Creating Cartograms: Making Geographic Areas Speak Volumes

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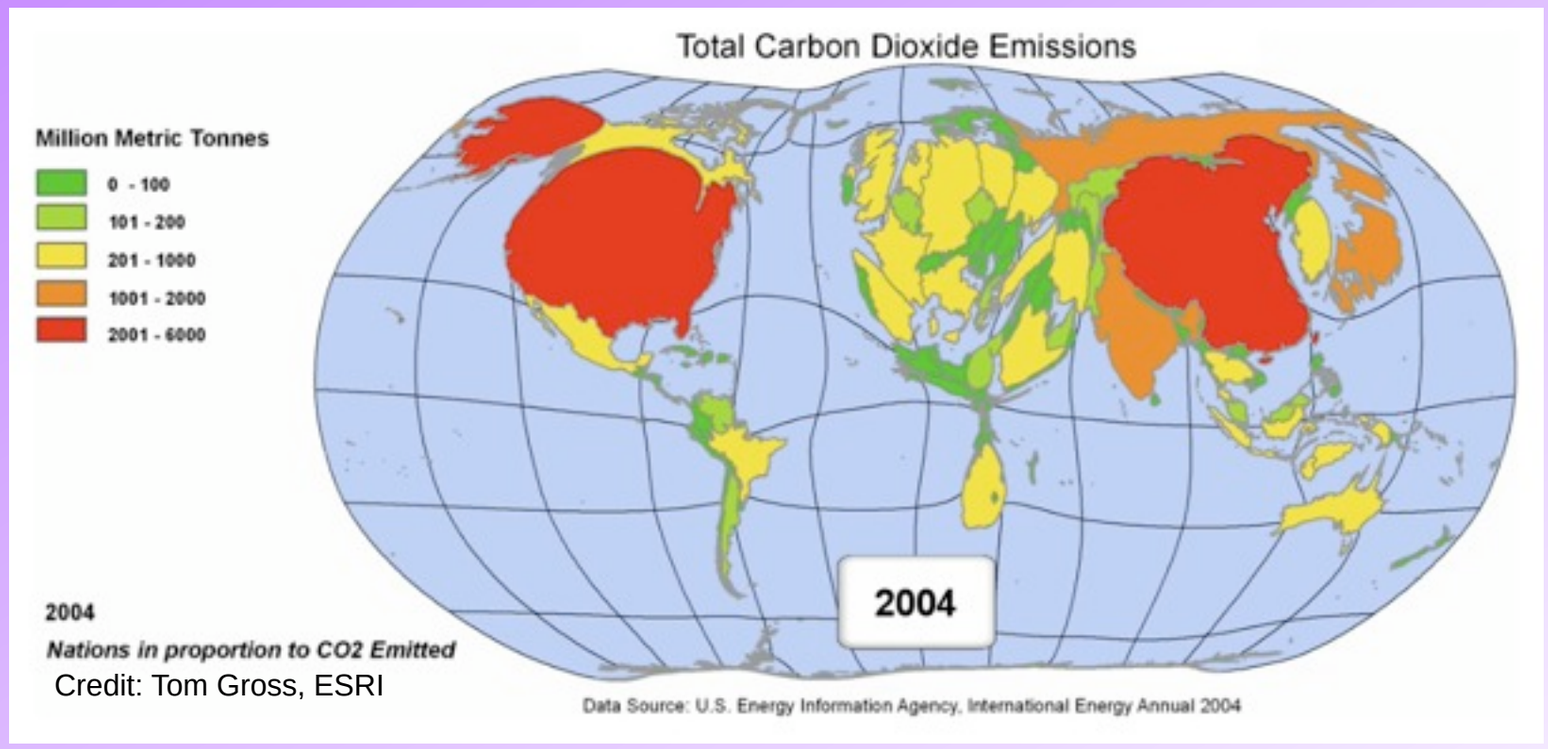
What's a Cartogram?

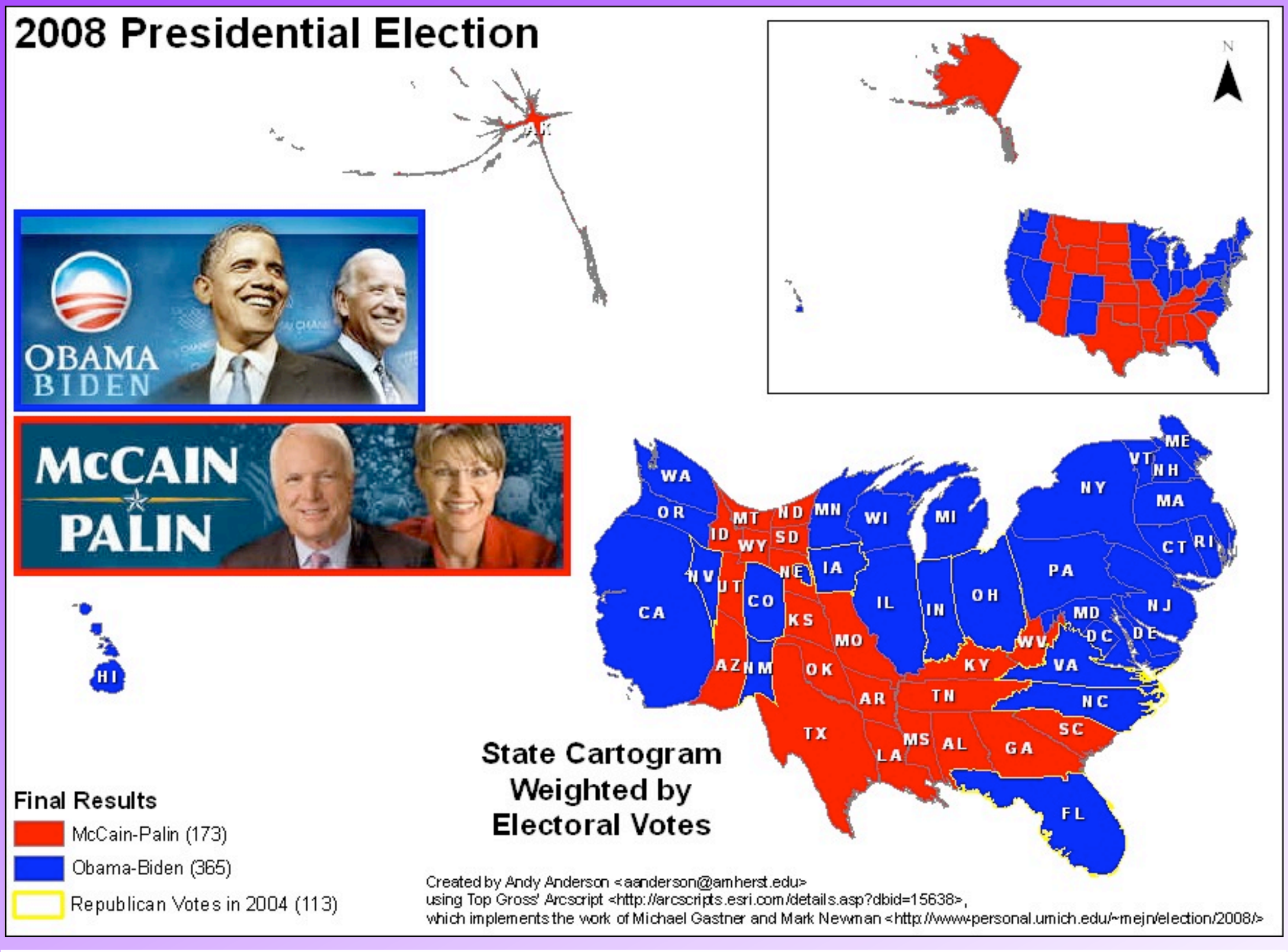
- Maps that distort area to reflect the importance of some other characteristic, such as population.
  - A "cartographic diagram" or "diagrammatic map".
- Cartograms provide **visual emphasis**, such as in this map of global carbon dioxide emissions.



Global Carbon Dioxide Emissions
1980 - 2004
Represented as Cartograms

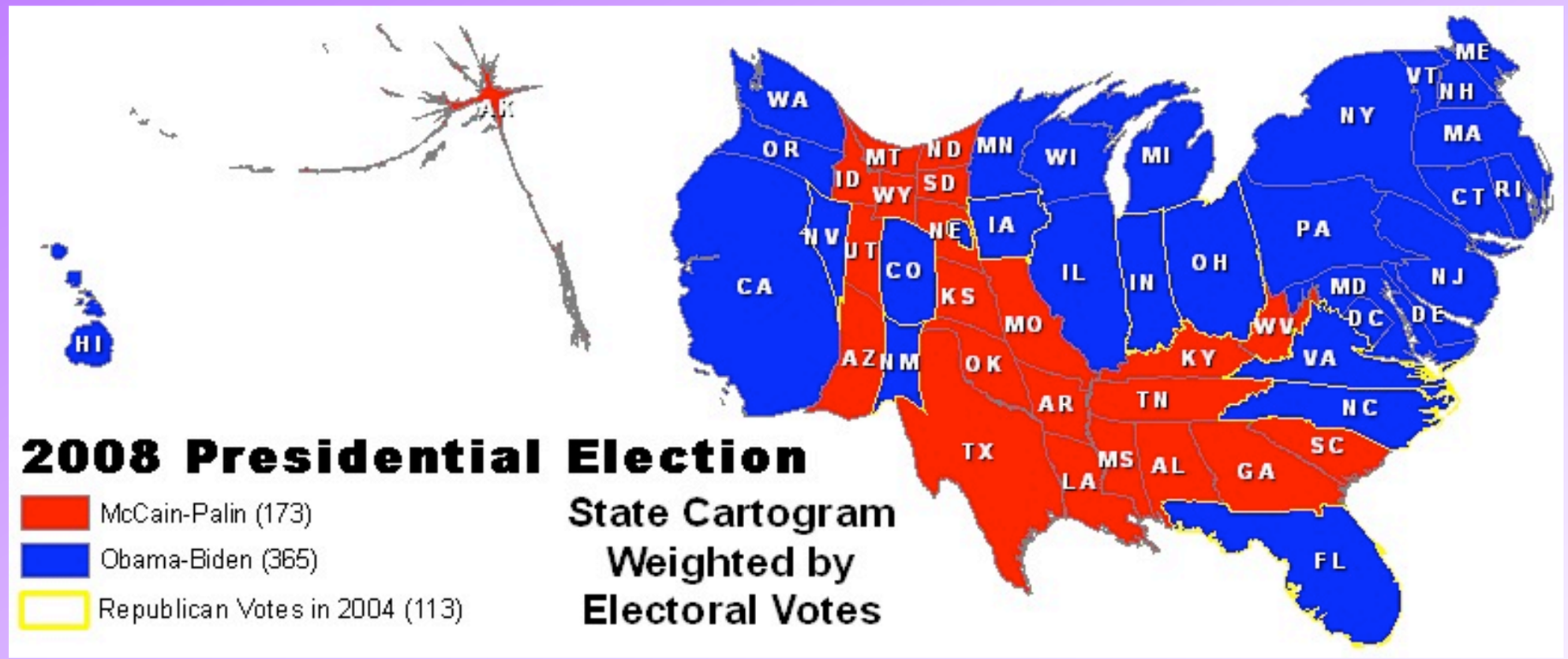
Applications Prototype Lab, ESRI, May 2007

Distorting the Original:

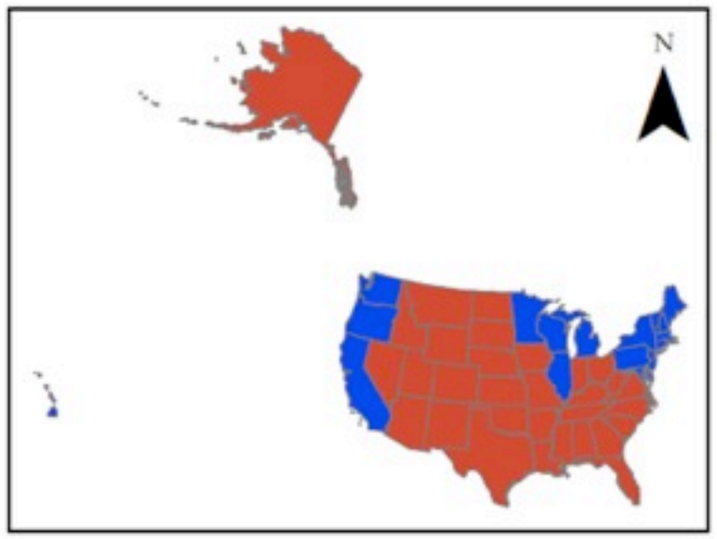


Adding an Extra Dimension

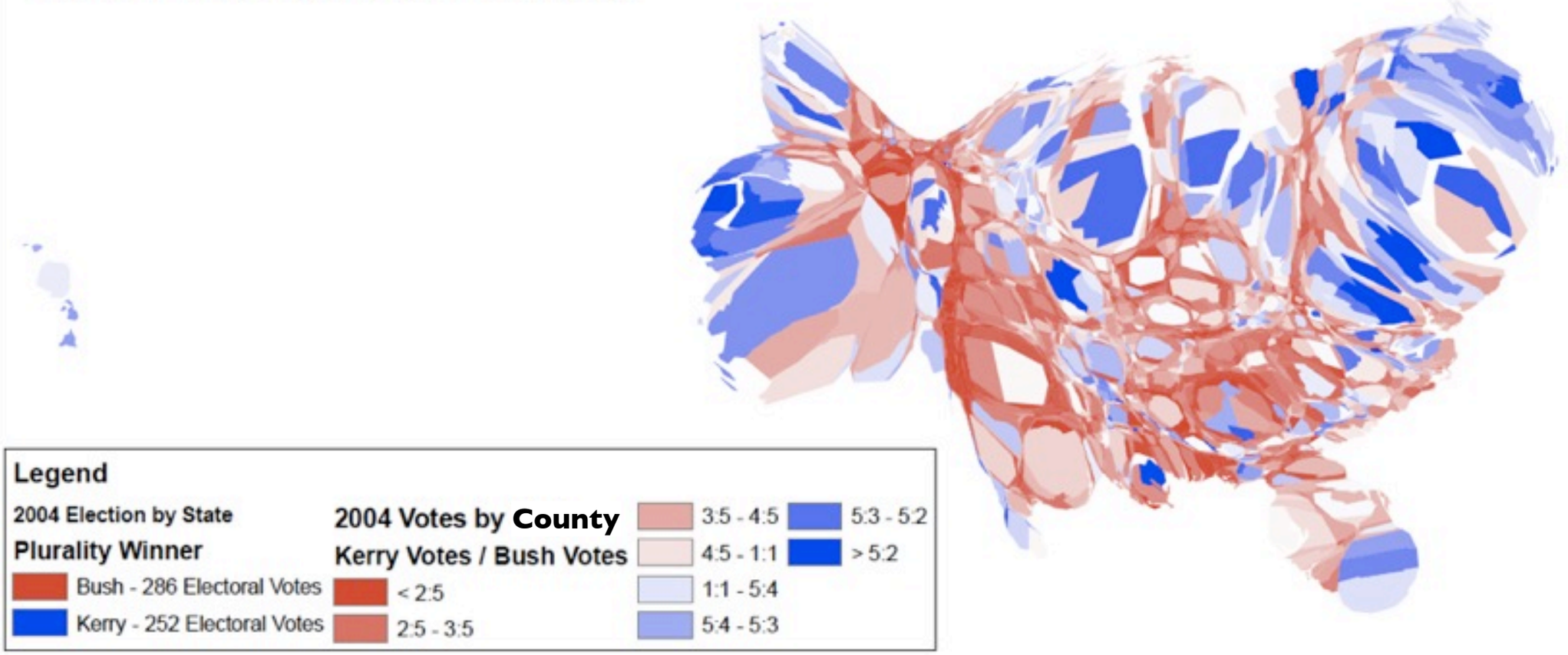
- Cartograms provide another way to display quantitative data in a map, beyond color/pattern.
- This lets it be visualized together with other information, e.g. categorical data.



Coloring with Quantitative Data is "Impressionistic"



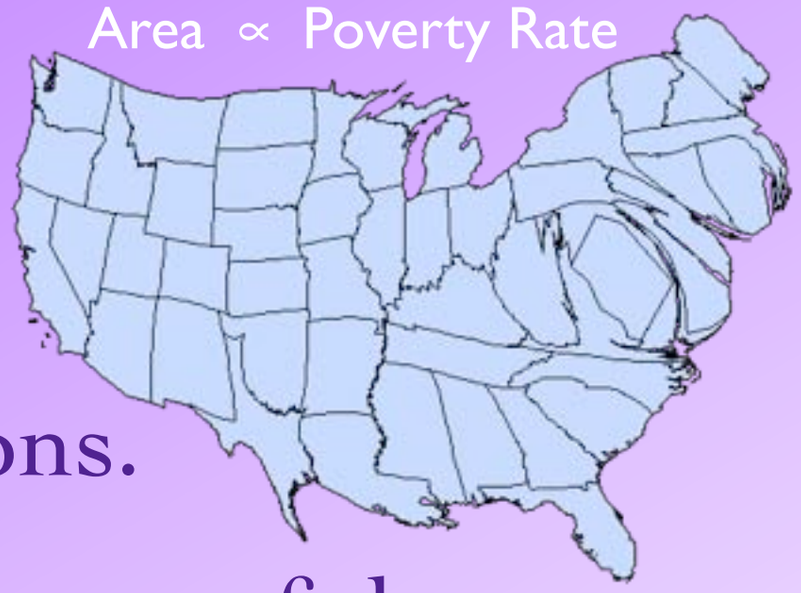
2004 Presidential Election



ArcGIS Cartogram Tool

Anyone can Create Cartograms!

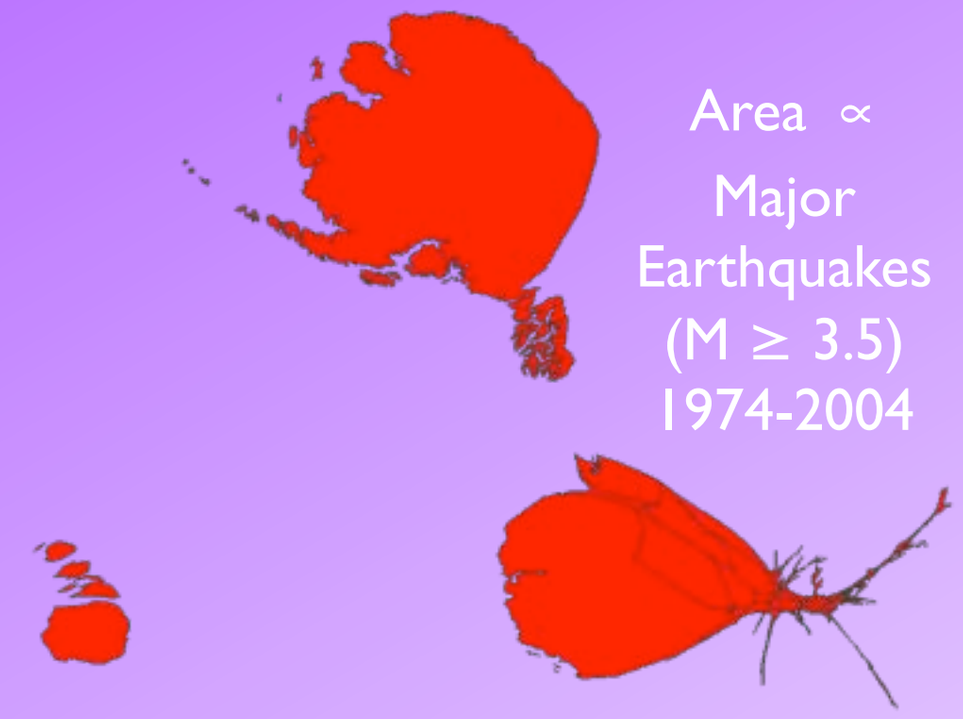
- A cartogram takes the density of an attribute of interest (e.g. poverty rate per unit area) and equalizes it through a set of regions.



- Michael Gastner and Mark Newman of the University of Michigan developed a "diffusion" method that equalizes while minimizing distortion.
- Tom Gross of ESRI implemented their approach as a free ArcGIS Toolbox extension (needs 9.2+).

ArcGIS Cartogram Tool

Installation in Windows



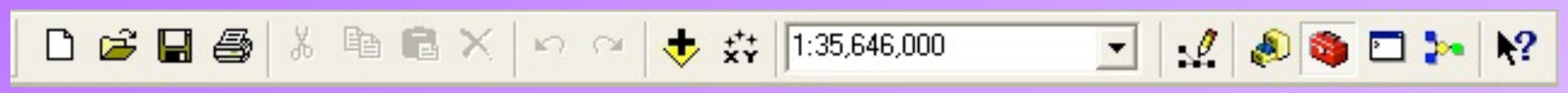
- The ArcGIS Cartogram Tool comes with an installer that places the software in the folder:
  - C:\Program Files\ArcGIS\Arcscripts\Cartograms
  - Included: a ReadMe file and a demo map.
    - Note: these are linked in the Start Menu => All Programs!
- The instructions in the ReadMe are fairly complete, but we'll quickly summarize them.

ArcGIS Cartogram Tool

Installation in ArcGIS

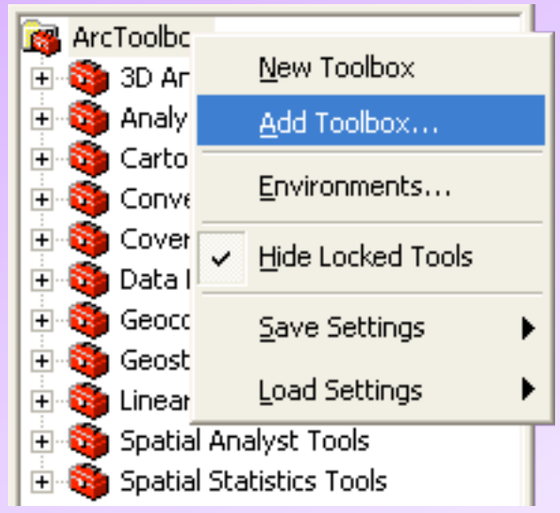
- The Cartogram Tool must be added into ArcGIS:

1. Start ArcMap and, in the standard toolbar,



click on ArcToolbox.

2. A new pane will open; right-click on the folder ArcToolbox at the top.



3. Select Add Toolbox…
   and then navigate to

   ⋆ C:\Program Files\ArcGIS\Arcscripts\Cartograms

Creating a Cartogram

Preparing Your Polygon Features

- You are now ready to create a cartogram by distorting a polygon feature class into a new one.
  - You can start with any projection, but less initial shape distortion is better, to keep the cartograms recognizable.
  - There is an advantage to equal-area projections, as they can be reprojected and still be meaningful:

Albers Conic

Eckert IV

Lambert Azimuthal

Creating a Cartogram

Reprojecting a Shapefile/Geodb

- If you haven't reprojected a shapefile/geodatabase before…

  1. In ArcGIS, add a shapefile/geodb with any projection;
  2. Change the projection of the data frame (aka Layers) to the desired one in its dialog Properties and tab Coordinate System;
  3. Right-click on the shapefile/geodb, select Data and then Export Data…;
  4. Use the same coordinate system as the data frame.

Creating a Cartogram

Preparing Your Attribute

- Your polygon features must have an interesting attribute to equalize.
  - ✳ The attribute field should be directly in the feature class (not joined to it).
  - ✳ The values must all be non-negative.
    - ★ Features with a negative value can be hidden in the **Layer Properties** dialog, **Definitions Query** tab, for example with the requirement:

"Earthquakes" ≥ 0

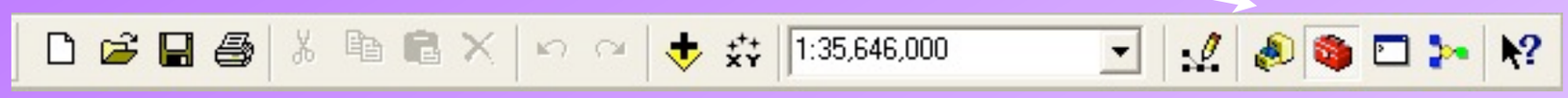
STATE_NAME *	Earthquakes
Alabama	15
Alaska	12053
Arizona	32
Arkansas	34
California	4895
Colorado	24
Connecticut	0
Delaware	0
District of Columbia	0
Florida	0
Georgia	7
Hawaii	1533
Idaho	404
Illinois	17
Indiana	6
Iowa	0
Kansas	4
Kentucky	15
Louisiana	1
Maine	16
Maryland	0
Massachusetts	2
Michigan	2
Minnesota	2
Mississippi	2
Missouri	21
Montana	186
Nebraska	8
Nevada	778
New Hampshire	6
New Jersey	2
New Mexico	38
New York	16
North Carolina	3
North Dakota	0
Ohio	8
Oklahoma	17

Creating a Cartogram

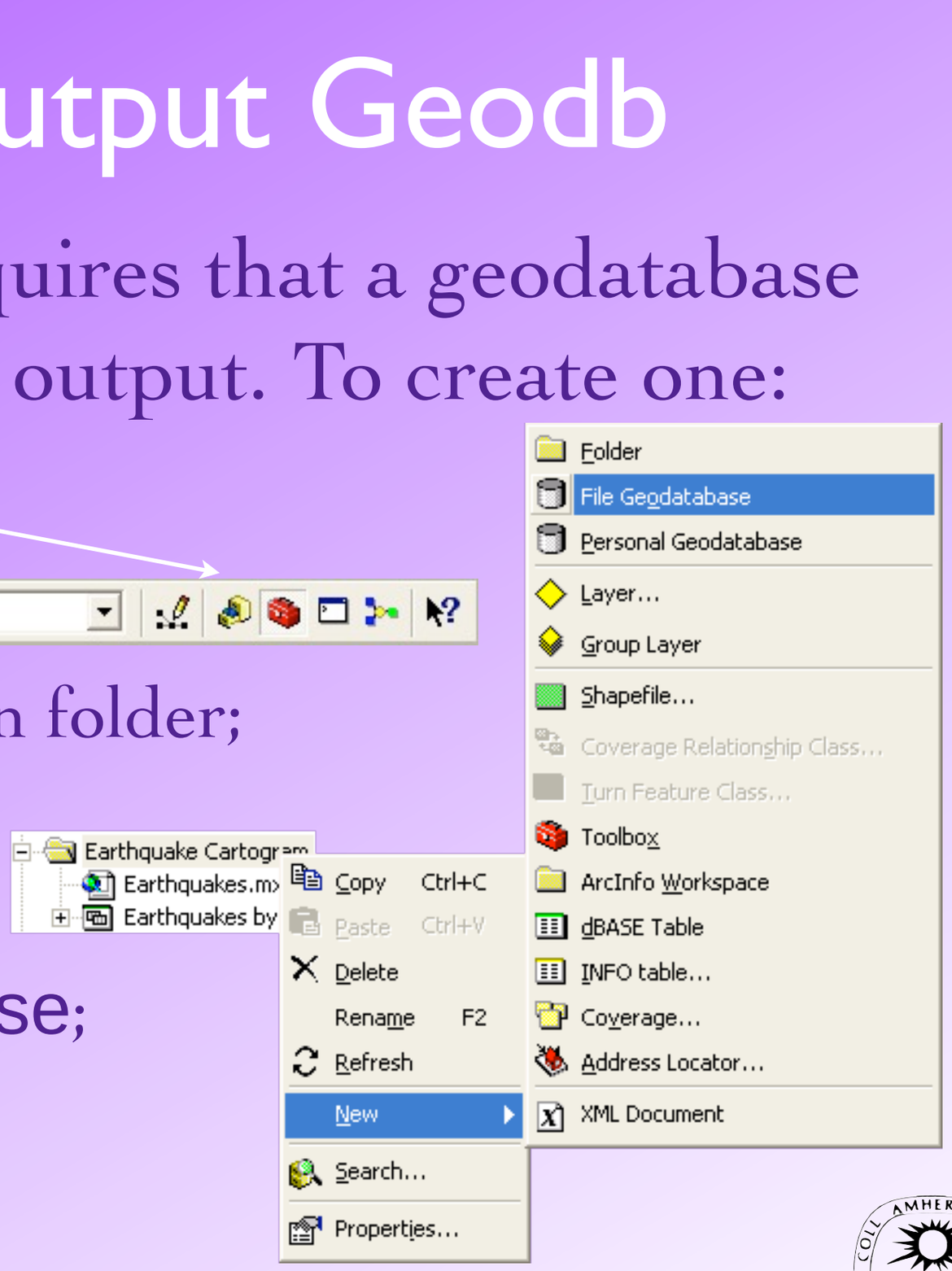
Preparing Your Output Geodb

- The Cartogram Tool requires that a geodatabase be present to contain its output. To create one:

1. Launch ArcCatalog;



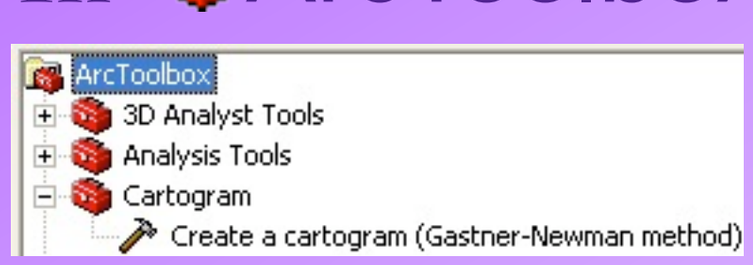
2. Navigate to the destination folder;
3. Right-click on it and select New, and then File Geodatabase;
4. Name the geodatabase.



Creating a Cartogram

Using the Cartogram Tool

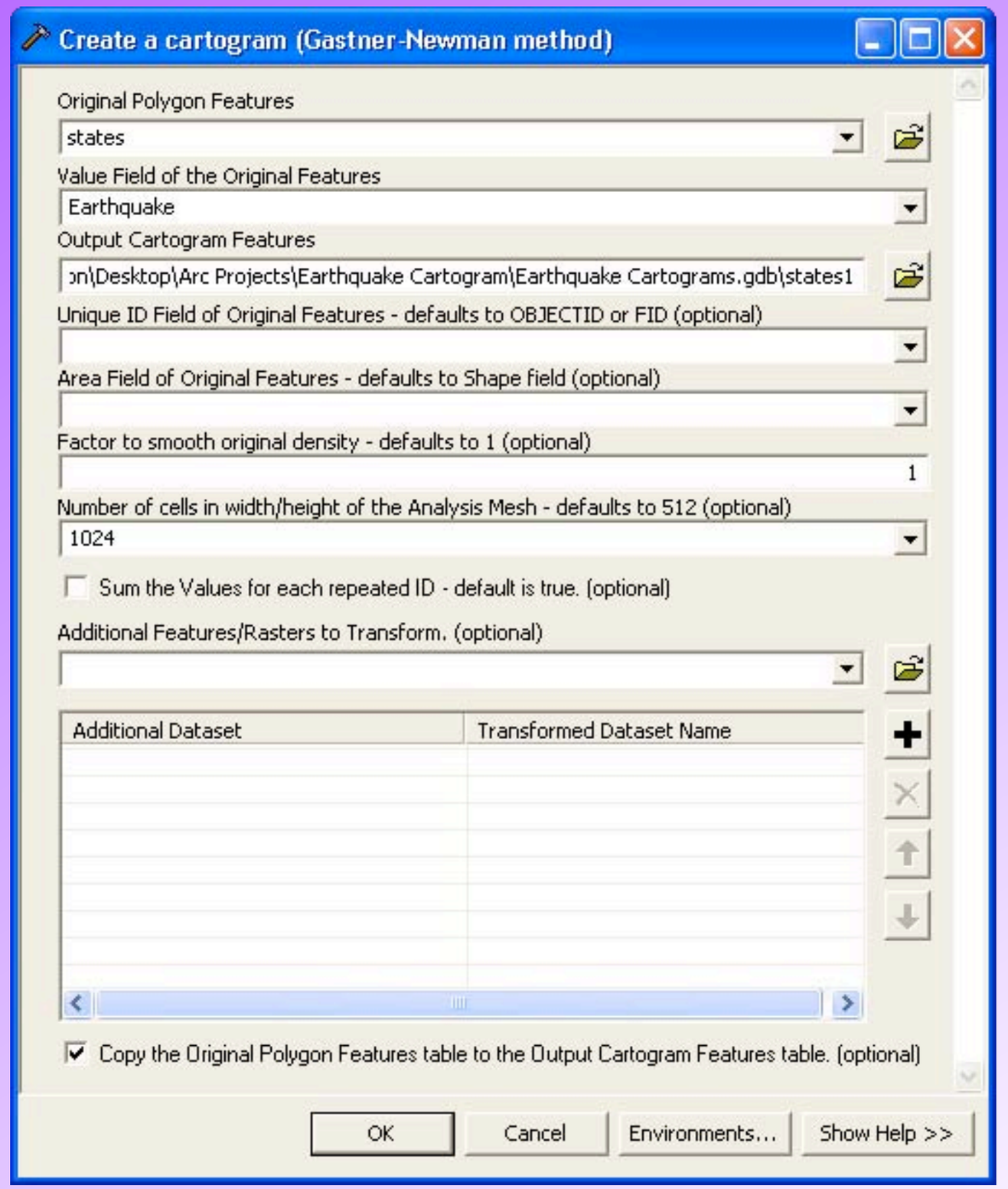
- In ArcToolbox,



double-click:

Create a cartogram

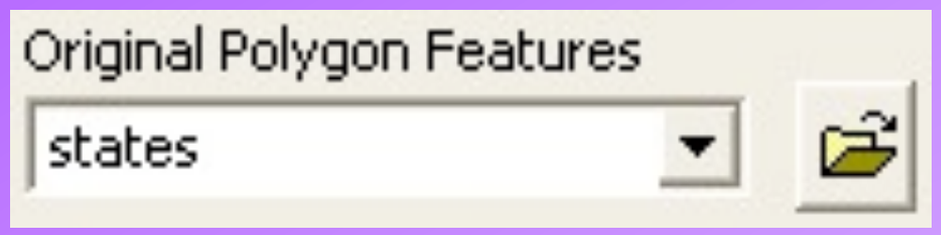
- This dialog requires a few pieces of information…



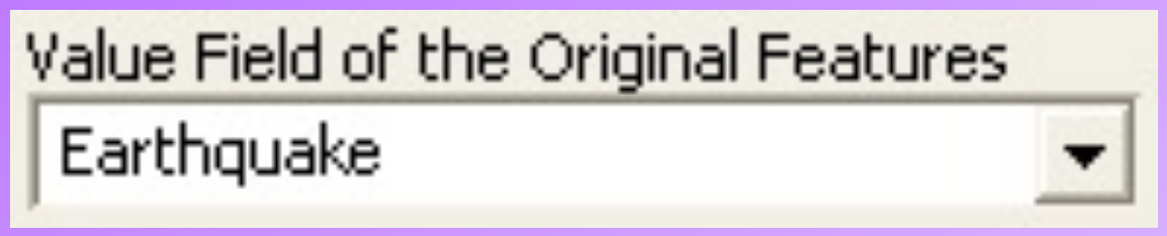
Creating a Cartogram

Setting up the Cartogram Tool

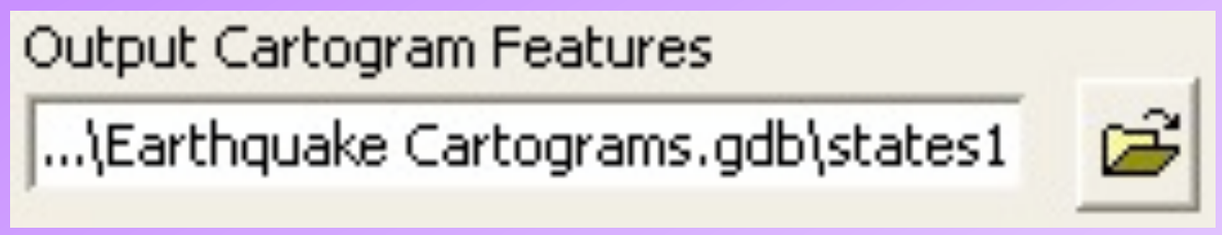
- The Create a cartogram dialog requires:



The polygon features to distort.

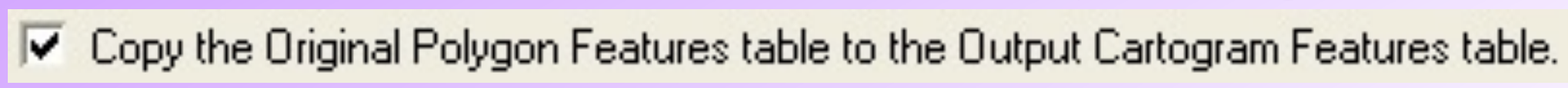


The feature class attribute whose values will become proportional to area.



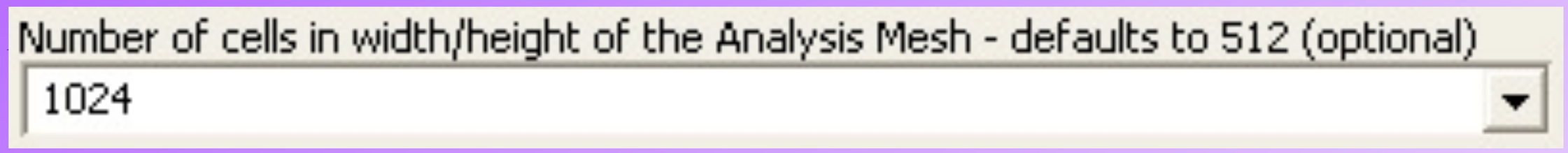
The full path name to the destination features within the geodatabase.

- Recommended option (to avoid joining later):

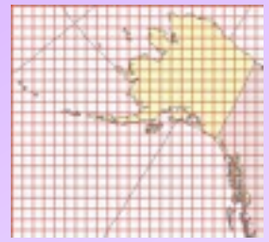


Cartogram Tool Analysis Mesh

- The Create a cartogram dialog also requires:



  - The polygons are placed on a grid of this size, and the grid nodes "diffuse" to even out the density.

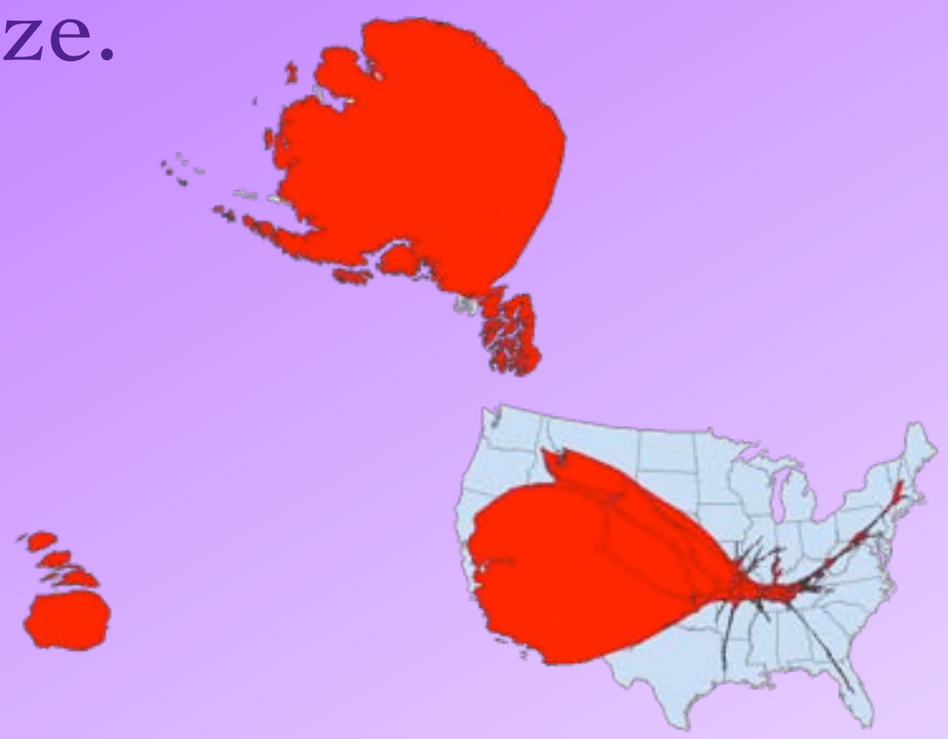


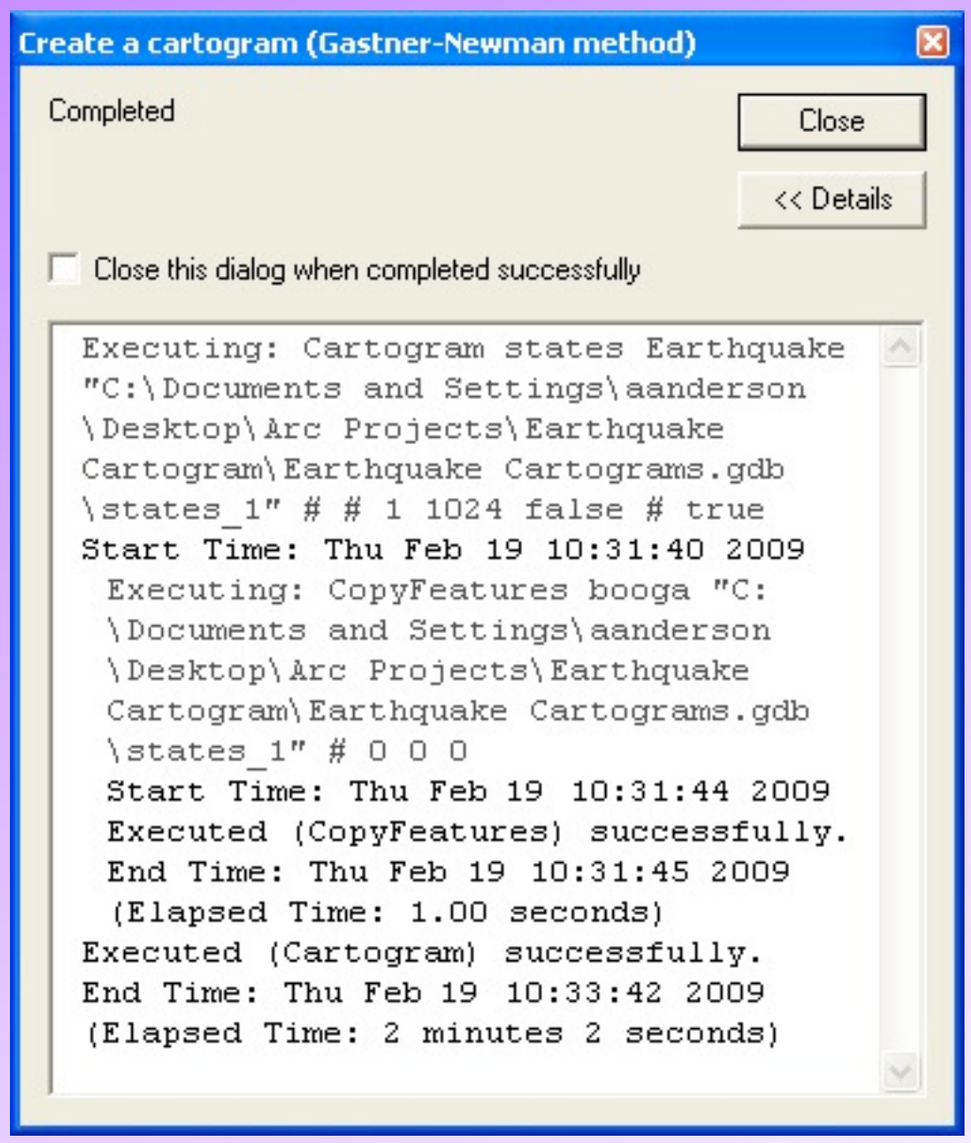
  - This value should be large enough so that the grid cells are smaller than any of the polygons… (Why?)
    - A Definitions Query can be used to exclude too-small areas.
  - The larger this value, the diffusion will get closer to uniform density. But if it's too large… (What?)

Creating a Cartogram

Cartogram Tool Results

- The cartogram tool can run for several minutes depending on the polygon feature class and the mesh size.





Cartogram Verification

How Good is your Cartogram?

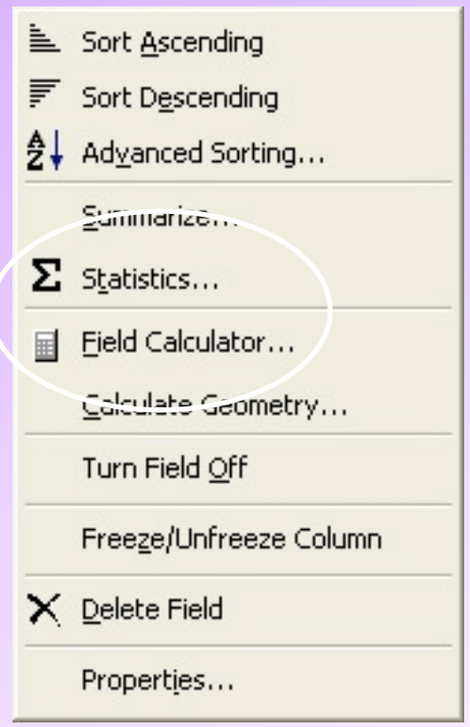
- The Gastner-Newman method is iterative, and it continues only for a certain number of steps.
- Between 1974 and 2003, Alaska and Massachusetts had 12,053 and 3 earthquakes of magnitude ≥ 3.5, respectively.
  - Their initial (calculated) areas are 1,493,263 Km^2 & 21,167 Km^2, for *specific areas* of 124 & 7,056 Km^2/equake.
  - After one application, these values are 4,916,219 Km^2 & 5,557 Km^2, or 408 & 1,852 Km^2/equake.
- So the result may not be "perfect", in that uniform density may not be achieved immediately.

Cartogram Verification

Calculating Density / Specific Area

- The new cartogram's attribute table has two extra fields, Shape_Length and Shape_Area, measuring its geometry. You can use the latter to calculate the diffusion's accuracy:

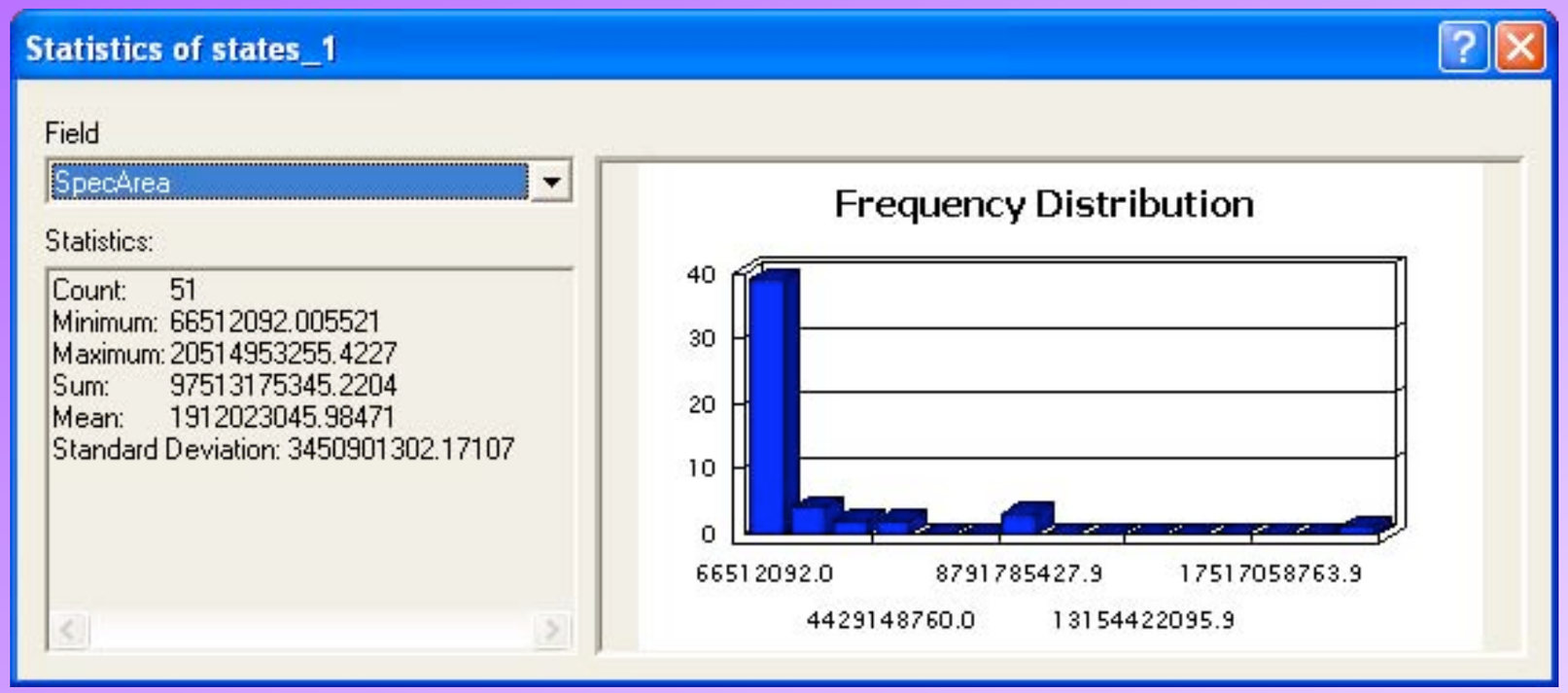
1. Click on the button Options… to create a new double-precision field.
2. Right-click on the field header and select Field Calculator… to compute either density (value/area) or specific area (area/value) — ratios ≥ 1 are easier to compare.
3. In the standard toolbar, click on the button Save.
4. Right-click on the field header and select Σ Statistics…



Cartogram Verification

Cartogram Statistics

- What can you tell about the new set of polygons from this data?



- You can input this cartogram and repeat the procedure to improve the results! (Usually...)

Cartogram Verification

Cartogram Statistics

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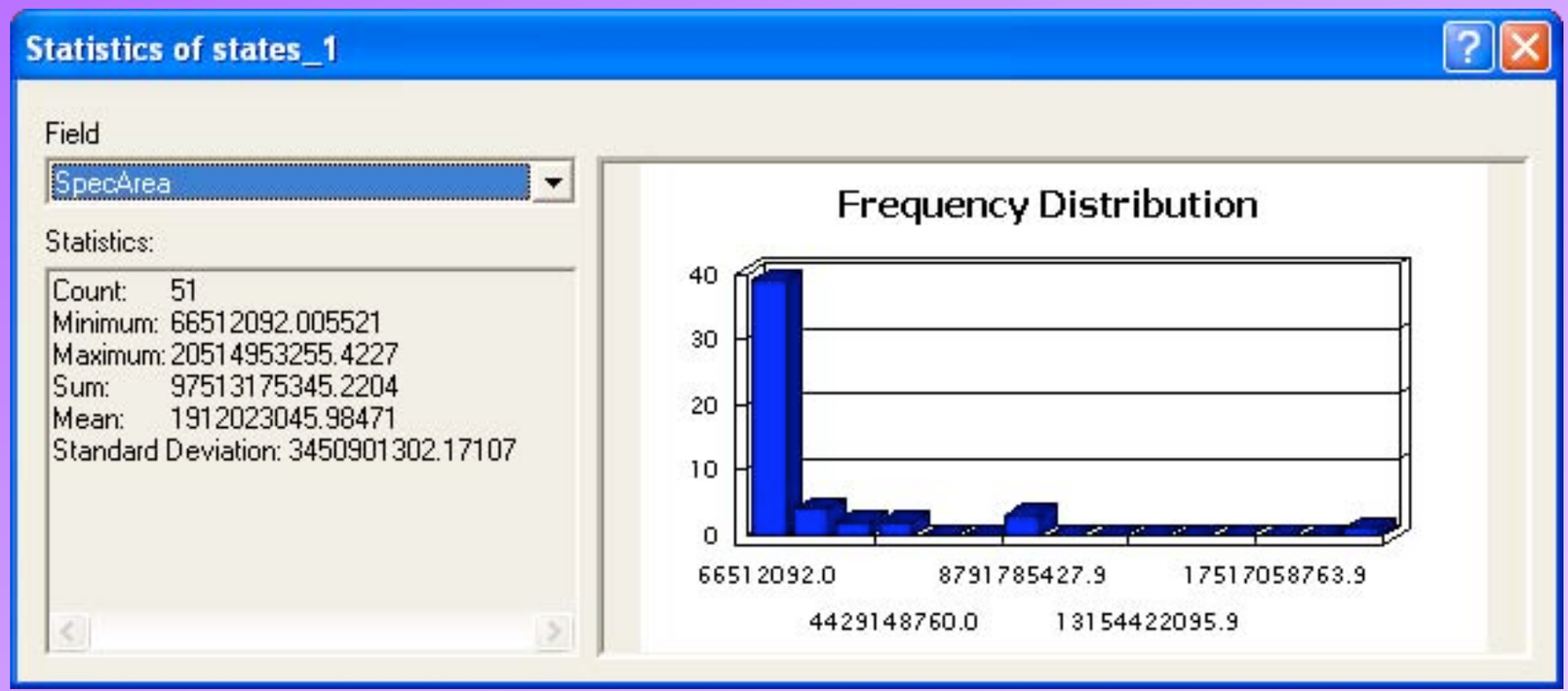
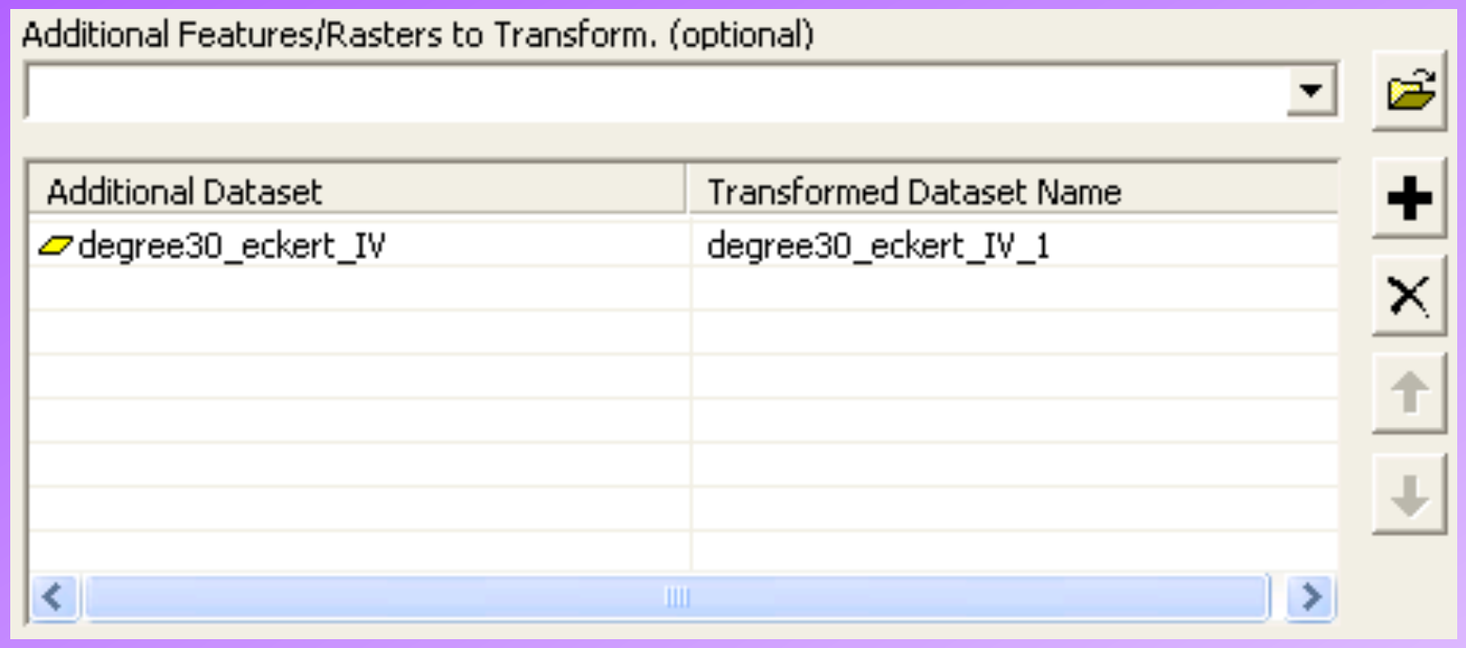


The "Lie Factor"
Max/Min = 308!
or
SD/Mean = 1.8

- You can input this cartogram and repeat the procedure to improve the results! (Usually...)

Cartogram Tool Extras

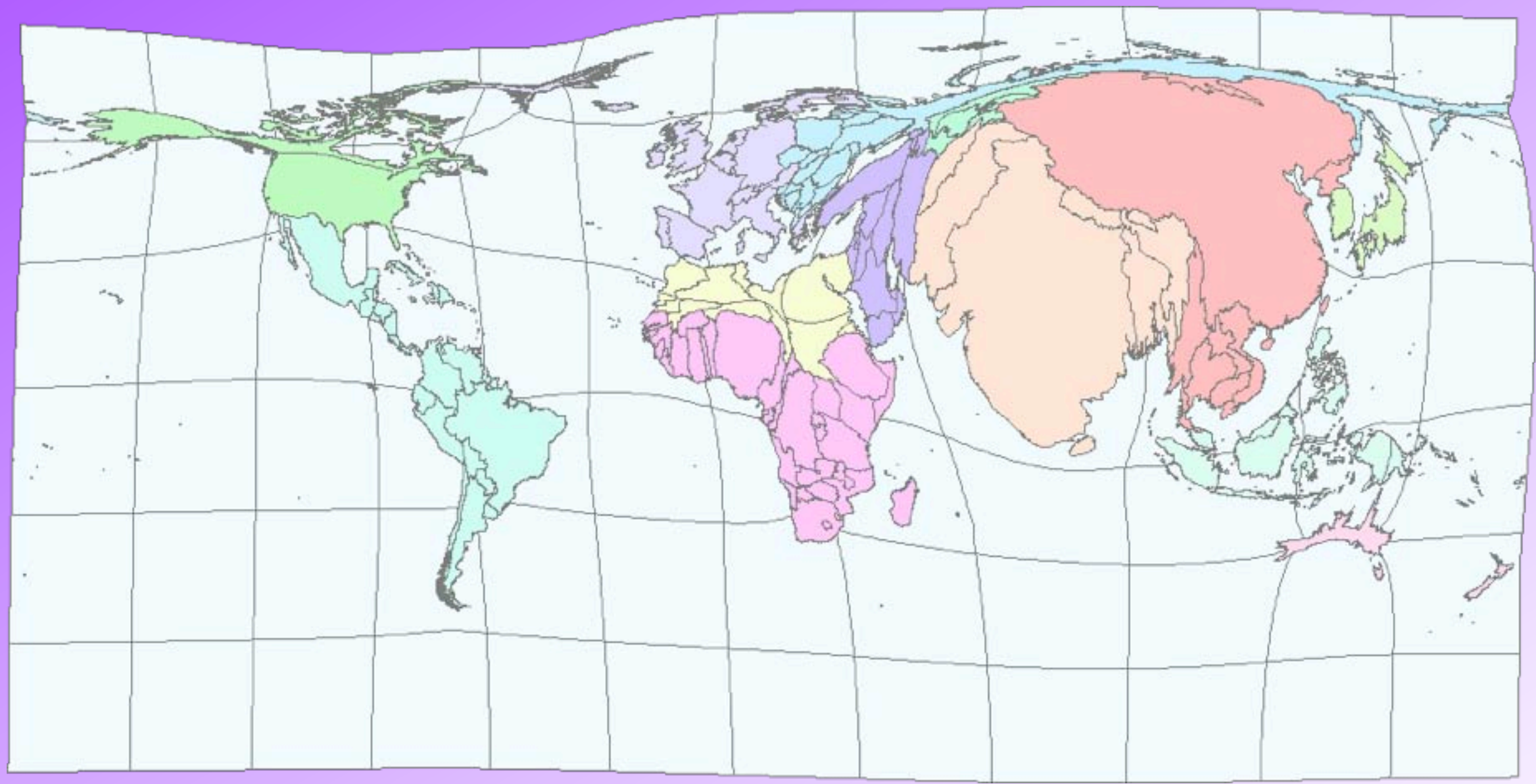
Distorting Additional Features



- If you include other shapefiles, geodatabases, or rasters in this list, they will be distorted along with the cartogram.
- This would allow, for example, cities to stay in their same relative location within their state or country.
  - Additional Features must have the *same* spatial reference.
  - Only the FID is copied to the new data set, so you'll need to join with the original data set.

Cartogram Tool Extras

Distorting Additional Features



- Sometimes these extra features can extend beyond limits.

Cartogram Tool Extras

Working with Related Features

- **Unique Field of Original Features:** Some polygon feature classes use distinct polygons to represent parts of a whole (think Hawaii). This is the field linking them so they distort together. (Usually data is identical.)

- **Sum the Value for each repeated ID:** Some polygons stand on their own but also collectively form a larger region (e.g. counties within states). If this box is checked and you set the Unique Field that links them, the larger unit is distorted.

Resources

- **Presidential Elections:**
  - 2008: http://www.amherst.edu/~aanderson/presidential_elections/2008-results.png
  - 2004: http://www.amherst.edu/~aanderson/presidential_elections/2004-analysis.pdf
- **ArcGIS Cartogram Plug-In:**
  - http://arcscripts.esri.com/details.asp?dbid=15638
- **Mark Newman @ the University of Michigan:**
  - http://www-personal.umich.edu/~mejn/election/2008/