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STATISTICAL ANALYSES OF U.S. TORNADOES BASED ON THE GEOGRAPHIC DISTRIBUTION OF POPULATION, COMMUNITY, AND OTHER PARAMETERS

Jaime J. Tecson and T. Theodore Fujita
The University of Chicago
Chicago, Illinois

Robert F. Abbey, Jr.
U.S. Nuclear Regulatory Commision
Washington, D.C.

1. INTRODUCTION

Not all tornadoes are reported uniformly from all over the country, due mainly to factors which may be divided into (1) the public's and climatologists' awareness and effort, and (2) geographical parameters affecting the probability of tornadoes being spotted and confirmed.

Prior to the 1950s, collection of data on weak and moderate tornadoes was relatively poor; only violent and/or killer tornadoes were well documented. From the 1950s on, however, an organized and conscientious effort by the U.S. Weather Bureau resulted in a significant increase in the number of tornadoes reported, as well as the quality of tornado data.

Using the 28,534 tornadoes from 1916 through 1982 archived in the University of Chicago (DAPPL) Tornado Tape, an attempt is being made to obtain the most realistic patterns of path length characteristics, by adjustments using road, population, topography, forest, water, and community indices.

2. INDICES

Indices for six parameters (Tecson et al, 1982) that may affect reported path lengths are listed in Table 1. They are for water, forest, topography, road, community, and population. Index values are 1,2,3,...,8,9. Every parameter has an index value representative of each subbox of 15-min latitude and longitude within the contiguous U.S. (There are 13,690 such subboxes.) Data sources are the 1970 census and the latest editions of the USGS quarter-million topographic maps.

Table 1. List of six indices, water index WI, forest index FI, topography index TI, road index RI, community index CI, and population index PI.

	INDEX, 1 to 9								
WI	1	2	3	4	5	6	7	8	9
Water area. . . . W	0/9	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9 or larger
FI	1	2	3	4	5	6	7	8	9
Forest area . . . F	0/9	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9 or larger
TI	1	2	3	4	5	6	7	8	9
Slope within mi^2. T	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6 x 1000' or larger
RI	1	2	3	4	5	6	7	8	9
Road separation . R	1	2	3	4	5	6	7	8	9 miles or larger
CI	1	2	3	4	5	6	7	8	9
Community C	0	1	2	4	7	11	16	22	28 or more
PI	1	2	3	4	5	6	7	8	9
Population. . . . P	0.0	0.1	0.8	2.7	6.4	12.5	21.6	34.3	51.2 x 1000 or larger

2.1 Normalization by latitude and water area

Population and communities within a subbox with latitude ϕ and water index, WI, are normalized to a subbox at 37°N latitude that contains no water. The normalization factor, n, is expressed by

$$n = \frac{\cos 37°}{\cos \phi} WI \qquad (1)$$

where WI is the water index in Table 1.

The population index, PI, is computed from the normalized population in each subbox, using

$$PI = 1 + (nP/100)^{1/3} \qquad (2)$$

where P is the population within a subbox.

The community index, CI, is computed from the normalized value of the communities in each subbox, using

$$CI = 1 + 1.5(nC)^{1/2} \qquad (3)$$

where C is the number of communities in each subbox.

3. INDEX MAPS

Index maps for all six parameters have been prepared. Those on forest, population, and road are shown in Figs. 1, 2, and 3, respectively. Each subbox is printed in overprint mode; the overall printout thus generates a visual pattern of the geographical and density distribution of the parameters for the U.S.

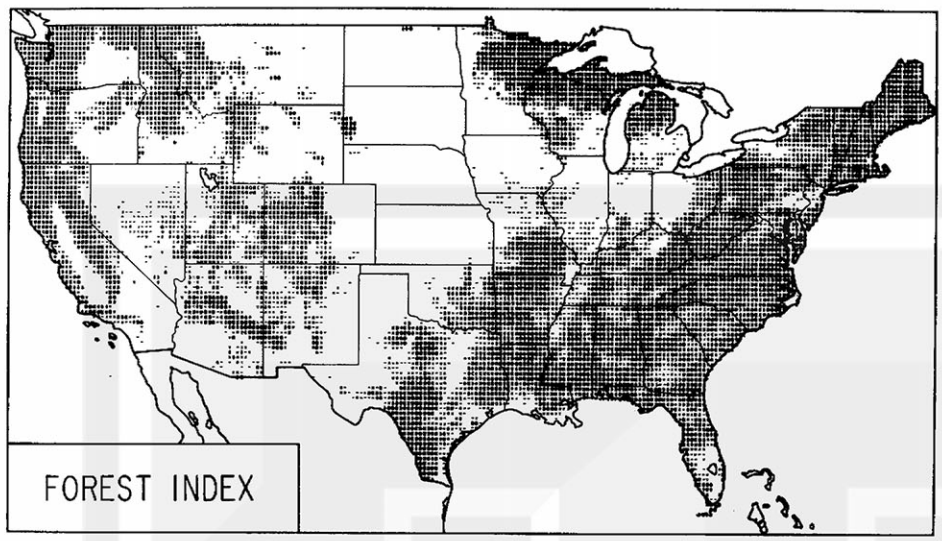

Fig. 1 Forest index for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol as follows: 1 blank; 2 -; 3 =; 4 +; 5 ¥; 6 @; 7 @: 8 @, and 9 ■. Data from USGS quarter-million maps.

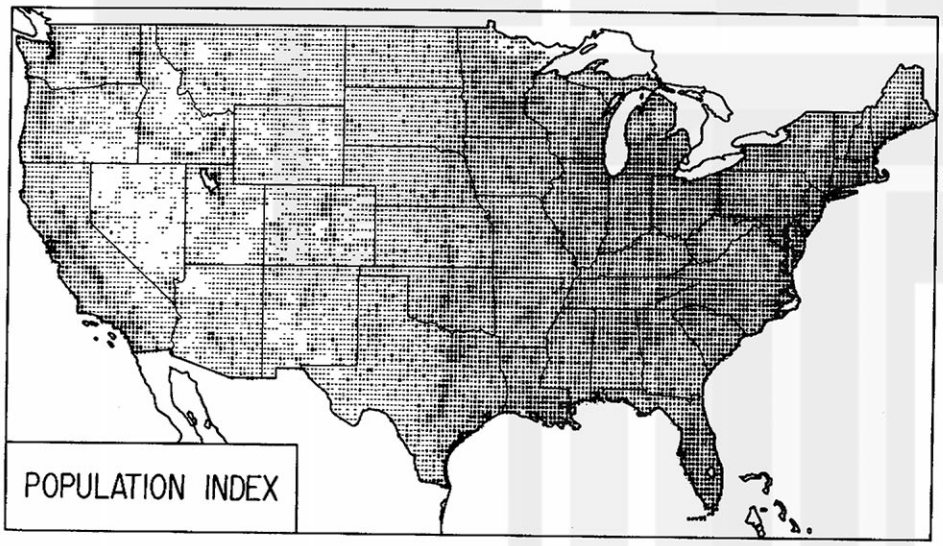

Fig. 2 Population index corrected for water area for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol as follows: 1 blank; 2 -; 3 =; 4 +; 5 ¥; 6 @; 7 @, 8 @, and 9 ■. Data from the 1970 census.

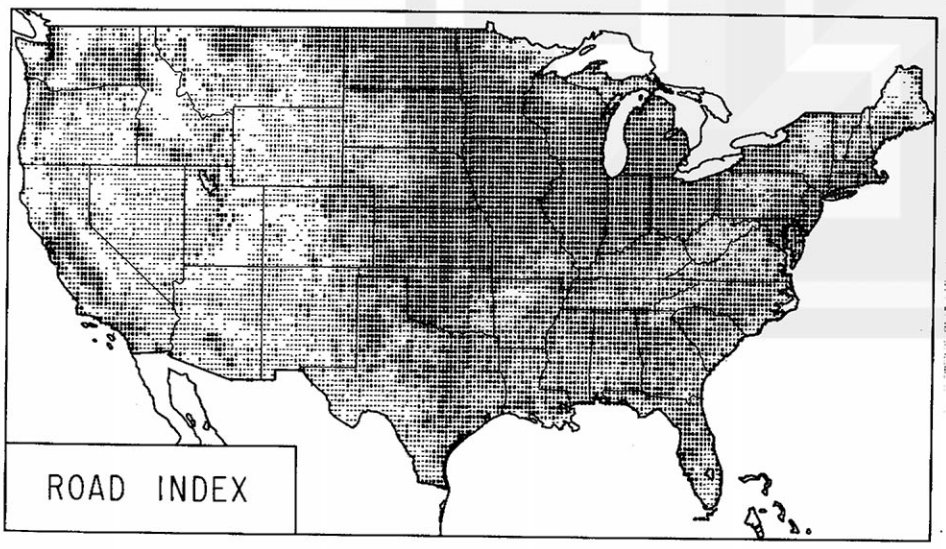

Fig. 3 Road index for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol as follows: 1 ■; 2 @; 3 @; 4 @; 5 ¥; 6 +; 7 =; 8 -; and 9 blank. Data from USGS quarter-million maps.

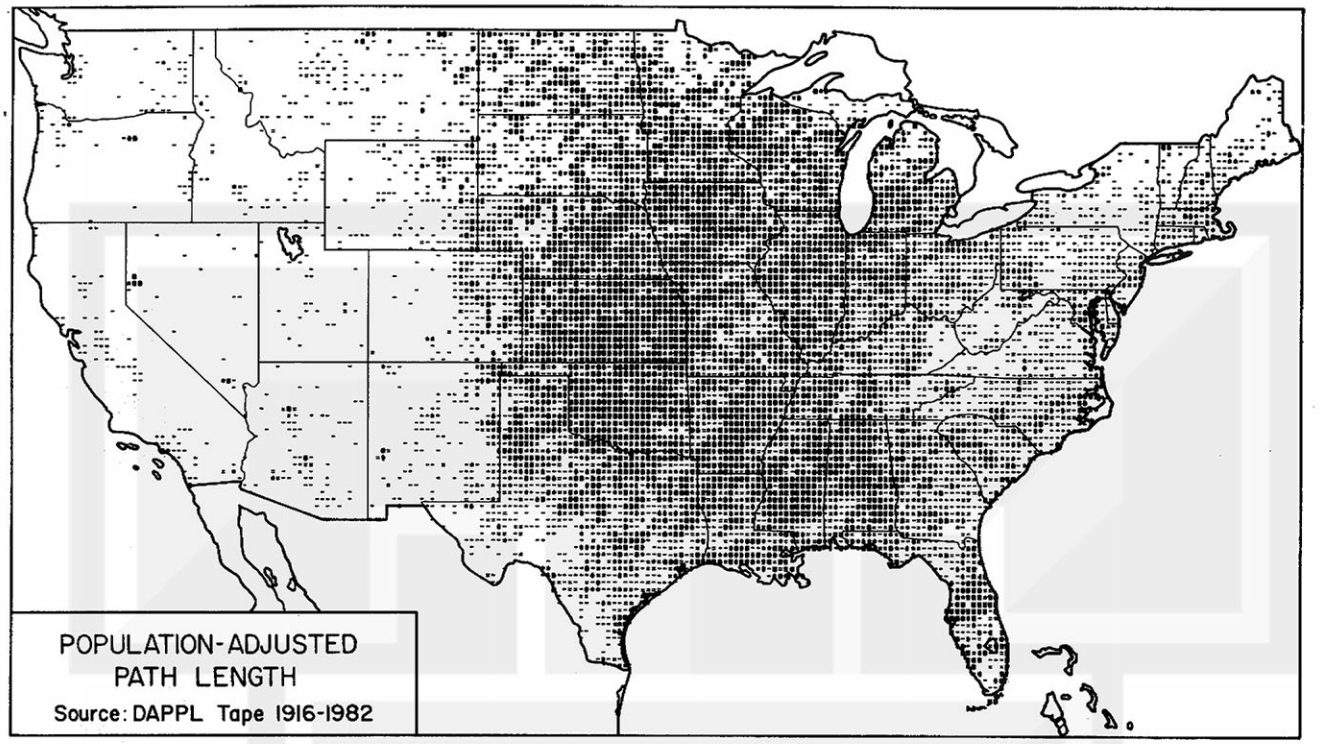

Fig. 4 Population-adjusted path length for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol corresponding to the path length, PL, in miles as follows: PL=0 (blank); 0<PL<10 (-); 10≤PL<20 (=); 20≤PL<30 (*); 30≤PL<40 (‡); 40≤PL<50 (⊕); 50≤PL<60 (⊗); 60≤PL<70 (⊗), and PL≥70 (■). Data from the 1970 census and DAPPL tape (1916-1982).

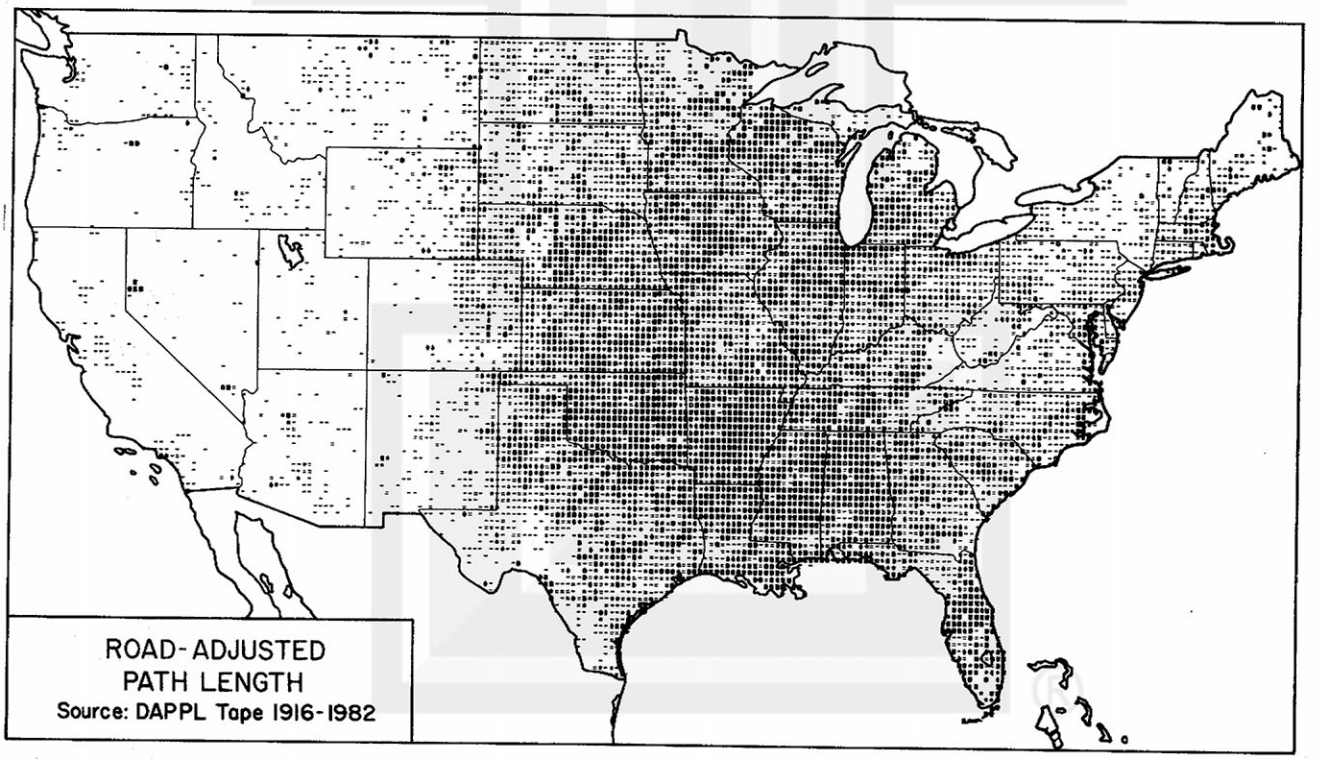

Fig. 5 Road-adjusted path length for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol corresponding to the path length, PL, in miles as follows: PL=0 (blank); 0<PL<10 (-); 10≤PL<20 (=); 20≤PL<30 (*); 30≤PL<40 (‡); 40≤PL<50 (⊕); 50≤PL<60 (⊗); 60≤PL<70 (⊗); and PL≥70 (■). Data from the USGS quarter-million maps and DAPPL tape (1916-1982).

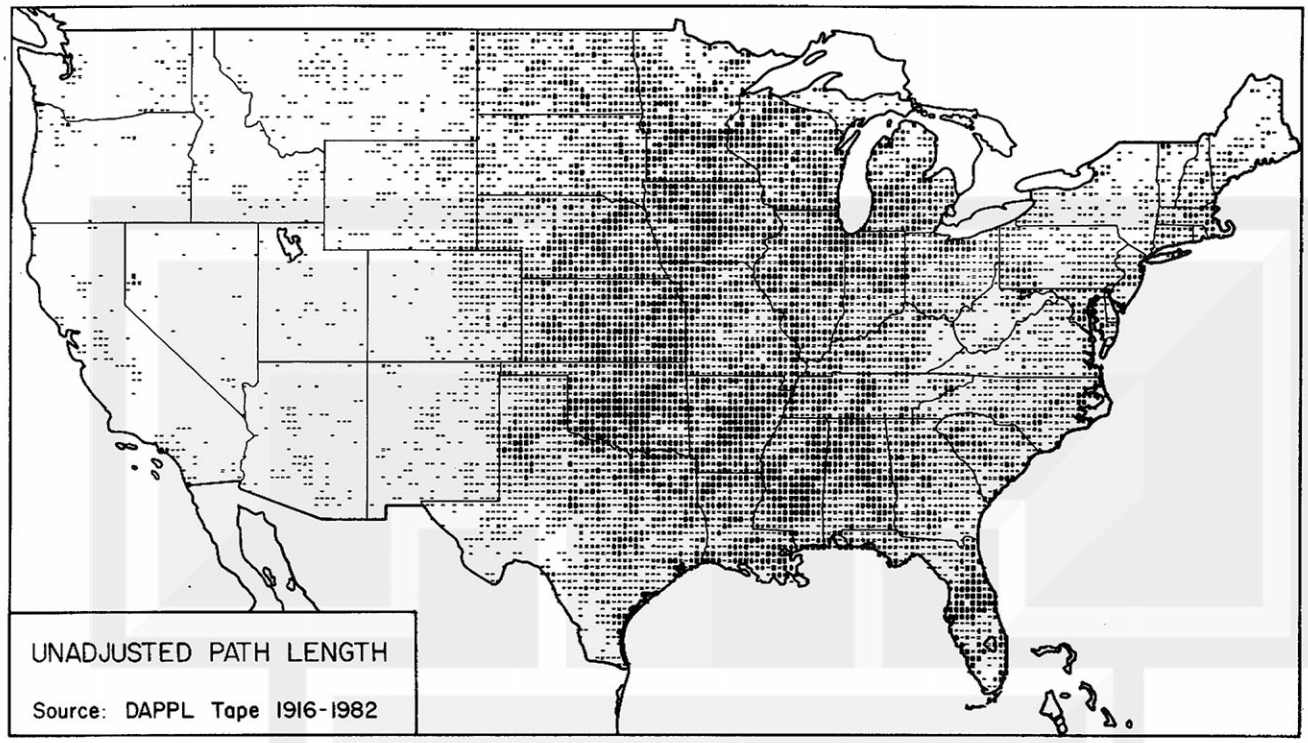

Fig. 6 Unadjusted path length for the U.S. Each subbox of 15-min latitude and longitude has an overprint symbol corresponding to the path length, PL, in miles as follows: PL=0 (blank); 0<PL<10 (-); 10≤PL<20 (=); 20≤PL<30 (*); 30≤PL<40 (#); 40≤PL<50 (@); 50≤PL<60 (%); 60≤PL<70 (&); and PL≥70 (■). Data from DAPPL tape (1916-1982).

4. COMPUTATION OF ADJUSTED PATH LENGTHS

In order to determine the adjusted path lengths, it is necessary to analyze an area with geographically uniform tornado distribution. For this purpose, the region bounded by 45° and 30°N latitude, and 105° and 80°W longitude, roughly the states between the Rockies and the Appalachians, was used (5768 subboxes). The linear coefficient of correlation "r" was computed for each parameter. The values were -0.075 for forest, -0.212 for topography, 0.278 for community, 0.313 for population, and -0.363 for road. The relationship is poor for most of the parameters. The correlation between population and road seems satisfactory at -0.524, and good between population and community at 0.786.

4.1 Adjusted path length

The computation for adjusted path length APL is

$$APL = a \times nPL \qquad (4)$$

where a is the adjustment factor computed from

$$a = f(PI,CI,RI), \qquad (5)$$

PL is the total path length for each subbox.

4.2 Adjustment factors

As an initial attempt, the adjustment factor determined for one parameter was

$$AF_p = \frac{18}{18 - 20\exp(-0.23PI)} \quad \text{(for population)} \qquad (6)$$

and

$$AF_r = \frac{30.35}{30.35 - 3.5(RI-1)} \quad \text{(for road)} \qquad (7)$$

The population-adjusted path length, $nPL \times AF_p$, and the road-adjusted path length, $nPL \times AF_r$, are shown in Figs. 4 and 5, respectively.

For comparison, the unadjusted path length, nPL, is shown in Fig. 6.

5. CONCLUSION

The adjustment factors for population and roads, as applied to path lengths, appear to provide an improved method for estimating path lengths from archived data.

Further applications for community and forest adjustments are being worked out. It is intended to combine these index adjustment factors to produce a final correction factor. This will be used in preparing the monthly, diurnal, hourly, and other path length distribution maps.

Acknowledgement

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REFERENCES

Tecson, J.J., T.T. Fujita, and R.F. Abbey, Jr., 1982: Climatological mapping of U.S. tornadoes during 1916-80. Preprints, 12th Conf. on Severe Local Storms, San Antonio, Amer. Meteor. Soc., 38-41.