THE IMPACT OF A VIOLENT TORNADO IN NORMAN, OKLAHOMA

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ABSTRACT

Several previous studies have estimated impacts from significant tornadoes in large metropolitan areas like Chicago and Dallas-Fort Worth. Such a study has not been completed for the Oklahoma City/Norman, Oklahoma areas, despite their residence in one of the most tornado-prone areas in the world. Norman has had several close calls with violent tornadoes in recent years, including the May 24, 2011 Chickasha-Newcastle and Dibble-Goldsby EF4 tornadoes, the May 20, 2010 Little Axe tornado, the May 19, 2013 Shawnee/Bethel Acres EF4 tornado, and the May 20, 2013 Moore EF5 tornado. Norman has been rather fortunate with regard to significant tornadoes, which have largely avoided the most densely populated areas of the city.

The current study investigates the potential of a violent tornado impacting the most densely populated areas of the city of Norman. In order to evaluate this impact, a simulated tornado track was created by transposing the May 24, 2011 Chickasha-Newcastle EF4 tornado track into the most populated areas of Norman using ArcGIS software. GIS datasets provided by state and local governments, including the locations of buildings within Norman, were analyzed to assess specific impacts on critical infrastructure, commercial, and private residences.

Results from this study indicate that totals from structures impacted directly by this tornado have a cumulative value of approximately $800 million. This figure does not incorporate other peripheral losses (i.e., from vehicles, power poles/street markers, or contents of homes) nor does it incorporate damage at businesses/commercial infrastructure. Additionally, five city government buildings were directly impacted: as well as nine schools and the main hospital in the city. Several major highways in Norman are also included in the damage path, with likely traffic jams on these roads similar to past tornado events occurring in the region. 8,186 buildings were affected by the simulated tornado in this study, which is nearly double the number of buildings impacted in the May 20, 2013 Moore, Oklahoma tornado, where 4,253 buildings were damaged. It is conceivable that losses in Norman could easily exceed the $2 billion of damages that occurred in the Moore tornado, suggesting a potential worst-case scenario for the region.

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1. INTRODUCTION

Geographic information Systems (GIS) technologies are becoming a resource for meteorologists, sustainability developers and emergency management officials (Hubbard and MacLaughlin et al. 2006). The North Central Texas Council of Governments and officials at the National Weather Service Forecast Office in Fort Worth, Texas conducted a study to assess several scenarios the potential impact of tornado tracks from the May 3, 1999 Oklahoma tornado outbreak if that outbreak were to occur in the Dallas/Fort Worth Metropolitan area (Rae and Stefkoovich, 2000). These scenarios superposed 53 damage paths from the Oklahoma tornado outbreak and found that 124,163 structures were impacted, resulting in well over $2 billion in damage and 50,000 people directly affected by these storms. Officials in Wisconsin conducted a similar study in their area during an August 18, 2005 tornado outbreak that affected their region (Hubbard and MacLaughlin et al. 2006). Despite the abundance of studies that have investigated these types of simulated impacts (Wurman et al,. others 2007), none of them have addressed the potential impact of a tornado in the Norman, Oklahoma metropolitan area, despite its residing in one of the most tornado prone regions in the world. The city of Norman has been quite fortunate in this regard, with multiple significant tornadoes striking nearby municipalities (e.g., EF4 in Shawnee, Oklahoma on May 19, 2013; EF5 in Moore, Oklahoma on May 20, 2013; EF2 in Moore, Oklahoma on March 20, 2015; EF4 in Little Axe, Oklahoma on May 10, 2010 among others, Figure 1). These 'near-misses' do not necessarily eliminate the risk of a high-impact event in Norman, and a study of this nature would likely help risk management professionals address the real threat of a worst-case scenario directly impacting Norman.

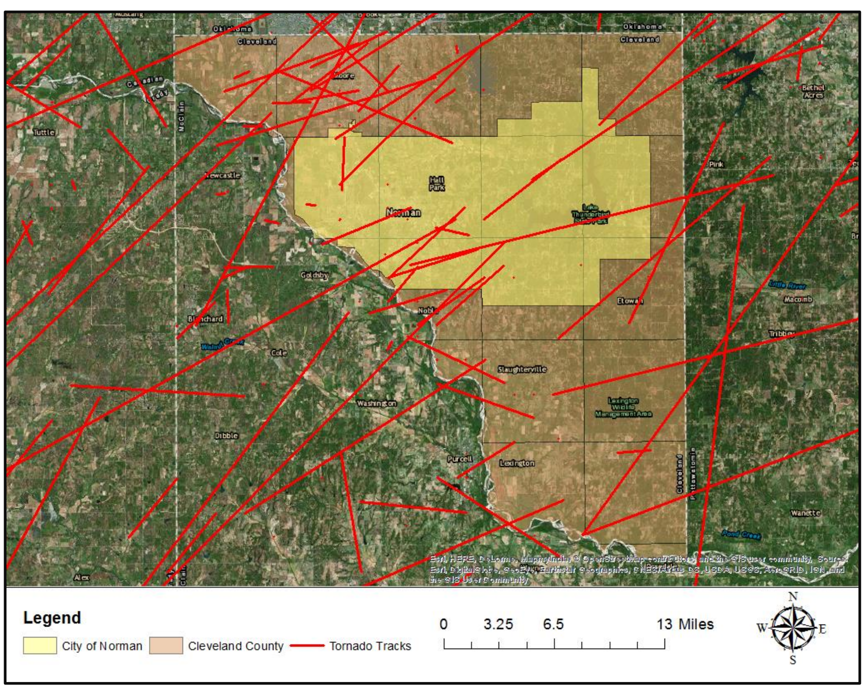

Figure 1: Tornado tracks from 1950-2015 in Cleveland County and surrounding areas.

2. DATA AND METHODS

This study utilized data from the City of Norman's Online GIS Database (GIS Division, Planning & Community Development Department, 2016) and data from the State of Oklahoma's Online GIS Database (OK Office of Geographic Information, 2016). The database consisted of shapefiles containing all public and privately owned buildings in the city limits and included information on schools, hospitals, commercial buildings, parks, land parcels, roads, city infrastructure (e.g., police, fire, city hall), etc. ArcGIS 10.2.1 was utilized for visualization and further processing of this data.

Monetary values of residences within the building dataset were retrieved using the Zillow Home Value Index database. Data obtained for this study was acquired from addresses inside the tornado track by a selection of the parcels' shapefile in ArcGIS. These home values were linked to the parcel addresses by a joint performed also in ArcGIS. Addresses from the parcels dataset were concatenated into a file in Microsoft Excel. All addresses retrieved were divided in 16 groups in order to facilitate their value retrieval from Zillow's database.

A tornado track from the May 24, 2011 tornado outbreak was superposed onto the buildings dataset utilized herein, as shown in Figure 2. The tornado track used in this study originates from the May 24, 2011 Chickasha-Blanchard Newcastle EF4 track, the light pink track displayed in Figure 2. The track selected had an EF4 damage rating, travelling a total of 32 miles with its widest point at 0.37 miles. This track represents a potential worst-case scenario, with the violent tornado moving through the city during early afternoon. In order to simulate a worst case scenario, a buffer of 0.35 miles was made to each side to make the track at least a mile wide, adding up to 1.07 miles throughout Norman.

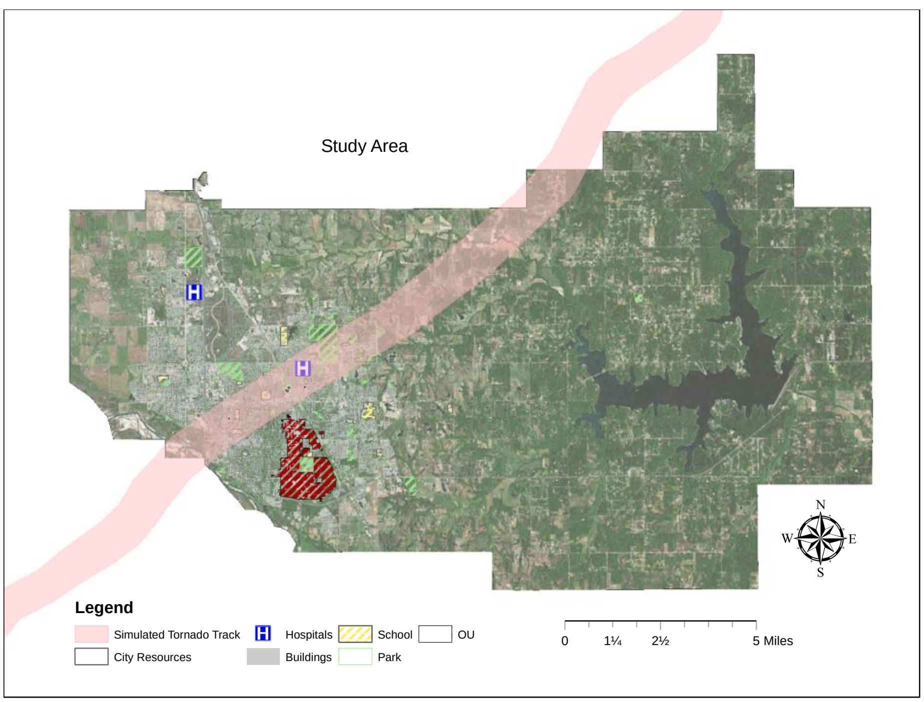

Figure 2: Simulated tornado track used for this study along with the study domain.

3. FINDINGS

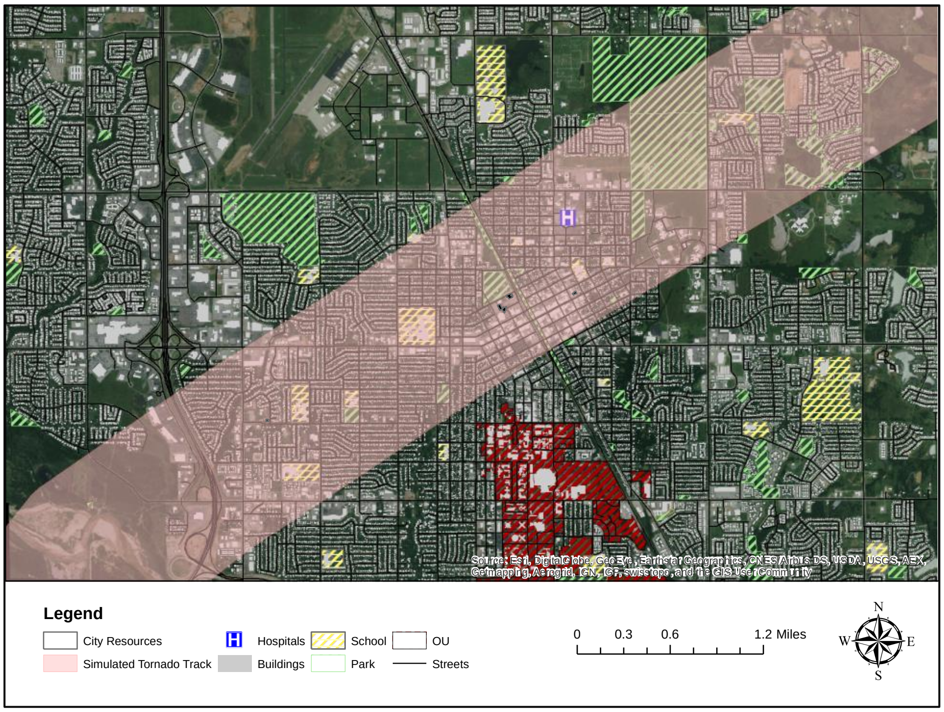

Figure 3: General Overview of the simulated track over more densely populated areas of Norman. Key city infrastructure (schools, hospitals, etc.) are highlighted.

The simulated tornado track analyzed in this study will likely have a higher impact than that observed in the aftermath of the Moore, OK tornado of May 20, 2013. In the current study, 8182 structures sustained a direct impact, compared to only 4253 structures impacted in Moore. Of the impacted structures in the current study, 5718 (73%) were classified as residential, with 5392 addresses matched to home values in the Zillow dataset. Accumulating the values of the residences directly impacted by the tornado resulted in a total of $801,238,814 in potential losses, although this figure does not account for 1) the 326 residences that were not contained in the Zillow database, 2) varying degrees of damage to each residence (some residences would likely sustain greater damage than others), and 3) losses from peripheral properties (home contents) and commercial properties. Assuming a mean home value for each of the 326 residences would increase the potential losses to approximately $1.1 billion.

Traffic emerged as one of many significant challenges for first responders in the immediate aftermath of the Moore, OK tornado of May 20, 2013. That tornado crossed two major interstate thoroughfares (Interstate 44 and Interstate 35), directly resulting in damage to each along with closures for many hours. In the simulated tornado track in this study, Interstate 35 is also impacted, along with portions of all main north-south thoroughfares in the extent of the city. This scenario would likely result in impossible travel across the city in the immediate aftermath of the tornado, with significantly restricted traffic flow in the days and weeks following the tornado.

Impacts to critical city infrastructure are also more extensive in the simulated tornado track in this study when compared to the Moore, OK tornado of May 20, 2013. 24 schools reside within the city limits of Norman, of which 9 receive a direct impact. The impacted schools have a total enrollment of 6,377 students. This is a substantially higher number of people at potential risk than in the Moore tornado, where two schools were devastated. Clearly some of this risk would depend on the time of day of the tornado; a tornado threat during normal business hours would pose a much higher risk to these schools than on weekends or after hours.

Some of the oldest areas of Norman (near downtown) would also sustain major damage from the tornado. These areas are likely far more vulnerable to tornadic winds as the origin of many of these structures predate 1950 and contain a lower quality of construction compared to more recently built structures. Some of these old structures may not be strong enough nor have adequate storm shelters for protection, similar to the Central Business District. The Central Business District, the oldest part of Norman and major economic pillar for the city, is entirely located inside the tornado track. Prime buildings are situated in the area, such as City Hall along with the Police Headquarters. Furthermore, one of the two hospitals in the city is located in the tornado's path. With a high number of government buildings throughout the damage path, emergency management officials may not be able to secure the city and assess the damage of these structures. In addition with the historic buildings, which may be up to date with building codes, the infrastructure may not be up to date with modern demands to withstand a natural hazard. The structure of the building may not be strong enough to sustain damaged caused by violent tornadoes, which can be critical with so many important buildings in the area, either historic or government buildings.

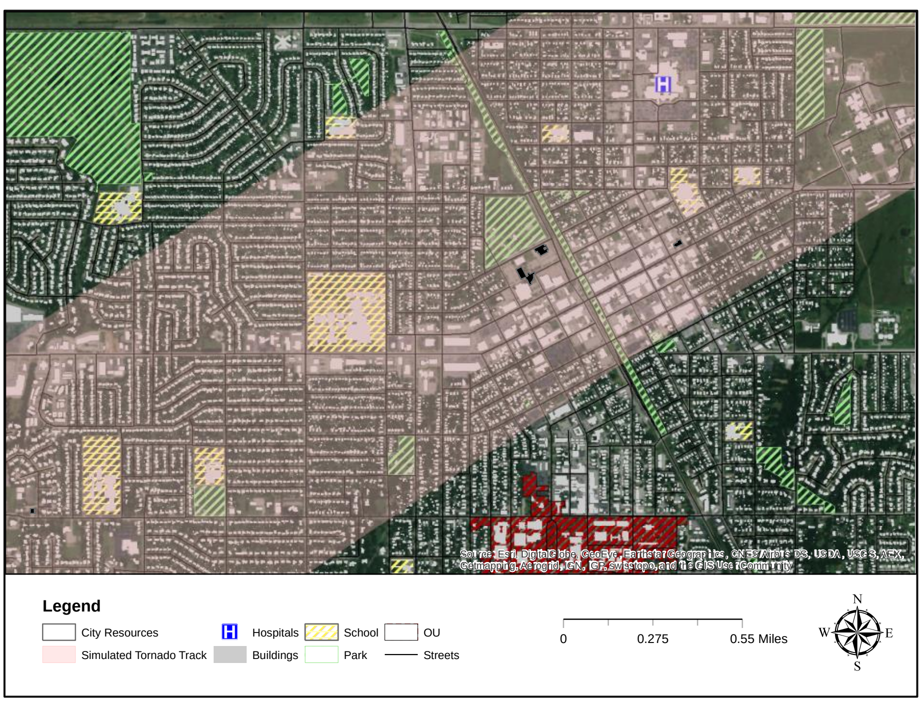

Figure 4: City resources (i.e., city hall, courthouse, fire departments, police departments, and schools) with superposed simulated tornado track (pink).

4. CONCLUSIONS

The simulated tornado track described herein represents unprecedented tornado disaster for the city of Norman, although a few additional analyses are needed to more completely replicate the impacts from such a storm. The current study indicates a potential for $800+ million from residential structures alone, and this figure does not account for contents of those structures, nor does it account for monetary impacts to critical city and state infrastructure (i.e., schools, roads, hospitals, police/fire) or commercial structures. When accounting for these structures, damages are likely to exceed that of the Moore, OK tornado of May 20, 2013, which accounted for nearly $2 billion in damages. Fatalities and injuries would likely be greater than that of the Moore, OK tornado based on the increased number of buildings directly impacted by the tornado. Future research will need to address the aforementioned issues, although the detailed nature of the building and parcel dataset used herein suggests potential for very detailed modeling of impacts.

5. ACKNOWLEDGEMENTS

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