EFFECTS ON MAPLES OF PROLONGED EXPOSURE BY ARTIFICIAL GIRDLING ROOTS[1]

by Francis W. Holmes

Abstract. Artificial girdling of silver, sugar, Norway, Schwedler Norway, Crimson King Norway, and red maples was achieved by applying pressure of the trees' own growth against trunk expansion at ground level. Single angle irons plus a cable (Type I) were applied in 1966, and two parallel angle irons, bolted at their ends (Type II) were applied in 1967. Where girdles were applied, trunks were 6 to 8 cm (2.5 to 3 in.) in diameter. Next to each treated tree was an untreated one. Type I was associated with early fall color on all silver maples the first summer. The next year those trees died, completely girdled. Red and sugar maples slowly filled the entire Type I girdle, and all died after 7-8 years, but Norway maples engulfed the Type I devices and are alive as of 1983. In Type II, bolts were 30 cm apart; silver and Norway maple trunks filled these gaps after 16 years. The angle irons remained straight or bent only slightly. Tree bases with Type II treatment were greatly distorted but no foliar symptoms appeared. Trunk diameters and heights were equivalent to those of check trees. Tree vigor and growth were not affected until all or nearly all the circumference was girdled.

For many years arborists have been cautioned that a tree's own roots may "strangle" or "girdle" it (Haller 1959, Marshall 1948, Pirone 1978). Any roots found growing around, partly around, or tangential to, the base of the trunk, it was said, should be cut off. This at times has required the arborist to inflict a potentially large, associated wound and to detach a major component of the root system.

According to Pirone (1978), "Many trees are weakened and some are killed by the growth habits of certain of their roots. Such roots grow closely appressed to the main trunk or large laterals...this choking action restricts the movement of nutrients in the trunk or in the strangled area of the large roots..." [His illustration (#10-9) show numerous girdling roots, the cumulative effect of which clearly is to strangle the entire circumference of the trunk.]

Distortion of stem xylem vessels in a Norway maple girdled by its own roots was shown with the scanning electron microscope by Hudler (1981), who reported, however, that the vessels were not appreciably harmed in the root that was doing the girdling.

Alternatively, we commonly see tree *wounds* (from pruning, storms, motor vehicle accidents, vandalism, etc.) that occupy a quarter or more of the trunk's circumference. These trees usually neither die back nor even show leaf "scorch" symptoms that normally results from stress of water inadequacy. Trees even can recover from a saw cut made half-way around the trunk, although decay organisms may invade the trunk before the wound closes.

Can girdling roots, then, kill trees? Or can't they? These contradictory observations led the Shade Tree Laboratories to establish what finally developed into a 16-year experiment with synthetic or artificial "girdling" roots affecting the bases of tree trunks.

We chose maples because in the 1950's, according to those Massachusetts city and town Tree Wardens who participated in 3 annual surveys, a predominance (85% to 90%) of the trees then being planted in the public tree belts or adjacent property were maples (McKenzie 1960).

Materials and Methods

In a block of 360 maples, planted in 1964 in the Shade Tree Laboratories' Hadley Research Nursery as part of the Maple Decline Project (McIntire-Stennis #2), two transects were later assigned to this study. Each transect comprised: 5 sugar maples (*Acer saccharum* Marsh.); 5 silver maples (*A. saccharinum* L.); 1 red maple (*A. rubrum* L.); 5 Norway maples (*A. platanoides* L.); 1 Schwedler Norway maple (*A. plantanoides* cv. 'Schwedleri'); and, 1 Crimson King Norway maple

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(*A. plantanoides* cv. 'Crimson King'). Each tree was within a row of 20 trees of the same kind. The trees were 2.4 m (8 ft) apart in each direction. At first, the small trees did not compete for light or water; grass between them was mowed regularly. Later, crowns expanded so that deep shade killed all grass and also the slower-growing trees.

A tree with natural girdling roots, is always pushing against *itself.* Trees can, and commonly do, easily shove aside objects that threaten to girdle them on only one side (example: the lifting of adjacent sidewalks by root pressure). The creation of artificial girdling on one side of a tree could not be achieved by the juxtaposition of an unattached heavy object. We had to pit the tree against itself, like an isometric exercise.

In nature, girdling roots ordinarily occur around or against larger roots and around or against the trunk, either below, at, or slightly above ground. We placed our devices on the ground surface near the area of natural girdling roots.

Type I. Initially we tried to girdle in a limited way by means of a cable, attached at each end to one or other end of a horizontal angle iron that passed and touched the other side of the tree (Fig. 1a). The device was applied on May 31, 1966, to 18 trees and 18 similar trees were assigned as untreated controls.

The Type I devices failed to yield even limited injury. By the second year silver maple growth filled the two little triangles between each bar and its cable. These trees become entirely girdled and in every case their above-ground portions died. We had to design a device that could not be filled for many years. However, from these preliminary results we realized that the angle iron girdled as effectively as the cable.

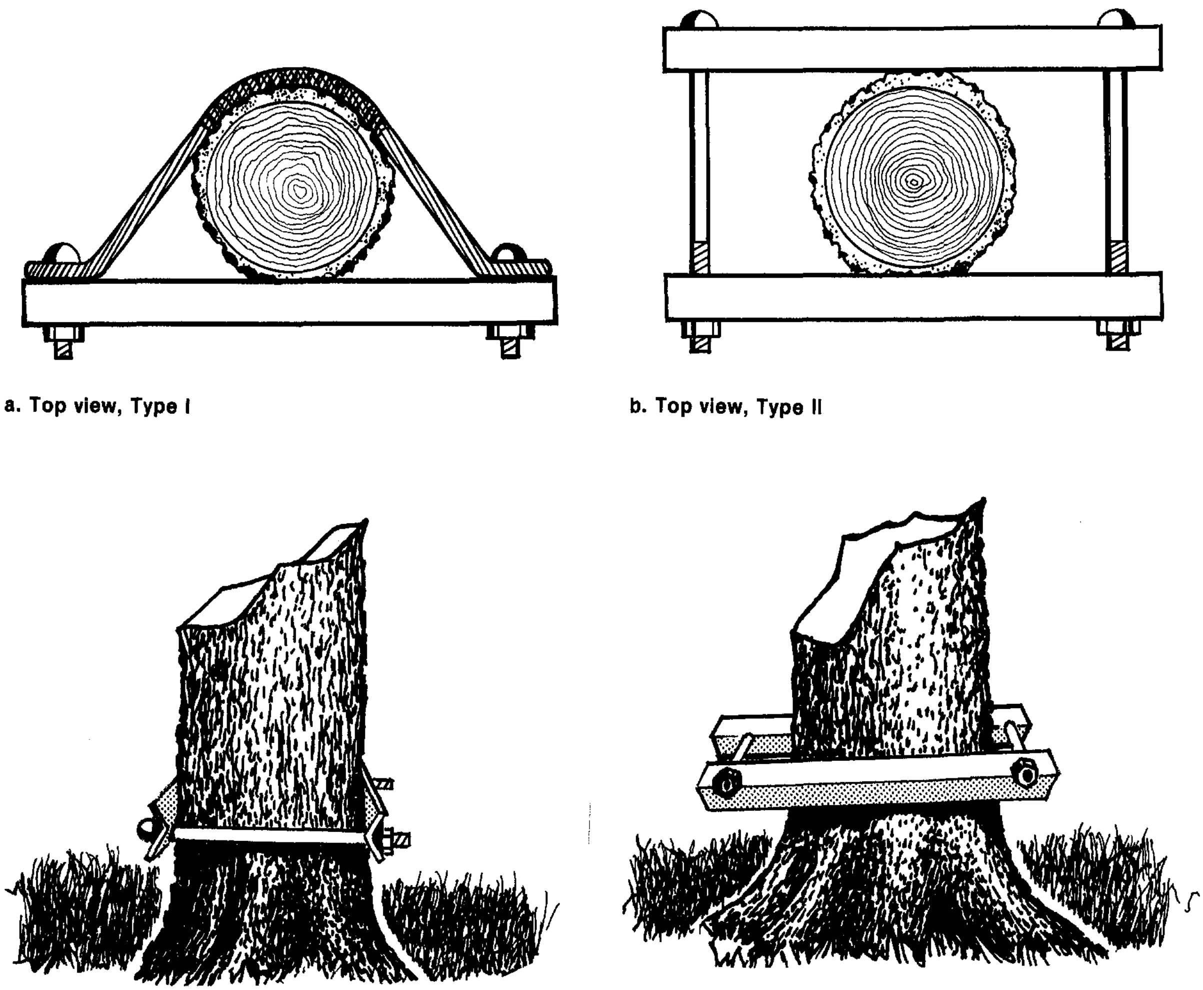
Type II. In our second effort, on July 20, 1967, we applied (again to 18 trees with a parallel 18 control trees) *two* such angle irons, of 4 mm (3/16 in.) thick iron, each about 5 cm (2 in.) wide by 0.4 meters (15 in.) long, bolted at each end with 15 cm (6 in.) × 1 cm (3/8 in.) bolts, to create a very long, narrow rectangle instead of a blunt isoceles triangle (Fig. 1 b,c,d). The tree trunk then would have to grow to about 6 or 8 times its starting basal diameter before it would be able to fill the empty spaces at each end. There was no cable: girdling would be solely by the angle irons. The tree would have, in effect, *two* girdling roots: on opposite sides of the trunk. We did not imitate the single girdling root on one side only.

Results

Type I. There was variation among species to our Type I synthetic "girdling roots." The silver maples grew so fast that they filled the pairs of triangles in a single year. The first year they showed early fall color in late summer, and they died the next year before they had had time to overlap and engulf the cables. The sugar and red maples grew very slowly. After several years they finally filled the triangular gaps. They died before they had time even to begin to overlap the cables. But all three varieties of Norway maples, with an intermediate rate of growth, managed to form natural bridge-grafts over the cables before they had filled the triangular gaps. As a result, some of these Norway maples still stand. By now each tree has entirely engulfed the Type I girdling apparatus.

Type II. For 16 years we watched the growth and health of the trees treated with our Type II girdling roots, and their control trees. The entire plantation grew taller and the foliar canopy merged. One control tree and one treated tree (Fig. 2) lagged behind the others in growth early in the study. Both were shaded and soon died. But the others, surprisingly, showed almost no differences in growth rate. Norway and sugar maples, 2" dbh in 1965, now are becoming large enough to fill the rectangle of angle irons plus bolts. Many died in the last year or two, until now 11 girdle-treated and 10 untreated ("control") trees are alive in each original group of 18. However, the Norway maples are likely to engulf the girdles by self-grafting: their trunk tissues now have met outside the angle irons.

Average dbh's (diameters at breast height), in inches, at the end of the experiment, for girdled vs. nongirdled trees, and number (n) of survivors, were: Norway maple, 6.7 (4.8 to 9.5, n=5) vs. 4.8 (3.8 to 5.3, n=2); Silver maple, 9.1 (6.5 to 11.5, n=4) vs. 9.9 (8.5 to 10.5, n=4), Sugar maple 5.3 (n=1) vs. 4.2 (2.8 to 5.0, n=2); most sugar maples were cut by an unknown person several years ago), red maple 4.0 vs. 5.5 (only one red maple replicate in the experiment). The



a. Top view, Type I

b. Top view, Type II

c. End view, Type II

d. Side view, Type II

Figure 1. Diagrams to illustrate installation of synthetic girdling roots.

bases of all the girdled trunks were enlarged (through accumulation of translocated food above the blockage) and became greatly distorted over the 16 years (Fig. 2).

Discussion

It has been almost a fad recently to debunk various beliefs that have been held almost as matters of faith by earlier arborists and arboricultural scientists. Our study shows that the earlier tenets on girdling roots are *not* all wrong. Girdling all the way around finally *does* kill a tree, unless it engulfs the girdling object and completes a natural bridge graft over it on one side of the tree before too much interruption occurs in the upward flow of water and/or downward flow of nutrients at all other points.

Tate (1980, 1981), in Ann Arbor, MI, also found no difference in growth rate, in this case between 336 Norway maple street trees with one or more "girdling" roots and 74 without such roots.

Even partial girdling, as it approaches completeness, reportedly may weaken a tree enough to entice attack by secondary insects and pathogens, although we did not encounter this effect in our experiment. On the other hand, the word "girdle" means something that goes all the way around an object. It seems fair to suggest that a single tangential "girdling" root is not actually *girdling* the tree and is not a serious threat to well-being. Such a root, that occurs only on one side and causes only partial girdling, might better be called an "embedded root."

The wound that would be left by removal of such a very large embedded root in a large tree might be worse than leaving the embedded root in place. The injury through potential invasion of wood decaying organisms would be accentuated by the loss to the tree of the considerable root system that is naturally associated with such a root, as pointed out by Hudler (1981).

One caution: Our experience has been that after a single embedded root is removed, digging often reveals others at lower levels. The sum of the effects of *several* such roots may indeed be to girdle the tree in the true sense of all-the-way-around!

Conclusions

The Shade Tree Laboratories now advise preventative steps against girdling by roots. The first step can be taken at the time of transplanting. Allow ample lateral space to spread the roots, to allow for symmetrical growth. The second step should be taken early in a tree's development — after it has been in place no more than about a decade. With a trowel, gently (to avoid wounding large roots) turn back the turf over the roots system, out to at least half a meter from the trunk. Any small roots that branch at right angles to the main radiating root, and hence appear to lie in a position to become embedded once the trunk enlarges enough to reach them, or any small roots that cross over large radiating roots, can easily be snipped off with hand shears.

The discovery of a large embedded root also should lead to more digging. With trowel and whisk broom, explore underground all the way around the base of the trunk, and also along all the major buttress roots. If there are multiple embedded roots around the circumference, which would combine with the visible one to girdle the tree, surgery is unavoidable. But if we find no trouble except the one embedded root, and if most of the root system is intact, we would leave it alone — especially if there are no foliar symptoms of concern. Tate (1980, 1981) also concluded that removal of such roots was not cost-effective. Only 5% of his 336 cases were "girdled" more than halfway around the trunk, and 53% were less than ¼ "girdled."

Girdling roots usually are diagnosed because they are visible above ground. Other times they are suspected because of crown dieback ("stag-heading") or, at an earlier stage, because of leaf "scorch" resulting from water deficiency. If exploration by careful digging shows many girdling roots, adding up to near-complete girdling, then their removal may offer hope for recovery.

If, however, only a single, tangential, embedded root is found, it could also be dangerous to delude

Figure 2. Photograph of a synthetic girdling root on a tree trunk that was removed from the experiment six years after installation. The device presumably did not kill this tree, since at this time only one of the 18 treated trees and one of the 18 untreated trees died.

oneself that the sole cause of the dieback has always been found. We no longer consider a *single* embedded root (on *one side* of a tree trunk) to be sufficient diagnosis for scorched foliage and/or for dead upper branches. Our study indicates that then, for maples at least, **some other cause** remains to be found and appropriately corrected before hope can be held out for restoration of the tree to vigor and thrift.

The fact that Norway maples engulfed and self-grafted over the synthetic girdling roots should not be taken as conclusive evidence that they would necessarily accomplish this feat with natural girdling roots. After all, the synthetic devices did not grow any larger with time, whereas the tree's own girdling roots enlarge every year. Tate (1980, 1981) did not report engulfing of such embedded roots on any of his 336 Norway maples.

This study does not purport to show a critical point below which girdling is of minor consequence and above which it is a threat to tree survival (either directly or by opening the way for secondary attacks). We have, however, modified our views at the Shade Tree Laboratories as to how much girdling a tree can stand without obvious detriment, apart from basal distortion of appearance as only a blemish requiring no remedial treatment.

Literature Cited

1. Haller, J.M. 1959. Tree care. New York, Macmillan, 224 pages (see pages 184-485).
2. Holmes, F.W. 1975. *Effects of 8- and 9-years' artificial pressure girdling of silver, sugar, red, Norway, Schwedler, and Crimson King maples at ground level.* (Abs.) Am. Phytopath. Soc. Proc. 2: 98.
3. Hudler, G.W., and M.A. Beale. 1981. *Anatomical features of girdling root injury.* J. Arboric. 7 (2): 29-32.
4. Marshall, Rush P. 1948. Care of damaged shade trees. U.S. Dept. Agriculture, Farmers' Bulletin #1987.
5. McKenzie, M.A. 1960. Personal communication.
6. Pirone, P.P. 1978. Tree maintenance. (edition 5). New York, Oxford Univ. Press, 587 pages (see pages 219-222).
7. Tate, Robert L. 1980. Detection, description and treatment of girdling roots on urban Norway maple trees. Univ. Michigan Ph.D. dissertation, 93 pages.
8. Tate, Robert L. 1981. *Characteristics of girdling roots on urban Norway maples.* J. Arboric. 7(10): 268-270.
9. Tate, Robert L. 1981. *Bole characteristics associated with girdled Norway maple trees.* J. Arboric. 7(11): 308.

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ABSTRACT

THURMAN, PETER W. 1983. **The management of urban street trees using computerized inventory systems.** Arboric. J. 7: 101-107.

Trees are a vital part of our urban environment. In order for them to flourish and continue, man must manage them. The efficient management of urban trees is very difficult. A great deal of information is needed before a complete and truthful "picture" of the tree population is obtained. Computerized inventory systems (CIS) in the USA have proved to be extremely helpful in raising the effectiveness (and therefore reducing the costs) of the many and various activities involved in competent urban tree management. Local authorities in the UK are now faced with severe financial cutbacks. CIS's, despite the extra short-term costs, could make considerable long-term savings. One of the cheapest and most practical ways of starting such a system would be to exploit the knowledge and experience already gained in the USA. Already proven general systems in use in America would be the easiest to adapt for use in this country. Alternatively, local authorities could consider adapting existing computer programs, such as those that have been prepared for street lights, etc. A further option would be the organization of an investigative study group of professionals to visit the USA in order to study various successful systems and to make recommendations to the profession as a whole on their return.