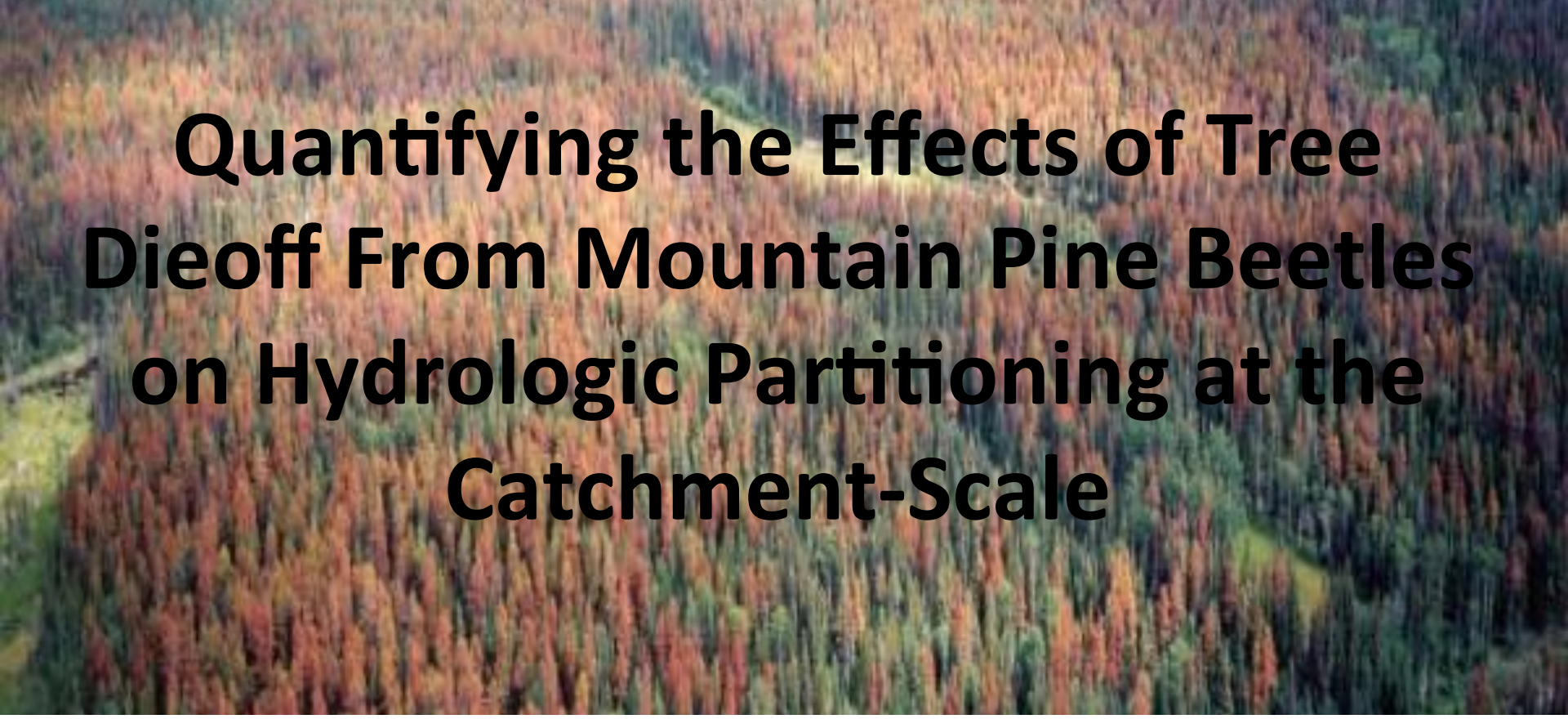

Quantifying the Effects of Tree Dieoff From Mountain Pine Beetles on Hydrologic Partitioning at the Catchment-Scale

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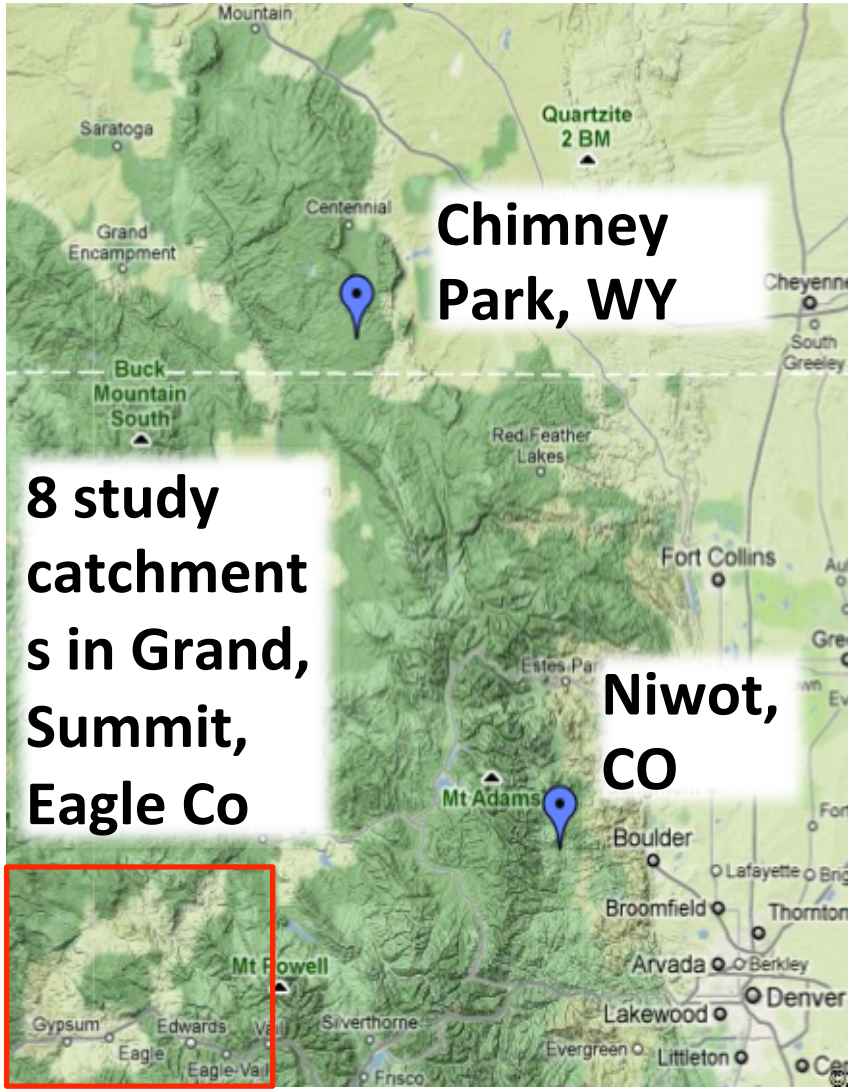
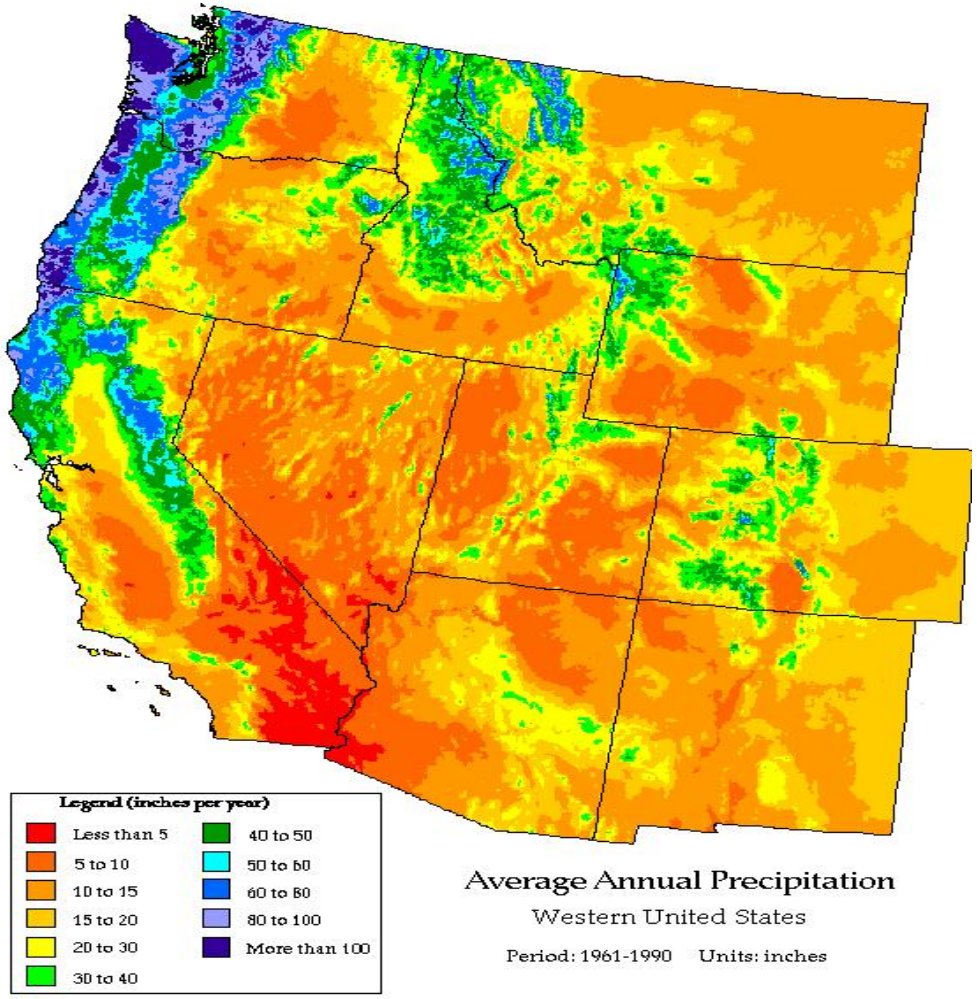
Overall research questions

- How do changes in vegetation structure associated with MPB alter the partitioning of energy and water, including evaporation, transpiration, recharge, and stream flow?
- How do these changes in energy and water availability affect local to regional scale biogeochemical cycles including a) carbon uptake, respiration, and export in stream flow, b) N deposition, availability, emission, and N export in stream flow, and c) emissions of biogenic trace gases?



Why we care about catchment-scale water partitioning?



- Assuming $\Delta S=0$

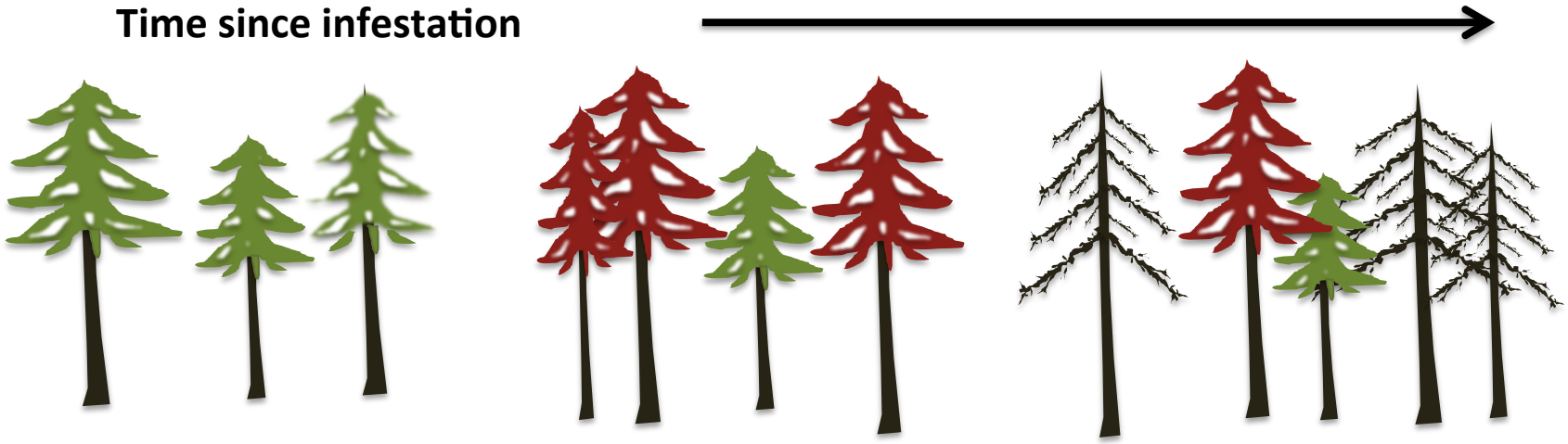
  $P = Q + ET$

- Runoff ratio RR is a simple proxy for water partitioning:

  $RR = Q/P$

- Around 70% of precipitation is returned to the atmosphere by evapotranspiration in these semi-arid regions
- In forested areas:
  - Transpiration ~40%
  - Interceptions reduces snowpacks by 20-50%

What are the hypothesized changes in hydrologic partitioning and runoff at the catchment-scale?

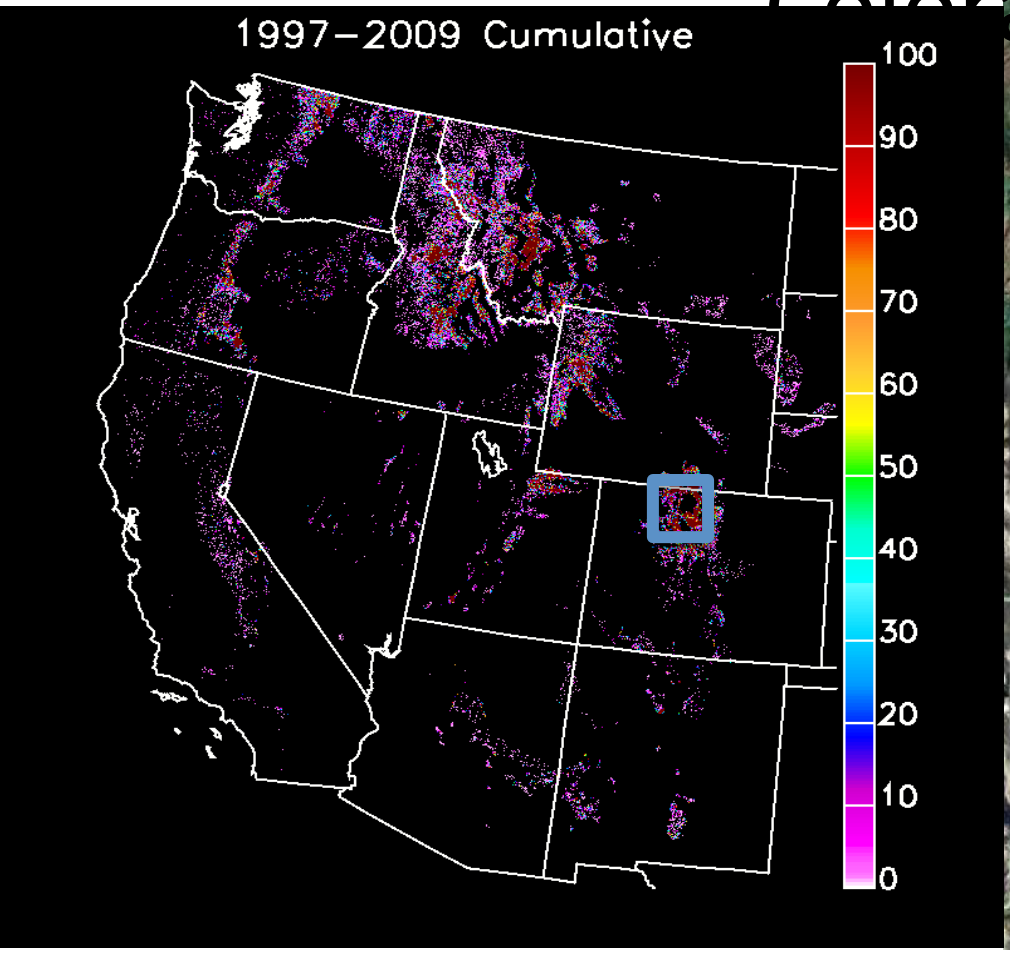


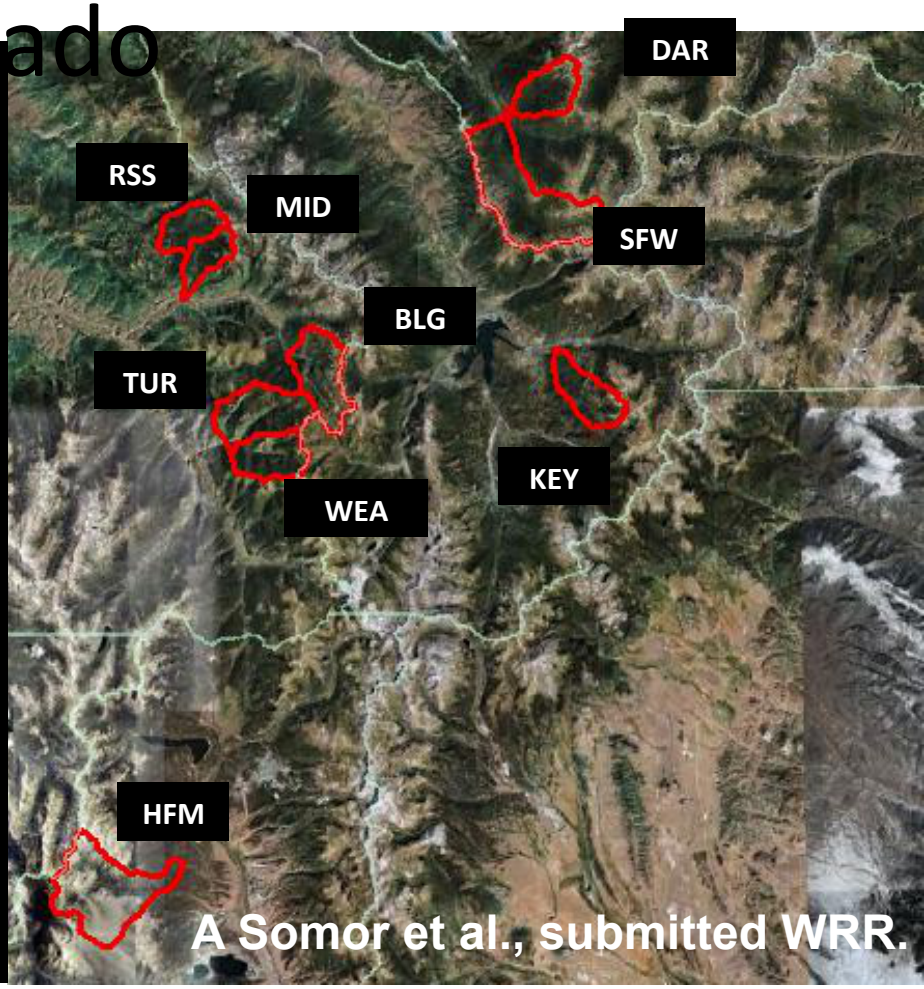
Processes	**Transpiration** ↓ **Interception ?** **Litter** ↑	**Interception** ↓ **Shading** ↓ **Sublimation ?**
Runoff Response	**Baseflow increase** **Timing?**	**Peak Q increase** **Earlier timing** **Baseflow increase**

Previous evidence of changes in water partitioning following tree dieoff

- Bethlahmy (1975) 10-20% increase in water yield on the Yampa and White Rivers
- Potts (1984) 15% increase in water yield on Jack Creek, MT
- Difficulties inferring causality in water partitioning
  - Precipitation was not considered
  - Paired catchments studies require 'unimpaired' area with similar hydrological properties and water inputs

Investigating changes in water partitioning following tree dieoff in Colorado





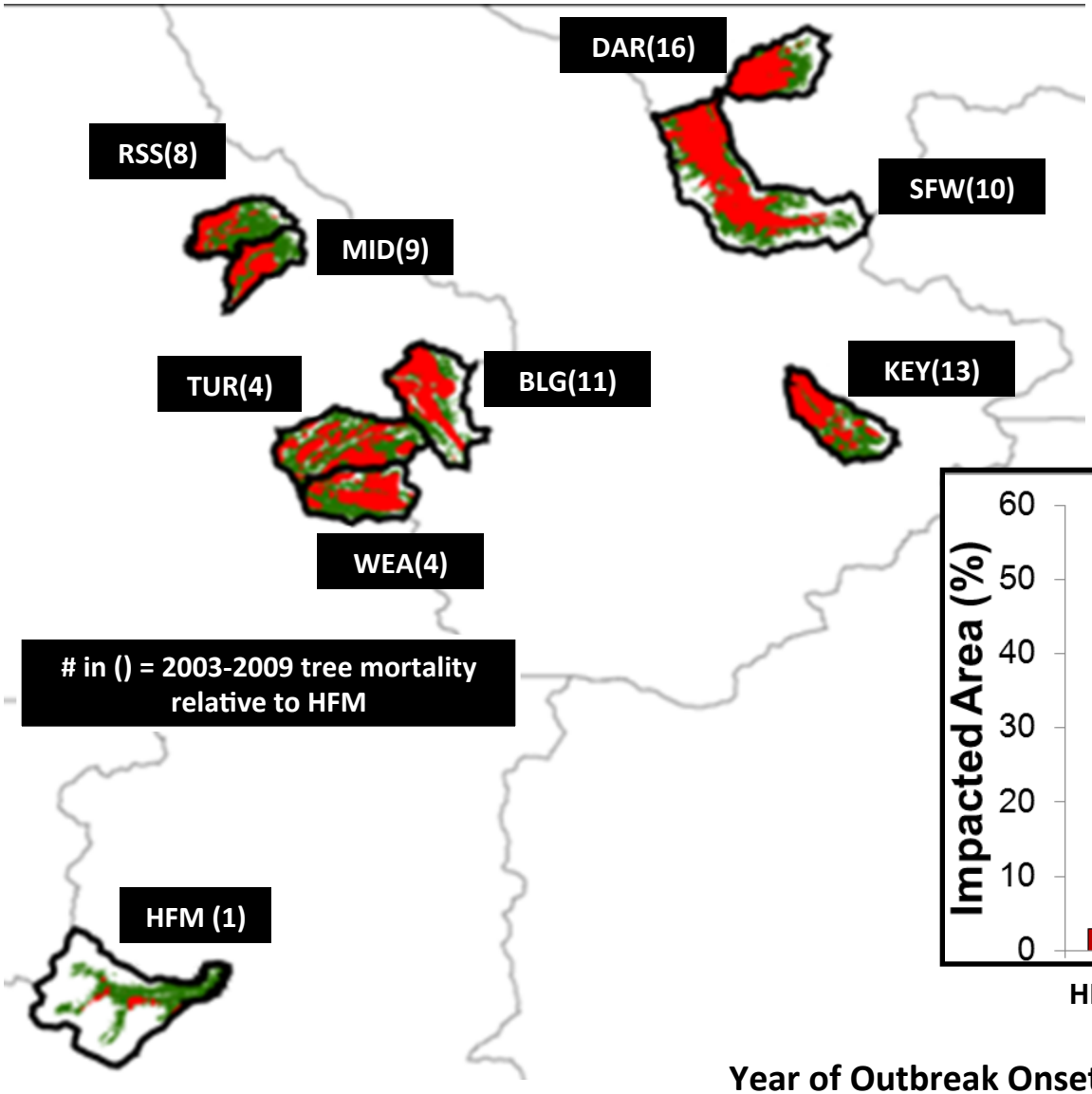
Site selection based on:

20+ year record of streamflow through water year 2008 or 2009

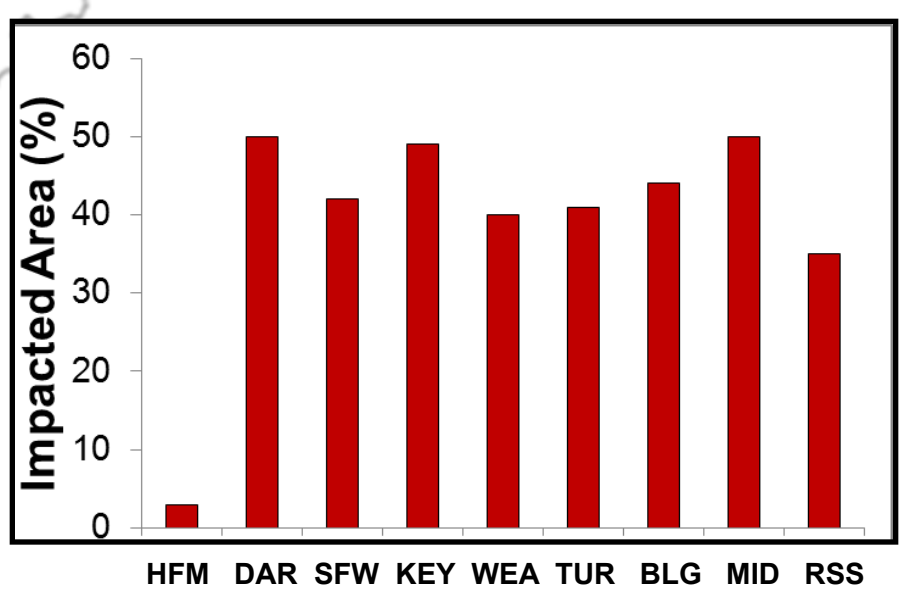
14+ year record of insect/disease induced tree mortality

No upstream diversions/flow regulation

An average of 43% catchment area affected



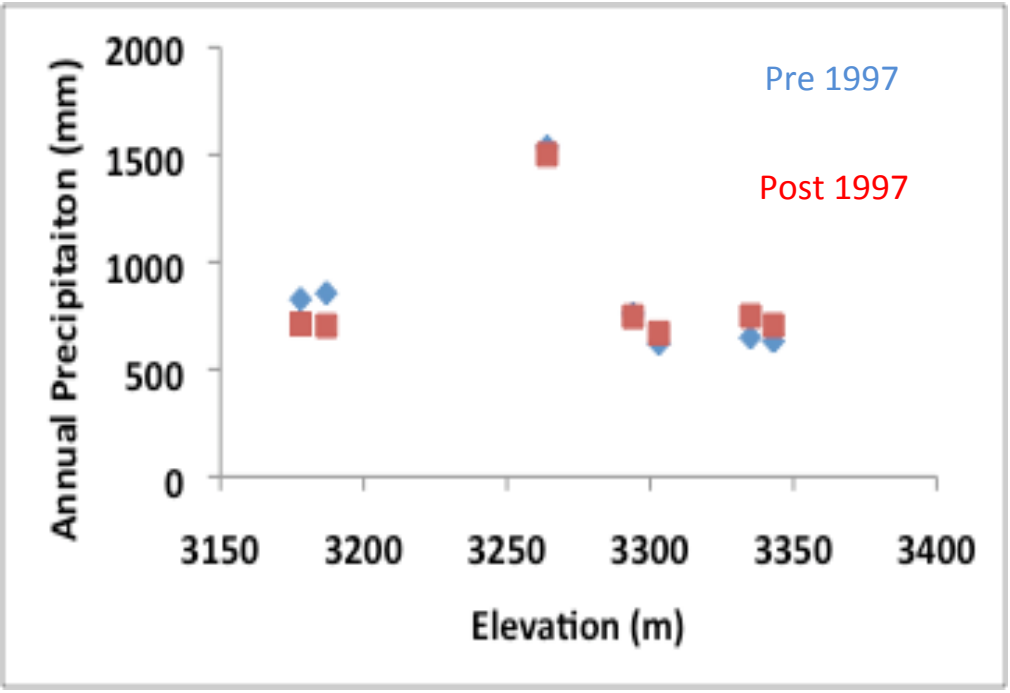
Level of infestation characterized by USFS using aerial surveys



Year of Outbreak Onset

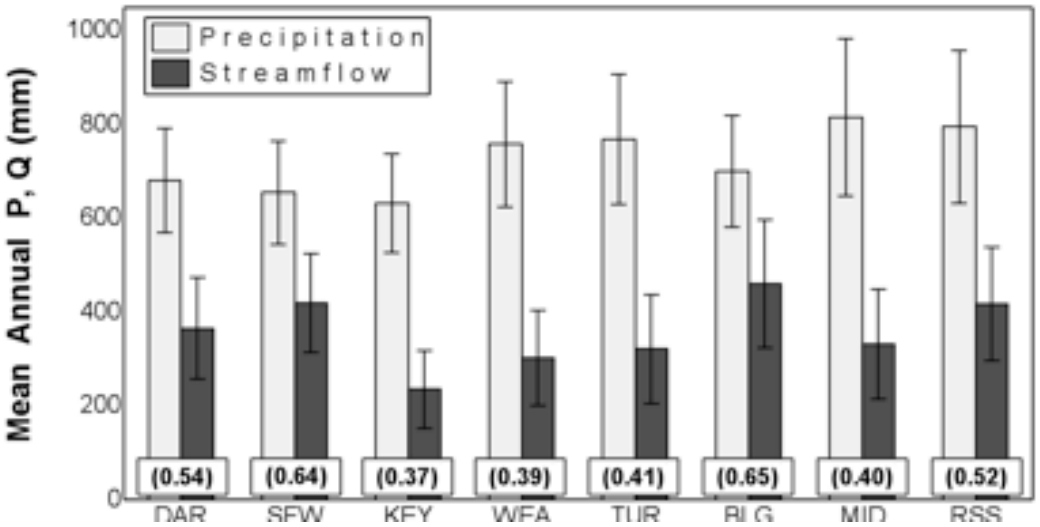
Darling	SF Williams	Keystone	Wearyman	Turkey	Black Gore	Middle	Red Sandstone
2004	2004	2007	2006	2006	2006	2006	2007

Variability in climate over the study period



- Large inter-annual variability in Q
- Pronounced warming since 1997
- Warming only above 3200 m
- Decreased precipitation at lower elevation and increased precipitation at higher elevations

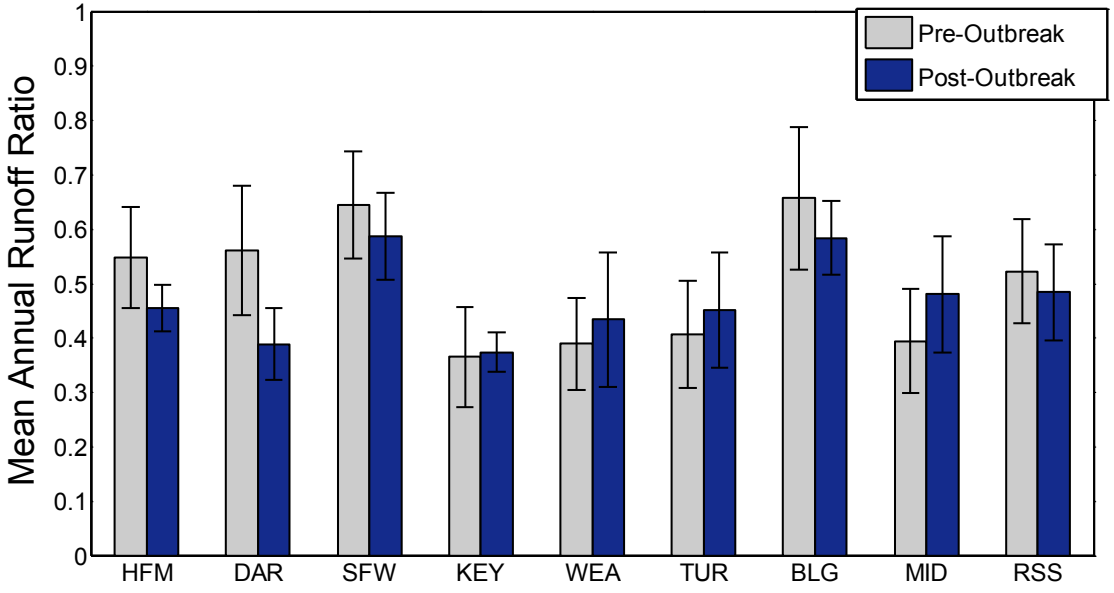
Catchment-scale hydrological response in central Colorado



Percent water yield exhibits large spatial and temporal variability

Water yield appears to *decrease* following tree mortality

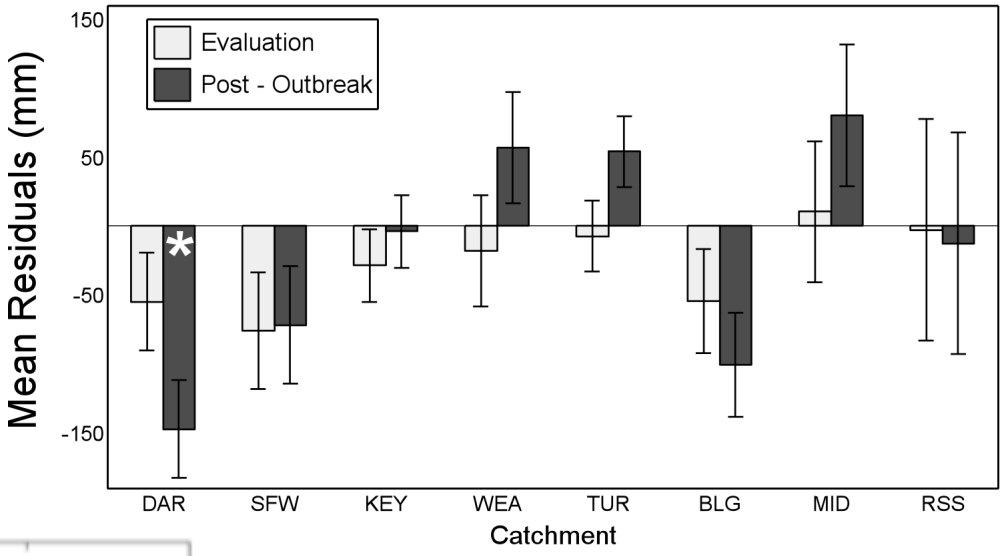
Statistically significant in only two catchments

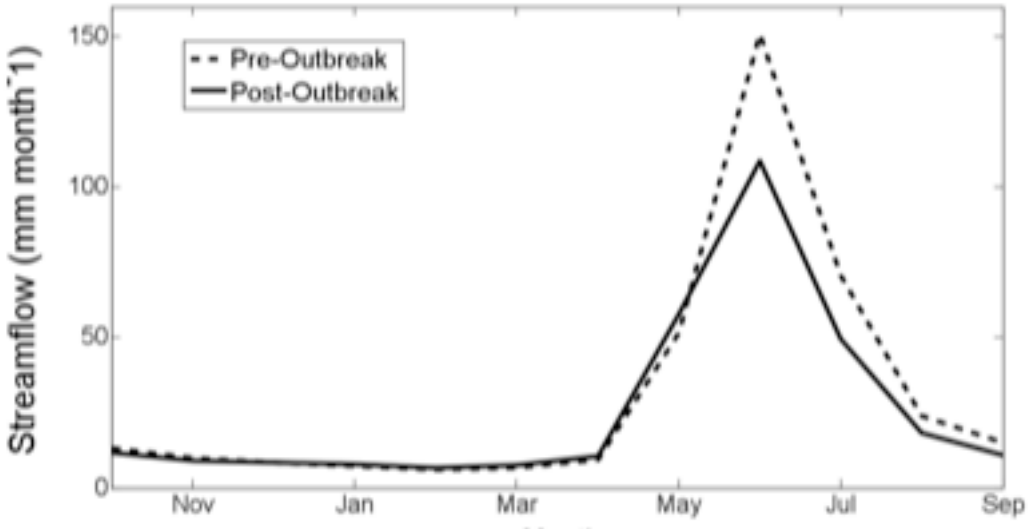


Catchment-scale hydrological response in central Colorado

Comparing observed response to predictions from a multiple linear regression model of hydrologic

The response to MPB is variable; the only significant change in annual water yield is a decrease in the most heavily impacted catchment





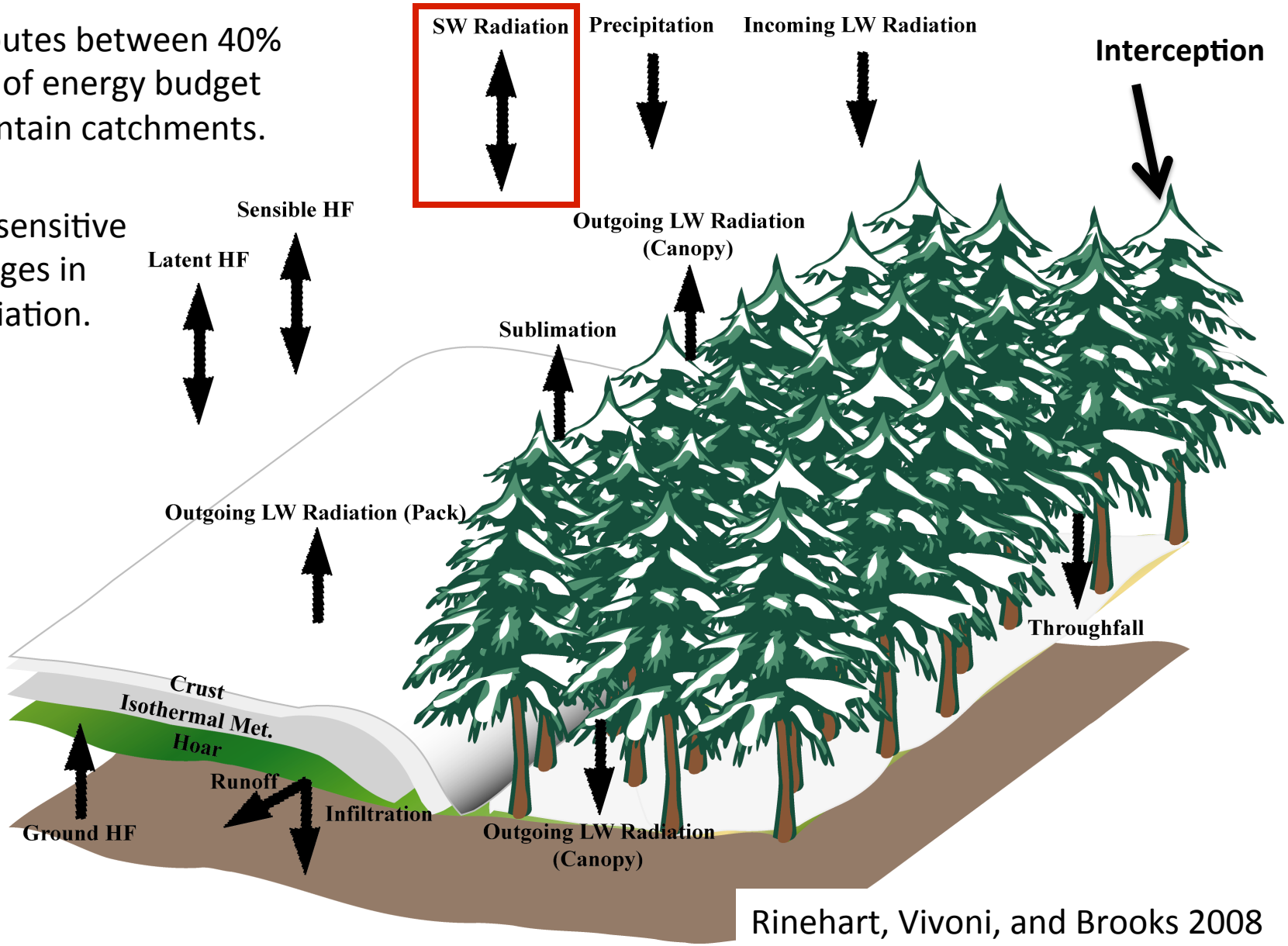
Common observations:

- **Slight increase in baseflow**
- **No change in timing**

What explains the decrease in runoff and presumed increase in vaporization?

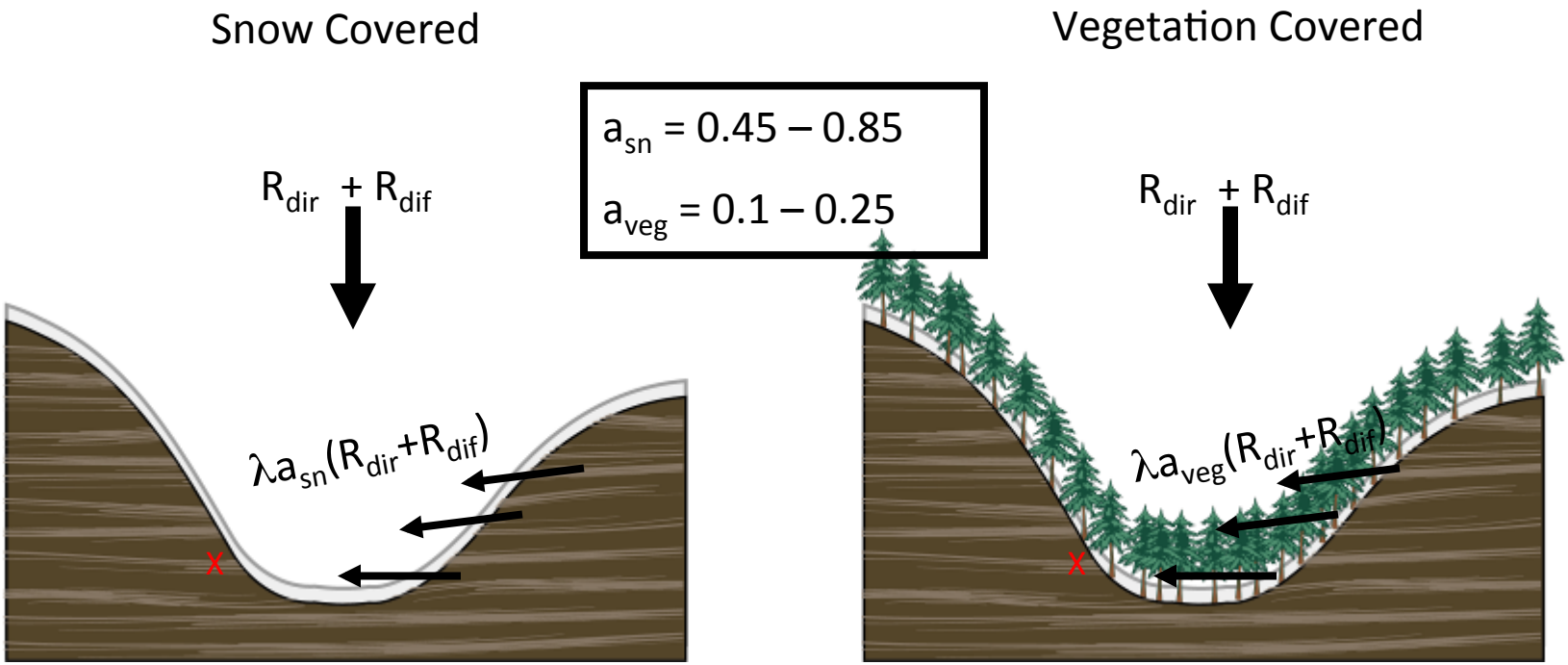
Contributes between 40% to 60% of energy budget in mountain catchments.

SWE is sensitive to changes in SW radiation.



Rinehart, Vivoni, and Brooks 2008

Vegetation structure changes both local shading and scattering of radiation to remote slopes

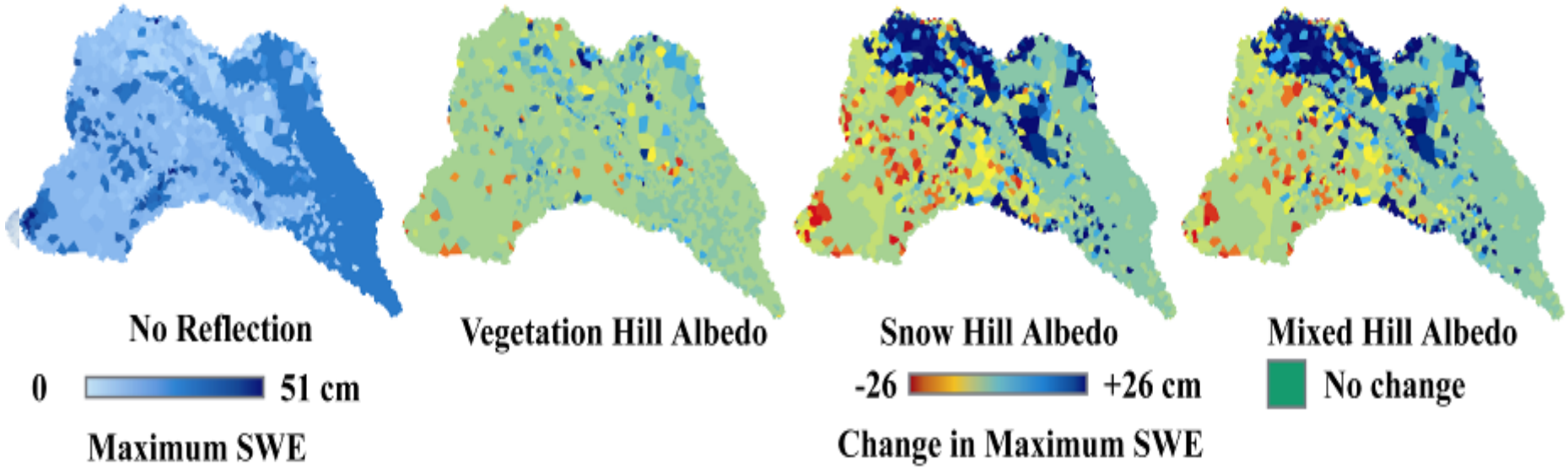


Complex terrain scatters can capture more light than a flat surface

The loss of needles in grey phase both decreases local shading and increases remote albedo

Combine with changes in albedo from needles and dust

How large an effect on radiation can the change in vegetation have?



A change from vegetated surface to exposed snowpack can increase the energy received by the snowpack 25 – 35%

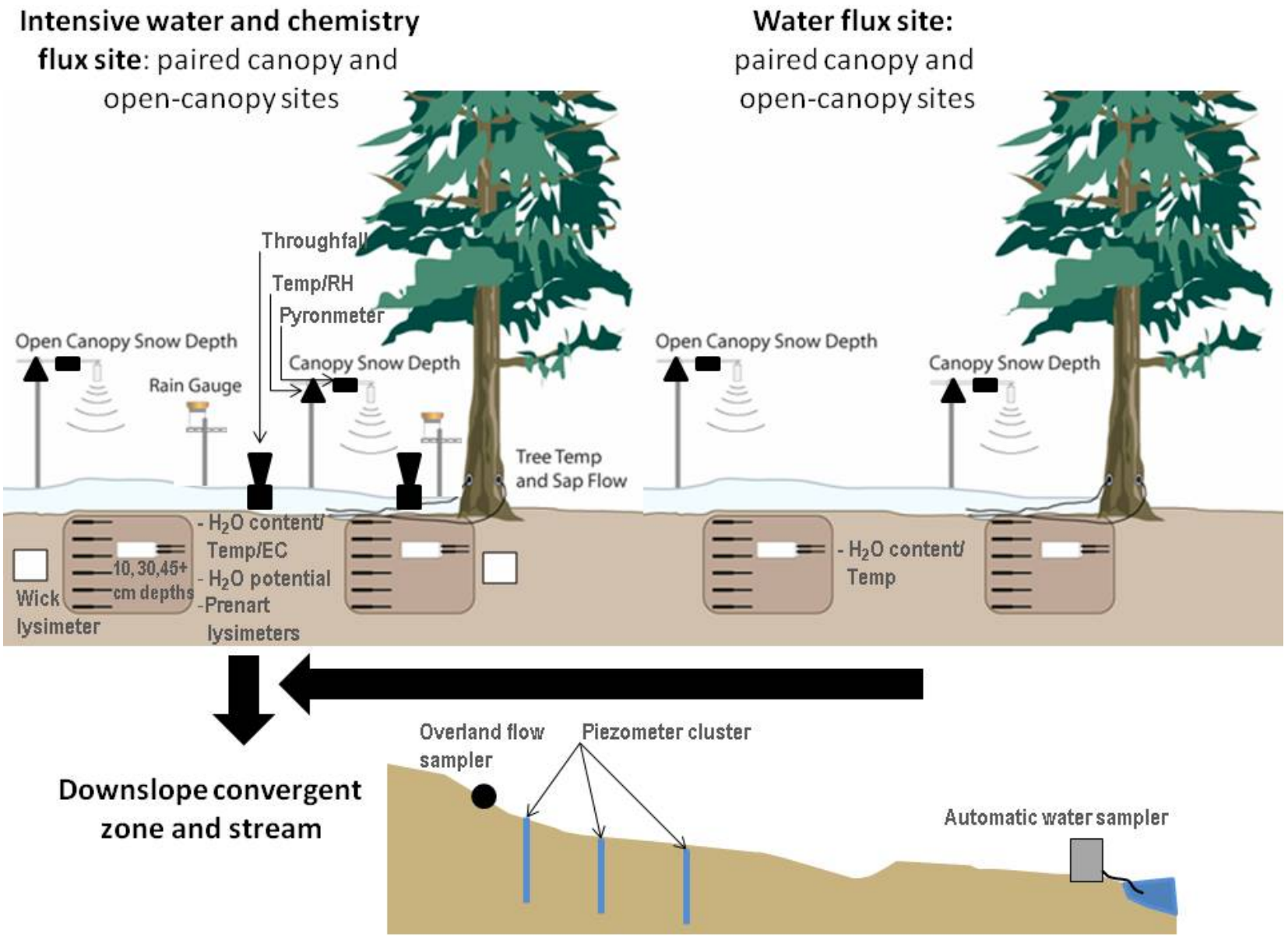
Scattering from a snow-covered catchment can change SWE +/- 50% at any point

The net effect in this catchment is ~ 35% reduction in SWE

How do we improve our understanding of water partitioning following tree dieoff?

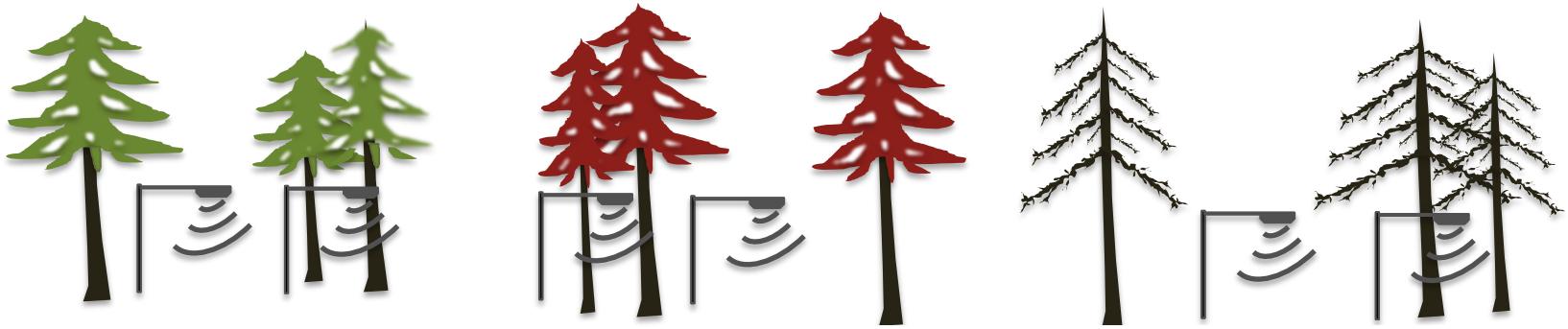
- Catchment-scale monitoring
  - Snow depth
  - Soil moisture/temperature
  - Groundwater levels
  - Surface runoff
  - Water chemistry at many locations
- Vertical flux measurements
  - Below canopy
  - Above canopy
- Catchment-scale modeling
  - RHESSys model

Overview of instrumentation

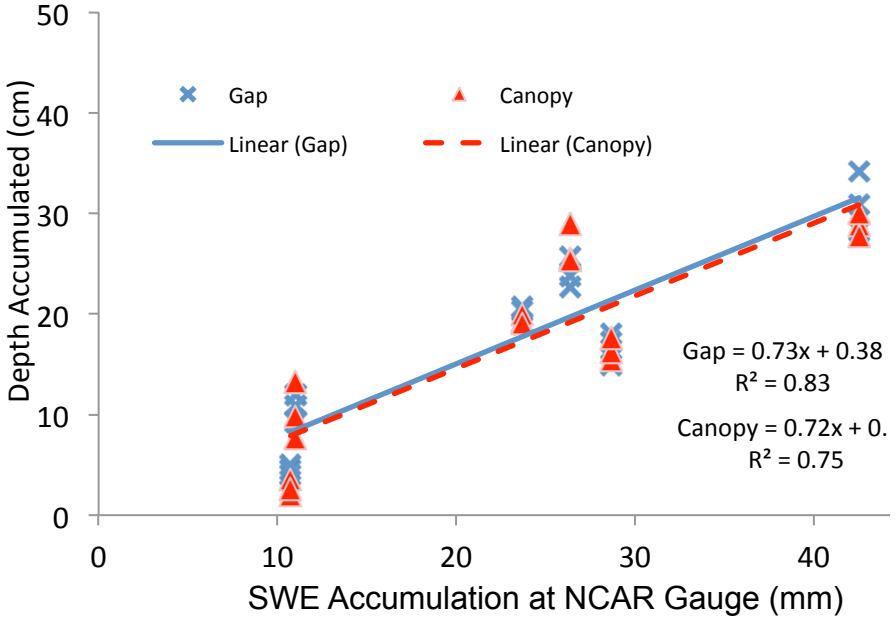


How does MPB affect snow accumulation?

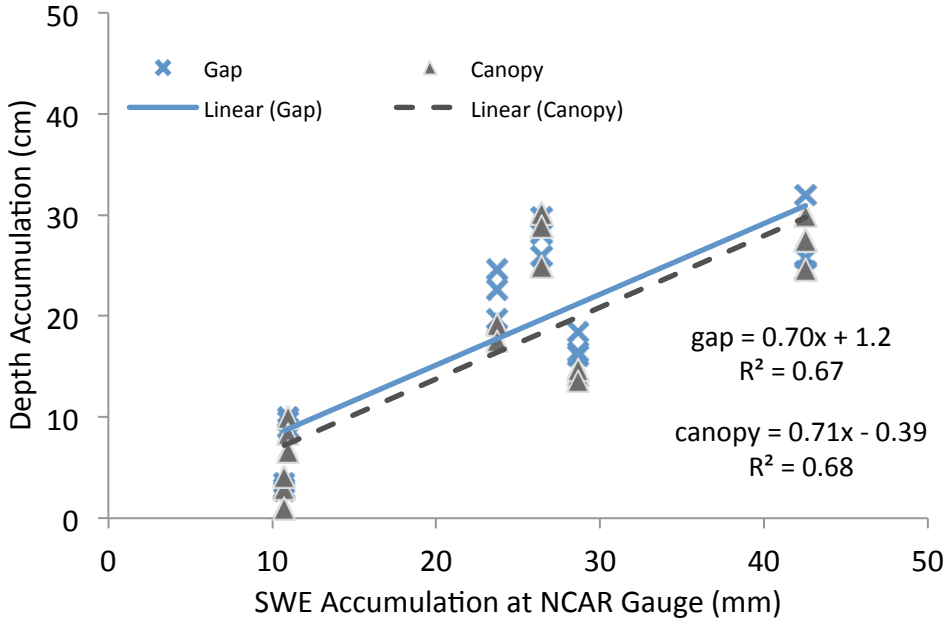
Continuous records of snowfall from snow depth sensors



Snow Input by Storm Size, Red Stand

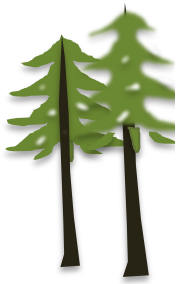


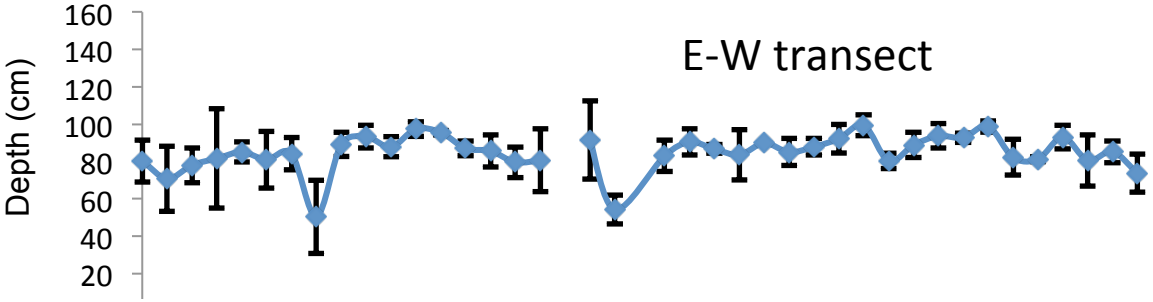
Snow Input by Storm Size, Grey Stand

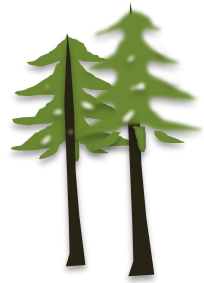


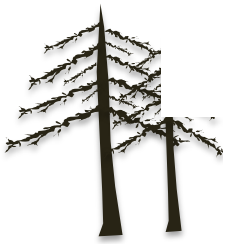
- ***Interception ~ 30% in green forests***
- ***Minimal interception in grey canopies***

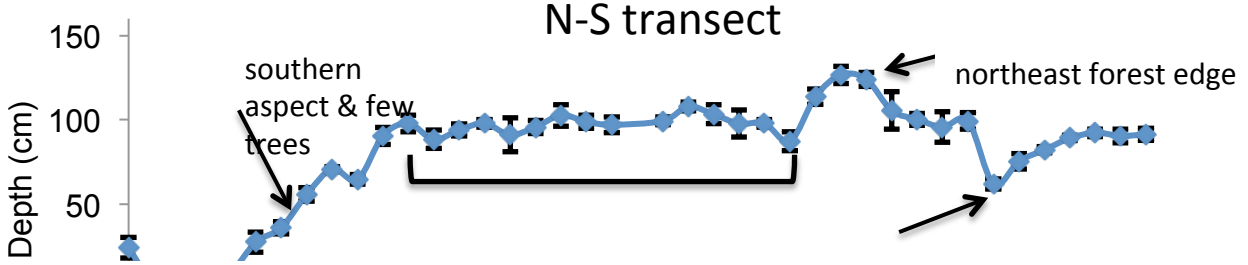
Snow surveys at intensive sites

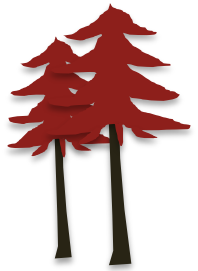


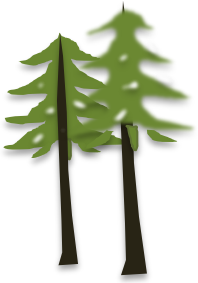


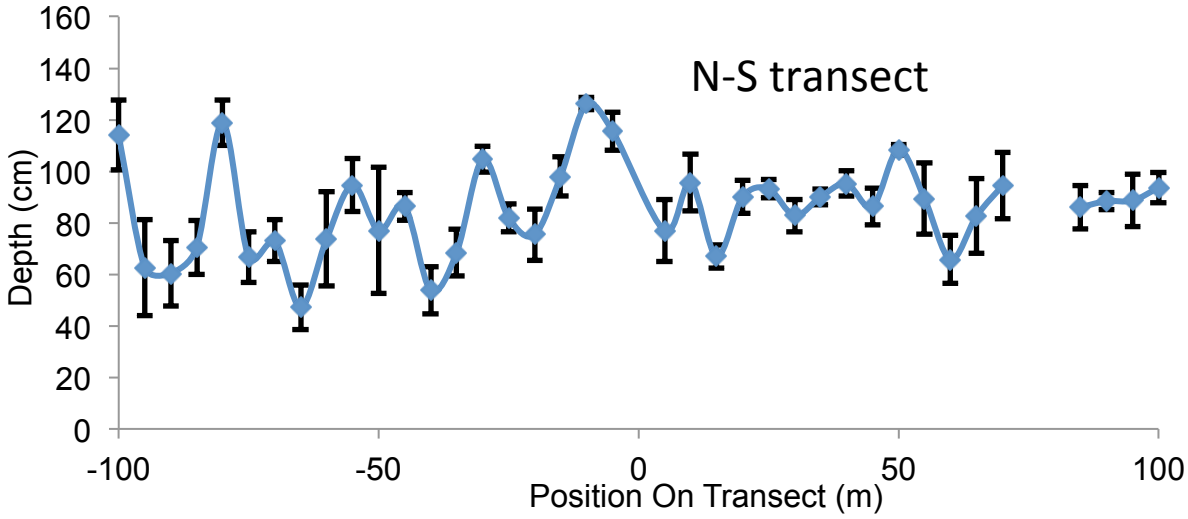


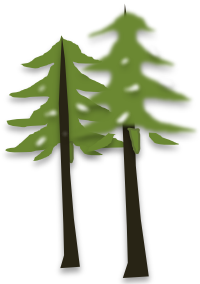












Larger-scale stand structure more important than individual trees

Questions?