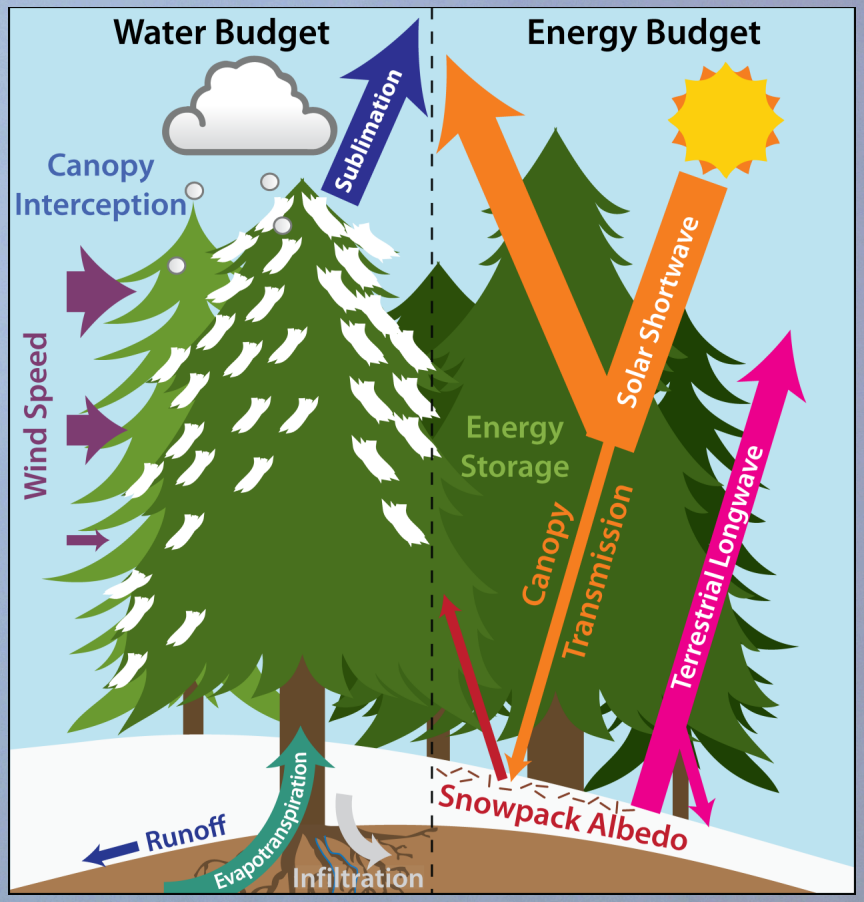
Bark beetle impacts on snowmelt processes & tree water use

Jeff Deems *Western Water Assessment*

infestation effects on:

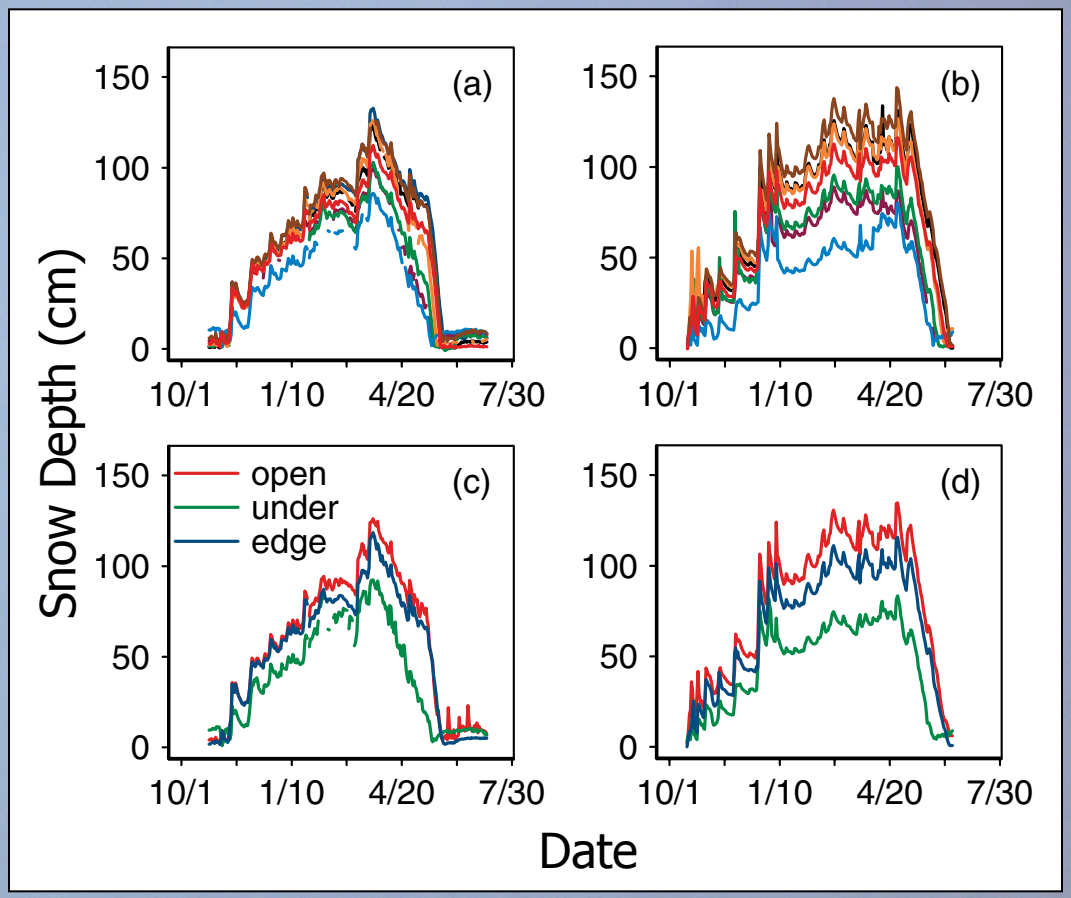
- snowmelt
  - increased accumulation
  - increased melt rates
- tree water use
  - transpiration reduced/ eliminated



Pugh and Gordon, *submitted to Hydrological Processes*

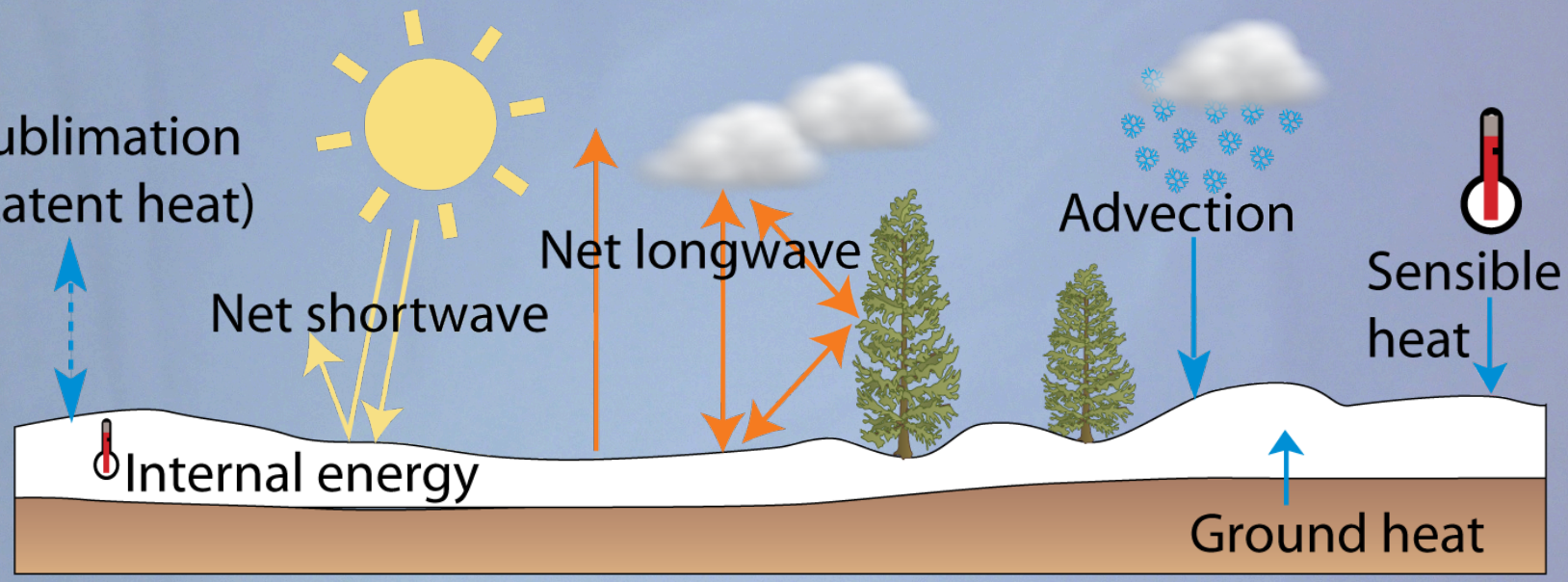
snow in undisturbed forests

- less snow in forest than in clearings/edges
  - interception
  - sublimation
- melt rates faster in clearings/edge
  - more solar
  - faster wind speed



Molotch et al., 2009, *Ecohydrology*

snow energy budget



$$Q_m + \frac{dU}{dT} = (1-\alpha)S + L^* + Q_s + Q_v + Q_a + Q_g$$

Change in internal energy

Melt energy

Albedo

Shortwave radiation

Net Longwave radiation

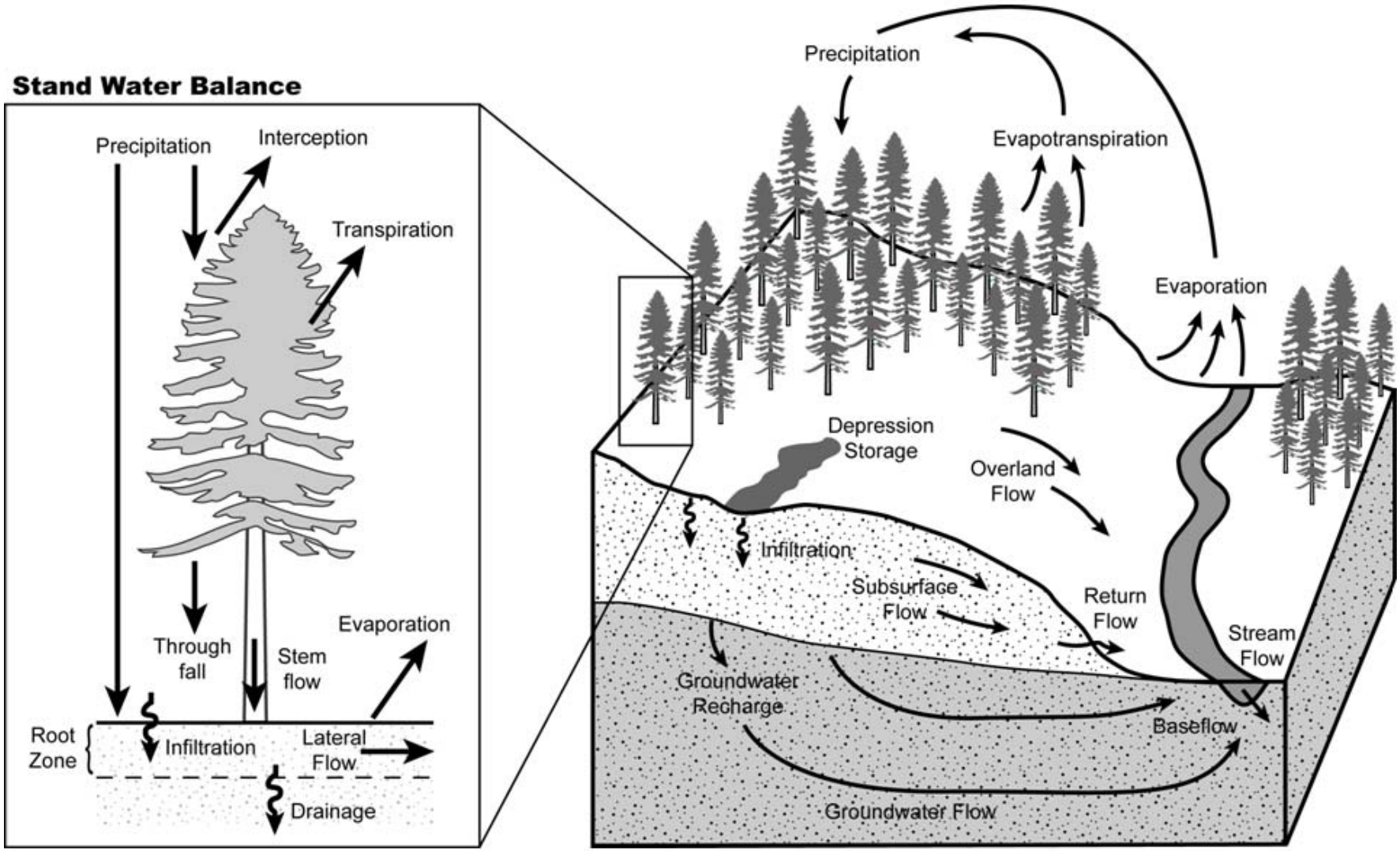
Sensible heat

Latent heat

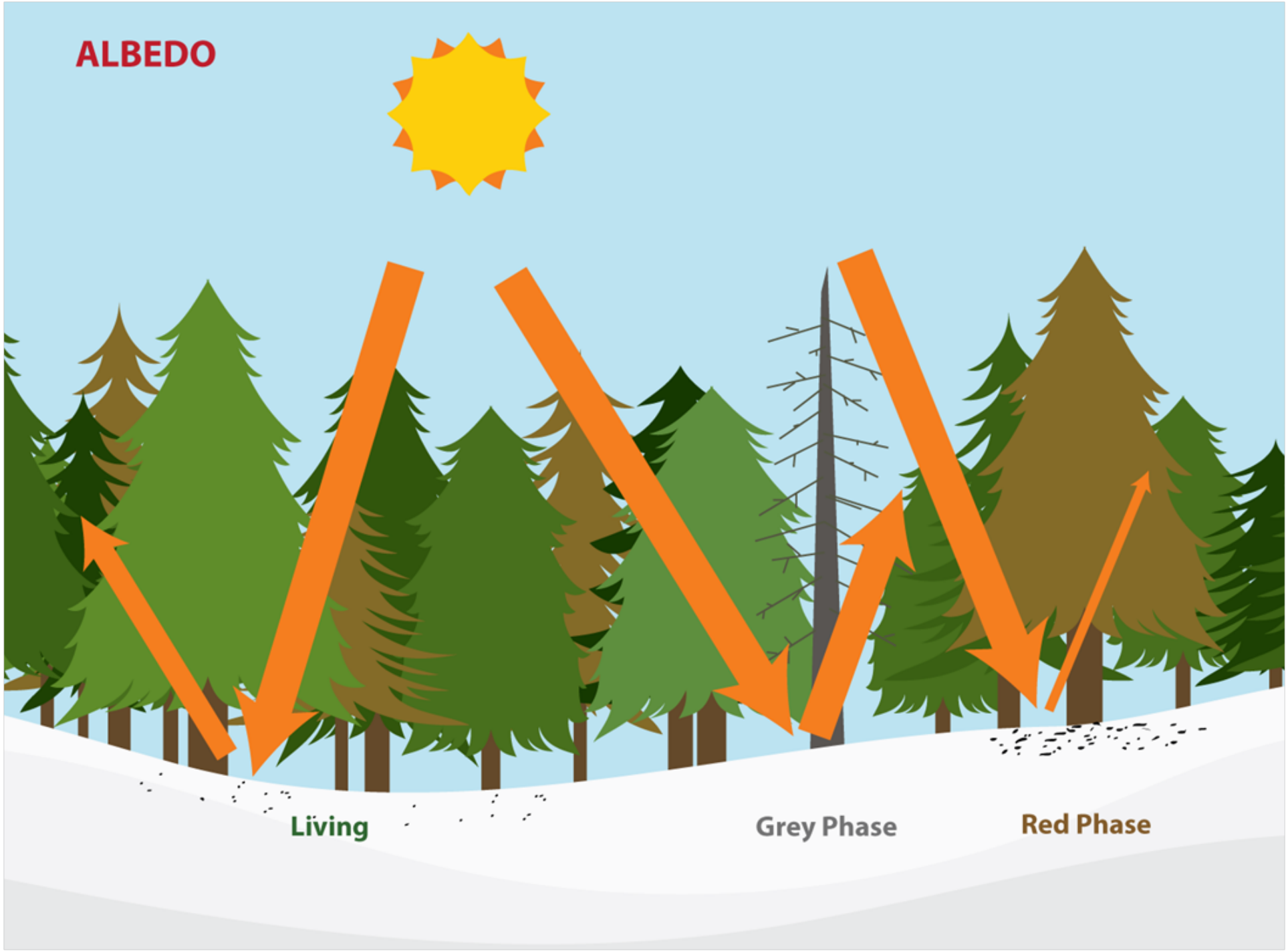
Advection

Ground heat

forest water budget

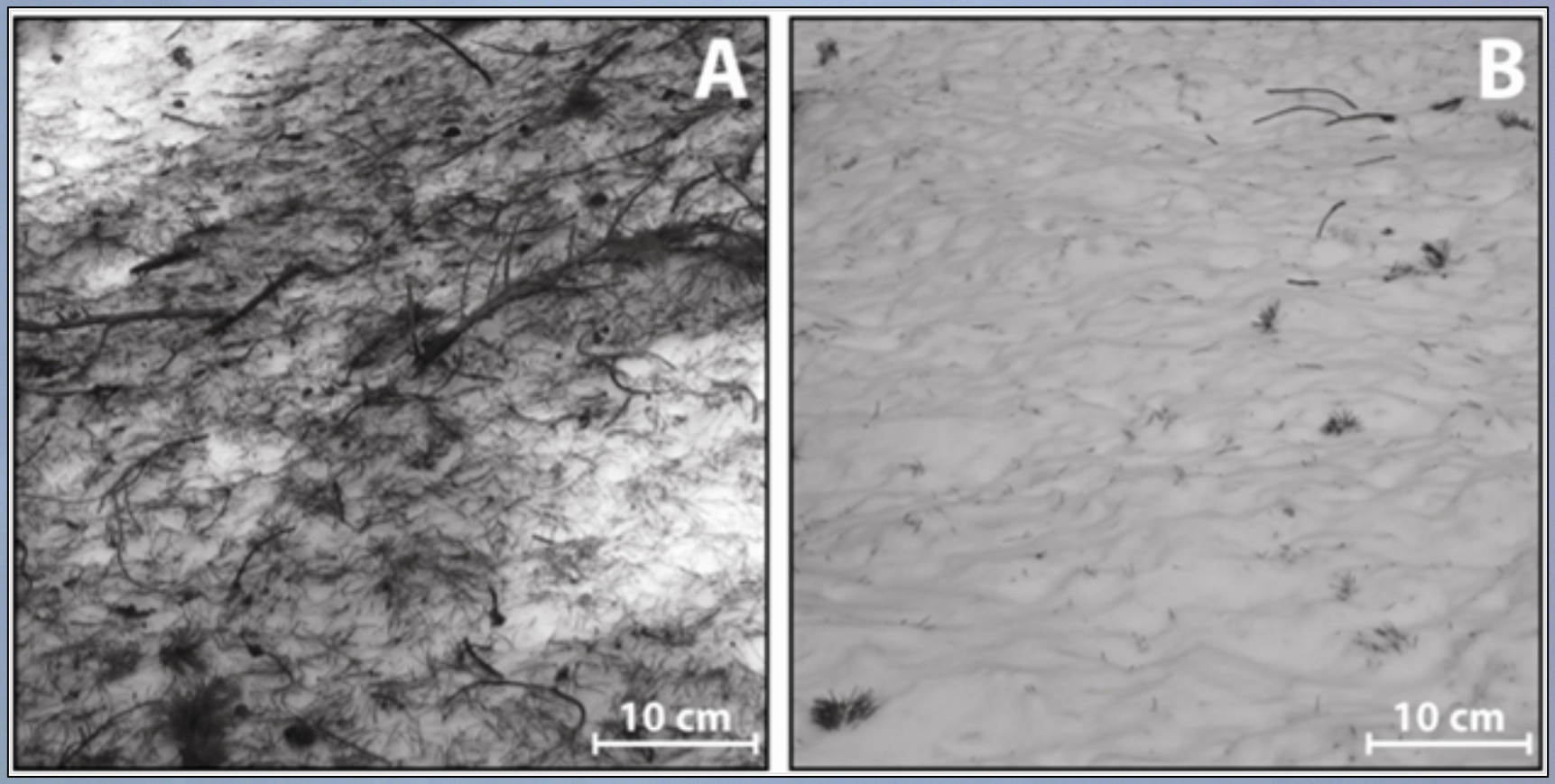


Redding et al., 2008


ALBEDO
Living
Grey Phase
Red Phase

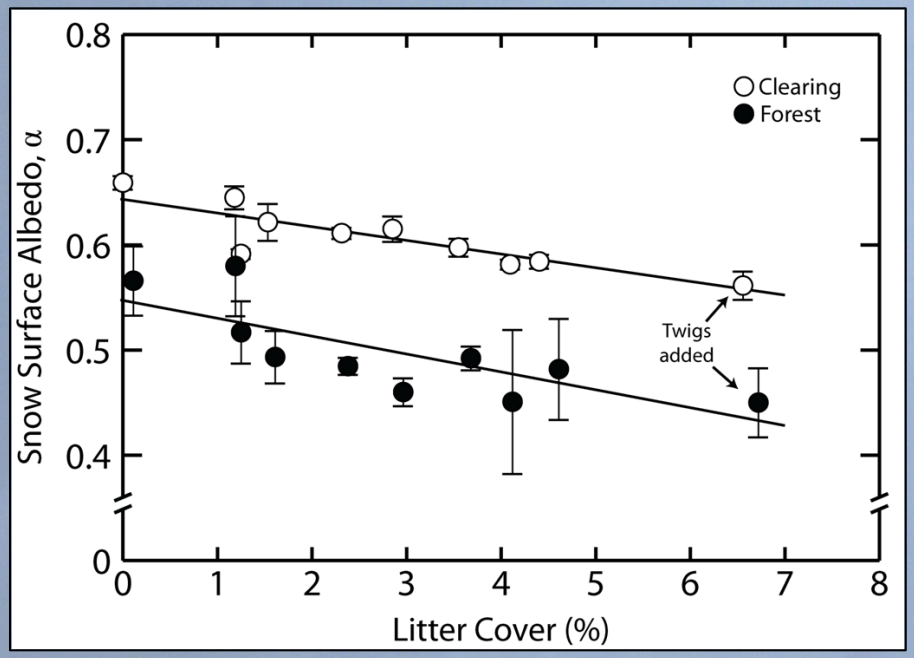
litter can strongly affect albedo

↓ albedo + ↑ solar is a powerful melt forcing

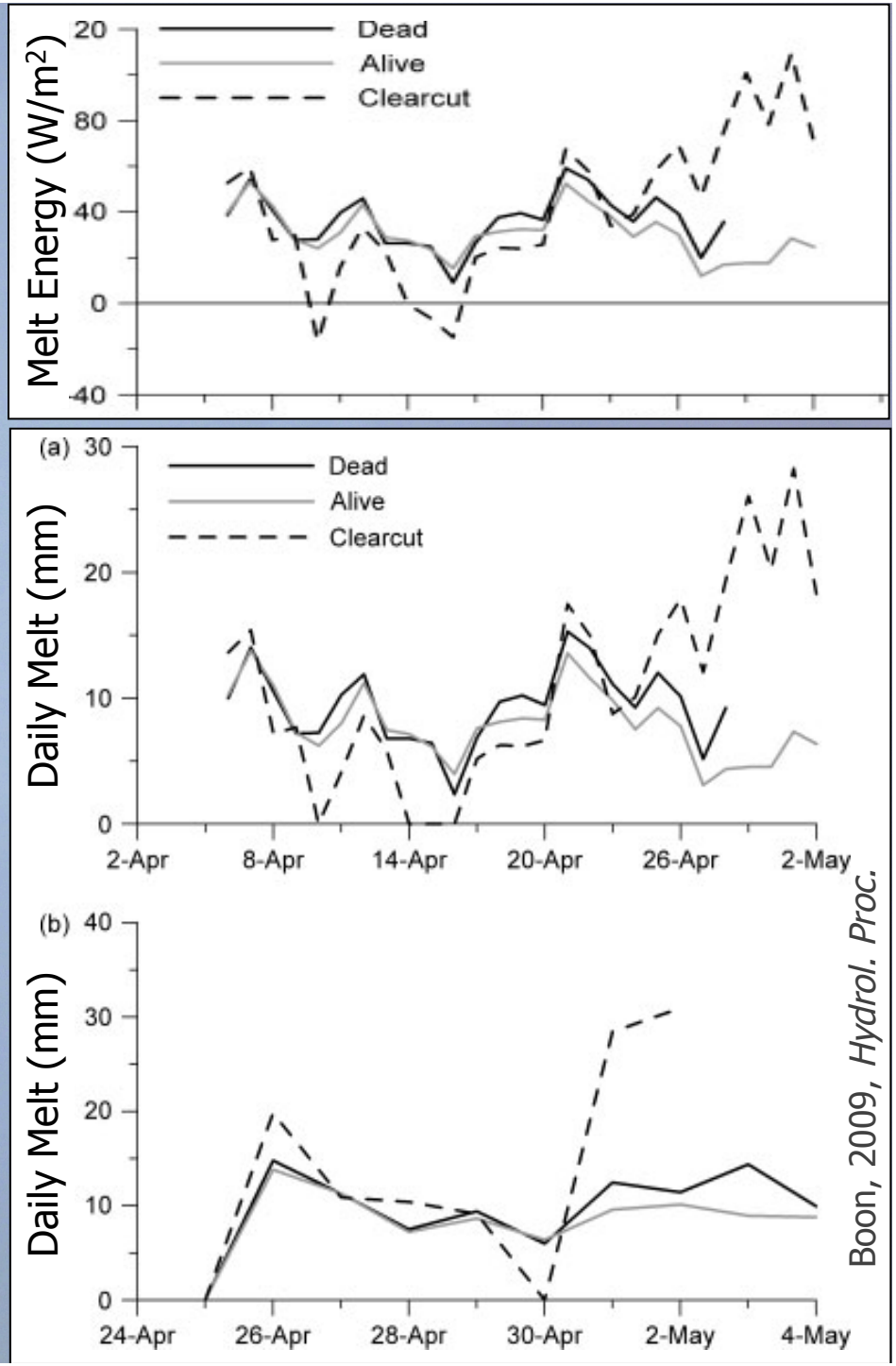


Pugh and Small, 2011, *Ecohydrology*

↓ albedo & shading = ↑ melt rates



Pugh and Small, 2011, *Ecohydrology*



Boon, 2009, *Hydrol. Proc.*

snow energy budget changes

due to beetle infestation

red phase

↓ snow albedo

↑ solar transmission

↑ net solar input

↓ longwave

grey phase

↔ snow albedo

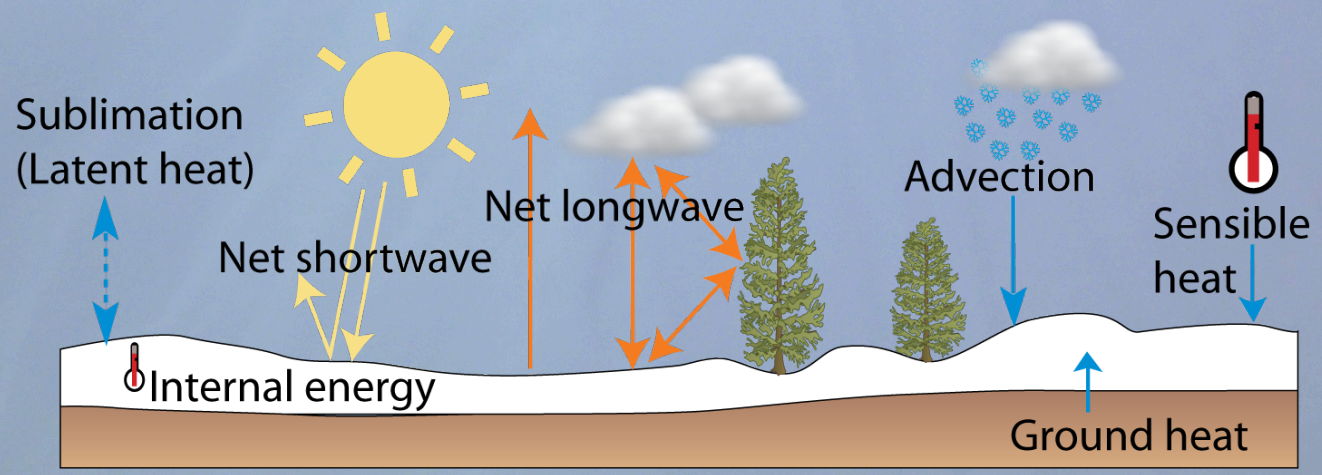
↑ solar transmission

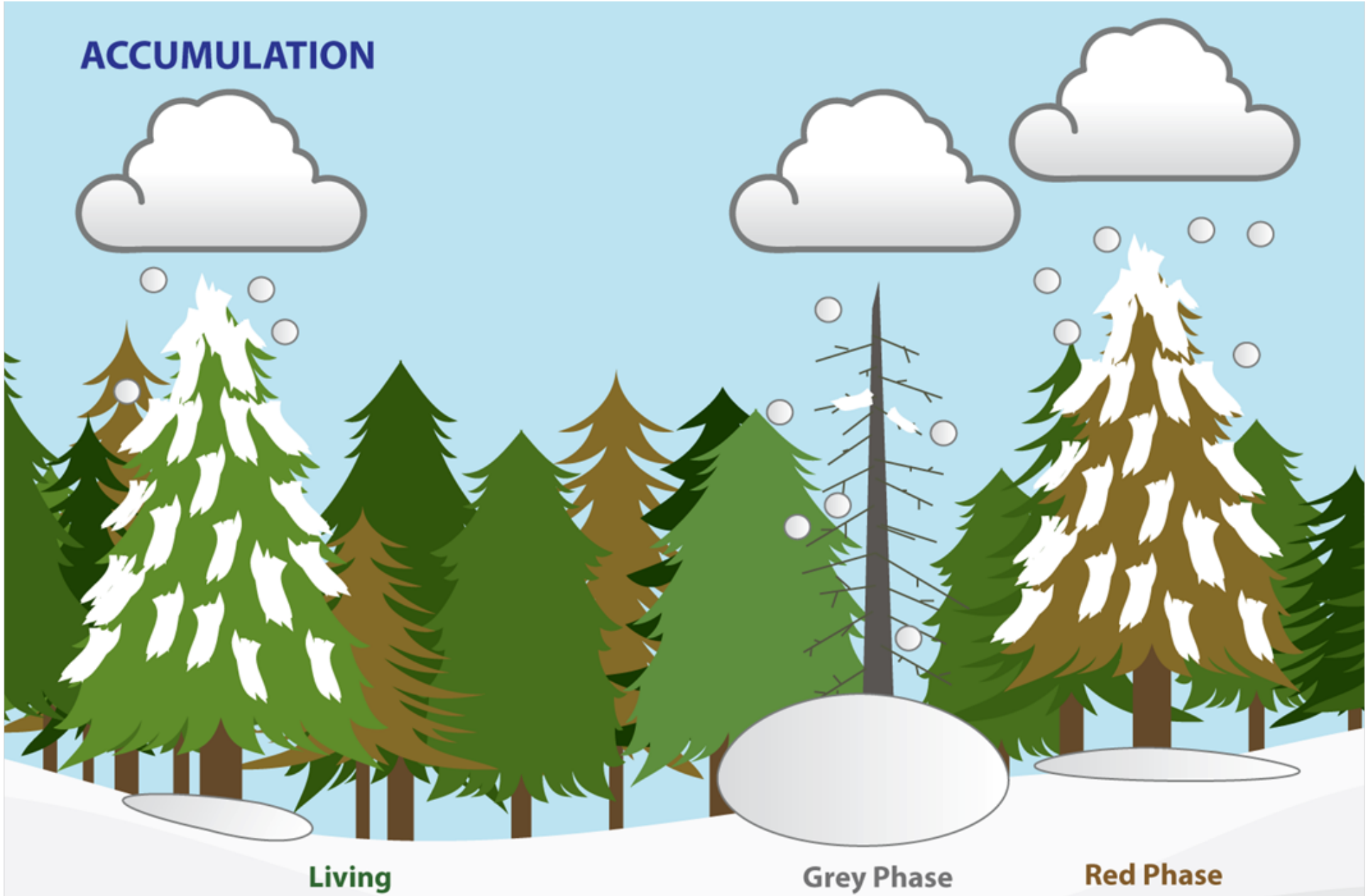
↑ net solar input

↓ longwave

↑ wind speed

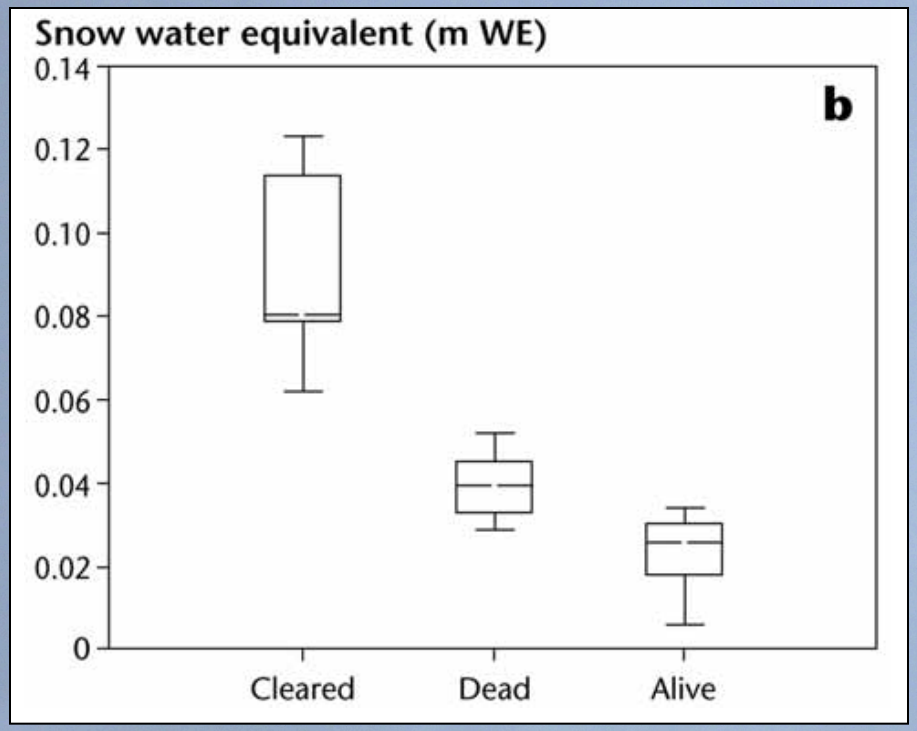
↑ sensible gain & latent loss



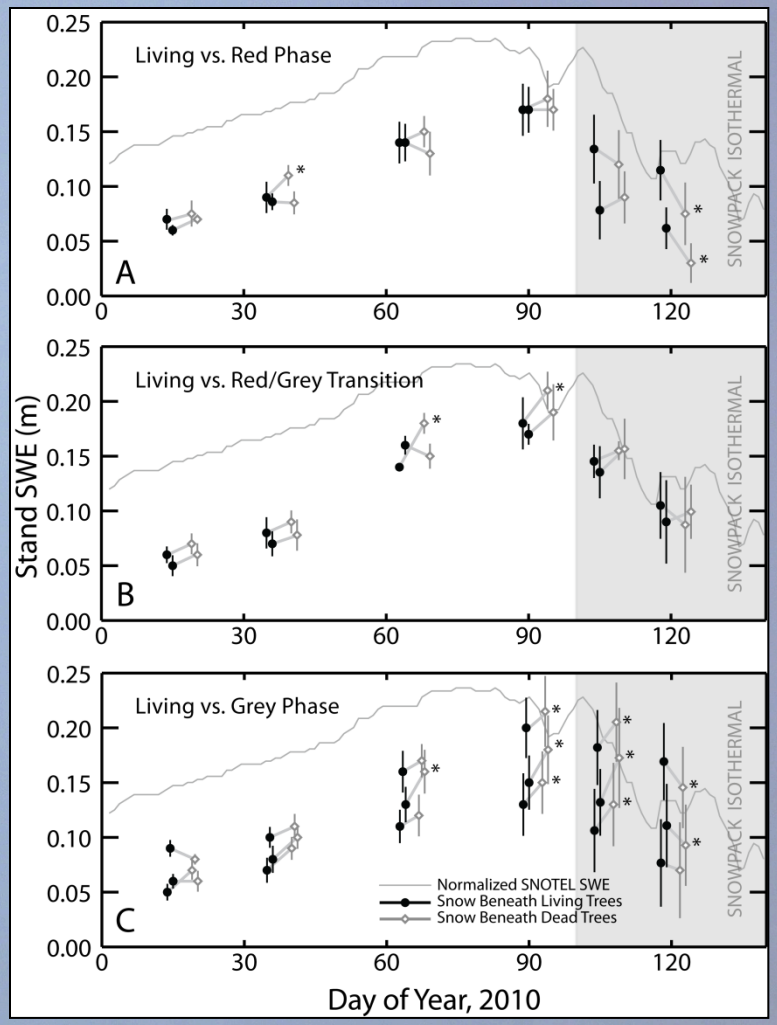


Interception losses are significant with green or red needles

↓ interception = ↑ SWE

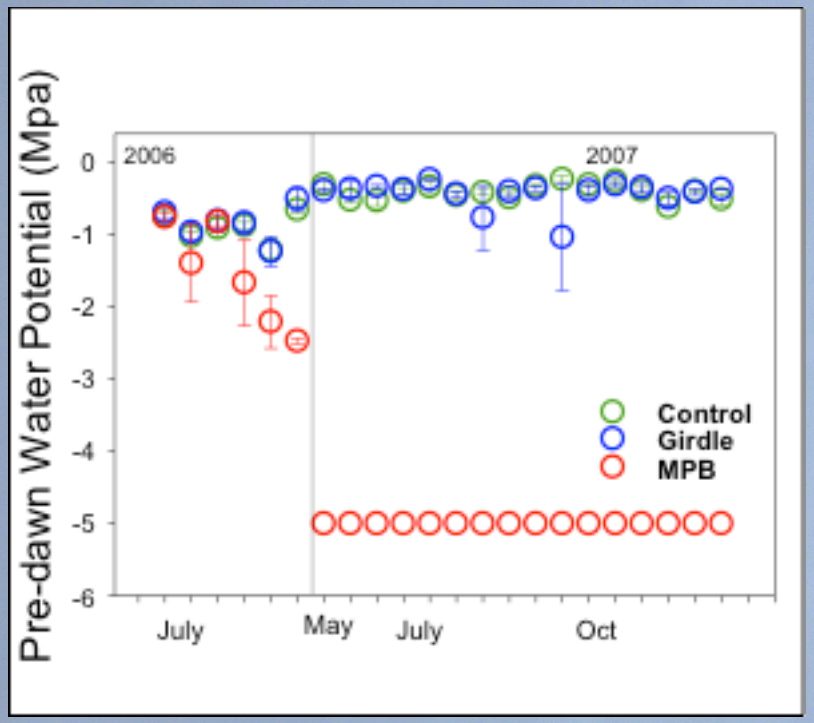


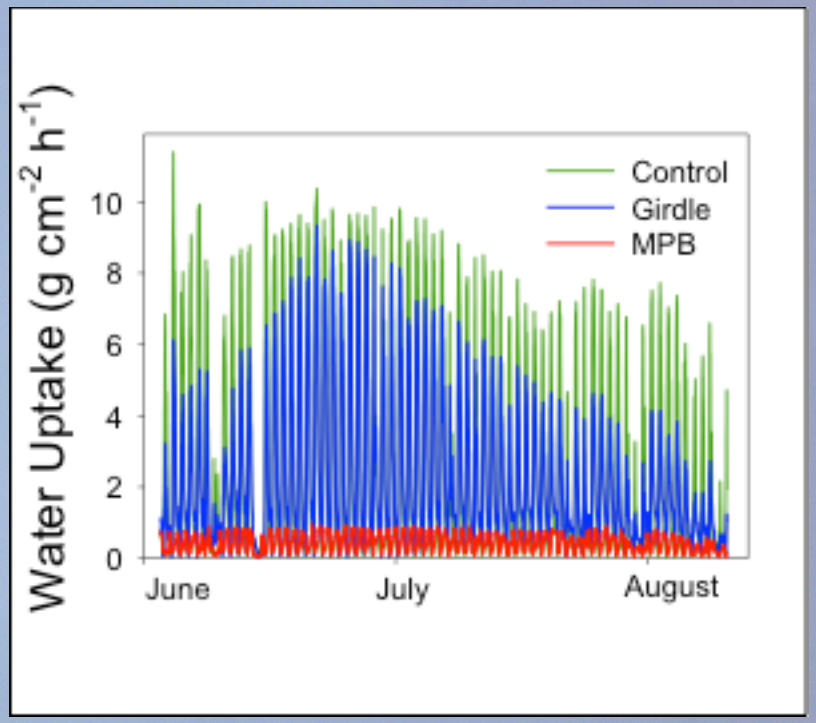
Boon, 2007



Pugh and Small, 2011, *Ecohydrology*

change in tree water use (pine)





Transpiration drops ~50% within 3 weeks of MPB

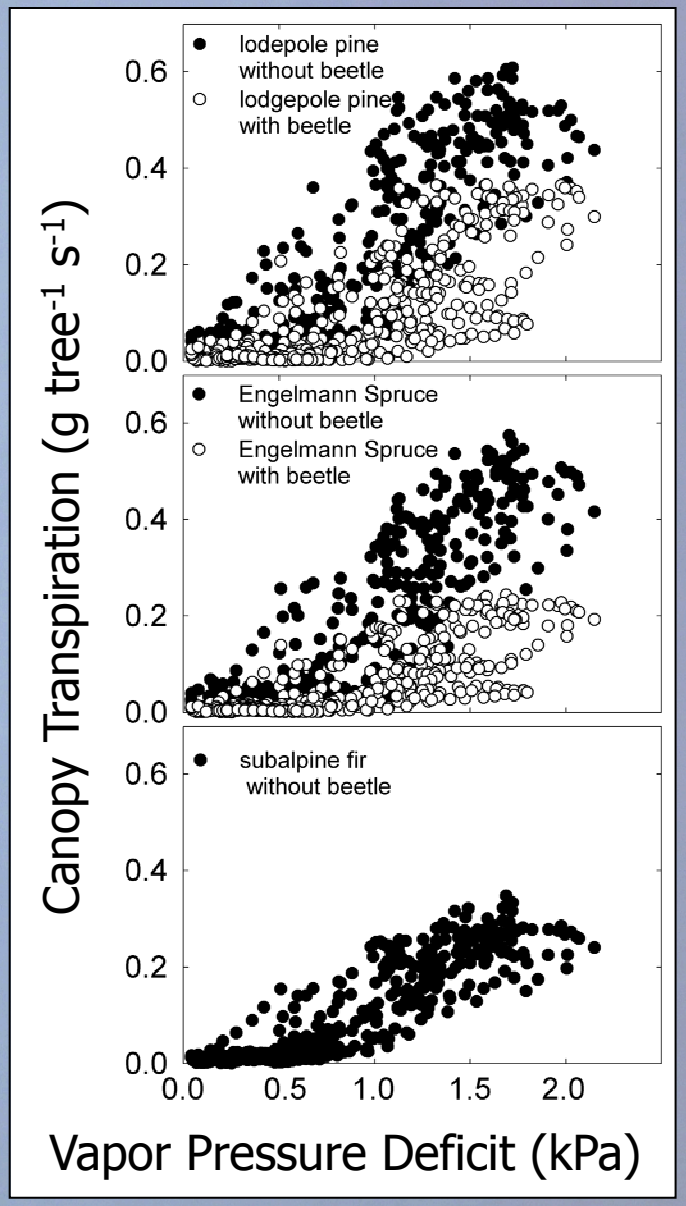
Water status of girdled trees unchanged – continued growing for 1 year after attack

Blue-stain fungus: primary mortality agent

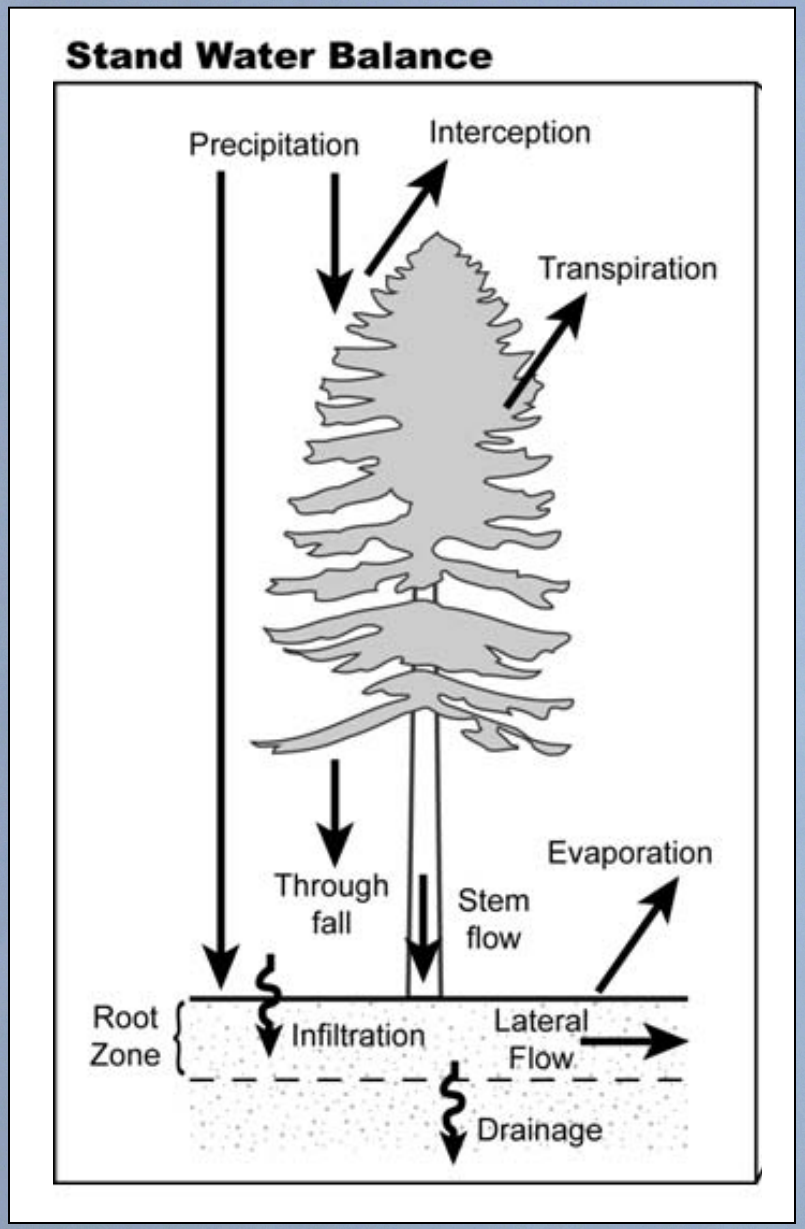
(Hubbard *et al.*, *in prep*)

tree water use

- initial attack suppresses water use
- change in water budget is stand-dependent
  - stand age & composition
  - understory age, condition & composition
- aggregation to watershed scale…



Pendall et al., 2010



water budget changes

due to beetle infestation

red phase

↓ tree water use

↓ transpiration

faster melt

grey phase

↓ interception

↓ sublimation

↑ accumulation

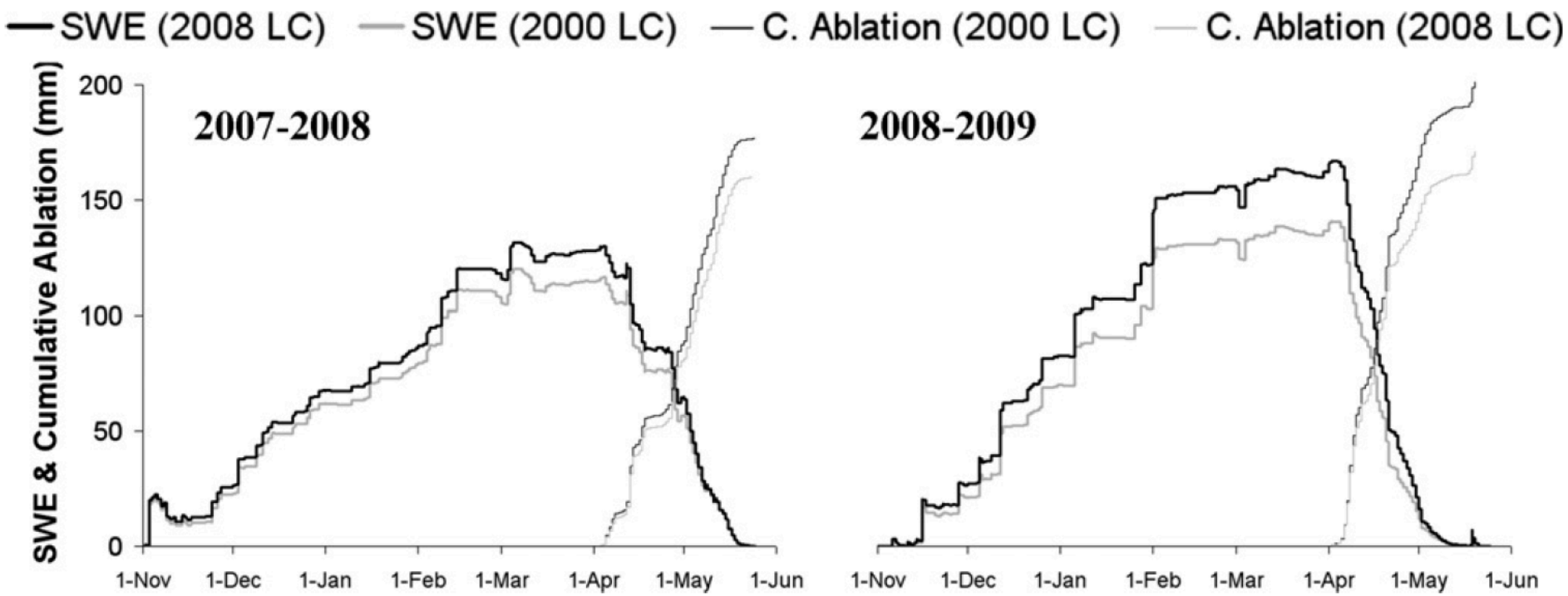
faster melt

↓ transpiration

↓ tree water use

net changes in water & energy budgets

↑ SWE, ↑ melt rates with reduced canopy



Bewley et al., 2010

influence on melt production (& runoff)

red phase = faster melt?

↓ snow albedo = ↑ melt

↑ solar transmission = ↑ melt

↑ net solar input = ↑ melt

↓ longwave = ↓ melt

grey phase = faster melt?

↔ snow albedo = ↔ melt

↑ solar transmission = ↑ melt

↑ net solar input = ↑ melt

↓ longwave = ↓ melt

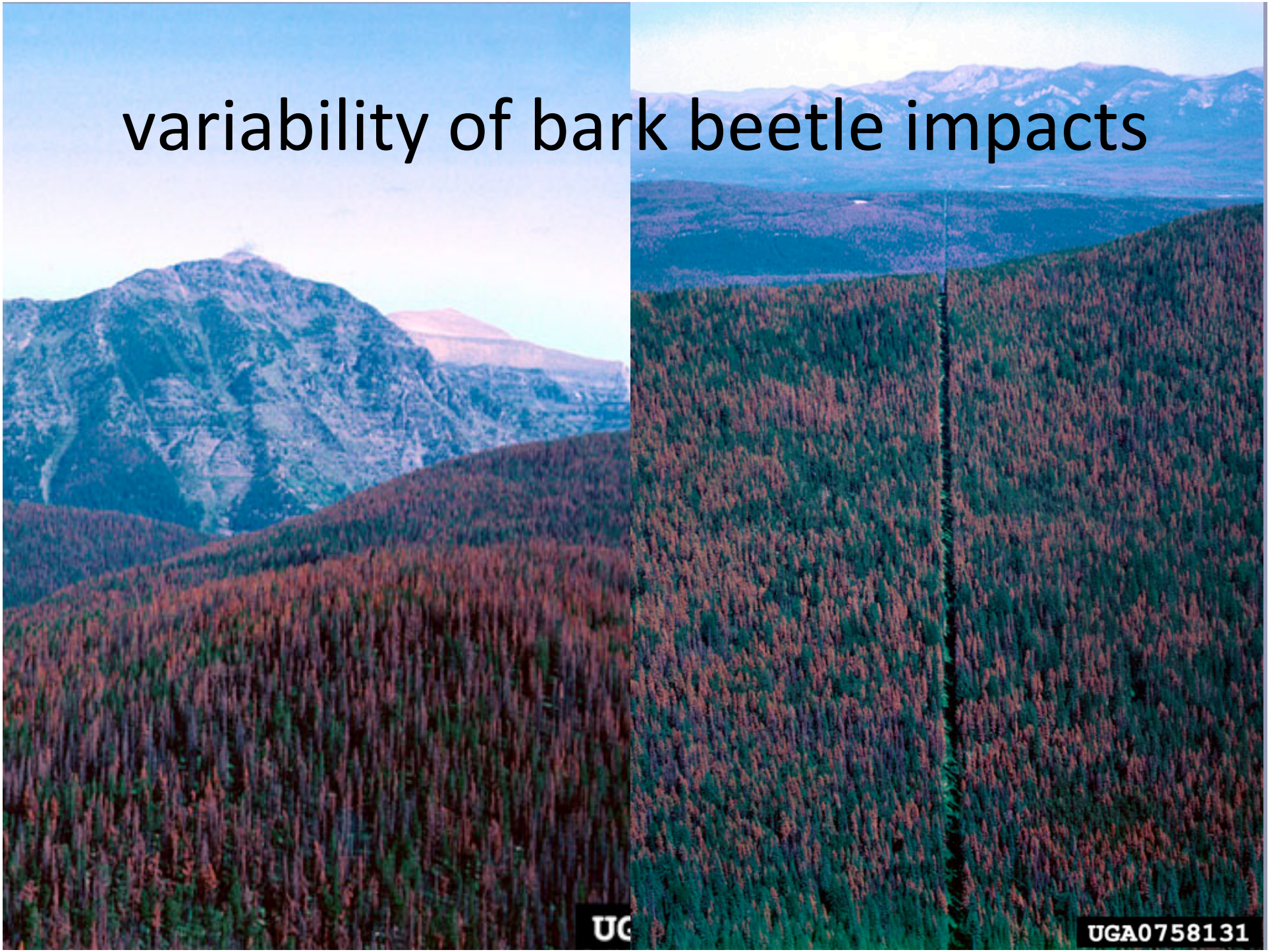
↑ wind speed = ↑ melt

↑ sensible gain & latent loss

balance of impacts is stand, basin, & snow year dependent

photo Matt Kennedy, Extreme Ice Survey

variability of bark beetle impacts



anticipating impacts…

- stand-scale impacts easy to conceptualize
  - ↓ interception, ↑ SWE
  - ↓ albedo & shading, ↑ melt rate

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  - basin characteristics
  - variability in snowmelt processes
  - variability in beetle impacts

anticipating impacts…

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- catchment-scale impacts depend on:
  - basin characteristics
  - variability in snowmelt processes
  - variability in beetle impacts
- harvesting likely to have much greater impacts on snow accumulation & melt than beetle kill