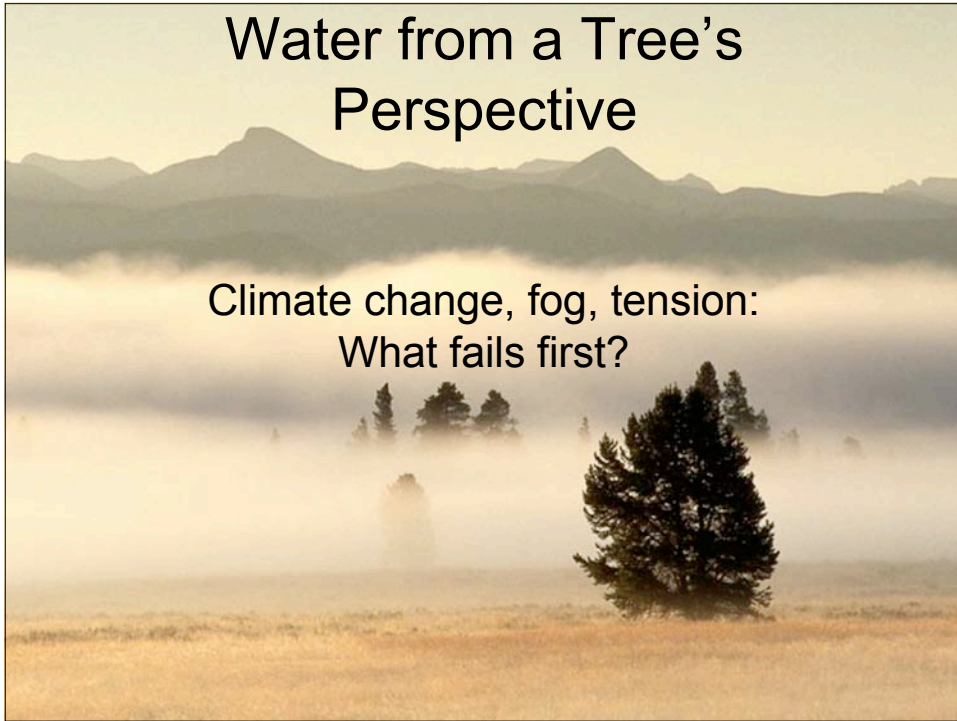
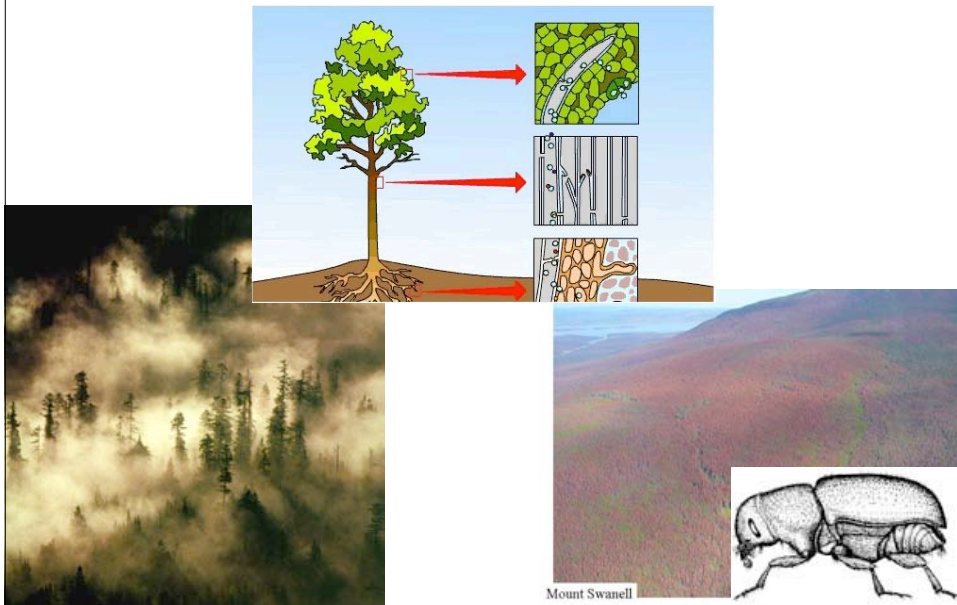


# Water from a Tree's Perspective

Climate change, fog, tension:  
What fails first?



## Where are we headed?



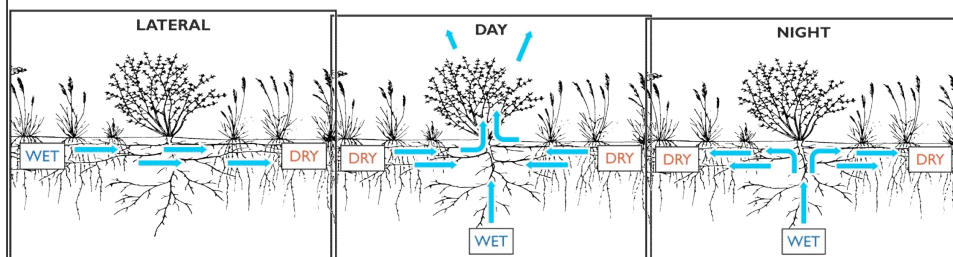
## Specific Issues to Address

- Role of trees & forests in the hydrologic cycle
  - Interception, stemflow, throughfall, evapo-transpiration
  - Individual ( $333 \text{ kg d}^{-1}$ ) versus stand (understory [ $1.7$ ] a fraction of the overstory [ $5.5 \text{ mm d}^{-1}$ ])
- Three unique aspects
  - Hydraulic redistribution - from the soil profile to the Amazon
  - Forest structure and hydrological modifications
    - Fog & cloud
    - Rain on snow
  - Night-time transpiration
- What limits the height of trees?
- Climate Change



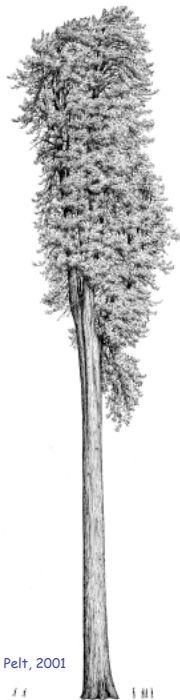
## Hydraulic Redistribution

- First described as hydraulic lift and noted in obvious situations (species x environment): Great Basin sagebrush, Tamarix spp., alfalfa.
- Then much more broadly noted
- What is it!



## Hydraulic Redistribution - Implications

- Varies seasonally - greatest impact under moderate drought ( $\leq 0.35 \text{ mm m}^{-1} \text{ d}^{-1}$ ).
  - Replenishes ~30% of the soil water removed each day by plants from the upper soil.
  - Results in delayed drying of the upper soil to critical levels by 16 to 31 d.
- Dry-tropical rainforest data from the Amazon (Lee et al. 2005 PNAS)
  - HR increases dry season (July to November) transpiration by 40% over the Amazon.
  - Indirectly affects area temperature via latent heat



From Van Pelt, 2001

### Fog and Tension - redwoods to the rescue

Stratosphere Giant

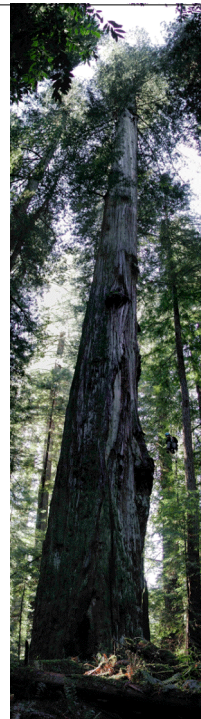
369 feet 9 inches

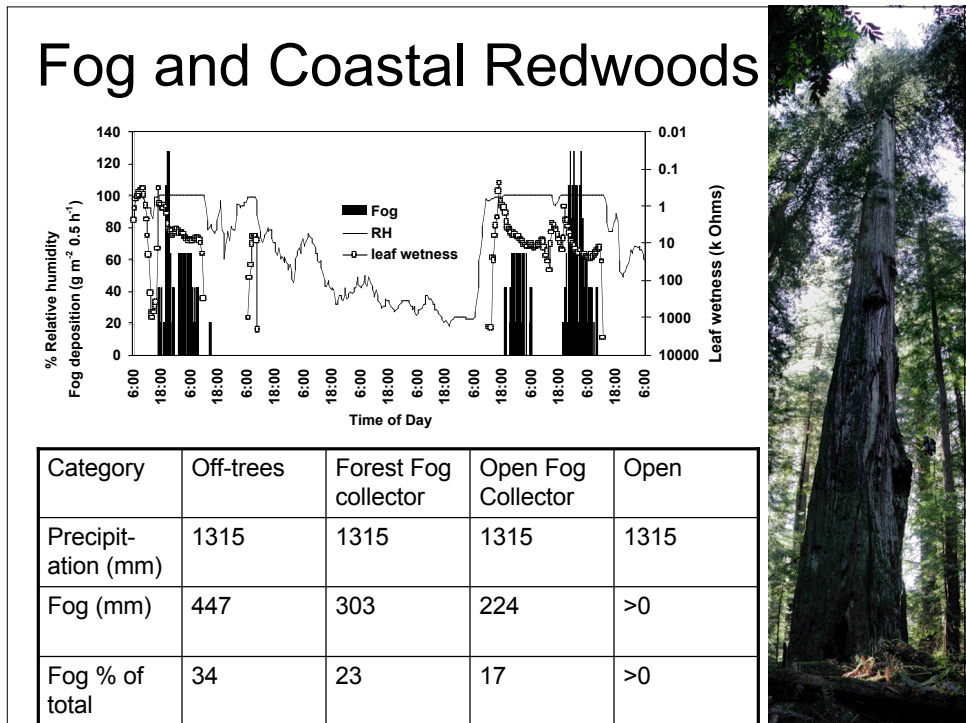
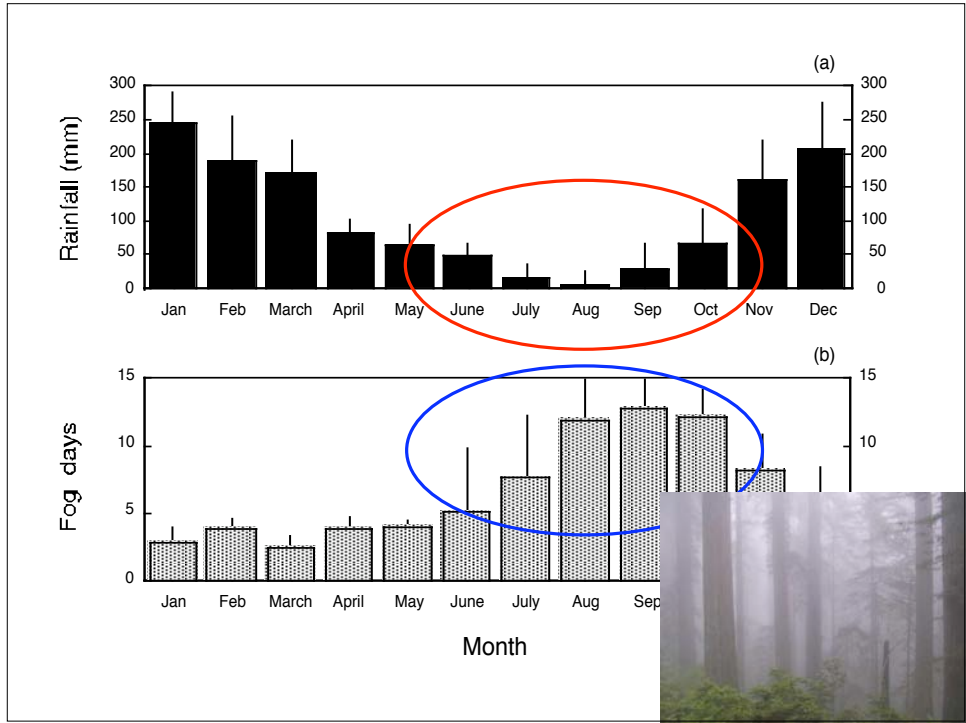
112.7 meters

Tallest known living tree

Discovered in Rockefeller Forest, HRSP in August 2000; 112.34m

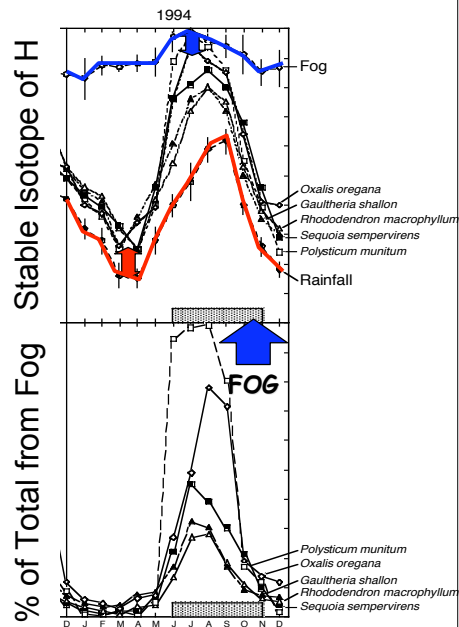
Has grown 0.36 m in 2 years (as of 11/02)





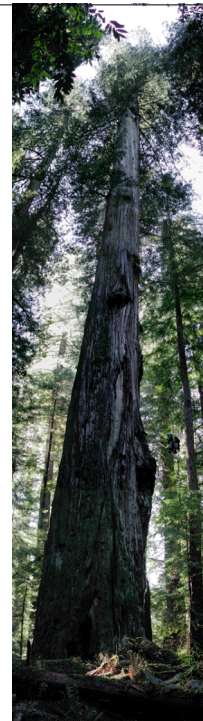
## Fog & Forest Ecosystems

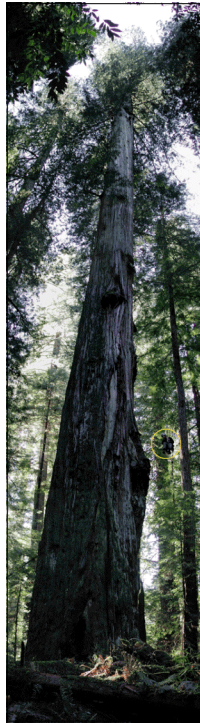
- Impacts at three scales
  - Leaf
  - Stand or ecosystem
  - Watershed to region



## What limits tree height?

- Genetics
- Environment
- Age - no, grafting experiments on ash, sycamore, scots pine and poplar by Maurizio Mencuccini and others.
- Size, hydraulic safety, and environment.
- Hydraulic limitation hypothesis of Barbara Bond and Mike Ryan





## Experiments that demonstrate

- George Koch +
- Duplicated theoretical gradient
- Sapling near top



## Remaining Height/Transport Issues

- Role of bending or motion (Meng and others)
- Xylem anatomy
  - Cell size
  - Cell wall features
  - Pores
- Cavitation and re-filling
- Is height growth commercially important?

## Trees in a stand - Synthesis



- Compositionally different
- Structurally different (above- and below-ground).
- Means that trees interact with above- and belowground environments differentially
- Means that variation above and belowground is greater than expected
- Means that variation changes as structure and composition change

## Trees, Stands & Climate Change

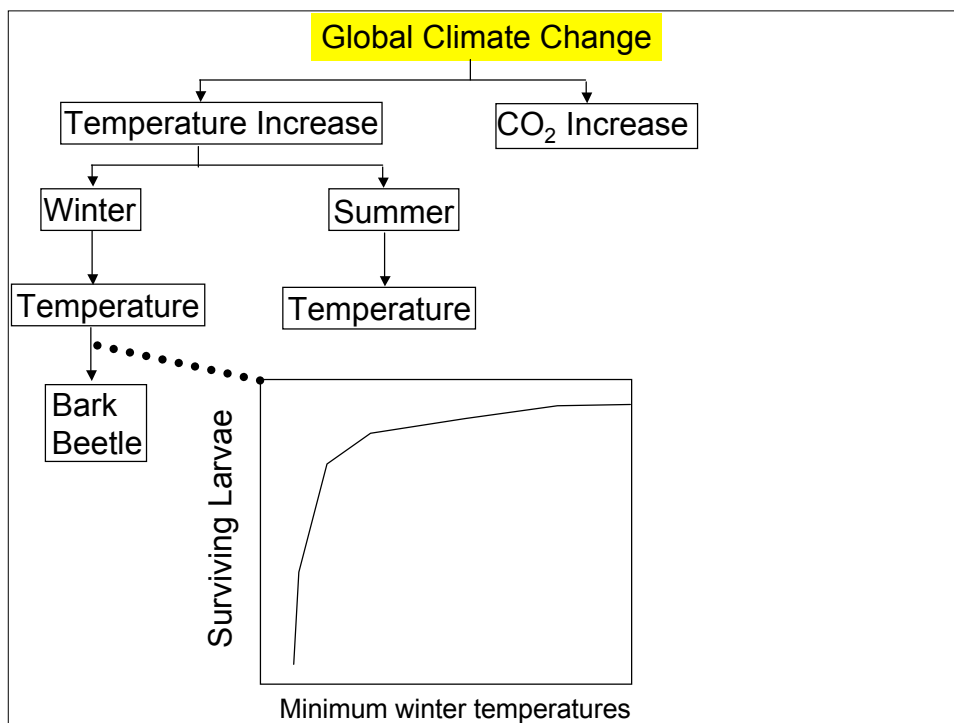
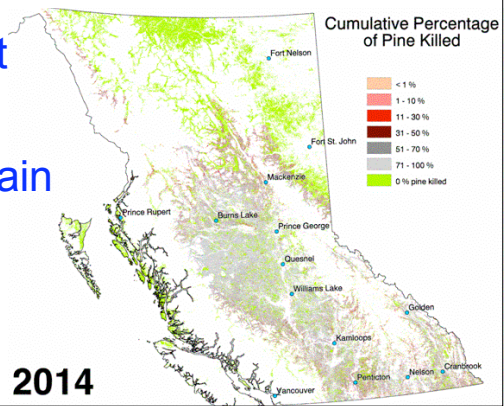
- Impact on life cycle of tree (reproduction & establishment)
- Impact on tree vigor
- Impact on disturbance regimes
- Impact on biotic organisms associated ( $\pm$ ) with trees
- Impact on invasive organisms
- Mountain pine beetle as a dramatic example

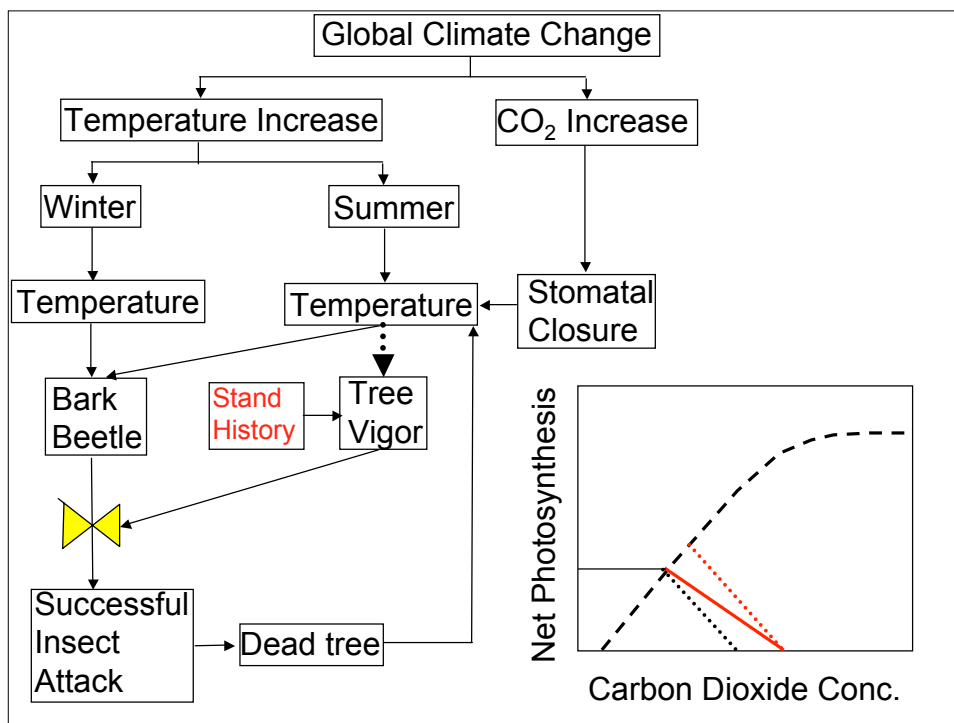
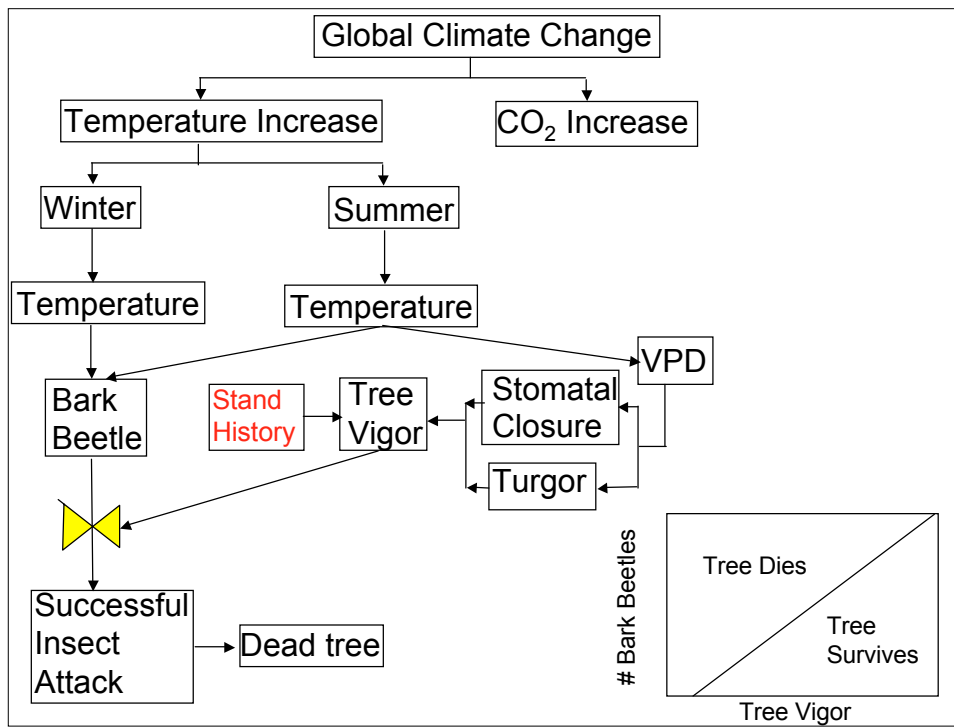
# Impact of Climate Change

- Life cycle of mountain pine beetle
- Vigor of tree

## Forest Management

- Fire Suppression
- Harvesting of certain species types





## Impacts of Water & MPB

- Mortality -- Incredible outbreak in intensity, impact and potential
- Salvage logging
- Pellets for biomass
- Nurseries
- Future
  - Forests
    - Fire
    - Landslides
  - Communities
  - Disturbances



**Question:** What gives?

Processes remain the same, outcomes change.

