Bark Beetle Impacts on Water and Carbon Cycling in Southern Wyoming Forests

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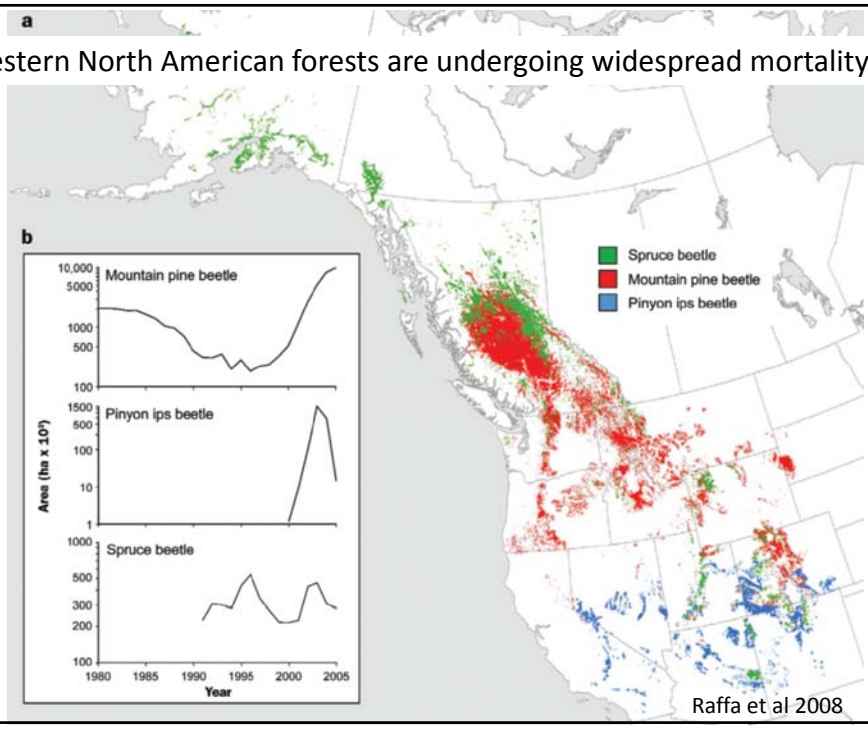
Western North American forests are undergoing widespread mortality

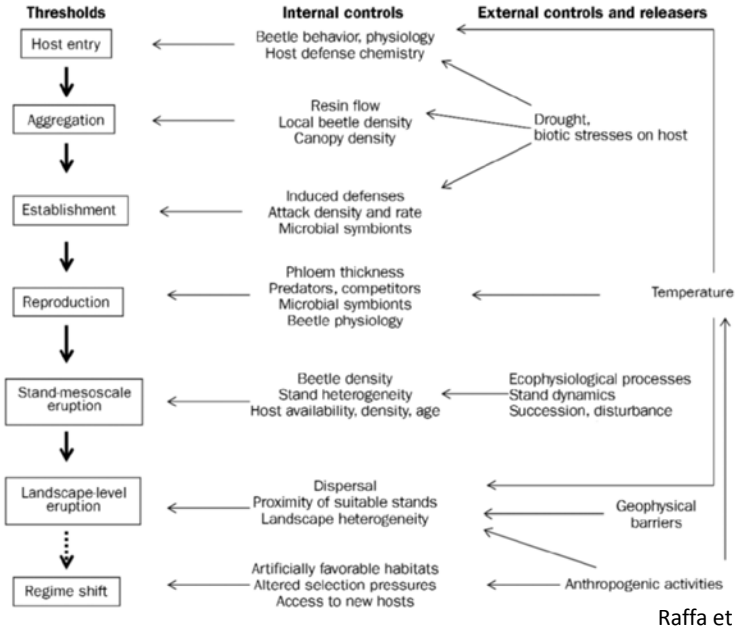


Raffa et al 2008

From green trees…

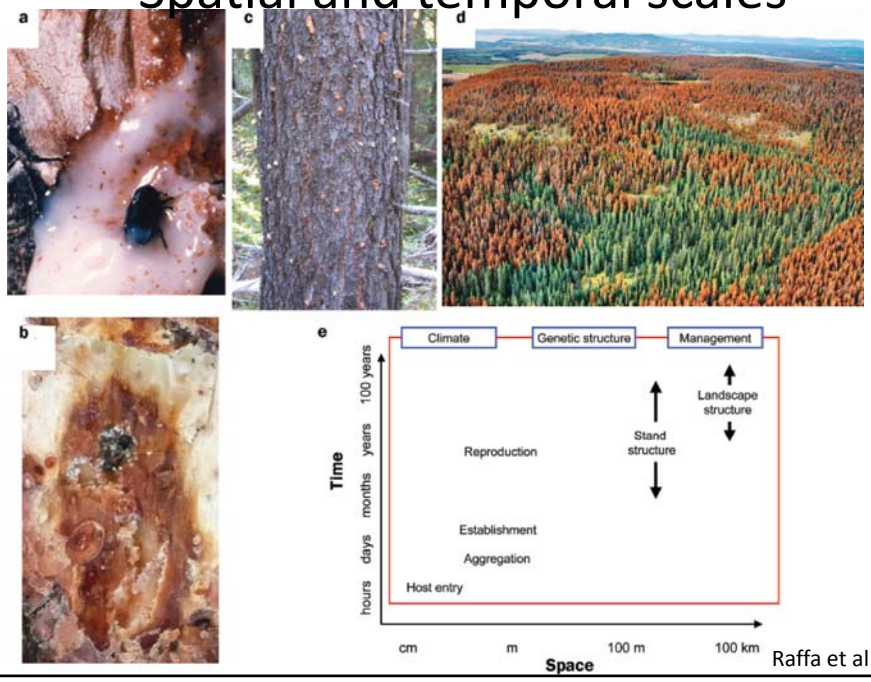
To red trees… in one year

Biotic and abiotic factors controlling MPB spread



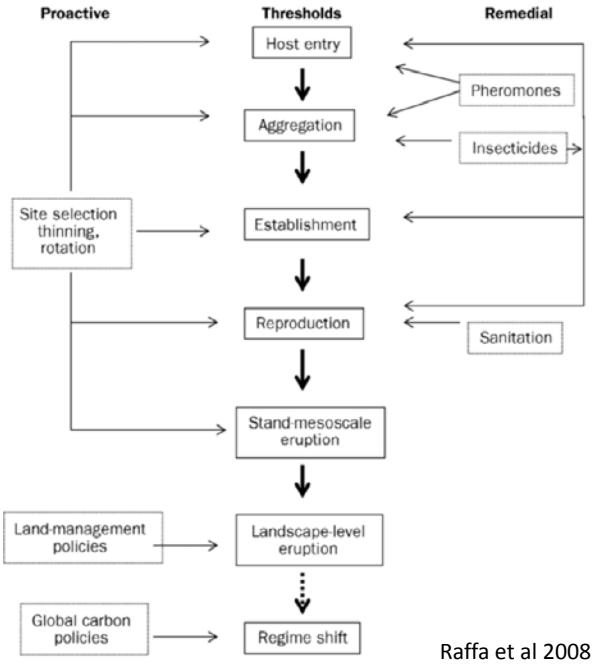
Raffa et al 2008

Spatial and temporal scales

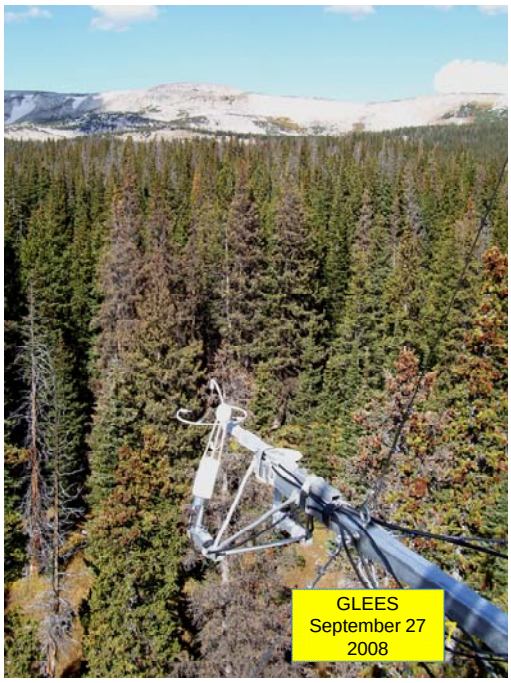


Raffa et al 2008

Management strategies

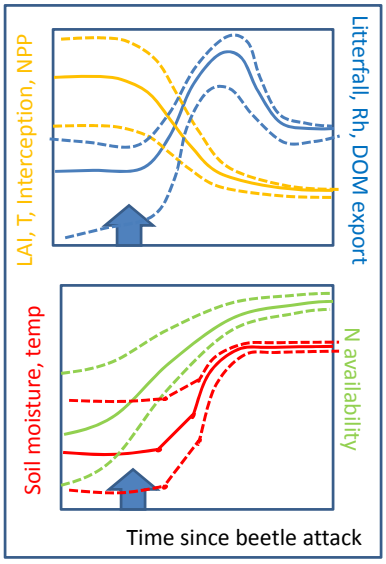


Raffa et al 2008



Forests are always a mosaic of living and dying trees

Hypothesized Ecosystem Impacts of Bark Beetle outbreaks



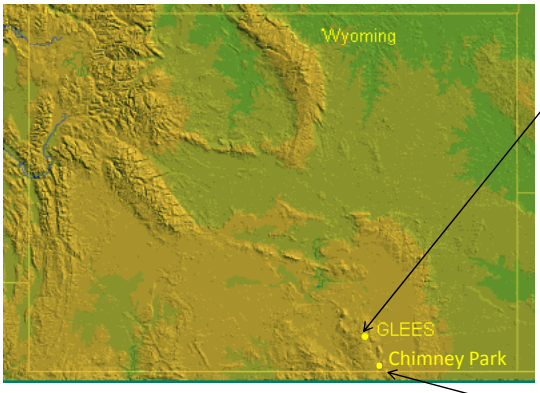
Leaf area index (LAI), Transpiration (T), Interception, Net Primary Productivity (NPP) will decline after outbreak

Litterfall, heterotrophic respiration (Rh), Dissolved Organic Matter (DOM) will increase then decrease

Soil moisture, temperature and Nitrogen will Increase

Variability (dotted lines) will decrease as more of the trees succumb to infestation

Glacier Lakes Ecosystem Experiments Site (GLEES; Spruce/fir) & Chimney Park (lodgepole pine)



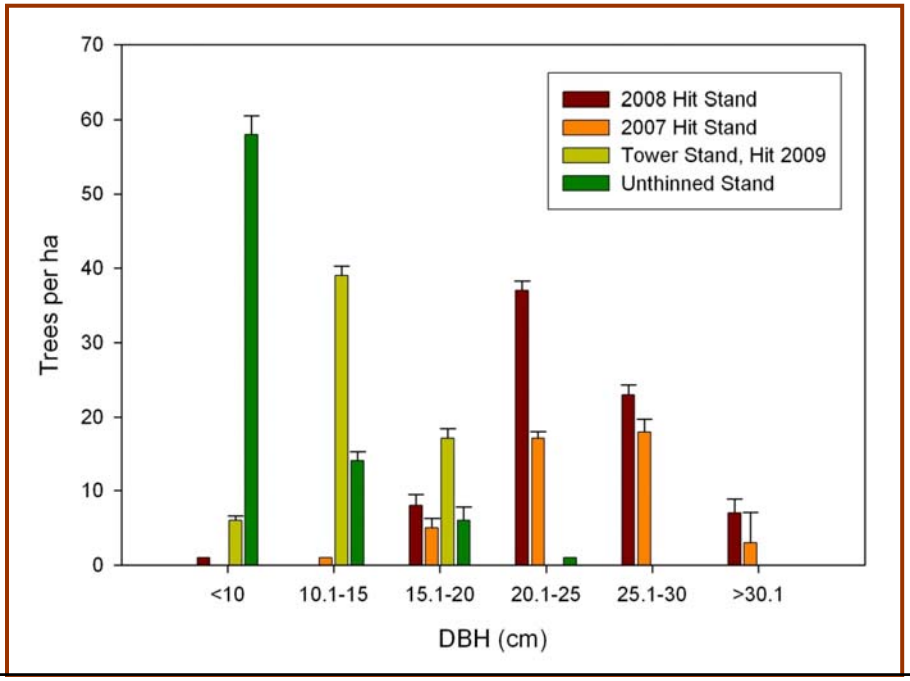
Eddy covariance towers measure ecosystem CO2 and H2O exchange

Leaf Gas Exchange

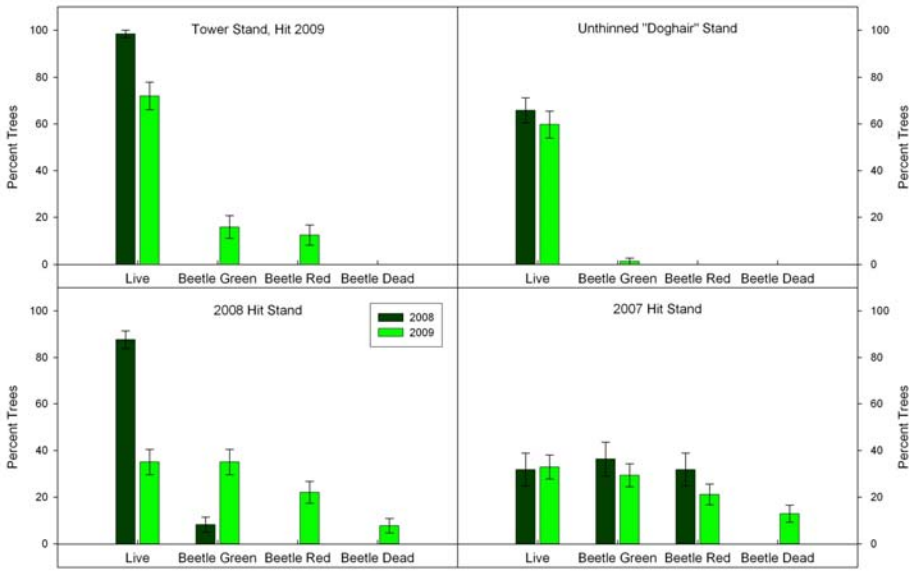
Sap Flux

Soil Respiration

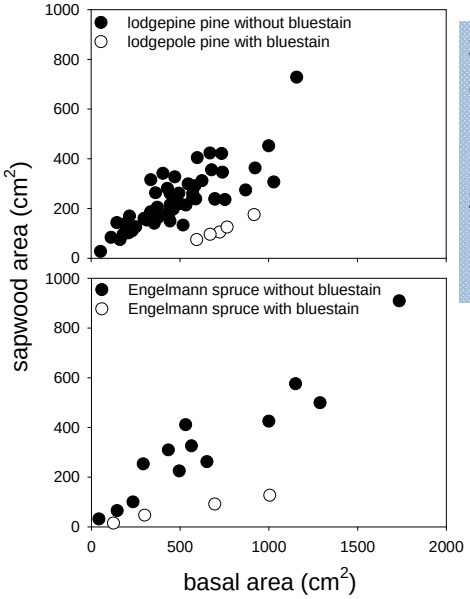
Stand structure affects likelihood of attack



Mortality is happening now

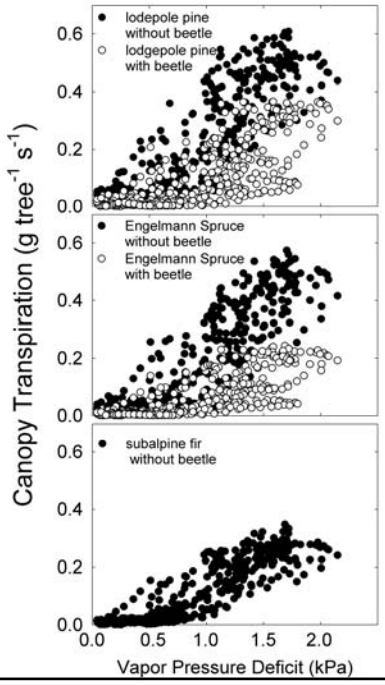


Blue stain fungi rapidly changes sapwood



Smaller sapwood area one month after blue stain infection due to loss of inner sapwood

Same results found in Norway spruce beetle/fungi attacks

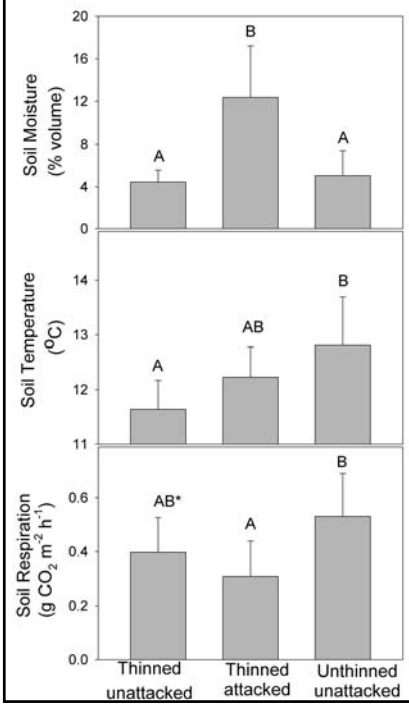


Bluestain fungi impact transpiration quickly

After one month, transpiration per tree is reduced to less than half

Transpiration still responds to environmental drivers probably because younger needles are last to die

Biological Response to Vapor Pressure Deficit saturates, not linear



Soil Impacts Vary Greatly in the Short Term

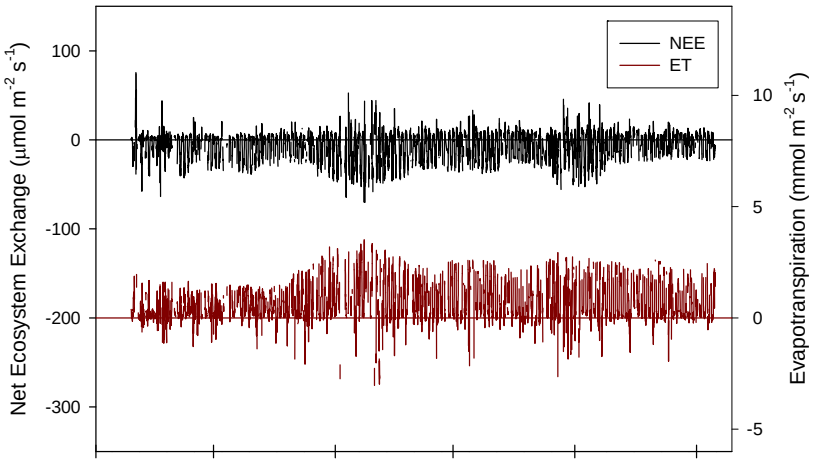
Soil moisture is increasing in response to transpiration decline

Soil moisture increase in attacked stands larger in late season (August)

Soil respiration is lower on attacked stands

Finding control stands is increasingly difficult, may not be possible

Individual trees die quickly but at the ecosystem scale the forest still took up CO2 in 2009



Conclusions

- Bark beetle/blue stain impacts are rapid in high and low elevation outbreaks
  - Large reduction in transpiration, photosynthesis within a month
  - Large increase in soil moisture, ramifications to stream flow
  - Greenhouse gas emissions being altered
- Traditional experiments using controls may not be possible due to extent of attack
  - Test mechanisms behind mass and energy dynamics with ecosystem, hydrological and regional models

Future Work (Research Opportunities)

- Determine successional impacts
  - Are seedlings limited by light, nutrients and/or water?
- Quantify N cycle changes and losses—water quality
- Scale to watersheds and regional extent using other locations and FoSTER

  (Forest Steppe Transition Ecosystem Research)