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# Cartogram

A cartogram can be thought of as a map in which at least one aspect of scale, such as distance or area, is deliberately distorted to be proportional to a variable of interest. In this sense, a conventional equal-area map is a type of area cartogram, and the Mercator projection is a cartogram insofar as it portrays land areas in proportion (albeit non-linearly) to their distances from the equator. According to this definition of cartograms, which treats them as a particular group of map projections, all conventional maps could be considered as cartograms. However, few images usually referred to as cartograms look like conventional maps.

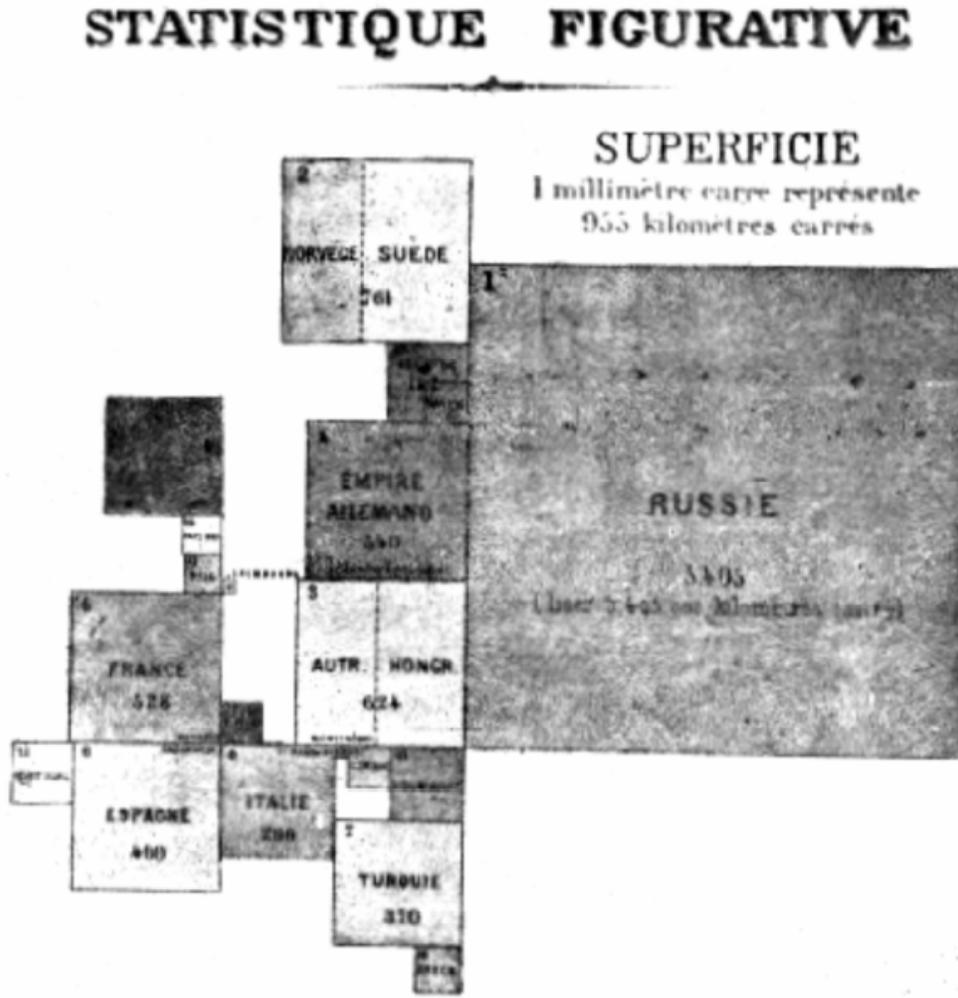
Many other definitions have been offered for cartograms. The cartography of cartograms during the twentieth century has been so multifaceted that no solid definition could emerge—and multiple meanings of the word continue to evolve. During the first three quarters of that century, it is likely that most people who drew cartograms believed that they were inventing something new, or at least inventing a new variant. This was because maps that were eventually accepted as cartograms did not arise from cartographic orthodoxy but were instead produced mainly by mavericks. Consequently, they were tolerated only in cartographic textbooks, where they were often dismissed as marginal, map-like objects rather than treated as true maps, and occasionally in the popular press, where they appealed to readers' sense of irony.

The heterogeneous development of cartograms in the twentieth century is partly reflected in the many names that exist for cartograms. For instance, cartograms that distort area have been termed anamorphosis; diagrammatic maps; map-like diagrams; varivalent projections; density equalized maps; isodensity maps; value-by-area maps; and even mass-distributing (pyncnomirastic) map projections. The subcategory of cartograms in which area is drawn in proportion to population have also been given many names, including political map; demographic map; population scale map; and many very specific titles such as “Population Map for Health Officers” (Wallace 1926). Moreover, there are noncontiguous (Olson 1976) as well as contiguous (Tobler 1973) varieties, and—insofar as an infinite number of correct continuous-area cartograms can be produced (Sen 1975) for any given variable—many visually different cartograms have been drawn scaled to the same quantity, usually population. Even so, by the end of the century it had become clear that only one area cartogram will approximate the best, least distorting solution (Tobler 2004). In the early twenty-first century a practical means for achieving that solution became available (Gastner and Newman 2004).

Motives for drawing cartograms were often related to the rapidly changing political geography of the twentieth century and the late nineteenth century, which was marked by the upheavals of industrialization, the concretization of nation-states, and the consequent need to visualize state-istics. The earliest known area cartogram is French statistician Émile Levasseur’s 1870 cartogram of Europe, which depicts countries in their “correct” size, in this case, their correct physical area. Levasseur’s aim, it seems, was to imply that Russia was somehow balanced by—if not a threat to—the combined European landmass. In the context of the political maps and data graphics of the era, his cartogram not only created an impression of an invulnerable Russia but also reinforced the threat of its land area in a way uncannily similar to

the Soviet Union's depiction on a Mercator world map a century later, as seen on U.S. television screens during the Cold War.

**Figure 0: The countries of Europe shown in proportion to their land area.**



Emile Levasseur's 1870 cartogram of Europe Tobler (2004, 29) portrayed countries with rectangles proportional in size to their land area. [Exclude figure from final draft if no good original copies found.]

In the final decades of the nineteenth century Russia was considered the largest potential threat to the new political systems emerging in Europe, and similar images implied that it had to

be taken more seriously than traditional cartographic treatments might suggest. It is perhaps no mere coincidence that Levasseur's cartogram was created using data for around the same year as Charles Joseph Minard's *Carte figurative* (drawn in Paris in 1869) showing the mounting losses of French army troops during the Russian campaign of 1812–13. On that well-known map—arguably a linear cartogram, but rarely discussed as such—a flow line that shrinks in width during the advance and retreat of Napoleon's army provides a dramatic description of the ill-conceived invasion.

While many *mappaemundi* and other ancient maps resemble modern cartograms because land was often drawn in rough proportion to its perceived importance, the modern cartogram is a comparatively recent invention. And because all but the simplest cartograms were tedious to produce by hand, more cartograms were probably produced in the first few years of twenty-first century than throughout the whole of the twentieth, thanks to new, highly efficient algorithms. These computer-generated cartograms were largely area cartograms because software for producing linear cartograms (and sophisticated flow maps) lagged behind that for creating their value-by-area counterparts.

The twentieth century also witnessed the theoretical description of cartograms yet to exist in practice (Angel and Hymen 1972). Examples include cartograms on which travel time is shown as distance not just from a single point, but between all points on the map. Such a linear cartogram would be possible—this has been proved mathematically if not visually—were the map to be drawn as a two-dimensional surface, or manifold, undulating within, wrapped up in, and occasionally torn within three-dimensional space, and thus no longer akin to the flat map of traditional statistical cartography. Moreover, linear and area cartograms could be combined in this way and together merged into quantity-by-volume cartograms, on which, for instance, each

person's life was accorded an equal volume in a deliberately distorted block of space-time. Such possibilities have been described and developed (Dorling 1996), but several decades often elapse between the proof of what is possible and its realization. Thus an intriguing part of the history of cartograms in the twentieth century has been imagining new possibilities demonstrated by existing theorems but not yet realized.

Because the software was not widely available, computer generation of what are now seen as traditional cartograms remained problematic through the early years of the twenty-first century and was nearly impossible as well as largely impracticable through the end of the twentieth century. Manual methods were daunting for anyone eager to base a cartogram on a large number of small area units. Many months, even years, could be spent creating a cartogram by hand showing, for instance, the populations of parliamentary constituencies of Britain in 1964, only to see their boundaries redrawn again by 1970, making the cartogram obsolete except for historical studies. Designers willing to accept suboptimal solutions could turn to analog approaches based on trial-and-error manipulation of hundreds of cardboard tiles (fig. 1) (Hunter and Young 1968) or thousands of ball bearings and hinged metal joints (Skoda and Robertson 1972). Early experimentation with computer modeling was frustrated by the massive computational demands of creating near-optimal solutions (Dougenik, Chrisman, and Niemeyer 1985), but substantial improvements in computer architecture toward the end of the century led to a plethora of algorithms able to cope with the iterative shifting of millions of vertices. Well after the end of the century mapmakers (this writer included) intent on drawing cartograms for atlases of socioeconomic data were still using paper and pen, albeit with a little aid from computers, to achieve aesthetic effects that computer algorithms alone could not.

Figure 1. Producing a cartogram of Africa. Melinda S. Meade moves thousands of tiles to produce a Hunter and Young type of cartogram.



Figure 5c: Constructing a population cartogram of Africa by hand (Hunter & Meade, 1971: 97).

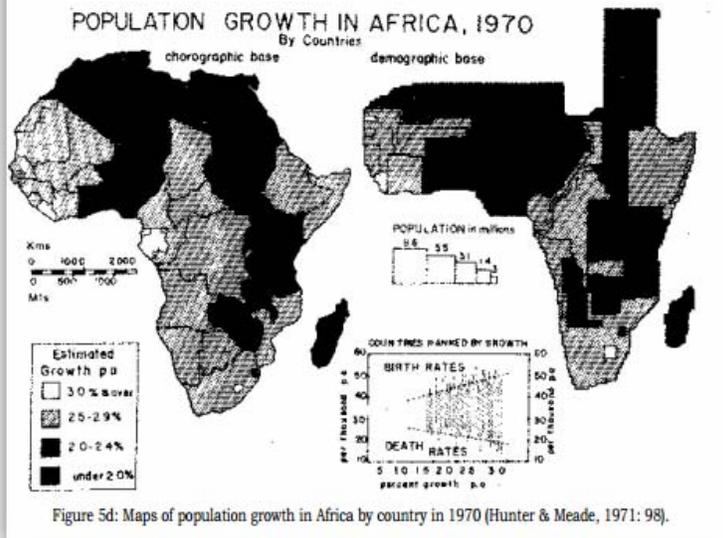


Figure 5d: Maps of population growth in Africa by country in 1970 (Hunter & Meade, 1971: 98).

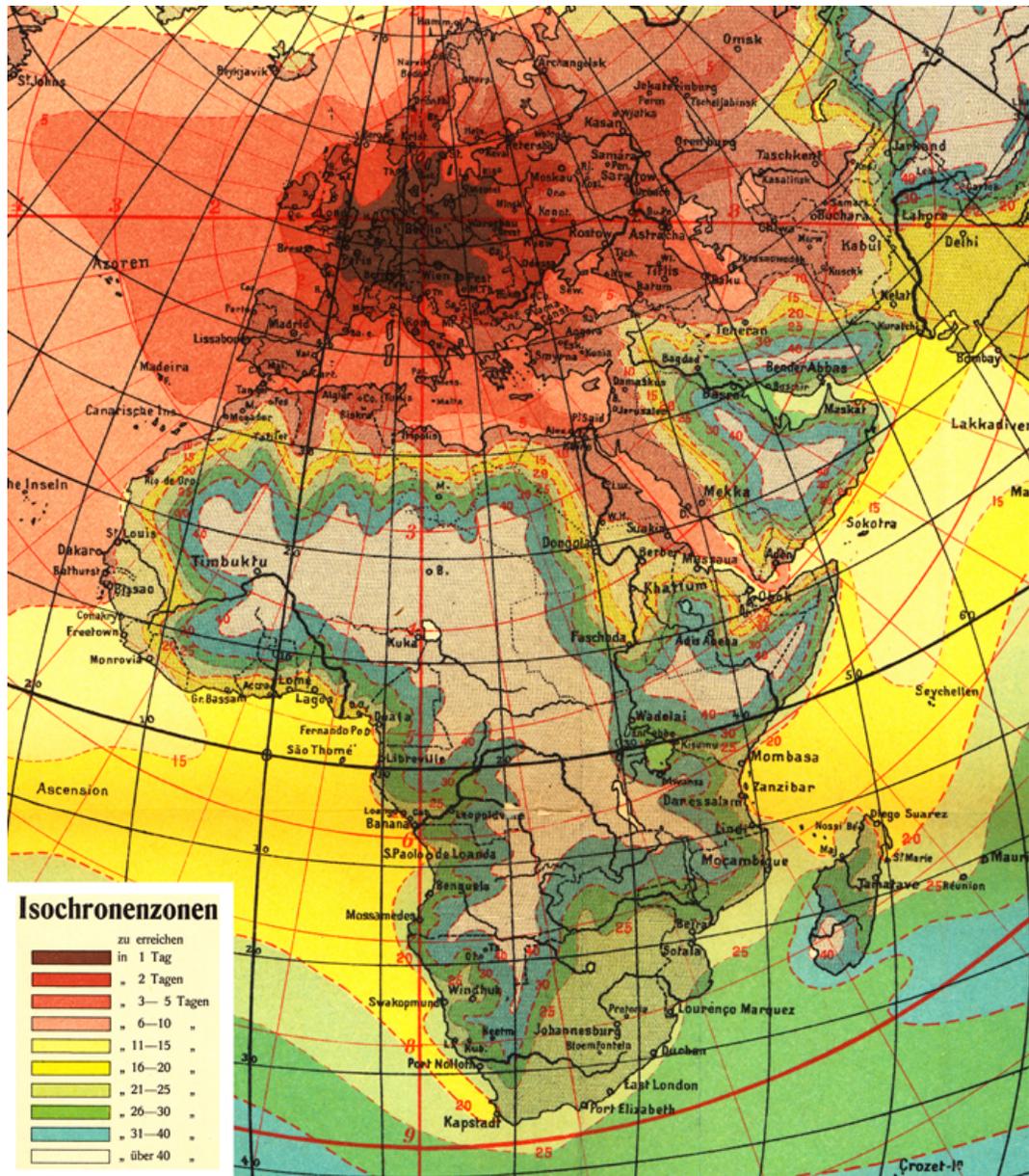
From John M. Hunter and Melinda S. Meade, "Population Models in the High School," *Journal of Geography* 70 (1971): 95–104, esp. 97 (fig. 1). [A far better quality image will be inserted]

Automated production of cartograms was instigated by the theoretical work of Waldo R. Tobler in the last third of the century. His seminal publication argued that cartograms could play a key role in the political redistricting that follows America's decennial population census (Tobler 1973). Tobler's review of the development of computer cartograms, published thirty-one years later, is one of the most useful summaries of the field (Tobler 2004). An isochronic map of travel time from Berlin in 1901, a redrawn portion of which was included in his 1961 doctoral dissertation (fig. 2), demonstrates the extreme contortions confronting construction of linear cartograms—Africa would literally be turned inside out, as it was politically during the twentieth century. That four decades elapsed without an efficient algorithm for describing this pattern with a cartogram attests to the difficulty of producing linear cartograms by machine.

However theoretically intriguing, cartograms have seen little practical application beyond the dramatic comparison of disparities among nations or between population and land area. For example, equal-population cartograms, once proposed as an objective approach to political redistricting, have (to this author's knowledge) never been employed for that purpose. The resulting areas would be far too hard to manipulate for subsequent partisan political gain. Even so, population cartograms have frequently been used to depict the outcome of elections—most frequently when the winning political party controls only a minority share of a territory's physical area. In these cases, a traditional base map could be misleading in implying that the party that had lost had in fact won. Cartograms were repopularized early in the twenty-first century in showing the results, across more than 3,000 counties, of the highly contested U.S. 2000 presidential election (Gastner and Newman 2004). Because Republican presidential candidates in the twentieth century tended to win in sparsely settled, comparatively rural areas,

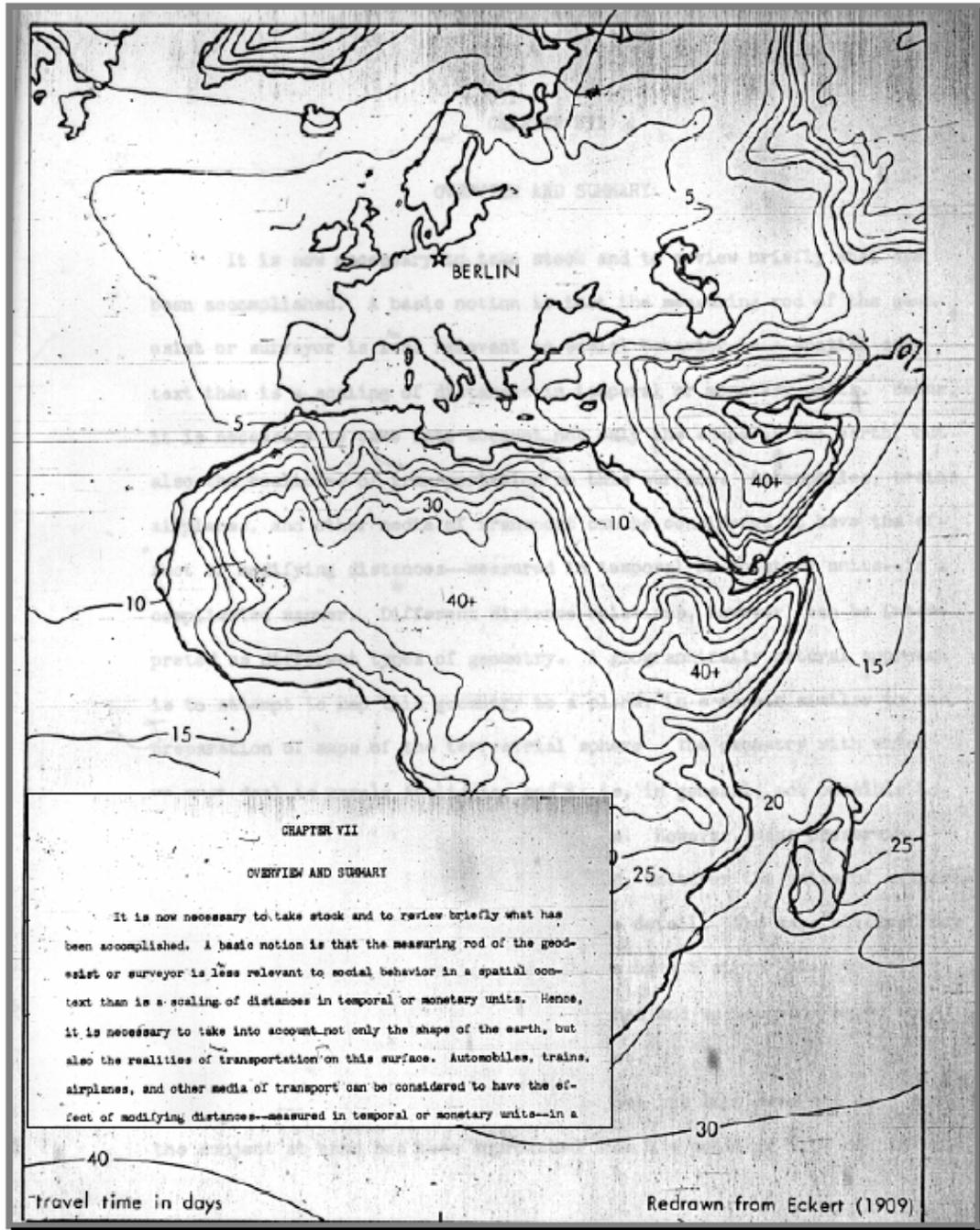
conventional maps—sometimes based on polls and released before an election as a forecast—could greatly exaggerate the party’s strength.

**Figure. 2. Travel time in days from Berlin at the start of the twentieth century. Redrawn detail. See figure ●●● [Petermann] for Max Eckert’s 1909 original of the entire world.**



From Waldo R. Tobler, “Map Transformations of Geographic Space,” PhD diss., University of Washington, 1961, 104 (fig. 4.12).

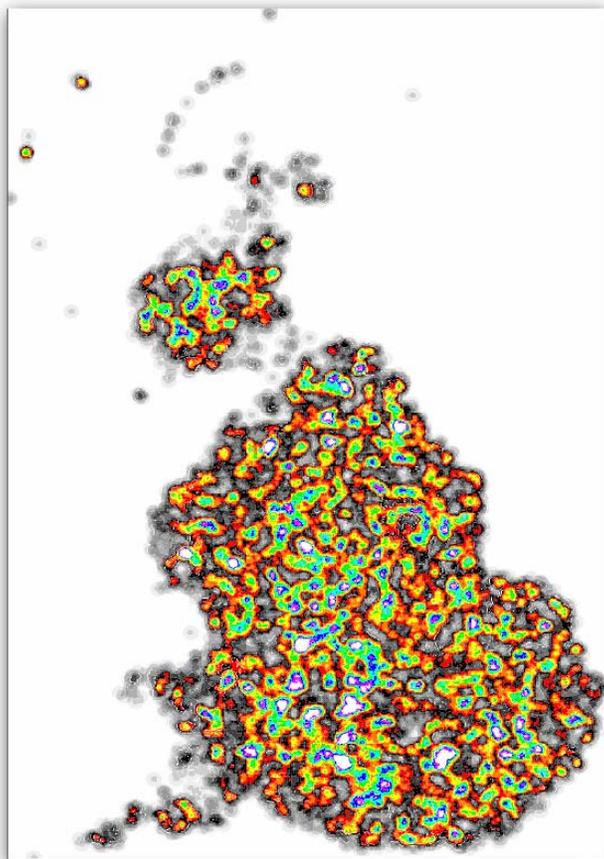
Not to be included in final draft – but here is Waldo’s hand drawn version of Figure 2



Continuous-area cartograms (in contrast to a rectangular statistical diagram) have been used to detect clustering in the population—especially for cancers and other medical conditions.

The example in figure 3 is an equal-population cartogram based upon over 100,000 areas in Britain; the superimposed surface represents the chances of dying from childhood leukemia over an eighteen-year period in the later half of the century. The risk of dying was highest in the areas shaded white, where cases appear to cluster. However, on closer examination many of these areas include hospitals that treated sick children or other areas with unusually high concentrations of such children. Medical cartography of this kind has often been frustrated by a dearth of meaningful case clusters.

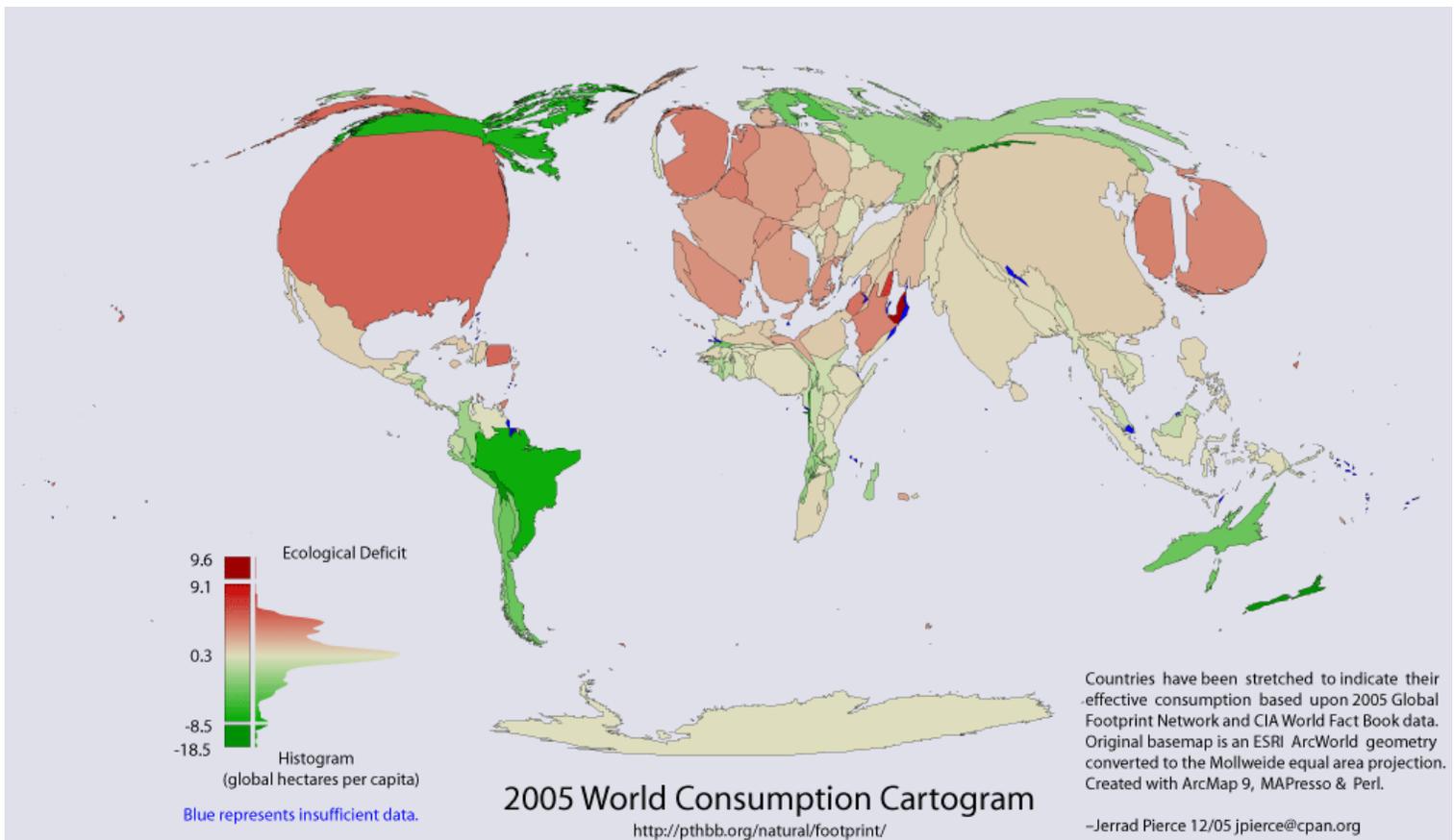
**Figure 3. Cases of childhood leukemia in population space in Britain 1966–83.**



From Daniel Dorling, "The Visualisation of Spatial Social Structure," PhD thesis, Department of Geography, University of Newcastle, 1991, pl. CLIX. [\[see image at the end of chapter for more detail\]](#)

Finally, over the course of the twentieth century the most important uses of cartograms have not been in political or economic mapping or for the discovery of clustering of disease but in social, environmental, and political mapping. Figure 4 shows one example—the world’s nations redrawn with areas proportional to the size of the collective environmental footprints of their inhabitants. Understandably, the United States, Europe, and Japan are especially large.

**Figure 4. Example of a modern world cartogram of our ecological footprint.**



Source: <http://pthbb.org/natural/footprint/> [there are many non copyright versions]

The explicit use of cartograms for social and environmental advocacy began with the work of political scientist Michael Kidron, widely known as a revolutionary thinker, cartographer, and joint author of the earliest of the *State of the World* series of atlases, initiated in 1981. The series was continued by Dan Smith, who had worked with Kidron on *The War Atlas: Armed Conflict—Armed Peace* (1983). Although early editions of the *State of the World Atlas* included few cartograms, these were more likely to be remembered by school children taught with the books (including this author). The widespread use of cartograms in social, political, and environmental campaigns is readily apparent to anyone who searches for these map-like images on the Web.

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