

Dynamic Cartogram Visualization of Presidential Election Results

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Abstract

Despite dramatic increases in the availability and cartographic processing capabilities of Geographic technologies, state delimited red and blue maps remain the dominant form of electoral result visualization disseminated by the mainstream media. While scaling the human voting process to physical geographic space and spatial aggregation are inherent weaknesses of red and blue state mapping, the power of such maps in affecting political perceptions is undeniable. Cartograms are familiar to most geographers but largely unknown to the voting public, and can produce intuitive electoral maps that overcome the limitations and biases of this traditional format. In addition, animated time series cartogram electoral visualizations can further understanding of the population shifts and demographic changes that underlie the continual realignment of national electoral constituencies. Application of these techniques provides the basis for a new paradigm in presidential election visualization that may reverse the popular misconceptions associated with traditional election maps. Animated cartograms can overcome the spatial mismatch inherent in projecting political space onto geographic place, and may prove invaluable to researchers and the voting public alike.

Introduction

Geographic phenomena have a highly variable spatial distribution on the surface of the earth, thus assumptions of uniformity are inherently flawed. (Tobler 1963) This basic law of geography has been largely ignored in cartographic representations of election results which assign a uniform color to an entire state area, a technique that has captured the collective American political imagination as the red state/blue state phenomenon. While election results can be displayed at finer scales that better capture spatial variability, the problem of projecting a human activity onto a map representing geographic area remains. Simply put, traditional election maps misrepresent political support because the area of a geographic unit on the map is not equivalent to the number of votes cast there. (Gastner, Shalizi et al. 2005) This flaw can be addressed through the creation of cartograms, maps in which geographic space is scaled by a value other than measured land area. These value-by-area maps are well suited to election visualization since they can represent actual levels of political support by scaling state sizes according to population or electoral votes. Scaling by other population characteristics such as income, age, educational achievement, and rural residency can provide new insights into the red and blue state divide. Animations showing cartogram change over time can further the understanding of electoral and partisan dynamics, as well as increase the accessibility and cognition of cartograms both within and outside the realm of academia.

This paper begins with review of past and present research on cartograms and map animations, from both a theoretical and applied perspective. After a brief overview of the data and methods behind the creation of animated electoral cartograms, the focus shifts to interpretations and potential applications of these maps. It is important to note that reader comprehension of the discussion section will be greatly enhanced by online viewing of the animations. (<http://www.geog.ucsb.edu/~brachman/anigrams.htm>) Future research directions are indicated, concluding with the broader implications of animated cartogram development and dissemination.

Overview

Historically, the term cartogram has been used to describe a statistical or thematic map as

well as the value-scaled area contiguous map that it generally describes today. One of the earliest examples of cartogram use by the American press appeared in the Washington Post in 1929, when state areas were scaled by population and by payment of federal taxes to demonstrate the unfairness of each state having equal voting strength on tariff measures. (Tobler 2004) A recent Lexis-Nexis search of the term 'cartogram' produced forty six hits, with the most relevant being a 2004 Washington Post article describing population-scaled cartograms of the 2004 Election Results as "images that make America look like a flabby cartoon character stretched into blue and red spandex." (Kennicott 2004) Despite this cognitive blasphemy, the creators of these maps argue that although previous cartograms were confusing and difficult to interpret, their new technique using basic diffusion physics principles overcomes these limitations. (Gastner and Newman 2004) Furthermore, demographic scaled cartograms can demonstrate the diversity of people representing states that are otherwise reduced to blue or red, thus helping to overcome the divisive nature of this classification. (Seyle and Newman 2006) New methods of spatial representation are an important component of the third culture of using GIScience to address important societal issues. (Sui 2004) Given the controversies surrounding the 2000 and 2004 presidential election outcomes and heightened public interest in the democratic primary of 2008, the time is ripe for geographers to contribute to the national electoral discourse. New ways of representing political space can prove useful to multiple segments of society (Leuthold, Hermann et al. 2007), thus overcoming the difficulties of election cartogram interpretation is an essential task of electoral cartography.

Map animation is one technique that can bridge the cognitive disconnect that many people feel when viewing a cartogram. Morphing the transition between a traditional area scaled map and a cartogram as well as dynamic interactive display of time series data harness the power of new media to address several fundamental Geovisualization challenges, including questions of data representation, user interfaces, cognition and usability. (MacEachren and Kraak 2001) The widespread use of electoral maps by major media outlets and prevalent misinterpretation of these maps by the public lends weight to the argument for new methods and techniques. While both cartograms and animated maps have been the subject of recent theoretical cartographic research, "the success of animated maps rests not on how they are made, but on understanding what they can do for us." (Harrower 2004)

Methods and Data

The Gastner-Newman method uses a linear diffusion algorithm to produce a readable and accurate cartogram in much less time than previous cartogram methodologies. Diffusion is based on calculations of density and velocity with respect to position and time, with shape boundaries constrained by the mean density of the entire map enclosed in a rectangular box. Using a fast Fourier Transform, this method can generate a cartogram of US states scaled by population in less than one minute with the ArcScript Tool produced for ESRI's ArcMap. Gastner and Newman use this method to create several 2004 presidential election cartograms, including state level results scaled by both population and electoral votes. In comparing these two maps they note how the least populated states appear larger on the electoral vote cartogram due to the automatic allocation of two electoral votes to all states mandated under the electoral college system. This intuitive visualization demonstrates the power of cartograms as a simple means of explaining our presidential election process. One of the more innovative cartograms created by Gastner and Newman is the population-scaled county level 2004 election results depicted in shades of purple determined by each candidate's respective vote percentage. While this map is an excellent visualization of the nuances of party preference, a traditional red/blue depiction better reflects the political reality of our winner take all electoral college system, and thus is used for all cartograms created for this paper.

Data used for cartogram creation were obtained from two primary sources, Dave Leip's Atlas of U.S. Presidential Elections (<http://www.uselectionatlas.org/>) and the US Census Bureau website. (<http://www.census.gov/>) The Atlas of Presidential Elections is a comprehensive source of election results, electoral vote tallies, and turnout percentage by state for every presidential election since 1789, featuring a variety of additional election datasets and as well as interactive user-controlled mapping. Electoral vote tallies by state for each election from 1968 through 2004 were obtained from this site for the time series animation of electoral vote scaled cartograms, which is discussed in detail in the next section. The decennial census 100-percent summary file provides states level total population, population by age, and rural/urban population counts, while median family income and educational attainment are from the one in six sample data. These data were acquired for 1990 and 2000 and yearly population estimates used to interpolate values to the 1992, 1996, and 2004 election years. Interpolation is done by

calculating the population rate of change between the census year and the election year and applying this rate to all variable values. This method inaccurately assumes that all variable populations grow at the same rate, and results in identical percentage values for 1992 and 1996 since the same rate of change is applied to both variables used in the calculation. A more robust statistical interpolation could be used, but since the changes are relatively small over these four year periods this methodology is sufficient for the ultimate Geovisualization goals.

These data are joined to an Albers Equal Area projected shapefile of the lower 48 states plus the District of Columbia which is then used to create cartograms using the aforementioned ArcScript. In addition to the electoral vote scaled cartograms from 1968 to 2004, a shorter time series is created for cartograms scaled by percentage of the population under 18 years old, 60 years and older, living in a rural area, and having completed a Bachelors, Masters, or Professional degree for each state. Since the Median Family Income and Voting Age Population cartograms are the only census maps not created from a percentage, some thought was given to using interpolated total populations for each demographic as the scaling factor. This method maintains the relative electoral voting power of each state but diminishes the visual impact of cross-sectional demographic differences, thus the percentage method is preferred.

After importing the cartograms into Adobe Flash MX, each time series map set is sequenced using the time line interface. Smooth 'fade in - fade out' transitions are utilized for each new cartogram displayed and a linear time scale is added to improve cognition of the passage of time. (Midtbo 2007) Shape 'tweening', a built in function of Flash MX that smooths changes between two animation frames, is used to create morphing animations showing changing area over time. Questions of the appropriateness of 'tweening' have been raised, especially during the transitions stage in which the software is interpolating between two graphic states. (Goldsberry 2008) These issues are addressed in detail in the discussion section below.

Discussion

One of the primary goals of this research is to further visual cognition and comprehension of election cartograms outside of the geographic community. The first animated map attempts to accomplish this by morphing the standard 2004 Red and Blue State Presidential Election Results map into a Voting Age Population scaled cartogram also displaying election

results by state. The user is presented with a simple interface allowing them to click a play button to begin the morphing process, at which point the state results fade into the red polygon shape of the contiguous United States. This polygon is morphed into the polygon showing the contiguous states scaled by voting age population using the shape 'tweening' capabilities of Flash MX, and the state election results fade back in.

This animated map aids in the cognitive processes of interpreting the distorted area of cartogram representation. Showing a smooth transition from the familiar election map to the unfamiliar cartogram provides a sense of the interrelationship between the two that might be missing when viewed independently, and allows intuitive visualization of differential area change in regions of the country. Combined with a brief verbal or written explanation of what a value-by-area map represents, this type of animation has the capability to make cartograms accessible to a broad cross-section of the voting public. This technique is not without its flaws. First, it should be noted that the morphing transition show significant cartographic skew, which could lead to confusion on the user end. The geographic relocation of several US states during the 'tweening' transition between the 2004 Presidential Election Results by State (figure 1) and the Voting Age Population Scaled Cartogram of 2004 Presidential Election Results by State (figure 2) provides an example. During this transition, Florida appears to move to the North East, eventually morphing into North Carolina on the final cartogram. Likewise, the 'new' Florida is created from what is previously Louisiana, thus demonstrating the spatial inaccuracies and potential cognitive disconnect caused by the 'tweening' process. Given that a cartogram is an abstracted representation of space in itself, the strengths of showing a smooth transition should outweigh these pitfalls. Another improvement suggested by Dr. Keith Clarke (personal communication, April 30, 2008) is using a mixed red and blue or purple color scheme during the transition between polygon shapes to better represent the political preferences of the country. This issue could also be addressed by maintaining state-by-state election results during the transition, which was not implemented during prototype development due to time constraints. For now, the nationwide red color is a means of showing which party has control of the White House for the given time period, a visualization technique further developed in the time series animation.

The next animated map shows a time series of electoral vote scaled cartograms for each election from 1968 to 2004, with morphing representation of the electoral vote reapportionment

that occurs each decade. The 1968 election (figure 3) is a logical starting point for this time series since it is the last presidential election in which a third party candidate captured any states, leading to Nixon's 'Southern Strategy' and the mass movement of white southerners to the Republican party. (Phillips 1969) The user clicks the play button to move through time to the next election year, with a solid blue or red fill showing the party of the president during inter-election periods. When the opposition party wins the White House, a red or blue tide appears to sweep across the nation before the relevant state level results are shown. Electoral reapportionment is represented by morphing the current electoral vote cartogram polygon into the new one using a shape 'tween' animation. Map titles indicating the election year and a dynamic linear time line are used to keep track of the changes represented through time.

This map (figure 4) shows the spatial patterns of support in the context of the relative power of each state in determining who wins the presidency, and provides intuitive visualization of political power, electoral differential, and party constituencies over time. Perhaps the two most striking electoral trends shown by this map are the dramatic increase in electoral power of the sunbelt states, typified by the increasing size of Florida, as well as the importance of winning southern states in building an electoral college majority. The American presidential contest has become increasingly competitive since the Regan electoral blowouts of 1980 and 1984, shown through the evening of proportions of red and blue on the map over time. The reapportionment animations are visually compelling but problematic. 'Tweening' adds value to the transition between the standard area map and the population scaled cartogram in that it overcomes the initial cognitive abstraction of viewing the cartograms' distorted shapes. As a means for demonstrating electoral vote reapportionment that occurs after each census, 'tweening' gives the inaccurate impression that greater change has occurred due to the emphasis on motion rather than smooth morphing. This limitation could be overcome by setting up an individual tween for each state, which may help control the random movements of state geographies across the animated map space. Another improvement to this prototype is an interface that allows the user to move backward as well as forward through time. This would give more flexibility in comparing elections and electoral reapportionments to one another. It is also important to note that election results and the population changes that determine reapportionment are orthogonal, thus might be better represented individually on separate maps. (M Goodchild, personal communication, April 28, 2008) Overall, linear flow of this time series cartogram animation

helps visualize changes over time and electoral trends that far exceed the capabilities of static maps as well as most written or verbal electoral communications.

Much has been made of the 'Great Divide' between red and blue states, where political division is explained by deeply ingrained geographic, economic, ethnic, religious, and cultural differences. (Sperling 2004) Cartogram visualization is one way to test the validity of these claims, particularly by mapping election results onto cartograms scaled by demographic space. Time series of the 1992 through 2004 presidential election results shown on cartograms scaled by rural population, education, income, and age categories are a first step in visual exploratory analysis of the demographics of political preference.

Cartograms scaled by the percentage of state population defined as rural (figures 5 and 6) seem to contradict conventional assumptions at first glance. We can clearly see Democratic party dominance in the highly urbanized states of California, New York, and Illinois, but several of the most rural states (Maine, Vermont) show a Democratic preference as well. The most compelling trend seen from 1992 to 2004 is the geographic divide of party support amongst eastern rural states, with the southeast moving to the Republican side and the rural northeast remaining in the Democratic fold. The band of rural states in the middle of the country (Arkansas, Missouri, Tennessee, Kentucky, and Iowa) have shifted to the Republican Party since being swept by Clinton in 1992 and 1996, thus showing their importance to any winning electoral strategy.

The education cartograms are scaled by the percentage of the population 25 years and older with a Bachelor's degree or beyond (figures 7 and 8). These maps seem to support the idea of a growing 'liberal elite', with voters in highly educated states trending democratic and those states with less highly education populations moving toward the Republicans. The predominance of the Northeast, Upper Midwest, and Pacific Northwest on these maps is closely mirrored by the median family income scaled cartogram as well (figures 9 and 10). This result is not surprising given the well established correlation between educational achievement and income level. One interesting map dichotomy challenges the long-standing assumption that the Republicans are the party of the rich. The income map clearly shows the Democratic preference of higher income states despite recent Republican tax cuts that disproportionately favor the wealthy, thus visually showing how people may vote against their economic self-interest.

Analysis of the age group scaled cartograms shows regional trends that could help predict

future electoral college power. The Northeast and Florida are noticeably larger than the rest of the country on the 60 and older age group cartogram (figure 11), while the interior western states, especially Utah, Nevada, and Texas gain size on the cartogram of the under 18 age group (figure 12). This visually demonstrates the decreasing importance of the northeast and increasing electoral relevance of the quickly growing Sunbelt and western states, a trend that is confirmed through the longer time scale changes in electoral college votes previously discussed. Given the generally low turnout rates for younger voters, this shift is likely to occur gradually unless a particular candidate or party is able to inspire political participation by this underrepresented demographic. These maps suggest that appealing to young voters may be a viable campaign strategy, especially in western battleground states like Nevada, which given the close electoral margins of recent elections may be crucial for victory.

No combination of demographics can explain electoral preference in its entirety, thus it is important to view each of these maps in context before drawing broad scale conclusions. The use of percentage based area scaling allows for comparison across states independent of total population, yet population is ultimately what determines the electoral college power of each state. For example, Utah has a population base that is highly urbanized, well educated, young, and quickly growing, yet its overall electoral college power of 5 votes is trumped by California (55), Texas (34), and even Arizona (10). What these cartograms show best is the electoral context of income, educational, age, and rural population differences between states, and how these variables correspond to political constituencies over time.

Conclusions and Future Research

Cartograms convey electoral results in a intuitive way that transcends the limitations of the standard electoral map. Projecting election results onto demographic space allows visualization of the divisions inherent in a red state/blue state America, showing political change through the lenses of population movement and settlement patterns, educational attainment, income and age. Animation is best applied for time series and demonstrating the difference between a standard map and a cartogram, but not necessarily appropriate for representing spatial changes over time. This is largely due to animation 'tweening', which is visually powerful but difficult to control, and could result in misinterpretation of changes in political and demographic

space due to the scaling and movement of mapped geographies. Adding shape hints to a 'tweened' sequence can help control the changes that occur, thus producing an animation that is less cartographically distorted. Additional animation techniques and software packages should be tested as well.

Future cartogram animations could implement longer time series, as this would provide much deeper insight into the changing demographics of political divisions. User experiments could test the validity of using morphing animation between static election maps and cartograms as a means of improving cognition. Election results mapped to other cartogram scaled spaces, such as religious preference, ethnicity, or country of origin, could be utilized to further test the assumptions of a deeply divided red/blue America. Internet publication of animated election cartograms is a first step in increasing accessibility and awareness of this powerful mapping platform, and combined with interactive user interfaces could prove to be a valuable tool for both researchers and the voting public.

References

- Gastner, M. T. and M. E. J. Newman (2004). Diffusion-based method for producing density-equalizing maps. *Proceedings of the National Academy of Sciences of the United States of America* 101(20): 7499-7504.
- Gastner, M. T., C. R. Shalizi, et al. (2005). Maps and cartograms of the 2004 US presidential election results. *Advances in Complex Systems* 8(1): 117-123.
- Goldsberry, K. (2008). Tweening in Cartographic Animation. Paper Given at the American Association of Geographers Annual Meeting. Boston.
- Harrower, M. (2004). A look at the history and future of animated maps. *Cartographica* 39(3): 33-42.
- Kennicott, P. (2004). Election Map Makers, Exercising Some Latitude. *The Washington Post*: C01.

- Leuthold, H., M. Hermann, et al. (2007). Making the political landscape visible: mapping and analyzing voting patterns in an ideological space. *Environment and Planning B-Planning & Design* 34(5): 785-807.
- MacEachren, A. M. and M.-J. Kraak (2001). Research Challenges in Geovisualization. *Cartography and Geographic Information Science* 28(1).
- Midtbo, T., Clarke, K. C., and Fabrikant, S. I. (2007). Human interaction with animated maps: The portrayal of the passage of time. 11th Scandinavian Research Conference on Geographical Information Science, As, Norway.
- Phillips, K. P. (1969). *The emerging Republican majority New Rochelle, N.Y*, Arlington House
- Seyle, D. C. and M. L. Newman (2006). A house divided? The psychology of red and blue America. *American Psychologist* 61(6): 571-580.
- Sperling, J. (2004). *The Great Divide: Retro vs. Metro America*, PoliPoint Press.
- Sui, D. Z. (2004). GIS, cartography, and the third culture: Geographic imaginations in the computer age. *Professional Geographer* 56(1): 62-72.
- Tobler, W. (2004). Thirty five years of computer cartograms. *Annals of the Association of American Geographers* 94(1): 58-73.
- Tobler, W. R. (1963). Geographic Area and Map Projections. *Geographical Review* 53(1): 59-78.

Figure 1: United States Presidential Election Results by State, 2004

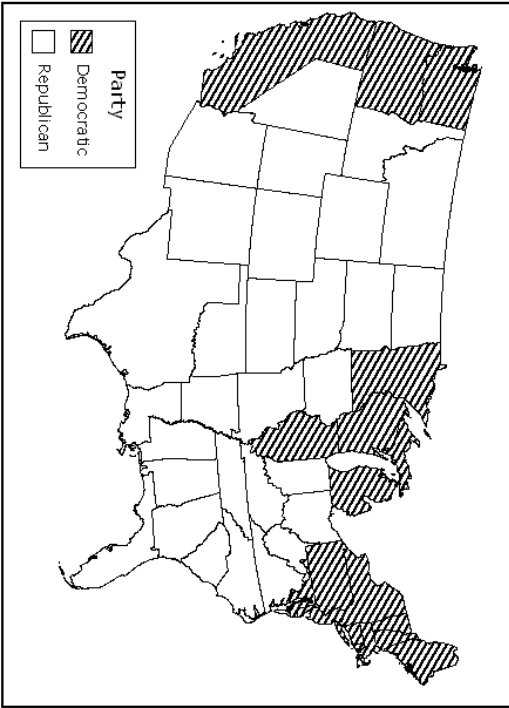


Figure 2: Voting Age Population Results Scaled Cartogram of United States Presidential Election Results by State, 2004

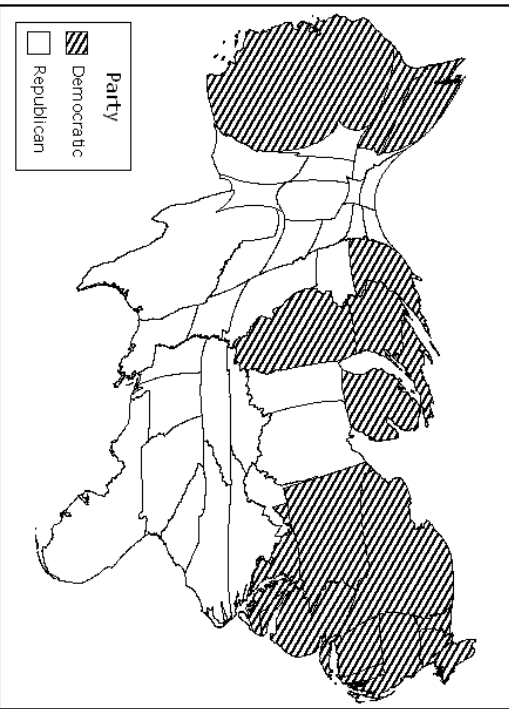


Figure 3: Electoral Vote Scaled Cartogram of United States Presidential Election Results by State, 1968

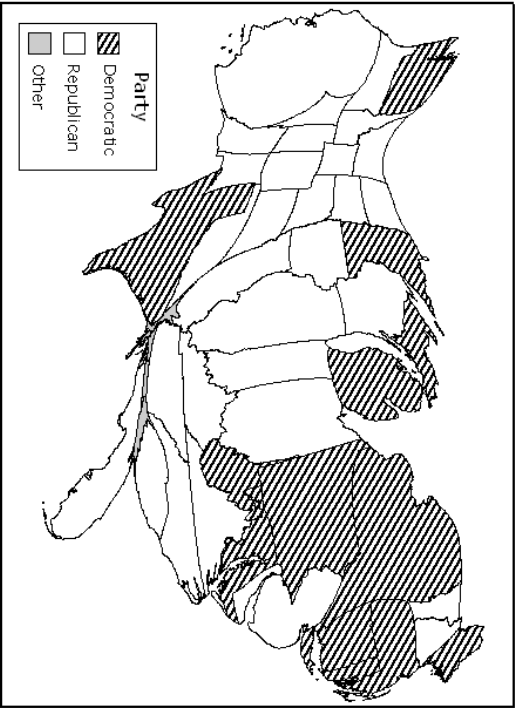


Figure 4: Electoral Vote Scaled Cartogram of United States Presidential Election Results by State, 2004

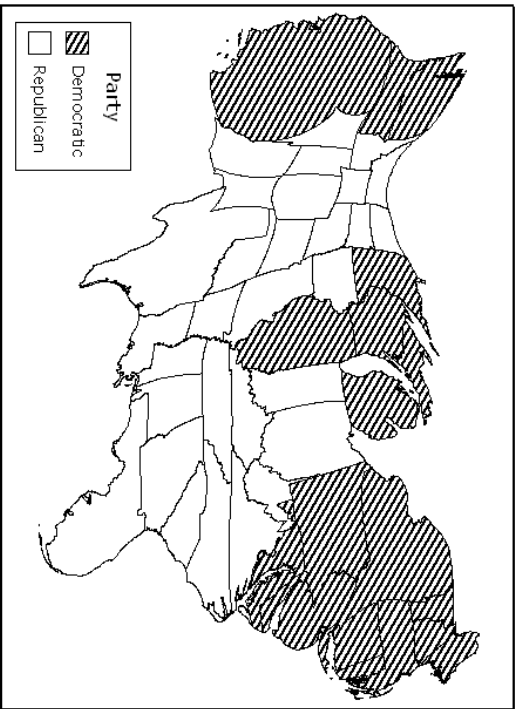


Figure 5: Percentage Rural Scaled Cartogram of United States Presidential Election Results by State, 1992



Figure 7: Percentage Bachelor's Degree or Beyond Scaled Cartogram of US Presidential Election Results by State, 1992

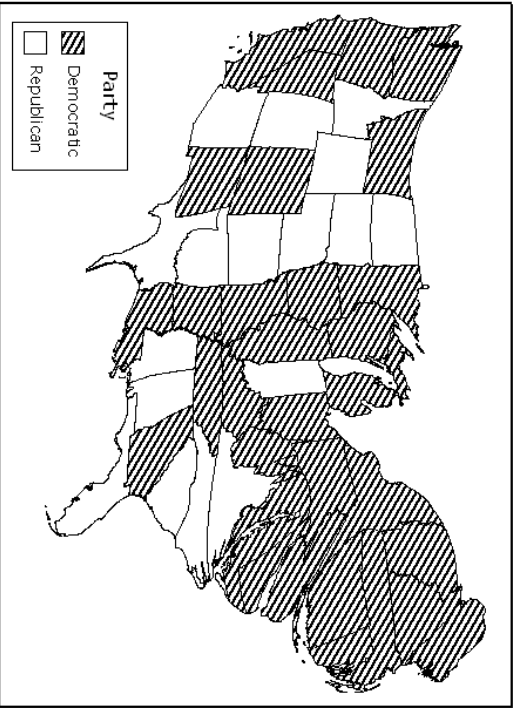


Figure 6: Percentage Rural Scaled Cartogram of United States Presidential Election Results by State, 2004

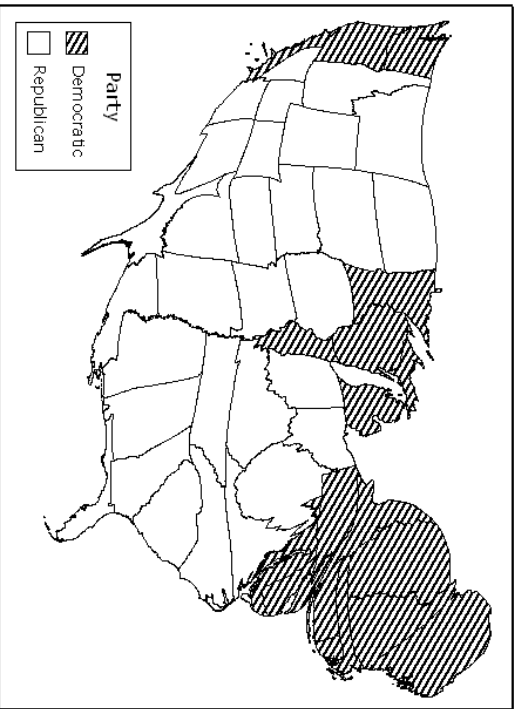


Figure 8: Percentage Bachelor's Degree or Beyond Scaled Cartogram of US Presidential Election Results by State, 2004

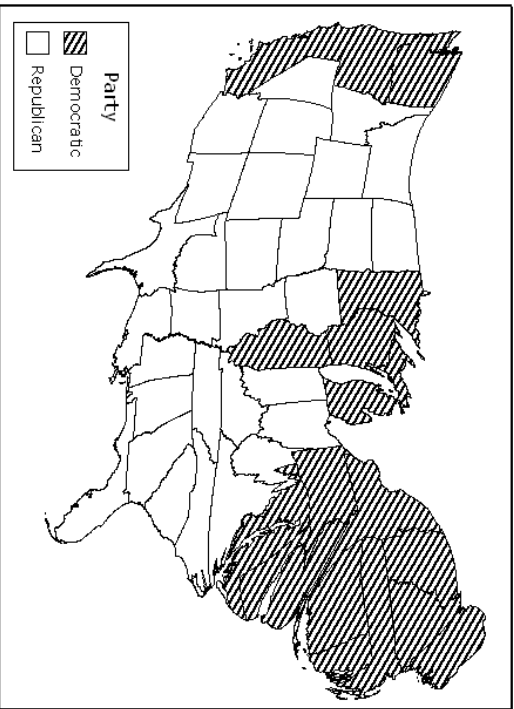


Figure 9: Median Family Income Scaled Cartogram of United States Presidential Election Results by State, 1992

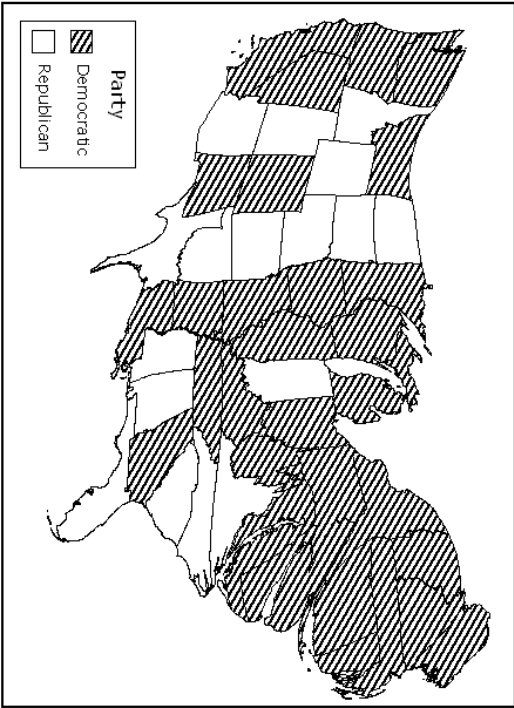


Figure 11: Percentage 60 years and older Scaled Cartogram of US Presidential Election Results by State, 2004

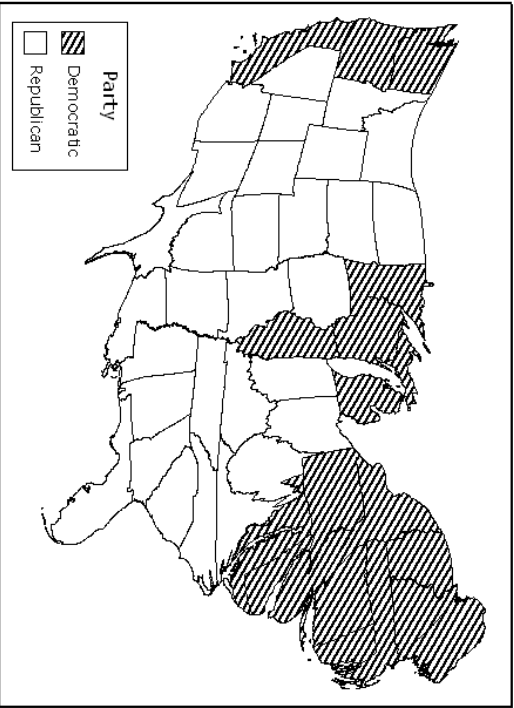


Figure 10: Median Family Income Scaled Cartogram of United States Presidential Election Results by State, 2004

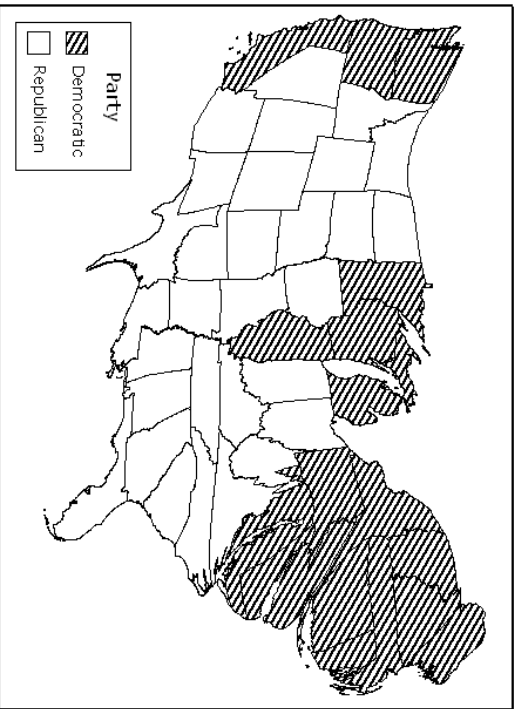


Figure 12: Percentage Under 18 years old Scaled Cartogram of US Presidential Election Results by State, 2004

