Modeling Ecohydrologic Impacts of Mountain Pine Beetle Infestation

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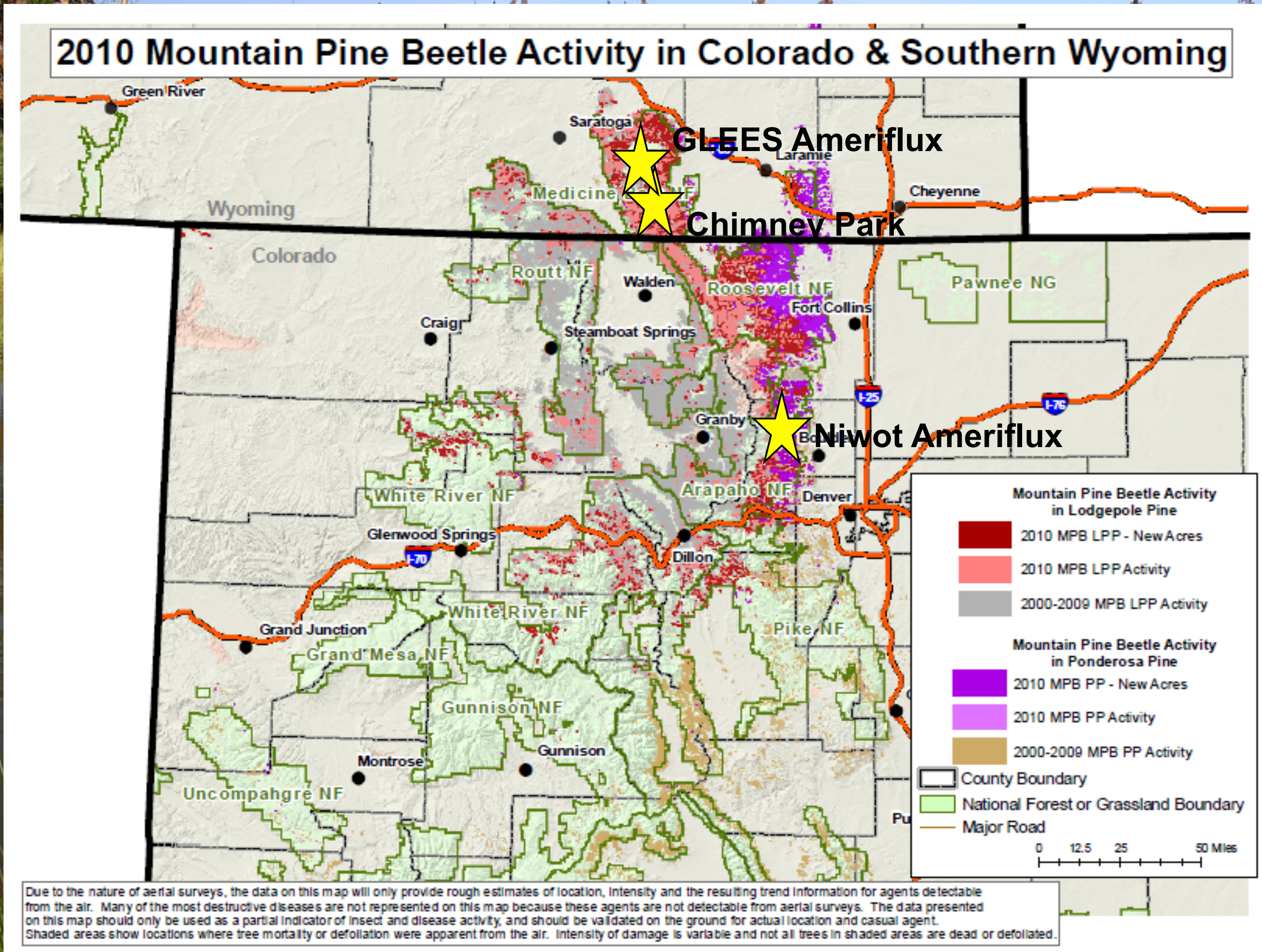
Motivation

- Most land surface models (LSMs)/parameterizations or catchment hydrology models have not been developed or adapted to this disturbance, limits predictability

- Science/modeling questions relating to ‘Model sensitivity to infestation’:
  - What is the sensitivity of model structure (1-d vertical and 3-d) catchment-scale energy and water fluxes to infestation in terms of loss of plant conductance and loss of canopy (e.g. leaf/needle area and roughness)?
  - How does the ‘patchy’ nature of infestation impact system responses? Thresholds?
  - Can infestation be properly parameterized through existing parameter adjustments or are more fundamental conceptual developments necessary?
  - Can we develop a reliable multi-model framework for scenario development?

Ecohydrologic Impacts of Mountain Pine Beetle Infestation: Observational Facilities



Variability in Outbreak Conditions

- Severity and duration
- Treatment of dead standing snags
  - Harvest & immediate transfer of snags
  - Snag fall rate and delay period

Photo by Arjan Meddens

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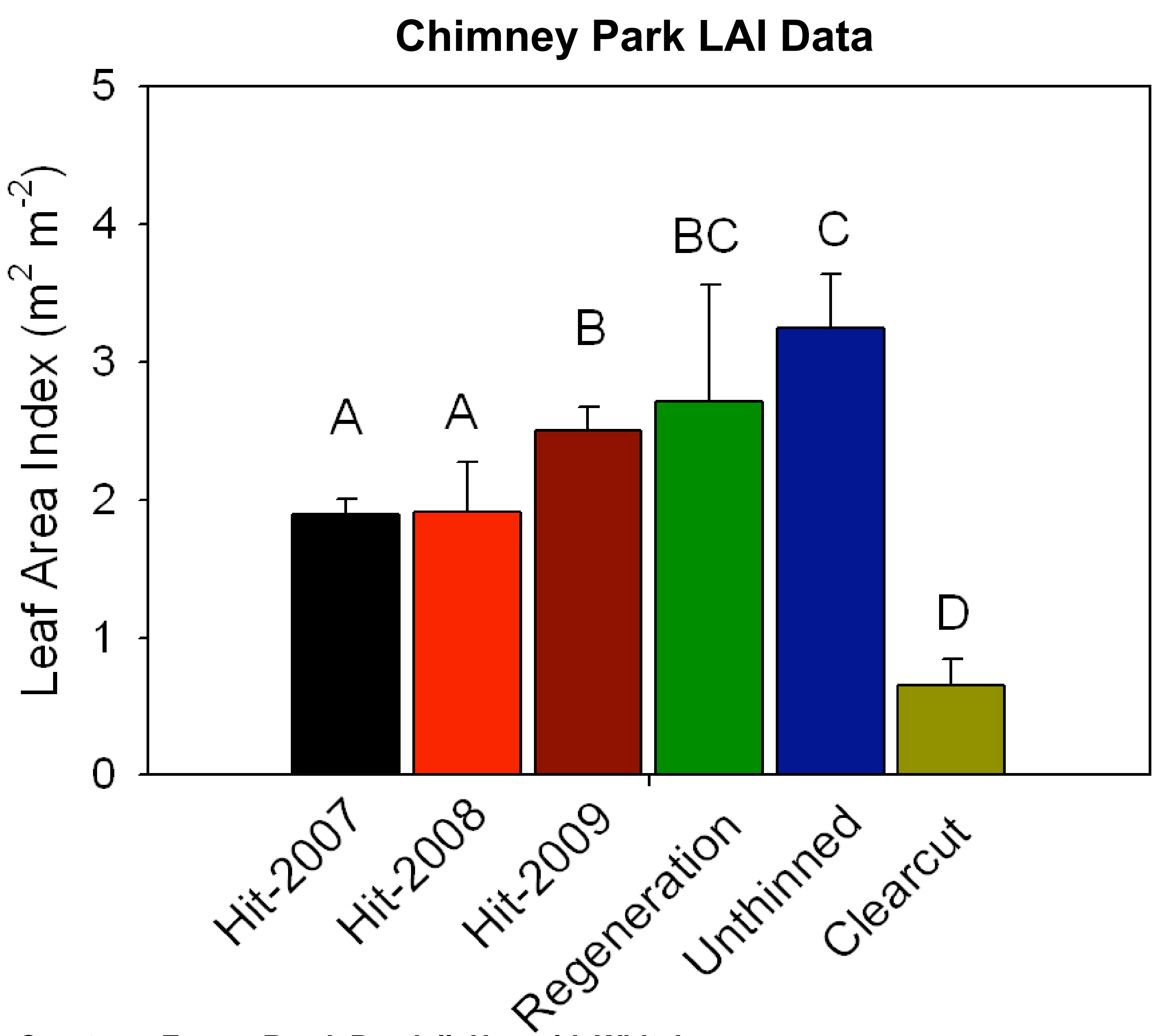
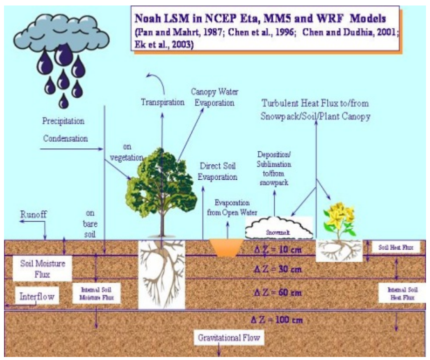
Photo by C. Schnepf, forestryimages.org

Model Sensitivity Studies to Hypothetical (Typical?) Infestation



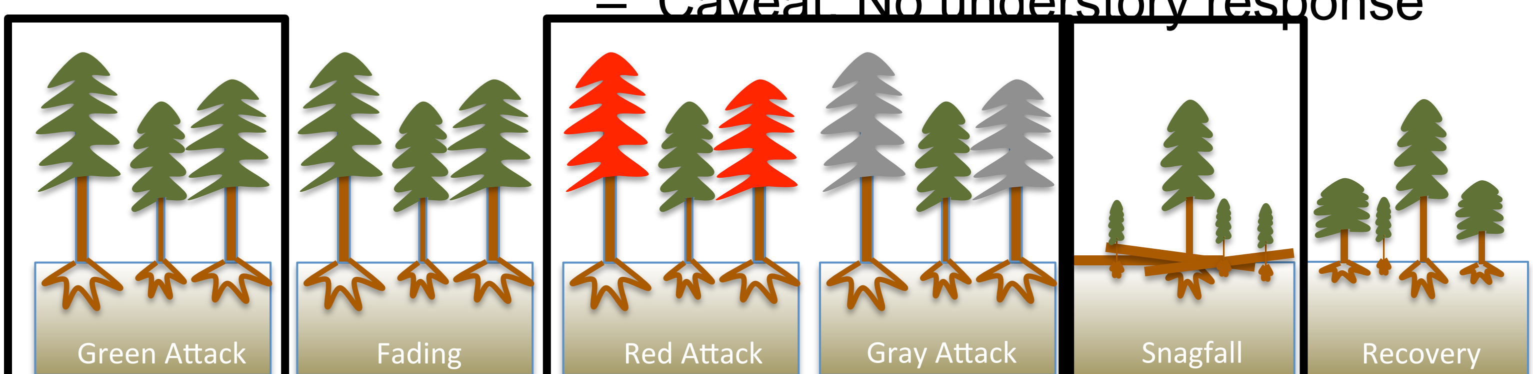
Courtesy: Ewers, Reed, Pendall, Harpold, Whitehouse

Model Sensitivity Studies to Hypothetical Infestation Prescription

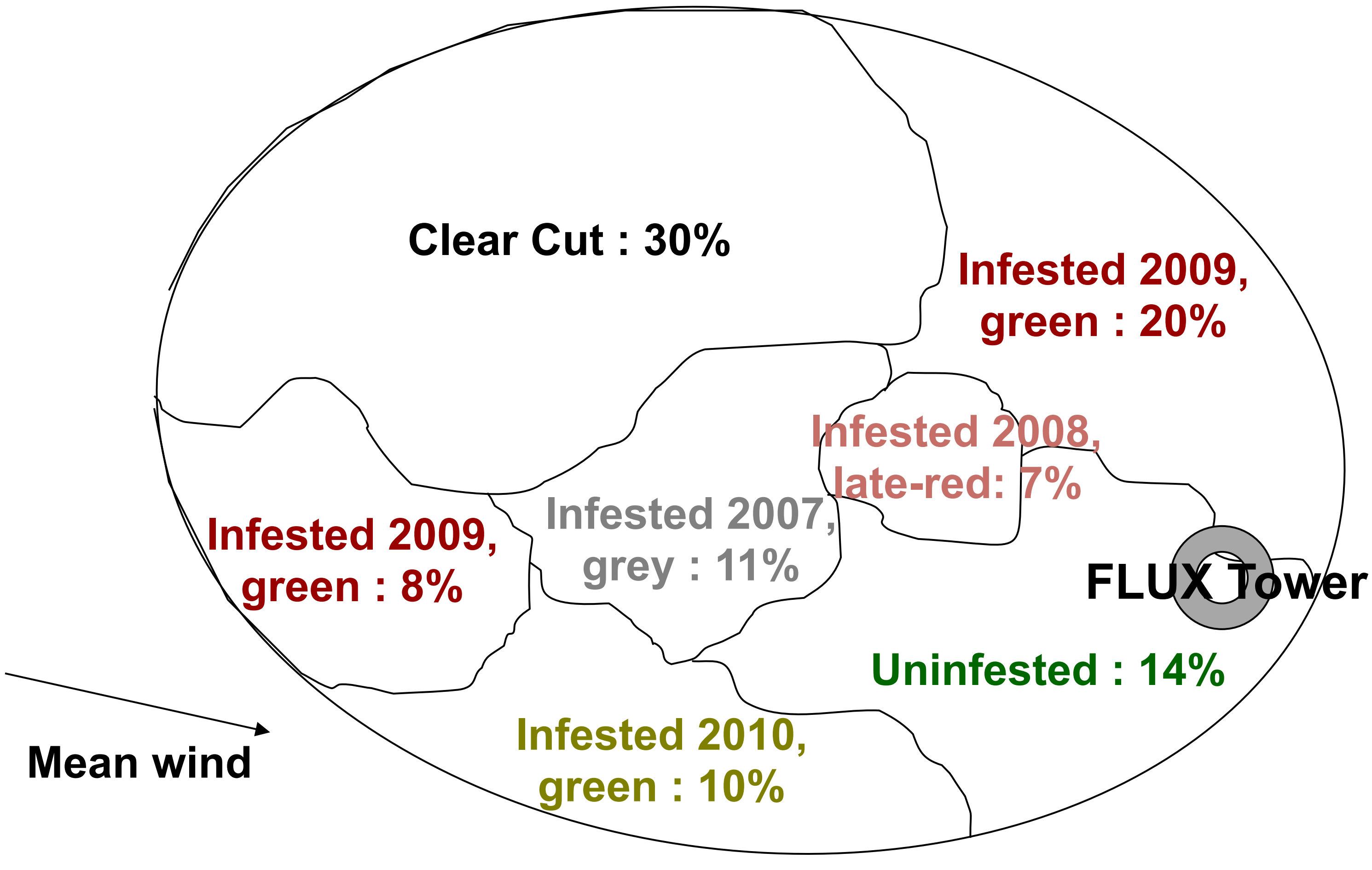


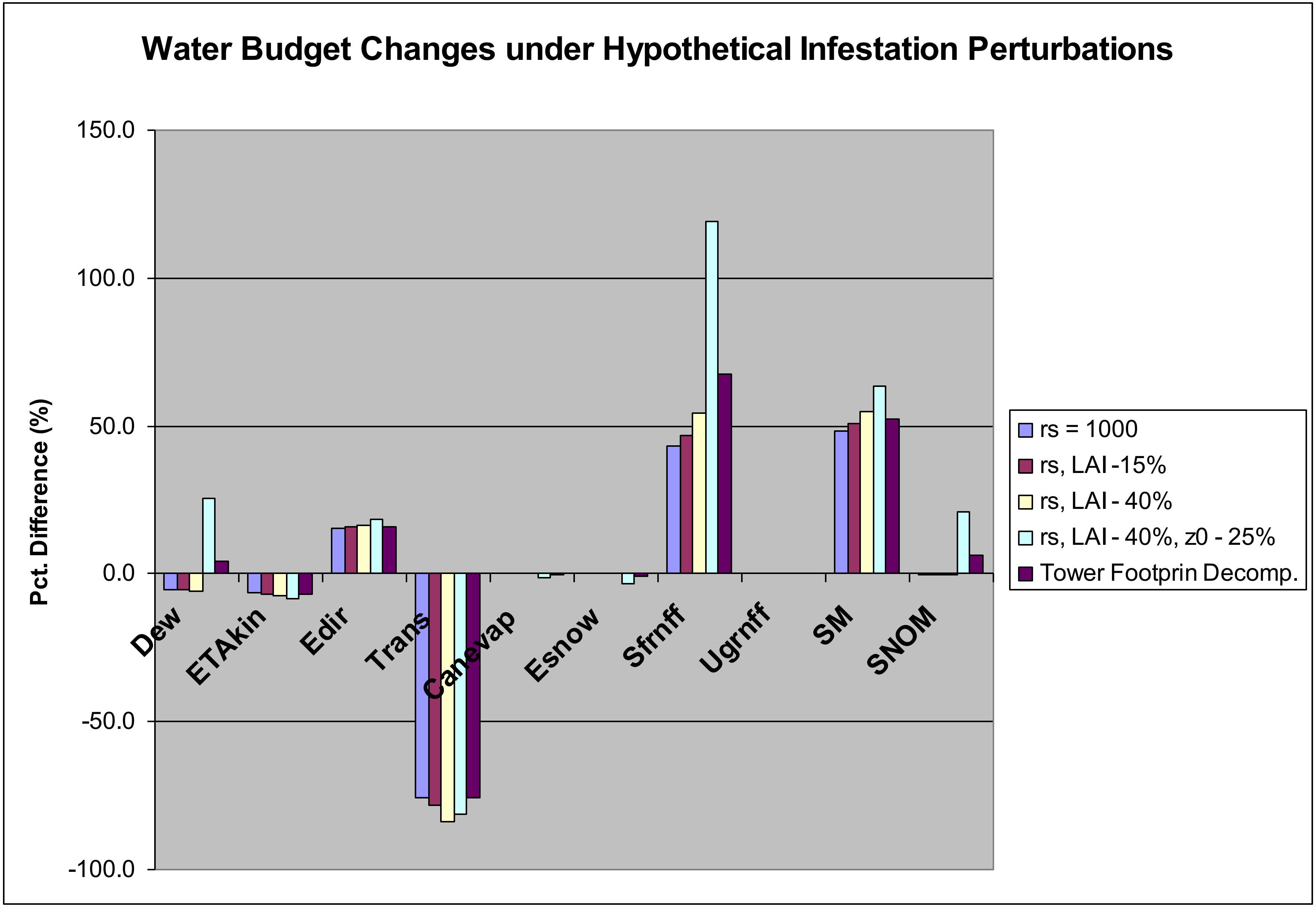
Noah 1d/3d

- Prescribed Evolution:
  - Assume staged and 'steady-state' response to infestation
  - Perturb 3 physiological and structural parameters (stomatal resistance, LAI and roughness length)
    - Transpiration shut-down due to blue-stain fungus: : rs = 125.0 → 1000 s/m
    - Loss of needles: LAI=2.75-3.25 → 15%, 40% (LAI)
    - Tree fall: z0 = ~0.5m → 25%(z0)
  - Caveat: No understory response



Hypothetical Tower Footprint Analysis:

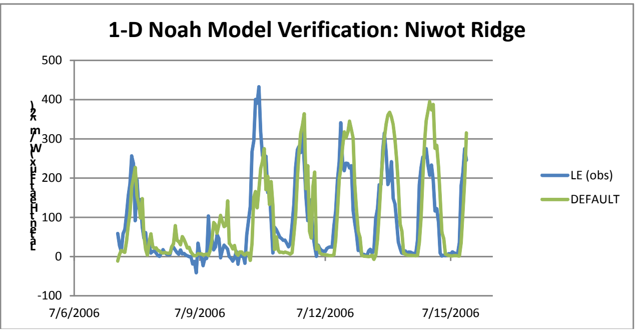


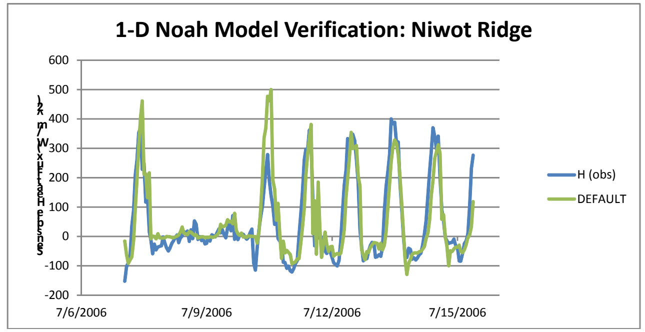


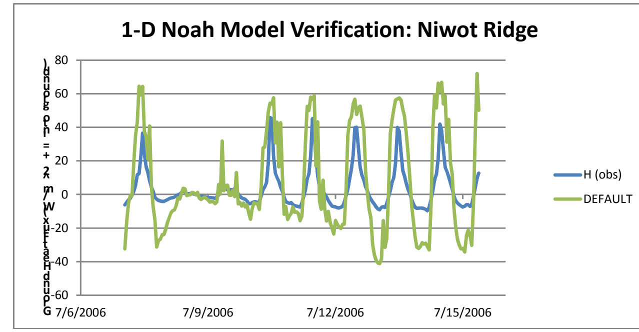
Water Budget Changes under Hypothetical Infestation Perturbations
150.0
100.0
50.0
0.0
-50.0
-100.0
Pct. Difference (%)
Dew
ETAkin
Edir
Trans
Canevap
Esnow
Sfrnff
Ugrnff
SM
SNOM
rs = 1000
rs, LAI -15%
rs, LAI - 40%
rs, LAI - 40%, z0 - 25%
Tower Footprin Decomp.

1-D Noah Model Validation: Niwot Ridge

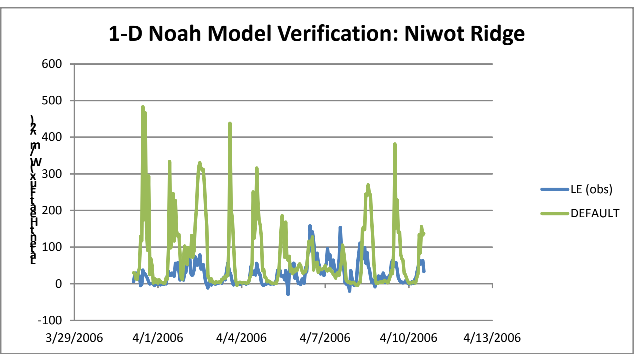
Latent Heat Flux | **Sensible Heat Flux** | **Ground Heat Flux**

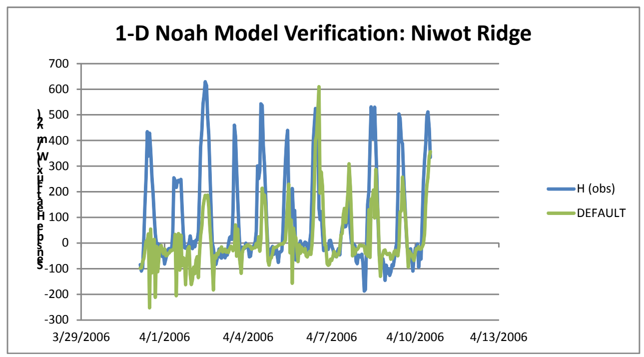


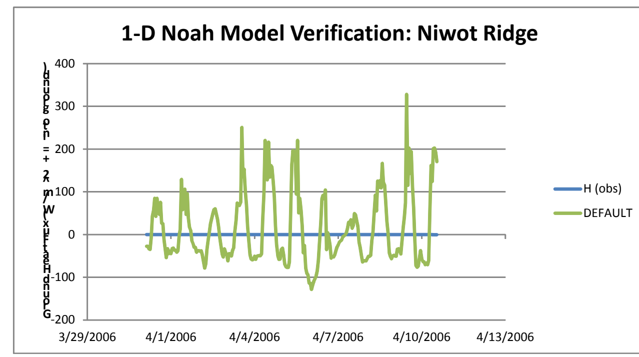




July 6-16



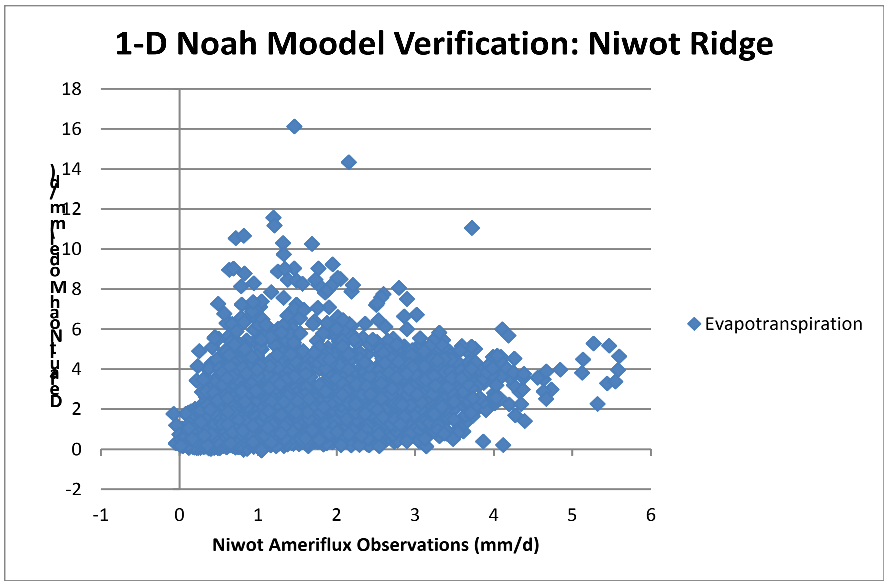


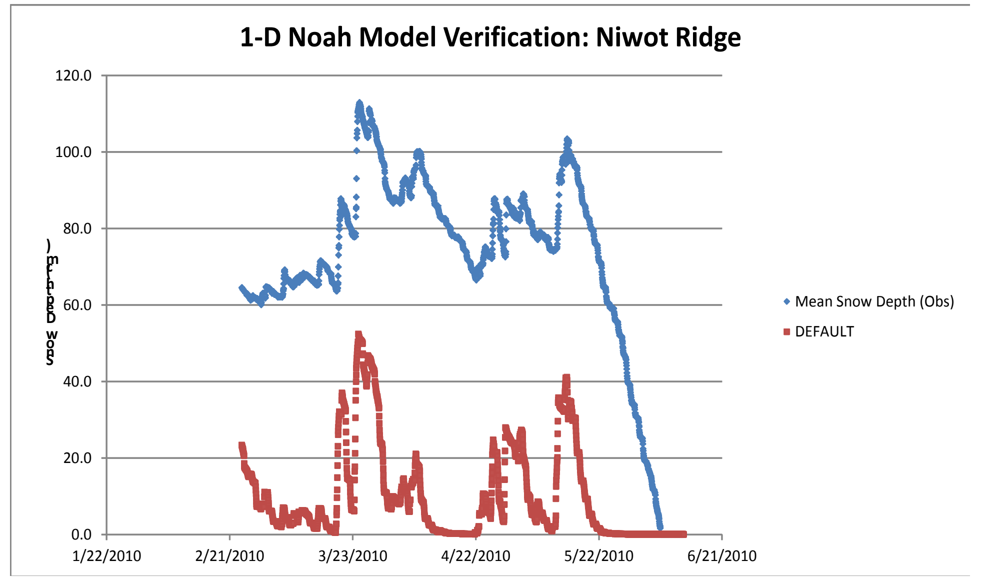


Mar 29- April 11

- Mid-summer fluxes appear reasonable
- Major problems with winter/spring fluxes
  - LE-H partitioning is wrong in Noah
  - Note large difference in winter/spring Ground Heat Flux

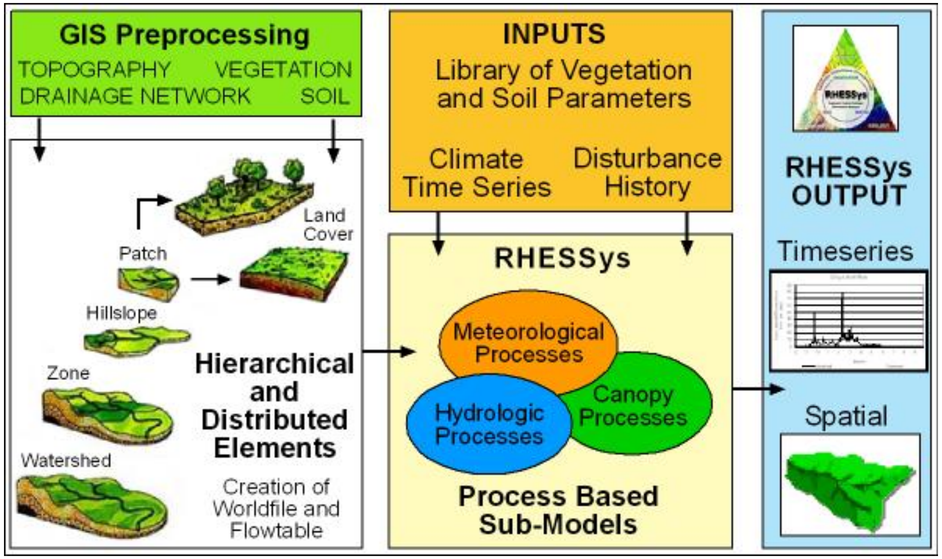
1-D Noah Model Validation: Niwot Ridge



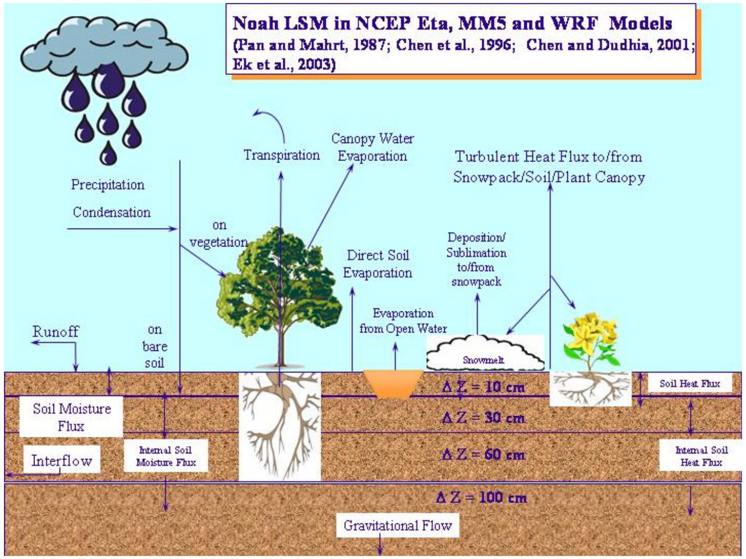


- Positive ET Bias and weak correlation (0.43)
- Poor snowpack dynamics appears to be leading issue

Multi-model assessment: Noah vs. RHESSyS

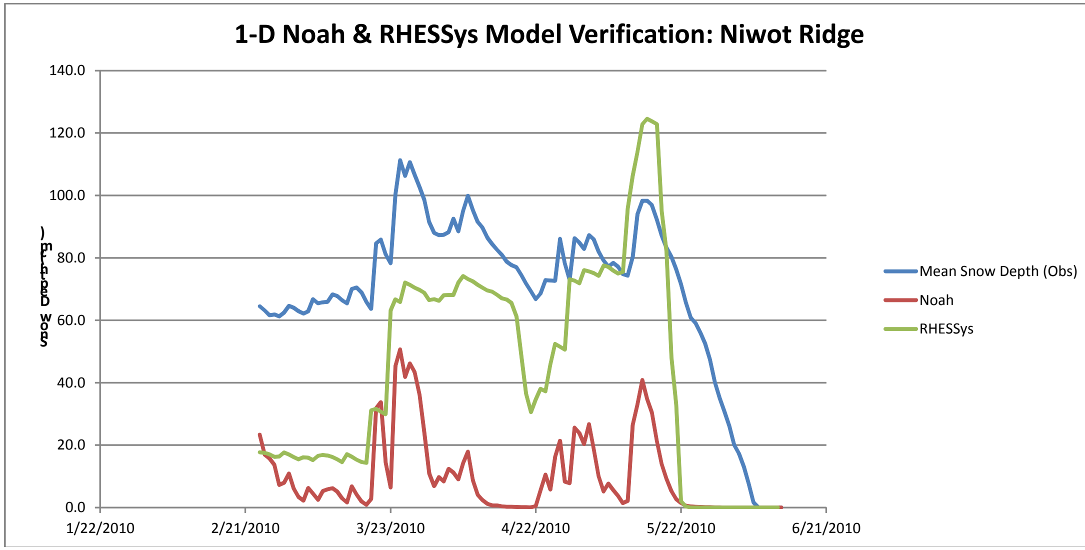


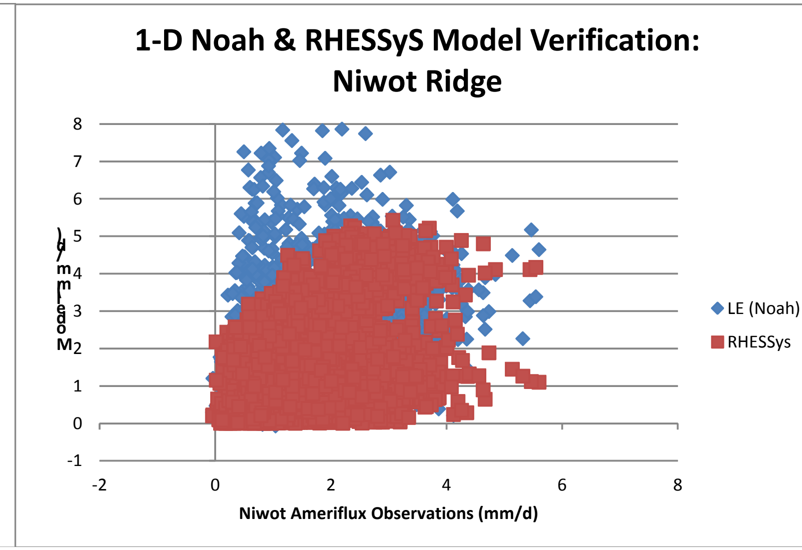
RHESSys (1d & 3d)



Noah (1d & 3d)

Multi-model assessment: Noah vs. RHESSyS





- Differing snowpack dynamics:
  - RHESSyS showing better storage properties during 2010
- Differing ET characteristics:
  - RHESSyS less biased but also less correlated

Conclusions:

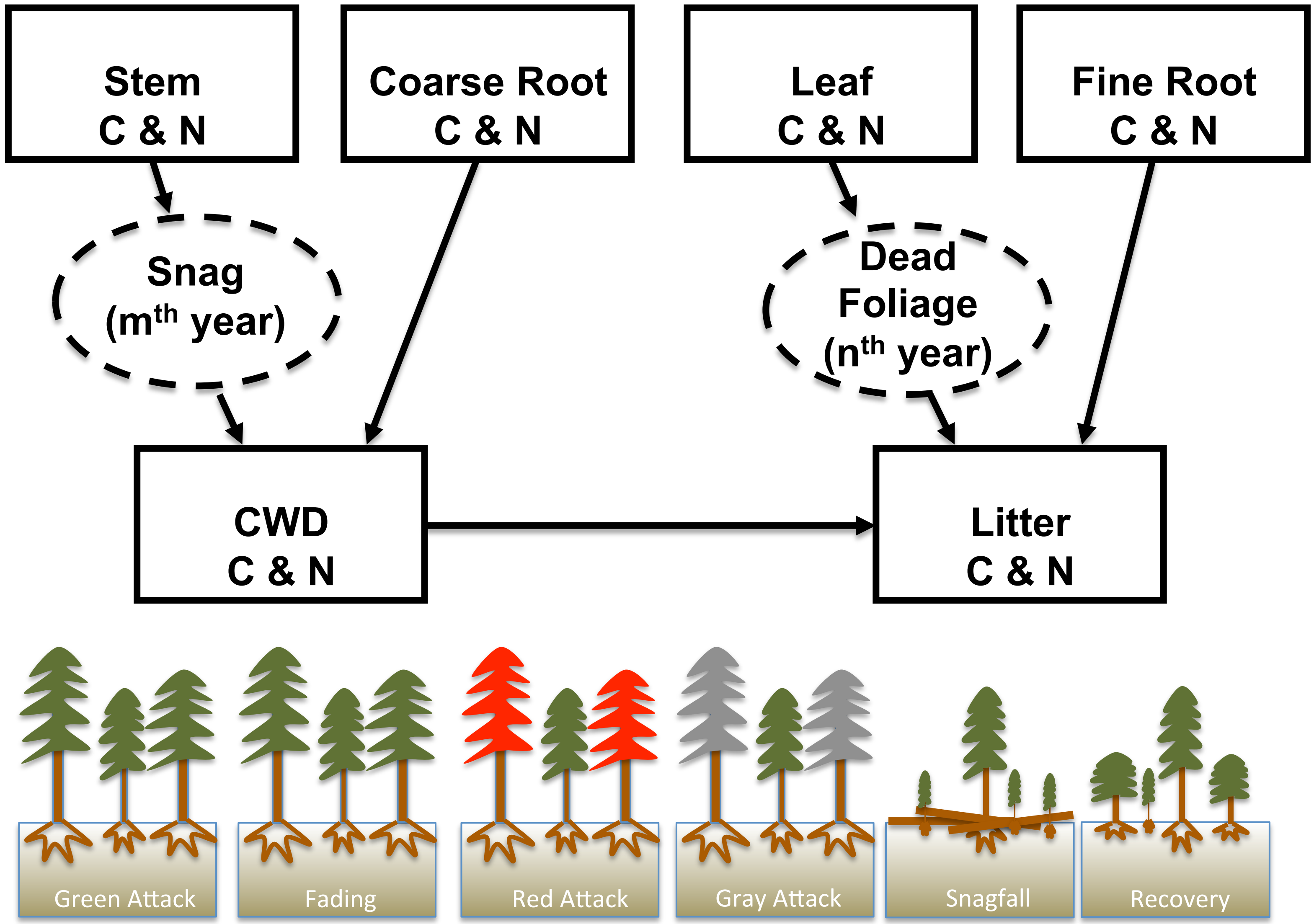
- Initial Sensitivity Tests: <u>'Early conceptual model holds…'</u>
  - Loss of transpirative function yields large, positive response in soil moisture and, less so, runoff
  - Changes due to LAI reduction modestly impact soil hydrology
  - Decrease in canopy roughness also enhances soil moisture, runoff, and dewfall, while decreasing canevap, snomelt and sublimation
  - Aggregation mitigates extreme responses from individual class

- Caveats to initial tests: <u>'Understory response is missing…'</u>
  - No understory response in Noah
  - No transience in vegetation
  - More work to do on aggregation

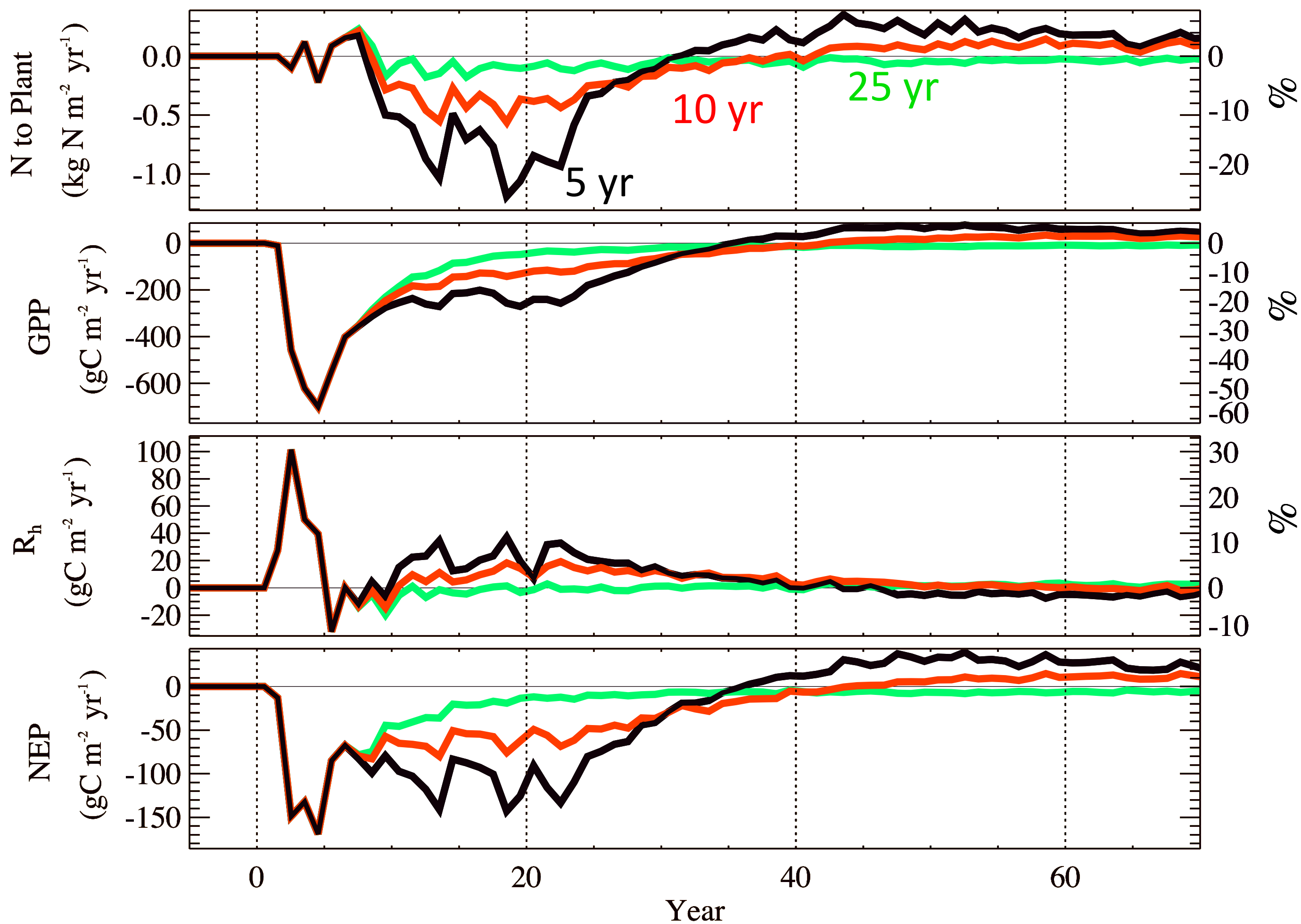
- However!: <u>'Suite of models currently inadequate…'</u>
  - Validation for an inclusive range of state AND flux variables across all seasons is proving difficult at Niwot site
  - Inter-model differences appear to be complicated
  - Much more work is needed to make these models applicable…


Questions....?

Modifications to CLM-CN



Simulated Soil N Dynamics Play a Key Role in C Fluxes and Recovery



Point simulation in Idaho: 95% mortality over 3 years