HOW TREES STARVE

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Fungi, insects, and pollution are real problems that can kill trees. Wounded trees and starving trees are also realities and part of the total picture. Declines and death of our urban trees are a many-sided problem. Knowing how a tree dies is as important as knowing the causal agent. It is time for the whole story.

Trees suffer more than mechanical wounds to trunks and roots. Injuries can also be caused by soil compaction, alteration of drainage patterns, and disruption of niches for soil microorganisms. The list goes on.

Starving trees face limitations other than water, oxygen and other chemical elements, and energy. Trees may also starve because of space reduction within the tree. As storage space for energy reserves in the tree decreases, so do reserves. Trees can starve in the midst of plenty if storage space is reduced sufficiently.

Starving trees in cities are nothing new. Investigators debate the effects of stress and environmental factors that predispose trees to additional problems. The words stress and predisposition occur frequently in the literature. What do these words mean, and how do they relate to the mixed ingredients of current tree problems?

Voltaire said, "Define your terms and arguments will be less than a few minutes". Here are some terms and definitions based on energy relations--more from a view of physics than pathology. It is doubtful that readers will agree totally with them. These terms are commonly used but seldom defined (that is one reason for so many arguments).

HEALTH is the ability -- dynamic state -- to resist strain.

STRAIN is an injurious, irreversible condition caused by excessive stress.

STRESS is a reversible condition where a system operates near the extremes for which it was designed, and the condition is caused by a drain, blockage, disruption, or shunt of energy.

ENERGY is the force that maintains vitality.

VITALITY is the dynamic ability to grow and reproduce within the limits of vigor

VIGOR is the genetically controlled capacity--potential--to survive after injury and infection.

INFECTION is a process of energy transfer from host to pathogen.

PATHOGEN is an agent that causes disease.

DISEASE is a process that transfers energy from host to pathogens and results in a condition of strain to all or part of the host.

HOST is the organism that has stored energy and is interacting with a pathogen in energy transfer.

ENERGY TRANSFER must consider the three laws of thermodynamics (para-phased here for emphasis): 1. You can never win, only break even; 2. You can only break even at absolute zero; and 3. You can never reach absolute zero.

DEATH of organisms occur three ways: By mechanical disruption, dysfunction, or infection (energy transfer and starvation).

Predisposition and Survival

Some disease-causing agents are virulent and invade rapidly. Consider the fungi that cause chestnut blight and white pine blister rust. But in most cases, disease-causing agents injure organisms that have been predisposed to disease. Factors that predispose an organism are usually different from those that cause symptoms later. Measuring how much an organism is predisposed presents difficulties.

When a disease-causing agent injures an organism that is predisposed to disease and another that is not, the difference between the organisms becomes obvious. The intensity of the diseases often depends on the degree of predisposition.

Predisposition results from stress--a reversible condition--which means that energy reserves are lowered, and the stage is set for "strain"--an irreversible condition. Energy is required to fuel the biological machinery of the tree: to build cells, maintain living functions, reproduce, and defend the tree after injury and infection.

Survival of all living things depends on energy, space to grow, concentrations of water and essential elements, temperature, time and genetic capacity to resist stress and strain. Because trees cannot move, all these survival factors are linked. Trees either grow on suitable sites, adapt to unsuitable sites, or die. Because survival factors are linked, any disruption in one affects the others.

Gun Analogy

Three events must occur in sequence to fire a gun: load, cock, fire. We must be careful to distinguish the agent's that "load" and "cock" the tree from those that "pull" the trigger.

How Trees Starve

Trees can trap energy from the sun, but they must have a place to store it. Tree structure is built up by compartmentation. Trees are highly compartmented, perennial, woody plants that are usually large and single-stemmed. The nonwoody parts--foliage, reproductive parts, absorbing roots--are shed after they age to a genetically programmed point.

Trees have a protection system--static--based on an arrangement of wood cells, corky bark, extractives in aged wood, and the low nitrogen content of wood. As highly compartmented organisms, trees set boundaries to resist the spread of pathogens. Rather than restore injured and infected cells, trees separate strained parts from healthy wood by forming barrier zones. This active, dynamic defense system called compartmentalization, has long-term survival benefits.

Trees have static protection features and dynamic defense systems. Groups of trees in the forest also have protection features such as their gregarious nature, spatial associations with neighbors, and asynchronous timing of growth processes. But little is known about group defense systems (I suspect that in the future we will learn more about changes in electrical fields and how they play a role in group defense. I believe insects can detect a sick tree long before the tree emits any chemical signals.)

A tree remains alive after injury and infection because of its ability to set firm boundaries around affected tissues. Like many natural processes, compartmentalization can be both beneficial and life threatening, depending on concentrations. While forming barrier zones to isolate a pathogen, the tree also decreases space used for storing energy reserves. As long as the volume of new energy storing tissue formed after injury and infection is equal to or greater than the volume of tissues that are walled off, the tree can survive. The tissues involved are crucial. Branches may be walled off, and new branches will form at new locations, and older tissue in the center of the stem may be walled off without loss of energy-storing space.

Problems develop when energy storing tissues in the most recently formed growth rings are walled off. Injuries and infections that result in compartmentalization of cells where energy reserves are normally stored, can seriously affect survival of the tree. The tree still requires energy to build new cells, maintain biological machinery, reproduce, and defend itself. When a tree cannot do these things, it dies.

Reduced energy reserves may delay or prevent reproduction in some trees. In others, like the American elm, reproduction occurs before leaves are formed; high energy demands for reproduction are met first. Much stored energy goes for defense. Boundaries in wood present at the time of infection are called reaction zones, and are made up of phenol-based materials that act as carbohydrate sinks. Once energy is used for defense, that energy cannot be used again for other tree functions. Energy reserves decrease as storage space shrinks. Growth is slowed, reproduction is stalled in some trees, and yet defense is increased. The defense system demands energy to wall off tissues as it sets new boundaries--barrier zones--about the infected wood.

A tree could live on a single growth ring provided that no new infections occurred. The current growth ring usually does not store energy reserves until the end of the growth period. If a new agent arrives that causes additional stress, the tree starts its final survival tactic; it begins to wall off more and more of itself as it walls off the injured and infected wood. This response can still save the tree, if the tree becomes smaller in mass and maintains a reduced energy budget. Tree starvation due to reduction of storage space, while not the sole cause of many tree problems, is an important ingredient that has been overlooked.

WHAT CAN BE DONE?

1. Prevent wounds. Avoid lawnmower damage.
2. Select the right trees for the right site: Sun trees, shade trees
3. Start selecting and planting tough trees that can compartmentalize more effectively than others.
4. Prune properly to reduce injuries. No stubs! No flush cuts!
5. Maintain health by sound cultural practices: watering, fertilization, aeration, wound treatments, etc.
6. Avoid construction damage. Avoid compaction.
7. Keep grass away from tree base (if possible).
8. Do not brace trees so tight that they cannot move.
9. Use injections and implants with great care.
10. Do not paint wounds.
11. Plant properly. Do not injure roots. Do not over-amend the soil. Do not fertilize at planting time.
12. Do not top trees.
13. Do not use climbing spikes (except for removal and rescues).
14. Do not fertilizer stressed trees until they recover, then fertilize after leaves form.

Final Point

Starvation starts when essential substances become limiting, and when storage space for energy reserves in the tree decreases. Stress is an energy problem. Trees planted in our urban world need proper care. Proper care depends on a sound understanding of tree biology. The more you learn about how trees work, the better you will be able to work with trees.