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WOUND DRESSINGS ON RED MAPLE AND AMERICAN ELM: EFFECTIVENESS AFTER FIVE YEARS

by Alex L. Shigo and Charles L. Wilson [1]

Abstract. Closure and internal compartmentalization of wounds on red maple and American elm were not stimulated by dressings of an asphalt-based material, orange shellac, or polyurethane varnish. After 5 years, decay fungi had infected many treated and control wounds. Some trees closed wounds rapidly; others closed wounds slowly regardless of the treatments.

The value of wound dressings has been questioned many times. And recent research shows that there is very good reason to question their value.

In 1934, Collins stated that *the ideal dressing for a wound is yet to be discovered* (Collins 1934, p. 21). Later, Marshall made a similar statement (Marshall 1950, p. 18).

Marshall (1932) stated that asphalt-based wound dressings stimulated the decay of wood and that many of the other materials tested had a deleterious effect on callus production. Recently, Neely (1970) stated that, *while wound dressings may prevent dieback of wound margins, not one wound dressing used* (in his experiments) *was of appreciable benefit in increasing the rate of wound healing.*

Wound-healing in trees is usually thought of as wound-closure, or callus growth. Many investigators have studied callus formation associated with wounds and dressings that stimulate the formation of callus (Swarbrick 1926, Marshall 1931, Block 1941, McQuilkin 1950, Crowdy 1953). Various chemicals have been incorporated in dressings. Some have been reported to accelerate closure (Tamir 1953). Others

exhibited beneficial properties against specific diseases (Dye 1971).

Few studies have been done on the internal effects of the dressings. Houston (1971) conducted a study on the effect of some chemicals on the development of discoloration and decay in red maple (*Acer rubrum*) and yellow birch (*Betula alleghaniensis*). He reported that some chemicals slightly reduced the amount of discoloration and decay associated with wounds, while others increased the amount of discoloration and decay.

After a careful search of the literature, the only conclusion one can reach, is that of Collins (1934) and Marshall (1950): the ideal dressing is yet to be discovered. But the practice of dressing wounds still continues. Why?

There are good reasons why confusion still exists over the value of wound dressings. The most important is that many people do not understand the tree decay process. Regulation of any process depends on understanding. Decay is the final stage of a complex process that involves the interactions of the tree with a wide variety of microorganisms — bacteria, nondecay fungi, and decay fungi — over a long period (Shigo and Wilson 1971).

The process of healing is also poorly understood by many people. Healing is generally considered to mean closure of a wound. But healing is much more than that in trees. Healing also includes internal walling-off or compartmentalization of infected and invaded tissues

associated with the wound. Unless wounds — treated or untreated — are dissected and studied from the inside, the complete healing process will not be understood (Houston 1971). In the past, most wound studies have dealt with healing only from the external aspect — closure (McQuilkin 1950). Then, at best only a portion of the complete healing process could be understood.

Another important factor concerning wounds and healing is the dieback of cambial tissues around wounds (Neely 1970). Some trees have a strong response to wounding, and no cambial dieback occurs; in others the wound keeps enlarging as the cambium around its margins continues to die.

Yet another important factor affecting healing is the time of wounding (Marshall 1931, Neely 1970). Wounds made at, before, or after the leaves have expanded fully react differently. A wound at the time of leaf flush is much more serious because stored materials in the roots have been depleted.

And finally, the individual response of different trees of the same species to wounds must be recognized. Some trees have stronger responses to wounding — closure and compartmentalization — than others. All these factors must be considered in wound-treatment studies.

Decay is an essential recycling process in nature. Decay decomposes and recycles dead matter, making it available for new life. But there are ways to live with the decay process and minimize its damage. It is essential to know that most trees have effective built-in systems for healing wounds and combating decay. But care must be taken when attempts are made to help trees that the treatments do not do more harm than good.

This is a report on data from 5 years of wound-dressing studies.

Materials and Methods

On 18 August 1970, 30 red maple trees (*Acer rubrum*) in the Hubbard Brook Experimental Forest at West Thornton, New Hampshire, were wounded. On 19 August 1970, 30 red maple trees in the Bartlett Experimental Forest at Bartlett, New Hampshire, were wounded. On 14 and 15 September 1970, 50 American elm trees (*Ulmus americana*) at the U.S. Department of Agriculture Shade Tree and Ornamental Plants

Laboratory at Delaware, Ohio were similarly wounded. All trees ranged from 15 to 30 cm diameter at 1.4 m aboveground.

Each tree received 4 wounds with an ax. All wounds were of the same size and severity. The wounds were diamond-shaped, the long vertical axis 15 cm and the horizontal axis 7.5 cm. After the bark was removed carefully, the ax was driven in 1 cm horizontally and 1 cm vertically to form a cross in the center of the wound. Wounds were inflicted in a spiral pattern around the trunk from 0.5 to 2.0 m aboveground, and were approximately 40 cm apart.

Dressings were applied immediately after wounding. Each tree had one wound coated with a thick asphalt-type material (the commonly used commercial preparation), one wound painted with orange shellac, one wound painted with a polyurethane varnish, and one wound was left untreated.

In 1971, 10 trees each from New Hampshire and Ohio were cut for dissection and study (Shigo 1971). Ten trees were cut each year in 1972, 1973, and 1974 in New Hampshire, and 5 were cut in 1975. In 1975, 20 trees were cut in Ohio.

Microorganisms associated with the discolored and decayed wood were determined by removing chips of wood 3 x 3 x 10 mm from the infected zones and placing them in a medium consisting of 10 g malt extract, 2 g yeast extract, 20 g agar, and 1 liter distilled water. The cultures were incubated at 25 deg. C and examined after 1 and 2 weeks. Additional details on isolation techniques and materials and methods have been published (Shigo and Wilson 1972).

A Shigometer, an electrical device that delivers a pulsed electric current and measures resistance to 500K ohms (thousands), was used to determine relative degree of tissue deterioration of infected wood associated with wounds on trees cut in New Hampshire in 1973 (Shigo and Shigo 1974).

As wood deteriorates, the resistance to a pulsed electric current decreases. Needle probes were forced into the wood at the midpoint of the wound after dissection, and then two additional readings were made, 10 cm above and 10 cm below the midpoint (Fig. 1). At these three positions, the contiguous clear wood was also probed.

Figure 1. Needle-probe electrodes and Shigometer used to measure resistance to a pulsed electric current from discolored and decayed wood associated with 3-year-old wounds on red maple. Measurements were also made of contiguous clear wood. Three sets of measurements were made: at wound midpoint, 5 cm above, and 5 cm below. The lower the resistance, the more decayed the wood.

Table 1. Vertical extension (column length) of discolored and decayed wood associated with 2-, 3-, and 4-year-old wounds on red maple.

Year of cutting, tree number	Bartlett Trees, by treatment				Hubbard Brook trees, by treatment			
	A[1]	P	S	C	A	P	S	C
	cm				cm			
1972:								
1	22[2]	19	18	23	30	27	20	40
2	16	25	19	19	16	31	20	40
3	14	16	17	17	23	45	35	22
4	34	27	28	21	17	30	14	25
5	16	18	18	22	37	33	43	35
1973:								
1	20	32	25	23	31	24	37	25
2	19	23	37	30	26	17	45	28
3	25	24	29	21	28	35	34	27
4	50	28	35	29	30	20	26	34
5	23	13	22	26	39	32	23	24
1974:								
1	27	40	21	28	35	45	35	33
1	21	26	46	17	31	35	27	30
3	24	20	22	23	29	30	30	25
4	15	25	31	25	29	31	31	24
5	23	22	18	21	24	32	34	26
Mean[3]	24.0				29.7			

[1] A, asphalt; P, polyurethane; S, shellac; C, control.

[2] Single underline indicates isolation of *Hypoxylon* spp., double underline indicates isolation of Hymenomycetes.

[3] Means significantly different at the 95% level of probability (F test).

Results

Red maple. — An analysis of variance of the vertical extensions of discolored and decayed wood associated with the 2-, 3- and 4-year-old wounds revealed no significant differences among dressings and control (Table 1). The trees from the Hubbard Brook Experimental Forest had statistically significant longer columns of discoloration and decay than the trees from the Bartlett Experimental Forest (Table 1).

No red maple wounds closed after 5 years. However, vigorous callus ridges formed around all four wounds on some trees (Fig. 2), while on other trees all four wounds had large areas of cambial dieback and only small callus ridges (Fig. 3).

Of major importance was that hymenomycetous fungi and species of *Hypoxylon* that cause decay were recovered from wood associated with many wounds, regardless of treatment (Table 1). Hymenomycetous fungi were isolated frequently from the 2-year-old wounds, and *Hypoxylon* spp. more frequently from the 4-year-old wounds. Only two trees from the 30 cut in 1972, 1973, and 1974 had wounds that did not yield decay fungi. On eight trees, all four wounds yielded decay fungi.

Statistical analysis of the electrical resistance measurements of the discolored and decayed wood associated with the 1973 wounds indicated that the control wounds were significantly less decayed than the dressed wounds (Table 2). The most decayed wood was associated with
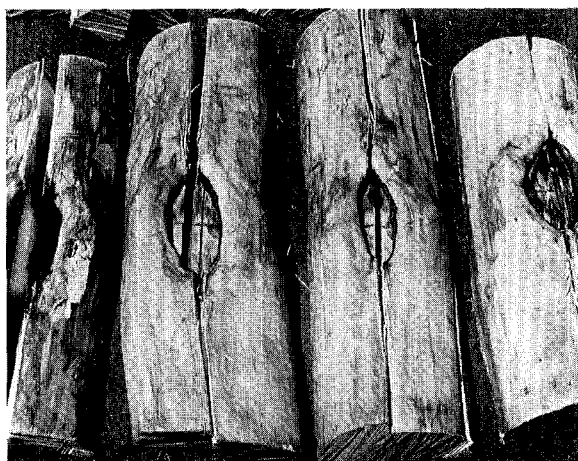
Figure 2. Vigorous callus ridges on 4-year-old wounds from one red maple tree. The tree had a strong wound response.
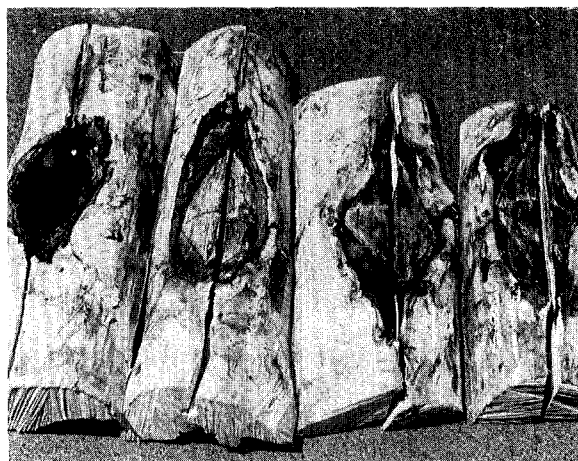

Figure 3. Poor callus formation on 4-year-old wounds from one red maple. This tree had a weak wound response.

Table 2. Electrical resistance of discolored and decayed wood associated with 3-year-old wounds on red maple, in K ohms.

Tree[1]	Treatment											
	Control			Orange shellac			Polyurethane varnish			Asphalt dressing		
B-1	2	4	7[2]	6	14	1	2	1	2	2	1	1
B-2	3	6	5	2	4	9	1	1	1	1	1	1
B-3	7	15	2	5	2	2	1	1	1	3	1	1
B-4	2	2	1	1	1	1	1	3	5	1	3	2
B-5	20	26	26	12	2	2	3	1	1	1	1	4
H-1	5	2	2	1	2	2	2	3	5	8	2	1
H-2	5	20	6	20	29	15	3	9	17	3	4	7
H-3	15	35	4	3	5	2	3	10	23	5	2	3
H-4	2	30	22	9[3]	6	6	8	1	5	15	2	3
H-5	25	21	10	—[3]	24	4	1	2	2	2	1	1
Mean[4]	11.1			6.6			4.1			2.7		

[1] B = Bartlett; H = Hubbard Brook.

[2] In each group, the first figure is measurement made 5 cm above wound center; middle figure, at wound center; third figure, 5 cm below wound center. Measurements made with needle probes and Shigometer (Fig. 1). The measurements of the contiguous clear wood were fairly consistent per tree at readings above 40 K ohms, and for that reason they are not included here.

[3] No measurement.

[4] LSD = 3.4 (P V 0.05).

treatments of asphalt-based dressing and polyurethane varnish (Table 2). The wood associated with the wounds on the Bartlett Experimental Forest trees was decayed more than the wood associated with the wounds on the Hubbard Brook trees, although the columns of discolored and decayed wood associated with the Bartlett tree wounds were smaller (Table 1).

Measurements of the control wounds showed that the wood in the center of the wounds was not as decayed as the wood near the vertical margins (Table 2). This was not the case with the other wounds. The measurements of the contiguous clear wood were fairly consistent per tree at readings above 40 K ohms, and for this reason they were not included in Table 2.

American elm. — Many of the wounds on the 20 elm trees had closed after 5 years (Table 3). The two lower wounds on the trees closed more rapidly than the two higher wounds (Fig. 4). On some trees all wounds were closed (Fig. 5), while on other trees most wounds were still open (Fig. 6). An analysis of variance showed that there was no statistically significant relationship between wound closure and treatments, but that there were significant differences among heights. The top wounds were more open.

After 5 years, the columns of discolored wood associated with all four wounds coalesced to form one central column of discolored wood; therefore it was not possible to measure the columns associated with each wound. Dissections and isolations revealed that decay fungi were associated with only two wounds on one tree (a species of *Coprinus*).
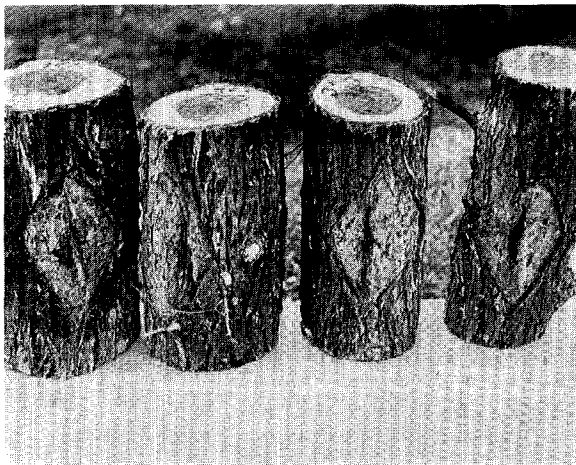

Figure 4. Four 5-year-old wounds from one elm tree. The two lower wounds (left) were closed more than the two higher wounds (right).

Discussion

The treatments used had no effect on the rate of closure, vertical extensions of discolored and decayed wood, or presence of decay fungi. The dressings did not prevent infection by decay fungi. The results of the electrical measurements showed that the least decay occurred in the control wounds.

The asphalt dressing used in this experiment is still the most common treatment for tree wounds.

Table 3. Wound closure on American elms 5 years after treatment: basis, four wounds per tree.

Tree no.	Wound height, meters			
	0.5	1.0	1.5	2.0
	TREATMENT [1]			
	C	A	P	S
1[2]	4	4	3	1[2]
2	4	3	3	4[3 4]
3	3	3	3	1
4	4	4	4	2
5	4	3	1	3
	TREATMENT			
	A	P	S	C
6	4	3	1	1
7	1	1	1	1
8	4	4	3	1
9	4	4	3	1
10	2	2	3	4
	TREATMENT			
	P	S	C	A
11	4	3	2	1
12	4	4	4	4
13	3	4	4	4
14	4	4	4	4
15	3	4	4	4
	TREATMENT			
	S	C	A	P
16	4	4	4	4
17	3	3	3	3
18	3	3	3	1
19	3	3	3	3
20	4	4	4	4
Total	69	67	60	51
Mean closure[5]	3.45	3.35	3.0	2.55

[1]A, asphalt; P, polyurethane; S, shellac; C, control.

[2]Each horizontal row represents 4 wounds on 1 tree.

[3]Wound-closure index: 1, open; 2, open narrow vertical slit; 3, narrow vertical slit present; 4, wound closed, narrow vertical slit fused into a ridge.

[4]Data groups to show closure index for each treatment at each height. Total wound closure for each treatment: C=62, A=66, P=61, and S=58.

[5]LSD = 0.41 (P V 0.05).

The treatment was of no value. In fact, the asphalt dressing was the worst, as measured by the electrical-resistance technique. This is possible because the coating serves to hold moisture in the wound. The small cracks around the margin of the wound and the cambial dieback were infection courts for the wood-inhabiting microorganisms, and the dressing protected them, and kept moisture in. This finding supports
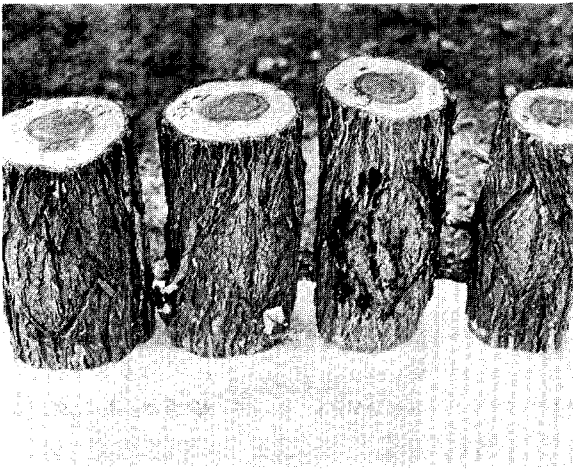
Figure 5. Four 5-year-old wounds from one elm tree. All wounds were closed. This tree had a strong wound response.
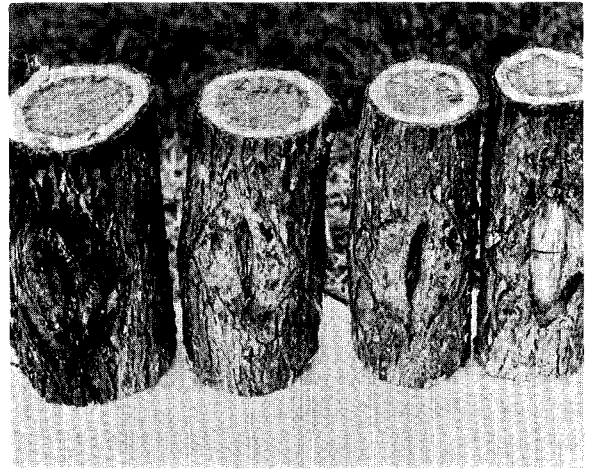

Figure 6. Four 5-year-old wounds from one elm tree. All wounds were open. This tree had a weak wound response.

observations made by Marshall (1932).

The results raise the possibility of genetic control of the wound response, which leads to wound healing. Some trees can apparently heal wounds — by internal compartmentalization as well as by external closure — more effectively than others. Studies must now be conducted to verify this assumption; and, if it is valid, to begin selecting trees that can heal their wounds most effectively.

The studies here also point out again the fallacy that dressings shield against wood-inhabiting microorganisms. A new approach must be taken. One approach is to focus on the tree's built-in healing systems.

The dressing of the future may help the tree help itself after wounding. It may be that biological control agents serve this purpose best. Results from recent experiments suggest that *Trichoderma viride* delayed the development of decay in red maple wounds for a year (Pottle and Shigo 1975).

Results of other experiments indicate that trees that close their wounds rapidly have a high concentration of mobile ions in their cambial zone. When measured with the Shigometer and the needle probes, these trees can be separated from trees that have low concentrations of ions in their cambial zones. The Shigometer may be a valuable tool for judging the wound-closing potential of trees.

It will be difficult to eliminate the use of wound dressings by the public. Dressings still have a strong cosmetic appeal, and they also have a psychological affect on the tree's owner who feels that he has done the best he could to help the tree.

If in the future we can develop trees with a more vigorous healing response, and wound treatments that will stimulate the natural built-in systems for wound healing, we can say that we have finally done something to minimize the damage caused by decay. Until then, Collins's (1934) and Marshall's (1950) statement still stands: *The ideal dressing for a wound is yet to be discovered.*

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MANGANESE DEFICIENCY OF RED MAPLE

by Elton M. Smith and Cynthia D. Mitchell

In certain alkaline soil regions, the lack of available manganese can cause Red Maple foliage to turn yellow with brown areas followed, in some cases, by defoliation. The leaf symptoms (green veins with the interveinal tissue yellow) resemble the condition of iron deficiency of Pin Oak. In more pronounced cases, the tissue between the veins turns brown, especially on the youngest or outermost foliage. The symptoms are most pronounced under the same soil conditions (moist with a pH above 6.5) as those which favor iron deficiency.

Since yellowing of the foliage is a common symptom on a number of landscape trees, a soil test and leaf tissue analysis are recommended prior to treating with any fertilizer. The proper diagnosis is important because maples treated with iron, rather than manganese, will cause the symptoms to become more severe, since iron further suppresses manganese uptake due to an iron-manganese antagonism.

Recent studies at The Ohio State University with Red Maple have shown that treatment with manganese compounds will help to restore the foliage to a more normal green color. The data in Table 1 indicate that trunk implantations of capsules of manganese citrate and two forms of manganese sulfate will improve foliage color and increase the chlorophyll content of Red Maple. Two of these compounds are still in experimental stages of development, however, the 78% Mn-SO$_4$ is on the market in capsule form as Mn Medicaps.

TABLE 1. The Effect of Limb Implantation of Manganese Compounds on the Foliage Color and Chlorophyll Content of *Acer rubrum* 5 Months following Treatment on April 29, 1975.

Treatment	Foliage Color*	Total chlorophyll**
Tree No. 1		
Limb A—Check	5.0	188
Limb B—Monohydrate MnSO$_4$—98%	8.0	214
Limb C—MnSO$_4$—78%	10.0	241
Tree No. II		
Limb A—Check	6.5	238
Limb B—Mn citrate—43%	8.5	246
Limb C—MnSO$_4$—78%	9.0	257
Tree No. III		
Limb A—Check	4.0	83
Limb B—Monohydrate MnSO$_4$—98%	7.0	174
Limb C—MnSO$_4$—78%	9.0	180

*Foliage Color—Figures represent a visual evaluation on a scale of 1-10 with the highest number the darkest green.

**Total Chlorophyll—Figures expressed as mg. total chlorophyll per g. of leaf tissue.

Manganese deficiency can also be prevented, although on a more temporary basis, by treatment with chelated manganese (Table 2). Foliar treatment with manganese sulfate is effective too. Both are commercially available.