
Dry, Drier, Drought in Colorado

Setting the Stage

The 2012-13 North American Drought originated in the midst of a record-breaking heat wave, and was an extension of the 2010-13 Southern United States Drought. In 2018, Colorado drought conditions were the worst since that time. By the end of 2018, the Southwest Region was experiencing “exceptional drought”, which is the most severe intensity of drought. The 2018 drought is part of a trend towards increasing frequency and severity of drought globally. This lesson will investigate the causes, effects, and impacts of this phenomenon in Colorado.



Impacts of drought on the Colorado River in the Southwest U.S.
Photo Credit: USGS <https://pubs.usgs.gov/fs/2004/3062/>

Lesson Overview

Students will build understanding about drought in Colorado through the following learning activities:

- *Activity 1 – Engage (15 minutes) Drought in Colorado*
As a class, watch videos about drought in Colorado and have a class discussion on what students know and wonder about drought.
- *Activity 2 – Explore & Explain (35 minutes) Drought & Case Study Data Analysis*
In teams, analyze drought information and data to build understanding of the causes, impacts, location, and frequency of drought in Colorado.
- *Activity 3 – Elaborate (50 minutes) Drought Public Information Notification*
In teams, create a public information notification educating your community about the causes and impacts of drought, past and current drought status, and tips on preparing and responding to drought.

Instructional Overview	
Grade Level	Middle School
Instructional Time	100 minutes
Standards Alignment	NGSS: MS-ESS3-2 CDE: MS3.ESS.GLE9
Anchoring Phenomenon	<ul style="list-style-type: none"> Causes and effects of drought can be identified and measured Natural factors, such as weather and climate, affect the potential and severity of drought Natural and human-impacted environments, including agriculture, tourism, and residential development, are affected by drought
Driving Questions	<ul style="list-style-type: none"> What causes drought? How is drought measured and monitored? Which areas in Colorado are more vulnerable to drought impacts? In what season are drought impacts most likely to occur?
Learning Goals	<ul style="list-style-type: none"> Students will understand the basic causes and impacts of droughts Students will analyze case study and current drought data in Colorado Students will summarize the main preparedness steps and response strategies for drought events
Materials	<ul style="list-style-type: none"> <input type="checkbox"/> <i>Students:</i> One <i>Drought Diary student handout</i> per student (digital access or printed copy & pencil) <input type="checkbox"/> Individual student computer devices or classroom computer with projector, and internet <input type="checkbox"/> <i>Entire class:</i> 12 Large Post-Its or pieces of large paper, 12 packs of sticky notes, and 12 felt markers
Material Preparation	<ul style="list-style-type: none"> <input type="checkbox"/> Print <i>Drought Diary Student Handouts</i> if needed <input type="checkbox"/> Assure computer access <input type="checkbox"/> Cue and test web links <input type="checkbox"/> Plan vocabulary integration <input type="checkbox"/> For Activity 2 stations: If internet is available, use student handouts with embedded activity links with student personal devices or 2-4 shared devices with activity links bookmarked at each station. If internet is unavailable, print 2 copies of materials located in the MS Drought Resources Folder per station and show video links as a class. Set up 2 sets of large Post-It or large paper, sticky notes, and markers.
Vocabulary	<p><u>Natural hazards</u> are naturally occurring phenomenon such as drought, wildfire, extreme heat, or drought, which may disrupt or damage a community.</p> <p><u>Drought</u> is a prolonged drier-than-normal period in a natural climate cycle</p>

	<p>that results in water-related problems.</p> <p><u>GIS</u> is an abbreviation for <i>Geographic Information System</i>, which is a computer-based process that gathers, manages, analyzes, and visualizes spatial data.</p> <p><u>Precipitation</u> is any type of water that forms in the Earth's atmosphere and then drops onto the surface of the Earth (e.g., rain, snow, sleet or hail).</p> <p><u>Snow Water Equivalent (SWE)</u> is the amount of water contained in the snowpack at a location (if the entire snowpack were to melt).</p> <p><u>Water Year</u> is a 12-month period that runs from October 1 through September 30 each year.</p>
Instructional Strategies	<p><u>Mind mapping</u> (used in Activity 2): A creative way to “map out” students’ thoughts and ideas. Similar to a concept map, multiple formats can be used to develop students’ trains of thought, and make connections between main ideas or concepts.</p>

Activities	Web Links for Lesson Resources Note: all resources are downloaded as pdfs in the <i>Activity Resources Folder</i>
Activity 1	<ul style="list-style-type: none"> • Video: KOAA 5 News, Drought conditions in June 2018 similar to 2012-13 https://www.youtube.com/watch?v=7NERthvNN_I • Video: Assessing Drought in the United States https://www.youtube.com/watch?v=i7F6QwRqyVI
Activity 2	<p>Activity 2.1</p> <ul style="list-style-type: none"> • Text: Drought in America: Slow moving, far reaching https://www.noaa.gov/explainers/drought-in-america-slow-moving-far-reaching <p>Activity 2.2</p> <ul style="list-style-type: none"> • Video/Data Visualization: Drought Monitor Time Lapse Nov. 2011-Dec. 2012 https://www.youtube.com/watch?time_continue=36&v=O88n48q1za0 • Data Visualization: Drought History in Colorado Xxx need link • Data Visualization: Drought Data Snapshots https://www.climate.gov/maps-data/data-snapshots/usdroughtmonitor-weekly-ndmc-2019-05-07?theme=Drought <p>Activity 2.3</p> <ul style="list-style-type: none"> • Text (Map included): Dry Southwest still waiting on winter in January 2018 https://www.climate.gov/news-features/event-tracker/dry-southwest-still-waiting-winter-january-2018 • Text (Map included): Intense drought in the U.S. Southwest persisted throughout 2018, lingers into the new year https://www.climate.gov/USdrought2018 <p>Activity 2.4</p> <ul style="list-style-type: none"> • Video: To Escape Drought, Slow and Steady Wins the Race https://www.climate.gov/news-features/videos/video-escape-drought-slow-and-steady-wins-race • Text: Drought Ready https://www.ready.gov/drought
Activity 3	<ul style="list-style-type: none"> • Video: HEART Force Drought Expert https://drive.google.com/file/d/1UfHSt8dbFLKPqOk_fqWnaC_1NCAjOXvw/view

	<ul style="list-style-type: none"> • Data Visualization: CoCoRaHS Condition Monitoring Map https://www.cocorahs.org/Maps/conditionmonitoring/ • Text: Recent and Current Drought Conditions in Colorado Xxx need link • Website: Drought.gov Portal https://www.drought.gov/drought/ <p>Optional Resources:</p> <ul style="list-style-type: none"> • Text: Colorado Planning for Hazards - Drought https://www.planningforhazards.com/flood#dd-contents-410 • Website: Drought for Kids https://drought.unl.edu/Education/DroughtforKids.aspx
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Activity 1 (Engage)

Drought in Colorado (15 minutes)

Drought, wildfire, and weather: What's the connection in Colorado?

Think: What do you know about drought?

1. In one minute, jot down as much information as you know about droughts in the "What I Know" section of the KWL Chart in your *Drought Diary student handout*.

Responses vary.

First watch the [drought news clip](#) (2:43) to get a feel for the impacts of drought on people and the environment, and how drought conditions are mapped. Make mental notes about what you see and hear in the video.

Next, watch [Assessing Drought in the United States](#) to learn how scientists assess the causes and impacts of drought in our country, including Colorado.

Pair: Discuss your observations and wonderings about the drought videos with a partner.

2. Write down your observations and questions about drought as a natural hazard in the "What I Wonder" section of the KWL Chart in your *Drought Diary student handout*.

Responses vary.

Share: As a class, briefly discuss observations and wonderings about the drought videos. Individually answer the following questions about measuring drought in your *Drought Diary student handout*, and then share responses as a class.

3. List the four categories of drought, in order from the least to greatest level of drought, and their color coding.

DO=Abnormally Dry (yellow)**D1=Moderate Drought (light orange)****D2=Severe Drought (orange)****D3=Extreme Drought (red)****D4=Exceptional Drought (dark red)**

4. Which organization tracks the level of drought across our country?

The U.S. Drought Monitor

Activity 1 - Drought in Colorado (continued)

KWL Chart	
What I Know (Activity 1)	
What I Wonder (Activity 1)	
What I Learned (Activity 3)	

Activity 2 (Explore & Explain)Drought & Case Study Data Analysis (35 minutes)

Activity 2.1 What is drought, its causes, and impacts?

As a drought research team, use the [Drought in America: Slow moving, far reaching](#) website to build your knowledge about drought. Write responses to the following questions in your *Drought Diary student handout*.

5. What is drought?

Drought is when less than normal or no precipitation falls for an extended period of time (usually a season or longer), and results in a water shortage.

Additional details: Drought is caused by below-normal precipitation (rain and snow), leading to a shortage of water in the soil and in streams, rivers, and lakes. Unusual heat is often part of drought, since dry weather is associated with sunny and warm conditions. This heat makes the impacts of drought even worse. Drought is called a “creeping” hazard; its impacts emerge slowly compared to flooding or wildfire.

6. What are some causes and impacts of drought?

Changes in normal weather and precipitation patterns (e.g., El Nino/La Nina) can lead to drought, as can overuse of water resources by humans. In ecosystems, lack of water can affect animals and plants by reducing food supplies, increasing wildfire risk, and damaging habitats (e.g., decreased streamflow affects fish). Drought can affect the health and safety of people due to heat-related illnesses, and conflicts over water resources. Drought is one of the most expensive natural hazards due to the costs of crop failure, increased energy and water use, and infrastructure and human property losses from drought-related wildfires.

Additional details:

Drought vulnerability varies from place to place, depending on what drives the local economy. In general, cities with more diverse economies are less vulnerable than rural areas dependent on agriculture or outdoor tourism and recreation.

Water supplies for communities can be threatened by severe drought. Most communities have reservoirs to store surplus water and buffer the impacts of drought, but droughts lasting 2 years or longer may use up that buffer. Similarly,

Activity 2.1 (continued)

irrigated agriculture is vulnerable to drought. Many farmers don't have water stored in reservoirs, so they may have to stop irrigating crops during droughts.

Dryland agriculture and ranching are also at risk from drought. Additionally, outdoor recreation and tourism that relies on water is also impacted by drought (e.g., rafting, skiing, fishing, boating, swimming, etc.)

Activity 2.2 What were past droughts in Colorado like?

As a drought research team, build your understanding of the causes, effects, and historical impact of drought by watching the National Geographic [Droughts 101](#) clip (2:58):

Next, review the graph of [Drought History in Colorado](#) graph (scroll down the webpage and click the "Percent Area for Colorado" graph). In your *Drought Diary student handout*, record your observations about the drought trends and patterns that you notice in Colorado from 2000 to the present.

7. Which years did Colorado experience extreme drought (D3) and exceptional drought (D4)? Which specific timeframe had the greatest level of exceptional drought (D4)?
Colorado was in extreme and exceptional drought 2002-2004, 2006, 2011-2014, 2018-early 2019. July 2012 to July 2014 had the greatest amount of exceptional drought.
8. When Colorado is experiencing drought (D1-D4), especially intense drought (D3, D4) what percentage of the state is generally affected?
When Colorado is experiencing drought, a majority of the state is affected.

Then, explore the [Drought Data Snapshots](#) interactive to compare and contrast the 2012 drought in Colorado.

Using the adjustable timeline located below the map screen, move the "Year" tab over two marks to the right to select 2012, and slide the "Day" tab from the far left (January) to the far right (December) to observe changes in the map data (spatial data) over the year.

9. During 2012:
 - Which month and what general location in Colorado first experienced extreme drought (red)?

Activity 2.2 (continued)

- Which month and what general location in the state was first affected by exceptional drought (dark red)?
- Which month of 2012 was the severity and expanse of drought the greatest in Colorado, and what was the primary level of drought?
- Describe the level of drought in Colorado at the end of December 2012.

Colorado first experience extreme drought in May 2012 and it was located in northwest Colorado.

Exceptional drought first affected the state in July 2012 in the northwest and southeast areas of the state.

In July 2012, all of Colorado was experiencing the greatest severity and expanse of drought. Most of the state was in extreme drought status and the remaining areas were in severe drought.

At the end of 2012, the entire state of Colorado was in drought (moderate to exceptional drought).

Activity 2.3 What is the story of the 2018 American Southwest Drought and its severity in Colorado?

The American Southwest is defined as New Mexico, Colorado, Utah, Nevada, Southern California, and Arizona. Review the maps of the 2018 southwest drought; first the map from the start of the year and then at the map at the end of the year:

- [Dry Southwest still waiting on winter in January 2018](#) (start of 2018)
- [Intense drought in the U.S. Southwest persisted throughout 2018, lingers into the new year](#) (end of 2018)

Now read a short article from the Denver Post from May 2019:

- [Finally! Colorado's drought is nearly officially over](#)

Next, answer the following questions about drought in Colorado in your *Drought Diary student handout*.

10. What were the drought categories throughout Colorado at the start of 2018? Which areas of the state had the greatest drought level, and which areas had the lowest? Describe the overall drought conditions at this time. Note that the dates for each map are in the bottom left corner of the animation.

Activity 2.3 (continued)

The drought categories in Colorado at the start of 2018 included abnormally dry (eastern, northwest corner, partial central area) moderate drought (western and southwestern area), and severe drought (southwest corner). A majority of the state was drier than normal and western, southwestern, and southern parts of the state were in drought at the start of 2018.

11. What were the drought categories throughout Colorado at the end of 2018? Which areas of the state had the greatest drought level, and which areas had the lowest? Describe the overall drought conditions at this time.

The drought categories in Colorado at the end of 2018 included abnormally dry (northeast and southeast areas), moderate drought (small portions of north central and southeast areas), severe drought (northwest and southeast areas), extreme drought (west and south central areas), and exceptional drought (southwest corner). A majority of the state was in drought and the level of drought was much greater at the end of 2018 than the start of the year.

12. Explain how snowpack levels affect the potential for drought in Colorado.

Colorado's weather is impacted by El Nino and La Nina (climate phenomena), which affect precipitation. If the snowpack is low in the mountains then there is less water runoff and water availability, which affects downstream users and ecosystems and increases the drought risk. In Colorado, melting snow makes up most of the water supply, and severe droughts often begin with "snow drought" due to dry and warm conditions in the winter months.

Additional information: In recent years, Colorado has experienced warmer temperatures (due to climate change), which tends to make drought worse when we do have a dry year (below-normal precipitation). Climate change may also change our precipitation patterns, which could also worsen drought in the future.

Activity 2.4 Drought Preparation & Response How can our community prepare for and respond to drought?

Drought is described as a slow moving and long-term natural hazard, which is a different experience from fast-acting and shorter duration natural hazards, such as floods, wildfires, earthquakes. How does this difference affect how people are able to prepare for, respond to, and rebound from drought?

Activity 2.4 (continued)

With your drought research team, watch the video [To Escape Drought, Slow and Steady Wins the Race](#).

Then, review the [Drought Ready.gov](#) webpage. In your *Drought Diary student handout*, write down key tips for your community to manage drought.

12. What are ways that your family and community can do to conserve water during a drought?

Take shorter showers, turn off the water while brushing teeth or shaving, wash full loads of laundry or adjust the water level for the size of load, use dishwashers only when fully loaded or wash dishes by hand and rinse in a filled basin not with running water, water lawns less and in the morning or evening hours (or not at all), catch and reuse any water from sinks and showers for watering plants, repair any indoor or outdoor plumbing and sprinkler leaks, etc.

13. Drought increases the risk of wildfire due to vegetation drying out and dying. What are some fire prevention actions you and your family can take during a drought?

Do not use fireworks, completely put out campfires and fire pits, properly dispose of cigarettes, and follow any fire ban and/or water use restrictions, etc.

Activity 2.5 Class Mind Mapping Session

Have a 10-min [mind mapping](#) session or consensus discussion session about your findings and learning from the activity sections. Start the class mind map with “Drought” labeled in the center of a large Post-It, large paper, or shared digital document.

As a class, briefly share findings for Activities 2.1 through 2.4 to check and correct your responses, as needed, and add key information to the drought mind map.

Ensure the share-out sessions for each station are focused and concise. Ask if there are any questions before reiterating the key learning points from each station activity. Then, move to the next station share-out. Collect students’ *Drought Diary student handouts* and/or have them digitally share their copy with you. Student handouts will be used for Activity 3, and it is important students have complete and correct responses to communicate information.

Activity 2.5 (continued)

Suggested discussion questions:

- What are key factors about the causes and impacts of drought?
- Which locations and what time of year do most droughts occur in Colorado?
- How should people prepare for and respond to be safe in the event of a drought?

Activity 3 (Elaborate)**Drought Public Information Notification (50 minutes)**

How can communities know about and manage their drought risk in Colorado?

In this activity, your goal as part of a hazard expert team is to raise community awareness educate people in your community about drought as a natural hazard that has, is, or will potentially impact your area. To support this work, your team will watch a video interview with a drought expert, and use two drought Geographic Information System (GIS) web portals.

Using information from the Activity 3 drought expert video and GIS portals, plus data recorded in your *Drought Diary student handouts* and screen shots from Activities 1 and 2, your hazard expert team will create a *Local Drought News Story* in a format of your team's choice that includes the following four elements:

- Causes and impacts of drought
- Highlights of the 2012 and 2018 Colorado droughts
- Recent and current drought conditions around Colorado and in their community
- Tips for people in preparing and responding to drought

Activity 3.1 Drought Expert Interview (5 min)

First, watch the short video with Doug Kluck who is the NOAA Regional Climate Services Director for the Central Region of the country. Doug talks about many of the drought concepts that you learned in the previous activities, and that you will present about in this activity:

[Drought Expert Video](#)

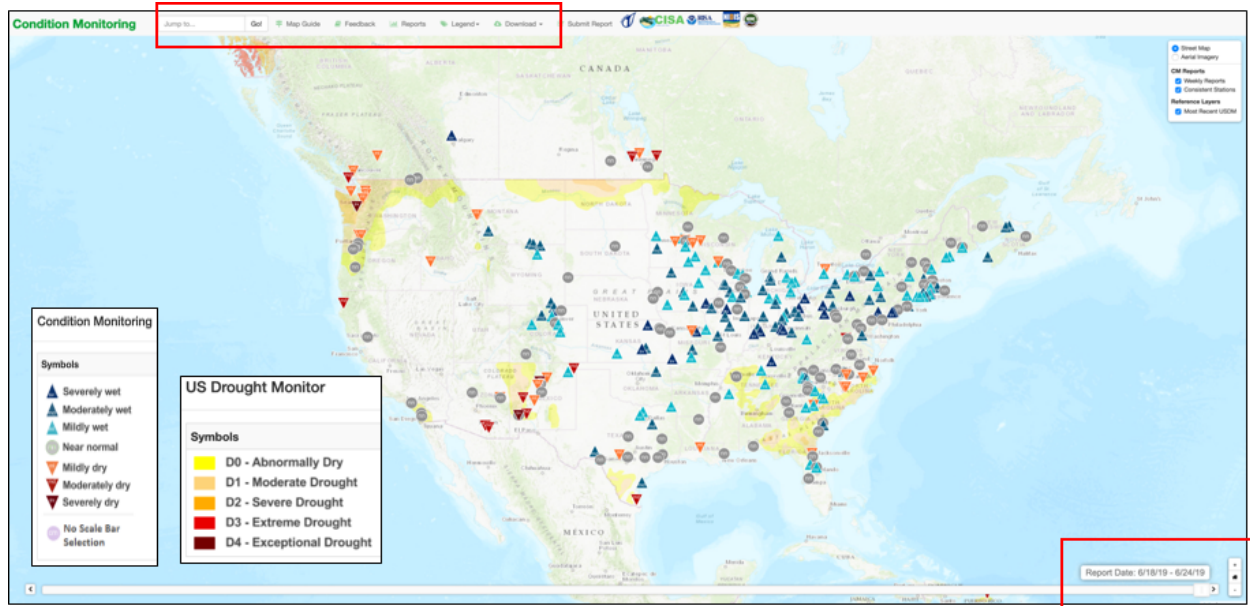
**Activity 3.2 Drought GIS Websites (20 min)**

Explore the 2018 drought conditions in Colorado with the [CoCoRaHS Condition Monitoring Map](#), which shows the U.S. Drought Monitoring conditions from the present day back to October 2016. This GIS website also has the option to display on-the-ground reports made each week by CoCoRaHS volunteer citizen scientist observers.

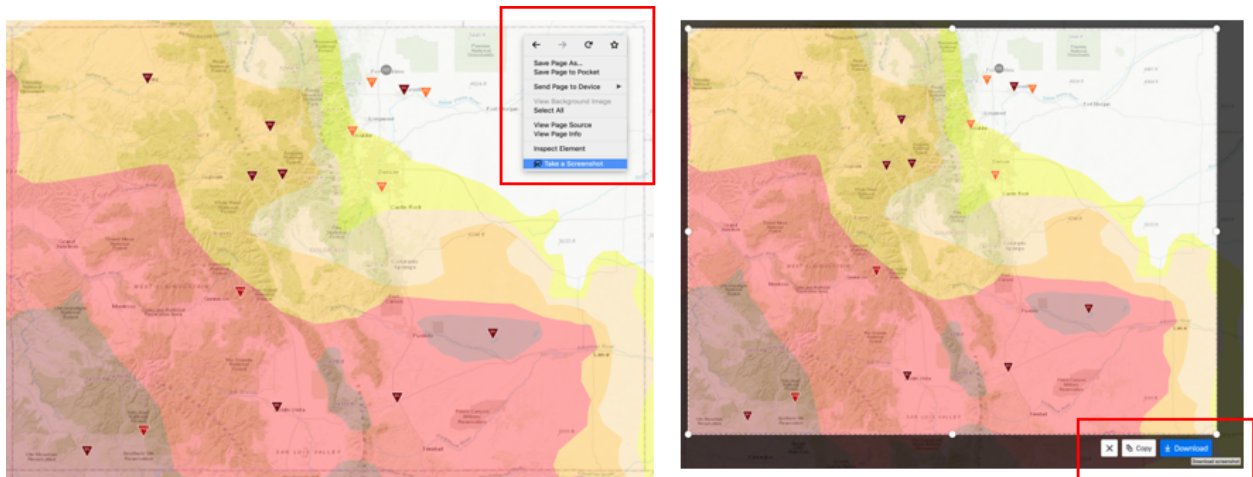
Activity 3.2 (continued)

In the lower right, use the “+” symbol to zoom in on the map, the “-” symbol to zoom out, and the home icon to return to the default map view screen. Use the timescale slider at the bottom of the screen to change the date of the maps, which you are viewing.

There is an [online GIS web interface tutorial](#). In the top menu bar, click “Legend” for both the Conditions Monitoring Report icons and the U.S. Drought Monitor colors:

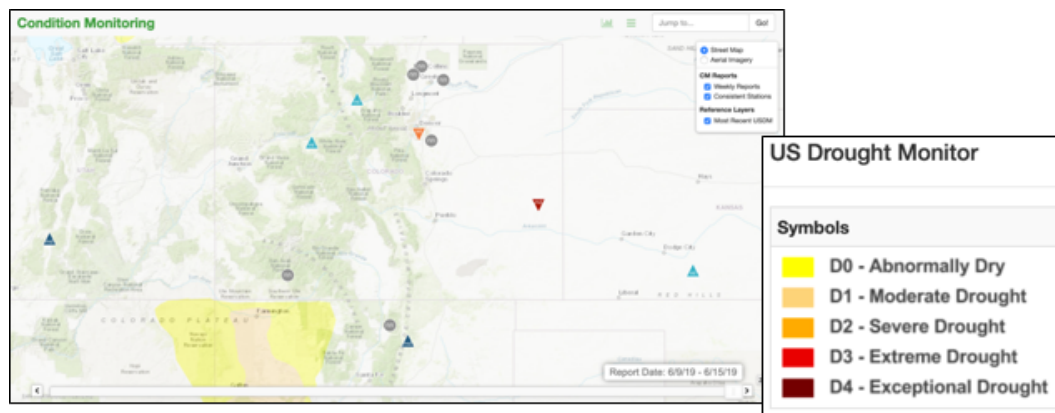


Your team will be taking and saving a series of screenshots using this GIS website. Right click on the mouse and select “Take a Screenshot” option (if needed, become familiar with how to do this task depending on the technology that you are using). Then, select the download option to save the screenshot.



Your team task: Use the Condition Monitoring Map Students to explore the evolution of local impacts in Colorado during the 2018 drought.

1. From the homepage, click the “+” symbol to zoom in and use the mouse to drag the map and center Colorado in the screen.



2. Use the date slider at the bottom of the screen to change the weekly date view of the drought monitor image and reports.
 - a. Move the slider on the bottom of the screen to the week of 12/19/17-12/25/17 (the week of the winter solstice), and take a screenshot image of Colorado drought conditions at this time, and scroll through the observer reports to the left of the GIS map. What do you notice about the drought level around the state?

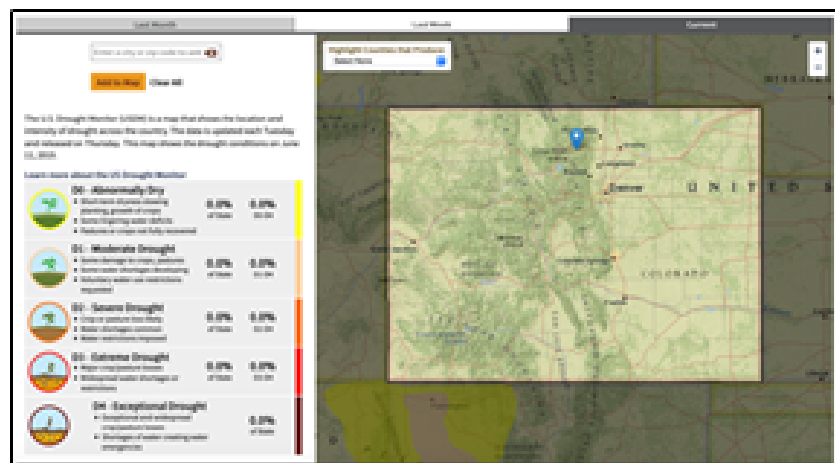
Activity 3.2 (continued)

- b. Now move the “>” arrow symbols to the right of the slider to advance to following weeks. You may have to wait a moment for the drought data to load as you advance. Skim through some observer reports. What do you notice about the pattern of drought in Colorado during the winter of 2018? Take a screen shot the week of 3/20/18 (the week of the spring equinox).
 - c. Continue advancing each week through 2018 in Colorado using the “>” on next to the slider, and reading some observer reports. How is the level and location of drought changing during the spring? Take a screen shot the week of 6/19/18 (the week of the summer solstice).
 - d. Keep advancing weekly during the summer of 2018 using the “>” button. What changes do you observe in the drought level in Colorado, and what are the observers reporting during the summer? Take a screen shot the week of 9/18/18 (the week of the autumn equinox).
 - e. Finish observing the final weeks of 2018 and reading some observer reports. Are there any changes in the level and location of drought in Colorado during the fall and at the start of winter? Take a final screen shot approximately one year later at the end of 2018 the week of 12/25/18.
3. Now, with your team, analyze the [Recent and Current Drought Conditions in Colorado](#) GIS map. Complete the following tasks, and save the requested screen shots.
 - a. First check the current drought conditions in your community and around Colorado. Using the [Drought.gov](#) web portal, enter the zip code for your community or the city name, and click the orange “Get Conditions” tab. Take a screen shot of the “How is Drought Affecting you Neighborhood” text box. If the map shows any shade of orange or red, your community is currently experiencing drought conditions. If the map shows yellow, your community has abnormally dry conditions. If the map does not display any color, your community is not very dry or in drought.

Activity 3.2 (continued)

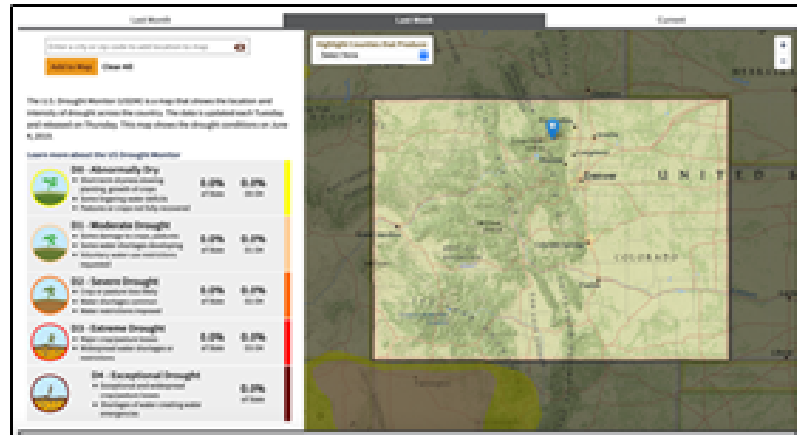
Click on the brown “Colorado Conditions” box, located in the bottom right corner of the “How is Drought Affecting you Neighborhood” text box, to see drought conditions around the state.

- b. The screen displays the current status of drought in Colorado. Take a screenshot of the current drought conditions for Colorado. Are there currently drought conditions in the state?

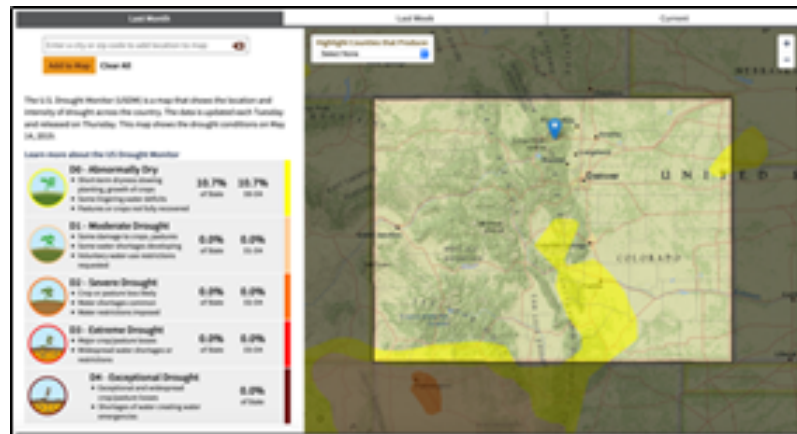


Activity 3.2 (continued)

- c. Click on the “Last Week” tab at the top center, and take a screen shot of the drought conditions for the state over the past seven days.



- d. Click on the “Last Month” tab at the top left, and take a screenshot of the recent past drought conditions for the state.



Activity 3.3 Drought Public Information Notification (25 min)

Using information from the drought expert video (3.1), GIS data and screen shots (3.2) and information gathered in your *Student Drought Diary student handout*, your team will now create a concise Drought Public Information Notification for your community that summarizes and communicates key facts and information about:

- Causes and impacts of drought
- Highlights of the 2012 and 2018 Colorado droughts
- Recent and current drought conditions around Colorado and in your community
- Tips for people in preparing and responding to drought

The format choices for the Drought Public Information Notification include:

- Poster (approx. 2' x 3' digital or hard copy)
- Slideshow (8-12 slides)
- Tri-fold leaflet (8.5" x 11" digital or hard copy)
- Radio story (; 2-3 min in length)
- Video (2-3 min in length)

Follow the steps in the table below to create your Drought Pubic Information Notification. Be creative, but accurate.

Additional drought resources can be found here:

[Colorado Planning for Hazards—Drought](#)
[Drought for Kids](#)

Drought Public Information Notification	
<p>KWL Chart: "What I Learned" (see Activity 1)</p> <p><input type="checkbox"/> Check when completed</p>	<p>As a group, reflect on what was learned in Activities 1, 2, and 3. Then independently complete the "What I Learned" section of your KWL Chart (see Activity 1) to summarize your learning. Use these prompts to reflect on what you learned:</p> <ul style="list-style-type: none"> • What important things do you now know about drought that you didn't know before? • What should people do to be "drought wise" before, during, and after a drought?

<p>Choose a Format</p> <p><input type="checkbox"/> Check when completed</p>	<p>As a team, choose one of the following formats for your group's <i>Drought Public Information Notification</i>:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Poster (approx. 2' x 3' digital or hard copy) <input type="checkbox"/> Slide product (8-12 slides) <input type="checkbox"/> Tri-fold leaflet (8.5" x 11" digital or hard copy) <input type="checkbox"/> Audio PSA (public service announcement; 2-3 min in length) <input type="checkbox"/> Video (2-3 min in length)
<p>Create a Draft</p> <p><input type="checkbox"/> Check when completed</p>	<p>Referring to notes and responses in your <i>Drought Diary student handout</i>, make a quick draft of your group's ideas. Your team's notification should summarize and share information about:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Causes and impacts of drought in Colorado <input type="checkbox"/> Locations and times of higher drought risk in Colorado <input type="checkbox"/> Describe how people and communities prepare for, respond to, and rebound from drought
<p>Create Final Product</p> <p><input type="checkbox"/> Check when completed</p>	<p>Create your team's Drought Public Information Notification. Remember to keep your notification brief and summarize these key elements for your community audience:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Causes and impacts of drought <input type="checkbox"/> Highlights of the 2012 and 2018 Colorado droughts <input type="checkbox"/> Recent and current drought conditions around Colorado and in your community <input type="checkbox"/> Tips for people in preparing and responding to drought
<p>Lesson Rubric</p>	<p>Refer to the rubric to help you assess Activity 3.</p>

If there is extra time, participate in a [class gallery walk](#) where your team shares what they have learned about how people and communities prepare for, respond to, and rebound from drought.

Presentations will vary; may be assigned as homework, if needed.

Post presentations in the classroom and/or online for hosting the class gallery walk.