FORCES OF NATURE

TEACHER'S GUIDE

NARRATED BY KEVIN BACON
The giant-screen film *Forces of Nature* highlights the awesome powers of the Earth and the brilliant, dedicated scientists who perform valuable and sometimes dangerous work to understand these forces — and to save lives.

The lessons in this guide were designed to bring the real-world issues of natural hazards — as current and important as today’s headlines — to students. Each addresses one or more of the “forces” featured in the film — volcanoes, earthquakes, and tornadoes — and suggests ways to address local natural hazards. These lessons can be adapted for other grade levels or used independently of the film. They were written and evaluated by educators, and align with the U.S. National Geography Standards and the National Science Education Standards.

Each lesson combines content and inquiry skills in science and geography, with applications for other content areas. Collectively, the lessons offer a variety of integrated content and classroom strategies — individual, small group, discussion, brainstorming, Internet research, presentation, and more. Each lesson is constructed with objectives and an assessment component, and includes extensions and online resources for educators and students.

Resources related to this film, including these lessons, can be found online at

www.nationalgeographic.com/forcesofnature

These lessons are also online at

www.nationalgeographic.com/xpeditions
www.destinationcinema.com/our_films/fon/fon.asp

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**INDEX**

**Grades 6 – 8**

Lesson 1: When Natural Hazards Become Human Disasters...........................................................................................................................................................................................................................................................................................................Page 1
Lesson 2: Natural Hazards: Same Forces, Different Impacts...........................................................................................................................................................................................................................................................................................................Page 8
Lesson 3: Dealing With Disasters...........................................................................................................................................................................................................................................................................................................Page 15

**Grades 9 – 12**

Lesson 4: Twister Tracking...........................................................................................................................................................................................................................................................................................................Page 22
Lesson 5: Earthquakes: A Whole Lot of Quakin’ Goin’ On!...........................................................................................................................................................................................................................................................................................................Page 30
Lesson 6: Volcano Hazards: Describing a Dangerous Mix...........................................................................................................................................................................................................................................................................................................Page 42
In this activity, students will gain a better understanding of natural events and consider the dangers that natural hazards and natural disasters pose to humans. Through writing, and by gathering and comparing data, students will examine factors that make hazards a threat to people. This activity, which can be adapted for older students, is a good accompaniment to the giant-screen film Forces of Nature. It is suggested that this activity be conducted before students see the film. (For information about the film go to www.nationalgeographic.com/forcesofnature.)
When Natural Hazards Become Human Disasters

Connections to the Curriculum: Geography, Earth science, language arts

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 7: “The physical processes that shape the patterns of Earth’s surface”
Standard 15: “How physical systems affect human systems”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 5–8 Content Standard D. Earth and Space Science: Structure of the earth system
Grades 5–8 Content Standard F. Science in Personal and Social Perspectives: Natural hazards

Time: Will vary; two hours minimum

Materials Required:
• Computer with Internet access
• Pencils, color markers
• Chart paper or poster board
• National Geographic Xpeditions maps of the world and the U.S., at www.nationalgeographic.com/xpeditions/atlas
Objectives:

Students will:

• describe aspects of natural events that pose threats to humans and the impacts of these events on people, in writing and through discussion;
• use scientific vocabulary to summarize research about natural hazards; and
• compare and discuss the relative dangers posed by tornadoes, volcanoes, and earthquakes (and, possibly, other natural hazards).

Geographic Skills:

• Acquiring Geographic Information
• Organizing Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure

Opening:

Introduce the activity by asking for a show of hands to the question, “Have you ever been in a severe thunderstorm?” Have each student write 1) words or phrases that describe the storm (e.g., dark, loud, windy, extremely rainy), and 2) words or phrases that describe how it made them feel (e.g., scared, soaked, vulnerable, happy to be indoors). Students might compare their answers briefly with a neighbor and then share with the class, either orally or by writing a class list on the board.

Explain that scientists might describe their feelings about natural hazards much as students did about thunderstorms, but scientists use special words and phrases to accurately describe and measure hazards. Tell students they’re going to learn about natural events that pose hazards to people.

Development:

Clarify the terms “natural hazard” and “natural disaster” with the definitions at the NaturalHazards.org Web site: http://naturalhazards.org/discover/index.html.

With a neighbor, students should — based on their existing knowledge — list types of natural events (only those generated by physical processes) that harm people, homes, or possessions. They can also list actual events, such as a recent earthquake. Ask students to decide which hazard they consider the “worst” and jot down their reasons.
Make a class list of the hazards. Have students vote with a show of hands for the “worst” type of event. Each student should be prepared to defend his or her choice. Have the class rank the events in order of severity. (Save the list.) Students could also construct bar charts of the natural hazards and the number of students who voted each as “worst.”

In small groups, have students research a natural hazard, perhaps only those featured in the *Forces of Nature* film (tornadoes, volcanoes, and earthquakes) or others, as well (e.g., blizzards, drought, floods, forest fires, hurricanes). (A hazard can be researched by more than one group.) Some Web sites for research are listed under Related Links (page 6). Ask students to save compelling first-person descriptions of natural disasters.

Research focus questions might include:

- Why is this natural event hazardous for people (e.g., consider the frequency and severity of the event, the number of people affected, whether or not the event can be predicted)?
- In what states, countries, or regions does this natural event occur? Is there a spatial pattern to the event? Have students map incidents of the event. For National Geographic Xpeditions maps of the world, the U.S., and more, go online to [www.nationalgeographic.com/xpeditions/atlas](http://www.nationalgeographic.com/xpeditions/atlas).
- What words and phrases are used when studying, describing, and measuring the event? For example,
  - Terms for scientists who study the event (e.g., volcanologist, seismologist, meteorologist)
  - How the intensity of, or damage from, the event is measured (e.g., Modified Mercalli Intensity Scale, Fujita Scale)
  - Different types of an event (e.g., tornadoes, waterspouts, dust devils)
- How many human casualties (injuries or deaths) are caused annually by the hazard? What amount of property damage does the hazard cause?
- What do scientists understand about this natural event? What do they not yet understand?

On chart paper or poster board, via a computer presentation, or in a short report, ask each small group to summarize their findings to the class. They should describe and illustrate the events as scientists would. Groups should answer as many of the focus questions as possible. Students could also read aloud first-person accounts.
Closing:
Ask the class to vote again for the “worst” natural hazard, and to defend or debate their decisions. Discussion could also focus on common aspects of the various natural hazards.

In addition, discuss careers related to natural hazards. If students will see the film *Forces of Nature*, mention that it profiles volcanologist Dr. Marie Edmonds, geophysicist Dr. Ross Stein, and meteorologist Dr. Josh Wurman, who are at the cutting edge of the science surrounding volcanoes, earthquakes, and tornadoes. Students can also learn about these scientists at the “Forces of Nature” Web site, at www.nationalgeographic.com/forcesofnature.

Suggested Student Assessment:
Ask students to generate a list of all the things that the natural hazards discussed in class have in common (e.g., all can damage property, endanger people). Ask them to generate another list of things that are different (or perhaps unique) about the hazards (e.g., methods of study and prediction, locations where events occur or are likely to occur, caused by different physical processes).

Write a paragraph describing which of the particular natural hazards discussed would be the most challenging to study or predict and why.

Guidelines for Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:

- Describes aspects of a natural event that pose a threat to humans
- Describes impacts of natural hazards on people
- Uses scientific vocabulary to summarize research about natural hazards
- Generates a list of characteristics that natural hazards have in common and characteristics that are different, identifying the most challenging hazard to study, and why

Extending the Lesson:
Have students draw or sketch a first-person account of one of the natural hazards researched.

After students see the film *Forces of Nature*, ask them to vote again for the “worst” type of disaster. Did the movie change their perceptions? Ask them to recall scientific terms or phrases they recognized in the movie.
RELATED LINKS:

When Natural Hazards Become Human Disasters

Earthweek: Diary of the Planet
www.earthweek.com

FEMA for Kids
www.fema.gov/kids

Franklin Institute Online: Earthforce
www.fi.edu/earth/earth.html

National Earthquake Information Center
www.neic.cr.usgs.gov

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

National Severe Storms Laboratory: Tornadoes . . .Nature’s Most Violent Storms
www.nssl.noaa.gov/NWSTornado

NaturalHazards.org
www.naturalhazards.org

USA Today Weather Resources: Tornadoes
www.usatoday.com/weather/resources/basics/twist0.htm

USGS: Volcano Hazards Program
http://volcanoes.usgs.gov

Volcano World
http://volcano.und.nodak.edu
Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity — Stormy Stories
www.nationalgeographic.com/xpeditions/activities/07/stormy.html

National Geographic: Xpeditions Lesson — Dealing With Disasters
www.nationalgeographic.com/xpeditions/lessons/18/g68/fondisasters.html

National Geographic: Xpeditions Lesson — The Impact of Natural Hazards Around the World
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazards.html

National Geographic: Xpeditions Lesson — Natural Hazard Risks in the United States
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazard.html

National Geographic: Xpeditions Lesson — Natural Hazards: Same Forces, Different Impacts
www.nationalgeographic.com/xpeditions/lessons/15/g68/fonhazards.html

National Geographic: Xpeditions Lesson — What Happened to Whom?
www.nationalgeographic.com/xpeditions/lessons/07/g68/whatwhom.html
Lesson: 2
Natural Hazards: Same Forces, Different Impacts

Beginning of fountaining eruption in Pu`u `O`o crater, Kilauea volcano, Hawai`i

In this activity, students will consider the threats that natural disasters (specifically, tornados, volcanoes, and earthquakes) pose for humans, then compare and contrast two disasters. It is suggested that students do this activity before seeing the giant-screen film *Forces of Nature*. (For information about the film go to [www.nationalgeographic.com/forcesofnature](http://www.nationalgeographic.com/forcesofnature).)
Natural Hazards: Same Forces, Different Impacts

Connections to the Curriculum: Geography, Earth science

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 7: “The physical processes that shape the patterns of Earth’s surface”
Standard 15: “How physical systems affect human systems”
Standard 17: “How to apply geography to interpret the past”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 5–8 Content Standard D. Earth and Space Science: Structure of the earth system
Grades 5–8 Content Standard F. Science in Personal and Social Perpectives: Natural hazards

Time: One to two hours

Materials Required:
• Computer with Internet access (for each group, if possible)
• Writing materials
• Poster board or chart paper
Objectives:
Students will:
• compare data for natural disaster events (tornadoes, earthquakes, or volcanic eruptions);
• analyze data about the magnitude and impacts of natural disaster events; and
• assess the value of scientific research into the causes and impacts of natural events.

Geographic Skills:
• Asking Geographic Questions
• Acquiring Geographic Information
• Organizing Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure

Opening:
Ask students why they think some tornadoes, earthquakes, and volcanic eruptions harm people and damage property, while other similar events do not. List students’ responses on the board or overhead; save the list for later use. (List will likely include ideas such as greater intensity or magnitude of event, number of people living near event, methods of warning about event, and level of preparedness for event.)

Development:
Break the class into small groups. Assign each group to research and make notes about a set of natural disasters listed below (i.e., two tornadoes, two earthquakes, or two volcanic eruptions). More than one group can research the same set of events. These questions can guide students’ research:
• When did the event occur?
• Where did it occur?
• What were the characteristics of the event?
• How many people were injured or killed?
• What kind of property was damaged? What was the cost of the property damage?

Compare these two tornadoes (at www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwevent~storms):
— In Kansas, on May 3, 1999. Search by selecting: State: Kansas; Begin Date 05/03/1999; No End Date; All Counties; Event Type: Tornadoes; F4 Tornadoes
— In Arkansas, on January 21, 1999. Search by selecting: State: Arkansas; Begin Date 01/21/1999; No End Date; All Counties; Event Type: Tornadoes; F4 Tornadoes

Compare these two earthquakes:
— Izmit, Turkey; August 17, 1999 (USGS: Earthquakes Hazards Program, at http://quake.wr.usgs.gov/research/geology/turkey)
— Loma Prieta, California; October 17, 1989 (USGS, at http://geopubs.wr.usgs.gov/dds/dds-29)
Compare these two volcanic eruptions:
— Soufriere Hills, Montserrat; 1997 (Montserrat Volcano Observatory, at www.mvo.ms)

As groups finish their research, provide chart paper or poster board. Each group should write the names of the two events at the top of the paper. Then each group should make a table, Venn diagram (with illustrations, if desired), or illustrate in another way (a) the similarities between the two events; (b) the differences between the two events; and (c) the factors that make the two events different. (Optional: Students can also use graphic organizing software. The Graphic Organizer — at www.graphic.org/index.html — gives an overview of concept mapping, a tool for gathering and sharing information with maps, charts, Venn diagrams, and more, at www.graphic.org/concept.html.)

Closing:
Discuss and summarize students' findings. Even though groups studied three completely different kinds of natural disasters, students likely gathered data on common aspects, which may include:
• Different periods in time (e.g., from the time Mount Pelée erupted in 1902 to Soufriere Hills erupting in 1997, scientific understanding, prediction capabilities, and community preparedness had advanced)
• Location (e.g., the tornado in Clay County, Arkansas, caused moderate damage to that rural area, while the tornado in Sedgwick County, Kansas, which includes the city of Wichita, caused several fatalities and 140 million dollars' worth of property damage)
• Level of preparation (e.g., the high standard of living in the Loma Prieta area meant communities had adequate resources to plan for disasters; that was not the case for Izmit)
• Time of day or year (e.g., a tornado or earthquake at night will affect people differently than one in the daytime; the impact of a disaster during tourist season will differ from an event in the off-season)

Refer back to the class list of responses to the opening question: “Why do some tornadoes, earthquakes, and volcanic eruptions harm people and property, while other similar events do not?” Ask students which, if any, of their original responses do not seem to apply to their research findings. Would they reconsider any of their original answers? Can they add anything to their original list?

Optional: Students can learn about the pioneering predictive efforts of the three scientists in the giant-screen film Forces of Nature or at the “Forces of Nature” Web site, at www.nationalgeographic.com/forcesofnature. After students see the film or review the Web site, refer them to the list of responses they developed in the closing. Is there anything they would add to this revised list?
Suggested Student Assessment:
Ask students to list things that scientists now understand about the natural event their group researched that was not understood in the past 50 to 100 years. Or have students write ideas for things that they reason could or should be done to reduce loss of life from the natural event. (Answers may reflect scientists’ efforts to enhance their ability to predict events through studying the characteristics, location, timing, and severity of events.)

Guidelines for Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:
• Compares data for natural disasters, analyzing the magnitude and impacts of these events
• Identifies and compares past and current knowledge about a natural hazard, citing how the impacts of that hazard might be minimized with scientific research

Extending the Lesson:
Have students, independently or in groups, find two other similar disaster events (e.g., hurricanes or snowstorms), or choose two events of local importance. They should write a report on similar characteristics and differing impacts of the two events.

Have students compare the impacts of two dissimilar natural events. The events could be either (a) two specific events or (b) the cumulative impact of one type of natural event (e.g., impact of all tornadoes versus impact of all snowstorms in the U.S. or in a state in a given year). Online databases include:
• National Climatic Data Center: Storm Events Database (data for drought, flood, hail, hurricanes, lightning, tornadoes, fires, more): www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent-storms
• National Earthquake Information Center: Earthquake Catalog Search: http://neic.usgs.gov/neis/epic/epic.html
• National Geophysical Data Center: Significant Earthquake Database: www.ngdc.noaa.gov/seg/hazard/sig_srcidb.shtml
• Smithsonian National Museum of Natural History: Global Volcanism Program: www.volcano.si.edu/gvp
• Tornado Project Online: www.tornadoproject.com
• USGS Volcano Hazards Program: Notable Volcanic Disasters: http://volcanoes.usgs.gov/Hazards/Effects/Fatalities.html
RELATED LINKS:

Natural Hazards: Same Forces, Different Impacts

National Climatic Data Center: Storm Events Database
www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwevent~storms

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

National Severe Storms Laboratory: Tornadoes . . . Nature’s Most Violent Storms
www.nssl.noaa.gov/NWSTornado

PBS Savage Earth Online
www.pbs.org/wnet/savageearth

USGS: Earthquake Hazards Program
http://earthquake.usgs.gov

USGS: Volcano Hazards Program
http://volcanoes.usgs.gov

Dr. Ross Stein

Grade Level: 6-8
Related National Geographic Activities and Lessons:
National Geographic: Xpeditions Lesson — Dealing With Disasters  
www.nationalgeographic.com/xpeditions/lessons/18/g68/fondisasters.html  

National Geographic: Xpeditions Lesson — The Impact of Natural Hazards Around the World  
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazards.html  

National Geographic: Xpeditions Lesson — Natural Hazard Risks in the United States  
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazard.html  

National Geographic: Xpeditions Lesson — When Natural Hazards Become Human Disasters  
www.nationalgeographic.com/xpeditions/lessons/15/g68/fonhuman.html
In this activity, students will study potential natural hazards in their community, report on local hazards in small groups, and discuss community preparation and response for one or more of these forces of nature. This activity would be appropriate to conduct after viewing the giant-screen film *Forces of Nature*. (For information about the film go to [www.nationalgeographic.com/forcesofnature](http://www.nationalgeographic.com/forcesofnature).)
Connections to the Curriculum: Geography, Earth science, government/civics

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 3: “How to analyze the spatial organization of people, places, and environments on Earth’s surface”
Standard 6: “How culture and experience influence people’s perceptions of places and regions”
Standard 7: “The physical processes that shape the patterns of Earth’s surface”
Standard 15: “How physical systems affect human systems”
Standard 18: “How to apply geography to interpret the present and plan for the future”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 5–8 Content Standard F. Science in Personal and Social Perspectives: Natural hazards, risks and benefits

Time: Will vary; minimally two hours

Materials Required:
• Computer with Internet access
• Chart paper or poster board, or PowerPoint
Objectives:
Students will:
• describe potential natural hazards in their community;
• prepare and present, in groups, a natural hazards report;
• in order of potential impact, rank natural hazards that are possible in the community;
• learn about disaster preparation and response strategies; and
• identify individual and/or community action plans for local natural hazards.

Geographic Skills:
• Asking Geographic Questions
• Acquiring Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure

Opening:
Ask students to recall the Soufriere Hills volcano in the film Forces of Nature. (For information about the film go to www.nationalgeographic.com/forcesofnature.) Scientists had warned about the danger from the volcano, and the government had evacuated the capital city, Plymouth, and surrounding areas well before Soufriere Hills’s violent events of 1997. Tragically, people died because they had secretly returned to the exclusion zone area against government orders. The applicable lesson is that loss of life can be minimized in natural disasters if good preparation is in place and if citizens follow instructions.

Development:
Ask students if a volcano is a natural hazard in their community. Have them brainstorm a list of potential local “forces of nature” (e.g., avalanche, blizzard, drought, earthquake, flood, hurricane, landslide, tornado, tsunami, volcano, wildfire). Make a class list of known or potential natural hazards (the list could also include nonlocal hazards). Save the list. These Web sites address geographical distribution of some hazards:
• ESRI: Hazard Information and Awareness — www.esri.com/hazards/makemap.html
  Select city, state, and hazard to make a local hazard map.
• USGS: Geographic Distribution of Major Hazards in the U.S. — www.usgs.gov/themes/hazards.html
  Maps indicate areas of risk or occurrences of six natural hazards.
Dealing With Disasters

Break the class into small groups of “Natural Hazard Experts” and assign one of the natural hazards on the class list to each group. (Depending on class size, more than one group could research the same hazard.) Each group should research their assigned hazard and prepare a presentation. Focus questions could include:

• What are the characteristics of the natural hazard?

• How real or likely a threat is the hazard locally?

• What has been the history and impact of the natural hazard locally? (Was property damaged? Were people injured or killed? Was there financial impact?)

• What aspects of the local physical geography (e.g., topography, geology, watershed characteristics, soil, precipitation) might contribute to the likelihood or severity of the natural hazard? What aspects of physical geography might reduce the impact of the hazard?

• What aspects of local human geography (e.g., population distribution and density, settlement patterns, type of land use) increase or reduce the natural hazard’s impact?

• Can the hazard be predicted?

During their presentations, each group of “hazard experts” should make a case for their hazard as having the greatest potential threat to the community. Ask students to keep careful lists of the similarities and differences among the threats. When all presentations have been made, have the class or “natural hazard expert” groups rank, in order of severity, the class list of natural threats to their community. Students should be able to explain and defend their choices.

Closing:
Ask students to list the procedures that have been — or could be — taken to protect their community from natural hazards. How are local organizations prepared to help before, during, and after a natural disaster? What can students do, individually or as a class? Students can go online for information:

• American Red Cross — www.redcross.org
  To find local chapters, scroll to “Find Your Local Red Cross” and enter zip code.

• FEMA: Hazards — www.fema.gov/hazards
  Information is given for preparation for different types of hazards.
Suggested Student Assessment:
What common threads for natural disaster planning and response have students found (e.g., designate “safe places” at home and school; discuss disasters with family; practice evacuations; get information from NOAA Weather Radio)?

Guidelines for Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:

• Prepare and present a group presentation that identifies potential local natural hazards, connecting information to the local physical and human geography

• Rank local natural hazards (actual and potential) in terms of potential impact

Extending the Lesson:
Students might work with the local chapter of the American Red Cross or other agencies to prepare a cache of emergency supplies for home and school.

Invite a local disaster preparedness official to class to review reports and provide advice on local hazards.

Have students utilize GIS (Geographic Information Systems) technology to research and report on local natural hazards.

Have students describe a local, national, or international disaster, and then answer the following: What were the impacts of the disaster? How did the community react? Could people have prepared in a better way?

Have students read “Whose Problem, Whose Price Tag?” at www.nationalgeographic.com/ngm/9807/forum/natualessay.html. As a class, debate the issues the essay addresses.

Design an action plan and response initiative for a natural disaster in the community, citing ways the community could best be prepared and identifying organizations that could help.
RELATED LINKS:
Dealing With Disasters

American Red Cross
www.redcross.org

FEMA for Kids
www.fema.gov/kids

FEMA: Hazards
www.fema.gov/hazards

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

National Hurricane Center: Hurricane Awareness
www.nhc.noaa.gov/HAW2/english/intro.shtml

National Severe Storms Laboratory: Tornadoes . . . Nature’s Most Violent Storms
www.nssl.noaa.gov/NWSTornado

NaturalHazards.org
www.naturalhazards.org

USGS: Earthquake Hazards Program
http://earthquake.usgs.gov

USGS: Volcano Hazards Program
http://volcanoes.usgs.gov
Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity — The Power of Fire
www.nationalgeographic.com/xpeditions/activities/15/powerfire.html

National Geographic: Xpeditions Activity — Understanding Disasters
www.nationalgeographic.com/xpeditions/activities/13/disaster.html

National Geographic: Xpeditions Lesson — The Impact of Natural Hazards Around the World
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazards.html

National Geographic: Xpeditions Lesson — Natural Hazard Risks in the United States
www.nationalgeographic.com/xpeditions/lessons/15/g68/hazard.html

National Geographic: Xpeditions Lesson — Natural Hazards: Same Forces, Different Impacts
www.nationalgeographic.com/xpeditions/lessons/15/g68/fonhazards.html

National Geographic: Xpeditions Lesson — When Natural Hazards Become Human Disasters
www.nationalgeographic.com/xpeditions/lessons/15/g68/fonhuman.html
Lesson: 4
Twister Tracking

Overview:

In this activity, students will use a database to learn about, organize, and compare tornadoes in their home state and across the country. This activity can be conducted either before or after students view the giant-screen film *Forces of Nature*. (For information about the film go to [www.nationalgeographic.com/forcesofnature](http://www.nationalgeographic.com/forcesofnature).)
Twister Tracking

Connections to the Curriculum: Geography, Earth science

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 1: “How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective”

Standard 7: “The physical processes that shape the patterns of Earth’s surface”

Standard 17: “How to apply geography to interpret the past”

Standard 18: “How to apply geography to interpret the present and plan for the future”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 9–12 Content Standard F: Science in Personal and Social Perspectives: Natural and human-induced hazards

Time: Two to three hours

Materials Required:
• Computer with Internet access
• Pencils or markers
• Graph paper or computer program for constructing graphs and tables
• Handout (or transparency) of the map “Annual Average Number of Strong-Violent (F2–F5) Tornadoes, by State, in the U.S., 1950–1995” (after page 28)
• Outline map of counties in your state
• National Geographic Xpeditions maps of the U.S., at www.nationalgeographic.com/xpeditions/atlas
Objectives:
Students will:
• apply aspects of tornado science, including the Fujita scale;
• demonstrate skills in searching a database to answer questions; and
• analyze data on charts and maps, comparing tornadoes in their state to other states.

Geographic Skills:
• Asking Geographic Questions
• Acquiring Geographic Information
• Organizing Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure

Opening:
Note: This opening may vary, depending on your community’s or state’s experiences with tornadoes, or whether or not students have seen the giant-screen film Forces of Nature. To set the stage for the activity, you could have students:

• Review the “National Geographic: Forces of Nature” Web site at www.nationalgeographic.com/forcesofnature
• Take the National Geographic Weather Wizard quiz on tornadoes at http://magma.nationalgeographic.com/ngexplorer/0401/games/game.cgi
• Check out an animated Quick Flick on tornadoes at http://magma.nationalgeographic.com/ngexplorer/0401/quickflicks/index.html

Ask each student to write a list of “Tornado Knowns and Unknowns” — things they think they know about tornadoes, and things about tornadoes they would like to learn. Students might briefly compare their lists with a neighbor, then as a class share their lists orally or on the board; this will help determine their level of understanding and clarify any questions.

Tell students that they will be working in groups to research and display actual tornado data. To set this up, ask:

• What factors can contribute to the formation of a tornado?
• Do tornadoes occur in our state? Are they more likely to occur in our state than in others? Where are they likely to occur? When might they occur?
• Why are some tornadoes more destructive than others?
• How do atmospheric scientists study tornadoes? (If students have seen the giant-screen film Forces of Nature, methods of tornado chasers like Dr. Josh Wurman might be discussed. For information about the film go to www.nationalgeographic.com/forcesofnature.)
Twister Tracking

Tell students that one important way in which scientists classify tornadoes is by their estimated force, based upon damage observed. Introduce the Fujita scale, which measures and ranks tornadoes. Students can learn about the scale at www.ncdc.noaa.gov/oa/satellite/satelliteseye/educational/fujita.html (National Climatic Data Center).

Development:
In groups of two to four, students will investigate the searchable Storm Events Database at www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent-storms. (The database is maintained by the National Climatic Data Center.) They will retrieve some of their state’s tornado data, then construct charts of the data. Because this database is comprehensive, give students parameters for their search; for example:

- Select their own state.
- Set a “Begin Date” in the past 10 years or fewer. (For states with few tornadoes, retrieve data for more years.)
- Use default “End Date” or set a recent date.
- Select “all” counties.
- Select “tornadoes” for “Event Type.”
- Search for tornadoes “F2 and Higher.” (For states with few tornadoes, students can choose another state where they reason more tornadoes might occur, or search for “all” tornadoes in their own state.)
- Click “List Storms.”

Note: If a single tornado occurred in more than one county, the database lists all counties in which it occurred in the “Location or County” column.

Once groups have retrieved the data, assign each group a different way to organize and analyze their tornado data:

- Create a bar chart of total tornadoes, by year (e.g., all tornadoes in the past 10 years).
- Create a bar chart of tornadoes, by Fujita scale ranking.
- Create a bar chart of total tornadoes, by month.
- Create a bar chart of tornadoes by time of day (by the hour, or in blocks of hours).
- Create a bar chart or other graphic to depict casualties, property damage, or other characteristics.
- Create a map showing the county or location of each tornado (by Fujita scale ranking or number of casualties, if appropriate).

As they complete their task, tell each group to analyze their results and write one or two descriptive statements about their results. (e.g., The most tornadoes occurred in 1998. There were fewer F3 than F2 tornadoes. More tornadoes occurred in spring than in other seasons. There were more afternoon than morning tornadoes. More tornadoes occurred in the western part of the state.)

These analyses can be shared (as scientists do) via brief group presentations and with summary statements written on the board. Each group’s findings will have added to the understanding of the entire group. Explain to students that they have collectively constructed a set of (probable) “Tornado Truths” for their state.
Closing:
Show students the map “Annual Average Number of Strong-Violent (F2–F5) Tornadoes, by State, in the U.S., 1950–1995.” Ask:

- How does our state compare to others, tornado-wise?
- Does our state have many or few tornadoes?
- What states have the most tornadoes, on average?
- Does this data mean that each state will have the number of tornadoes indicated on the map every year (e.g., Texas will have 29 and Colorado will have 2)?
- How would you describe the spatial pattern of tornado events in the U.S.?
- Does Tornado Alley live up to its name, according to this map?

Suggested Student Assessment:
Retrieve data for a single year of F2–F5 tornadoes in the U.S. from the Storm Events Database (www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwevent-storms). Print out the data for students. Give each student a U.S. outline map (can be found online at www.nationalgeographic.com/xpeditions/atlas). Students should put the data for the “single year” on the outline map. Ask students to carefully study and compare their map with the map “Annual Average Number of Strong-Violent (F2–F5) Tornadoes, by State, in the U.S., 1950–1995,” then write answers to these questions:

- Does the number of tornadoes in this one-year period “fit” the annual average number of tornadoes nationwide? State-by-state?
- Did tornadoes occur in this year in a similar spatial pattern?
- Based upon the patterns displayed in your map, can you predict in which states the highest number of tornadoes might occur in the following year? (Students can check their estimate online in the database.)

Guidelines for Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:

- Applies the Fujita scale to classify tornadoes
- Uses a database to gather information, create bar charts and a map, and to ask and answer questions about tornadoes
- Analyzes and compares tornadoes in their state with other states
- Predicts tornadoic occurrences, based on collected data

Extending the Lesson:
Ask students to find out why some tornadoes cause more loss of life and damage than others.

In the Storm Events Database, have students examine different Event Types (hail, drought, snow and ice, etc.) in their state. Which type of event caused the most property damage (or crop damage, loss of life, or injury) in their state for the most recent year of recorded data? Students could construct tables, charts, or maps of events.

The U.S. has more tornadoes annually than any other country. Ask students why that is so. Then ask students to find data and descriptions of tornadoes in other countries or regions. Do these other countries or regions share any similarities with the areas of the U.S. where tornadoes are more likely to occur? Are there different names for tornadoes in other regions?

Ask students to research the reasons that their state has few or many tornadoes annually.
RELATED LINKS:

Twister Tracking

National Climatic Data Center: Storm Events Database
www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwevent~storms

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

National Geographic: Tornadoes Quick Flick

National Geographic: Weather Wizard Game
http://magma.nationalgeographic.com/ngexplorer/0401/games/game.cgi

National Severe Storms Laboratory: Tornadoes . . . Nature’s Most Violent Storms
www.nssl.noaa.gov/NWSTornado

Scholastic Weather Watch: Tornadoes

Tornado Project Online
www.tornadoproject.com

USA Today Weather Resources: Tornadoes
www.usatoday.com/weather/resources/basics/twist0.htm

Why Files: Twister — The Tornado Story
http://whyfiles.org/013tornado/index.html

Meteorologist Dr. Josh Wurman

Grade Level: 9-12
In this activity, students will delve into seismology — the study of earthquakes — learning about and contrasting two scales used by seismologists to categorize and compare these quaking forces of nature. Students will review firsthand accounts from people who experienced an earthquake, then employ one of these scales to categorize and map the earthquake’s intensity. This activity might productively be conducted either before or after viewing the giant-screen film *Forces of Nature*. (For information about the film go to www.nationalgeographic.com/forcesofnature.)
Connections to the Curriculum: Geography, Earth science

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 1: “How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective”

Standard 7: “The physical processes that shape the patterns of Earth’s surface”

Standard 15: “How physical systems affect human systems”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 9–12 Content Standard E. Science and Technology: Understandings about science and technology

Grades 9–12 Content Standard F. Science in Personal and Social Perspectives: Natural and human-induced hazards

Time: Two hours

Materials Required:
• A variety of colored pencils
• Computer with Internet access
• Photocopies of the following:
  — National Earthquake Information Center (NEIC) description of the Modified Mercalli Intensity Scale (MMI), at http://neic.usgs.gov/neis/general/mercalli.html
  — Handout 1*: Zip Code Base Map for the Northridge, Calif., Earthquake, January 17, 1994
  — Handout 2*: “Earthquake Experiences”
  — Handout 3*: USGS-defined MMI Values for the Northridge, Calif., Earthquake, January 17, 1994

* Handouts 1, 2 and 3 follow page 36.
Objectives:
Students will:
• apply Modified Mercalli Intensity (MMI) values to written descriptions of an earthquake;
• map MMI values on a large-scale zip code map and defend their decisions;
• compare their MMI maps to a USGS map of MMI values, noting similarities and differences; and
• explain how measures of magnitude and intensity are applied to earthquakes.

Geographic Skills:
• Asking Geographic Questions
• Acquiring Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure
Opening:
Ask students if they’ve ever been startled in their sleep — “jolted” awake. Some people who’ve been sleeping when an earthquake struck weren’t sure whether they were waking up naturally or experiencing a real earthquake. Others had no doubt about the nature of the jolting event!

Tell students they are going to study and compare the size, intensity, and destructive power of earthquake “jolts,” as seismologists do. Seismology — from the Greek seismos, which means “shock” or “earthquake” — is the science that deals with earthquakes and other artificially-produced vibrations of the Earth. Scientists such as geophysicist Dr. Ross Stein, featured in the giant-screen film Forces of Nature, study earthquakes in the attempt to better predict them, and save lives. (For information about the film go to www.nationalgeographic.com/forcesofnature.)

Development:
Tools called seismographs (http://neic.usgs.gov/neis/seismology/keeping_track.html) record an earthquake, and the value of its magnitude is determined using the recording and a mathematical formula. Magnitude measures the energy that’s released by an earthquake.

What other kinds of information might seismologists and others want to learn about an earthquake beyond its size in quantitative terms? (e.g., What kinds of problems did the quake create for people and property? Were people hurt? Killed? Were homes or other buildings damaged?) The Modified Mercalli Intensity scale (MMI), used in the U.S., is a more subjective, qualitative measure of an earthquake’s effects. The MMI value assigned depends on vibrations experienced by people in an earthquake, and by the amount of building damage done.
Earthquakes: A Whole Lot of Quakin' Goin' On!


As a class, discuss how the different methods rate and describe earthquakes. Which way of measuring — by magnitude or by intensity — seems more useful? Why?

Ask students what other factors might contribute to an earthquake’s effect. (The type of underlying rock or soil affects damage. Areas underlain with solid bedrock typically “ride out” earthquakes with less damage than areas with soft, unconsolidated sediments. The Multidisciplinary Center for Earthquake Engineering Research offers an overview of “Soils and Earthquakes” at http://mceer.buffalo.edu/education/exercises/soil.asp.)

Give each pair or group a copy of Handout 1: Zip Code Base Map for the Northridge, Calif., Earthquake, January 17, 1994; a copy of Handout 2: “Earthquake Experiences,” and a description of the MMI scale (from http://neic.usgs.gov/neis/general/mercalli.html). Explain that the magnitude of the Northridge earthquake measured 6.7, but its effects varied throughout the region. Students will analyze responses from people who experienced the quake, then determine the locations of respondents on a map.

Students should:
1) Color in the boxes of the “Intensity” key at the bottom of the map using increasingly darker colors or shades for higher intensity values (this will result in an easier map to interpret).
2) Read the “Earthquake Experiences.” Assign an MMI rating (I—X+) to each experience.
3) Using the appropriate color for the degree of intensity, color the zip code regions on the map with the MMI rating their group assigned to each earthquake experience. (A region can have more than one MMI rating.)
4) Title the map. Analyze the patterns of earthquake intensity on the map and write observations below the map.

Closing:
As a class, discuss differences in the maps. Did groups rate some experiences differently on the MMI scale? Why? Do some color keys work better than others in depicting the intensity pattern? Ask students if they were able to determine the earthquake’s epicenter. If so, how? Give students Handout 3: USGS-defined MMI Values for the Northridge, Calif., Earthquake, January 17, 1994. How does that map — with the MMI ratings determined by the USGS — compare with their maps?
Suggested Student Assessment:
Ask students what they think contributes to the different intensities of shaking that occur in different areas, but that are caused by the same earthquake. (The intensity generally decreases with distance from the epicenter. It is also influenced greatly by the type of underlying material — soft sediments shake more than hard rock.)

Ask students to agree or disagree — in writing — with the following statement: “An earthquake has one magnitude, but many intensities.”

Guidelines to Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:
• Matches MMI values to descriptions of earthquake events
• Creates a map based on the interpretation of MMI data and defends decisions for placement of MMI values
• Compares student-made MMI map to the USGS map with actual MMI data, noting similarities and differences
• Explains how magnitude and intensity scales are applied to earthquakes, speculating on how similar intensity and magnitude of an earthquake impacts locations differently

Extending the Lesson:
Tell students that they are U.S. government officials or explorers who have been asked to give the USGS an MMI ranking of the New Madrid earthquakes of 1811–12, and to write a summary about one or more of the towns or regions affected. Their report should justify the intensity level (or levels) they chose. The USGS Earthquake Hazards Program reports on the New Madrid quakes at www.earthquake.usgs.gov/bytopic/new_madrid.html.

As an ongoing extension, have students monitor the “everyday earthquakes” that seismologists study to improve their understanding of — and their ability to predict — earthquakes. Several Web sites with maps and data:
• Incorporated Research Institutions for Seismology: Seismic Monitor: www.iris.edu/seismon
• NEIC: Last 8 to 30 Days of Earthquake Activity: http://gldss7.cr.usgs.gov/neis/qed/qed.html

Research other earthquake scales. What do they have in common? For what purposes are they used? Where are they used?
RELATED LINKS:

Earthquakes: A Whole Lot of Quakin' Goin' On!

American Museum of Natural History: Quakes From Space
http://earthbulletin.amnh.org/A/1

Exploratorium: Life Along the Fault Line
www.exploratorium.edu/faultline/index.html

National Geographic: Eye in the Sky — Earthquakes
www.nationalgeographic.com/eye/earthquakes/earthquakesintro.html

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

National Geophysical Data Center: Significant Earthquake Database
www.ngdc.noaa.gov/seg/hazard/sig_srch_idb.shtml

PBS Savage Earth Online — The Restless Planet: Earthquakes
www.wnet.org/savageearth/earthquakes

USGS: Earthquake Hazards Program
http://earthquake.usgs.gov

USGS: Response to an Urban Earthquake — Northridge ’94
Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity — The Power of Fire
www.nationalgeographic.com/xpeditions/activities/15/powerfire.html

www.nationalgeographic.com/xpeditions/lessons/04/g912/processes.html

National Geographic: Xpeditions Lesson — The Ring of Fire
www.nationalgeographic.com/xpeditions/lessons/15/g912/ring.html

National Geographic: Xpeditions Lesson — Twister Tracking
www.nationalgeographic.com/xpeditions/lessons/01/g912/fontwister.html

National Geographic: Xpeditions Lesson — Volcano Hazards: Describing a Dangerous Mix
www.nationalgeographic.com/xpeditions/lessons/07/g912/fonvolcano.html

National Geographic: Xpeditions Lesson — What’s Up With the Weather?
www.nationalgeographic.com/xpeditions/lessons/07/g912/weather.html

Credits: Lesson adapted from an activity by Lisa Wald, USGS. Data courtesy of the USGS for Handout 1: Zip Code Base Map and Handout 3: USGS-defined MMI Values. Responses courtesy of the USGS for Handout 2: “Earthquake Experiences.” Note: Zip code regions were combined and data was modified for the simplified maps in Handouts 1 and 3, which represent the general pattern of intensity. For this activity, only selected earthquake experiences are provided.

Zip code areas with no data shown in gray.
Zip codes are not indicated for all of the zip code areas that are outlined above.
Earthquake Experiences

The USGS distributes questionnaires after an earthquake to determine its intensity, which is measured by the Modified Mercalli Intensity Scale (MMI). On January 17, 1994, an earthquake hit Northridge, California. Each paragraph below is a response to the USGS questionnaire from a person in a different zip code region in that area. The magnitude of the Northridge earthquake measured 6.7, but its intensity varied throughout the region.

Zip Code: 90027
“I was driving home from work and it felt like I had a flat tire. I pulled off the road to check and as I stopped the car I saw the chimney on a nearby house collapse. It fell right on a new Lexus that was parked in the driveway.”

Zip Code: 90037
“I had just gotten up to give my baby daughter her bottle when I felt a violent jolt. I knew we were having an earthquake so I tried to run into her room to get her but it was so hard to walk! I could hear things outside falling and hitting the ground, and all of the pictures in the hall were falling and breaking. I was so scared!”

Zip Code: 90044
“I was asleep when the earthquake hit. It woke me up right away. I wasn’t sure what to do so I stayed in bed and watched the pictures on the wall swing.”

Zip Code: 90503
“I am a nurse at a local hospital. I was attending to Mr. Jones when I first felt the earthquake. He woke up and we watched a glass of juice on his bedside table slide back and forth. I caught it before it tipped. Most of the patients woke up. Let me tell you, it was a long night!”

Zip Code: 90706
“My parents were out of town visiting my brother at college so my best friend John and I decided to have a party. The party was pretty much over and we were doing damage control in the backyard when I felt something weird. I thought it was just me, but then everything started to shake. I mean, even the pool had waves in it and the water was spilling out over the edges! And so much stuff in the house had fallen over and broken you couldn’t even tell we had a party!”

Zip Code: 90720
“I was asleep when I felt my bed start to shake. I thought it was my brother but then I realized it was an earthquake. I was scared but then I remembered that my mom had said if there was an earthquake to get under the kitchen table and hold on. I could see things falling — pictures and books and dishes and stuff. It was pretty scary but we were all okay.”

Zip Code: 90650
“My wife woke me up and asked if I felt anything. I told her that I certainly did not feel anything except her shaking me. She said she thought she felt an earthquake but maybe it was a big truck — we live close to the freeway. Turns out it was an earthquake, a pretty big one! Who knew!”

Zip Code: 90631
“I work the late shift at Denny’s. I was outside on my break when I felt the first shake. Then everything started shaking so hard I could even hear the bushes rattling! The people inside felt it, too. Their plates and glasses were shaking and bouncing and a bunch of them came running outside. I don’t know where they thought they were going to go — it was shaking outside too!”
Earthquake Experiences

Zip Code: 90808
“I am from Virginia and I was in California visiting my grandchildren. In the very middle of the night I woke up and felt a strange rumbling. Then things started to shake a bit and my grandson ran into my room and told me to stand in the doorway, that we were having an earthquake. Well, that door was swinging back and forth and I told him that I would stay right where I was, thank you very much! I wasn’t going to get knocked out by some door and have to be taken to the hospital in my nightclothes!”

Zip Code: 90806
“I am a really heavy sleeper and I didn’t even wake up, but my husband was up getting a snack and he said he felt it. He said the dishes in the cupboard rattled and he could see the hanging plants swaying.”

Zip Code: 91011
“I am a seismologist with the USGS and my first thought when I felt the earthquake was, ‘I’m going to work tonight!’ My husband and I watched as several picture frames slid off the mantle, and then we ducked under the table. We had to hold on because the table was trying to slide away. A few dishes that had been left out fell and broke, but we suffered no severe damage.”

Zip Code: 91311
“I was sleeping soundly when I was suddenly thrown out of bed. I could hear my kids crying and I was trying to run, trying to get to them. The walls were shaking and cracking and pieces of plaster were falling from the ceiling. I could barely stand. The noise was deafening. By the time I got to my kids and got them outside the whole thing was over. We have a lot of damage to our house but not as much as our neighbors. Their house partially collapsed.”

Zip Code: 91706
“I thought the earthquake was great! What a ride! I was up studying for my English test when I felt the shaking. I could hear the house creak and some of the dishes were clinking and making noise. I wonder if we’ll still have the test?”

Zip Code: 91384
“I’m a night watchman at an apartment complex. It was pretty late and everything was real quiet. I was making my rounds when I felt a strong jolt — it almost knocked me off my feet! I ran out into the middle of the street and it’s a good thing I did, too! Bricks were falling off of the building and the trees were shaking so hard that branches were breaking and falling off. All of the parked cars around me were shaking and bouncing and the car alarms were all going off.”

Zip Code: 91320
“My daughter had just arrived home (way past her curfew) and we were arguing in the den. When we felt the shaking we just stared at each other. The sound of a glass smashing snapped us out of it. We both ran to the china hutch, where I keep my mother’s china — it was just about to tip over! We held it up and we could hear other things around the house falling and breaking. Needless to say, I wasn’t worried about the curfew violation any more!”

Zip Code: 91745
“I had a terrible cold and I had just taken some Nyquil and had finally fallen asleep. When the earthquake woke me up I was more irritated then scared. After the shaking stopped I walked around and picked up a few knickknacks that had fallen and put them back on the shelves. It was no big deal, but it took me forever to get back to sleep!”
Earthquake Experiences

Zip Code: 93015
“I was up late working on a briefing when I first felt the earthquake. It didn’t seem too bad at first so I stayed put to see if it would get worse. It did! I tried to get up and could barely stand. I remembered that you’re supposed to get under a table if it’s a bad earthquake so I got down on my hands and knees and crawled under my table. Just as I got under there my big bookcase fell and smashed on the table. If I had still been sitting there it would have crushed me.”

Zip Code: 93505
“We were out of town when the earthquake hit. Of course, we were scared for our friends and family and for our home. We called our son and he said that everyone was alright, but they had a lot of structural damage to their house, and had lost some personal items. We called the neighbors and they gave us a grocery list of damage to our house — chimney broken at the roofline, cracks in the masonry, fallen bricks, stuff like that. I’m afraid to go home and see the damage inside.”

Zip Code: 93023
“My husband woke me up yelling that we were having an earthquake. As we ran into the kitchen I could hear the plates and cups banging and rattling, and all of the pictures were falling off the walls. We grabbed the dog and all got under the table. I knew we were going to be alright because our house is retrofitted and all of our things are secured, but I was worried about my mom and dad.”

Zip Code: 91754
“I was asleep when the earthquake came. I was so scared and I didn’t know what to do. The house was shaking so bad that I couldn’t even walk. My dad came into my room and got me and we got under the table. We could see the refrigerator sliding back and forth across the kitchen with its door opening and shutting and all of the stuff falling out onto the floor. Our TV went flying across the room and smashed into the wall. All over we could hear things breaking. Then the lights went out. After it stopped we went outside. We could see all of the other people outside too. They were crying and looking around. Part of our apartment building fell down and now those people have to find another place to live. We might have to, too.”

Zip Code: 93060
“I was asleep in my tent when I felt the earthquake. It woke up my whole family, and all of the other campers in the campground. Since there were no rocks, trees or buildings around we all felt pretty safe. It was a thrilling way to experience the power of nature.”

Zip Code: 93523
“I was just finishing a great Tom Clancy novel when I felt the earthquake. At first I thought it was a passing truck but then I noticed that the blinds were swinging a little bit. I thought about calling my buddy to see if he had felt it but it was late and I was pretty sure it wouldn’t have woken him up.”

Zip Code: 93501
“I was sleeping over at my friend’s house when the earthquake came. We were supposed to be asleep but we were telling stories so we felt it first. She said that her family had an earthquake plan and we were supposed to go into the dining room and get under the table. It was kind of scary because all of the furniture was moving around and her dad’s computer fell on the floor and broke, but I wasn’t really scared because her mom and her dad said that we were prepared and we’d be okay.”

Credit: Questionnaire responses courtesy of USGS

Zip code areas with no data shown in gray.
Intensity is indicated for some areas for which zip codes were not given on Handout 1.
Students will work cooperatively to become “Volcano Hazards Experts.” Groups will research and create posters illustrating dangers from volcanic eruptions, as well as determine the dangers of specific volcanic eruptions. They will present their research to the class. Finally, students will write about a volcanic eruption and present their work orally. This activity can be conducted before or after viewing the giant-screen film Forces of Nature. (For information about the film go to www.nationalgeographic.com/forcesofnature.)
Volcano Hazards: Describing a Dangerous Mix

Connections to the Curriculum: Geography, Earth science, language arts

Connections to the National Geography Standards:
(For information about these standards go to www.nationalgeographic.com/xpeditions/standards.)

Standard 7: “The physical processes that shape the patterns of Earth’s surface”
Standard 15: “How physical systems affect human systems”

Connections to the National Science Education Standards:
(For information about these standards go to www.nap.edu/readingroom/books/nses/html.)

Grades 9–12 Content Standard F. Science in Personal and Social Perspectives: Natural and human-induced hazards

Time: Will vary; two hours minimum

Materials Required:
• Computer with Internet access
• Writing and drawing materials
• Poster board or chart paper
• National Geographic Xpeditions outline maps of the world, at www.nationalgeographic.com/xpeditions/atlas
Objectives:
Students will:
• describe the dangers of volcanic eruptions through illustrated, oral, and written accounts; and
• identify the dangers associated with 10 volcanic eruptions.

Geographic Skills:
• Asking Geographic Questions
• Acquiring Geographic Information
• Organizing Geographic Information
• Analyzing Geographic Information
• Answering Geographic Questions

Suggested Procedure

Opening:
List the volcanoes and year of eruption (below) on the board, the overhead, or on sheets of paper for each group. Do not list the location or hazards; leave room for students to fill in those categories in the table after their research. (A volcano may have had more than one eruption; years listed below indicate a single eruption.)

<table>
<thead>
<tr>
<th>VOLCANO</th>
<th>(YEAR)</th>
<th>LOCATION</th>
<th>HAZARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesuvius</td>
<td>(A.D. 79)</td>
<td>Italy</td>
<td>pyroclastic flows, tephra</td>
</tr>
<tr>
<td>Mount Pelée</td>
<td>(1902)</td>
<td>Martinique</td>
<td>pyroclastic flows, tephra</td>
</tr>
<tr>
<td>Heimaey</td>
<td>(1973)</td>
<td>Iceland</td>
<td>lava flows</td>
</tr>
<tr>
<td>Kilauea</td>
<td>(1983–present)</td>
<td>Hawai`i, U.S.A.</td>
<td>lava flows, gas</td>
</tr>
<tr>
<td>Nevado del Ruiz</td>
<td>(1985)</td>
<td>Colombia</td>
<td>pyroclastic flows, lahars</td>
</tr>
<tr>
<td>Lake Nyos</td>
<td>(1986)</td>
<td>Cameroon</td>
<td>gas</td>
</tr>
<tr>
<td>Unzen</td>
<td>(1991)</td>
<td>Japan</td>
<td>pyroclastic flows</td>
</tr>
<tr>
<td>Pinatubo</td>
<td>(1991)</td>
<td>Philippines</td>
<td>tephra, lahars</td>
</tr>
<tr>
<td>Soufriere Hills</td>
<td>(1997)</td>
<td>Montserrat</td>
<td>pyroclastic flows, tephra</td>
</tr>
</tbody>
</table>

There are more than 500 active (i.e., capable of erupting) volcanoes in the world. Ask students if they think all volcanoes are alike. Do they all look the same? Do they all erupt in the same way? Are the dangers from all volcanoes the same?

Read aloud two first-person accounts, and ask students to listen for differences.
• In the first account, Pliny the Younger describes Pliny the Elder’s experience with Mt. Vesuvius in A.D. 79, at www.pbs.org/empires/romans/voices/voices1d.html. (From PBS “Ancient World,” “The Roman Empire in the First Century”)
• The second account (next page) is excerpted from a newspaper article by Samuel Clemens, writing as Mark Twain, about Kilauea volcano, in Hawai`i.
“Through the glasses, the little fountains scattered about looked very beautiful. They boiled, and coughed, and spluttered, and discharged sprays of stringy red fire - of about the consistency of mush, for instance - from ten to fifteen feet into the air, along with a shower of brilliant white sparks - a quaint and unnatural mingling of gouts of blood and snow flakes!

“I could see the North Lake lying out on the black floor away off in the outer edge of our panorama, and knitted to it by a webwork of lava streams. . . .

“I forgot to say that the noise made by the bubbling lava is not great, heard as we heard it from our lofty perch. It makes three distinct sounds - a rushing, a hissing, and a coughing or puffing sound; and if you stand on the brink and close your eyes it is no trick at all to imagine that you are sweeping down a river on a large low pressure steamer, and that you hear the hissing of the steam about her boilers, the puffing from her escape pipes and the churning rush of the water abaft her wheels. . . .”

After students have listened to both descriptions, ask again: Are all volcanoes alike?

Explain that volcanologists — scientists who study volcanoes — classify volcanoes in a number of ways (e.g., by structure, tectonic origin, type of eruptive material, level of activity, location). Such categorization helps scientists such as Dr. Marie Edmonds, featured in the giant-screen film Forces of Nature, to understand, prepare for, and predict eruptions. If students have seen the film, ask them to recall Dr. Edmonds’s pioneering prediction research, which includes measuring Soufriere Hills’s volcanic gases. (For information about the film go to www.nationalgeographic.com/forcesofnature.)

Introduce students to one method of classifying volcanoes — by type. The Volcano World Web site reviews six types, including the two most common on Earth: shield volcanoes (like Kilauea) and composite volcanoes (like Vesuvius) at http://volcano.und.nodak.edu/vwdocs/vwlessons/volcano_types/index.html.

Development:
Another way to classify a volcano is by the dangers posed by its eruption, which is useful in predicting eruptions. Divide students into six groups of three to five students each. Each group of “Volcano Hazards Experts” should have a separate work space (table or cluster of desks). Assign each group to research one of the terms below. (As groups research, they should note if “their” hazard occurred in any of the 10 volcanic eruptions.)

• tephra  • volcanic gases  • pyroclastic flows  • lava flows  • landslides  • lahars

Each group should design and construct a poster that illustrates its assigned volcanic hazard. What are the characteristics of the hazard? What dangers or problems does it pose for people, property, habitats, wildlife? What type or types of volcano — shield, composite, etc. — would feature the hazard?

When posters are completed, have groups make brief oral presentations to the class, or have students move — half a group at a time — to the other groups for two- to three-minute sessions to learn about each hazard. Students should take notes and ask questions in the sessions.
Volcano Hazards: Describing a Dangerous Mix

As a class or in groups, have students write the location of each of the 10 volcanoes in the table, then locate and label the volcanoes on a world map (a National Geographic Xpeditions world map is available at www.nationalgeographic.com/xpeditions/atlas). Is there a pattern to the locations of the volcanoes?

As a class, determine which hazard or hazards occurred in each of the 10 volcanic eruptions; add the hazards to the table. Which hazard do students think is the most dangerous? Why? What hazards, other than the six studied in this lesson, are associated with volcanic eruptions (e.g., tsunamis, earthquakes, post-eruption starvation)?

Closing:
Ask students to recall the earlier descriptions of volcanic activity. Pliny the Younger wrote a factual account, while Twain wrote with metaphors (“They boiled, and coughed, and spluttered, and discharged sprays of stringy red fire . . . a quaint and unnatural mingling of gouts of blood and snow flakes. . . .”). Individually or in groups, ask students to describe — accurately and using as many details as possible, yet creatively — the hazard and volcano( es) they focused on in their group. Their creative writing should be shared orally with the class, discussed, and handed in. The assignment can take the form of a newspaper article, scientific journal entry, letter to a family member, poem, diary entry of someone who lives near a volcano, or song lyric.

Suggested Student Assessment:
Ask students to write a paragraph that answers the question, Which volcanic hazard is the most dangerous? Provide specific reasons why.

Guidelines for Evaluation:
Evaluate students’ work based on the amount of detail and accuracy in oral and written presentations and on the use of research for each of the following:
• Describing volcanic hazards in various formats: illustrated, oral, and written
• Locating volcanoes on a world map and identifying hazards specific to each
• Identifying volcanic hazards associated with four specific eruptions
• Evaluating which volcanic hazard is the most dangerous, explaining and stating reasons

Extending the Lesson:
Have students research tsunamis and how these hazards can be associated with volcanic eruptions (or with earthquakes).

Have students research paintings or other art forms that portray volcanoes, either erupting or dormant. How have artists portrayed volcanoes — as a threat, or, as Mark Twain wrote, “very beautiful”?

Have students research ways in which volcanoes are beneficial, as well as destructive, forces of nature.

Have students compile their research in a class chart and/or map of volcanic eruptions or hazard types.
RELATED LINKS:

Volcano Hazards: Describing a Dangerous Mix

Annenberg/CPB: Can We Predict Volcanic Eruptions?
www.learner.org/exhibits/volcanoes/

Michigan Technological University
www.geo.mtu.edu/volcanoes/hazards/primer

Montserrat Volcano Observatory
www.mvo.ms

National Geographic: Forces of Nature
www.nationalgeographic.com/forcesofnature

PBS Savage Earth Online—Out of the Inferno: Volcanoes
www.wnet.org/savageearth/volcanoes

San Diego State University: How Volcanoes Work
www.geology.sdsu.edu/how_volcanoes_work

USGS: Volcano Hazards Program
http://volcanoes.usgs.gov

Volcano Information Center
http://volcanology.geol.ucsb.edu

Volcano World
http://volcano.und.nodak.edu/vw.html

Why Files: Volcano Lovers
http://whyfiles.org/031volcano
Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity — The Power of Fire
www.nationalgeographic.com/xpeditions/activities/15/powerfire.html

National Geographic: Xpeditions Lesson — Earthquakes: A Whole Lot of Quakin’ Goin’ On!
www.nationalgeographic.com/xpeditions/lessons/07/g912/fonquakes.html

www.nationalgeographic.com/xpeditions/lessons/04/g912/processes.html

National Geographic: Xpeditions Lesson — The Ring of Fire
www.nationalgeographic.com/xpeditions/lessons/15/g912/ring.html

National Geographic: Xpeditions Lesson — Twister Tracking
www.nationalgeographic.com/xpeditions/lessons/01/g912/fontwister.html

Credit: Excerpt from an article by Samuel Clemens, writing as Mark Twain. For the full article go to www.twainquotes.com; then click “Newspaper Articles,” click “Sacramento DAILY UNION 1866,” and click “November 16, 1866 — The Great Volcano of Kilauea.”
This companion piece to the giant-screen film FORCES OF NATURE was created by National Geographic Education & Children’s Programs. This guide and resources related to the film can be found online at www.nationalgeographic.com/forcesofnature

Images in this guide are from the giant-screen film FORCES OF NATURE, from National Geographic and Graphic Films, except as follows: p. 6 courtesy of Marie Edmonds; pp. 13 and 20 courtesy of Ross Stein; p. 27 courtesy of Josh Wurman

Photographs on cover (top to bottom): Supercell storm in Texas; Kilauea volcano, in Hawai`i; Tornado in South Dakota; Dr. Richard Herd and Dr. Marie Edmonds on Soufriere Hills

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