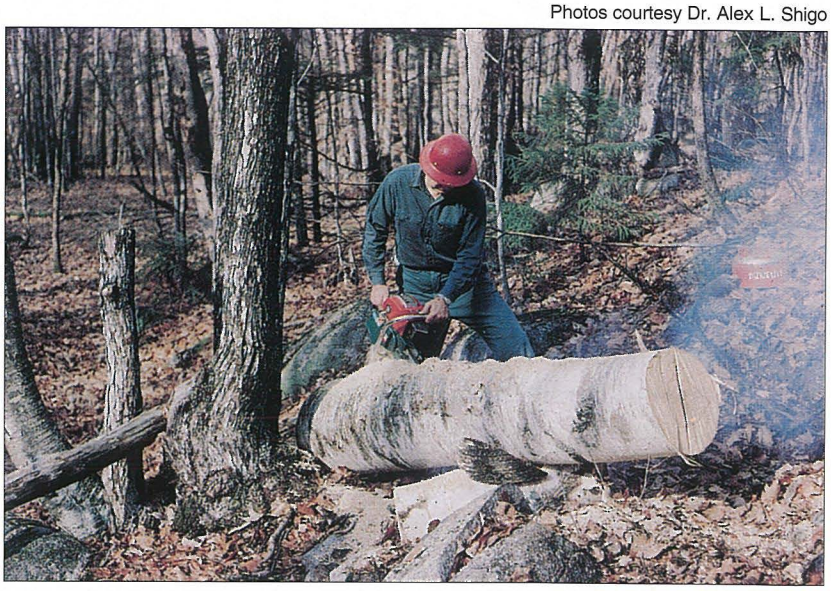
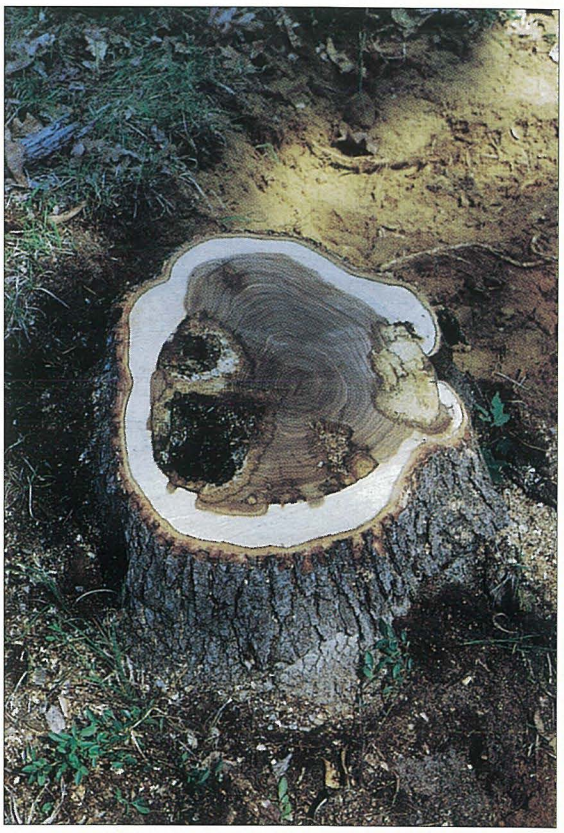
Photos courtesy Dr. Alex L. Shigo

Dissection of thousands of trees with a chain saw started a New Tree Biology in 1959.



Dissections showed that there were highly ordered patterns of discolored and decayed wood associated with wounds and branch stubs.



Patterns of discoloration and decay in many trees could not be explained by the heartrot concept. Heartwood in this white oak was sound in the center yet distinct columns of decay were associated with the wounds. The decay did not spread at-will in the heartwood.

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(84" cab to axle chassis required)

General

1. All G-60 galvannealed material (Zinc coated, Resists Rust)
2. One piece design in body sides
3. All wiring in conduit
4. Sealed lexan lens lights meet FMVSS 108 specs
5. Anti-sail mud flaps
6. Class C Hoist
7. Safety body prop
8. Trailer light connector 6 pole
9. Pintle, or pintle/ball combintation trailer hitch w/tow hooks
10. Bodies: mounted, undercoated, chemically degreased, cold tar epoxy coating inside chip box, primed and painted (paint warranteed)
11. Tool Boxes w/theft resistant rods
12. Tool Boxes "weatherproofed"
13. Tool Box Hinges: include grease zerks
14. Chipper air exhaust vents

Overall Body Dimensions:

1. Length: 138"
2. Height: 60"
3. Width: 92"

Chip Box Material: (galvannealed)

1. Floor: 10 ga. plate
2. Sides & Front: (1) pc. design - 12 ga. plate
3. Top: 14 ga. plate
4. Tailgate: (270 swing) 12 ga. plate w/tubing frame
5. Runners: 6" structural channel
6. Cross members: 3" structural channel
7. Rear vertical support: formed ¼" plate
8. Rear horizontal support: 3" x 2" x ¼" rectangular tubing

Tool Boxes (14 ga. galvannealed material):

1. "L" cross box - which includes underbody tool box
   Cross box: 24" long x 92" x 37" high across chassis rails; (6) swivel rope hooks; (1) shelf; (3) gal. water cooler holder
2. Underbody tool boxes: (two) 55" long x 20" high x 17" deep
3. Ladder box (inside chip box) 107" long x 12" wide
4. Pruner Box: (inside chip box) 132" long x 12" wide
5. Locks: Keyed alike

Optional:

1. Top ladder & pruner rack.
2. **NOTE: Chassis cabs available to complete the package.**

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A New Tree Biology Comes of Age

By Dr. Alex L. Shigo

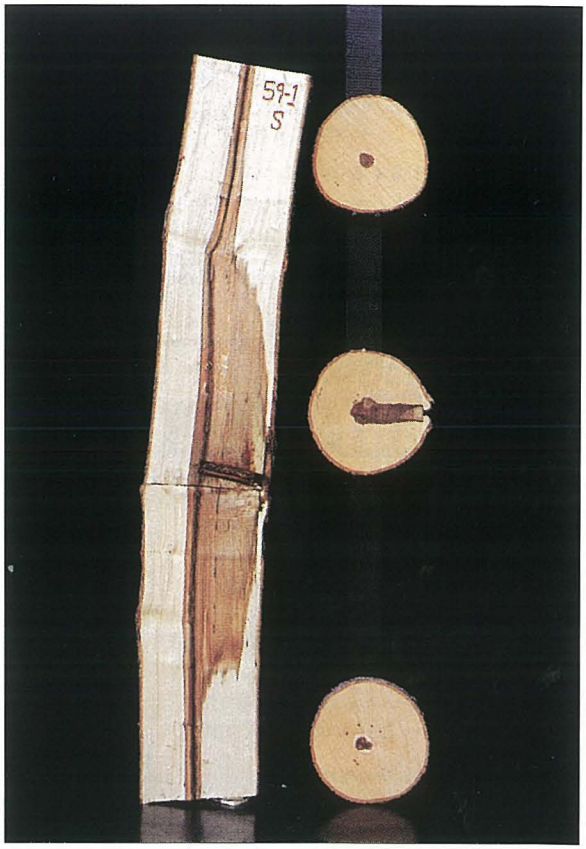
Is Wood Living or Dead?

Light; is it a wave or a particle? Yes! A duality that started quantum mechanics. Newtonian physics started to be replaced by new concepts, especially concepts dealing with the atomic world.

Wood; is it living or dead in growing trees? Yes! Another type of duality that started new concepts dealing with trees and their associates. A New Tree Biology started to develop.

Trees Are Generating Systems

A New Tree Biology is based on concepts of the tree as a compartmented, generating system that survives, when injured, by forming new barriers and strengthening old barriers that resist the spread of microorganisms, and that protect the structural, transport and storage systems. Organisms that infect trees counter the tree's response by attacking in successions. The survival pressures of the tree are met with the survival pressures of the microorganisms that attack trees. Another type of duality begins to develop as trees survive, so long as they are not digested by wood-inhabiting microorganisms, and the microorganisms survive so long as they digest trees.



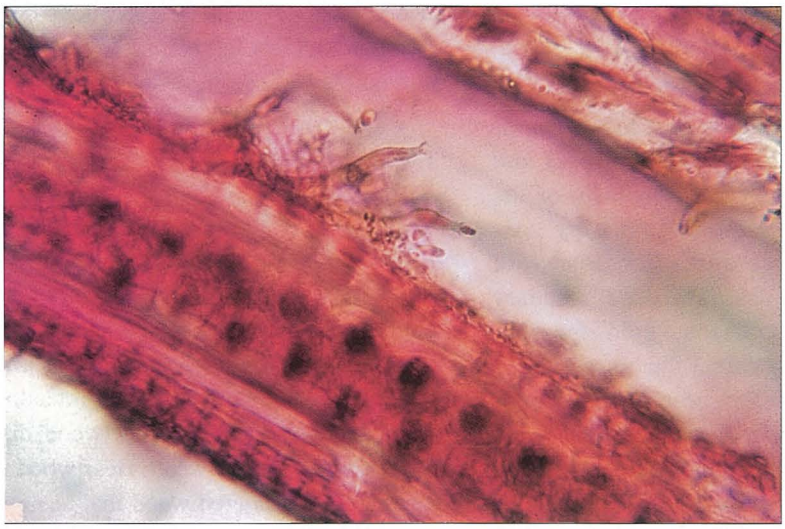
Thousands of trees were treated and later dissected to map the spread of infections. This dissected sugar maple shows the discolored wood associated with the experimental drill wound.

New Concepts Needed

New concepts had to be developed that would serve both parts of this duality. One concept was called compartmentalization. Trees survived so long as they could compartmentalize the infections. Wood-inhabiting microorganisms survived so long as they could compete successfully in successions as the wood in the compartments was digested. This was the other concept. Compartmentalization then served the survival time for trees and the succession concept served microorganisms that attacked trees.

Compartmentalization is under moderate to strong genetic control. The ability of microorganisms to compete successfully with others and to spread within the compartments is also under genetic control.

These concepts help explain long-term survival of trees and their associates. Some of the associates benefit the tree while others act against the tree. However, while events are happening, the tree as a generating system is growing new



Hundreds of thousands of isolations for microorganisms from sound and infected wood showed that bacteria and non-decay causing fungi were usually the first organisms to invade wood through wounds and branch stubs. Here is a non-decay causing fungus, *Phialophora mellinii*, in a vessel in discolored wood in a red maple.

parts in new spatial positions. In this sense, the tree does not heal or restore injured and infected tissues. While all of these events are taking place, time is going by. The events explain the long-term survival of trees and their associates.

Old Problems Persist

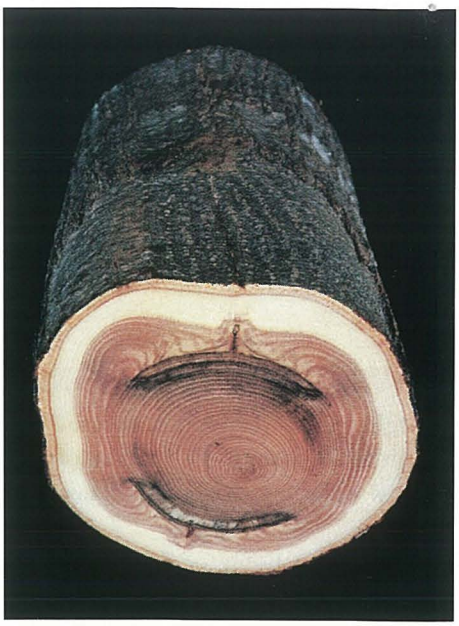
The concept of compartmentalization, as simple as it is, is still not understood by many people. Proof of this can be found in the words used by some researchers as they talk about "wound healing," "regenerating roots," and "wound repair." If the tree is accepted as a generating system, then terms that imply regenerating processes create oxymorons. The terms also block clear thinking needed to help solve other problems.

One concept that has blocked progress with understanding tree defense is the heartrot concept. Along with the concept has come "heartrot fungi." The heartrot concept is based on wood as a dead, nonresponsive substance. The heartrot concept is a wood decomposition concept. The concept states that wounds expose heartwood, which is dead wood, and the wood-rotting "heartrot fungi" then infect the dead wood and grow at will, eventually producing fruiting structures on the wound face. If the wound does not expose heartwood, then the injured wood soon becomes "wound heartwood," "pathological heartwood," or "precocious heartwood." This concept is still alive and very well in many textbooks and in the classrooms of the world. A major problem is the confusion about wood. It is seldom defined.

Symplast Concept

Wood is an organ made up of living, dying and dead cells that have boundaries of cellulose, hemicelluloses and lignins, mostly. The protoplasm of the living cells in wood and bark are connected in a three-dimensional network called the symplast. The dead boundary walls and dead cells that "hold" the symplast in place is called the apoplast.

The symplast is concentrated in a circumferencial zone between the wood and bark called the cambial zone, and an outer bark circumferencial zone called the phellogen and in radial bundles called meristematic points. This symplast concept is essential to an understanding of compartmentalization. Once the symplast concept is understood, then many parts of the compartmentalization concept fall into place. Just as you cannot have regenerating terms for a generating system, you cannot have dead wood terms for an organ that contains living cells. The easiest way to see the extent of the symplast is to pour a solution containing iodine (I_2-KI) over a freshly cut wood section. The iodine stains starch grains purple, and except for a few rare exceptions, the purple dots will only be seen in living cells. (The exceptions deal with starch grains left behind in cells that died quickly.)



Wounding experiments on heartwood-forming trees, such as the red oak shown here, helped to prove further that infections spread in highly ordered and predictable patterns.

Tree Defense & Protection

The symplast defines the limits of the tree defense system. Defense is dynamic and protection is static. As the inner symplast dies, the wood becomes protection wood. There are four types of protection wood: heartwood and false heartwood, discolored wood and wetwood. Heartwood is genetically age-altered wood that has a

Sharon Ossenbruggen (now deceased) developed many teaching programs that used a wide variety of models and other materials designed to help clarify the new concepts.

greater protection capacity than the sapwood that contains the symplast. False heartwood is wood so depleted of elements essential for life that few organisms can grow in it. False heartwood is often trunk wood associated with dying and dead branches. As the branches die, the trunk wood associated with the branches deplete their supply of elements, especially nitrogen-based molecules, that are essential for life. Discolored wood is wood infected by non-hymenomycetous, or non-decay causing fungi. In the early stages, discolored wood is a protection wood, but in later stages, as more organisms infect, the wood may lose its protection properties. As this happens, the discolored wood may take on the characteristics of soft rot where the S2 layer of the secondary layer of fibers is infected and altered. Wetwood is wood infected by anaerobic bacteria mostly. The infected wood is altered in ways that disrupt membranes, and leakage of substances leads to high concentrations of elements, high pH, and low amounts of free oxygen as micro spaces are filled with water.

Genetics Yes; Absolutes No

In nature, there are no absolutes. Strong defense and protection mean that there will be longer time periods before decomposition. Boundaries resist, not stop, infections. Strong tree defense reactions favor longer time periods, but eventually all living matter will be reduced to its primary parts, which will be reused, or recycled, for new life.

Some tree species, or even individuals within a species, have stronger and faster response systems for defense, or stronger

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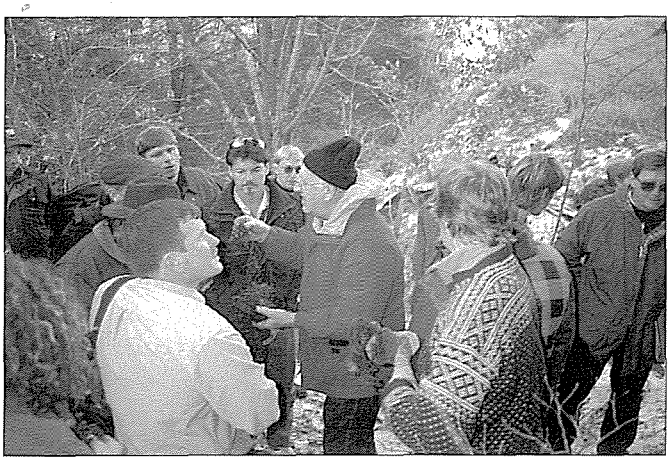


Many workshops were conducted to help arborists learn about the new concepts by touching all parts of the tree, inside and outside. Here participants are getting ready to dig roots and to touch mycorrhizae under snow-covered soils.

protection properties. These features are under genetic control. A major protection boundary that determines the longevity of many trees is the protection zone at the base of branches. All trees have branches and as some branches die or are mechanically removed, the openings are infection courts for wood-inhabiting microorganisms. The tree species that have the strongest branch-protection boundaries are those that usually live the longest.

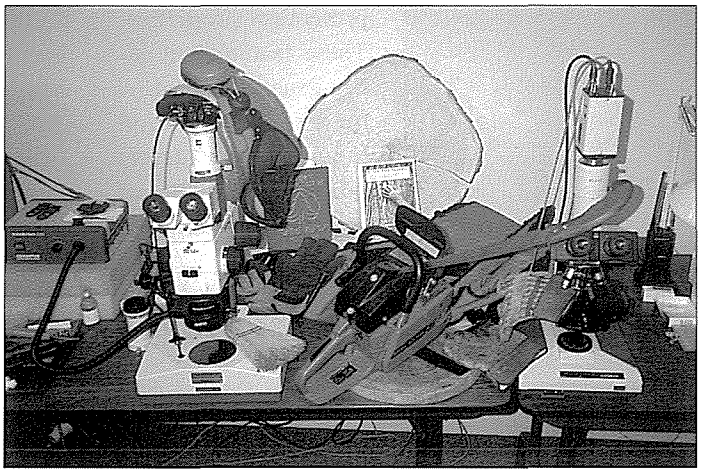
As microorganisms invade trunks by way of branch openings, the tree may eventually compartmentalize the infecting microorganisms. However, over time as the trunk wood walls off more symplast, the space for storage of energy reserves is also walled off. This is a major way root-rotting fungi slowly kill trees. The tree keeps losing space for storage, and as energy storage materials decrease, so does the capacity for defense.

The compartmentalization concept includes more than the tree; it also includes organisms associated with the tree. If trees had absolute defense and protection, wood would never decay. But, it does.

Tree Associates and Successions

The tree has as a defense system dynamic processes that resist the spread of invaders, or resist their advance with substances that temporarily stall their growth. The grand "natural idea" of succession is: if one group of organisms is not able to continue the invasion, another group will be able to do so. The group following the one before them also uses the dead organisms for a food source. This is a major way nitrogen-based substances are brought back into the wood. A major protection

scheme of trees is to "move" the supply of nitrogen-based substances out to the younger symplast as the wood ages. All organisms must have some nitrogen-based substances to build amino acids for proteins. The amount of new protoplasm is directly proportional to the amount of nitrogen-based substances available. Successions solve this problem by reusing the nitrogen-based substances left behind in the dead cells of those organisms that proceeded them. All these processes take time. As time goes by, the generating tree continues to grow new parts in new spacial positions.



A New Tree Biology brings together the microscope and the chain saw. The concepts that have developed over the last 40 years have been made possible because of the hard work done by many people. There is still a long way to go.

Mass, Energy Limits

Such a system has long-term, but not absolute, survival. As any system increases in mass, the energy to maintain order in the system increases exponentially. However, the tree has "a way" to minimize this threat to survival by shedding parts. The tree "uses" and sheds leaves and needles, reproductive parts, twigs, dying branches, and non-woody roots—root hairs, mycorrhizae. In a sense, the compartmentalized wood is a type of shedding. (Another type of duality arises, as a tree is both an annual and a perennial.)

CODIT Is a Model

To help people in the field understand and use the compartmentalization concept, a simple model of the concept called CODIT was developed. CODIT is an acronym for Compartmentalization Of Decay In Trees. Decay is defined here as a process where a highly ordered substance—wood—begins to become more disordered. Some people have substituted the words damage or defect for the D of CODIT. The problem here is that the altered wood in the compartments is not always an economic loss. In some cases the lightly colored wood adds value to a product.

The real problems with CODIT are that some people forget that it is a model and they think of the model terms as real anatomical walls. The more serious problem is one where the model is taken as an absolute process where the boundaries *stop* the infection.

Practical Applications

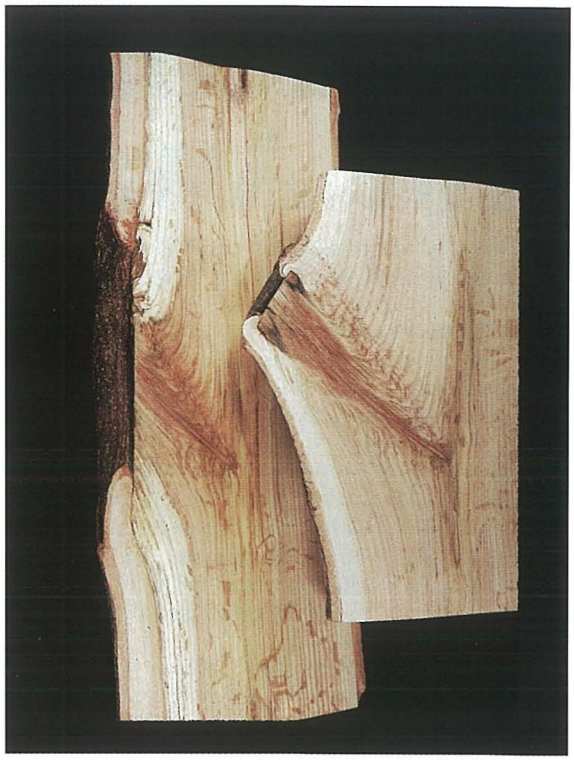
If a person understands A New Tree Biology with the concepts of compartmentalization and successions, old practices will be quickly recognized as being more harmful than beneficial.

Flush cuts on branches remove the tree's protection boundaries and create wounds in the trunk. Painting wounds blocks the normal successions, which stimulate the tree to form boundaries. Many of the organisms that are first on a fresh wound are those that "keep away" the more destructive types. Callus and woundwood form after wounding. Compartmentalization is a separate process that takes place in wood present at the time of wounding.

Digging into cavities breaks the compartment boundaries that resist the spread of infections. Drilling holes to drain liquids exposes healthy wood to infections. When wetwood is drained, the wood first infected by bacteria will usually be infected by wood-decaying fungi. As some trees are wounded repeatedly during treatments, the storage spaces for energy reserves is reduced, and defense is also reduced. Many insects and microorganisms attack when defense is low. As stored energy reserves

begin to become depleted, the processes that support compartmentalization no longer function. Then invaders have opportunities to grow rapidly in the wood.

In desperation, some people add fertilizers and call them tree foods. Worse yet is the practice of injecting nitrogen-based substances into trunk wood. This defeats the tree's protection feature where nitrogen-based substances move out of dying wood. The introduced nitrogen-based substances stimulate growth of microorganisms. As the tree compartmentalizes the infections, space for storage is decreased, along with defense. The leaves may get greener, and growth may be stimulated. These obvious signs are usually short-lived. Also, as nitrogen-based substances are absorbed, the nitrogen quickly bonds with carbon to form amino acids that in turn form more protoplasm. This is at the expense of the defense system because the carbon for the amino acids comes from the already low resources. Insect borers are common attackers, along with sap-feeding insects on leaves. They usually get the blame for the decline or death of the tree.



Many adjustments in treatments came from the new concepts. Wound dressings were shown to do more harm than good. Flush pruning was shown to cause many problems for trees. Here, a flush cut is compared to a proper cut that did not remove the branch collar.

A New and Better Future for Trees

A New Tree Biology focuses on defense as the major theme of a tree. Trees cannot move from destructive agents. They grow as highly defensive organisms. Their anatomy and physiology are ties to their defense actions, and later to features providing strong protection.

Trees connected with many other organisms, and synergistic processes led not only to stronger tree defense but to greater opportunities for survival of the associates. Forests came. Forests are systems made up of trees and many other organisms connected in such highly ordered ways that high-quality survival is ensured for all members.

Trees have developed ways to minimize the dangers of an increasing mass to energy ratio. Trees shed parts.

Trees grow within their means, or within the limits of their environment.

It is essential to understand first how any system operates at its most efficient and effective way. Then, when problems start, the chances for a remedy are much better.

As more people begin to understand A New Tree Biology, more old practices will slowly give way to new and better practices that will benefit the tree, the tree owner, and the people who care for the tree.

Touch Trees. Connect with Nature.

Dr. Alex L. Shigo is owner of Shigo & Trees, Associates in Durham, N.H. TCI

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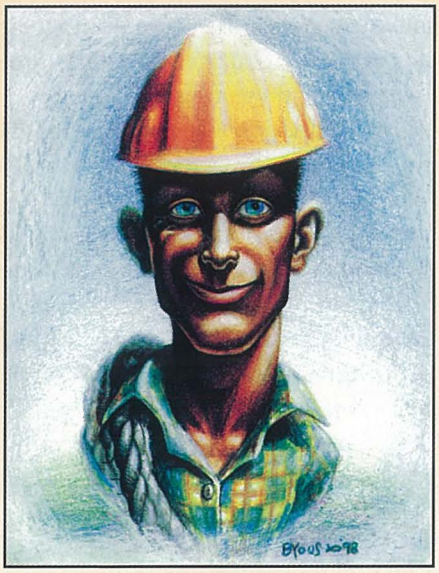
THE ARBORIST MONTHLY ADVISER

Leaving the Widow Carter's yard, Big Al Fontaine beamed with "fatherly" pride and confidence as he turned to take just one more look at his newly christened bucket truck. With this "new baby" on the job, Al was confident that his ace man, Max Bunyan, would carry out the day's work and pull down a hefty profit as well.

But, once Big Al was out of sight, a maverick idea wormed its way into the soft tissues of Max's brain. Max started figuring and he "figured" that this new bucket truck could not only elevate him into the tree to do the standard pruning job, but, with a little ingenuity, the lifting power of that bad boy could easily get the 36 inch boxed tree over the fence and into the Widow Carter's back yard, shaving *hours* off the job. Under his breath, Max chuckled at his own cleverness.

The movement of the articulating boom appeared a most lifelike as Max danced it over the boxed tree. Deftly he attached the lanyard from his body belt around the trunk of the tree and finished the connection by attaching the other end to the upper boom of the truck just below the bucket.



"Max Bunyan"

Just as Max had planned, the bucket lifted the tree off the ground. Then, with a creak and a mortal groan, the outstretched arm of the boom strained beneath the weight of the load. Suddenly, the lanyard gave way and snapped with a "*pop*" like a giant firecracker. The giant arm flexed and catapulted a helpless Max out of the bucket and flung him beyond the horizon, with the velocity of a Nolan Ryan fastball. In all his "figuring," Max hadn't figured on that.

The potential for accidents involving bucket trucks is too numerous to calculate. Nonetheless, the likelihood of an accident can be greatly reduced if a few simple ANSI requirements are met.

- **Understand the Manufacturer's Intended Application**: "An aerial device or aerial ladder shall not be used as a crane or hoist to lift or lower materials unless specifically designed to perform such operations by the manufacturer." (ANSI Z133.1-1994,5.2.5).

- **Tie in to the Lift**: "When aloft, the operator shall be secured with a body belt and personnel lanyard." (ANSI Z133.1-1994,5.2.2).

- **Inspect the Equipment**: "Prior to the daily use of an aerial lift device, a visual inspection and operational check can be made in accordance with the manufacturer's instructions. This inspection should be duly recorded." (ANSI Z133.1-1994,5.2.1).

Don't be lulled into a false sense of security. When working in an aerial lift, realize **that like a well-trained arborist, it has limits too**. Just as when you're climbing, be cautious, be careful, be aerial lift aware.