DISCOLORED AND DECAYED WOOD ASSOCIATED WITH INJECTION WOUNDS IN AMERICAN ELM

by Alex L. Shigo and Richard Campana[1]

Abstract. Dissection of 80 large American elm trees with a chainsaw revealed discolored and decayed wood associated with holes drilled for injections to control Dutch elm disease. Discolored wood was associated with every injection wound; injection wounds made in several successive years caused severe internal injuries. Until less injurious injection methods are developed, we suggest that injection holes be as small, shallow, clean-edged, and few as possible. Later injection sites should be at least 46 cm (18 in) above and not directly over older ones. If possible, drilling should be avoided at budbreak and in the valleys of fluted roots.

A lot is known about drill wounds in trees. The information comes from many studies on holes made by increment borers (Lorenz 1944, Hepting et al. 1949, Toole and Gammage 1959, Houston 1971), holes for tapping sugar maples (Shigo and Laing 1970), and holes for experiments on the wound response (Shigo 1976). The senior author has been studying wounds in trees for more than 18 years. From these studies three points have emerged that are relevant to injection wounds: 1) after a hole is made the tree reacts; discolored wood develops, microorganisms infect, and decay may set in; 2) if more holes are made later, the individual columns of discolored wood associated with each wound begin to coalesce to form large columns of dead discolored wood that may contain some early decay; and 3) the rate and extent of the first two events differ greatly among trees of the same species.

A treatment that requires many drill holes may cause only slight injury to one tree, while the same treatment of another tree of the same species may cause severe injury. However, even a tough tree that can respond effectively to many drill wounds will be injured if drilling is repeated often enough.

The purpose of this paper is to show what happens to the wood of some American elm, *Ulmus americana*, trees injected during a period of 1 to 4 years. Our intent is to illustrate the three salient points relevant to drill wounds and to suggest that great care must be taken lest injections do the trees more harm than good. It it not the purpose of this paper to discuss the efficacy of chemicals used in attempts to control Dutch elm disease. Nor is it our intent to suggest that injections be stopped.

Materials and Methods

Eighty trees ranging in diameter at 1.4 m above ground from 10 to 120 cm were dissected with a chainsaw in 1976 and 1977. The trees came from the University of Maine campus (UMO) (35 trees), Portland, Maine (15 trees), Harvard University campus (3 trees), Kennebunkport, Maine (2 trees), and Delaware, Ohio (25 trees). These trees had received injections of Benlate, Benomyl, MBC-HCl, Lignasan (BLP), or Ceratocide (Nystatin). The injection methods included gravity feed, deep holes with pressure, shallow holes with pressure, and slanted holes with pressure.

The trees from the University of Maine had received various combinations of treatments and chemicals over a 4-year period from 1971 to

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1975. Four noninjected but diseased trees were cut for comparison as control trees. The trees examined from Harvard University had received deep (5 to 8 cm) injections in 1974 and 1975. The Portland and Kennebunkport trees had been subjected to combinations of treatments and chemicals for 1 and 2 years—1974 and 1975. Wound sites ranged from 8 to 140 cm above ground, but most were 15 to 30 cm.

The University of Maine trees and those at Portland and Kennebunkport had been treated with benomyl derivatives (MBC-HCl and Lignasan BLP) at 6 g/l at 14 to 28 liters per tree. Ceratocide-treated trees received 1500 units in the same volumes used for the benomyl derivatives.

The 25 trees from Delaware, Ohio, were those that remained after experiments on the efficacy of MBC-HCl introduced under pressure by the Agricultural Research Service (ARS) method (slanted hole) and the U.S. Forest Service (USFS) method (shallow hole). The work was done by Dr. Lawrence R. Schreiber and Thomas Jones. The trees were 10 to 15 cm in diameter at 1.4 m above ground when injected in June and July, 1974. Each tree received four injections; at 0.8 m above ground in the ARS method and at 0.3 m above ground in the USFS method. Concentrations were 6 and 3.2 g/l and the trees received from 0.5 to 4 liters. In October 1976, the trees were cut. A section of trunk approximately 20 cm long, with the injection wounds in the center was cut from each tree and sent immediately to the Forestry Sciences Laboratory in Durham, New Hampshire. In the Durham laboratory the bolts were dissected to determine the pattern of discolored and decayed tissues associated with the wounds. Microorganisms were isolated by standard methods and media (Shigo 1976); chips of wood 3 x 3 x 10 mm were cut out with a sterile gouge from the discolored and decayed wood and placed in an agar medium consisting of 20 g agar, 10 g malt extract, and 2 g yeast extract. Twelve chips were taken from each tree.

Results

Control trees. The control trees had from 15 to 28 nondiscolored growth rings of sapwood (Fig. 1). The typical grey-green discoloration associated with injection by *C. ulmi* occurred on the wood cylinder under the peeled bark on the control trees.

Fig. 1. Dissection of noninjected tree that died from Dutch elm disease. The sapwood was clear. Discoloration associated with the disease was in the tissues between the wood and bark.

Delaware trees. Some trees injected by the USFS method had small columns of discolored wood that was well compartmentalized within the tissues present at the time of wounding (Fig. 2). Other trees had large columns of discolored wood that almost completely filled the cylinder of wood present at the time of injection (Fig. 3). Obvious decay was associated with some wounds (Fig. 4).

The same patterns were observed in trees injected by the ARS method. Some trees compartmentalized the injuries effectively and some did not,, and decay was associated with some injections.

Isolations of decay fungi and obvious visual signs showed that 3 of 8 ARS trees had decay and 11 of 17 USFS trees had decay. In total, 14 of 25 trees had decay associated with the 3-

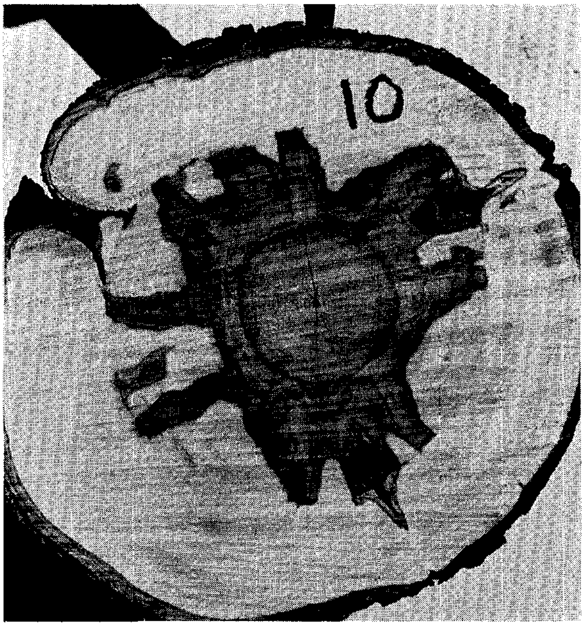

Fig. 2. The discolored wood associated with the four USFS injection wounds in this tree was well compartmentalized within the tissues present at the time of injection.

Fig. 3. The discolored wood associated with the four USFS injection wounds in this tree was throughout almost the entire cylinder of wood present at the time of injection.

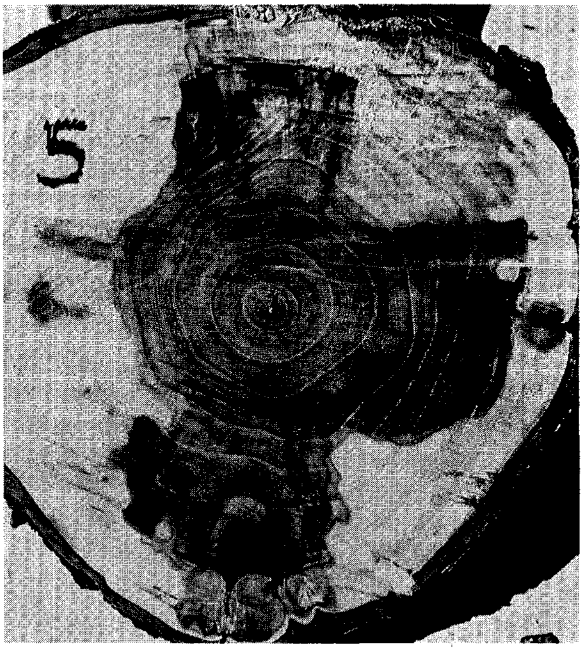

Fig. 4. Obvious decay associated with a USFS injection wound.

year-old wounds. Six of 14 trees had received 6 g/l of the chemical; 7 of 9 trees had received 3.2 g/l of the chemical. There was no correlation between the amount of actual chemical received and the presence of decay.

The Hymenomycetes isolated most frequently were *Collybia* sp. from 8 trees, and *Coprinus* sp. from 2 trees. Both fungi produced mushrooms in culture.

University of Maine trees. The trees examined were large (50 to 120 cm diameter) and fairly old (50 to 80 yrs). Most trees had severe internal injuries associated with repeated injections by the gravity flow method (Fig. 5), the deep hole method with pressure (Fig. 6), and the shallow hole with pressure (USFS) method (Fig. 7). Obvious decay was associated with some wounds, in one case within 1 year of injection.

Harvard University trees. The trees examined were large (70 to 120 cm diameter) and old (60 to 80 yrs). The drill holes had been plugged with wooden dowels. In one tree the discolored wood associated with the drill holes was very dark (Fig. 8). Large necrotic areas surrounded some of the holes. In another tree, the holes on the ridges of

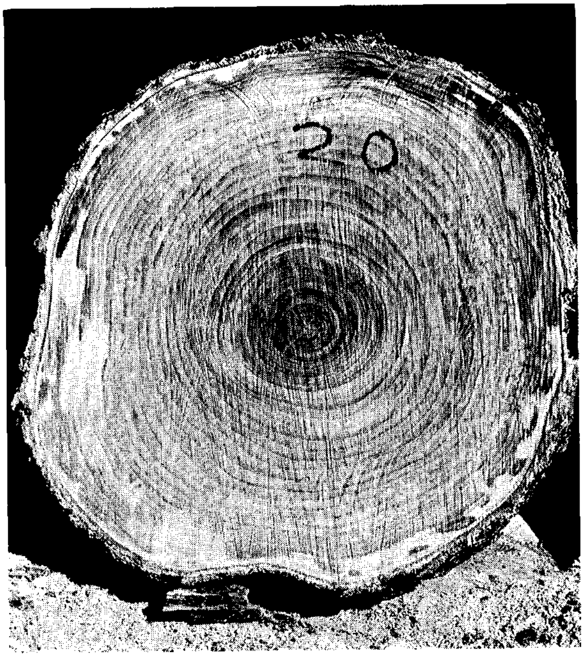

Fig. 5. Discoloration associated with gravity-flow injections repeated for 3 consecutive years.

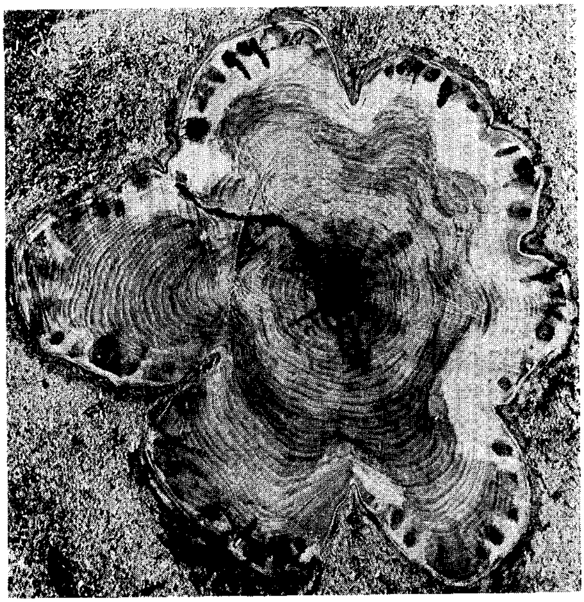

Fig. 7. Discoloration associated with wounds from deep drill-hole pressure injections followed the next year by the USFS shallow-hole pressure injection.

Fig. 6. Discoloration 8 feet above injection wounds made in 4 consecutive years by the deep drill-hole method with pressure.

Fig. 8. Dark discoloration associated with deep drill-hole injections made for 2 consecutive years.

Fig. 9. The discolored wood associated with injection wounds made on the flat side of the tree coalesced, while those made on the ridges of large roots did not.

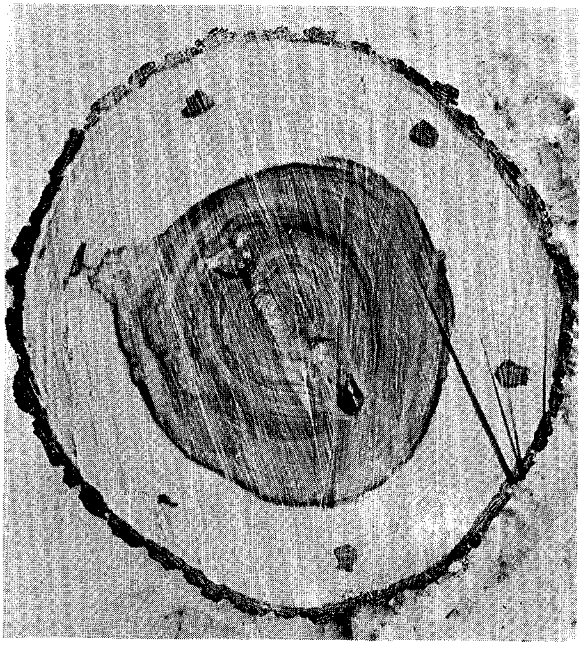

Fig. 10. Very slight injury was associated with shallow injection wounds inflicted in 1 year, especially when the sapwood was wide.

Fig. 11. The discolored areas associated with the drill wounds in this tree spread into a wedge shape when they touched the large central core.

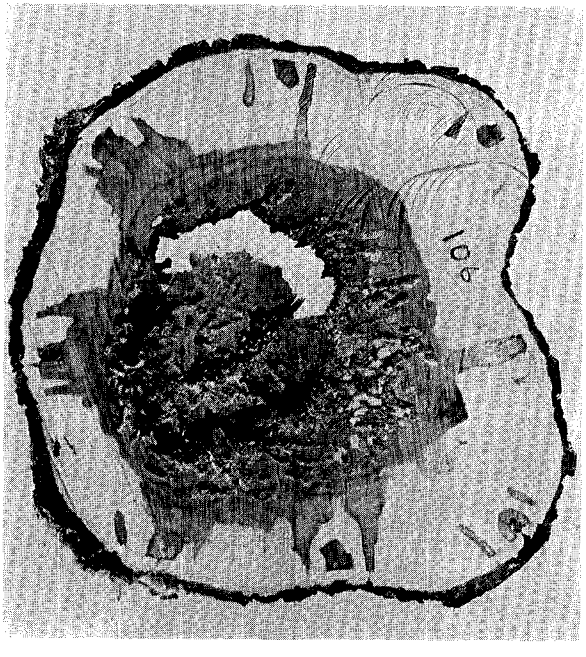

Fig. 12. The injection wounds that touched the internal decay spread rapidly to form large columns. The wounds that were surrounded by clear sapwood were well compartmentalized.

prominent roots were well compartmentalized, but the holes on the flat side of the tree had extensive discoloration (Fig. 9). Decay was associated with some wounds.

Portland and Kennebunkport trees. Some of the trees from this collection had very small central cores of heartwood. Trees that received one injection treatment had very slight injury (Fig. 10). Trees that had large central cores of heartwood showed a different pattern: the wounds from a single treatment coalesced with the central core (Fig. 11). When the wounds penetrated older central columns of decay or even came close to them, the new column of discolored wood was much larger than those not near other internal defects (Fig. 12). Small pockets of decay were associated with a few holes.

Discussion

Injections repeated for several years caused severe internal injuries.

There was great variation among individual trees in their response to the injection wounds. The large amount of decay associated with the 3-year-old wounds in the Delaware trees indicates some of the problems that can arise from even a single treatment. The necrotic spots around other holes add to the problem.

When a tree is infected with the Dutch elm disease fungus, every reasonable treatment should be tried or the tree will die. But the use of injections for prevention of the disease poses some serious problems.

Until better methods are developed, we suggest the following guidelines when injections must be made: make holes as shallow as possible, as few as possible to introduce the desired amount of material, as clean-edged as possible to reduce wound dieback that could lead to dead spots or cankers, as small as possible in diameter, as low as possible for the first treatment, and at least 18 inches above it for a second treatment, and inject on the ridges of roots, not in the depressions.

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ABSTRACT

Staley, J.G. and J. Dickson. 1977. **Transplanting tolerances of seven tree species.** Weeds, Trees and Turf 16(3): 18.

Although there is apparent universal knowledge of transplanting requirements for trees there are few reported articles on tree transplanting research. The purpose of this study was to expand knowledge of tree transplanting tolerances of various species of different sizes. Information was obtained on the following trees: bald cypress, green ash, Norway maple, red maple, sugar maple, pin oak and willow oak.