*:** Develop a pest species management plan.

Learning Level 1 Outcomes

- Students should be able to list the steps of a pest species management plan (see Figure 11.6, p. 336 of the textbook).

Learning Level 3 Outcomes

- Students should be able to create a management plan for a particular species on a particular site. See the discussion of Food for Thought questions above.

Learning Objective 5. Develop an early detection and rapid response plan.

Learning Level 2 Outcomes

- Students should be able to explain what is meant by "early detection" and "rapid response," and to link these ideas to material in a previous chapter.(This is the if/then scenario discussed in Section 10.2 of Chapter 10.)
- Students should be able to anticipate what kinds of species may colonize and behave as pests on a particular restoration site, and they should be ready to implement a particular management protocol if and when it is needed.

Learning Level 3 Outcomes

- Students should be able to create and apply the plan to an actual situation.

Potential Issues, Questions, and Misconceptions

- Labels can be confusing in discussions of pest species. In the textbook, we list several terms that are often used interchangeably with "pest species" ("invasives," "aliens," "exotics"), to which we might also add "weeds." Whichever term you prefer, it is important to stress that the label is "situational"—that is, a species can be a pest in one situation, but not in others. A particular species may always be classified as being a grass, no matter where it is growing, but it is not always a pest.
- Similarly, although it is true that many pest species have character traits that favor invasion (see Section 11.4.1), not all species with these traits behave as pests in restorations, and some pest species lack the traits.
- A very interesting avenue for research, given the rapidity with which species are being carried across the globe, is identifying characteristics to use to predict what the new restoration pests will be in a particular region.

    1. Does it have to do with inherent biology (fecundity, dispersal ability, range of tolerance, adaptability)?
    2. Does it have to do with the composition and structure of the community/ecosystem restoration that the species colonizes—for example, the absence of competitors/predators; the presence of symbionts; the nature of the disturbance regime?
    3. Are there markers within a species genome?

    It will be interesting to see what transpires in the next few years.

- Sometimes restoration managers focus on the removal of pest plants in the short term, without considering if removal is enough to bring a site back into compliance with the restoration goals in the long term. For example, the local eradication of a "follower" species does not mean that it will not return, especially if the source that allows invasion is not eliminated as well (e.g., floodwaters)

A good approach in dealing with long-term compliance is that when pest species appear on a site in enough abundance to trigger management intervention, their appearance should also trigger a review of the monitoring plan. In this way, once the pest species have been controlled (or eradicated or contained), post-treatment monitoring can detect if additional actions are needed to be sure that the restoration continues to meet its objectives.

Also, some pest plant species management protocols involve their removal in conjunction with plantings of other plants that are thought to compete with any reinvasions. These plantings also need to be monitored for influence on the objectives.

- A good reason to think through the pros and cons of any approach to pest species management is to avoid the trap of single-issue thinking—a situation in which you solve one problem only to discover that the cure has caused several other problems to surface. It is a consequence of the interconnections of nature. For example, using a herbicide to control a pest plant also, because of unanticipated drift, causes the death of a nearby rare species. Or the removal of shrubs and saplings that have grown under a savanna tree for decades because of fire suppression results in the tree's being toppled in a windstorm.

  Not every event can be anticipated, but it is important to use your community/ecosystem model as well as knowledge of the impacts of each strategy to predict potential management outcomes.

Online Resources

National Invasive Species Council

http://www.invasivespecies.gov/index.html

National Park Service, Forest Health: Mountain Pine Beetle

http://www.nps.gov/romo/naturescience/mtn_pine_beetle_background.htm

The Nature Conservancy, archived website for its disbanded (as of 2009) Global Invasive Species Team

http://www.invasive.org/gist/index.html

Whitebark Pine Ecosystem Foundation

http://www.whitebarkfound.org

Chapter 12

User Impacts

People are major disturbance agents both within and outside of restorations. User impacts and cross-boundary influences are management concerns for restorationists in both urban and rural areas throughout the world. In this chapter, we focus on those human impacts at the local and regional scale that can be avoided or mitigated in the context of individual restoration projects. We provide planning, policy, and design approaches that you can use.

Major Themes

- User activities that occur onsite impact restorations, as do activities that happen beyond the site's administrative boundaries (cross-boundary influences). The users of a restored site include visitors, neighbors, local and regional residents, and the restoration team (staff, contractors and volunteers) working on the site. Cross-boundary influences include such effects as air and water quality pollution, the spread of pest species, restrictions of management activities, population declines in migratory birds due to human-caused impacts elsewhere, and conflicts with neighboring land uses.
- Unless human impacts are addressed early on—before the problems become expensive to fix or before use patterns become established—restoration goals will be difficult to achieve.
- Approaches to avoid or mitigate human impacts include establishing visitor use policies and implementation and management protocols in collaboration with local residents and potential user groups, managing impacts through site design, and engaging the community to help with stewardship and outreach.

Comments on Food for Thought Questions

Question 1. Visit a local restoration or nature preserve and do the following: (a) Observe any signs of human impact that you see, (b) decide whether these are internal or cross-boundary impacts, (c) talk with the managers about the kinds of human impact they are dealing with and how they are addressing the issues, and (d) describe what you like about the managers' approaches and what you would change.

How to Use or Expand on This Question

- This experience gives students a chance to practice their observational skills. It also enables them to learn from additional (aside from yourself) experienced restoration planners and managers. It provides an opportunity to understand the complexities of an actual situation and to learn how human impact is handled in a specific situation. The experience can also lead students to reflect on the possible impacts of their own visitations to natural areas.

    1. You can ask students to reflect on the visit in written form by asking them to prepare and submit answers to each of the subquestions, or you can use the subquestions as the foundation

of a class discussion (using one of the formats we have described in earlier chapters) held after your visit.

2. We have also asked students to take a specific example or situation they have learned from their site visit and to investigate restoration and conservation literature to understand it further and/or compare similarities and differences among sites.

- If it is not possible to take students on a visit, consider inviting area practitioners to visit your class. They could give individual presentations about their experiences or perhaps serve as panelists in a discussion of the impacts of visitors and cross-boundary influences on restorations in your area. We have found that planners and managers are very happy to share their experience with students, some of whom may become their employees. Even if restorationists or managers are not able to lead a class visit, it is beneficial for the class to visit a site to look for existing or potential impacts. Then have the students reflect on their experiences as above.
- Another approach is to divide the class into teams and assign each team to visit a different area and/or interview a different practitioner and write a report covering their findings with regard to the relevant subquestions. Then have each team report their findings to the class. This can also be an individual assignment, but we have found that students do better with this assignment if they can collaborate.
- Whichever version of the question you choose to use, be sure to engage the class and/or the restoration practitioners in some advanced planning. For example:

  1. Before a site visit, have the students list the kinds of impacts they expect to find and discuss why they have selected them and what evidence they will use to determine if they are occurring or are likely to occur.
  2. Before students interview the practitioners, either onsite or as part of a panel, have them prepare a list of questions that can be discussed in class and/or for which you can provide guidance.

- If you plan to convene a panel of experts, it helps to talk with each member about the format and what your learning goals are for the students. We have had success with the following format:

  1. Include from three to five practitioners.
  2. Begin by having the panelists introduce themselves and describe their duties.
  3. Next, ask the first question—something like: "What human impacts do you deal with most frequently, and how do you address each?"—and let the panelists answer. (You can even send several questions to the panelists in advance.)
  4. Follow-up questions should come from the class, based on those they prepared in advance, but if there is a lull, you can always ask more questions.
  5. Give each panelist a chance to make some concluding remarks at the end.

- Students can learn much from listening to and interacting with professionals. We have also had success with assigning students, individually or working in teams, to prepare written summaries of the panel discussion. Here are some approaches:

1. If you are working with a class that has both graduate and undergraduate students, consider having the graduate students serve as respondents; their job is to summarize and comment on the themes touched on by the panelists. We have the respondents speak either at the conclusion of the panel or during the next class period (gives more time for them to pull their thoughts together!).
2. You could follow up by having the undergraduate students describe individually what they have learned, what their reactions are to the presentations, and/or how the information in the textbook (or your presentations) relates to the themes developed by the panel.
3. Alternatively, you could have each undergraduate student be a respondent at the conclusion of the panel—either in written form or as part of a class discussion.

What to Look for in Student Responses

- The responses will differ according to which version of the question you use and the differing circumstances of the projects the class explores. In general, students' answers should demonstrate that they understand and can identify, define, and/or apply the following:
  1. The concept of human impact.
  2. Site conditions that result from particular types of human impact: for example, the direct loss of plants from being crushed under the feet of hikers or the increase in thorny shrubs in areas grazed by cattle.
  3. Differences and similarities between impacts that originate onsite and those that originate offsite: for example, increased stormwater runoff caused by impermeable building surfaces will produce erosion whether the runoff comes from on or off the site, but the offsite sources are generally more difficult to manage.
  4. Similarities and differences between onsite visitor impacts and those impacts that are the result of restoration or management itself—for example: members of a restoration team can kill plants through trampling on their way to control an exotic species; hikers can trample vegetation by moving off-trail to see a wildflower. The results are the same; the motivations are different.
  5. Management techniques used to mitigate the effects of human impact and criteria that can be used to select which one to use in a particular case: the facilities and criteria discussed in questions 2 and 3 below would be examples; also consider techniques to replace plants lost by trampling (hand or machine planting) or actions to replace natural processes such as wildfires or grazing (prescription burns, mowing; introduction of domestic grazers). The latter techniques are described in Chapter 8 (especially Section 8.4.8) and Chapter 10 (see Section 10.3).
  6. The relationship between theory and practice in dealing with human impacts: the idea is that theory informs practice, and practice raises questions to be explained by theory.
- Students should identify some of the common ways humans can disrupt a site. Some examples might include:
  1. Soil erosion and topographic changes resulting from stormwater runoff

2. Soil compaction
3. Introduction of invasive exotic species
4. Aesthetic degradation
5. Noise pollution
6. Trampled vegetation
7. Plant or animal harvest
8. Disrupted nest sites
9. Accumulation of trash

These actions result in changes in plant and animal community composition, structure, and dynamics and ecosystem function; and may influence the quality and enjoyment of human use of the site.

- Students should indicate that they recognize that onsite and cross-boundary impacts are often related. For example, the origin of an exotic species may be offsite, but it reaches the site only because a human visitor inadvertently carries it there. One difference that students should note is the relative difficulty in lessening or preventing cross-boundary influences owing to a lack of the ability to control them. This difference is most relevant to managers and is most likely to be mentioned by them
- Students should also recognize that one of the major sources of management impacts is "collateral damage," in which nontarget species or site features are harmed as a direct result of the action. For example, a prescribed burn can increase the vigor and reproduction rates of some plants, but, depending on the timing, also disrupt ground-nesting birds, thus affecting recruitment of new individuals for that season. Usually the restorationists know of these risks and choose to apply the technique anyway. In some cases, however, managers fail to identify all of the interconnections among species in a community or all the functions in an ecosystem. In such cases, a management action can harm nontarget species indirectly. For example, in some cases, the removal of exotic shrub species may impact the reproduction of birds that rely on the shrubs to support their nests.
- Criteria for choosing impact management techniques that students should be able to identify include:

1. Reliability
2. Effectiveness
3. Cost
4. Number of personnel and degree of training needed
5. Whether the technique prevents or reacts to an impact
6. Specificity (whether the technique can be target specific)
7. Flexibility (the ability to be adapted to several different situations)

Question 2. Assume you are in charge of managing a restored community in your area that is open to visitors for the purpose of nature study. Discuss what criteria you would use to determine whether or not hiking trails should be included in the design of the restoration. What are the benefits of including trails? What are the drawbacks? If you decide trails should be included, specify the design criteria in terms of trail length, grade, width, and surface materials.

Question 3. Discuss the pros and cons of using each of the following techniques to minimize human impact on a restoration: (a) limiting access through controlled entryways, (b) providing educational signage, (c) using volunteer rangers to monitor activities, (d) allowing access only with guided tours.

How to Use or Expand on These Questions.(Questions 2 and 3)

- The focus of this chapter is on human impacts. Questions 2 and 3 ask students to explore several of the most common approaches used by managers of outdoor facilities to limit direct human-use impacts. You could use the questions as written as the basis of a classroom discussion. Following are some approaches:

1. One way to begin would be to have the students describe what kinds of impacts each technique (providing trails, controlling entryways, providing signage, monitoring visitor activities with rangers, allowing access only in the form of guided tours) is designed to minimize and how it works.
2. Next, ask students what role each technique might play in enhancing human use and enjoyment of the restoration. Their answers will provide the basis for listing the pros and cons of each technique.
3. Then, if you are addressing Question 2, ask, from the perspective of limiting impacts, under which circumstances students would or would not provide a trail for the purposes of nature study, and why or why not.
4. You can also use a similar question in addressing each technique listed in Question 3.
5. With regard to both questions 2 and 3, it is important to have students think about how their responses might differ if the restoration goals were different—that is, if the purpose of the site is to protect an endangered species or to provide outdoor recreation. In other words, consider how the restoration goals might affect the types of human use-impacts that might occur, and therefore the effectiveness of the techniques.
6. Be sure to ask students to describe any experiences they have had visiting outdoor nature parks or conservation areas. For example:
    a) Did the sites have trails, signage, or controlled entryways? Were rangers present?
    b) How were each of these features constructed—what materials were used, how large were they?
    c) What are their reactions, thinking back, to the presence of absence of each of these features in terms of minimizing impacts?

7. For those students who have little outdoor experience, or even for those who are very familiar with conservation areas, it is very helpful to start the discussion by showing images of different kinds of trails and signage. You will find many examples on restoration project websites.

- These questions also provide good opportunities to have students visit the literature and practice their reference search skills concerning the design of trails, parking facilities, signage, and entranceways, and the use of rangers and guided tours in terms of their abilities to influence impact. You can assign students to write reports or to give a class presentation based on their findings.
- Another idea is to have the students visit restoration project websites of governmental agencies and nonprofit conservation organizations to learn how others have handled the issue of public access to restoration sites. Ask whether governmental agencies and nonprofits address the issue differently.
- Because most people have visited a restoration site, conservation area, or a state or national park, this question could form the basis for a rich classroom discussion of personal experiences.

1. Ask some students to assume the role of visitor/user and discuss their personal experiences with points (a) through (d) in Question 3. If some students in your class have a background as rangers, managers, planners, or naturalist/guides, ask them to discuss the pros and cons from that perspective.
2. Ask "visitor/user" students to describe their expectations of the restoration sites and how the use policy and design features of the sites they discuss enhanced or detracted from their visitor experience. Ask "manager" students to describe their responses in reference to the site's use policy and restoration goals. They should be able to discuss pros and cons of (a) through (d) in relation to how well the protective measures achieved the desired outcomes.

- You can also broaden both questions 2 and 3 to consider additional use-policies—for example, research, hiking, jogging, or nature photography.

What to Look for in Student Responses

- In order to address how different design features and activity programs might mitigate human use-impact, students will first need to identify the kinds of impacts to expect. Impacts are disruptions to the restoration goals and objectives and will likely be a subset of those listed above with regard to Question 1.
- Next, students should think about how each approach is meant to work. For example:

1. Because most users stay on trails, trails can be laid out to provide access to only portions of a site, thus containing any use-impact that does occur. This can be an important feature if a site has particularly sensitive areas, for example, nesting sites or populations of endangered plants.
2. The construction and use of trails involves the removal of vegetation, both on the ground and on the edges and canopy of the corridor. If particularly desirable species are located near a trail, they are more vulnerable to harvest than if they were located a distance away.

3. Trails create impermeable soil surfaces and, depending on their construction and layout, may generate onsite erosion through water runoff.
4. Exotic plant species often enter a site by hitching a ride with human visitors. If most visitors stay on the trails, site managers can readily spot new invasions.
5. If the nature study experience includes explanatory signage and/or audio narratives, trails are an obvious location to place these stations.
6. If trail usage is heavy and/or the users engage in disrupted behavior, the educational experience may be diminished.
7. Also, some people do leave trails to strike out on their own and in the process create numerous unauthorized pathways that other people then follow. As a result, a site may suffer from impacts the trails were designed to prevent.
8. Limiting access by restricting parking places or by providing only a few apparent entrance points can limit impact if these measures reduce user density and/or numbers. On the flip side, these actions can also discourage use, which is a problem if the purpose of the project is nature education.
9. Providing rangers can reduce impacts if people know they are not supposed to engage in an activity but choose to do so anyway. If people know that a ranger is on duty, they will often think twice about picking plants or going off-trail if there is a chance they could be caught. However, the use of rangers adds a cost in time, if not in money, to a project; even if a site uses volunteers for this purpose, the volunteers need to be trained.
10. Allowing access only in the form of a guided tour will limit impact by allowing the site managers to keep a close eye on visitor behavior. It will also restrict the educational experience to particular classes or groups. This tactic also incurs the expense of training and/or paying the tour guides.
11. Using informative signage to educate people about use impact can work if they pause to read the signs. However, the signs can intrude on people's experience of a site (they are viewed as an intrusion on the otherwise natural experience), and people often don't bother to look at or read them.

Question 4. At the restoration site you visited in Question 1, can you foresee how patterns and levels of internal visitation will change over the next 20 years? Are there likely to be unanticipated kinds of recreational and other kinds of uses? What do you foresee as possible changes in the nature and extent of cross-boundary influences in the next 20 years? What actions (planning, management, other) would you recommend the managers to take to prepare for these changes?)

Question 6. We discussed three major planning approaches:

- Setting visitor use-policy, visitor experience, and restoration protection objectives in collaboration with stakeholders.
- Managing people through the site design; establishing infrastructure (signs, trails, roads, etc.) to minimize potential use impacts.
- Inviting people to participate in managing the restoration.

We also illustrated a variety of ways restoration projects use these approaches. Can you think of ways that new technologies (e.g., social media, GPS, smart phones, etc.) could change the ways people interact with the natural world? Would these changes be beneficial or detrimental to restorations? How could managers use these new technologies to their advantage?

How To Use or Expand on These Questions (Questions 4 and 6)

- Both questions 4 and 6 can be approached by applying them to actual restoration projects or by considering them in relation to restorations in general.
- Question 6 in particular is a chance for students to have some fun, use their imaginations, and be creative in a realm they are very familiar with. Here are some approaches you might use:

    1. Ask individual students or working groups to select one of the three major planning approaches to address a user impact they have been discussing.
    2. Then ask the students to develop a concept for a computer or smartphone application (an app) that would help deal with the impact.
    3. Alternatively, ask the students how they would improve on, or make use of, an existing app to facilitate implementation of one of the major planning approaches.

    Have the students present their concepts and explain how these concepts would: (a) help managers manage; or (b) assist interactive communication/education between the public and managers; or (c) increase enjoyment and appreciation of the natural resource.

What to Look for in Student Responses to Questions 4 and 6

- You should expect students to demonstrate their understanding of the restoration impacts of both onsite and offsite human activities in answering both questions. Students should illustrate the relationships among the biological, physical, and sociocultural aspects of restoration.

    1. An approach students might take is to look to the past and think about how predictable changes in technology must have been. They are likely to conclude that many modern

developments were hard to predict. For example, 100 years ago, no one foresaw the popularity of snowmobiles or all-terrain vehicles (ATVs), both of which have the potential of damaging restorations. By developing monitoring activities with the potential of uncovering unforeseen impacts, managers are prepared.

2. However, as we discuss in Chapter 10, we know that it is possible to anticipate some future changes. Students could discuss the possibility of estimating the probability of a newly arrived species' becoming a pest by looking at the characteristics discussed in Chapter 11 (see Section 11.4.1) and by keeping in touch with restorationists around the world. By so doing, managers can be on the lookout for potential pests during monitoring.

3. Students might take this concept further and suggest that monitoring protocols should be designed not only to look for site changes that move a restoration away from matching its goals, but also to try to determine what is causing the change. Doing so might involve establishing research projects, or even, as discussed below, to modifying the goals.

4. 4. Another point to look for in student responses is the importance of subjecting all restoration plans to a regular, systematic review process in order to respond to changes not anticipated from the beginning of a project. Flexible plans can respond to future kinds of human impacts in a number of ways, not the least of which is modifying restoration use-policies.

Question 5. Determining the attitudes and expectations of visitor groups to natural areas and restorations is important but can be fraught with difficulties. For example, what are the characteristics of the average visitor? Is there an average visitor? What do you imagine are some of the variables that determine visitor attitudes and expectations? How would you go about answering such questions?

How to Use or Expand on This Question

- One approach would be to do a before-and-after exercise:
  1. First have students answer the questions based upon their existing knowledge and experience.
  2. Next, invite a panel of experienced restoration planners and managers to describe their visitor experiences and programming.
  3. Finally, ask the students to tackle the questions again. (See the suggestions regarding panel presentations in connection with Food for Thought Question 1 above.)
- If you have easy access to a restoration site that is open to the public, you can assign students to visit the area and collect their own information about the visitors. There are a number of ways to go about this, ranging from making systematic observations about the visitors to conducting interviews or distributing questionnaires. Chapter 5 (see Section 5.10) discusses each of these in brief. The systematic observations work well for understanding how the visitors behave (what they do, where they go), and you can make informed guesses about age. However, to understand motivations, attitudes, expectations, user satisfaction, and the like, interviews or questionnaires will be needed. To create the assignment, it is important to remind students of the following:

1. Determine in advance the kinds of information you seek, design your protocol accordingly. This is true even if you aren't sure exactly what you are looking for. Just design the visit so that you can record anything of interest.
2. The privacy of the users must be protected, especially if you are conducting interviews. Your institution may have specific rules about how to ensure this. One way is to not use names or other identifying information in recording or reporting the information. Alternatively, you can have interviewees sign a consent form before the interview.
3. Try to be as inconspicuous as possible if you are observing how people use a restoration site. If people know they are being watched, they behave differently! (This principle is sometimes referred to as the Hawthorne effect.) One way to avoid detection is to act like a user yourself. Record your observations later or, better yet, use a digital recorder disguised in some way—cell phone?

- If there is no restoration site nearby, your assignment can be for the students to plan a visit to a site, either a known location or a virtual one. This is essentially a structured version of the final subquestion.
- Assign students to check the literature to discover what others have found about visitors to restorations or, more broadly, to nature preserves, wilderness areas, or conservation parks.

What to Look for in Student Responses

- The specific results will, of course, vary. Important themes to look for include:

1. The nature of the information researchers collect is influenced by the collection methods they choose.
2. Any generalizations or conclusions students present should be supported by evidence.
3. Students will likely discover that it is difficult to generalize about attitudes and expectations, and that working with the public in restorations adds layers of complexity and uncertainty that make simple answers elusive.

Have the students present their concepts and explain how these concepts would: (a) help managers manage, or (b) assist interactive communication/education between the public and managers, or (c) increase enjoyment and appreciation of the natural resource.

Sidebar: The Golden Gate National Parks Conservancy: Food for Thought Questions

- Go to the Golden Gate National Parks Conservancy website (www.parksconservancy.org) and read about the Park Stewardship program. What types of community groups are targeted for participation? What kinds of activities do you think would have the most appeal for volunteers from different age groups?
- What skills are required of someone looking to volunteer with the Golden Gate National Parks Conservancy, according to information on its website? Do you agree with the skill set described, or do you think the requirement should be different?

- According to the website, "Trails Forever interns work four days a week, ten hours a day with the same four- to six-person National Park Service trail crew." What do you think would be the highlights of this experience? What might be the challenges?
- Figure 12.7 shows the rope fence erected at the Presidio. However, restoration ecologists often use only a simple rope fence with hand-lettered informational signs to convince visitors to respect the restoration. How might you determine what type of fence to use for a given project?

What to Look for in Student Responses

Question 1: Park Stewardship Program

- When discussing the Park Stewardship program, students should include information from the Park Stewardship website. Students can navigate to this page by clicking on the "Get Involved" link from the homepage (www.parksconservancy.org) and then on "Volunteer," "Individuals," and then "Habitats." The points students should find include:

  1. The Park Stewardship program has three main groups, organized by county: Marin, San Francisco, and San Mateo.
  2. They have programs for:
     a) Individuals and families, ages 8 to adult (sign up or drop in for already scheduled days)
     b) Groups of 5 or more (arrange volunteer activity for the group)
     c) Youth (elementary, middle school, high school), including organized leadership training, internships, habitat restoration days for college students in conjunction with the City College of San Francisco and the College of Marin.
  3. Activities include:
     a) Beach clean-up and maintenance
     b) Restoration and monitoring of critical habitat
     c) Groundskeeping and historical site restoration
     d) Growing plants and caring for plant nurseries
     e) Leading tours and staffing visitor center
     f) Hawk watching and banding
     g) Trail maintenance and repair

  Note to instructors: The above information is current as of March 2012, be sure to check out the website yourself for up-to-date information.

- As to which activities might best appeal to different age groups, since this is an opinion question, there is no set answer; however, students need to be clear about why they reach the conclusions they do. Ask for more than "personal opinion." For example, students could cite their experiences in working with different age groups or find information in the literature.

Question 2: Skills required of volunteers

- The website indicates that no experience is required: "No experience necessary. Training and tools will be provided." Things students should consider in deciding whether this is a reasonable requirement include:
  1. Technical requirements of the activity
  2. Cost/benefit of teaching novice individuals how to do a task according to the managers' standards rather than having volunteers have to unlearn behaviors
  3. Likelihood of attracting volunteers with and without previous training
  4. Liability for accidents

Question 3: Trails Forever

- Information about Trails Forever can be found at: www.parksconservancy.org/programs/trails-forever
- Students should list the following highlights of being a Trails Forever volunteer:
  1. Learning to work efficiently with a small team
  2. Understanding and making use of individual strengths and weaknesses
  3. Having sufficient time to travel to a site and complete projects
  4. Enjoying 3 days off in a row
  5. Having weekday time to run errands.
- Students should list the following possible challenges of being a Trails Forever volunteer:
  1. Physically demanding sustained effort
  2. Issues with group members
  3. Boredom if work is too repetitive

Question 4: Fencing shown in Figure 12.7

Although many people follow simple cues such as the rope shown in Figure 12.7 (see textbook p. 355), others may not. Things students might consider include:

1. Danger to users if they go beyond a fence (steep slope drop-off, poisonous plants or animals)
2. Danger to the roped-off area (particularly fragile plants or animals)
3. Intrusion of the fencing material on the user experience (blocking a view, disrupting a natural experience)
4. Legal restrictions and liabilities

Supplemental Activities and Exercises

See the textbook website (www.introrestorationecology.com) for examples of activities.

Suggested Learning Objectives

Learning Objective 1. Identify user impacts and cross-boundary influences that require management actions.

Learning Level 1 Outcomes

- Students should be able to define the following terms:
    1. *Impact:* an action that interferes with the goals and objectives of a restoration
    2. *User impact:* an impact that occurs while people are onsite
    3. *Cross-boundary influence:* an impact that originates offsite.
- Students should be able to identify and list both onsite and cross-boundary influences.
- Students might include the following examples of user actions that can impact a restoration mentioned in the textbook:
    1. Trampling
    2. Soil compaction
    3. Loss of desired species through harvest or changed habitat
    4. Trash scattering
    5. Creation of unplanned trails
    6. 6Increased soil erosion
    7. Introduction of pest species
- Students might include the following examples of cross-boundary influences mentioned in the textbook:
    1. Storm water runoff
    2. Groundwater depletion
    3. Pollution (air, noise)
    4. Aesthetic degradation
    5. Source of pest species
    6. Herbicide drift
    7. Prohibition of the use of fire, herbicides due to adjacent land uses

Learning Level 2 Outcomes

- Students should be able to identify these or other impacts as being present on a particular site.

Learning Objective 2. Understand the role of the site use-policy in setting goals for the visitor experience and resource protection.

Learning Level 1 Outcomes

- Students should be able to explain the link between the restoration use-policy and the restoration goals aimed at providing a particular kind of user experience while at the same time protecting the biological/physical/ecological restoration goals. The use-policy attempts to create a balance between human benefit through site use and the site impacts brought about through that use.

Learning Level 2 Outcomes

- Students should be able to evaluate site use-policies for the potential to cause harmful impacts

Learning Level 3 Outcomes

- Students should be able to create site use-policies that effectively achieve the balance

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Learning Objective 3. Utilize social-ecological management plans for long-term protection from internal and external threats.

Learning Level 3 Outcomes

- Students should be able to recognize and create monitoring and management plans that address the components of community/ecosystem models that list current and potential stressors in order to anticipate and prepare for those stressors that may be caused by onsite and offsite human activities.

Learning Objective 4. Identify opportunities to build partnerships and collaborations with adjacent landowners.

Learning Level 1 Outcomes

- Students should be able to identify and describe potential cross-boundary influences that are potentially under the control of the owners/managers of properties adjacent to or in watersheds or landscapes of a restoration site (for example, stormwater runoff, herbicide use, the active cultivation of or encouragement of potential pest species).

Learning Level 3 Outcomes

- Students should be able to describe potential solutions for managing cross-boundary influences for a particular project.

Learning Objective 5. Employ a few simple onsite design techniques to manage visitor impacts.

Learning Level 3 Outcomes

- Students should be able to create a site plan so as to minimize damage from the site users

Potential Issues, Questions, and Misconceptions

- Experience has shown that one or two inappropriate human uses—for example, an unauthorized trail—are all it takes to establish a use pattern. Swift action is required to correct the situation

before it is too late to correct the impact. Ignoring the situation and hoping it will go away does not work.

- Restoration success is enhanced, and human impacts avoided or mitigated, by establishing support from citizens and public institutions from the outset of the restoration. Your strongest advocates and most faithful supporters are found in your local community.
- Many people are unaware of the undesirable impacts of their activities and are eager to change and help once they are given behavior alternatives. This human response is why you can count on avoiding or mitigating impacts by using planning approaches that include establishing visitor use policies in collaboration with local residents and potential user groups; managing impact through site design; establishing trail systems; managing the size of parking lots; and engaging the community to help with stewardship and outreach.

Online Resources

Parks for All Forever: The Nonprofit Partner of the Golden Gate National Parks

http://www.parksconservancy.org

Chapter 13

Working with People

In this chapter, we bring together themes concerning the human aspect of restoration that we have been introducing throughout the textbook. Ecological restorations are created by people for people. Most restorationists have come to recognize that understanding how people benefit by interacting with nature and what motivates humans to be concerned about the loss of natural areas is as important as understanding ecological processes and theory to creating successful restorations. In Chapter 12, we discuss human impacts; here we cover several of the ways in which people can actively participate in the planning and execution of restorations in all stages of the process, from planning to management. We focus in particular on tools for gathering input from potential stakeholders and on techniques for working with volunteers.

Major Themes

- Public support is crucial for the long-term survival of a restoration, whether it be a public or a private project. One of the best ways to gain and keep support is to involve as many members of the public as possible in all stages of the restoration process. Creating "involvement" means providing information and opportunities to take part in restoration activities and also soliciting and responding to opinions, even (and perhaps especially) to those opposing the project.
- Public opinion and participation are crucial during the creation of the master, site, implementation, and management plans and during the periodic formal reviews of the plans. Stakeholders can provide valuable background information at each of the stages and become important participants in the discussions of alternative solutions.
- Variations of the nominal group method are effective tools to involve stakeholders during public meetings and workshops.
- To create a successful volunteer program for a restoration project, it is important to build relationships among the land, the project, and the people involved with it and to treat everyone with respect. Volunteer programs provide training and learning opportunities, create social networks, give participants the satisfaction that comes from making a positive difference to the world, and even provide recognition in the form of tangible rewards.

Comments on Food for Thought Questions

Question 1. Building partnerships with landowners of property adjoining the restoration project area is a key factor in maintaining sustainable restoration projects in urban and suburban areas. Think about how you would engage these different groups to discuss and develop shared understandings of the concept of your restoration project.

How to Use or Expand on This Question

- You can use this question in a general sense as it is written, or you can provide more direction either by specifying a particular location or by creating a hypothetical site and context. You can use it as a charrette (see the discussion of Food for Thought Question 5 in Chapter 7 of this manual), as the basis for an in-class discussion, or as a take-home assignment. It is helpful if you give students a chance to do some research to supplement the information in the textbook with more examples and in-depth analysis before they tackle the question.
- The focus of the question is on engaging adjacent landowners at the beginning stages of the creation of the master plan. You could modify the question by focusing on different stakeholder groups—for example, members of a local civics club, members of a school conservation club, the local hunt club, or, if you specify that the project is on public land, current site visitors.
- You might also consider specifying a purpose and use-policy for the restoration.
- Another approach is to invite restoration professionals to give a presentation to the class about how they engage project neighbors or participate in a panel discussion about tips for interacting with the public. These interactions can be very engaging for students and panelists alike, especially with some advanced preparation for both groups!

What to Look for in Student Responses

- If you are using the general form of the question, student answers will likely focus on identifying the approaches for obtaining input from the public identified in Section 13.1.4 of the textbook, as well as in Chapter 6 (Section 6.1). These include:
    1. Holding initial brainstorming sessions
    2. Conducting public hearings and workshops to discuss potential alternative solutions
    3. Providing field trips to view the site and talk over the situation
    4. Scheduling opportunities for the public to provide written comments
- In addition, students should also be able to explain how to conduct a nominal group process in the context of these different approaches (see outline in Section 13.1.4) and to suggest ways to get in touch with the landowners through mailings or personal contacts (one way restorationists can identify property owners is by using local government web-based "property look-up" functions).
- If you use an actual site, students should include the general ideas identified above using the context of the specific assignment. For example, given a particular site, students can determine how many landowners live adjacent to the project versus conducting business there or simply managing the property. This will make a difference as to how to make contact. Similarly, if you choose to focus on a different group of stakeholders, determining how to identify, contact, and engage them will present different challenges.

Question 2. Land managers need to work at geographic and temporal scales that represent a broader context than the boundaries of their project areas; this requires management across ecological, political, generational, and ownership boundaries. Consider the geographic and temporal scales that would be applicable for a restoration project with which you are familiar.

How to Use or Expand on This Question

- You can use this question as the basis of an in-class discussion, an individual take-home assignment, or even as an essay question on an exam. To provide more focus, specify the restoration project—this could be a site in your area or the topic of a case study found on the web. The more concrete the situation is, the more specific the answers can be.

What to Look for in Student Responses

- This question is similar to the discussion of context asked about in Food for Thought Question 5 in Chapter 4, in which the focus is on physical and biological factors and sources of human impacts. It also relates to questions 1 and 2 in Chapter 7. In this case, the focus is on considerations of the dimensions of time and space and the operation of social as well as biological systems. Using examples from previous chapters as well as Chapter 13, students should address the following topics in their answers:

    1. Site history, from the perspective of selecting restoration targets (what native communities formerly existed either onsite or in the geographical region) and from that of selecting implementation techniques
    2. The regulatory arena, a nested hierarchy of scales in which local (municipalities such as villages, cities, or zones within cities); regional (in the US, town, county, state); and/or national (in the US, federal) governmental regulations may pertain.
    3. The stakeholders, who may include close neighbors or members of international organizations
    4. The cross-boundary interactions of plants and animals, storm systems, fire and water movement, and ecosystem processes such as nutrient cycles and energy flows

Question 3. Describe the methods you would use to maintain a high level of civic interest and participation in a restoration project. What would be the costs and benefits to your restoration project? What skills and talents would your restoration team need to have or acquire to be able to use these methods?

Question 4. What opportunities would you provide for volunteers to help you in the planning and goal establishment phases of your restoration project?

Question 5. Think of a restoration project that's familiar to you. Consider its role in the community, and define the community of interest. What perceptions does the local community have of the restoration project? How does the restoration draw upon the resources of the community to aid its work? What contributions does the restoration make to the community?

How to Use or Expand on These Questions (Question 3 through 5)

- Questions 3, 4, and 5 ask students to describe how the techniques covered in this and previous chapters might be put to use in restoration ecology. These work well as class discussion topics or as individual take-home assignments. Also refer to the discussion of Food for Thought Question 3 in Chapter 7 for suggestions as to how to use these questions.

What to Look for in Student Responses to Question 3 through 5

Responses to Question 3

- Students should describe how they would implement one or more of the following techniques:

  1. Holding initial brainstorming sessions
  2. Conducting public hearings and workshops to discuss potential alternative solutions
  3. Providing field trips to view the site and talk over the situation
  4. Scheduling opportunities for the public to provide written comments

  They should explain why each technique will engage the public and should provide step-by-step directions as to how they would use it (see for example, the steps given for the nominal group technique in the textbook). (This part of Question 3 is similar to some versions of Question 1, so you may not wish to use both.)

  The costs and benefits of the techniques might include:

  Cost: Expense of time and money

  Cost: Raising unfeasible expectations or unintentionally alienating people

  Benefit: Helping people feel ownership in the project

  Benefit: Alleviating fears

  Benefit: Opportunity to educate the public about the project and potentially clarify misconceptions

  The Chicago Preserve case study discussed in the textbook and mentioned in the "Resources for Further Study" section at the end of Chapter 13 can be a good resource for answering this part of the question.

Students should list, in addition to the skills described in Section 13.1.1, expertise in conducting public meetings, interacting with many different kinds of people, and organizational skills.

Responses to Question 4

- Students might mention that, in addition to providing the opportunity for volunteers to participate in the public engagement techniques that are the topic of Question 3 above, it can be a good idea to include one or more volunteers as members of the official planning team—the team that, for example, creates the plan alternatives that are discussed during public meetings.

Responses to Question 5

- The responses to this question will vary, depending on the situation. See the entry for the Food for Thought Question 3 in Chapter 7 for a discussion of how students might proceed to discover the perceptions of the local community, how community members are involved in the restoration, and the contributions the restoration makes to the community.

Sidebar: Teamwork: Food for Thought Questions

1. How do you define teamwork?
2. Do you think teamwork is necessary for all projects? Why?
3. What are the qualities of a good teammate?
4. Over the course of the project, did people's roles change?
5. When your team was at its best, what did it do well?
6. When your team was not performing well, what was it like for you? What would you have changed?

How to Use or Expand on These Questions

- We use these sidebar questions as the basis of an in-class discussion.
- The sidebar introduces Question 1 by asking students to reflect on their past experiences as a team member in any context. Because we use many group projects in our restoration courses, we like to ask a version of this question at the very beginning of the semester as a sort of pre-test, in order to understand how much experience students have had working in teams and the nature of that experience. Then, at the end of the class, we ask the question again. In both cases, this is usually in the form of a written response survey, either delivered through the University's web-based software or as a paper survey.
- Especially in our sophomore-level class (and also in our upper-level classes if we find that the teams are having difficulties), we spend time at the beginning of the semester discussing how to organize and work in problem-solving teams. As you know, there are many excellent resources available on how to create effective learning teams. You will find an example of one of the handouts we provide for the students on the textbook website (www.introrestorationecology.com).

What to Look for in Student Responses

- The responses to these sidebar questions will, of course vary. We look for students to provide their own definitions of "teamwork" rather than copying a definition found online. We also look for students to provide explicit explanations for their answers, preferably including specific examples.

For example, it is not enough to respond to Question 4 ("Over the course of the project, did people's roles change?") by answering yes or no. Students need to explain how the roles changed and what may have caused the switch. If you have chosen to provide background material on group learning or effective teamwork before asking the questions, students should refer to the information provided in creating their responses.

Supplemental Activities and Exercises

- There are a number of interesting case studies found on the Internet that describe volunteer programs associated with restoration projects. You might consider assigning students to compare and contrast the approaches used.
- Similarly, there are many articles describing volunteerism in general and conservation volunteers in particular. It is helpful to have students review one or more recent articles and provide brief summaries for the class—in essence, create an informal journal club for students to keep abreast of the latest findings.
- Many restoration projects sponsored by public and private conservation agencies maintain websites as part of their outreach programs to gain support for their projects. Have students review four to six examples and identify the strategies they use to attract public support and involvement (pictures, progress reports, announcements of volunteer opportunities or educational filed trips, and the like.)
- The case studies presented in Chapter 14 of the textbook all involve people. Have students use the textbook, the references found in the back of the textbook, and additional information they can find on the Internet to describe and document the different roles of people in one or more of the projects (e.g., as members of the restoration team; political supporters; participants in public meetings; volunteers involved in implementation, monitoring, or management; users; field trip leaders; or other possibilities).

Suggested Learning Objectives

Learning Objective 1. Assess the common interests and differences that exist in a stakeholder group concerning restoration values, practices, and procedures.

Learning Level 1 Outcomes

- Students should be able to define, using their own words, "stakeholder group," "restoration values," "restoration practices," and "restoration procedures."
- Students should be able to identify different stakeholder groups.

Learning Level 2 Outcomes

- Students should be able to identify the interests of members within a particular stakeholder group concerning restoration values, practices, and procedures and should be able to identify common patterns of similarities and differences.

Learning Objective 2. Design a strategy for using an array of tools and techniques to develop public involvement in planning and management.

Learning Level 1 Outcomes

- Students should be able to identify the public involvement techniques mentioned in the textbook, including, for example:
    1. Public workshops and meetings
    2. Participatory planning techniques, such as the nominal group method
    3. Volunteer programs
    4. Field trips

Learning Level 2 Outcomes

- Students should be able to discuss the pros and cons of the different techniques they have identified.

Learning Level 3 Outcomes

- Students should be able to provide directions for carrying out each of the techniques mentioned above in order to involve people in a specific restoration project.

Learning Objective 3. Identify several ways to build and maintain community interest in, and support for, your restoration.

Learning Level 1 Outcomes

- Students should be able to list such approaches as:
    1. Reaching out to the community using various forms of media—websites, social media sites such as Facebook or Twitter
    2. Creating educational experiences and skill and leadership training opportunities
    3. Organizing community festivals and other events

Learning Level 2 Outcomes

- Students should be able to critique existing examples of restoration outreach programs and to devise ways to evaluate their effectiveness.

Learning Level 3 Outcomes

- Students should be able to design an outreach program for a particular restoration.

Learning Objective 4. Recognize the constraints and opportunities of working in the regulatory arena.

Learning Level 1 Outcomes

- Students should be able to describe, in their own words, what is meant by the "regulatory arena" and to list examples, such as local laws governing burning or state laws regulating pesticide use.

Learning Level 2 Outcomes

- Students should be able to describe which regulations apply to a particular restoration situation.

Learning Level 3 Outcomes

- Students should be able to evaluate whether a specific regulation has a positive or negative effect on restoration (or perhaps both in different ways) and to suggest better alternatives.

Learning Objective 5. Understand what motivates people to volunteer.

Learning Level 1 Outcomes:

- Students should be able to list and correctly identify the following motivations discussed in the textbook:
    1. For educational experiences
    2. To acquire an avocation
    3. To learn new skills
    4. To teach skills or knowledge to others
    5. For a social experience and to make new friends
    6. To contribute to society and make the world better
    7. To enjoy nature
    8. To enjoy physical labor

Learning Objective 6. Apply a range of techniques to reward and retain volunteers.

Learning Level 1 Outcomes

- Students should be able to list a variety of approaches used in restoration to cultivate volunteers. Some that are mentioned in the textbook include:
    1. Providing a variety of jobs (website management, physical labor, individual and team projects, for example)
    2. Matching tasks with volunteer skill levels to ensure success
    3. Treating volunteers with respect
    4. Providing training and feedback
    5. Providing recognition and other rewards (food!)

Learning Level 2 Outcomes

- Students should be able to evaluate existing volunteer programs and provide directions as to how to apply each technique.

Learning Level 3 Outcomes

- Students should be able to design a volunteer program for a restoration project.

Potential Issues, Questions, and Misconceptions

- Students who are primarily interested in restoration ecology from the perspective of creating complete restorations or habitat for the preservation of endangered species often underestimate the importance of addressing the social dimensions of restoration. One thing we try to stress is that every plan should consider people, if only as sources of political and financial support. Starting with the creation of the restoration use policy, all restoration plans should address how people will interact with the site, and how to maintain the interest and support of the human community.
- Restoration volunteers are often essential to the implementation and management of a restoration. Sometimes, however, the dedication and involvement of long-term volunteers can lead to conflicts as to who is in charge of a project—the professional staff or the volunteers. Different ideas as to how to proceed if unexpected events occur or if priorities are not held in common can lead to conflicts resulting in hurt feelings and consequent withdrawal of physical, monetary, and political support for a project. For example, if volunteers believe that it is imperative to physically remove a previously unstudied invasive species and managers wish to begin with a series of experimental trials to determine the best way to proceed, problems can arise.

  Similarly, restoration teams often underestimate the resources required to maintain a volunteer program. It takes time and resources to train people and to provide them with incentives to keep involved once they are trained. Sometimes managers would rather do the work themselves in the short term, thereby sacrificing the long-term benefits of having an engaged and supportive cadre of community supporters.

  It is important to acknowledge these and other possible downsides of using volunteers.

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