Image from NASA: https://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_transparent_background.png#filelinks

GIScience

Digital Cartography

WV VIEW

AmericaView
Empowering Earth Observation Education
AmericaView.org - Est. 2003

This module is a review and introduction to digital cartography copied from our GIScience course.

In this module, we provide an overview of digital cartography, data symbology, and map design.

Module Topics

1. Designing maps for an intended audience
2. Reference vs. thematic maps
3. Types of thematic maps
4. Working with font/text and labeling
5. Map element design
6. Scale and orientation
7. Map legends
8. Data classification methods
9. Data export and sharing

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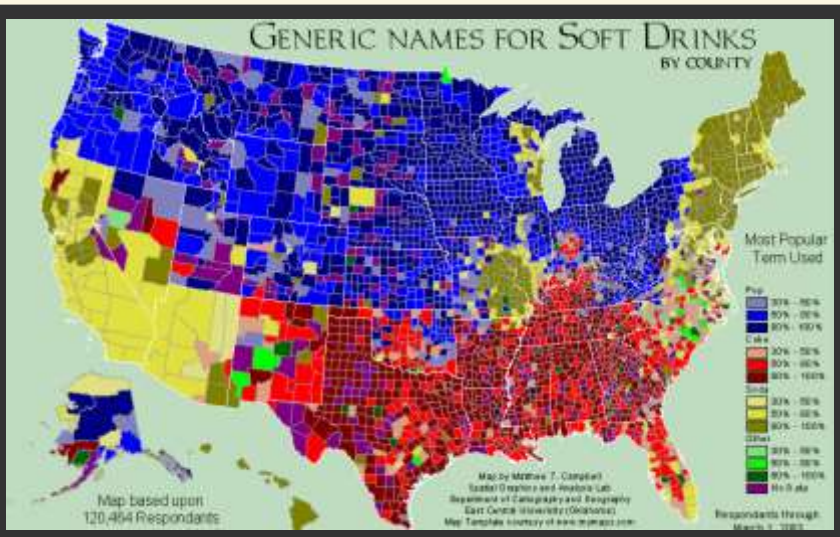
These are the topics covered in this module.

Example Map



http://www.popvssoda.com/countystats/total-county.html

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As an example, this slide provides a map highlighting the different names for soft drinks by county in the United States.

Cartography

- The art and science of making maps

https://commons.wikimedia.org/wiki/File:Austria_hungary_1911_and_post_war_borders.jpg

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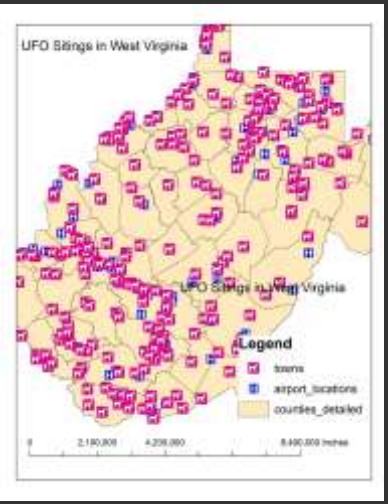
Cartography is the art and science of making maps. Digital cartography deals with designing maps in a digital environment using digital data and computer software. That will be our focus here.

Maps as Communication

With GIS, it is becoming easier to make maps



- However, its easy to design a poor map

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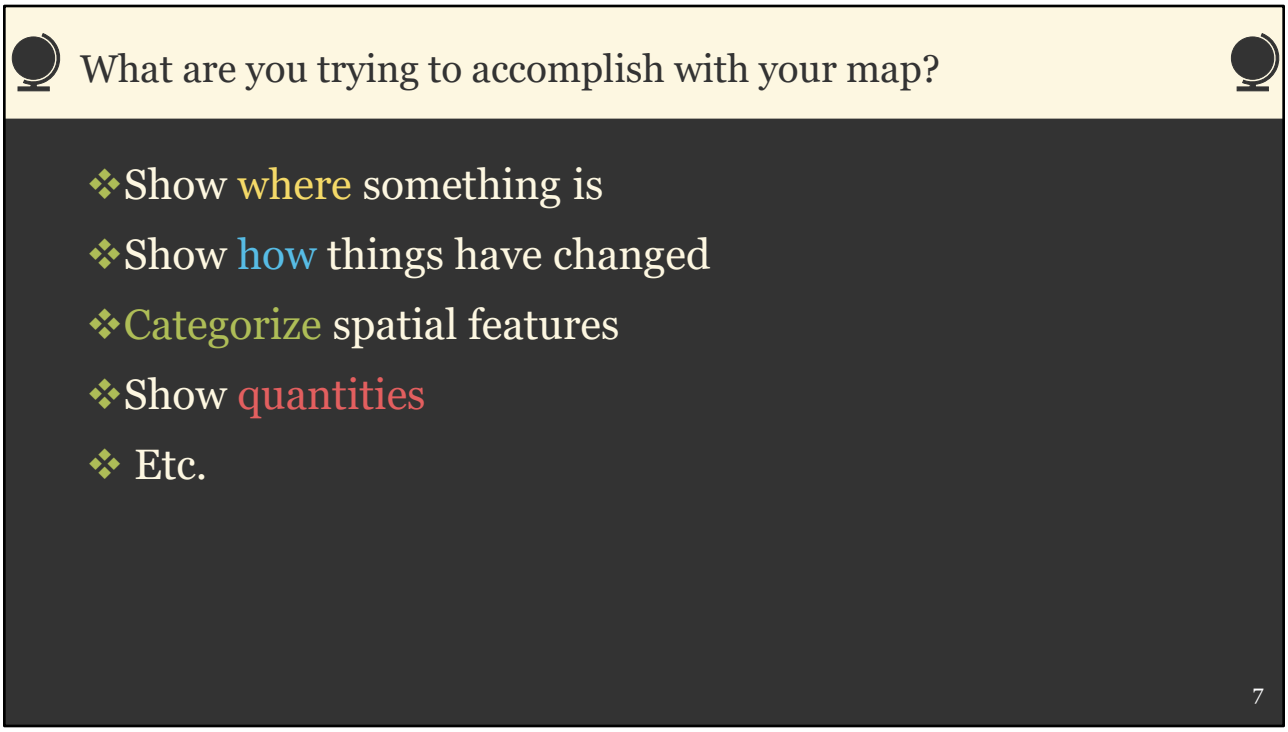
With modern technologies, it has become easier to make a map. However, without appropriate training these maps can be quite poor. My goal here is to give you some pointers on making quality maps that communicate data well for an intended audience.



You should have clear goals in producing a map. You might design a map to show where something is, how things have changed, categories of features, or quantities. You should design your map with clear goals in mind.

Who's your audience?

- Other professionals in your field
- Your client
- Your boss
- The general public
- Children

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Again, you should design a map with an audience in mind. A map produced for professionals in your field should be different from a map designed for the general public.

If you are presenting the same information, it is generally best to create different map layouts for different audiences as opposed to a single, all purpose product.

Considering the audience is key.

Visual Hierarchy

- A map's purpose determines which of its elements are the most important and should be displayed most prominently in the visual hierarchy
- Map design is largely a process of deciding how prominent to make each element of your map layout
- Hierarchy is established by an element's:
  - Position in the map layout
  - Size
  - Amount of open space around it
  - Contrasting colors, line weights, and line details

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A map's purpose determines which of its elements are the most important and should be displayed most prominently in the visual hierarchy. Map design is largely a process of deciding how prominent to make each element of your map layout.

Visual hierarchy is established by an element's position in the map layout, an element's size, the amount of space around an element, contrasting colors, line weights, and line details.

The best way to learn how to establish visual hierarchy in your maps is to practice.

Quality Maps

1. Communicate effectively
2. Are designed for a specific audience
3. Have visual hierarchy
4. Use colors effectively
5. Use space well
6. Follow cartographic principles

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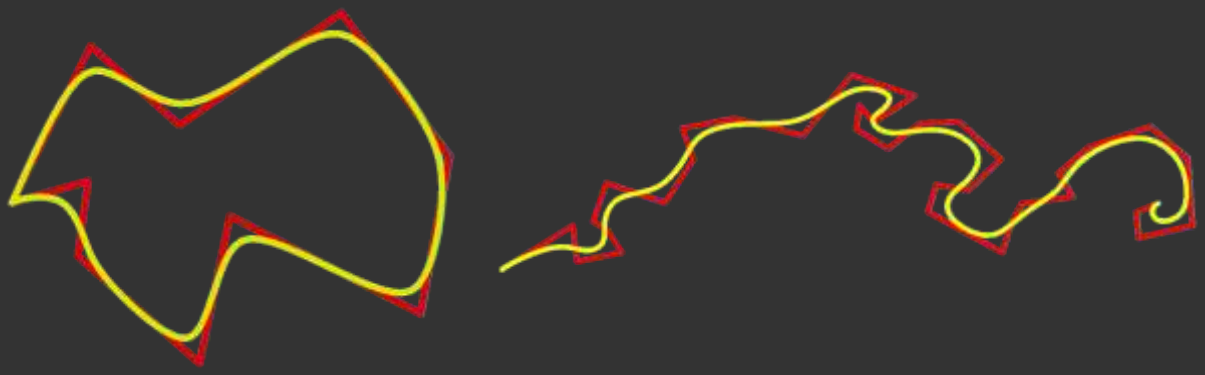
In summary, quality maps communicate effectively, are designed for a specific audience, have effective visual hierarchy, use colors effectively, use space well, and follow cartographic principles.

All maps require generalization

- Real world features must be simplified



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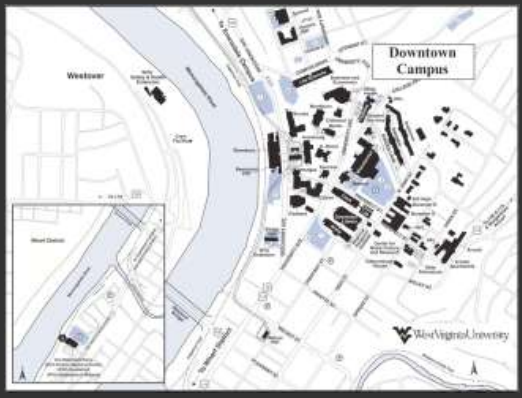
The real world is infinitely complicated. We can't map every blade of grass or every atom or every quirk. So, all geospatial data and maps are simplifications or generalizations of reality.

A large component of map design is deciding the level of detail or generalization required.

Map Scale

Small Scale = Zoomed Out, Less detail



Large Scale = Zoomed In, More detail

Assumes maps are printed at same size

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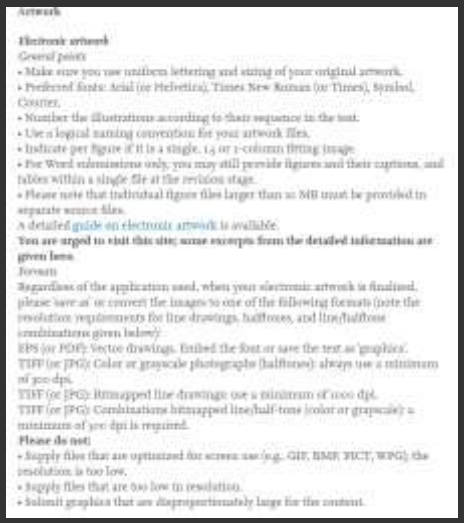
Small scale maps are more zoomed out or show less detail. In contrast, large scale maps are more zoomed in or show more detail.

For example, if a map of the United States and a map of New York city are printed at the same size, the United States map would be a smaller scale map in comparison to the New York map.

In what format will it be presented?



Artwork

Electronic artwork

General points

- Make sure you use uniform lettering and sizing of your original artwork.
- Preferred fonts: Arial (or Helvetica), Times New Roman (or Times), Symbol, Courier.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Indicate per figure if it is a single, 1.5 or 2-column fitting image.
- For Word submissions only, you may still provide figures and their captions, and tables within a single file at the revision stage.
- Please note that individual figure files larger than 10 MB must be provided in separate source files.

A detailed guide on electronic artwork is available.

You are urged to visit this site; some excerpts from the detailed information are given here.

Formats

Regardless of the application used, when your electronic artwork is finalized, please save as or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):

EPS (or PDF): Vector drawings. Embed the font or save the text as 'graphics'.

TIFF (or JPG): Color or grayscale photographs (halftones): always use a minimum of 300 dpi.

TIFF (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.

TIFF (or JPG): Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.

Please do not:

- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); the resolution is too low.
- Supply files that are too low in resolution.
- Submit graphics that are disproportionately large for the content.

- Color print
- Black-and-white print
- Academic journal
- Newspaper
- Trade journal
- White paper
- Large format
- Computer screens
- Projectors
- Presentations

Guide to Authors: Applied Geography (https://www.elsevier.com/journals/applied-geography/0143-6228/guide-for-authors)

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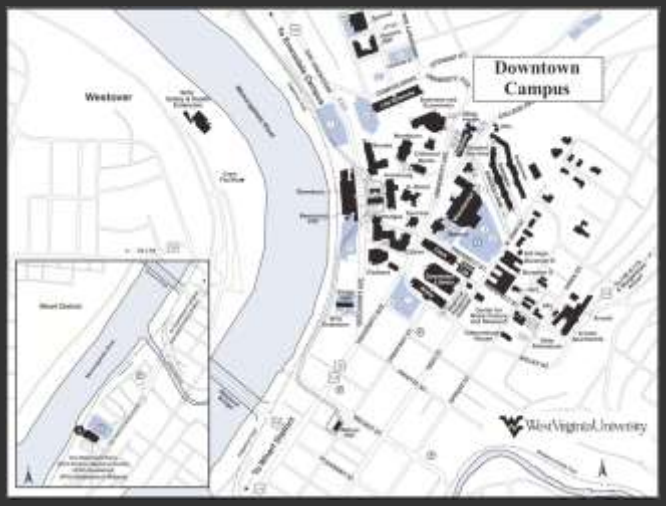
It is also important to consider the medium of presentation for the map.

This can have an impact on the color space used, the required resolution, font sizes, and whether to use color or black-and-white.

Types of Maps

Reference Maps

- Shows the location of features



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We will now discuss types of maps.

Reference maps are designed to show locations and features or act as a reference.

Common reference maps include road maps, park maps, subway maps, and campus maps.

Thematic Maps

Displays a specific theme or feature using a graphical property

- Color
- Size
- Shape
- Density
- Etc.

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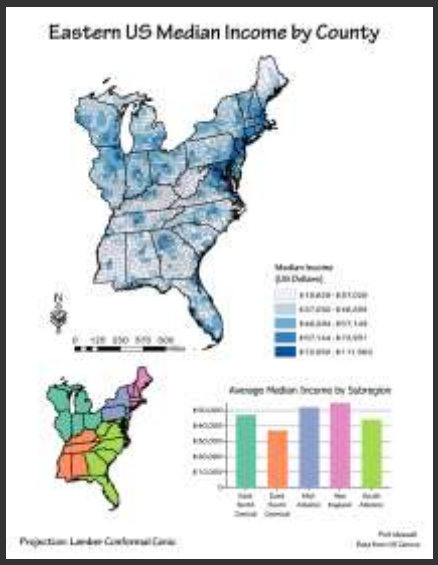
In contrast to reference maps, thematic maps are designed to represent a specific theme, value, quantity, or category using graphical parameters such as color, size, shape, or density.

I will now provide some examples of thematic maps.

Choropleth



- Use color to show a quantity or category

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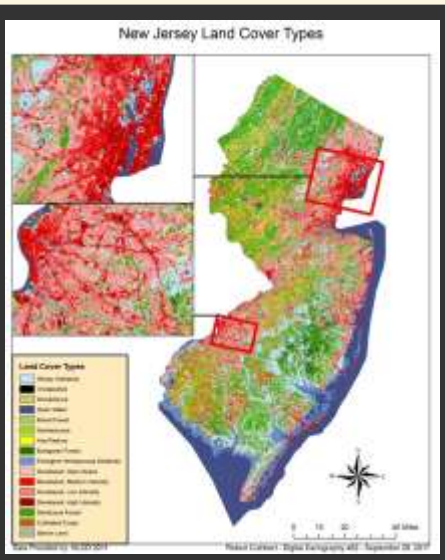
Choropleth maps use color to represent a category or quantity.

In the example provided, shades of blue are being used to represent a quantity, in this case medium income by county.

Also, colors are being used to represent categories, in this case different regions of the eastern United States.

Choropleth



- Use color to show a quantity or category

Map by Robert Cuthbert

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This is an example of a choropleth map showing categories. Different land cover types are symbolized using different colors.

Choropleth Maps

- Use color to show a quantity or category

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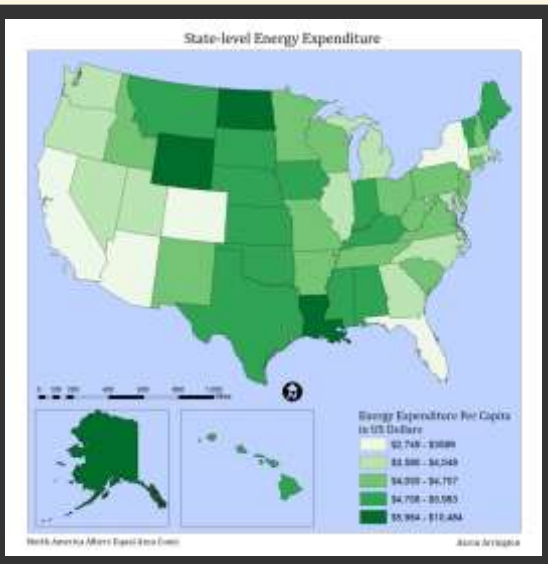
This is another example of a thematic map representing categories.

The two different colors show whether a country was visited or not during a hypothetical trip.

Choropleth Maps



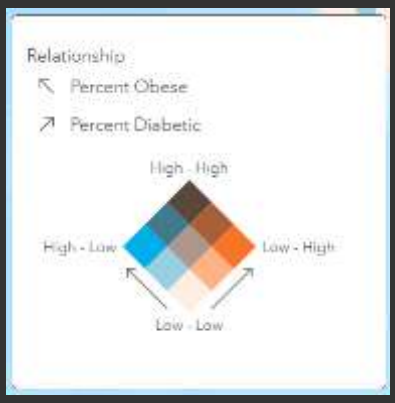
- Use color to show a quantity or category

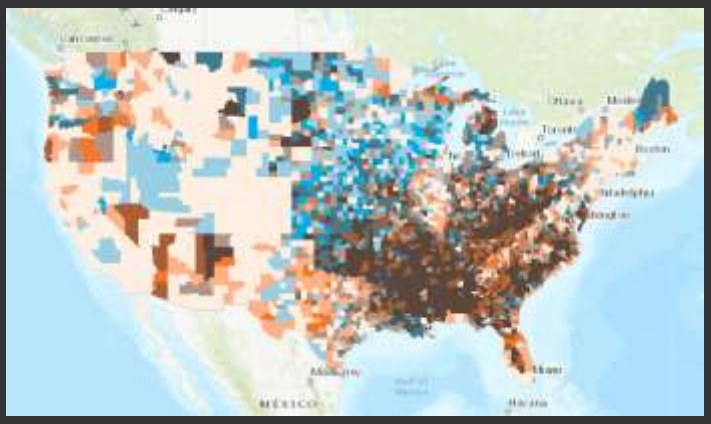
Map by Aaron Arrington

20

This choropleth map is showing a quantity as opposed to a category, in this case energy expenditure per capita in US dollars.

Bivariate Choropleth Map





Example from ArcGIS Online using County Health Rankings 2018

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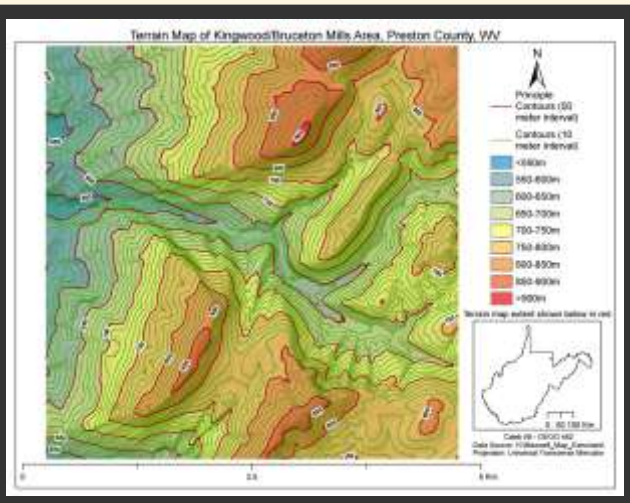
It is possible to map two continuous variables using a bivariate choropleth symbology. When this method is used, legends are commonly provided as a diamond representing the different color combinations and how they relate to the two variables being mapped. This will also require that the axes are clearly defined.

In the provided example, percent obese is symbolized with the blue ramp while percent diabetic is symbolized with the orange ramp. The color at the top of the diamond corresponds to both high percent obese and high percent diabetic. The color at the bottom of the diamond corresponds to low for each while the left and right positions are high for one variable and low for the other.

Isarithmic Map



- Use lines of equal value to show a quantity

Map by Caleb Alt

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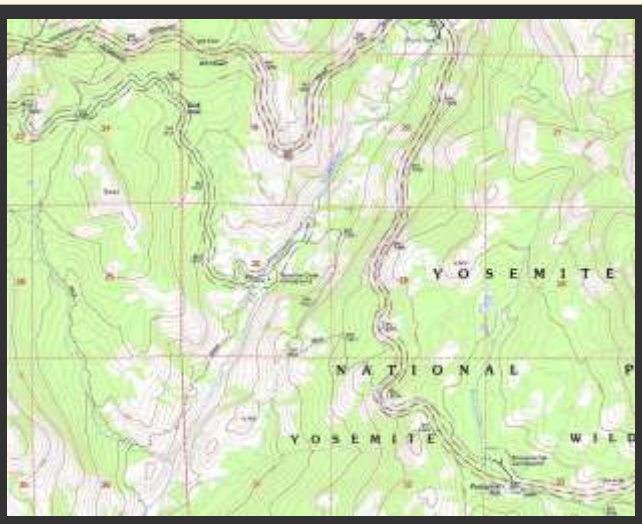
Isarithmic maps use isolines, or lines of equal value, to represent quantities. They cannot be used to represent categories.

Here isolines are being used to represent elevation. If you would walk one of these lines, you would not go up or down hill or change elevation.

Isolines can also be used to represent other continuous phenomenon, such as temperature, barometric pressure, relative humidity, and depth to bedrock.

This map is technically a combination of an isarithmic map and a choropleth map since both color and isolines are being used to show elevation.

Isarithmic Map



https://commons.wikimedia.org/wiki/File:Yosemite-creek-campground-topo.jpg

- Use lines of equal value to show a quantity
- Topographic Maps

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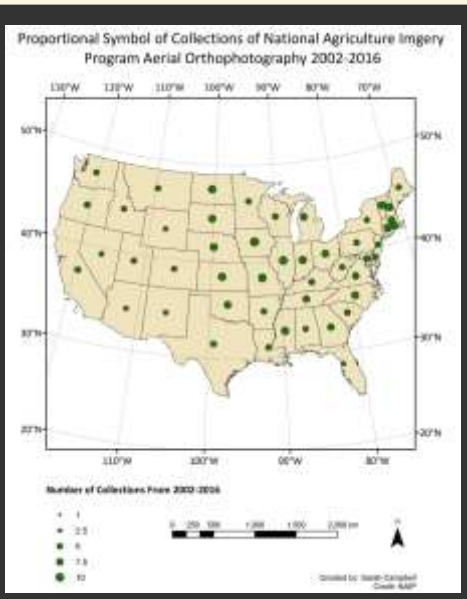
Topographic maps are another example of isarithmic maps since contour lines are used to show elevation.

I consider topographic maps to be a combined reference and thematic map since they are commonly used for navigation but also represent topography as a theme.

Proportional Symbol Map



- Use size to represent a quantity (scaled continuously)

Map by Sarah Campbell

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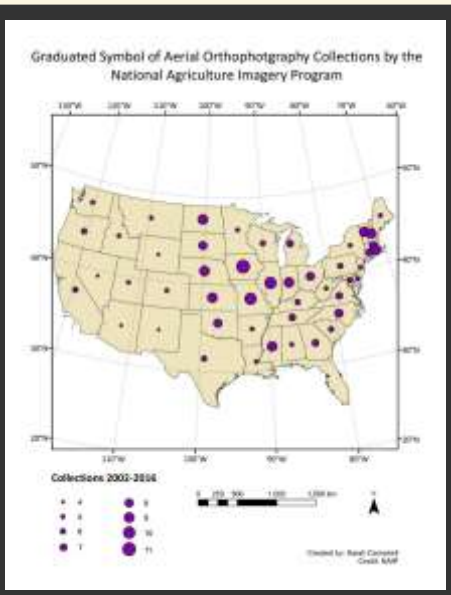
In contrast to choropleth maps, proportional symbol maps use size as opposed to color to show a quantity. Proportional symbol maps cannot be used for categories.

For proportional symbol maps, the size of the symbol is scaled continuously relative to a quantity.

The example above represents the number of aerial image collections by state.

Graduated Symbol



- Use size as bins or ranges to represent a quantity

Map by Sarah Campbell

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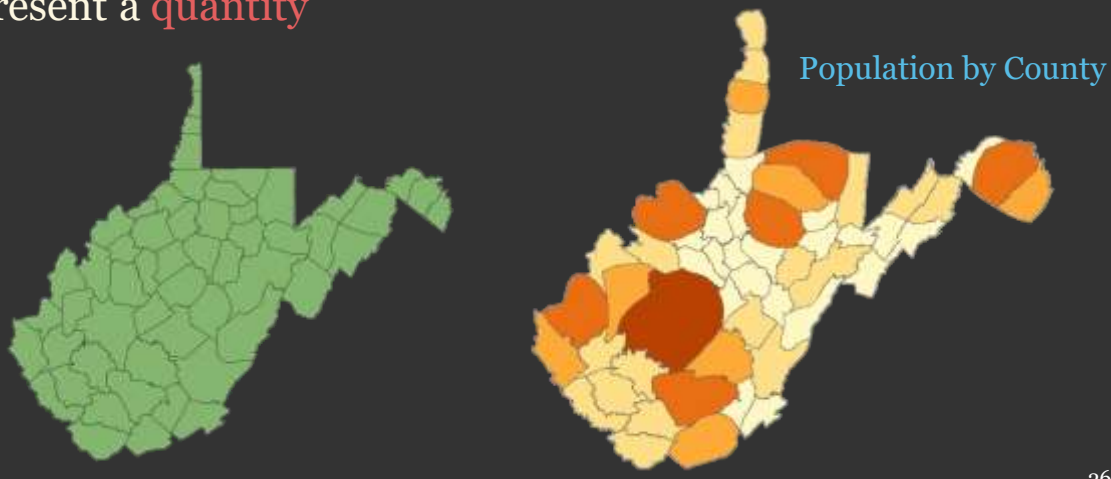
Graduated symbol maps are often confused with proportional symbol maps.

In graduated symbol maps, instead of scaling the sizes continuously, a single size will represent a range of measurements. In other words, data are classified or binned.

As with proportional symbol maps, these maps are generally only used for quantities and are not appropriate for categories.

Cartograms

- Resize the map feature to represent a quantity

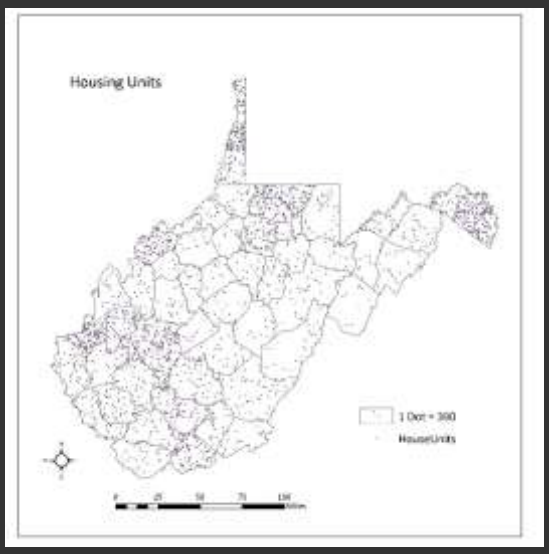


26

Another way to represent a quantity using size is to make use of cartograms. Instead of scaling a symbol relative to a quantity, the actual geographic feature is scaled relative to a quantity.

So, the size of the map features are distorted to represent a quantity as opposed to changing the size of a symbol.

Dot Density



- Use density of dots to represent a quantity

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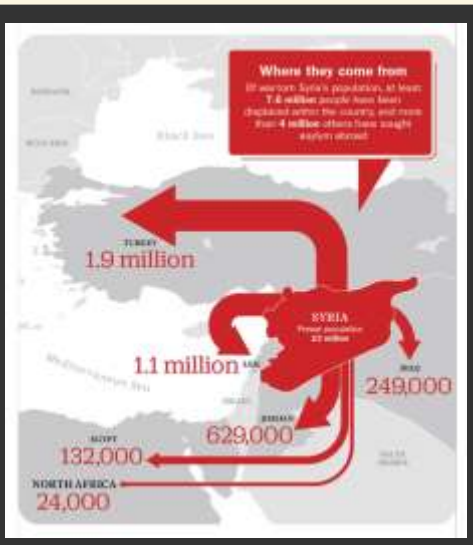
Dot density maps represent a quantity using the density of dots. They are not used to represent categories.

In the provided example, the number of houses per county is symbolized using dot density. More dots in a county represent more houses. Each dot will represent a certain number of features. In the example, each dot in the example map represents 390 homes.

It is important to note that the location of the dots do not correspond to the true location of homes. Instead, the dots are randomly placed in the polygons and the number or density of dots per polygon represents the quantity.

Flow Maps



- Show movement or migration using arrows
- Can also show magnitude with arrow size or color

http://time.com/4028055/syria-europe-refugees-graphic/

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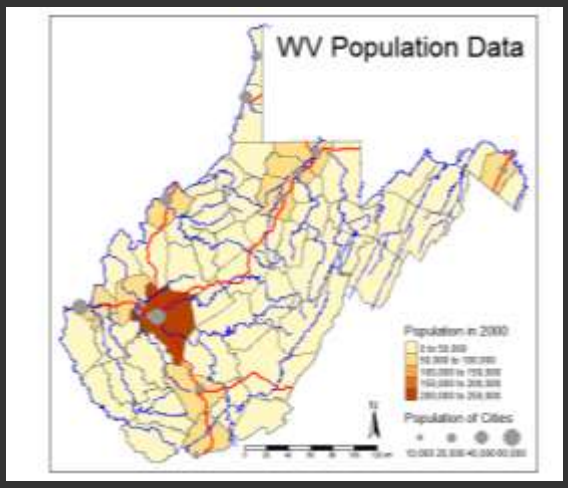
Flow maps are used to show movement or migration. In the example, the arrows are being used to show the direction of migration of war refugees while the size of the arrow shows the magnitude or number of refugees.

Multivariate Maps



- Maps that show multiple quantities and/or categories using different graphical parameters

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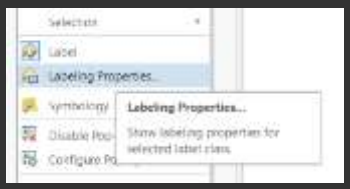
Multivariate maps show more than one theme using different graphical parameters.

In the example map, size is being used to show city populations while color is being used to show county populations.

Type and Fonts

Map Text

- You should think about text font, size, and positioning
- Generally, the titles have the largest font size



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The goal of this section is to provide some advice for using fonts and labels. Text should be intentionally designed and placed. Generally, the title uses the largest text on the map, and all other text are scaled relative to it.

Type

- Type Family = group of type designs that reflect common design characteristics and share a common base name (Calibri, Arial, Comic Sans, Cambria, Courier New, Times New Roman, Verdana)
- Type Style = Roman (normal), bold, *italic* (Less common: condensed, expanded, light, and extra bold)
- Type Face = Family + Style (Gill Sans Ultra Bold)
- Type Size = height (11 pt, 14 pt, 18 pt)
- Font = a set of all alphanumeric and special characters of a particular family, style, and size (Times New Roman 12 pt)

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This slide describes the key characteristics of a font including the font family, style, face, and size. Take some time to read through these descriptions.

Case

- Title Case = lowercase letters with the first letter of each word set to upper case (except linking words like in, on, or, of, per, by, for, with, the, and, over, etc.)
- Sentence case = only first letter of first word in the sentence is capitalized
- UPPERCASE = all caps

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Title case involves capitalizing only the first letter of each word, except linking words.

Sentence case means to capitalize only the first letter of the first word.

Uppercase implies that everything is capitalized.

Serif vs. Sans Serif

- Serif = has short extensions at the end of major letter strokes (This is a serif font).
- Sans serif = does not have serifs (This is a sans serif font).

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Serif fonts have serifs, or extensions at the end of major letter stokes.

San serif fonts do not have serifs.

Spacing

- Letter Spacing = space between letters in a word
  - Here I have changed the letter spacing.
- Word Spacing = spacing between words
- Kerning = variation of spacing between adjacent letters
- Leading = vertical spacing between lines
  - Here I have changed the leading.
  - Here I have changed the leading.
  - Here I have changed the leading.
  - Here I have changed the leading.

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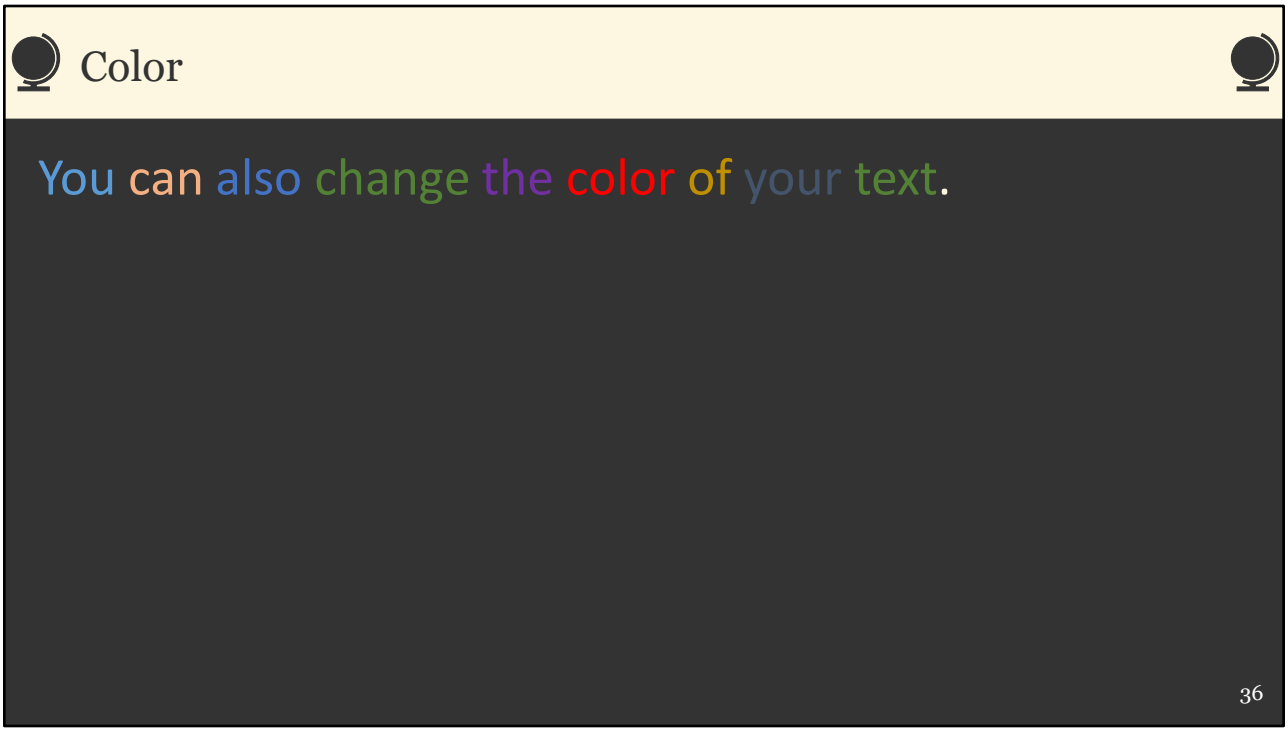
Letter spacing refers to the spacing between letters in a word while word spacing relates to spacing between words.

Kerning relates to variation of spacing between adjacent letter combinations. Letter spacing adjusts spacing between letters consistently while kerning applies specific spacing depending on the letter combination in question.

Leading relates to spacing between lines of text.



You can also change the color of font for visual effect or to establish visual hierarchy.

General Typographic Guidelines

1. Avoid the use of decorative fonts.
2. Do not overuse *italics* and **bold**.
3. *Hydrographic features are often in italics*.
4. *Data sources are often in italics*.
5. The wide variety of features on general reference maps might require that you use bold and italics styles outside of these guidelines.
6. Avoid using more than two font families on a map.
7. If you use two font families, they should be distinctively different.
8. Serif fonts tend to be used for natural features.
9. Sans serif fonts tend to be used for cultural features.
10. All type should be readable at the intended reading distance and at the printed size. You may want to show sample maps to the intended audience.
11. Type size should correspond with the size or importance of map features.
12. Avoid font size differences less than 2 points as these can be hard to discern.
13. Critically evaluate and apply type specifications such as font family, font style, type size, letter spacing, word spacing, kerning, and leading.
14. Spell check your work.

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This slide provides some general guidelines for typology on maps. Take some time to read through these guidelines.

General Guidelines for Labeling Features

1. Generally, orient type horizontally (with some exceptions).
2. If graticules are used with curved parallels, orient text with parallels.
3. If labeling diagonal or curved linear or areal features, orient type with orientation of the feature.
4. Avoid overprinting or placing a block of type over a map feature such that the feature is obscured and the text is difficult to read.
5. If overprinting is an issue, consider using a mask or a halo. Make sure that masks or halos do not draw too much attention.
6. If overprinting is an issue, consider using callouts. Make sure that the callout does not draw too much attention.
7. Ensure that all type labels are placed so that they are clearly associated with the features they represent.

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These guidelines relate to labeling features in general.

Labeling Point Features

1. Avoid overprinting.
2. Preferred positions are shown on the next slide.
3. Do not allow other map features to come between a point symbol and its label.
4. Emphasize the association between the label and symbol, even if it means choosing a less preferred location.
5. If the sequence of preferred locations does not provide a suitable option, consider using a mask, halo, callout, or leader line.
6. Multi-line labels should be placed according to the sequence of preferred locations and horizontally aligned to emphasize the association between the label and point symbol.
7. Point symbols on land that are close to coastlines should be labeled entirely on land if possible.
8. Point symbols that touch coastlines should be labeled either entirely on land or entirely on water.
9. Avoid overprinting coastline with type.
10. Do not exaggerate letter or word spacing.

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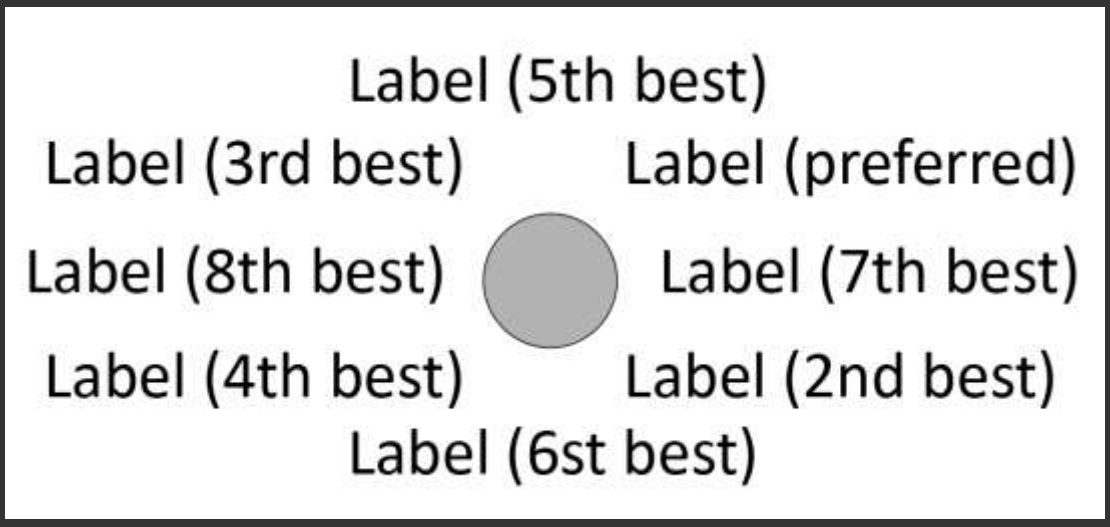
These guidelines relate to labeling point features.

Label Positioning



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The best location to label a point feature is to the upper-right. If you can't use this position due to overprinting or crowding, you should choose the position based on the rules described here.

Labeling Line Features

1. Place type above line features. Type should be close to the line but not touching it.
2. If labeling features on both sides of a boundary, type can be above and below the line.
3. If feature has complex curves, follow the general trend of the feature and avoid labels that are too curvy and difficult to read.
4. Very long linear features can be labeled more than once. The use of multiple labels is preferred to the exaggeration of letter and word spacing to emphasize linear extent.
5. Text should be upright, not upside down. Text should read left to right.

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This slide provides guidelines for labeling line features, such as rivers and roads.

Labeling Polygon Features

1. Visually center the label within the feature.
2. Allow some space between the label and the feature boundary to avoid crowding.
3. Generally, label along the longest axis of the feature.
4. Consider using all-uppercase type, especially for larger features.
5. Letter and word spacing can be exaggerated to emphasize aerial extent, especially if applied to all upper-case type.
6. Exaggerated leading can also be used to emphasize areal extent.
7. Areal features that are too small to contain a label should be labeled like point symbols.
8. Leader lines can be used to label small areal features.

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This slide provides guidelines for labeling polygon or areal features, such as political boundaries.

ArcGIS Maplex

- Well-placed labels can make a map more understandable and useful.
  - Maplex provides a special set of tools that allows you to improve the quality of the labels on your map.
  - Define parameters to control the positioning and size of your labels; Maplex uses these parameters to calculate the best placement for all the labels on your map. You can assign different levels of importance to features to ensure that more important features are labeled before less important ones.
- Maplex controls:
  - how labels should be placed relative to features
  - how labels can be modified or reduced to allow more label placement when the available space is constrained
  - how conflicts between labels are resolved

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ArcGIS makes use of the Maplex labeling engine to aid in labeling features. Read through the descriptions provided here to get a sense of how this tool functions.

ArcGIS Maplex

- Advanced placement styles for polygons including styles that represent land parcels, rivers, and boundaries
- Special placement for lines that represent street, river, and contour features
- Ability to offset labels from features
- Repetition of labels at a specified distance along a line or within a polygon
- Control of word and character spacing
- Alignment of labels to projection graticules
- Control of label placement zones
- Flexible placement to allow more labels to fit in an area
- Fine control of label stacking
- Label abbreviation and truncation
- Font reduction parameters for congested areas
- Control of whether a label may extend beyond a feature
- Enhanced weighting of features to determine label placement
- Control over the minimum feature size that will be labeled
- Placement of labels as background text
- Search tolerance to remove duplicate labels
- Ability to control the order in which the label fitting strategies are applied

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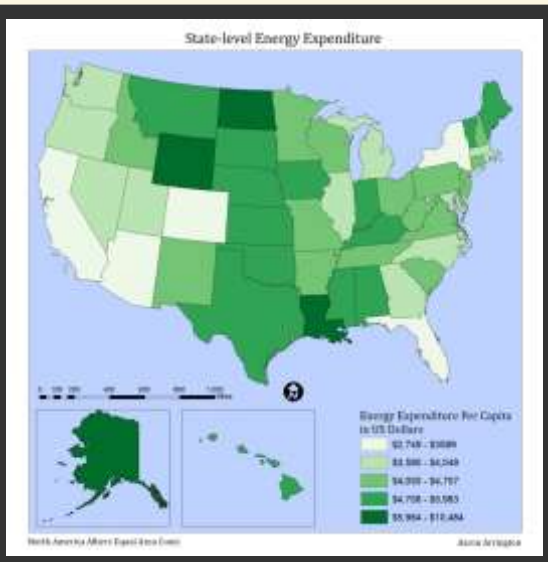
These are some of the labeling tasks that can be semi-automated using the Maplex labeling engine.

Map Elements

Map Elements



1. Map area
2. Title
3. Map text
4. Inset maps (multiple map frames)
5. Scale
6. Orientation
7. Graticules
8. Coordinate Grids
9. Legend
10. Credits
11. Frames and neat lines
12. Graphics

Map by Aaron Arrington

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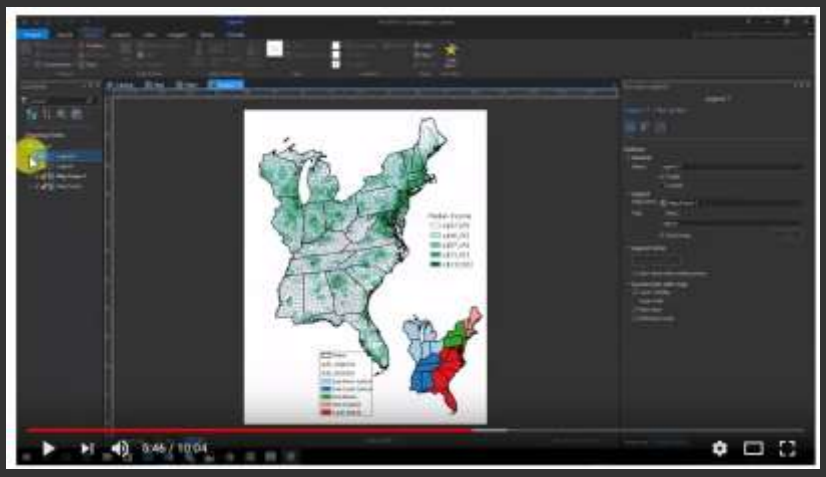
This slide provides examples of some of the common map elements used in map layouts. We will now discuss these elements and provide some recommendations for designing and placing them.

Map Elements in ArcGIS

1. Work in Map Layout
2. Insert options
3. Change symbology in original map
4. Can work with multiple maps
5. Can change map projection for map



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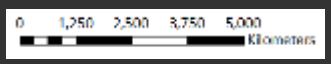
When designing a map in ArcGIS Pro, you must create a new map layout.

I have found that it is best to prepare your legend and symbology in the map before adding the map to a layout.

You can add multiple maps to the same layout and even change projections.

Scale

- Scale Bars
  - Most useful



- Representative Fraction
  - 1:10,000
  - 1:1,000,000
- Verbal
  - One inch to one mile
- Neither Representative Fraction nor Verbal used if map is to be enlarged or reduced in size

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Scale can be represented using a scale bar, representative fraction, or verbal scale.

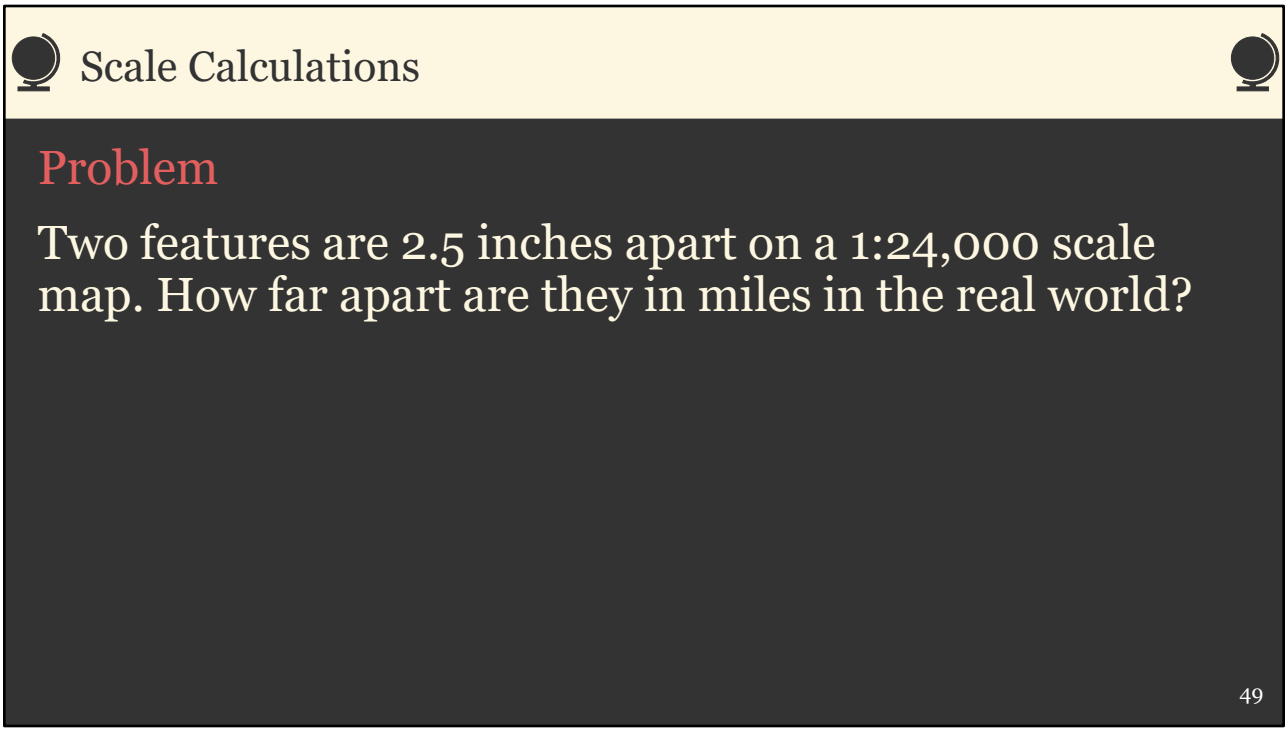
Scale bars provide a graphical representation of scale.

An example of a representative fraction would be 1:24,000. This indicates that one unit on the map is equivalent to 24,000 units on the ground.

An example of a verbal scale is “1 centimeter is equal to 5 kilometers”.

If a map is going to be resized, representative fractions or verbal scales should not be used, as the defined relationship will not hold at different sizes.

A scale bar can be used if the map is going to be resized; however, it must be resized along with and proportional to the map.



If the scale of a map is known, then measurements can be made on the map then converted to real world measures.

Here is a problem: If two features are 2.5 inches apart on a 1:24,000 scale map, how far apart are they in miles in the real world?

First, you will need to multiply the measurement by the map scale, so 2.5 X 24,000 or 60,000 inches. You would likely not want to provide this measure in inches. Instead, miles would be more appropriate. You can use conversion factors to change the units.

There are 12 inches in a foot, so you will need to divide by 12 to convert to feet. There are 5,280 feet in a mile, so you will need to then divide by 5,280 to convert to miles.

This works out to 0.95 miles.

Scale Bar Tips

1. Make sure your units make sense
2. Reference maps often require more detailed scale bars than thematic maps
3. Is a scale bar always required?
4. Breaks should be clean numbers (such as multiples of five or ten)
5. You can control the number of divisions and subdivisions
6. You can include a representative fraction or verbal scale
7. It might be worth stating the projection on the map, as this makes your scale bar more meaningful
8. It should have the same font as the rest of the map
9. It should fit within the visual hierarchy of your map
10. The size and position should be consciously determined
11. You can change the label and position of the label
12. You can change the position of numbering
13. You can change the frequency and position of marks

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Here are some tips for designing and placing a scale bar.

Note that a scale bar can sometimes be misleading, especially on small scale or global maps. This is because some projections distort distance and size, so scale will actually vary across the map space.

For larger scale maps, graticules are sometimes used instead of a scale bar as a representation of scale.

Orientation

- North Arrow
- Graticules = latitude and longitude
- Coordinate Grids = grid of map coordinates (UTM grid)
- References Grids = grid of reference cells

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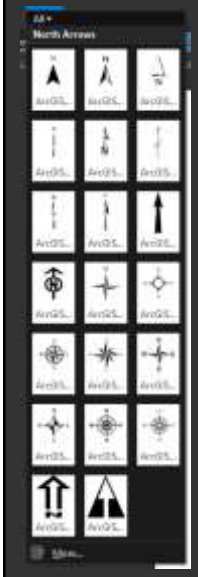
We will now discuss means to describe the map orientation.

North Arrow Tips



1. Make sure it fits within the visual hierarchy of your map
2. It should not be too big
3. The size and position should be consciously determined
4. You can use ArcGIS north arrows or create your own
5. North may not always be up
6. Is a north arrow always required?

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Here are some tips for designing a north arrow.

ArcGIS Pro provides many north arrows to choose from.

Similar to scale bars, north arrows can also be misleading on small scale or global maps, as some projections distort directions. In this case, you may choose to use graticules in place of a north arrow.

Graticules

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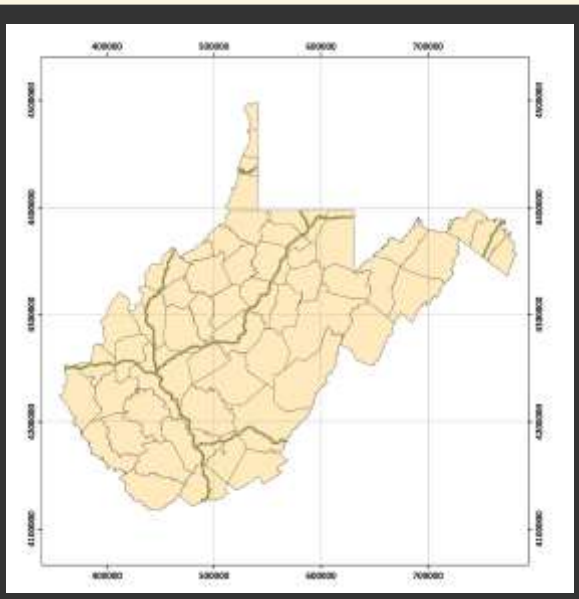
Graticules represent latitude and longitude or parallels and meridians, and they are often used on small scale maps. They can be used to represent scale and orientation.

Coordinate Grid



54

Coordinate grids are similar to graticules except that a projected coordinate system is displayed as opposed to latitude and longitude. An example would be a UTM grid of easting and northing values.

Reference Grid

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Reference grids break the map space into labeled rows and columns. In the example above, the map space is divided vertically into columns A through E and horizontally into rows 1 through 5.

Legend Tips

1. You do not need to include all information
2. Often can leave out base map data
3. Never have file names in the legend
4. Never label the legend as “legend”
5. Make sure units are clear
6. Place elements in a logical order
7. Use the same font as other map elements
8. Should fit within the visual hierarchy of your map
9. Think about the size and positioning of your legend
10. Legends can be converted to graphics
11. Legend elements can be ungrouped
12. Legends can be edited in graphics software
13. Legends can have frames, backgrounds, and specified gaps

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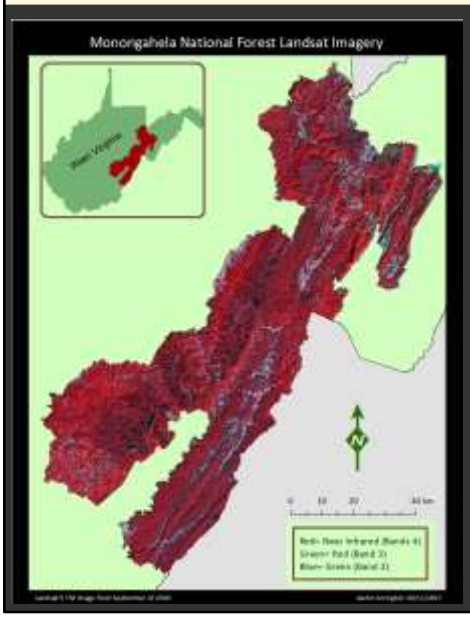
Here are some tips for designing a legend.

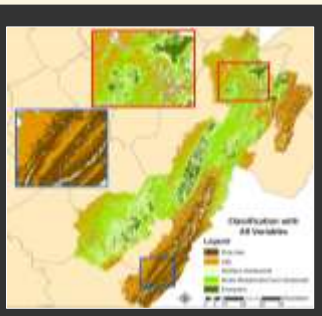
Note that it is generally not necessary to include all layers in the legend. You only need to include layers that must be described to make the map useable. It is common to include operational layers but not base map or reference layers.

One of my pet peeves is including file names or field names in the legend. All text should be meaningful.

It is generally considered unnecessary to label a legend with a title of “Legend,” so avoid doing this. Provide a meaningful legend name or no title at all.

Inset Maps





Map by Aaron Arrington

- Locator
- Enlarge important areas
- Show related topics
- Show different areas

Map by Adam Sharp

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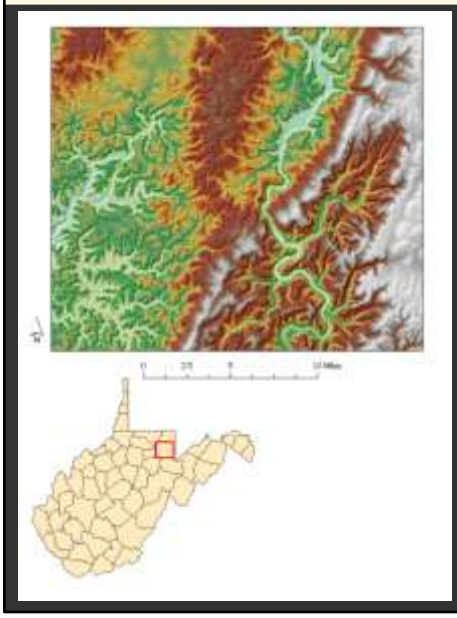
Inset maps can be used to provide a locator, or show where your main map occurs within a larger spatial extent, enlarge important areas, show related topics, or show different areas.

One common use of inset maps for the United States is to include Hawaii and Alaska in separate frames.

In ArcGIS Pro, inset maps can be created by adding additional map frames to a layout.

Extent Indicators



- Show the extent of one map on another map

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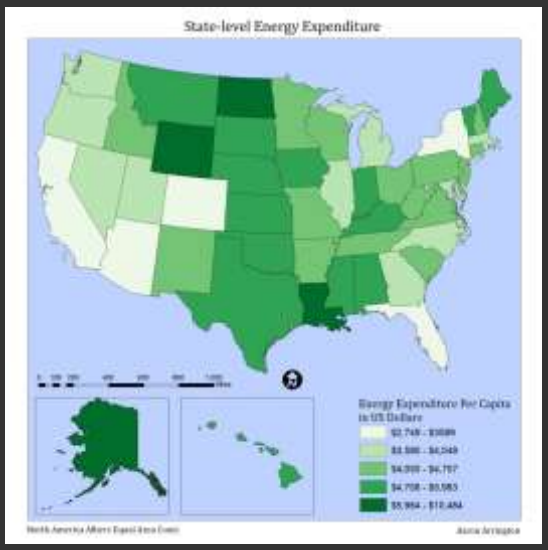
Relating to inset maps, extent indicators can be used to show the extent of one map on another, smaller scale map.

In the example provided, the extent of the terrain map is shown within West Virginia.

Extent indicators can be useful for making the spatial relationships between different map frames clear.

Frames and Neatlines



- Divide space
- May be useful for providing visual hierarchy

Map by Aaron Arrington

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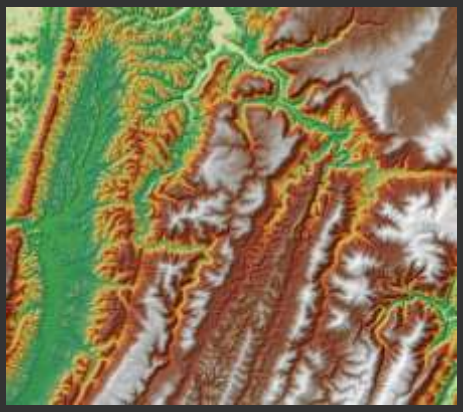
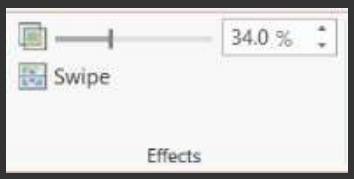
One means to establish visual hierarchy or offset specific features from the rest of the layout is to include frames and/or neatlines. In the example, frames have been added to the main map and the two inset maps.

Transparency



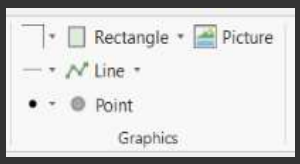
- Transparency can be effective in overlay



60

Transparency can be used to combine overlapping layers. In the example, a hillshade and digital terrain model have been displayed with transparency to visualize a terrain using a combination of color and shaded relief.

Insert Graphics



- Make sure graphics are of adequate quality
- Make sure you have permission to use the graphic

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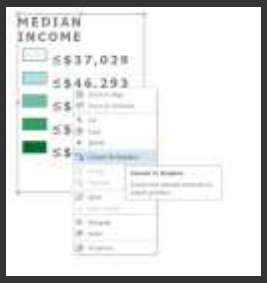
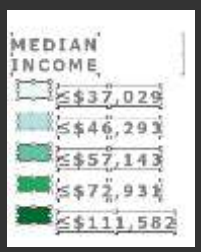
You can add graphics to a map as vector or raster graphics. For example, you could provide your company logo or insert a chart or graph. If you add graphics to your layouts, make sure they are of adequate quality and resolution for the display scale.

Convert to Graphic/Group/Ungroup

- Can convert map element to graphics for further editing
- Can group and ungroup map elements





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Some map layout elements, such as legends and scale bars, can be converted to graphics.

Once converted to graphics, the elements can be ungrouped so that they can be edited separately. It is also possible to group elements.

You should wait to convert objects to graphics until your layout is nearly complete because, once converted to graphics, they are no longer dynamic. For example, if you change the scale of the map, the scale bar will not update. If you change the symbology, the legend will not update.

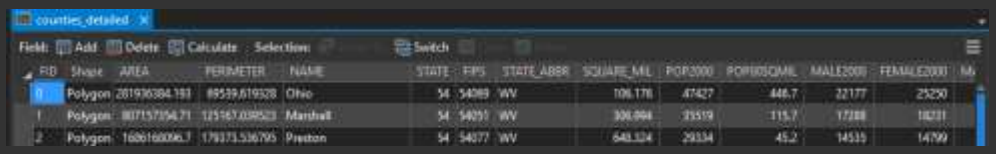
Legend Classification

Non-Spatial Data in GIS

Attributes = non-spatial characteristics associated withspatial data

Categorical
- Nominal = A unique identifier or unique types
- Ordinal = Ranked data

Numeric
- Interval = Difference between numbers is significant, but no fixed, non-arbitrary zero point
- Ratio = Difference between numbers is significant, and there is a fixed, non-arbitrary zero value



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We will now discuss how data are classified. This is an important consideration, since different types of data are often visualized and analyzed differently.

Data can be broken into two broad categories: categorical and numeric.

Categorical data represent discrete categories that are either unordered (nominal) or ordered (ordinal). Examples of nominal data include land cover types, soil types, or vegetation types while an example of ordinal data would be rankings such as 3rd place, 2nd place, and 1st place.

Numeric data represent continuous numbers or measures and can be further subdivided into interval and ratio types. For both types the difference between subsequent numbers is fixed; for example, the length difference between 2 meters and 3 meters is the same as the difference between 7 meters and 8 meters. However, they differ in regards to how the zero value is defined. For interval data, the zero value is arbitrary whereas this value is non-arbitrary for ratio data. Temperature in Fahrenheit or Celsius is an example of interval data as zero temperature on these scales does not mean “no temperature.” Further, ratios cannot be calculated for interval data because, without a fixed zero value, values that are twice as large do not indicate twice the magnitude. For example, 40° Celsius in not twice as hot as 20° Celsius. Examples of ratio data

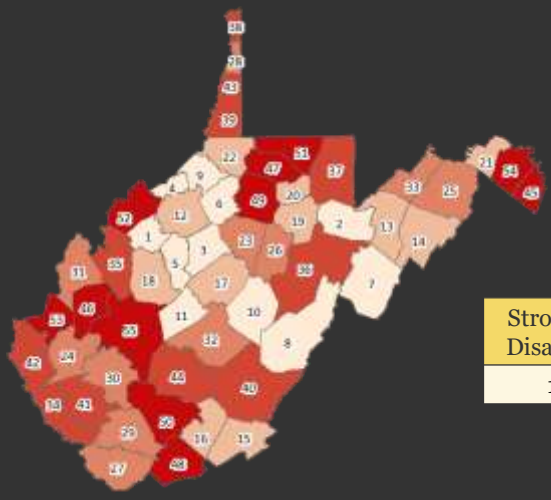
include lengths, areas, and percentages since the zero value does have meaning or is non-arbitrary. For example, 0% unemployment indicates that no proportion of the working population is unemployed.

Nominal Data

This slide provides some examples of nominal data as county names, county FIPS codes, and land cover categories. These are all unique categories with no implied order.

Note that it is possible to use numbers to represent categories. For example, FIPS, or Federal Information Processing Standard, codes are numbers. However, in this case they are not being used as numbers. Instead, they are being used to represent a specific feature. Another similar example would be ZIP codes.

Ordinal Data



Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

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Ordinal data represent categories with an applied order, such as ranks.

Survey questions, such as Strongly Disagree to Strongly Agree (Likert Scale), are also ordinal data since there is an implied order in the categories.

Interval Data

Image from the National Weather Service

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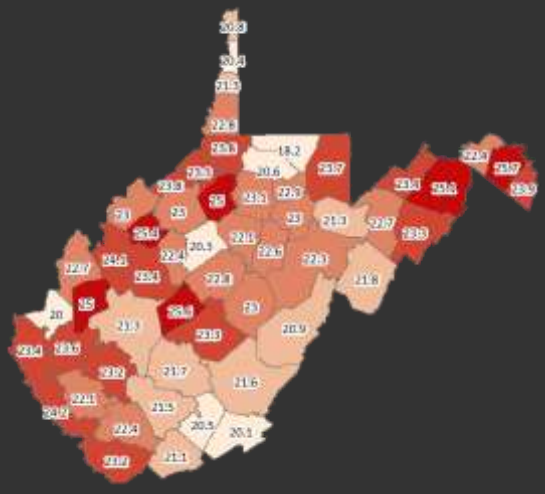
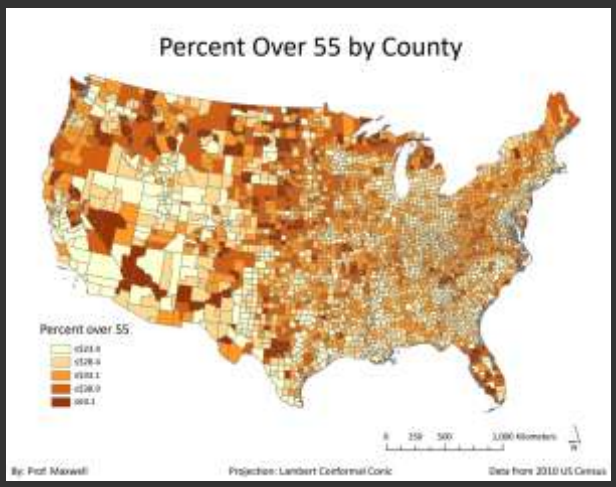
Temperature in Fahrenheit or Celsius units and time are examples of interval data.

The zero value is arbitrary and meaningful ratios cannot be calculated.

Ratio Data





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Percentages are examples of ratio data.

The zero value is non-arbitrary and meaningful ratios can be calculated.

Layer Symbology in ArcGIS

- Same symbol for all features
- Different symbol for each category or unique value
- Graduated colors
- Unclassified colors
- Graduated symbols
- Proportional symbols
- Dot Density

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There are many different ways to symbolize data, as highlighted by the different types of thematic maps previously discussed.

You can display each feature with the same symbol, for example display all polygons as black outlines with a gray fill. In this case, you are not showing a theme, just the spatial extent.

For categorical data, you can use different colors to represent different categories. You can also assign a different color to each unique feature.

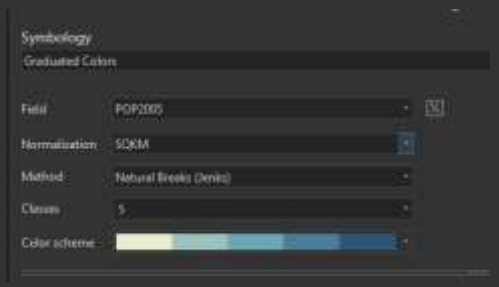
Graduated colors and unclassified colors are used to produce choropleth maps to symbolize numeric or ordinal data.

Graduated and proportional symbols are used to produce graduated and proportional symbol maps that use size to represent a quantity.

Dot density is used to generate dot density maps.

Normalization

- Divide value by another value to normalize the measurements
- For example: population vs. population per square kilometers
- Provides for a fairer comparison
- Should normalize when producing choropleth maps



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When symbolizing a quantity, it is also possible to apply normalization.

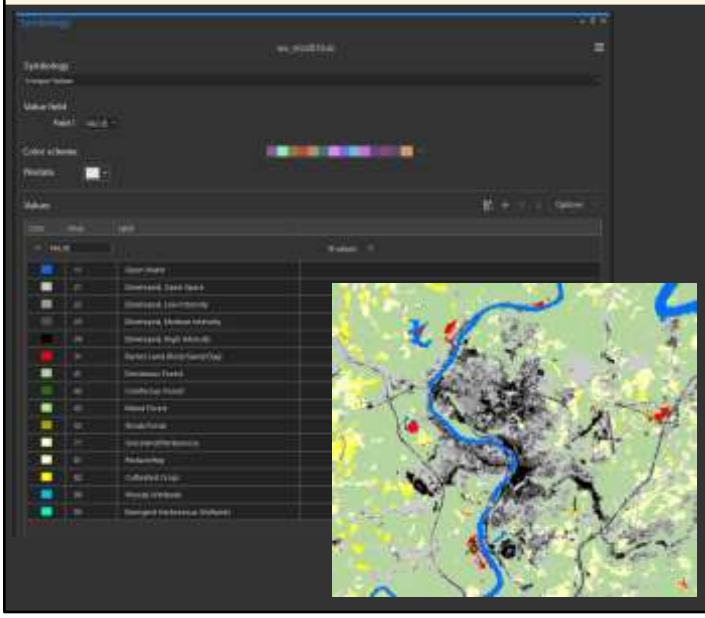
To apply normalization, an attribute is divided by another attribute. For example, population can be normalized by area to obtain population density. The number of disease occurrences can be normalized by population to obtain the rate of the disease in the population.

It is possible to normalize by area or by number of individuals.

All proportions or percentages are already normalized.

When generating choropleth maps, normalized data should be used. This is not required when generating proportional or graduated symbol maps.

Symbolizing Categories



- Land cover type, private vs. public, urban vs. rural, soil types, etc.
- Use colors that make sense for the category (if appropriate)
- Colors should not be ordered

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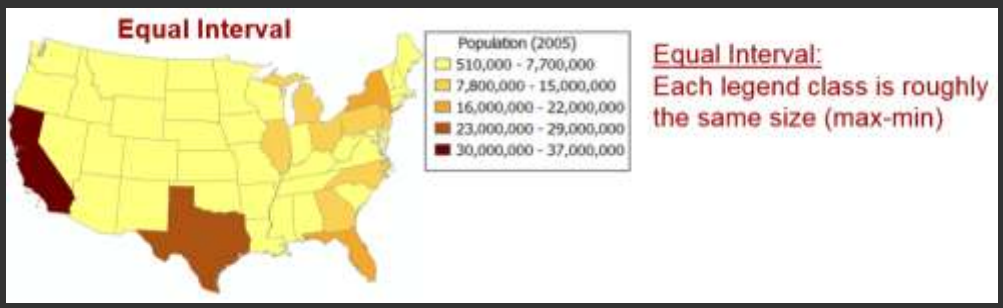
When you display nominal data using colors, it is best to use non-order colors, since you don't want to imply that the data are ordinal or numeric.

Some features are commonly associated with a color. For example, in a land cover dataset water is generally associated with blue and forest is associated with green. In these cases, it is best to use colors that are associated with these features.

Some features will not have colors that are associated with them. For example, we don't generally associate colors with soil types. In this case, you would choose colors based on visual appeal and the ability to tell the categories apart.

Equal Interval

- Breaks data range into equal intervals
- Does not take into account natural breaks in the data



Created by Mike and Jackie Strager

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When using colors to map a quantity, the data are often binned so that a range of values is represented by a single color.

In ArcGIS, this is known as graduated colors. This binning or classification is also performed for graduated symbol maps.

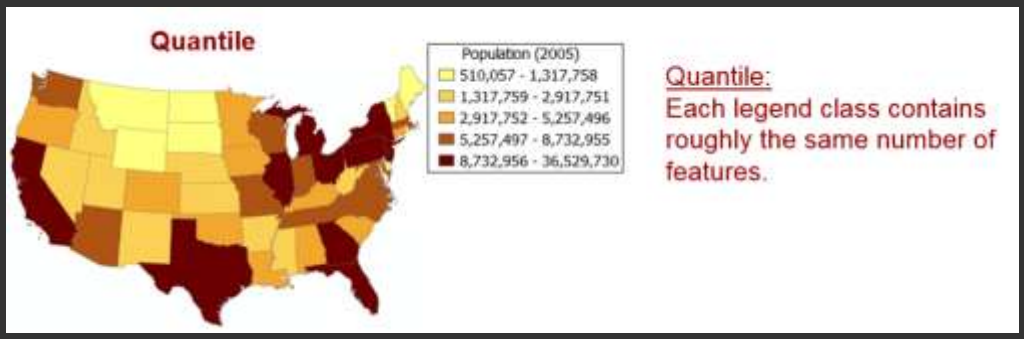
A method must be used to determine breaks between the bins.

One method used is equal interval. In this case, the same range of values occur in each bin.

For example, if you had a range of values from 0% to 100% and five bins, then the data would be divided into 0-20%, 20-40%, 40-60%, 60-80%, and 80-100%.

Quantiles

- Same number of features in each bin
- Does not take into account natural breaks in the data



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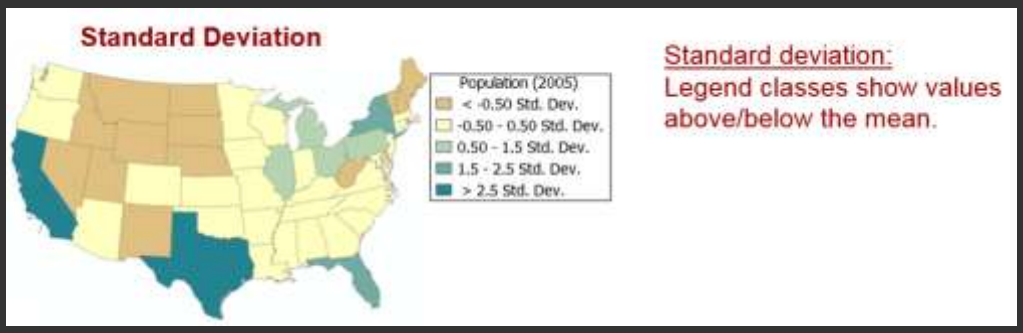
The quantiles classification method is commonly confused with equal interval. Using this method, an equal number of map features is placed in each bin as opposed to an equal range of values.

For example, if all 50 states were being symbolized using 5 classification bins, then 10 states would be placed in each bin.

This is generally the preferred classification method for ordinal data.

Mean-Standard Deviation

- Bins defined based on standard deviation of data subtracted or added to mean



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The mean-standard deviation method makes use of the central tendency and variability of the data.

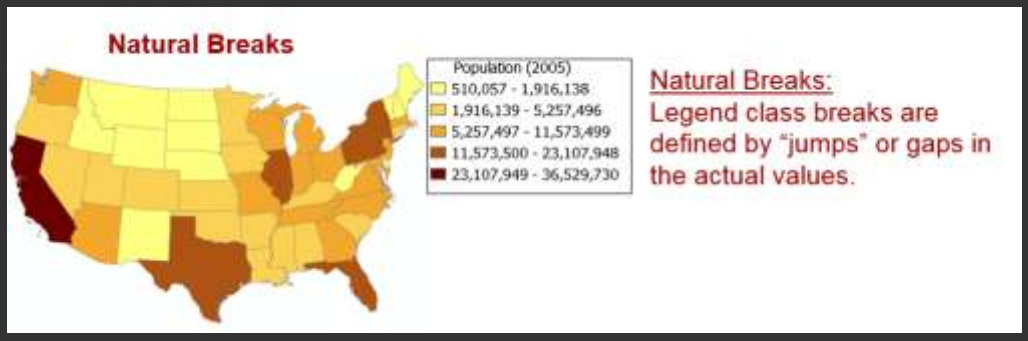
The data are symbolized based on their standard deviation from the mean. Values that are much lower than the mean will show a negative standard deviation, values close to the mean will have a standard deviation near zero, and values much higher than the mean will have a positive standard deviation.

This method can be useful if you want to compare how a feature deviates from the average or mean conditions.

This method generally should not be used if the data have a distribution that is far from normal, such as multimodal or skewed data.

Jenks-Caspell/Fisher-Jenks

- Algorithms that attempts to find "natural breaks" in the data
- ArcGIS uses an implementation of Fisher-Jenks



Created by Mike and Jackie Strager

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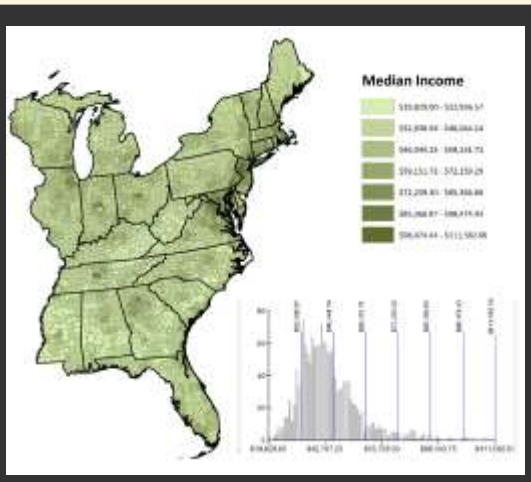
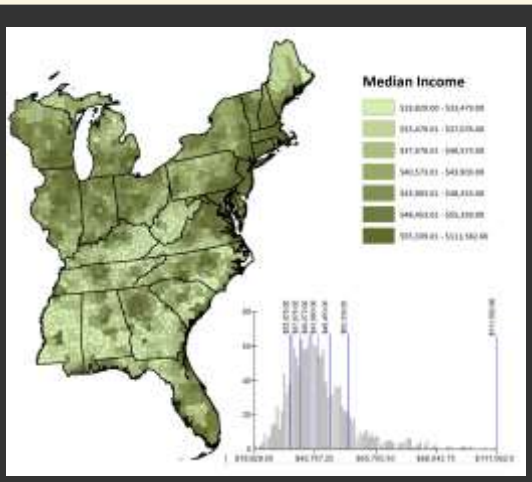
The natural breaks method makes use of an algorithm to find "natural breaks" in the data. Class breaks are then positioned relative to these natural data breaks. This is a data-driven classification scheme.

It can be misleading if there are no breaks, jumps, or gaps in the data distribution. In that case, it would be finding breaks that don't really exist or are just noise.

Classification Methods Compared



Equal Interval



Quantile

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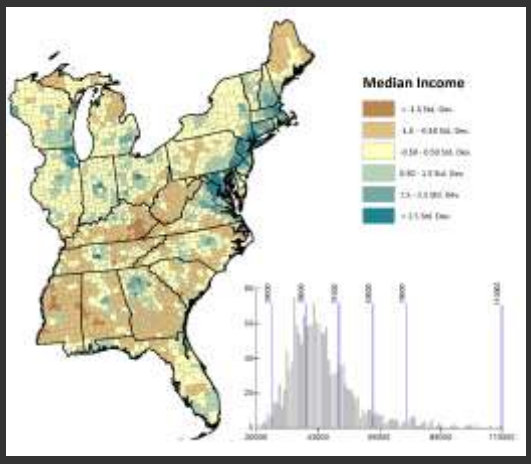
Here are some comparisons.

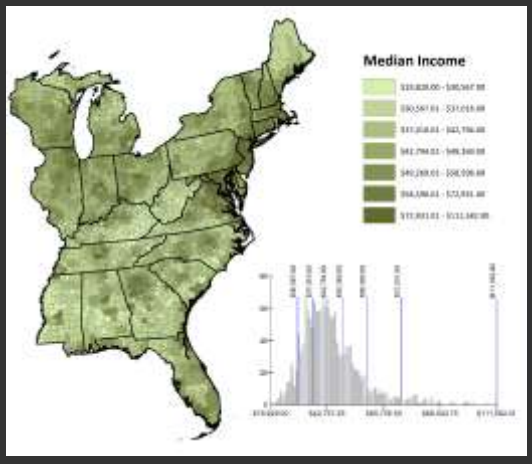
For equal interval, the class breaks, represented by the blue lines in the distribution, are equally spaced, or there is an equal range of values in each classification bin.

In contrast, the breaks are not evenly spaced for the quantile classification. Instead, a roughly equal number of features will be placed in each bin.

Classification Methods Compared



Mean-Standard Deviation



Natural Break

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In the mean-standard deviation classification, we can represent deviation from the mean median income by county. Orange counties are lower than the mean while blue counties are higher than the mean.

The last example represents natural breaks in which an algorithm selects the breaks based on jumps or gaps in the data distribution.

There is not necessary a best classification method, as this is case specific and there are pros and cons for each. When deciding on a classification method, you should think about the nature of the data and how best to represent it.

Manual Classification

- Define your own breaks

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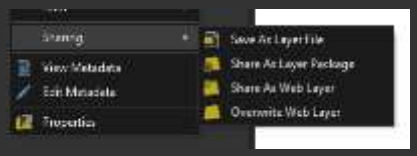
It is also possible to define your own breaks or classification bins. When you do this, it is important to not manipulate the data to tell the story you want to tell. There is a whole book on this topic called “How to Lie with Maps.”

If you decide to use manual breaks it is generally best if the breaks have some meaning.

For example, if a program that awards grant money for economic development to counties makes its decision based on certain percent poverty thresholds, it would make sense to symbolize using these thresholds to see which counties are candidates for a certain dollar amount from the program.

Layer Files (ArcGIS)

- Can be used to save layer symbology for later use



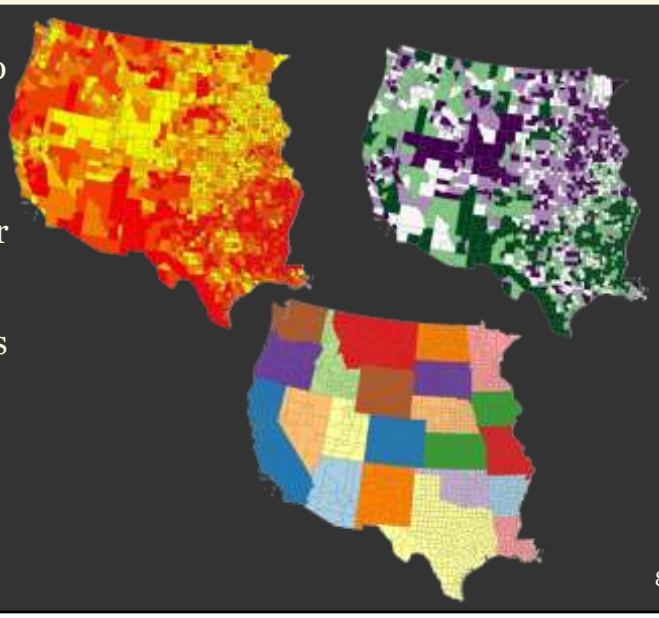
79

Layer files can be generated in ArcGIS Pro to store the symbology used to display a layer. This will include the legend labels and the display method.

If you plan to reuse the symbology, I would recommend saving it as a layer file.

Color Ramp

- You can change the colors used to symbolize your data
- You can also change the number of categories
- Nominal Color Scheme = used for categorical data (not ordered)
- Sequential Color Scheme = used for continuous data that increases in one direction
- Diverging Color Scheme = used for continuous data that diverges
- Think about how we perceive colors



80

Different types of color ramps are available to symbolize data.

Nominal color schemes are used to display nominal data or unordered categories. Since you don't want to imply an order, you should never use ordered colors. In the example above, unordered colors are assigned to represent each different state.

Sequential color schemes are used when data values increase in one direction. For example, you could use this to symbolize elevation, temperature, or median income.

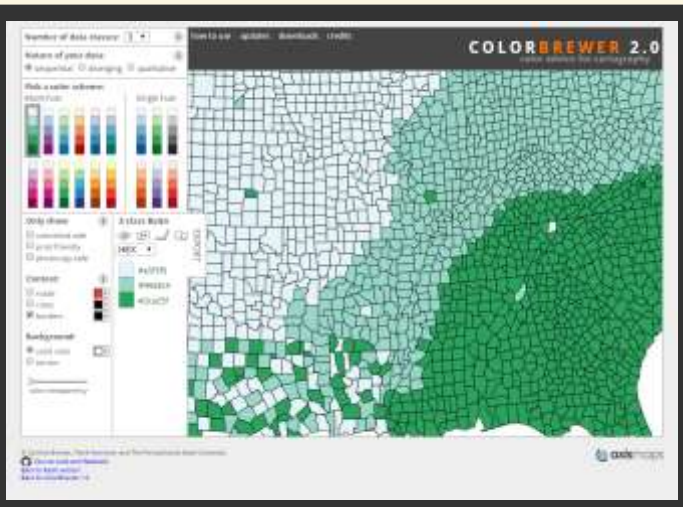
Divergent color schemes are used to symbolize patterns that diverge. You could use this method to display population change where one set of ordered colors represents loss, another represents gain, and a neutral color represents no change. Diverging ramps are also commonly applied to data classified with the Mean-Standard Deviation method since it shows divergence or difference relative to the mean.

Other than just choosing from one of these color schemes, you can also choose what colors and number of classification bins to use.

It is also important to think about how we perceive color. For example, in

western cultures, red generally indicated danger or alert while blue indicated calm or safe. Green could indicate money/currency or ecological health. These perceptions are important to consider, as they can have a large intended or unintended impact on how your maps communicate data.

ColorBrewer 2.0



http://colorbrewer2.org/#type=sequential&scheme=BuGn&n=3

81

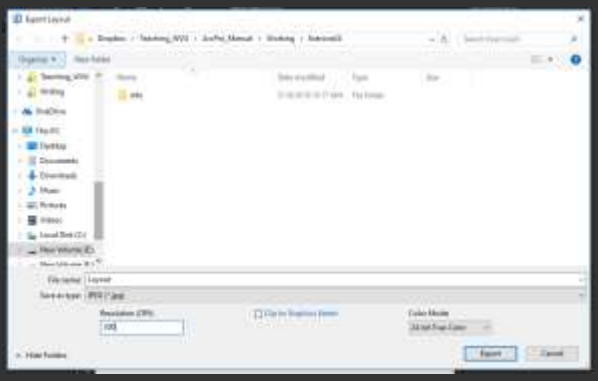
The ColorBrewer2 website is made available by Cynthia Brewer, Professor of Geography at Penn State. This website can be used to help you decide on appropriate colors to use in a map layout. It provides options for sequential, diverging, and qualitative color schemes. You can also explore colors that are color vision impairment, print, and photocopy safe. You can also change the number of bins.

Once you have found a color ramp you like, these colors can be applied to a map in your GIS or graphics editing software using the provided HEX, CYMK, or RGB codes.

This is a great site, and I highly recommend that you check it out.

Map Export and Sharing

Export Resolution



- Measured in dpi (dots per square inch)
- Pixels per square inch for screens
- In this class, 300 dpi is good

83

Resolution for pixel-based or raster images are measured in dots per square inch (dpi) or pixels per square inch (ppi). In print, dots per square inch represent the number of dots that are placed within a square inch of paper. On the screen, pixels per square inch represent the number of pixels in a square inch of screen space.

I generally recommend using at least 300 dpi/ppi when publishing maps; however, you should determine what is required for your specific publication outlet.

Increasing the dpi will increase the file size.

File Formats

- JPEG (Joint Photographic Exerts Group)
- TIFF (Tagged Image File Format)
- PDF (Portable Document Format)
- AI (Adobe Illustrator)
- PNG (Portable Network Graphics)
- BMP (Bitmap)
- EPS (Encapsulated PostScript)
- EMF (Enhanced MetaFile)
- SVG (Scalable Vector Graphic)

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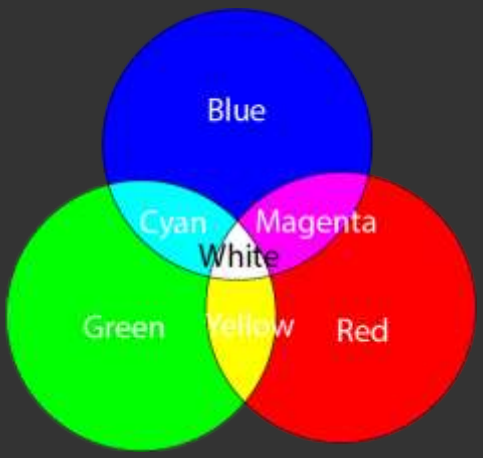
There are many different file formats to which your map layouts can be exported.

If you are exporting to a pixel-based or raster file, I would suggest TIFF for uncompressed files. JPEG and PNG are good pixel-based formats for compressed or smaller files. They are often used on websites.

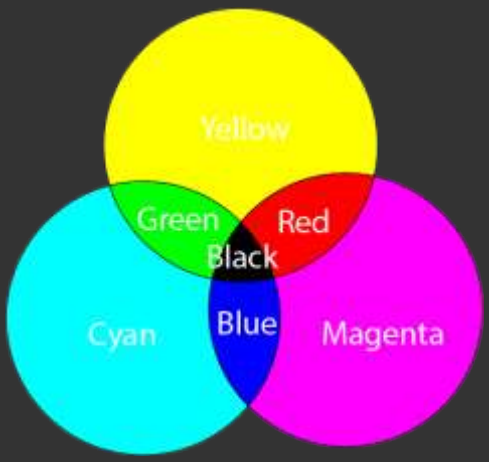
If you plan to export as a vector graphic, I recommend SVG.

PDF files offer a middle ground, as they incorporate some components of raster files and vector files. They can generally be edited in vector graphics editing software.

Color Space



Additive Colors = used with computer monitors



Subtractive Colors = used in printing

85

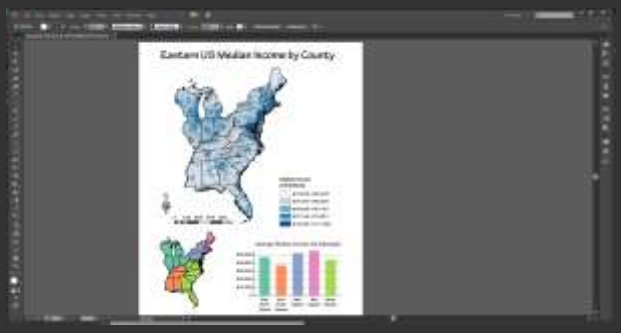
Additive color space is generally used when you are working with projected light, such as computer monitors, web sites, or projectors.

In contrast, subtractive color space is generally used when you are working with inks and print, such as printed books or journals.

So, if you are making a map to show on a computer screen, you should use additive color space. If you are needing to print a map, use subtractive color space.

Vector Graphics

- Allows you to edit your map in a graphics software such as Adobe Illustrator in a vector environment
- Important export option when you want to further edit your map in graphics software
- AI, EPS, or SVG formats are a good choice
- Vector graphics editing software:
  - Adobe Illustrator: https://www.adobe.com
  - Inkscape: https://inkscape.org/en/



86

Vector graphics allow you to edit your map in a graphics editing software such as Adobe Illustrator or Inkscape.

Vector file formats include AI, EPS, and SVG.

Vector graphics are different from pixel-based or raster graphics, as they allow you to edit text and vector objects, such as points, lines, and polygons, as part of the post-production process. This information is generally not maintained for raster graphics.

So, if you want to do additional graphics editing on your maps outside of your GIS software, it is generally best to export to a vector format. If you are looking for a free vector graphics editing software, I would suggest Inkscape.

Web Maps

- We will discuss this in more detail later

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Another way to represent map data is as an interactive map on a webpage, web app, or mobile app. We discuss this in a separate module.

Symbology and Cartography In ArcGIS Pro

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This section provides some specific examples within ArcGIS Pro.

Symbology Pane

Right-click on layer in Contents Pane → Symbology

- Choose attribute/method to symbolize data
- Edit bin number and breaks
- Configure legend
- Import symbology

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The Symbology Pane is used to change layer symbology.

Editing Specific Symbols

- Click on Symbol in Contents Pane
- Select from Gallery
- Configure with Properties

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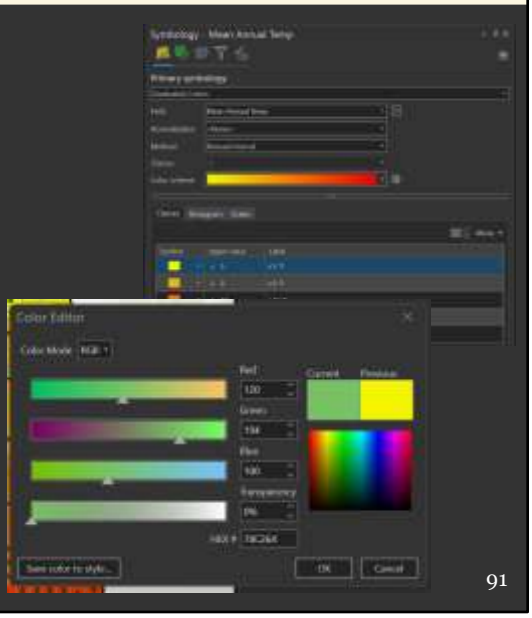
This slide describes how to select and edit individual symbols.

Symbology in ArcGIS Pro (Vector)

- Right-click layer in Contents Pane → Symbology
- Symbology options will depend on layer type
- Methods = Single Symbol, Unique Values, Graduated Colors, Bivariate Colors, Unclassified Colors, Graduated Symbol, Proportional Symbol
- Selecting Colors
  - Gallery
  - Properties



91

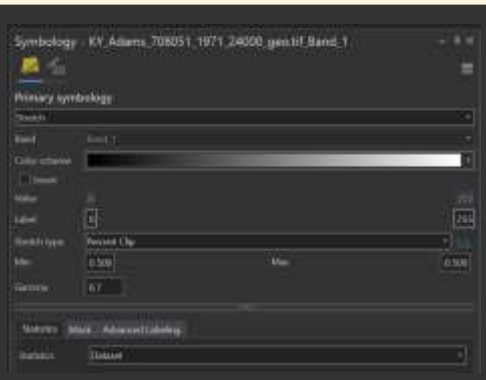
This slide discusses symbology options within ArcGIS Pro for vector data specifically. Symbology options can be accessed by right-clicking on the layer in the Contents Pane then selecting symbology. This will open the Symbology Pane.

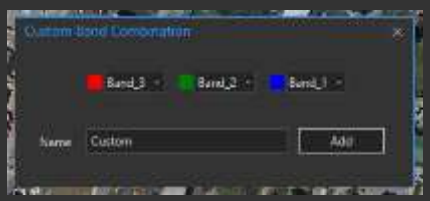
A variety of methods are available to symbolize vector data. A single symbol can be used when no attribute information is displayed. When categories are differentiated, you can use Unique symbols. To show or map a continuous variable, you can use graduated colors, unclassified colors, graduate symbols, or proportional symbols. To display two continuous variables using two color ramps, you can use bivariate colors.

You can choose from pre-defined colors and symbols using the Gallery in ArcGIS Pro. To select your own symbols and associated graphical parameters, you can use the Properties options in ArcGIS Pro.

Symbology in ArcGIS Pro (Raster)

- Right-click layer in Contents Pane → Symbology
- Symbology options will depend on layer type
- Methods = RGB, Stretch, Discrete, Classify, Unique Values, Vector Fields
- Selecting Colors
  - Gallery
  - Properties





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Symbolizing raster data in ArcGIS Pro is similar to symbolizing vector data; however, different symbology options are available. Symbology options can be accessed by right-clicking on the layer in the Contents Pane then selecting Symbology.

RGB symbology can be used to display a multi-band raster grid as an RGB composite where bands or layers are assigned to the RGB channels. This is commonly used for imagery to generate simulated true color or false color composites.

For single-band raster grids, data can be symbolized using stretch, discrete, classify, unique values, or vector fields methods. For continuous data, stretch and classify are commonly used. For categorial raster data, such as land cover, unique values are commonly used.

Raster Layer Tab

- Visibility scales
- Transparency
- Blending mode
- Swipe
- Symbology
- Contrast stretch
- Band combinations
- Masking
- Brightness, contrast, gamma

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This slide lists some of the options for symbolizing raster data that are provided in the Raster Layer tab.

Layer Symbology in ArcGIS

- Same symbol for all features
- Different symbol for each category or unique value
- Graduated colors
- Unclassified colors
- Graduated symbols
- Proportional symbols
- Dot Density

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There are many different ways to symbolize data, as highlighted by the different types of thematic maps previously discussed.

You can display each feature with the same symbol, for example display all polygons as black outlines with a gray fill. In this case, you are not showing a theme, just the spatial extent.

For categorical data, you can use different colors to represent different categories. You can also assign a different color to each unique feature.

Graduated colors and unclassified colors are used to produce choropleth maps to symbolize numeric or ordinal data.

Graduated and proportional symbols are used to produce graduated and proportional symbol maps that use size to represent a quantity.

Dot density is used to generate dot density maps.

Change Single Symbol

1. Navigate to the vectorSymbology map.
2. Right-click on symbol associated with the usDataAgg layer in the Contents Pane.
3. Select a new color.

Alternative:

1. Double-click on the usDataAgg layer in the Contents Pane. This will open the Symbology Pane.
2. Select a new symbol from the Gallery or change the symbol options using Properties.

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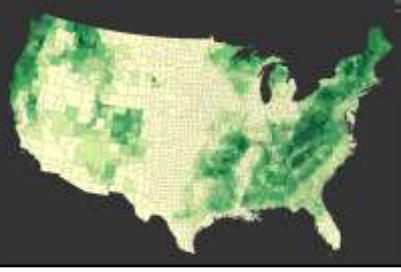
The following exercises step you through working with layer symbology and map layout design in ArcGIS Pro.

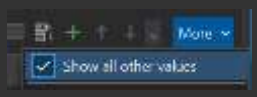
Choropleth Symbology (Continuous Variable)

1. Right-click on the usDataAgg layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
2. In the Symbology Pane make the following changes:
   - Change the **Primary Symbol** to *Graduate Colors*
   - Set the **Field** to "per_for" (percent forest cover for the county)
   - You do not need to apply **Normalization**
   - Change the **Method** to *Equal Interval*
   - Change the number of **Classes** to 7
   - Change the **Color Scheme** to a ramp you feel is appropriate for displaying percent forest cover



Choropleth Symbology (Categorical Variable)

1. Right-click on the usDataAgg layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
2. In the Symbology Pane make the following changes:
   - Change the **Primary Symbol** to *Unique Values*
   - Set the **Field** to "SUB_REG" (subregion of country in which county occurs)
   - Experiment with selecting a **Color Scheme**
   - Experiment with Changing the labels in the legend as follows: *East North Central*, *East South Central*, *Mid-Atlantic*, *Mountain*, *New England*, *Pacific*, *South Atlantic*, *West North Central*, and *West South Central*.
   - In the More options for the legend, deselect *Show all other values*.



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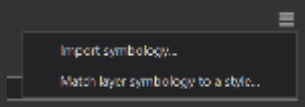
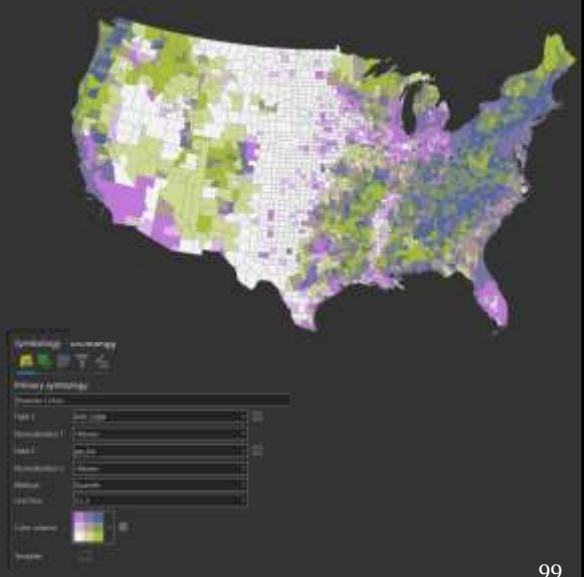
Save/Use Layer File

1. Right-click on the usDataAgg layer in the Contents Pane and select Sharing → Save As Layer File.
2. Save the symbology as a layer file to the rawFiles folder.
3. To apply the saved symbology, change the usDataAgg layer to a *Single Symbol* symbology type
4. Next, change it back to a *Unique Values* type.
5. Click on the hamburger menu in the Symbology Pane for the layer and select Import symbology…
6. In the Apply Symbology From Layer Tool set the following settings:
   - **Input Layer** = usDataAgg
   - **Symbology Layer** = saved .lyrx file
   - You should not have to make any other changes
   - Click Run to execute the tool. This should re-apply you saved symbology.



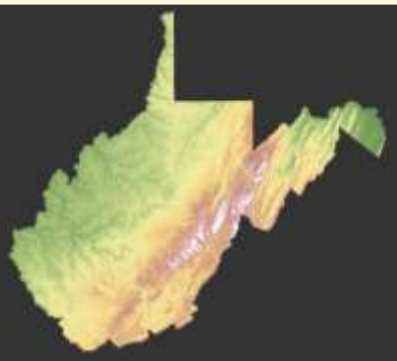
Bivariate Choropleth Symbology

1. Right-click on the usDataAgg layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
2. In the Symbology Pane make the following changes:
   - Change the **Primary Symbol** to *Bivariate Colors*
   - Set **Field 1** to "per_for" (percent forest cover for the county)
   - Set **Field 2** to "POP_SQM" (population density in people/sq. mi.)
   - Change the **Color Scheme** to a method you feel is appropriate for displaying these variables
   - You do not need to make any additional changes



Continuous Raster Symbology

1. Navigate to the rasterSymbology map.
2. Turn off the wvLC layer in the Contents Pane using its radio button.
3. Right-click on the wvDEM10m layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
4. With the **Primary Symbology** set to *Stretch* (should be the default) choose a new **Color Scheme** to display the layer.



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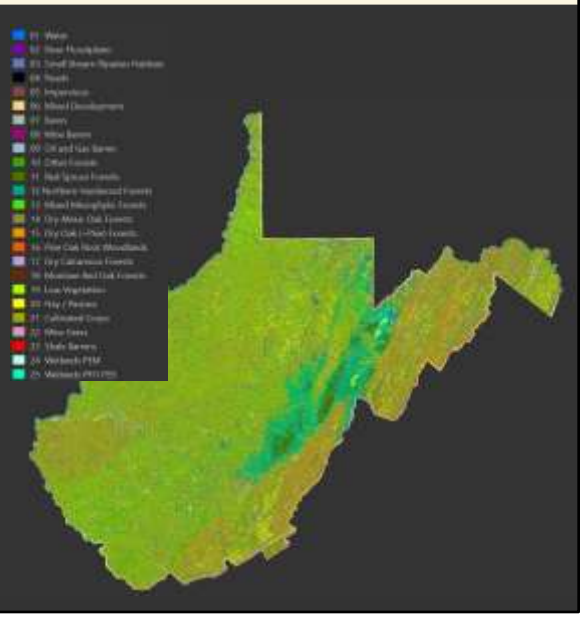
Categorical Raster Symbology

1. Navigate to the rasterSymbology map.
2. Turn on the wvLC layer in the Contents Pane using its radio button.
3. Right-click on the wvLC layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
4. Click on the hamburger menu in the Symbology Pane for the layer and select Import from layer file...
5. Select the WV_LULC_NAIP_2018.lyr file from rawFiles folder.

The symbology should now be updated.



Proportional Symbols

1. Navigate to the vectorSymbology map
2. Right-click on the usDataAgg layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
3. In the Symbology Pane make the following changes:
   - Change the **Primary Symbol** to *Proportional Symbols*.
   - Set **Field** to "POPULAT" (population
   - Set the **Minimum size** to *4 pt* and the **Maximum size** to *24 pt*.
   - You can experiment with changing the point symbol and/or background color.

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Dot Density Symbols

1. Right-click on the usDataAgg layer in the Contents Pane and select Symbology. This will open the Symbology Pane for the layer.
2. In the Symbology Pane make the following changes:
   - Change the **Primary Symbol** to *Dot Density*.
   - Set **Field** to "hosholds" (number of households)
   - Set the **Dot Size** to *2 pt*.
   - Set the **Dot Value** to *5000*.
   - You can experiment with changing other settings.

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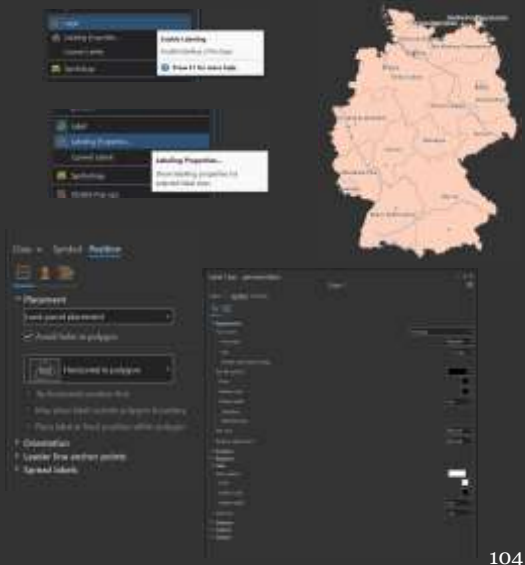
Add and Edit Labels

1. Navigate to the germany map.
2. Right-click on the germanyStates layer in the Contents Pane and select Label. This turns on the labels for the layer.
3. Right-click on the germanyStates layer in the Contents Pane again and select Label Properties.... This turn on the Label Pane.
4. Make the following changes in the Label Pane:
   - Navigate to the Symbol options and change the **font size** under Appearance to *14 pt*.
   - Change the **Font** under Appearance to *Georgia*.
   - Add a white halo under the Halo options.
   - Under the Position options, change the Placement to *Land Parcel Placement*.



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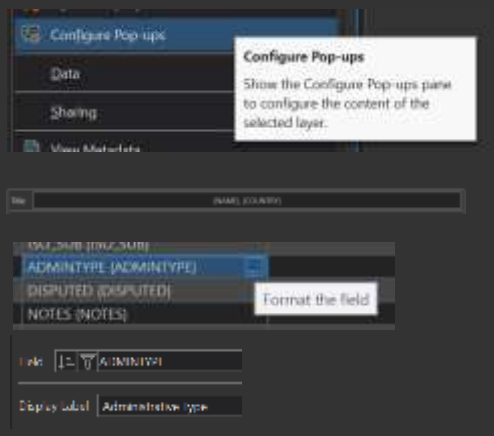
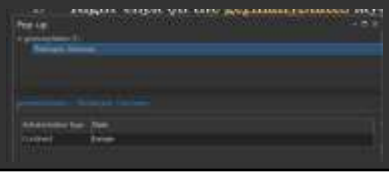
Configure Pop-Up

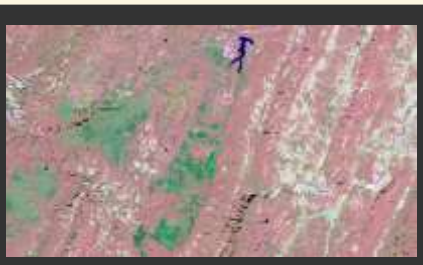
1. Right-click on the germanyStates layer in the Contents Pane and select Configure Pop-ups. This will open the Configure Pop-ups Pane. Note that the pop-ups should be enabled as opposed to disabled.
2. Make the following changes in the Configure Pop-Ups Pane:
   - Change the Title to: *{NAME}, {COUNTRY}*
   - Only show the "ADMINTYPE" *and* "CONTINENT" fields.
   - Change the Display Label for the "ADMINTYPE" field to "Administrative Type" and the Display Label for the "CONTINENT" field to "Continent". This can be accomplished using the Format the field options within the field list in the Configure Pop-Ups Pane.
3. Click on a German state in the map to test your pop-up configuration.





Change Band Combinations

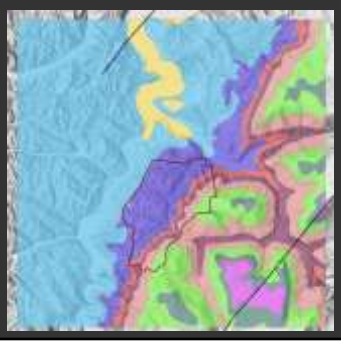
1. Navigate to the imagery map.
2. Make sure the s2LeafOff image is selected in the Contents Pane.
3. Navigate to the Raster Layer Tab and click the Band Combinations icon and select Custom.
4. Change the Band Combination to **Red** = *Band_10* (SWIR2), **Green** = *Band_7* (NIR), and **Blue** = *Band_2* (Green).



The image should be updated in the map to reflect the new band combination.

Prepare Map for Layout

1. Navigate to the fernow map.
2. Turn off the base map layers (World Topographic Map and World Hillshade).
3. From wvData.gdb add the wvDEM10m layer.
4. Using the Raster Functions, as demonstrated above, calculate a hillshade from the wvDEM layer.
5. Apply the geology_legend.lyr layer file to the fernowGeology layer to use a pre-defined symbology.
6. Apply the folds_legend.lyr file to the folds layer to use a pre-defined symbology.
7. Apply a transparency to the fernowGeology layer so that the hillshade is visible beneath it. This option is available under the Feature Layer Tab when the geology layer is selected in the Contents Pane. We used a 30% transparency.
8. Change the symbology for the fernowBoundary layer so that it is hollow with an outline.
9. For each vector layer in the map, change the layer name using the General options in the Layer Properties window to give them more meaningful/user-friendly names.



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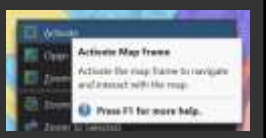
Create New Map

1. Create a new map using the Catalog View. Add the countiesWV layer from wvData.gdb and apply a desired symbology.
2. Turn off the base map layers.

Create New Layout

1. Navigate to the Insert Tab. Click on the New Layout icon.
2. Choose a paper size of 8.5” by 11” in a landscape orientation.
3. Add the fernow map to the layout by selecting it from the options available when clicking the Map Frame icon in the Map Frames area of the Insert Tab. Draw the extent in the map space. It should take up most of the page.
4. Once the map is added, right-click on it in the layout space and select Activate to adjust the extent and zoom level of the map. It should be centered over the Fernow boundary. Once you are happy with the scale and extent of the map, click the small “x” at the top of the layout view to de-activate the map.



Add and Edit North Arrow and Scale Bar

1. Make sure the fernow map is selected within the layout and click the North Arrow icon in the Map Surrounds area of the Insert Tab. Choose a north arrow and place it in the layout space.

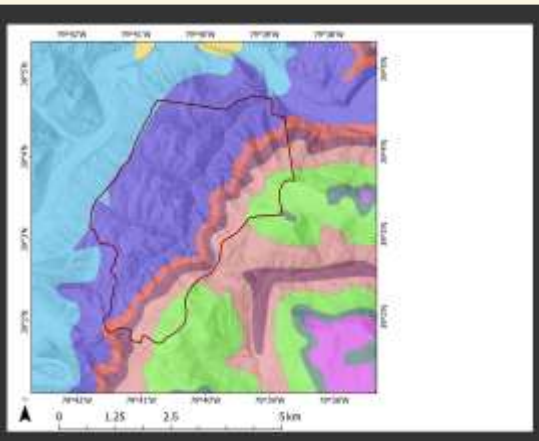
2. Make sure the fernow map is selected within the layout and click the Scale Bar icon in the Map Surrounds area of the Insert Tab. Place a scale bar of your choosing in the layout.

3. With the scale bar selected in the map layout, use the Scale Bar and Design tabs to edit the scale bar as desired. For example, we changed the font to Tahoma and the font size to 16 pt. Make sure the units are in kilometers.

Add and Edit Graticules

1. Make sure the fernow map is selected within the layout and click the Grids icon in the Map Frames area of the Insert Tab. Select a graticule style to use.
2. Double-click the graticules in the Contents Pane for the layout. This will open the Graticules Pane and allow you to configure the graticules. Take some time to improve the graticules.

Note that you may need to resize the map on the page to make room for the graticules. The scale bar will automatically adjust to compensate for scale changes.

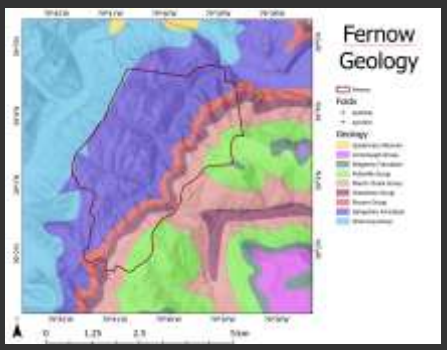


Add and Edit Legend

- Make sure the fernow map is selected within the layout and click the Legend icon in the Map Surrounds area of the Insert Tab. Choose a north arrow and place it in the layout space.
- Draw a box to place the legend on the page.
- In the Contents Pane for the layout, expand the legend. Turn off layers so that only the folds, fernowBoundary, and fernowGeolgoy layers are shown.
- Remove the attribute names for the folds and fernowGeology layers from the legend by double-clicking on the legend item in the Content Pane and turning off the Heading in the Element Pane for each element.

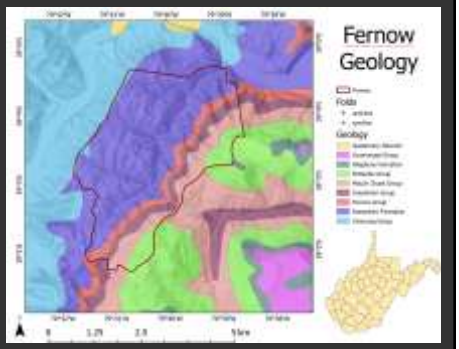
Add Title

1. Insert a tile (“Fernow Geology”) by clicking the Straight Text icon in the Graphics and Text area of the Insert Tab.
2. Draw a box within the layout to add the text. You can change its font and font size in the associated Element Pane.



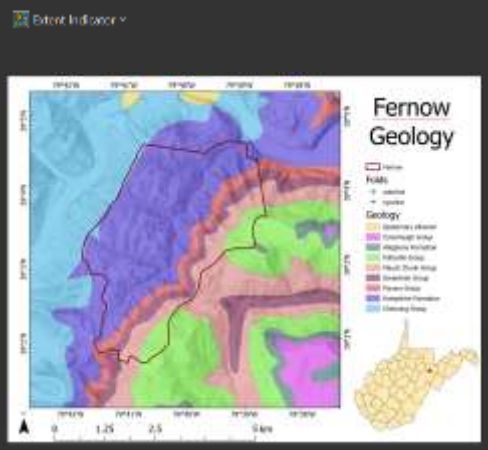
Add Inset Map

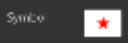
1. Add the map with the West Virginia counties to the layout by selecting the Map Frame icon in the Map Frames area of the Insert Tab and selecting the desired map. Draw a box to place it in the layout. You may need to move/resize elements to make room. This map is just an inset, so should be smaller then the Fernow map.
2. You may need to activate the map to change the extent and scale as desired.



Add Extent Indicator

1. To show the extent of the Fernow map within the West Virginia inset map, you will now add an extent indicator. With the West Virginia map active in the layout, select the Extent Indicator icon in the Map Frames area of the Insert Tab. Select the only other available map.
2. The extent indicator is small at this scale, so you will convert it to a point. Double-click the extent indicator in the Contents Pane for the layout to open its Element Pane. Change the **Collapse to Point Smaller than** option to *12pt* (or the value need to cause the symbol to convert to a point graphic).
3. Choose a point symbol to use for the indicator.





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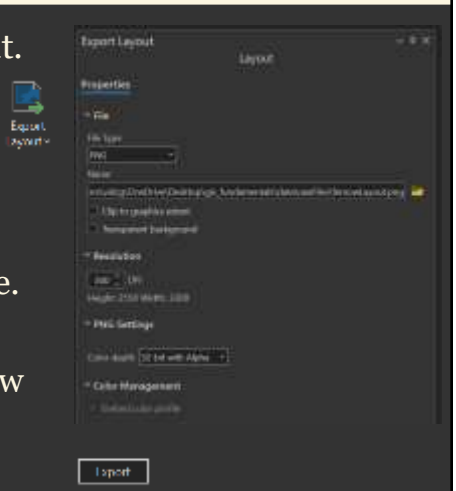
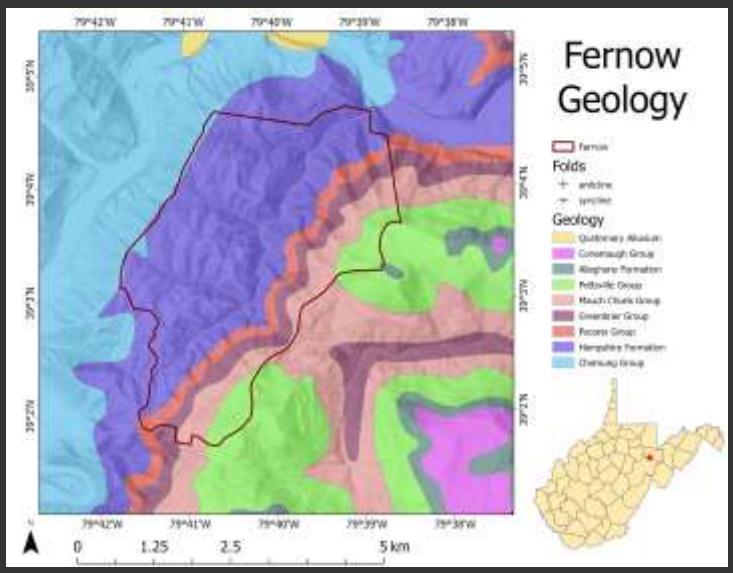
Export Map

1. Make any desired final changes to the map layout.
2. Once you are happy with your map, navigate to the Share Tab and click the Export Layout icon. This will open the Export Layout Pane.
3. Save the layout to PNG format to a location of your choosing. Click Export to save the image file.
4. Using Windows File Explorer, navigate to the location where the image is stored to open or view it.



Final Layout

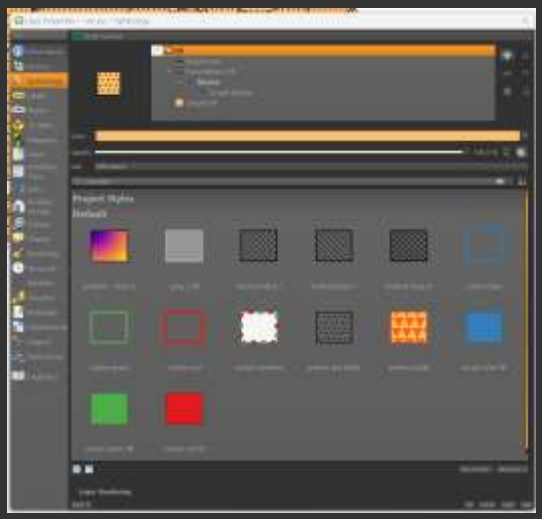


Symbology and Cartography In QGIS

118

This section provides some examples for using QGIS for data symbology and map layout design.

Symbolize Vector Data: Polygons



- Can add multiple, stacked symbols

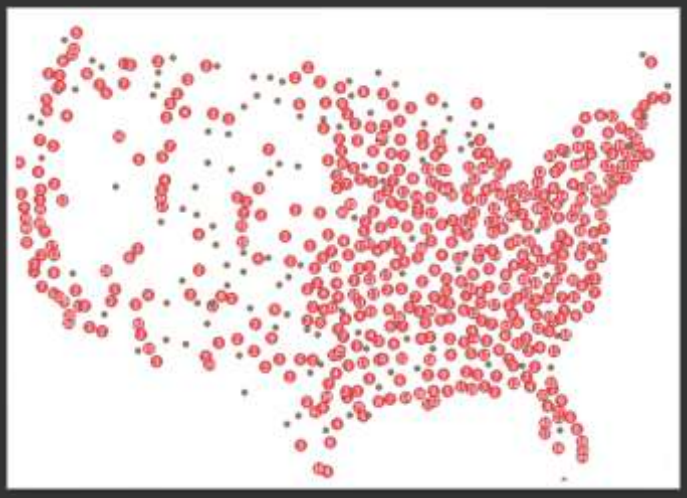
119

The following slides highlight some of the options for symbolizing vector geospatial data. These options are available under Symbology for the layer.

This slide specifically highlights options for symbolizing polygon data.

Symbolizing Vector Data: Point

- Single Symbol
- Categorized
- Graduated
- Other
  - Rule-Based
  - Point Displacement
  - Point Cluster
  - Heatmap

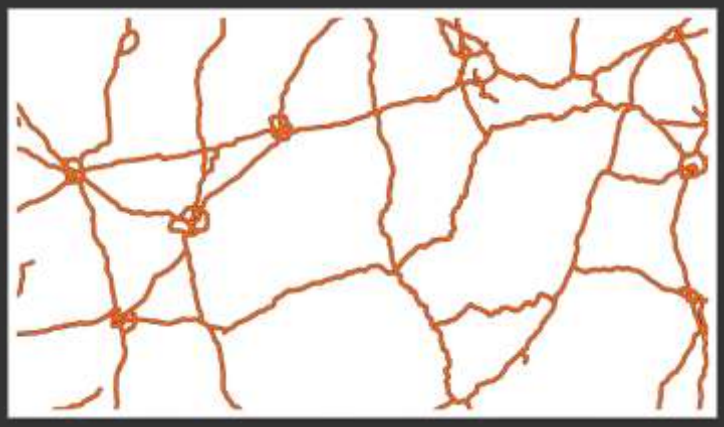


120

This slide highlights options for symbolizing point data.

Symbolizing Vector Data: Line

- Single Symbol
- Categorized
- Graduated
- Other
  - Rule-Based
  - Merged Features

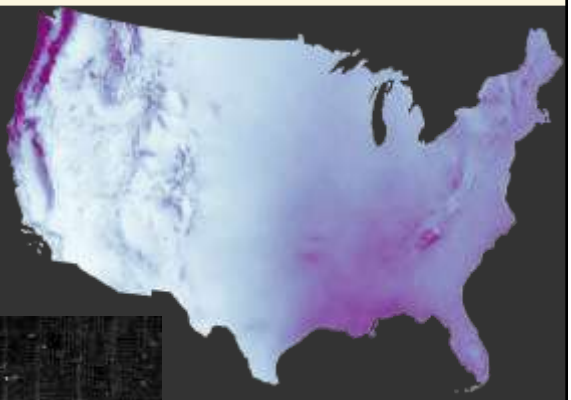


121

This slide highlights options for symbolizing line data.

Symbolize Raster Data

- Multiband Color
- Paletted/Unique Values
- Singleband Gray
- Singleband Pseudocolor
- Hillshade
- Contours



122

This slide highlights options for symbolizing single-band raster data.

Symbolize Raster Data

- Multiband Color
- Paletted/Unique Values
- Singleband Gray
- Singleband Pseudocolor
- Hillshade
- Contours

123

This slide highlights options for symbolizing multiband raster data.

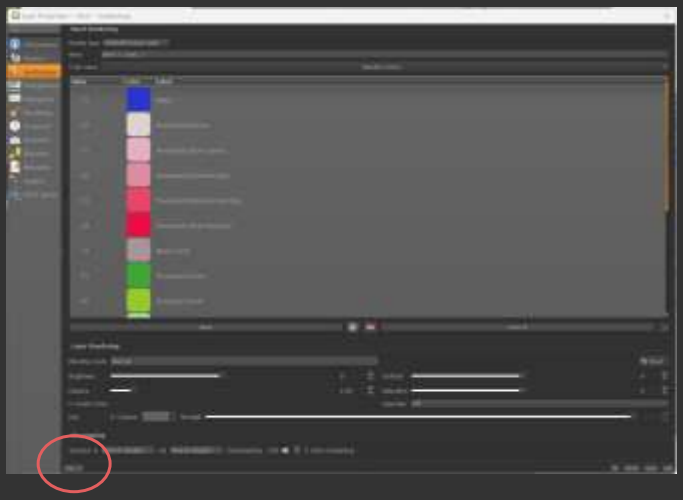
Layer Symbology in QGIS

- Use the utah project.
- Change the symbology of the censustracts2020 layer. Display the POP100 field using gradated colors. You can choose the classification method, number of classes, and color ramp.
- Change the symbology of the elev layer. Use a Singleband Pseudocolor rendering method, continuous mode, and a color ramp of your choosing.

Raster Grid Symbology in QGIS

- Use the sand_fire project.
- Change the symbology of one of the Landsat 8 OLI images using the following band combination:
  - Red Channel = NIR
  - Green Channel = Red
  - Blue Channel = Green
- Band 1 = Blue Edge, Band 2 = Blue, Band 3 = Green, Band 4 = Red, Band 5 = NIR, Band 6 = SWIR1, Band 7 = SWIR2

Saving Styles



- Right-Click → Export → Save as QGIS Layer Style File
- Properties → Symbology → Style → Load Style

126

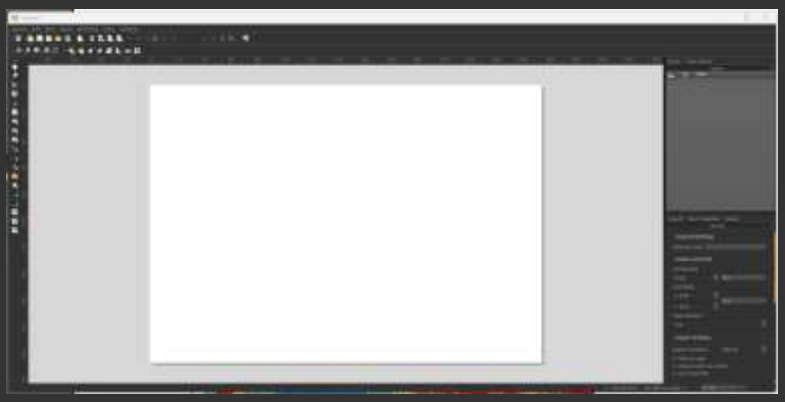
This slide explains how to save layer symbology to a file for re-use.

Save Style File

- Use the sand_fire project.
- Save your band combination symbology to a style file then apply this style to the other image.

Layouts

- Project → New Print Layout
- Layout Manager
- Layout Options
- Layout
  - Export resolution
  - Layout size
- Change page size
  - Right-click on page
  - Page Properties

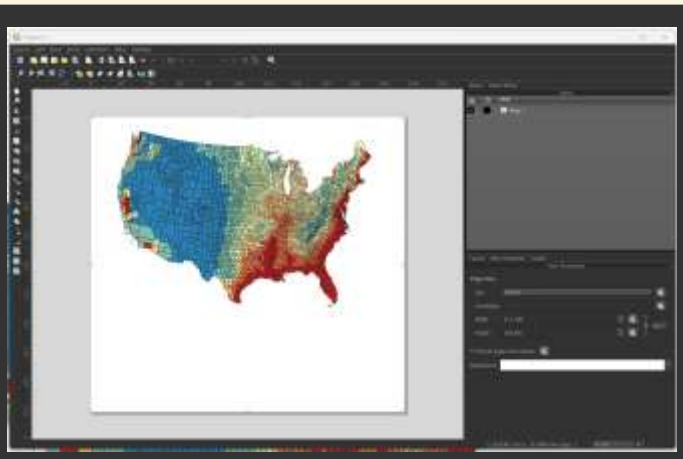


128

This slide explains how to create a new layout in QGIS.

Map Frames

- Add Item → Add Map
- Add Item → Add 3D Map
- Can add multiple frames
- Item Properties
  - Position
  - Rotation
  - CRS
  - Scale/Extent
  - Dimensions
  - Add Background
  - Add Frame
  - Lock relative to reference map

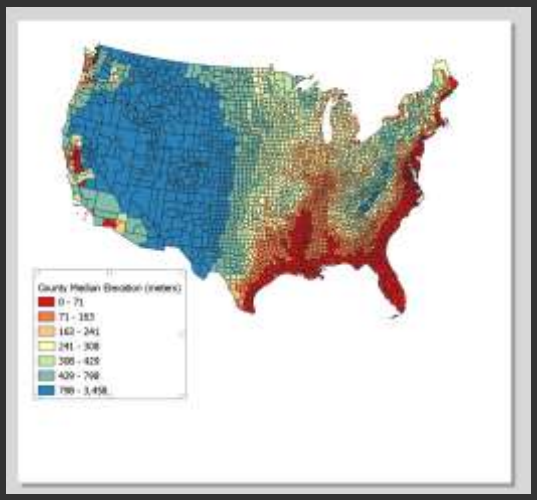


129

This slide explains how to add and manipulate map frames within a layout.

Legends

- Add Items → Add Legend
- Edits to map will impact legend
- Item Properties
  - Columns
  - Fonts
  - Font sizes
  - Symbol sizes
  - Spacing
  - Position and Size
  - Rotation
  - Background

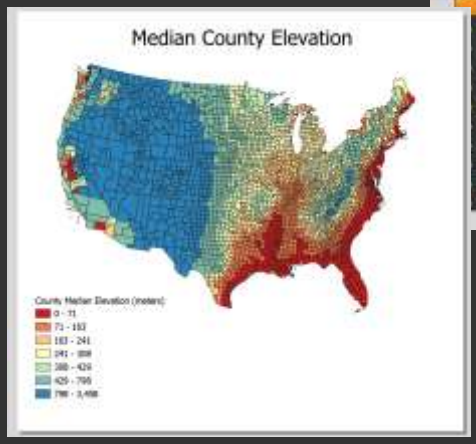


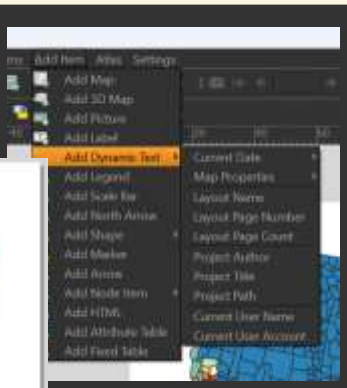
130

This slide explains how to add and manipulate legends within a layout.

Text, Shapes, and Graphics

- Add Items
  - Add Label
  - Add HTML
  - Add Dynamic Text
    - Current Date
    - Map Properties
    - Layout Name
    - Layout Page Number
    - Layout Page Count
    - Project Author
    - Project Title
    - Project Path
    - Current User Name
    - Current User Account



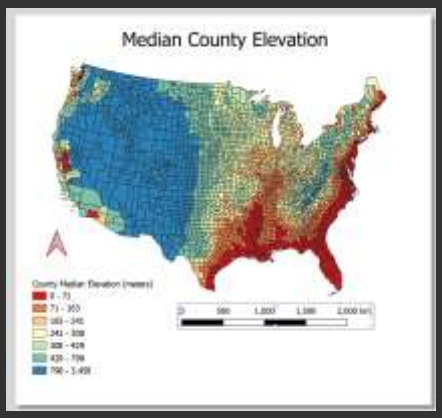


131

This slide discusses how to add and manipulate text, shapes, and graphics within a layout.

Orientation and Scale

- Add Item → North Arrow
- Add Item → Scale Bar
- Item Properties
  - Symbol
  - Colors
  - Fonts
  - Font size
  - Break
  - Units

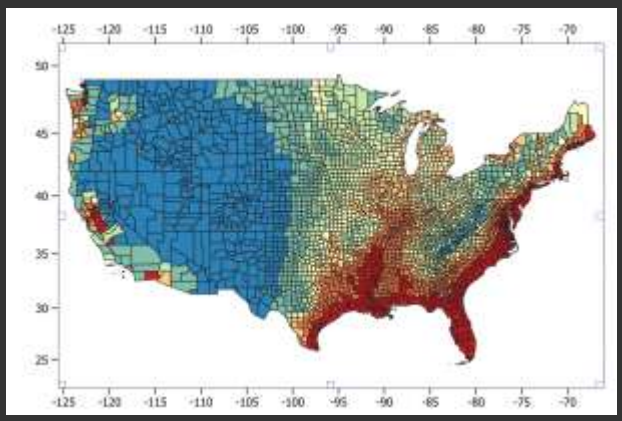


132

This slide discusses adding and configuring north arrows and scale bars.

Coordinate Grids

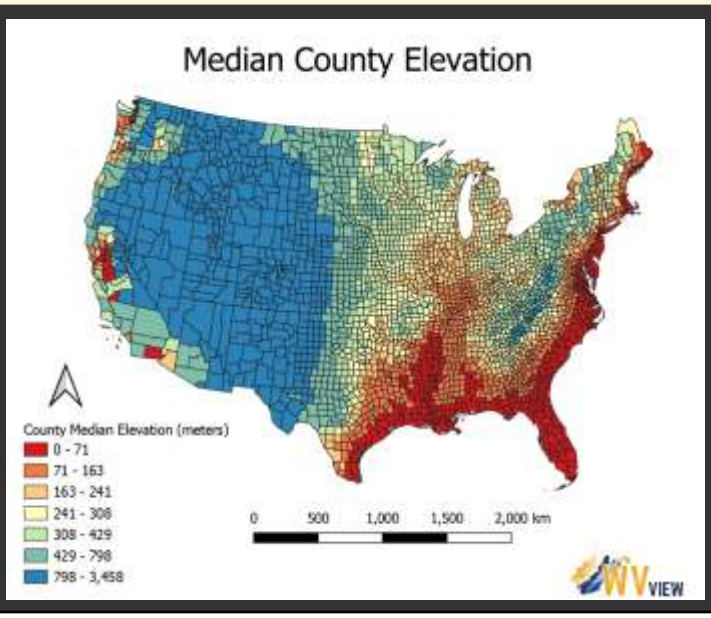
- Item Properties → Grids
- Can use different coordinate systems
- Can add multiple grids
- Can edit:
  - Lines
  - Ticks
  - Markers
  - Text
  - Interval
  - Offsets
  - Fonts



133

This slide discusses adding and configuring coordinate grids/graticules.

Other Items



- Picture
- Shape
- Marker
- Arrow
- Table

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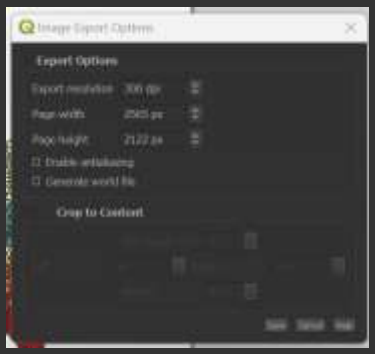
Other items that can be added to layouts include pictures/graphics, shapes, markers, arrows, and data tables.

Layout Export



- Layout → Export as Image
- Layout → Export as SVG
- Layout → Export as PDF
- Save as Template
- Print

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Once a layout is created, it can be converted to a raster graphic, vector graphic, or PDF. It can also be saved as a template or printed.

qgis2web

- OpenLayers
- Leaflet
- Mapbox GL JS

https://github.com/tomchadwin/qgis2web/wiki

136

It is also possible to export as HTML web maps using the qgis2web plugin. This plugin makes use of OpenLayers, Leaflet, and/or Mapbox.

Map Layout in QGIS

- Use the utah project.
- Make sure that the symbology of the censustracts2020 layer has been changed to display the POP100 field using gradated colors. You can choose the classification method, number of classes, and color ramp.
- Create a map layout that includes the map, a north arrow, a scale bar, a legend, and a title.
- Make sure the layout uses space effectively and is well defined.
- Export your map as a PDF file.

This is the end of this lecture module.

Please return to the West Virginia View Webpage for additional content.

Thanks! Hope you found this useful.