Photo by Babs McDonald.

At Your Service

Developing Models To Help Natural Resource Managers Make Better Decisions

◄ **Dr. Colin Beier**, Ecologist: My favorite science experience was the first time I visited Chichagof (**chə** chug ȯf) Island in southeast Alaska. We left Juneau and flew across the islands and ocean channels in a four-seat floatplane, circled, and landed in a beautiful green-water cove. We spent the next 2 weeks camping and doing fieldwork. We were studying why Alaska's yellow-cedar trees were dying across southeast Alaska and collecting samples from the cedar trees to measure their rings.

While doing fieldwork, we encountered several big coastal brown bears. We had one very close call with a mother and her cubs. It was scary at the time, but also an amazing experience. I was deep in the ancient rainforest surrounded by two of my favorite things—huge trees and huge bears.

► **Dr. Trista Patterson**, Ecological Economist: My favorite science experience is kind of "the darkness before the dawn." So many times I've been hashing over a difficult problem for weeks, months, years… and then one day some missing piece falls into place. Usually when this experience occurs, I am not in my office or in front of a computer. I am hiking with a colleague or having a conversation about something totally different and unexpected with someone I've just met!

For more information about Dr. Patterson, download her scientist card at http://www.naturalinquirer.org/scientists-v-92.html (Set 8). Photo courtesy of Doug Demarest.

◄ **Dr. Terry Chapin**, Ecosystem Ecologist: My favorite science experience has been talking with Alaskan Native hunters. Alaskan Native people depend on hunting and fishing for food and for their cultural connections to the land and sea. These men and women know how climate change is affecting Alaskan ecology more directly than does any scientist. I've learned from them that the ice is thinner and more dangerous for winter travel. I've learned that new birds and fish are appearing, and the ones on which they have depended in the past are changing in behavior and health. These changes affect all aspects of their lives. These Alaskan Natives, however, have good ideas about how they and the ecosystems on which they depend can adapt to change.

What Kinds of Scientists Did This Research?

ecological economist: This scientist studies the relationships between human **economies** and natural ecosystems.

ecologist: This scientist studies the relationships of living things with each other and with the nonliving environment.

ecosystem ecologist: This scientist studies the physical and biological characteristics of an ecosystem and how these characteristics interact with each other.

Thinking About Science

How do the words "adaptive management" relate to science? If you read the introduction to this journal, you already know something about adaptive management. Adaptive management is treating decisions as experiments and learning from successes and failures. Managing adaptively means being willing to change actions and try something new. Natural resource managers are the professionals who practice adaptive management. These managers, however, rely on scientists to create models, design ways to **monitor** natural resources, and evaluate results so that the managers' decisions are based on scientific information.

To be successful, adaptive management relies on a team of professionals. This team involves scientists and managers working together. In this article, you will learn how a team of scientists created models to help managers improve their decisionmaking. For more information about models, read "Welcome to the Scientific Models in Adaptive Management edition of the *Natural Inquirer*!" on page 4.
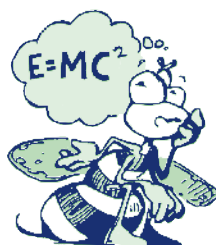
Thinking About the Environment

Although many things about the natural environment are uncertain, one thing is certain: the environment will continue to change. Human activities have caused environmental change to happen faster in recent decades. With change comes uncertainty—we are not always sure what will happen. One way that natural resource managers prepare for change is by using adaptive management. Managers use adaptive management so they can make the best decisions possible about protecting and using the environment.

Some environmental changes occur naturally. Volcanoes, floods, and earthquakes are natural events that create sudden change. Human activities can also create rapid change, as when a forest is cut down to build a shopping mall (**figure 1**). Some human-caused changes occur over longer periods of time. Climate change, for example, is one change that is creating uncertainty about the future. In this research, you will learn how scientists use information to help managers prepare to make good decisions, in spite of change and uncertainty.

Figure 1. Sometimes, humans cause rapid environmental change. Photo by Babs McDonald.

Introduction

Natural resource managers often face a **dilemma**. When a natural area provides a lot of ecosystem services, many people want to use the services in that area. This use can disturb ecosystems. Humans can disturb ecosystems when one service is used at the expense of another service. An example of this tradeoff is using an area to produce food. When land is used to produce food, wildlife habitat is lost. Too much disturbance can, in time, reduce the amount of all ecosystem services provided. This reduction occurs because the natural area becomes **degraded.** After an ecosystem is degraded, people cannot benefit from its many services. A degraded ecosystem can take many years to recover.

This dilemma of too much use might happen to many natural areas at the same time. When many areas need attention, natural resource managers must have a way to determine which areas need the most attention. Natural resource managers have limited time and money but must work in large areas that cover many hundreds or thousands of hectares. Managers need a way, therefore, to identify **priorities** for natural resource management.

The scientists in this study developed a process to help managers identify management priorities. The managers needed a process that is useful as conditions change over time. As conditions change over time, the managers wanted to adapt their management priorities to fit the changing conditions.

Glossary words are **bold** and are defined on page 30.

Reflection Section

- What was the problem the scientists were trying to solve?

- Identify one area of your life in which you have to set priorities.

- What is one similarity between your need to set priorities and the managers' need to set priorities?

What Are Ecosystem Services?

Ecosystem services are the variety of benefits that ecosystems provide to people. These services include, for example, clean air, clean water, pollination, food, control of climate change, wildlife habitat, outdoor recreation, soil **erosion** control, building products, and scenery (**figure 2**). As you can see, a lot of different kinds of ecosystem services can be identified. For more information, download or order the *Natural Inquirer* "Ecosystem Services" edition at http://www.naturalinquirer.org.

Figure 2. Name two ecosystem services being provided by this ecosystem. Photo by Babs McDonald.

What Is Adaptive Management?

Have you ever heard that experience is the best teacher? This idea is the foundation of adaptive management. Adaptive management is a way for land managers to deal with an unknown future and to learn from trying new things. When land managers try something new, the outcome is evaluated. Based on the evaluation, the managers try another approach to improve their management. The process continues, and managers continue to learn and adapt.

Scientists often help managers by designing and implementing the evaluation process. As you can see, scientists are involved in some parts of the adaptive management process. Land managers, however, treat the entire adaptive management process as an experiment. What occurs when you do an experiment? Hopefully, you learn from your experience!

Methods

The scientists first developed an illustration (**figure 3**). This illustration is a model that shows the relationship between ecosystem services and human use of natural resources.

The scientists and managers then created models of what might happen as more or fewer natural resources are used (**figure 4**).

The scientists studied the ecosystems of southeastern Alaska (**figures 5 and 6**). They collected existing information about the ecosystems from different sources. The information described southeastern Alaska's land characteristics.

The scientists were interested in the following characteristics: (1) physical land characteristics, (2) human use, and (3) disturbance caused by human activities.
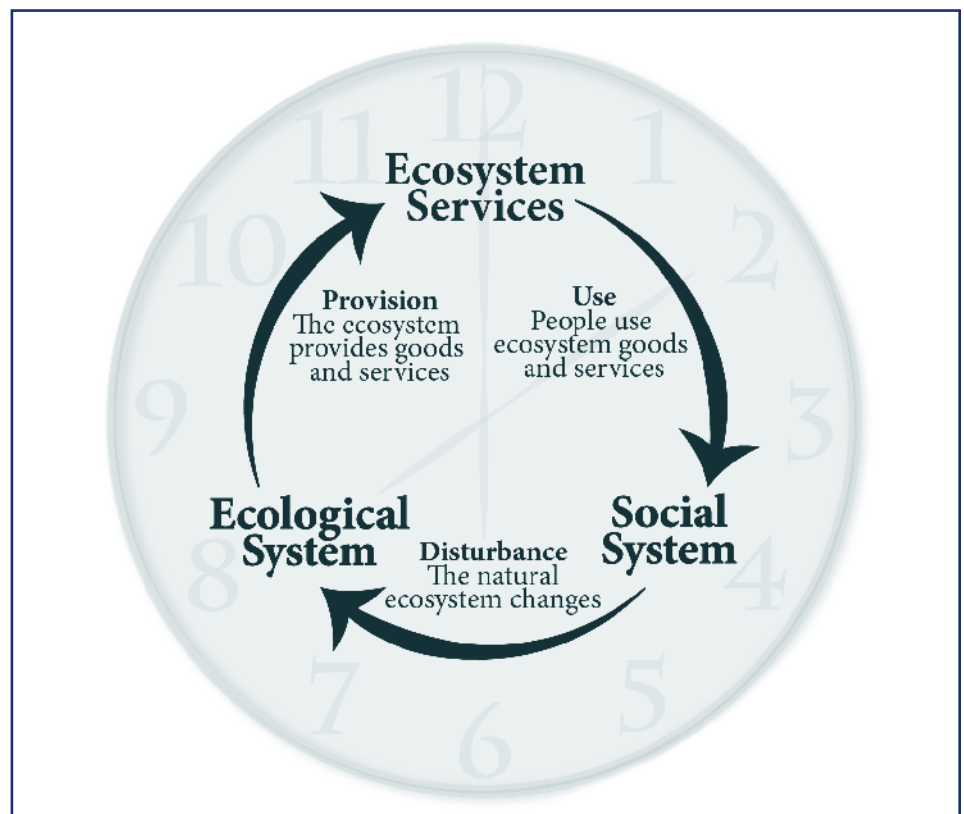

Figure 3. Ecosystem services, human use, and ecosystem **disturbance** are related to each other. Pretend this model is sitting inside a clock face. In this model, an ecosystem is shown at 8 o'clock. At 10 o'clock, the model shows that the ecosystem provides ecosystem services. At 2 o'clock, the model shows that people use ecosystem services (the social system). At 6 o'clock, the model shows that too much human use may result in disturbance to the ecosystem. The scientists included changes that result from natural resource management as a disturbance. They considered management a disturbance because management modifies the natural ecosystem. Illustration by Stephanie Pfeiffer.
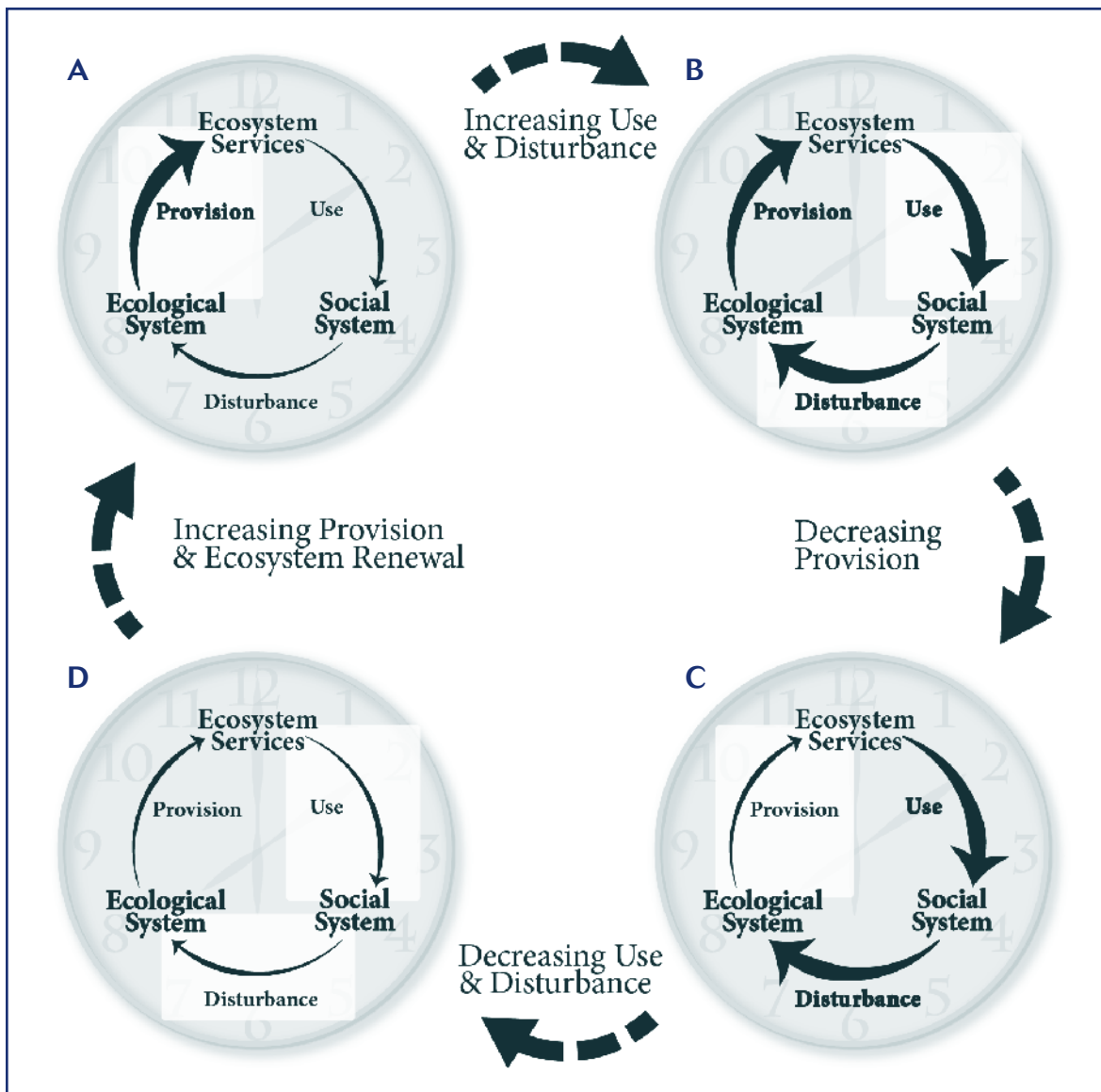
Figure 4. This illustration is a model representing what can happen to ecosystems when people use natural resources. Arrow thickness represents the **magnitude** of ecosystem **provision**, use, and disturbance. Illustration by Stephanie Pfeiffer.
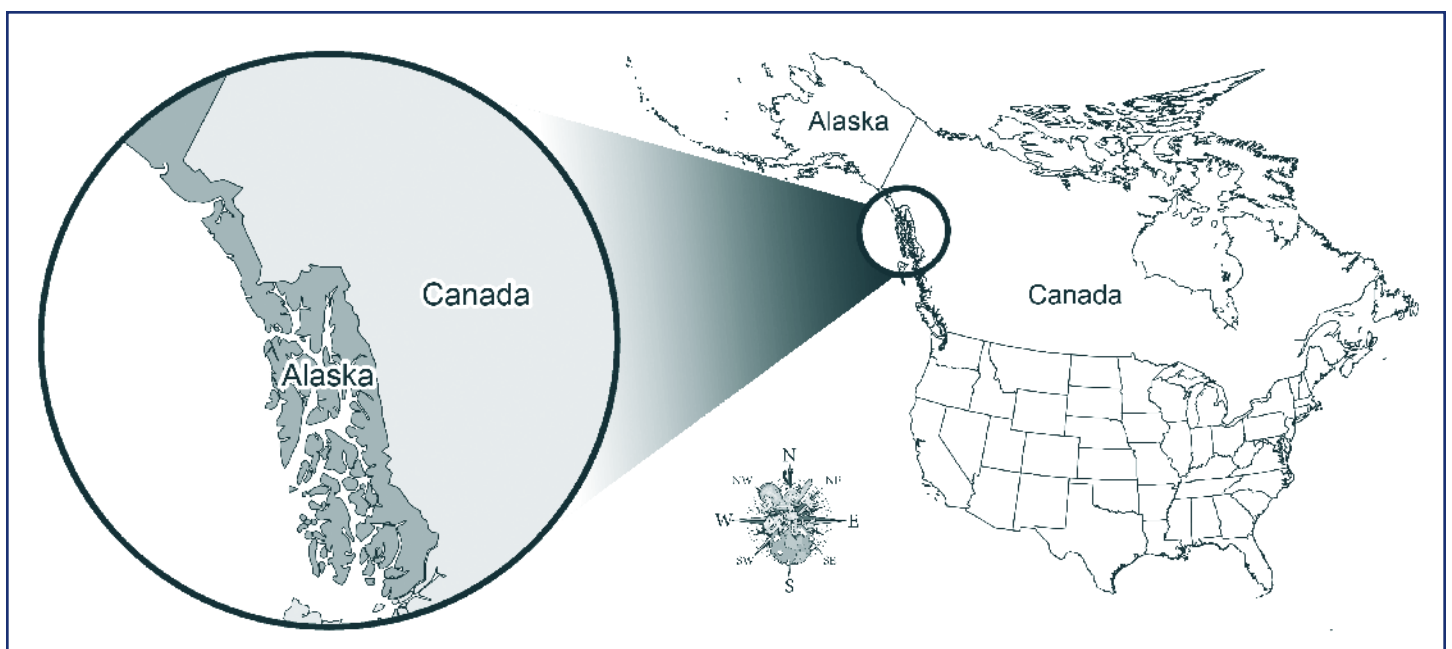

Figure 5. The scientists studied southeastern Alaska. Map by Lindsay Gnann.
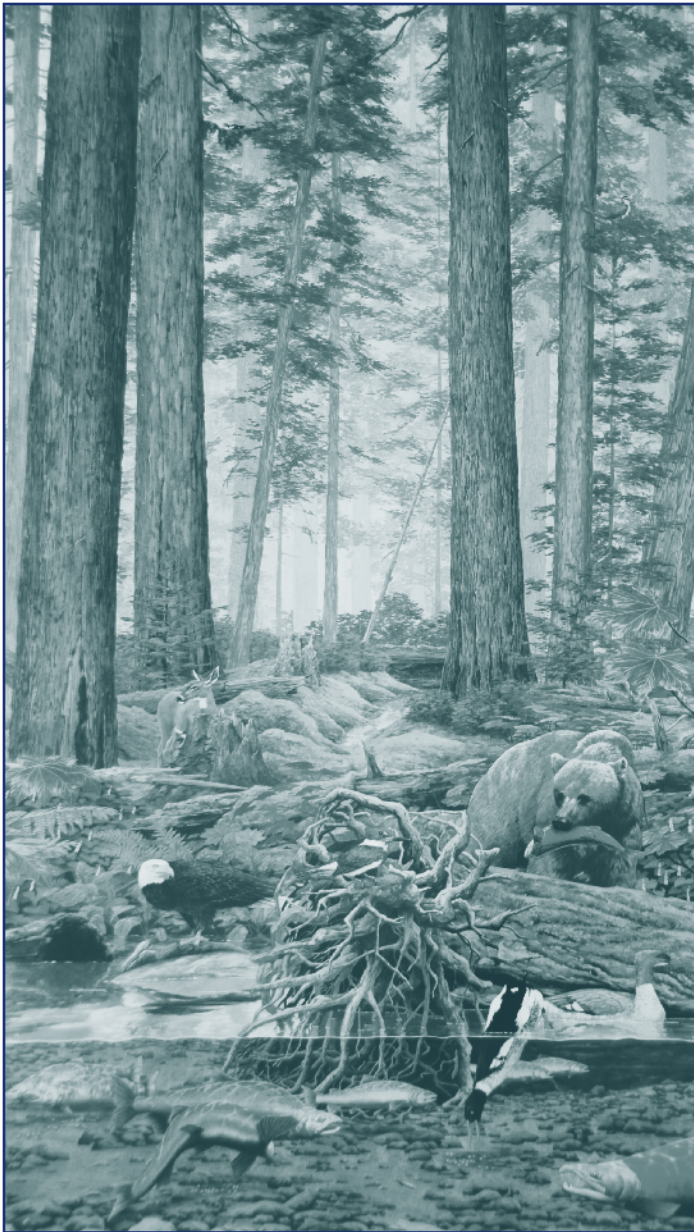
Figure 6. Southeastern Alaska is a **temperate** rain forest. Some areas of southeastern Alaska receive an average of 160 inches of rain every year. Poster courtesy of Paul Kratter, http://www.paulkratter.com.

Number Crunch

🍁 How many centimeters of rain fall in some areas of Alaska's temperate rain forest? Multiply 160 inches by 2.54 centimeters to find out.

The scientists gathered this information from different sources. The scientists placed each of the **variables** under one of the three parts of the model shown in figure 4 (**figure 7**). These three parts of the model were called **criteria**.

Criteria	Variables
Provision of ecosystem services	Number of hectares of forest lands capable of providing timber or other forest products
	Number of hectares of forest lands providing deer and bear habitat
	Number of kilometers of rivers and streams providing salmon and trout habitat
	Number of kilometers of rivers and streams providing habitat for a variety of fish
	Number of hectares of areas providing waterfowl habitat
Use	Amount of seafood and shellfish caught; sport-fishing
	Numbers of deer and bear killed during hunting season
	Number of cabins available for people to use
	Number of hectares used to transfer logs from land to sea
	Number of hectares used for harbors
	Number of hectares used for fish **hatcheries**
	Hectares of water used for fish farming
Disturbance	Number of hectares of harvested forest lands
	Number of hectares in urban areas or for urban use
	Number of roads crossing salmon streams

Figure 7. The scientists grouped the variables under three criteria.

Adaptive Management in Your Life

Do you have an outdoor classroom in your schoolyard? If you do not, pretend that you do. Your class has decided to use adaptive management to improve the outdoor classroom. First, you must identify the problem and your objective. Let's say that the outdoor area has no habitat for lizards. A lack of lizard habitat is the problem. Your objective is to have at least one lizard species visiting the outdoor classroom. Your class does research in the media center. You identify a way to use rocks to create a habitat that is favorable to lizards. Your class creates the habitat. After 2 weeks, you observe and record any lizard species in the area. One lizard species is identified.

After evaluating your results, your class does more research. You discover that lizards like shallow pools of water. You create a shallow pool, wait 2 more weeks, and observe and record the lizard species present. After evaluating the results of your management, your class does more research. You discover that lizards like to have a variety of places to hide. What steps will you take next?

When the scientists were finished, they had one **database**. The database contained variables describing the ecosystem services provided, human use of the ecosystem, and any human-caused disturbance. For each of the criteria, the scientists calculated one number. This number represented the magnitude of the ecosystem services being provided, the amount of human use of the natural resource, or the amount of disturbance.

Using equations, the scientists calculated a score for each criterion (criterion is the singular of criteria) for every watershed in southeastern Alaska. Using the three scores, the scientists compared the relationships between provision, use, and disturbance for each watershed. The scientists wanted to identify the watersheds that provided a lot of ecosystem services, had a lot of human use, and had a high level of disturbance. Managers should focus their management activities on these watersheds.

What Is a Watershed?

A watershed is an area of land where all the water that is under it or drains off of it goes into the same place. The United States has 2,267 watersheds (**figure 8**).
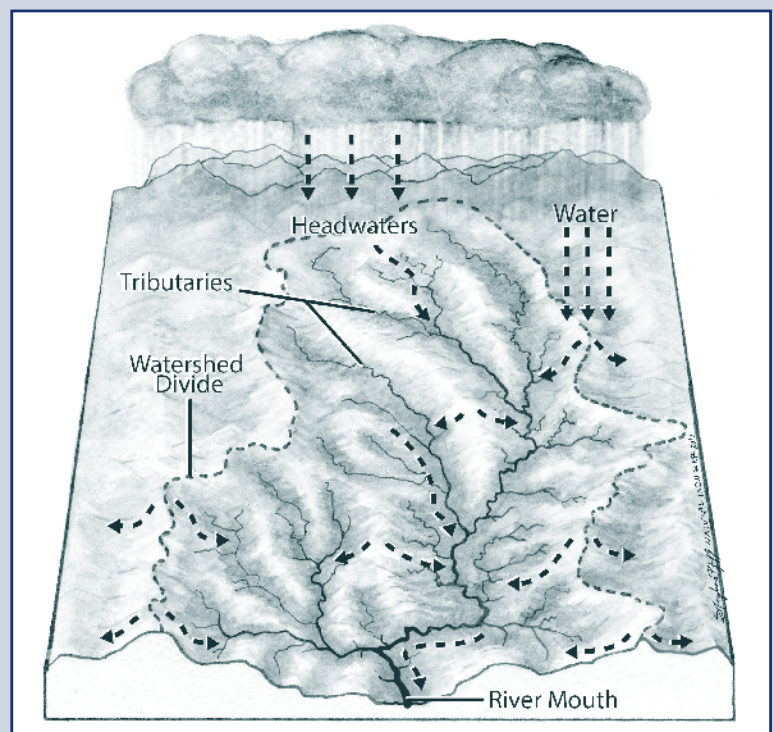

Figure 8. All the water in a watershed drains into the same place. Do you live in a watershed? How do you know? Illustration by Stephanie Pfeiffer.

Reflection Section

🍁 Look at figures 3 and 4. Pick one of these figures and explain it in your own words.

🍁 Look at figure 7. Do you think these variables completely described southeastern Alaska's ecosystems? Why or why not?

You Are the Adaptive Manager!

In this article, you are learning about research and evaluation as a part of the adaptive management process. One important feature of adaptive management is its focus on an uncertain future. Scientists help managers by doing research. Scientists provide information that can be used to predict what might happen in the future. Pretend you are the land manager of the area being studied in this research. How would you use the findings of this study? What management action would you take? After taking the action, what would you do next?

Findings

The scientists identified a group of watersheds in which high provision, high use, and high disturbance were closely related. The scientists were able to use some of this information to create a map of southeastern Alaska (**figure 9**). This map is a geographic model of natural resource relationships in southeastern Alaska.

Reflection Section

🍁 Which illustration in figure 4 describes the situation in which the scientists were most interested? Based on this model, what is likely to happen to an ecosystem described by illustration B?

🍁 How will the identification of high provision, high use, and high disturbance areas help managers make better natural resource decisions?
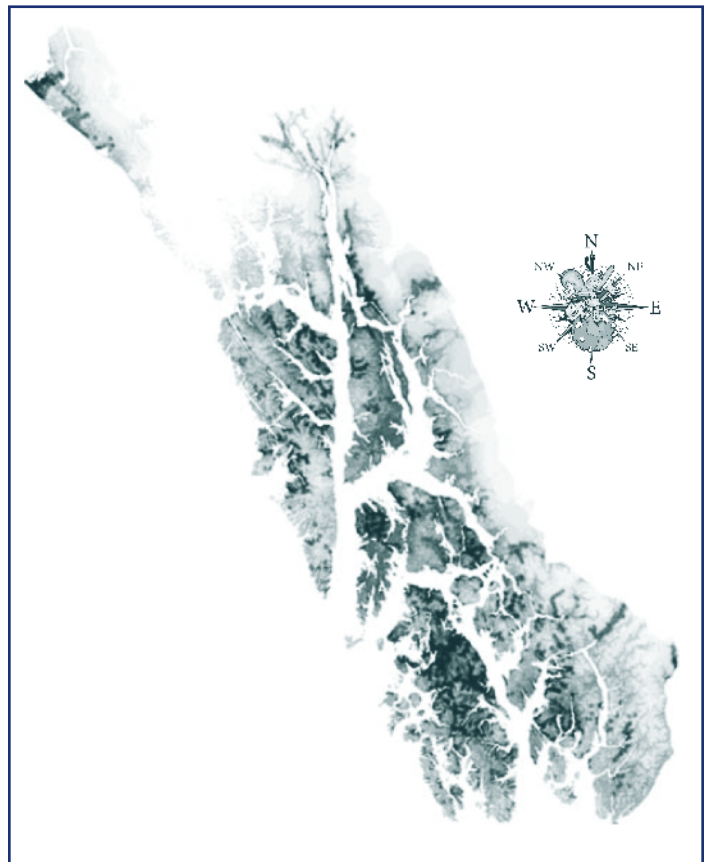

Figure 9. The relationship of ecosystem provision, human use, and human disturbance in southeastern Alaska. Darker areas show a closer relationship among the three criteria. These dark areas represent priority areas for management.

Discussion

The scientists believe that more accurate and complete information about southeastern Alaska should be included in the model. Managers need the most accurate information available to successfully identify priorities. The number of people using an area for recreation, for example, would be a more accurate measure of use than the number of cabins available.

The scientists believe the model they developed will be useful to natural resource managers. Identifying areas where ecosystem provision, use, and disturbance are greatest can help managers set management priorities. Identifying these areas will help managers take action based on these priorities. By using models, mathematical equations, and new information in those equations, managers can make better decisions and take better actions as conditions change.

Reflection Section

🍁 If you were a scientist doing this study, would you recommend that managers base their natural resource management decisions on the map in figure 9? Why or why not? (Hint: Reread the first paragraph in the "Discussion" section.) What is one advantage and one disadvantage of basing management decisions on the map in figure 9?

🍁 Explain in your own words how models and mathematical equations can help natural resource managers make better decisions about changing ecosystems.

Glossary

criteria (krī **tir** ē ə): Standards upon which a judgment or decision may be based. Singular is criterion.

database (**dā** tə bās): A usually large collection of data organized especially for rapid search and retrieval (as by a computer).

degrade (dē **grād**): To lower to an inferior or less effective level.

dilemma (də **le** mə): A usually undesirable or unpleasant choice.

economy (ē **kä** nə mē): A system of interaction and exchange; often relates to the exchanges of goods, services, and money.

ecosystem (ē **kō** sis təm): A system made up of an ecological community of living things interacting with their environment especially under natural conditions.

erosion (i **rō** zhən): The state of being washed away.

hatchery (**ha** chə rē): A place for hatching eggs.

magnitude (**mag** nə tüd): Size, quantity, or number.

monitor (**mä** nə tər): To watch, keep track of, or check usually for a special purpose.

priority (prī **or** ə tē): A condition of being given attention before others.

variable (**ver** ē ə bəl): Something that is able or apt to vary.

Accented syllables are in **bold**. Marks and definitions are from http://www.merriam-webster.com.

FACTivity

Time Needed

One class period

Materials

- "At Your Service" article
- Blank piece of paper (one for each student, plus a blank paper for each group)
- Pencils (one for each student)
- Graphic organizers (in the following section)

A model is a simple representation of a system. The model can be an illustration (as **figures 3** and **4**), it can be a mathematical model and include symbols such as the equation v = h * w * l (volume = height times width times length), or it can be a physical model, such as a model car. A map may also be considered a model.

In this FACTivity, you will create an illustration model of your schoolyard's ecosystem. The question you will answer in this FACTivity is: How is a schoolyard ecosystem model similar to and different from the ecosystem model created for southeastern Alaska?

Methods

Your teacher will have you work with other students in small groups. First, you will critically review **figure 3** from this article. Based on what you learned in the article, draw a model of your schoolyard's ecosystem. The goal is to produce a model that describes how the schoolyard ecosystem works. The model should include natural and human criteria. (You may go outside to observe and record your observations about the schoolyard ecosystem.)

Use your own paper and pencil to sketch ideas. The final model for each group should be developed as a group and drawn on the extra blank paper. Ask questions such as:

- What ecosystem services are provided by the schoolyard ecosystem?
- Is the schoolyard ecosystem used and if so, how and by whom?
- Does the schoolyard ecosystem experience disturbance and if so, what kinds?

You should also ask whether other criteria should be added to your schoolyard model. Use your imagination and creativity to create your model. Develop a list of criteria that will become a part of you model.

Think about every aspect of your schoolyard ecosystem. For example, think about the ecosystem services your schoolyard provides. One way to analyze this process is to identify variables for each identified criterion. Thoroughly label each model. After your group completes its model, compare and contrast it with **figure 3**. Use the graphic organizers on pages 32 and 33 to guide your work.

Your teacher will hold a class discussion about the model-building exercise. Compare and contrast each group's model. What do the models reveal about the similarities and differences between the schoolyard ecosystem and the ecosystem studied in southeastern Alaska? The graphic organizers presented next may be used to guide the discussion and listing. Finally, as a class, brainstorm a list of model characteristics.

Schoolyard ecosystem criteria	Schoolyard ecosystem variables
Example: Ecosystem: natural characteristics	Example: Number of trees
	Example: Number of acres/hectares
Example: Ecosystem services provided	Example: A place to play outside
	Example: Habitat for songbirds

Similarities between schoolyard ecosystem and southeastern Alaska ecosystem	Differences between schoolyard ecosystem and southeastern Alaska ecosystem

Model characteristics

FACTivity Extension

Time Needed

At least 30 minutes

Using the list of criteria and variables for the schoolyard ecosystem, develop ways to measure the variables you have identified. After this exercise has been completed, your teacher will hold a class discussion about measurement and its importance to scientific study.

In this FACTivity, you will create a management objective for your schoolyard. Then you will create an adaptive management process. Review the sidebar titled, "Adaptive Management in Your Life" on page 28. You may also review the adaptive management models on page 5.

Time Needed
One class period

Materials
- "At Your Service" article
- A blank piece of paper
- Pencils (one for each student)

Methods
Working in small groups with other students, draw a circle on your paper. Beginning at the top, write a statement that describes your management objective. Examples of management objectives include: (1) develop a wildflower garden, (2) reduce stormwater runoff from parking lots, (3) improve landscaping at the school's entrance, and (4) provide habitat for three songbird species. Pretend you are a land manager practicing adaptive management. Write the cyclical steps you would take to address your management objective. Your teacher should emphasize that adaptive management includes the following four steps:

- Plan (in which a management objective and actions are identified)
- Act (in which a management action is taken)
- Monitor (in which data are collected and analyzed to determine the effect of the management action)
- Evaluate (in which learning occurs and informs the next round of management actions)

Remember that adaptive management does not have an endpoint. Focus on developing a cyclical process where you are learning from experience.

Note that you can use the information and model created in the first FACTivity to help identify management objectives.

Your teacher will hold a class discussion about adaptive management. Explore whether this process could be used in other areas of an individual's life. You may want to develop an adaptive management process for a personal objective.

Note to Educators: If you are a trained Project Learning Tree (PLT) educator, you may use "Forest Consequences" as an additional activity.

The title "At your service" is a phrase that means "Committed to satisfying you." How do you think this title relates to the article you read?

Web Resources

Ecological Society of America: Ecosystem Services
http://www.esa.org/ecoservices/comm/body.comm.fact.ecos.html

Forest Service: Ecosystem Services
http://www.fs.fed.us/ecosystemservices/

Natural Inquirer Ecosystem Services edition
http://www.naturalinquirer.org/Ecosystem-Services-Natural-Inquirer-i-26.html

Ecological Disturbances
http://en.wikipedia.org/wiki/Disturbance_(ecology)