A COMPARISON OF SEVERE THUNDERSTORM WARNING VERIFICATION STATISTICS AND POPULATION DENSITY WITHIN THE NWS ATLANTA COUNTY WARNING AREA

Jeff C Dobur*
National Weather Service Forecast Office
Peachtree City, Georgia

1. INTRODUCTION

The National Weather Service (NWS) is responsible for issuing severe weather warnings across the United States. In addition, the NWS continuously dedicates resources and training to improve the accuracy and timeliness of these warnings. Verification of severe weather warnings is necessary in providing the probability of detection (POD) and false alarms rates (FAR) of the issuance of weather warnings. The purpose of this paper is to gain an increased understanding as to whether population density plays a part in the warning and verification process.

2. DATA AND ANALYSIS

Severe thunderstorm warnings issued from the NWS Forecast Office in Peachtree City, Georgia (FFC) from January 1995 through December 2002 were examined in the study. The NWS Peachtree City, Georgia office is responsible for a 96-county area of north and central Georgia. Over 6000 severe thunderstorm warnings taken from the NWS Verification Web Page were used in the analysis during the 8-year period. County population and area data were taken from Arcview GIS (Geographic Information Systems) data dated 1997. Data were divided into five statistically-defined groups based on population density (population per 100 square miles for each county) (Table 1). The five groups were derived by defining outliers greater than one standard deviation from the mean population density and then defining four other groups of counties based on quartile. Mean population density was 19,363 people per 100 square miles across the county warning area (CWA). One standard deviation from the mean was 36,247 people per 100 square miles illustrating the large variance in county population density within the CWA. Data showed eight counties within the FFC CWA had a population density above one standard deviation of the mean. This group was the outlier group, appropriately named the "Urban 1" group. Four other groups were named based on quartile. These were named Urban 2, Rural 3, Rural 2, and Rural 1 in order of decreasing population density (Figure 1). For each of these groups, county averages, rounded to the nearest whole number, were calculated for severe thunderstorm warnings issued, severe thunderstorm warnings verified, severe thunderstorm warnings unverified, severe thunderstorm events, missed severe

* Corresponding Authors address:
Jeff Dobur, National Weather Service,
Peachtree City, GA 30269
e-mail: Jeffrey.dobur@noaa.gov

thunderstorm events, and severe thunderstorm events warned (Table 2). Each county averaged value was initially normalized using the mean county area in square miles. This was to take in account county size as a factor in the distribution of warnings and events.

Group	Average Pop per 100SM
Rural 1	2,115
Rural 2	4,136
Rural 3	8,374
Urban 2	25,160
Urban 1	122,949

Table 1: Population Density Groups within the NWSFO Peachtree City, Georgia County Warning Area

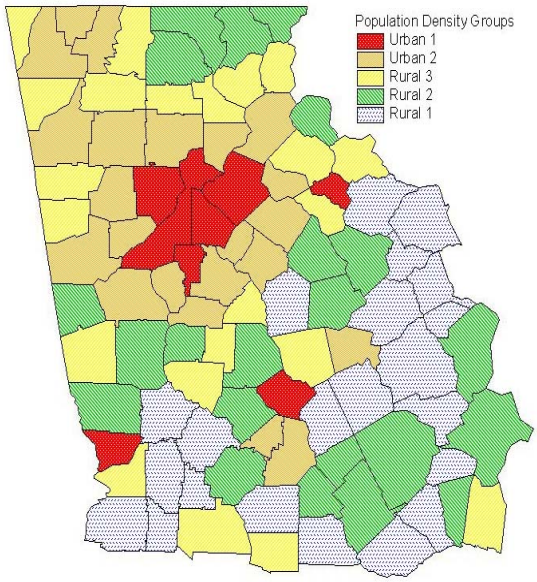

Figure 1: Population Density Groups within the NWSFO Peachtree City, Georgia County Warning Area

3. RESULTS

When comparing the average number of severe thunderstorm warnings versus the average county population density within the five groups, there was an overall increase in the number of severe thunderstorm events and warnings with increasing population density. (Figure 2). The greatest increase was noted in going from the Rural 3 group to the Urban 1 group hinting at the fact that counties with the greatest population density including large cities may receive more warnings, a result reported in Davis and LaDue (2004). The correlation between the county population density and the number of severe thunderstorm warnings issued was 0.52 with an R^2 value of 0.27, while the correlation between the county population density and the number of severe thunderstorm events was 0.60 with an R^2 value of 0.36. The correlation between the number of severe thunderstorm warnings and the number of severe thunderstorm events is 0.88 with an R^2 value of 0.77. Correlations show a slight positive relationship exists between the population density to both the average number of severe thunderstorm warnings issued and the average number of severe thunderstorm events. In addition, an obvious relationship exists between the number of severe thunderstorm warnings and the number of severe thunderstorm events. These correlations compare well to Davis and LaDue who found R^2 ranged from 0.71 to 0.26 when comparing population density with events and an R^2 value of 0.44 to 0.14 when comparing population density with warnings. It is also important to note, as Davis and LaDue had also found, that the correlations between population density

Group	Warn	Events	Warn Verified	Events Warned	Warn Unverified	Events Unwarned
Urban 1	117	93	65	68	52	25
Urban 2	84	62	44	45	41	17
Rural 3	63	38	26	27	37	11
Rural 2	55	26	20	20	35	7
Rural 1	52	19	16	16	36	4

Table 2.
Average county warnings, events, etc normalized by county area for each population density group within the Peachtree City WFO.

and warning density are significantly weaker than the correlations between population density and event density.

4. POD and FAR

Further evidence in supporting the relationship between population densities, severe thunderstorm warnings issued and severe thunderstorm events can be found by examining the Probability of Detection (POD) and False Alarm Rate (FAR) for the five defined groups (Table 3). POD was highest in the Rural 1 Group with little change in increasing population density. Data showed that FAR decreased with increasing population density (Figure 2).

Group	POD	FAR
Urban 1	0.73	0.45
Urban 2	0.73	0.48
Rural 3	0.70	0.59
Rural 2	0.75	0.64
Rural 1	0.81	0.70

Table 3: POD and FAR for each population density group.

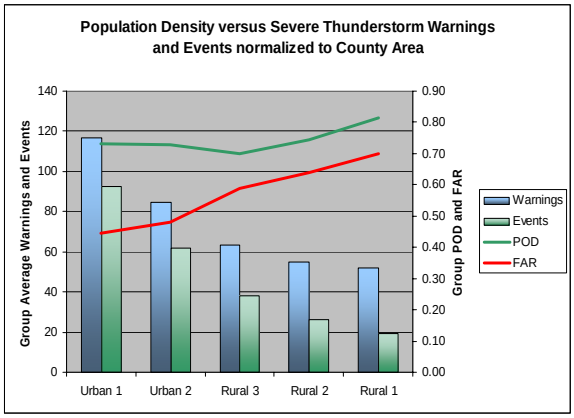

Figure 2: Population Density versus Severe Thunderstorm Warning and Event Data

5. SUMMARY

The population density of the CWA does appear to have some effect on both the number of severe thunderstorm warnings issued and the number of severe thunderstorm events. There were nearly twice as many warnings issued on average for the Urban 1 group compared to the Rural 1 group through the period with nearly four times the number of events on average for the Urban 1 group compared to the Rural 1 group. The greater number of warnings in the urban groups relative to the rural groups is likely related to the far

greater number of events that are reported in the urban groups relative to the rural groups. Denser populations would likely have a greater capacity for observing an event and reporting it which, in turn, would lead to a possible warning for that particular county or a county downstream of the observed event if a warning had not already been issued. In addition, with time and experience, forecasters can become "conditioned" to the fact that counties with a high population density may be more apt to observe and report a marginal severe event (two trees blown down, three-quarter inch hail) compared to those with low population density. Thus, a warning meteorologist may be more inclined to warn on a marginal storm in a county with a high population density compared to a county of low population density. It is important to note that it is not the practice of the National Weather Service warning meteorologist to consciously warn more on storms in counties with higher population densities rather than counties with lower population densities. In fact, verification scores suggest that increasing the number of warnings in rural areas would in turn increase the FAR.

While POD scores appear to have no correlation to population density, FAR scores are higher in the rural groups compared to the urban groups. The higher FAR scores in the rural areas can be caused by a lack of a populous to observe and report an event or by over-warning. Evidence to support the former "cause" is found in the fact that the more populated areas receive a greater number of severe thunderstorm warnings yet have a lower FAR relative to the rural groups. This would suggest that the capacity to obtain reports is an important part of FAR scores. Overall, data supports the hypothesis that the population density does have an effect on the warning and verification process.

Additional research is needed to further discuss the relationship between the warning decision process and various socio-economic factors that may affect warning verification scores. It is important to note that to improve the warning process in addition to deriving meaningful performance scores, not only is there a need for continual development of advanced warning tools but there is a need to increase spotter networks, mesoscale observing networks, and programs such as StormReady to provide greater ground truth to warning meteorologists, especially in rural areas.

6. REFERENCES

Davis, S.M., LaDue, J.G., 2004: Nonmeteorological Factors in Warning Verification. Cooperative Institute for Mesoscale Meteorological Studies and Warning Decision Training Branch.