Where's your county seat? A modern mathematical method for calculating centers of geography

April 3 2017, by Peter Rogerson

Ten states need to move the markers. Credit: Nicolas Henderson, CC BY

People have long been intrigued by figuring out the center of the places where we live.

You're probably familiar with the concept of center of population. Imagine placing an equal weight at the residential location of each individual; the center of population would be the single point on a map that balances all those weighted spots. The U.S. Census Bureau, for example, produces a map each decade showing the location of the country's center, summarizing the geographic distribution of the national population. The U.S. center has moved steadily west – it first crossed the Mississippi River in 1980 – and in recent decades has taken a turn to the south.

What about if you sweep all the people off the landscape? Where is the geographic center of a region? This simple question has both a clear answer and an interesting history. The geographic center is also a balance point – it's analogous to a center of mass or a center of gravity. For a two-dimensional region, it is the point at which you could balance, say, a cardboard cutout of the region on the head of a pin.

And that, surprisingly, is exactly how the geographic center of the United States and its states were found by the U.S. Geological Survey in the 1920s. Spots in Piscataquis County, Maine, Twiggs County, Georgia, and McCulloch County, Texas, for instance, all got their claims to fame almost a century ago based on the head-of-a-pin method. The USGS' findings at that time have since been perpetuated and sustained as lists you'd find in almanacs, statistical abstracts, various online sites and beyond.

Surely we can improve upon this cardboard cutout approach. I've come up with a new technique that can, in fact, find more accurate geographic centers.

What's at stake

Who really cares about finding a geographic center, though? After all, it has no real-world correlation with how a landscape functions or the way an ecosystem works.

One motivating reason is that a geographic center is a location that provides maximum accessibility to all parts of the region. Historically, they were often used as the location for the seats of county government. Such locations ensured government offices would be equally accessible to all.

A second raison d'etre for geographic centers is that the concept has given places a way to claim something unique – a perhaps odd, but nevertheless definite, source of civic pride that simultaneously allows individual identification with place. It's a way to tout the town and market it to tourists. Just as some people want to visit all state capitals or every state's highest point, geographic centers offer yet another inventory for those compiling creative bucket lists. Other tourists simply find themselves close to the center and are drawn to it for a classic photo opp in front of a plaque or monument.

A third reason is more basic – as a fundamental summary measure for regions, we should make sure that we locate them accurately. Just as the center (or average, or mean) of a set of data provides a convenient summary measure, a geographic center summarizes succinctly the location of a region.

We want to find the one spot where, when we square the great-circle distances from it to every other point in the region and add them all up, it's the smallest sum. The arrows are just four of the great-circle distances that would be used to find the geographic center of North America. Credit: Becky Farnham, CC BY-ND

A more precise calculation

So, how do we find this point accurately? Most states have somewhat irregular shapes which make it harder to answer this question than if their borders described simple rectangles, for instance.

Some people have found the geographic center of two-dimensional polygons by taking a mathematical approach that uses the coordinates of the polygon's corners. We know that the average of a set of numbers is the number which minimizes the sum of squared distances from all numbers in the set to itself. This is a characteristic of simple averages as well as centers of gravity. We can apply it to our region. We're looking for the one spot in the region's interior that has the smallest sum of squared distances from each point in the region.

While this two-dimensional solution might be adequate for finding the center of small geographical regions, for large regions we need to consider that they lie on the surface of what is close to a three-dimensional sphere – Earth.

Now the goal becomes one of finding the balance point as the location that minimizes the sum of squared great-circle distances from all points in the region to it. (The great-circle distance is the shortest distance between two points located on the surface of a sphere.)

To do this, the trick is to find an appropriate map projection. All map projections result in distortion of the Earth's surface – the familiar Mercator projection, for example, is well known for its distortions of areas at high latitudes.

It turns out that another projection – the azimuthal equidistant projection – provides exactly what we want: It measures distance accurately from the center of the map. This is the version of our planet that you find on the United Nations' emblem, where the map has been centered on the North Pole.

So, we can find the geographic center of a large region as follows, using a process of repeated refinement:

1. Map the region's boundary using the azimuthal equidistant projection, initially guessing where the geographic center might be, and centering the map there.
2. Use the existing mathematical method for finding the center of a two-dimensional polygon to find the geographic center on this initial map.
3. Use the result from step 2 to create a new azimuthal equidistant map, this time centered on the new estimate of the center.
4. Repeat steps 2 and 3 until the location of the center does not change from one step to the next.

How much of an improvement is this over the old cardboard method? Road-trippers and tourist bureaus don't need to panic, but there are 10 states where the geographic center, as determined by this method, moved by more than five miles from the old USGS centers. Discrepancies tend to be largest for the largest states and states with more complex shapes (including Alaska, Florida, Texas and New York). The geographic center for the entire contiguous U.S. lies near Agra, Kansas, 27.9 miles from the USGS' long-designated center in Lebanon, Kansas. No word on whether a rivalry has emerged in the Sunflower State.

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