

User Manual

The Geographic Gerrymandering Website currently accommodates one use types:

1. Geographic Analysis: Analysis of district shapefiles (.shp).

This use case along with associated inputs and outputs is addressed in detail below.

Inputs

1. Shapefiles

- a. *Description of file format:* Shapefiles (.shp) is a geospatial vector data format compatible with many geographic information systems (GIS). The shapefile itself contains geometric and attribute information for the spatial features of a dataset, in this case the districts corresponding to a legislative redistricting map. Users interested in the technical definition of shapefile creation and use should see the [ESRI Shapefile Technical Description White Paper](#).
- b. *Organization of the shp. File:* Main file record contents should include... Main file header data description must include...
- c. *Optional input of index files (.idx):* Optionally, users can upload an index file with their shapefile. The index file

Outputs

1. Compactness Measures

Compactness measures have been widely used to assess geographic gerrymandering. Although it is generally accepted that legislative districts should be “compact” the definition of compactness has proved elusive. Numerous, sometimes conflicting, measures of compactness across a number of theoretical dimensions have been proposed in the academic literature. These measures are typically based on comparing geometric features of the district (e.g. perimeters, areas) to the features of a related base geometric object (e.g. minimum bounding circle, convex hull). Here we provide six of the most frequently used measures of compactness used by academic researchers: (1) Polsby-Popper (Polsby and Popper, 1991); (2) Schwartzberg (1965); (3) Reock (1961); (4) Convex Hull; (5) X-Symmetry; and (6) Length-Width Ratio (C.C. Harris, 1964). As no one threshold for determining if a district has been gerrymandered exists we provide three cutoffs from which to compare scores from different districts (1) the scores for the original gerrymander, (2) the state median, and (3) user-chosen values.

2. The Original Gerrymander

The term Gerrymandering refers to the act of manipulating the boundaries of voting districts to achieve some political advantage. The term was coined during tenure Massachusetts Governor Elbridge Gerry, who in 1812 redrew the voting districts for the Massachusetts State Senate to favor his own party. One district caught the attention of the Boston Gazette, who published a political cartoon likening the district's shape to that of a salamander and labeling the phenomenon "The Gerry-mander" after the Governor. All measures are calculated for the Original Gerrymander as a comparison for district-level values.



Figure 1: The Original "Gerry-mander"

3. Compactness Measures

Polsby-Popper

The Polsby-Popper (PP) measure (polsby & Popper, 1991) is the ratio of the area of the district (A_D) to the area of a circle whose circumference is equal to the perimeter of the district (P_D). A district's Polsby-Popper score falls with the range of $[0, 1]$ and a score closer to 1 indicates a more compact district.

$$PP = 4\pi \times \frac{A_D}{P_D^2}$$

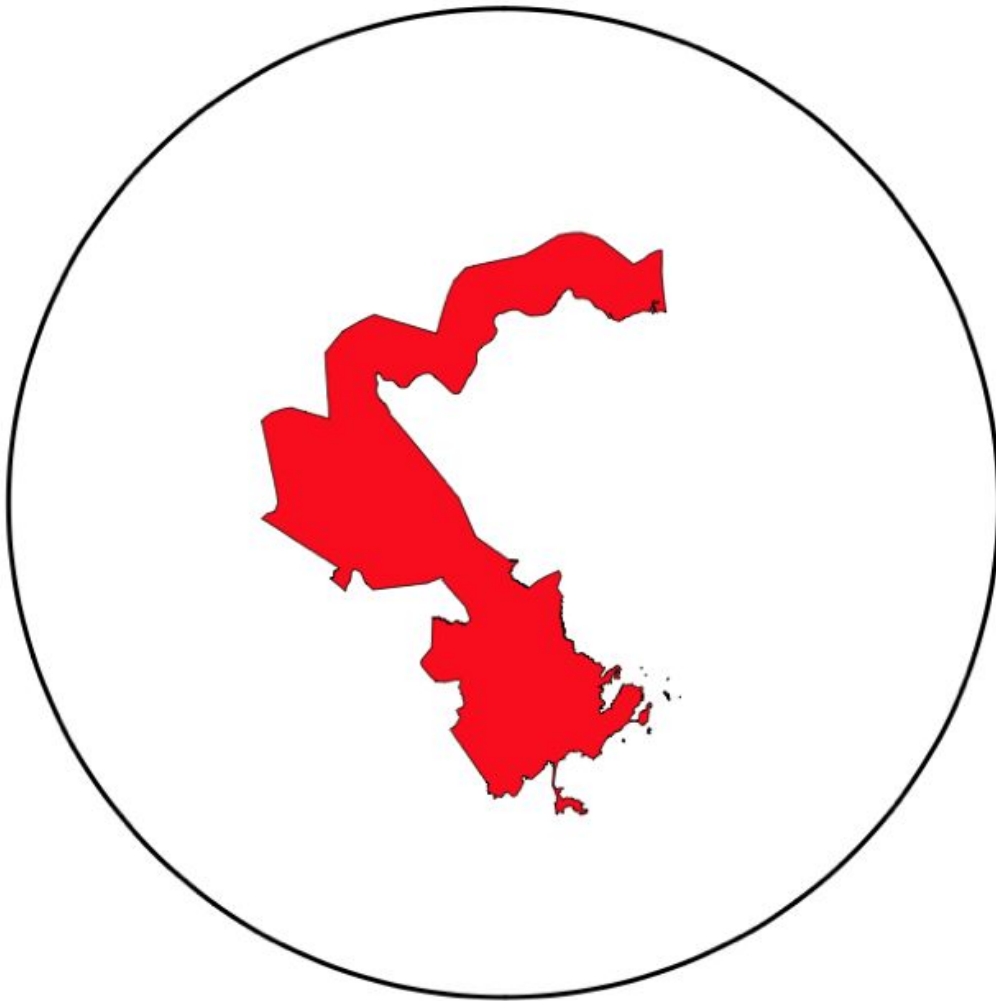


Figure 2: Circumference Equal to District Perimeter

Schwartzberg

The Schwartzberg score (S) compactness score is the ratio of the perimeter of the district (P_D) to the circumference of a circle whose area is equal to the area of the district. A district's Schwartzberg score as calculated below falls with the range of $[0,1]$ and a score closer to 1 indicates a more compact district.

$$S = \frac{1}{P_D/C} = \frac{1}{P_D/(2\pi\sqrt{A_D/\pi})}$$

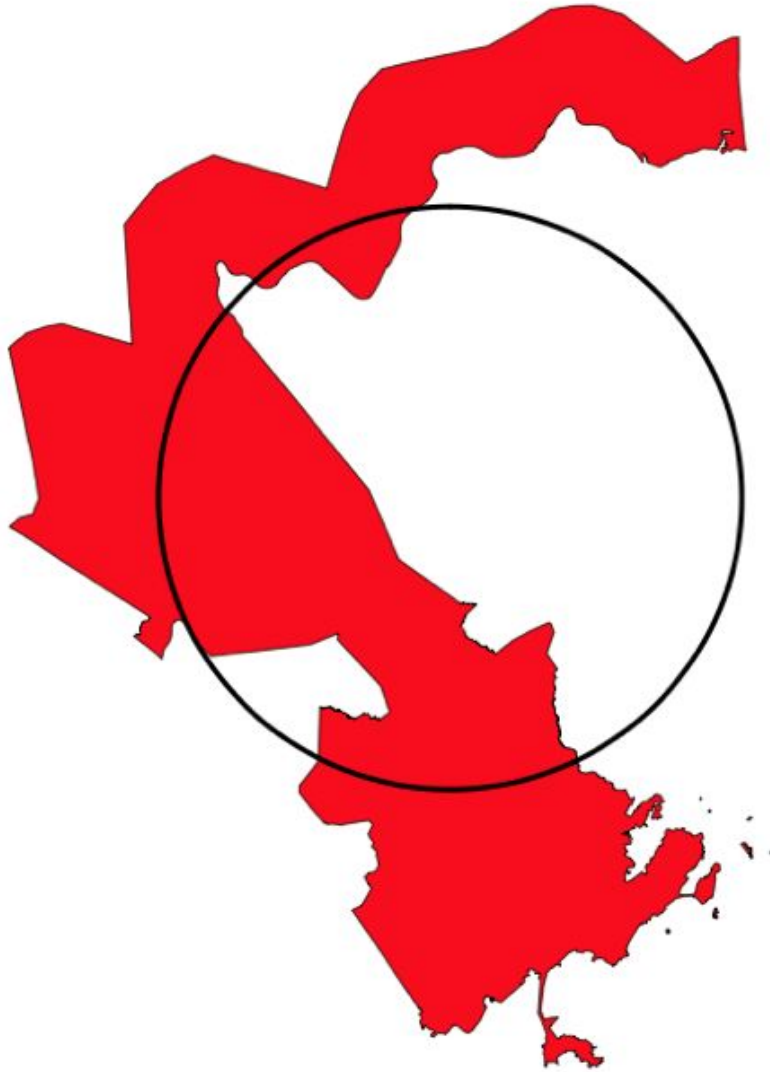


Figure 3: Circle with Area Equivalent to the District

Reock Score

The Reock Score (R) is the ratio of the area of the district A_D to the area of a minimum bounding circle (A_{MBC}) that encloses the district's geometry. A district's Reock score falls within the range of $[0,1]$ and a score closer to 1 indicates a more compact district.

$$R = \frac{A_D}{A_{MBC}}$$



Figure 4: Minimum Bounding Circle of Original Gerrymander

Convex Hull

The Convex Hull score is a ratio of the area of the district to the area of the minimum convex polygon that can enclose the district's geometry. A district's Convex Hull score falls within the range of $[0,1]$ and a score closer to 1 indicates a more compact district.

$$CH = \frac{A_D}{A_{MCP}}$$

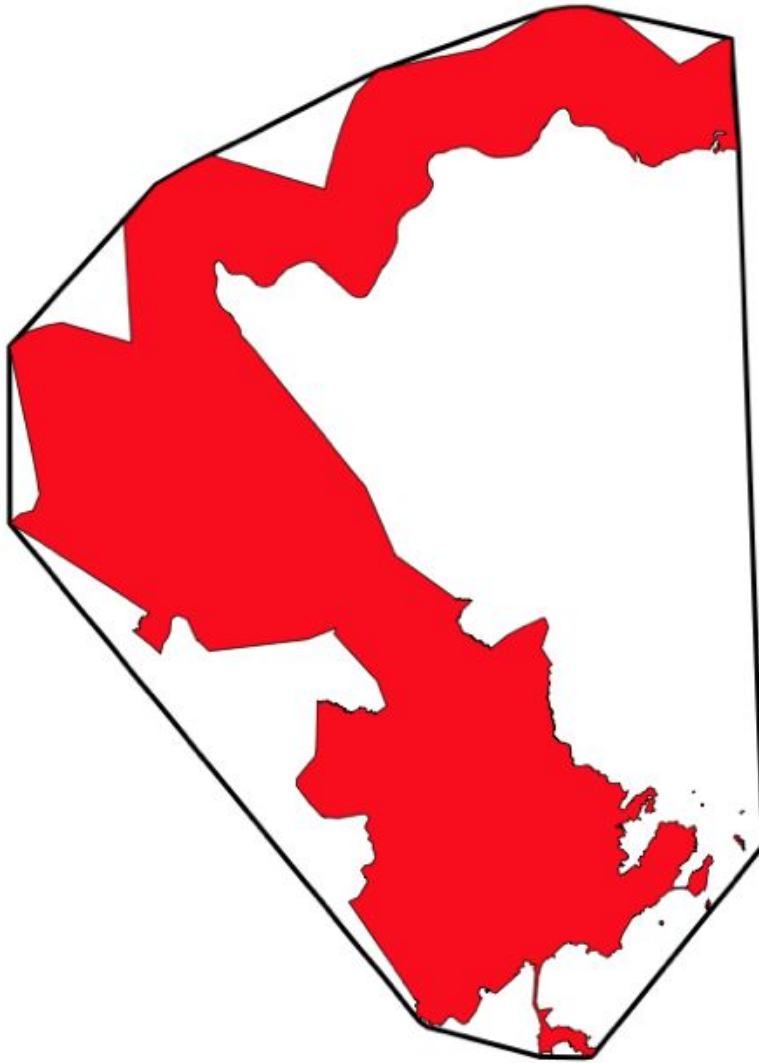


Figure 5: Convex Hull of Original Gerrymander

X-Symmetry

X-Symmetry is calculated by dividing the overlapping area A_O , between a district and its reflection across the horizontal axis by the area of the original district A_D . A district's X-Symmetry score falls with the range of $[0,1]$ and a score closer to 1 indicates a more compact district.

$$XS = \frac{A_O}{A_D}$$



Figure 6: Area of Overlapping X-Symmetry

4. Select Measure Boundaries Option

Users can select one of three options for the thresholds on which to classify districts as geographically gerrymandered (1) Original Gerrymander, (2) Median, or (3) Custom. Original Gerrymander gives cutoffs that are calculated from based on the original gerrymandered district. Median gives cutoffs based on the median value of the measure across all districts. Custom allows the user to input their own values.

Select Measure Boundaries

✓ Original Gerrymander
Median
Custom

ndaries.

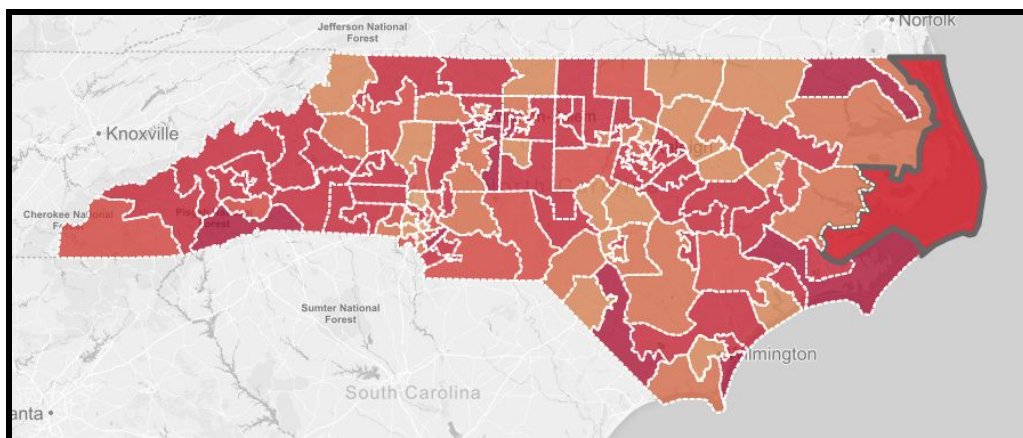
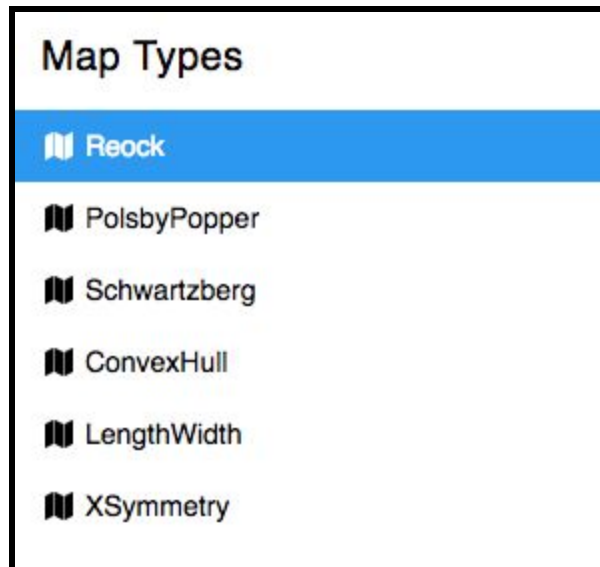
Reock:	0.289
Polsby-Popper:	0.095
Schwartzberg:	0.308
Convex-Hull:	0.494
Length-Width:	0.384
X-Symmetry:	0.717

Based on the chosen cutoffs cells in the data table are highlighted as green if they are above the given threshold, indicating more compact districts, or red if they are below, indicating less compact districts.

Schwartzberg↑↓	Convex-Hull↑↓	Length-Width↑↓	X-Symmetry↑↓
0.430	0.704	0.786	0.706
0.701	0.804	0.976	0.456
0.575	0.691	0.767	0.454
0.606	0.767	0.874	0.724
0.516	0.666	0.499	0.359
0.486	0.598	0.794	0.445
0.591	0.839	0.947	0.717

5. Choropleth Maps

Users can select a specific Map Type for any one of the six provided compactness metrics. From the selected metric two displays are changed. The first of these plots is a choropleth plot overlaid on current map data for the location specified in the original shapefile.



6. Histograms of Compactness Measures

Once a district and compactness measure have been selected histograms for all the district's scores. In addition, a comparison between the stage average and district-level measure will be given in the second plot pane.

