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Warnell School of Forestry & Natural Resources

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Storms & Lightning Ground Strike Numbers & Locations

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Lightning formation requires large energy transformations. These lightning generators are thunderstorms. Thunderstorms can be found across the continent. Thunderstorms generate updrafts in the atmosphere, large columns of falling rain and air, and ground level winds. Straight line winds in a thunderstorm can be caused by downbursts of various sizes: microbursts (<1 mile diameter & 160 mph winds); macrobursts (>2.5 miles diameter & 130 mph winds); and, derechos (bands of downburst clusters >240 miles long & >100 mph winds). Hot, humid air running into colder air masses tend to generate storms with massive, energetic air flows.

Figure 1 shows a historic map of annual thunderstorm days recorded in the United States over a 30 year period. Figure 2 shows a current map of thunderstorm day averages per year. Figure 3 provides a map of thunderstorm days per year averaged over the 1990's. Note the general trend for increased thunderstorms days as you travel South and East in the United States. The Tampa Bay area of Western Florida is the storm (and lightning) capital of the United States.

Storming On

Within thunderstorms, intense updrafts can occur spinning up into tornadoes. Tornado events are on the rise in the United States. Since 1950, tornado events have increased roughly seven-hundred percent (7X). Figure 4 shows tornado numbers over the last 55 years. Tornadoes generate intense lightning discharges. Figure 5 provides a map of average number of tornadoes per year expected. The map categories are broad but demonstrate a concentration of storms in the legendary “tornado alley” of the Great Plains. Separating tornado initiated and general thunderstorm lightning events is not possible. Faster updrafts have the potential for greater charge separation and generation.

Storm Intensity Zones

In trying to summarize storms and lightning associated damage to trees, the Coder Storm Intensity Map was developed for the continental United States. This map was created using averages of historic data for thunderstorms, hurricanes, tornadoes, lightning ground strike frequency, ice glazing events, snow fall accumulation values, and general wind speed values. The result is shown in Figure 6, a map of storm intensity as it relates to potential tree damage.

The range of storm intensity impacting trees are categorized into zones from 0 to 10. The most intense area of potential tree damage from storms is in zone 10, the southern tip of Florida. Thunderstorms (hurricanes are series of thunderstorms), tornadoes, and lightning events were part of this composite cluster analysis. Note some areas are dissimilar in climate and weather events, but share similar total composite tree damaging environments.

Lightning Location

To arrive at actual lightning ground strikes per year, there are a number of equations using thunderstorm days per year. One general estimate of lightning ground strikes per year is multiplying thunderstorm days for an area times 0.2. (Uman 2008) A research formula is given in Figure 7. In this figure the number of lightning ground strikes per square mile per year is determined by using the number of thunderstorm days per year. This formula is modified using average values from multiple papers. Figure 8 provides another way to compare lightning ground strikes per square mile per year with annual thunderstorm days. These thunderstorm days formula are only for rough estimation of lightning strikes.

With improving technology, cloud to ground lightning strikes can be directly measured and mapped. Figure 9 is a simplified map of lightning ground strikes per square mile per year over a decade. Figure 10 provides ground strikes per square mile per year for the last 15 years. For example, using 40 lightning ground strikes per square mile per year means there is a 90% chance of a strike within 725 feet, 50% chance of a strike within 395 feet, and 10% chance of a strike within 165 feet for any point on the ground per square mile per year. (Uman 2008).

Comparing ground strike maps from many years suggest complex changes are occurring in number and location of lightning ground strikes. As global climatic changes increase average temperatures, a 2^{o}F increase in average temperature increases by 11% atmospheric energy and increases by 10% the number of lightning strikes. (Bouquegneau & Rakov 2010).

Citation:

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THUNDERSTORM DAYS

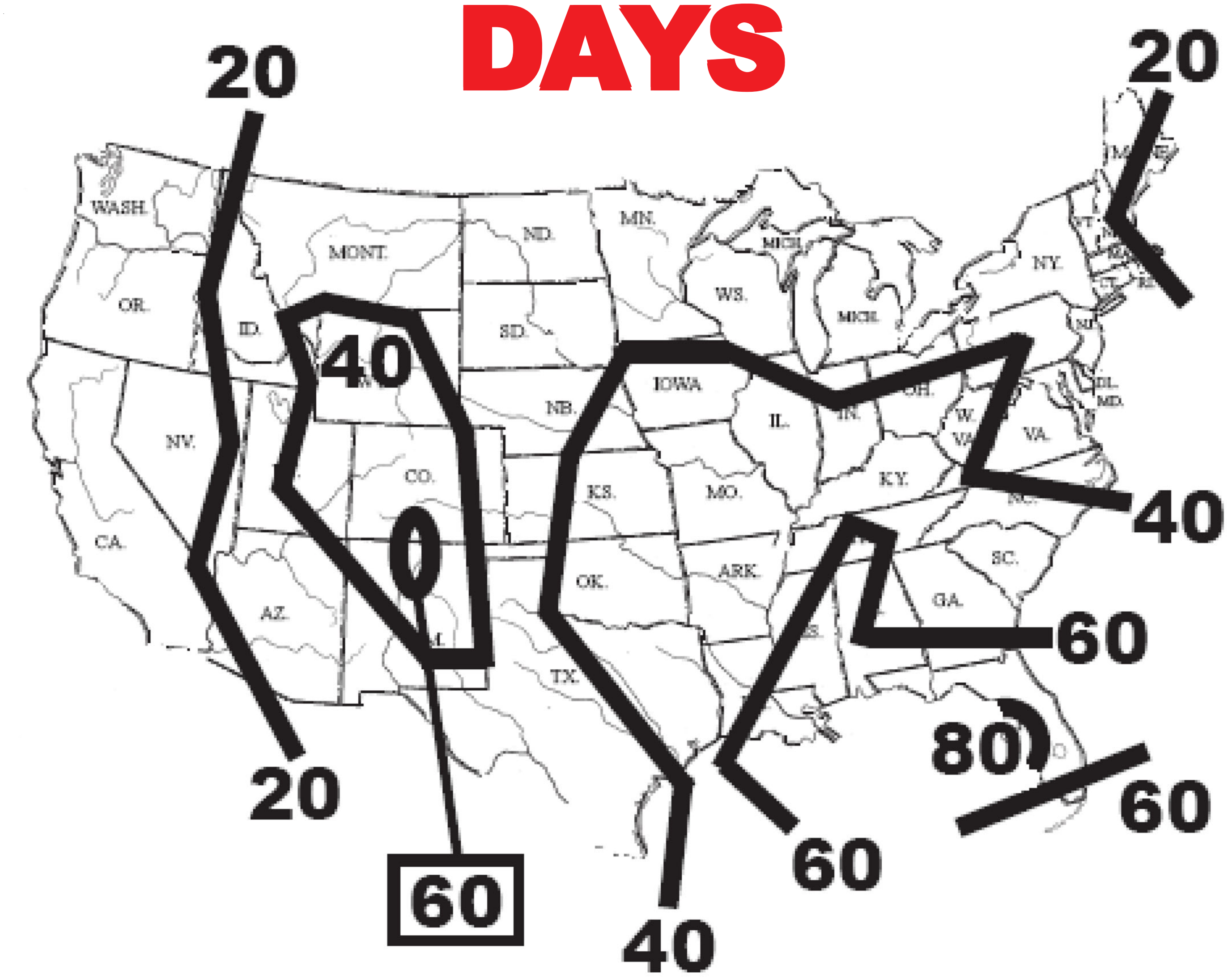

Figure 1: Average thunderstorm days per year.
(30 year national summary -- NOAA)

THUNDERSTORM DAYS

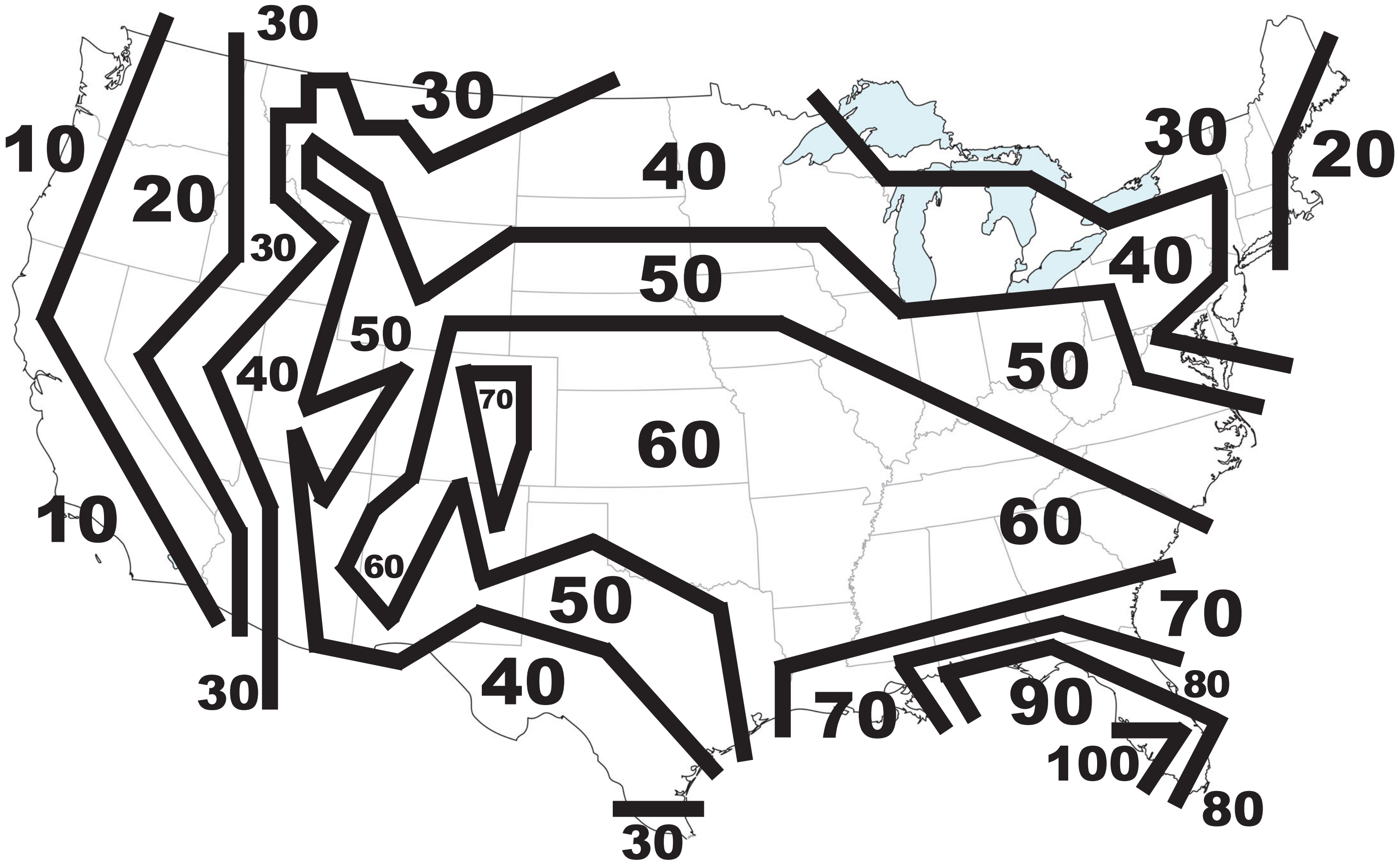

Figure 2: Average thunderstorm days per year.

THUNDERSTORM DAYS

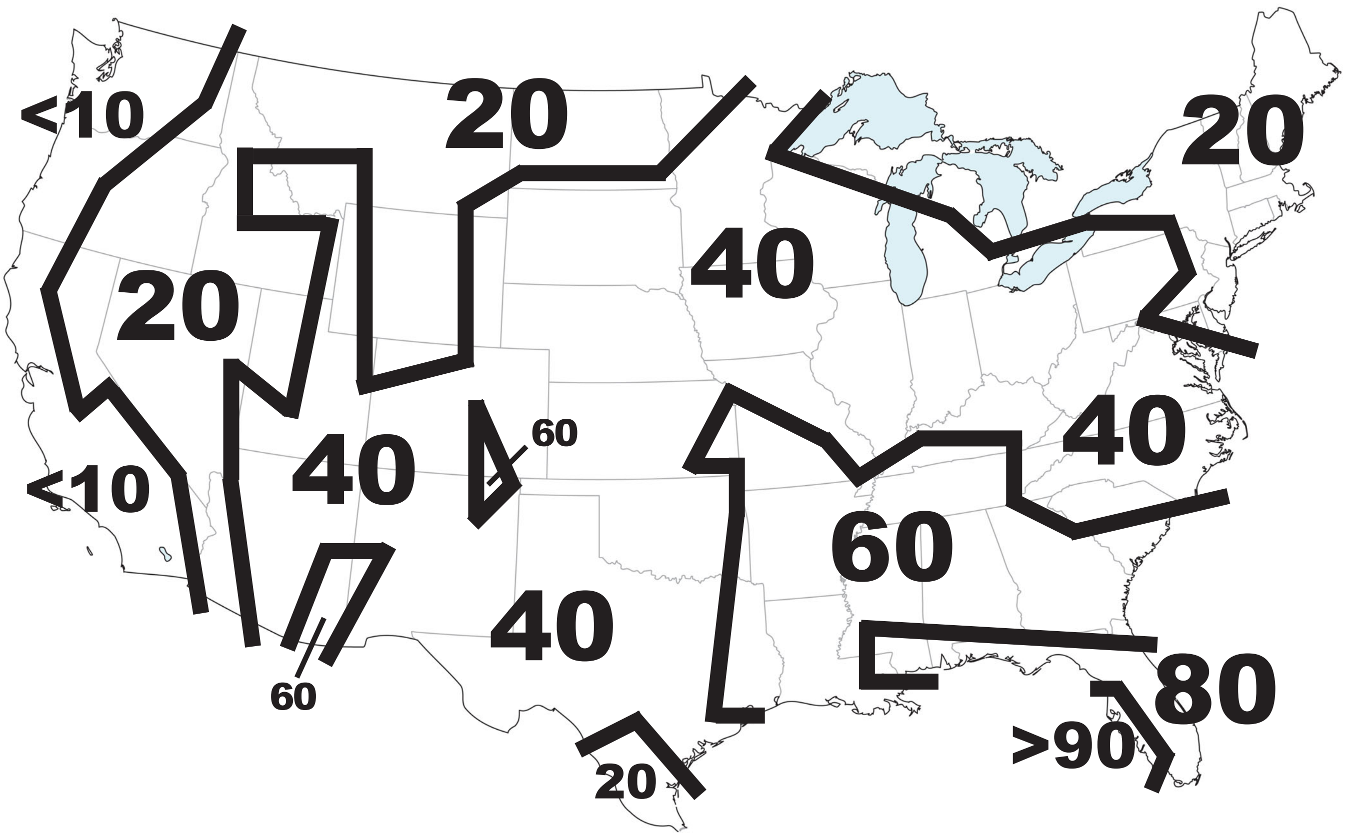

Figure 3: Average thunderstorm days per year.
(national 1990-1999 data)

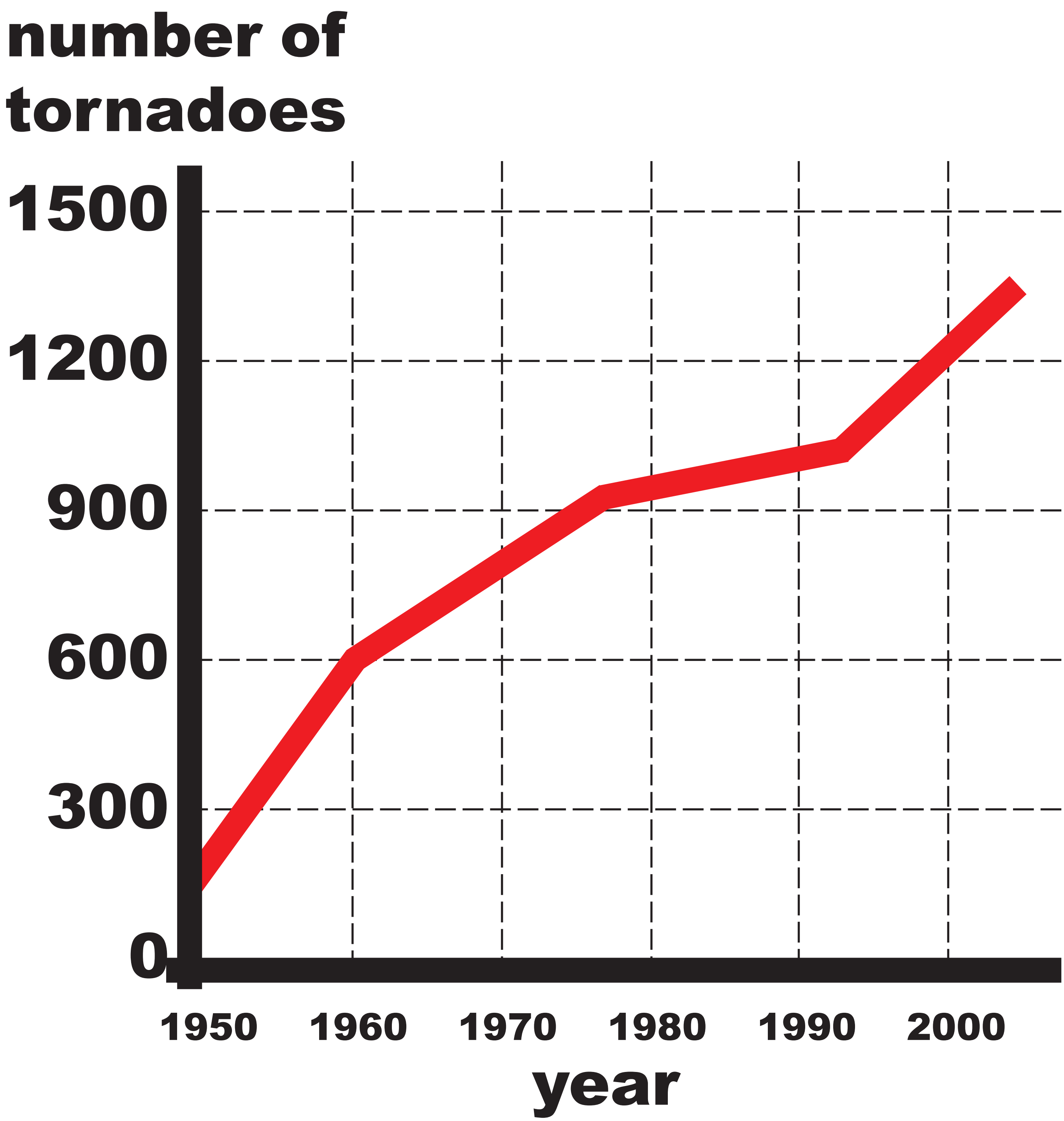

Figure 4: General trend line for tornado numbers in the United States over 55 years. (NOAA data)

TORNADOES

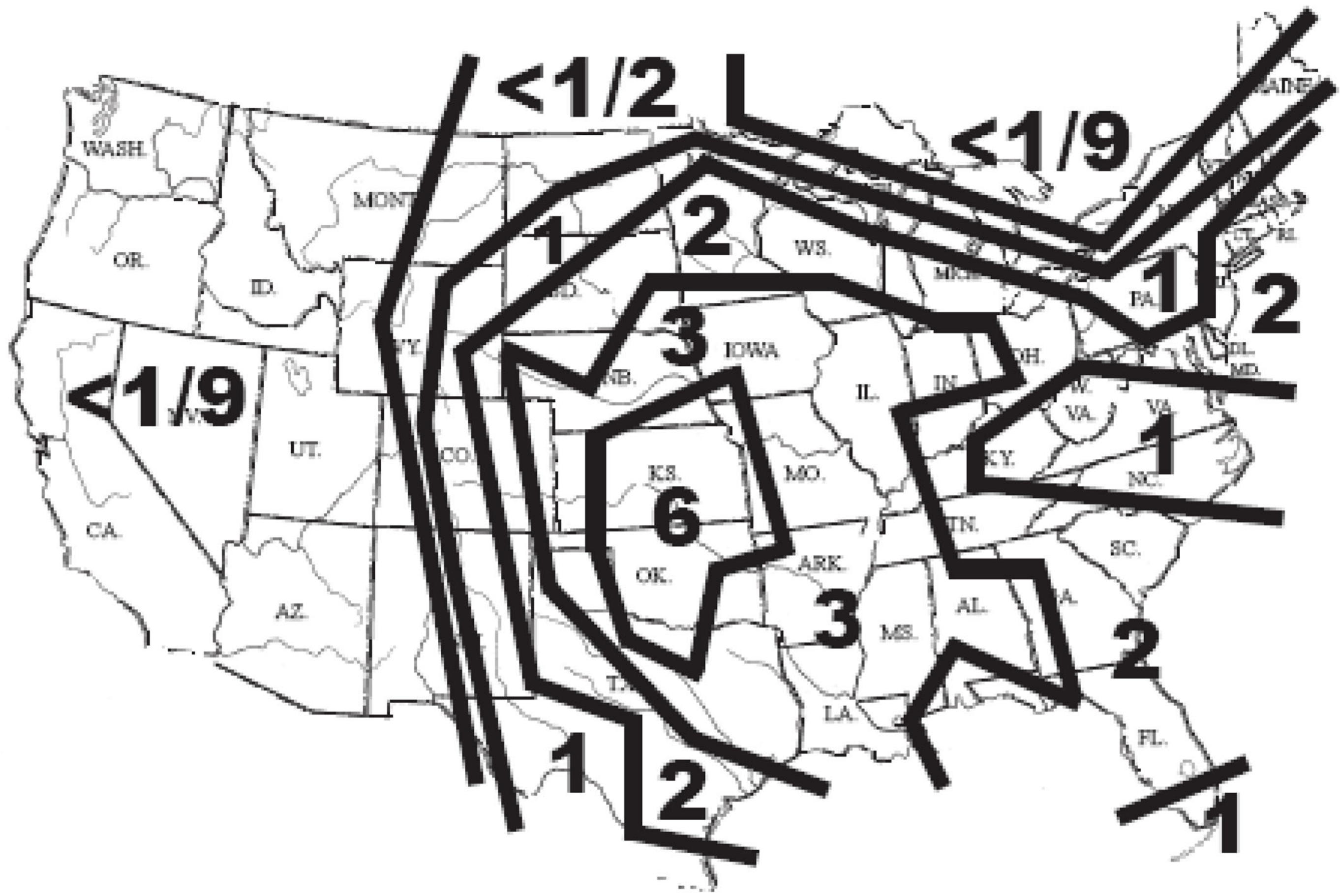

Figure 5: Average tornadoes per year. (45 year data -- NOAA)

TREE DAMAGE

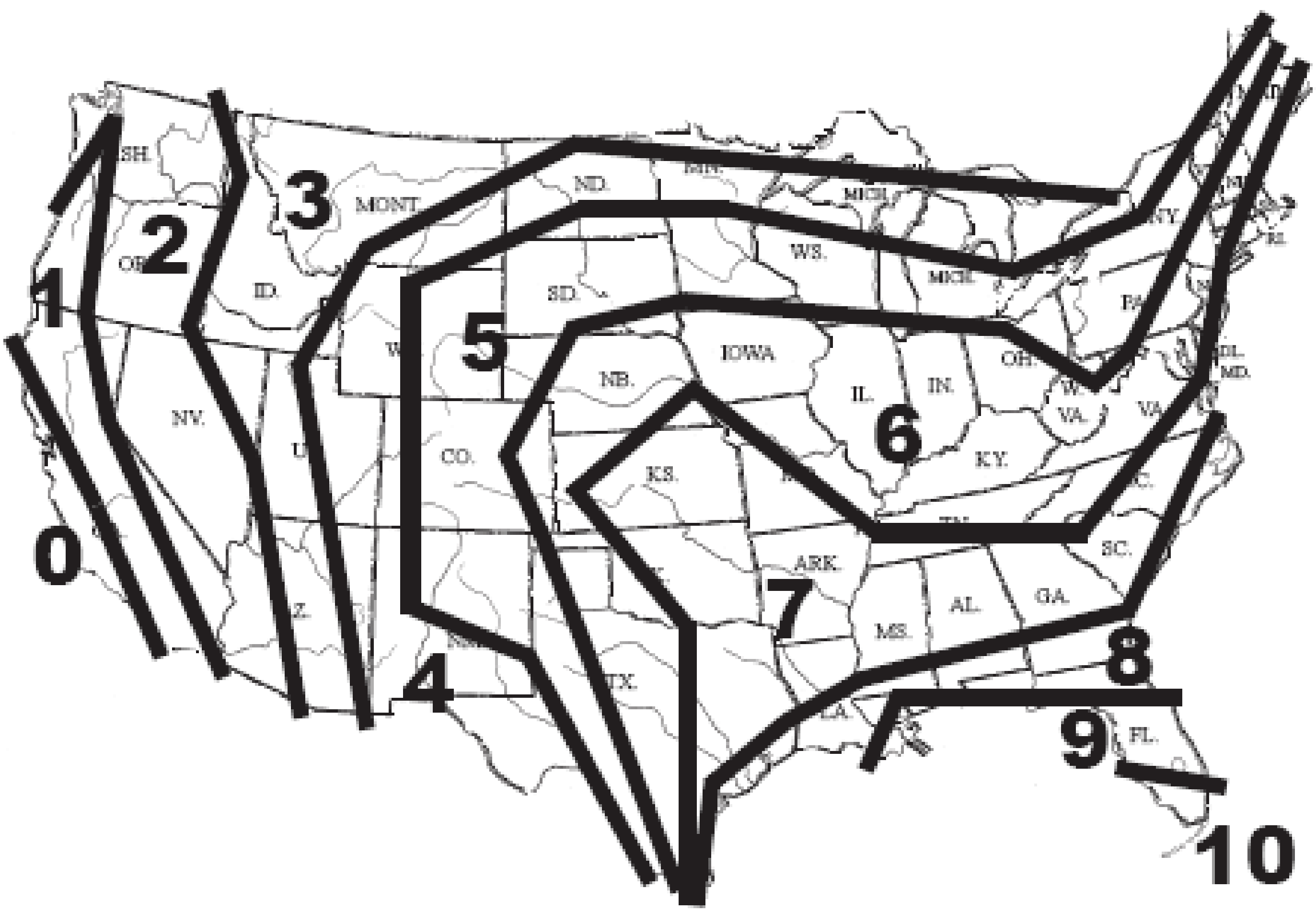

Figure 6: Coder composite storm damage intensity map for potential tree injury / damage, with lightning as one of the damaging components. (highest risk = 10; lowest risk = 0)

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Number of Lightning Ground Strikes per square mile per year = N

Number of Thunderstorm Days per year = T

$$N = (0.015 \times (T)^{1.34}) \times 2.59$$

Figure 7: Estimating cloud to ground lightning strikes per square mile per year using thunderstorm days per year.
(after Cooray & Fernando 2010)

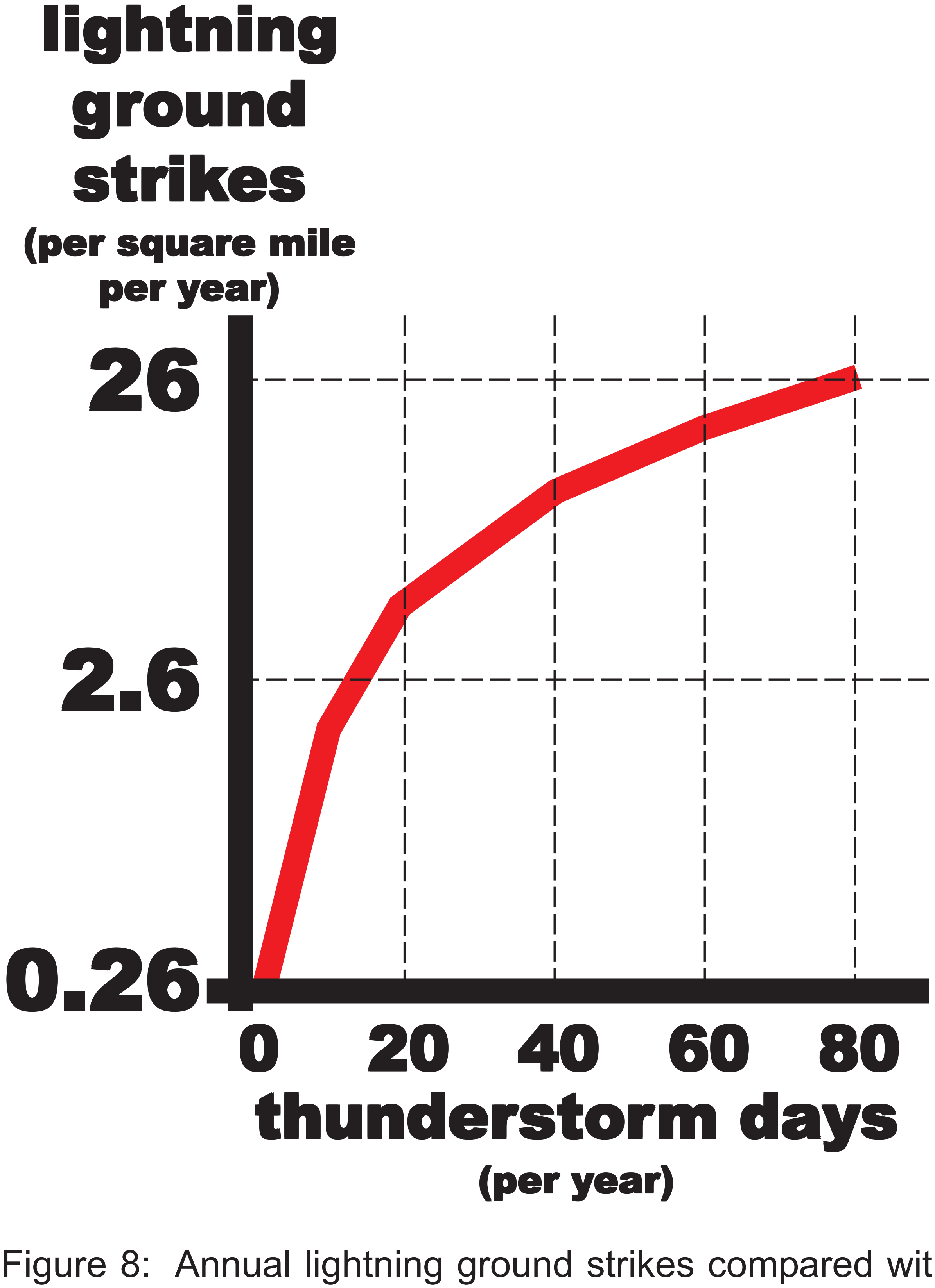

Figure 8: Annual lightning ground strikes compared with annual thunderstorm days. (Rakov & Uman 2013)

LIGHTNING GROUND STRIKES

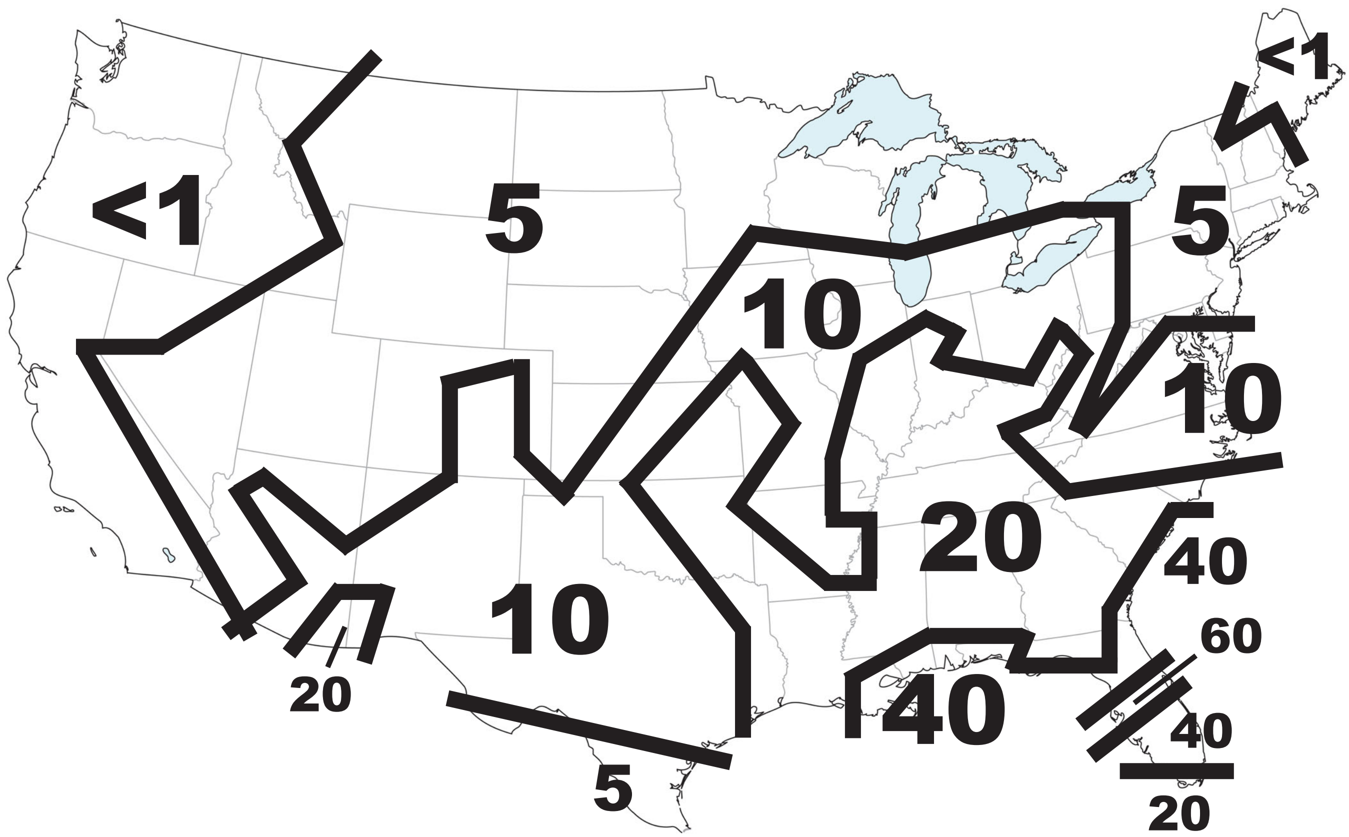

Figure 9: Cloud to ground lightning stikes per square mile per year. (1997-2007 national data)

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LIGHTNING GROUND STRIKES

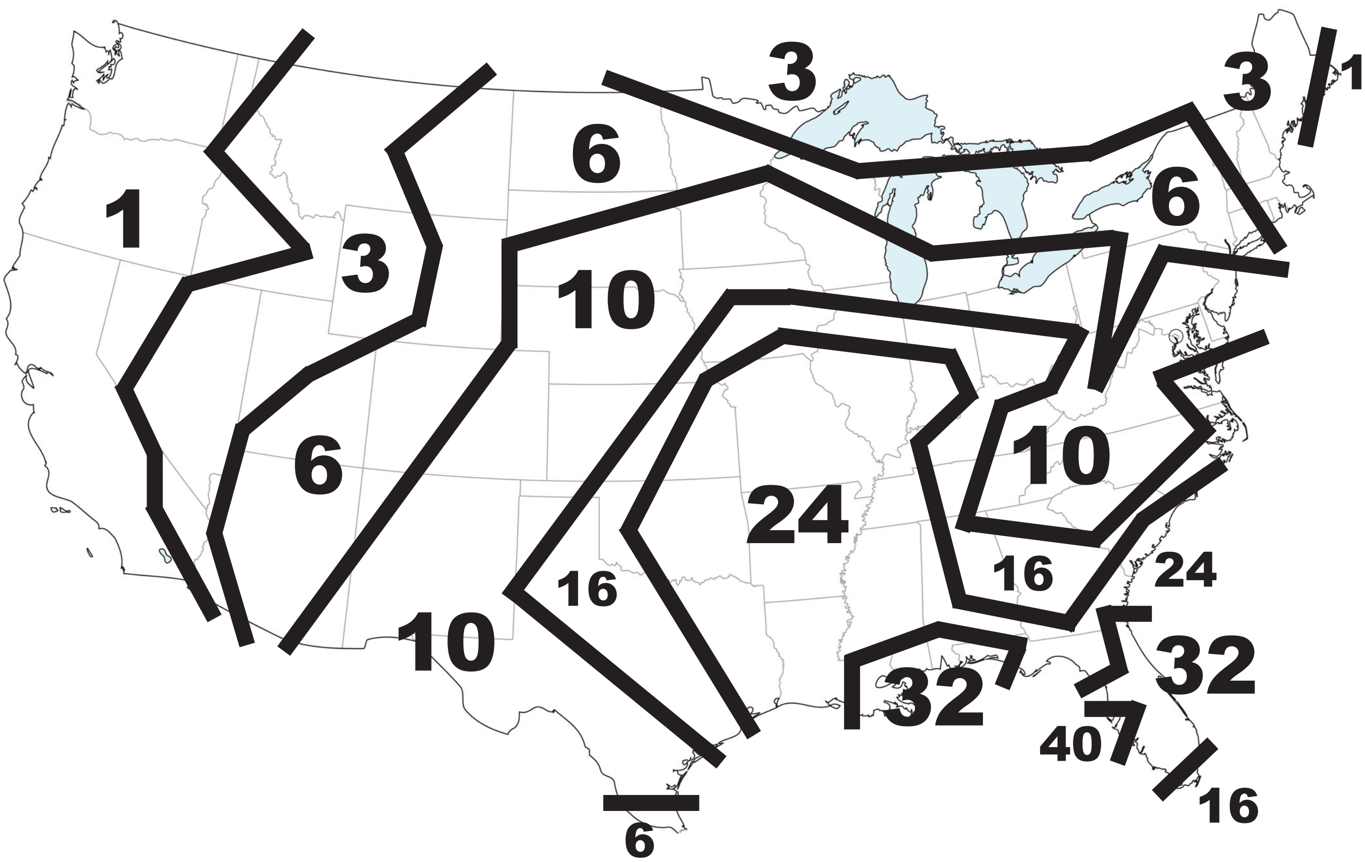

Figure 10: General cloud to ground lightning strikes per square mile per year (national data of past 15 years)