

# A Conceptual Model of Water-Related Impacts from Bark Beetle Infestations



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# Overview

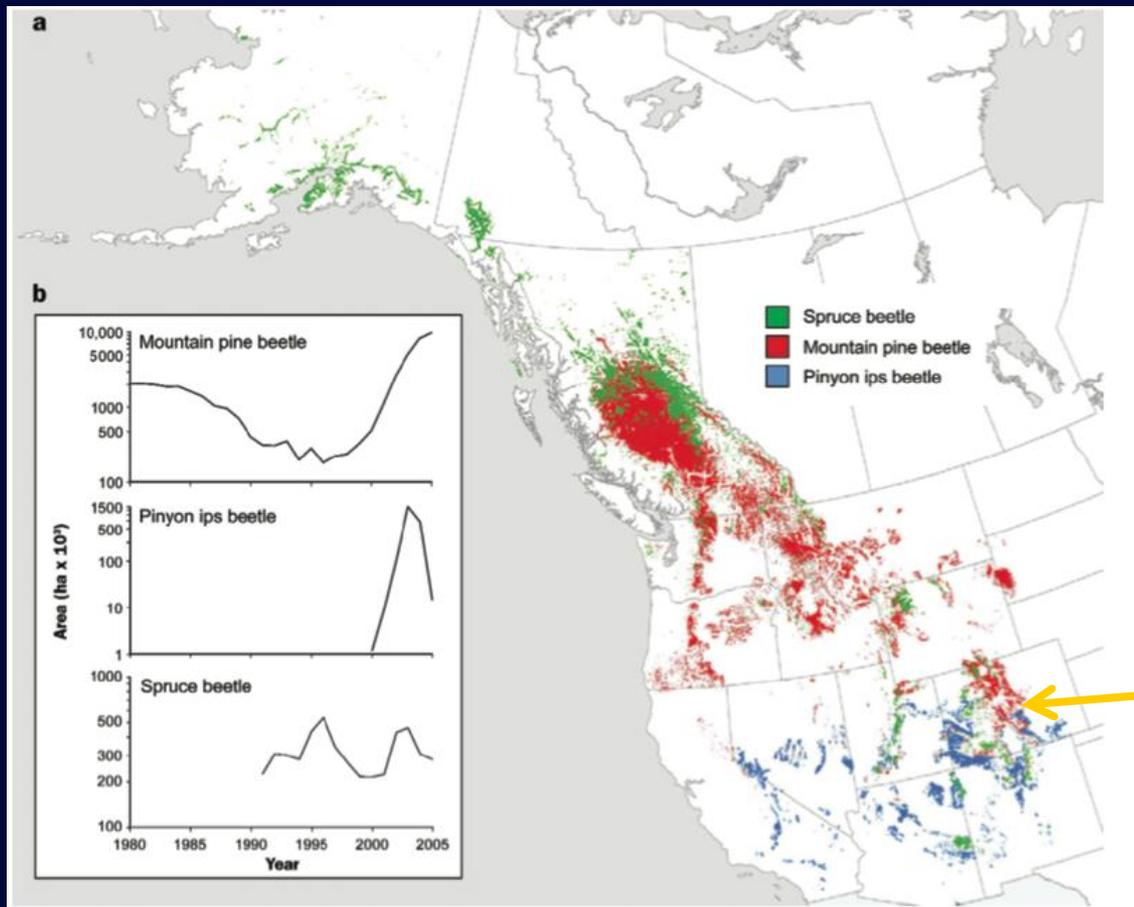
- ✓ Background
- ✓ Conceptual Model
- ✓ Confounding Factors
- ✓ Conclusions



Pugh E.T. and Gordon E.S. (2012), A conceptual model of water yield effects from beetle-induced tree death in snow-dominated lodgepole pine forests, *Hydrological Processes*. doi: 10.1002/hyp.9312



# The Extent of Pine Beetle Infestation



**By 2011, 42% of the forested watersheds in Colorado had been affected!**

**2011:  
>4M acres**

Raffa et al. 2008



# Beetle-Impacted Forests

**Living**



**Red / Grey  
Phase  
Dead**



# The Forest System

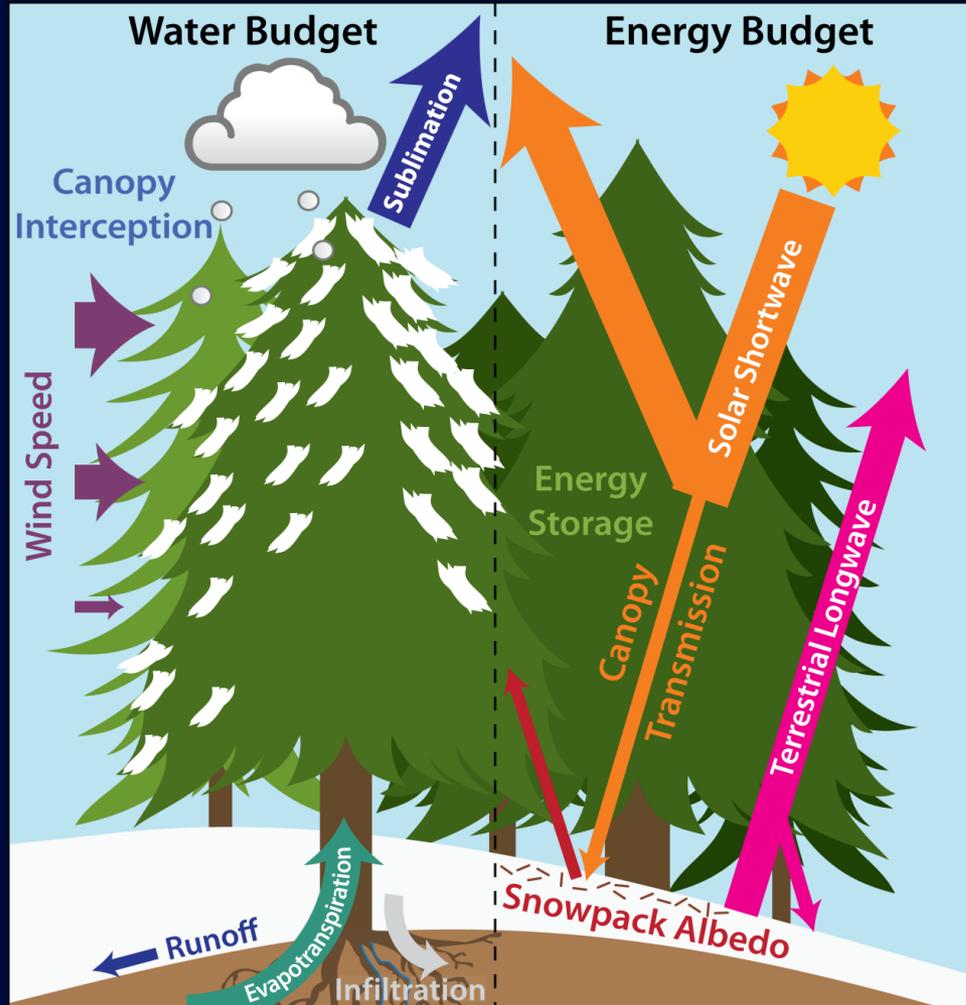
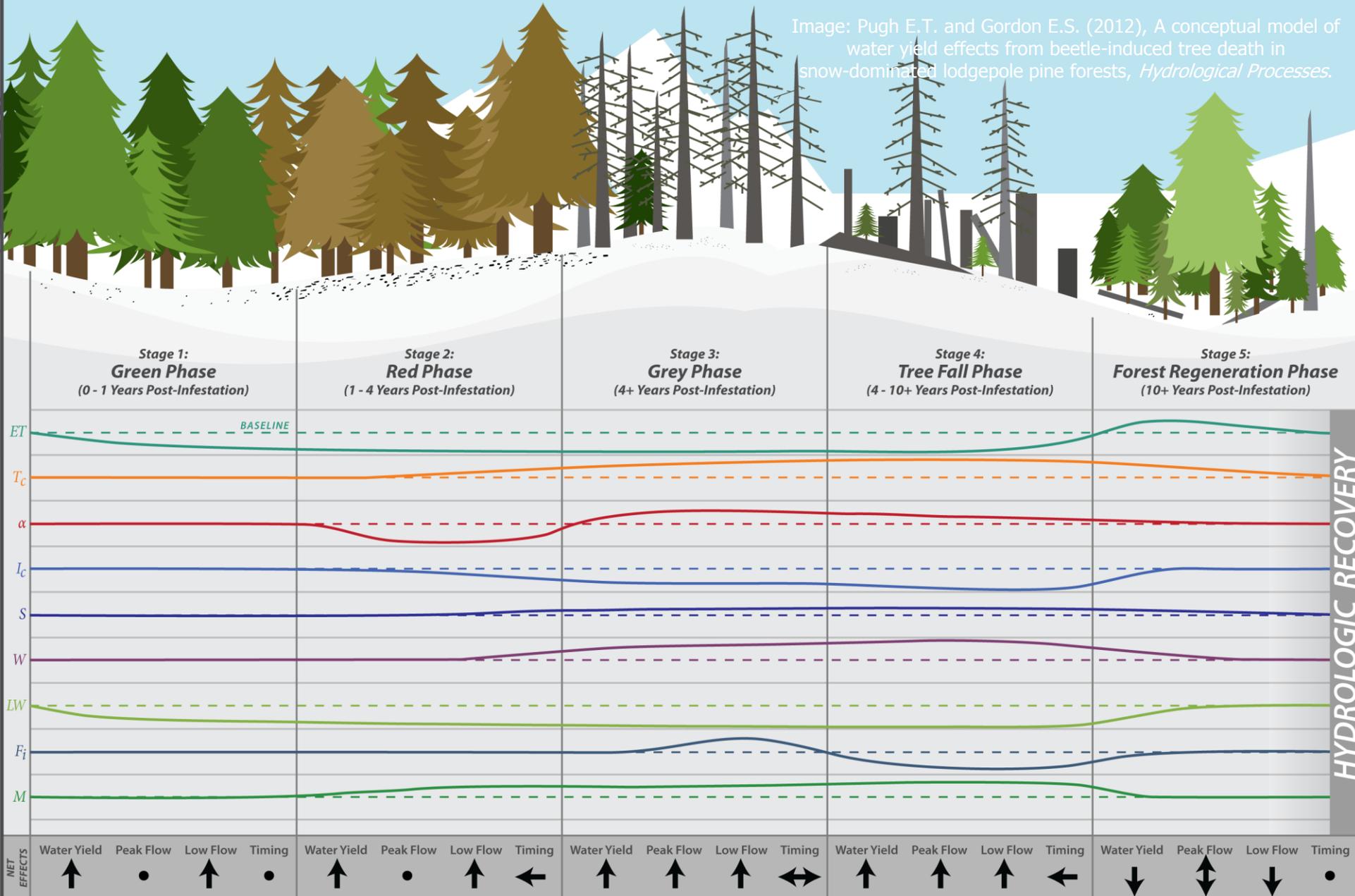
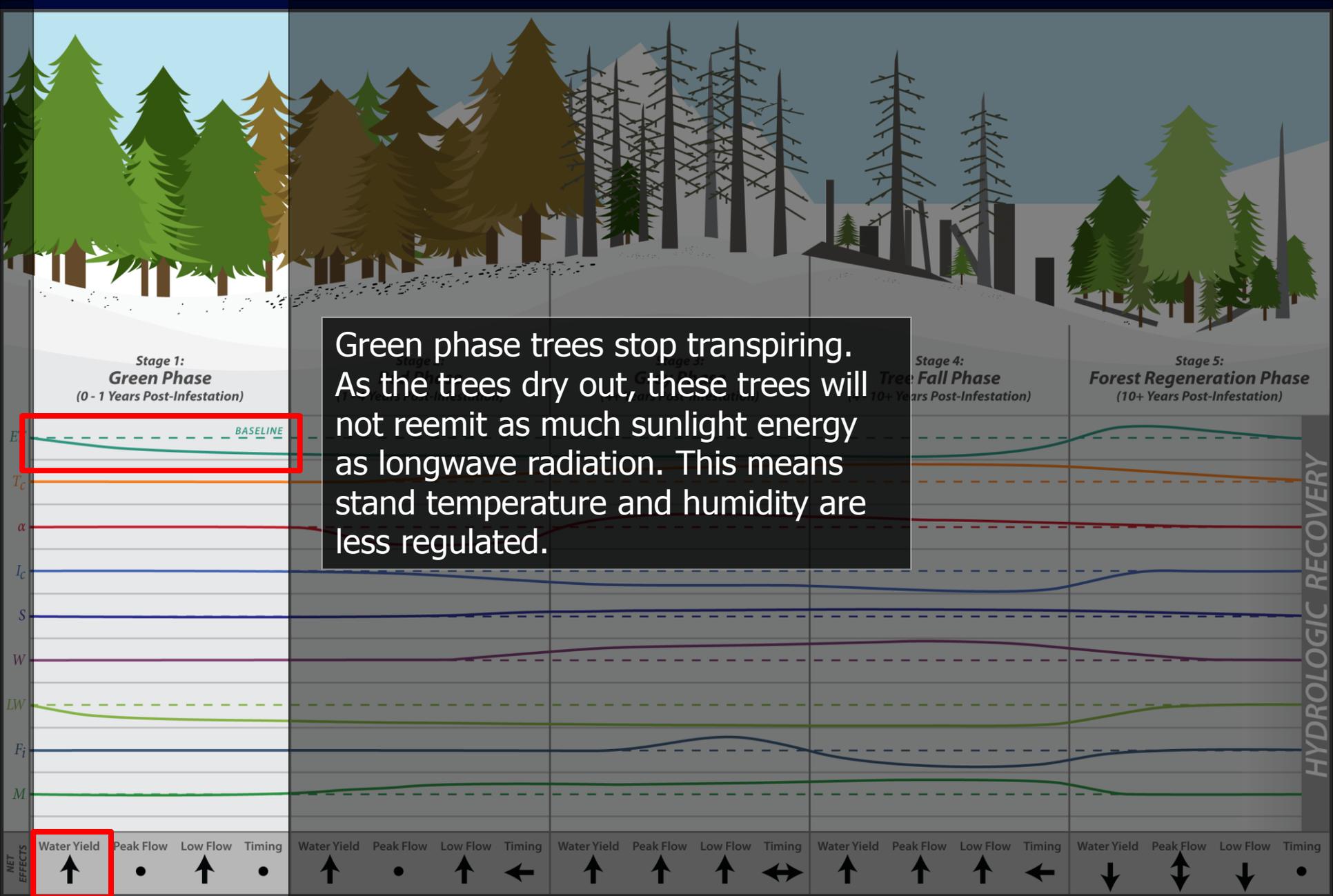


Image: Pugh E.T. and Gordon E.S. (2012), A conceptual model of water yield effects from beetle-induced tree death in snow-dominated lodgepole pine forests, *Hydrological Processes*. doi: 10.1002/hyp.9312

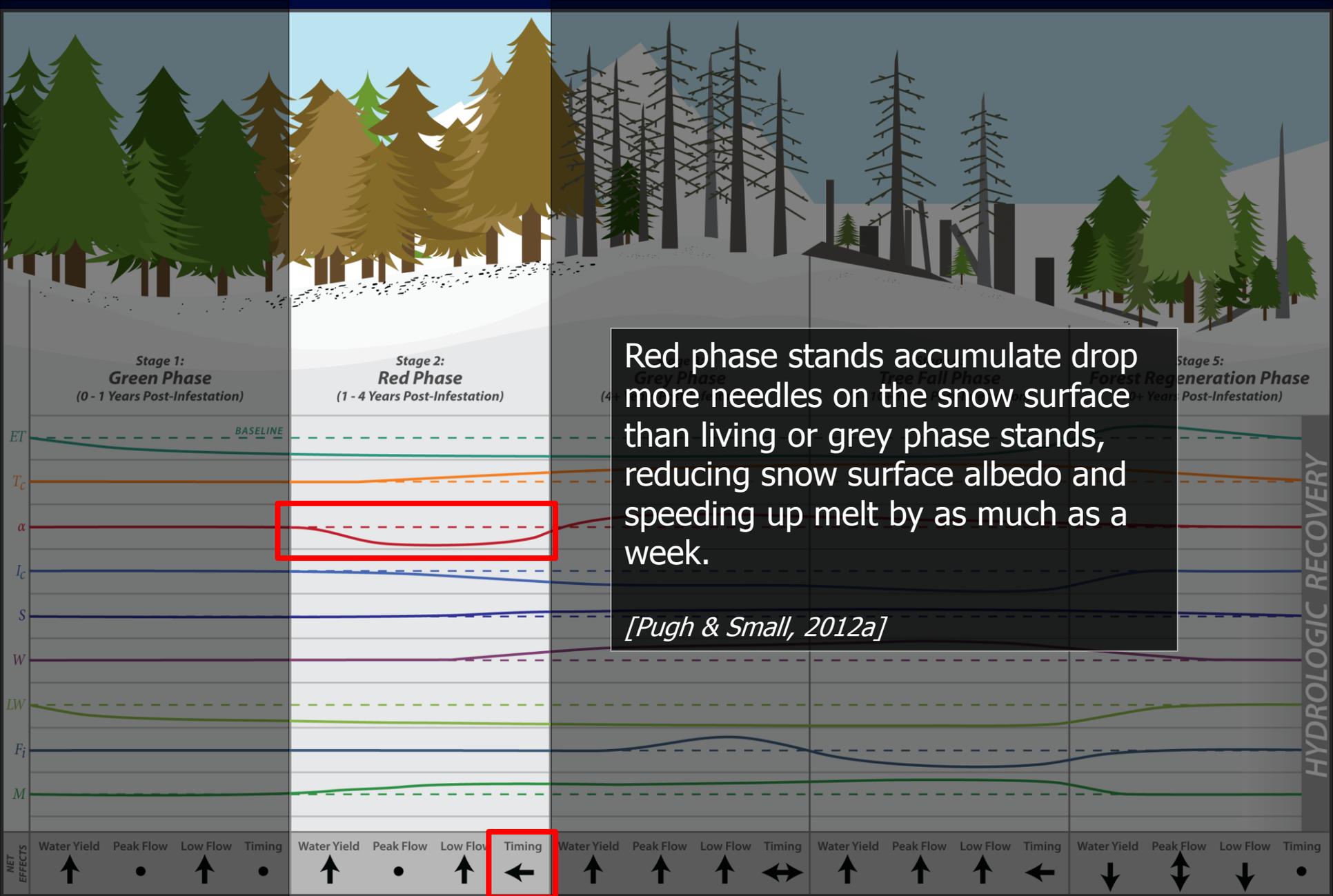


Image: Pugh E.T. and Gordon E.S. (2012), A conceptual model of water yield effects from beetle-induced tree death in snow-dominated lodgepole pine forests, *Hydrological Processes*.





Green phase trees stop transpiring. As the trees dry out, these trees will not reemit as much sunlight energy as longwave radiation. This means stand temperature and humidity are less regulated.



Red phase stands accumulate more needles on the snow surface than living or grey phase stands, reducing snow surface albedo and speeding up melt by as much as a week.

*[Pugh & Small, 2012a]*

# Snow Surface Albedo

Late Spring 2009

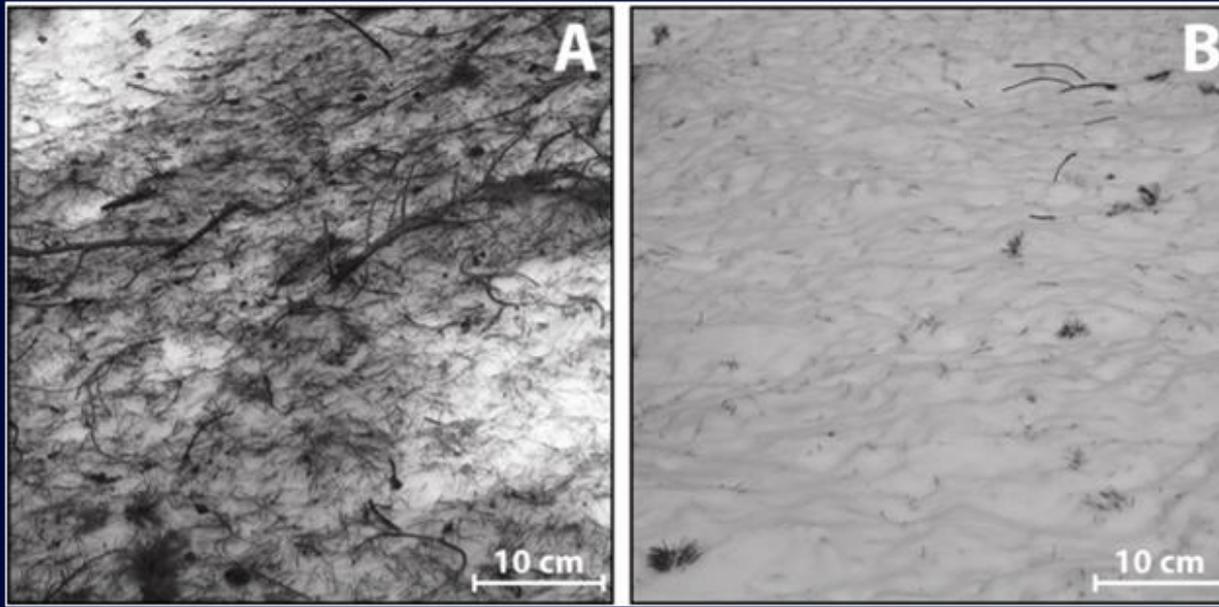
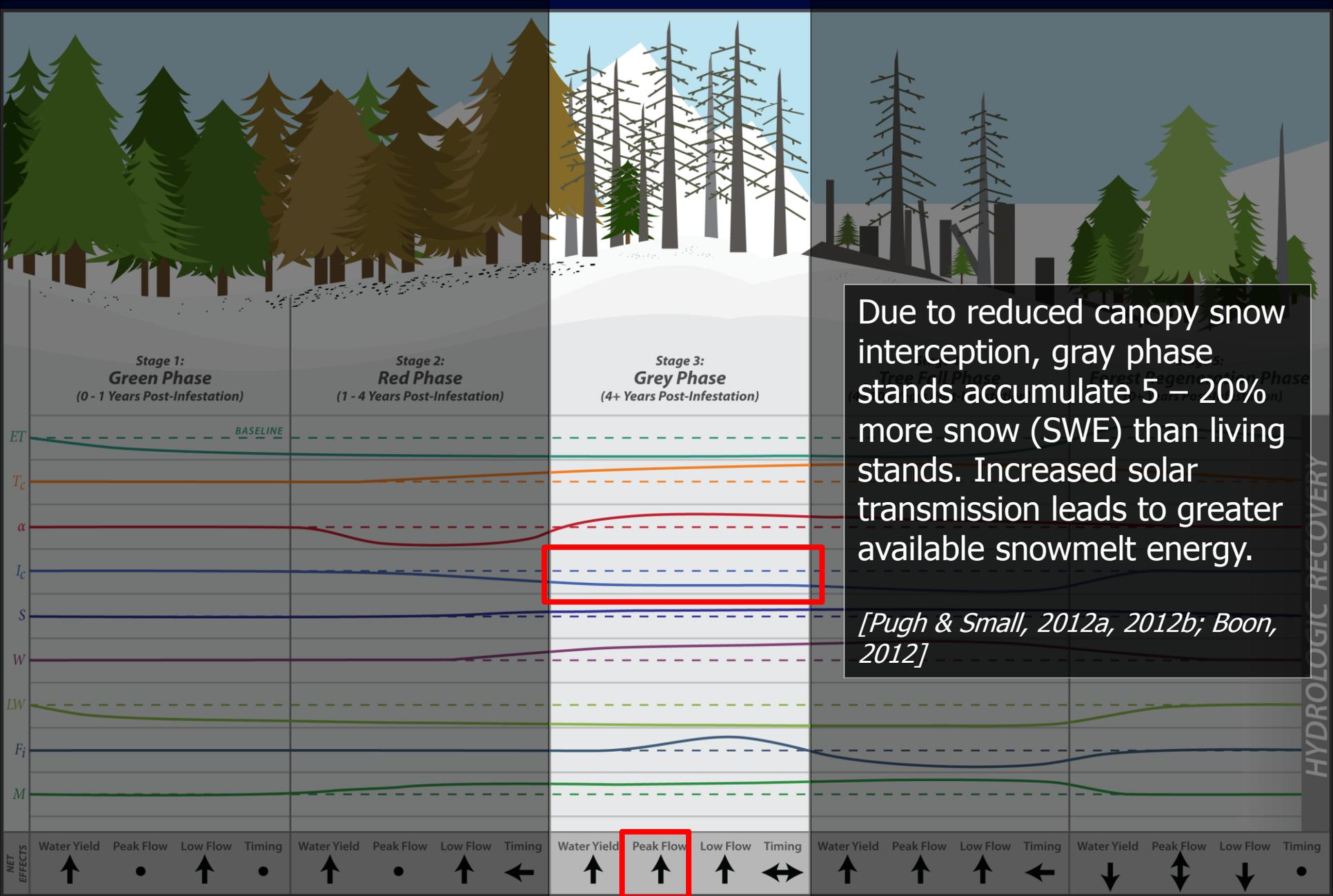


Image: Pugh E and Small EE. 2012. The impact of pine beetle infestation on snow accumulation and melt in the headwaters of the Colorado River. *Ecohydrology*.



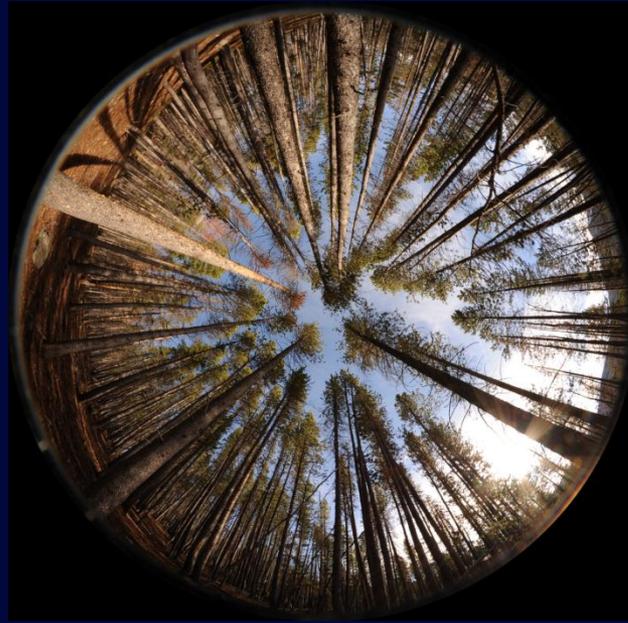


Due to reduced canopy snow interception, gray phase stands accumulate 5 – 20% more snow (SWE) than living stands. Increased solar transmission leads to greater available snowmelt energy.

*[Pugh & Small, 2012a, 2012b; Boon, 2012]*

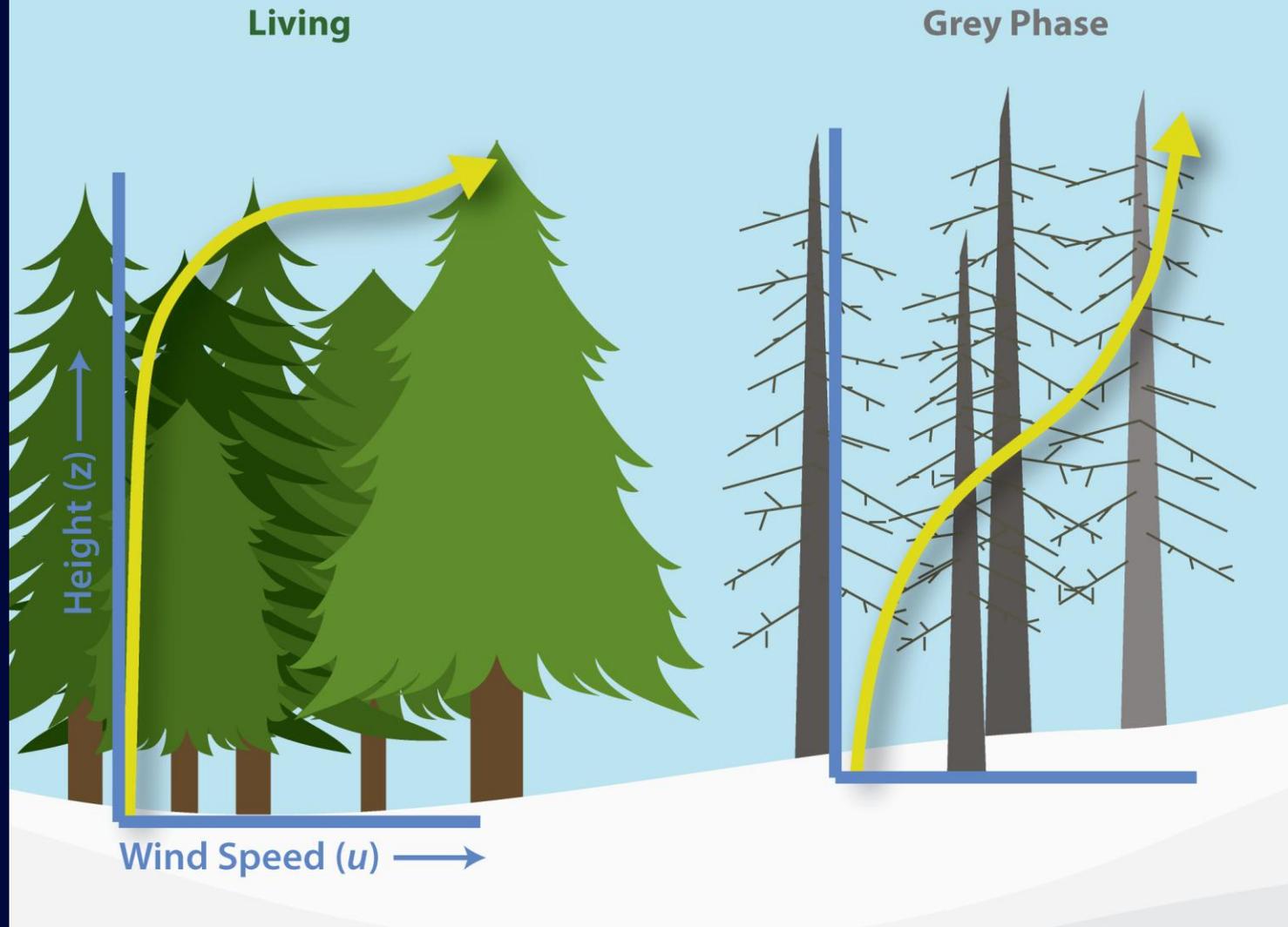
# Gray Phase Canopy Snow Interception

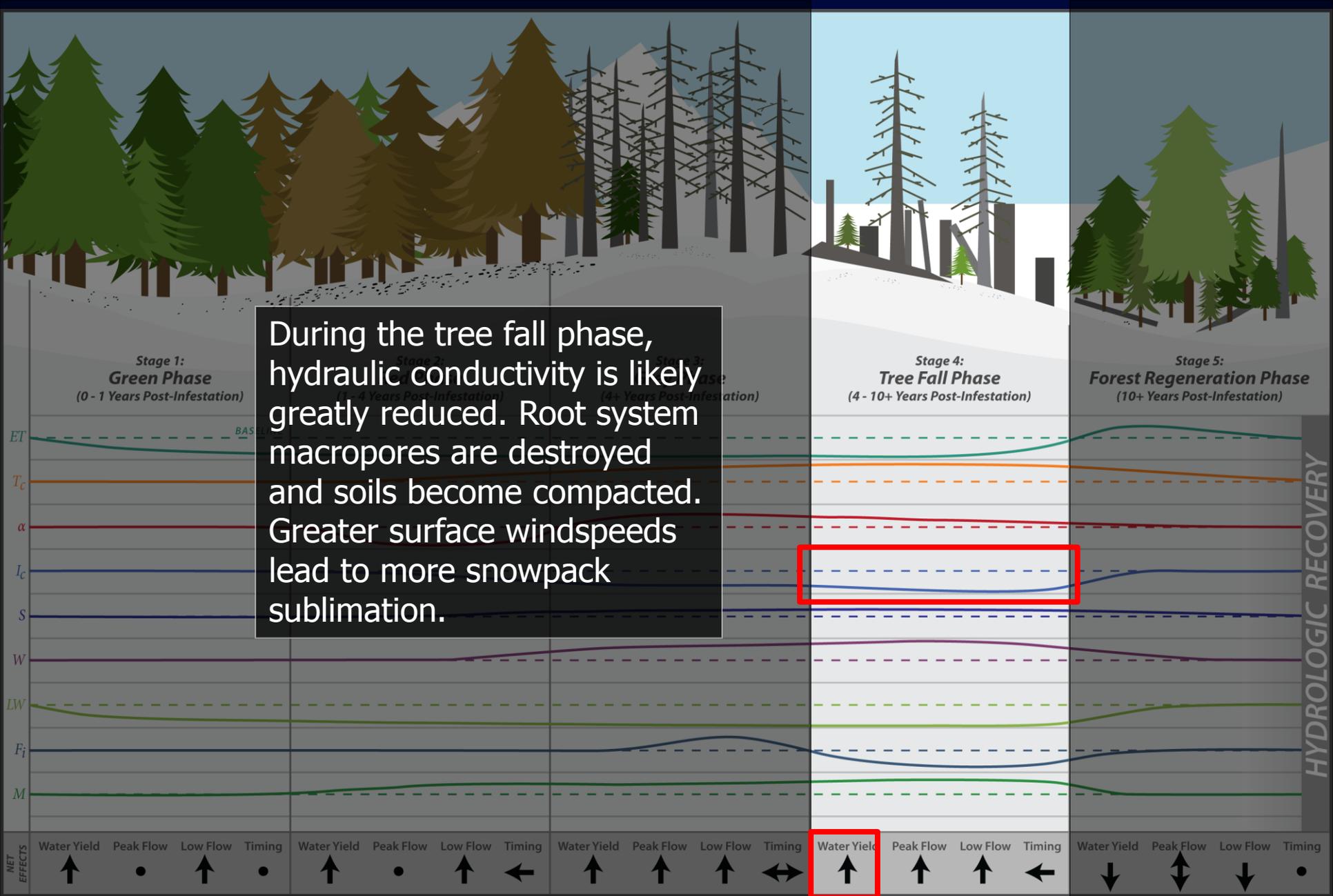
For more, see:  
Pugh E.T. and Small E.E. The  
impact of beetle-induced conifer  
death on stand-scale canopy  
snow interception, *Hydrology  
Research*, in press.

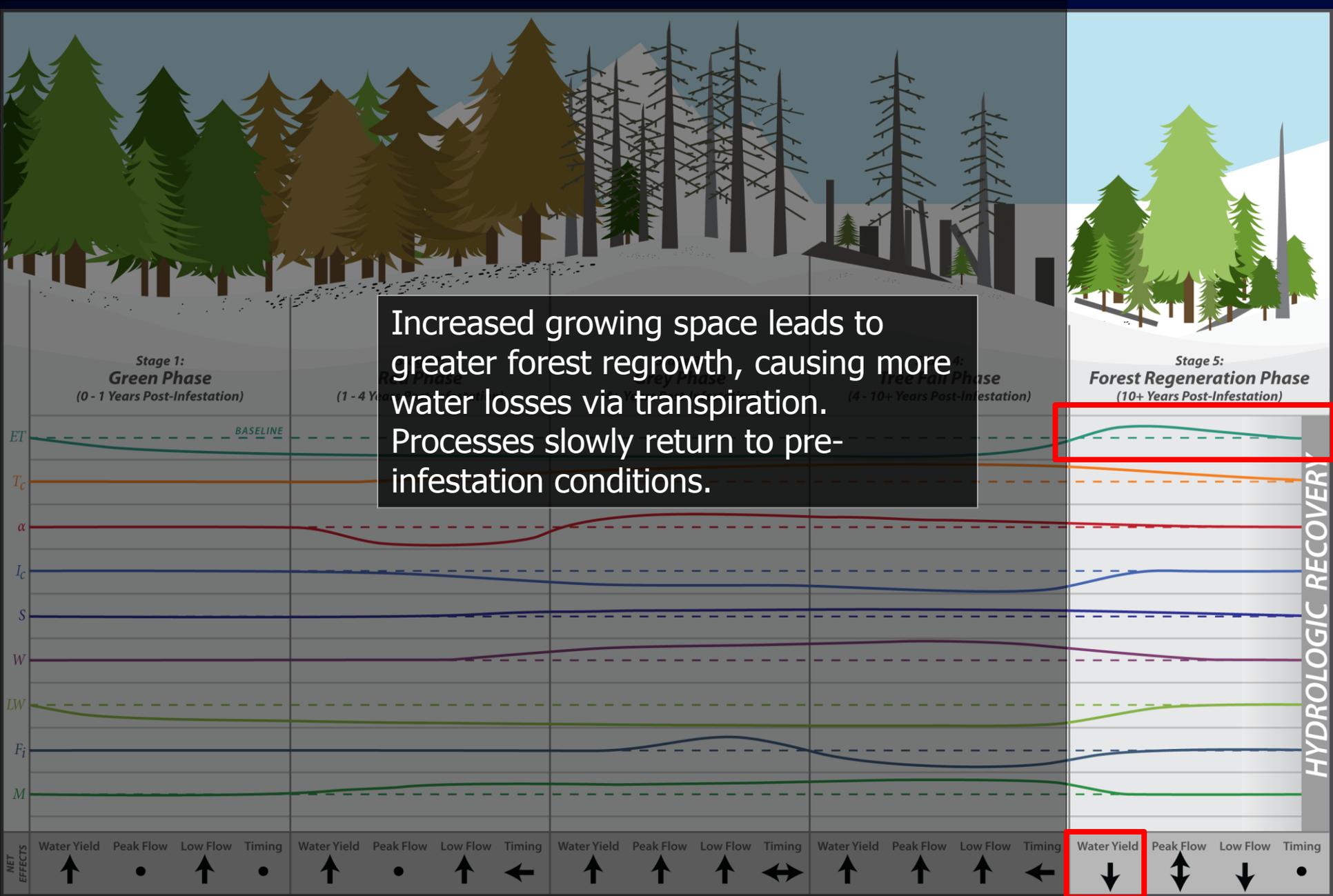


# WIND SPEED

## Faster Average Wind Speeds







# Caveat:

## Likely depends on site-specific factors

Table V. Site-specific factors that can influence the changes in hydrologic processes associated with tree death

Forest characteristics	Watershed	Climate/weather	Mortality
Species composition	Elevation	Temperature	Rate of change
Stem density	Slope	Precipitation	Total extent of mortality
Canopy leaf area	Aspect	Humidity	Extent of each mortality phase
Canopy geometry	Basin area	Wind speed	
Tree height	Forested area	Cloudiness	
Regenerating species composition			



# Scale



**Study findings at the stand scale...**

# Scale



**...may not be representative of watershed scale hydrology (alpine zones, meadows, etc)**

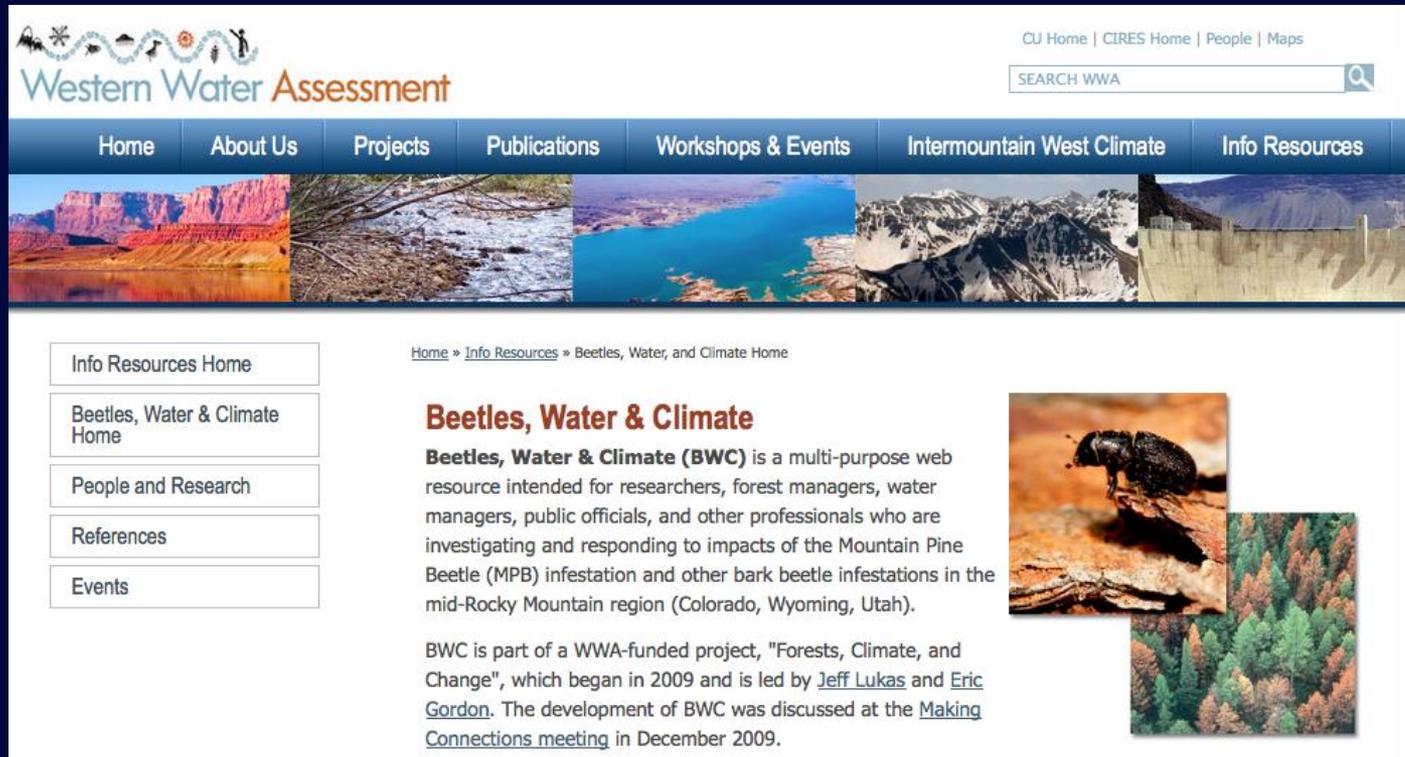


# Are We Really Getting More Runoff?

- Bark beetle infestations lead to evolving changes in hydrologic processes with mortality stage
- Changes in streamflow in MPB-affected areas in CO have not yet been detected
  - Grey phase = +10–20% more snow, which is less than interannual variability
  - During high snow years, effects of tree canopies are likely much smaller
- Hydrologic modeling can help answer the question



# For More Information



The screenshot shows the Western Water Assessment website. At the top left is the logo with icons for a mountain, water, sun, and people, followed by the text "Western Water Assessment". To the right are links for "CU Home", "CIRES Home", "People", and "Maps", and a search bar labeled "SEARCH WWA". Below the logo is a navigation menu with buttons for "Home", "About Us", "Projects", "Publications", "Workshops & Events", "Intermountain West Climate", and "Info Resources". A banner image below the menu shows five panels: a canyon, a snowy stream, a blue lake, snow-capped mountains, and a dam. On the left side of the page is a sidebar with buttons for "Info Resources Home", "Beetles, Water & Climate Home", "People and Research", "References", and "Events". The main content area has a breadcrumb trail: "Home » Info Resources » Beetles, Water, and Climate Home". The main heading is "Beetles, Water & Climate". The text describes the "Beetles, Water & Climate (BWC)" as a multi-purpose web resource for researchers and professionals studying bark beetle infestations. It mentions the Mountain Pine Beetle (MPB) and other bark beetles in the mid-Rocky Mountain region. It also states that BWC is part of a WWA-funded project "Forests, Climate, and Change" led by Jeff Lukas and Eric Gordon, and that its development was discussed at a "Making Connections meeting" in December 2009. To the right of the text are two images: a close-up of a dark beetle on a piece of wood, and a photograph of a forest with trees showing autumn colors.

<http://wwa.colorado.edu/resources/beetle>