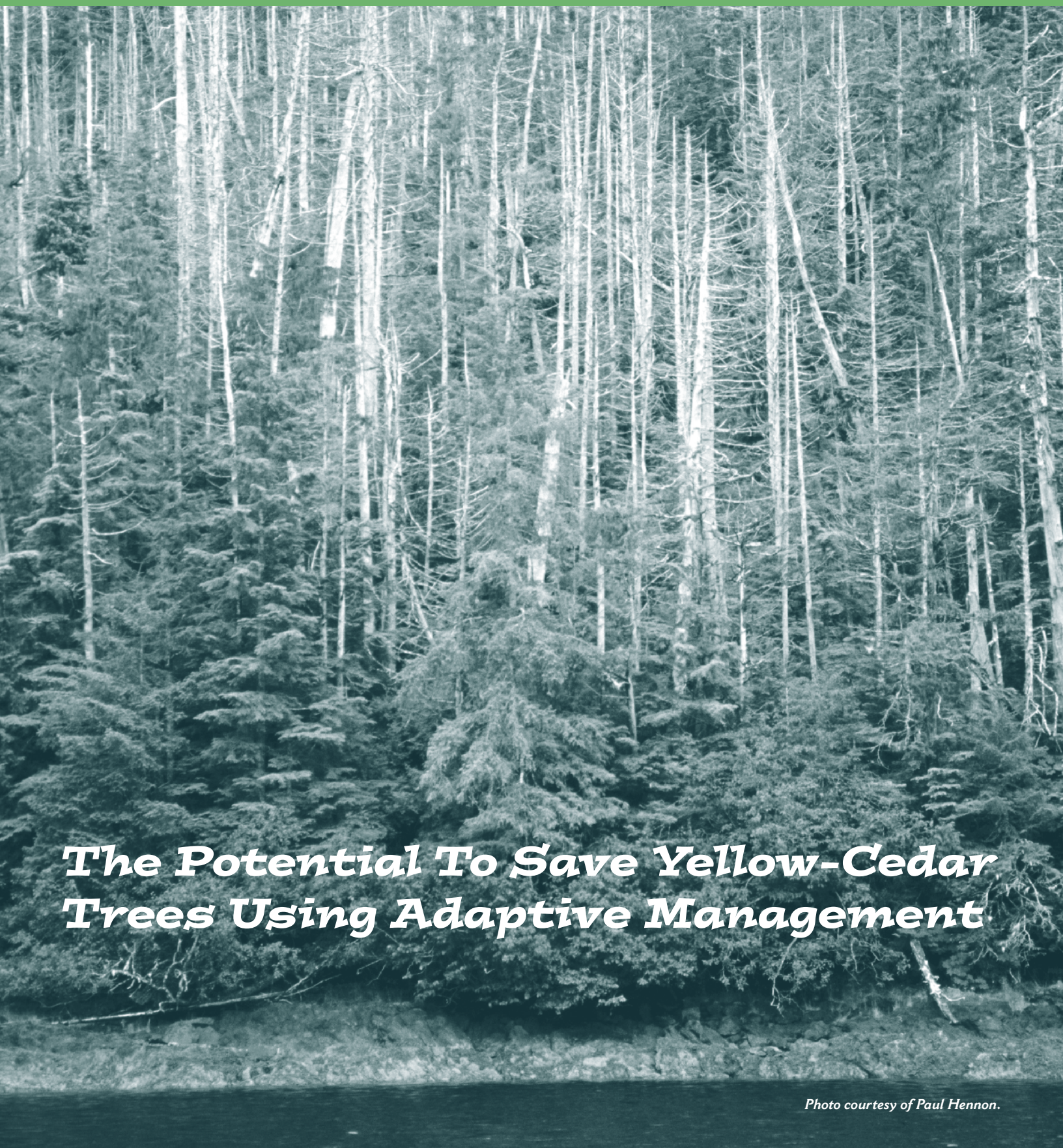
Cedar Waxing or Waning?



The Potential To Save Yellow-Cedar Trees Using Adaptive Management

Photo courtesy of Paul Hennon.

Meet the Scientists

◀ **Dr. Paul Hennon**, Plant Pathologist: My favorite science experience is working on a research team with scientists from different fields. Plus, my job takes me to so many remarkably beautiful, **pristine**, and remote places.

◀ **Dr. Dustin Wittwer**, Geospatial Services Specialist: My favorite science experience is collecting and analyzing geographic data from the remote and wild locations of Alaska. I love testing and using new and innovative technology to collect geographic data. After collecting the **spatial** data, I feed it into Geographic Information Systems (GIS), like Google Earth, and then use the geographic data to solve scientific puzzles.

I used geographic data to help determine the causes of tree death in Alaska. I flew in small floatplanes and used mobile computer mapping systems and global navigation satellite systems to collect the data. We would be so remote at times that the airplane pilot would camp with us at the end of each day. The work, however, wasn't always without risk. One time the airplane's engine failed, and we had to land without power. Fortunately, the plane had floats, and we could glide to the water. I've also encountered bears, wolves, whales, caribou, moose, and musk ox while collecting data. I think seeing Alaskan wildlife is pretty cool!

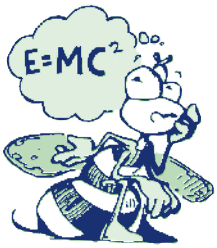
▼ **Dr. David D'Amore**, Soil Scientist: My favorite science experience was conducting bird surveys in the forest. I assisted the bird survey crew and had to get up before dawn, which meant 2 a.m. in Alaska. We hiked up into the forest, sat down in an area, remained very quiet, and listened to the different birds calling in the early morning light. During my normal workdays, I would be moving around making all kinds of noise, measuring trees, shouting instructions, or digging soil pits. I was amazed to hear the "noise" of the forest after I was quiet enough to listen.

▶ **Dr. Colin Shanley**, Geographic Information Systems Analyst: My favorite science experience was spending the summer tracking mountain goats by foot in the Cascade Mountains of Washington and Oregon.

◀ **Dr. Paul Schaberg**, Plant Physiologist: My favorite science experience is getting an unexpected result to an experiment. Sure, it is great to develop a hypothesis, test it in an experiment, and then get results that show your hypothesis was correct. But sometimes you get results that are surprising and interesting. The results teach you something totally new. These **novel** results can be very exciting. They help open up your imagination to unique thoughts and lead to the development of new hypotheses, new experiments, and new insights about the natural world.

Glossary words are **bold** and are defined on page 58.

Thinking About Science



Some research questions are complicated and can take many years to answer. Sometimes, many research studies are needed to discover the answer. When a research question is complicated, it may be answered slowly by different studies and over many years. Each study usually confirms or disproves what is thought to be true about one aspect of the question. In this research, the scientists wanted to know why a particular tree **species** was dying in the north Pacific coastal rainforest. To discover why this species was dying, scientists had to investigate aspects of the question one by one. When they got one answer, they were ready to advance to the next study.

This process of asking research questions, getting answers, and then asking more questions is similar to adaptive management. In adaptive management, however, managers make decisions and take actions each time new information is discovered. For scientists and managers, these actions create new research questions to explore.

What Kinds of Scientists Did This Research?

geographic information systems analyst: This scientist uses the relationship of information and places on Earth's surface to produce maps. Using these maps and other information, these scientists evaluate what the maps reveal about any place shown on the map.

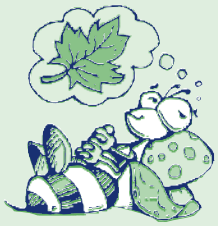
geospatial services specialist: Like a geographic information systems analyst, this scientist uses any type of technology that accurately relates information to a place on Earth's surface to increase understanding of that place.

plant pathologist: This scientist studies plant diseases. Most diseases in trees are caused by fungi. Plant pathologists also investigate other injuries to plants and trees, such as those caused by weather and climate.

plant physiologist: This scientist studies how plants function.

soil scientist: This scientist studies Earth's soils.

Thinking About the Environment



A changing climate is causing some plant and animal species to move from their current habitat to a new habitat. For plants, the need to move might cause a problem. How does this move happen for plants, which are unable to move like animals? In new areas where the climate is favorable, plants spread through their seeds. Plant species move, therefore, by having their seeds **germinate** in more favorable environments.

Natural resource managers want to make the best possible decisions as the climate changes. To make these decisions, managers need as much information as possible. They get some of that information from scientists. In this study, the scientists wanted to understand how climate change was affecting the health of a particular tree species.

The scientists developed information to find the best way for the tree species to survive as the climate changes. Many tree species may be able to survive on their own as the climate changes. Others might need the help of humans. In this study, the scientists showed that the tree species they studied might need human help to survive in a changing climate. Now, managers can experiment with adaptive management options to see which one works best for this tree species.

How Do Plants Move?

To learn more about the movement of plants, visit http://www.scienceinvestigator.org, Climate Change edition, and read, "Seed Ya Later!"

Introduction

One factor affecting the type, number, and location of tree species within forests is climate. As the climate changes, the tree species living in a forest may also change. This change means that some trees species may die and new species may move into the area. Scientists find it difficult to know for sure whether tree movement and tree death result from a changing climate. Other factors, not related to climate, may also cause a forest's tree species to change.

In this study, the scientists were interested in a change they observed in a particular rainforest. This rainforest is located along the Pacific coast in southeastern Alaska (**figure 1**). In this rainforest, about 70 percent of the

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 might try another approach to improve their management. The process continues, with managers continuing 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. To use adaptive management to solve the problem of dying trees, managers must learn many things. What occurs when you do an experiment? Hopefully, you learn from your experience!

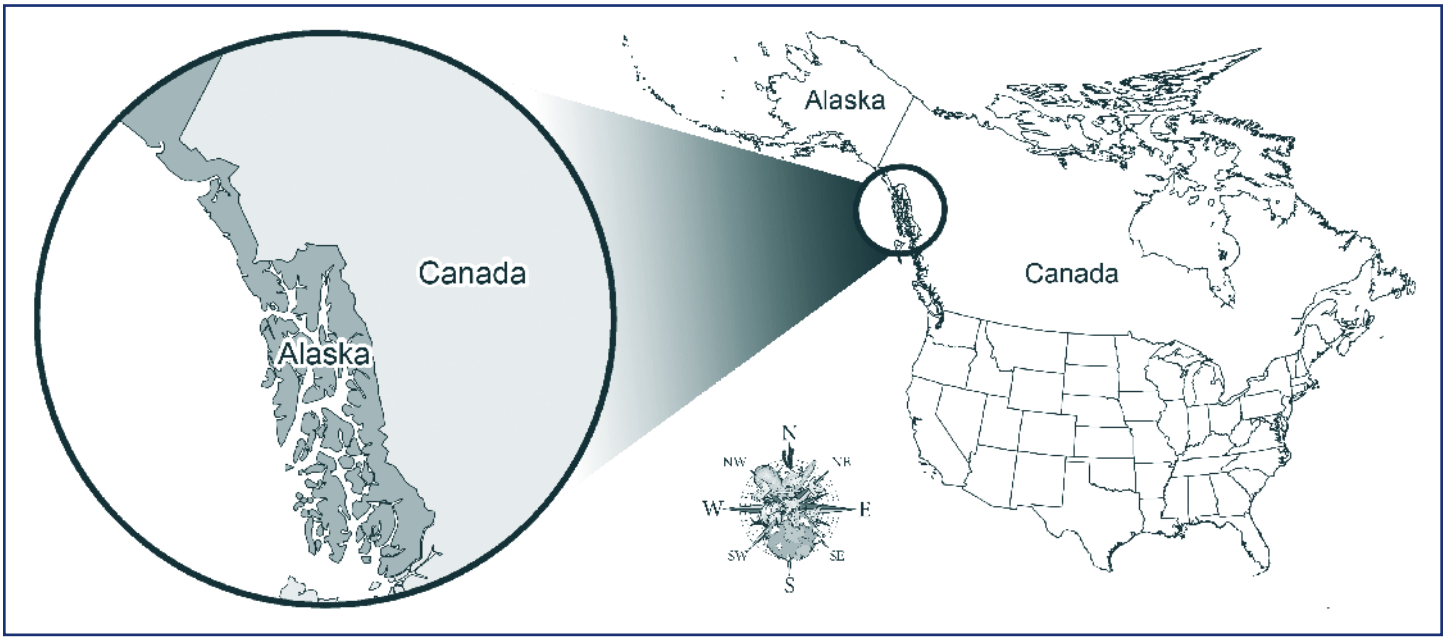


Figure 1. Yellow-cedar grows in the north Pacific coastal rainforest of southeastern Alaska. Map by Lindsay Gnann.

yellow-cedar trees have died in the past 100 years (**figures 2 and 3**).

The cause of yellow-cedar death was unknown for many years. The scientists in this study spent 20 years discovering the probable cause of yellow-cedar death. Like detectives, when the scientists solved one riddle, they moved to the next. The question the scientists hoped to answer was, "What is causing the death of yellow-cedar trees in the north Pacific coastal rainforest?"

Figure 2. A mature yellow-cedar tree. Photo courtesy of Dr. Paul Hennon.

Reflection Section

- What change did the scientists observe in the north Pacific coastal rainforest?
- Name two reasons why yellow-cedar is important to Alaskans. You must read "What Is Yellow-Cedar" on page 53 before you answer this question.
- What might be lost if yellow-cedar trees continue to die in the north Pacific coastal rainforest? You must read "What Is Yellow-Cedar" on page 53 before you answer this question.

Figure 3. The light-colored tree **boles** show what is left of dead yellow-cedar trees in the West Chichagof-Yakobi **Wilderness Area** of coastal Alaska. Dead yellow-cedar trees can remain standing for 80 years after death. They can remain standing because of **aromatic** chemicals in their wood. These chemicals protect the wood from fungi. Photo courtesy of Dr. Paul Hennon.

What Is Yellow-Cedar?

To Alaska Natives and all Alaskans, yellow-cedar is a culturally important tree. The wood and bark of yellow-cedar trees are used by Alaska Natives for constructing shelter, clothing, baskets, canoes, canoe paddles, and **totem poles** (**figure 4**). Yellow-cedar is resistant to insects and decay. Because of this resistance, yellow-cedar wood is used for many durable products and is important to Alaska's economy. Yellow-cedar trees grow slowly and can live up to 1,000 years.

Figure 4. A handmade, yellow-cedar canoe made by ▶ Larry Bowers. Photo courtesy of Larry Bowers, http://www.westcountrycanoes.com.

Methods

In the late 1980s, a team of scientists observed the roots, boles, and **crowns** of yellow-cedar trees that were in various stages of dying. The scientists carefully observed the trees. The scientists found that in order of occurrence, the symptoms of upcoming death were: (1) **fine root** death; (2) **coarse root** death; (3) attack of the weakened tree's bole by insects, fungi, viruses, and other organisms; and (4) crown death (**figure 5**). The last leaves in the crown to die were the ones most distant

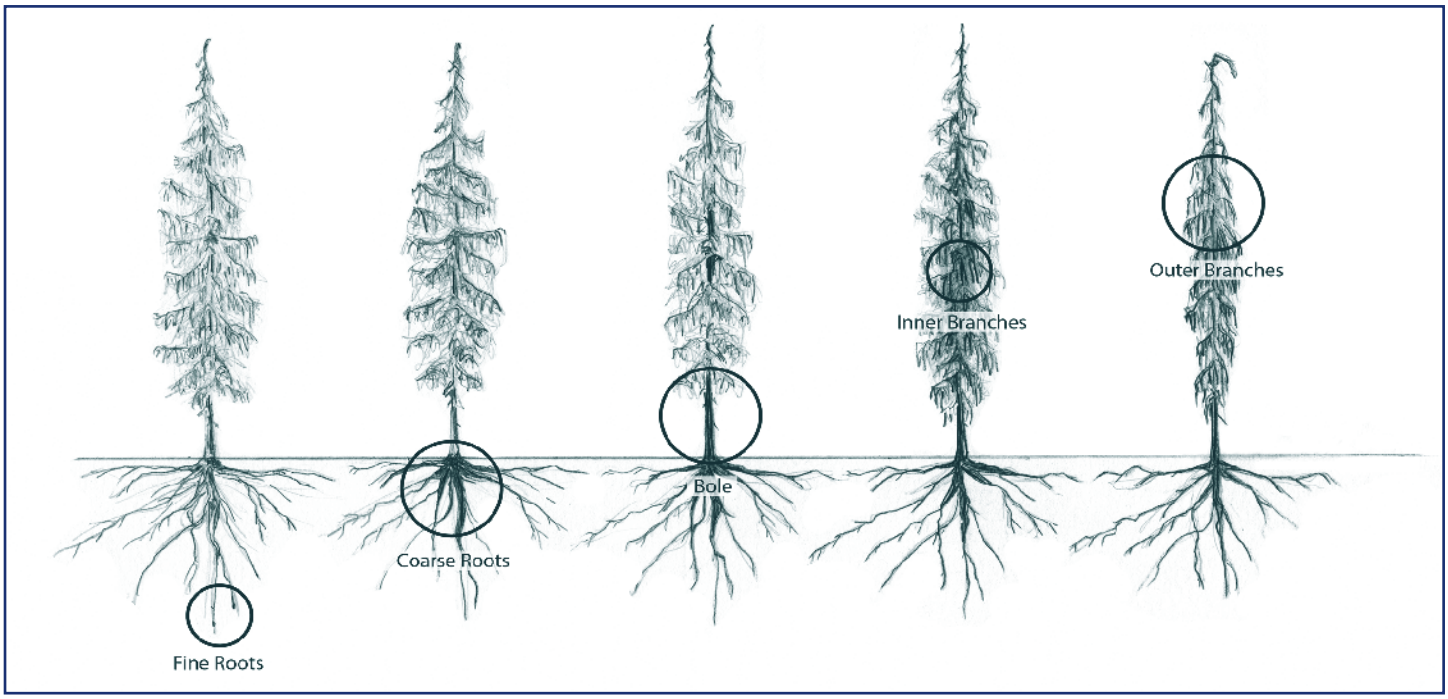


Figure 5. Death of yellow-cedar trees seemed to start from the fine roots and move upward through the tree. (1) shows a tree's fine roots and (2) shows a tree's coarse roots. Illustration by Stephanie Pfeiffer.

from the tree's bole. From these observations, the scientists concluded that a living organism, such as an insect, did not cause the trees' death. The scientists concluded the deaths had a nonliving cause related to the fine roots. It would be unlikely for an insect to cause the fine roots to die. It was only after the fine and coarse roots had died that insects attacked the trees.

To determine the cause of death, the scientists divided their research into smaller studies. In each of these studies, scientists observed and measured a different abiotic (**ā** bī **ä** tik) factor. Abiotic means it is a nonliving factor. Examples of abiotic factors studied include the amount of water in the soil, soil temperature, soil chemistry, air temperature, amount of **forest cover**, and the state of the climate near the soil surface. The scientists spent nearly 20 years studying these different abiotic factors.

One of the abiotic factors studied was how well fine roots tolerated cold temperatures. It was difficult to study the roots because they were underground, so the scientists used a **surrogate** for the roots. The scientists measured the cold tolerance of leaves. They observed whether the tips of the leaves died following cold temperatures (**figure 6**). Cold tolerance is the degree to which leaves can live despite freezing temperatures. The scientists compared the cold tolerance of leaves of yellow-cedar with western-hemlock trees. Western-hemlock trees growing in the same area were not dying. If the yellow-cedar trees were less cold tolerant than western hemlock trees, the scientists had another clue about yellow-cedar tree death.

The scientists also **simulated** snow cover on young yellow-cedar trees (**figure 7**). They did this simulation because snow has an insulating effect on the ground. In cold climates, a blanket of snow keeps the ground warmer than it would be without the snow.

Adaptive Management in Your Life

Do you have a vegetable garden in your schoolyard? If you do not, pretend that you do. Your class has decided to use adaptive management to improve the garden. First, you must identify a problem and your objective. Let's say that all of the vegetables in the garden are ready during the summer. This summertime harvest is a problem because your class observes a summer holiday.

The class objective is to produce vegetables that can be harvested during the school year. Your class does research in the media center. You identify four fall and winter vegetables and plant them in the garden. After 2 months, you observe and record the plants' progress. One of the vegetables has not survived. Two additional winter vegetables are identified. These vegetables are planted, and all vegetables are evaluated after another 6 weeks. After evaluating your results, your class does more research. What steps will you take next?

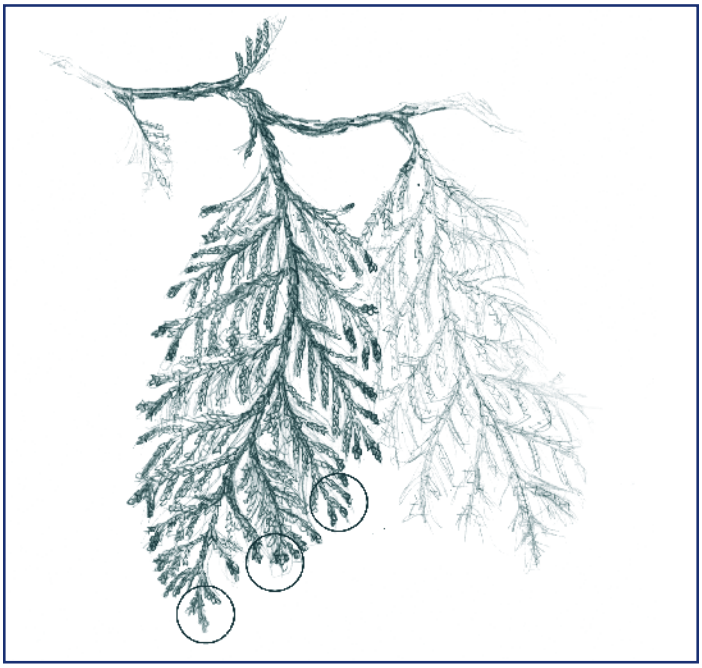


Figure 6. The scientists measured the cold tolerance of leaves as a surrogate for the cold tolerance of roots. Illustration by Stephanie Pfeiffer.

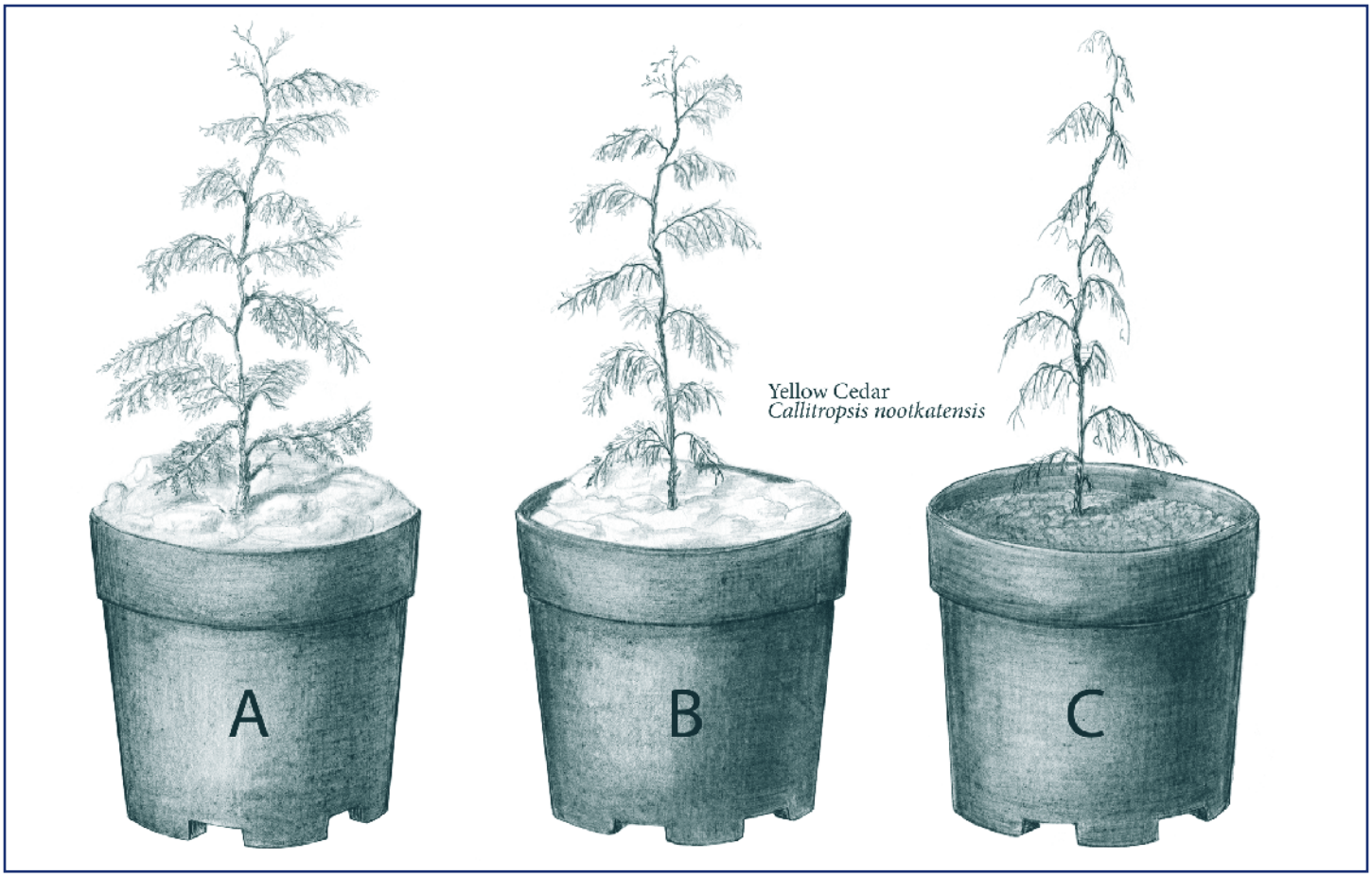


Figure 7. The scientists simulated snow cover around young yellow-cedar trees to measure the snow's insulating effect on the ground and the yellow-cedar roots. What do you notice about the tree on the right? This tree did not have simulated snow cover. Illustration by Stephanie Pfeiffer.

Reflection Section

- Examine figure 5 and reread the final two paragraphs of the previous section. What do you think the scientists discovered about the cold tolerance of yellow-cedars?
- How might climate change be involved in the death of yellow-cedar fine roots?

Findings

The scientists discovered that when the soil temperature around a **seedling** dropped to less than -5 degrees Celsius (C), the fine roots were severely injured and the seedling died. The temperature dropped below this point when snow cover had melted enough so that it no longer provided protection from the cold. Later, the scientists discovered that when the temperature was less than -5 degrees C, fine roots of large, mature trees also died. This temperature was reached in shallow soils when no snow was on the ground.

The scientists also discovered that the yellow-cedar trees were dying on wet, poorly drained soils. When soils are wet, the fine roots tend to be shallow. These shallow roots

are more likely to be affected by freezing temperatures when no snow is present.

The scientists compared the progression of yellow-cedar tree death with other studies of tree death. When the roots of trees are injured, they cannot provide the tree with water and nutrients, and the tree eventually dies.

The scientists concluded that snow cover that remains into the spring protects yellow-cedar roots from injury. As the climate warms, snow cover does not remain as long into the spring. Although the climate is gradually warming, Alaskan spring temperatures may still drop to less than freezing. A lack of or reduced snow cover enables the soil to freeze, killing the fine roots near the soil surface.

Reflection Section

- A paradox is a seeming contradiction. What is the paradox of this study's findings?
- Reread "Thinking About the Environment." What do you think the scientists recommended to help keep yellow-cedar trees alive in Alaska?

Discussion

The scientists' research revealed some actions that managers can take to help yellow-cedar trees adapt under changing climate conditions. Yellow-cedar trees grow slowly. Without help from managers, the trees may be unable to reproduce in colder areas that still have enough spring snow cover. The scientists recommended that managers plant yellow-cedar seedlings in colder areas (**figure 8**).

The scientists also recommended that yellow-cedar seedlings be planted in deeper, well-drained soils. Yellow-cedar trees need help to move into these two kinds of areas. Without help, the trees may not be able to move fast enough on their own to adapt to climate change.

You Are the Adaptive Manager!

Pretend you are the natural resource manager for these areas of yellow-cedar. You have just been told about the findings of this research. You want to use adaptive management in your practice. What are two things you would do next?

Reflection Section

- Adaptive management is a way to manage natural resources so the best decisions can be made under changing conditions. Explain how the scientists' recommendation about yellow-cedar can be used in adaptive management.
- Why would yellow-cedar trees need managers' help to move into a more suitable environment? See "Thinking About the Environment" for a clue.
- How could the model in figure 8 be used in adaptive management?

Adapted from Hennon, P.E.; D'Amore, D.V.; Schaberg, P.G.; Wittwer, D.T.; Shanley, C.S. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. Bioscience. 62: 147- 158. http://www.treesearch.fs.fed.us/pubs/40035.

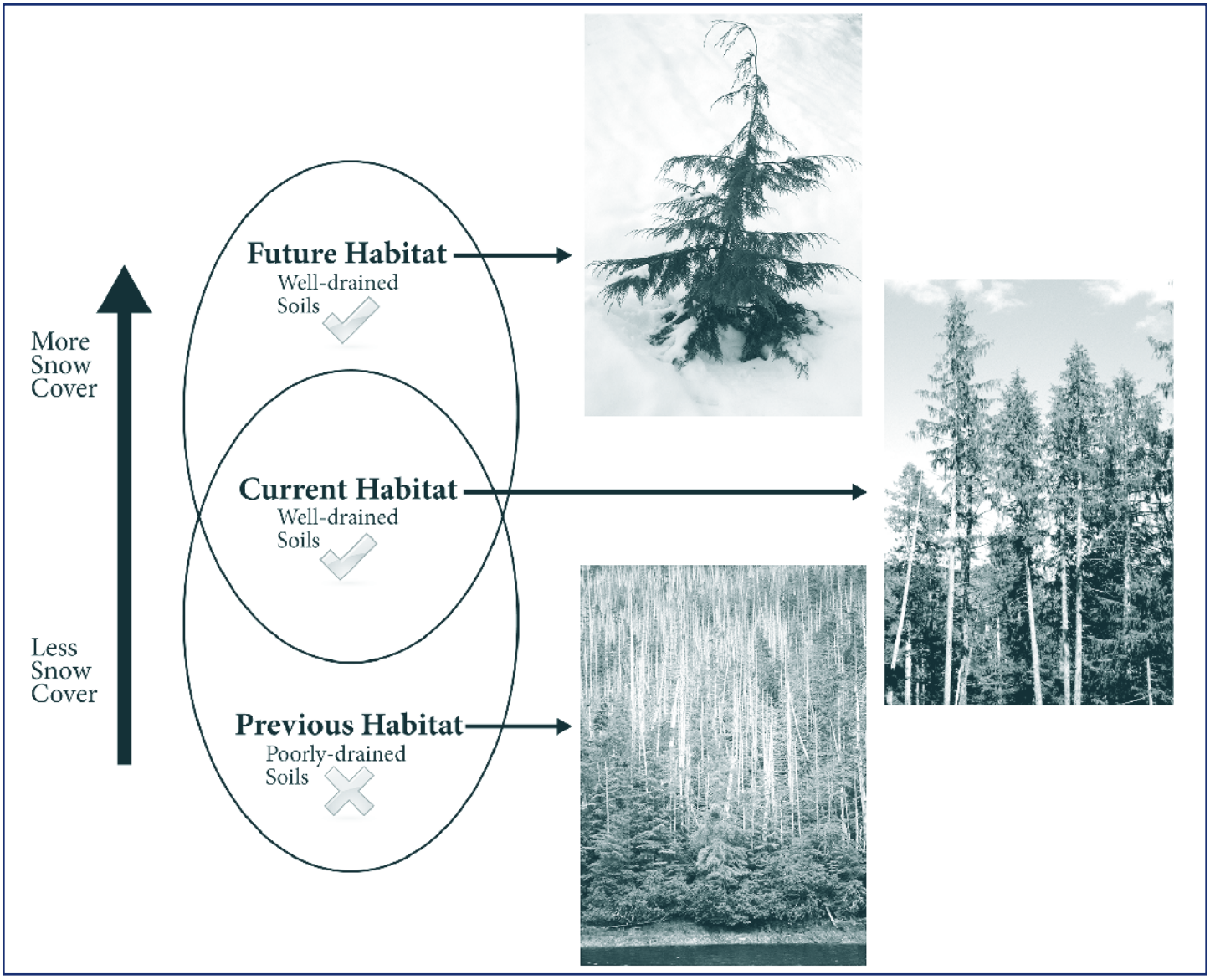


Figure 8. Three zones for yellow-cedar were identified. This illustration is a model of the scientists' yellow-cedar management recommendations. The scientists recommended that managers take action to help yellow-cedar move into a zone that will help them live into the future. Illustration by Stephanie Pfeiffer.

The title, "Cedar Waxing or Waning?" comes from two sources. Waxing means getting larger and waning means getting smaller. The moon, except for its full and new moon phases, is always either waxing or waning. (Will the moon be waxing, waning, full, or new tonight?) The second source is the cedar waxwing (**figure 9**). The cedar waxwing is a migratory bird that eats fruit, particularly berries. In the winter, the bird migrates from Southern Canada to the Southern United States. The cedar waxwing can be found in the Northern United States all year.

Figure 9. Cedar waxwing. Photo by Bill Thompson and courtesy of the U.S. Fish and Wildlife Service.

Glossary

aromatic (**a** rə **ma** tik): Having a strong smell.

bole (bōl): Tree trunk.

coarse root (kȯrs rūt): The thicker root structure of a plant when compared with the finer roots.

crown (kraun): The leaves of a tree.

fine root (fīn rūt): The small, hair-like roots growing out of a plant's coarse roots.

forest cover (**fȯr** əst **kə** vər): The area of land covered by forest crowns.

iconic (ī **kän** ik): Of or pertaining to an icon. An icon is a picture representation, a symbol.

maladapted (ma lə **dap** təd): Poorly suited or unsuited.

novel (**nä** vəl): New and not resembling anything used or known before.

pristine (pris **tēn**): Not spoiled or polluted.

seedling (**sēd** liŋ): A young plant grown from seed.

simulate (**sim** yə lāt): To give the appearance or effect of.

spatial (**spā** shəl): Relating to, occupying, or having the character of space or area.

species (**spē** sēs): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

surrogate (**sər** ə gāt): Substitute.

totem pole (**tō** təm pōl): A pole carved and painted with totems and set up by native Alaskan peoples. A totem is an honored symbol.

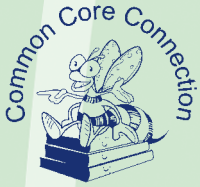
wilderness area (**wil** dər ness **er** ē ə): An area in the United States designated by law for preservation and protection in its natural condition. A wilderness area also refers to a large unspoiled natural area.

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

FACTivity

Time Needed

One class period



Materials (for each small group)

- Blank sheets of paper
- Pencils
- *Natural Inquirer* Wilderness Benefits edition (order for free or download at http://www.naturalinquirer.org)
- *Natural Inquirer* Invasive Species edition (order for free or download at http://www.naturalinquirer.org)
- USA Today article on yellow-cedar decline: http://www.usatoday.com/weather/climate/2006-03-27-yellow-cedar_x.htm
- Wikipedia article on assisted tree migration: http://en.wikipedia.org/wiki/Assisted_migration
- This article

In this FACTivity, you will consider the recommendation made by the scientists in this study. You will also discuss the advantages and disadvantages of following the scientists' recommendation. You will then consider a bigger question: When, if ever, should natural resource managers make changes to large areas of wildland?

Background

When managers practice adaptive management, they anticipate and prepare for the future. They take actions now that they believe will bring about desired results in the future. Managers continually evaluate what they are doing and make changes as needed. In this research, the scientists recommended planting yellow-cedar trees in areas where they have not been found before. In Alaska, these areas are large areas of undeveloped forest land where other tree species currently grow.

Methods

Consider a section of a newspaper article written by Barry Saxifrage. This newspaper article was published on February 9, 2012, in the Vancouver (British Columbia, Canada) *Observer*. This newspaper article was written about the yellow-cedar research you just read. The first sentence that follows refers to the scientists' suggestion that yellow-cedar seedlings be planted in areas where they do not now live.

> In other words, we may be forcing ourselves and future generations to become permanent gardeners of the "wilderness." And not just for yellow-cedars. Already serious discussions are underway for other **iconic** long-lived trees like the giant sequoias of California. They too are becoming "**maladapted**" to their ancient habitat as a result of fossil fuel pollution reducing snowfall and overall precipitation. Surveys show the number of giant trees dying each year has doubled. Concern is growing over the inability of seedlings to thrive in the drying climate. Scientists and forest managers talk about the need to water, raise, and even possibly transplant these trees to new regions. For trees that can live thousands of years, the rapid climate shift underway now is going to be a struggle.

Note that Mr. Saxifrage also mentioned another tree species humans may need to rescue from a warming climate. Many tree species may need help being located to a new habitat. Mr. Saxifrage asked the question:

> How long will humans choose to garden increasingly large swaths of the wild to try to prevent a collapse of species richness and biodiversity? How much can we really do even if we decide we want to?

Your teacher will divide the class into small groups. Each group will do research and decide which of the following two positions to take: (1) We must modify large areas of forest now by planting yellow-cedar tree seedlings or (2) We should not modify native forests by planting yellow-cedar tree seedlings where yellow-cedar has not grown before. You may use the resources given to you by your teacher, or you may access the Internet, use the media center, and simply reflect on and discuss the question.

Take a blank sheet of paper and write either "Plant yellow-cedar" or "Do not plant yellow-cedar" at the top. Draw a line down the middle of the page and across the page, half way down. Label the top section "Advantages" and the bottom "Disadvantages." As a group, research and discuss your topic.

As a group, take 20 minutes to discuss and list the advantages and disadvantages of planting or not planting yellow-cedar. Then, present your findings and hold a class discussion about planting yellow-cedar. Share your group's position and reasons for taking that position. Finally, consider and discuss the related larger question, "When, if ever, should natural resource managers make purposeful changes to large areas of wildland?"

FACTivity Extension

You will write a short newspaper editorial or a blog that responds to Mr. Saxifrage's questions.

Additional FACTivity Extension

In small groups, create an adaptive management experiment to figure out where yellow-cedar seedlings grow best. Write up your experiment to include a research question, management action, and what and how you will monitor the effects of the management action. Use your knowledge of adaptive management to place this experiment into an adaptive management process.

Note to Educator: If you are a Project Learning Tree (PLT) educator, you may use "Trees in Trouble" as an additional activity.

Web Resources

How trees might move in a changing climate
http://www.naturalinquirer.org and read, "Moving On Up" in the Climate Change edition

"Freezing to Death in a Warming Climate: Yellow-Cedars in Trouble"
http://www.vancouverobserver.com/blogs/climatesnapshot/2012/02/09/freezing-death-warming-climate-yellow-cedars-trouble?page=0,0

USA Today article on yellow-cedar decline
http://www.usatoday.com/weather/climate/2006-03-27-yellow-cedar_x.htm

Assisted tree migration
http://en.wikipedia.org/wiki/Assisted_migration

Totem poles
http://www.native-languages.org/totem.htm

For a *Natural Inquirer* article about the roots of trees
http://www.naturalinquirer.org, "FACE Look"