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A SEVERE WEATHER CLIMATOLOGY FOR THE BIRMINGHAM, ALABAMA COUNTY WARNING AREA

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UNITED STATES
DEPARTMENT OF COMMERCE
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National Oceanic and Atmospheric Administration
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1. Introduction

The National Weather Service (NWS) has no greater responsibility than warning the public of impending severe weather. A thorough understanding of severe weather climatology can better prepare forecasters for anticipating the timing, strength, extent and nature of severe weather. The purpose of this study is to quantitatively describe the severe weather climatology for Birmingham's County Warning Area (CWA). The Birmingham CWA has undergone several changes through the years. From the early 1970s through the mid-90s the warning responsibility for Alabama's 67 counties was split among six NWS offices, with Birmingham's CWA encompassing 25 counties in north and west-central Alabama. As the modernization and associated restructuring of the NWS drew to a close, CWA configurations in Alabama changed significantly. Birmingham's area of responsibility expanded to include 50 counties in north and central Alabama, including most of the CWA's previously served by Huntsville and Montgomery.

The Birmingham CWA comprises 34,613 square miles of Alabama's 50,744 square miles (U.S. Census Bureau and Murphy 2001). The CWA offers much topographical diversity (Fig. 1). The rich agricultural valley of the Tennessee River occupies the extreme northern part of the state. The southern fringe of the Appalachian Mountains extends southwest across far northeast and east Alabama. Below that a band of prairie lowland stretches across central Alabama. Piney woods encompass the area east and southeast of the Montgomery area.

Although the average elevation of Alabama is about 500 ft above sea level, this represents a gradation from 2,407 ft atop Cheaha Mountain in east central Alabama, down to sea level at Mobile Bay.

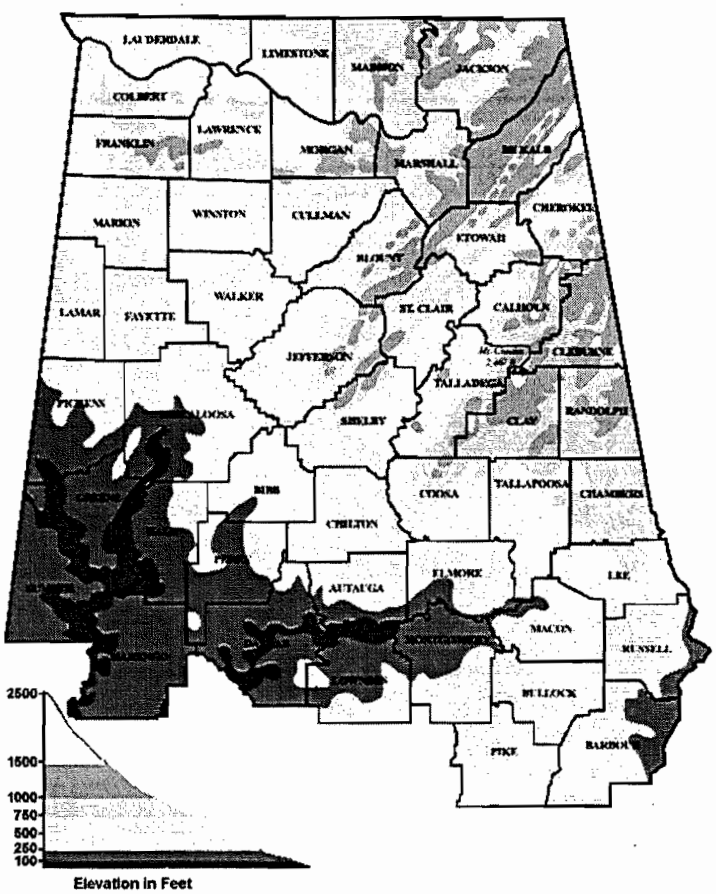

Figure 1: Map of WFO Birmingham's CWA. Shaded areas show changes in elevation across the CWA.

2. Data

The data used for this study came from several sources. The primary source was a database of tornado reports dating from 1950 to 1994 provided by the Storm Prediction Center (SPC). This database was supplemented with *Storm Data* publications, the reference book *Significant Tornadoes 1680-1991* (Grazulis 1993), and local records. These resources were used to compile

a list of all known tornadoes in Birmingham's CWA from 1880 to 2000. Each of these sources uses a different method by which to list tornadoes. Most notably, *Storm Data* and the SPC database list tornado events on a county by county basis, which in turn leads to "tornado segments" when a tornado crosses several counties. In contrast, Grazulis denotes a tornado by a single path length, regardless of the number of counties it affects. In order to have the most complete and comprehensive database of tornadoes, "tornado segments" have been combined into single tornado events. Prior to 1950, the main source for tornado data is the Grazulis text. However, Grazulis only documented strong tornadoes (F2 - F5), so prior to 1950, there is no documentation of F0 or F1 tornadoes.

The hail and wind data used for this study were taken from several sources as well. SPC maintains a database of both wind and hail data. The data were archived in different formats and were only available through 1995. The SPC database was supplemented with Storm Data publications, and the National Climatic Data Center's storm events Web page. Local records were also used to complete the databases, especially between 1996 and 2000.

Due to the increased number of severe weather reports after the 1950s, the time frame of 1961 to 2000 was chosen for this study.

The NWS defines a severe thunderstorm as one which meets one or more of the following criteria:

- hail three-quarters of an inch in diameter or larger
- wind of at least 50 knots (58 mph) or wind which causes damage, including trees or power lines blown down.
- a tornado.

3. Climatology

a. *Tornadoes*

1) YEARLY DISTRIBUTION

Tornadoes have occurred in Birmingham's CWA almost every year since 1880. Analysis of the annual tornado frequency indicates a rise in the number of reported tornadoes after the mid-1950s. This does not mean that there has been an increase in the number of tornadoes after that time; more likely it is due to increased population and awareness of severe weather (Hales, 1993). Indeed, between 1990 and 2000 there was a 10.4% increase in total population across the Birmingham CWA. Another pivotal event was the onset of the NWS warning verification program in 1980. The increased awareness of tornadoes resulted in many more reports of relatively weak events (F0 and F1) which may not necessarily cause widespread destruction, injuries, or fatalities.

Two-thirds of all tornadoes reported since 1880 occurred after 1961 (Fig. 2). In fact, even with the increased awareness after the beginning of the verification program in 1980, the Birmingham

CWA only reported 50 more tornadoes in the years 1981 through 2000 compared with 1961 through 1980. Since the majority (63%) of the reported tornadoes occurred between 1961 to 2000, any analysis of tornado events would be skewed toward those years. Therefore it was decided to focus our analysis on this period.

During the period 1961 to 2000, the Birmingham CWA has averaged slightly more than 16 tornadoes per year. However the area experiences only seven tornado days on average each year. Multiple tornado events occur on an average of three days per year. Years in which major tornado outbreaks have occurred stand out, such as 1973 and 1974, as well as the mid-1980s and late 1990s (Fig. 3).

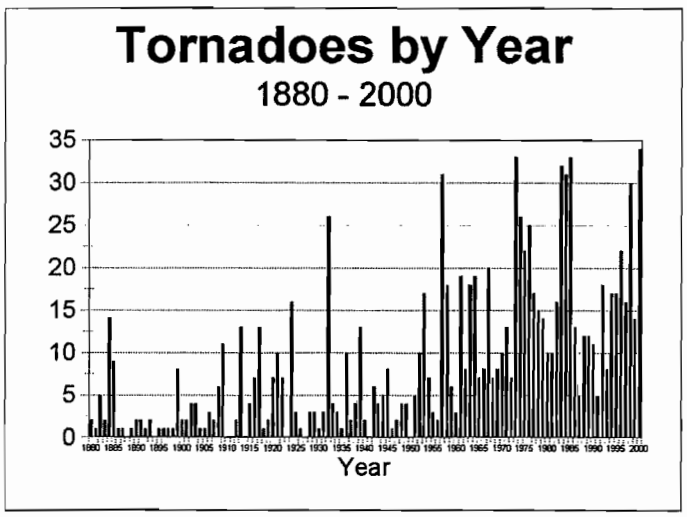

Figure 2: Tornadoes affecting WFO Birmingham's CWA since 1880.

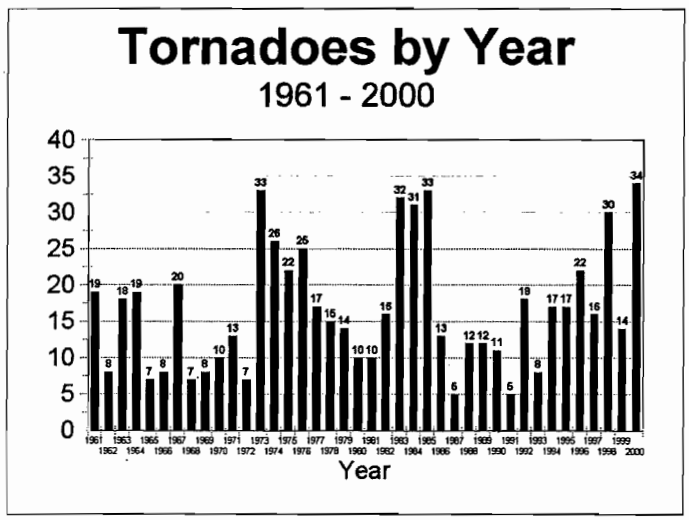

Figure 3: Tornadoes affecting WFO Birmingham's CWA since 1961

2) MONTHLY DISTRIBUTION

Early spring is the time of year when the main ingredients for severe weather (atmospheric instability, moisture, surface boundaries, and wind shear) come together across the southeastern United States. March, April and May are the most active months for tornadoes in the Birmingham CWA, accounting for 351 events, or 54% of all tornadoes reported between 1961 and 2000. The summer and early fall months experience a sharp decrease in tornadic activity, accounting for just 15% (101) of all tornadoes. A secondary maximum is also noted in November, as forcing coincides with good instability across the southeastern states. The winter months see a small decline, followed by a rapid rise in early spring (Fig. 4).

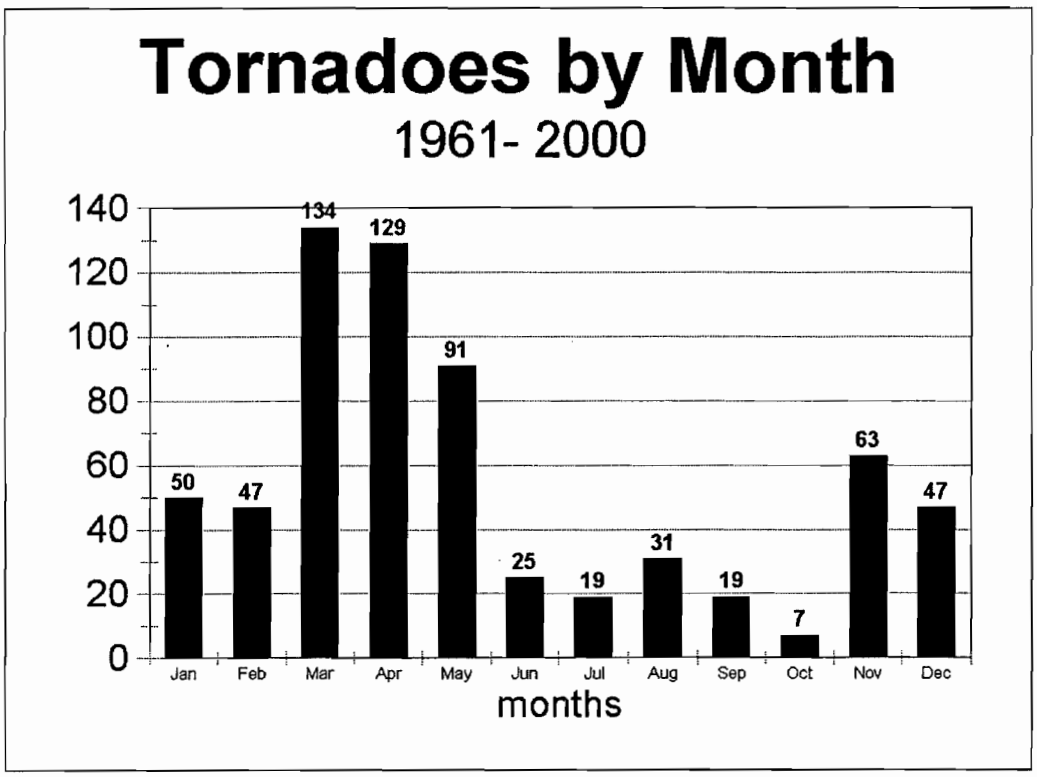

Figure 4: Tornadoes affecting WFO Birmingham's CWA by month.

3) HOURLY DISTRIBUTION

Tornadoes typically occur during the afternoon and early evening hours, peaking between 4 and 5 pm Central standard time (CST) (Fig. 5). The hours between noon and 7 pm account for 61% of all tornado reports. This period correlates to the peak time of deaths and injuries caused by tornadoes (Fig. 6).

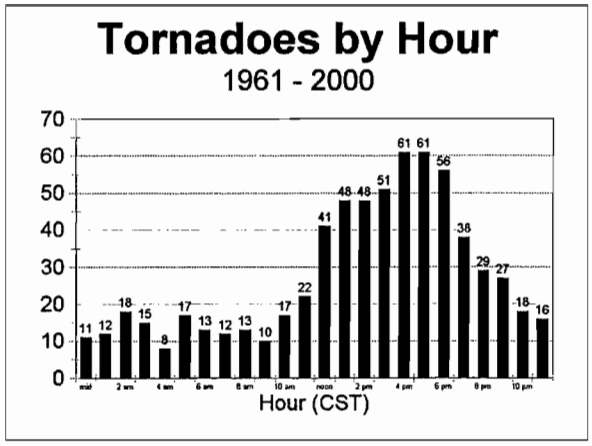

Figure 5: Tornadoes affecting WFO Birmingham's CWA by hour.

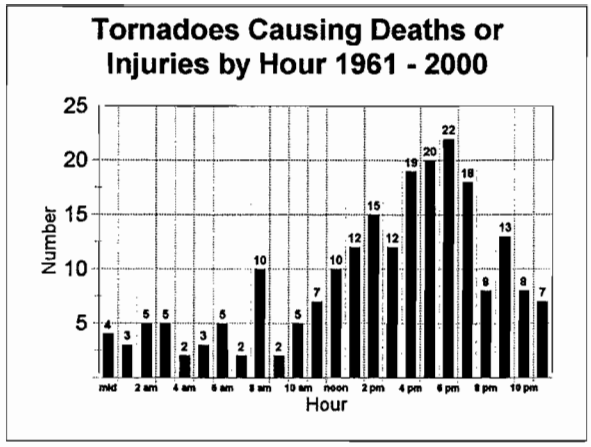

Figure 6: Tornadoes causing deaths and injuries in WFO Birmingham's CWA.

4) F-SCALE

Relatively weak - F0 to F2 - tornadoes account for 85% of tornadoes reported from 1961 to 2000 (Fig. 7). The number of F0 and F1 tornadoes has increased steadily since the mid-1980s. From 1961 to 1980, an average of 5.6 F0 or F1 tornadoes was reported each year, compared to 9.6 F2 or greater tornadoes during the same time frame. Since 1981 the average yearly number of weak tornadoes has doubled to 12.6, and may be attributable to the increased emphasis on verification. On the other hand, the average number of stronger tornado reports has declined to near 5.1 per year (Fig. 8).

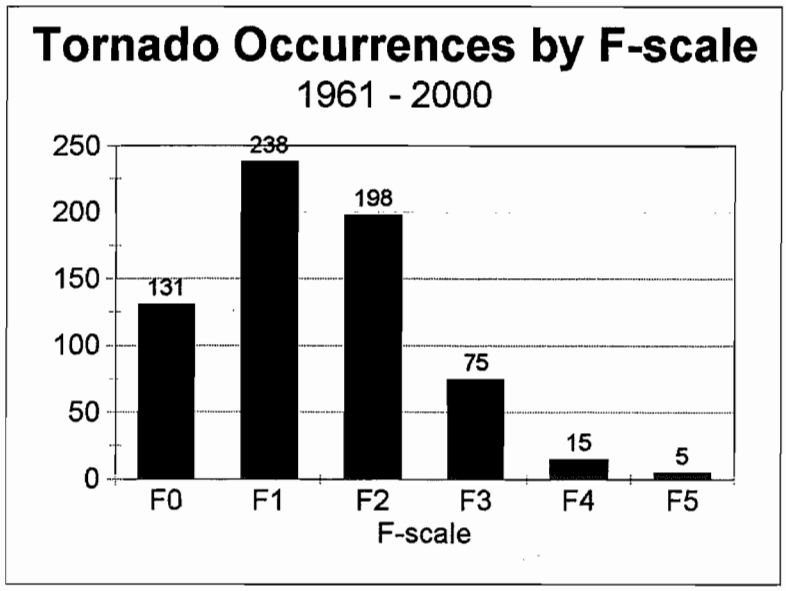

Figure 7: F-scale distribution of tornadoes affecting WFO Birmingham's CWA.

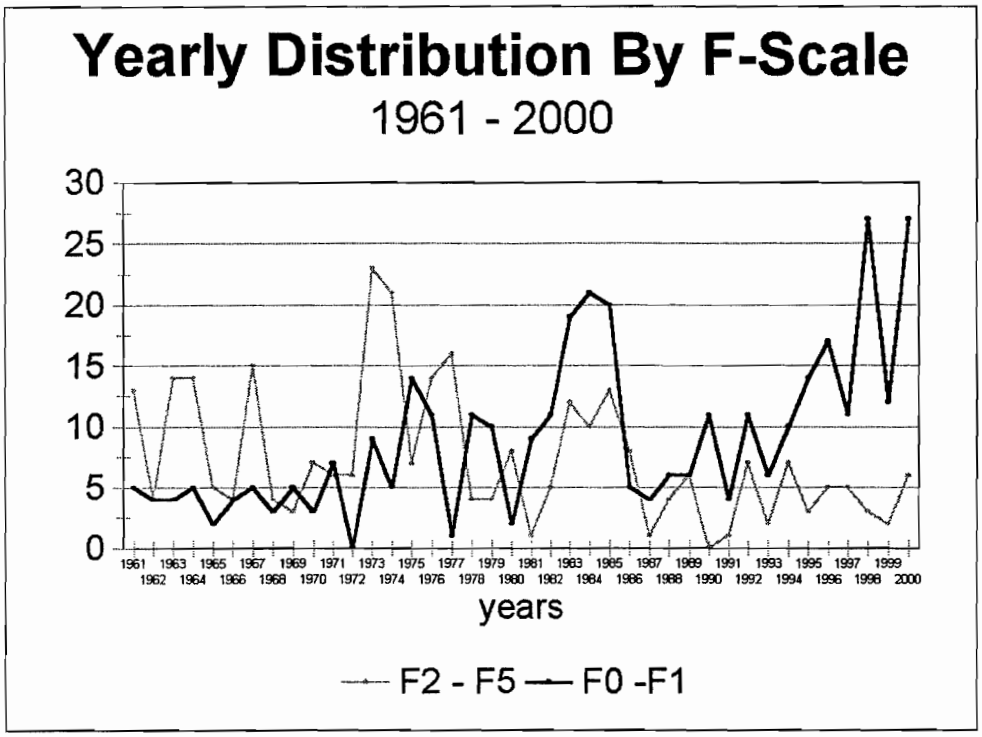

Figure 8: Distribution of F0/F1 tornado reports versus F2 and greater tornado reports.

5) F-SCALE EFFECTS ON DEATHS AND INJURIES

While F0 and F1 tornadoes account for 55% of all tornadoes since 1961, less than 5 % of injuries and 3% of deaths have been attributed to F0 and F1 tornadoes. On the other extreme, F4 and F5 tornadoes account for just more than 3% of all tornadoes, but more than 60% of injuries and more than 76% of all deaths (Figs. 9 and 10).

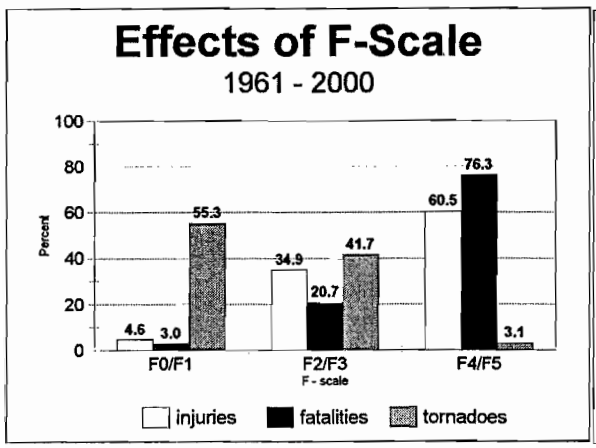

Figure 9: Percentage of Deaths and injuries versus F-scale in WFO Birmingham's CWA.

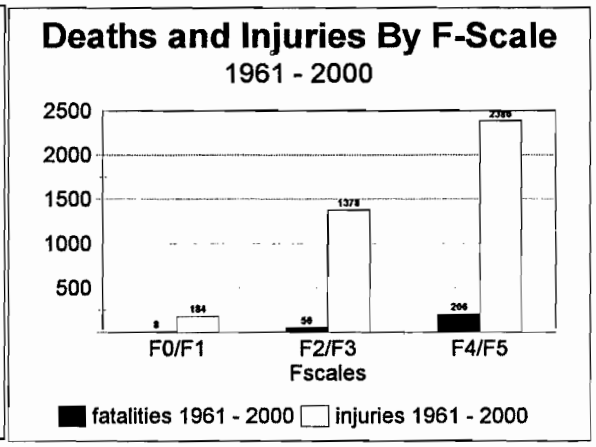

Figure 10: Number of deaths and injuries versus F-scale in WFO Birmingham's CWA.

b. *Hail*

1) YEARLY DISTRIBUTION

The number of hail reports received at the Birmingham NWS has increased dramatically in recent years (Fig. 11). In the 1960s, fewer than 10 reports of hail were received each year, but since 1995 no fewer than 100 yearly reports of hail were received with 340 reports received in 1998. Once the NWS verification program was emphasized in the mid-1980s, the number of hail reports grew with each year.

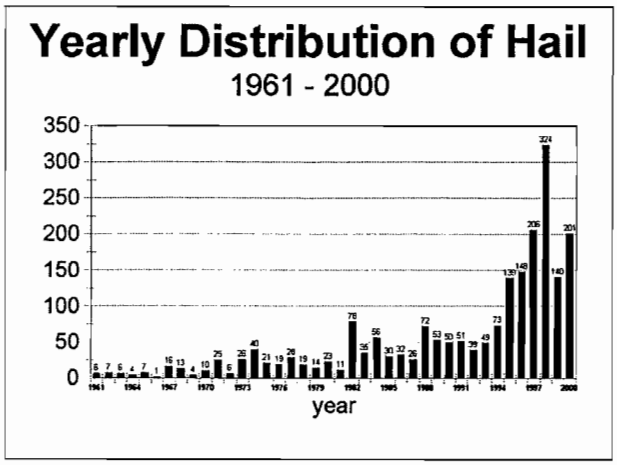

Figure 11: Hail events reported in WFO Birmingham's CWA since 1961.

2) MONTHLY DISTRIBUTION

Typically in north and central Alabama, the spring months (March through May) are the main times of the year for hail. Reports of hail will taper off throughout the summer months reaching their lowest values during the fall and early winter (Fig.12).

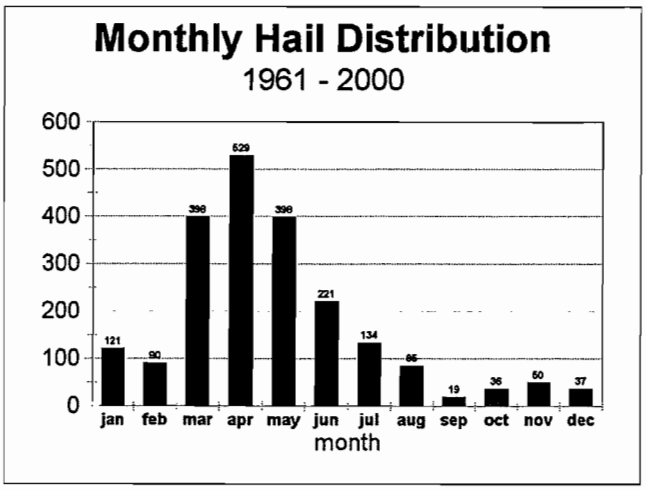

Figure 12: Hail events reported by month in WFO Birmingham's CWA.

3) HOURLY DISTRIBUTION

Hail generally occurs during the afternoon, but can occur at any time, day or night. Between 1961 and 2000, fewer than 30 reports of hail occurred during each hour between 1 and 9 am. The number of reports of hail increased throughout the late morning, peaking around 3 pm afternoon with just over 250 reports of hail (Fig. 13).

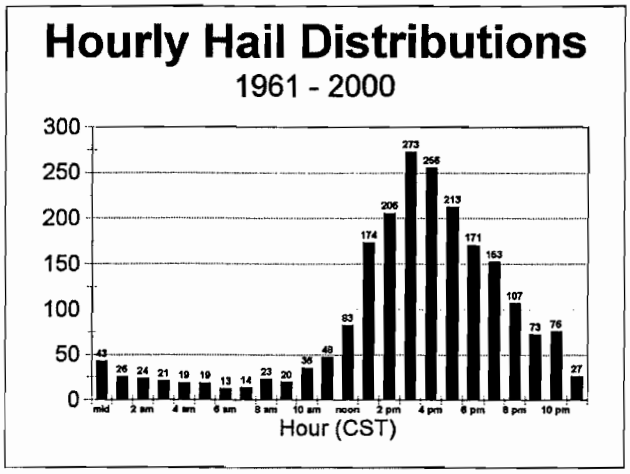

Figure 13: Hail events occurring in WFO Birmingham's CWA by hour.

4) HAIL SIZE DISTRIBUTION

The National Weather Service utilizes the criterion of hail diameter three-quarters of an inch or greater to verify a severe thunderstorm. For the purposes of this study, only hail that met this criterion was included. Hail less than 1 inch accounted for 48% of all hail reports between 1961 and 2000. Hail 2 inches or greater accounted for 3% of all hail reports (Fig. 14). From 1961 to the early 1980s, hail larger than 1 inch accounted for a large percentage of all hail reports each year. After the NWS verification initiative, hail larger than 1 inch accounts for about one-half of all reports each year (Fig.15).

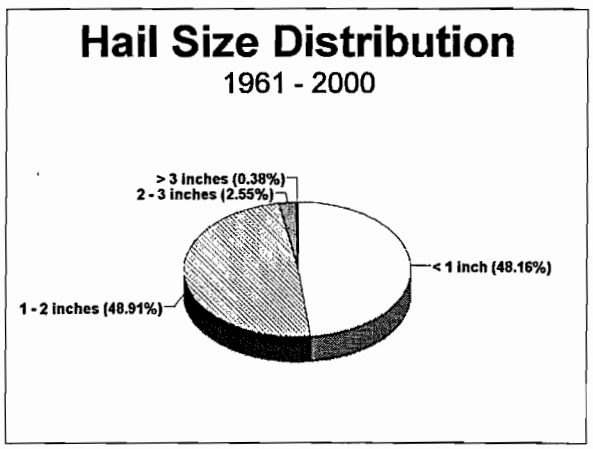

Figure 14: Distribution of hail events in WFO Birmingham's CWA since 1961.

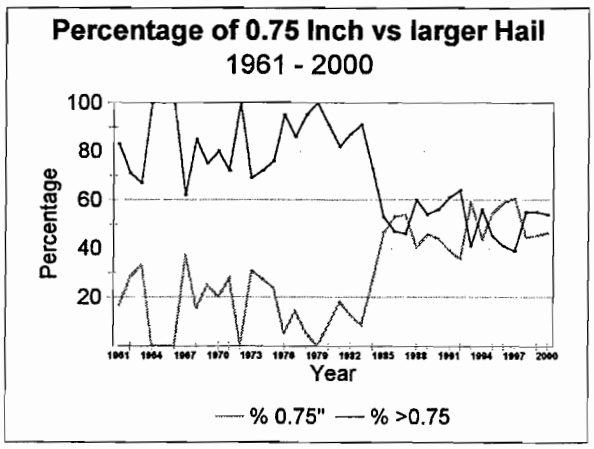

Figure 15: Comparison of hail size reports across WFO Birmingham's CWA since 1961.

c. *Thunderstorm Wind*

1) YEARLY DISTRIBUTION

There was a marked increase in thunderstorm wind reports in the early 1980s. In 1980 the National Weather Service began its intensive severe weather verification program. There is an upward trend in thunderstorm wind reports since the early 1980s (Fig. 16).

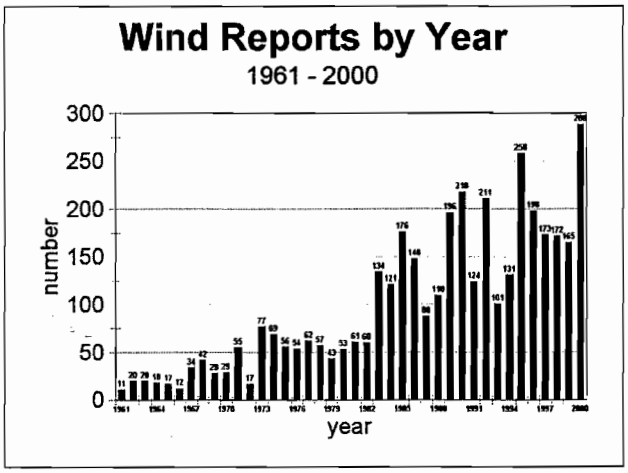

Figure 16: Thunderstorm wind reports across WFO Birmingham's CWA.

2) MONTHLY DISTRIBUTION

Severe thunderstorm winds in the Birmingham CWA are most likely to occur during the spring and summer months, with reports falling off during the early fall months (Fig.17). During the spring, squall lines often move across the area producing widespread wind damage. Although widespread convection is less likely during the summer months, summertime pulse thunderstorms will often produce wet microbursts which can cause localized damage paths.

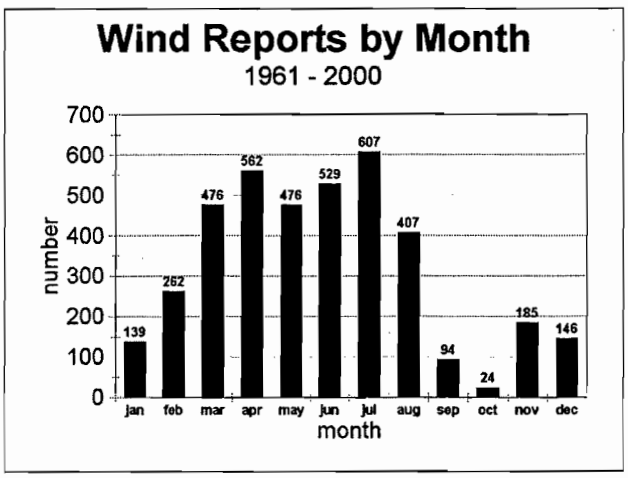

Figure 17: Thunderstorm wind reports by month across WFO Birmingham's CWA.

3) DAILY DISTRIBUTION

Thunderstorm wind damage is reported on an average of 27 days each year. The most days in a single year in which thunderstorm wind damage was recorded is 52 in 1998, the least seven in 1966.

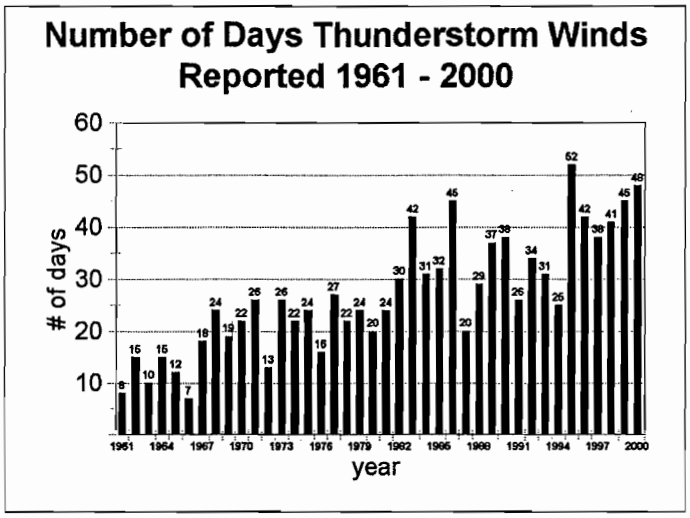

Figure 18: Distribution of thunderstorm days across WFO Birmingham's CWA.

4) HOURLY DISTRIBUTION

Thunderstorm wind damage occurs most often in the late afternoon and early evening. Although thunderstorm wind reports peak around 5 pm, they do not decline until late in the evening when daytime heating is lost (Fig.19). Severe thunderstorm winds are most likely to occur during the afternoon and evening during the spring and summer months, which correlates with diurnal-type convection (Figs. 20 and 21). Severe thunderstorm winds during the fall and winter months do not indicate a particular pattern, likely due to the variable nature of frontal passage (Figs. 22 and 23).

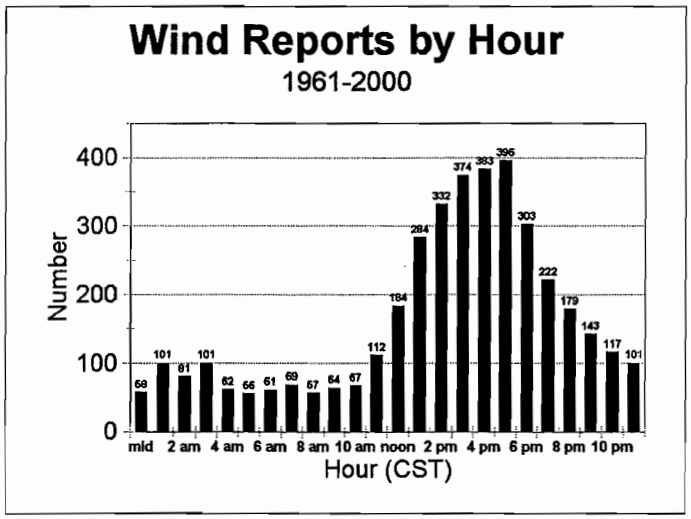

Figure 19: Hourly distribution of thunderstorm wind events.

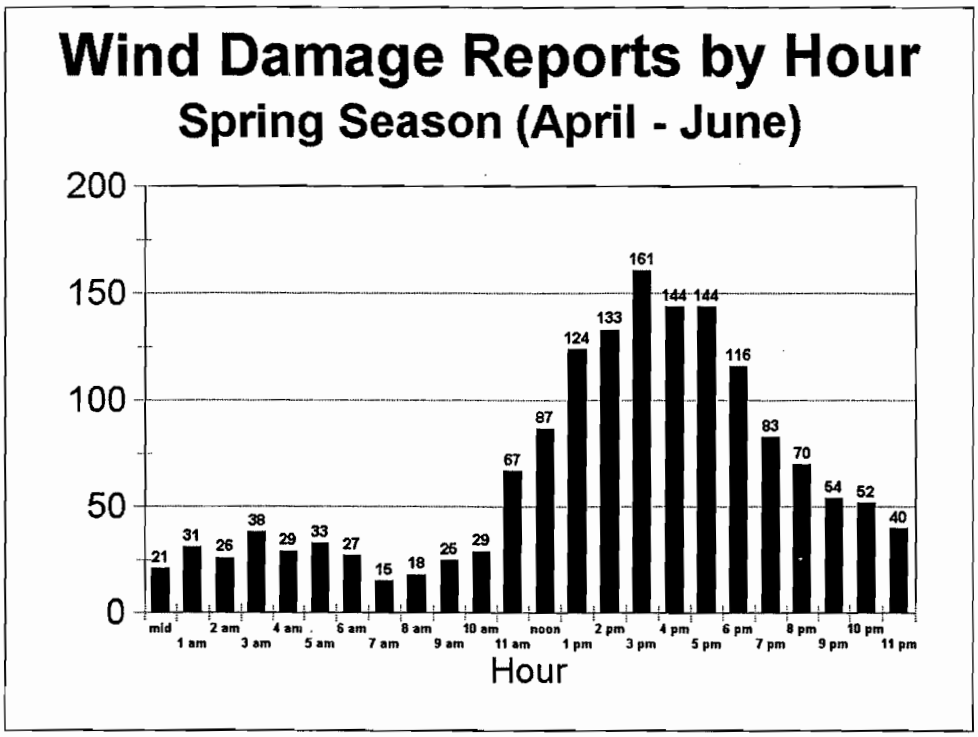

Figure 20: Hourly distribution of thunderstorm winds across WFO Birmingham's CWA during the spring months.

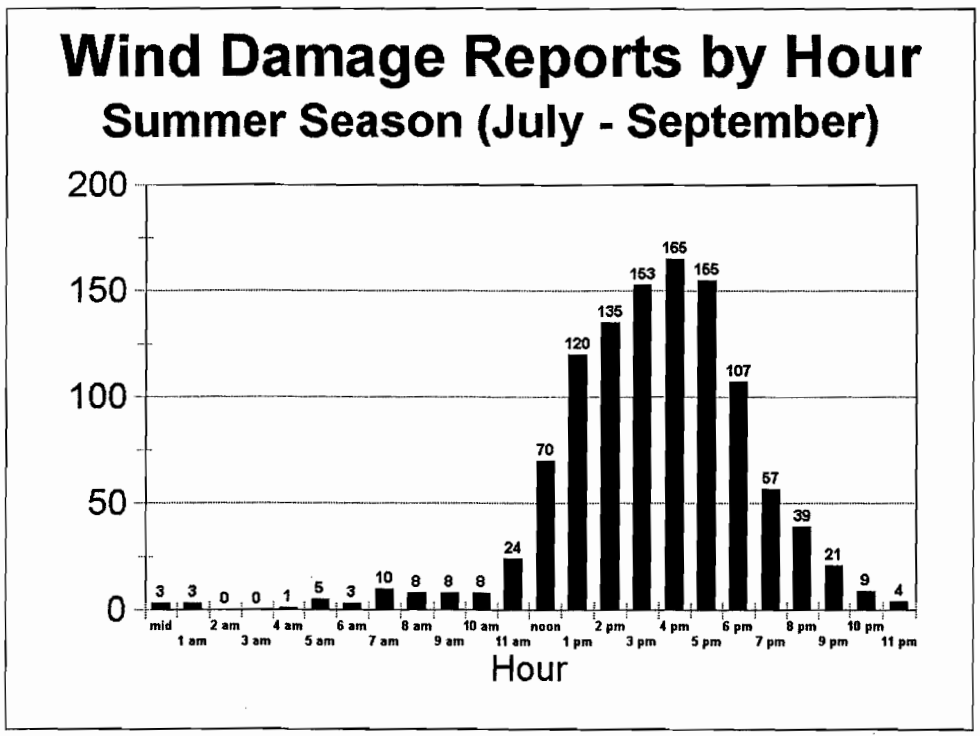

Figure 21: Hourly distribution of thunderstorm winds across WFO Birmingham's CWA during the summer months.

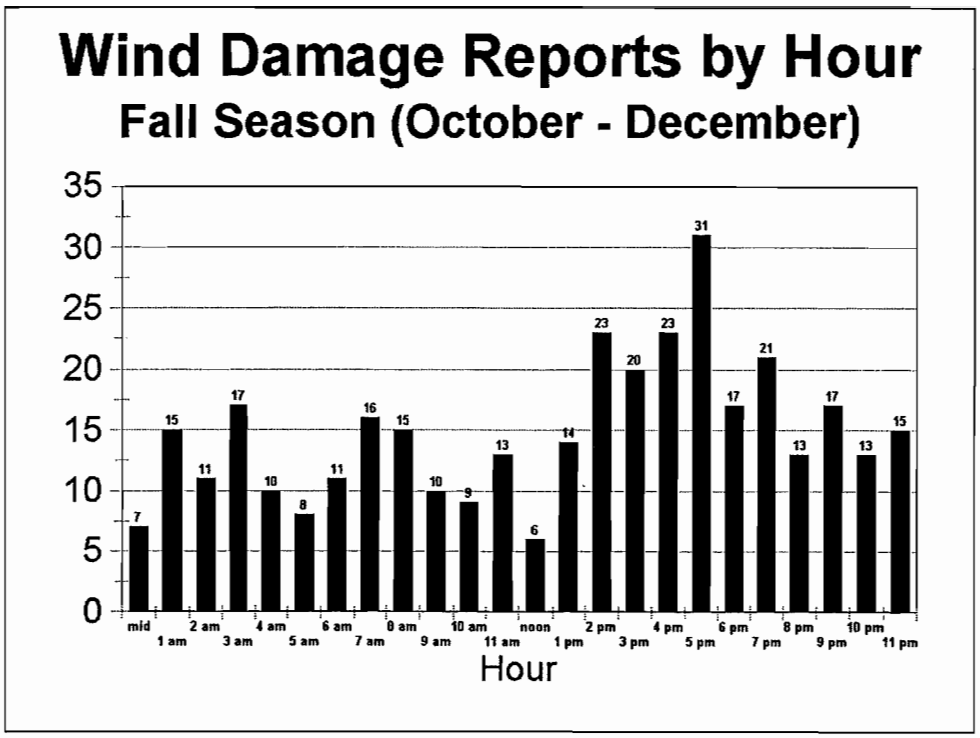

Figure 22: Hourly distribution of thunderstorm winds across WFO Birmingham's CWA during the fall months.

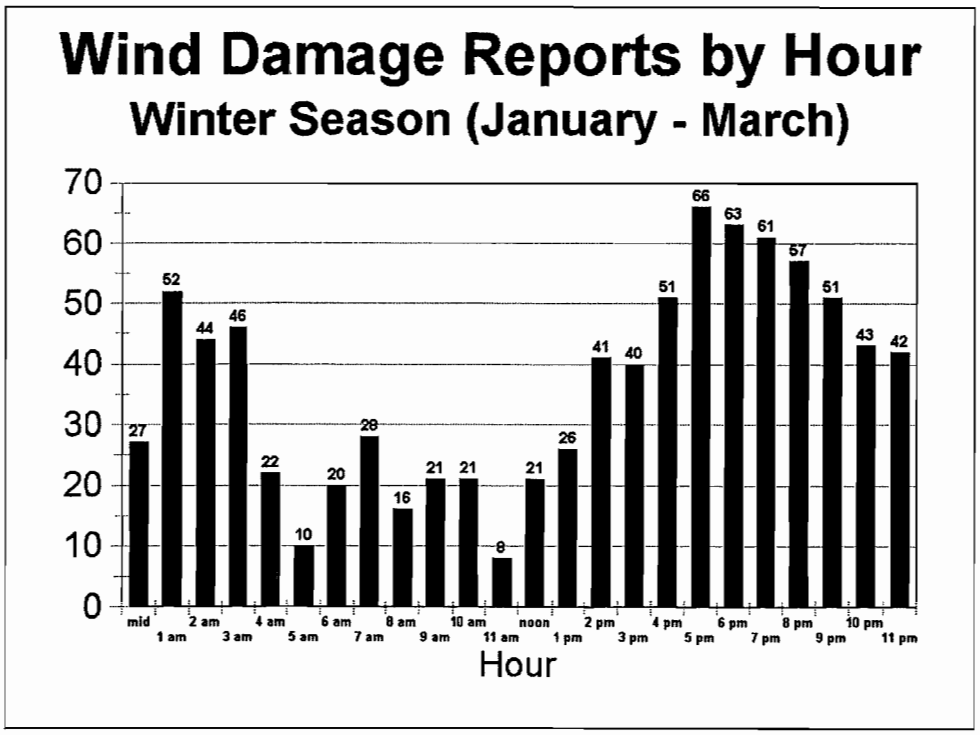

Figure 23: Hourly distribution of thunderstorm winds across WFO Birmingham's CWA during the winter months.

4. Summary

- March, April and May are the most active months for tornadoes in the Birmingham CWA, with a secondary maximum in the month of November.

- The Birmingham CWA reports tornadoes on an average of seven days per year; multiple tornadoes occur on three of those days.

- Tornado reports peak between the hours of 5 and 6 pm CST, which correlates to the peak time of deaths and injuries. A secondary peak of death and injuries occur near 2 am CST.

- Relatively weak tornado (F0/F1) reports have increased over time, while strong tornado (F4/F5) have decreased.

- F0/F1 tornadoes account for 55% of all tornadoes; less than 5% of injuries; 3% of deaths.
  F2/F3 tornadoes account for 42% of all tornadoes; 35% of injuries; 21% of deaths.
  F4/F5 tornadoes account for 3% of tornadoes; 60% of all injuries; 76% of deaths.

- The most tornadoes reported during a year is 33, in 1985 and again in 2000. The least tornadoes reported during a year is five, in 1987 and again in 1991.

- Hail reports peak during the months of March, April and May.

- The peak time of day for hail is 3 pm CST.

- Hail greater than three-quarters of an inch and less than one inch in diameter is reported 48% of the time.

- Severe thunderstorm winds are most likely to occur during the spring and summer months.

- Severe thunderstorm wind damage occurs most often in the afternoon hours, with a peak around 5 pm CST.

- Severe thunderstorm winds are most likely to occur during the afternoon and evening during the spring and summer months, which correlates to diurnal-type convection.

- Severe thunderstorm winds during the fall and winter months does not indicate a particular pattern, likely due to the variable nature of frontal passage.

Additional graphics showing the number of tornadoes by county, the number of tornadoes normalized by land area, and the average population of each county normalized by land area are attached to the end of this study. They reflect effects of the often-noted bias of tornado reports toward population centers. A factor which should always be kept in mind when evaluating tornado statistics.

5. Acknowledgments

The authors would like to thank MIC Gary Petti, SOO Kevin Pence and FIC Tom Bradshaw at WFO Birmingham for their help, reviews and suggestions during the development of this study.

6. References

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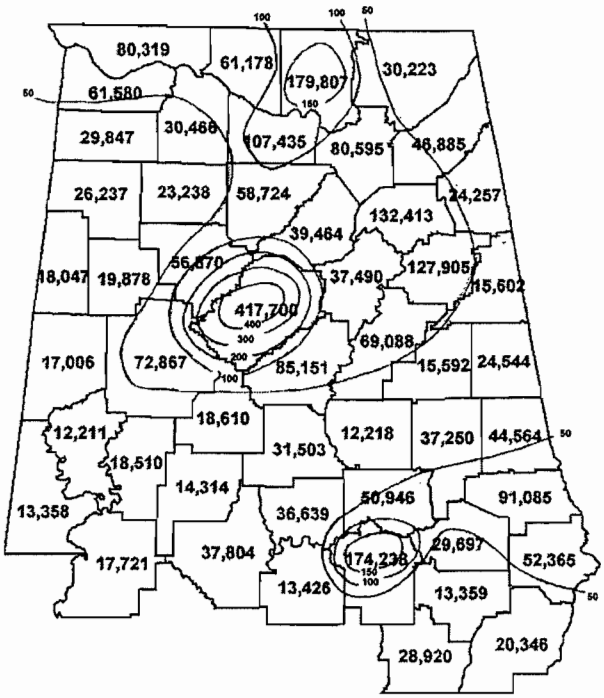
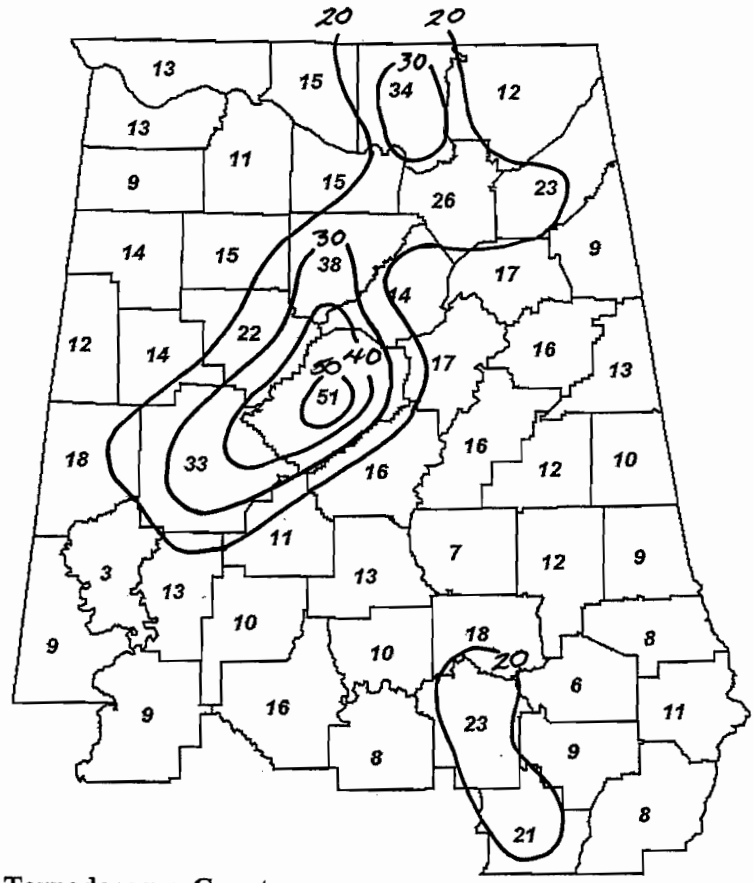
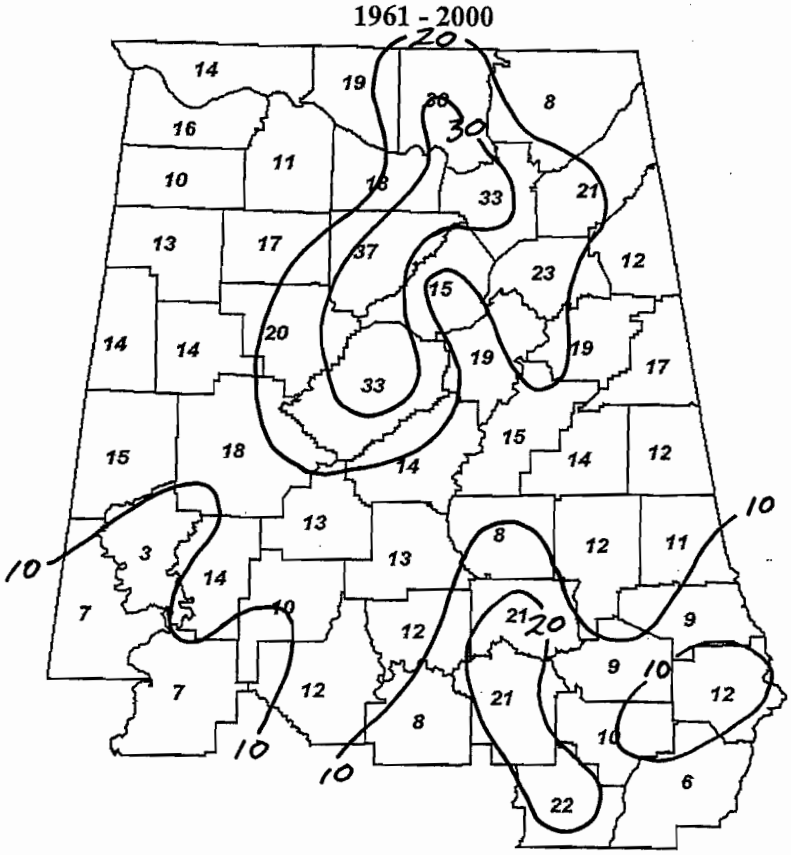
Average Population (1961-2000)
Normalized by Land Area



Number of Tornadoes per County
1961 - 2000



Number of Tornadoes per County
Normalized by land area
1961 - 2000