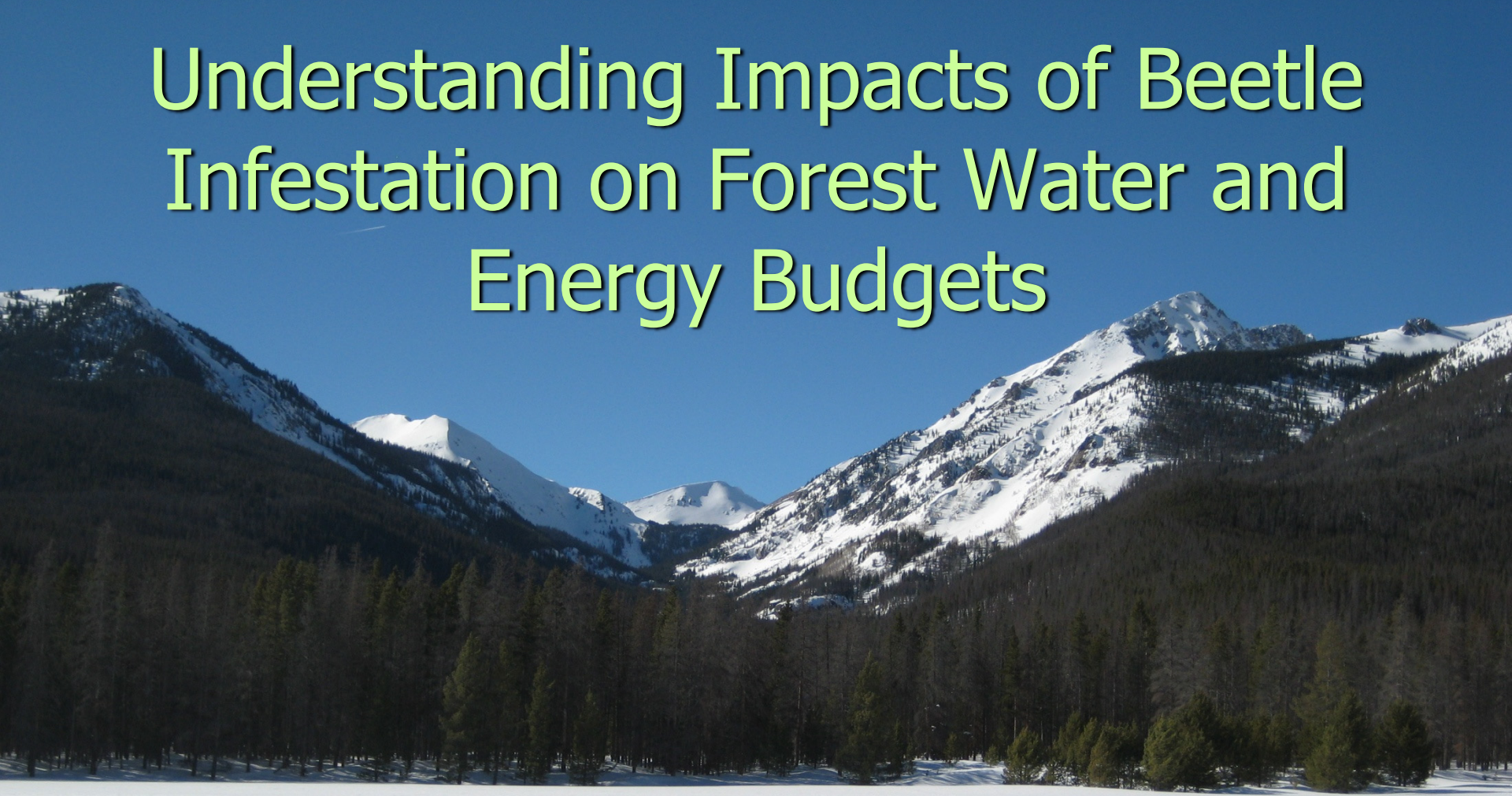
Understanding Impacts of Beetle Infestation on Forest Water and Energy Budgets



Evan Pugh

University of Colorado – Geological Sciences

Eric Small Tilton's Terrestrial Hydrology Lab

Utah Bark Beetles and Watersheds Workshop – Dec 1st, 2011

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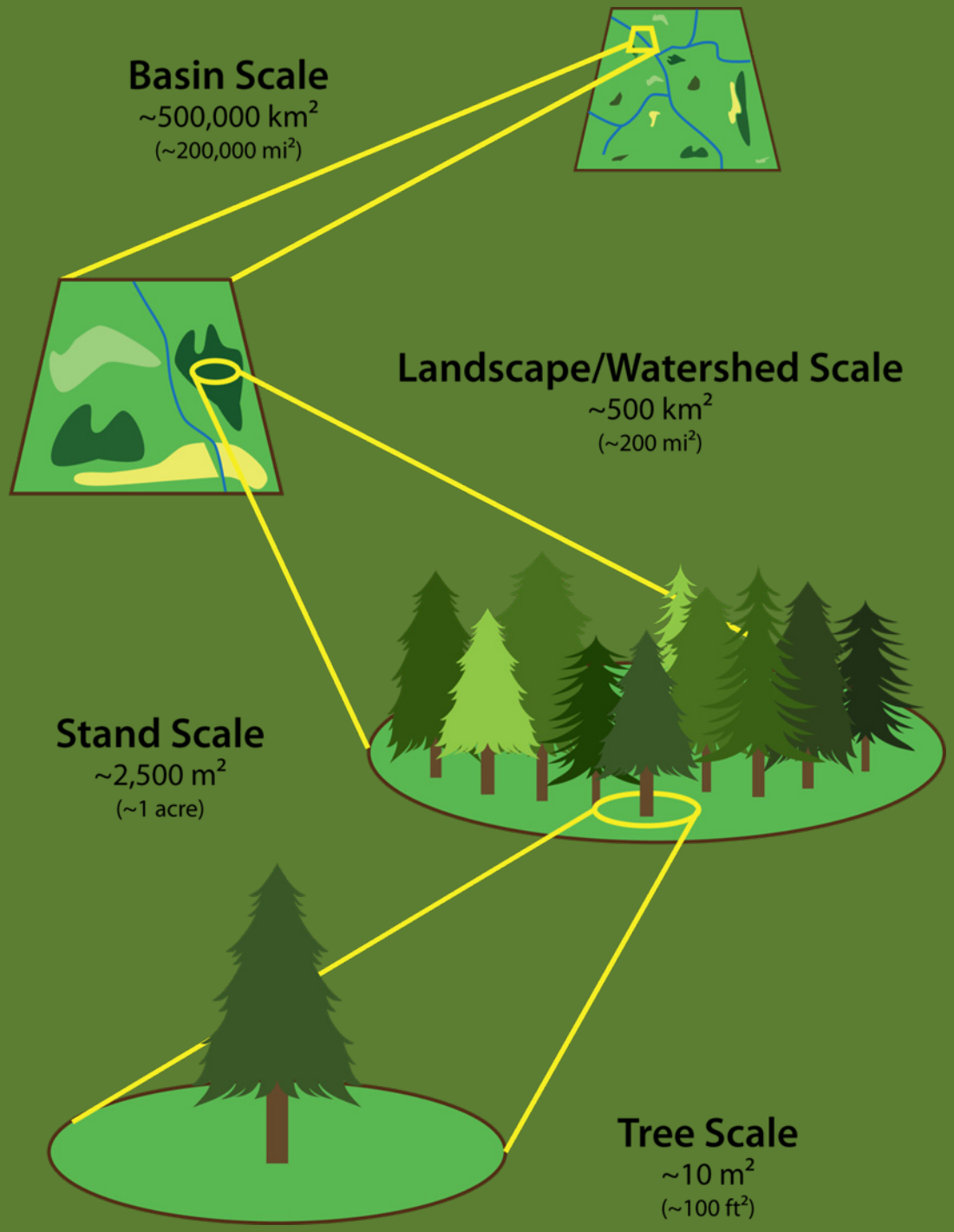

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Scale

Study findings at the stand scale…

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

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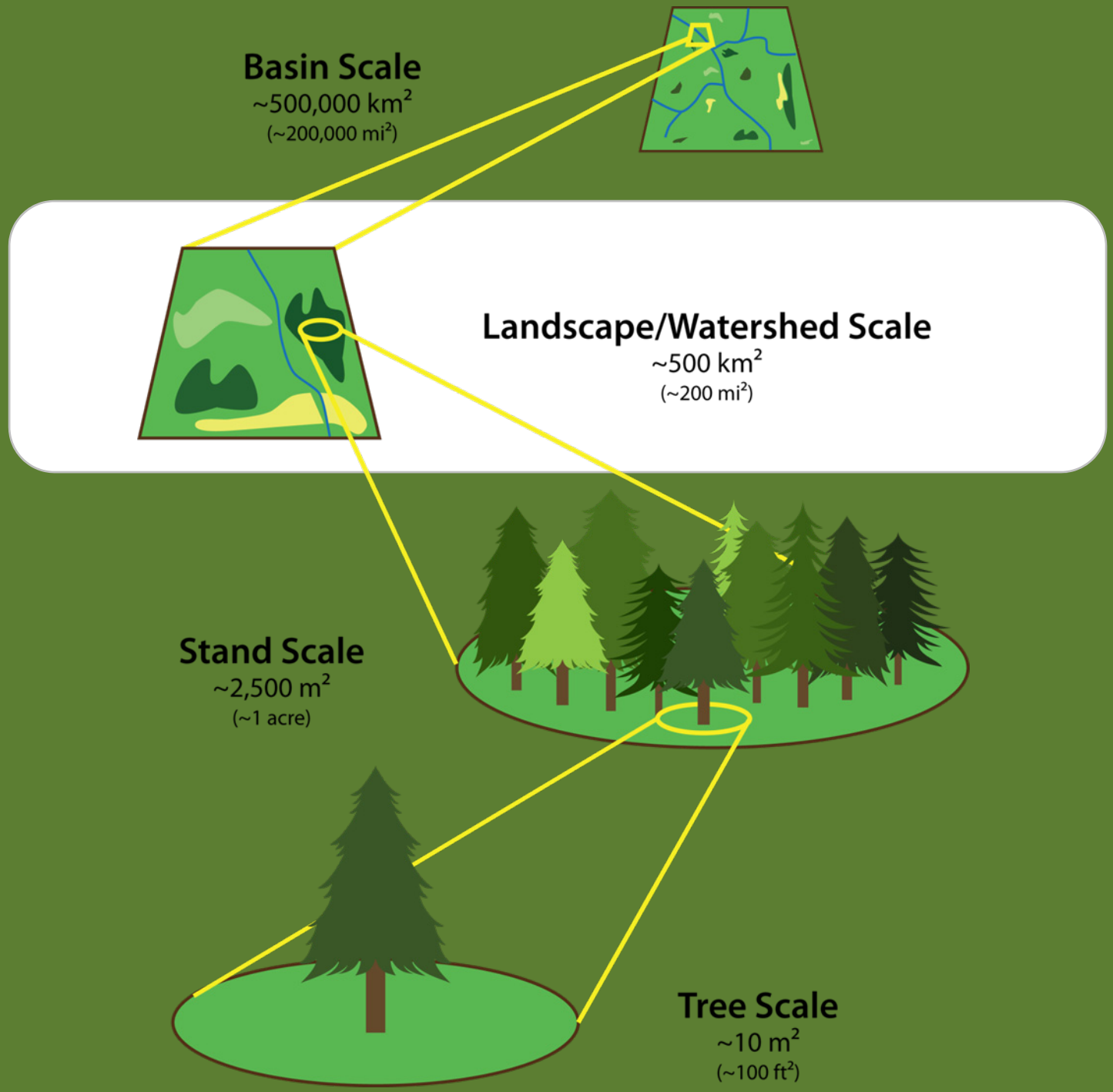

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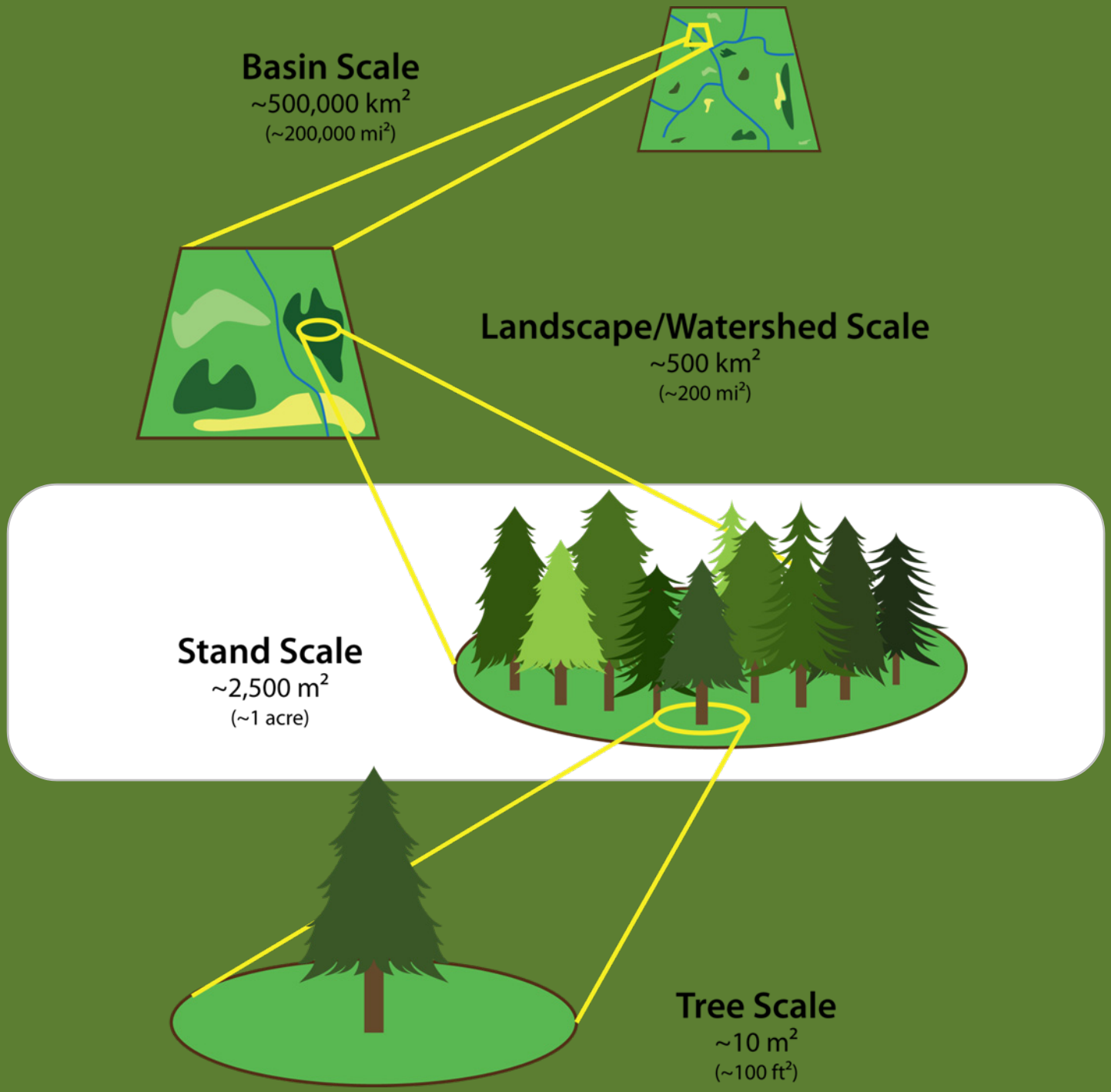

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The Forest System

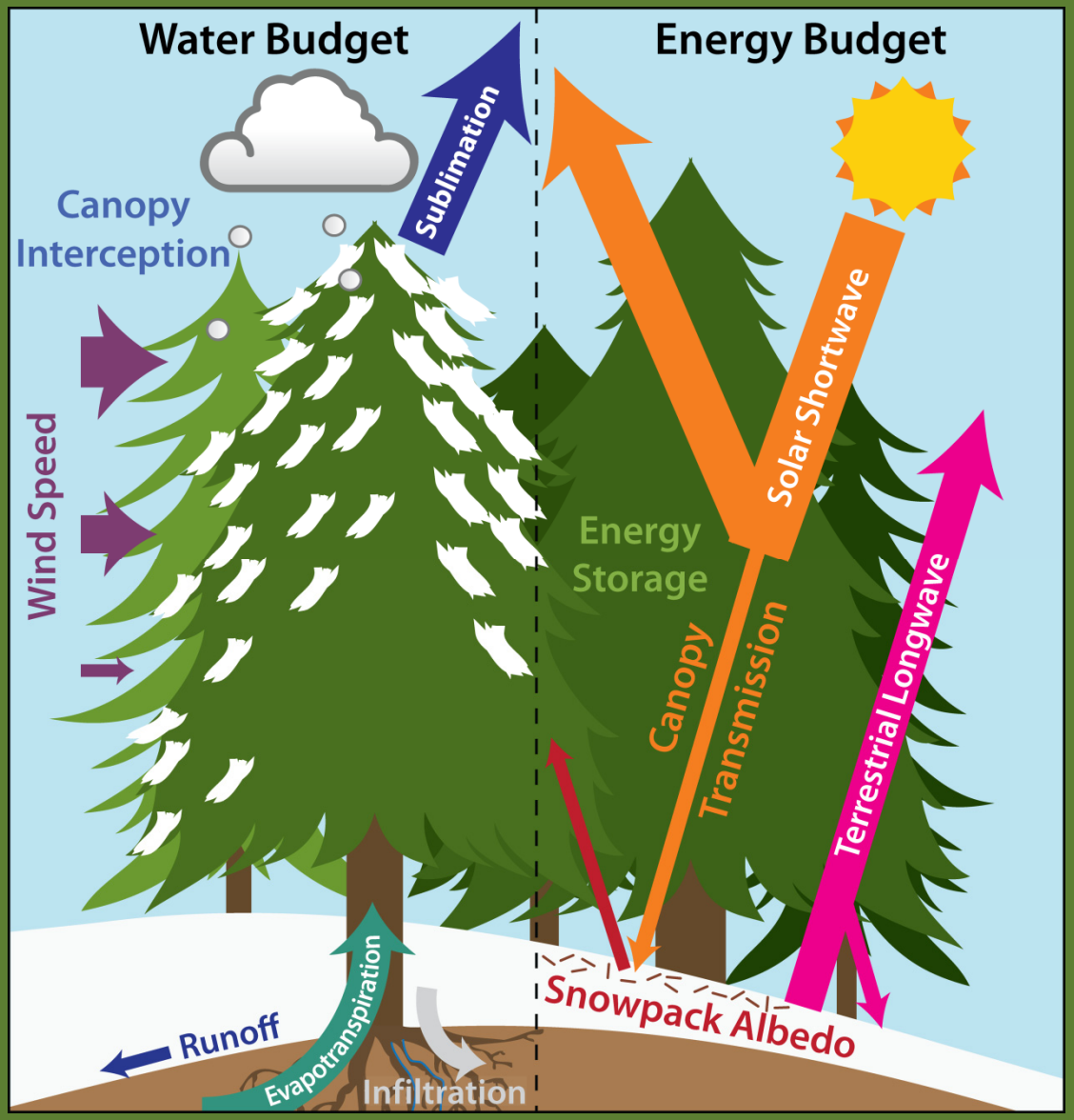

Image: Pugh ET and Gordon ES. A conceptual model of water yield impacts from insect-induced tree death in snow-dominated coniferous forests, *Hydrological Processes*, submitted October 2011.

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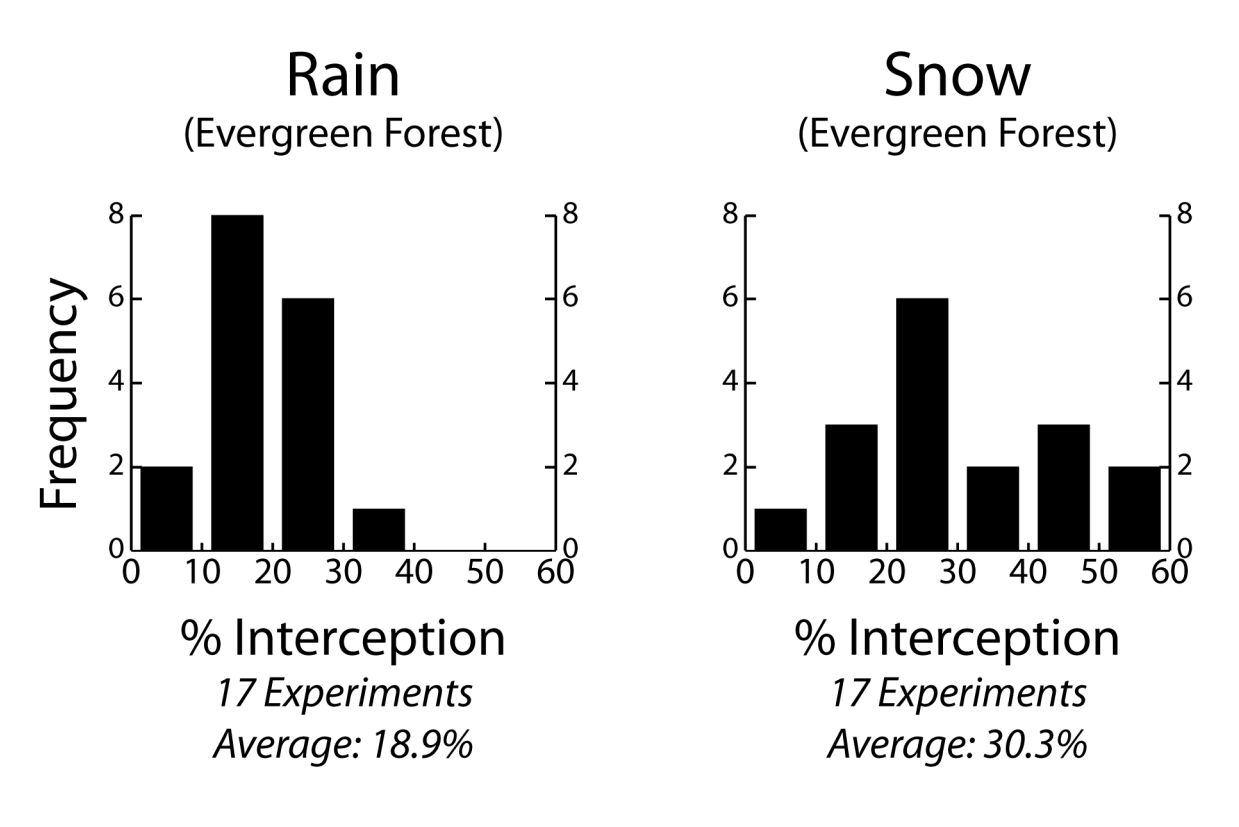
Canopy rain/snow interception controls the input of water to the forest system



- Lots of variation due to stand species, age, climate, etc…
- More snow than rain is caught in conifer canopies
- Important process because more evaporation occurs from the canopy than the ground

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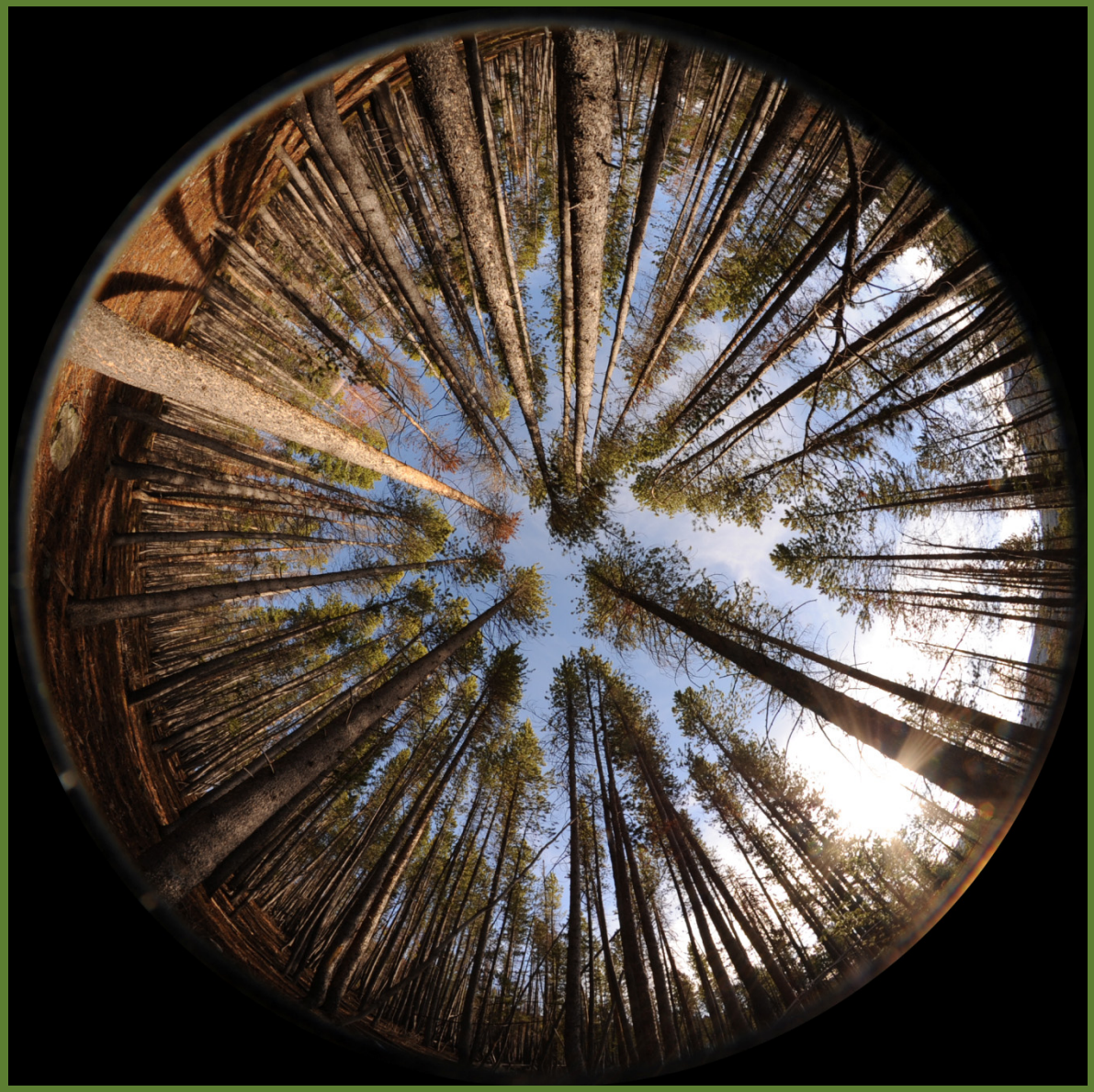

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Gray Phase Dead Forests

Gray Phase Dead Forests

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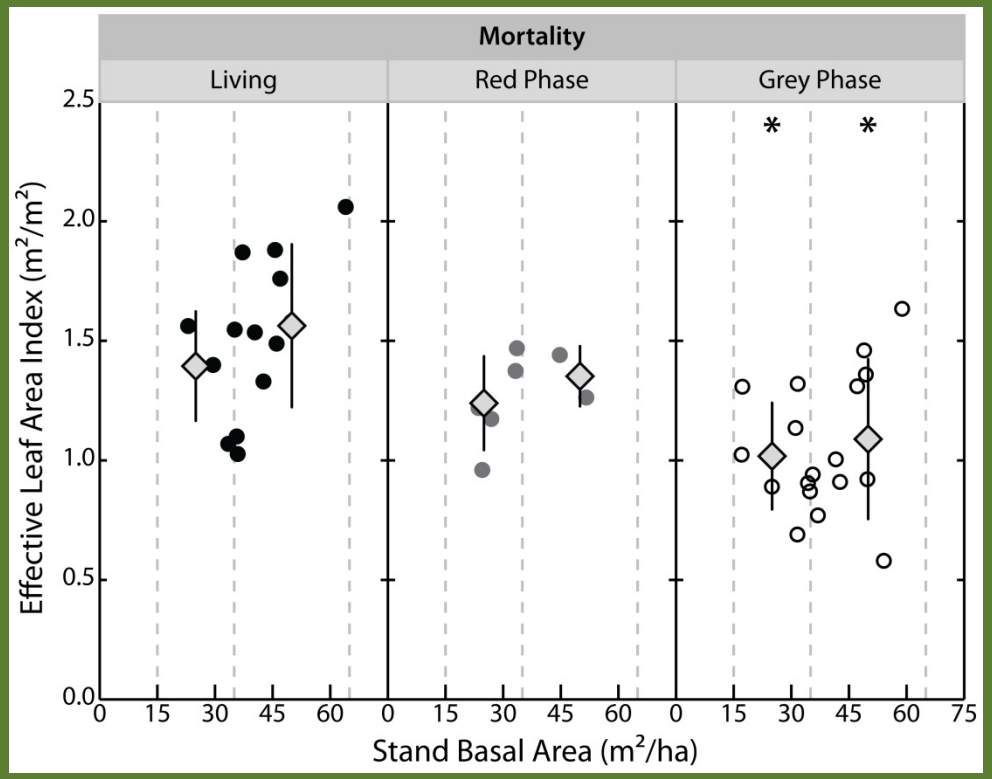

More than 600

Hemispherical Photos

Image: Pugh ET and Gordon ES. A conceptual model of water yield impacts from insect-induced tree death in snow-dominated coniferous forests, *Hydrological Processes*, submitted October 2011.

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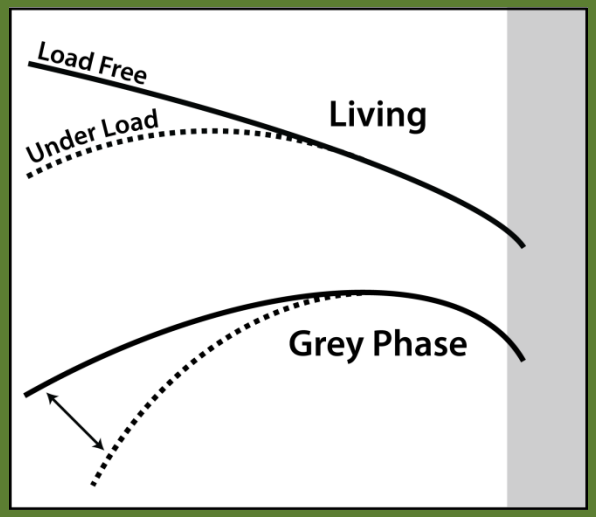
Gray Phase Dead Forests



Dead branches

Downward branch orientation leads to a steeper bedding plane for intercepted precipitation

Branches are more brittle and break rather than bend when under load

The removal of twigs and needles decreases the potential for "snow bridging"

With less/bent canopy material, tree "footprints" are smaller

Image: Pugh E and Small EE. 2012. The impact of beetle-induced conifer death on stand-scale canopy snow interception, *Water Resources Research*, in prep.

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Bent and broken branches

Snow bridging

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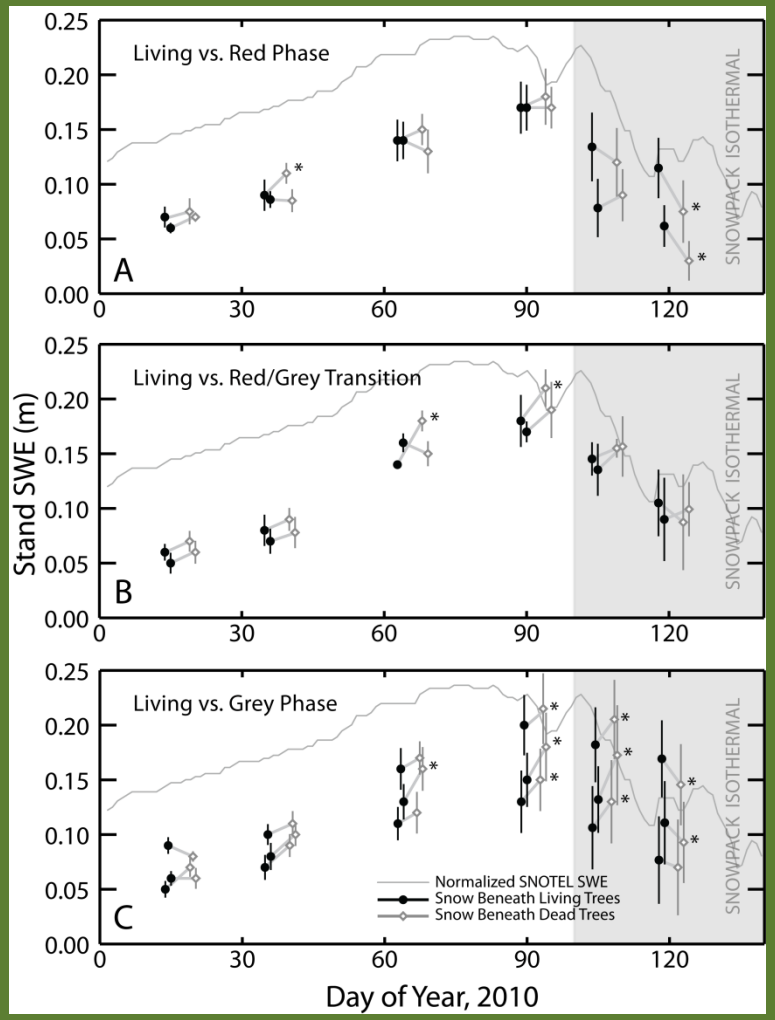
Does snow accumulate and melt differently in dead stands?



Faster Melt

From 2008 - 2011, we compared 8 pairs of living and dead lodgepole pine stands (~3600 m^2)

Image: Pugh E and Small EE. 2011. The impact of pine beetle infestation on snow accumulation and melt in the headwaters of the Colorado River. *Ecohydrology*,.

Understanding Changes to Snow Accumulation and Melt

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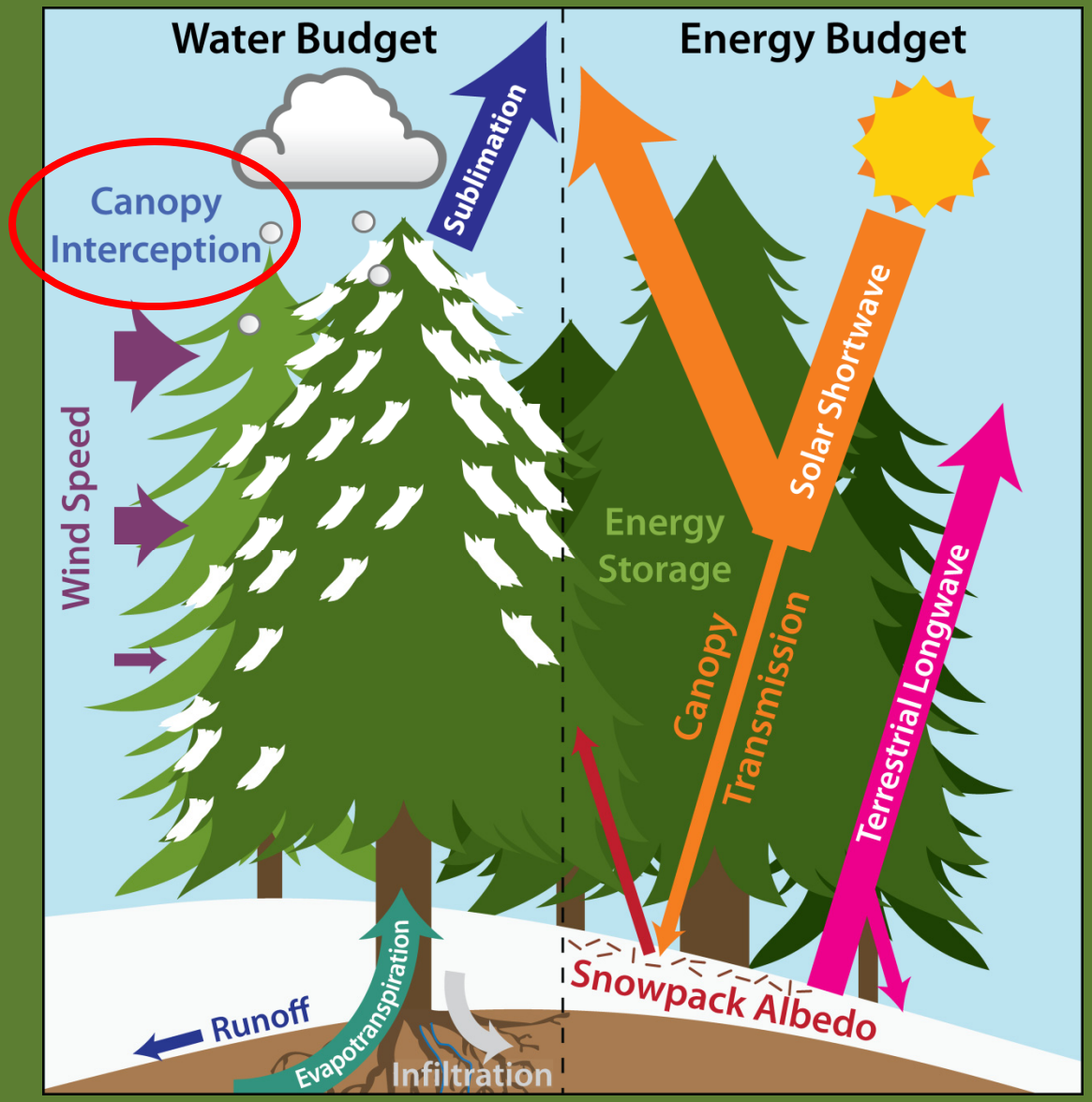

Image: Pugh ET and Gordon ES. A conceptual model of water yield impacts from insect-induced tree death in snow-dominated coniferous forests, *Hydrological Processes*, submitted October 2011.

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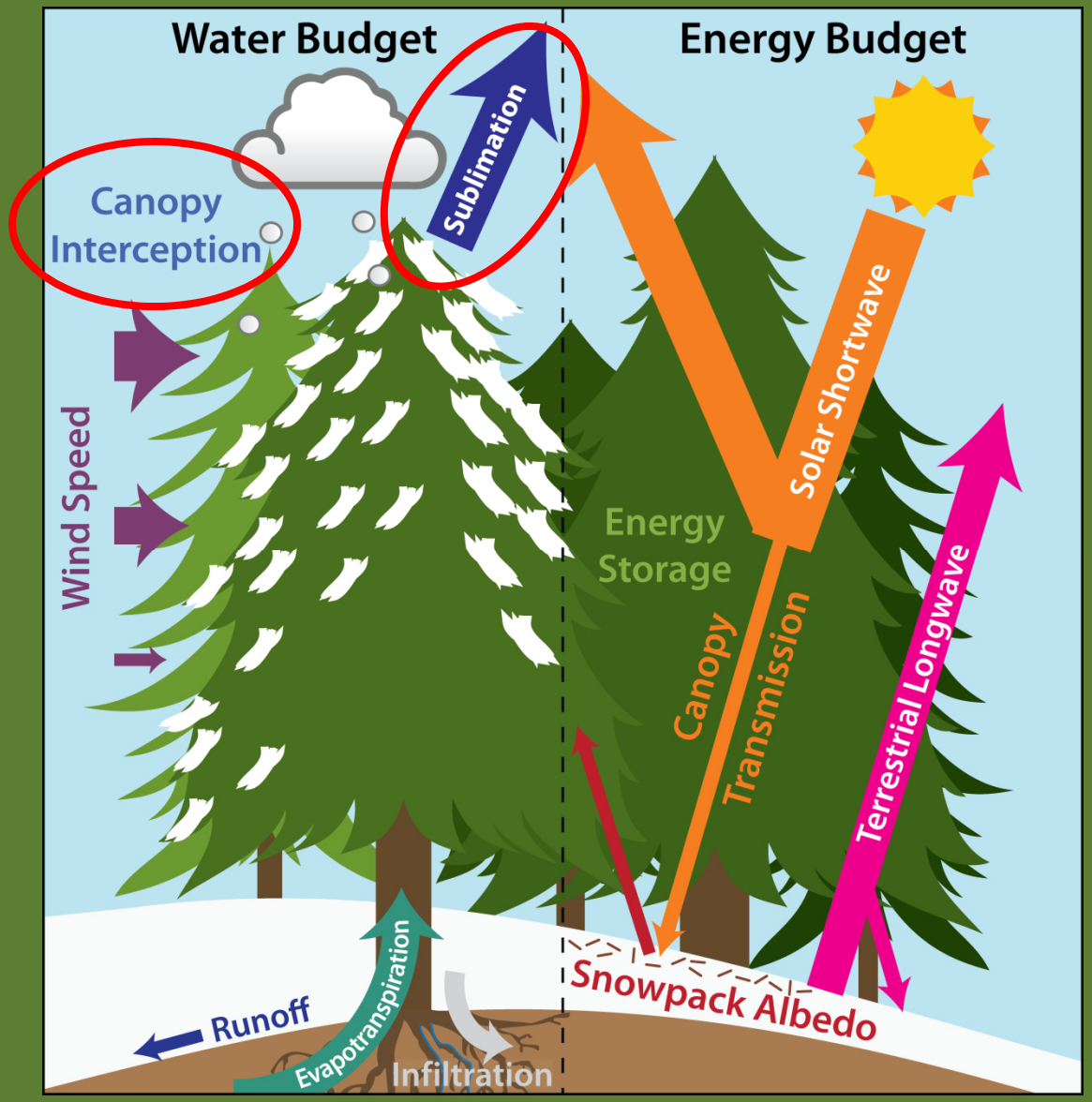

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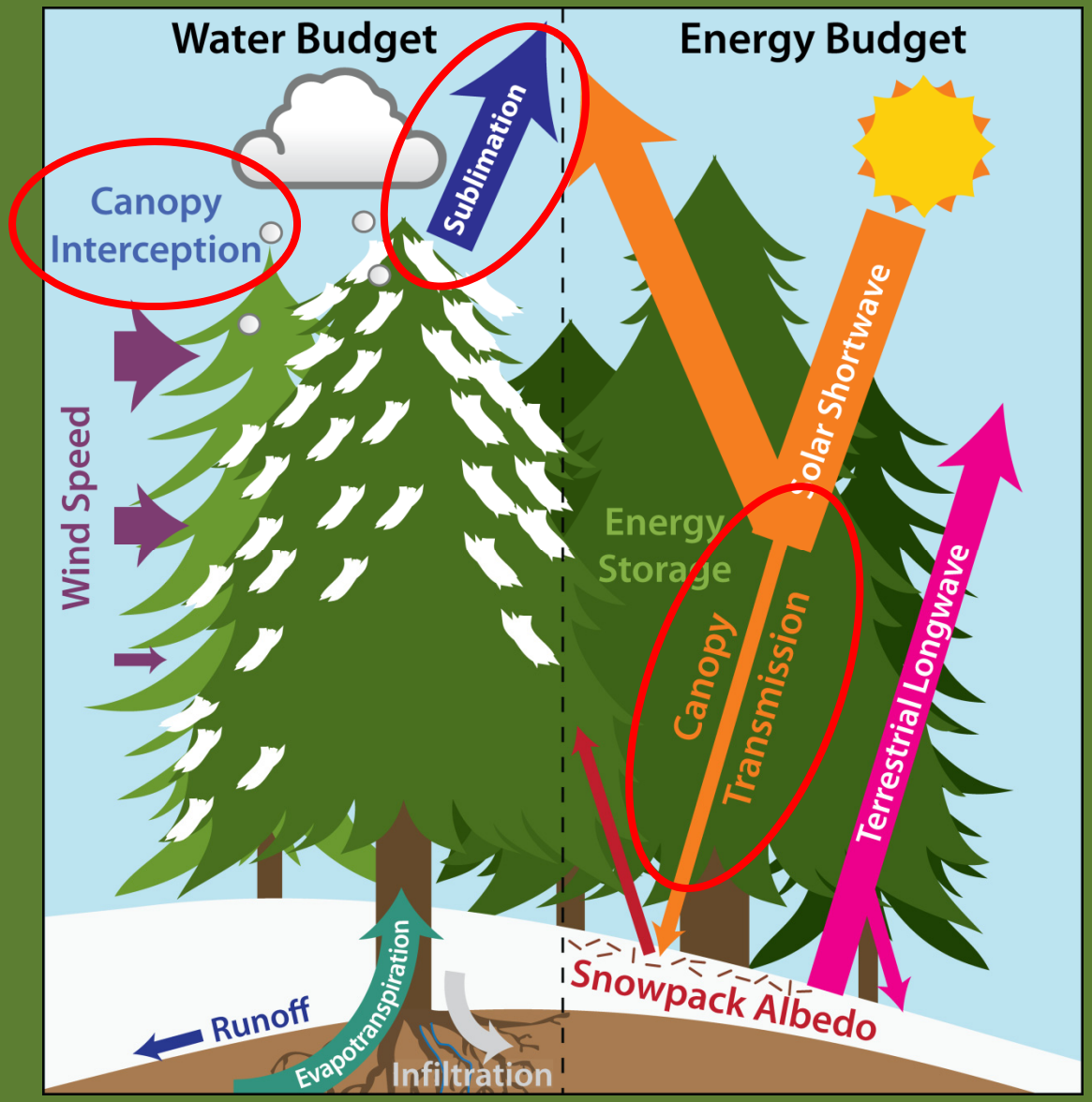

Image: Pugh ET and Gordon ES. A conceptual model of water yield impacts from insect-induced tree death in snow-dominated coniferous forests, *Hydrological Processes*, submitted October 2011.

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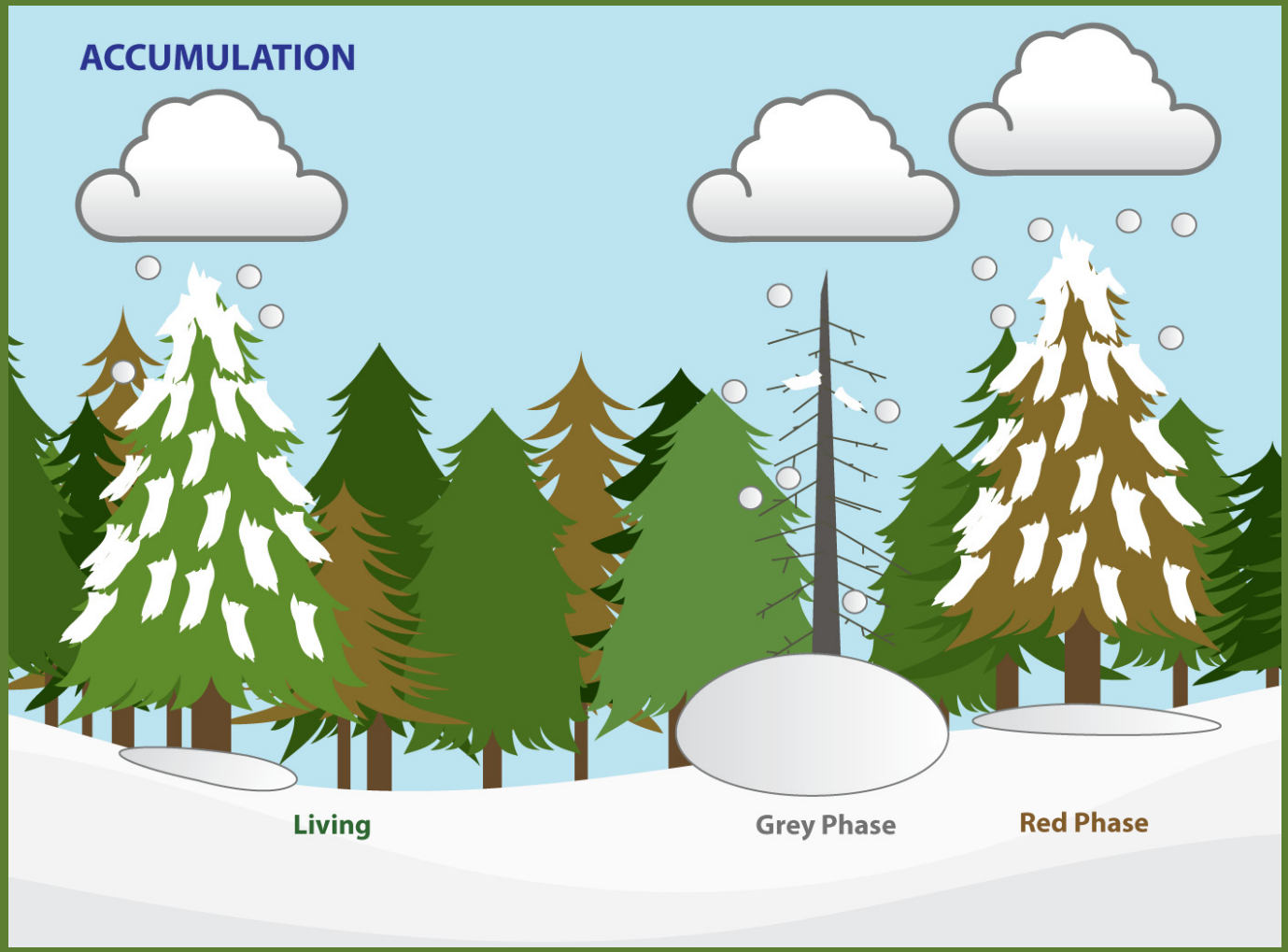
Subcanopy Snow Accumulation



Observations: Similar accumulation under red phase stands, more under gray phase stands

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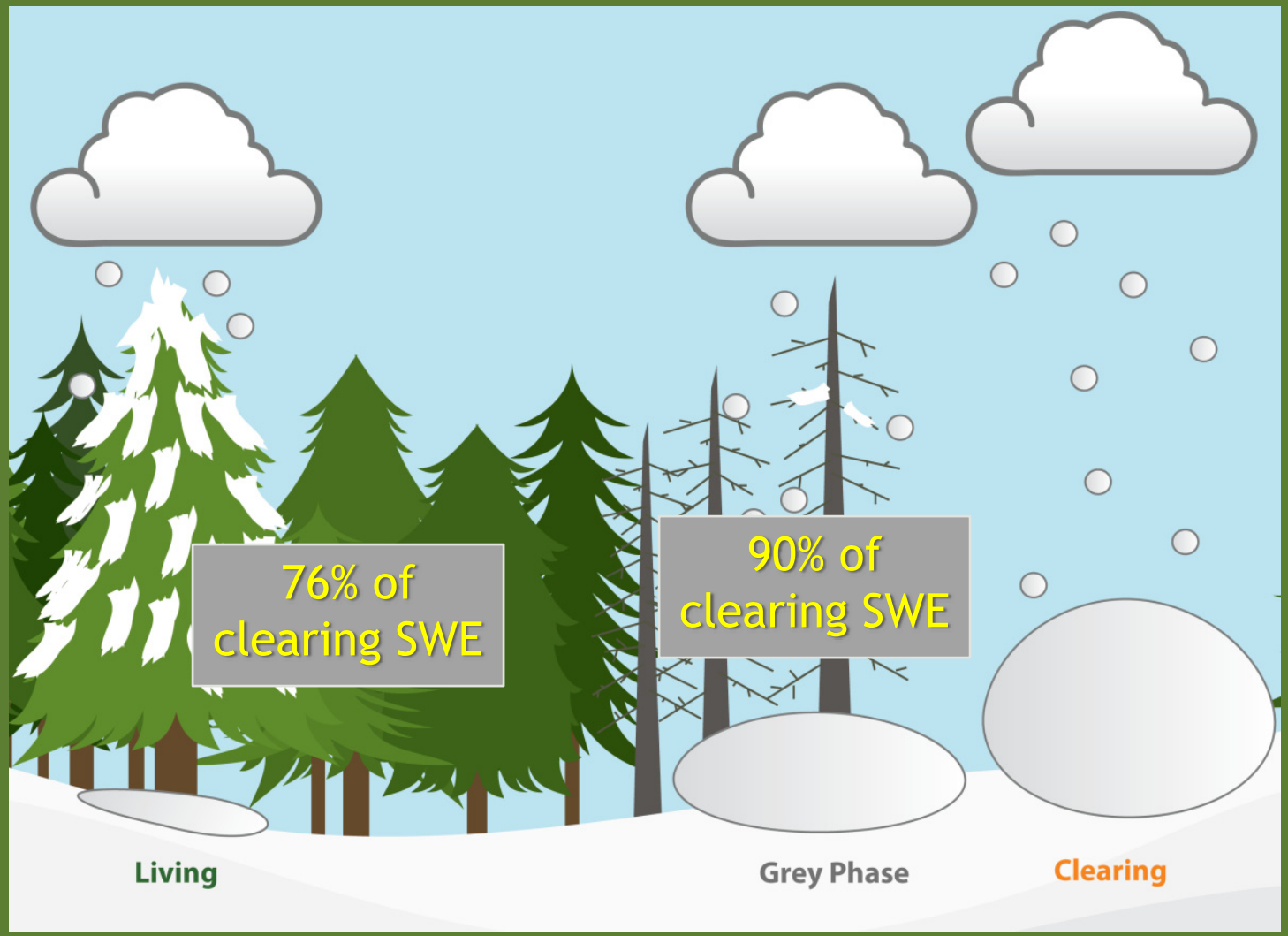
Canopy Snow Interception

Over the course of a season…



Measured daily in 5 stands and 3 clearings

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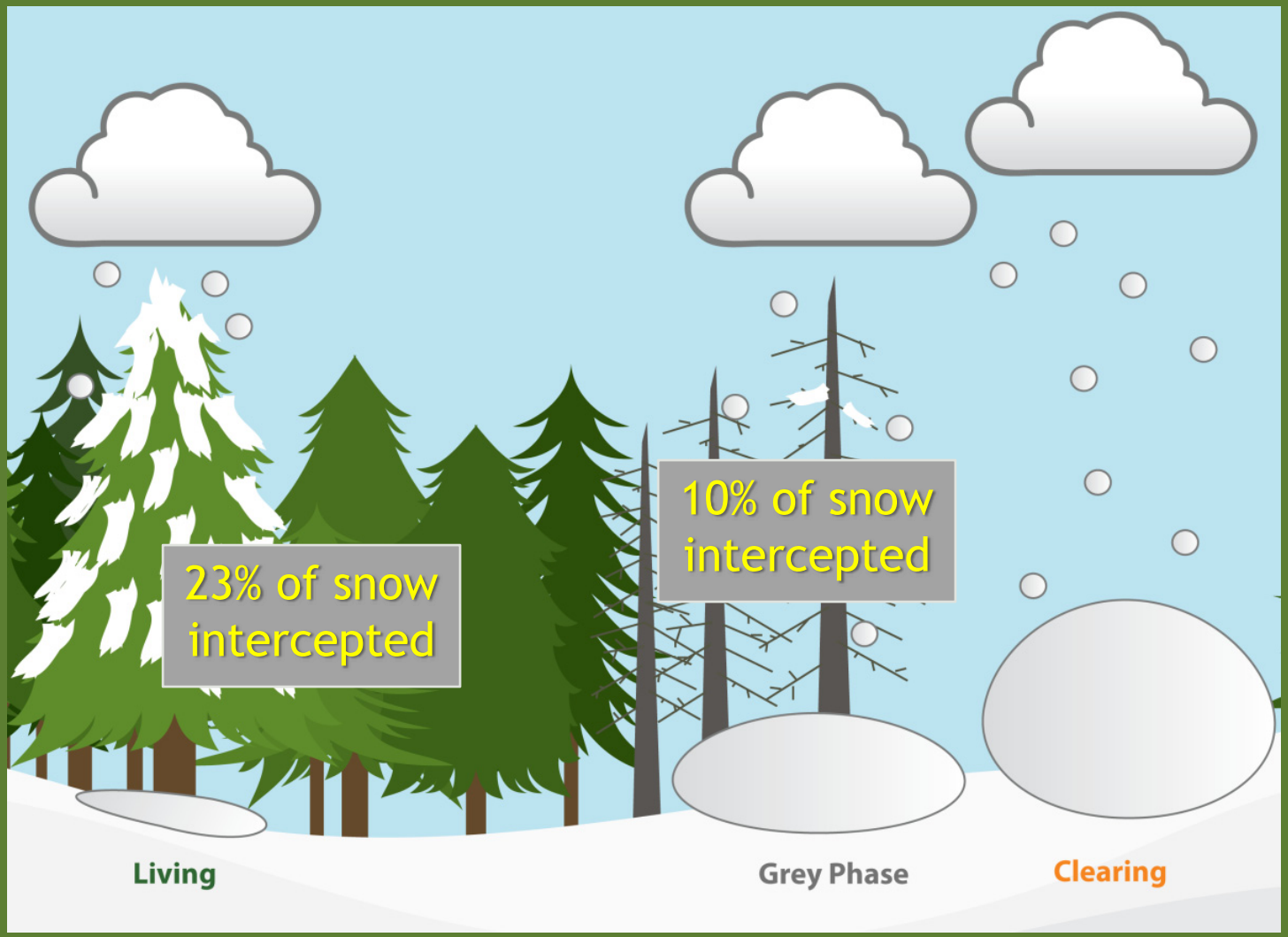
Canopy Snow Interception

During individual storms…



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Storm-scale snow accumulation

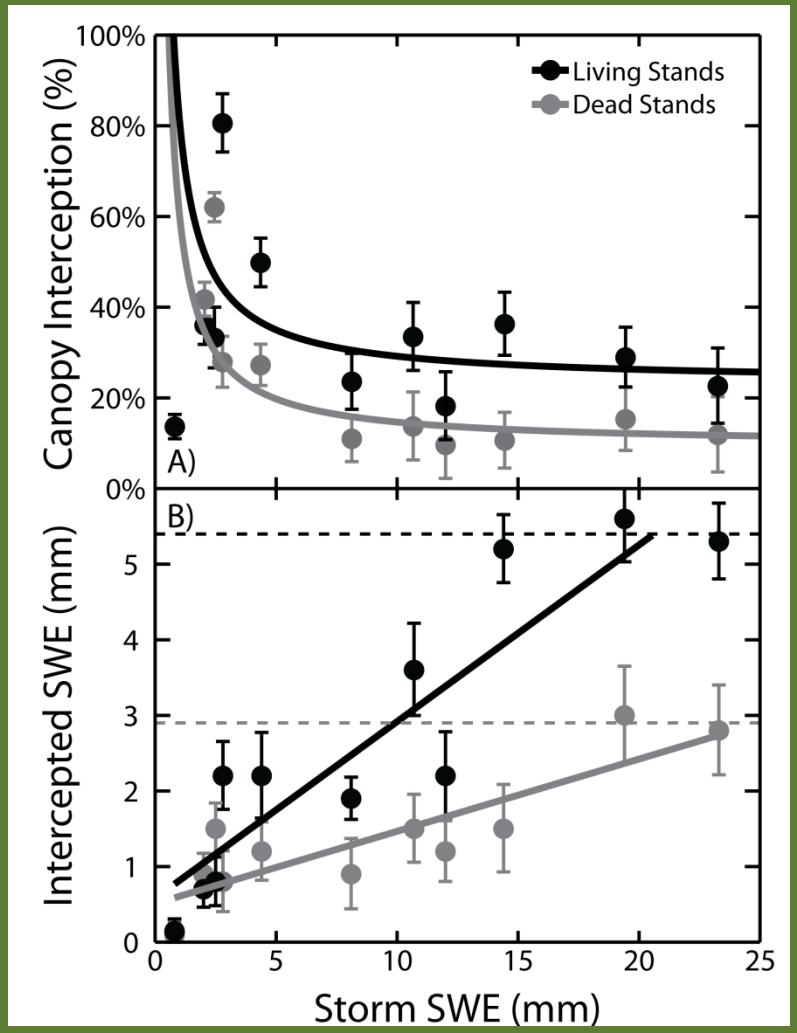

Image: Pugh E and Small EE. 2012. The impact of beetle-induced conifer death on stand-scale canopy snow interception, *Water Resources Research*, in prep.

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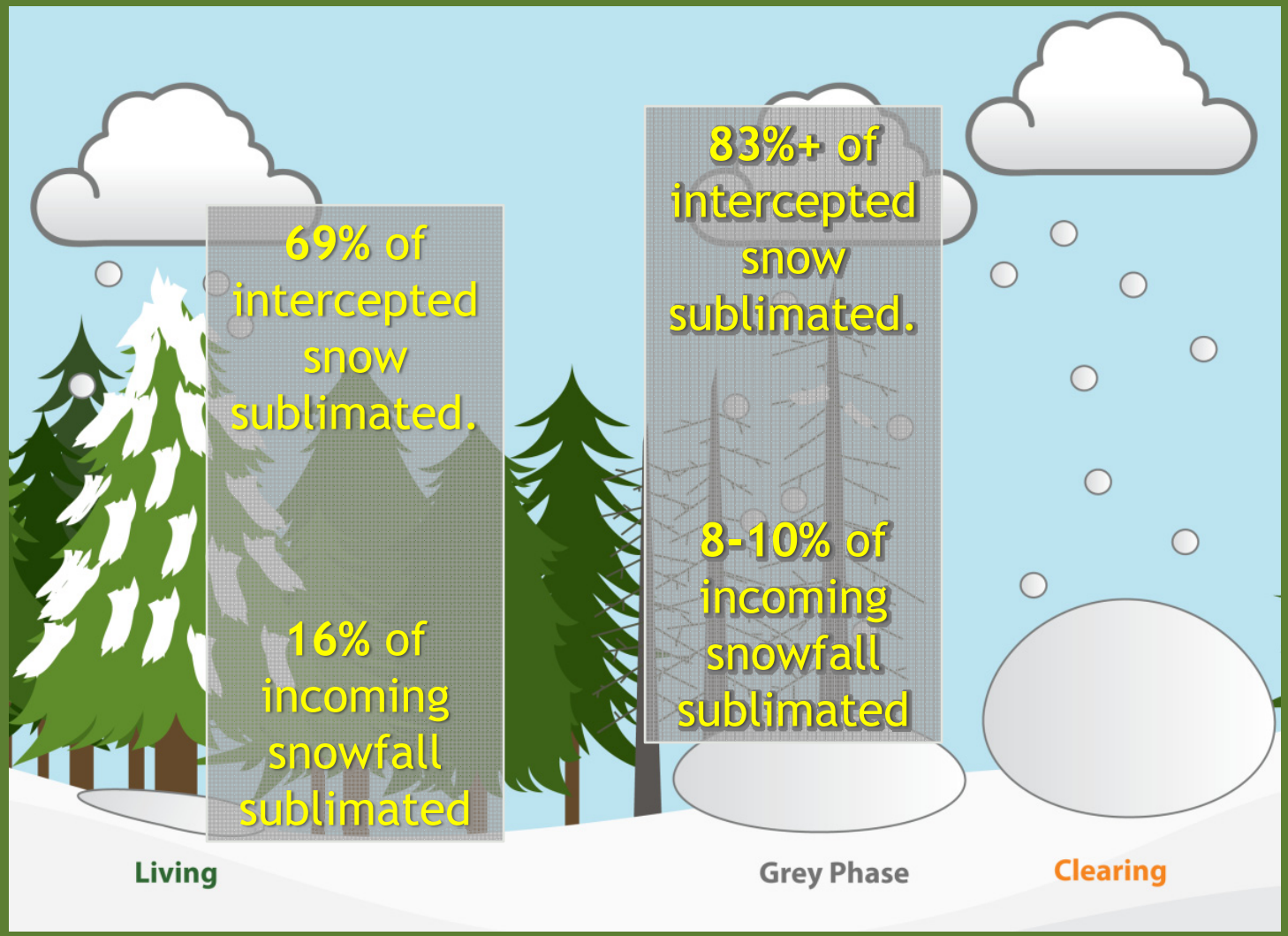
Canopy Snow Interception

By comparing interception to subcanopy accumulation…



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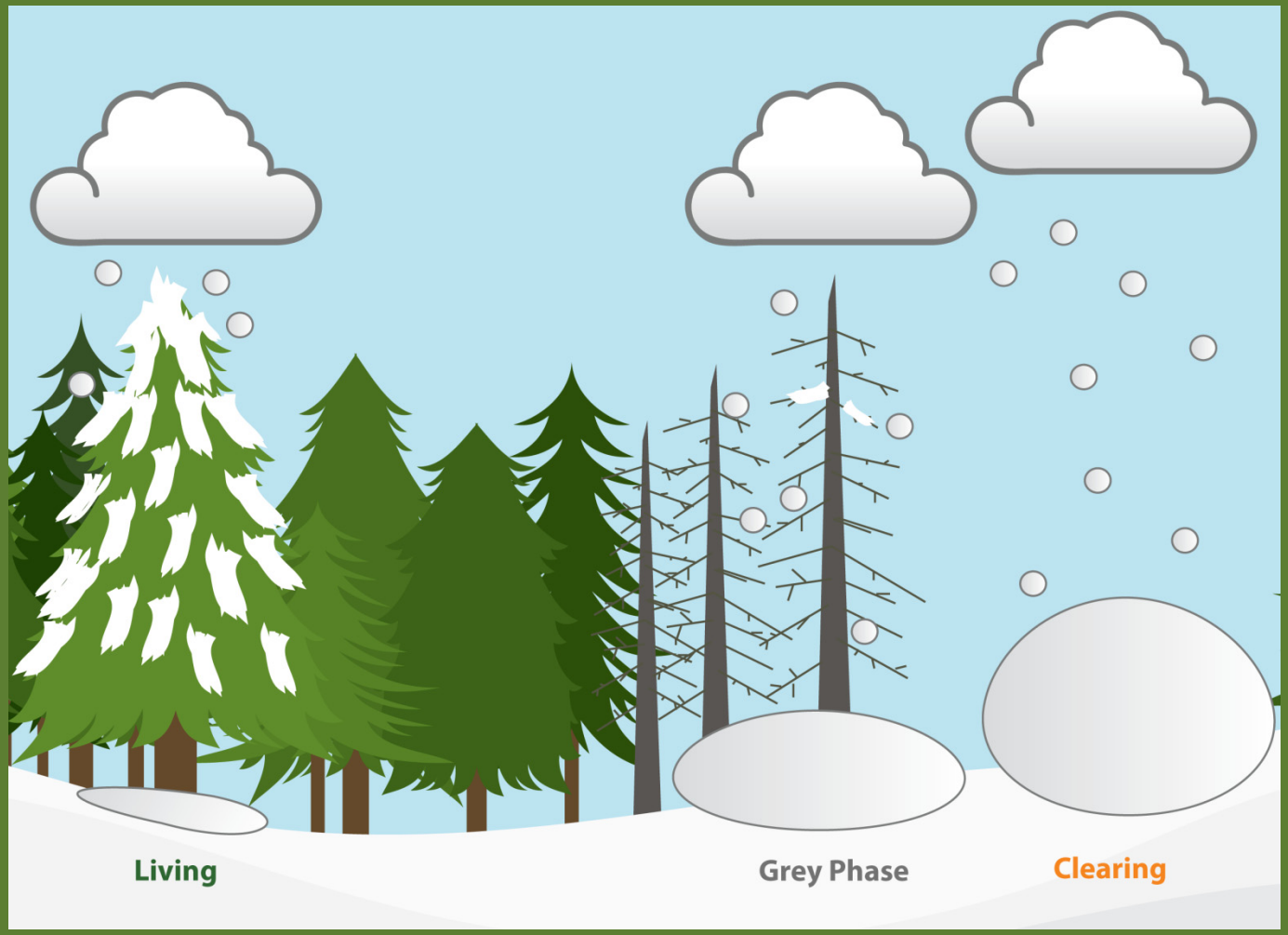
Canopy Snow Interception

~20% more snow accumulation under dead pine stands (from numerous snow/beetle studies)



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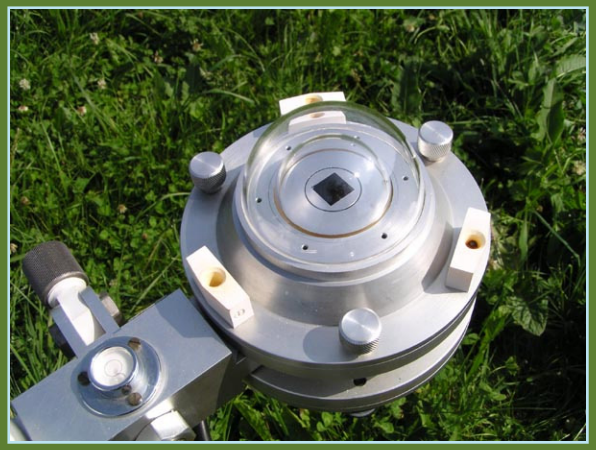
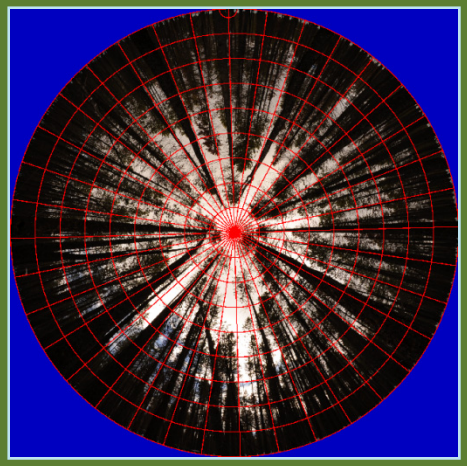
Canopy Solar Transmission



Paired pyranometers



Hemispherical photography

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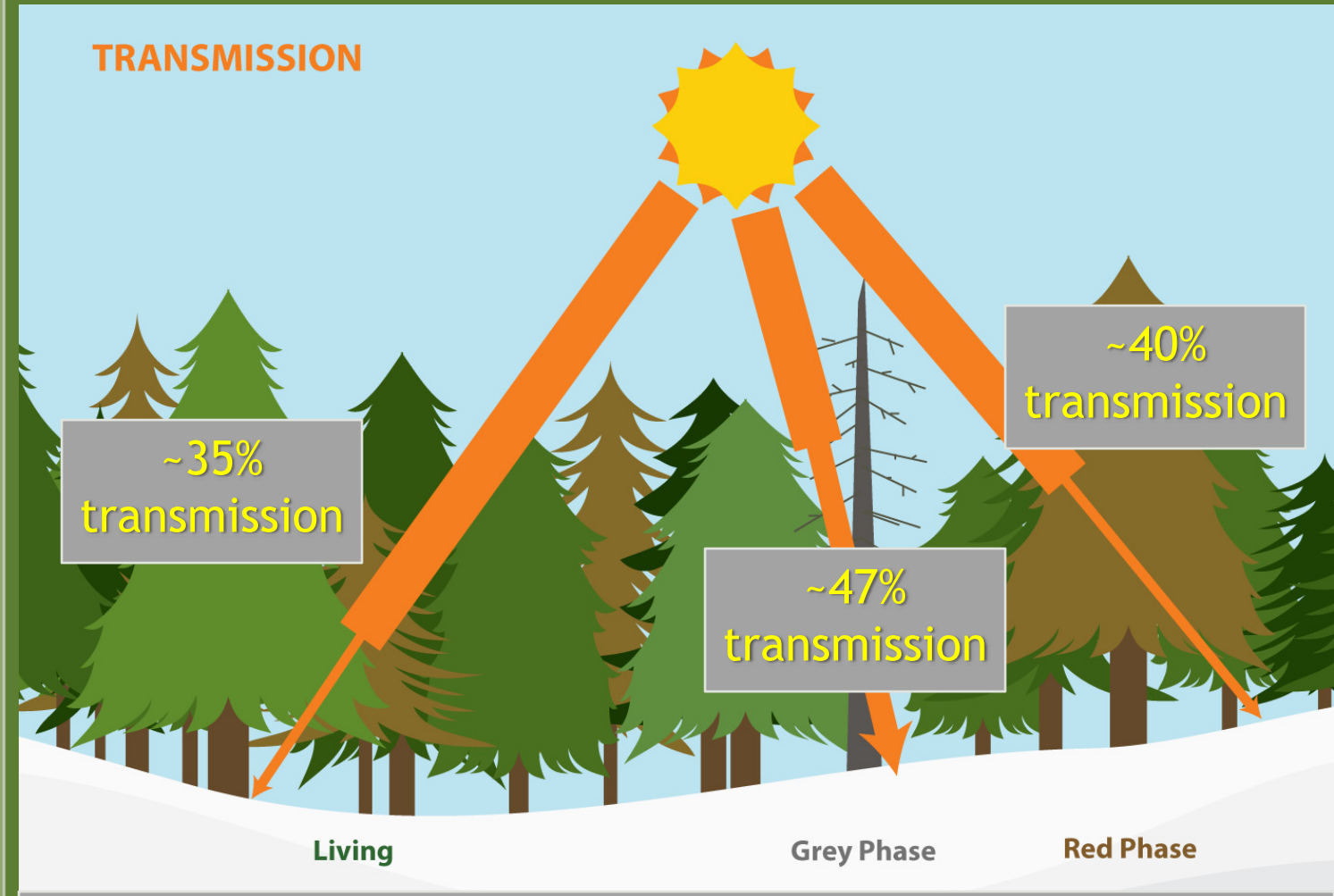
Canopy Solar Transmission



Thinned canopies let in more light!
Can expect: faster snowmelt, warmer ground

Conclusions from Lodgepole Pine

- Red phase stands accumulate a similar amount of subcanopy snow as living stands
- Red phase stands transmit slightly more light than living stands, but less than grey phase stands
- Grey phase stands intercept less snow, leading to additional subcanopy accumulation (~20%)
- Grey phase forests transmit more solar radiation to the forest floor than either living or red phase
- Snow under grey phase stands may or may not be depleted more quickly than living stands – depends on snow year

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Questions?

Collaborators: Eric E. Small, Noah Molotch, Eric Gordon, Danielle Perrot, Jeff Lukas, Jeff Deems
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