ACTIVITY

4 The Changing Forests

In small groups, students learn about research that is helping forest managers monitor and respond to climate change using new tools and management techniques.

Subjects
Agriculture, Biology, Environmental Science, Language Arts

Skills
Communication, Cooperative Learning, Critical Analysis, Leadership, Making Conclusions

Materials
Student pages, answer keys, and presentations (see Activity Webpage link below)

Time Considerations
One or two 50-minute class periods

Related Activities
Students should have an understanding of climate change (Activity 2) and the relationship between forests and climate (Activities 1 and 3). This activity can be followed with additional activities that show how forest managers can address climate change (Activities 5, 6, or 8).

Research Connection
Forest scientists focus their research in many areas, including forest health, fire ecology, genetics, and modeling.

Activity Webpage
Find online materials for this activity at https://sfcc.plt.org/section2/activity4

Objectives
By the end of the activity, students will be able to
- identify three ways that climate change could affect a forest ecosystem, and
- explain two monitoring or management techniques for exploring climate change and forest health.

Assessment
- Use students' answers on the student page to assess their understanding of the articles.
- Ask students to write an essay describing three changes in southeastern forests that may be due to climate change, and at least two ways that forest managers can monitor and respond to these changes.

Background

Additional background information can be found in the **Section 2 Overview**.

Forests are an important part of the landscape in the southeastern United States. They cover much of the land area; they are owned by public agencies, private landowners, and other entities; and they are managed for multiple objectives, including ***timber*** production, wildlife ***habitat***, recreation opportunities, and water quality protection. Given the many benefits of forests, it is important to gain a better understanding of how long-term changes to average temperature and ***precipitation*** will influence ***forest health*** and survival. For example, if temperatures are too high or too low, or if temperatures fluctuate too quickly, trees can become stressed and may die prematurely. Similarly, trees can be affected if too much precipitation results in flooding or if too little precipitation causes drought. In particular, trees growing at the edges of their ***species*** range, where they may already be stressed, could suffer the worst impacts of changes in ***climate***. These changes could cause some species of trees to die and allow for growth of other tree species that are better adapted to these different climate conditions. Over time, some trees may expand their ranges northward or to higher elevations if seedlings and young trees are able to survive in these new habitats.

In addition, forest health, ***structure***, and ***composition*** are influenced by disturbances, such as ***wildfire***, insect and disease outbreaks, ***invasive species***, and storms. If these disturbances become more frequent and severe, entire forest ***ecosystems*** may change. Prolonged hot, dry ***weather*** can increase wildfire risk. Drought also creates ideal conditions for the ***southern pine beetle***, and a population explosion of this insect pest can significantly impact forest health. Many invasive species can outcompete native tree species under a wider variety of temperature and moisture conditions that may result from ***climate change***. As a result of more frequent severe weather events, such as hurricanes in the Southeast, trees that are already stressed from drought are likely to be more susceptible to additional damage from high winds.

GREGORY FREY, VIRGINIA STATE UNIVERSITY

Scientists and forest managers are monitoring changes in southeastern forests and exploring how to respond to these changes with new tools and management strategies.

As climate conditions change, there are many ways to approach ***forest management***, but no one strategy will work for every forest. In general, it is important to create ***resilient*** forests—those that can resist and recover from disturbance—that are better able to adapt to change. Given enough time and ***genetic diversity***, many species can biologically adapt and thus survive changes in environmental conditions. However, rapid changes in the environment make it less likely that plant and animal populations will be able to change with new conditions. ***Adaptation*** to climate change includes actions taken by humans to avoid, benefit from, deal with actual, or plan for expected climate change impacts. Specific forest-related adaptation strategies include

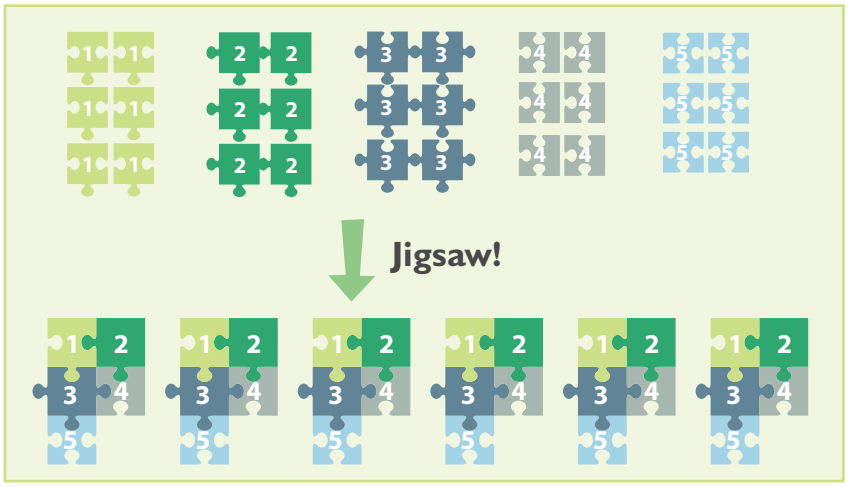
1. instituting seed-bank programs for tree species that can tolerate drought and floods;
2. improving forest health and resilience by reducing forest stresses such as pollution, fragmentation (i.e., breaking up large continuous forests into smaller parcels by converting the landscape to other uses such as farming or subdivisions), risk of wildfire, invasive species, insects, and diseases;
3. preparing to respond to forest declines by monitoring forest health and establishing criteria for prompt intervention; and
4. planting new seed sources from trees that are adapted to growing with less water or adapted to higher temperatures.

Many scientists are currently exploring how projected climate changes might affect forests. The U.S. Forest Service employs research scientists who conduct studies, collect long-term data, and monitor forest resources on national forest lands. Results of these studies are shared with the scientific community and with forest managers, in hopes to direct management practices with the best available science-based information. In the Southeast, these U.S. Forest Service scientists work at the Southern Research Station (SRS). They are monitoring a variety of ecosystem components to better understand what is changing, whether changes can be explained by any predictable factor, and how forest managers can respond to change through adaptation strategies.

Teaching This Content

This activity uses a "jigsaw" cooperative learning technique, which allows students to more easily digest complex information and helps them practice important communication skills. Using this technique, students become responsible for part of the information the class is learning and teach other students about the most important aspects of specific topics. Before teaching others, the students work in small groups; in each group students are focused on the same topic. This time is important for students to become comfortable with the information and to share ideas

with one other. The students then "jigsaw" so that new groups are formed, and each new group contains at least one member of each old group. At this point, each student has a chance to teach the new group a specific aspect of the topic. This format gives students a structured way to work in groups and provides an opportunity for practicing communication skills with a small group of peers. It enables everyone to contribute.



ORIGINAL IMAGE: ELLIOT ARONSON, WWW.JIGSAW.ORG

Getting Ready

The Activity 4 webpage provides **Teacher Tools** that you can use to become more familiar with this activity's background and procedure (https://sfcc.plt.org/section2/activity4).

Download the Introduction to Southeastern Forests presentation and review it to determine how much you wish to present to students. The presentation and notes are available in editable format so you can shorten or modify both as needed.

This activity uses five short articles that appeared in the June 2011 issue of *Compass Magazine* published by the U.S. Forest Service, Southern Research Station. The articles can be accessed on the Activity 4 webpage, where all five articles are provided in one PDF document.

1. "Trees in Transition" by Stephanie Worley Firley
2. "Forest Ecosystem Stress in Real Time" by Zoë Hoyle
3. "More Fuel for Fire?" by Susan Andrew
4. "CRAFTING Future Forests" by Zoë Hoyle
5. "Climate Change Invasions" by Teresa Jackson

Or, you may wish to find other articles to use for this activity. See the Additional Resources section of this activity for a few starting points to find additional articles.

In this activity, each student group begins by focusing on a different reading. Next, the groups "jigsaw" and teach each other about the key aspects of each reading.

Systems Thinking Connection

A CLASSROOM OF STUDENTS is an example of a complex ***system.*** The class roster may be relatively stable throughout the year, but the mood and behavior of the class can vary from day to day. Good teachers understand how even slight changes (e.g., a storm, an assembly) can cause noticeable changes in the students' behavior.

Forests are also complex systems in a constant state of change, as students learn in the reading, "Trees in Transition." The reason that scientists are concerned about climate change is not simply that the climate is changing, but that the pattern of changes that scientists have observed over the last several decades has never been experienced before.

Understanding these new patterns of change requires us to look for indirect connections. For example, in "More Fuel for the Fire?" students learn how severe wildfires and severe rainstorms are connected. The casual observer would likely fail to understand how these seemingly independent events could be linked, just as a novice teacher may fail to understand how an event in the morning can have an important impact on students' work during afternoon classes. Systems thinkers gain insight into the behavior of a system by focusing on the cause-effect connections that spread like a web through a complex system.

Understanding the weblike structure of cause and effect can help us avoid tunnel vision so that we can see the effects of actions that are outside of our narrow focus. For example, in "CRAFTING Future Forests" students learn how forest managers no longer focus on a single value or variable. Instead, they learn to take a broader view regarding the impacts of their decisions. Expanding the way we think to include the most appropriate systems boundaries is an important systems thinking skill.

TEACHERS SAY ...

I loved the lesson and the jigsaw with articles. Students were willing to share the information they learned and were able to answer questions. I was thrilled at their efforts.

—Earth and Environmental Science Teacher, North Carolina

Make copies of the Changing Forests student pages (each student should receive one student page to correspond with his or her *Compass* article).

If you have more than one class period for this exercise, students can read the article in their groups. If you have only one period, ask students to read the articles for homework and to be prepared to discuss the information when they come to class. You can assign the questions as homework as well or save them for the first group activity.

Doing the Activity

1. Ask students to imagine a forest. What types of trees do they see in their forests? Where are their forests located? Did any students think about a forest close to home? Explain that forests are an important part of the landscape in the southeastern United States and provide a short introduction to forests and forest management in the region. You may want to use the Introduction to Southeastern Forests presentation on the Activity 4 webpage. You can also use information provided by your state forestry agency's website to share locally relevant information.

2. Ask students to imagine their forests again, but now have them consider how their forests will respond to future changes in climate. What might they see change in their forests as a result of anticipated changes in temperature and precipitation patterns? If they were scientists, what sort of observations or data would they collect to study these changes? Explain to students that the U.S. Forest Service employs scientists who conduct research on national forest lands, and these scientists are investigating strategies to monitor and detect change and adaptation strategies that forest managers can implement to respond to those changes.

3. If you didn't previously complete Activity 1 with your students, consider taking 15 minutes to complete Part B of the activity. Part B provides a worksheet for students to complete while watching a video from the U.S. Forest Service, which introduces climate change science, impacts on forest ecosystems, and the Forest Service response to climate change (video is available on the Activity 1 webpage).

4. Divide the class into five equal topic groups. Each topic group should be assigned to read one of the five *Compass* articles. These articles contain information about climate change research being conducted by U.S. Forest Service scientists. Give each student in each group a copy of the article and the associated Changing Forests student page. Alternatively, the articles can be read online.

5. Ask students to read the articles and complete the Changing Forests student page as a group or as homework. Answer keys are available on the Activity 4 webpage. The group task is to make sure each student is familiar enough with the information to be able to teach it to other students in 3 minutes. Give students in the topic groups at least 15 minutes to discuss and answer the questions based on the articles. Allow more time if necessary.

6. Ask students in each topic group to count off so that each person has a different number. The students should then reform new groups according to their numbers. Each new group should have at least one person from each previous topic group.

7. In the new groups, ask one student in each group to be a timekeeper. Each student should take 3 minutes to explain his or her article to the other students. When the student is done, the other students may ask questions.

8. When everyone understands all five articles (about 20 minutes), ask students to discuss the following questions.

- What common themes do the five readings have?
  Answers may include: climate changes are causing changes in forest ecosystems; climate changes are causing a variety of different forest stresses; new models are being developed to predict climate changes and the impacts of these changes; scientists are studying ways to understand the effects of climate change on forest ecosystems and to develop ways managers can help ecosystems adapt to these changes.
- What are some indicators that changes have occurred during the past 30 years?
  Answers may include: warmer, drier conditions have occurred; extreme weather events happen more often; species that thrive in warmer climates are able to expand their ranges.
- What are some impacts from climate change that southeastern forests might face in the future?
  Answers may include: changes in the genetic makeup of forest tree species, changes in ranges of forest tree species, increased drought, more frequent and more intense forest fires due to greater fuel loads, stronger and more frequent tropical storms, and greater opportunities for invasive species, which could jeopardize the health of native forest species.
- What strategies can forest managers and scientists use to respond to climate changes and to improve forest health?
  Answers may include: prescribed burnings, conserving genetic variation, using models to predict changes, and using models to determine areas of forest stress.
- From the readings, what future career opportunities can you identify?
  Answers may include: forest ecologist, land manager, and research scientist in various related fields, including plant genetics, hydrology, dendrology, and agricultural technology.
- Why are adaptation strategies important for forest ecosystem health?
  Adaptation strategies are important to help humans and forest ecosystems adjust to climate change already occurring. Human assistance is needed because many of these changes might happen too quickly for the crops we depend on to naturally adapt.
- Systems Reflection: How are severe storms and severe wildfires related to climate change?
  In some cases, severe storms can create more fuel by blowing down large trees. More fuel may mean more intense wildfires. However, as the article explains, that is not always the case. The authors also note that these large fallen trees may keep enough moisture through the dry season to help decrease fire risk.
- Systems Reflection: In what way has human development around forests made forest management decisions more complex?
  When forest managers make decisions, they must keep in mind the needs of the people living near those forests. In some cases, managing for the most resilient forest possible might create other problems for local residents. The CRAFT resource discussed in the article is designed to help forest managers recognize how their decisions affect other systems and people as they ripple out through the web of social and ecological connections.
- Systems Reflection: What variables should be considered as part of the forest system to best understand forest changes caused by climate?
  The important variables will vary somewhat, depending on the forest. However, precipitation and available water, nutrient levels and soil health, low- and high-intensity fires, and temperature are all likely to impact the health and growth of any forest.

9. Summarize this activity by asking students to reflect on the importance of conducting research on forested lands.

TEACHERS SAY ...

After discussing the questions with my students from the various articles, they seemed to really understand a whole lot more about climate change.

—Earth Science Teacher, Florida

TEACHERS SAY ...

I will be doing this activity again because I think the articles were good and the discussion questions were appropriate for my lesson plan.

—AP Environmental Science Teacher, Florida

Why is it valuable to collect data over long time periods? How do they think research projects like the ones described in the articles benefit society? Remind students that national forests are public treasures that provide wildlife habitat, clean water and air, places for people to recreate, timber products, and natural scenery. U.S. Forest Service researchers are exploring climate change and forests to better understand how to care for these areas through appropriate management practices.

Modifications

Depending on your students' needs and abilities, you may want to provide students with a short overview of each article before they break up into their small groups.

You can reduce the number of articles so that you can more easily help each group as they complete the activity. You can also reduce the number of questions on the student pages using the file provided on the Activity 4 webpage.

You may choose to forego the jigsaw approach, read the articles together, and complete the student pages together. Keeping the class together, rather than splitting into groups, may be helpful if your students become easily distracted or find it hard to stay on task. If you choose to read fewer articles, we suggest you pick those that cover both the impacts of climate change and how scientists are modeling and monitoring those changes in the forest: "Climate Change Invasions," "Forest Ecosystem Stress in Real Time," or "Trees in Transition."

Enrichment

Partner with a local natural resource expert for a class field trip that investigates how climate change might affect schoolyard trees and wildlife, wetland habitats, or nearby forests.

Suggest that students interested in science read the scientific articles linked to each of these *Compass* articles by searching for the authors name on TreeSearch (www.treesearch.fs.fed.us). They can also find additional articles written by other authors.

Have students read the introduction of "Science at Your Fingers" to learn about a U.S. web-based tool called TACCIMO (Template for Assessing Climate Change Impacts and Management Options). TACCIMO is intended for use by land managers and provides the most current climate change projections and research in an effort to link science to forest management and planning. The "Science at Your Fingers" article is available at http://www.forestthreats.org/products/fact-sheets/EFETAC_TACCIMO_2013_printerfriendly.pdf). Students can then explore TACCIMO and develop management ideas to address negative impacts of climate change on forest ecosystem (http://www.taccimo.sgcp.ncsu.edu).

Invite a forest researcher to class to talk about the types of research he or she conducts and how climate change might affect forests.

Advanced students can explore a web-based tool called WaSSI (Water Supply Stress Index Ecosystem Services Model, http://www.forestthreats.org/research/tools/WaSSI) to learn how changes in precipitation and temperature may affect water resources and forest ecosystems at the regional watershed level.

Additional Resources

Climate Change Impacts and Adapting to Change
U.S. Environmental Protection Agency (EPA)
www.epa.gov/climatechange/impacts-adaptation/index.html
This section of the U.S. EPA climate change website provides information about the impacts of climate change and adaptation efforts by region and by sectors, such as forests, agriculture, and ecosystems.

CompassLive Blog
U.S. Forest Service, Southern Research Station
http://www.srs.fs.usda.gov/compass/
A blog designed to share the latest information on southeastern forests from the U.S. Forest Service.

Effects of Climatic Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S.
U.S. Forest Service, Pacific Northwest Research Station
http://www.treesearch.fs.fed.us/pubs/42610
This assessment analyzes current and future conditions of forests with specific interest to climate change impact.

Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers
Chris Swanston and Maria Janowiak, Editors; 2012
http://www.nrs.fs.fed.us/pubs/40543
This US Forest Service General Technical Report provides resources, including a workbook, to help forest managers incorporate climate change considerations into management and devise adaptation tactics.

Neil Sampson Says Climate Change Speeding Flux of Forest Ecosystems
EarthSky
http://earthsky.org/earth/climate-change-speeding-flux-of-forest-ecosystems
During this 90-second podcast, scientist Neil Sampson describes how forests may be affected by climate change.

State Climatologist Interview with NC People
State Climate Office of North Carolina
http://video.pbs.org/video/2134881398/?starttime=671000
During this video, the North Carolina State Climatologist, Ryan Boyles, Ph.D., explains how climate change can impact southeastern forests.

Southern Forest Futures Project: Summary Report
U.S. Forest Service, Southern Research Station
http://www.srs.fs.usda.gov/pubs/42526
This summary includes results from the Southern Forest Futures Project technical report and provides a set of key findings and implications.

State Resources, Southern Regional Extension Forestry
Southern Regional Extension Forestry
http://sref.info/resources/state-resources
From this website, you can click on any state in the Southeast and find a listing of the state's forestry agency, university or college with a forestry school, and Extension programs. These state-specific resources provide localized information about forest research and resources. You can also check out the Current Projects page (http://sref.info/projects/current) to learn about regional forestry projects in the Southeast.

U.S. Forest Service, Research and Development
U.S. Forest Service
http://www.fs.fed.us/research/
The U.S. Forest Service has research stations located regionally throughout the country. Their websites are a good starting point for identifying current forest research and can be accessed, along with other news and highlighted research, through the Research and Development webpage.

In the **PINEMAP Focus on Research** video on the Activity 4 webpage, you can learn about WaSSI model from a U.S. Forest service scientist who helped develop the model.

STUDENT PAGE

Changing Forests: Trees in Transition

NAME DATE

1. The introduction states that the only constant is change. If forests always change, what's the problem?

2. How might tree populations respond to changes in the climate?

3. What is the ForeCASTS project? How are ForeCASTS maps useful?

4. Why is it important to conserve genetic variation?

Changing Forests: Forest Ecosystem Stress in Real Time

NAME DATE

1. What is RAFES and what is it intended to do?

2. What is the problem with current ecosystem assessment, and why is the new approach more effective?

3. What important forest stressor is being researched for this project? Why is this stressor important?

4. How do you think drought increases forests' susceptibility to pests, disease, and wildfire?

Changing Forests: More Fuel for Fire?

NAME DATE

1. What is the KBDI? What does a high KBDI mean?

2. In which geographic area is the increase in the length of fire season expected to be the greatest?

3. Describe the changes in fuel loads predictions. Which areas will have a decline? Which areas will have an increase?

4. What is a management option to reduce wildfire risk?

Changing Forests: CRAFTING Future Forests

NAME DATE

1. What is the Forest Service National Roadmap for Responding to Climate Change?

2. Why is there a strong interest in restoring longleaf pine forests in the Southeast?

3. What challenges do forest restoration specialists face?

4. What is CRAFT? How does CRAFT help managers and stakeholders make decisions for the future?

STUDENT PAGE

Changing Forests: Climate Change Invasions

NAME DATE

1. How will invasive plants likely be affected by climate change?

2. What types of tools are EFETAC researchers using to assess how climate change will affect the distribution of plant species?

3. What is required to understand how invasive species affect native habitats and species?

4. What is the goal of the EFETAC research?