Fire Case Study for Students: Marshall Fire

Overview

Thank you for bringing NOAA into your classroom! This pdf includes “evidence” for students to explore first hand information related to the Marshall Fire, which occurred on December 30, 2021 in Boulder County, Colorado. This evidence is in the form of maps, data, forecasts and communications from National Weather Service forecasters, as well as other primary source information. Additionally, there are fictional conversations between investigators Nora and Noah and National Weather Service forecasters. Conversations were created by the NOAA Boulder Outreach and Education team and approved by the Warning Coordination Meteorologist in the Denver/Boulder forecasting office of the National Weather Service.

If you have any questions, comments, or suggestions you can reach the NOAA Boulder Outreach and Education Team at boulderoutreach@noaa.gov. You can also find student activities, printable information, and videos with our scientists at www.boulder.noaa.gov/outreach/teacher-resources/.

Objectives

Students will explore information from the National Weather Service, US Drought Monitor, National Centers for Environmental Information and Colorado State Forest Service to understand the various factors that increase fire risk and actions taken by the National Weather Service during a fire.

Students will explain learn information from classmates.

Students will explain what they have learned to classmates.

Prepare

Evidence and conversation is divided into four categories:

- **Precipitation** (found here)
- **Temperature** (found here)
- **Wind** (found here)
- **Forecasting** (found here)

There is an Investigator’s Notebook (1 page, double sided, folded) that correlates with each category. Additionally, there is an Investigator’s Expanded Notebook in a similar style.

Each student should have an Investigator’s Notebook that corresponds to their topic, evidence and conversations for their topic, and an Investigator’s Expanded Notebook. Students can either work individually or in groups with others investigating the same topic.

Optionally, each student can have a badge that corresponds to their topic. The badge can be printed and taped to their shirt.

NOAA Investigators

Instructions

1) Have each student read the NOAA News article about the Marshall Fire as an introduction.
2) Give each student an Investigator's Notebook for one of the topic areas and the evidence and conversations that correspond with their topic. Students can work individually or in small groups with others investigating the same topic.
3) Students should start by reading the two conversations between investigators Nora and Noah and NWS forecasters.
4) Students next look through primary evidence and use it to answer questions in their notebook.
5) When students have completed the Investigator's Notebook, give each student the Investigator's Expanded Notebook. In this notebook, students will think about what they still do not know about the Marshall Fire. Students may benefit by working with one or two students investigating the same topic to generate questions.
6) When questions are all written, students will be walking around to ask each other questions. This is where it would be helpful for students to wear a badge identifying which topic they investigated. Students find a classmate who investigated a different topic. They will take turns asking one question they think that student can answer, based on what their classmate investigated. They should write down answers.
7) Students will repeat step 6, partnering with different classmates who can answer their remaining questions.
8) Discuss with a class. Were all your questions answered? Do you have any remaining questions? How could those questions be answered?

Extensions

Students can use their investigation to write a report, a visual presentation, a video or a podcast.

Paleoclimate - Here are two activities that use tree ring data to learn about fires.

Tree Rings: Precipitation and Fire (https://www.boulder.noaa.gov/wp-content/uploads/2024/07/Tree-Rings-Precip-and-fire.pdf)
Tree Cores: Historic Fires in Colorado (https://www.boulder.noaa.gov/wp-content/uploads/2025/12/Tree-Rings-Fires-in-CO.pdf)

Data puzzles are enriching activities that allow students to learn from scientists and the data they collect. Our partners at CIRES (Cooperative Institute for Research in Environmental Sciences) have created two data puzzles related to fire.

Megafire - Rare Occurrences or the New Normal?
Wildfire, Drought, and Future Forests

You can find both of these Data Puzzles at datapuzzles.org.

Videos from National Weather Service forecasters.

Incident Meteorologists and Forest Fires (www.youtube.com/watch?v=EzeClmsO2Iw&t=1s)
How do Fires Create Weather? (www.youtube.com/watch?v=eIXU_BLxwVA&t=3s)
Interview with Incident Meteorologist Bruno (www.youtube.com/watch?v=o1aSUNVtr_Y&t=1s)
National Weather Service Incident Meteorologist YouTube Channel (www.youtube.com/@nwsimet-noaaserviceaccount7597)

Resources

National Weather Service:

- Many resources came from the National Weather Service.
  - You can explore weather information from your area by going to weather.gov and entering your zip code or city, state.
  - A wealth of past weather data can be found in the “Climate and Past Weather” section.
  - You can find more resources from the National Weather Service at www.weather.gov/education.

National Centers for Environmental Information

- Climate Information
  - You can find climate maps on a global, national and state scale by going to www.ncei.noaa.gov/products/climate-monitoring and clicking “Launch Monitoring Application”. Maps used in these lessons were made in “Climate at a Glance” then “Mapping”.
- Paleoclimate Information
  - You can find tree ring data and other paleoclimate information in NOAA’s Paleoclimate Archive. Go to www.ncei.noaa.gov/products/paleoclimatology.

US Drought Monitor

- The U.S. Drought Monitor is produced through a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture and the National Oceanic and Atmospheric Administration.
  - You can find information from the US Drought Monitor at droughtmonitor.unl.edu/.
  - The maps used in these lessons are from the “Map Archive” under the “Maps” menu.

US Forest Service

- Bark beetle information came from the Colorado State Forest Service. You can find information about Colorado forests at their website csfs.colostate.edu/.

Looking for other information?

- You can connect with NOAA education and outreach specialists by emailing education@noaa.gov or boulderoutreach@noaa.gov.

NOAA Fire
Investigator
Marshall Fire
Precipitation Unit

NOAA Fire
Investigator
Marshall Fire
Wind Unit

NOAA Fire
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Marshall Fire
Temperature Unit

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Forecast Unit

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NOAA News

VOL. N. No 1 December 2021

Most Destructive Fire in Colorado History

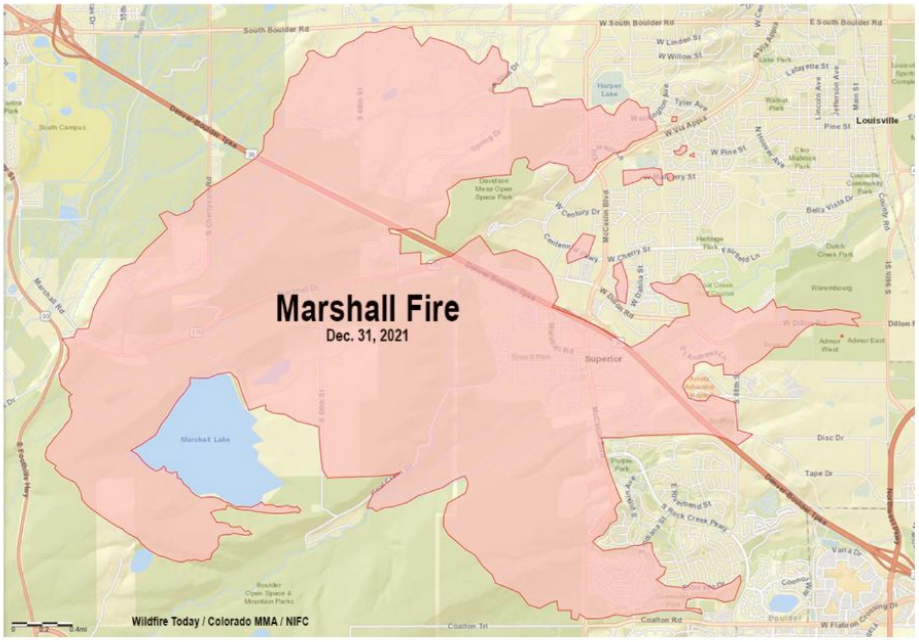
The Marshall Fire from south Boulder. Credit: Patrick Cullis/NOAA

Night falls as the Marshall Fire continues to burn through Louisville (left) and Superior (right). Credit Patrick Cullis/NOAA

A fast moving grass fire started near Marshall in Boulder County around 11:00 am on December 30th. It quickly spread to the east into Superior and Louisville, fueled by winds gusting over 90 miles per hour. Fire fighters from all over the Denver metro responded to the fire. They had a hard time controlling the fire because of the high winds.

Overnight on December 30th, winds began to slow and snow fell. This allowed firefighters to finally control the fire. Over 1,000 structures burned, including houses, a hotel, and other businesses. Sadly, two people died in the fire.

Investigators still have many questions. They would like to know what conditions made Boulder County susceptible to fire on December 30th. What were the weather conditions on the day of the event? What climate factors in the year before the event made the area vulnerable? Investigators Noah and Nora are working with the National Weather Service to find answers.



The Marshall Fire burned more than 6,000 acres and over 1,100 structures in Louisville, Superior and unincorporated Boulder County. Credit: Wildfire Today/Colorado MMA/NIFC

Q #5: _____ ?

A #5: _____

Q #6: _____ ?

A #6: _____

Fire Report

Investigator's Expanded Notebook

Name _____

Fire under investigation:

Location of fire:

Date(s) of fire:

You are now an expert in one aspect of the fire. Now you need to learn from your fellow investigators.

Think of what you do not yet know about the Marshall Fire. Write 6 questions about the fire that you cannot currently answer. Next, you will ask your questions to investigators in your class to find answers.

Q #1: _____ ?

A #1: _____

Q #2: _____ ?

A #2: _____

Q #3: _____ ?

A #3: _____

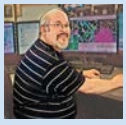
Q #4: _____ ?

A #4: _____

Investigation Interviews

Conversation between Investigator Noah and Forecaster Chad Gimmestad

Noah: Chad, I understand you were working the day of December 30th, 2021.



Chad: Yes, I worked the day shift on December 30th. It was a scary day.

Noah: Did you think there would be high fire danger on December 30th?

Chad: I saw that Bob issued a High Wind Warning. I also knew climate conditions were very dry. Well, sure enough downsloping winds were very strong. There was actually a fire earlier in the day in a different area of Boulder County, north of the Marshall Fire. That was quickly contained, but shortly after the Marshall Fire started.

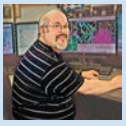
Noah: What did you do then?

Chad: We did everything we could. We regularly talk to emergency managers and fire departments, so we know who to talk to in emergencies. We made sure fire fighters were getting regular weather updates. We also knew it was a dangerous situation. A lot of people live in the direction the fire was spreading. So we wanted to warn the community.

Noah: How did you message the community?

Chad: We know a lot of people follow us on social media, so we posted about the danger and evacuation orders. I can show you some of our posts.

Noah: Did winds weaken on December 30th?



Chad: Wind did lessen that night, and temperatures became much colder. Firefighters were able to contain the fire. Then the first significant snow of the season fell the night of December 31st.

Investigation Interviews

Conversation between Investigator Nora and Forecaster Bob Kleyla

Nora: Bob, I understand you were working the night of December 29th, 2021.

Bob: Yes, I was on the night shift on December 29th.

Nora: Were you concerned about fire danger when you forecasted the weather for December 30th?

Bob: I was very concerned! I use a lot of weather information when I forecast. One thing I look at are weather models. We have many different weather models actually. Some of the models were not showing very high winds for December 30th. But the HRRR model was telling me extremely high winds were possible.

Nora: Did you think the HRRR model might be more accurate than the other models?

Bob: Well, I knew if winds would become that strong, it would be a very dangerous situation, so I had to look into the possibility. The HRRR model gives us a new output every hour, and it continued to show high winds occurring, which made me more confident.

Nora: Are strong winds unusual in Boulder County?

Bob: No, this area can have very strong downslope winds. We actually see the fastest winds in December and January.

Nora: Why would strong winds be so dangerous?

Bob: Well, the precipitation that fell in 2021 was very unusual.

Nora: What do you mean?

Bob: There was a lot of rain and snow between January and June. Well above average. But then there was very little rain and no measurable snow between July and December 30th. Take a look at this graph of precipitation in Boulder County. It was also much warmer than average in December. You can also see these drought maps from the US Drought Monitor. In the six months before the Marshall Fire Boulder County goes from no drought to extreme drought.

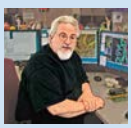
Nora: Do these conditions increase fire danger?

Bob: Yes! You see, all the moisture from January through June meant a lot of plants grew tall, especially grasses in east Boulder County. But the lack of moisture after June meant all those grasses and other plants dried out. Usually by the end of December Boulder County receives many inches of snow, but not in 2021.

Nora: Did you issue a Red Flag Warning?

Bob: No, humidity was too high for a Red Flag Warning. But I was still worried.

Nora: So what did you do?



Bob: No, humidity was too high for a Red Flag Warning. But I was still worried, so I issued a High Wind Warning. This puts emergency managers on alert for fire danger.