The Mathematics and Geography of Mass Shootings in the U.S., 1982-2017

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The authors use simple bilinear regression to assess changes in the geographical movement (latitude and longitude) of mass shootings in the United States between 1982 and 2017. The path taken by the location of the ninety-five mass shootings over the 36-year period has shifted south. An analysis of differences by census region and blue/red state distinctions within each census region reveals disproportionately many mass shootings in Midwestern states between 2000 and 2008, and disproportionately many in red Southern states over the past three-plus decades.

Keywords: mass shootings in the U.S., red states and blue states

Mass shootings are horrific and heart-wrenching. Since 1982, there have been ninety-five public mass shootings, forty of which have occurred in the past six years alone (2012 – 2017), or about one every fifty-two days. Many people have studied the weapons used, the characteristics of the perpetrators (mostly white males), and the number of victims injured and killed. In this brief research note, we examine the geography of mass shootings in the United States (see Berkowitz et al. [1] and Lankford [2]).

A map of the United States identifying the locations of all mass shootings over the past three-plus decades seemingly defies explanation. That is, a line connecting the ninety-five sequential dots would look like the path taken by a seriously confused butterfly. Yet, has the latitude or longitude of these events changed over time? Is there any regional pattern over time? Is there any evidence that mass shootings occur disproportionately more often in blue states or red states? And, does the blue/red state distinction vary over time?

The Data

Follman et al. [3] recently updated their 2012 database documenting mass shootings in the United States. A "mass shooting" was defined as an incident in a public place in which four or more people (not including the perpetrator) are killed. In January 2013, Congress lowered that baseline to *three* or more victims killed (U.S. Congress, [4]).

Table 1. Mass Shootings in the United States, 1982- 2017, by Date, Location, Latitude, Longitude, Blue/Red State, President's Party[a,b]

Date	Location	Latitude	Longitude	Blue/Red State	President's Party
November 14, 2017	Rancho Tehama, CA	40.0007	-122.4580	Blue	R
November 5, 2017	Sutherland Springs, TX	29.2733	-98.0567	Red	R
November 1, 2017	Thornton, CO	39.8680	-104.9720	Blue	R
October 18, 2017	Edgewood, MD	39.4187	-76.2944	Blue	R
October 1, 2017	Las Vegas, NV	36.1699	-115.1400	Blue	R
June 14, 2017	San Francisco, CA	37.7749	-122.4190	Blue	R
June 7, 2017	Tunkhannock, PA	41.5387	-75.9466	Red	R
June 5, 2017	Orlando, FL	28.5383	-81.3792	Red	R
May 12, 2017	Kirkersville, OH	39.9595	-82.5957	Red	R
April 18, 2017	Fresno, CA	36.7468	-119.7730	Blue	R
January 6, 2017	Fort Lauderdale, FL	26.1224	-80.1373	Red	D
September 23, 2016	Burlington, WA	48.4757	-122.3250	Blue	D
July 17, 2016	Baton Rouge, LA	30.4583	-91.1403	Red	D
July 7, 2016	Dallas, TX	32.7767	-96.7970	Red	D
June 12, 2016	Orlando, FL	28.5383	-81.3792	Blue	D
February 25, 2016	Hesston, KS	38.1383	-97.4314	Red	D
February 20, 2016	Kalamazoo County, MI	42.2278	-85.5726	Blue	D
December 2, 2015	San Bernardino, CA	34.1083	-117.2900	Blue	D
November 27, 2015	Colorado Springs, CO	38.8339	-104.8210	Blue	D
October 31, 2015	Colorado Springs, CO	38.8339	-104.8210	Blue	D
October 1, 2015	Roseburg, OR	43.2165	-123.3420	Blue	D
July 16, 2015	Chattanooga, TN	35.0456	-85.3097	Red	D
June 17, 2015	Charleston, SC	32.7765	-79.9311	Red	D
June 11, 2015	Menasha, WI	44.2022	-88.4465	Blue	D
October 24, 2014	Marysville, WA	48.0518	-122.1770	Blue	D
May 23, 2014	Santa Barbara, CA	34.4208	-119.6980	Blue	D
April 3, 2014	Fort Hood, TX	31.1950	-97.7413	Red	D
February 20, 2014	Alturas, CA	41.4871	-120.5430	Blue	D
September 16, 2013	Washington, D.C.	38.9072	-77.0369	Blue	D
July 26, 2013	Hialeah, FL	25.8576	-80.2781	Blue	D
June 7, 2013	Santa Monica, CA	34.0195	-118.4910	Blue	D
April 21, 2013	Federal Way, WA	47.3223	-122.3130	Blue	D
March 13, 2013	Herkimer County, NY	43.1631	-74.8741	Blue	D
December 14, 2012	Newtown, CT	41.4141	-73.3036	Blue	D
September 27, 2012	Minneapolis, MN	44.9778	-93.2650	Blue	D
August 5, 2012	Oak Creek, WI	42.8859	-87.8631	Blue	D

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Date	Location	Latitude	Longitude	Blue/Red State	President's Party
July 20, 2012	Aurora, CO	39.7294	-104.8320	Blue	D
May 20, 2012	Seattle, WA	47.6062	-122.3320	Blue	D
April 2, 2012	Oakland, CA	37.8044	-122.2710	Blue	D
February 22, 2012	Norcross, GA	33.9412	-84.2135	Red	D
October 14, 2011	Seal Beach, CA	33.7414	-118.1050	Blue	D
September 6, 2011	Carson City, NV	39.1638	-119.7670	Blue	D
January 8, 2011	Tucson, AZ	32.2217	-110.9260	Red	D
August 3, 2010	Manchester, CT	41.7759	-72.5215	Blue	D
November 29, 2009	Parkland, WA	47.1554	-122.4340	Blue	D
November 5, 2009	Fort Hood, TX	31.1950	-97.7413	Red	D
April 3, 2009	Binghamton, NY	42.0987	-75.9180	Blue	D
March 29, 2009	Carthage, NC	35.3460	-79.4170	Blue	D
June 25, 2008	Henderson, KY	37.8362	-87.5900	Red	R
February 14, 2008	DeKalb, IL	41.9295	-88.7504	Blue	R
February 7, 2008	Kirkwood, MO	38.5834	-90.4068	Red	R
December 5, 2007	Omaha, NE	41.2524	-95.998	Red	R
October 7, 2007	Crandon, WI	45.5719	-88.9029	Blue	R
April 16, 2007	Blacksburg, VA	37.2296	-80.4139	Red	R
February 12, 2007	Salt Lake City, UT	40.7608	-111.8910	Red	R
October 2, 2006	Lancaster County, PA	40.0467	-76.1784	Blue	R
March 25, 2006	Seattle, WA	47.6062	-122.3320	Blue	R
January 30, 2006	Goleta, CA	34.4358	-119.8280	Blue	R
March 21, 2005	Red Lake, MN	47.8763	-95.0169	Blue	R
March 12, 2005	Brookfield, WI	43.0606	-88.1065	Blue	R
December 8, 2004	Columbus, OH	39.9612	-82.9988	Red	R
July 8, 2003	Meridian, MS	32.3643	-88.7037	Red	R
February 5, 2001	Melrose Park, IL	41.9006	-87.8567	Blue	R
December 26, 2000	Wakefield, MA	42.5039	-71.0723	Blue	D
December 30, 1999	Tampa, FL	27.9506	-82.4572	Blue	D
November 2, 1999	Honolulu, HI	21.3069	-157.8580	Blue	D
September 15, 1999	Fort Worth, TX	32.7555	-97.3308	Red	D
July 29, 1999	Atlanta, GA	33.7490	-84.3880	Red	D
April 20, 1999	Littleton, CO	39.6133	-105.0170	Red	D
May 21, 1998	Springfield, OR	44.0462	-123.0220	Blue	D
March 24, 1998	Jonesboro, AR	35.8423	-90.7043	Blue	D

Date	Location	Latitude	Longitude	Blue/Red State	President's Party
March 6, 1998	Newington, CT	41.6973	-72.7228	Blue	D
December 18, 1997	Orange, CA	33.7879	-117.8530	Blue	D
September 15, 1997	Aiken, SC	33.5604	-81.7196	Red	D
February 9, 1996	Fort Lauderdale, FL	26.1224	-80.1373	Red	D
April 3, 1995	Corpus Christi, TX	27.8006	-97.3964	Red	D
June 20, 1994	Fairchild AFB, WA	47.6183	-117.6440	Blue	D
December 14, 1993	Aurora, CO	39.7294	-104.8320	Blue	D
December 7, 1993	Garden City, NY	40.7268	-73.6343	Blue	D
August 6, 1993	Fayetteville, NC	35.0527	-78.8784	Red	D
July 1, 1993	San Francisco, CA	37.7749	-122.4190	Blue	D
October 15, 1992	Watkins Glen, NY	42.3806	-76.8733	Blue	R
May 1, 1992	Olivehurst, CA	39.0954	-121.5520	Red	R
November 14, 1991	Royal Oak, MI	42.4895	-83.1446	Red	R
November 1, 1991	Iowa City, IA	41.6611	-91.5302	Blue	R
October 16, 1991	Killeen, TX	31.1171	-97.7278	Red	R
June 18, 1990	Jacksonville, FL	30.3322	-81.6557	Red	R
September 14, 1989	Louisville, KY	38.2527	-85.7585	Red	R
January 17, 1989	Stockton, CA	37.9577	-121.2910	Red	R
February 16, 1988	Sunnyvale, CA	37.3688	-122.0360	Red	R
April 23, 1987	Palm Bay, FL	28.0345	-80.5887	Red	R
August 20, 1986	Edmond, OK	35.6528	-97.4781	Red	R
July 18, 1984	San Ysidro, CA	32.5556	-117.0470	Red	R
June 29, 1984	Dallas, TX	32.7767	-96.7970	Red	R
August 20, 1982	Miami, FL	25.7617	-80.1918	Red	R

[a]Blue states and red states refer to U.S. states whose voters chose either the Democratic Party (blue) or Republican Party (red) presidential candidate in the presidential election prior to the date of the mass shooting.
[b]Party of the sitting president at the time of the mass shooting.
Sources: *Date* and *Location* [3]; *Latitude, Longitude* of location [5]; and *Blue/Red State*, *President's Party* [7].

Table 1 indicates the date and location of each of the ninety-five mass shootings between 1982 and 2017. The latitude and longitude of each location (expressed in degrees decimal) were obtained from [5]. The 36-year geographic midpoint (using [6]) is 38.9543° latitude and -97.4675° longitude, near Solomon, Kansas, about six miles west of Abilene. U.S. states whose voters chose either the Democratic Party or Republican Party presidential candidate in the presidential election prior to the date of the mass shooting were labeled blue and red, respectively [7]. The final column lists the party of the president in office at the time of the incident. For example, on January 6, 2017, President Barack Obama (D) occupied the Oval Office, although President-elect Donald J. Trump would take the oath of office of the President of the United States just two weeks later. Finally, the data are divided into four census regions (Northeast, South, Midwest, and West) and four nine-year periods (1982-1990, 1991-1999, 2000-2008, 2009-2017) as well as two eighteen-year periods (1982-1999 and 2000-2017).[1]

Methodology

Once the latitude and longitude are found for each of the ninety-five mass shootings, one can then test for temporal movements. This will be done by means of regressions of the form:

(1) $Latitude = b_0 + b_1 Year$

where the dependent variable of the trend line regression is the "latitude" (or "longitude") of the mass shooting location) and the independent variable is the "year" of the incident. If the dependent variable is "latitude" and the estimated slope coefficient, b_1, of the trend line is negative and statistically discernible from zero ($\alpha = .05$), then the movement is "south." Smaller values for the latitude (that is, distance north from the equator or 0° latitude) indicate that the geographic location of mass shootings in the U.S. is moving over time south or closer to the equator. When the dependent variable is "longitude" and the estimated slope coefficient, b_1, of the trend line is negative and statistically discernible from zero, then the movement is "west." Increasingly negative values for the longitude (that is, distance west from the Prime Meridian or 0° longitude) indicate that the geographic location of mass shootings in the U.S. is moving west (farther from the Prime Meridian) over time.

A series of chi-square tests will be run on contingency tables relating (i) mass shootings by census region and nine-year periods, (ii) the blue/red state distinction and nine-year periods, and (iii) the blue/red state distinction and census regions.

Results
Table 2. The Regression Results

1982 − 2017						
Dependent Variable	*Constant*		*Year*		*R²*	
Latitude	-157.952	[120.962][a]	.097	[.060]	.027	
Longitude	109.293	[375.331]	-.103	[.187]	.003	

1982 − 1999						
Dependent Variable	*Constant*		*Year*		*R²*	
Latitude	-109.953	[453.099]	.073	[.227]	.004	
Longitude	524.072	[1486.271]	-.312	[.746]	.006	

2000 − 2017						
Dependent Variable	*Constant*		*Year*		*R²*	
Latitude	733.389	[309.055]	**-.345**	[.154]	.075	
Longitude	1392.989	[982.184]	-.741	[.488]	.036	

[a]Numbers in square brackets are standard errors and the number in boldface is significant at better than the .05 level.

The regression results in Table 2 for the entire 36-year period reveal no discernible change in longitude ($b_1 = .097$, $p = .109$) or latitude ($b_1 = -.103$, $p = .582$). When, however, the 36-year period is divided into two eighteen-year periods, there is again no discernible change north or south during the period 1982-1999 ($b_1 = .073$, $p = .751$), but there *is* a discernible change south during the more recent period 2000-2017 ($b_1 = -.345$, $p = .028$). Insofar as longitude is concerned, there is no discernible change east or west in either eighteen-year period (1982-1999: $b_1 = -.312$, $p = .679$; 2000-2017: $b_1 = -.741$, $p = .134$).

Table 3. Two-Way Classification of Mass Shootings, by Census Region and Nine-Year Periods, 1982 – 2017

	Nine-Year Periods			
	1982-1990	1991-1999	2000-2008	2009-2017
Census Region				
Northeast	0	3	2	5
South	6	9	3	15
Midwest	0	2	8	6
West	3	8	3	22

Table 3 relates the number of mass shootings by census region to each of four nine-year periods ($\chi^2 = 21.129$, $p = .012$). The cell in this contingency table that contributes the most to the calculated χ^2 test statistic is the disproportionately large number of mass shootings in the Midwest between 2000 and 2008 (observed frequency = 8, expected frequency = 2.7).

Table 4. Two-Way Classification of Mass Shootings, by Blue/Red States and Nine-Year Periods, 1982 – 2017

	Nine-Year Periods			
	1982-1990	1991-1999	2000-2008	2009-2017
Blue/Red States[a]				
Blue	0	12	9	34
Red	9	10	7	14

[a]See footnote *a* in Table 1.

Table 4 relates the blue/red state distinction to each of the four nine-year periods ($\chi^2 = 15.790$, $p = .001$). The cell that contributes the most to the calculated χ^2 test statistic is the disproportionately large number of mass shootings in red states between 1982 and 1990 (observed frequency = 9, expected frequency = 3.8).

Table 5. Two-Way Classification of Mass Shootings, by Blue/Red States and Census Region, 1982 – 2017

	Census Region			
	Northeast	South	Midwest	West
Blue/Red States[a]				
Blue	9	7	10	29
Red	1	26	6	7

[a] See footnote *a* in Table 1.

Finally, Table 5 relates the blue/red state distinction to each of the four census regions over the 36-year period ($\chi^2 = 30.168$, $p < .001$). Most notable in this contingency table is the disproportionately large number of mass shootings in red Southern states (observed frequency = 26, expected frequency = 13.9).

Concluding Remarks

Regression analysis has been used to gauge movements north or south (using "latitude" as the dependent variable) and east or west (using "longitude" as the dependent variable). For the ninety-five mass shootings between 1982 and 2017, the path of their locations has been pulled south, but neither west nor east. A series of chi-square tests reveals most notably disproportionately many mass shootings in Midwestern states between 2000 and 2008 and red Southern states over the entire 36-year period.

On February 14, 2018, fifty-five days into the new year, seventeen students and faculty were fatally shot at a high school in Parkland, Florida, 26.3108° latitude and -80.2532° longitude. The latitude of Parkland, Florida (a red Southern state) is south of the 36-year average geographic midpoint, a result that underscores the statistical results presented here.

Footnote

1.   The states included in each census region are: *Northeast* (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania); *South* (Texas, Oklahoma, Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama, West Virginia, Virginia, Maryland, Delaware, DC, North Carolina, South Carolina, Georgia, Florida); *Midwest* (North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio); and *West* (Hawaii, Alaska, Washington, Oregon, California, Idaho, Nevada, Montana, Wyoming, Utah, Colorado, Arizona, New Mexico).

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