Special Joint HGRG/EEO Event

16:00, Fri 23 May, 2008

Human Cartography: Local and Global Mapping of Life and Death

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One small step for two men, one giant leap for mapping

This talk begins with the breakthrough of 2004 in the creation of a new density-equalizing map projection by Michael Gastner and Mark Newman of the University of Michigan, USA. Although this may sound like the most obscure of topics this talk will attempt to make the claim that what these two have achieved is potentially the most significant breakthrough in cartography since Gerardus Mercator's wall maps of 1569. The talk will be illustrated by numerous images and no equations (well – almost no equations ☺). Gastner and Newman have made their projection widely available. However, for mapping life and death it is not the only solution.

solution to the diffusion equation has the form

$$\rho(\mathbf{r},t) = \frac{4}{L_x L_y} \sum_{\mathbf{k}} \tilde{\rho}(\mathbf{k}) \cos(k_x x) \cos(k_y y) \exp(-k^2 t), \tag{8}$$

where the sum is over all wavevectors $\mathbf{k} = (k_x, k_y) = 2\pi(m/L_x, n/L_y)$ with m, n non-negative integers, and $\tilde{\rho}(\mathbf{k})$ is the discrete cosine transform of $\rho(\mathbf{r}, t = 0)$:

$$\tilde{\rho}(\mathbf{k}) = \begin{cases} \frac{1}{4}\int_0^{L_x}\int_0^{L_y} \rho(\mathbf{r},0)\,\mathrm{d}x\,\mathrm{d}y & \text{if } k_x = k_y = 0, \\ \frac{1}{2}\int_0^{L_x}\int_0^{L_y} \rho(\mathbf{r},0)\cos(k_y y)\,\mathrm{d}x\,\mathrm{d}y & \text{if } k_x = 0 \text{ and } k_y \neq 0, \\ \frac{1}{2}\int_0^{L_x}\int_0^{L_y} \rho(\mathbf{r},0)\cos(k_x x)\,\mathrm{d}x\,\mathrm{d}y & \text{if } k_x \neq 0 \text{ and } k_y = 0, \\ \int_0^{L_x}\int_0^{L_y} \rho(\mathbf{r},0)\cos(k_x x)\cos(k_y y)\,\mathrm{d}x\,\mathrm{d}y & \text{otherwise.} \end{cases} \tag{9}$$

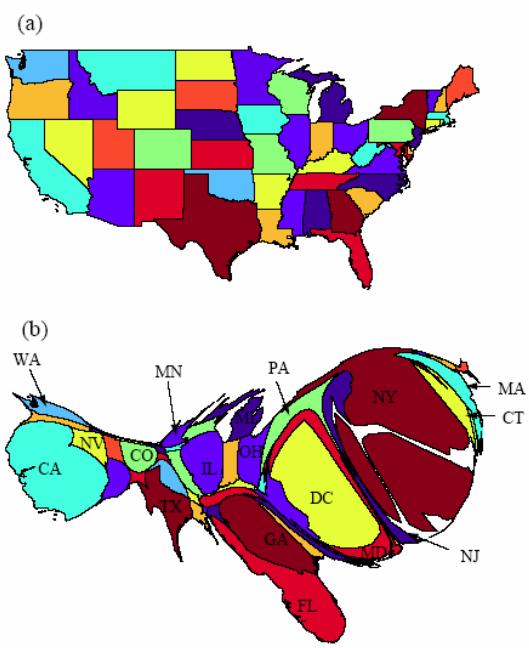
The velocity field $\mathbf{v}$ is then easily calculated from Eqs. (6) and (8) and has components

$$v_x(\mathbf{r},t) = \frac{\sum_{\mathbf{k}} k_x \tilde{\rho}(\mathbf{k}) \sin(k_x x)\cos(k_y y)\exp(-k^2 t)}{\sum_{\mathbf{k}} \tilde{\rho}(\mathbf{k}) \cos(k_x x)\cos(k_y y)\exp(-k^2 t)}, \tag{10a}$$

$$v_y(\mathbf{r},t) = \frac{\sum_{\mathbf{k}} k_y \tilde{\rho}(\mathbf{k}) \cos(k_x x)\sin(k_y y)\exp(-k^2 t)}{\sum_{\mathbf{k}} \tilde{\rho}(\mathbf{k}) \cos(k_x x)\cos(k_y y)\exp(-k^2 t)}. \tag{10b}$$

Equations (9) and (10) can be evaluated rapidly using the fast Fourier transform (FFT) and its back-transform respectively, both of which in this case run in time of order $L_x L_y \log(L_x L_y)$. We then use the resulting velocity field to integrate Eq. (7), which is a nonlinear Volterra equation of the second kind and can be solved numerically by standard methods [13]. In practice it is the Fourier transform that is the time-consuming step of the calculation and, as we will see, with the aid of the FFT this step can be performed fast enough that the

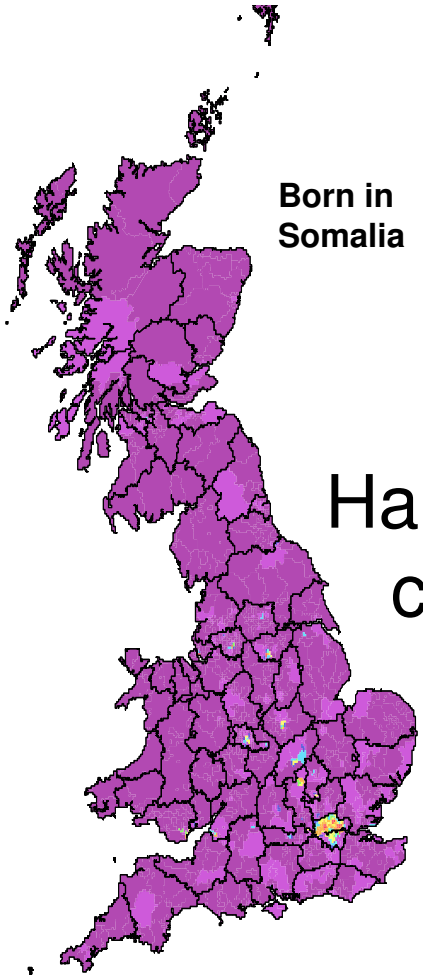
Gastner and Newman example

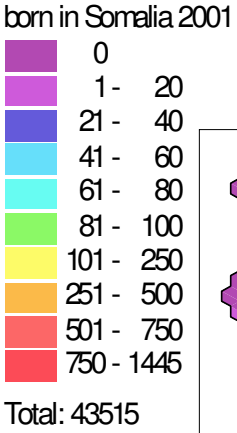


The distribution of news stories in the United States.

(a) Conventional map of the states.

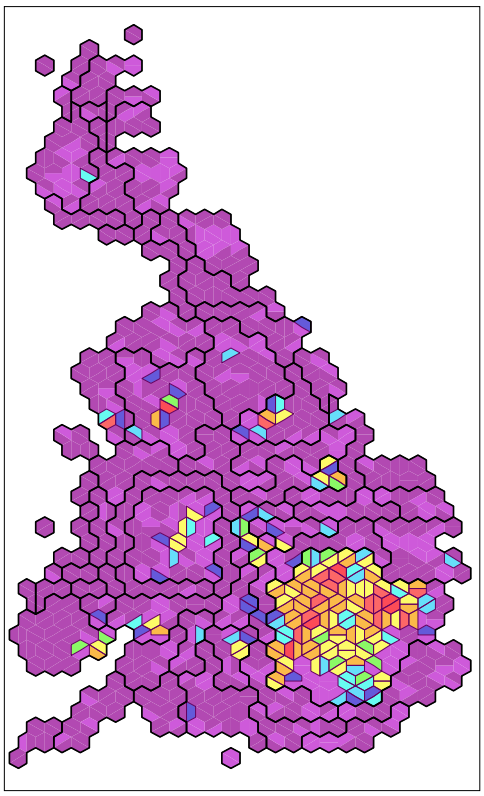
(b) “Mindshare map” in which the sizes of states are proportional to the frequency of their appearance in news stories.





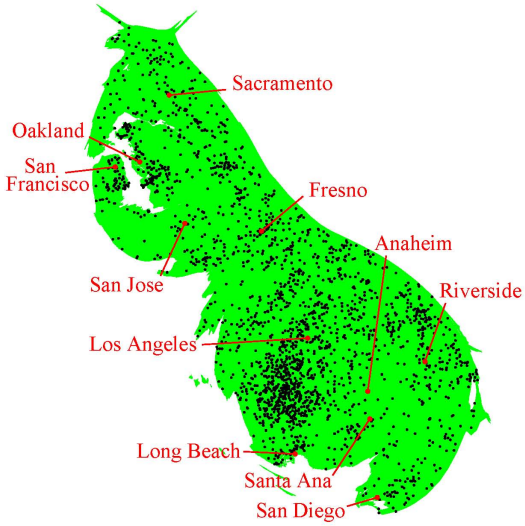
Hand drawn cartogram example

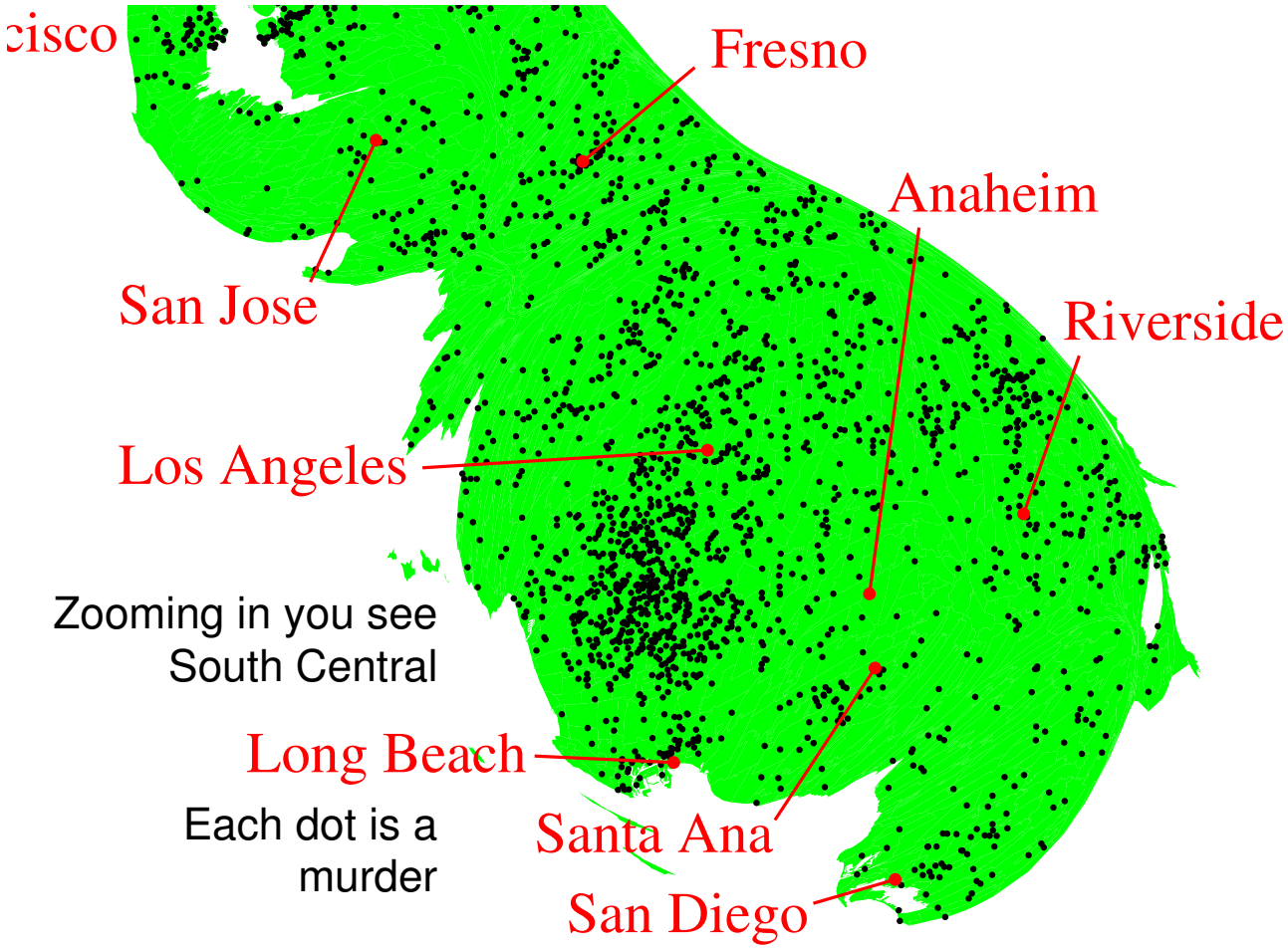
See who is invisible on a "normal" map



Event mapping example

Events which appear clustered on a "normal" map are seen at their actual density in population space.
In his case that space is California (example courtesy Mark Newman)

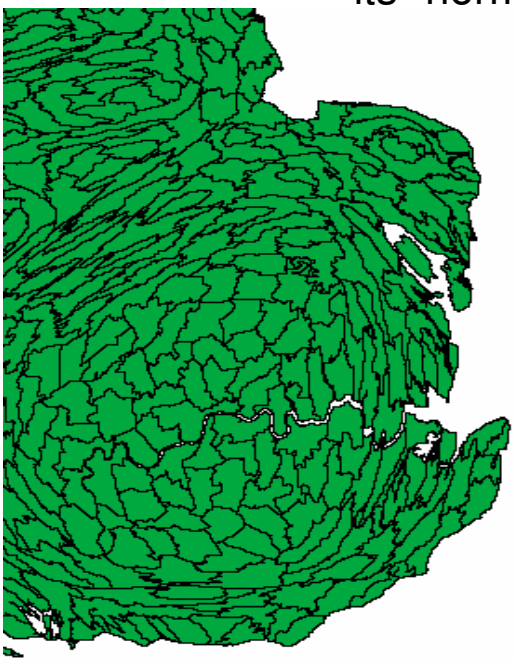




Zooming in you see South Central

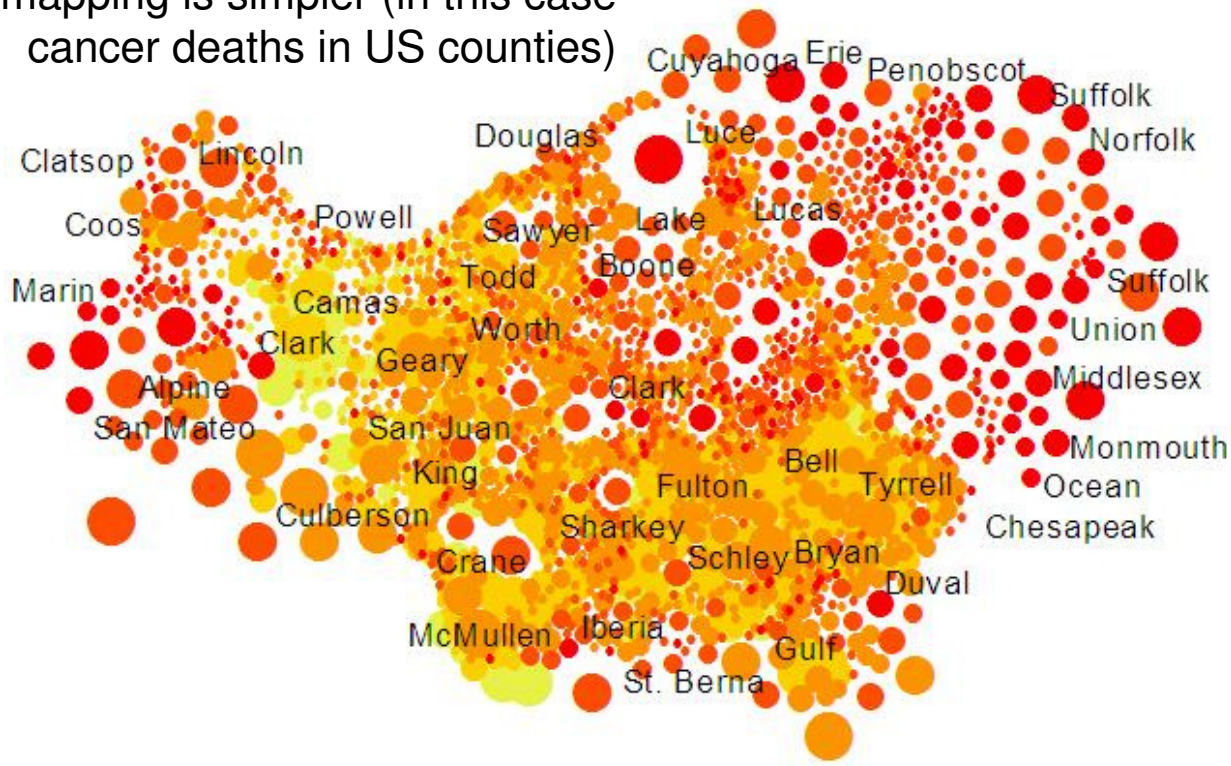
Each dot is a murder

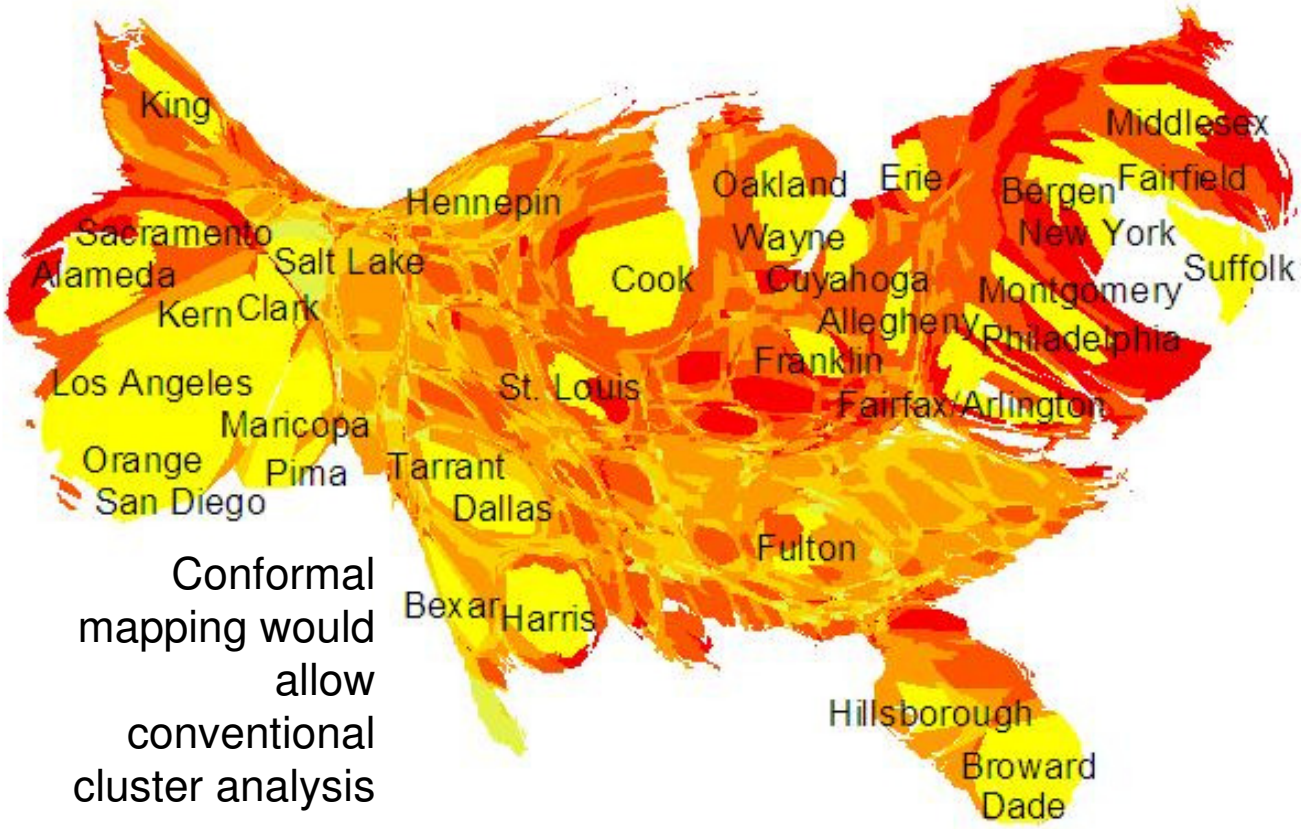
This is a Conformal Equal Population Projection – look at the Thames, its "normal"



Here every constituency is drawn with area proportional to its electorate.
The conformal property of the projection is the breakthrough not yet recognised.

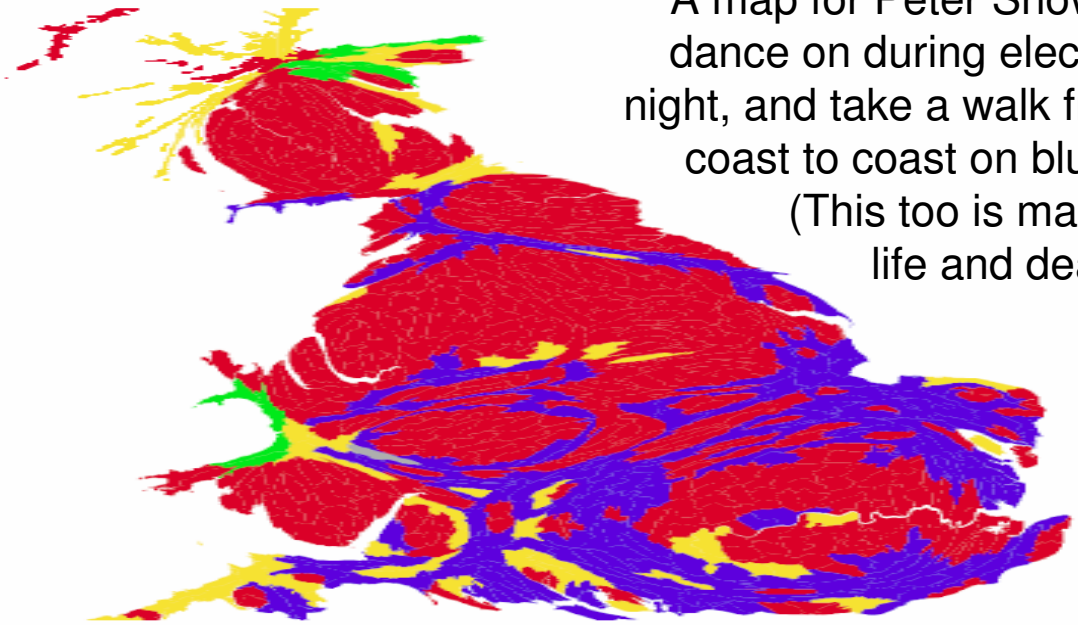
Sometimes non-conformal mapping is simpler (in this case cancer deaths in US counties)





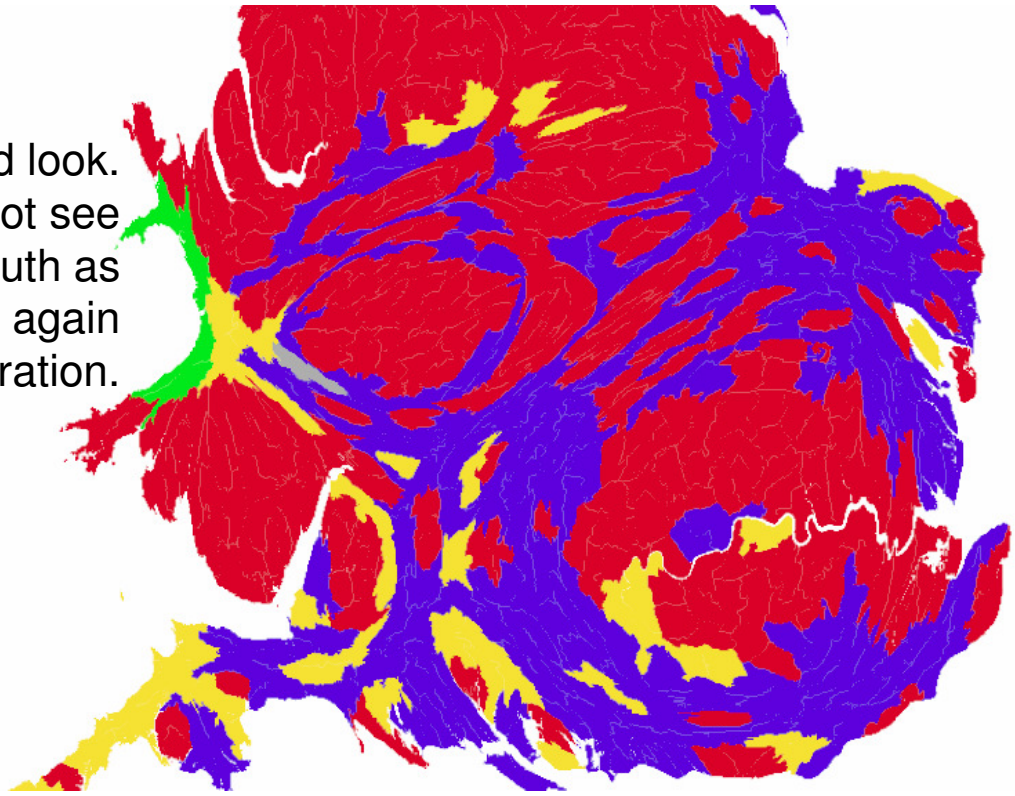
Conformal mapping would allow conventional cluster analysis

British Constituencies (2001)



A map for Peter Snow to dance on during election night, and take a walk from coast to coast on blue?. (This too is map of life and death)

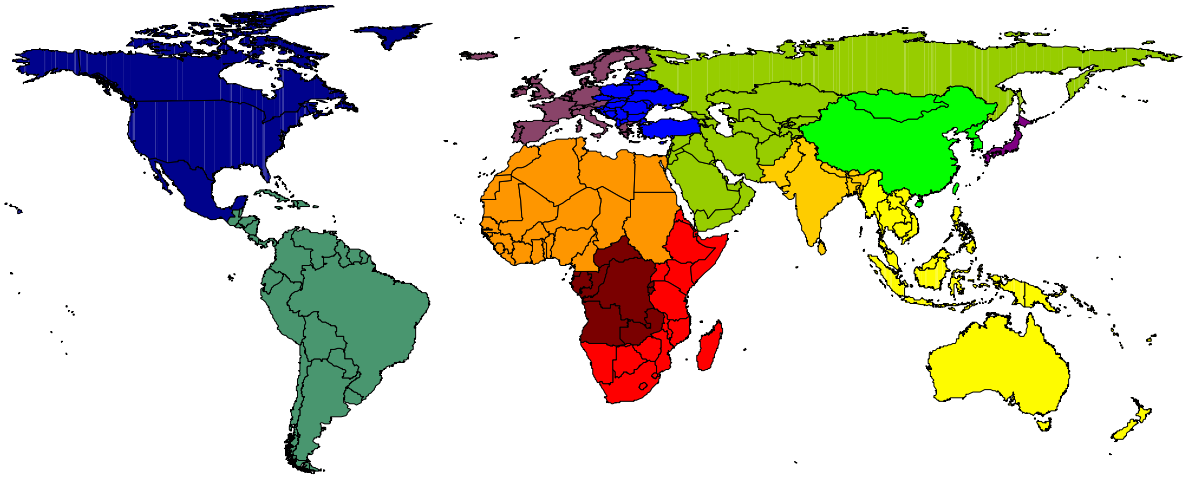
Take a good look. You may not see the South as red again for a generation.



Nor Scotland either?

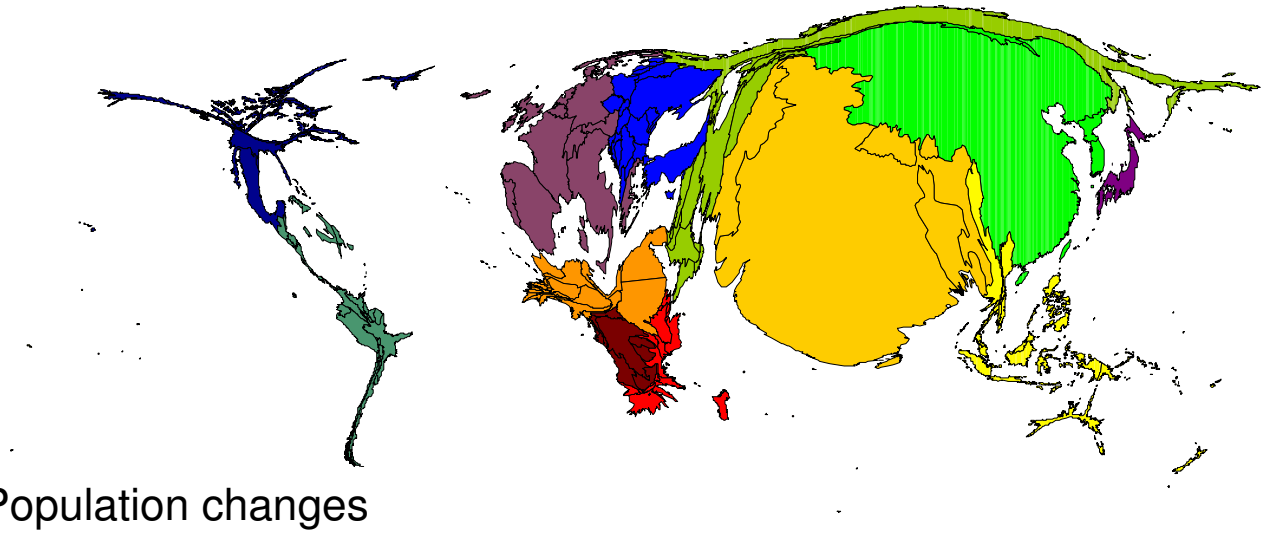
See how the Clyde,
The Forth, the Tyne,
The Wear and Humber
Flow between people
Rather than across land.

Land Area



One of first world cartograms I drew using Gastner and Newman's algorithm – the clue that it's a cartogram is the size of Greenland (ice is not land).

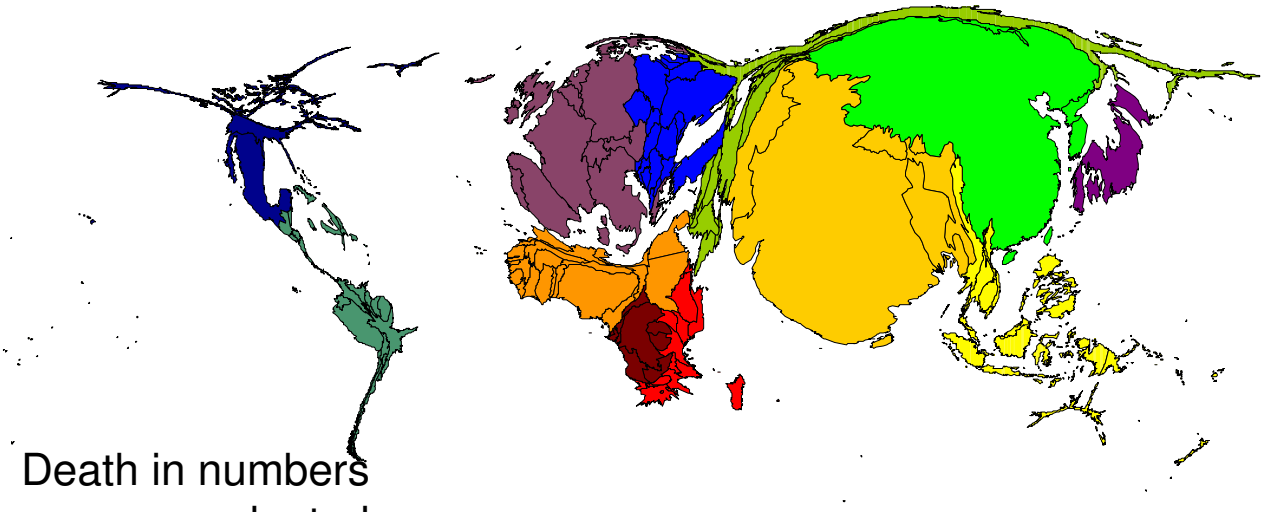
Population year 0



Population changes
over time.

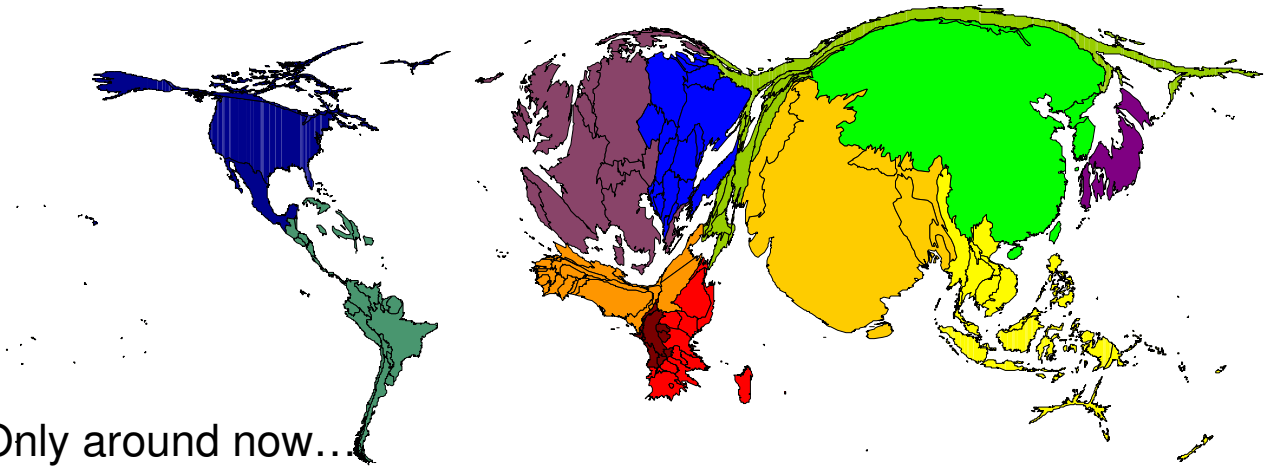
Watch Japan

Population year 1500



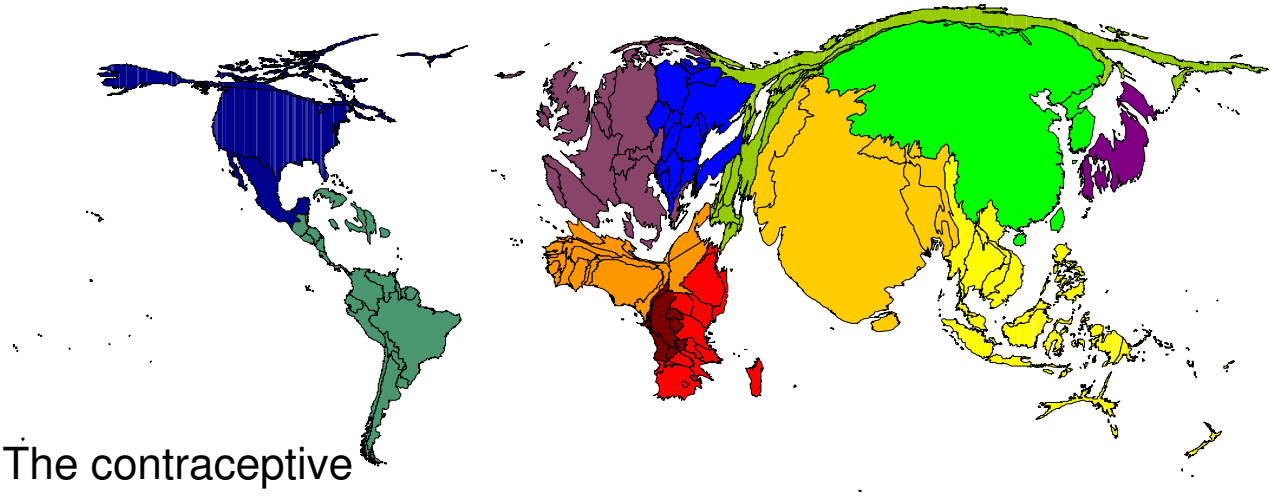
Death in numbers
unprecedented
Is about to reshape
The Americas
But Watch Africa

Population year 1900



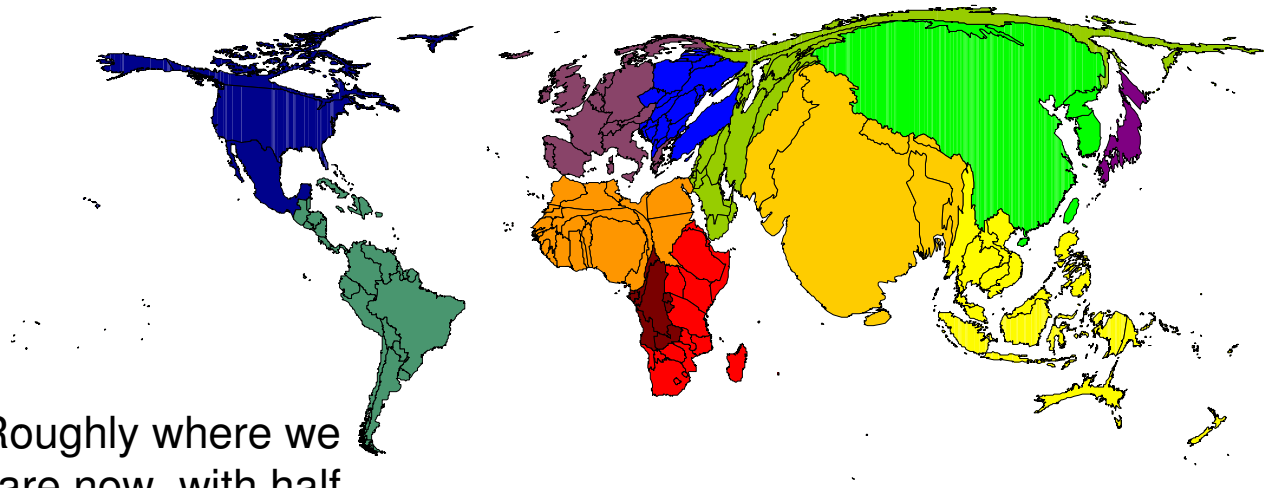
Only around now…
did even a minority
Of the lines drawn
Here have any
meaning.
Watch Britain.

Population year 1960



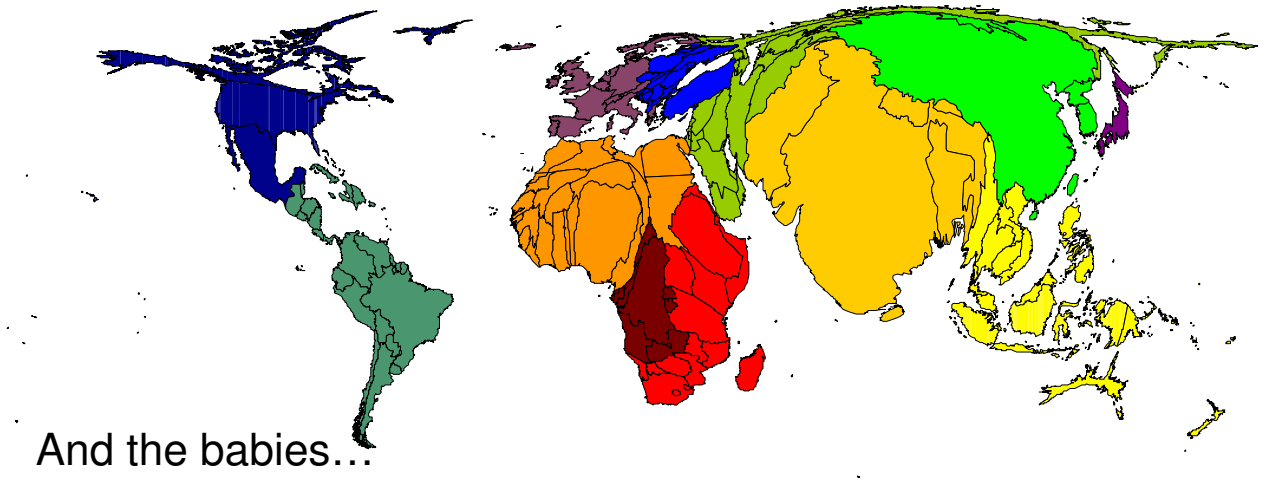
The contraceptive
pill arrives this
decade in Europe.
Watch that
continent.

Population year 2002



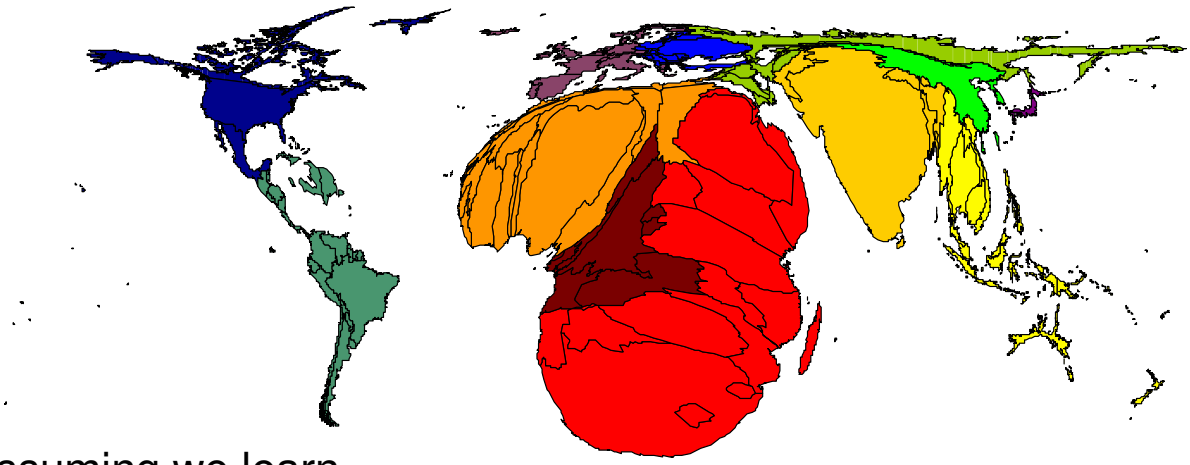
Roughly where we
are now, with half
The world at or
below fertility
replacement.

Births 2002



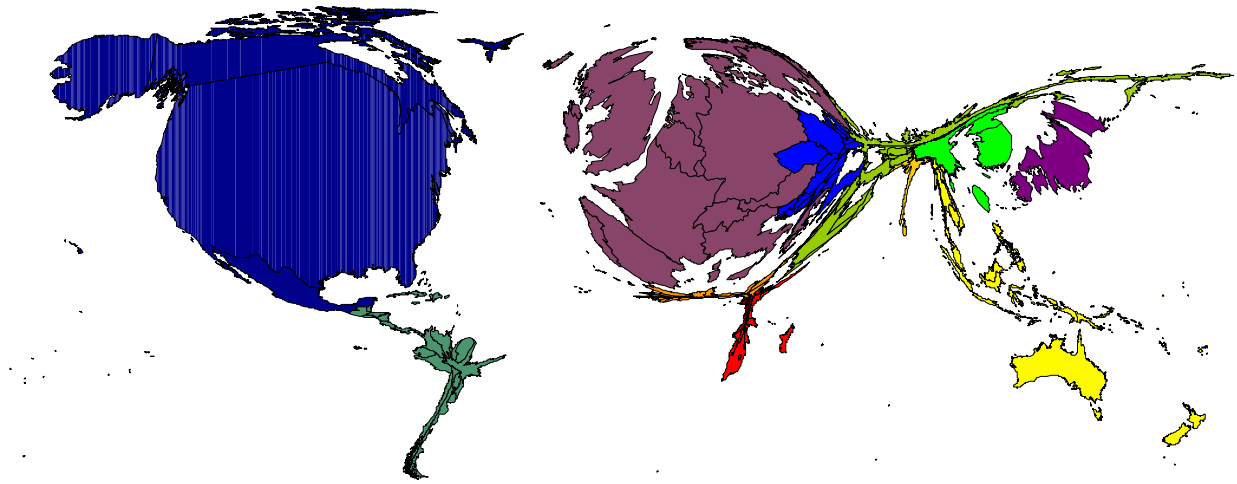
And the babies…
Destined, if the UN
Is right, to take us
to the 9 billion
“soft landing”.

HIV/AIDS 2002



Assuming we learn to care more about others we see as far away.

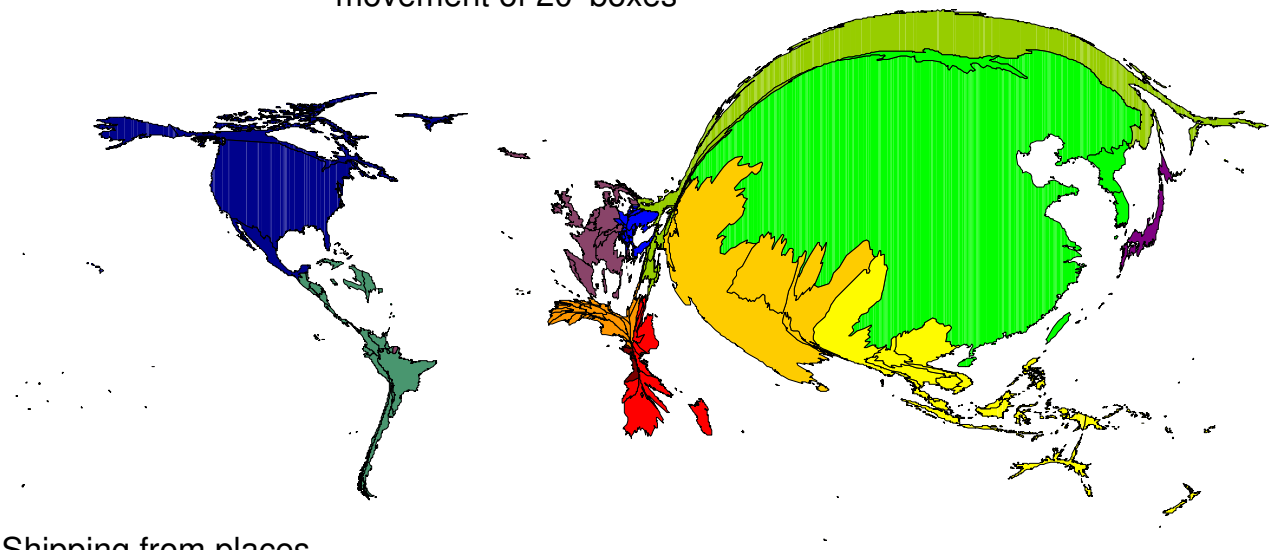
Toys Imported ($)



And learn to care a little less for things that need not be made of plastic and shipped round the globe in quite such volumes as today.

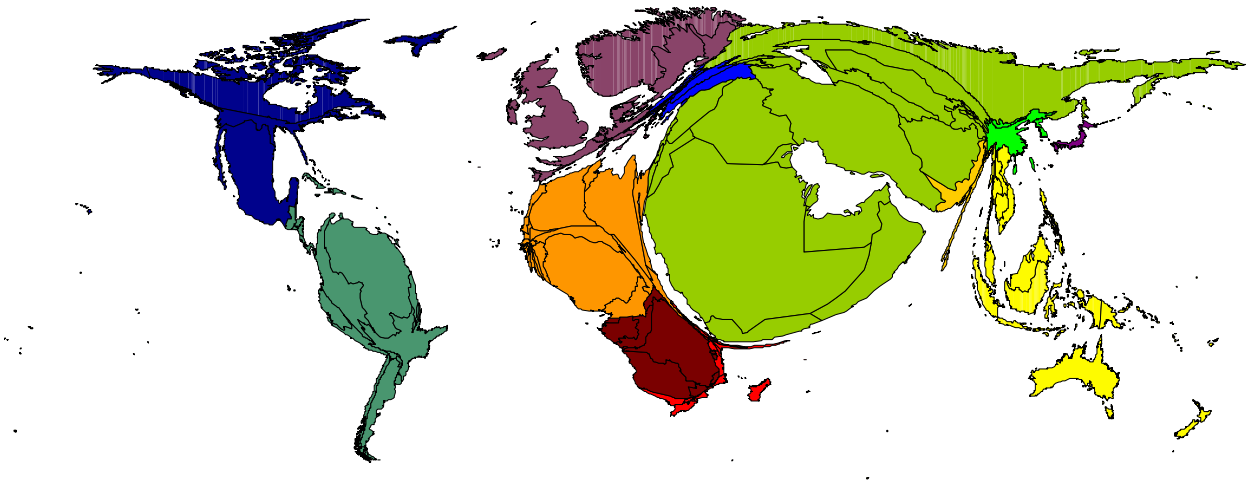
Containers loaded

The world drawn in proportion to the movement of 20' boxes



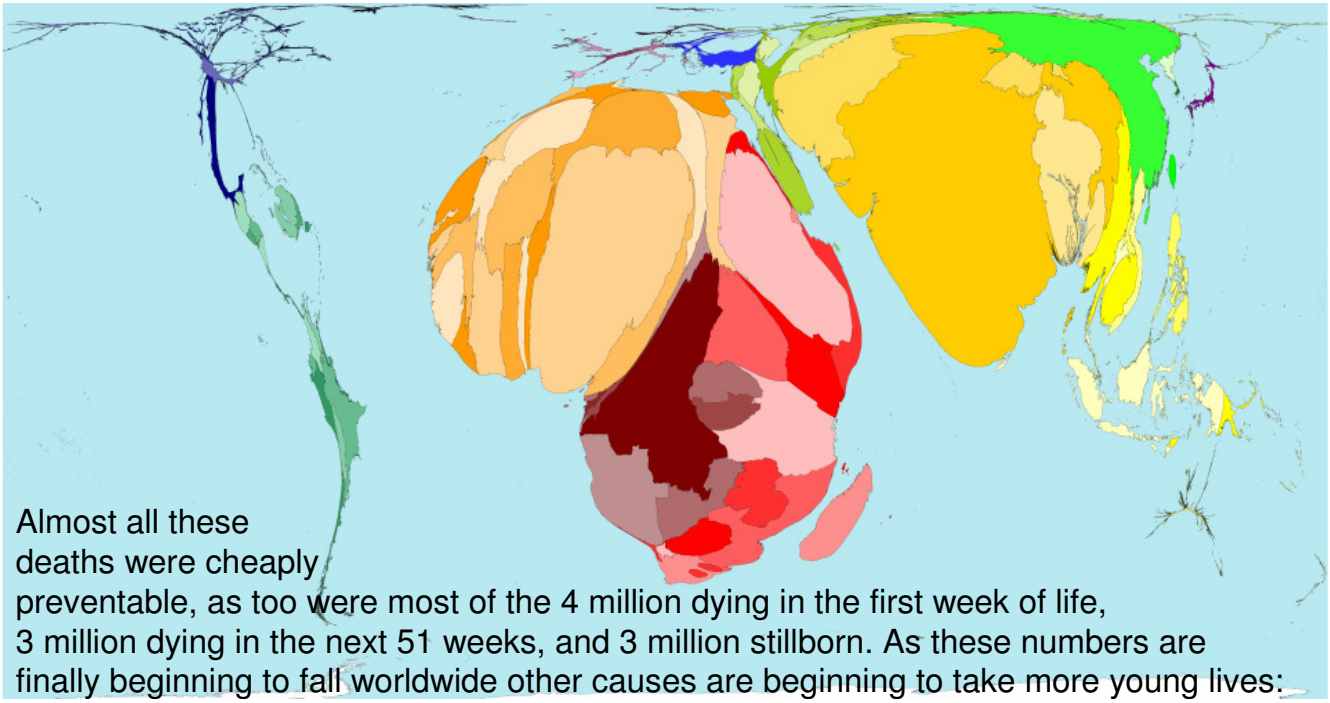
Shipping from places we accuse of polluting when they burn coal to run factories to make the toys for our children.

Crude exported



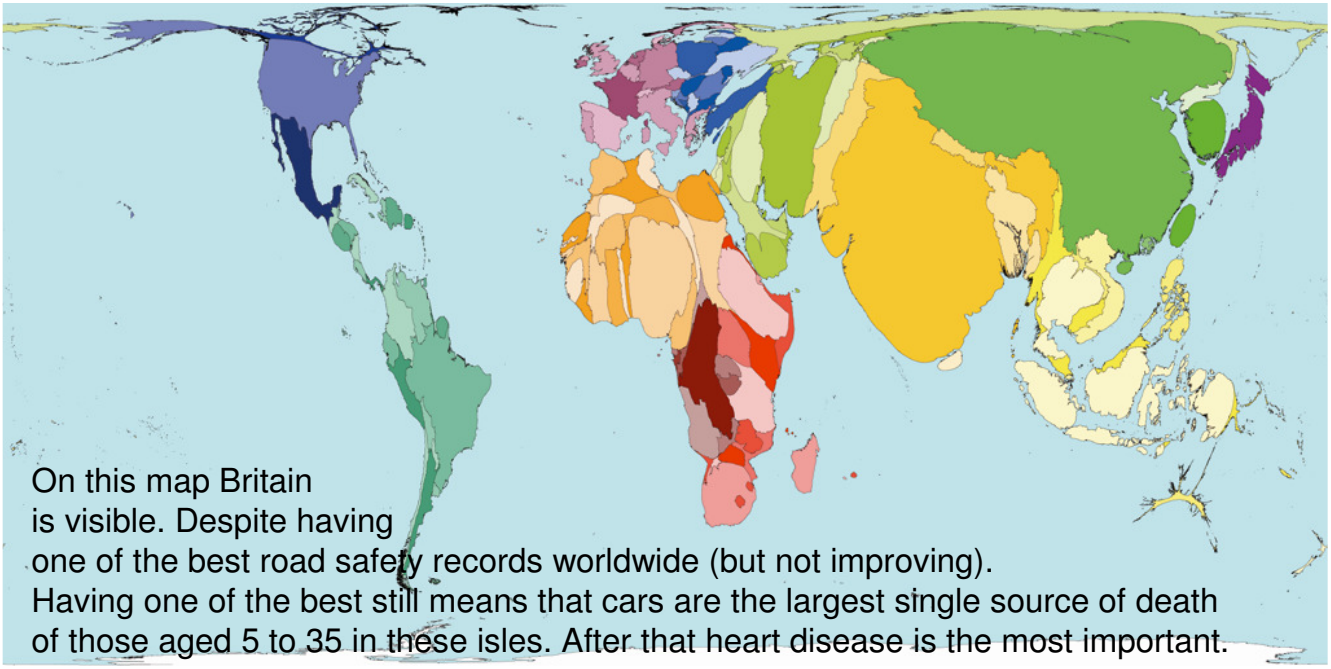
If you see the world as available oil resources and outflows of crude, then this is the shape of the plannet you see.
This too leads to maps of preserving life and causing death, not just through war, but in a myriad of ways; pesticides; to fostering indifference:

Children aged 1 to 4 who died in past twelve months (3 million and slightly falling)

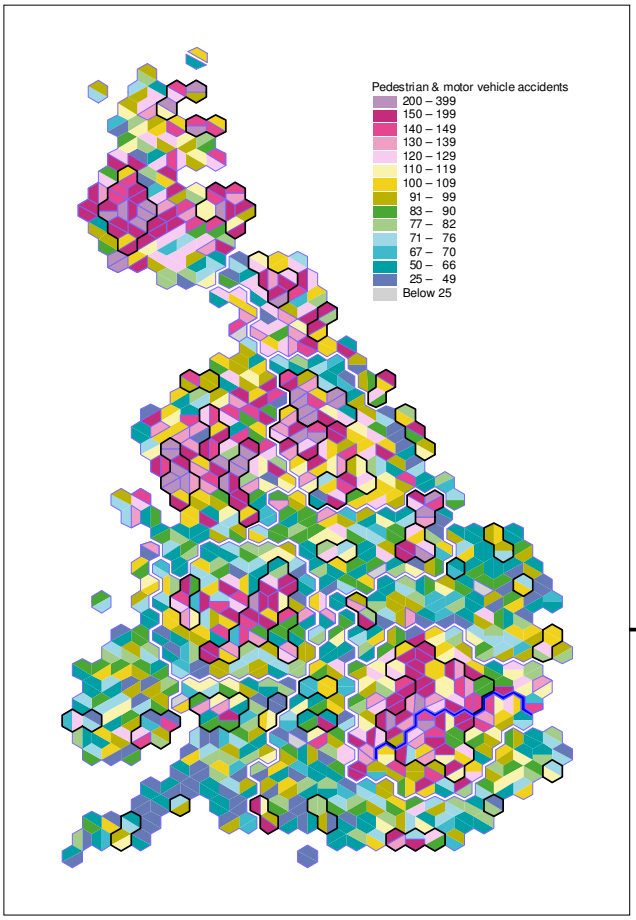


Almost all these deaths were cheaply preventable, as too were most of the 4 million dying in the first week of life, 3 million dying in the next 51 weeks, and 3 million stillborn. As these numbers are finally beginning to fall worldwide other causes are beginning to take more young lives:

People of all ages who died in a road traffic accident in past year (1 million and rapidly rising)



On this map Britain is visible. Despite having one of the best road safety records worldwide (but not improving). Having one of the best still means that cars are the largest single source of death of those aged 5 to 35 in these isles. After that heart disease is the most important.

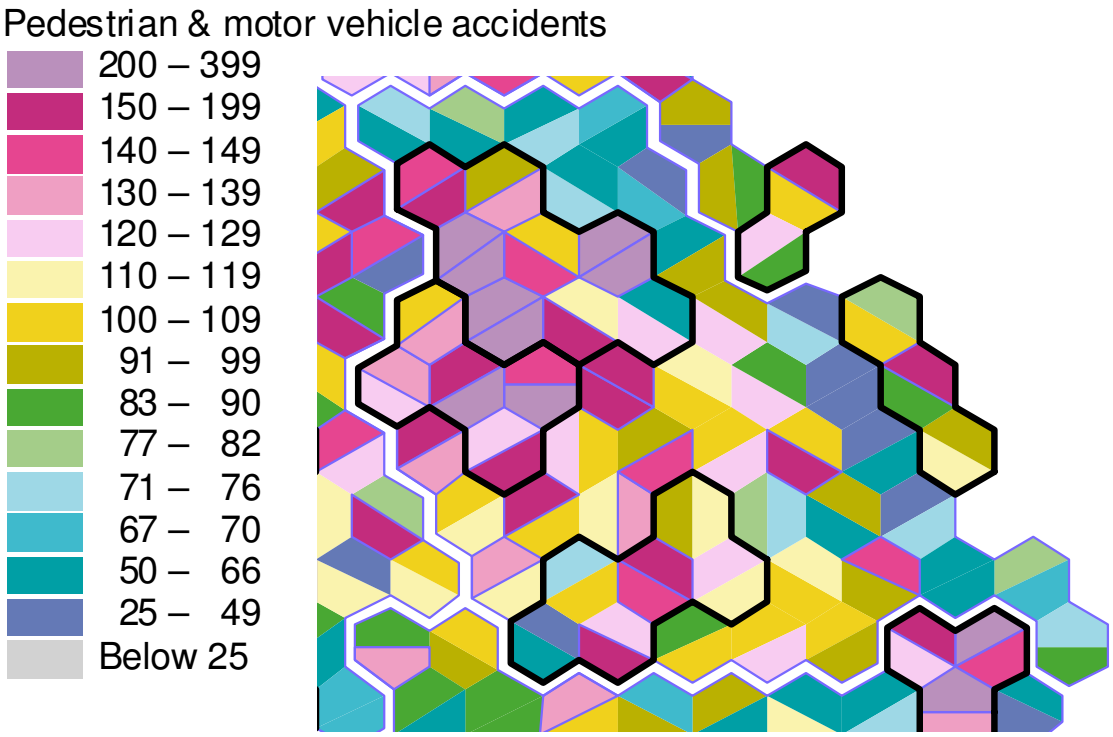


Pedestrians
killed in accidents
involving motor vehicles
1981-2004
29,000 deaths
Mostly in
Cities
(up to 10 times
more frequent)

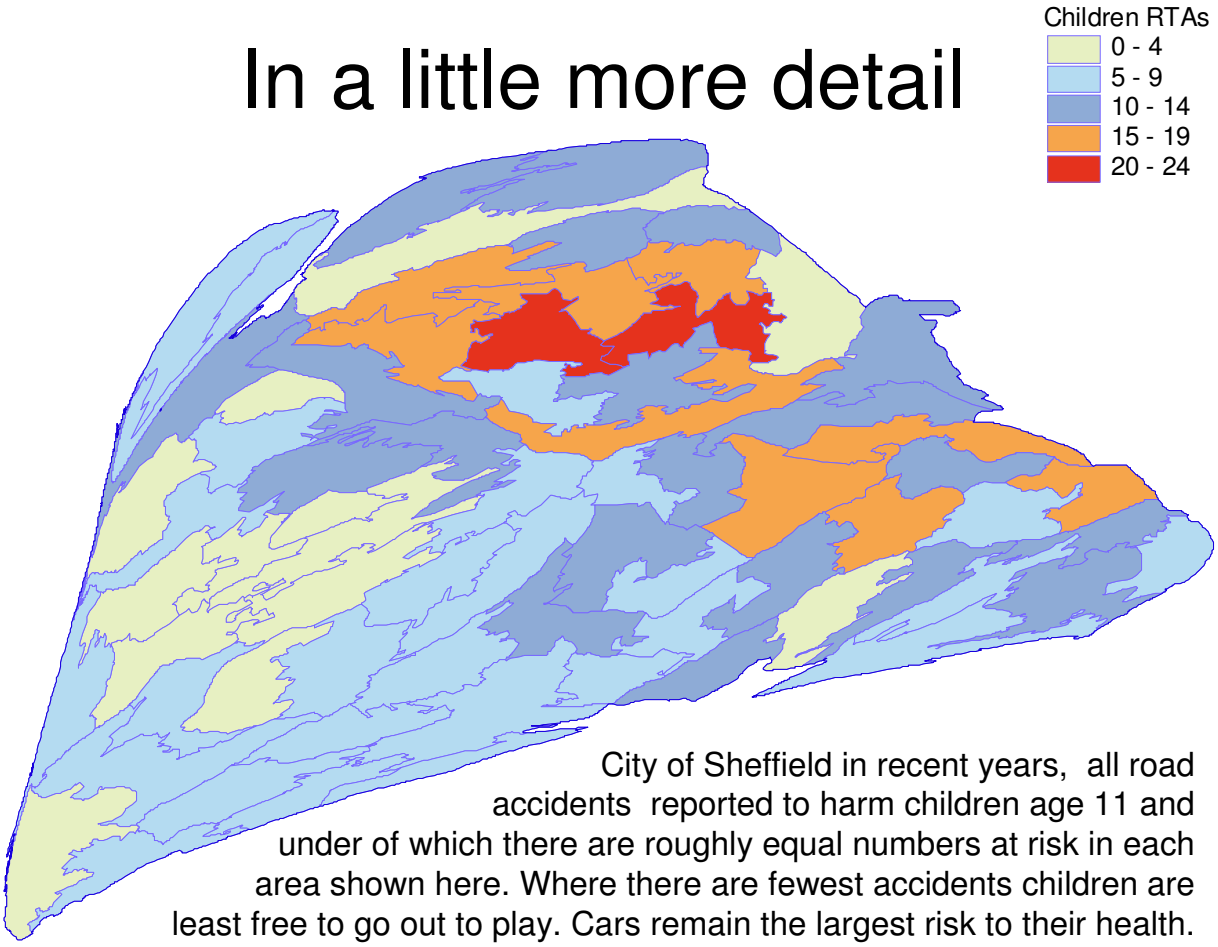
The map of the majority of deaths involving motor vehicles has the inverse geography to this.

Zooming, in, and in…

Deaths in Yorkshire 1981-2004



In a little more detail



City of Sheffield in recent years, all road accidents reported to harm children age 11 and under of which there are roughly equal numbers at risk in each area shown here. Where there are fewest accidents children are least free to go out to play. Cars remain the largest risk to their health.

Conclusion

GIS can be used to undertake Human Cartography: the Local and Global Mapping of Life and Death. For more examples of a new health atlas see "worldmapper" and www.shef.ac.uk/sasi

In this talk some examples here have been taken from the 'grim reaper's road map' of Britain and the 'real world atlas', multi-authored & being published autumn 2008.

Gastner and Newman have made their projection widely available – but will it be widely used in GIScience?

In GIS, changing the projection is a first step in changing how you think about what it matters to count and map.