



Forest Service
U.S. DEPARTMENT OF AGRICULTURE



FOREST
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NATURE
DISCOVERY™

Natural Inquirer

Number
29

The *Natural Inquirer* Monograph Series: **FIRE**

FIRE TOOLBOX

Reducing Wildfire Severity
With Prescribed Fire and Thinning





Natural Inquirer

Monograph Series: Fire

Fire Toolbox

Reducing Wildfire Severity With Prescribed Fire and Thinning

Produced by

Forest Service, an agency of the U.S. Department of Agriculture (USDA)

FIND Outdoors

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Join us in being green!

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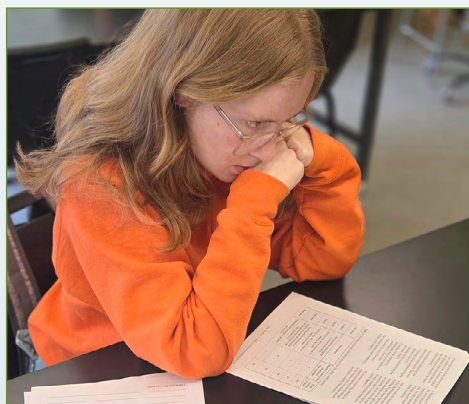
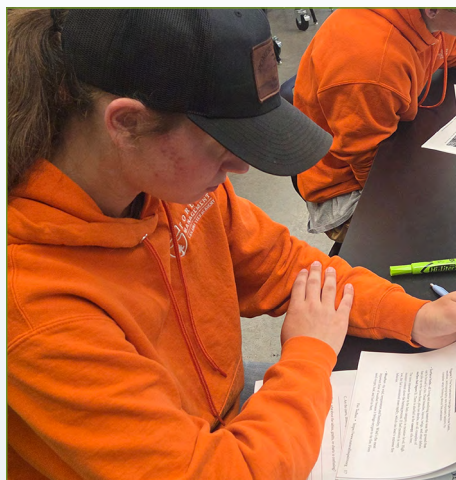
These resources can be found on
the “Fire Toolbox” Monograph page:

- **Educator Guide**
- **Lesson Plans**
- **Reflection Section**
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- **National Education Standards**
including:
 - Next Generation Science Standards
 - National Curriculum Standards for
Social Studies
 - Common Core Standards

Natural Inquirer

Editorial Review Board Hard at Work

**Sarah Callaghan's Forest Management Class
Cascadia Tech Academy, Vancouver, WA**



"I enjoyed learning what different ecologists do."

"I knew thinning and prescribed burns were used, but I'd never seen collected data to back it up."

"The labels on the charts and drawings were easy to understand. The reflection sections helped ensure that I was actually paying attention to what I was reading."

"Fire especially wildfire can be successfully mitigated and made less severe through prescribed fire and thinning."

"This was a very enlightening and informational read/story."

"I like the career spotlight, and I think it would be cool to read an article on the cultural significance of prescribed fire within tribes."

"The most important thing I learned is what a red flag warning is."

"Not all fires are bad. Prescribed fire is an important aspect of forest management."

About *Natural Inquirer* Monographs!

Scientists report their research in a variety of special books called journals. Although journals have been produced in hard copy, they are increasingly produced online. Journals usually contain between four and seven scientific papers. Journals enable scientists to share their research with one another and the public. A monograph is a type of journal that focuses on a single scientific paper.

This *Natural Inquirer* monograph was created to give scientists the opportunity to share their research with you and other students. This monograph presents scientific research conducted by a Forest Service scientist and other scientists. If you want to know more about the Forest Service, you can read about it on the inside back cover of this monograph, go to the Forest Service website at <https://www.fs.usda.gov>, or visit the *Natural Inquirer* website at <https://naturalinquirer.org/>.

All the research in *Natural Inquirer* concerns the natural environment, such as trees, forests, animals, insects, outdoor activities, and water. First, you will meet the scientists who conducted the research. Then you will read about one of the interesting aspects of science and the natural environment. You will also read about a specific research project. The research article follows the format that scientists use when they publish their research in

scientific journals. Then YOU will become the scientist when you complete the FACTivity associated with the article.

At the end of each section of the article, you will find a few questions to help you think about what you have read. These questions will help you think like a scientist. They will help you think about how scientists conduct research. Your teacher may use these questions in a class discussion or in a small group.

Each *Natural Inquirer* monograph will help you explore the exciting world of science and prepare you to become a young scientist. You will learn about the scientific process, how to conduct scientific research, and how to share your own research with others.

Visit <https://www.naturalinquirer.org> for more information, articles, and resources.

Be sure to try the eyeChallenge on page 37!



WHO ARE SCIENTISTS?

Scientists are people who collect and evaluate information about a wide range of topics. Some scientists study the natural environment.



Top row, left to right: Forest Service scientists Marcus Warwell, Emily Rhoades, and Brian Potter.
Bottom row, left to right: Forest Service scientists Mary Lata, Kayla Herriman, and Kevin Hernandez.

To be a successful scientist, you must:

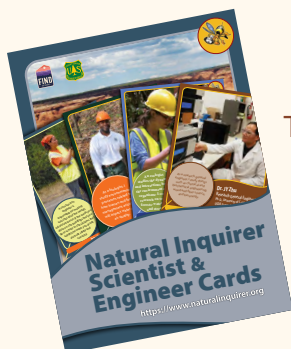
Be curious: Are you interested in learning?

Be enthusiastic: Are you excited about a particular topic?

Be careful: Are you accurate in everything you do?

Be open-minded: Are you willing to listen to new ideas?

Question everything: Do you think about what you read and observe?



To learn more about your favorite scientists and their work, you can view and order scientist cards and print your own posters online at <https://www.naturalinquirer.org>.

Welcome to the *Natural Inquirer* Monograph Series: **FIRE!**

The word “fire” brings many images to mind. Images of campfires and s’mores, birthday candles on cakes, and forest fires are all different images associated with fire (**figure 1**). Just like there are different images

associated with fire, there are also different types of fire. When we talk about fire related to forests and other lands, we generally discuss two types of fire: prescribed fire and wildfire.



Figure 1. This family enjoys a campfire and s’mores. Remember to always make sure your campfire is completely out before leaving it!

Glossary words are in **bold** and are defined on page 32.

Prescribed fire is fire that is set on purpose by trained professionals and monitored by them (**figure 2A**). Prescribed fire burns forest fuels such

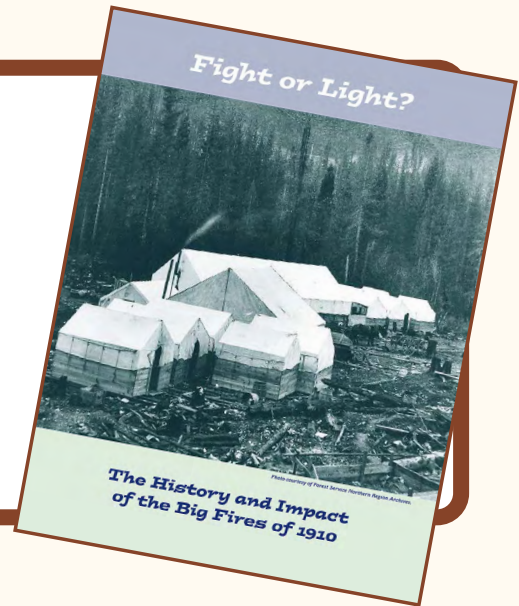
as dead and downed wood and twigs and branches that have fallen to the forest floor. Wildfire is an uncontrolled fire (**figure 2B**).



Figure 2. (A) Prescribed fire operations occurring on Inyo National Forest in California. (B) A wildfire burns on the Lolo National Forest in Montana.

did you know?

The wildfires of 1910 heavily influenced wildfire policy in the United States. Read “Fight or Light?” in the Wildfire 2 *Natural Inquirer* to learn more about the fires of 1910!



In the past, forest managers always put out wildfires. However, scientists and forest managers now know that fire can sometimes be good for an ecosystem. For example, some ecosystems have fire-dependent plants that need fire on a periodic basis to flourish. Additionally, fire burns dead and downed wood providing nutrients for the soil. Fire also can stimulate new growth and improve habitat for wildlife.

Therefore, wildfires are sometimes allowed to burn rather than always being **extinguished**. When a wildfire threatens human communities, however, it is extinguished. Forest managers have several strategies to help communities deal with wildfires.

One strategy is to reduce fuel so that if a wildfire threatens a community, it has nothing to burn. Forest

managers reduce fuels in two main ways. First, they might purposely burn small areas of land with a prescribed fire to remove the fuel. These fires burn cooler than wildfires and only burn near the ground (see **figure 2A**). Forest managers only start these controlled fires if the right weather conditions are in place so that the fire does not spread beyond the area that they want treated.

Another strategy is a process called thinning. Forest thinning means that trees are removed from the forest in a planned way. Thinning helps reduce overcrowding in forests. Overcrowding can lead to unhealthy trees and can provide more fuel for wildfires. Thinning can also help create fuelbreaks. Fuelbreaks are created by the thinning and/or removal of vegetation to reduce the intensity and spread of the fire (**figure 3**). In this

monograph, you will learn about how prescribed fire and thinning affected wildfire behavior and severity.

Other strategies include teaching people about fire and fire safety. There are programs that help communities and individuals identify

wildfire risk in their communities. Smokey Bear is an example of a public service campaign highlighting ways to reduce human-caused wildfires (**figure 4**). Learn more about Smokey Bear on page 12.



Figure 3. A fuelbreak in Flathead National Forest in Montana.



Figure 4. The Smokey Bear public service campaign has been going since 1944.

Photo Credits: Figure 2A: Forest Service photo by Lisa Cox; figure 4: USDA photo by Lance Cheung; Spotlight on Smokey Bear figures 1–4: images from USDA National Agricultural Library.

Spotlight on Smokey Bear

For over 80 years, Smokey Bear has been one of the longest running public service advertising campaigns. Because nearly 9 out of 10 wildfires are caused by humans, Smokey Bear's message that "only you" can prevent human-caused wildfires has been an important message to share with generations of people.

The public service campaign idea started in 1944, and artist Albert Stahle created the first Smokey Bear poster during this time (**figure 1**). Rudy Wendelin became Smokey Bear's illustrator starting in 1946 (**figure 2**). Smokey Bear's catch phrase "Remember... Only YOU can prevent forest fires!" began in 1947.



Figure 1. The first Smokey Bear poster was created by artist Albert Stahle in 1944.



Figure 2. Rudy Wendelin illustrated Smokey Bear from 1946 to 1973.

In May 1950, a living symbol of Smokey Bear was introduced to the world when a bear cub was orphaned in a wildfire in the Capitan Mountains in New Mexico (**figure 3**). They named him Smokey. Smokey was injured during the fire and needed rehabilitation. The cub was transported to the National Zoo in Washington, DC, and was one of the most popular exhibits (**figure 4**).

Over the decades, Smokey Bear has taught people about fire prevention and what they can do to help prevent wildfires. Examples include how to safely have a campfire, maintain and

operate a vehicle, and take care of the area around your home. Smokey Bear also has five rules for fire prevention. They are the following:

-  **Only you can prevent wildfires.**
-  **Always be careful with fire.**
-  **Never play with matches or lighters.**
-  **Always watch your campfire.**
-  **Make sure your campfire is completely out before leaving it.**



Figure 3. The young cub, Smokey, climbing on a rock.



Figure 4. Adult Smokey at the National Zoo in Washington, DC.

To learn more about prevention of human-caused wildfires, please visit <https://smokeybear.com> for more information. Also visit the *Natural Inquirer* Smokey Bear resource page for free educational materials and resources for Smokey Bear (<https://naturalinquirer.org/smokey-bear/>).

FIRE TOOLBOX:

Reducing Wildfire Severity With Prescribed Fire and Thinning

MEET THE SCIENTISTS!



◀ EMILY BRODIE, Ecologist/Forest Monitoring Scientist

I really love field work and data collection. In particular, there are times when the place where you are or the thing that you are measuring just blows you away. I have felt this while installing **subalpine** monitoring plots just feet from glaciers in North Cascades National Park in Washington State and measuring 6-foot-wide pine trees at the Stanislaus Experimental Forest in California!

I also love when having an experience in the field or crunching numbers on the computer unlocks a theoretical concept—maybe one that you learned years ago but now finally understand. Building this kind of understanding over time is gratifying.



◀ ERIC KNAPP, Forest and Fire Ecologist

There are many favorite science experiences, including collecting data after the Antelope Fire that occurred in California in 2021. It was fascinating trying to reconstruct how the fire moved and to experience how quickly fire effects **moderated** once fire encountered an area that had been previously treated with thinning or prescribed fire.

Experiences with a drip torch in my hand helping with ignition on prescribed burns also come to mind. It is fun to observe fire behavior in different fuel types and when varying the ignition pattern. The glow of the forest from a prescribed burn at night is incredibly beautiful.



Caution: Prescribed fires or prescribed burns are controlled fires that are monitored and extinguished by professionals only.



◀ **STACY DRURY,** **Plant Ecologist**

I focus on plant and fire interactions. I am interested in how fire helps shape the vegetative landscape around us. I have had a long, successful career, so picking out a specific science experience is difficult. But a few things come to mind—like flying around in a helicopter to identify historic fires in Alaska or learning how tree seedlings get established after fires in Mexico or looking at patterns of vegetation change in the Amazon forests of Brazil. Every day outside is a good one.

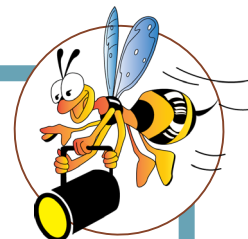
WHAT KINDS OF SCIENTISTS DID THIS RESEARCH?

ECOLOGIST: This scientist studies the relationship of living things with their living and nonliving environment.

FIRE ECOLOGIST: This scientist studies the relationship between fire and the environment that it affects.

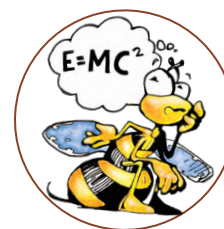
PLANT ECOLOGIST: This scientist studies the way plants interact with their environment or with other organisms, including other plants.

CAREER SPOTLIGHT



Did you know that there are many different types of ecologists? One of the ecologists in this study, Dr. Brodie, is also called a forest monitoring scientist. She studies and monitors different areas of the forest for changes. Dr. Brodie also works for a State science agency called California Department of Forest and Fire Protection (CalFire). As an ecologist, you can work in a variety of places such as private companies, nonprofit organizations, Federal agencies, and State governments.

Thinking About Science



Scientists work together to solve problems. They develop research studies to help them answer questions. Scientists often create experimental designs to help them answer those questions. With an experimental design, there is a structured process that uses an experiment to test a hypothesis.

In this study, the scientists had a unique opportunity to study wildfire using an experimental design. Due to the uncertain nature of wildfire, setting up an experimental design is difficult; it is hard to know with certainty where and when a wildfire will burn. Experiments with wildfire may also be difficult because of a lack of data on the condition of the forest before the fire.

However, the area that was burned by a wildfire in this study had been used for forest research for many years before the wildfire went through it. Therefore, there was a lot of data available about the land. This circumstance allowed the scientists to gather data for a large-scale wildfire forest management study.



Thinking About the Environment

Wildfires can be highly unpredictable. The fire behavior triangle is a way for people to think about how wildfires move and change, or basically how a wildfire behaves.

The fire behavior triangle helps people make predictions about what might happen during a wildfire. The three sides of the triangle are fuels, weather, and topography (**figure 1**).

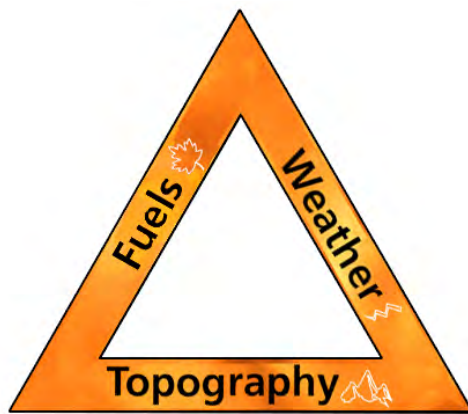


Figure 1. The fire behavior triangle shows how fuels, weather, and topography are important factors to consider when thinking about fire behavior.

- **Surface fuels**—all living and nonliving material near the ground that can be burned by a fire. Dead branches, leaves, twigs, and other debris that pile up on the forest floor, plus low shrubs, are all examples of **surface fuel** (**figure 2**). There is also fuel in the **canopy** of a tree.

The most important factor in the fuels category is moisture level. High moisture content slows the burning process. If fuel moisture is very low, the fuel is consumed more rapidly, which can lead to extreme fire behavior.

- **Weather**—the wind, temperature, and humidity. Wind is the most important factor of weather because it brings oxygen to the fire. Fires need oxygen, heat, and fuel to burn.

Another weather factor is temperature. Generally, fuels ignite faster with higher temperatures. Finally, humidity is also an important weather factor. Low humidity means drier fuels. Drier fuels catch fire more quickly.

- **Topography**—the shape of the land. Topography can help or hinder the spread of the fire. For example, a rocky area can act as a fuelbreak.

Elevation is another important component of topography. Higher elevations tend to be windier but colder. The slope of the topography is also useful to understand. For example, fire at the bottom of a steep slope may move more quickly. This quick movement is because the heat rising from fire at the bottom of the slope may preheat the area above the fire. Then the preheated area catches fire more quickly as the fire moves up the slope.



Figure 2. Forest Service personnel complete pile burns. Pile burns help reduce surface fuels. The firefighter uses a drip torch to start the prescribed fire.

Introduction

People take care of forests for a variety of reasons. One reason is to prevent severe wildfires that can hurt people and damage land and property. As you read in Thinking About the Environment, wildfire behavior is influenced by the fuels in a forest (both on the surface and in the tree canopy), weather, and topography. People can't really control the weather or topography of a forest, but they can manage the availability of fuels.

Forest thinning and prescribed fire are two forest treatment tools that are used to help reduce canopy fuels and **ladder fuels** in the forest. Canopy fuels are fuels in the top portion of the tree, otherwise known as the crown of the tree (**figure 3**). Ladder fuels are fuels, like grass, shrubs, and low

branches, that allow fire to climb from the ground to reach the tree crown.

Forest thinning means that trees are removed from the forest in a planned way (**figure 4**). Thinning prevents the overcrowding of trees. Overcrowded areas create stress on the trees, which can lead to unhealthy and diseased trees. Additionally, overcrowded areas provide more fuel for wildfire if it burns through that area.

Thinning generally removes smaller trees that can act as ladder fuels. Crown fires, in the tree canopy, move quickly when a forest is overcrowded because the crowns of the trees are closer together (**figure 5**).

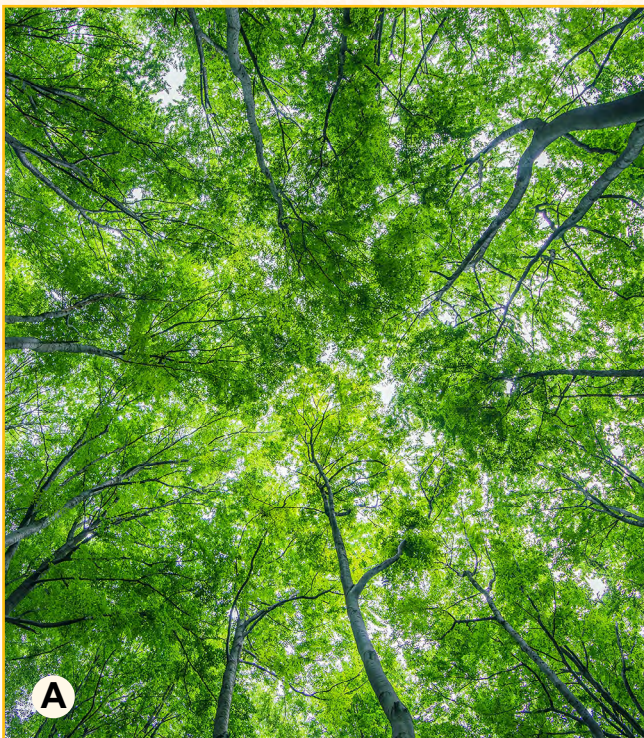


Figure 3A. A tree crown is the top portion of the tree with leaves and branches.



Figure 3B. Fire burns through trees and the tree crowns.



Figure 4. (A) This photo shows a forested area before thinning on Lolo National Forest in Montana. (B) This photo shows the same area but after thinning. What differences do you notice?



Figure 5. Look at these two illustrations. Would the forest shown in (A) or (B) be more likely to have a crown fire? Why?

Prescribed fire is a treatment that uses controlled fire. Controlled fire is fire that is set on purpose by trained professionals and monitored by them. Prescribed fire burns surface fuels such as dead and downed wood and twigs and branches that have fallen to the forest floor (**figure 6**). It also helps to control **understory** shrubs (**figure 7**).

Prescribed fire can also help create fuelbreaks. Fuelbreaks are areas in a forest that contain less trees and vegetation (**figure 8**). The lack of fuel in fuelbreaks means that the wildfire may be slowed down or have nowhere else to go. Prescribed fire helps to reduce overall fuel

in a forest and to maintain a healthy forest ecosystem.

In this research, scientists were interested in understanding the impacts of different forest treatments, like thinning and prescribed fire, on forest conditions. Because it would be dangerous to test their hypothesis by creating a wildfire, they collected data on forest treatments like thinning and prescribed fire. When a real wildfire burned unexpectedly through those study plots, the scientists were then able to study how different forest treatments affected the behavior and severity of wildfire.



Figure 6. Prescribed fires help burn forest fuels.



Figure 7. Understory shrubs are plants that are lower to the ground.



Figure 8. This fuelbreak on Hungry Horse Mountain in the Flathead National Forest can help stop a wildfire from spreading.



What are the two forest treatments described in the Introduction section and why are they important?

In the form of a question, describe what the scientists were interested in learning from this research.

Methods

The study took place on the Klamath National Forest in northern California in an area where long-term research was

already being conducted (**figure 9**). In the late 1990s, scientists began studies in this area to assess different forest

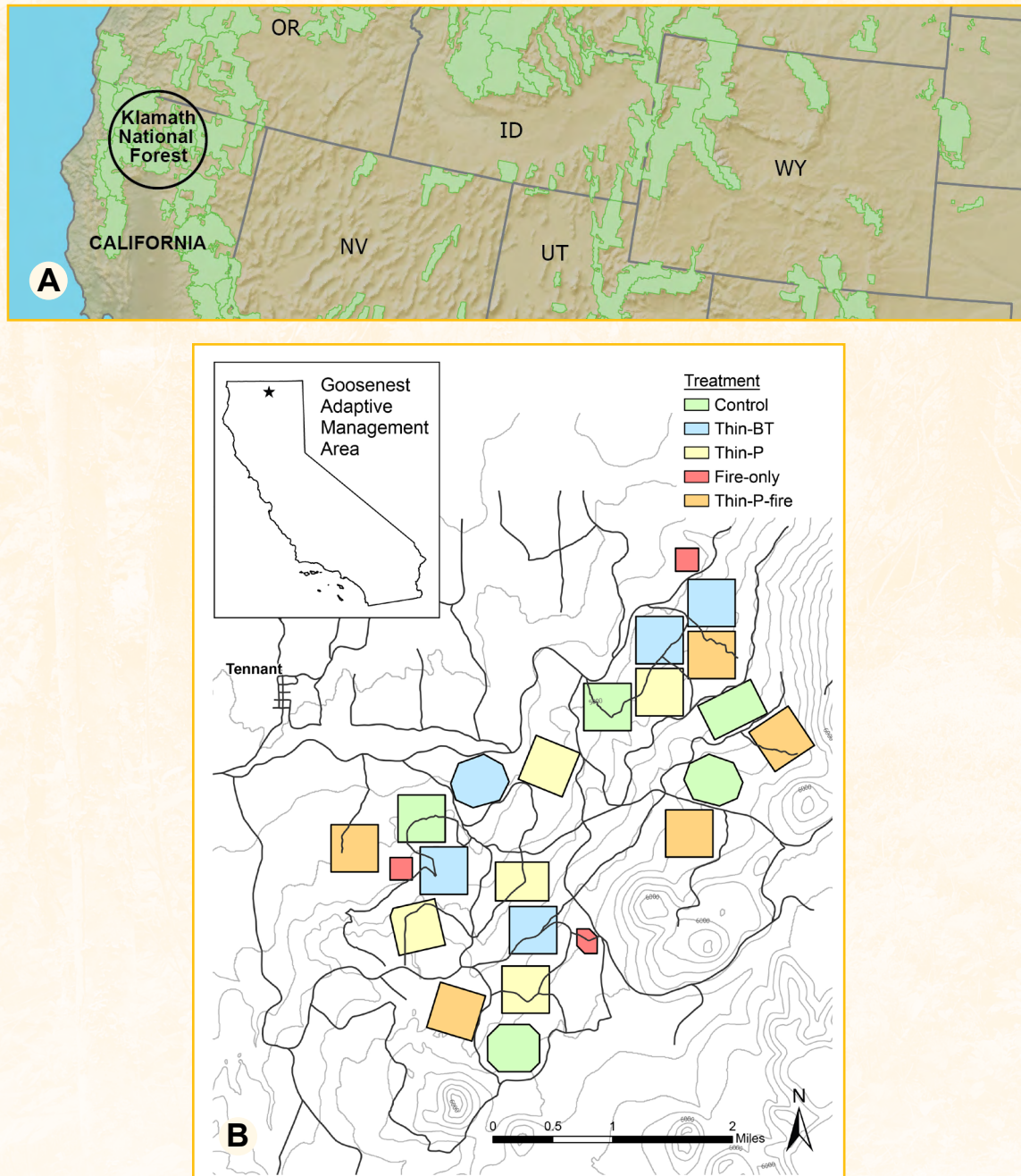


Figure 9. (A) California is located on the west coast of the United States. The Klamath National Forest is located in northern California. (B) The map shows the study locations in the Klamath National Forest. The dark black lines on the map show the roads in the area. The lighter gray lines are contour lines. Contour lines are used on topographic maps to show elevation.

treatment methods such as thinning and prescribed fire. The study area contained mostly ponderosa pine and white fir. The scientists visited the plots **periodically** to assess the effects of the treatments.

Over a century ago, long before these research plots were installed, forests in the study area were quite open. Studies of the tree rings show that in the past this area burned about every 11 years, which helped thin the forest and benefited ponderosa pine. Ponderosa pine is a species that is well adapted to frequent fire.

The forest was logged in the 1920s and many of the larger pines were cut. Larger trees can also be more resilient to fire. Wildfires, which occurred frequently before, were extinguished. Because of this management, smaller ponderosa pine and white fir trees grew back (**figure 10**). Smaller trees and white fir are more sensitive to fire. This combination of trees was far **denser** than the original forest.

The research area contained control plots that were not treated. Therefore, the control plots had more trees and greater tree canopy cover than the other treated



Figure 10. (A) Ponderosa pines can be seen in the photo on the left. (B) The photo on the right shows a white fir tree.

areas. Controls are important in scientific experiments because they provide a point of comparison. Controls allow a scientist to know that what is being observed is not just a random event. Scientists compared the different forest treatment plots with the control plots to determine the impact of the treatments.

The plots that were treated had four different treatments applied. They were:

- Thinning with an emphasis on keeping big trees (Thin-BT)
- Thinning with an emphasis on keeping pine trees (Thin-P)
- Prescribed fire only (Fire-only)
- Thinning with an emphasis on keeping pine trees plus the addition of prescribed fire (Thin-P-fire)

The scientists repeated each treatment in multiple plots (**table 1**).

In the summer of 2021, the Antelope Fire, which started with a lightning strike, burned through all the plots in the study area. The study area burned from August 4 through August 9 under a range of weather conditions.

Some of the study units burned while a Red Flag Warning was in place. A Red Flag Warning means that there are extreme conditions such as high wind, low humidity, and dry fuels that make conditions ideal for wildfires to start or for ones already burning to spread more quickly (**figure 11**).

The scientists realized that, although the research plots had been heavily damaged by the wildfire, there was another research opportunity available. The scientists could study how the wildfire affected the treatment areas in the research site. This information would provide valuable

Table 1. Plot names and treatment descriptions for the study in the Klamath National Forest

Plot name	Description	Number of times the treatment was repeated	Total number of plots
Control	No treatments since logging occurred in the 1920s	5	90
Thin-BT	Thinning only, with an emphasis on keeping big trees	5	91
Thin-P	Thinning only, with an emphasis on keeping pine trees	5	89
Fire-only	Prescribed fire occurred in fall 2002 and fall 2011	3	30
Thin-P-fire	Thinning with an emphasis on keeping pine trees and prescribed fire (prescribed fire occurred in fall 2001 and fall 2010)	5	91

data about how best to manage forests to survive wildfires.

After the Antelope Fire, the scientists inspected the trees from all the plots in the study area, collecting data on fire

damage—also known as fire severity. The severity ranged from mild to high.

The scientists gathered data on the amount of tree crown that was scorched or consumed by the wildfire and the

WHAT IS A RED FLAG WARNING?

A warning issued when **critical fire weather conditions** are happening or about to happen.

It does not necessarily mean there is a fire, but that conditions will be very dry and windy. If a fire is present, it can become extreme!

Avoid activities that could spark a wildfire!



Take Action!

- ✓ Make your wildfire plan, with at least 2 evacuation routes
- ✓ Maintain your go kit
- ✓ Follow fire prevention tips and regulations
- ✓ Listen to local officials for updates and evacuation orders

weather.gov 

Figure 11. This is an example of a Red Flag Warning.

did you know?

Did you know that wildfires are often named for a geological feature that is close to the wildfire? For example, the 2021 Antelope Fire was named after Antelope Creek, an area close to where the fire started. Naming wildfires something simple is a way to quickly and easily identify a wildfire and streamline communication with the public regarding the fire.



height of charring on the bark (**figure 12**). Trees that had any green needles left on them were considered “live.” The scientists also collected the same data in the untreated control areas. The scientists

used all the data they gathered and information about forest treatments in the past to determine if the forest treatments influenced wildfire behavior and severity.



Figure 12. Scientists examine the burned area and record data.



The area that was burned by the Antelope Fire had also been a long-term research site before the fire. Why did that fact end up being useful for the scientists?

After reading about the Red Flag Warning, think about what you read about the fire behavior triangle (see Thinking About the Environment). Why does it make sense that a Red Flag Warning signals the potential for a more severe fire?

Findings

Before the wildfire, the control plots had five to seven times more trees per hectare than the thinned treatment areas. One hectare is about 2.5 times the size of an acre (and just slightly smaller than a soccer field). The treatment areas that included thinning contained 98–120 trees per hectare. After the wildfire, the

scientists found that all treatment areas experienced lower fire severity than the control.

The most noticeable decrease in fire severity was for treatment areas that had been both thinned and treated with prescribed fire (Thin-P-fire) (**figure 13**).



Figure 13. In this photo, the area to the left of the road is a control plot and the area on the right of the road had treatments applied. What do you notice about how the wildfire affected the two areas?

Number Crunch

Based on the scientists' calculations, what is the approximate highest number of trees that might be in 1 hectare of the control plot?



The scientists found some interesting results depending on the condition of the treatment area before the wildfire. Within a treatment area, fire severity increased if the plots had a dense canopy and a large amount of surface fuel (**figure 14**).

Plots with a less dense canopy and/or less surface fuel had lower fire severity.

Additionally, the scientists found that larger trees were less likely to die in the wildfire and had less of their crown affected or killed by the fire.



Figure 14. Scientists discuss what happened at the burn site.



The severity of the fire increased in areas with a dense canopy and a lot of surface fuel. Why do you think this might have been the case?

What is one finding you thought was interesting or surprising? Why?

Discussion

This research is the first large-scale study with treatment areas for thinning and prescribed fire that burned almost entirely during a wildfire. The scientists found the treatments helped with fire behavior, fire severity, and tree **mortality** even though it had been 20 years since thinning and 10 years since a prescribed fire for some of the plots. Moreover, all treatment areas did better than the control plots.

The results held true even when fire weather conditions were the most extreme, like during the Red Flag Warning,

indicating that thinning and prescribed fire are useful ways to help **mitigate** fire behavior and severity. Additionally, the findings suggest an advantage to retaining the larger trees when thinning, as the larger trees showed more **resilience** to the fire.

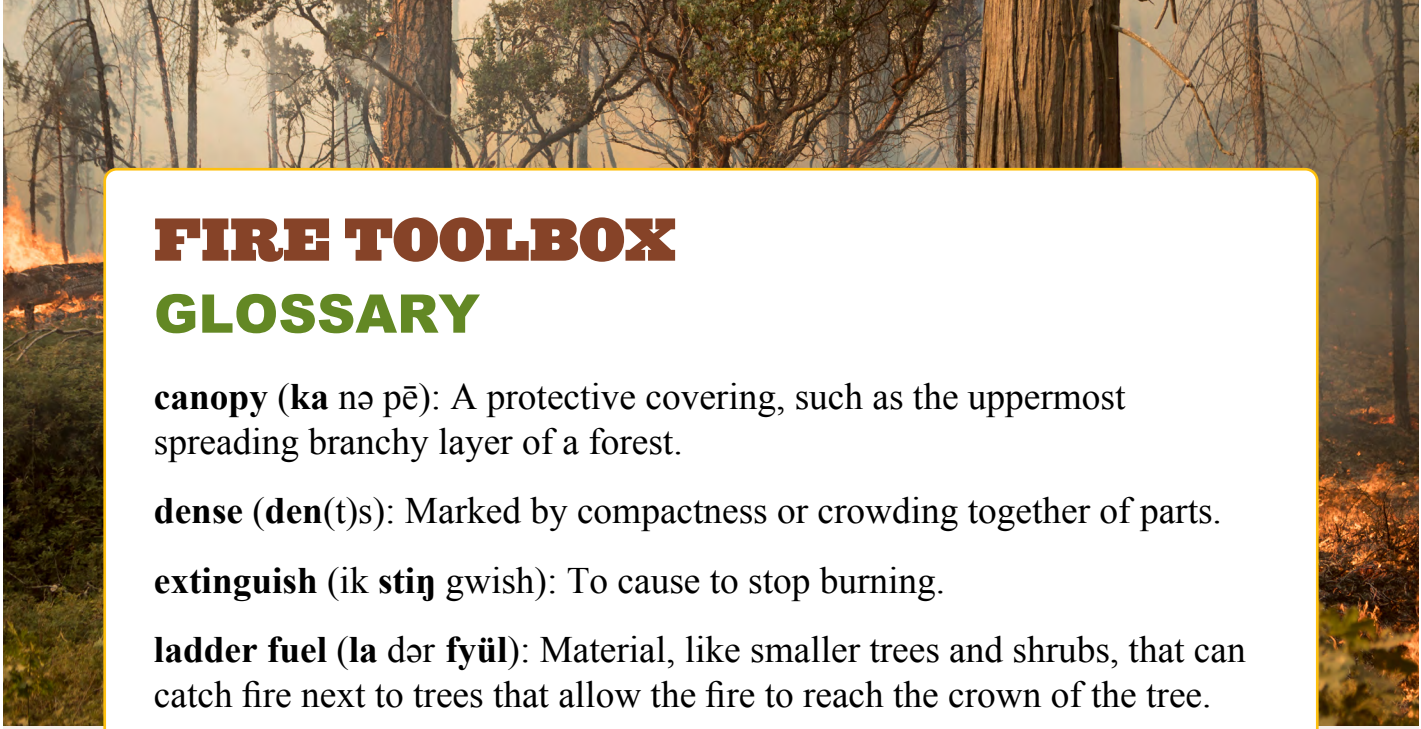
These results can help land managers and people who work in forest management and with wildfires to understand how thinning and prescribed fire may impact wildfire behavior and reduce wildfire severity.



Imagine that you manage a large area of forested land. Describe one way you would try to reduce the impact of wildfire on your forest.

Why do you think it is important to understand ways to manage a forest so that wildfires are not as severe?

Adapted from: Brodie, Emily G.; Knapp, Eric E.; Brooks, Wesley R.; Drury, Stacy A.; Ritchie, Martin W. 2024. Forest thinning and prescribed burning treatments reduce wildfire severity and buffer the impacts of severe fire weather. *Fire Ecology*. 20(1): 11770. <https://doi.org/10.1186/s42408-023-00241-z>.



FIRE TOOLBOX

GLOSSARY

canopy (ka nə pē): A protective covering, such as the uppermost spreading branchy layer of a forest.

dense (den(t)s): Marked by compactness or crowding together of parts.

extinguish (ik stiŋ gwish): To cause to stop burning.

ladder fuel (la dər fyül): Material, like smaller trees and shrubs, that can catch fire next to trees that allow the fire to reach the crown of the tree.

mitigate (mi tə gāt): To make (something) less severe, painful, or intense.

moderate (mä də rāt): To lessen the intensity or extremeness of.

mortality (mòr ta lə tē): The number of deaths in a population during a given time or place.

periodically (pir ē ä di k(ə-) lē): At regular intervals of time; from time to time.

resilience (ri zil yən(t)s): The ability to recover from or adjust to misfortune or change.

subalpine (səb al pīn): Of, relating to, or inhabiting high upland slopes and especially the zone below the timberline.

surface fuel (sər fəs fyül): Material found on or near the forest floor that can catch fire, such as twigs, branches, leaves, and low shrubs.

understory (ən dər stòr ē): The plant layer, especially the trees and shrubs, between the forest canopy and the ground cover.

Accented syllables are in **bold**. Definitions are based on those from <https://www.merriam-webster.com/>. Definitions are limited to the word's meaning in the article.

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FACTivity



Time Needed

Two class periods

Materials

- Graph paper
- Pencil
- Data from the National Interagency Fire Center (NIFC)

Background

The National Interagency Fire Center (NIFC) is made up of nine different agencies, including the Forest Service, that work together to help fight wildfires. NIFC compiles data and maps about wildfires from daily reports by staff at the National Interagency Coordination Center. The tables below provide data from NIFC about the number of acres burned by wildfire as well as the cost of fighting fires.

The question you will answer in this FACTivity is: What does the data from NIFC tell us about wildfires over time?

FACTivity Methods

Look at the two data tables provided. You will create a bar or line graph for each one.

For the graph for wildfire acres burned (**table 1**), create a graph using the even year data. You will start with 1984, then 1986, 1988, etc.

For the wildfire fighting cost data (**table 2**), you will create a graph for the data at 5-year intervals.

FACTivity *continued*

After you create the graphs, answer the following questions based on your observations of the data and the graphs you created.

- 1) Look at the acres burned by wildfire. What do you notice about the graph overall? Are there any trends you can spot? Any outliers?
- 2) Now examine the wildfire fighting cost data. What do you notice over time about the cost of fighting wildfires?
- 3) Compare the two graphs. Do you notice anything when you compare the two graphs?
- 4) As a class, discuss what you learned by looking at the wildfire data. Why is it useful to analyze data? What are some challenges of analyzing data?

Table 1. Total acres burned by wildfire in the United States (1983–2025)

Year	Total area burned (acres)
2025	5,131,474
2024	8,924,884
2023	2,693,910
2022	7,577,183
2021	7,125,643
2020	10,122,336
2019	4,664,364
2018	8,767,492
2017	10,026,086
2016	5,509,995
2015	10,125,149
2014	3,595,613
2013	4,319,546
2012	9,326,238
2011	8,711,367
2010	3,422,724
2009	5,921,786
2008	5,292,468
2007	9,328,045
2006	9,873,745
2005	8,689,389
2004	8,097,880*
2003	3,960,842
2002	7,184,712

Year	Total area burned (acres)
2001	3,570,911
2000	7,393,493
1999	5,626,093
1998	1,329,704
1997	2,856,959
1996	6,065,998
1995	1,840,546
1994	4,073,579
1993	1,797,574
1992	2,069,929
1991	2,953,578
1990	4,621,621
1989	1,827,310
1988	5,009,290
1987	2,447,296
1986	2,719,162
1985	2,896,147
1984	1,148,409
1983	1,323,666

*Wildfire data for 2004 does not include fires on State lands in North Carolina.

Source: National Interagency Fire Center

Table 2. Estimated Federal costs for wildland firefighting in the United States by year

Year	Firefighting costs (dollars)
2020	2,274,000,000
2015	2,130,543,000
2010	809,499,000
2005	818,954,000
2000	1,410,802,000
1995	477,126,000
1990	397,952,000
1985	239,943,000

Source: National Interagency Fire Center

Natural Inquirer Connections

You may want to reference these *Natural Inquirer* articles for additional information and FACTivities:

- For more on how prescribed fire affects pollinators, read “A Flame Changer,” a *Natural Inquirer* monograph.
- For more on the relationship among fire, wildlife, and trees, read “Knock on Wood,” a *Natural Inquirer* monograph.
- For a collection of studies relating to fire, read the Wildland Fire 1 and Wildland Fire 2 editions of *Natural Inquirer*.
- For more resources about experimental design, check out the “Designing Your Own Study” special collection from *Natural Inquirer*.

These articles, along with others, can be found at <https://www.naturalinquirer.org>.



If you are a trained Project Learning Tree educator, you may use “Living With Fire” as an additional resource.

Web Resources



National Park Service: “Wildland Fire Behavior”

<https://www.nps.gov/articles/wildland-fire-behavior.htm>

Forest Service video: “Through the Fire”

<https://research.fs.usda.gov/psw/products/multimedia/videos/through-fire>

“Forest Service’s burned research area fuels case for thinning and prescribed burns”

https://www.kdrv.com/news/firewatch/forest-services-burned-research-area-fuels-case-for-thinning-and-prescribed-burns/article_9fecb3e6-cc2b-11ee-8eb6-a3d485a5ede5.html

Forest Service: “Prescribed fire boosts community safety & forest health”

<https://www.fs.usda.gov/about-agency/features/prescribed-fire-boosts-community-safety-forest-health>

Forest Service: “Saving the Klamath—A Firsthand Account of the Antelope Fire and its Aftermath”

<https://www.fs.usda.gov/inside-fs/delivering-mission/excel/employee-perspective-saving-klamath-firsthand-account-antelope>

Klamath National Forest Flickr

<https://www.flickr.com/photos/usfsregion5/albums/72157710075069956/with/50275749457>

Fire Toolbox

eyeChallenge

Each of the following images represents something from the article. Explain what each image represents. You may write your explanation or hold a class discussion. If you write your explanation, use complete sentences, proper spelling and grammar, and appropriate punctuation.



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National Education Standards

For more detailed correlations of this *Natural Inquirer* Monograph and National Education Standards, visit the *Natural Inquirer* website (<https://www.naturalinquirer.org>).

Social Studies Education Standards Addressed in This Article

- People, places, and environments
- Science, technology, and society

Common Core Education Standards Addressed in This Article

- Key Ideas and Details
CCSS.ELA-Literacy.RST.6-8.1
CCSS.ELA-Literacy.RST.6-8.2
CCSS.ELA-Literacy.RST.6-8.3
- Craft and Structure
CCSS.ELA-Literacy.RST.6-8.4
CCSS.ELA-Literacy.RST.6-8.5
CCSS.ELA-Literacy.RST.6-8.6
- Integration of Knowledge and Ideas
CCSS.ELA-Literacy.RST.6-8.7
CCSS.ELA-Literacy.RST.6-8.8
CCSS.ELA-Literacy.RST.6-8.9
- Range of Reading and Level of Text Complexity
CCSS.ELA-Literacy.RST.6-8.10

Next Generation Science Standards Addressed in This Article

Science and Engineering Practices

Asking Questions and Defining Problems
Planning and Carrying Out Investigations
Analyzing and Interpreting Data
Using Mathematics and Computational Thinking
Constructing Explanations and Designing Solutions
Engaging in Argument From Evidence
Obtaining, Evaluating, and Communicating Information

Disciplinary Core Ideas

Life Science:

- LS2.A-M1 Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.C-M1 Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Earth and Space Science:

- ESS3.B-M1 Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.
- ESS3.C-M1 Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ESS3.C-M2 Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Crosscutting Concepts

Patterns
Cause and Effect
Systems and System Models
Structure and Function
Stability and Change
Influence of Engineering, Technology, and Science on Society and the Natural World
Connections to Nature of Science



What Is the Forest Service?

The Forest Service is part of the U.S. Department of Agriculture (USDA). The Forest Service is made up of thousands of people who care for the Nation's forest land. The Forest Service manages 154 national forests and 20 national grasslands. These are large areas of trees, streams, and grasslands. National forests are similar in some ways to national parks. Both are public lands, meaning they are owned by the public and managed for the public's use and benefit. Both national forests and national parks provide clean water, homes for the animals that live in the wild, and places for people to do fun things in the outdoors. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists whose work is presented in the monograph. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

For more information, visit <https://www.fs.usda.gov>.



What Is FIND Outdoors?

Formerly the Cradle of Forestry in America Interpretive Association, FIND Outdoors is a reimagined 501(c)3 nonprofit organization based in Pisgah Forest, NC. We are the Southeast's leader in providing access to public lands, environmental education, recreation, and front country camping experiences. We maintain and operate recreation, education, and camping facilities across western North Carolina, northern Georgia, and beyond—serving approximately 800,000 visitors each year with over 150 recreational and environmental education programs, special events, and tours.



Our story is rooted in education about the **forest**.

Our passion is to help people become **inspired**.

Our goal is to help people connect with **nature**.

Our drive is to help people learn through **discovery**.

We help people...FIND Outdoors.

We are...FIND Outdoors.

For more information, visit <https://www.goFINDoutdoors.org>.

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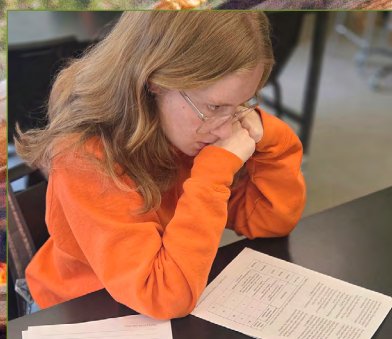
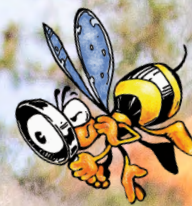
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FS-1278
August 2026