Measuring Fires
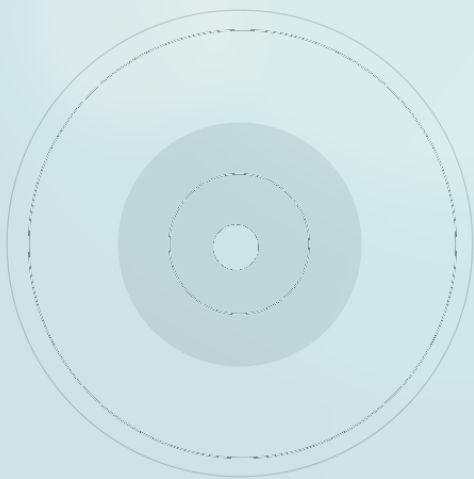
Lesson Overview

For nearly 50 years, eight generations of Landsat satellites have been imaging the earth. These satellites provide valuable data for decision makers overseeing agriculture, cartography, geology, forestry, regional planning, surveillance, and education. Every location on the planet has its picture retaken every 16 days.

These satellites use combinations of red, green, and blue— the visible colors within the electromagnetic spectrum— to collect information the naked eye often can't see. In this lesson, you'll use those colors to collect information and assess damage from the 2016 Soberanes Fire, which burned more than 132,000 acres in California's Los Padres National Forest. That blaze took three months to contain and $260 million to suppress. You'll also assess a 2015 wildfire in Australia's Gibson Desert that left a peculiar-looking, 10-kilometer scar, which has been compared to many objects (including a perched parrot). You'll also examine a 2016 fire on the Portuguese island of Madeira. You'll use Landsat's pre- and post-fire imagery to assess the damage in those areas.

Build Skills in These Areas

➢ Creating maps from scratch

➢ Filtering data

➢ Using geospatial tools to assess burned areas

Software Requirements

➢ ArcGIS Online account (obtain a free ArcGIS Public Account or ArcGIS trial)

Estimated Time

➢ 30 minutes – 1 hour

Exercise

Modern imagery began with World War I when pilots could take pictures from biplanes. It evolved into the science we know today after the first Landsat satellite was launched on July 23, 1972. The topics addressed in this lesson are detailed in The ArcGIS Imagery Book.

## Step 1: The Soberanes Fire in Monterey County, California

The Soberanes Fire, blamed on an illegal campfire, started on July 22, 2016, and consumed more than 132,000 acres before it was extinguished on Oct. 12 of that year.

Locate the fire

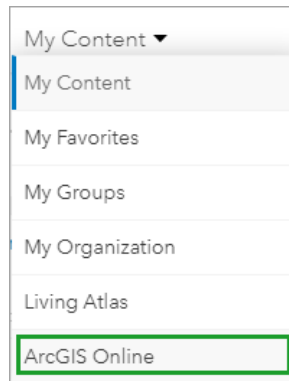1. Sign in to your ArcGIS online organizational account.
2. On the ribbon, click **Map**.
3. In the search box, type **Los Padres National Forest** and press *Enter*.
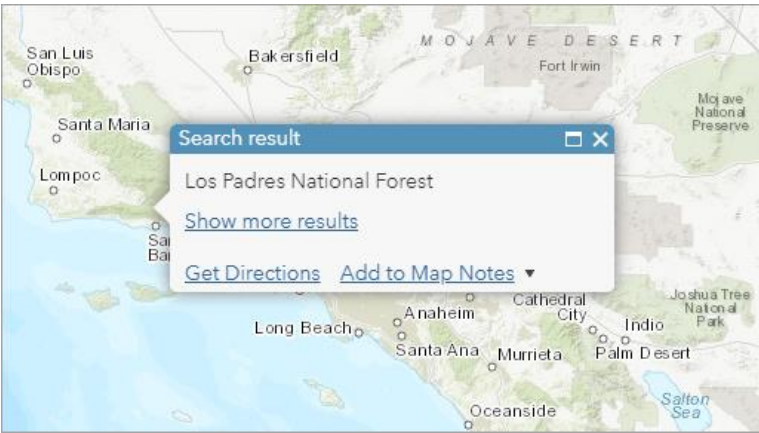
4. Close the **Search result** pop-up.
5. On the ribbon, click **Content**.
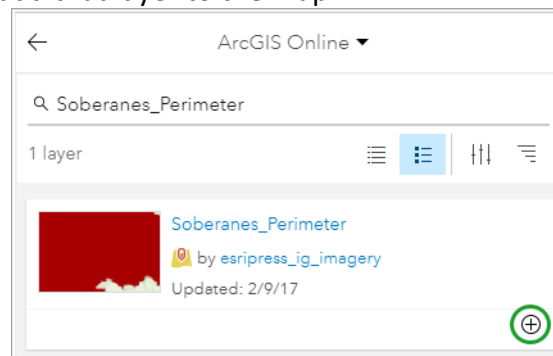6. On the ribbon, click **Add** and select **Search for Layers**.
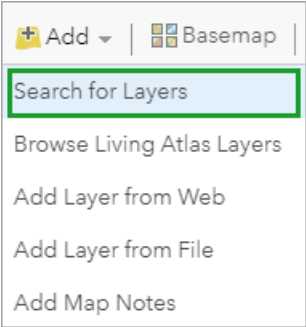
7. In the pane, click the drop-down arrow and select **ArcGIS Online**.

8. In the text box, type **Soberanes_Perimeter** and press *Enter*.
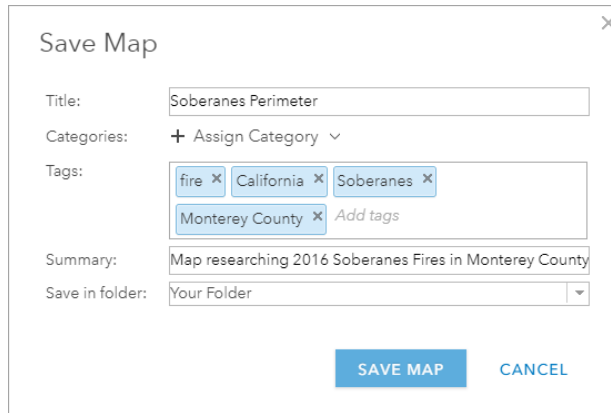9. Click the **Add** button to add that layer to the map.

The map zooms in to Los Padres National Forest in Central California, where a layer showing the fire area is imposed on your map.

10. On the ribbon, click **Save** and **Save As**.
11. In the **Save Map** window, do the following:
    - For **Title**, type **Soberanes Perimeter.**
    - For **Tags**, type **fire**, **California**, **Soberane**, and **Monterey County** (press *Enter* after each tag).
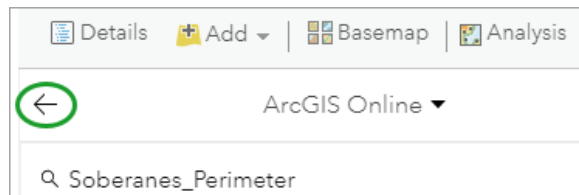   - For **Summary**, type **Map researching 2016 Soberanes Fires in Monterey County, California.**
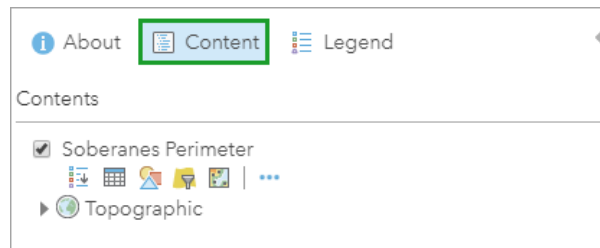   - Save in your folder.

- Click **Save Map**.

The map is saved to My Content.

12. Click the **Back** button.

13. If necessary, click **Content**.

14. Save the map.

Q1. Click the link to Landsat satellites. When was the latest satellite, Landsat 8, launched?

A1. _____

Q2. Click the first chapter in The ArcGIS Imagery Book called Imagery is Visible Intelligence. During World War II, Allied pilots took photographs of German V2 rocket systems targeting Great Britain. The resulting 3D aerial photographs enabled the Allies to identify precise locations of those V2 rockets. What was the name of the operation identifying and locating those rockets?

A2. _____

Q3. Click the Soberanes Fire story map and scroll to its conclusion. How do fire managers benefit from maps showing burn severity?

A3. _____

Landsat imagery before and after the fire

The Landsat satellite retakes images of each location on earth every 16 days. This repetition creates an opportunity for you to download before and after images of terrain-altering events such as wildfires. The Soberanes Fire started on July 22, 2016, and lasted through October 12, 2016. Here, you will create layers showing the area before and after the fire.

1. Click **Add** and select **Search for Layers**.
2. Click the drop-down arrow and select **ArcGIS Online**.
3. In the search box, delete any text and type **Landsat 8 Views**.
4. Click the **Add** button.
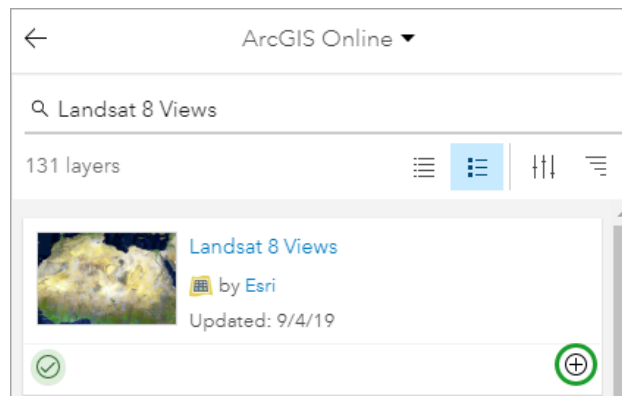
5. Click the **Back** button.

Now, you'll filter the layer to show Landsat images before and after the fire. You'll use the Filter tool on the Landsat 8 Views layer you just downloaded.
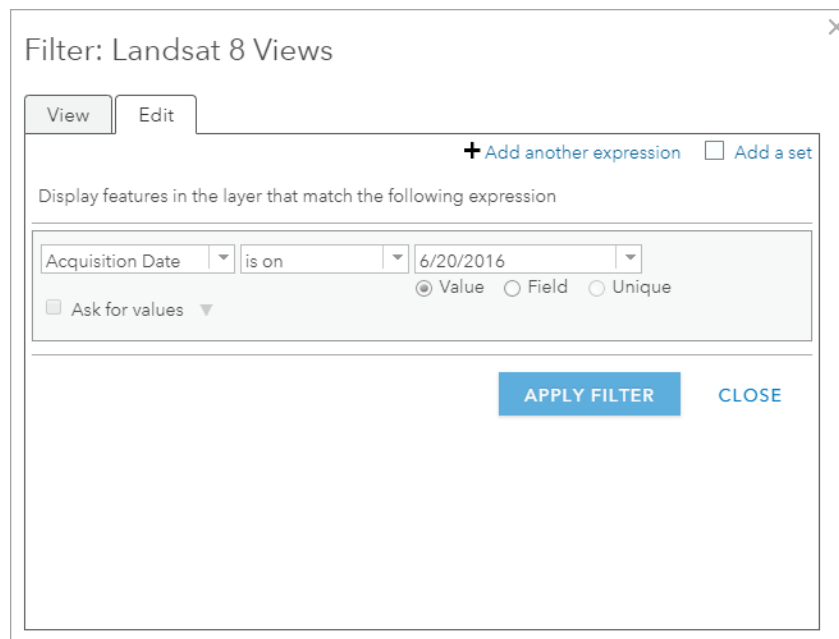
6. On the **Landsat 8 Views** layer, click the **Filter** button.
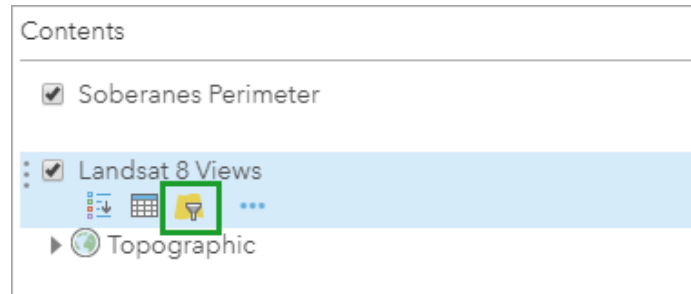
Here, and with the help of the drop-down boxes, you'll create the expression, **Acquisition Date is on 06/20/2016**.

In the **Filter: Landsat 8 Views** window, do the following:

- Click the **Edit** tab.
- In the first box, click the drop-down arrow and select **Acquisition Date**.
- Verify the middle box is set to **is on**.
- In the third box, click the drop-down and, in the calendar, set the date and year to **06/20/2016**.
- On the second expression box, click the red X to delete the expression.


- Click **Apply Filter**.

Landsat uses a mixture of red, blue, and green.

7. In **Contents**, click the **Landsat 8 Views** to expose the layer's colors.

The default display for Landsat is Agriculture with DRA, or Dynamic Range Adjustment, which stretches the pixels within your display to create sharper images. Here, you see bright greens, which represent healthy vegetation, and dull greens, which represents stressed vegetation.

You've seen how green helps you understand the landscape. Now, you'll look at how red can help you understand it even more.

8. Close the legend by clicking the **Hide Legend** button.
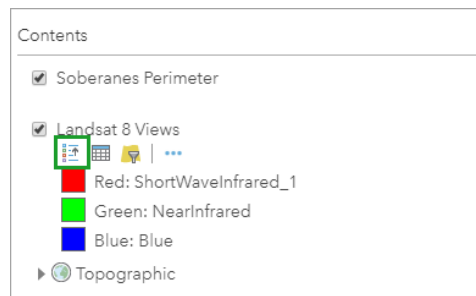
9. In **Contents**, point to the **Landsat 8 Views** layer. Select **More Options** and go to **Image Display**.
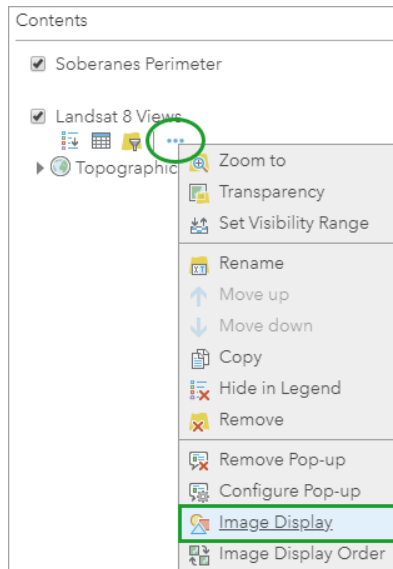
10. In the **Image Display** pane, do the following:

- For **Renderer**, select **Color Infrared with DRA**.
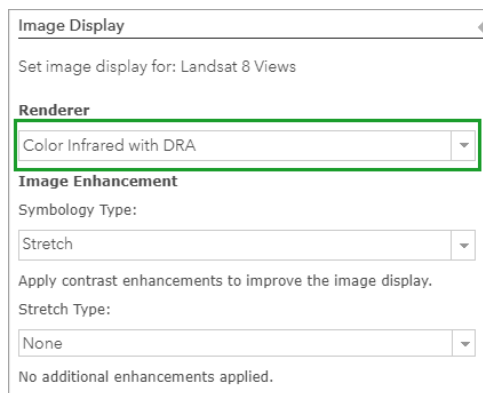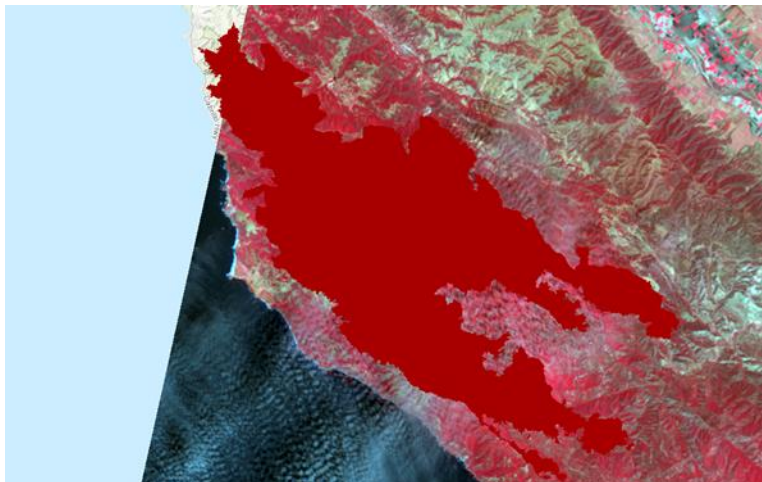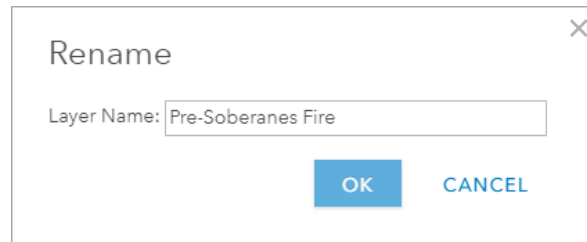

- Click **Apply**.

In this display, healthy vegetation is bright red while stressed vegetation is a dull red.

11. In the **Renderer** box, select **Agriculture with DRA** (its original setting) and click **Apply** and **Close**.

12. On the **Landsat 8 Views** layer, click **More Options** and select **Rename**.

13. In the **Rename** window, delete the text and type <u>**Pre-Soberanes Fire**</u> and click **OK**.

14. On the ribbon, click **Add** and select **Search for Layers**.

15. If necessary, type <u>**Landsat 8 Views**</u> and verify that the search is set to **ArcGIS Online**. Press *Enter*.

16. Add the **Landsat 8 Views** layer, click the **Back** button to return to **Contents**, and rename the layer by typing <u>**Post-Soberanes Fire**</u>.
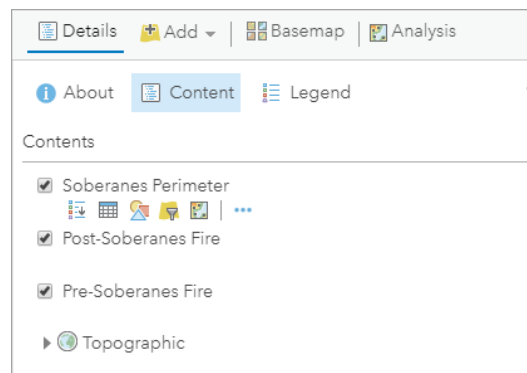
17. Point to the **Post-Soberanes Fire** layer and select **Filter**.

18. Click the **Edit** tab.

19. In the **Filter: Post-Soberanes Fire** window, change the expression to read the following:

   - **"Acquisition Date is on 10/17/2016"**.

   - Delete the second expression box.

   - Click **Apply Filter**.

Now, with your data assembled, you're in position to learn more about the fire by contrasting the three layers in your map. You can do this by adjusting a layer's transparency or checking a layer on or off.

20. Point to the **Soberanes Perimeter** layer and click **More Options**. Point to **Transparency** and move the **Layer Transparency Slider** to **75%**.
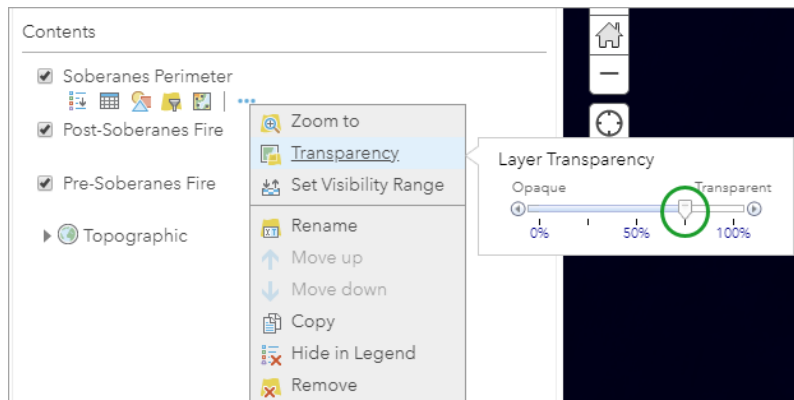
The transparent Soberanes Perimeter layer casts a shadow over the Post-Soberanes Fire layer.

21. Uncheck the **Post-Soberanes Fire** layer.
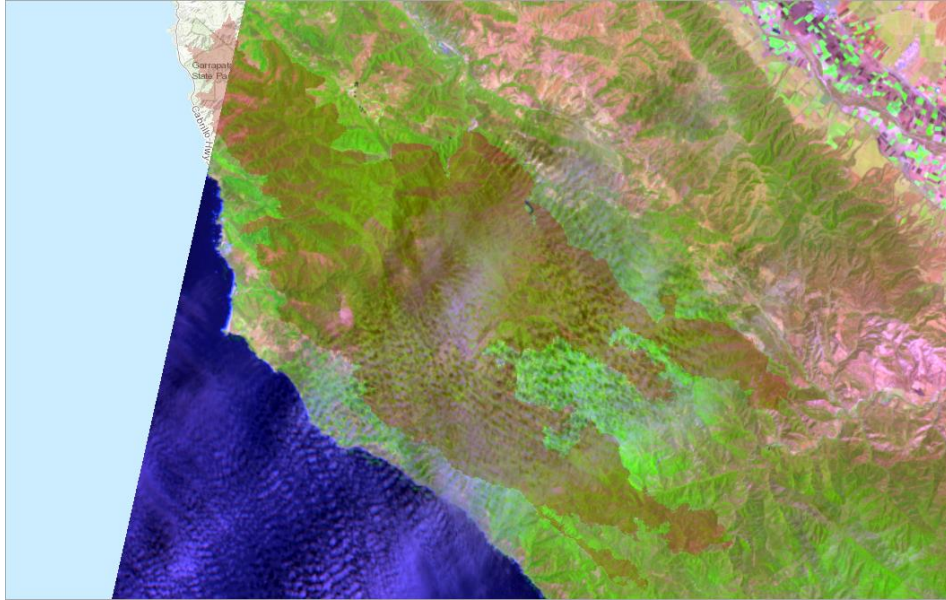
22. Uncheck and check the **Soberanes Perimeter** layer.

Q4. In your opinion, was the Pre-Soberanes Fire layer a good indicator of where the fires would inflict damage?

A4. _____

23. When complete, check on all layers and, in the **Soberanes Perimeter** layer, move the **Layer Transparency** slider to **0%**.

24. Save the map.

Determine the fire area

You can use the map to determine the size of the fire.

1. On the ribbon, click the **Measure Area and Distance** button and select **Area** and **Acres**.

2. To measure the fire, click the map once for every vertex you want to measure. When you return to your initial point, double-click.
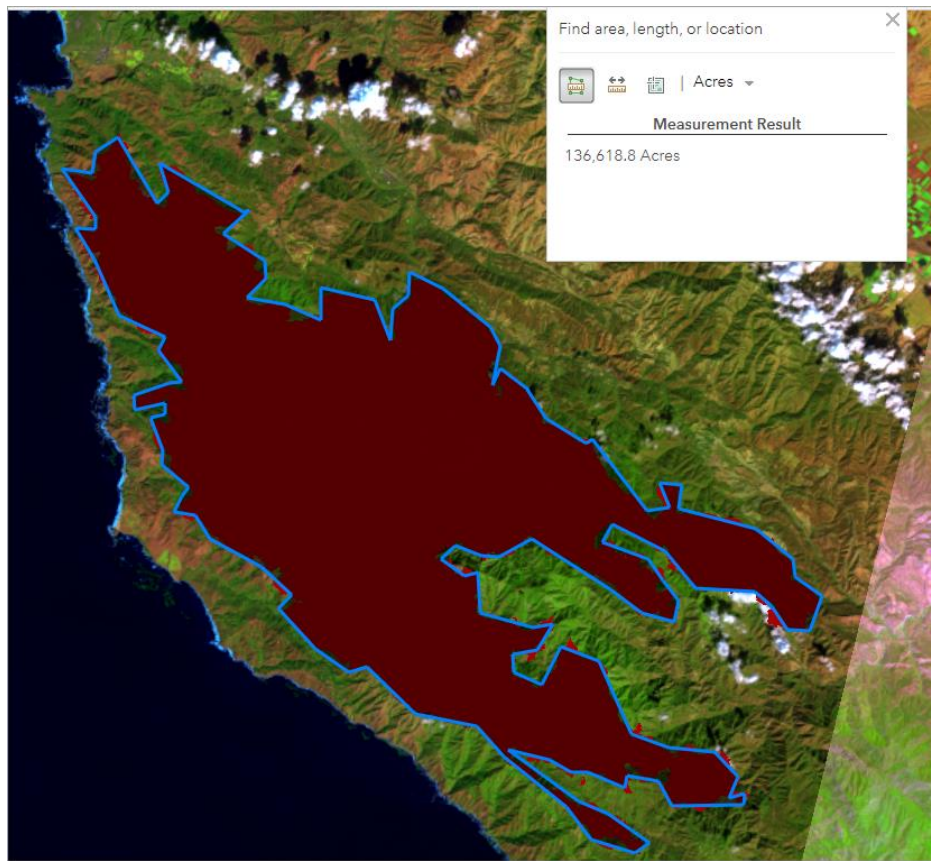
As mentioned, more than 132,000 acres burned.
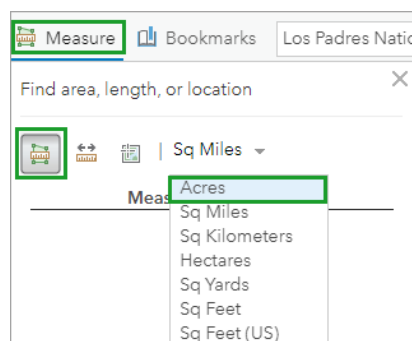
Q5. How many acres did you measure?

A5. _____

3. Close the **Measure** box and save the map.

Calculate the burn index to show severity

The Normalized Burn Ratio (NBR) calculates the severity of the burn. Low-end numbers, such as .1, indicate unburned areas while numbers .66 and greater point to a severely burned area.

1. Click the **Post-Soberanes Fire** layer and select **Image Display**.
2. For **Renderer**, select **NBR Raw**.
3. Click **Apply** and **Close**.
4. Uncheck the **Soberanes Perimeter** layer.

You can see the burned areas in the map. By calculating the NBR, you can see the range of the damage.
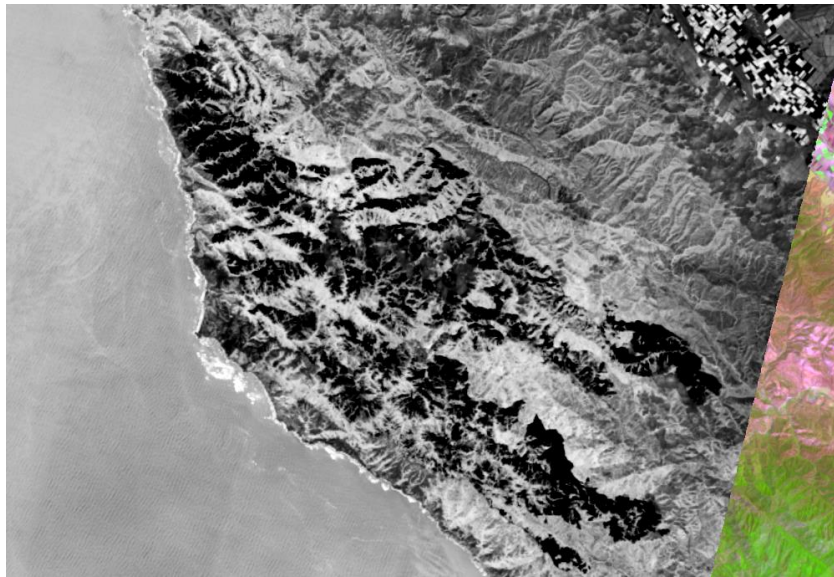
5. Click the **Post-Soberanes Fire** layer.
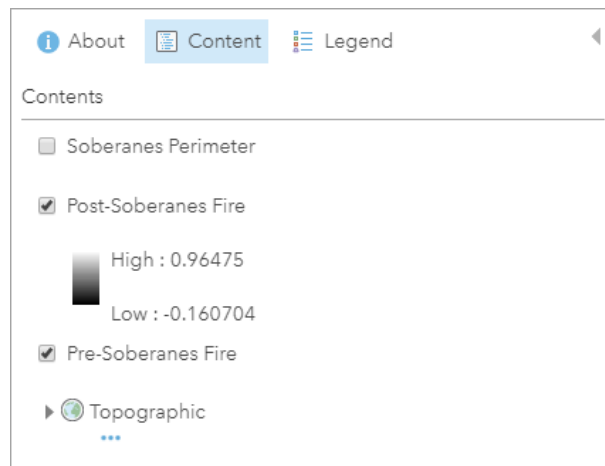
The burn index is calculated and added to your legend.

6. Check the **Soberanes Perimeter** layer.
7. Save the map.

In this step, you analyed the Soberanes Fire by comparing before and after images, measuring the fire area, and calculating the burn severity.

Step 2: Western Australia's Gibson Desert Fire

The grasslands of the Gibson Desert cover a vast area of Western Australia. The area is characterized by thin desert grass and red sand dunes. These grass fires char the landscape and leave scars visible from space. On Nov. 19, 2015, Landsat 8 recorded an image of a peculiar-looking burn scar—it has been compared with an impressionist painting, a perching bird, and a swimming whale—resulting from a recent desert fire.

Using the workflow from the Soberanes Fire, you'll examine the Gibson Desert Fire before and after the image of the interesting scar was captured from Landsat 8. In this step, the instructions are written in a more general style, so you'll be forced to recall the process; if necessary, scroll up for a refresher.

Locate the fire

1. Create a map.
2. Change the Basemap to Imagery.

Instead of typing the name of the Gibson Desert, you'll type in its longitude and latitude.

3. In the search box, type **127.859769, -23.284888** (include the comma, space, and minus).
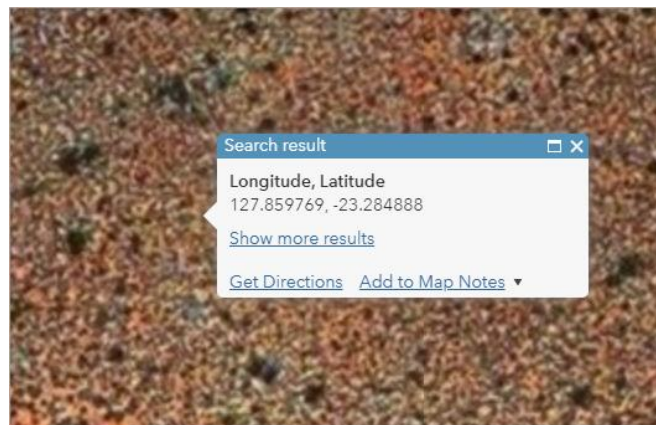
4. Click **Add to Map Notes**.
5. Click the blue marker.
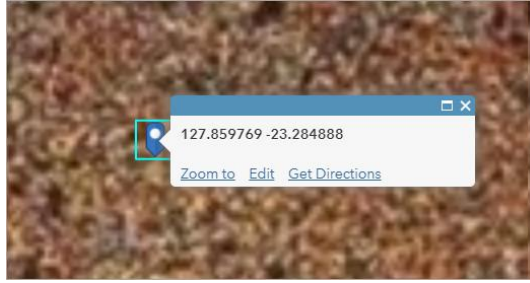
When creating a Map Note, your information stays in the map as well as in Contents.

6. Close the pop-up.

Landsat imagery before and after the fire

Here, you'll replicate the workflow you used to analyze the Soberanes Fire; only the data you enter will be different.

1. Add the Landsat 8 Views to your new map and zoom out so you can see the entire image.

2. Filter the **Landsat 8 Views** layer and set the pre-fire images to **Acquisition Date 10/17/2015**.

3. Rename the feature service by typing **Pre-Gibson Desert Fire**.
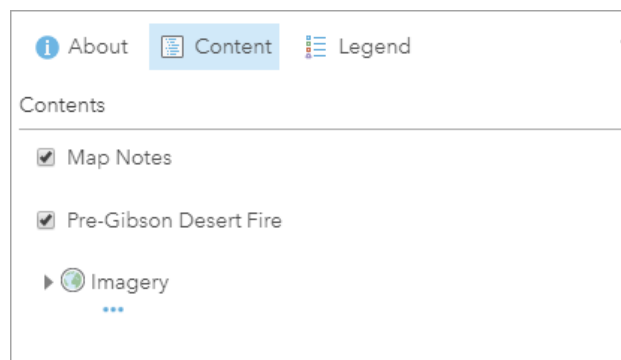
4. Add the **Landsat 8 Views** feature service again.

5. Filter the **Landsat 8 Views** and set the acquisition date to **09/01/2016**.

6. Rename the layer **Post-Gibson Desert Fire**.

7. On the **Post-Gibson Desert Fire** layer, change the **Image Display** to **Natural Color with DRA**.

8. In **Contents**, uncheck the **Post-Gibson Desert Fire** layer and compare the damage with the **Pre-Gibson Desert Fire** layer.

Q6. What's your impression of the peculiar-looking scar?

A6. _____

9. Check the **Post-Gibson Desert Fire** layer.

Determine the fire area

Here, you'll measure the burned areas.

1. Use the Measure tool to determine the size of the image. As before, you'll calculate acres.

Q7. How many acres was your measurement?

A7. _____

    2. Close the Measure tool and delete the polygon measuring the burned area.

Calculate the burn index to show severity

As before, you'll calculate the Normalized Burned Ratio (NBR) to estimate the severity of the burned area.

    1. Use the **Post-Gibson Desert Fire** layer to calculate the **NBR**. (In the **Image Display** tool, for the **Renderer**, you'll select **NBR Raw**.)

The renderer will take several moments to run.

The image is too dark to be helpful. By changing the Stretch Type in the Image Display, you'll create the contrasts needed to better understand the image.

2. On that same layer, rerun the **Image Display** tool; only this time, for **Stretch Type**, change **None** to **Standard Deviation**. (The tool may take serveral moments to run.)
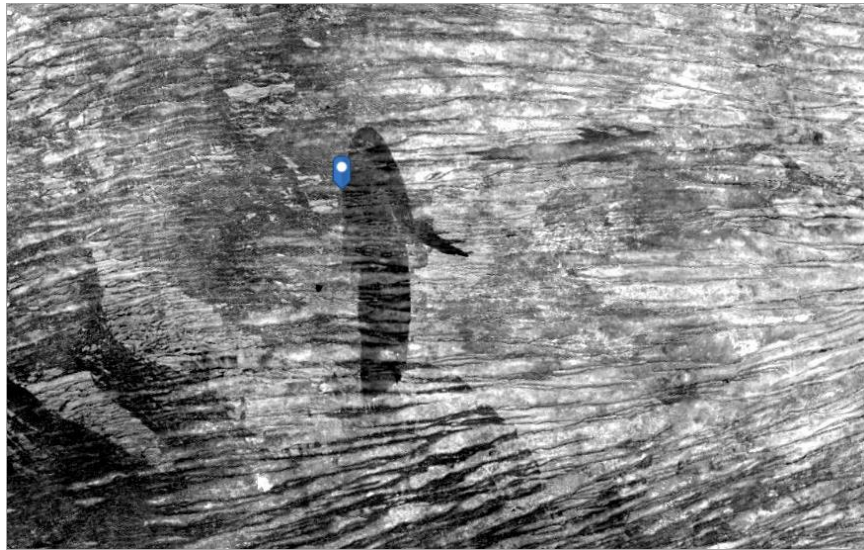
3. Save the map and add appropriate metadata.

Q8. What can you infer from the image with the Standard Deviation?

A8. _____

Step 3: The fires on the island of Madeira, Portugal

In August 2016, a series of wildfires struck Portugal's Madeira archipelago, a popular Atlantic Ocean tourist destination nearly 400 miles northeast of Morocco and 600 miles southwest of the Portuguese capital of Lisbon. According to The New York Times, the fires did reach Funchal, Madeira's capital, where it killed three people and destroyed more than 150 homes.

In this section, you'll adapt the workflow from the Soberanes and Gibson Desert scenarios and apply them to the Madeira fires.

Locate the fire

In this step, you'll replicate the workflow from the previous two steps. Only the data will differ.

1. Create a map.
2. Change the basemap to **Imagery with Labels**.
3. In the search box, locate Madeira, Portugal, and zoom in until the island fills your screen.

4. Close the pop-up.

Landsat imagery before and after the fire

Here, you'll replicate the steps you used to analyze the Soberanes and Gibson Desert fires.

1. Add one **Landsat 8 Views** layer to your map.

2. Filter the **Landsat 8 Views** layer for a pre-fire acquisition date of **06/08/2016**.

3. Rename the layer **Pre-Madeira Fire**.

4. Add a second **Landsat 8 Views** layer.

5. Filter the **Landsat 8 Views** layer for a post-fire acquisition date of **08/11/2016.**

6. Rename the layer **Post-Madeira Fire**.

7. On the **Post-Madeira Fire** layer, change the **Image Display** to **Color Infrared with DRA**.

Q9. With Color Infrared with DRA applied to your map, how do you know which areas have healthy vegetation and which areas were burned?

*A9. _____*

8. Use the Measure tool to calculate the acreage of the two burn areas.

The Measure tool deletes a polygon when you start measuring the second area.

9. Close the **Measure** tool.

Q10. What was the total of your two burned areas?

A10. _____

Calculate the burn index to show severity

1. On the **Post-Madeira Fire** layer, change the **Image Display** to **Normalized Burn Index** (**NBR Raw**).

2. Change the **Stretch Type** to **Standard Deviation**.
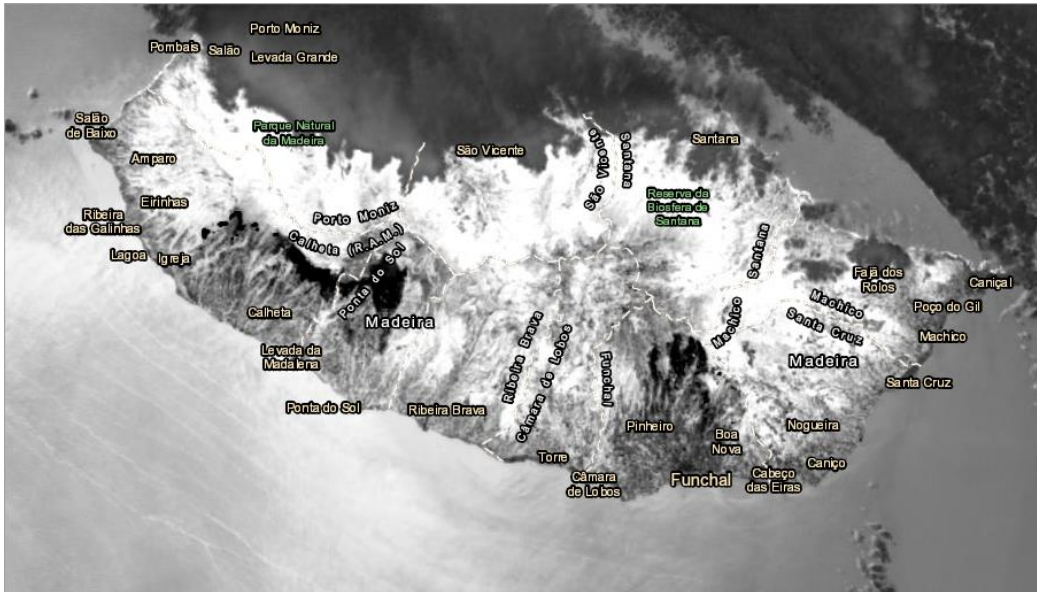
Q11. Compare the burn areas on this map with the burn areas you measured in the previous step. Why are the burn areas on the two infrared maps larger than the ones shown here?

A11. _____

3. Add appropriate metadata to the map and save it.

In this lesson, you downloaded imagery from Landsat 8 and applied it to wildfires in California, Australia, and Portugal. By comparing pre- and post-fire imagery, you could further analyze and explore the burned areas.

Exercise Answers

Q1. Click the link to Landsat satellites. When was the latest satellite, Landsat 8, launched?

A1. February 11, 2013.

Q2. Click the first chapter in The ArcGIS Imagery Book called Imagery is Visible Intelligence. During World War II, Allied pilots took photographs of German V2 rocket systems targeting Great Britain. The resulting 3D aerial photographs enabled the Allies to identify precise locations of those V2 rockets. What was the name of the operation identifying and locating those rockets?

A2. Operation Crossbow.

Q3. Click the Soberanes Fire story map and scroll to its conclusion. How do fire managers benefit from maps showing burn severity?

A3. These maps can influence homeowners about where to build their homes as well as the level of preparedness needed to protect their property.

Q4. In your opinion, was the Pre-Soberanes Fire layer a good indicator of where the fires would strike?

A4. The Pre-Soberanes Fire layer shows a mix of healthy and stressed vegetation where the fires struck. But in general, the Pre-Soberanes Fire layer was a good indicator of where the fires occurred because most of the burned areas appear to have included stressed vegetation. Answers could vary. Students should be prepared to defend their answers.

Q5. How many acres did you measure?

A5. Answers may vary. Overall, answers 5 percent above or below 132,000 acres (between 125,000 acres and 139,000 acres) are acceptable.

Q6. What's your impression of the peculiar-looking scar?

A6. Answers will vary.

Q7. How many acres was your measurement?

A7. The image shows 5,200 acres. Answers will vary. The fire is estimated to have burned more than 6,100 acres; however, that estimate likely includes areas outside of the scar image.

Q8. What can you infer from the image with the Standard Deviation?

A8. The darker the area, the more severe the burn.

Q9. With Color Infrared with DRA applied to your map, how do you know which areas have healthy vegetation and which areas were burned?

A9. Healthy vegetation is bright red and stressed vegetation (the areas that burned) are dark red.

Q10. What was the total of the two burned areas you measured?

A10. The total of the two areas measured in the images is 16,524. Answers between 13,000 and 19,000 are acceptable if students can demonstrate that they know how to measure burn areas.

Q11. Compare the burn areas on this map with the burn areas you measured in the previous step. Why are the burn areas on the two infrared maps larger than the ones shown here?

A11. The infrared maps show degrees of severity while the Stretch Types emphasize the most severely burned areas.

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About the Author

Kathryn Keranen is an award-winning teacher and author. She serves as an instructor in geographic science at James Madison University and is the co-founder of the award-winning Geospatial Semester. With Bob Kolvoord, she is the co-author of the *Making Spatial Decisions* series from Esri Press.

Support

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