

Slide Notes: GIS Symbolization

Table of Contents

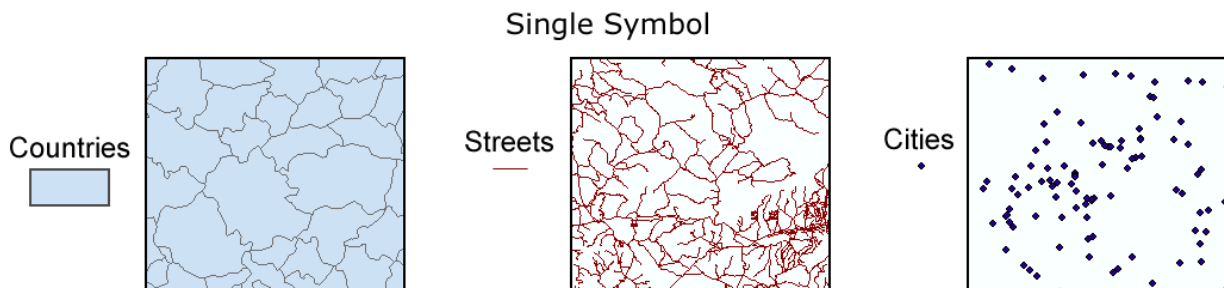
Symbolization.....	2
A Note on Color Ramps.....	5
Changing the number of Decimal Places.....	6
A Note on Color Blindness.....	6
Symbolizing Vector Objects.....	6
Labels and Text Symbolology.....	8
Lab Exercises.....	8
Appendix: Color Blindness and Cartography.....	9

Symbolization

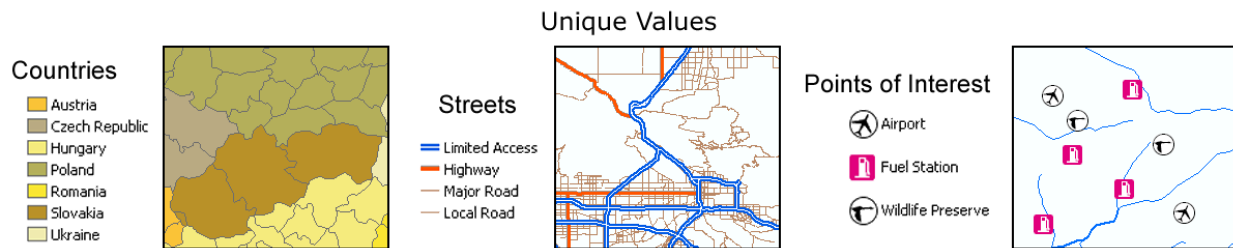
- 1) Slide 2: Main Topics. We will cover how to symbolize layers using a few common methods, then get into techniques for modifying the actual symbols used, and finally discuss text symbology.
- 2) Slide 3: Symbolizing layers gives us the ability to see not only where features are, but to quickly learn something about the features as well. In this example, we easily see both where fires occurred, and which fires were the most expensive.

Pumpkin fire cost 0? Probably not. Hochderffer cost a lot, as did the Schultz fire

- 3) Slide 4: Symbolization is set in the “Symbology” pane. To get to the Symbology pane, either right-click the layer name and choose “Symbology” in the drop-down menu, or select the layer name and then click the “Feature Layer” or “Raster Layer” tab, then click “Symbology” in the ribbon.
- 4) Slide 5: You can symbolize by various criteria:
 - a) Make all features look the same
 - i) Single Symbol, in Features
 - b) Slide 6: Symbolize by unique attribute values
 - i) Unique Values, in Categories
 - c) Slide 7, 8, 9, 10, 11, 12: Symbolize by quantity or magnitude
 - i) Various options in Quantities
 - d) Slide 13, 14: Symbolize by charts
 - i) Pie charts, Bar charts, Stacked Bar Charts
 - e) Slide 15: Symbolize by a Specific Symbol specified in a Dictionary.
 - i) ArcGIS includes some predefined dictionaries for military applications, but you can also create your own.
- 5) Slide 16, 17, 18: **Make all features the same.**
 - a) This is the most basic method of symbolizing data because it doesn’t use any attribute data at all.
 - b) All features in the layer are displayed with the same color and symbol.
 - c) This is useful when you only need to show where the features are located, without differentiating between specific sets of features.



- 6) Slide 19, 20, 21: **Symbolize by Unique Value:** Each unique attribute value in a layer is symbolized with a different symbol. This method is most useful with datasets that are separated into classes or categories, such as country or province boundaries.



- 7) Slide 22, 23, 24, 25: **Symbolize by Quantity:** Graduated Colors, Graduated and Proportional Symbols, and Dot Density:

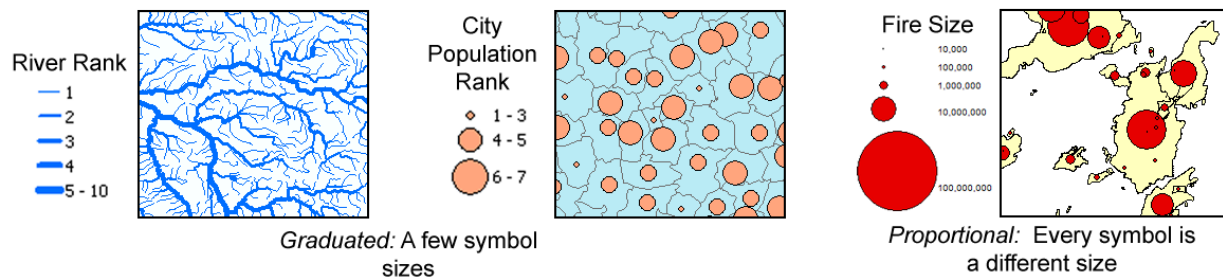
These types of legends are used to classify and display quantitative, numeric attributes, such as sizes, rates, densities or amounts of some variable.

Graduated Colors



Features symbolized with graduated colors are displayed with the same symbol type, but different colors. The colors generally follow a shading pattern that illustrates how some attribute value changes.

Graduated Symbols

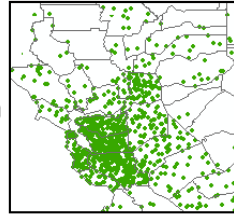


Features symbolized with graduated symbols are displayed with the same color, but with different sizes. Larger sizes generally indicate higher values or greater magnitudes.

Note: It is also possible to use both graduated colors and graduated symbols on a single dataset, and sometimes this is a useful method. However, you must take care not to make the symbology so complex that it is not intuitive to the viewer. For more information, look at the “Multiple Attributes” category in the Symbology tab of the Layer Properties window.

Dot Density

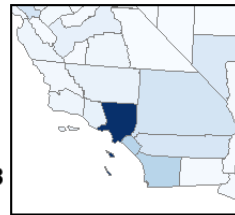
Population
1 Dot = 20,000



Dot density legends are a method of symbolizing numeric values within polygons. The individual dots do not represent any actual features on the ground and in fact are **distributed randomly** within the polygon. The number of dots is based on some attribute value, where higher numbers of dots reflect higher values.

Unclassified

Population
67
9,519,338



Unclassified legends just stretch the symbology over a color ramp. You can adjust the minimum and maximum values, and you can alter the characteristics of the color ramp.

Slide 26: ArcGIS offers a method to change the symbolization of a layer in your map so that it changes by both graduated symbols and by graduated colors. You simply click the “Vary Symbology by Attribute” command in the Symbology pane, and you can add a color ramp.

Slide 27: However, this fancy symbology doesn’t actually transfer to the legend itself. You can add a second legend item that shows the color range, but your legend still doesn’t accurately reflect the symbology in the map.

Slide 28: If you want to symbolize a single variable (like temperature) by both **graduated colors** and **graduated sizes**, and have it be accurately represented in your legend, then you’ll need to modify each symbol manually.

Slide 29: You can even have the **symbols change** if you do it manually. This takes a lot of time, though.

- 8) Slide 30: When symbolizing by Quantity: ArcGIS provides sophisticated tools for separating continuous data into classes. In the Symbology pane, simply click the “Methods” drop-down list, and set the number of classes you want to create.
- 9) Slide 31, 32, 33, 34, 35, 36, 37, 38: The statistics and histogram help to show the distribution of the data, and the blue vertical bars in the histogram show where the current classification breaks would occur.

This tool offers 7 methods to classify your data:

- **Manual:** The simplest method. You specify exactly where every classification threshold should be.

- **Equal Interval:** The range of data is divided into equally-sized classes. You specify how many intervals you want and ArcGIS determines the size of those intervals automatically.
- **Defined Interval:** Similar to Equal Interval above, except that you specify the interval size and ArcGIS automatically determines the number of intervals necessary.
- **Quantile:** Each interval has exactly the same number of samples.
- **Natural Breaks (using Jenks method):** A method of classification based on natural groupings of data. This is often the default method.
- **Geometric Interval:** Similar to the Quantile method in that it attempts to produce intervals with roughly the same number of samples, but using a mathematical approach to adjust the interval sizes.
- **Standard Deviation:** A method for showing how far each class deviates from the sample mean. This method is most appropriate for normally-distributed data.

10) Slide 39: You can use any method you want to make an initial classification, and then you can easily adjust the class breaks and make it a Manual classification.

11) Slide 40: Which method is best? Depends on what you are trying to say. If we care about some specific threshold value, such as maximum slope for a timber harvesting operation, then clearly we would want to symbolize by that value. This is a **Manual** classification method.

- a) Slide 41: If we are looking for natural groupings in the data, we'd use **Natural Breaks**.
- b) Slide 42: The **Equal Interval**, **Defined Interval**, **Geometric Interval** and **Quantile** methods are good when you want each class to cover the same range or have the same number of observations.
- c) Slide 43: The **Standard Deviation** method is best when we are looking for extreme values. We just want to know which ones are unusual.

12) Slide 44, 45, 46, 47: **Symbolize by Charts:** These types of legends are used to display some **combination** of attribute values. They are especially useful when you want to show how sets of attribute values compare with each other within each feature.

There are three common types of chart symbols used in ArcGIS. Pie charts are best for showing proportions of each class, while bar charts and stacked bar charts are best for showing absolute values of each class.

You can also make bar charts show relative proportions by normalizing the values by the sum of the values.

A Note on Color Ramps

13) Slide 48, 49: A Note on Color Ramps: ArcGIS provides a large number of color ramps to choose from. Some are designed to ramp between specific colors and are usually used when symbolizing by graduated colors. Others are designed to randomly pick colors within a set of color criteria, and are usually used when symbolizing by unique value or by non-numeric categories.

- 14) Slide 50, 51: You are not limited to just the color ramps you see in the list! ArcGIS lets you edit any of the existing ones by right-clicking on the color ramp and clicking “Properties”. This is an example of the random-color color ramp, which randomly picks colors within a range of HSV (Hue-Saturation-Value) criteria.

Changing the number of Decimal Places

- 15) Slide 52: A very common question is how to change the number of decimal places of your labels, or just modifying the format in general (like adding commas, showing them as percent, etc.).
- 16) Slide 53: In the **Symbology** pane, click the **Advanced symbology options** and then **Format labels**.
- 17) Slide 54: Here we have set the labels to cost values formatted as Currency, so there are commas, two decimal places and a “\$” character in front..

A Note on Color Blindness

- 18) Slide 55: Nearly 10% of the population has some level of color blindness! This is a common condition, and we should take it into consideration when making our maps.

Remember how satellites take images in multiple spectra and our computer turns images from the Red, Green and Blue bands into a true-color image? Our eyes work in a similar manner. We have three types of cone cells in our eyes that detect light, and each type is most sensitive to a particular frequency. They overlap a lot, but we generally are sensing at three frequencies and our brain converts that to the colors we are used to.

Some people either have one or two types of cone cells that are not working correctly, or else two types that are too similar (especially the L and M cells), and therefore their brain is basically interpreting colors from either 2 wavelengths or a single wavelength. If the brain only has one wavelength to work with, then that person is essentially seeing in black and white (or, what reflects brightest at that wavelength). Most people with color blindness have the L and M cells too close to each other and therefore cannot, or at least have difficulty with, distinguishing between red and green.

- 19) Slide 56: This shows what a map might look like under various types of color blindness. Design your maps accordingly!
- 20) Slide 57: Take advantage of ArcGIS Pro’s **Color Vision Deficiency Simulator** to see what your map would look like to people with various common conditions.

Symbolizing Vector Objects

- 21) Slide 58, 59, 60, 61, 62: Creating Custom Point, Line and Polygon Symbols
- a) These are the symbols used to display vector features.
 - b) There are lots of nice-looking predefined symbols available to you.
 - c) Even better, there are powerful tools that let you build your own. These are confusing at first, mainly because you have to step through lots of dialogs. It is not hard once you get used to it, though.
- 22) Slide 63: To build a complex symbol, we need to get to the Symbol Property Editor window. This shows the Symbol Property Editor window for Line symbols, and the editor windows for points (markers) and polygons (fills) are similar.

- 23) Slide 64: For your reference, here is another way to get to the Format Symbol window.
- 24) Slide 65: Once at the Format Symbol window, first observe that there are many predefined symbols you can choose from in the **Gallery** tab.
- 25) Slide 66: Back to the **Properties** tab, notice that you can make several types of symbols. For Line symbols (as in this illustration), we can make Solid, Picture and Gradient line symbols. We won't work with 3D symbols in this class, but I'll show you what all the other symbol types look like for points, lines and polygons.
- 26) Slide 67: Symbols that represent Points are called Marker symbols. You can make Simple marker symbols using basic shapes or characters in any font, and you can also use images for Picture marker symbols. In all cases, you can rotate the markers in any direction, based on a constant value, a random value or a value in an attribute field.
- 27) Slide 68: Multiple types of line symbols available
- a) Simple line symbol: A solid line.
 - b) Dashed line symbol: A dashed line
 - c) Shape Marker line symbol using a Line Shape: Made of a series of short lines (hash marks) oriented at some constant angle from the actual polyline direction.
 - d) Shape Marker line symbol using a Character from a Font: Made of Marker symbols, which you can create from the marker symbol editor.
 - e) Picture line symbol: Fills up a region around the polyline with a tiled (repeating in both up/down and right/left directions) image.
 - f) Gradient Line Symbol, which shades the color of the line symbol across its width.
- 28) Slide 69: Symbols that represent polygons are called Fill symbols.
- a) Simple Fill symbol: A solid color with an outline. You can make the outline with the line symbol editor.
 - b) Line Fill symbol: A set of parallel lines, which you can make with the line symbol editor, with an outline.
 - c) Gradient Fill symbol: Fills the polygon with a color ramp, with an outline. Gradient can be circular, linear, etc.
 - d) Marker Fill symbol: Fills polygon with Marker symbols, which you can create from the marker symbol editor.
 - e) Picture line symbol: Fills up the polygon with a tiled (repeating in both up/down and right/left directions) image.
- 29) Slide 70: Multilayer symbols: You can combine symbols to make a multilayered compound symbol. This is less complicated than it sounds. Basically, if you can make a symbol in the Symbol Editor, then you can also make a multilayer symbol. They can have some neat effects, too.
- 30) Slide 71: Examples of multilayer Marker (Point) symbols.
- 31) Slide 72: Examples of multilayer polyline symbols. Notice that if you want, you can use a multilayer marker symbol as the "Marker" in a Marker Line Symbol.

- 32) Slide 73: Examples of multilayer polygon fill symbols. Notice that all polygon fill symbols have an outline, which is symbolized with a line symbol. All line symbols used by polygons (including outlines and the interior lines of Line fills) can be built using the Line symbol editor. Marker fills can be distributed randomly or in a grid.

Labels and Text Symbology

- 33) Slide 74: Adding labels is easy, but label placement can get quite complex. This unfortunately would take too long to go over in the limited time we have left, but it is worth playing with if you ever have some time.
- 34) Slide 75: Play with this and learn how it works. One of the lab exercises shows how to add halos around text to make it more readable.

Lab Exercises

- 35) Slide 76: Get familiar with layer symbology, including learning how to symbolize a layer using graduated colors and unique values.
- 36) Slide 77: Learn to change symbol properties
- 37) Slide 78: Learn how to build complex multi-layer symbols
- 38) Slide 79: Learn how to construct the USGS “Unimproved Roads” symbol.
- 39) Slide 80: Learn the labeling and text symbol editor tools.

Appendix: Color Blindness and Cartography

Just FYI: This is a newsletter article I wrote a couple of years ago for the Spatial Ecology and Telemetry Working Group of The Wildlife Society

Between 8 – 10% of the general population experience some sort of color blindness, causing them to have either partial or total inability to perceive colors in some part of the visible spectrum. For some quick background, the eye contains two general types of light-sensing cells including Rod cells (more active in low-light conditions) and Cone cells (more active in bright light). Human eyes typically have three types of cone cells, each of which are each sensitive to different regions of the visible spectrum.

1. The “S” cone cells are sensitive to short wavelengths in the Blue region, and are also called Blue cone cells.
2. The “M” cone cells are sensitive to medium wavelengths in the Yellow-green range, and are also called Green cone cells.
3. The “L” cone cells are sensitive to longer wavelengths in the Yellow region, and are (somewhat counter-intuitively) called Red cone cells.
4. Many animal species (especially some fish, birds, amphibians, insects and reptiles) have a fourth class of cone cells that would allow them to perceive colors that humans would not be able to distinguish. Some of these species are able to see farther into the ultraviolet range.

The color that our brain perceives is based on how all three types of cone cells sense the light, similar to how we perceive millions of colors on a computer monitor based on different brightness levels of red, green and blue pixels. If a light is viewed as bright by the “S” cone cells, and dim by the “M” and “L” cone cells, then our brain will perceive that color as blue.

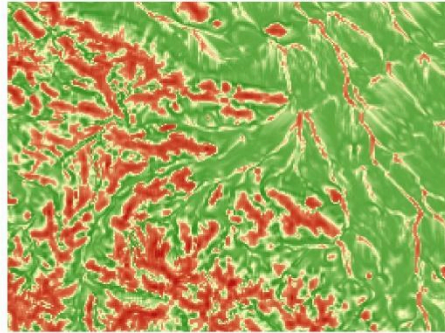
There are several variations of color blindness, almost all of which are caused by problems in one or more of these classes of cone cells.

1. **Protanopia** is the condition where “L” (Red) cone cells are all missing or nonfunctional. **Protanomaly** is the case where the red cells are at least partially functional, or are more sensitive to a different frequency than most of the population. People with these conditions have trouble distinguishing between red and green. Approximately 2.6% of males and 0.04% of females experience these conditions.
2. **Deutanopia** is the condition where the “M” (Green) cone cells are missing or nonfunctional, and **Deuteranomaly** is the condition where the green cells are partially functional or shifted to a different frequency. As with Protanopia and Protanomaly, people with these conditions have trouble distinguishing between red and green. Approximately 6.1% of males and 0.04% of females experience these conditions.
3. **Tritanopia** is the condition where the “S” (Blue) cone cells are missing or nonfunctional, and the milder condition is **Tritanomaly**. People with these conditions have trouble distinguishing between blue and yellow. Approximately 0.01% of males and 0.36% of females experience these conditions.
4. **Monochromacy** is the condition where two or all three classes of cone cells are damaged or nonfunctional. Vision is reduced to shades of gray. Approximately 0.00001% of males and 0.00001% of females experience this condition.

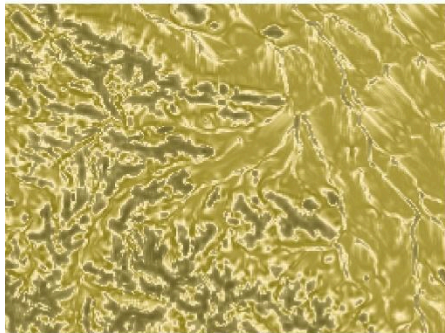
I am no expert on color blindness, but I do care about making maps that tell a clear story. Unfortunately, one of my favorite color ramps (from red to yellow to green), is difficult to perceive for approximately 9%

of the population (those with Protanopia, Protanomaly, Deuteranopia or Deuteranomaly). Because I have been fortunate enough not to have to deal with color blindness myself, I rarely think about it when I am making maps and I am quick to throw my favorite color ramp on a map without thinking that some people might have trouble with it. For example, what looks good to me would completely fail for people with Protanopia, Deuteranopia or Monochromacy:

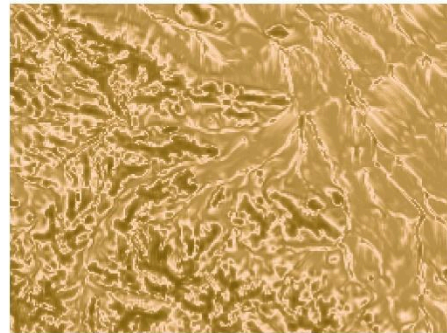
Original Map



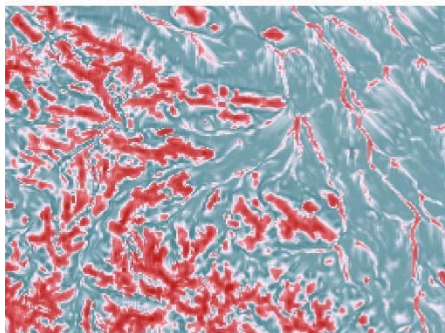
Protanopia
Red-Green Color Blindness



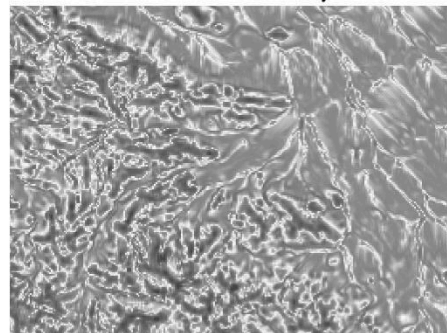
Deuteranopia
Red-Green Color Blindness



Tritanopia
Blue-Yellow Color Blindness



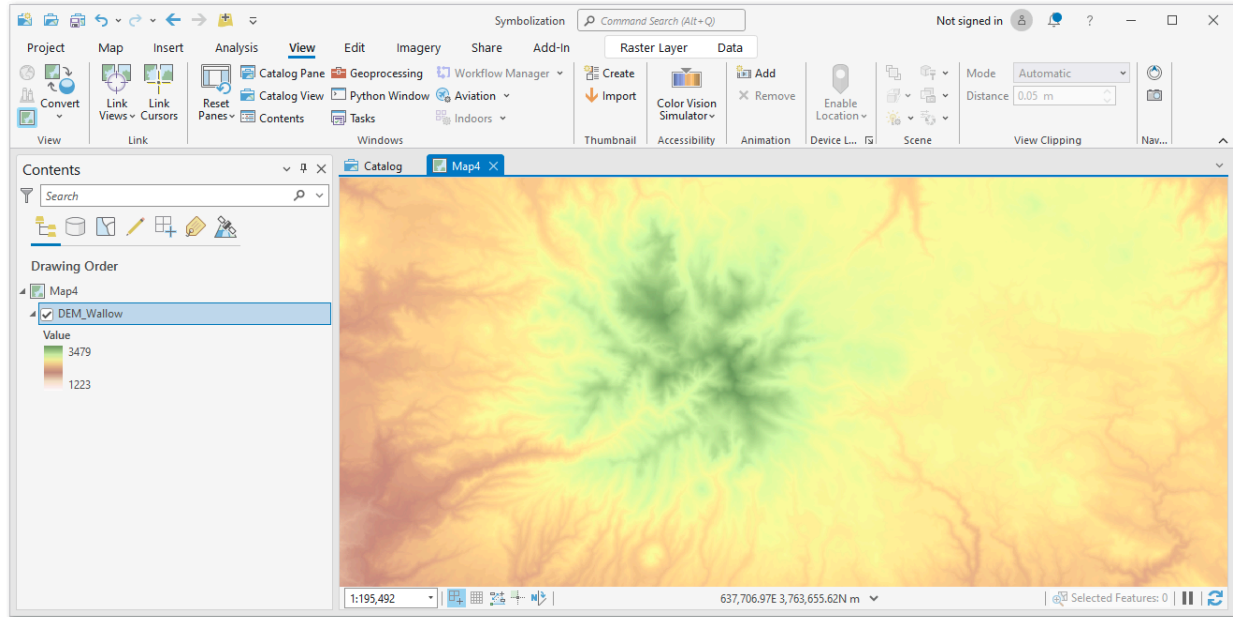
Monochromacy



So how can we tell if our map might cause problems? I recently stumbled across some great free software tools to show how any image would be seen by a person with the most extreme cases of color blindness. Color Oracle (<http://colororacle.org/>) was created by cartographers in Switzerland, and can switch your entire monitor temporarily to a *Protanopia*, *Deuteranopia* or *Tritanopia* view, and is available for Windows, Mac and Linux. Many more tools are listed at <http://colororacle.org/links.html>. Tools such as these will help us to create easily-readable maps that work for a greater proportion of readers, and I highly recommend them.

And ArcGIS Pro has introduced tools right in the software that allow you to view your map as a person with any of these conditions would see it. In the “View” tab, in the “Accessibility” group, there is a tool called “Color Vision Simulator” that does a similar function to the tools listed above.

Unmodified View



View modified to simulate Deuteranopia

