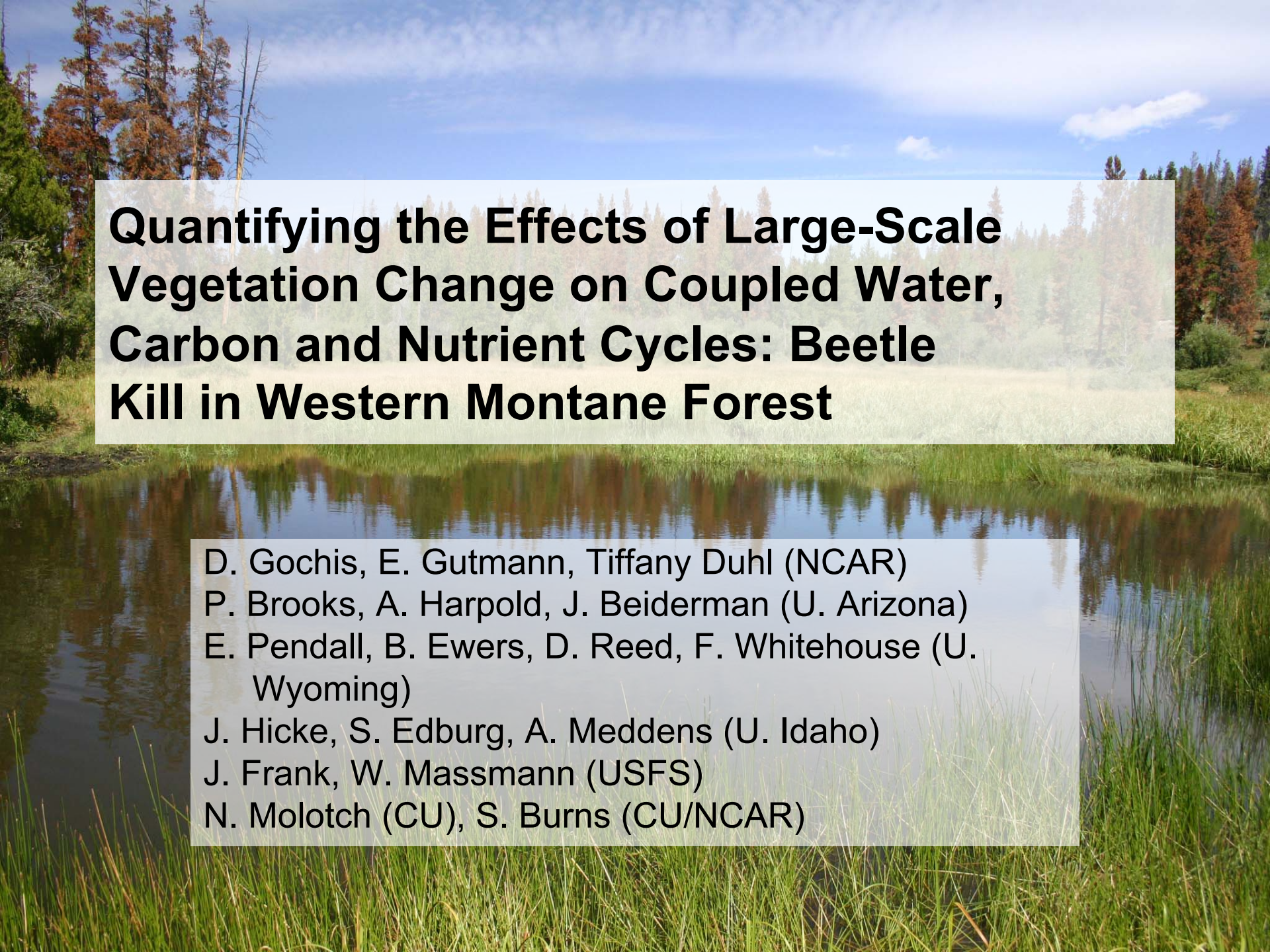

Quantifying the Effects of Large-Scale Vegetation Change on Coupled Water, Carbon and Nutrient Cycles: Beetle Kill in Western Montane Forest

D. Gochis, E. Gutmann, Tiffany Duhl (NCAR)
P. Brooks, A. Harpold, J. Beiderman (U. Arizona)
E. Pendall, B. Ewers, D. Reed, F. Whitehouse (U. Wyoming)
J. Hicke, S. Edburg, A. Meddens (U. Idaho)
J. Frank, W. Massmann (USFS)
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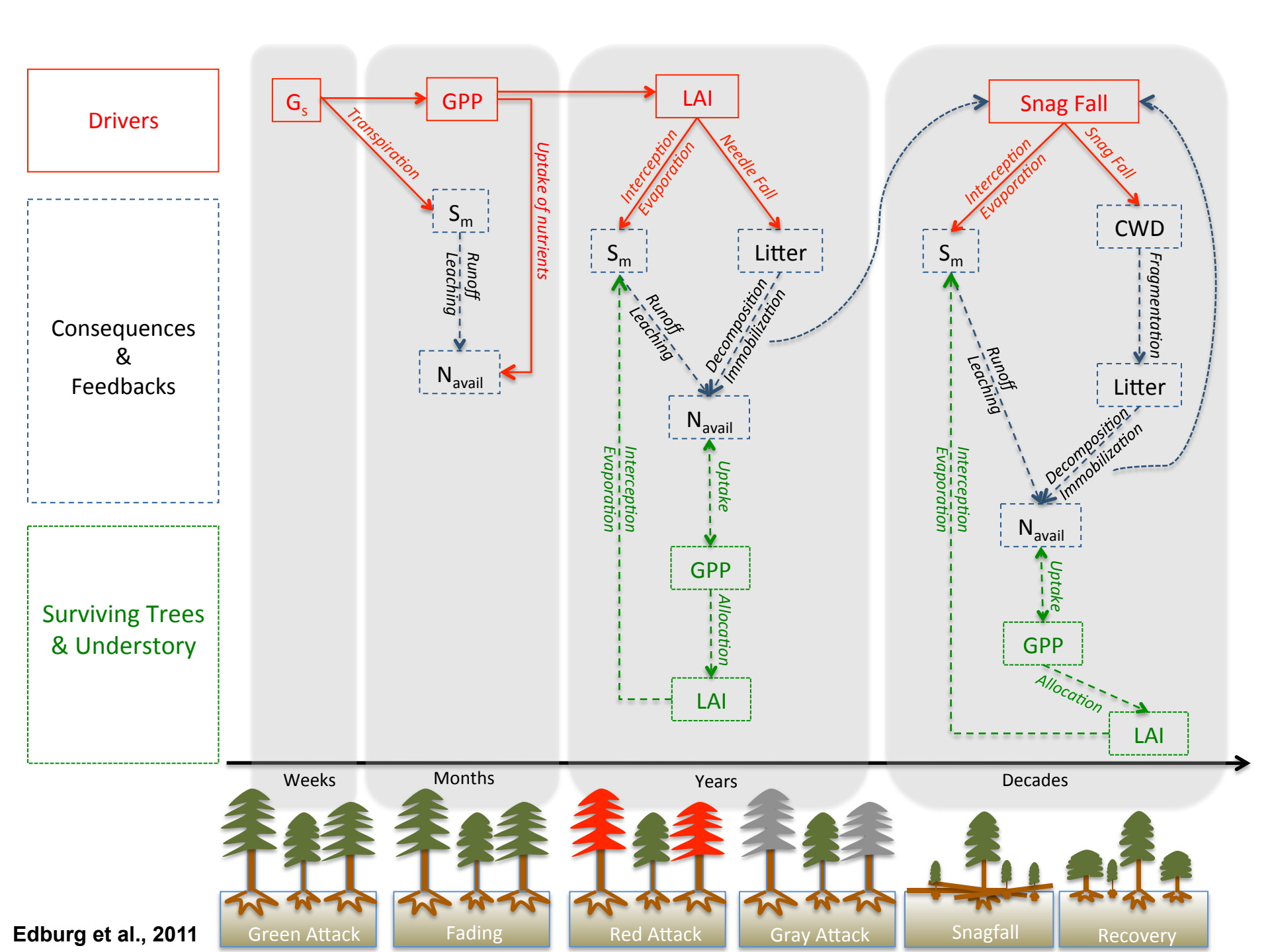
U.S. Forest Service Rocky Mountain Experiment Station

National Science Foundation support of NCAR

Motivation

- Infestation initiates a cascade of ecohydrological and biogeochemical responses that will take decades to evolve



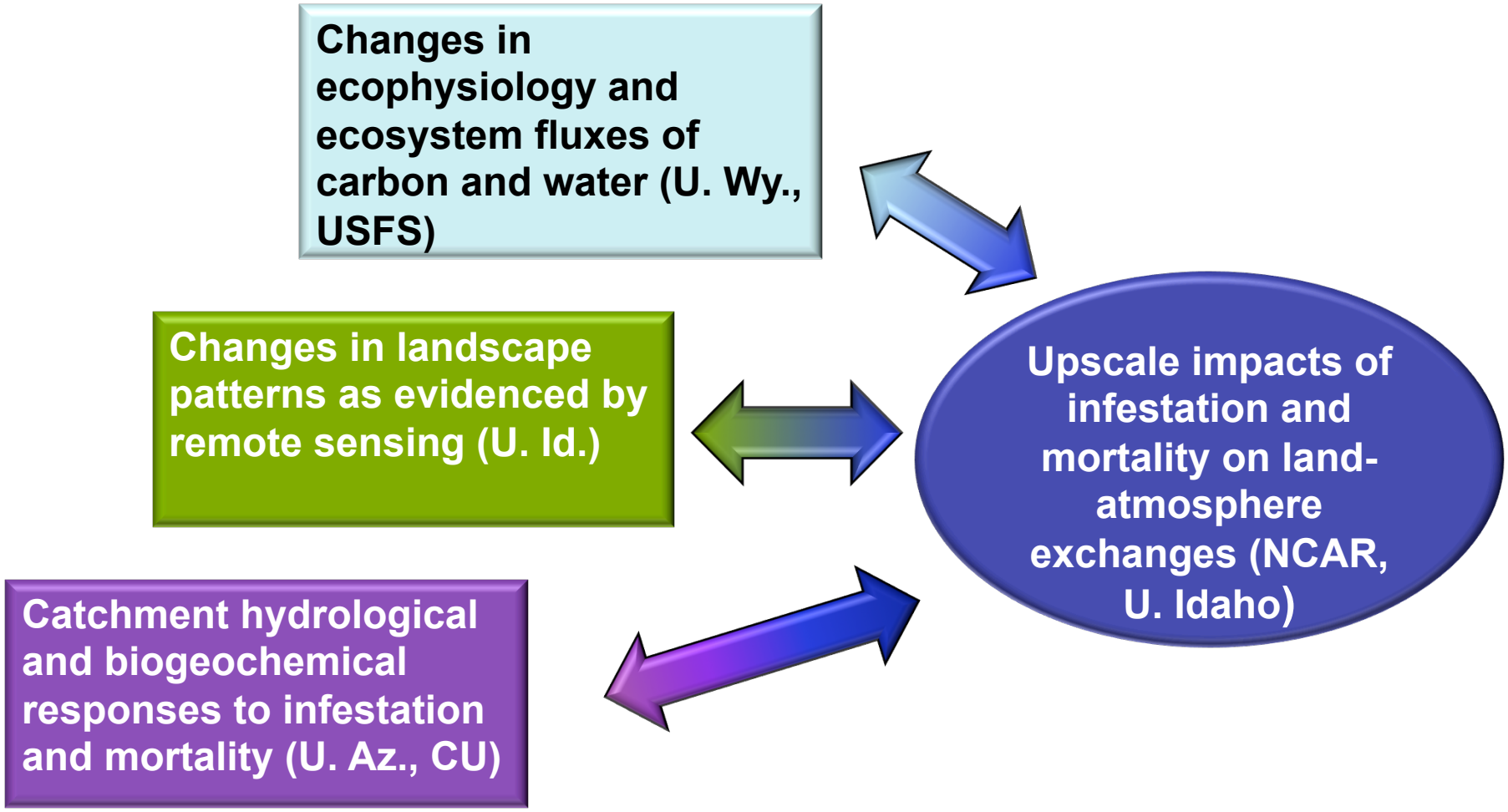
Edburg et al., 2011

Motivation

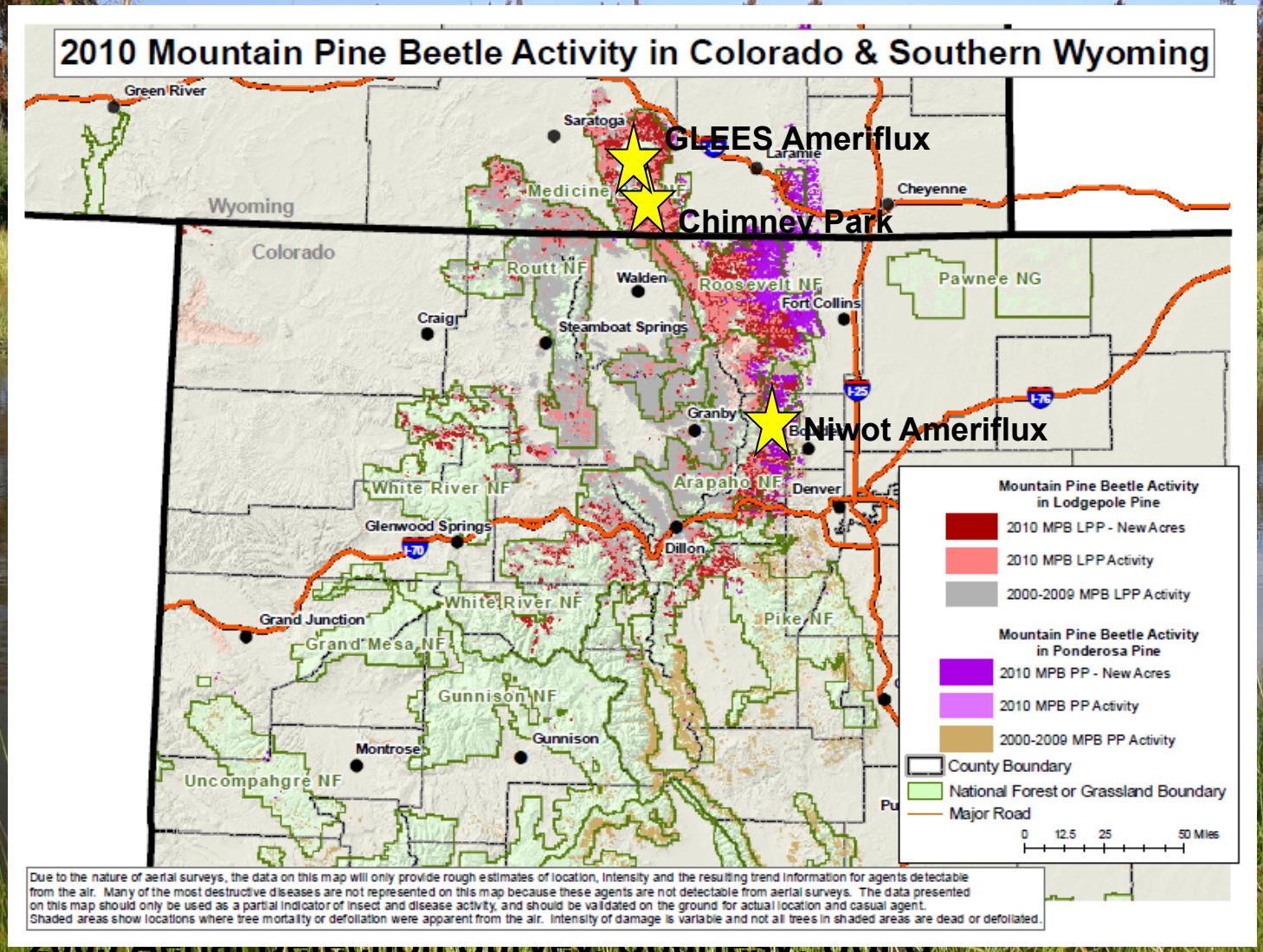
- Infestation initiates a cascade of ecohydrological and biogeochemical responses that will take decades to evolve
- Most land surface models (LSMs)/parameterizations or catchment hydrology models have not been developed or adapted to this kind of disturbance which ultimately limits predictability
- Research questions:

1. How do changes in vegetation structure associated with MPB, including density, leaf area, and species composition, alter the partitioning of energy and water, including evaporation, transpiration, recharge, and stream flow?
2. 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?
3. What are the manifestations of these processes and responses on *long-term* ecosystem fluxes of water, energy biogeochemicals and biogenic emissions?

Research Themes:



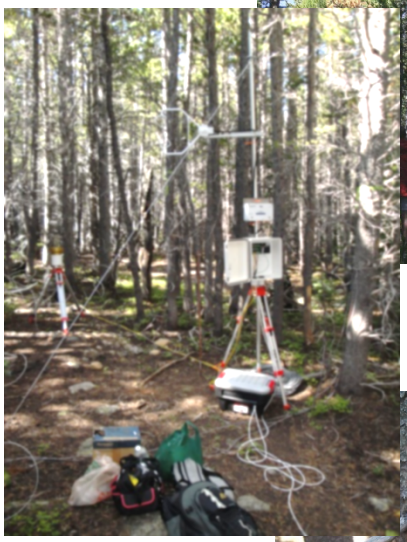
Ecohydrologic Impacts of Mountain Pine Beetle Infestation: Observational Facilities



2009 Aerial Detection Survey, Courtesy: USFS

Impact of Bark Beetles on Land-Atmosphere and Catchment Hydro-Bio-Geochemical Responses :

- Project initiated in FY2010
- Instrumenting 2 sites (Wy. & Co.):
  - Chimney Park, Wyo.
  - Niwot Ridge* Co.
  - 3rd collab. site at GLEES* Wy. (USFS)
- Measurements:
  - snow depth
  - soil moisture/temperature
  - under canopy T/RH, radiation, turbulence
  - sapflow
  - Volatile Organic Compound (VOC) emissions
  - biogeochemistry
- Remote sensing analysis of forest structure following infestation

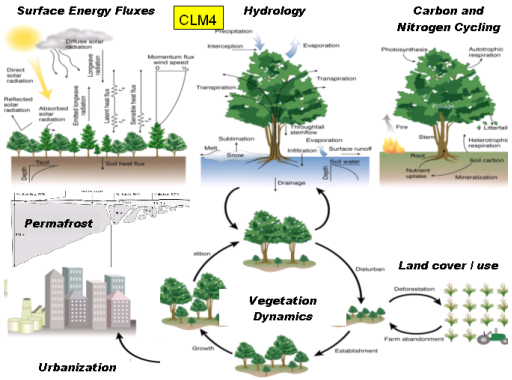


2009 2010 2011 2012

*** Denotes long-term Ameriflux site**

Land Modeling Activities: Scenario Development

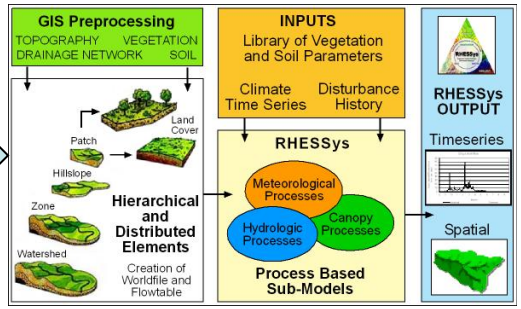
Ecohydrology models:



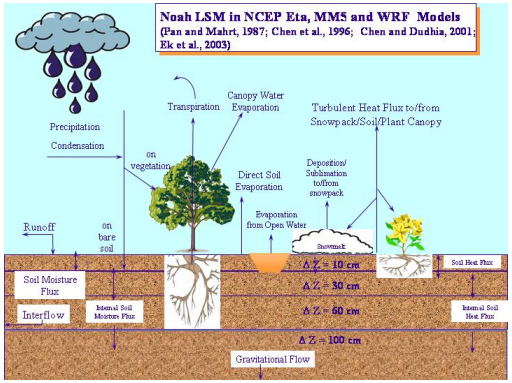
CLM-C/N v4 (1d)

Scenarios of:

- **Mortality**
- **Regeneration**
- **Climate variability and change**



RHESSys (1d/3d)



Noah (1d/3d)

Plausible Futures of:

- **Snowpack**
- **Runoff**
- **Soil Moisture**
- **Carbon/nitrogen fluxes**
- **Weather and climate impacts**

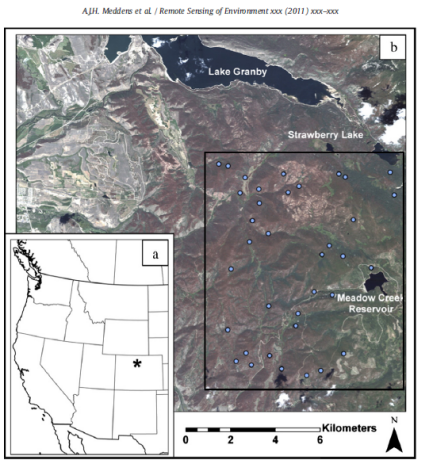
Gochis et al., 2011

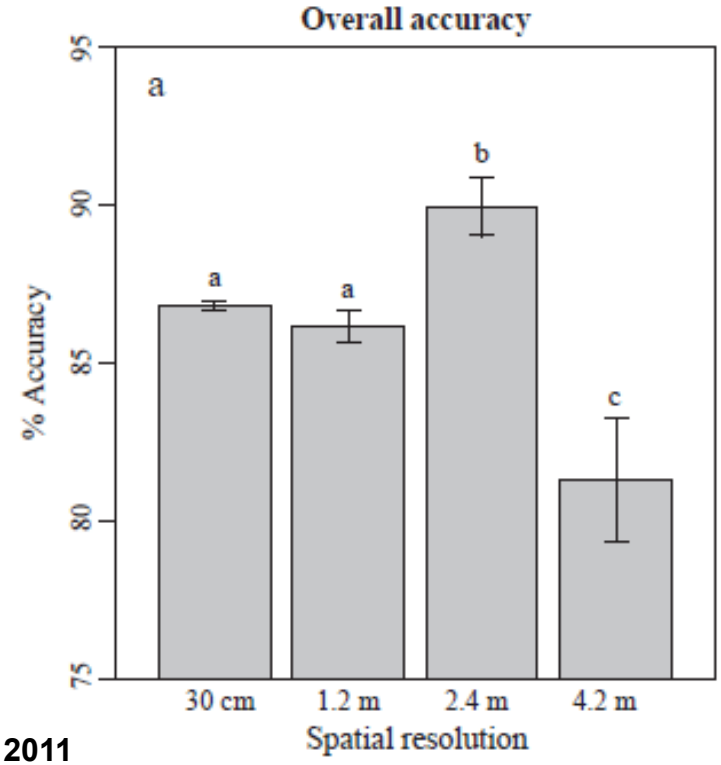
Results:

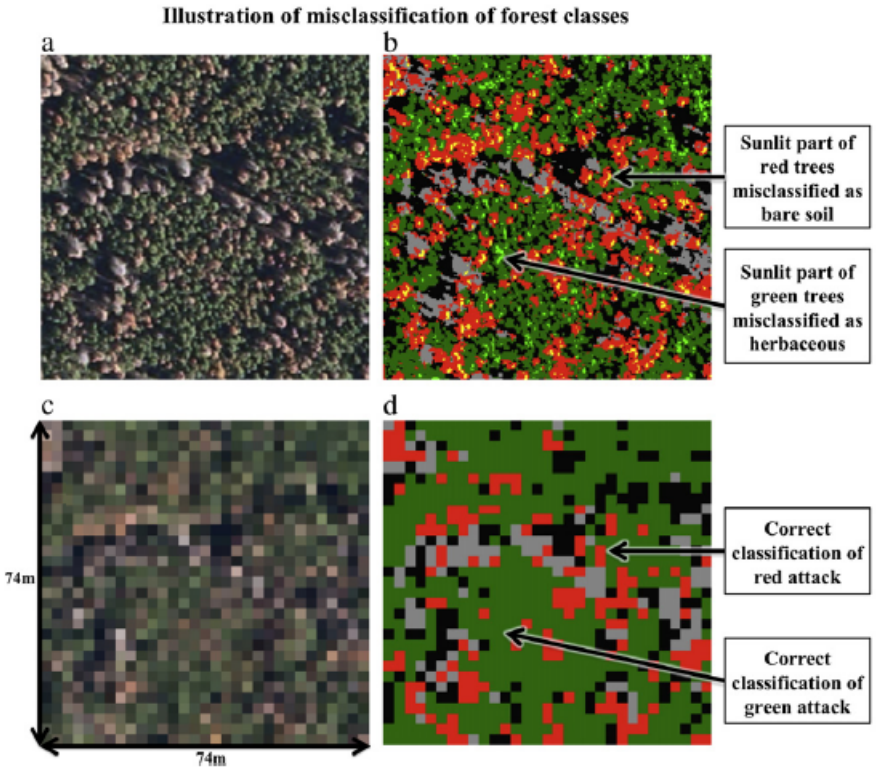
- Today's lineup:
  - Adrian Harpold: Changes in catchment partitioning of hydrological and biogeochemical fluxes
  - David Gochis: Understanding the role of model structure in simulated responses to infestation
  - David Reed: Linking water cycle impacts to energy storage changes
  - Faith Woodhouse: Applying knowledge of tree physiological responses to infestation in a predicative capacity
  - John Frank: Changes in evapotranspiration fluxes following infestation

- Other key findings:
  - Arjan Meddens et al.: Mortality and forest classification using high resolution spectral imagery
  - Duhl et al: Changes in biogenic emissions structures following infestation
  - Barnard et al: Tracing moisture storages and fluxes with isotopes

Remote sensing/classification activities:







Meddens et al., 2011

Chimney Park BVOC Sampling 9.15→9.17.2010; description

Enclosures

3 live green (uninfested) Lodgepole pine trees (LG)

3 live green infested trees (BG)

2 late-stage (dead) infested trees (BR)

- Mid-day branch-level BVOC emissions measured

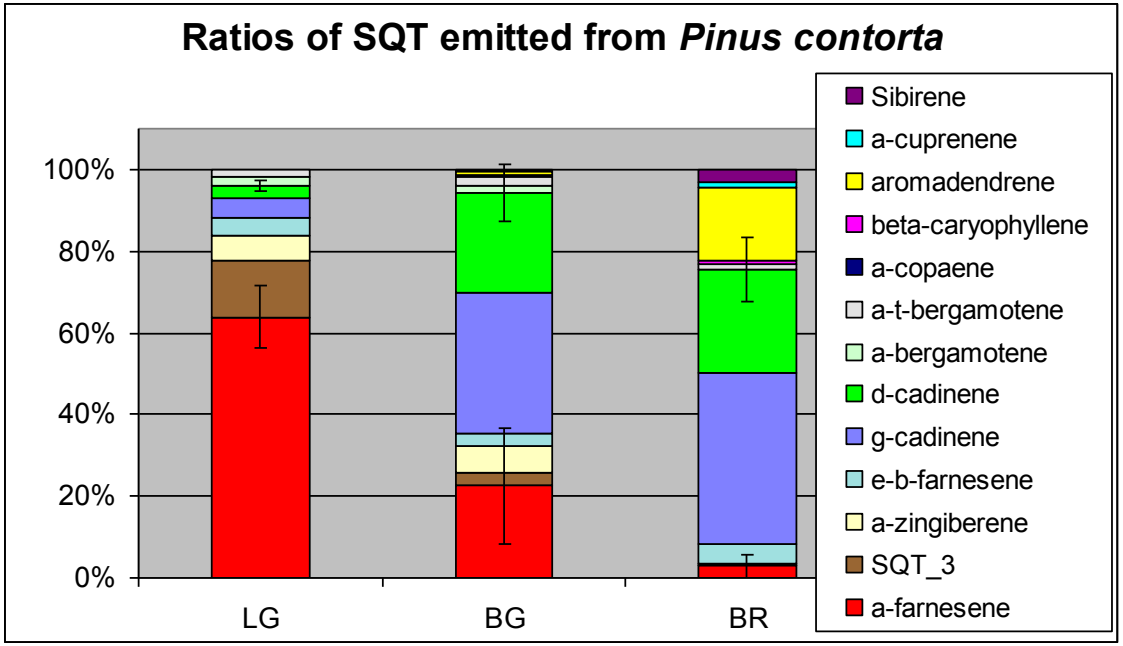
Live trees, whether infested or not did not emit significantly different quantities of MT or MBO (not shown) or ratios of MT (left figure)

Red-needled infested trees released significantly different quantities (not shown) and ratios (left figure) of MT and emitted no MBO

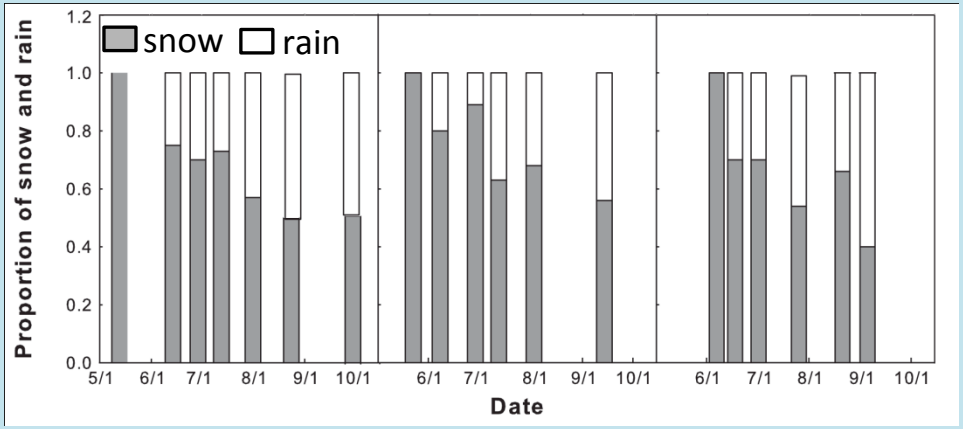
Uninfested trees emitted ~10x more linalool than live infested trees, while dead trees did not release detectable amounts of linalool (not shown)

Duhl et al., 2011

MT = monoterpenes, SQT = sesquiterpenes, MBO = methylbutanol



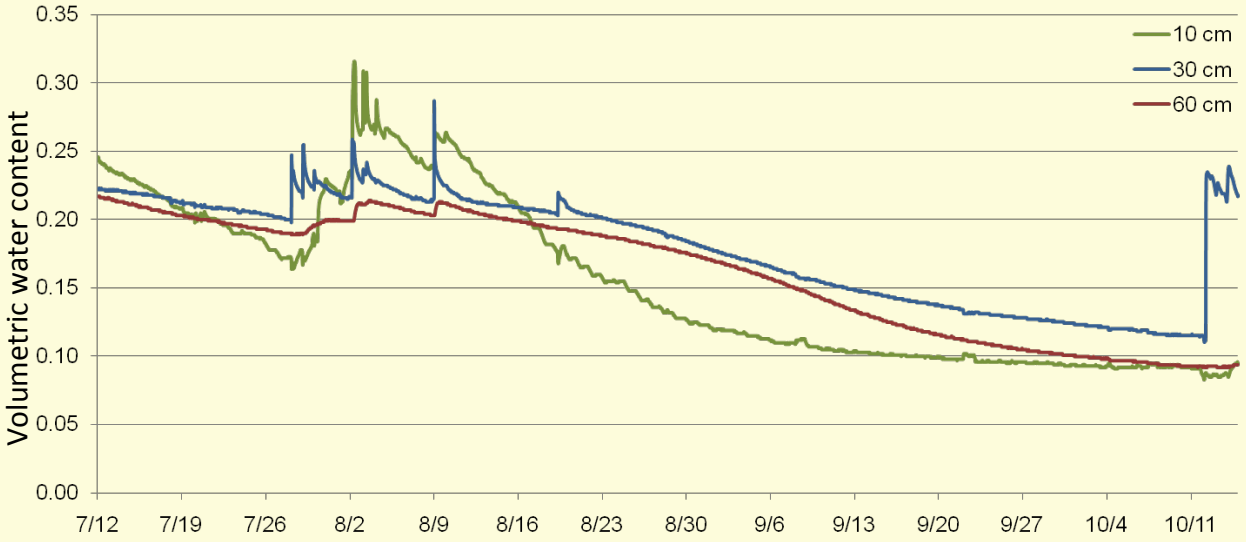
How is Transpiration Connected to Subsurface Flow Paths and Storage within a Catchment?



Hu *et al.* (2010) found that trees at Niwot appear to be strongly dependent on water from snowmelt for the entire growing season.

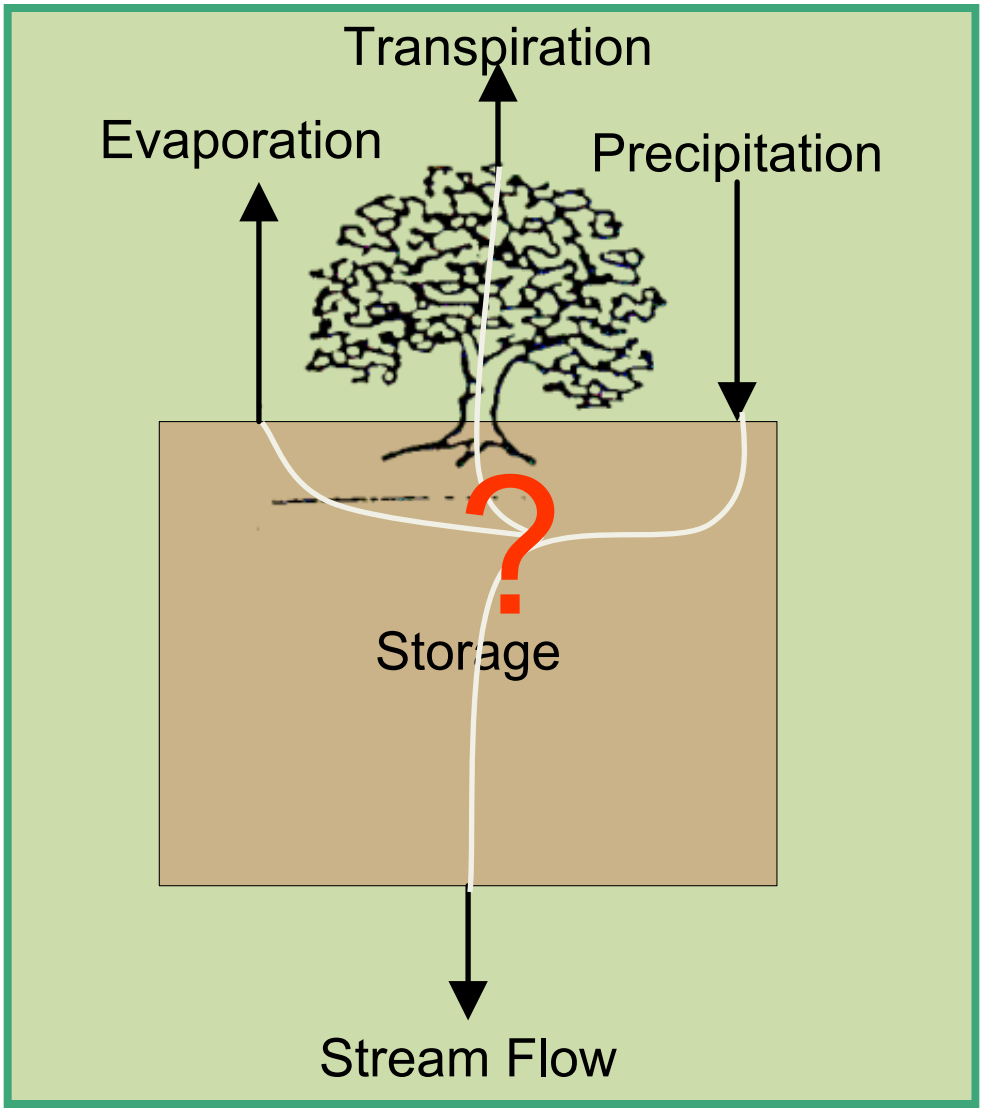
From *Hu et al. 2010* with permission

Soil moisture data indicates that summer rain events rarely penetrated depths below 30 cm. This shallow soil recharge is rapidly depleted post-rain event – indicating strong ET losses.



H. Barnard et al., 2011

Water isotopes can shed light on hydrologic flowpaths and pools.



H. Barnard et al., 2011


Questions……?