4.1 ON ISSUES OF TORNADO DAMAGE ASSESSMENT AND F-SCALE ASSIGNMENT IN AGRICULTURAL AREAS

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1. INTRODUCTION

It is well established that the majority of the world's tornadoes occur in "tornado alley" of the United States plains region. The plains is generally characterized by an agrarian based economy and a relatively low population density.

While the plains region receives the bulk of the tornadoes in the United States, from a tornado climatology standpoint, the tornadoes are of a lesser F-scale rating (Fujita 1971) on average than those of the higher populated areas of the eastern United States. This geographic discrepancy of F-scale climatology has been well documented in previous research literature (Kelly et al. 1978, Doswell and Burgess 1988, Grazulis 1993). As these studies have noted, this is not necessarily attributed to a difference in tornado intensity, but instead, is an artifact of population bias and associated lack of structures.

Doswell and Burgess (1988) discussed the reality of the F-scale as a damage scale versus an intensity scale. They noted tornadoes which occur in open country oftentimes do not damage structures, hence making an F-scale estimation more difficult. Schaefer and Galway (1982) noted a population bias in tornado climatology in the western plains from Oklahoma through Kansas to the Dakotas, finding that tornadoes that strike higher populated areas tend to have a higher rating than those that remain in open country.

Furthermore, the number of structures in the plains will only continue to diminish as an ever-increasing trend toward agribusinesses or expanded family farms results in a less "usable" tornado intensity detection grid (Grazulis 1993).

Presently, F-scale definitions only provide vague guidance for damage assessment as "official" documentation favors structural-based definitions. These aforementioned factors ultimately pose special challenges to a consistent operational assignment of F-scale ratings to tornado damage in predominately agricultural areas.

To compensate for the lack of structures in the plains region, it is theorized by the authors that expanded rating considerations should be formalized for the sake of climatological and historical consistency regarding the F-scale. Potential incorporation or standardization of rating criteria that is native to the plains region, namely agricultural structures (e.g., irrigation pivots) and crops in Nebraska in this instance, will be discussed as a potential basis for F-scale rating guidance.

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2. CENTER PIVOT IRRIGATION

Due to a slightly drier climate, coupled with an abundance of underground water, Nebraska relies heavily on irrigation for crop production. There are two methods of irrigation, one being gravity or flood irrigation, and the other the use of center pivot irrigation systems. Center pivot systems are more efficient than the traditional gravity and flood irrigation methods. The four major center pivot irrigation system manufacturers are located in Nebraska and account for 90% of sales worldwide.

Figure 1. Center pivot irrigation. Image courtesy United States Geological Survey (USGS).

Over 42,000 center pivot irrigation systems are registered in Nebraska, with that number continuing a steady increase. Center pivot irrigation accounts for more than 4.6 million acres of cropland in Nebraska, roughly 62% of the total irrigated cropland. With irrigation pivots taking a more prevalent role over the last quarter of a century, the amount of irrigated cropland has tripled during the past 25 years. It is estimated that as much as 70% of Nebraska's irrigated acreage could be under center pivot systems by 2010. (UNL Institute of Agriculture and Natural Resources, 2001).

Although design specifications vary between manufacturers, center irrigation pivots typically extend for 0.25 miles in length and consist of 6 to 11 spans. Generally made of galvanized steel, the total weight for each tower and span (void of water) may range from 3500 to 5000 lbs. The average irrigation pivot is capable of moving more than a million gallons of water per day (T-L Irrigation, 2002).

Consultation with irrigation pivot manufacturers (i.e. T-L Irrigation) indicates a general 80 mph design standard for resistance to overturning in high wind situations (void of water loading). Although specific criteria for typical wind resistance for water loaded pivots are sparse, the overall overturning threshold would be considerably higher.

Aside from fundamental design specifications, several additional factors must be considered when assessing damage to irrigation pivots. For example: (1) the original orientation of the pivot (2) whether the pivot is designed to "rock" or "roll" – is a braking system employed by the pivot? and (3) proximity of the damage to the center of the pivot – i.e. better anchoring near the tower directly attached to the water source.

Given the propensity of irrigation pivots in the plains region, it would seem appropriate for inclusion into F-scale definitions and/or standards. Additional information and guidance by wind and agricultural engineers would ultimately be necessary to refine potential applications to damage assessment techniques.

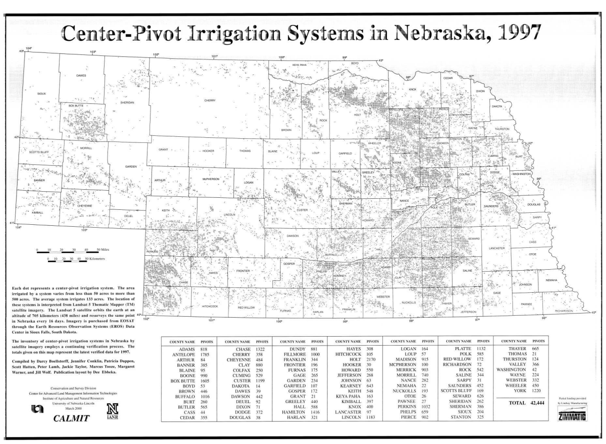

Figure 2. Map of center pivot irrigation systems in Nebraska based upon 1997 data. Map courtesy of the Center for Advanced Land Management Information Technologies (CALMIT).

3. CROPS

According the United States Department of Agriculture, nearly 76 million acres of corn were planted in the United States in 2001, of which 8 million acres were planted in Nebraska. In south central Nebraska, approximately 5 million acres of corn and soybeans were planted, representing around one-half of the total land area.

Fujita (1993) utilized crop damage in his review of the Plainfield, IL tornado of 28 August 1990. He appeared to place a high factor of reliability and importance on the damage observed in the crops (namely corn, wheat, and beans). Fujita went as far as identifying "comma-shaped", "swirl-shaped", and "eye-shaped" patterns in the crops.

Representative pictures encompassed the entire F0 to F5 gamut. In the case of the Plainfield tornado, damage was so intense, Fujita surmised an area of F5 winds based upon corn damage alone. In this case, the corn stalk was almost completely ripped from the ground. Fujita characterized the "corn crops were stripped of leaves and ears and pushed practically down to the ground. In the worst damaged area, corn crops were blown away entirely, leaving behind the remnants of small roots connected to the underground root system."

Figure 3. Tornado damage to a corn field. Photo by first author.

In assessing F-scale damage in rural areas, notably corn fields, many conditions should be considered. Obviously the timing and velocity of the wind is important, but so is the stage of growth of the corn plant. The plant is most susceptible to breakage during rapid growth stages (approximately 2 to 3 feet high), which is usually in June. Historically, June corresponds to peak tornado activity in Nebraska. As the plant matures to the tasselling stage in July, the stalk will strengthen and may be able to withstand stronger winds (Pioneer Hi-Bred International, 1999).

Different corn plants, or hybrids, are tested for stalk breakage. Brittle snap (also known as green snap) is a term which describes a corn plant stalk which has been broken by high winds. The brittle stalk score is a score which reflects artificial testing of a hybrid's tendency and frequency for brittle stalk breakage. A score of 9 indicates the least risk of breakage and 1 indicates the highest risk. A score of 9 does not guarantee resistance to brittle snap though. Other factors such as planting practices, fertilizing methodology, and soil conditions can also affect a plant's susceptibility to damage caused by high winds or tornadoes (Pioneer Hi-Bred International, 1999).

Too many factors (e.g., growing cycle, soil moisture variability, crop health) may be involved to reliably utilize crop damage as a sole source of an F-scale rating; nevertheless, there may be utility as a supplementary means of guidance.

4. CONCLUDING REMARKS AND SUGGESTIONS

For the sake of consistency in operational F-scale assignment amongst geographic regions, the authors suggest the F-scale incorporate additional non-structural types of damage. The authors propose that F-scale definitions and/or guidelines be expanded to better incorporate those things native to rural and agricultural settings.

Specifically, it is suggested F-scale descriptions should be refined to incorporate such things as irrigation pivots, agricultural crops, and other types of vegetation. With more inclusive definitions, it is theorized that the discrepancy in F-scale climatology between rural and higher populated areas may at least be partially minimized.

Furthermore, the authors encourage other National Weather Service (NWS) offices to research local standards and specifications within their own area of responsibility. The authors recommend those who routinely conduct surveys in rural areas consider the unique nature of the structures and green cover in their areas. If relatively little background information is known about the structures (i.e. pivots) or green cover (crop maturity and hybrids), the authors suggest obtaining information from local producers and manufacturers to provide more consistency in tornado damage assessment. Ultimately, the locally derived information should be shared for the purposes of statewide and regional uniformity.

5. ACKNOWLEDGEMENTS

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