RESEARCH LABORATORY TECHNICAL REPORT

Lightning Protection for Trees

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Thousands of trees are struck by lightning every year. These trees will have varying degrees of damage ranging from complete shattering and destruction of the tree, to a slow lingering death, to virtually no apparent damage at all (Figure 1). When severe damage does occur, parts of the tree can fall or be thrown hundreds of yards causing extensive damage to people or property. In dry conditions the electrical current may also flow through the root system, potentially damaging and destroying it. Trees with lightning damaged roots rarely survive.

Figure 1: Moderate lightning damage showing bark damage and groove in the sapwood

Lightning

Lightning is a transient, high current electric discharge whose path length is measured in miles. The main type of lightning we are concerned with is between clouds and ground. The first portion of lightning typically seen is the "stepped leader" that descends from a storm cloud. As it nears earth, "streamers" aredrawn from tall and /or conductive structures. The streamers and the leader attach 30 to 100 yards above the structure. At this connection the first stroke of lightning occurs. After this initial stroke there are usually two or three more exchanges of current that comprise a strike. Each stroke lasts about 1/100 to 3/100 of a second and each strike 2/10 or 5/10 of a second. The total current in a strike is usually between 20,000 and 50,000 amps at about 100,000 volts or 10 to 30 Coulombs. Some strikes have a longer lasting, continuous flow of current (100 amps for 0.1 second). These strikes are more likely to start fires.

Sideflash

When lightning strikes a tall tree it may travel down the stem for a distance, then leave the tree "jumping" to a more conductive tree, structure or animal. This is called sideflash. In urban areas this sideflash can cause serious damage to structures, often starting fires. It is also responsible for the death of groups of trees or people/animals taking refuge under the tree during a storm.

Step Voltage

As lightning leaves an unprotected tree it goes into the soil. At the soil surface there will be a great difference in the electrical potential. This is called "step voltage". If people or animals are standing in the area, potentially deadly electricity may flow through them rather than staying in the soil.

The National Fire Protection Association (780 F-1) recommends that trees within 10 feet (3m) of a structure, that are taller than the structure or have branches over the structure, should be protected. This is to reduce the risk of sideflash and to reduce the risk of damage from the tree being splintered by lightning. The Tree Care Industry Association goes beyond this to recommend protecting trees of historical interest, high value, in recreational areas, parks, golf courses, and those more prone to strikes because of their location, isolated on hills, pastures or near water.

Lightning Protection Systems

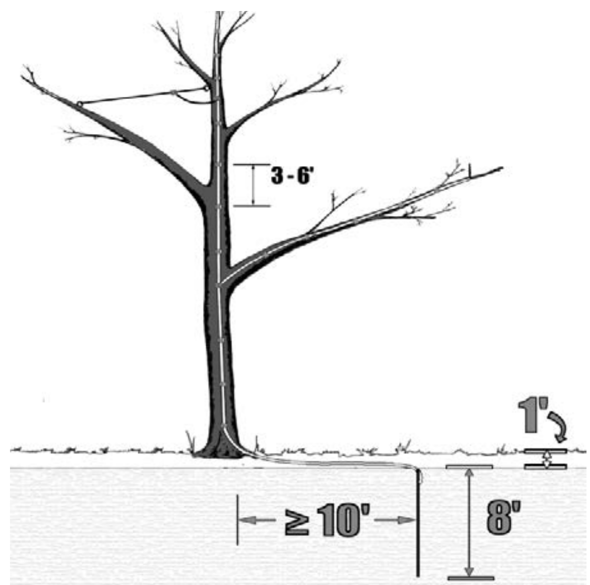
Lightning protection systems are installed in trees to provide a preferred, non-damaging path to ground for a lightning strike. Since trees are often much taller than adjacent houses or other structures, the streamer produced at the top of a tree's lightning protection system will be much higher than those from most adjacent structures. This results in the tree's lightning protection systems being more likely to be struck. Lightning protection systems in trees are not intended to dissipate the electrical charge, but rather they are intended to be receptive to a strike and safely conduct it to ground. This local receptiveness may act to protect adjacent structures. Protected trees should not be considered safe havens for people during storms.

Lightning protection systems are extremely effective at preventing damage to trees. Systems that are correctly installed and maintained are thought to be over 98% effective at preventing serious damage to trees. The working life of lightning protection systems can be very long. The conductor and major components may last for 50 years. If parts do deteriorate, they can be replaced or upgraded.

Materials and installation techniques used in lightning protection systems are specified by the American National Standards Institute (ANSI) A300 standard for Tree Lightning Protection. Since the objective of a lightning protection system is to provide a preferred path to ground for lightning strikes, a conductor is installed in the tree from near the top, down the trunk and major branches, to a grounding system (Figure 2). Conductors are copper cables composed of 14 strands of 17 gauge copper wire. Aluminum conductor is not used because of problems with corrosion when in contact with acidic soil. Copper or bronze fasteners driven into the tree to attach the conductor are not toxic to the tree because they are compartmentalized by the xylem.

Systems should be inspected regularly and maintained to ensure reliability. Tree protection system installation and inspection, as with all tree maintenance, needs to be performed by a qualified arborist.

Figure 2: Example of a lightning protection system



Susceptibility to Lightning Strikes

When considering susceptibility, often the location of th tree is more important than the species. Those considered more susceptible to strikes are as follows:

- Trees on hill tops
- Trees in local areas or geographic regions with a history of numerous lightning strikes.
- The tallest tree in a group
- Trees growing in the open or small groups.
- Trees that border woods or line a street
- Trees close to water

Some tree species are thought to be more receptive to lightning than others. The reason for this is not known; it most likely has to do with tree height and electrical conductivity. Lists of susceptibility vary among authors. Table 1 provides a summary of species susceptibility.

Table 1: Susceptibility of non-protected temperate zone trees to lightning strikes

Tree genera	Susceptibility to lightning strikes
Acer (maple)	High
Aesculus (horsechestnut)	Low
Betula (birch)	Moderate to low
Catalpa	Moderate
Fagus (beech)	Low
Fraxinus (ash)	High
Ilex (holly)	Low
Liriodendron (tulip poplar)	Very high
Palm	High/moderate
Picea (spruce)	Moderate
Platanus (sycamore)	Moderate
Populus (poplar)	High
Quercus (oak)	High
Robinia (black locust)	High
Tsuga (hemlock)	High
Ulmus (elm)	High

Inspection/Maintenance

The working life of lightning protection systems can be very long. However, over time the tree will grow making the system potentially less effective. To avoid this, the system needs to be inspected on a regular basis (e.g. annually on fast growing trees, every two or three years on slow growing trees). Scheduling inspections is the responsibility of the tree's owner.

If the conductor has been grown over by the tree, this does not necessarily mean that the system will not function. However, to find out if the conductor is intact, an electrical continuity test will need to be performed. When problems are found during the inspection, they should be corrected as soon as possible.