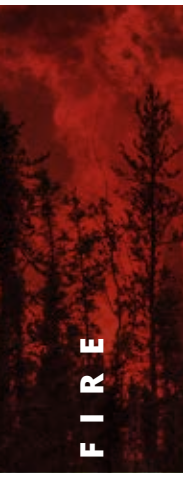
EARTH

AIR



FIRE

WATER

THE HUMAN ELEMENT

> *"In all of our lives, fire is a combination of a fascinating, useful substance and an incredibly horrifying, destructive one."*
>
> **—James Balog, *The Human Element***

FIRE LESSON OBJECTIVES

At the end of this lesson, students will be able to:

- Articulate three ways in which climate change has contributed to an increase in the number and severity of wildfires.
- Understand the "fire triangle" of heat, fuel and oxygen.
- Use visual evidence to illustrate one of the ways in which humans have contributed to increased fire danger.
- Discuss new ways of thinking about forest management and the wildland-urban interface.
- Communicate how human behavior is increasing the frequency and scope of megafires, how those changes are affecting humans, and how human efforts might help or ameliorate them.

MATERIALS

- You can find the Fire Chapter here: **https://vimeo.com/328528089**. The password is: **THEedu**.
- Projection equipment to screen the "Fire" chapter of ***The Human Element***.
- Printed copies of **Handout One—Fire Note Catcher**
- As needed, copies of **Handout Two—Artist Statement**. Student access to the internet or copies of **Research Appendices One–Three**

DURATION

Two 50-minute class periods plus homework or extension for final project.

OPENING EXERCISE: CLIMATE CHANGEMAKER

As a class, read this quote from historian Stephen Pyne:

> *"It is interesting to think about the ancient Greek elements of earth, air, water and fire. Earth, air and water are all substances, but fire is the odd man out; it's a reaction. It synthesizes its surroundings. It takes its character from the context around it in ways the other elements don't."*
>
> **—Dr. Stephen Pyne, Professor Emeritus, School of Life Sciences, Arizona State University, in an interview for *The Human Element***

Read aloud, project or distribute this background information on historian Stephen Pyne:

Stephen Pyne spent part of his young adulthood fighting fire on the North Rim of the Grand Canyon. During that time, he became curious about fire itself and the role it plays in human culture and industry. He believes our present geological era could reasonably be called the "Fire Age," given how the control of fire and the discovery of geologic fuels played such an integral role in the industrial revolution, which in turn has changed the shape of human culture and the world.

Yet most of us barely understand our own connection to fire. Pyne points out that we use controlled fire constantly, but mostly in unseen ways – like burning fuel inside automobile, truck and airplane engines, or in the furnaces of electricity generating plants. "When we drive our cars, we're driving a fire engine," he says, "but we can't see it."

Stephen Pyne's work challenges us to complexify our understanding of fire from its current dichotomy: controlled fire is good, and wildfire is bad. From changing the way we manage and build around forests and open spaces to shifting how we conceive of and use fossil fuels, Pyne encourages us to reconsider how humans interact with fire.

Suggested discussion questions:

- In his quote about fire, Stephen Pyne says that it "takes its character from its context." What do you think he means by that?
- In what context is fire good? In what context is it bad?
- Briefly discuss how accepting fire as inevitable and necessary might change the way we put out and manage fires, as well as how we construct our communities.

Watch the Film Chapter "Fire" (run time, 19:41)

Students will use **Handout One—Fire Note Catcher** to record their thoughts and questions as they watch. After the chapter ends, offer students the opportunity to debrief about what they noticed or learned about current fire activity in America.

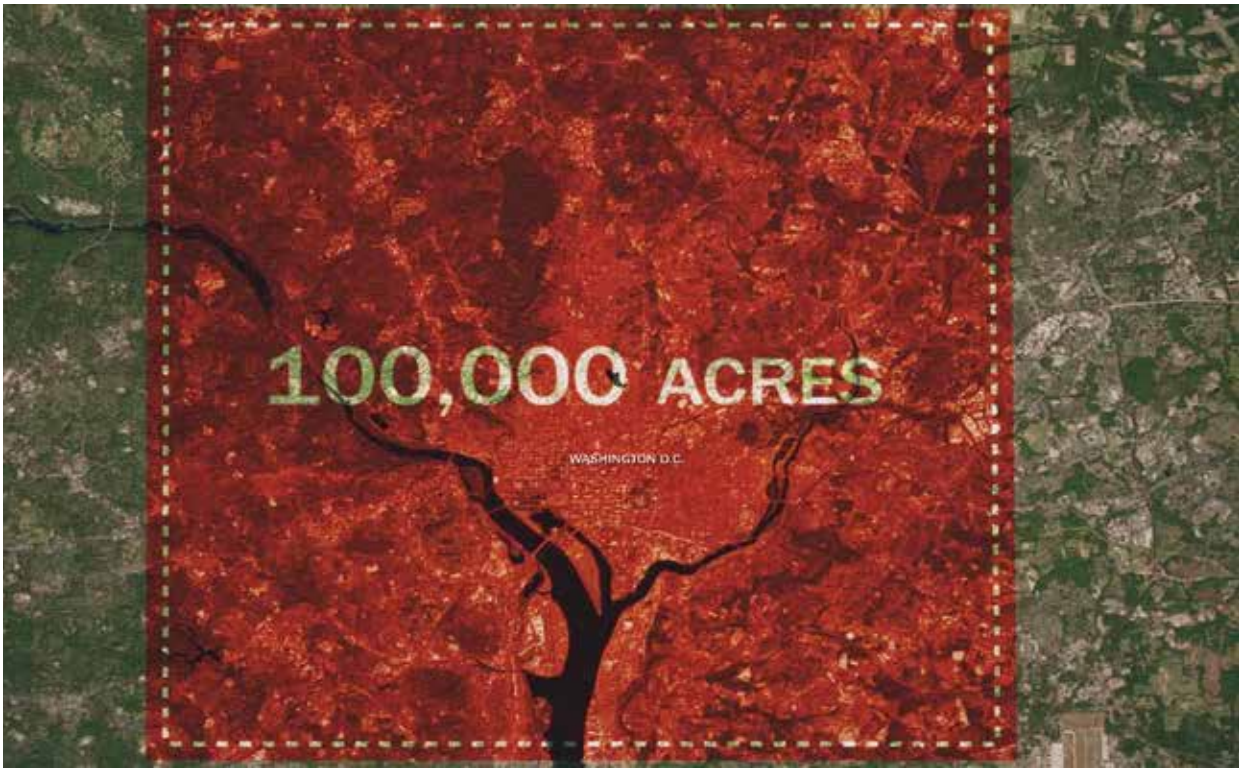
EXPLORE THE HUMAN CAUSES OF WILDFIRE

Discuss, read through, project or print the following background information about wildfires:

In recent years, wildfires have dramatically increased in frequency and severity, causing "megafires" that challenge our capacity to fight and control them.

The increase in the size and intensity of wildfires is due to a combination of human causes, all deeply intertwined with the way humans use and fight fire.

- The annual number of large fires. (>1,000 acres) in the United States has tripled since the 1970s.
- Wildfires burn six times more land area per year than they did four decades ago.
- The years of 2015, 2016 and 2017 marked the three hottest years in the global record.
- Arizona and California are the two states with the greatest projected increase in high wildfire potential days by 2050.
- The cost of fighting U.S. wildfires topped $2 billion in 2017.
- More than 44 million people live in areas where human habitation is encroaching on land that had previously been untouched by human development. This contact zone is called the human-wildland interface.
- Every year, 15,000 deaths in the U.S. are tied to the respiratory stress of wildfire smoke.[1]

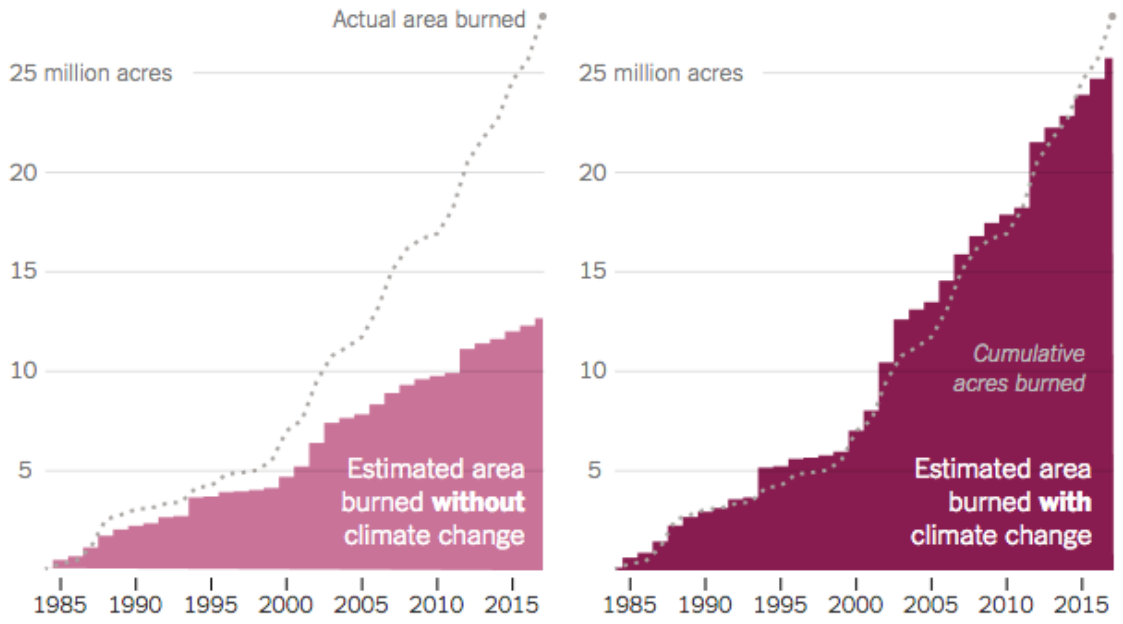


In the United States, 85 percent of wildfires are started by humans through unattended campfires, industrial and powerline equipment failure or malfunction, careless cigarette disposal, arson, and other incidents.2 The number of wildfires started by humans has increased over time but, more importantly, the impact of those fires has changed. Since the 1990s, the number of megafires – fires that burn more than 100,000 acres – has increased exponentially. As shown in the below map, 100,000 acres is equal to 156.25 square miles, or roughly the size of Washington D.C.

Though these fires are sparked by human causes, their scope and intensity is fueled by climate change. According to the Fourth National Climate Assessment, published in November 2018, the burning of fossil fuels has led to global warming, which has incited massive droughts and insect infestations that have made forests more susceptible to fire, and made those fires more difficult to control.[3]

The below figure shows a model of how much smaller the recent wildfires in California would have been without the added effects of climate change:[4]

In the West, Forest Fires Burn More Acres In a World Warmed by Climate Change



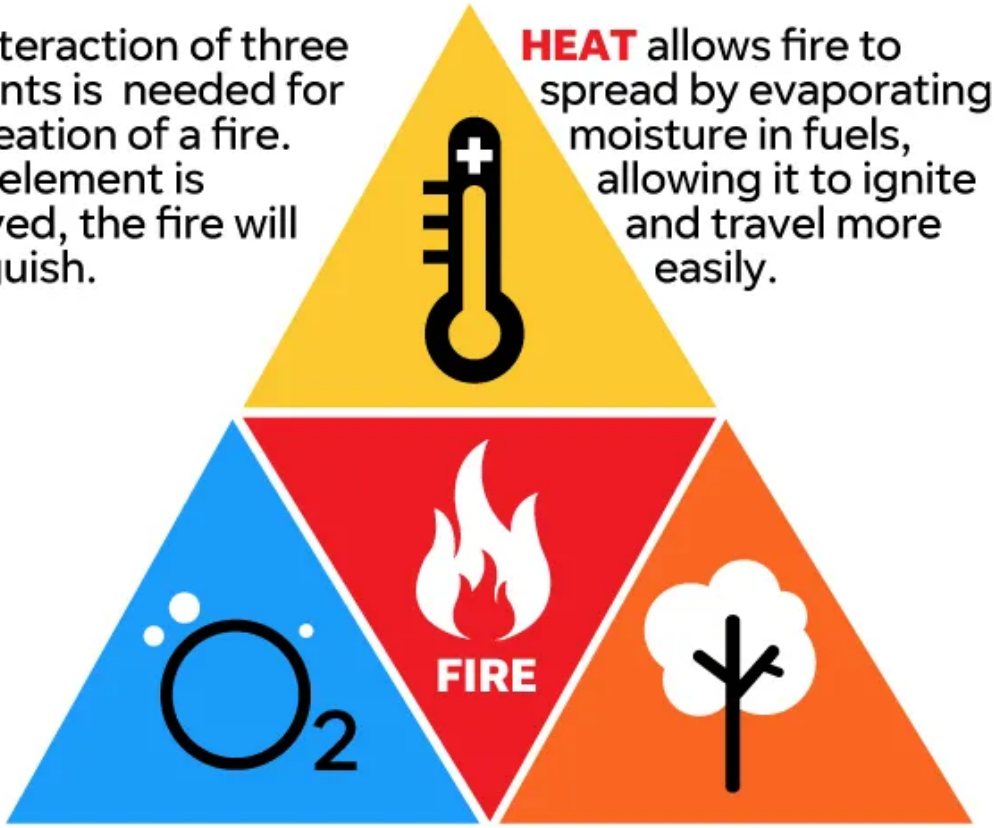
Source: Proceedings of the National Academy of Sciences; data updated through 2017 by A. Park Williams

Project or print this graphic of the "fire triangle."

In order to burn, fire requires the "fire triangle" of heat, fuel and oxygen.[5]

Science of a wildfire

The interaction of three elements is needed for the creation of a fire. If one element is removed, the fire will extinguish.



SOURCE National Interagency Fire Center

Using a jigsaw structure, split students into groups to research and report on these three human causes of increasingly dangerous wildfires:

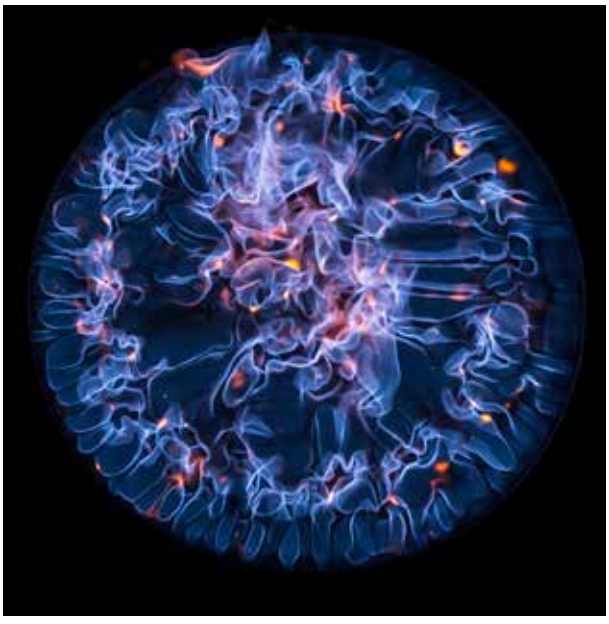
1. Fire fighting methods
2. Wildland-urban interface
3. Climate change

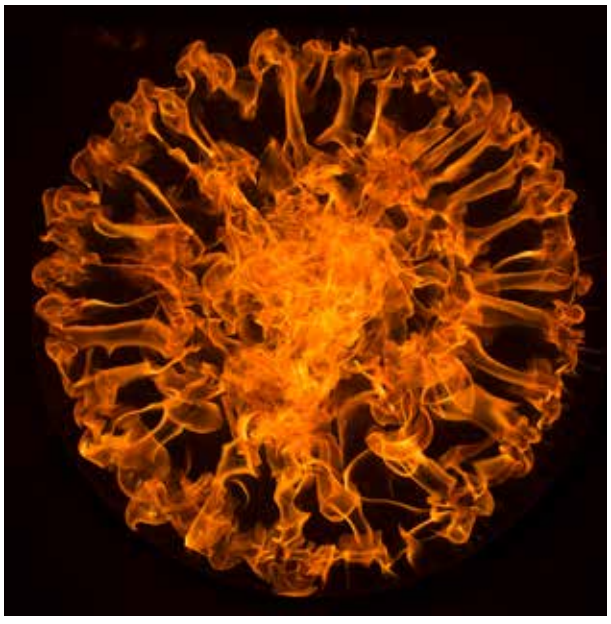
Ask students to research their own reliable sources to answer the following questions about each cause.

If you do not have easy access to the internet in your classroom, use the recommended articles provided in **Research Appendices One–Three**.

1. Which of the three factors of the "fire triangle" —heat, fuel or oxygen—is addressed in your topic?
2. How has [***your topic – see above***] changed over time?
3. What social or economic forces caused those changes?
4. In what way has this contributed to the increasing rates and severity of wildfires?
5. What is the cost of [***your topic***] to the stakeholders involved?
6. What actions and policies are emerging to decrease the contribution of [***your topic***] to megafires?

When students are finished researching, ask each group to present their learning about the causes of megafire to the class. After all the groups present, discuss the question, "How do these causes of wildfire increases relate to one another?"





EFFECTS: VISUAL EVIDENCE

> *"My message to the firefighters: stop saying that we've never seen a fire like this, because guess what? This is becoming the new normal, so we can't be surprised by it anymore."*
>
> **—Cal Fire Director Ken Pimlott, in *The Human Element***

Keeping students in their small groups, ask them to find an image that best represents a cause or an effect of the megafires they researched to present to the class.

Images may come from the film chapter, be printed from the **TheHumanElementMovie.com/fire/** website, or other images they found during their research. Students can use the questions below to guide their presentation:

1. What do you see in this image?
2. What does this image tell you about the human causes or effects of megafires?
3. Where does the image come from? Do you trust what you see in the image? Why or why not?
4. What do you hope the person looking at the image learns about wildfires from it?
5. What ideas or actions does this photo suggest to you as you think about preventing or minimizing damage from megafires?

THE HUMAN ELEMENT OF CHANGE

> *"We can change the landscape to accept the fires under a different climate better. We can adjust how we operate and how we live. There are many points of intervention without trying to reverse climate change. There are still many things we can do."*
>
> **—Stephen Pyne**

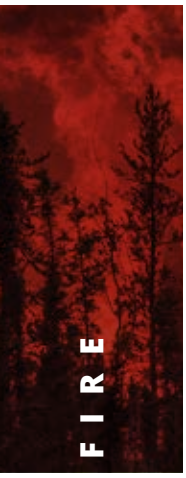
This lesson culminates with a project to help students synthesize their learning. These projects can be completed during class time or assigned as homework. If you are planning to complete all four of ***The Human Element*** lessons, this portion of the lesson can be used as part of the final culminating lesson.

Suggested project ideas:

1. Interview a firefighter about fire historian Stephen Pyne's suggestion that we make our thinking about fire more complex. Here are a few sample questions:
   a. How have ideas and strategies about firefighting changed over time in your community?
   b. What roles, good and bad, does fire play in your community?
   c. If you live in an area that is susceptible to wildfires, ask how the firefighter's experience of fire has changed over time, and how the increase in frequency and scope of megafires has changed their work.
2. Using art, photography, found objects or other creative mediums, create two art pieces that represent the human relationship to fire. The first image will represent one or more of the human causes of megafires. The second image will represent how humans can act to change the frequency and scope of megafires in the future. See the **Handout Two—Artist Statement** handout for a prompt and suggestions for peer reviews of each project.
3. Research a megafire that occurred in the United States in the last three years. Write a short essay about the ways in which human activity influenced that fire, both in the way it began and how it became a megafire. Identify how humans responded to the fire as well as new ways of thinking about fire management that may have developed as a result

EXTENDED LEARNING OPPORTUNITY

Explore the National Interagency Fire Center's resources **https://www.nifc.gov/prevEdu/comm_guide/ch2.html** and other websites to to learn more deeply about the "fire triangle"of heat, fuel and oxygen, and how each figures into wildfire management strategies.



HANDOUT ONE

FIRE NOTE CATCHER

As you watch the "Fire" chapter of ***The Human Element***, write down ideas, words or phrases that stand out to you:

What is the film telling you about the human causes and costs of fire?

What further questions do you have?

HANDOUT TWO

ARTIST STATEMENT

For students who choose the artistic expression for their final project to describe how their work represents the human element of wildfires.

Artist Statement:

Write a paragraph about your artwork and how it relates to specific ways climate change and human behavior have increased the scope and frequency of wildfires. Be sure to clearly state your message.

Peer Review Questions:

What message do you gain from the artwork and the artist's statement?

What questions arose for you, what would you like to know more about?

What did you like about this work?

What opportunities for growth do you see?

RESEARCH APPENDIX ONE

METHODS OF FIRE FIGHTING

Article adapted from **ForestHistory.org (https://foresthistory.org/research-explore/us-forest-service-history/policy-and-law/fire-u-s-forest-service/u-s-forest-service-fire-suppression/).**

Legendary forest fires in the late 1800s bolstered the argument by early conservationists that forest fires threatened future commercial timber supplies. Concern for protecting those supplies and also watersheds helped conservationists convince the U.S. government in 1891 to begin setting aside national forest reservations. When the U.S. Forest Service was established in 1905, it was given managerial control of these lands, soon renamed national forests. Forest management necessitated fire protection. After all, foresters argued, why create national forests if they were going to burn down?

Just five years later, a series of forest fires burned three million acres in Montana, Idaho, and Washington in only two days. The 1910 fires had a profound effect on national fire policy. Local and national Forest Service administrators emerged from the incident convinced that the devastation could have been prevented if only they had had enough men and equipment on hand. They also convinced themselves, and members of Congress and the public, that only total fire suppression could prevent such an event from occurring again, and that the Forest Service was the only outfit capable of carrying out that mission. Three of the men who had fought the 1910 fires served from 1920 to 1938 as Forest Service chiefs, which put them in a position to institute a policy of total fire suppression.

This policy had two goals: preventing fires, and suppressing a fire as quickly as possible once one started. To prevent fires, the Forest Service came out in opposition to the practice of light burning, even though many ranchers, farmers, and timbermen favored because it improved land conditions. It must be remembered that at this time foresters had limited understanding of the ecological role of fire. Forest Service leaders simply argued that any and all fire in the woods was bad because it destroyed standing timber. Educating the public about the need for fire prevention became an important part of this goal. In 1944, the Forest Service introduced the character Smokey Bear to help deliver its fire prevention message.

The other goal the Forest Service had was to develop a systematic approach to fire protection. In the decades after the 1910 fires, this involved building networks of roads, communications systems, lookout towers, and ranger stations. To protect both federal and non-federal lands, the agency won passage of the Weeks Act of 1911, which in part established a framework between the federal government and the states for cooperative firefighting (the framework would later include private forest associations and landowners). By offering financial incentives to states to fight fires, the Forest Service came to dominate and direct what amounted to a national fire policy.

Following several severe fire seasons in the early 1930s, fire suppression took on even greater urgency. In 1933, the federal government created the Civilian Conservation Corps, which put thousands of men to work building fire breaks and fighting fires. In 1935, the Forest Service established the so-called 10 a.m. policy, which decreed that every fire should be suppressed by 10 a.m. the day following its initial report. Other federal land management agencies quickly followed suit and joined the campaign to eliminate fire from the landscape. Fire suppression efforts were aided by the development of new technologies, such as airplanes, smokejumpers, and fire suppression chemicals. With such tools, fires could be fought anywhere—and were.

Until around 1970, federal land managers remained obsessed with controlling large fires. But during the 1960s, scientific research increasingly demonstrated the positive role fire played in forest ecology. This led in the early 1970s to a radical change in Forest Service policy—to let fires burn when and where appropriate. It began with allowing natural-caused fires to burn in designated wilderness areas. From this the "let-burn" policy evolved, though it suffered a setback in the wake of the 1988 Yellowstone fires. Since around 1990, fire suppression efforts and policy have had to take into account exurban sprawl in what is called the wildland-urban interface. Another issue the Forest Service now faces is that fires have grown in size and ferocity over the last 25 years. The fire-fighting budget has grown to about 50 percent of the agency's entire budget, which limits funds available for land management activities such as land restoration and forest thinning that could aid in fire suppression.

RESEARCH APPENDIX TWO

WILDLAND-URBAN INTERFACE

Article adapted from: "Americans are Moving Closer to Nature, and to Fire Danger" by Kendra Pierre-Louis and Jeremy White, Nov. 15, 2018, New York Times (https://www.nytimes.com/2018/11/15/climate/california-fires-wildland-urban-interface.html).

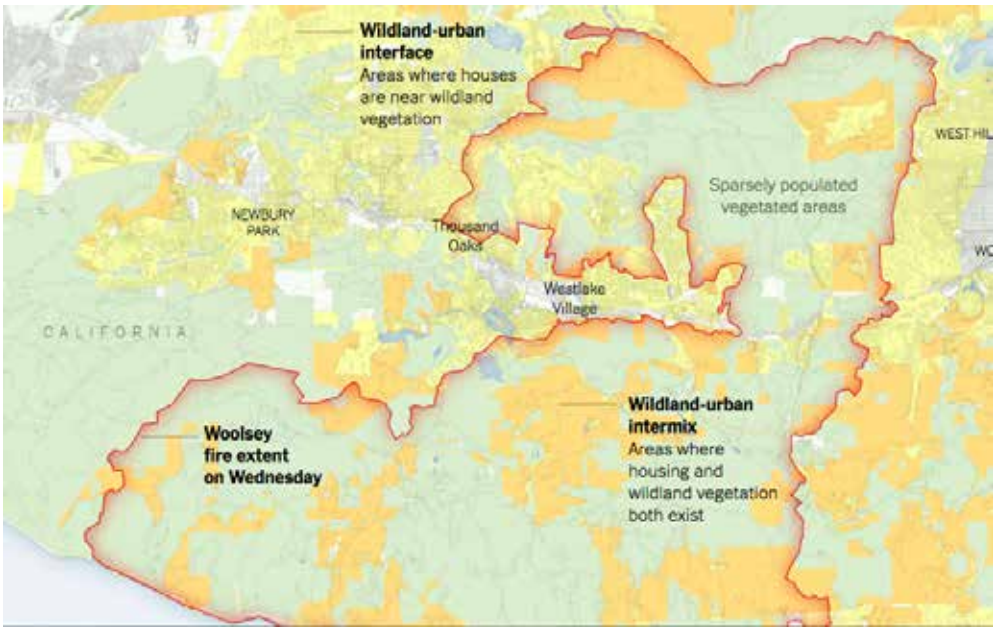
The deadly wildfires that are devastating communities in parts of Northern and Southern California first ignited in an expanding part of the American landscape: not in forests, not in cities, but in the areas that experts call the wildland-urban interface.

It is the transition zone between wildlands — such as forests, grasslands and scrublands — and human development.

Researchers say that wildfires pose the greatest risk to people along the wildland-urban interface. This is partly because the homes in those areas butt up against the vegetation that can fuel fires, putting their occupants in significant danger. And there are more fires in those areas because of the presence of humans, who often ignite them.

Despite the risks, an increasing number of Americans are living in the wildland-urban interface. There were 12.7 million more houses and 25 million more people living in these zones in 2010 than in 1990.

In a few places, like New England, the numbers have increased as forested land has retaken abandoned farmland: The wildlands have encroached on people. But in California, where roughly one million homes were built in the wildland-urban interface over that time period, it's because people are moving into these areas. At the same time, because of climate change, the state's dry periods have become hotter and drier, increasing fire risk.



Source: SILVIS Lab, Department of Forest and Wildlife Ecology of the University of Wisconsin-Madison

It isn't easy to generalize why people are moving into these regions, said Anu Kramer, a postdoctoral researcher at the University of Wisconsin-Madison.

Some move to live closer to nature, others to avoid government regulations or find a lower cost of living. There are also indigenous communities and people who work the land.

"We're talking timber-dependent or ranching communities that really spend a lot more time interfacing with that land and have a lot more of their livelihood tied to it," said Travis Paveglio, an assistant professor of natural resource sociology at the University of Idaho.

Northwest of Los Angeles, the Woolsey Fire has ripped through densely populated areas in cities like Thousand Oaks and Malibu, and other areas that some researchers call the wildland-urban intermix. It is a type of wildland-urban interface where areas of housing and vegetation commingle.

Fire has not deterred development in these types of areas, nor redevelopment. Using aerial photos, researchers looked at how many buildings were rebuilt in California after wildfires.

In 29 fires between 1970 and 2009, 49 percent of burned buildings were rebuilt within six years, said Miranda H. Mockrin, a research scientist with the United States Forest Service.

For 11 of those fires, data was available for a 25-year span after the fire. Researchers found that 94 percent of damaged buildings had been rebuilt, although they couldn't tell whether the original owners or someone else had done the rebuilding.

"In general for wildfire, as other hazards, there is a big push to sort of return to normal, to encourage rebuilding," Dr. Mockrin said.

Since 1991, a structure built in the wildland-urban interface "has to be made up of noncombustible materials, noncombustible roof, closed eaves," said Jonathan Cox, a division chief with the California Department of Forestry and Fire Protection.

The regulations are on top of any local requirements. But those rules don't apply to buildings constructed before 1991. According to Zillow, the average home in California was built in the 1950s.

"What we don't have is retrofit programs," said Max Moritz, a cooperative extension specialist in wildfire at the Bren School of Environmental Science and Management at the University of California, Santa Barbara. "We retrofit for earthquake safety. And there's public funding for mitigating flood exposure. But we don't do that for fire."

There have been efforts in recent years to create "fire-adapted communities" that are better situated to handle fires.

"We know these lands are dangerous," Chief Cox said. "We know they're susceptible to fire. How we build on these lands is an important consideration as we move forward."

If your students have access to the internet, look for your state map at http://silvis.forest.wisc.edu/data/wui-change/ to see how the WUI (wildland-urban interface) has changed near you since 1990.

RESEARCH APPENDIX THREE

CLIMATE CHANGE AND DROUGHT

Article adapted from "Is Global Warming Fueling Increased Wildfire Risk?", Updated July 24, 2018, Union of Concerned Scientists (https://www.ucsusa.org/global-warming/science-and-impacts/impacts/global-warming-and-wildfire.html#.XEJaJ2RKj3A).

The effects of global warming on temperature, precipitation levels, and soil moisture are turning many of our forests into kindling during wildfire season.

As the climate warms, moisture and precipitation levels are changing, with wet areas becoming wetter and dry areas becoming drier. Higher spring and summer temperatures and earlier spring snowmelt typically cause soils to be drier for longer, increasing the likelihood of drought and a longer wildfire season, particularly in the western United States.

These hot, dry conditions also increase the likelihood that wildfires will be more intense and long-burning once they are started by lightning strikes or human error.

The costs of wildfires, in terms of risks to human life and health, property damage, and state and federal dollars, are devastating, and they are only likely to increase unless we better address the risks of wildfires and reduce our activities that lead to further climate change.

Wildfires are already on the rise

Wildfires in the western United States have been increasing in frequency and duration since the mid-1980s. Between 1986 and 2003, wildfires occurred nearly four times as often, burned more than six times the land area, and lasted almost five times as long when compared to the period between 1970 and 1986.

Natural cycles, human activities like land-use change and fire exclusion, and human-caused climate change can all influence the likelihood of wildfires. Many of the areas that have seen increased wildfire activity, like Yosemite National Park and the Northern Rockies, are protected from or relatively unaffected by human land-use change, suggesting that climate change is a major factor driving the increase in wildfires in these places.

Precipitation patterns, global warming, and wildfires

Though the current trend of increasing severe wildfire frequency in parts of the US is projected to continue as the climate warms, droughts and wildfires are not equally likely to occur every year.

Natural, cyclical weather occurrences such as El Niño events also affect the likelihood of wildfires by affecting levels of precipitation and moisture and lead to year-by-year variability in the potential for drought and wildfires regionally.

Nonetheless, because temperatures and precipitation levels are projected to alter further over the course of the 21st century, the overall potential for wildfires in the western United States is projected to increase.

As the world warms, we can expect more wildfires

US wildfire seasons—especially those in years with higher wildfire potential—are projected to lengthen, with the Southwest's season of fire potential lengthening from seven months to all year long. Additionally, the likelihood that individual wildfires become severe is expected to increase.

Researchers project that moist, forested areas are the most likely to face greater threats from wildfires as conditions in those areas become drier and hotter.

Surprisingly, some dry grasslands may be less at risk of catching fire because the intense aridity is likely to prevent these grasses from growing at all, leaving these areas so barren that they are likely to lack the fodder for wildfires to start and spread.

A conflagration of costs

The economic costs of wildfires can be crippling. Data on total US property damage from wildfires are hard to come by, but the costs are estimated to be on the level of hundreds of millions of dollars per year.

In addition to property damage, wildfires cost states and the federal government millions in fire-suppression management. The US Forest Service's yearly fire-suppression costs have exceeded $1 billion for 13 of the 18 years between 2000 and 2017. In 2015, these costs exceeded $2 billion, and in 2017 they totaled almost $3 billion. The risk to property owners is particularly acute in areas at the "wildland-urban interface." In California alone, this area includes more than 5 million homes in coastal southern California, the Bay Area, and northeast of Sacramento.

The environmental and health costs of wildfires are also considerable. Not only do wildfires threaten lives directly, but they have the potential to increase local air pollution, exacerbating lung diseases and causing breathing difficulties even in healthy individuals.

Additionally, a counterintuitive aspect of mountain forest wildfires is their ability to increase flash flood risk. The loss of vegetation from wildfires and the inability of burned soil to absorb moisture can cause flash floods in lower-lying areas when rains do come in the days and months following fires, especially to the semi-arid Southwest.

Wildfire safety and prevention

Greenhouse-gas emissions from human activities are raising global temperatures and changing the climate, leading to a likely rise in wildfire severity and frequency.

But it is not too late to act. What we do now has the power to influence the frequency and severity of these fires and their effects on us.

By engaging in fire safety efforts—creating buffer zones between human habitation and susceptible forests, and meeting home and city fire-safety standards—we can help reduce our current risks, and by taking steps to reduce our impact on the climate, we

Last revised date: July 24, 2018

ENDNOTES

1 https://thehumanelementmovie.com/fire/
2 https://www.nps.gov/articles/wildfire-causes-and-evaluation.htm
3 https://nca2018.globalchange.gov/chapter/6/
4 https://www.nytimes.com/interactive/2018/11/27/climate/wildfire-global-warming html?mtrref=www.google.com&gwh=347CF425F82740E15EDF1792467DBB7E&gwt=pay
5 https://www.usatoday.com/story/tech/science/2017/10/10/what-fueled-californias-brutalethal-combination-fierce-winds-low-humidity-fueled-california-wildfire/751063001/