Climate Change and Urban Trees: effects on disease and insect pests

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Longer, hotter, and dryer summers are expected in the PNW

- Other climate related impacts on plant health:
  - Elevated atmospheric CO$_2$ (no real question about this one)
  - Potentially warmer and wetter winter months

- Both Direct and Indirect Effects are expected
  - CO$_2$
  - Moisture
  - Heat
General Effects of Elevated CO$_2$ on Plants

• More growth (short term)
  • CO$_2$ is a major limiting factor (in C3 plants)
  • Only with ample Nitrogen

• Longer term:
  • Higher C/N ratio in leaves, less proteins
  • Reduced transpiration, higher WUE
Why does C/N ratio shift?

- Less CO$_2$ fixing enzyme needed (RuBisCO)
  - More efficient (Nitrogen use)
  - Less photorespiration

- Build up of carbon-based defense compounds and NSC’s
  - Lignin, tannins, other phenolic compounds
Higher Carbon to Nitrogen ratio

• Leaves are less nutritious to insects.
• Smaller insects, or bigger appetites?
Elevated CO$_2$ in geologic past led to increased insect damage on plants

- > 5,000 fossils
- 55 MYA
  - Coincides with spike in global CO$_2$ and Temp.
- Increased damage by all feeding types

Currano et al, 2008: PNAS 105 (1960-4)
Modern elevated CO$_2$ experiments support increased damage hypothesis

Soybeans in a FACE experiment suffered increased foliar feeding by Japanese beetles

- DeLucia et. al PNAS 105 (1781-2)
FACE experiments at Duke Forest

- Free Air Carbon Enrichment
Effects of CO$_2$ on disease = variable

- Defense chemistry, foliar content, effects on pathogen, stomatal density and opening, etc.

Elevated CO$_2$ reduces disease incidence and severity of a red maple fungal pathogen via changes in host physiology and leaf chemistry

Combined effects of elevated CO$_2$ and natural climatic variation on leaf spot diseases of redbud and sweetgum trees

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What about the effects of elevated temperatures?

- Warmer temps will go hand in hand with longer dry periods
Disease at elevated temperatures

- More impact on bacterial pathogens than fungal
  - Fireblight, Bacterial leaf scorch, Bacterial blights (fruit)
  - Q-10 has large impact on single cell organisms
Insects at Elevated Temperatures

- Faster development
- Earlier emergence, longer season
- More generations per year
Aphids are a good example:
Drought Factors affecting disease susceptibility

- Reduced carbon for defense compounds
  - Nitrogen-based vs. Carbon-based defenses

- Reduced calcium and potassium affect cell walls and signaling

- Reduced water potential of wood and leaves
Drought Factors affecting disease pressure

• Foliage - less fungal germination and growth

• Reduced breakdown of OM and inoculum.

• Reduction in beneficial soil microbes.
  • Many soil bacteria suppress plant disease
Foliar diseases

• Generally *reduced* for several reasons-
  • Most require free moisture or high humidity
  • Stomata are closed (common infection site)
  • Leaves developing during drought tend to be *thicker* and *smaller*
Wet leaves and Drying time

- *Old News*: 1978 study on anthracnose of walnut shows **6 hour** minimum free moisture requirement.

Fig. 2. Influence of the length of time free moisture remained on leaflet surfaces at three postinoculation temperatures on incidence of infection of walnut leaflets following artificial inoculation with *Gnomonia leptostyla*. Each bar on the graph

Possible exception

- Powdery mildews do not require free moisture
Drought and Insect Pests

- Drought stressed trees release chemical attractants to borers

- Drought stressed conifers lack the ability to ‘pitch out’ borers

- Drought reduces populations and virulence of entomopathogenic fungi
Bark beetles are a major problem following long-term drought stress.

- Mountain Pine Beetle: 35 million acres and counting in B.C.
- 21 different beetles in western U.S.: 42 million acres and counting
- Aided by monoculture planting, increases risk of catastrophic wildfires.
Beetles that serve as disease vectors are attracted to stressed trees.
Drought will also increase the stress caused by wilts like *Verticillium* spp.
Susceptibility to many canker diseases is also related to plant moisture status
Drought increased canker disease in Birch

- Size of canker is larger at water potentials that limit photosynthesis
- Less energy for defense compounds
Drought followed by heavy rains create perfect conditions for *Phytophthora* root diseases…

- Drought affects membrane permeability.
- “Leaky” roots attract spores.
In dry weather, conk formation is less likely (advanced inspection more important)
Drought effects on decay?

Fungi in tissue can grow under water potentials that inhibit photosynthesis.

Reduced carbon and compartmentalization.
Review

- Elevated atmospheric carbon dioxide
  - Insect damage: likely to increase feeding
  - Disease: variable results, changes in leaf chemistry, wetness, stomata, etc.

- Elevated temperatures
  - Insects: reduced generation times, faster development
  - Disease: higher rates of bacterial reproduction, variable on fungal disease

- Prolonged dry periods
  - Insects: (borers) attracted to stressed trees, less defense compounds
  - Disease: foliar reduced, secondary (cankers) increase, root rot variable
What can be done?

• Plant Selection
  • Very important for longer lived species
  • Native only? Native to what?
  • Look to the south or the Mediterranean for adapted, non-invasive plants

• Stress reduction
  • Mulch
  • Proper irrigation
  • Proper planting and good nursery stock

• Manipulate stress tolerance?
  • Maybe
Chemical or Biological Treatments?

- Insect control: earlier emergence, faster generation times
  - Biological control example: predatory mites

- Very few chemical options for cankers, wilts, etc.

- Efficacy of products with living organisms may be reduced
  - Bt products
  - Fungal spore based products (Met 52, Trichoderma, etc.)

- **Most stress-related diseases have poor chemical options**
Planting: Native to what?

• Young trees are vigorous, can tolerate many different growing conditions.

• Mature trees are less tolerant of stress.
  • What will conditions be like at maturity?
Coast Redwoods in California

- Native from Orange county through Oregon border, but...
Moisture monitoring and irrigation

• Tensiometers are simple and effective tools for monitoring soil moisture.

• Sentinel plants (Early Wilters) may serve same purpose.
  • Hydrangea
Mulch!!! (reason # 1,245 for mulch)

- Adds Organic Matter
- Reduces evaporation
- Improves structure / distribution of water
- Suppresses or eliminates competition
Not all ‘mulch’ is good mulch

• Stone may super-heat roots, root collar, and stem.

• Rubber releases toxic leachates
Can we manipulate drought tolerance?

- Endophytic fungi and bacteria impart stress tolerances

- Factors associated with drought tolerant species:
  - Increased leaf pubescence
    - Larger barrier zone of humid air
    - Increased reflectance of energy

- Smaller and thicker leaves:
  - Less leakage of humidity (surface area and cuticle thickness)
  - Deeper stomatal pits
  - More chlorophyll in deeper layers
Type-II Growth Regulators

- Gibberellin biosynthesis inhibitor
- Same number of cells, less elongation
  - Thicker, smaller leaves
- Decreased vegetative growth
  - Higher R:S ratio
- Thicker cuticle and increased pubescence

Smaller leaves (Bert Cregg, Garden Prof Blog)

Thicker Leaves (Bill Chaney via Shawn Bernick)

Hairier Leaves (Bill Chaney via Shawn Bernick)
Bottom line:

- Insects may eat more, have shorter generation times
- Foliar disease reduced in low-moisture
- Wilts and bacterial disease worsen
- Secondary pathogens (canker fungi) increase

- No direct chemical options for disease
- Various potential materials for stress reduction

- Nothing beats plant selection, moisture management, and mulch
Thank You!