WHERE THERE'S SMOKE, THERE'S FIRE

Is Climate Connected to Very Large Wildland Fires?

U.S. Fish and Wildlife Service photo.

Meet the Scientists!

Photo courtesy of Natasha Stavros, used with permission.

Natasha Stavros,

Jet Propulsion Laboratory Research Scientist

My favorite science experience is learning about fire and its role in the earth sciences. Fire has touched my life in a personal way because I grew up in Southern California where fires occur frequently.

John Abatzoglou (ā **bäks** ə glü),

Climatologist

My favorite science experience is exploring the large amount of historical weather and climate data. I also like to look at climate data from **models**. I use the climate data like a detective, trying to learn more about the "why" and "how" of the climate system.

Photo courtesy of John Abatzoglou, University of Idaho, used with permission.

Glossary words are in **bold** and are defined on page 28.

Photo courtesy of E. Ashley Steel, USDA Forest Service.

◀ **E. Ashley Steel,**
Statistician and Quantitative Ecologist

One of my favorite science activities is creating a cool graph that helps everyone understand a story from a big mess of data.

What Kind of Scientists Did This Research?

- **Jet Propulsion Laboratory scientist:** This scientist works at the Jet Propulsion Laboratory (see page 12 for more information about the Jet Propulsion Laboratory). He or she uses new technologies to collect data and create new information. This scientist also examines information coming from current space missions and satellites, and he or she shares that information with other scientists, land resource managers, and the general public.
- **climatologist:** This scientist studies climate change, climate variation, and the effects of climate on Earth.
- **statistician:** This scientist uses **statistics** to design data collection plans, analyze data, graph data, and help solve real-world problems in business, engineering, the sciences, or other fields.
- **quantitative ecologist:** This scientist uses statistics and mathematics to solve problems in ecology. Ecology is the study of the interactions of living things with each other and with the nonliving environment.

WHAT IS THE JET PROPULSION LABORATORY?

The Jet **Propulsion** Laboratory works with the United States National Aeronautics and Space Administration (NASA) and is managed by the California Institute of Technology. Some scientists who work at the Jet Propulsion Laboratory construct and operate spacecrafts within Earth's orbit and farther into space. They also test new technologies on aircraft.

You may have heard about missions organized by the Jet Propulsion Laboratory. Jet Propulsion Laboratory projects include the *Curiosity* and *Opportunity* rovers, the Cassini-Huygens orbit around Saturn, and the *Juno* expedition to Jupiter. Other projects include *Voyager 1*, a satellite that was launched in 1977 and is still in space (figure 1).

Figure 1. Scientists believe that *Voyager 1* has gone farther into space than any other human-made object. *Voyager 1* is one of many spacecrafts that Jet Propulsion Laboratory scientists have helped design, construct, or operate.

National Aeronautics and Space Administration photo.

Many other Jet Propulsion Laboratory projects take place on Earth and study the environment. Some Earth missions include studying soil moisture, carbon dioxide, and global precipitation.

The Jet Propulsion Laboratory has many other projects. To learn more about the Jet Propulsion Laboratory, visit https://www.jpl.nasa.gov/.

Thinking About Science

As you read in “About *Natural Inquirer* Monographs” on page 5, scientists write and share information with one another in scientific journals. Reading scientific journals adds to a scientist’s understanding of a topic. Scientists may read articles from many different journals before they begin their own research. This process is often called a “literature review.” Performing a literature review ensures that a scientist is using accurate and up-to-date information. It also helps scientists identify the best methods for their research. Scientific research may not improve the science community’s understanding of a topic if scientists do not first conduct a literature review.

In this article, the scientists performed a literature review before beginning their research on wildland fires. During their literature review, the scientists discovered previous research on wildland fires. Using the information gathered during the literature review, the scientists created new research questions.

Thinking About the Environment

Scientists compare and contrast Earth’s ecosystems using many different **criteria**. For instance, some scientists compare the diversity of animals across ecosystems, while other scientists compare ecosystems by levels of air pollution.

Scientists may collect many pieces of information to compare wildland fire across ecosystems (figure 2). These pieces of information are **influenced** by climate and plant communities in an ecosystem (figure 3). The information may include:

1. How often natural wildland fires are expected to occur,
2. The amount of area burned by an average wildland fire,

continued on page 14

3. Wildland fire severity, which is a measurement of how plants, soils, and animals are affected by a wildland fire, and

4. The expected wildland fire intensity, which is a measurement of the amount of heat released from a fire.

Using these pieces of information, scientists can place each ecosystem into a "group" or "regime," which indicates how wildland fire interacts with the ecosystem.

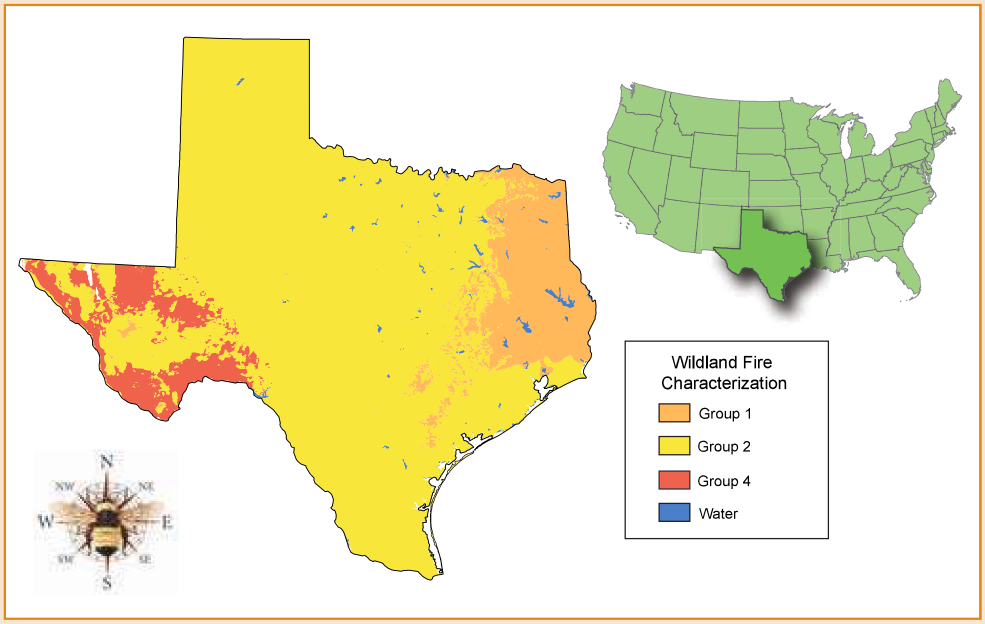


Figure 2. Scientists place ecosystems into groups based on how wildland fire interacts with each ecosystem. The groups provide a general understanding of the ecosystem and the wildland fires that may occur.

On this map, "Group 1" indicates ecosystems with frequent, low-severity wildland fires. Ecosystems in Group 4, however, have infrequent wildland fires that are often severe. Groups 3 and 5 are not pictured on this map because ecosystems in those groups do not occur in Texas. Only wildland fires started by natural causes, such as lightning, are included in this assessment. What similarities or differences do you see between the eastern and western parts of Texas?

Illustration by Carey Burda and Stephanie Pfeiffer.

Figure 3. Longleaf pine forests would be characterized as Group 1 (see figure 2). These forests have wildland fires often due to lightning strikes. The plants and animals within longleaf pine forest ecosystems are **adapted** to survive wildland fires.

U.S. Department of Agriculture photo.

Introduction

Wildland fires are considered a natural part of many ecosystems on Earth. The scientists in this study knew that wildland fires were common in many parts of the Western United States.

The scientists observed, however, that wildland fires in some areas were growing larger than they expected. The scientists called these fires "very large wildland fires." Very large wildland fires are fires that burn more than 50,000 acres of land. Each year, very large wildland fires account for large portions of the total area burned in the Western United States. Very large wildland fires are expensive to **suppress** (figure 4). They are also potentially damaging to ecosystems and human health (figures 5 and 6).

The scientists read past research, which showed that climate can influence wildland fires. However, past research did not focus on very large wildland fires. The scientists, therefore, were interested in using weather data to understand the connection between climate and very large wildland fires.

Figure 4. Land and fire resource managers, firefighters, scientists, and community leaders are all involved in managing wildland fires.

U.S. Fish and Wildlife Service, USDA Forest Service, and Bureau of Land Management photos.

Figure 5. Smoke from wildland fires can negatively affect human health.

Photo by Susy Walton, USDA Forest Service.

Figure 6. Very large wildland fires can threaten buildings, roads, homes, and ecosystems.

U.S. Fish and Wildlife Service photo.

Number Crunch

One acre is equal to about 16 tennis courts (figure 7). Very large wildland fires are considered to be 50,000 acres or more. How many tennis courts would fit on 50,000 acres?

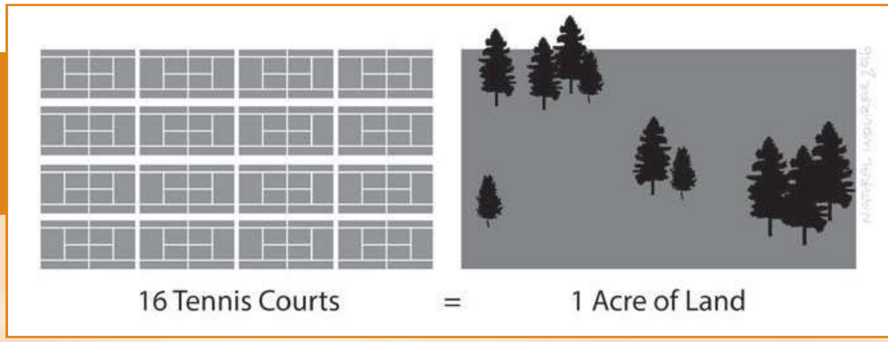


Figure 7. An acre is equal to about 16 tennis courts. Illustration by Stephanie Pfeiffer.

Reflection Section

In your own words, and in the form of a question, state the question that the scientists were trying to answer with this research.

How did the scientists come up with their research question? What is another way that scientists can create a research question?

(Watch the *Natural Inquirer* Scientist Video series to see how scientists create a research question. To learn more, visit http://www.naturalinquirer.org/Science-Fair-Connections-v-146.html)

Methods

To answer their question about climate and very large wildland fires, the scientists selected eight study regions. These study regions had been created by the National Interagency Fire Center (figures 8a and 8b).

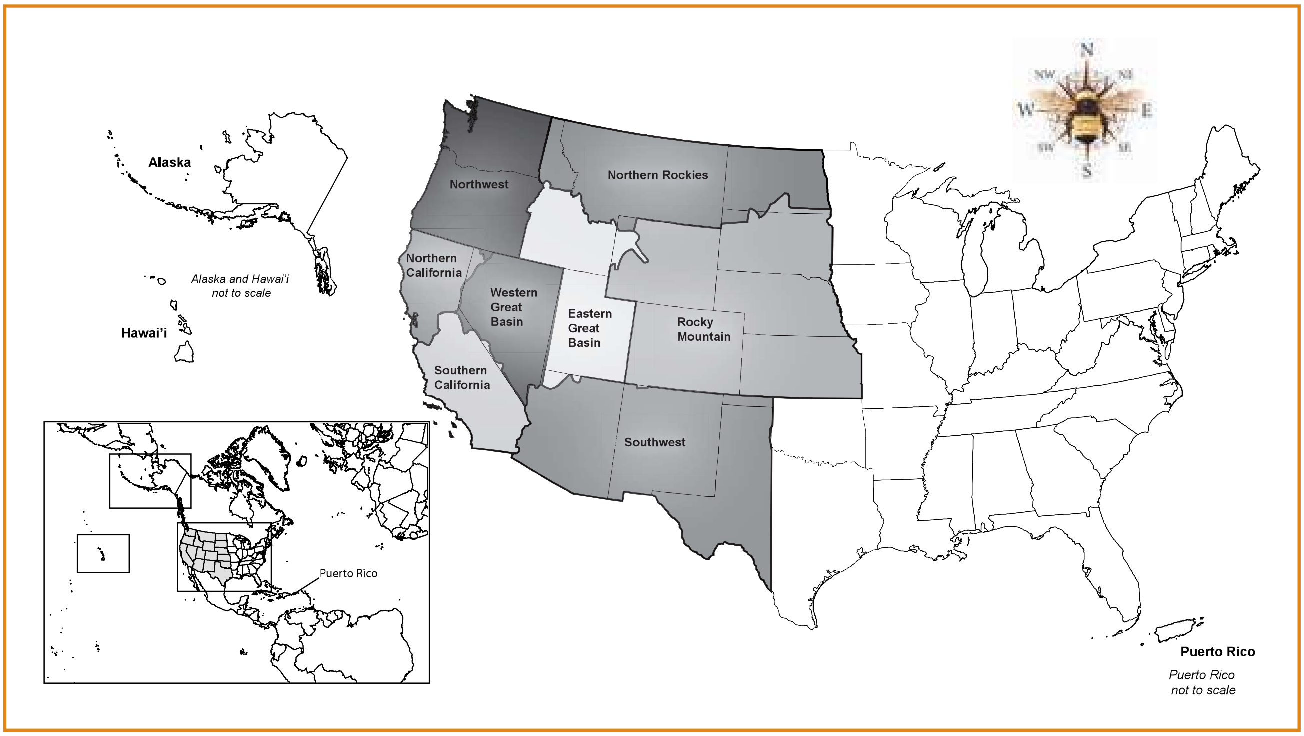


Figure 8a. The scientists chose eight study regions. The regions included: Southwest, Rocky Mountain, Northern Rockies, Northwest, Northern California, Southern California, Western Great Basin, and Eastern Great Basin. All eight of the study regions were located in the Western United States.
Map by Carey Burda.

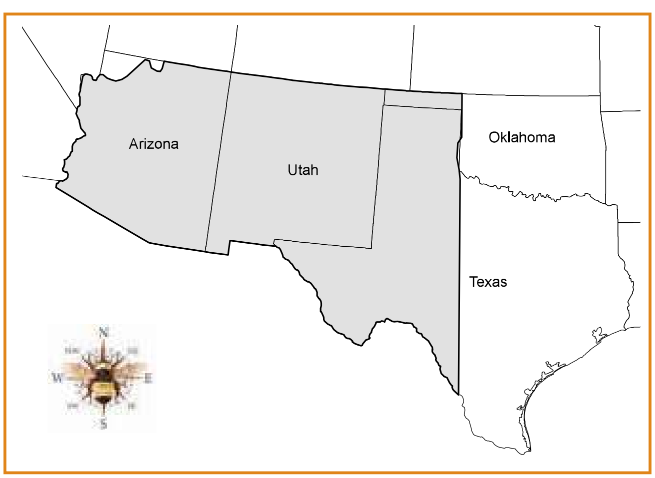


Figure 8b. Study regions may **encompass** multiple States and ecosystems.
Map by Carey Burda.

WHAT IS THE NATIONAL INTERAGENCY FIRE CENTER?

Photo by Babs McDonald, used with permission.

The National Interagency Fire Center (NIFC) is located in Boise, Idaho. NIFC focuses on organizing and managing resources needed to fight wildland fires in the United States. Staff at the NIFC facility help distribute materials and direct firefighters. Wildland firefighters receive training at the center. NIFC staff also conduct research to help predict wildland fires.

NIFC is composed of many cooperating Federal agencies. These Federal agencies, along with State agencies, are responsible for understanding and managing wildland fires across the United States.

NIFC helps manage other dangerous situations that occur in the United States, such as floods. To learn more about NIFC, visit https://www.nifc.gov/.

Next, the scientists found wildland fire data from the years 1984–2010. Data were available for each of the eight study areas. These data showed the amount of land burned in each wildland fire. The data enabled the scientists to classify each week of data as either a “very large wildland fire week,” “large fire week,” or “no fire week.”

The scientists then gathered weather data and **biophysical** observations to use as climate **variables**. Weather data and biophysical observations studied over long time periods, such as months, years, or decades, help scientists understand climate.

Weather data used in this study included monthly average air temperature and monthly average precipitation. Seven different biophysical observations were used in the study (table 1). Biophysical observations help scientists analyze parts of the environment, like soils and plants, to better understand climate conditions.

The scientists combined the wildland fire data and the climate variables (weather data and biophysical observations) in a computer for analysis. The analysis enabled the scientists to look for patterns between the climate variables, very large wildland fires, and large wildland fires. The scientists were also able to compare patterns occurring across the eight study regions.

Table 1. The scientists chose seven biophysical observations. Biophysical observations are useful for understanding climate conditions related to **drought** or the potential for wildland fires to start and grow.

Name	What does it represent?
100-hour fuel moisture (FM100)	Moisture content of small dead plant material (1–3” diameter).
1000-hour fuel moisture (FM1000)	Moisture content of large dead plant material (3–8” diameter).
Energy Release Component (ERC)	Amount of heat that a fire could create based on the amount of living plants and dead plants.
Burning Index (BI)	Effort needed to control a fire.
Fine Fuel Moisture Content (FFMC)	Moisture content of fine dead plant material.
Duff Moisture Code (DMC)	Moisture content of material on forest floor.
Palmer Drought Severity Index (PDSI)	Dryness of soils in a location based on recent weather.

WHAT IS THE DIFFERENCE BETWEEN CLIMATE AND WEATHER?

Oftentimes, scientists say, “Climate is what we expect. Weather is what we get.”

Each winter, we get our pants, gloves, and jackets ready for the colder days. We use experiences from past years to judge how we should dress for the winter. Occasionally, on some days in the winter, it might be surprisingly warm. It can be so warm, in fact, that we need to remove the jackets, hats, and gloves that we thought we needed.

If the above situation has happened to you, you have thought about both weather and climate. Climate is the range of possible weather conditions in a location. On the other hand, weather is the current condition of the atmosphere in a location, including air temperature, precipitation, or wind (figure 9). By looking at weather over time, such as months, years, or decades, we can better understand the climate for a location.

For example, many years of weather data indicate that the State of Florida should expect a climate with warm, sunny summers. Using this knowledge of Florida’s climate, we would bring shorts, t-shirts, hats, and sunscreen on summer vacation. However, weather can suddenly change. A storm could bring unexpected weather with clouds and cool winds for a few days. With an understanding of Florida’s climate, we realize that the warm and sunny summer weather will return following the unusual weather.

Scientists can look at the distribution of weather data to find patterns that indicate the climate. In this research, the scientists wanted to know more about how climate was linked to very large wildland fires. To do this, they analyzed weather data and biophysical observations before, during, and after very large wildland fires.

Definitions of climate and weather can be easily confused. To learn more about climate and weather, visit:

National Snow and Ice Data Center
https://nsidc.org/cryosphere/arctic-meteorology/climate_vs_weather.html

National Oceanic and Atmospheric Administration
https://oceanservice.noaa.gov/facts/weather_climate.html

National Aeronautics and Space Administration
https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

Figure 9. Weather information is reported daily in newspapers, on television, on the radio, and on the internet. Weather, such as air temperature and precipitation, can vary. The weather we get may be different from the weather we expect.

Photo by Brian Cooke, used with permission.

Reflection Section

Review the weather data and biophysical observations used to represent climate in this research. What similarities or differences do you see among these data and observations?

Why do you think the scientists decided to look at weather data and biophysical observations from before, during, and after wildland fires?

Findings

Results show patterns that suggest climate before, during, and after very large wildland fires is different than climate for large wildland fires. Some biophysical observations showed clear patterns involving very large and large wildland fires, while weather data show no clear patterns (figures 10 and 11). Specifically, climate variables related to drought conditions, like DMC or PDSI, can indicate times in which very large wildland fires may occur.

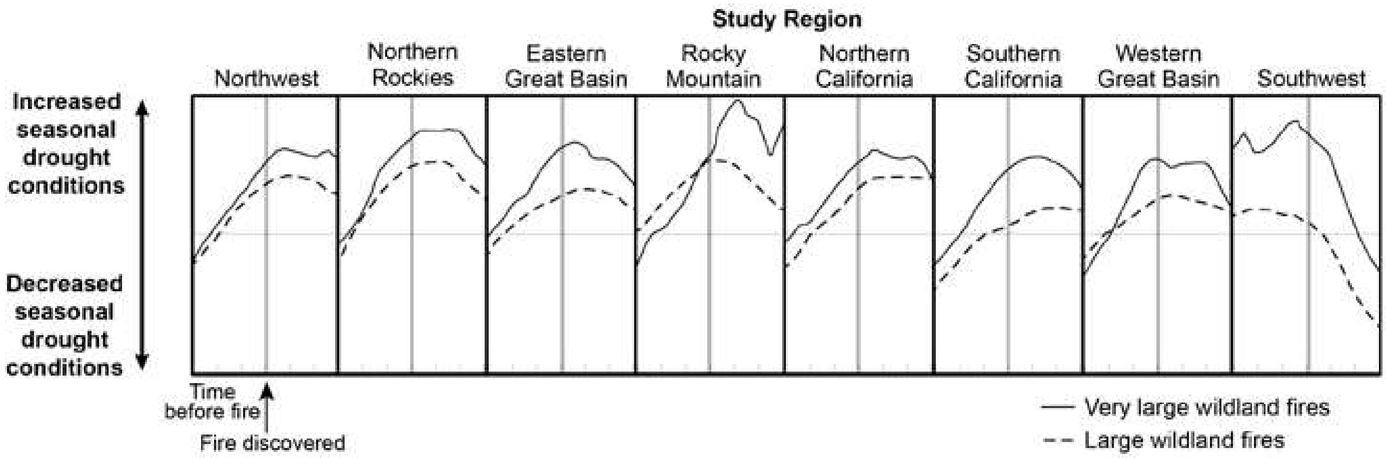


Figure 10. DMC is a measure of the moisture content of materials on the forest floor (see table 1). DMC indicates seasonal drought conditions. DMC was different for very large wildland fires and large wildland fires across the eight study regions.
Illustration by Stephanie Pfeiffer.

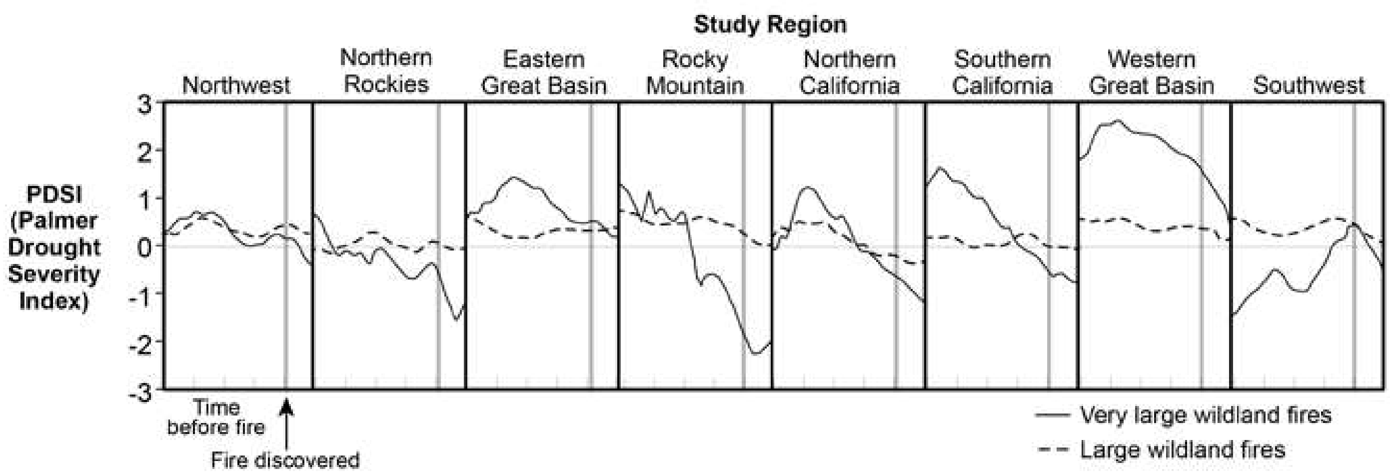


Figure 11. PDSI is a measure of the dryness of the soil (see table 1). PDSI in some study regions changed from moist soils (above 0) before a very large wildland fire to dry soils (below 0) when a very large wildland fire started.
Illustration by Stephanie Pfeiffer.

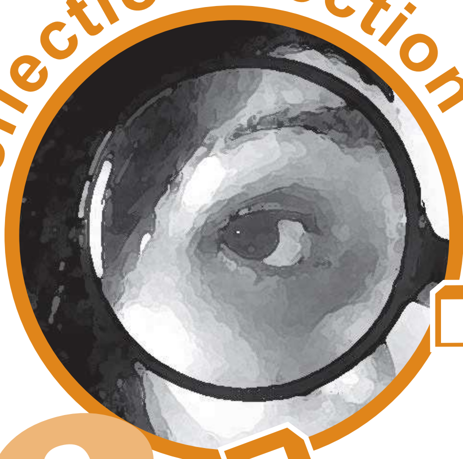
The scientists also discovered that plant communities within a study region influence patterns seen in the data for very large wildland fires. For example, some study regions contain ecosystems with few plants, like Western Great Basin and Southwest. In these study regions, biophysical observations often followed similar patterns. These study regions require high moisture in the year before a fire to lead to very large wildland fires. High moisture creates conditions for plant material to grow and later burn.

On the other hand, study regions like Pacific Northwest or Rocky Mountain have many plants and a lot of precipitation. The scientists observed that these areas require hot and dry conditions leading up to, and during, a fire to lead to a very large wildland fire.

What is the Pacific Wildland Fire Sciences Laboratory?

The Pacific Wildland Fire Sciences Laboratory is located in Seattle, Washington, and it is one of two National fire laboratories managed by the USDA Forest Service. Research at the laboratory involves many different disciplines that all focus on understanding fires that occur in wildlands. Topics that scientists study at the laboratory include wildfires and human caused fires, fire effects on the landscape, and how we can better manage fires in the future. Many of the studies done by scientists at the laboratory lead to tools used by national forests, national parks, and others to control and manage fire in wildlands. Scientists regularly train land managers on the latest findings, like using prescribed fire to reduce risks from large wildfires, how one can predict and warn nearby populations about potential smoke from fires, and how managers and the public can work together to better protect our communities.

Reflection Section



The scientists found some patterns in the data for many biophysical observations. The patterns were seen before, during, and after very large wildland fires. These patterns often occurred in multiple study regions. Look at figure 10, and examine the results. What is the pattern you see occurring for very large wildland fires in each study region? Which study regions are experiencing this pattern? How is that pattern different from large wildland fires?

Review figures 10 and 11. These figures illustrate the results of biophysical observations that are climate variables. Using the information you learned about these biophysical observations (see table 1), why do you think these variables are connected to very large wildland fires?

Discussion

In this study, the scientists observed that some climate variables followed patterns. These patterns were seen before, during, and after very large wildland fires, and in many cases, were seen in multiple study regions. Patterns are different between very large wildland fires and large wildland fires.

These patterns indicated to the scientists that very large wildland fires were linked to specific climate conditions. The link between climate and very large wildland fires is also influenced by the types of plant communities in a location.

This study improved scientists' understanding of very large wildland fires. Scientists may also use this information to understand how changes in climate might affect wildland fire in the Western United States. The scientists concluded that people need this information to prepare for and respond to wildland fires.

Reflection Section

The scientists noted that this research supports what they already believed about very large wildland fires. Why is it important for scientists to research questions even if they feel that they already know the answer?

Imagine you were given the opportunity to study this topic. What other factors would you test to see if they are connected to very large wildland fires? Why?

Adapted from Stavros, E.N.; Abatzoglou, J.; Larkin, N.K.; McKenzie, D.; Steel, E.A. 2014. Climate and very large wildland fires in the contiguous Western USA. International Journal of Wildland Fire. 23: 899-914. http://www.fs.fed.us/pnw/pubs/journals/pnw_2014_stavros.pdf. [7 October 2015].

Glossary

accumulation (ə **kyü** m(y)ə **lā** shən): The act of collecting or gathering.

adapt (ə **dap**): To adjust to new conditions.

analyze (**a** nə **līz**): To study or examine carefully.

biophysical (**bī** ō **fi** zi kəl): Living and nonliving parts of the environment, such as soil or moisture, that influence organisms or natural events.

climate (**klī** mət): The distribution of weather over a long time, such as months, years, decades, or longer.

criteria (krī **tir** ē ə): Standards on which a judgment or decision may be based.

drought (**drau̇**t): A period of dry weather with little or no precipitation.

encompass (en **käm** pəs): To include or surround.

hypothetical (hī pə **the** ti kəl): Imagined as an example for further thought.

influence (in **flü** ən(t)s): To affect something.

longitudinal (län jə **tüd** nəl): Involving the repeated observation over time with respect to one or more study variables.

model (**mä** dəl): A simplified copy or representation of something to help human understanding.

predict (pri **dikt**): To say that something might or will happen in the future.

prescribed fire (pri **skrīb(d) fīr**): Human application of fire to wildland vegetation under certain weather conditions as a forest management tool.

propulsion (prə **pəl** shən): The process of driving or propelling forward.

statistics (stə **tis** tiks): The branch of mathematics that deals with the collection, organization, analysis, and interpretation of numerical data.

suppress (sə **pres**): (1) To put an end to; (2) To subdue or conquer.

variable (**ver** ē ə bəl): A factor, trait, or condition that can be changed or controlled.

wildland fire (**wild land fīr**): Fires that burn in forests, on prairies, or over other large natural areas.

Marks and definitions are from https://www.merriam-webster.com. Accented syllables are in **bold**. Definitions are limited to the definition used in the article.