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# WHAT WOULD BE THE MONETARY LOSS IF THE 1896 ST. LOUIS/EAST ST. LOUIS TORNADO HAPPENED TODAY?

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## 1. INTRODUCTION

Over the past 150 years, severe thunderstorms have caused substantial property damages in the St. Louis, Missouri metropolitan area. Most recently, the hailstorm of 10 April 2001 caused widespread damage to property in north St. Louis County, with the latest estimate of $1.9 billon in loss burdened by the insurance industry (Property Claims Services; March 2002). Reported historic damage statistics indicate that individual tornadoes have caused losses of similar magnitude in the St. Louis metropolitan region. Wealth adjustments of estimated historic losses have indicated that the 27 May 1896 St. Louis/East St. Louis tornado (hereafter referred to as the 1896 tornado) may have been the most costly tornado in the U.S. since 1890, with damages amounting to an estimated $2.9 billion (Brooks and Doswell 2001).

This study employs an alternative approach to estimating the property related damages and insurance losses if the 1896 tornado were to occur again. This study uses year 2000 insured building, content, and time element exposures. The methodologies used to reconstruct the historic tornado path and model property monetary value over the historic damage area is described herein. The estimated range of property loss that would be produced by this scenario is an ongoing research effort to be presented at the conference.

## 2. OVERVIEW OF THE TORNADO PATH

A wealth of information exists on the property and human losses associated with the 1896 tornado. *The Great Cyclone at St. Louis and East St. Louis* (Curzon 1896) was the primary source of information used to construct the historic tornado path. Reported structure damages were mapped by address or street intersection, noting changes in road name/location (Magnan and Magnan 1997), in order to determine the damage area boundaries. These reports were supplemented by narrative accounts of the tornado, including estimates of path width and description of the path's orientation.

Historic casualty information was also used to refine the tornado path boundary in areas where property damage information was limited (Curzon 1896, St. Clair County, IL 2002). Since historic casualty information often includes the address of the individual's residence, numerous reports were found to lie well outside the area of reported property damage. Therefore, only those casualty reports within or in the immediate vicinity of the described path were used in this analysis.

The potential inaccuracy of textual historic damage accounts has been well documented (Grazulis 1993). To reduce inaccuracies in the determination of local intensity, only historic damage photographs (Curzon 1896, NOAA Photo Library 2002) were used in the assignment of ratings on the Fujita scale (Fujita 1981) within the damage areas. Photographs can also be misleading because they depend on the perspective of the photographer and the timing of the photograph relative to the event. Therefore, local F-ratings were manually smoothed to produce the final damage path shown in Figure 1. It is believed that the observed damage is indicative of a maximum F4 rating, consistent with the interpretation of Grazulis (1993).

Insufficient data was available to determine the path characteristics in region A (shown in Fig. 1) with confidence. The initial damage region has been described as consisting of three independent "strips" of damage (Curzon 1896). The available data was sufficient to determine the approximate path characteristics of the southwest "strip", determined to be the westward extension of the continuous tornado damage path. However, data was insufficient to define the middle and northernmost damage "strips". Region A is comprised of both commercial (Fig. 2) and residential structures (not shown), and therefore the exclusion damage within this area results in an underestimate of the total property loss.

Descriptions and photos of damage were most numerous in the area between Compton Heights (near the western extent of the F2 area) and the western bank of the Mississippi River. Confidence in the details of the path area and F-rating distribution is greatest in this region. The limited photographic evidence of F4 damage precluded the definition of a continuous F4 area. A range of possible F4 damage areas will be used in the final estimation of property loss. This process will also provide information on the sensitivity of the estimated loss to this underlying assumption.

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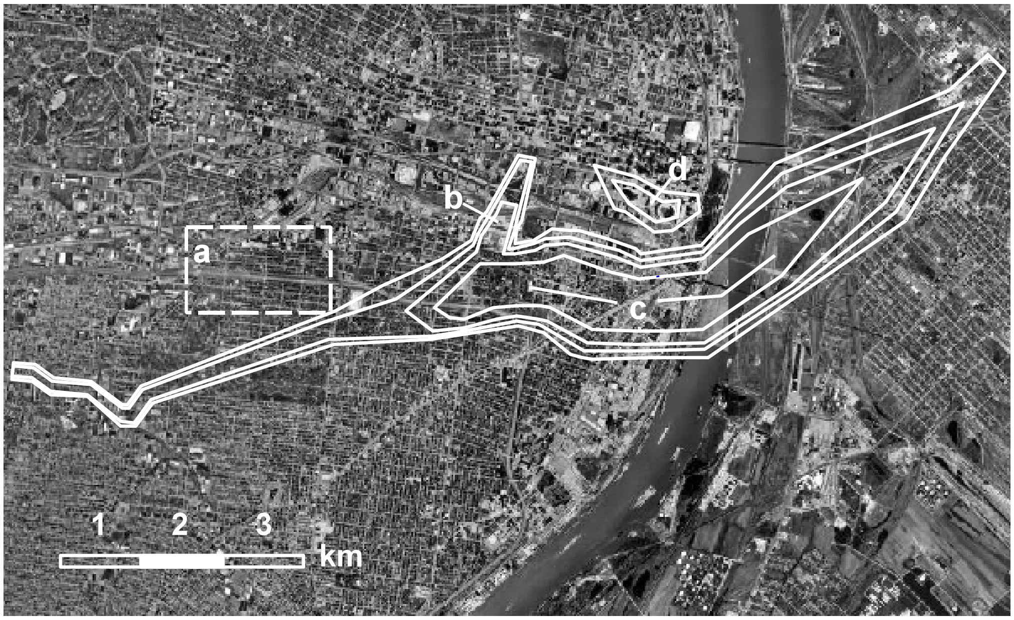


**Figure 1**: Approximate path and damage distribution of the 1896 tornado overlaid on an aerial photograph (vintage 1996, U.S. Geological Survey) of south St. Louis, Missouri. Contours are by F-rating with the outermost contour of the primary path representing F0 and the innermost contour representing F3. Data was insufficient to define a continuous area of F4 damage in the primary path (region C). The outermost contour of the discrete damage area to the north (labeled D) represents an area of F1 rating encircling an area of F2 rating.

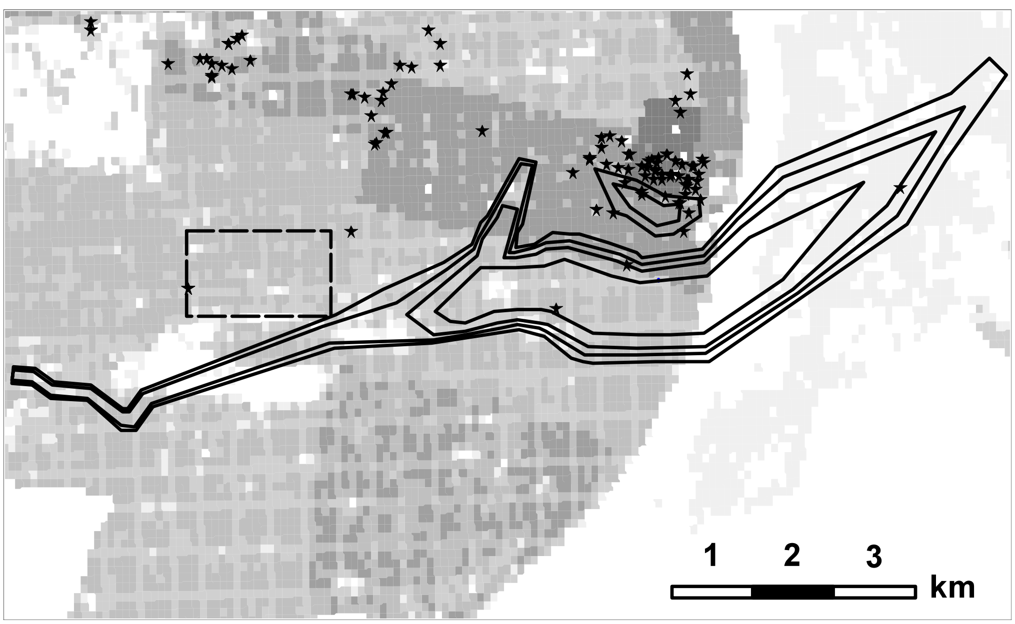


**Figure 2**: Approximate damage path of the 1896 tornado overlaid on a thematic depiction of year 2000 insured commercial structure value. Five levels of shading are used to illustrate natural breaks in exposure with the darkest shading representing values in excess of $11.4 million per 100 m by 100 m grid cell. The location of high-rise buildings is depicted with a star.

A northward extension of damage was reported north of the Lafayette Park district, outside the primary tornado path (region B in Fig. 1). Reports of damage in this region refer to “an arm” that produced damage as far north as Market Street. This extension of damage may have been associated with a satellite tornado or downburst. A cluster of damage to structures was reported immediately south of Downtown St. Louis, over what is now Busch Stadium (region D in Fig. 1). The damages were generally limited to the roofs of structures, consistent with F1 and F2 ratings. This cluster of damage near downtown may have been associated with a downburst that forced the tornado to move toward the west-southwest in this region.

Relatively little information was available on the distribution of damage in East St. Louis. Although several photographs of damage existed, few were accompanied by address information. The gross characteristics of the path area are believed to be accurate; the distribution of damage ratings within the path is more uncertain. However, since this portion of East St. Louis has considerably less exposure value, accuracy in F-rating in this portion of the tornado path is less essential for the estimation of total event loss. The overall characteristics of the 1896 tornado path are summarized in Table 1.

**TABLE 1: TORNADO SUMMARY STATISTICS**

| | |
|---|---|
| Path Length [km] | 13.9 |
| Maximum Path Width [km] | 1.5 |
| Total Path Area [km$^2$] | 11.9* |

*Excludes regions A and D shown in Fig. 1

## 3. MODEL OF EXPOSED PROPERTY

The property exposure model used in this study is derived from a proprietary database of ZIP-code level estimates of values for insured buildings, contents, and time elements (i.e. business interruption) developed by Risk Management Solutions, Inc. For the purposes of this study, exposures for insured commercial and industrial occupancies have been aggregated to the general category of “commercial” and single and multi-family residential occupancies (including condos and other rental units) have been aggregated to the general category of “residential”. A model of regionalized building construction characteristics for these occupancy classes is currently being developed and will be summarized at the conference.

Since ZIP-code resolution is relatively coarse for use in loss estimation from a single tornado, steps were taken to disaggregate these exposure values to a grid of 100-m by 100-m cells. For commercial exposures, distribution factors were developed using a weighting scheme based on 30-m by 30-m commercial land use pixel counts from National Land Cover Data (NLCD; U.S. Geological Survey). For residential exposures, a two-stage process was used to distribute insured values to the grid cell level. First, residential values were distributed to census tracts, weighted by year 2000 population data. These census-level residential exposures were then distributed to 100-m by 100-m grid cells using a weighting scheme based on 30-m by 30-m residential land use pixel counts from the NLCD data.

A thematic map of the resulting commercial structure values is shown in Figure 2. The corresponding content values are distributed similarly. The reported damage began near the current site of the St. Louis State Hospital, located at the westernmost extent of the damage path, in a region of mixed commercial and residential exposure (residential exposure not shown). The tornado moved in an east-northeast direction crossing the Tower Grove Park, just south of the Missouri Botanical Gardens. These landmarks are evident as a local minimum in commercial exposure to the south of region A (Fig. 2). Minima in commercial exposures are also evident in the Compton Heights neighborhood (located southeast of region A) and in the Lafayette Park region, located immediately south of region B, in the center of the historic damage path. The tornado progressed just south of Downtown St. Louis, bypassing what is now a region of maximum commercial (and absolute) exposure value over this domain.

In East St. Louis, the historic tornado path is located in a region of significantly lower-valued commercial and residential exposures. Unlike St. Louis, Downtown East St. Louis is located several kilometers east of the riverfront and consists of considerably lower property values than St. Louis. The tornado’s reorientation toward the northeast in East St. Louis places the historic damage path immediately north of a region of concentrated residential exposure, located to the south of Interstate 64 (immediately south of the tornado path in East St. Louis).

Only three high-rise buildings (taken here to be greater than 7 stories) are located within the historic tornado damage path. These include the St. Louis City Hospital, the Ralston Purina Headquarters and the Spivey building in East St. Louis, each 15 stories above ground level (depicted as stars in Fig. 2, Skyscrapers.com). Six additional high-rise buildings are located within the inferred downburst near Downtown St. Louis (stars in region D, Fig. 2). Of these, the 28 story Thomas F. Eagleton Courthouse building is tallest. The remaining commercial and residential exposures within the damage areas are a mix of mid (3-7 stories) and low-rise (<3 stories) buildings.

## 4. ESTIMATE OF LOSS

The estimated range of monetary loss for this event's potential reoccurrence today is part of an on-going research effort. Estimates of the residential and commercial building, content, and time element exposures losses will be presented at this conference.

## 5. DISCUSSION

There are many contributors to property loss that have not yet been discussed in detail. First, narratives of the 1896 tornado event describe widespread heavy rain in the damaged areas resulting in near total content losses at many locations. In addition, the 1896 tornado path crossed what is now Interstates 44 and 55 in St. Louis and crossed Interstate 55 in East. St. Louis at approximately 5 pm local time on a Wednesday afternoon. Traffic conditions during this near peak time places many automobiles at risk that otherwise would likely be outside the tornado's path. A tornado event crossing the Mississippi River could also cause additional damages to riverboats/barges in the Port of Metropolitan St. Louis.

Although an estimated range of loss for this scenario has not yet been obtained, preliminary analysis of the exposure data indicate that a greater property loss would be observed if a similar tornado were to transverse other portions of south St. Louis. The 1896 tornado moved over several areas that have little to no property exposure (e.g., Tower Grove Park and The Missouri Botanical Gardens). If a similar tornado followed a path approximately 1 km to the north, damage would be produced in the exposed areas to the north of the aforementioned parks and also in the region of mid and high-rise buildings within Downtown St. Louis.

A review of the F2 tornado that moved through the central business district of Fort Worth, TX provides perspective on the impact a tornado can have on such high-rise buildings. The 35-story Bank One Tower in Fort Worth was so severely damaged plans are underway to implode the building (Skyscrapers.com, 2002). The estimated $137 million in restoration costs greatly exceed the cost of implosion. According to Skyscrapers.com, this would be the tallest building in the world to ever be imploded.

## 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

Brooks, H. E., and C. A. Doswell III, 2001: Normalized damage from major tornadoes in the United States: 1890-1999. *Wea. Forecasting*, **16**, 168-176.

Curzon, J., 1896: *The Great Cyclone at St. Louis and East St. Louis, May 27, 1896*, Cyclone Publishing Company, St. Louis, MO, 416 pp.

Doswell, C. A. III, and H. E. Brooks, 2002: Lessons learned from the damage produced by the tornadoes of 3 May 1999. *Wea. Forecasting*, in press.

Fujita, T. T., 1981: Tornadoes and downbursts in the context of generalized planetary scales. *J. Atmos. Sci.*, **38**, 1511-1534.

Grazulis, T. P., 1993: *Significant Tornadoes*, Environmental Films, Inc., St. Johnsbury, VT, 1326 pp.

Magnan, W. B., and M. C. Magnan, 1997: The Streets of St. Louis, Virginia Publishing, St. Louis, MO, 232 pp.

NOAA Photo Library, 2002: Historic National Weather Service Album. [Available online at http://www.photolib.noaa.gov/historic/nws/torn3.html]

Rae, S., and J. Stefkovich, 2000: The tornado damage risk assessment predicting the impact of a big outbreak in Dallas-Fort Worth, Texas. *Preprints*, 20th Conference on Severe Local Storms, Orlando, Florida, American Meteorological Society, 2000.

Skyscrapers.com, 2002: High-rise buildings in St. Louis and East St. Louis. [Available online at http://www.skyscrapers.com]

St. Clair County, IL, 2002: The East St. Louis, Illinois 1896 Tornado. [Available online at http://www.iltrails.org/stclair/tornado.htm]