# COMPARTMENTALIZATION OF DISCOLORED AND DECAYED WOOD ASSOCIATED WITH INJECTION-TYPE WOUNDS IN HYBRID POPLAR

**by Alex L. Shigo, Walter Shortle, and Peter Garrett** [1]

**Abstract.** Sixty trees representing 9 different clones of *Populus deltoides* x *P. trichocarpa* hybrids were wounded in 1975, each tree receiving 14 drill wounds. Dissections of these trees after 6 months revealed several patterns of healing, ranging from poor closure and compartmentalization to excellent closure and compartmentalization. The results show that it is difficult to generalize on the healing patterns of injection-type wounds. One tree may have a strong healing response and another tree, of the same species, may have a weak response. The wound response seems to be under genetic control.

A variety of materials are injected into trees in attempts to prevent or minimize damage caused by insects and diseases. To get these materials into the tree, the bark is broken and the xylem is disrupted causing a wound, which can lead to discoloration and decay.

Most wounds heal and do not lead to decay. If this were not so, trees could not survive (14, 17, 18, 20). Most wounds do result in some discoloration. However, early stages of the discoloration processes do little or no harm to the structural integrity of the wood.

The purposes of this paper are: (1) to review past studies that give information about injection-type wounds, and (2) to report results of our recent studies that show the variations in healing patterns of injection-type wounds in hybrid poplar.

## Injection-type wounds

Many of the wounds made to inject materials into trees are the cylindrical type made with a drill bit. These wounds are similar to those made by an increment borer. Studies of increment-borer wounds in different tree species indicate that some wounds can lead to decay and that plugging these wounds does not prevent decay (2, 5, 6, 7, 8, 25).

The drill-bit type of wound is also made in collecting sap from sugar maple trees. Cambial dieback and internal decay are sometimes associated with such wounds, especially when the trees are overtapped or when paraformaldehyde pills are used to increase the sap-flow period (16, 21).

Another type of wound is the small drill hole made for detecting decay with the Shigometer (19). Discoloration is associated with these wounds, especially in birches (19). The drill wound made for the detection of decay is almost the same diameter as holes made by some ambrosia beetles (13). Discoloration and sometimes decay are associated with such ambrosia beetle holes (13).

Investigators have used injection-type wounds or drill wounds for studies of decay development (6, 7, 17, 18, 23, 24). In these experiments decay was sometimes associated with open control wounds and wounds plugged with sterile dowels (6, 7, 17, 23, 24).

Discolored wood was associated with chisel wounds 12 weeks after they were inflicted in red maple (15).

## Healing patterns: Closure and compartmentalization

Past studies of wound healing in woody plants have dealt almost exclusively with callus formation and wound closure (1, 4, 9, 11, 12, 22). Wound-closure has been considered by many investigators the same as wound-healing. In studies to determine the effect of wound dressings, wound closure has been used as the determinator of wound healing (3, 4, 6, 9, 10, 11, 12).

It must be realized that wound-healing in trees is more than wound-closure. Many large wounds on large old trees will never close, but they will heal. They heal from the inside.

It is conjectured that the survival of trees under constant wounding stress was possible because trees have developed, through evolution, some

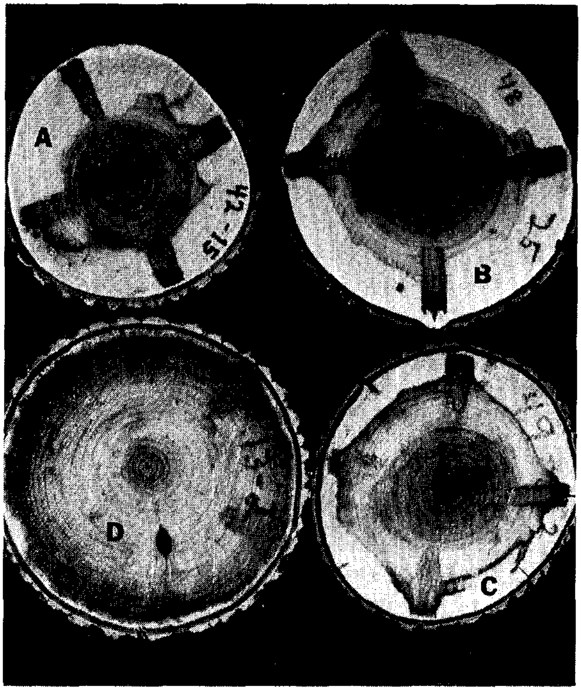


Figure 1. Cross-sections of four hybrid poplar trees showing degrees of internal compartmentalization: A, excellent; only tissues injured by the four drill wounds were discolored. B, good; discoloration spread tangentially from the four drill wounds. C, fair; discoloration spread tangentially from the four drill wounds. D, poor; the entire column associated with the wound was discolored.

very effective defensive systems for combating wound diseases. Trees developed built-in chemical protective systems that kept out most wood-destroying microorganisms. Trees developed also a built-in system for walling-off, confining, or compartmentalizing the few wood-destroying microorganisms that were able to surmount the chemical protective barrier and infect the wood (14, 15, 17, 18, 20). The internal phase of wound healing has received little attention, even though it is probably much more important as a survival system than the other part of wound-healing — closure.

Results of recent studies suggest that certain trees of the same species have more effective healing systems, external closure and internal compartmentalization, than others. The healing process and the events that follow (23) are also affected by the time of the year the wound occurs (9) and the position of the wound on the trunk.

Compartmentalization of injured and infected tissues is a two-part process: (1) to confine or wall off injured tissues to the smallest possible area; (2) to wall off the tissues present at the time of wounding from those that are formed subsequently.

Photographs of dissections are shown here to help clarify the first part of compartmentalization and to give added information about injection-type wounds.

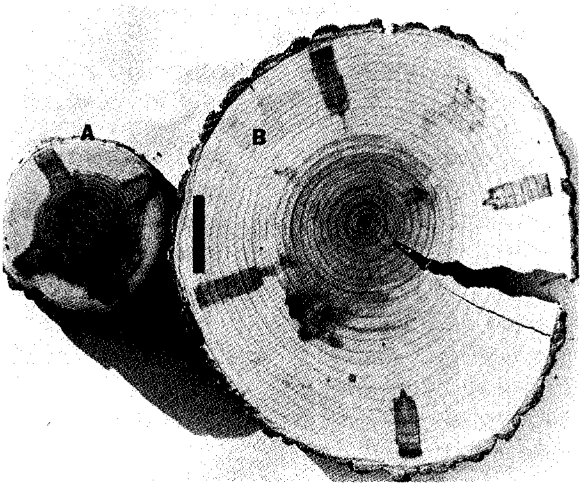


Figure 2. Cross-sections of two hybrid poplar trunks; A, poor growth, open wounds, but good internal compartmentalization. B, excellent growth, closure, and compartmentalization.

## Materials and methods

A total of 60 trees representing 9 different clones of *Populus deltoides* x *P. trichocarpa* hybrids on the Massabesic Experimental Forest at Alfred, Maine, were wounded in 1975. The trees were 25 years old, 10 to 20 m in height, 15 to 35 cm in diameter at 1.4 m aboveground, and all in the same planting.

Each tree received 14 wounds. Wounds, made with a drill bit, were 1.43 cm in diameter and 5 cm deep. On 27 March each tree received 6 wounds; 2 wounds each at approximately 0.5, 1.5, and 2.5 m aboveground. On 2 May each tree received 2 more wounds at 3 m aboveground. And on 3 June the trees received 6 additional wounds at the same heights as the

March wounds. In each whorl of wounds, the wounds were approximately 90 degrees from each other.

In October 1975, 3 trees each from each clone were cut and dissected.

**Results**

Dissections revealed several patterns of healing, ranging from poor closure and compartmentalization to excellent closure and compartmentalization (Fig. 1, 2, 3). In all trees, the new wood that formed after the wound was inflicted was not infected. In some trees the infections spread tangentially.

Trees in some clones had rapid, effective healing; trees in other clones had slow, poor healing.

Tree size was apparently not related to healing. Slow-growing trees and fast-growing trees often had the same internal healing pattern (Fig. 2).

**Discussion**

From our results it is difficult to generalize on the healing patterns of injection-type wounds. One tree may have a strong healing response and another tree, of the same species, may have a weak response.

The variations in response to increment-borer wounds on many tree species serve to complicate the subject (2, 5, 6, 7, 8, 25). Yet the common practice of tapping sugar maple trees for sap may lead some people to believe that trees can withstand the constant stress of many drill wounds.

Proper tapping procedures call for only a few tap wounds per tree. A general rule for tapping is one wound for each 6 inches of tree diameter. An 18-inch diameter maple would have 3 wounds.

Some other points should be mentioned about tapping of maples. Foremost is that sugar maple trees are, as a rule, strong compartmentalizers. In a short time after the wound in inflicted, the cambium begins to form new tissues.

For these reasons it would not be wise to use maple tapping as an example of injection-type wounds that cause no problems. When maples are overtapped, decay problems can result. When paraformaldehyde is added to the tap hole to increase sap yield, decay develops even faster (16). A combination of overtapping and paraformaldehyde can result in serious decay problems even in young, small trees.

The results of studies on hybrid poplar show that closure and compartmentalization are two separate parts of the healing process. Some drill wounds were closed, yet had large columns of discolored wood associated with them. Other wounds were open, yet had only small compartmentalized columns of discolored wood associated with them.

The healing process cannot be studied adequately without dissections. Studies that measure only external closure cannot be considered complete. Further studies on discoloration and decay associated with injection-type wounds must include internal examinations.

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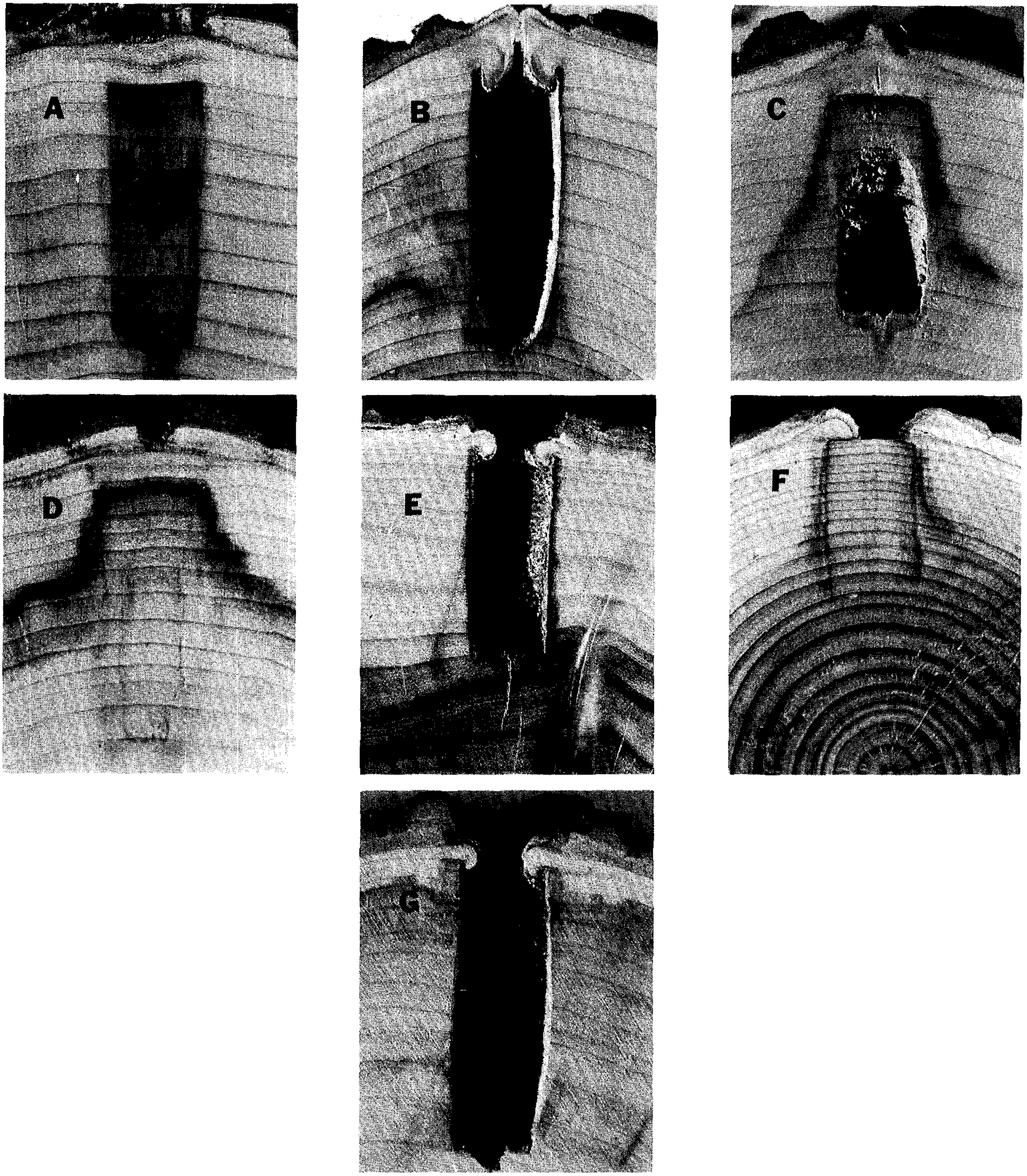


**Figure 3. Drill wounds in hybrid poplar. A, excellent uniform growth, excellent closure and compartmentalization. Note that discoloration did not move into the new ring that formed after wounding. B, good uniform growth, excellent closure and compartmentalization. C, good uniform growth, good closure and fair compartmentalization. D, good uniform growth, good closure, poor compartmentalization. E, excellent early growth, poor growth last 3 years, poor closure, excellent compartmentalization. F, poor uniform growth, poor closure, and good compartmentalization. G, excellent early growth, poor growth lasts 4 years, poor compartmentalization.**

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# TREE REPLACEMENT PROGRAM[1]

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**Abstract:** In the spring of 1973 Knoxville Utilities Board began the "Tree Replacement Program" as a possible means of reducing the overall cost of maintaining line clearance throughout our service area. The idea behind the program is to obtain permission from property owners to remove tall maturing, fast growing trees from under and alongside our power lines and replace them with low growing ornamental trees that in the future will need little or no pruning to maintain line clearance.

## Objective

The objective of this program is to stabilize or reduce line clearance costs. The purpose of this program is not to eliminate every tree that grows near or under our power lines, but to remove only those trees that have an excessive rate of growth. These trees, which must be pruned on a routine basis, are, in most cases, not beneficial to the customer or the landscape. According to a study made before this project was initiated, if trees that now need pruning away from lines once annually are removed and replaced with low growing trees that never need pruning, it would provide instant savings in the area of line clearance cost. Therefore, whether a tree needs pruning once each year or once every five years, a definite savings is realized with our present replacement program.

## Hypothetical Example

For an example, let us take a hypothetical situation. Suppose a five-man tree trimming crew has a tree to trim from under a power line. The job takes only ten minutes to prune and clean up the debris. That isn't much time! But, if the average wage for each man on the crew is 5 dollars per hour and the overhead is 30 percent, the expense of trucks, brush chipper, etc., are all included, that ten minute job would cost $8.74. If everything stayed the same and you pruned the tree every other year for the next twenty years, it would cost $87.44.

In actual practice, we have found that the removal cost for trees such as this one just described is little more than the routine pruning cost would have been for that time. Then, assuming we have removed this tree, we know from past experience the cost of a five to six-foot, balled and burlapped, replacement tree including labor involved in planting has averaged approximately $11.00 per tree. Then we can assume that for $19.74 we can eliminate all future cost.

[1] Presented at the 52nd Annual Convention of the International Society of Arboriculture in St. Louis, Missouri in August of 1976.