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BARK CRACKS ASSOCIATED WITH INJECTION WOUNDS IN ELMS

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Abstract. Bleeding or fluxing from injection wounds in elm is common, but the development of large bark cracks associated with such wounds has been unreported. In Maine, data were recorded on cracks in 148 elms (*Ulmus americana*) including vertical extent of crack from wounds, depth and configuration of cracks and electrical resistance of wood from trees with and without cracks. Cracks developed more frequently from stem wounds than from root flare wounds, extended upward to existing wounds or branch stubs and were widest at midpoints. Cracks developed more frequently from stem wounds than from root flare wounds, extended upward to existing wounds or branch stubs and were widest at midpoints. Cracks were limited to the separation of phloem and bark from xylem; and the exposed xylem was discolored along tangential and radial lines. Successive wounding upward on elm stems enhanced the formation of bark cracks.

Injection of systemic fungicides into living elm trees for the control of Dutch elm disease (causal organism *Ceratocystis ulmi*) has been a common practice throughout the past decade on high value elms in the Northeast. Damage to trees caused by the drilling of holes (0.9 cm diam) for the injection process has been noted (Campana 1977, Andersen *et al* 1979). Damage includes mortality of living sapwood tissue caused by fungicide or acid carrier toxicity (Andersen *et al* 1979, Andersen 1981), and spread of wetwood within the stem, often to the current years growth ring (Murdoch 1981). Bleeding of wetwood capillary liquid and wetwood slime have also been associated with injection holes (Campana *et al* 1979, Murdoch 1981), and subsequent localized mortality of cambial tissue observed (Carter 1945, Murdoch 1981). Earlier reports described the widespread occurrence of "frost cracks" on elm following extremely cold winters in Connecticut and Massachusetts (Stone 1912, Kienholz and Bidwell 1938). Stone (1912) reported that elm was more susceptible to "frost cracks", and exhibited greater crack length than other trees studied.

In most cases, root flare or lower stem injections are used for Dutch elm disease control. However, in trees injected over a period of successive years, it is common practice to elevate injection sites 46 cm (18") above the preceding wounds, while staggering sites for the purpose of obtaining adequate uptake and distribution of the chemical (Campana 1979). Also, for therapy injections after wilting symptoms are visible, stem injection sites may be preferred for strategic and rapid distribution of fungicides to critically diseased stem areas. This has lead to injection wounds 1-2 m high on the stem, as well as on upper branches. Some trees are still living with 60 or more stem injection related wounds.

Bleeding from injection wounds has been studied and was found to occur in 79% of such wounds observed (Campana *et al* 1979). This same study showed that bleeding was also common from other stem and crown wounds. Until now, bleeding or wetwood slime has not been associated with major disturbance to normal elm growth or vitality. It is the purpose of this paper to

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describe an association between injection wound position to other types of stem and crown wounds, and bleeding caused by bacterial wetwood as related to the formation of bark cracks in American elm.

Materials and Methods

Observations were made on cracks in 148 elms (*Ulmus americana*), 36-99 cm diam at 1.3 m stem height above mean ground level. The study trees were located on the University of Maine campus, Orono, ME. Data were recorded on vertical extent of cracks from wounds, bleeding or fluxing associated with wounds, depth and spatial configuration of cracks and electrical resistance of wood from trees as measured with a pulsed current resistance meter (Shigometer) equipped with a two prong surface probe.

Results

Linear extent of cracks ranged from up to 15.0 m above injection sites to 1.2 m below. Mean crack length by position of injection wound on the stem is shown in Table 1. Table 2 shows that 38 of 148 trees observed showed evidence of bark cracking (26%) both above and below the wound site. Injection sites located further up on the stem showed a higher probability of being associated with bark cracks than those located at or near the root flare. Only 8% of injection sites exhibited upward cracks when located at 2-30 cm stem height above mean ground level, compared to 52% at 90-155 cm stem height.

Bleeding or wetwood slime was associated with crack-related injection wounds in 74% of the cases observed, and in 87% of other crack-related crown wounds. There was no observed difference in electrical resistance in trees with or without bark cracks, or by aspect of reading on the stem.

A bark crack associated with an injection wound is shown in Figure 1. From a cross sectional view, bark cracks were seen to be limited to separation of bark and phloem from xylem (Figure 2). Cracks did not extend into the xylem. Spread of discolored wetwood tissue to areas directly under the cracks was observed, probably caused by mortality of associated ray parenchyma tissue due to interruption of food supplied from the phloem and colonization of the dead tissue by assorted bacterial microflora (Figure 3). The bark cracks were always associated with two areas of weakness, i.e., wounds, one of which was an injection hole and the other a crown wound such as a pruned branch or branch stub.

This pattern of bark cracking can be described in three stages (Shigo 1982). After the tree is wounded and injected (Stage 1) some cambial dieback occurs (Stage 2). The callus then begins to close the wounds and later the bark may continue to pull apart in a vertical direction above and below the limit of cambial dieback (Stage 3).

Table 1. Length of bark cracks from injection wound sites at varying bole elevations.

Position of injection wound above mean ground level (cm)	*Number of holes with cracks*[a]	*Mean crack length*	
		up (cm)	*down (cm)*
2-30	37	41.9	10.4
31-89	118	177.8	26.2
90-155	128	99.3	27.4
TOTAL	283	106.3	21.3

[a]Mean crack depth 0.8 cm (0.5-2.2 cm).

Table 2. Relationship of bark cracks to trees and position of injection wounds on stem.

	Total Observed	*Cracks-number(%)**	
		Above wound	*Below wound*
Trees	148	38 (26)	38 (26)
Injection holes by height above mean ground level (cm)			
2-30	396	32 (8)	36 (9)
31-89	278	103 (37)	107 (38)
90-155	185	97 (52)	98 (53)
Total	859	232 (27)	241 (28)

*Percentage data in parentheses

Discussion

The evidence of bark cracking here was observed following the atypical Maine winter of 1980-81. Mild weather (0-5 C) alternated with frigid (−10 C) conditions which might have been a contributing factor to the widespread occurrence

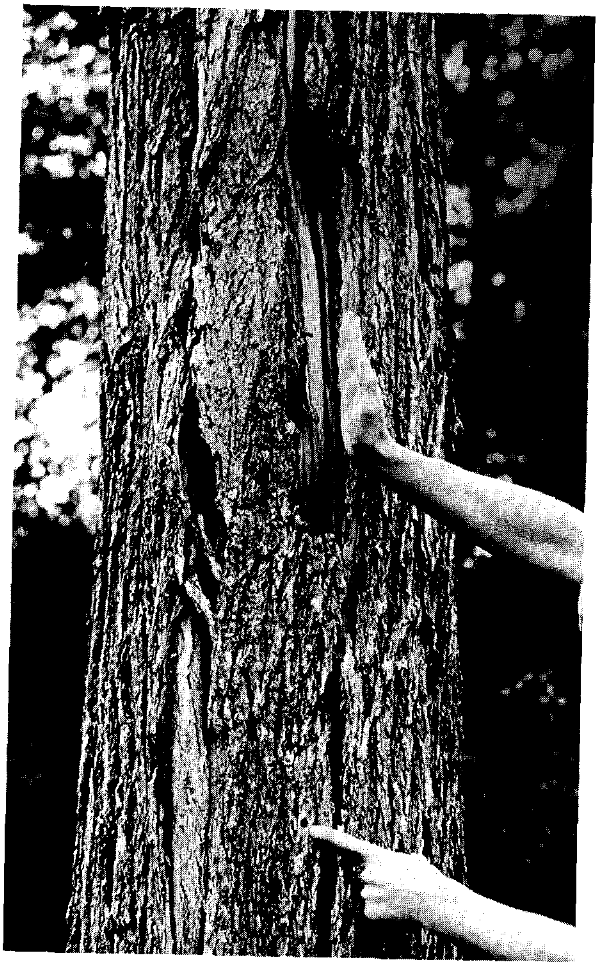

Figure 1. Large bark crack in American elm associated with an injection wound.

Figure 2. Cross section of American elm stem with bark cracks showing separation of bark and phloem from xylem.

Figure 3. Cross section of American elm stem showing spread of discolored wetwood to areas directly under cracks probably caused by interruption of food supplies from phloem with resultant mortality of ray parenchyma tissue.

of bark cracking. However, the authors have also observed cracking from wounds following milder winters. Cracking was not found to be associated with stem aspect, either by electrical resistance measurements or by visual inspection.

The number and extent of bark cracks observed are a cause for concern. These cracks cause mortality of underlying xylem tissue with resultant spread of bacterial wetwood outward in the stem. Also, fungal-caused decay may become a problem in the future, aggravating the structural integrity of the stem xylem tissue and hindering wound closure. In addition, bleeding from wetwood tissues and freezing-thawing actions could also act to enlarge the size of existing cracks over time.

To prevent the formation of bark cracks associated with injection sites, injection holes should be made as low as possible on the stem, preferably at or near the root flare, and successive injections to individual trees should be discouraged, if possible. In addition, holes should be made as shallow as possible to minimize excessive bleeding caused by bacterial wetwood which can cause mortality of cambial tissue (Shigo and Campana 1977). Crown wounds such as pruned branches should be made with care, and in such a way that walling off and successful closure of the wounds are promoted.

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ABSTRACT

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A sound reduction of only a few decibels can mean a significant difference in loudness. That kind of reduction can be accomplished with landscaping. Combining plants with a fixed barrier cuts sound better than either could do alone. The most effective way is to put buffering zones of plants on both sides of a berm or wall. The plants tend to reflect the sound down, where a lot of it is absorbed by the earth. Plants can reduce the air pollution around cities and industrial areas, too. Plants can absorb such pollutants as carbon monoxide, chlorine, fluorine, hydrocarbons, nitrates of oxygen and ozone. They can also remove dust particles from the air. In addition, they help modify air pollution by releasing oxygen through photosynthesis. Plant material can modify the climate of a small area most noticeably in its effects on sunlight and air speed. Vegetation can also raise the humidity and lower the temperature, but these effects occur over a much larger area. In much of the U.S. and in Canada, there are two primary goals in comfort control. In winter, the goal is to gain as much heat from the sun as possible and cut heat losses. In summer, it is to minimize solar gain and expand heat losses. Landscape design and maintenance programs must go beyond cost and cultural practices. They must also take into account people's attitudes, their physical and psychological health, and the economic benefits a landscape can provide.