Online Damage Report

The 9 April 2015 Illinois Tornado Outbreak

Fairdale, IL April 9, 2015
(Image Courtesy: Armando Sanchez, Chicago Tribune)

University of Florida's Wind Hazard Damage Assessment Team

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Executive Summary

18 months ago the University of Florida Wind Hazard Damage Assessment Group (WHDAG) reported on the damage caused by an EF4 tornado, which caused extensive damage to approximately 500 residential structures in the Illinois communities of Washington and New Minden (Prevatt et al, 2013). Last week, another Illinois tornado outbreak occurred, this time causing two fatalities and damaging or destroying 150 homes. The damage was mainly caused by a single long-track EF-4 tornado among the eight other tornadoes observed. While the damage and number of fatalities were not as great as the previous event, this tornado bears added significance to our research as we explore what *could have occurred* had this tornado outbreak shifted north or eastward to affect densely populated towns. WHDAG observed the potential exists for much greater damage to residential communities from powerful tornado. As we report, this region within the state of Illinois is no stranger to violent tornadoes, and communities play a game of chance with homes that are not designed with tornado-resilient features.

It is no surprise that residential structures suffer the most tornado damage and the majority of fatalities occur in homes. In response to the damage, the nonprofit Federal Alliance for Safe Homes (FLASH)® issued a statement on 10 April 2015, remarking that: "*Homes are a long-term investment. Eighty percent of our homes are more than 20 years old, and most of them will be around for at least another 30 years"*. Sustainable planning demands that communities and individual families make appropriate choices now for stronger construction as they build new or rebuild from disasters.

In addition to summarizing the tornado outbreak's characteristics and the major damage, this report goes further to explore the potential effects of a hypothetical tornado following a parallel path located 45 miles due east. Our analysis suggests that major damage to residential structures would increase from 150 to 6,500 homes and the immediate (direct) economic loss would likely exceed $1.5 Billion. In other words, the effects could have been just as severe as a Joplin, MO or Moore, OK tornado.

The intent of this report is to raise awareness among communities of the potential damage from tornadoes and the need to take action on strengthening our communities. Clearly our homes ought to be more resilient to natural hazards, and such effort should not be put off until it's too late. The choices and decisions we make today determine the structural resilience level of our communities we live for years to come. As populations grow and communities expand within tornado-prone regions, coordinated effort is required to implement construction standards for stronger, tornado-resilient homes. A future where loss of life and loss even billions of dollars from tornadoes is not a common occurrence requires the investment in our residential infrastructure today.

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PLEASE DISSEMINATE FREELY TO COMMUNITIES

About the Wind Hazard Damage Assessment Team

This report was prepared from online sources by University of Florida civil engineering students in Prof. David O. Prevatt's Research Group. The study is done in parallel to our experimental research seeking to understand and quantify the strength of tornadoes and their impact on vulnerable wood-framed residential structures. Compilation of this information is part of student learning objectives in forensic engineering and post-disaster damage investigation.

The students gathered the information from reliable online sources, such as the National Weather Service, Accuweather, the US Census Bureau and the national media. Photographs were also obtained from publicly available Twitter feeds.

Please visit our website, http://windhazard.davidoprevatt.com, for additional information, and to download previous damage reports, and filed survey results conducted by our group. Dr. Prevatt and his colleagues have published several papers on recent violent tornadoes, that stuck Tuscaloosa, AL, Joplin, MO, and Moore, OK. His group has also inspected damaged structures and compiled reports on tornadoes that occur in Florida. Information is also available on the research at www.davidoprevatt.com. Your questions and comments on any aspects of our work are most welcome. Please direct your enquiries to NSF Graduate Research Fellow and PhD Graduate Student, Mr. David B. Roueche, who can be reached at david.roueche@ufl.edu. Mr. Jeandona (JD) Doreste, is a civil engineering undergraduate student at UF and Webmaster of the Wind Hazard Damage Assessment Group's team website. JD is actively recruiting other UF students to join the team, and he can be reached at jdoreste1@ufl.edu.

The Wind Hazard Damage Assessment Team was created through support from the NSF Award #1150975. *Its mission is to train university students interested in building construction, engineering and architecture in the forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after several Florida tornadoes and continuously monitors the prevalence of tornadoes worldwide. Ultimately the Damage Assessment Team hopes to inspire upcoming engineers and building professionals in hopes to change the paradigm of widespread catastrophic damage to houses in tornadoes and other extreme wind events.*

Forecasts and Predictions

While the 2015 tornado season has gotten off to a slow start compared to average, the likelihood for convective storms, including tornadoes, has increased in April, with convective outlooks for four of the first nine days having regions of enhanced risk for severe storms. April 9th was one of those days, and also was predicted to have potential for tornadoes. The first outlook for tornado probability issued on April 9th is shown in Figure 1 and identified a large region from Texas to Michigan as having the potential for tornadoes within 25 miles. In the 11:30 CDT update, shown in Figure 2, this region remained largely the same, however the potential for strong tornadoes in northern Illinois was identified. Just over 7 hours later, the potential for strong tornadoes was realized as several strong tornadoes formed and tracked across northern Illinois.

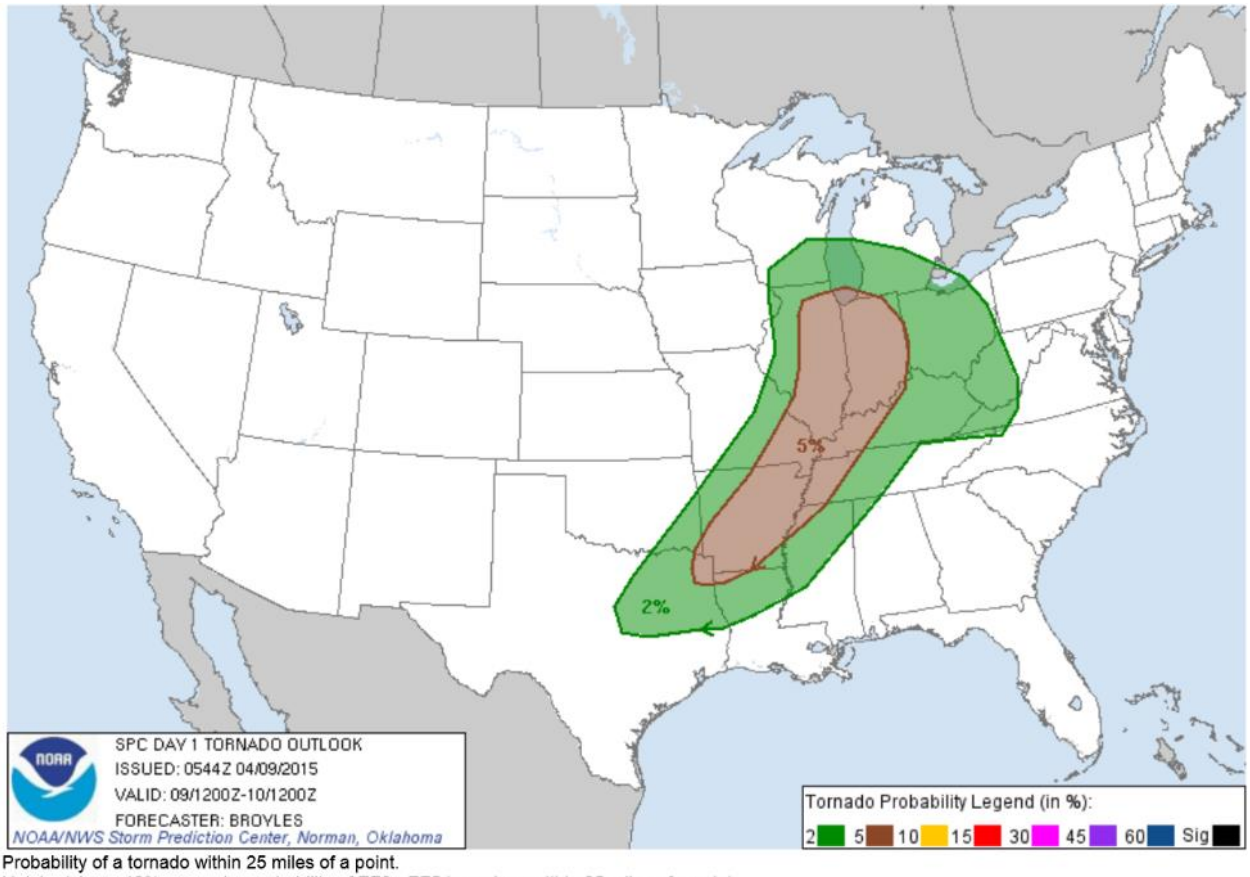

Figure 1: Tornado Probability for April 9, 2015 as Issued by NWS SPC at 12:44 AM CDT on the same day. A wide swath from Michigan down to Texas was identified as having 2% or 5% probability of a tornado within 25 miles of a given point with the region.

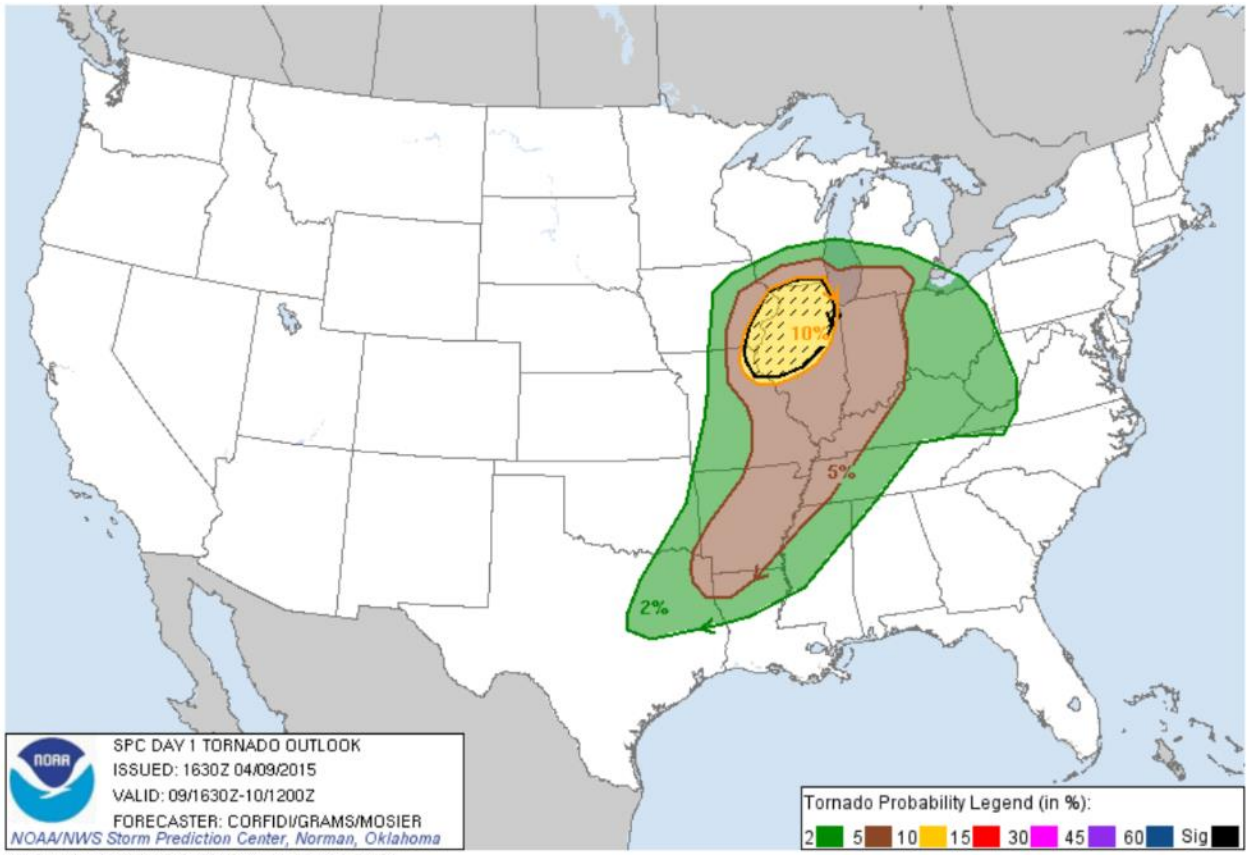

Figure 2: Tornado Probability for April 9, 2015 as Issued by NWS SPC at 11:30 AM CDT. The outlook was similar to those earlier in the day but now identified a hatched region primarily located in northern Illinois with a 10% or greater probability of EF2-EF5 tornadoes within 25 miles of a point.

Timing of Outbreak

The timeline of the tornado outbreak as it formed is given below. All times are Central Standard Time. The tornado reports and locations of key towns are given in Figure 3.

11:30 AM – SPC identifies region in northern Illinois as having potential for strong (EF2-EF5) tornadoes.
1:50 PM – Tornado Watch was issued for most counties in north and north-central Illinois
6:09 PM – First Tornado Warning is issued, including De Kalb, Boone, Ogle, and Winnebago counties
6:40 PM – Tornado reported near Ashton, IL in Lee County.
6:40 PM – Tornado reported near Cherry Valley, IL in Winnebago County.
6:40 PM – Tornado with debris reported in Franklin Grove, IL in Lee County.
7:02 PM – Reports of a large wedge tornado on the ground near Hillcrest, IL in Ogle County.
7:10 PM – Tornado between Monroe Center and Fairdale, IL near Ogle and De Kalb County line.
7:15 PM – significant damaged reported near Kirkland, IL in De Kalb County.
7:34 PM – Tornado damage reported near Belvidere, IL in Boone County.
7:35 PM – Damaged reported near Harvard, IL in McHenry County.

7:40 PM – Tornado reported near Marengo, IL in McHenry County.

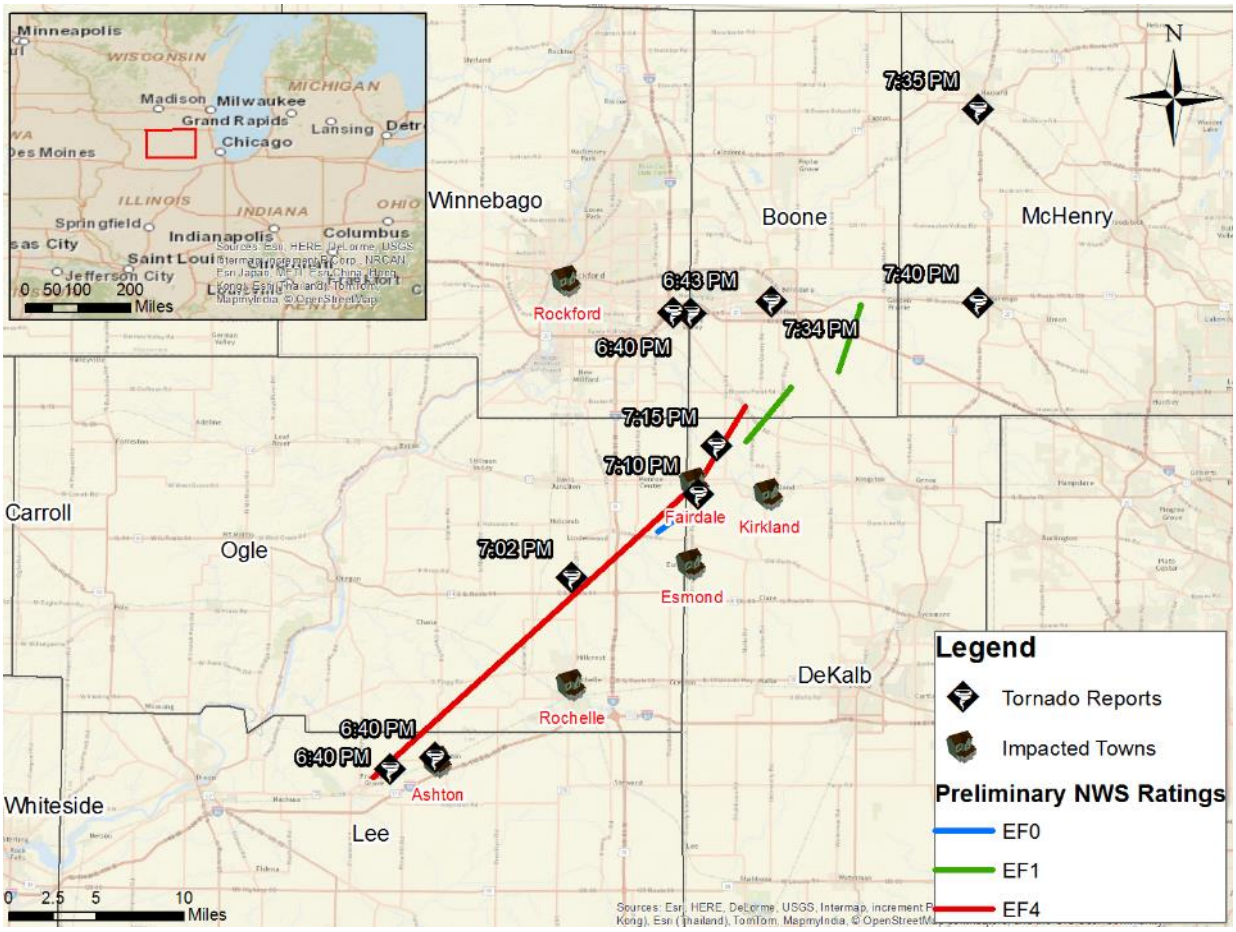

Figure 3: Timing and location of tornado reports to the NWS (obtained from http://nwschat.weather.gov). Impacted towns are labeled in red. Counties are labeled with black text. Preliminary tornado tracks are shown that were available at the time this report was written.

Confirmed Tornado Strikes

Preliminary data indicates that the majority of the damage from the 9 April tornadoes was due to a single long-track tornado that began near Ashton, IL and lifted approximately 5 miles north of Kirkland, IL. There were nine total confirmed tornadoes in Illinois, with more possible as field surveys are finalized in the coming days. Table 1 summarizes the known damage from tornadoes at the time of this report. Early reports indicated significant damage in Rockford, IL and Kirkland, IL, but no damage was confirmed in the main boundaries of these cities. However, Fairdale, IL, which sustained the heaviest damage from the tornado, is an unincorporated community that is officially part of Kirkland, IL even though it is located several miles away, which may have been the reason for some of the confusion. In addition to the tornadoes in Illinois,

tornadoes also struck near Longview, TX in Cherokee and Hamilton, near the Texas-Louisiana border. Two EF1 and one EF2 tornadoes were confirmed by NWS surveys.

Aerial imagery of the entire tornado path of the EF4 tornado is publicly available from the NOAA National Geodetic Survey flyover of the damage path as well as from the Civil Air Patrol (CAP), available through the FEMA geoplatform.

Table 1: Summary of Known Damage to Municipalities in the Paths of the 9 April 2015 Tornadoes

State	City	Population	Injuries	Fatalities	Buildings Damaged	Buildings Destroyed
IL	Rochelle	9574	3	0	50	30
IL	Rockford	152,871	0	0	-	0
IL	Kirkland	1744	0	0	-	0
IL	Fairdale	200	22	2	71	17
IL	Ashton	972	0	0	3	0
TX	Longview	80455	0	0	>2	0

SUMMARY OF DAMAGE

Ashton, IL Tornado

The long-track EF4 tornado that struck 9 April 2015 appears to have begun in Ashton, IL, where there were confirmations of a tornado sighting and reports of damage to the Crest Food West Warehouse, Mix Facility and West Production area. The impacted Crest Foods facility was located approximately 2 miles west of Ashton. The pre-tornado view of the West Warehouse is shown in Figure 4. Damage to the Crest Food facility can be seen in Figure 5. The warehouse appears to be a steel-frame structure with corrugated metal panels cladding the walls. Portions of the roof of the West Warehouse collapsed. Some local buckling of purlins is observable in Figure 5(c). The walls of the mixing facility appear to have collapsed inward, and the roof over the wall collapsed with it. No injuries were reported from the collapse or elsewhere from the tornado. No other damage was confirmed in Ashton, IL.

Figure 4: Crest Foods Warehouse in Ashton, IL (Before) (Source: Google Maps)

(a) Aerial view of damage to the main Crest Foods Warehouse in Ashton, IL (Courtesy Joe Gomez). The roof above the west loading docks collapsed.

(b) Front View of Damage to Crest Foods Warehouse

(c) Collapsed Walls and Roof, possibly in the mixing facility.

(d) Exposed metal framing

(e) Partially exposed foundation

Figure 5: Damage to Crest Food Warehouse in Ashton, IL (Source: http://wgntv.com/2015/04/10/photos-capture-tornado-touch-down-in-ashton-illinois/)

Rochelle, IL

Rochelle, IL missed a direct impact of the EF4 tornado, with it passing approximately 4 miles northwest of the town as shown in Figure 6. Approximately 80 homes northwest of the town were damaged however as the tornado passed by, 30 of them reported as completely destroyed, as shown in Figure 8. Many of the homes in this impacted area were less than 20 years old. Nearly 10,000 people live in Rochelle, IL and the main portion of the town was just a few miles from the tornado path. The town was fortunate to not sustain more damage than it did.

On the northeast side of Rochelle, the Grubsteakers' restaurant near Illinois Routes 251 and 64, in the direct path of the tornado, sustained major damage. From the photo in Figure 8 it can be seen that the Grubsteakers' restaurant was a wood-frame building with vinyl siding and wood panel façade on an adjacent section of the building. The section of the building, with the wood panel façade, experienced the more substantial damage and also seems to be a later adjudication to the original structure. The building had partial roof removal and the inner walls collapsed, followed by the inward collapsing of the exterior walls. No information can be seen to indicate the quality of the roof-to-wall or wall to foundation connections. Some damage to the restaurant building is shown in Figure 9.

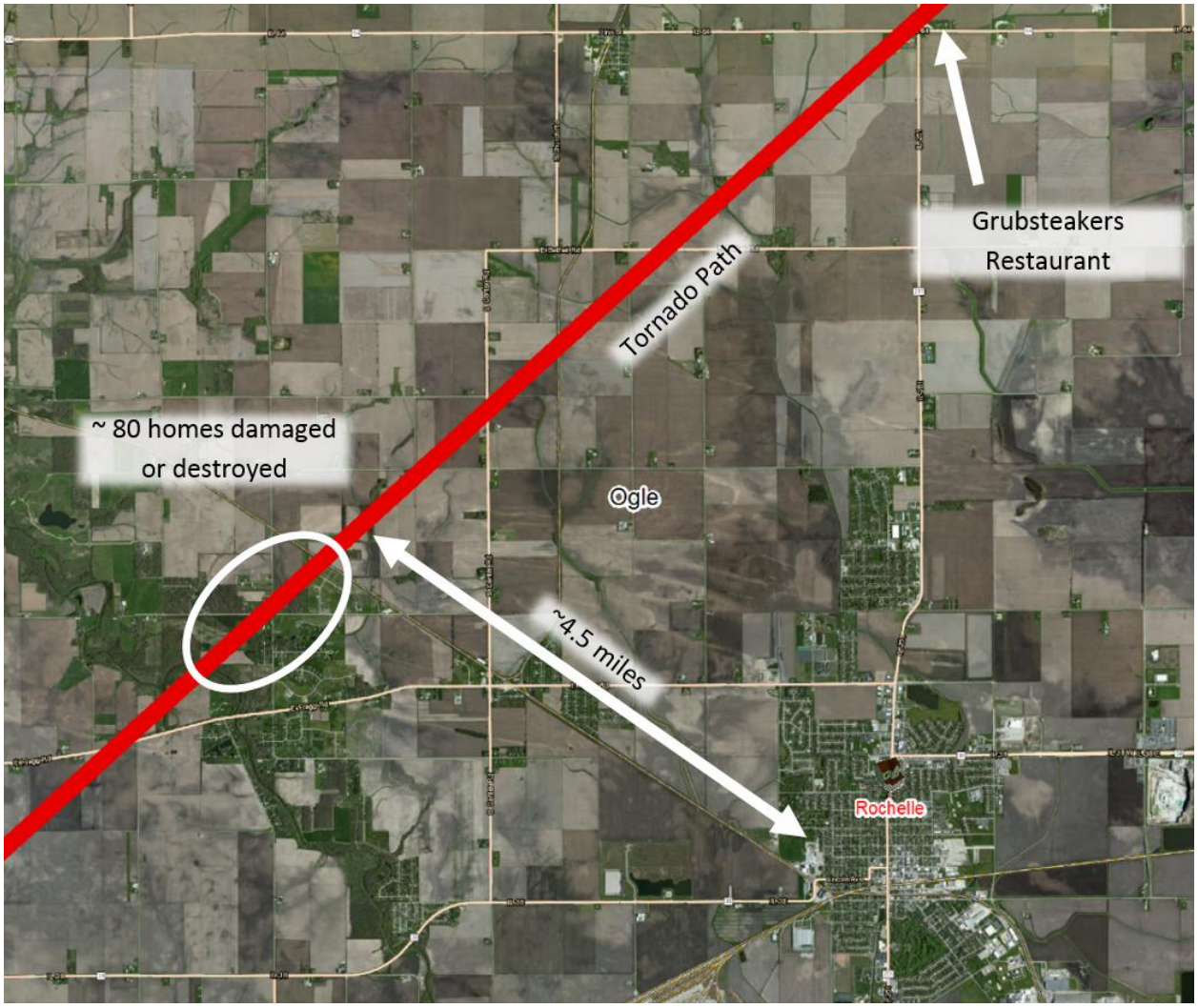

Figure 6: Local geography of the EF4 tornado path relative to the town of Rochelle, IL.

Figure 7: Home on S. Kuehl St, Rochelle, IL damaged by the EF4 tornado. The damaged and destroyed homes were located on the outskirts of Rochelle. (Image Courtesy of Laura Stoecker, Daily Herald.)

Figure 8: Grubsteakers' Restaurant (Before) (Source: Google Maps)

Figure 9: Grubsteakers' Restaurant (After) (Source: http://www.weather.com/storms/severe/news/severe-storm-outbreak-impacts-midwest)

Fairdale, IL

The heaviest damage from the long-track EF4 tornado occurred in the small community of Fairdale, IL, located approximately 4 miles west of Kirkland, IL. This small, unincorporated community reportedly incurred damage to each of the 71 structures in the community, with 17 homes completely destroyed. Two fatalities were also sustained in separate homes near the center of the tornado path through the town, in addition to a total of 22 reported injuries. A final EF-4 rating was assigned due to the complete destruction of numerous homes in the tornado path. An aerial view of the damage path is shown in Figure 10. The most devastating portion of the tornado was approximately 425 feet wide as it passed through Fairdale, although damaging winds extended out much further than this.

Figure 10: Aerial view of damage to Fairdale, IL, with north pointing up. The tornado traveled from southwest (bottom left corner) to northeast (top right corner). Aerial imagery from the NOAA National Geodetic Survey (http://storms.ngs.noaa.gov/storms/09apr2015_tornado/index.php).

Figure 11: Damage to a wood-frame home in Fairdale, IL.

Longview, TX Storm

On April 10, 2015 a severe thunderstorm passed through Longview, TX, resulting in several damaged structures many down power lines and trees. Much of the damage was due to downed trees. There was structural damage however to the Eden Select Specialty Care nursing home, a Church of Christ sanctuary, and a nearby mobile home park. The nursing home was later evacuated of its 75 patients. No fatalities or injuries were reported. See Figure 12 for damage to the nursing home. The Church of Christ, less than 400ft down the road, experience partial roof removal (See Figure 13). The National Weather Service rated the damage from this tornado as EF2. Two other tornadoes, in Harrison County and Gregg County, were rated EF1 and caused minimal structural damage.

(a) Before (b) After

Figure 12: (a) Before and (b) after images of Eden Select Specialty Care nursing home at 1301 Eden Dr Longview, TX (Google Maps & http://www.news-journal.com/news/2015/apr/10/tornado-rips-through-longview-area)

(a) Before (b) After

Figure 13: Before and after images of Church of Christ at 1401 Eden Dr
Longview, TX (Google Maps & http://www.news-journal.com/news/2015/apr/10/tornado-rips-through-longview-area)

DAMAGE TO A CHICAGO SUBURB FROM A HYPOTHETICAL TORNADO

The long-track EF-4 tornado that devastated Fairdale, IL and caused significant damage elsewhere, fortunately passed through an area with low population density. A shift in the tornado's path due north by 15 miles would have caused this half-mile wide tornado to pass directly through Rockford, IL, population 150,251. Even greater damage potential, indeed to catastrophic proportions would occur if a similar-sized tornado touched down 45 miles east of this location. In that hypothetical case, the tornado would have struck the densely populated suburbs of western Chicago, illustrated in Figure 15 (actual tornado hatched red polygon, and solid red polygon the hypothetical tornado.) Historically there have been at least ten confirmed EF3 or greater tornadoes in the Chicago area since 1950, so this possibility is not far-fetched.

The 9 April 2015 EF4 tornado skirted several towns and directly impacted the community of Fairdale, but much of its approximately 22 mile path was over farmlands and generally rural areas. The damage reported to just over 150 homes, is surprisingly low for a powerful that was on the ground for such a long time. In contrast, had a similar tornado followed a path shifted due east by 45 miles, the story would be entirely different with devastating effects. The difference in land use is clear with the aerial imagery shown in Figure 14. We estimate the number of real estate property directly within the path of the tornado to be 15,937 (using publicly available Cook County parcel data.) Figure 15 shows the high-population density communities that would be affected. Once we established this path we used our empirical model of damage caused by an EF4 tornado to estimate the number and extent of structures affected. The empirical damage model (shown in Figure 16)based on the three EF4 (Tuscaloosa, Joplin and Moore (2013)) tornadoes predicts that 85% of the damage would be caused by EF2 or lower wind speeds (Prevatt et al, 2012; Graettinger et al, 2013).

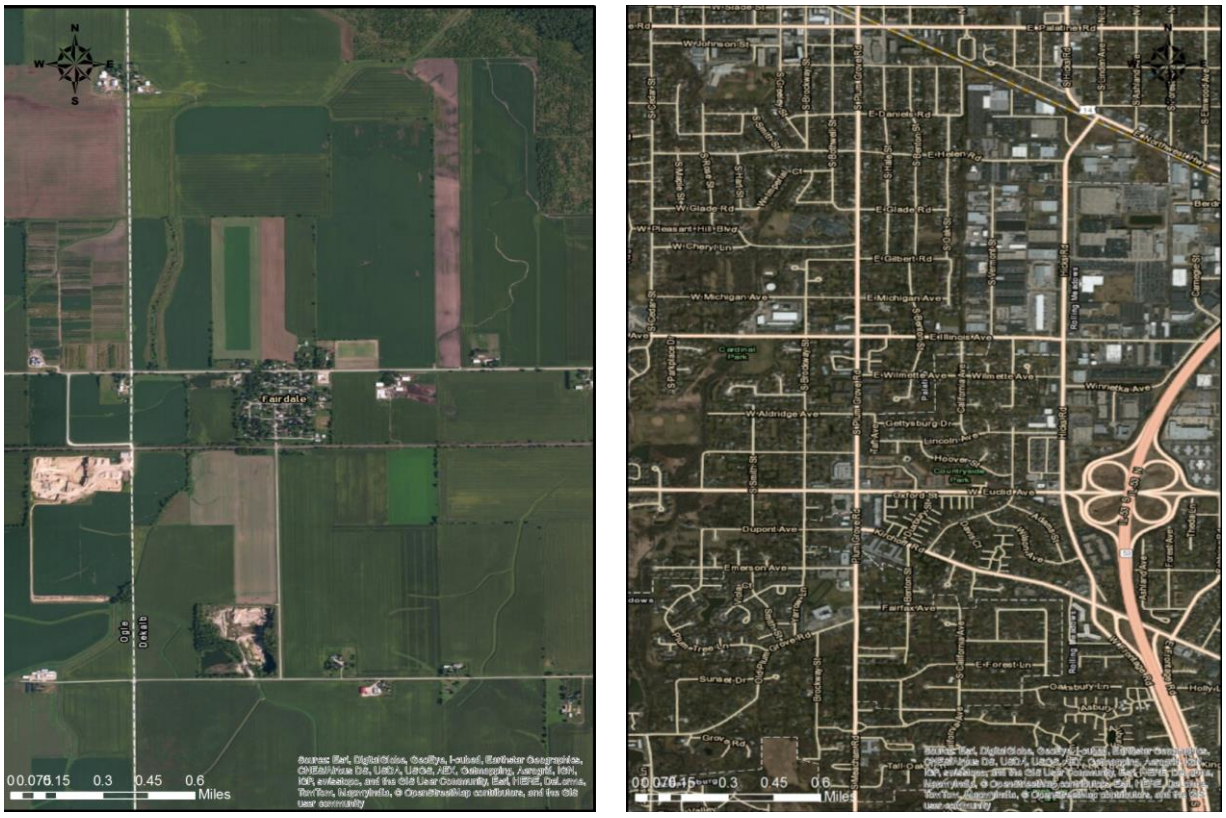

Figure 14: Land use in proximity to Fairdale, IL (left) compared to equivalent sized area in north-western Chicago suburb (right), approximately 45 miles away.

We estimated the total economic value of the homes in the path of our hypothetical tornado using average the market values for 25 homes listed on Zillow.com. For this preliminary analysis we used the average market value of the homes as $312,000 and extrapolated this over the entire path of the hypothetical tornado. The damage ratios for each tornado intensity level (e.g., EF1, EF2) were estimated based upon Simmons et al (2015). Damage ratios are the expected repair cost divided by cost to replace the house normalized to the original value of the home.

In an earlier paper, Wurman et al (2007) estimated the direct impact of an EF4/5 tornado on Chicago or other densely populated cities could cause $24 Billion of damage to single-family structure, almost 10 times larger than the most costly tornado on record thus far. Wurman et al.'s (2007) tornado was based upon the 1999 Mulhall, OK tornado however, which measured an incredible 5.5 miles wide (at 30m AGL) and was on the ground for 35 miles. Thus that tornado's path width was 11 times greater and its path length 1.5 times longer than the 9 April 2015 tornado we examine here. Wurman et al's case study and the analysis of a hypothetical tornado presented below, highlights the "luck of the draw" feature that is present in many tornado impacts. The same tornado path, width and intensity could result in substantially greater damage in urban areas that it would if it occurs within a rural, sparsely populated place. Ashley et al. (2013) highlighted the importance of the spatio-temporal variations in tornado damage as the odds of a long-track tornado impacting densely populated regions are yearly increasing. They asserted that while the tornado climatology (intensity, frequency and tornado paths) may not change by much the economic losses could see substantial increases with time as more densely populated and vulnerable "targets" are built in regions associated with such powerful tornadoes.

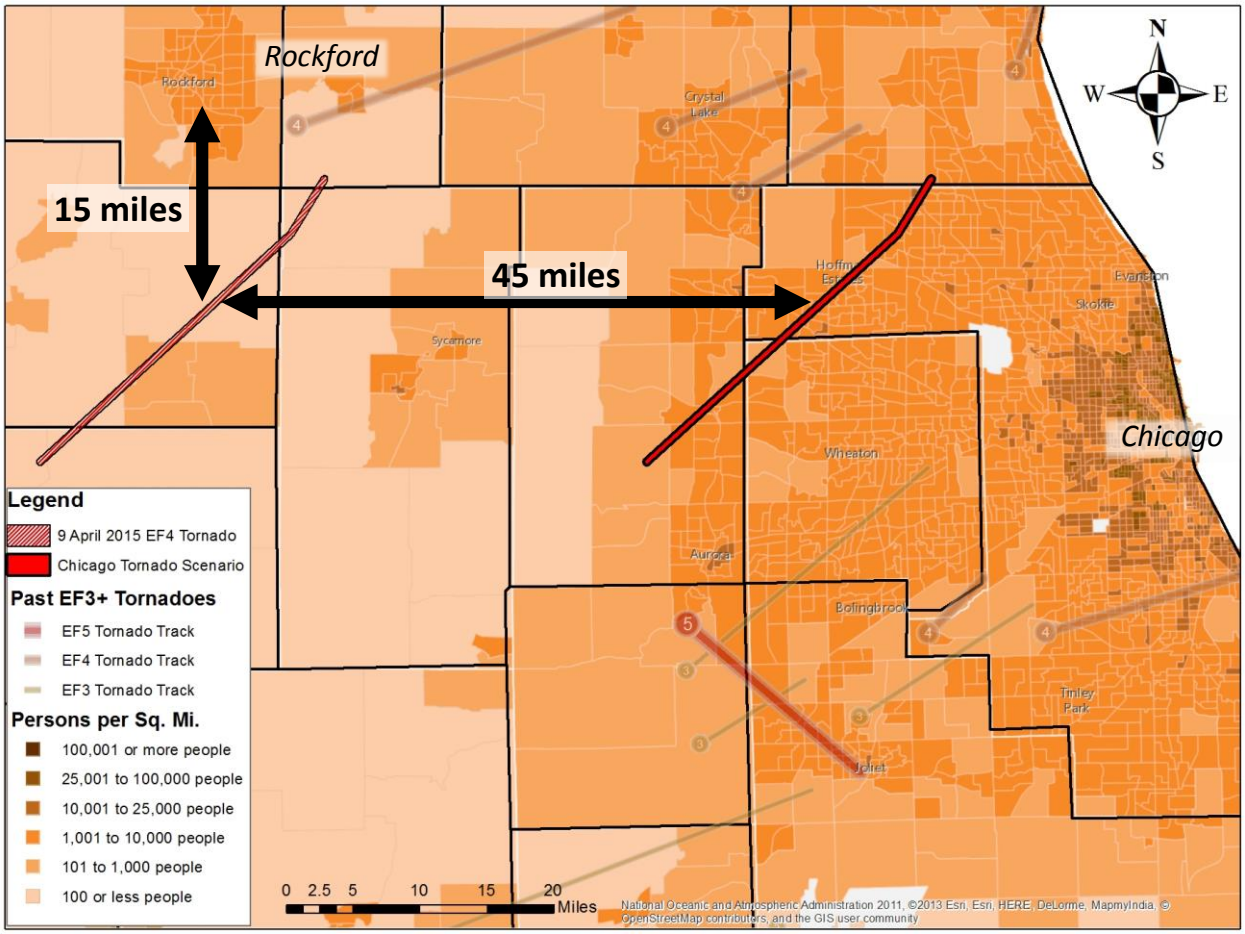

Figure 15: Alternative scenario considering the potential losses had the EF4 tornado on 9 April 2015 been shifted 45 miles to the east. Population density data is based upon the 2012 US Census and

compiled by ESRI. Gray lines indicate the intensity and paths of previous tornadoes affecting Chicago since 1950.

Our analysis assumes the homes in the Chicago suburb had similar structural performance, construction types and distributions of damage as those damaged in Fairdale. The average home price in Fairdale, IL (the actual town mainly affected by the 9 April 2015 tornado) is $110,000 (zillow.com), and our model assumes the damage breakdown by EF-range is the same (i.e., 85% of the houses experienced EF2 or less damage). For this tornado, the total direct economic cost of damage to residential structures in Fairdale, IL is $5.2 million. In contrast our analysis using the same methodology, found the direct economic losses to houses in the Chicago suburb affected by our similar hypothetical tornado ***would increase 300-fold*** to nearly $1.6 billion dollars (Table 2) – a starkly different and frightening situation.

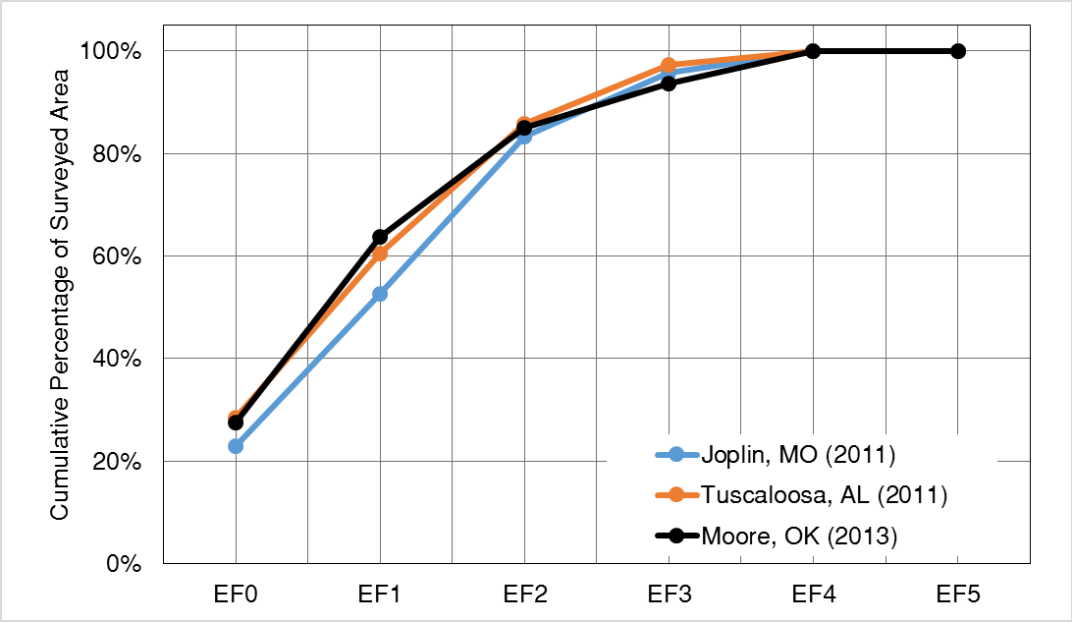

Figure 16: Distribution of damage within EF4/5 tornadoes from previous ground surveys by the PI. Nearly 85% of the damage area in all three tornadoes was EF2 or less.

Table 2: Comparison of estimated impacts from actual tornado to those from a hypothetical tornado of the same intensity and path in the Chicago suburbs

EF Rating	% of Path	Damage Ratio	Number of Homes		Economic Loss ($ thousands)	
			Actual*	Hypothetical	Actual	Hypothetical
EF0	26%	1%	39	4144	$42	$6,466
EF1	33%	10%	50	52591	$550	$164,087
EF2	26%	50%	39	4144	$2,145	$646,404
EF3	11%	100%	16	1753	$1,760	$546,957
EF4	4%	100%	6	637	$660	$198,893
				Total:	**$5,157**	**$1,562,807**

*Estimated the same way as the hypothetical tornado, not from survey results

The comparison of economic loss from the two tornadoes numbers is sobering when one considers the structural damage to residential houses provides only a lower-bound estimate of economic losses. Our analysis did not take into account loss of contents, temporary housing, debris removal, utility replacement, or many of the other costs associated with tornadoes. Further, for purposes of this preliminary study, we also did not consider the loss of life and injuries that would have occurred.

The single most costly tornado on record is the $2.9 billion Joplin, MO tornado of 2011, as estimated by the SPC (http://www.spc.noaa.gov/faq/tornado/damage$.htm). It is safe to imagine that the economic losses from this hypothetical tornado would easily exceed the losses occurring in Joplin. UF's WHDAG is working on more detailed analysis approaches to link the EF-scale damage estimates and economic losses. As the research progresses, it is our intent to use a tornado damage catastrophe model, (presented at the ICMAE Chicago conference (Peng et al, 2014)) to more accurately predict the losses the Chicago suburb may expect. So far, the engineering-based damage assessment model has only been used with individual homes, but current development will enable it to be scaled up to estimate community or city level damage. No doubt this preliminary assessment illustrates that extensive damage and loss of life is an ever-present threat with tornadoes.

Conclusions

A severe weather outbreak on 9 April 2015 resulted in at least seven confirmed tornadoes, four in Illinois and three in Texas. The tornado outbreak was small by all accounts but still heavy damage occurred due to a 22-mile long EF4 tornado in northern Illinois. The communities of Rochelle and Fairdale, IL sustained the most damage, and two fatalities have been confirmed. While the damage to residential structures was severe, it could have been much worse. The 9 April 2015 Illinois tornado passed over very rural areas, skipping much of the populated regions. Our report analyzed the damage potential of a hypothetical tornado occurring 45 miles due east, but having the same length, width and intensity characteristics as the actual tornado. The north-western suburbs of Chicago, IL would be greatly affected by such an event, and there s historical precedent for tornadoes in that area. Using publicly available parcel data, GIS software and a recently developed tornado catastrophe model, direct economic losses to residential structures from the tornado would be $1.5 billion. The 300-fold increase in direct tornado losses is due to population density, the extent of the urban areas, and the higher average value of homes.

Acknowledgements

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About the PI

David O. Prevatt is an Associate Professor of Civil & Coastal Engineering, in the School of Sustainable Infrastructure & Environment, University of Florida, Gainesville, FL. He is a registered professional engineer registered in Massachusetts and in Trinidad and Tobago.

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