

Slide Notes: Making Maps

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Slide 1: Hello everybody, and welcome to our lecture on Map Making in ArcGIS. This lecture will include a brief introduction to basic Cartography, and discuss some guidelines and general strategies we use for making effective and interesting maps

Slide 2, 3, 4, 5: Just to start with some cartographic trivia: There once was a town named Agloe...

This was back in the day when people had to make these complicated maps by hand. Most mapmakers worried that other mapmakers would just copy their work, so they would make fake features such as little streets or towns. If these fake objects showed up in somebody else's map, then that would be proof of copyright infringement.

Agloe was purely made up by Otto G. Lindberg and Ernest Alpers back in the 1930's. They used an anagram of their initials to create a fake town, which they placed on a little dirt road in central New York. They then licensed their map to the companies that printed gas station road maps (Esso in this case).

Sure enough, within a short time Rand McNally had maps with Agloe on it. Lindberg and Alpers thought they had them, and took them to court. Rand McNally successfully argued that there actually was a town named Agloe at that location because they had a photo of the "Agloe General Store".

Turns out the people who lived there and picked up one of these Esso road maps and saw that there was supposed to be a town at their location, so they opened up a general store and named it accordingly. Rand McNally won in court.

Slide 6: Maps are an art form. I wish we had the time to really study cartography in this course because there is so much to it and so many ways you can go with it. It is far too large a topic to cover in an hour, though. You can't teach cartography in an hour any more than you can teach writing, painting or music in an hour.

Slide 7, 8, 9, 10: Main Topics. We'll do what we can, though. We will cover several common map components, how to make maps in ArcGIS Pro, and finally I'll mention a few good data sources and some professional societies.

Slide 11: In ArcGIS, we have lots of options open to us in our maps. We can use existing basemap data, such as the USGS topos. These are some of the most commonly used maps available for land management and ecological research, and are a fantastic resource.

Slide 12: We have lots of sources of imagery, at pretty spatial resolution. We even have several imagery sources, such as Landsat and NAIP, which show us imagery at various times and in wavelengths outside of the visible spectrum.

Slide 13: Making maps can be a lot of fun. Sometimes different phenomena just look cool. This is a map of annual solar duration (total number of hours that any point on the landscape has direct sunlight shining on it).

Slide 14: Sometimes you can tell interesting stories just by the way you symbolize. This map just symbolizes elevation below 2,100m in deeper blue, so it looks underwater.

Basic Map Components

Slide 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29: Common Map Components. There are not clearly-defined rules for what makes a good map. People can love or hate maps just like they do any other work of art. Personally I like adding hillshades to most of my maps, often as a low-contrast

background layer. It just give the maps a sense of depth to me. Other people probably disagree, and in fact there are opposing schools of thought on what makes a good hillshade. Some people think the hillshade should be smoothed over to de-emphasize topographic details. I disagree, but that just means different people have different opinions.

These items are commonly seen on maps and are usually good to add. In most cases they make your map easier to understand and use. There are exceptions to every rule, though.

For our purposes, we want to make a map that communicates well. If we want to communicate vegetation types over our study area, we may not want to clutter the map up with contour lines or reference grids, for example. If we want to show roads and trails, it may not be a good idea to use aerial photography because there is so much extra detail in the imagery.

Slide 30: Sometimes you want a map to be clean and simple, almost like a cartoon, telling a very basic story without a lot of background references. This map has no scale because the scale changes drastically over the vertical extent. It has no north arrow because north is obvious. However, it **does** have a title, legend, spatial reference, descriptive text, logo and author (FAO in this case, even though I made it).

This type of simple format is especially useful when you plan to present a series of maps, all showing different statistics over the same area. This particular example was one of several maps showing global aquaculture statistics.

Slide 31: Getting a nice basic template like this is useful when you have to make a lot of maps. Once the reader gets comfortable with one map, then the rest of the maps are much easier to understand because the basic format does not change. I actually made around 700 global climate change maps for this project.

Area of Interest (AOI)

Slide 32: We often want to focus the viewer's attention on some part of the map.

There is a lot of art to cartography, and you can spend enormous amounts of time fine tuning a map. I probably spent two weeks making this one for a fellow who was writing a book about the Colorado River basin. This is an example of how you might define and highlight a particular area of interest (AOI) in a map.

Slide 33: Here is another example of delineating an area of interest. It is not the prettiest map, but it tells the story it needs to. This is a map of fire severity and extent over a set of California spotted owl territories in the San Bernardino Mountains in 2003. In this example I made a large single polygon covering the extent of the map, then cut a hole in it over the area of interest. I then made the polygon semi-transparent. It has the effect of washing out the area outside of the AOI, but not removing it completely. This example also illustrates a **measured grid**, which is a type of grid that follows projected coordinates (UTM in this case). Other types of grid include **graticules**, which are exactly the same as measured grids except that the lines follow latitude and longitude, and **reference grids** which just divide the region up into arbitrary tiles. Reference grids usually have letters along one edge, and numbers along another, so you can reference a tile by letter/number coordinates (Tile B6, or D3, etc.).

Slide 34: I often like putting my AOI in color and leaving the rest in black-and-white. This was a map of a really weird spotted owl event, where we trapped and banded it as an adult near Silver City in 1999 and it was found dead near Questa in 2012. An amazing movement for an adult owl.

Slide 35: Another example of coloring the AOI and putting the outside in black-and-white. I also generally like topography in my maps, although sometimes it is inappropriate.

Slide 36: ArcGIS Pro gives you tools to really define your AOI by clipping the entire map to some polygon. Lots of other nice features, such as letting you create scale bars, north arrows, grids, etc. that are linked to the map, so they will change if the map changes. Also some sophisticated text tools, such as letting you fill an irregular polygon with text. This map is similar to one you will make in Lab 2.

Reference Lines on your Map

Slide 37, 38: There are three common grid types we often put on maps. **Measured Grids** and **Graticules** are essentially the same thing, except Measured Grids follow projected coordinate systems while Graticules follow Latitude and Longitude. Both form a grid of reference lines or tic marks over the map.

- a) **Graticules** follow Latitude and Longitude
 - i) Slide 39: An example of **Graticules**, from a map of New Mexican meadow jumping mice
- b) **Measured grids** follow projected coordinates.
 - i) Slide 40, 41: An example of a **Measured Grid**, from a map of New Mexican meadow jumping mice
 - ii) Slide 42: An example combining **Graticules** and **Measured Grids**, from a map of New Mexican meadow jumping mice
- c) **Reference grids** divide the map into rows and columns, and allow you to specify locations by tile (sort of like the game *Battleship*).
 - i) Slide 43, 44: An example of a **Reference Grid**, from a map of New Mexican meadow jumping mice

Slide 45, 46, 47, 48, 49, 50: There is also an interesting method of drawing reference lines that ancient cartographers used to help make accurate maps. These lines crisscrossing the map are called **Rhumb Lines**, and they attempt to follow a constant bearing. We really don't use these anymore for analytical purposes, although they do create an interesting and romantic cartographic effect.

An example of **Rhumb Lines**. Rhumb Lines are lines following a constant bearing, and were used by ancient cartographers to draw accurate maps. This example is called the Portolan Atlas of Central Mediterranean, by Joan Oliva, from 1590. See <https://www.loc.gov/resource/g3201pm.gct00065/?sp=2>

Multiple Maps

Slide 51: When we prepare a map for a report or a presentation, it is not unusual to use multiple maps to tell a single story. Foresters might present a set of maps to illustrate the consequences of different land management options. City planners might present multiple maps to show the expected growth of urban areas over time. This example is part of a single poster that shows expected changes in temperature and precipitation in the southwestern US given current climate models.

Inset Maps

Slide 52: Inset Maps are a common way to use multiple maps to tell a single story. We often want to add an inset map to either give a frame of reference, a close-up or even to show other areas. This inset map provides a frame of reference for the primary map, where the primary map shows a close-up of the San Francisco Peaks, and the inset map shows where the San Francisco Peaks lie on the larger landscape.

Slide 53: This example uses an inset map to zoom in on an area, so we see all of Northern Arizona in the primary map, and we see how Flagstaff is laid out in the inset map. Road atlases do this a lot.

Slide 54: This example uses an inset map to show other areas. Our primary map tells the story we are wanting to tell, but the inset map shows that the same phenomena occur in other parts of the world. Here we wanted to show suitable areas for marine aquaculture in Southeast Asia. Dotted lines represent exclusive economic zone boundaries for each country. The report was all about potential for marine aquaculture in Southeast Asia and Northern Australia, but with the inset map we could also show that regions existed elsewhere in the world without really distracting from the main story we were trying to tell.

Exceptions to the Rules

Slide 55, 56, 57, 58: We've been discussing a few common map components, and it is true that many map components, such as scale bars and north arrows, are almost always included with maps. However, remember that your goal here is not to satisfy a set of rules, but rather to tell a clear story. Usually throwing in a scale bar or a legend helps the story, but there are exceptions and sometimes these map components don't help tell the story but actually distract. It can sometimes be a difficult judgement call to make, but if a map is better without them then by all means don't add them.

The general rule is that certain map components should almost always be added to maps, but there are always exceptions. For example, we almost always want a scale bar when we map our survey areas. However, scale bars are not appropriate if the scale changes a lot over the map.

North arrows are often left out because we usually assume that north is to the top. You should definitely add a north arrow if the map is rotated!

Slide 59: But sometimes a north arrow doesn't make any sense because it varies over the extent of the map.

Slide 60: Here are a couple of maps I made for FAO. They wanted to show sub-Saharan African countries with significant aquaculture. For some maps they wanted countries named. Notice that there is no scale, legend or north arrow.

Slide 61: For other maps they just wanted regions distinguished by color, with no text, references, scales, north arrows or anything. Just clean and simple maps.

Slide 62: Sometimes you just want a map to be graphically interesting, without intending it to be used for any type of analysis. I made this map to serve as a background for some posters.

Slide 63: This is one of my favorite maps. Saul Steinberg's *A New Yorker's View of the World*. It makes me laugh because it shows the basic New Yorker's lack of interest in anything not New York.

A Few Guidelines and Common Issues

Slide 64, 65, 66, 67, 68, 69: A few guidelines: The main feature in your map should be the largest.

If you want the viewer to look at your map elements in a particular order, arrange them the way a person would typically read a document. In the United States, expect the person who sees your map to review it from left-to-right, and from top-to-bottom.

In Israel and Arab countries, you might arrange the map elements from the right side to the left.

In China, Japan or Korea, we might design the map to be read primarily top-to-bottom, and secondarily right-to-left.

Try to use colors that make sense. Don't map riparian areas or water sources in red, for example.

Slide 70: Remember how satellites take images in multiple spectra and our computer turns images from the Red, Green and Blue bands into a true-color image? Our eyes work in a similar manner. We have three types of cone cells in our eyes that detect light, and each type is most sensitive to a particular frequency. They overlap a lot, but we generally are sensing at three frequencies and our brain converts that to the colors we are used to.

Some people either have a condition in their eyes in which one or two types of cone cells that are not working correctly, or else two types that are too similar (especially the L and M cells), and therefore their brain is basically working with either 2 or 1 wavelength. If the brain only has one wavelength to work with, then that person is essentially seeing in black and white. Most people with color blindness have the L and M cells too close to each other and therefore cannot, or at least have difficulty with, distinguishing between red and green.

Slide 71: Another reminder that nearly 10% of people have some level of color blindness! Don't make maps that are unnecessarily difficult to read for many people.

Slide 72: Be careful with imagery! Aerial and satellite photography are often fun, but they can be overwhelming too. These types of maps usually do not communicate quickly.

Slide 73: Issues with Esri Basemaps: They often do not export at very high resolution, even if you set a high DPI value. Your printed map ends up very pixelated.

Slide 74: The workaround is to make your layout page larger. For example, if you want to make an 8.5 x 11 map, you could try setting the layout to be twice that size (17 x 22). Then, if necessary, shrink the final exported map back to 8.5 x 11 in Photoshop or something.

Making Maps in ArcGIS

Slide 75, 76, 77, 78, 79, 80: ArcGIS Pro provides many tools to make most maps. It does a great job for the great majority of maps. If you really want to make a beautiful work of art, though, you'll usually do most of the initial map in ArcGIS Pro and then fine-tune it in Photoshop or Illustrator.

In ArcGIS Pro, the map is made in the Layout.

- Each map in the ArcGIS Pro Project makes a separate map in the layout.
- Several things in your map are linked to the maps. Any scales, legends, north arrows, grids and/or dynamic text boxes, for example, are linked so that they will change automatically if you change the map.
 - You can have multiple scales, legends, etc. in your layout if you want. They can all link to the same map or to different maps.
 - For example, it is not unusual to have two scale bars linked to a single map. One scale bar will be in miles while the other will be in kilometers.

Slide 81: Adding these map elements (like legends, scale bars, north arrows, etc.) is easy. Just **make sure you have the right map active**, then click the Insert menu and pick the object you want to add.

Automatic Basemap Service Layer Credits

Slide 82: ArcGIS Pro automatically inserts text into your map giving source info for any online basemaps from Esri. Not everybody likes these.

Slide 83, 84, 85, 86: These automatic references **can** be nice. It is difficult to cite some of the basemap data. However, many people were angry that ArcGIS Pro now forces you to add the citations. It does kind of screw up your cartographic freedom.

You can't get rid of them, but you can turn them into graphic elements that you can drag off your map.

Slide 87: To turn them into graphic elements, you need to insert the Dynamic Text "Service Layer Credits".

Slide 88: Then just drag it off your map before you export the final map.

Data Sources and Other Resources

Slide 89: A few good data sources

- a) NED: National Elevation Dataset and The National Map
 - i) <https://www.usgs.gov/core-science-systems/ngp/tnm-delivery/>
- b) USGS Earth Explorer
 - i) Requires you to log in; no fee for this
 - ii) Lots of remote sensing imagery
 - iii) <http://earthexplorer.usgs.gov/>
- c) USFS Region 3 data (shortened link below)
 - i) <http://tinyurl.com/8dhq9eu>
- d) FSGeodata Clearinghouse
 - i) <https://data.fs.usda.gov/geodata/>

Slide 90: A few more good data sources

- a) Fire Severity and History Data
 - i) BAER: Burned Area Emergency Response
 - (1) <https://fsapps.nwcg.gov/afm/baer/download.php>
 - ii) MTBS: Monitoring Trends in Burn Severity
 - (1) <http://www.mtbs.gov/>
 - iii) USGS Rocky Mountain Geographic Science Center
 - (1) <http://rmgsc.cr.usgs.gov/outgoing/GeoMAC/>
 - iv) RAVG: Rapid Assessment of Vegetation Condition after Wildfire
 - (1) <http://www.fs.fed.us/postfirevegcondition/whatis.shtml>
- b) LANDFIRE; Lots of vegetation, habitat, fire data

- i) <https://www.landfire.gov/>
- ii) **Note:** LANDFIRE tends to become unavailable when the government shuts down.

Slides 91, 92: A suggestion for a more advanced GIS course dealing specifically with Incident Management. National Wildland Fire Training course S341, "GIS Specialist for incident Management".

- a) <https://nationalfiretraining.nwcg.gov/catalog/index/S341>

Slide 93: GIS Resources

- a) Esri Forestry GIS group
 - i) <http://www.esri.com/industries/forestry>
- b) The Wildlife Society has a GIS Working Group
 - i) SETWG: Spatial Ecology and Telemetry Working Group
 - ii) <https://wildlife.org/setwg/>
- c) Society for Conservation GIS
 - i) <https://www.scgis.org/>

Slide 94: Remote Sensing Resources

- a) Remote Sensing and Photogrammetry Societies
 - i) ASPRS: American Society for Photogrammetry and Remote Sensing
 - (1) <http://www.asprs.org/>
 - ii) ISPRS: International Society for Photogrammetry and Remote Sensing
 - (1) <http://www.isprs.org/>

Slide 95: Cartography Resources

- a) Cartography Professional Societies
 - i) NACIS: North American Cartographic Information Society
 - (1) <http://www.nacis.org/>
 - ii) ICA/ACI: International Cartographic Association
 - (1) <http://icaci.org/>
 - iii) CaGIS: Cartography and Geographic Information Society
 - (1) <http://www.cartogis.org/>