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# Lightning Ground Strikes & Associated Damage Costs

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Lightning and trees share a mythological association centered around forces of nature. Lightning strikes, thunder rolls, and trees stand (or fall) over many years. Tree damage from severe lightning strikes can be massive and terminal. Even small damage volumes can be susceptible to attack by secondary pests, like bark beetles, leading to tree death. Dehydration, tissue disruption, heating, and bark loss can all initiate critical problems in trees.

## What Is Lightning?

Lightning is an extremely long electrical spark greater than 0.6 mile. Average lightning length is between 3-6 miles, depending upon global location and storm energy. Maximum length is about 60 miles. (Uman 2008). Lightning is the result of electrical charge separation due to particle collisions in storm clouds areas with temperatures between 14°F and -4°F in the presence of super-cooled water. (Uman 2008)

Sparks generated by other means are not considered true lightning. Volcanic eruptions cause atypical lightning sparks generated from violent ash interactions. Nuclear ground and air bursts can also generate atypical lightning. (Uman 2008). Short sparks generated in laboratories (<10 feet) or in sand storms (<8 feet) are not considered lightning. Static electricity discharge from socks rubbed over a carpet generating <10,000 volts with spark length <0.15 inches is also not considered lightning. (Uman 2008).

## How Much

There are ~2,000 active thunderstorms per day worldwide. Lightning strikes ground somewhere on Earth 9 million times a day -- 6,200 times a minute -- 100 times per second. (Uman 2008) Lightning ground strikes for a typical small thunderstorm averages about 1 strike every 30 seconds for roughly 50 minutes over a ground area of 80 square miles. Figure 1 shows the world's top five recording stations for cloud to ground strikes per year per square mile. (Bouquegneau & Rakov 2010).

One estimate is 500,000 lightning strikes terminate on trees every day (~6% of all lightning strikes). Lightning severely damages and kills thousands of trees each year. Many of these trees line community streets, stand in parks, and surround homes and schools. Figure 2 provides a list of cloud to ground lightning strikes per square mile per year for states with the most and least strikes.

For example, Georgia has between 50-70 thunderstorm days per year. These thunderstorm events annually generate an average of 15-20 lightning ground strikes across every square mile in Georgia. Over a number of years, storms will produce many lightning ground strikes which cause extensive

damage to historic, rare, specimen, and valuable trees. Tree health care providers need to understand lightning forces, damage, treatment, and protection.

Damage Costs

The cost of lightning damage is large. In one study in Canada, Mills and his team found around $1 billion per year are lost in the largest four sectors of the economy plagued by lightning. These sectors are human health, property damage, forestry impacts (fire centered), and damage to the electric grid. Data is either poor or missing in several other sectors of the economy concerning lightning (i.e. aviation). Figure 3 provides the break down by sectors for lightning damage.

In the United States, average annual loss from lightning is cited as roughly $5 billion, $2 billion just from aviation sector alone not including $200 million cost in military aircraft per year. Approximately 30% of all power outages in the United States are lightning related accounting for $1 billion in costs. Annual insurance costs from lightning are given in Figure 4. (Uman 2008).

Human Health

Lightning has an important impact on human health. Lightning both injures and kills many people each year in the United States. About 500 people are seriously injured each year from lightning -- of these people, approximately 100 (20%) are killed. Feed lot and pastured animal losses are significant. Direct property damage has been estimated to be $175 million annually in the Southern United States. Damage to utility structures is immense. Both forest trees and trees along community streets and in yards are severely damaged.

Fatality data from lightning are given in Figure 5. This figure shows average deaths from storm events in the United states per year. Of the four major categories of storm fatalities -- flood, lightning, tornadoes, and hurricanes -- lightning is responsible for 27% of all deaths. Figure 6 provides a 10 year distribution of lightning caused death by location or activity. Hiding under, or in contact with, trees comprises 19% of all lightning fatalities. It is clear to stay out of the open and from under trees, and do not boat, farm, or golf under impending lightning generating conditions.

Figure 7 shows lightning deaths rankings by state per year. Injury to people (and domestic animals) is not just from being along the direct current path of a cloud to ground strike. People can be injured from:

1. being in the direct current path and ground surface arcing area;
2. standing in the step voltage area;
3. touch voltage (contact with objects along energized path);
4. side flash away from direct current path; and,
5. being a part of a ground streamer path not eventually connected to direct lightning path.

The electric field changes surrounding a lightning pathway can initiate many types of injury because of the massive field strength, and the electric field needed to impact humans physically and biologically can be so small. Figure 8 shows the top medical injuries and associated problems demonstrated by lightning strike survivors.

Conclusions

Lightning is a common occurrence across the globe and in the United States. Lightning causes great damage to people and property, including valuable tree. Modern life can be greatly disrupted by the unpredictable nature, undefendable attachment, and shear power of lightning.

| rank # | world location | annual lightning strikes per square mile |
|---|---|---|
| 1. | Kamembe, Rwanda | 215 |
| 2. | Boende, Congo | 172 |
| 3. | Lusambo, Congo | 135 |
| 4. | Kananga, Congo | 130 |
| 5. | Kuala Lumpar, Malaysia | 125 |
| | Tampa Bay, Florida (most lightning strikes in US) | 42 |

Figure 1: Top five places on Earth with the highest recored cloud to ground lightning strikes per year per square mile.
(Bouquegneau & Rakov 2010)

| rank | state | lightning strikes per year per square mile |
|---|---|---|
| 1. | Florida | 33.1 |
| 2. | Oklahoma | 32,7 |
| 3. | Arkansas | 29.2 |
| 4. | Missouri | 27.3 |
| 5. | Indiana | 27.0 |
| 5. | Kansas | 27.0 |
| 6. | Louisiana | 26.6 |
| 12. | Georgia | 22.1 |
| 45. | Idaho | 2.2 |
| 46. | Rhode Island | 1.8 |
| 47. | Oregon | 1.3 |
| 48. | California | 1.1 |
| 49. | Washington | 0.4 |

Figure 2: State rankings of average annual cloud to ground lightning strikes per square mile. (2005-2009 USPLN data)

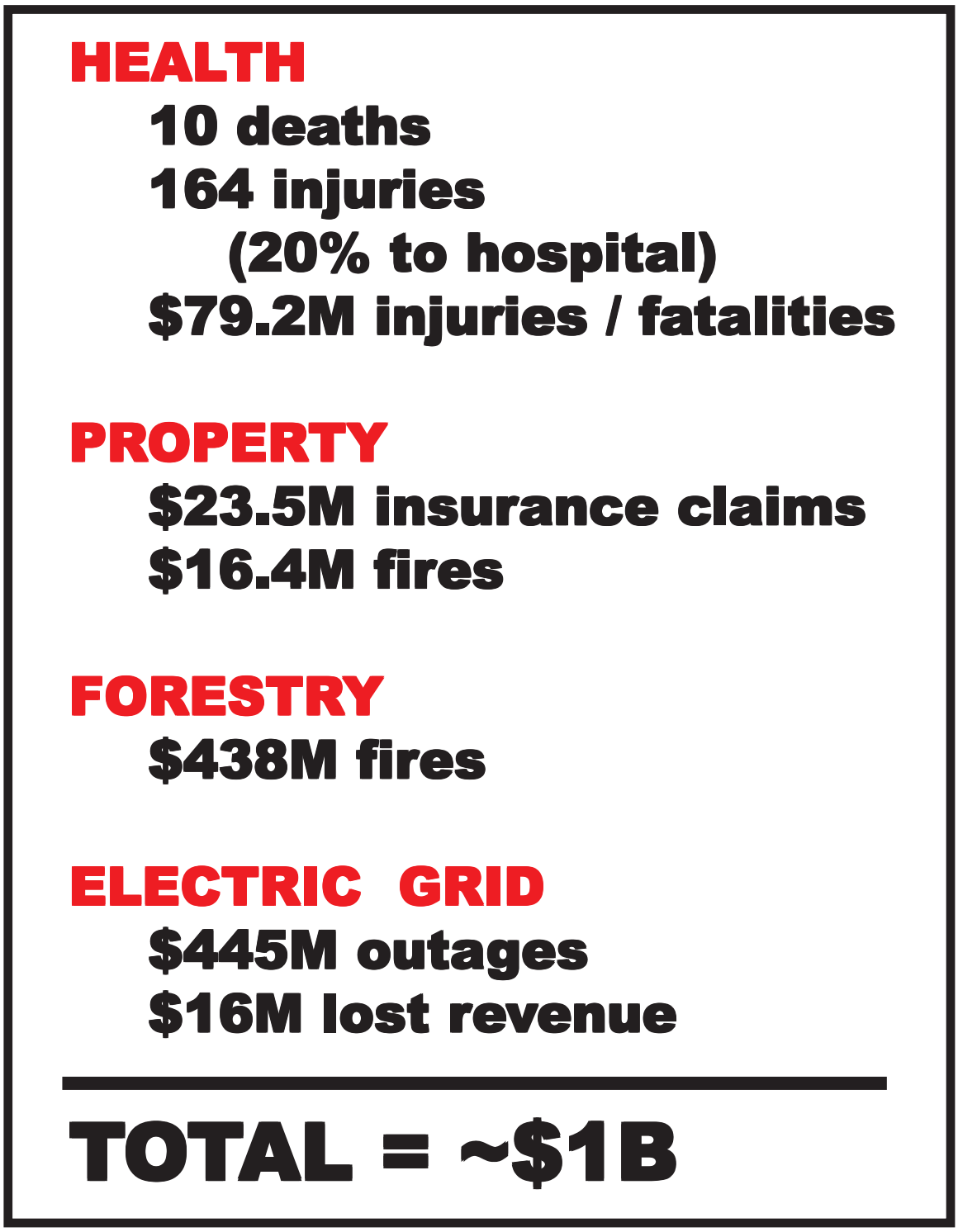


Figure 3: Annual lightning related losses within the largest four economic sectors in Canada. (Mills et.al. 2010)

# Insurance Costs / Losses From Lightning

**5% of all claims have lightning related damage (~$660 million)**

**average pay-out per lightning ground strike = $12.00**

**1 lightning related damage pay-out per 60 strikes**

**EXAMPLE DAMAGE / LOSS:**

- **house fires =**
  - **$175 million/year**
  - **30,000/year**
- **30% of all church fires**
- **10,000 wildland fires in Western US**
- **primary cause of farm / ranch fires**
- **80% of all livestock losses**
- **$100 million computer / electronics**

Figure 4: Annual lightning related losses in the United States from the insurance sector of the economy. (Uman 2008)

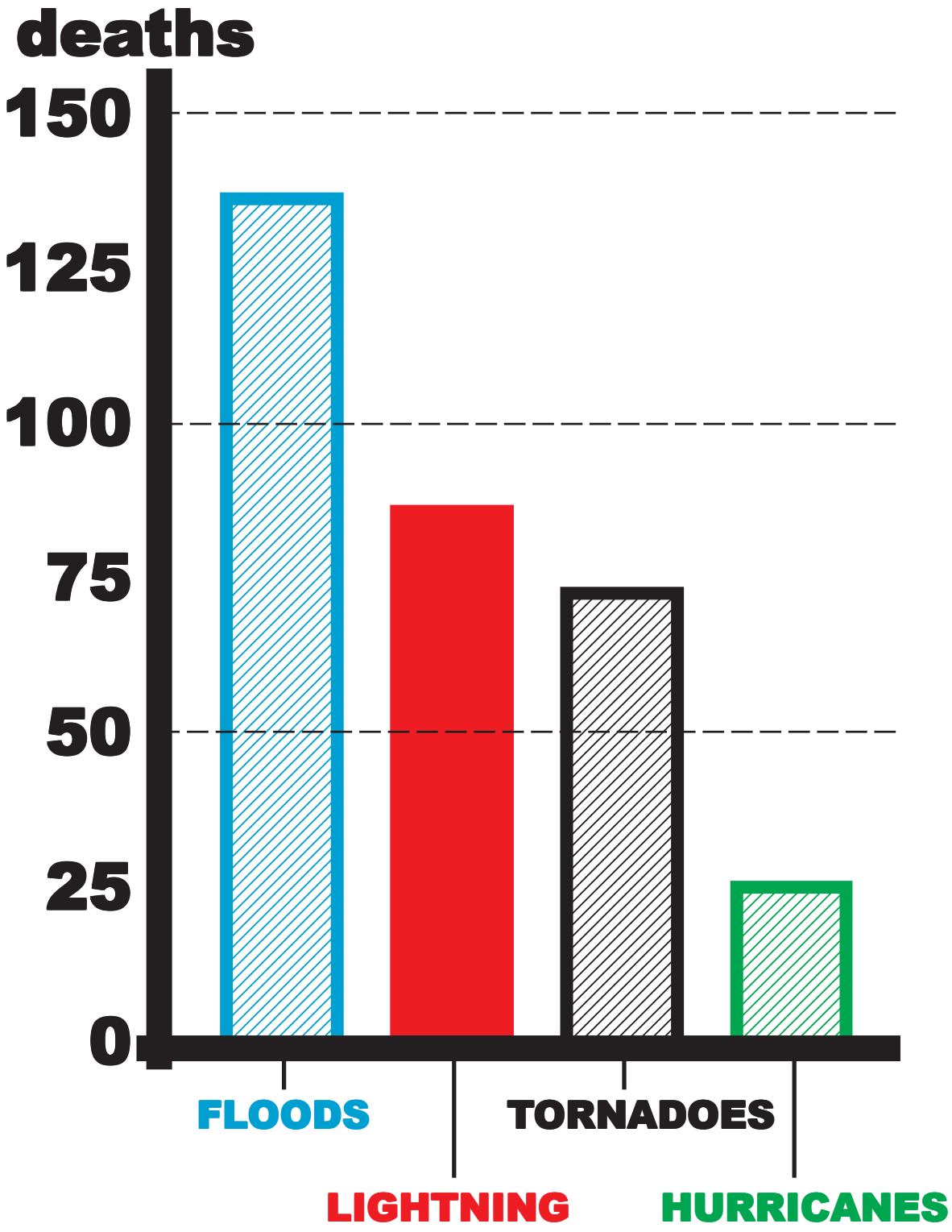


Figure 5: Average number of storm related deaths per year in the United States. (NOAA data from Rakov & Uman 2003)

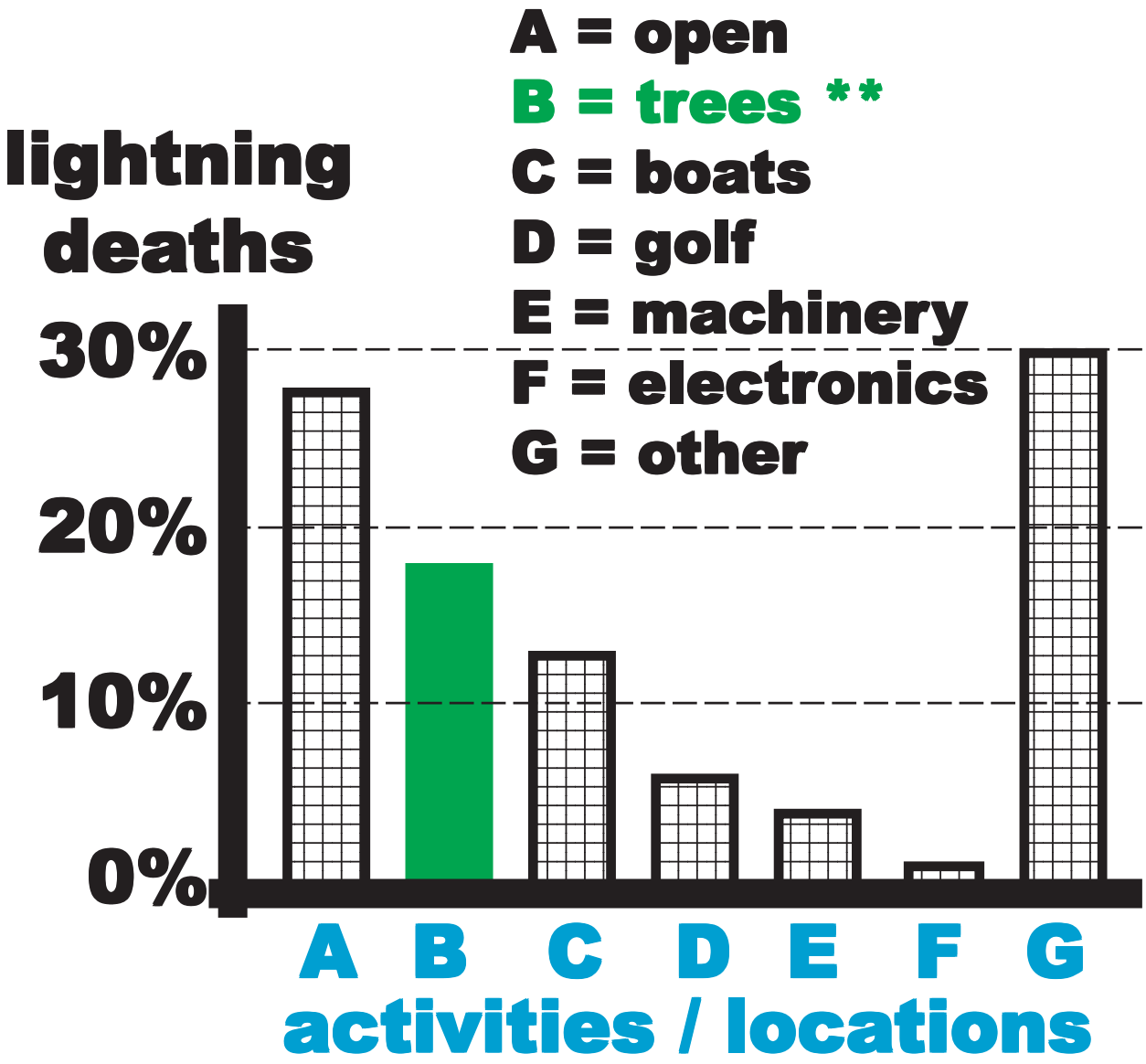


Figure 6: Lightning deaths for a 10 year period in the United States by location or activity.
(NOAA data listed in Rakov & Uman 2003)

| rank | state | annual deaths | deaths per million |
|---|---|---|---|
| 1. | Florida | 7.4 | 0.43 |
| 2. | Texas | 2.8 | 0.12 |
| 3. | Colorado | 2.7 | 0.59 |
| 4. | Georgia | 2.3 | 0.26 |
| 5. | North Carolina | 1.9 | 0.22 |

Figure 7: Top five state rankings for average lightning fatalities, and deaths per million people in each state. (1998-2007 data)

| top medical problems | percent of lightning survivors |
|---|---|
| memory problems | 52% |
| sleep disorders | 44% |
| attention deficits | 41% |
| dizzy | 38% |
| fatique | 37% |
| numbness / paralysis | 36% |
| joint stiffness | 35% |

Figure 8: Percent of lightning strike survivors claiming specific medical problems.

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