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A New Look at Decay in Trees

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Decay of wood is now and always has been one of the major problems affecting the quality of wood in all species of trees and in all types of wood products throughout the world.

This paper is about the decay process and a new technique for detecting discolored and decayed wood in living trees. The information is from research by the author during the last decade.

Decay in Living Trees

Soon after Robert Hartig—the father of forest pathology—developed his concept of decay, near the end of the last century, many investigators studied decay, and many outstanding contributions were made. Yet despite all this valuable new information, the problem of decay in trees was still overwhelming.

As a result, more attention was given to better methods for utilizing wood in trees that had some decay. At the same time, forest pathologists began to study other disease problems. Research on decay in trees began to wane. Decay was beginning to be accepted as a problem that had been researched to the point where it was thought that additional research would not add much more.

In a sense, decay was accepted as a natural phenomenon that man could regulate only so much. A decade ago, only a few studies on decay in living trees were going on.

The classical concept of decay as developed by Robert Hartig implied that decay fungi infected fresh wounds and caused decay. Recently, an expanded concept has been developed. In this new concept, host response to wounding and infection by bacteria and nondecay fungi must be taken into account.

A conceptual model of the decay process has been developed, based on the sequence of events that occur, from wounding of the tree to total decomposition of the wood. Three major stages in the model are: (1) host response to wounding, (2) invasion by pioneer microorganisms and host response to the invasion, and (3) decay of dead cells.

Decay is the *final stage* of the process. Yet, in the past, decay itself received almost all the research attention. Now, we in research and forest managers in the field must give more attention to the beginning stages of the process. If we can do this, then we will begin to change some of the old ideas about decay. No, we may not be able to stop decay, but we may be able to minimize it more than we are doing now!

Expanded Concept of Decay

Decay begins with the events that follow wounding. There is a protective chemical response in the living wood tissues exposed by the wound. The chemical changes form a protective barrier against invasion by microorganisms. This barrier is effective against most microorganisms, most of the time.

Bacteria and fungi that do not cause decay are usually, but not always, the pioneer microorganisms that are able to surmount this chemical barrier and invade the tree. The tree then responds further in a chemical way to the invasion. Most of the time the protective responses in the wood are effective in preventing invasion; but not always.

Other species of microorganisms continue to invade, in a wave action: a *succession.* After the living wood cells are killed, decay microorganisms invade and digest cell walls; or to say it another way, the decay microorganisms are the "clean-up crew." They do their job effectively.

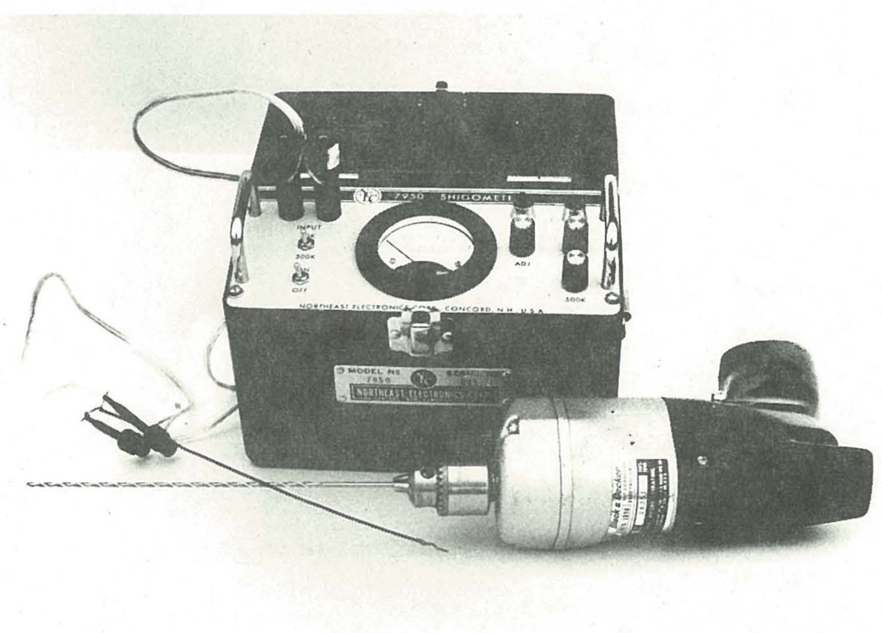
The chemical protective barrier is the tree's first line of defense. A second line of defense occurs after the microorganisms have invaded the tree. The tree walls off the invaded tissues. They are *compartmentalized.*

The new cells formed by the cambium after a wound has been inflicted are different in many ways from those cells formed normally. These altered cells act as a physical barrier to the invading microorganisms. After compartmentalization, the cambium begins to form normal tissues; and these new wood tissues are not affected unless other wounds occur.

Compartmentalization of invaded tissue has been observed in deciduous hardwoods, conifers, and tropical hardwoods. It is because of compartmentalization of invaded tissues that you will often see a tree that has a hole in it surrounded by clear, healthy wood. The diameter of the tree when it was wounded was the diameter of the defect.

Defects in Wood Products

One compartment of discolored and decayed wood may surround others as a result of wounds inflicted at different times. The degrees of tissue deterioration in each compartment may be dif-



The Shigometer for detecting discolored wood and decayed wood in living trees and utility poles consists of a portable battery-operated drill with a long narrow drill bit, a twisted-wire probe that is inserted into the hole made by the drill bit, and a meter that produces a pulsed electric current and measures resistance to 500 K ohms. When the probe tip passes from sound to unsound tissues an abrupt decrease in resistance is indicated on the meter.

ferent. This is most pronounced in ring rots in conifers.

The boundaries of the compartments in the growth rings are often zones that shake. Dissections and observations on thousands of wounded trees showed that ring shakes were associated with wounds: branch stubs, stem stubs, insect wounds, bird pecks, animal wounds, fire wounds, logging wounds, etc. But all wounds did not lead to shakes.

Star shake, ray shake, and some types of seams were also associated with basal wounds. In most cases the shakes did not become apparent until after the tree was cut and the wood began to dry.

Three Stages

The wood in the living tree that is altered only slightly after wounding may be difficult to detect in green timber. But these tissues will be different from healthy tissues after the wood has dried. In most cases the tissues in Stage I of the decay process—those altered primarily as a result of host response to wounding—will dry to a color slightly different from the healthy wood. In *Acer saccharum* and *Betula* spp. the tissues in Stage I dry to shades of pink, while healthy wood will remain white.

Tissues that are in Stage II present more severe problems during drying. Tissues in Stage II have been invaded by pioneer microorganisms. These microorganisms digest primarily the remains of the living cell contents, but it is thought that they may also digest some of the materials in the cell walls. The action of the pioneer microorganisms may cause the tissues to collapse or honeycomb after drying.

Discolored tissues in Stage I and the early part of Stage II can add value to some wood products. The wood may be colored but the strength not reduced. The colors also add figures to the wood. But where does valuable discolored wood in the early period of Stage II end, and where does valueless discolored wood in the later part of Stage II begin?

Too often valuable wood in Stage I and II is rejected because it is considered defective. An example is "redheart" in birch. The pink wood in Stage I is valuable, but "redheart" in Stage II is valueless. One of the major problems here is old terminology. "Redheart" in birch is often used to describe any discoloration, and sometimes even decay. The same can be said for "wetwood." Here we have Stage II tissues but only slight color changes.

A great saving can be made in time, labor, and money by recognizing many of these small but very important defects

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Decay in Trees

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in the living tree, cut log, or even in the freshly sawn board, by diverting the wood before it is made into a product that must be discarded because of the defect. The earlier the defect is detected, the greater the saving in time, labor, and money.

Many other examples can be given. But the questions will be asked. How can we detect discolored and decayed wood with accuracy in standing trees? How can tissues in Stage I and Stage II be distinguished easily? And even tissues in Stage II from decayed tissues in Stage III need to be distinguished.

The answers will not come from subjective experience. We must do better than that. And now we do have some new information and techniques that may help us to do better.

A New Technique for Detecting Discolored and Decayed Wood in Trees

As a result of research over the last 7 years with many other investigators—Dr. H. Richard Skutt and Mr. Ronald Lessard, Department of Electrical Engineering, University of New Hampshire, and Dr. Terry Tattar, Department of Plant Pathology, University of Massachusetts, mostly—an electrical device has been developed for detecting discolored and decayed wood in living trees (fig. 1).

Called a *Shigometer* by the manufacturers, Northeast Electronics Corporation, of Concord, New Hampshire, this device measures the resistance of the wood to a pulsed current. (Mention of products is for information only, and should not be considered an endorsement by the Department of Agriculture or the Forest Service.)

As invaded tissues die, discolor, and decay, concentrations of minerals increase. As mineral concentrations increase, resistance to a pulsed current decreases. This method for detecting discolored and decayed wood is very simple, and it has been field-tested on many trees during both winter and summer conditions.

First a small hole, 3/32 in. in diameter, is drilled into the tree. Drill bits 8 and 12 inches long have been used. It takes less than a minute to drill such a hole in an oak tree. The drill bits are mounted in light-weight portable battery-operated drills. Then a long twisted wire probe, which is attached to the meter, is inserted slowly into the hole.

As the probe tip passes through healthy wood, the resistance of the tissues to the pulsed current is fairly constant. The ohmmeter on the Shigometer indicates only very slight changes. But when the probe tip passes from healthy tissues to discolored or decayed tissues, there is an abrupt decrease in the resistance. The needle on the meter swings to the left.

The magnitude of the decrease in resistance indicates the degree of tissue deterioration. The position or depth of the probe tip in the hole at the moment the needle begins to swing to the left indicates the exact position of the defect column. Because of compartmentalization, most —but definitely not all—columns in the tree are fairly uniform in diameter so that two probes from opposite sides can detect the diameter of the defect columns.

The method will help to determine whether defective tissues are in Stage I, II, or III. The method will help a forest manager to know in a very short time the internal condition of many trees.

Experiments on the wounds made by the drill bits show that the slight injuries heal very quickly, and very little or no columns of discolorations develop. This is different from the large holes made by increment borers. And with an increment core, the condition of the wood may still not be known. Details on the use of the

Shigometer can be obtained from the author.

Some Key Points

Here is a brief summary of some key points that could help to minimize damage caused by discoloration and decay in living trees. Details on these points can be obtained from the author.

1. Learn how discoloration and decay develop after a tree is wounded. Know that there are successions of microorganisms and compartmentalization of defects.
2. When thinning, favor trees with well-healed branch stubs. Remove cankered trees.
3. Prevent wounds; use every possible means to minimize logging injuries. Impress on logging crews the damage that can result from wounds.
4. Learn to recognize the early signs of internal defects: sapsucker wounds, sugar maple borer wounds, branch cankers, etc.
5. Shakes—ring and ray—are associated with wounds, but not all wounds form shakes.
6. Shakes in hemlock are commonly associated with sapsucker wounds.
7. Seams—especially basal seams—start from wounds, often old basal fire wounds.
8. Know that healthy maple and birch trees have no colored heartwood cores. Trees with many poorly healed branch stubs will have large central cores of discolored wood.
9. Mineral streaks and stains start from small wounds, usually sugar maple borer wounds and sapsucker wounds.
10. Cambium miner defects can be seen on the cut ends of the logs or on the freshly cut stump.
11. Pink wood in birch—Stage I—is different in many ways from "redheart" —Stage II. Redheart has a foul odor.
12. Wetwood may not be darker in color than healthy wood; wetwood is associated with wounds.
13. Wood in Stage I will dry to a color slightly different from that of unaffected wood.
14. White, hard wound faces are usually associated with less decay than dark, soft wound faces.
15. Defects associated with stem stubs are the diameter of the stubs, and they go downward.
16. Cut the suppressed sprouts out; let the dominant ones with the well-healed branch stubs remain.
17. Minute insect holes in lenticels of paper birch indicate internal columns of discolored wood.
18. Discolored heartwood can form in oaks, pine, walnut, cherry, and other species that have a heartwood.
19. Prune dead and dying branches as well as low live branches from trees selected for pruning.
20. With the Shigometer it is possible to know with certainty the internal condition of the tree.