Why Do Trees Die?

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To Understand How Trees Decline and Die, We Must:

- Understand stress and how it affects trees
  - To do this, we must also understand:
    - Tree anatomy and how trees grow
    - The processes of respiration, photosynthesis, transpiration, and translocation
- Understand how trees allocate resources

What is “Stress?”

- Any condition, or complex of conditions, that limits the tree’s ability to obtain essential resources from the environment
- This can occur because of:
  - Actual shortage of resources in the environment
  - Inability of the tree to obtain/move/process resources that exist in adequate supply in the environment

Tree Physiology

- The study of processes that take place inside at tree
  - Photosynthesis
  - Respiration
  - Transpiration
  - Absorption
  - Translocation
  - Growth and Development
  - Defense
Photosynthesis

- Chlorophyll (Leaves and Green Twigs)
- Water (Soil)
- Carbon Dioxide (Air)
- Oxygen (Air)
- Light Energy

Water + Carbon Dioxide + Light Energy → Sugar + Oxygen

- This process allows us to live on this planet
- Sugar can function as both a potential and kinetic energy for the tree

What Happens to the Sugar?

- Much is used as a kinetic energy source for respiration
  - fuels day to day processes (makes things happen)
- Chained together to make “Cellulose”
  - more leaves, roots, wood, etc.
- Chained together to make “Starch”
  - stored for future energy needs as carbohydrate reserves (Potential Energy)
- Used for fuel to make protective chemicals

Respiration

- Reverse of photosynthesis
- Sugars are burned to produce kinetic energy for use
- Occurs both day and night (even when trees are dormant)
- Ultimately, this becomes the key process

Transpiration Pulls Water Up Stem

- Loss of water through the foliage in the form of water vapor
- As water vapor is lost, water molecules “pull” each other up the plant
- Direct connections exist from root hairs to leaves
- Rate of water loss is regulated by stomates
  - Usually open during day and close at night
- Temperature, humidity, light and other factors all influence transpiration
**Absorption/Translocation**

**Water Moves into Root By Osmosis**

- Plant cells have more solutes in their interior than does water in the soil
  - Water moves from low solutes to high solutes
  - Same principle as used in pickles or salted meats
  - Requires no or little energy
- Once water reaches xylem tissues in root, transpiration pulls water molecules up the tree

**Passive and Active Uptake of Nutrients**

- Passive Transport - movement of nutrients from higher to lower concentration (Diffusion)
- Active Transport - root selectively transports nutrients across plasma membrane and into the root against concentration gradient
  - Requires Energy

**Translocation**

- Food (sugars and other compounds) are moved in phloem tissues
  - Sources (where made)
    - Leaves/green twigs
  - Sinks (where needed)
    - Fruit
    - Seeds
    - Young foliage
    - Root tissues
- This movement can be up, down, or sideways in the tree
  - Loading the phloem requires energy
- The phloem, like the cambium, is very thin and easily damaged

**Growth**

- Tree Growth depends on two "pumps"
  - One produces water and elements
  - The other produces energy
- Each depends on the other
  - If one begins to fail, the other will soon follow
- Growth and health depend on how well both pumps can function as the tree grows larger
Trees are Generating Systems

- They must grow to survive
- They can grow fast or slow, a lot or a little, but they must grow
  » They have no choice
- If trees stop growing, they die!

Trees Allocate Resources

- Metabolism
- Growth
- Reproduction
- Defense

- Tree must finance all of these
- Maintaining a high level of potential energy is key to long-term health

Dynamic vs Static Mass

Dynamic Mass: Tissues that are alive and functioning
Static Mass: Tissues that are dead or not actively functioning

- As Trees Age:
  - Static mass increases relative to dynamic mass
  - Potential/Kinetic energy ratio decreases
  - Demand for carbohydrates increases
    » Volume of respiring tissues increases while photosynthetic volume remains fairly constant

Photosynthesis Vs Growth Vs Defense

- Can there be too much of a good thing?
- What about the low/moderate range?

How Does Nature Handle the Situation?
**Growth Strategy and Life Expectancy**

- **Fast Growth Tree Species**
  - Trees allocate energy to growth and defenses differently
  - Resulting life expectancy vary based on growth strategy
  - Poplars \( \rightarrow \) 60 years
    - “Live Fast, Die Young”
  - Oaks \( \rightarrow \) 200-300 years
    - “Slow and Steady Wins the Race”

- **Slow Growth Tree Species**

Quandary—Which is More Desirable?

**Resource Allocation Unequal Incomes**

- The tree with the greater income can allocate more to each use, but maintain the balance

**Tree Defense Systems CODIT**

- CODIT can be hard to visualize
  - Key points
    - It’s a survival mechanism
    - Wood that forms after wounding is more resistant to decay
    - Trees may become hollow as a result of CODIT
    - Decay spreads vertically faster than sideways and outward

- Requires Energy, but is funded at low priority

**Prioritization of Resources**

1. Maintenance of living tissues (Respiration)
2. Production of fine roots
3. Flower and seed production
4. Primary growth (elongation of shoots and roots)
5a. Secondary/Diameter growth
5b. Defensive chemicals

Oliver and Larson, 1996
The tree is committed to increasing its mass. With limiting resources, the tree regulates its dynamic/static ratio so that kinetic energy demands do not exceed potential energy reserves. It can’t keep doing this forever!

The Decline Spiral

- Predisposing Factor
  - Diminishes vitality from optimum
  - May not be noticeable
  - Long term
  - Character of tree or physical environment

- Inciting Factor
  - Especially damaging to Predisposed tree
  - Short term
  - Often very noticeable
  - Physical or biotic

- Contributing Factor
  - Perpetuates decline of already altered tree
  - Long term
  - Effect often very noticeable
  - Often opportunistic insect/pathogen

Patterns of Death in Landscape Trees

- Structural Failure
  - Branch, crown and stem failure, uprooting, decay, girdling

- Environmental Degradation
  - Acute
    - Flooding, fire, vandalism, construction injury, drought, high/low temperature
  - Chronic
    - Soil toxicity, soil compaction, air pollution, restricted growing space, low fertility, severe pruning

- Parasitic Invasion
  - Insects, fungi, bacteria, viruses, mycoplasma-like organisms, parasitic plants
So, Why Do Trees Die?

- **And finally, Respiration Terminates**
  - Which leads to carbohydrate production ceasing and/or carbohydrate stores being exhausted
    - Then, photosynthesis slows or discontinues
      - Factors necessary for photosynthesis are unavailable, interrupted, or obstructed
        - Because of physical, biological, environmental or human factors

Summary

- Each part of a tree’s anatomy contributes to its survival
- Photosynthesis produces energy, respiration uses that energy, and transpiration keeps trees hydrated
- A tree’s vascular system is responsible for moving water, nutrients, and foods to where they are needed
- Trees defend themselves from insects and diseases, **but ultimately, run out of energy**