

# Small to Large Scale Issues in Plant Water Use

Nighttime transpiration and  
hydraulic redistribution to Regional  
impacts of elevated CO<sub>2</sub> on Water  
Use Efficiency

The Water Center

2008 Annual Review

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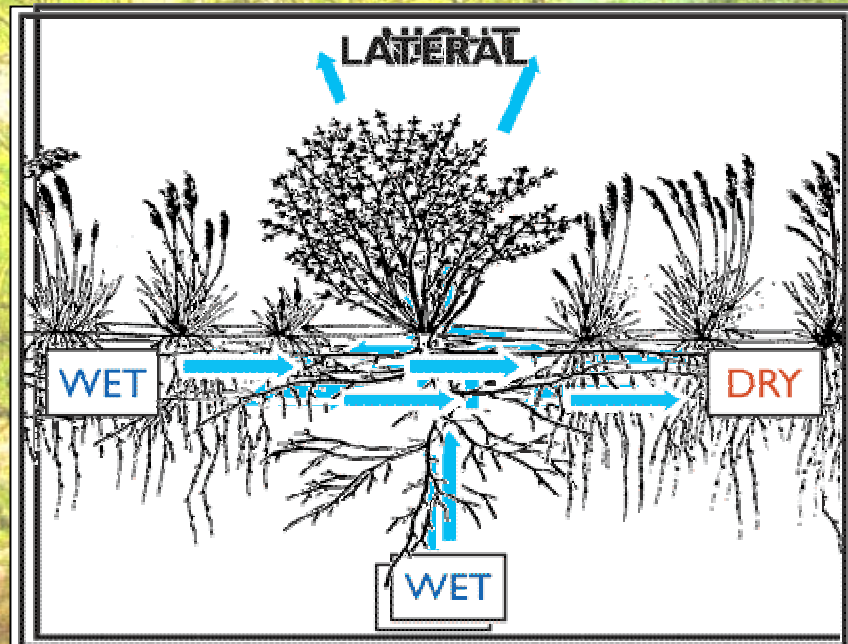
# Specific Tree/Stand Issues to Address

- 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 interesting tree/stand level issues
  - Night-time transpiration (**10 - 22% of the daily total**)
  - Hydraulic redistribution - from the soil profile to the Amazon
  - Forest structure and hydrological modifications
    - Fog & cloud
    - Rain on snow



# 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

# Fog and redwoods

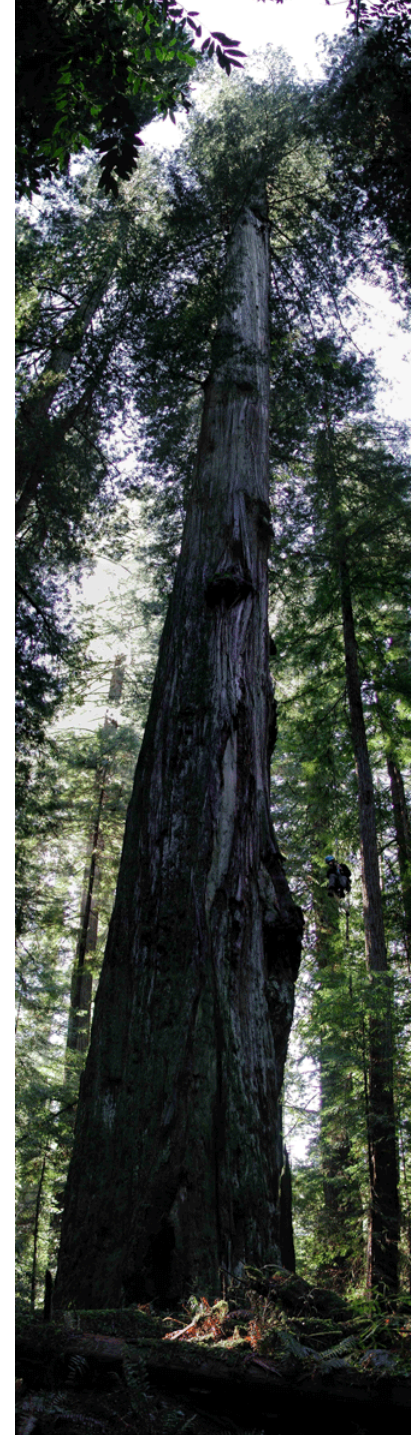
Stratosphere Giant

369 feet 9 inches

112.7 meters

From Van Pelt, 2001

Work of Dawson, Sillett, Koch

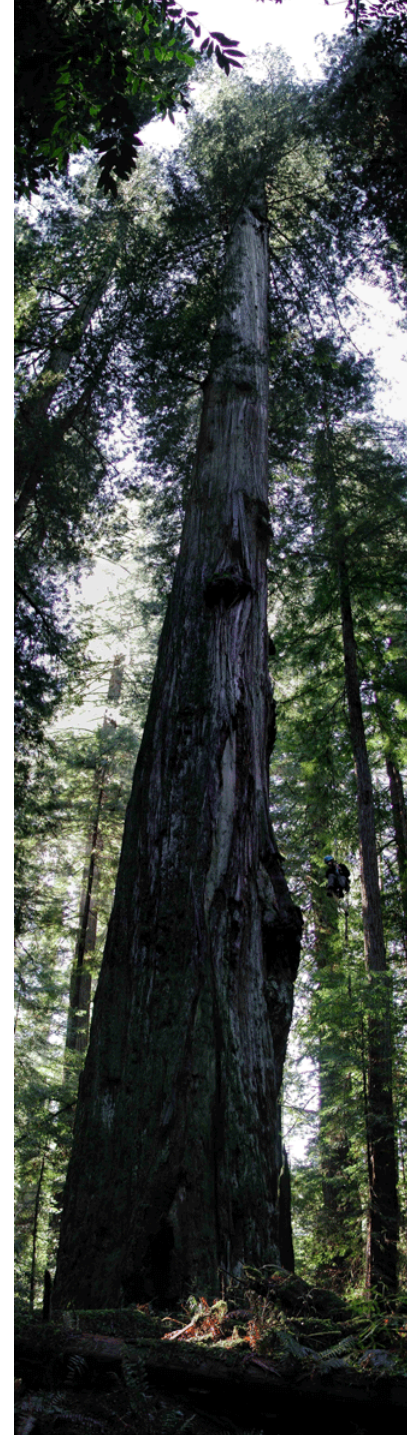




# Fog and Coastal Redwoods

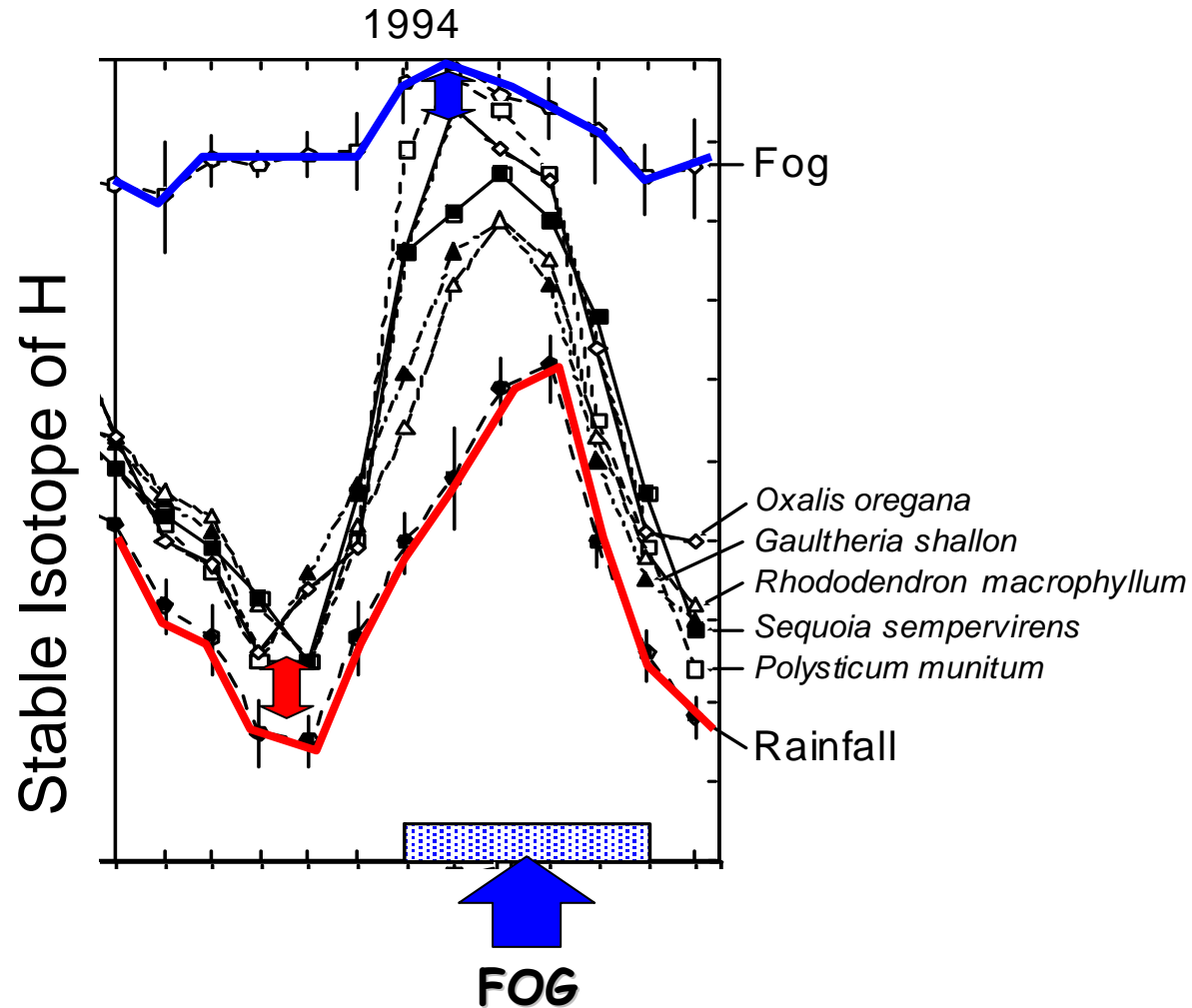
Category	Off-trees	Forest Fog collector	Open Fog Collector	Open
Precipitation (mm)	1315	1315	1315	1315
Fog (mm)	447	303	224	>0
Fog % of total	34	23	17	>0

- Increase in soil moisture
- Direct uptake by foliage (small)



# Fog & Forest Ecosystems

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



# Larger Scale Issues

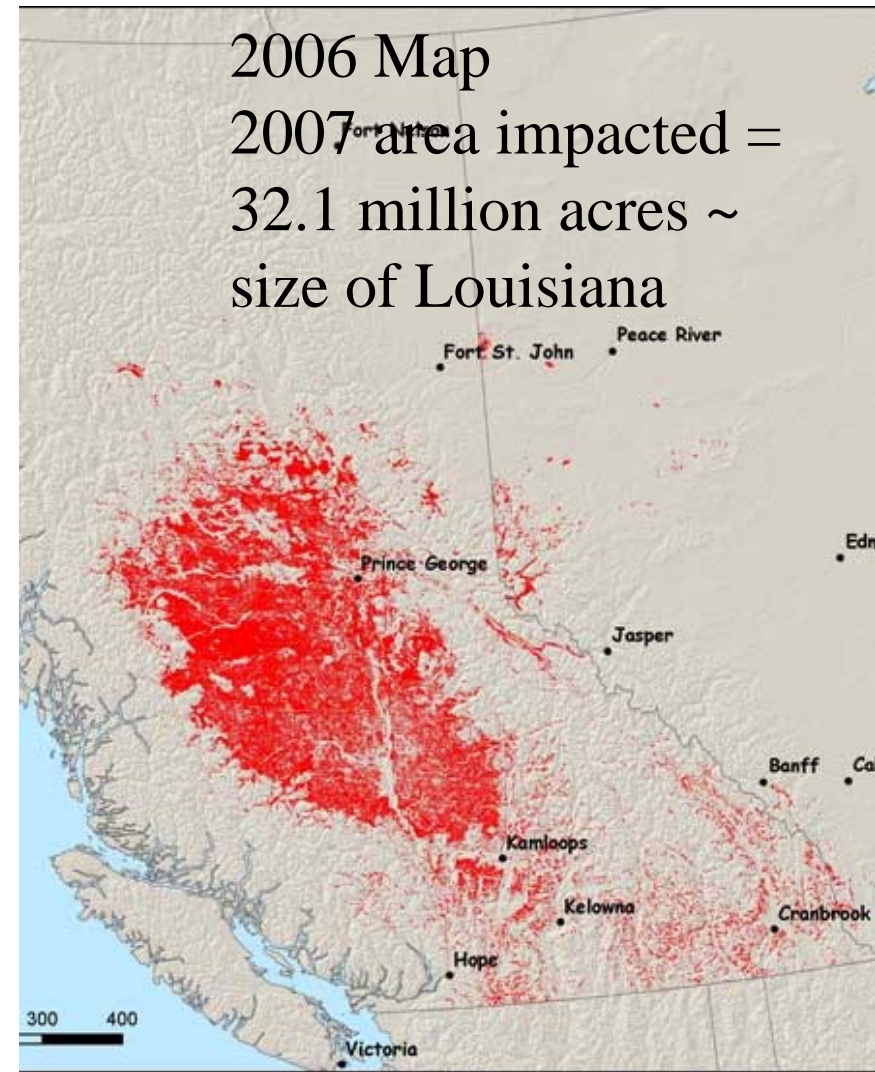
- Forest stand water use and stream runoff
- Bugs, trees and climate change
- Increases in baseflow as a result of increases in water use efficiency

# Work of Jeff McDonnell & Group

- **Assumption** - water at a given slope location is a function of the upslope cumulative area to that point.
- **Visual Connection** between stand water use & hydrograph
- Observed (HJ Andrews)
  - Water falling in a watershed moves mostly vertically in the soil profile
  - Trees use most soil water
  - Stream water is most ground water that has had a long-residence time in watershed

# Bugs, Climate Change, Trees

- The perfect 'storm'
  - Life cycle of mountain pine beetle
  - Historical fire management decisions
    - Fire suppression
    - Species chosen for harvest
    - Extent of lodgepole pine
    - Vigor of tree





**Photo Credit: Natural Resources Canada - Canadian Forest Service**



# Largest Scale

- Field et al. (1996): As  $[\text{CO}_2]$  increases, plants can close stomata, reduce transpiration, and maintain the same rate of photosynthesis (WUE increases).
- Gedney et al. (2006. Nature). Increases in global continental runoff are due to increases in WUE.
- Subsequent publications - increased ppt, changes in land use, etc.
- Broader implications of Field's paper

# Storm potentially gets worse

- Future Climate

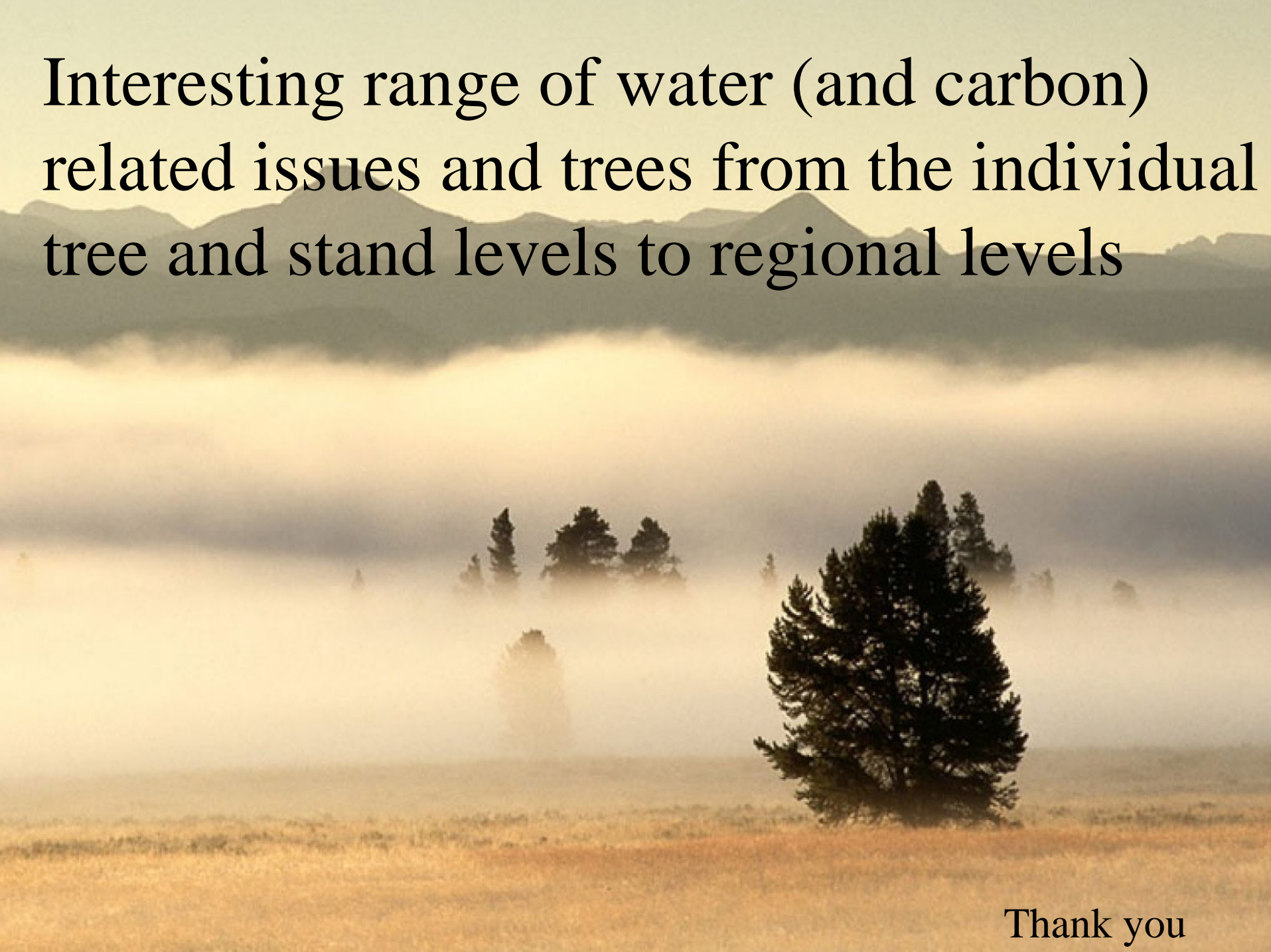
- Warmer, wetter winters, longer warm season, drier summers

- Future forests

- Largely unmanaged
- Dense, lots of mortality
- Fire suppression
- Insect and diseases (both native and non-native)
- Competition from invasive plants
- Disturbances (fire, landslides)



Interesting range of water (and carbon)  
related issues and trees from the individual  
tree and stand levels to regional levels

A scenic landscape photograph featuring a large, dark evergreen tree in the foreground on the right. The middle ground is filled with a thick layer of mist or fog, obscuring several smaller trees. In the background, a range of mountains is visible under a soft, hazy sky. The overall color palette is muted, with earthy tones and soft greys.

Thank you