RESEARCH LABORATORY TECHNICAL REPORT

BARTLETT TREE EXPERTS
SCIENTIFIC TREE CARE SINCE 1907

Determining Change of Lean

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Trees that do not grow perfectly upright are often considered predisposed to failure. While not all leaning trees are at a higher risk of failure, some may be. Failures related to lean can either be trunk failure or root-related failures. The International Tree Failure Database found that 10% of root failures and 7% of all reported trunk failures were related to a pre-failure lean.

While there is no generally accepted maximum angle of lean, the greater the angle, the greater the risk for tree failure. When lean exceeds 45 degrees, it is usually considered a higher likelihood of failure. If there are other defects associated with the tree such as decay, restricted root zone, soil mounding, high soil moisture, or severed roots, the potential for failure is even greater. The worst case is when the angle of lean is increasing. This usually indicates the tree is in the process of failing. If a change in lean angle is detected, the tree should be removed or other remedial action should be taken as soon as possible.

There are three types of leans: sweeps, bows and 'straight' leans (referred to simply as 'lean'). Sweeps or corrected leans usually develop from an event that altered stem growth years earlier (Figure 1). With this condition, the stem became deformed and then started growing upright again. In essence, sweeps are self-corrected leans. Another common cause of sweeps is when a young tree grows toward the light. This causes angled trunk growth. As the tree matures and has sufficient light, the new growth is more upright. Trees with sweeps are the least likely to fail of the three types of lean.

Figure 1: Oak with a sweep or corrected

Bows usually develop following loading by snow or ice. In this case, the tree is bent more at the top of the tree than the bottom (Figure 2). There is often internal xylem damage in trees with severe bows. Trees with poor stem taper are sensitive to bows.

Figure 2: Garry oak with a bow

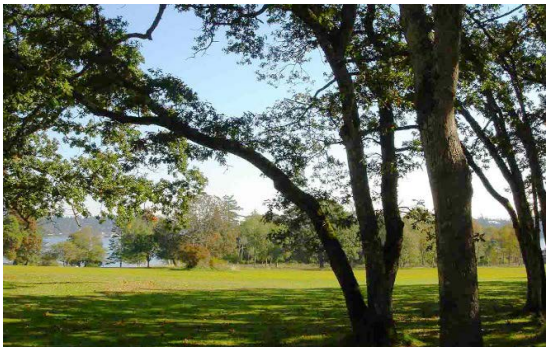

Figure 3: 'Straight' lean or simply 'lean'

The most common use of the term "lean" is when the angle of the trunk is uniform from top to bottom, a 'straight' lean. This often results from a failure of the root system or when the soil lacks the strength to keep the trunk upright (Figure 3).

Over the years, several methods have been developed to determine if the angle of a tree trunk is changing. The most common method is based on measuring the distance between two points. There are a couple of variations of this method. They both work best on trees with leans exceeding 25 degrees from vertical. First, is taking an actual measurement between a fixed point on the trunk or branch and another point on the ground. The point on the tree is fixed by driving a nail partially into the wood. The point on the soil is marked with a spike, stake or section of steel reinforcement bar. A tape measure determines the initial distance and, since the two points are fixed, the distance can be re-measured as desired (Figure 4).

Figure 4: Using a measuring tape to determine angle change

The second variation is attaching a plumb bob to the tree and marking its location at the soil line. If the angle of lean changes, the plumb line moves away from the soil mark (Figure 5). The plumb line can be left on the tree if it is in a low use area or can be reattached periodically to determine change in the angle of lean.

Figure 5: Using plumb bobs and fixed soil points

A newer method developed at the Bartlett Tree Research Laboratory is the use of a digital level to measure the angle of lean. This method provides a high degree of accuracy and allows for rapid and repeated measurement of the angle. It uses a relatively inexpensive digital level (Figure 6).

Figure 6: Measuring lean on the underside of a stem

Two nails are driven in the trunk, either the front or backside of the lean, along the length of the trunk. Good nails to use are long aluminum siding nails such as Homeshield Hy-Tensil 2 ¼ x 0.128 inch (Forestry Supplier 79285). The nails should be hammered a quarter to a half inch (0.5-1.2 cm) into the wood so trunk diameter growth does not interfere with future measurements. In high use areas, the nails may need to be driven more deeply to prevent vandalism and protect users from injury. Corrosion resistant deck screws may also be used.

The distance between the nails should be the same as the length of the digital level. Standard level lengths are 2, 3 and 4 feet. The two-foot length is easiest to use. Place the level on the nails, read and record the angle on the digital display. On your next visit, place the level on the nails again and check the angle. If it has changed more than a degree, the trunk angle is changing and action should be taken to reduce the likelihood of failure or move the target. The interval between inspections will be determined by the exact circumstances; it may vary from a day to a week to months. The greater the likelihood of injury or damage, the shorter the interval between measurements.

This new method to assess the angle of lean is easily adapted for use on any tree where there is a question of stability. It is fast, inexpensive and accurate. Also, it provides valuable information for making an informed decision on the likelihood of tree failure. It should be noted, however, that not all leaning trees that fail would be preceded by a measurable change in angle of lean. An abnormally severe weather event such as a hurricane, thunderstorm, freezing rain or heavy snow can cause the failure of a leaning tree that is otherwise stable, without being proceeded by a gradual change. Other times, a tree with only a slight lean may fail when a second factor such as decay or a root cut occurs.

Founded in 1926, The Bartlett Tree Research Laboratories is the research wing of Bartlett Tree Experts. Scientists here develop guidelines for all of the Company's services.