

Cartograms for spatial data visualization

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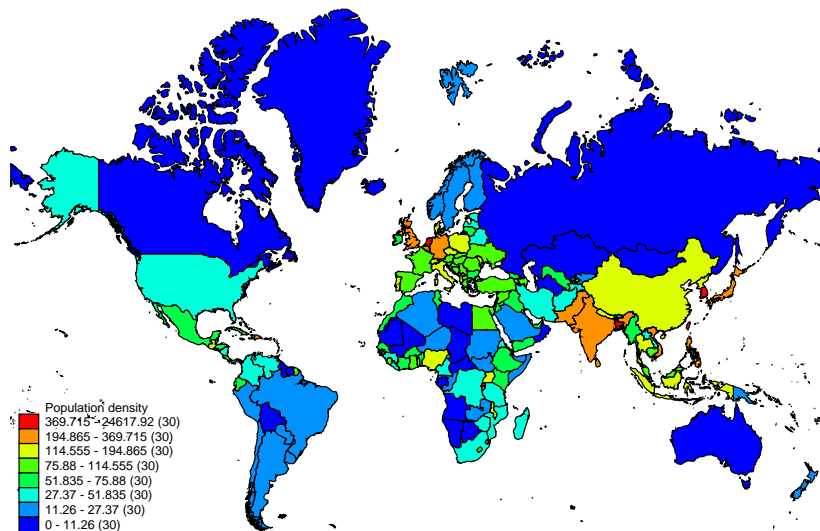
Belgian Stata User Group Meeting - September, 6th 2016

Maps as visualization tools of the world

- Powerful visualization tools when used with caution...
- BUT maps may also produce very biased views of the world.

Which parts of the world have the lowest population density?

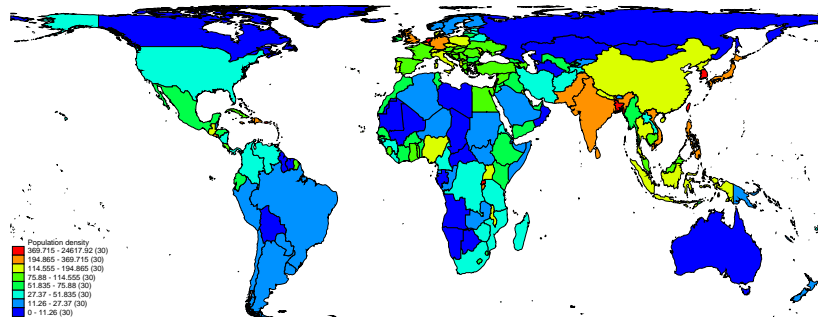
Population density by country



Cartogram: Mercator projection (conformal)

Which parts of the world have the lowest population density?

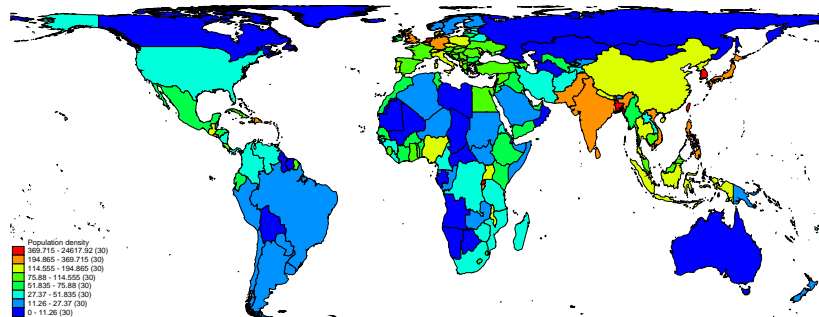
Population density by countries



Cartogram: NSIDC-EASE projection (equal area cylindrical)

Which parts of the world have the lowest population density?

Population density by countries



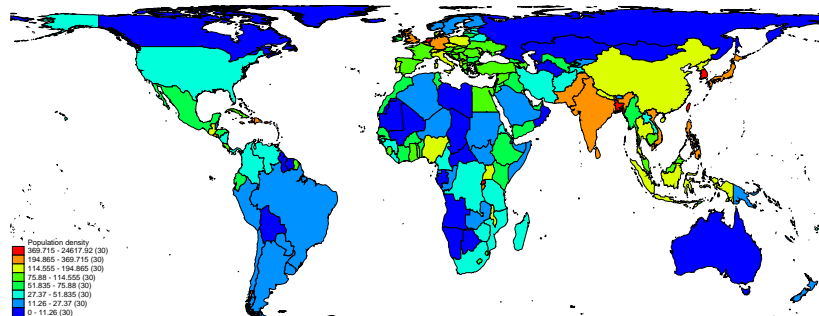
Cartogram: NSIDC-EASE projection (equal area cylindrical)

- Mercator projection:

- ▶ larger size distortion as distance to equator increases
- ▶ inflates the importance of some countries

Which parts of the world have the lowest population density?

Population density by countries

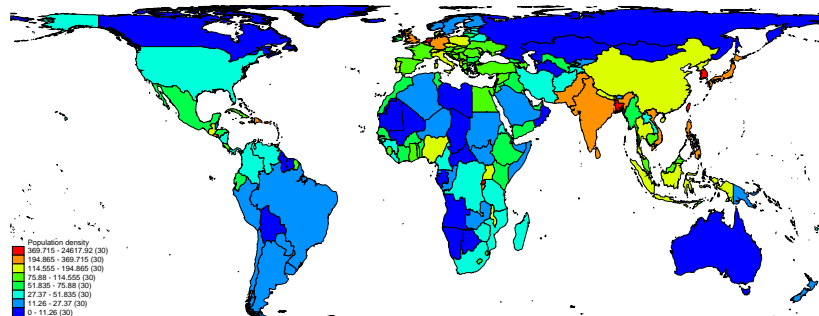


Cartogram: NSIDC-EASE projection (equal area cylindrical)

- Mercator projection:
 - ▶ larger size distortion as distance to equator increases
 - ▶ inflates the importance of some countries
- Equal area projection (NSDIC-EASE)
 - ▶ large shape distortion
 - ▶ area preserving

Which parts of the world have the lowest population density?

Population density by countries

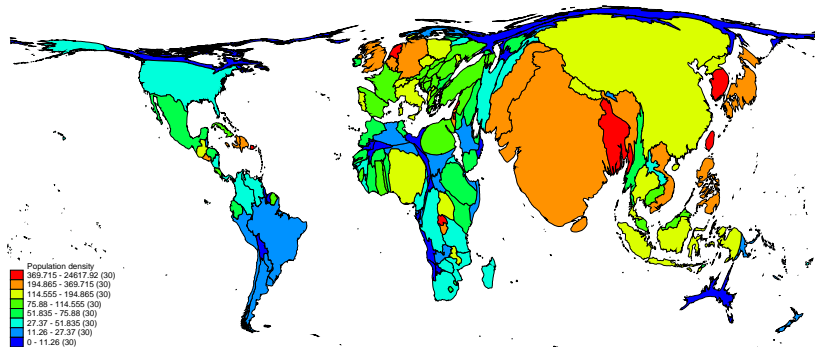


Cartogram: NSDIC-EASE projection (equal area cylindrical)

- Mercator projection:
 - ▶ larger size distortion as distance to equator increases
 - ▶ inflates the importance of some countries
- Equal area projection (NSDIC-EASE)
 - ▶ large shape distortion
 - ▶ area preserving
- Are area and shape the relevant characteristics for population density?

But most of the population lives in densely populated countries...

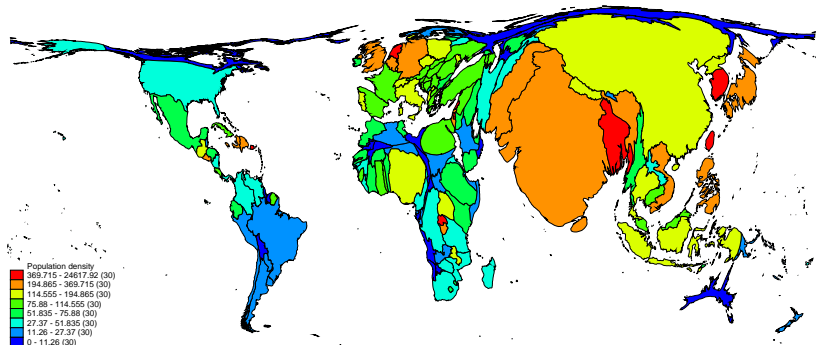
Population density by countries



Cartogram: NSIDC-EASE projection, reweighted by country population using ScapeToad

But most of the population lives in densely populated countries...

Population density by countries



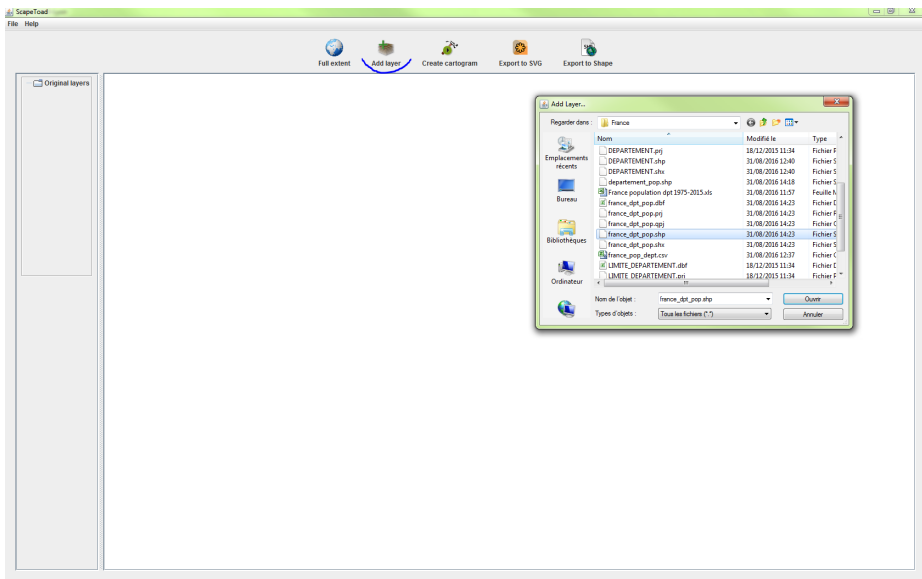
Cartogram: NSIDC-EASE projection, reweighted by country population using ScapeToad

- The area of countries can represent their relative importance in terms of population

The plan...

- Create a cartogram using **ScapeToad** (<http://scapetoad.choros.ch>)
- Create an (animated) map using **Stata** and `spmap` package by Maurizio Pisati
- Produce a short movie using **FFmpeg** (<http://ffmpeg.org>)

Cartogram creation: open ScapeToad and add a vector layer



Cartogram creation: create cartogram

The screenshot shows the ScapeToad software interface. The main window displays a map of France with its administrative regions highlighted in teal. The 'Create cartogram' button in the top toolbar is highlighted with a blue circle. A 'Cartogram creation wizard' dialog box is open in the foreground, showing a progress bar with steps 1 through 6, where step 1 is selected. The dialog contains the following text:

Cartogram creation wizard

1 2 3 4 5 6

You are about to create a new space. You will first define:

- 1 - A **spatial coverage**, by selecting a polygon layer to transform. Other layers can optionally be linked to this layer and be simultaneously transformed.
- 2 - A **statistical variable**, available for every polygon of the transformation layer. This variable will determine the metrics of the newly defined space.

Buttons for 'Cancel', a help icon (?), and 'Next >' are visible at the bottom of the dialog.

Cartogram creation: choose the spatial coverage

The screenshot shows the ScapeToad software interface. The main window displays a map of France with its administrative regions highlighted in teal. The top toolbar includes icons for 'Full extent', 'Add layer', 'Create cartogram', 'Export to SVG', and 'Export to Shape'. On the left, a 'Layers' panel shows 'Original layers' and 'france'. A 'Cartogram creation wizard' dialog box is open in the foreground, featuring a progress bar with steps 1 through 6, where step 1 is selected. The wizard includes a 'Spatial coverage' dropdown menu set to 'france_gst_psp', a 'ScapeToad' logo, and instructions for selecting a layer and ensuring clean polygon topology. It also provides visual examples of 'Perfect contiguity', 'Overlap error', and 'Gap error'.

Cartogram creation wizard

1 2 3 4 5 6

Spatial coverage: france_gst_psp

Select the **main** layer to transform from the above menu:

- The selected layer must be a polygon layer.
- It must provide a statistical variable for each polygon.
- Its topology should not contain any errors.

Polygon topology must be as clean as possible with respect to:

- overlapping (polygons should not overlap);
- topological continuity (there should be no gaps between polygons, except to describe real topological discontinuities, such as lakes or islands).

Perfect contiguity
All points are well aligned

Overlap error
Polygons share a common region

Gap error
Polygons create a hole

Cancel ? < Back Next >

Cartogram creation: choose the attribute - the weighting variable

The screenshot shows the ScapeToad software interface. The main window displays a map of France with a teal color scheme. The top menu bar includes 'File' and 'Help'. Below the menu bar are icons for 'Full extent', 'Add layer', 'Create cartogram', 'Export to SVG', and 'Export to Shape'. On the left, a 'Layers' panel shows 'Original layers' and 'france'. A 'Cartogram creation wizard' dialog box is open in the foreground, featuring a progress bar with steps 1 through 6, where step 3 is highlighted. The dialog contains the following text:

Cartogram creation wizard

Cartogram attribute:
pop_1975

Attribute type:
 Mass
 Density

The metric unit of the new space
Select a statistical variable from the menu above. It will determine the metric unit of the newly defined space.

Select the information type of the variable:
- **Mass**: the selected statistical variable represents a mass (e.g. a population or a wealth) measured or estimated over the whole surface of each polygon.
- **Density**: the selected statistical variable is a ratio between a mass and the surface of the polygon to which it is attributed.

Buttons: Cancel, ? (help), < Back, Next >

Cartogram creation: other layers and constraints

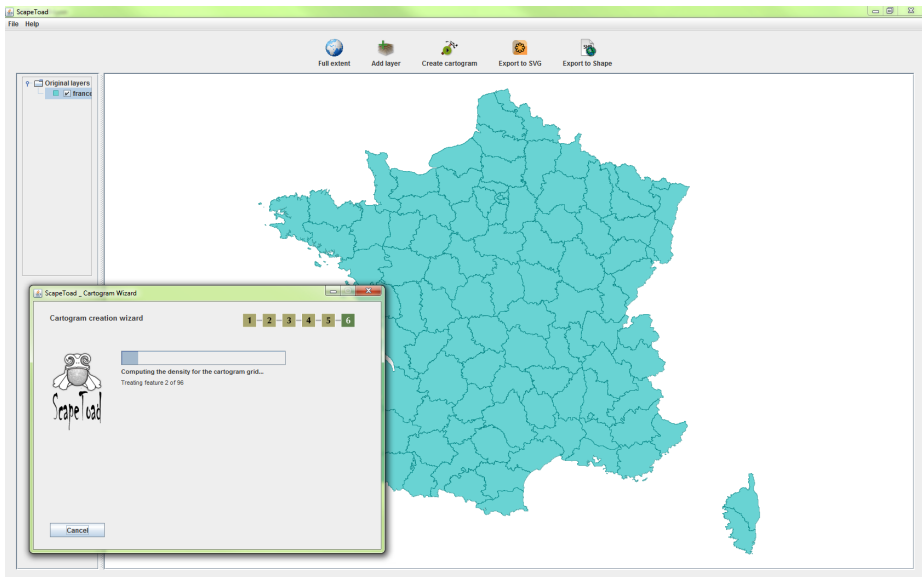
The screenshot displays the ScapeToad software interface. The main window shows a map of France with a cyan-colored cartogram overlay. The top menu bar includes 'File' and 'Help'. The toolbar contains icons for 'Full extent', 'Add layer', 'Create cartogram', 'Export to SVG', and 'Export to Shape'. On the left, a 'Layers' panel shows 'Original layers' and 'france'. A 'Cartogram creation wizard' dialog box is open in the foreground, featuring a progress bar with steps 1 through 6, where step 4 is selected. The wizard includes a 'ScapeToad' logo and two options: 'Layers to transform...' and 'Constrained transformation...'. The 'Constrained transformation...' option is selected, and its description reads: 'Limited transformation. One or more layers can restrict space transformation in order to preserve some topographical features. Please note that transformation prevails on feature conservation as far as required by the selected statistical variable.' The dialog box has 'Cancel', 'Back', and 'Next' buttons.

Cartogram creation: quality of the cartogram

The screenshot displays the ScapeToad software interface. The main window shows a map of France with a cyan cartogram overlay. The top toolbar includes icons for 'Full extent', 'Add layer', 'Create cartogram', 'Export to SVG', and 'Export to Shape'. On the left, a layer list shows 'Original layers' and 'france'. Two dialog boxes are open:

- ScapeToad_Cartogram Wizard:** This dialog has a progress bar with steps 1-6. Step 2, 'Transformation quality', is active. It features a slider from 'Low' to 'High' with a diamond marker at 'Medium'. Below the slider, text explains: "Transformation quality sets proportionality requirements between newly defined polygon surfaces and the specified statistical variable. Higher quality implies a longer computation time. Other parameters, such as polygon complexity or their number, can also make the computation longer." There is an 'Advanced options...' button and 'Cancel', 'Back', and 'Complete' buttons at the bottom.
- Advanced options:** This dialog is titled 'Advanced options' and contains:
 - A checked option: **Create a transformation grid layer!**. Below it, text states: "You can choose to include a grid into the visual output, as a separate layer. This rectangular grid is defined by the number of rows." A text box contains '100'.
 - An unchecked option: **Define cartogram parameters manually**. Below it, text says: "Only an overall quality parameter can be set with the slider in the basic step 5 window: here you can manually define three separate transformations:"
 - 1 - A grid is applied to the main transformation layer. This rectangular grid is defined by the number of rows. Higher numbers produce denser grids and thus a better cartogram quality. However, a denser grid also implies a longer treatment. A text box contains '200'.
 - 2 - A second grid is applied to the main transformation layer. This square grid is defined by the number of rows. Denser grids imply again a better cartogram quality but longer computation times. A dropdown menu shows '100'.
 - 3 - The second grid is transformed with the Gastner-Reverman diffusion algorithm, which can be run several times to obtain a higher transformation quality. Higher numbers of iterations also imply longer treatment times. A text box is empty.
 - 'Cancel' and 'OK' buttons at the bottom.

Cartogram creation: computations



Cartogram creation: report

The screenshot displays the ScapeToad software interface. The main window shows a map of France with a grid overlay, where the map area is colored in shades of orange and red, representing the cartogram. A legend titled "Size Error" is visible on the right, showing a color scale from blue (70) to red (120). A report window titled "ScapeToad_Cartogram Wizard" is open in the foreground, displaying the following information:

Cartogram creation wizard

1 2 3 4 5 6

Cartogram computation successfully terminated

Note

CONSTRAINED DEFORMATION LAYERS:

Note

CARTOGRAM ERROR

The cartogram error is a measure for the quality of the result.

Mean cartogram error: 97.39184519440501

Standard deviation: 0.22302422047071

25th percentile: 94.83262639968989

50th percentile: 97.81775655159483

75th percentile: 101.48777374261518

Features with mean error ± 1 standard deviation: 77 of 96 (80%)

Computation time: 351 seconds

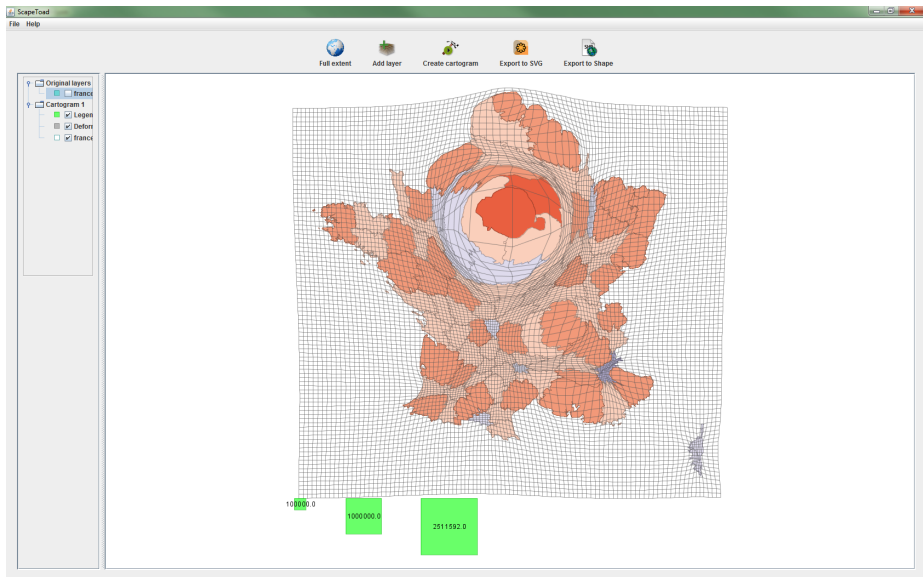
2511592.0

Buttons: End, Save report...

Cartogram creation: export to shape file

The screenshot shows the ScapeToad software interface. The main window displays a cartogram of France, where the landmass is distorted based on population density and overlaid with a grid. The cartogram is colored in shades of orange and red. The software's menu bar includes 'File' and 'Help'. The toolbar contains icons for 'Full extent', 'Add layer', 'Create cartogram', 'Export to SVG', and 'Export to Shape', with the latter being highlighted by a blue arc. On the left, a layer list shows 'Original layers' (france) and 'Cartogram 1' (Legen, Defon, france). A dialog box titled 'Export layer as Shape file' is open, showing 'france_dpt_pop (2)' selected. A 'Save Layer As...' dialog box is also open, displaying a file list for the 'France' folder. The file list includes various shapefiles and CSV files related to population and departmental boundaries. The 'Nom' column lists files like 'departement_pop.shp', 'france_population dpt 1975-2015.xls', 'france_dpt_pop.dbf', 'france_dpt_pop.prj', 'france_dpt_pop.shp', 'france_dpt_pop.shx', 'france_pop_dept.csv', 'LIMITE_DEPARTEMENT.dbf', 'LIMITE_DEPARTEMENT.prj', 'LIMITE_DEPARTEMENT.shp', and 'LIMITE_DEPARTEMENT.shx'. The 'Modifié le' column shows dates from 31/08/2016 to 18/12/2015. The 'Type' column lists file types such as 'Fichier S', 'Feuille h', and 'Fichier C'. The 'Nom de l'objet' field is set to 'france-cartogram_1315-2015' and the 'Type' is 'Tous les fichiers (*.*)'. At the bottom of the main window, there are three green boxes with the values '100000.0', '1000000.0', and '2511592.0'. The bottom status bar shows navigation icons and the text 'Fr. Libois (INRA & PSE) Cartograms 2016 Bruxelles 15 / 21'.

Cartogram created



French population density

Some Stata code

Import shape files in Stata using `shp2dta` by Kevin Crow

```
shp2dta using francecartogram1975.shp, database(deptpop1975) ///  
coord(deptpop1975coord) replace genid(id)
```

Some Stata code

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shp2dta using francecartogram1975.shp, database(deptpop1975) ///  
coord(deptpop1975coord) replace genid(id)
```

Create maps

```
use deptpop1975, clear  
spmap popdens using deptpop1975coord, id(id) ///  
plotregion(icolor(white)) graphregion(icolor(white)) ///  
clmethod(custom) clbreaks(0 20 40 60 80 100 150 200 500 1000 25000)  
fcolor(Rainbow) ///  
title("France: population by department") subtitle("1975") ///  
note("Cartogram: Lambert 93 projection, reweighted by département"  
"population using ScapeToad") ///  
legstyle(1) legtit("Population density") legcount
```

Some Stata code

Export the maps and create a video

```
graph export france-popdens1975.png, replace width(960) height(540)
winexec "C:/ffmpeg/_static/bin/ffmpeg.exe" ///
-report -framerate 2/3 -start_number 1975 -i france-popdens%04d.png ///
-c:v libx264 -r 24 -pix_fmt yuv420p france_popdens_video.mp4
```


Some Stata code

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graph export france-popdens1975.png, replace width(960) height(540)
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-c:v libx264 -r 24 -pix_fmt yuv420p france_popdens_video.mp4
```

Animated slide using beamer in L^AT_EX

```
\animategraphics[controls,buttonsize=0.3cm,autoplay,loop,
height=0.8 \textheight] {0.75} {"france-popdens"} {1975} {2015}
```

Many thanks

Which parts of the world have the lowest population density?

Population density by countries



Cartogram: NSIDC-EASE projection, reweighted by country population using spmap