Impact of Forest Treatments and Climate Change on Hydrologic Regimes

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USDA CSREES EDUCATION RESEARCH EXTENSION

Motivation: Logging and Peakflows

"Forest harvesting has increased peak discharges by as much as 50% in small basins and 100% in large basins over the past 50 years."

Jones and Grant, 1996

"We could not detect any effect of cutting on peak flows in one of the large basin pairs, and results were inconclusive in the other two large basin pairs."

Thomas and Megahan, 1998

"In summary, both T&M and J&G showed that forest harvesting has increased peak discharges by as much as 50% in small basins and 100% in large basins."

Jones and Grant, 2001

"J&G present no convincing evidence in their original paper or in their comment to support their contention that all event sizes including large floods react similarly."

Thomas and Megahan, 2001

Motivation: Logging and Peakflows

"Investigation of the effect of return period on peak flow changes shows an apparent increase in flood peaks for treatment relative to control catchments, the mean magnitude of which decreases with increasing return interval up to about the 10-year return period. In large part, owing to the small number of catchment pairs available, this analysis cannot be considered conclusive."

Bowling et al., 2001

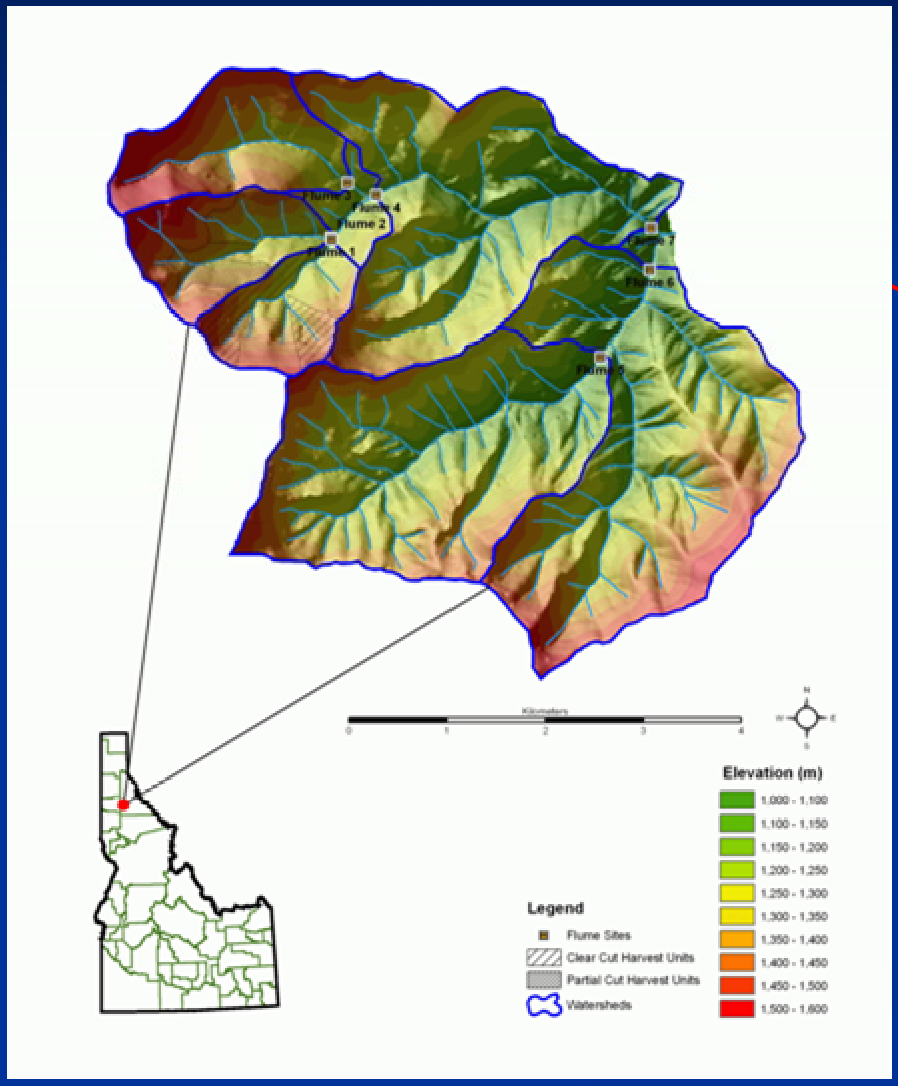
Research and Management Needs

- Data from “typical” managed forestlands
  - Second growth
  - Contemporary management practices
  - Watershed scale
  - Inland northwest under-represented
- Interdisciplinary connections
- Mechanistic understanding of processes
- Integrated, spatially-explicit management tools

Objectives:

- Assess cumulative watershed impacts of contemporary timber harvest practices
  - Flow
  - Sediment
  - Temperature
  - Macroinvertebrates
- Assess alteration of ‘internal’ watershed processes
- Develop well-validated parameter set for a physically-based watershed model
- Simulate future harvest and climate scenarios

Mica Creek Experimental Watershed



Location:

N. Central Idaho

Climate:

Continental/Maritime

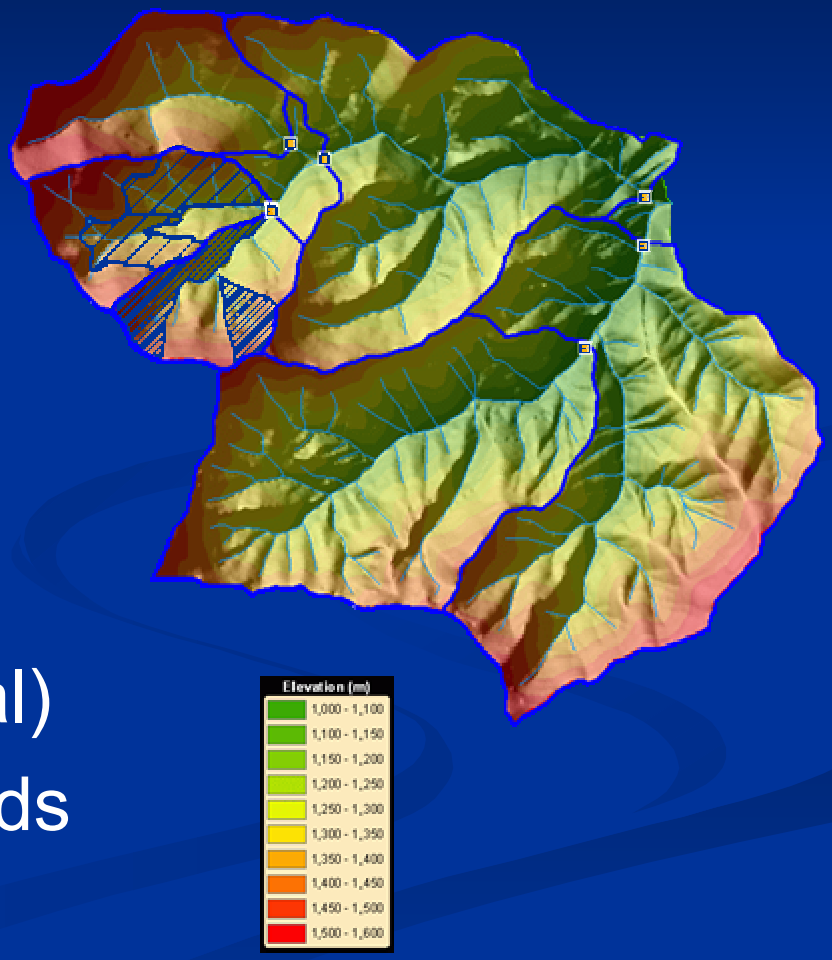
Historical Context

- Extensive logging
  - 1920-1930's
- Natural regeneration
- Limited anthropogenic disturbance until late 1990's
- Size: 27 km2 (~6700 ac)
- Elevation: 1000 – 1625m (3200 – 5240 ft)
- Precipitation: 1440 mm yr^{-1} (~57 in/yr)
- Vegetation: 65-75 yr. old mixed conifers

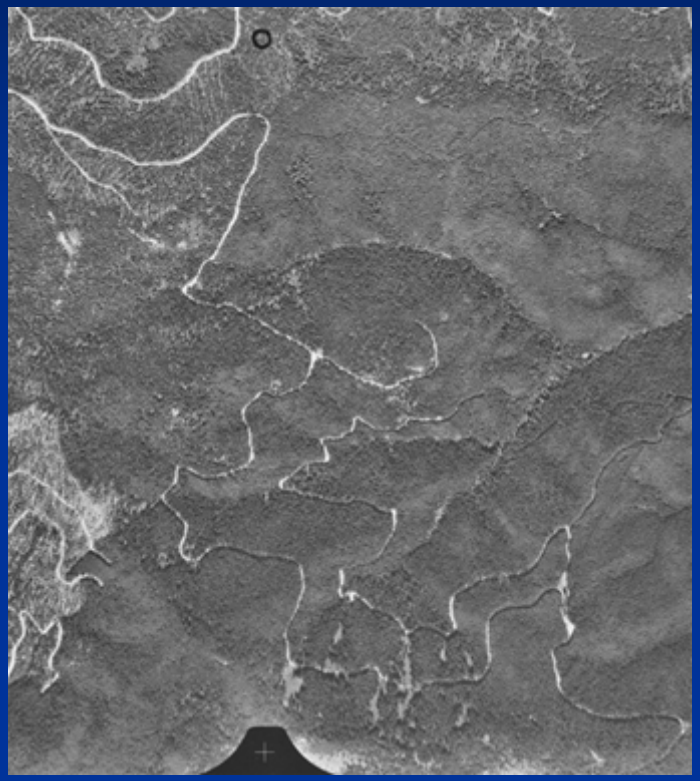
Mica Creek c. 1932

MCEW Study Design

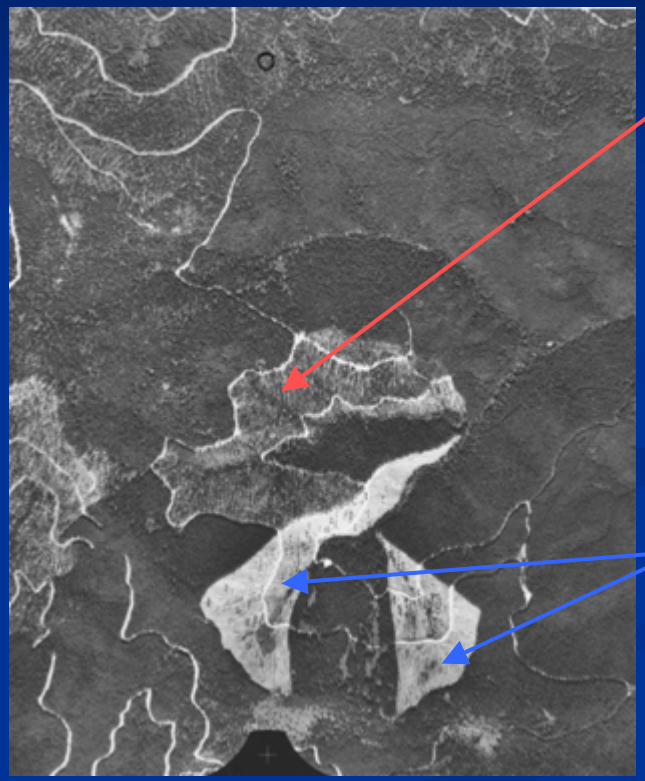
- Initiated 1990
- 6 years calibration period
- 4 years post-roads
- 5+ years post-harvest
  - 50% area impacted
    - Clearcuts
    - Partial Cuts
      (50% canopy removal)
- Paired & nested watersheds



Experimental Treatments



Pre harvest 2000



Post harvest 2002

Results – Post Harvest (mm/yr)

CC=↑254, (28%)

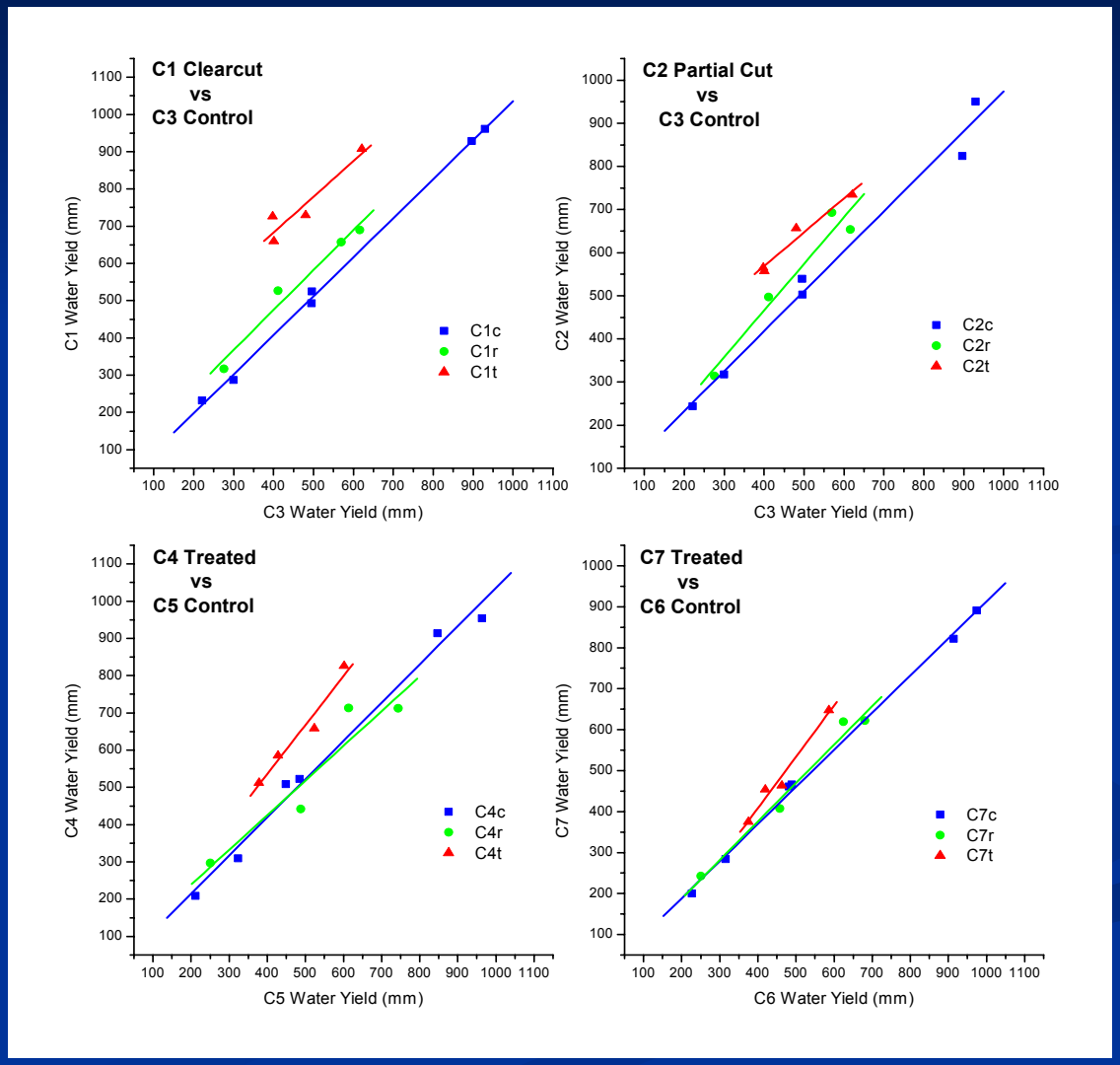
*PC=↑135, (20%)

*C4vsC5 = ↑130, (20%)

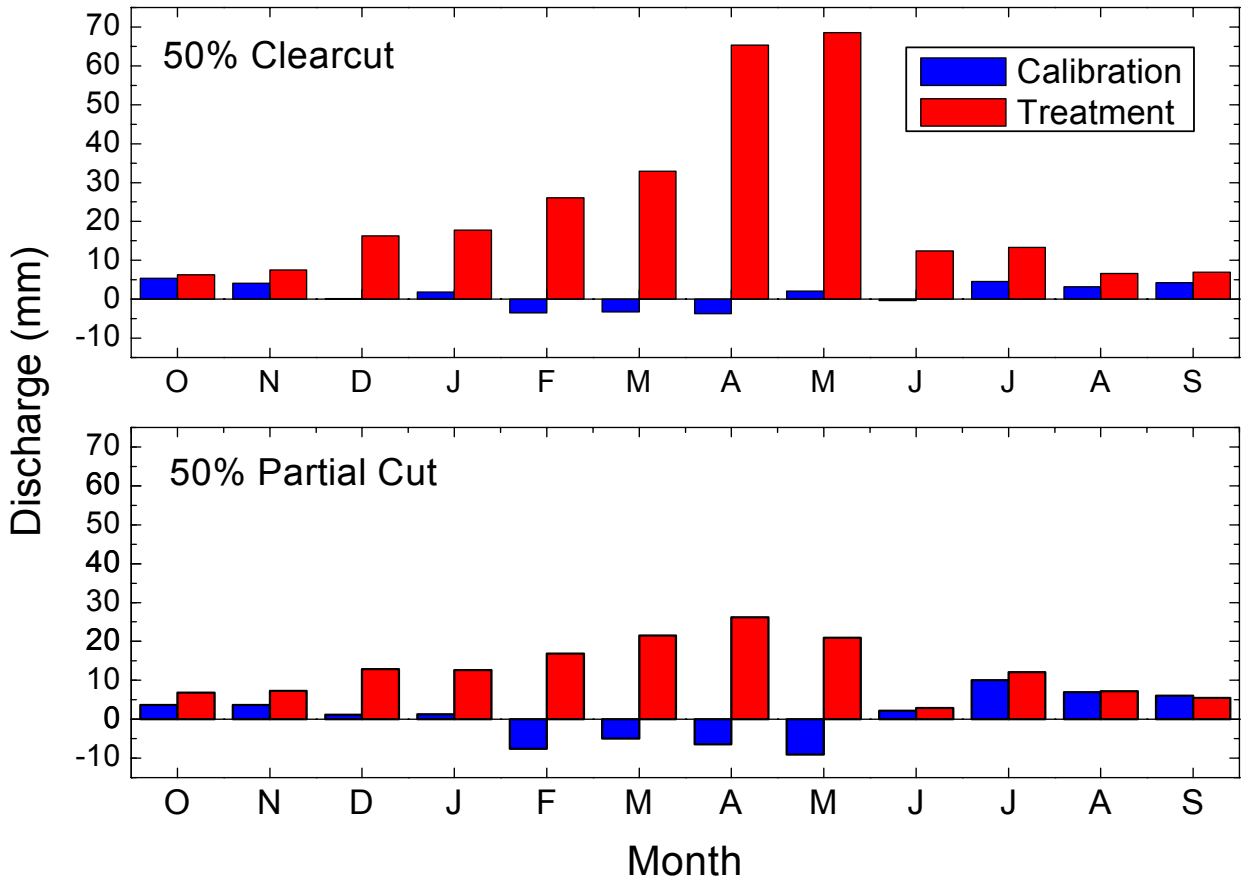
C6vsC7 = ↑76, (14%)

($p \leq 0.05$)

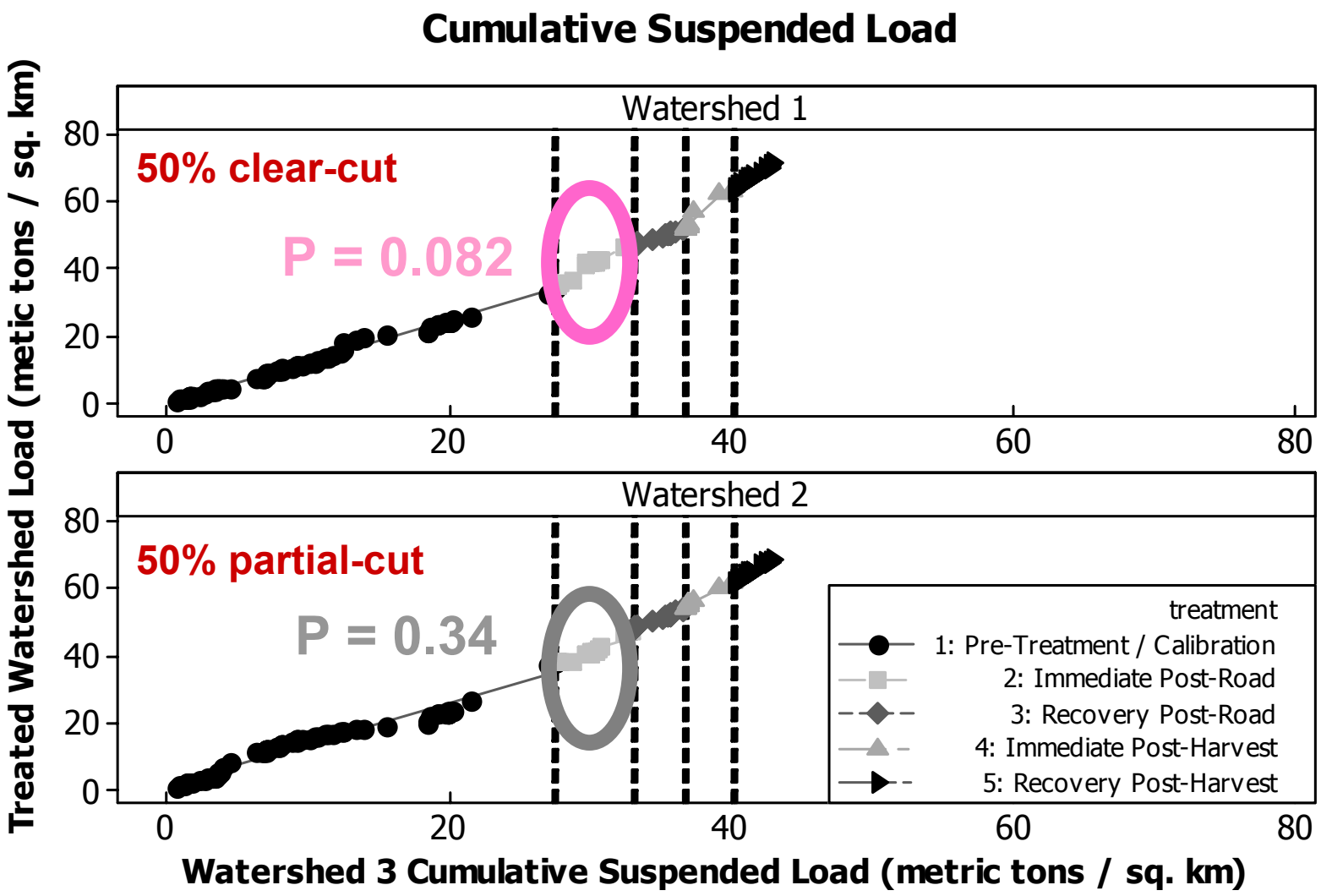
*= marginal statistical significance ($p \leq 0.05$)



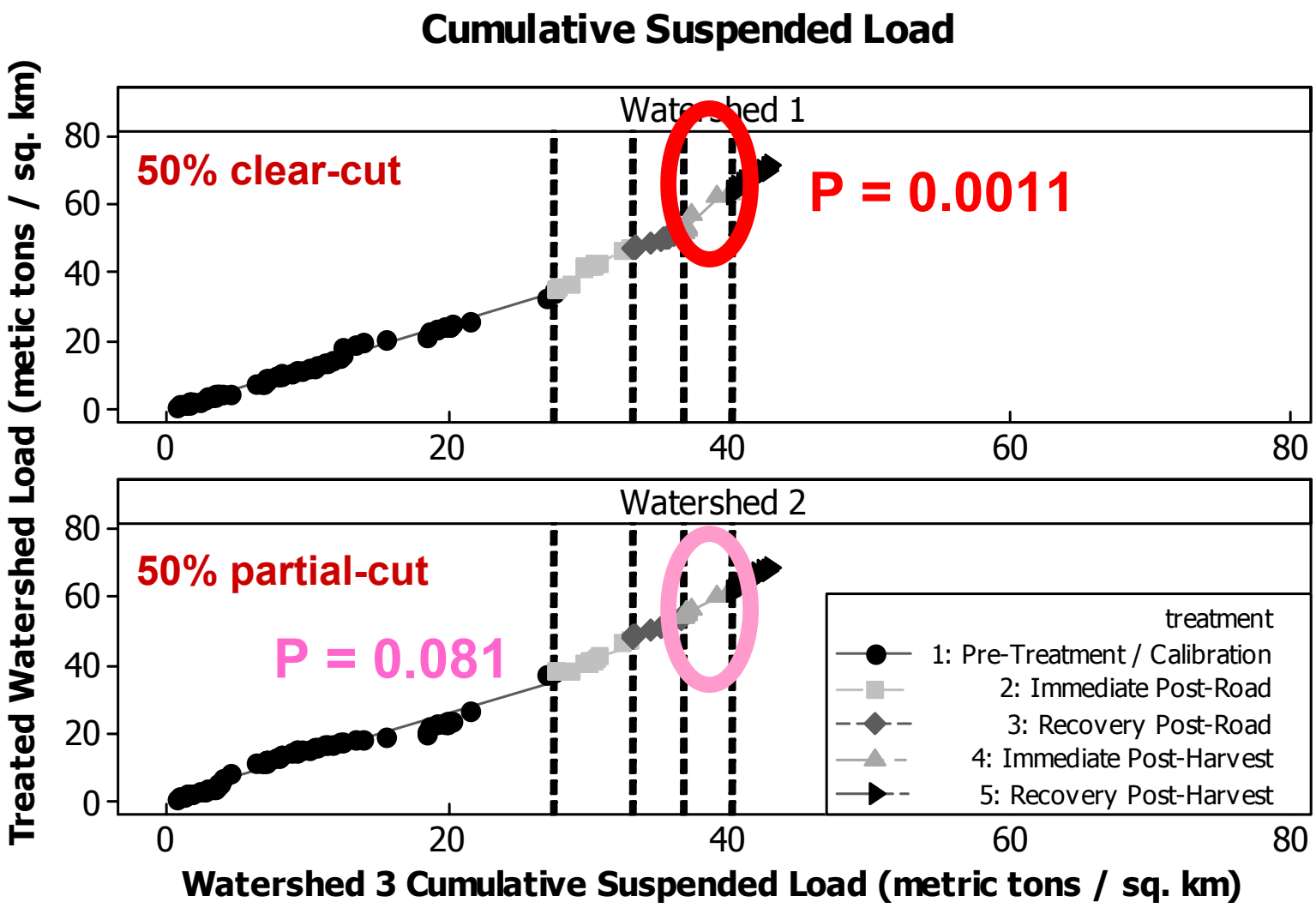
Seasonal Changes



Results: Suspended Load

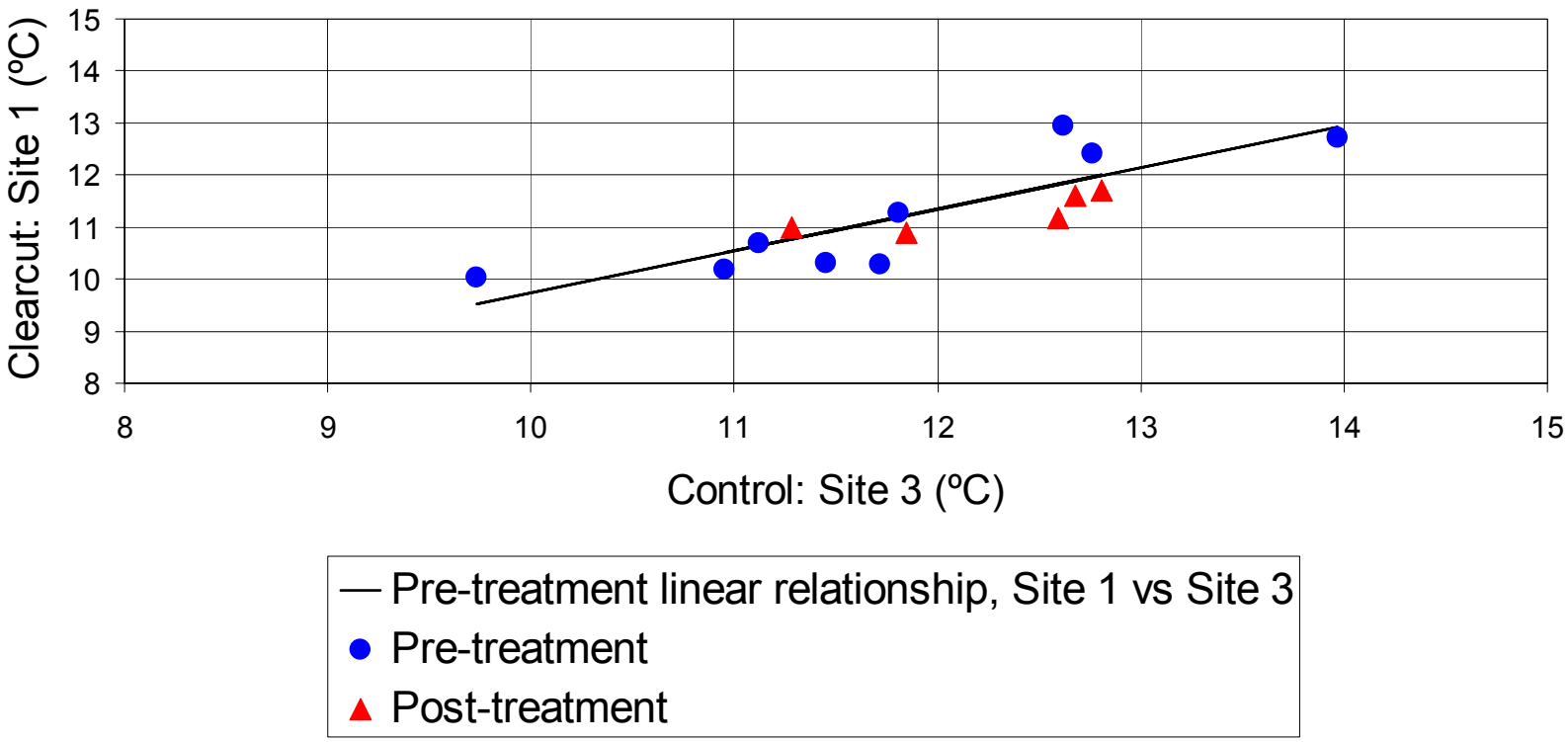


Results: Suspended Load



Results: Stream Temperature

Maximum Weekly Maximum Temperature (MWMT)
Clear cut catchment



*Partial cut catchment very similar…

Results: Macroinvertebrate Summary

- Repeat measures ANOVA
  (calibration, post-roads, post-harvest)
- Metrics:
  - Abundance
  - EPT Abundance
  - EPT Richness
  - Scraper Richness (cumulative, post-road)
  - Predator Richness
  - Sediment Intolerant Taxa Richness
  - Shannon-Weaver H' Diversity
  - Hilsenhoff Biotic Index (HBI) (partial cut, post-harvest)
  - Fine Sediment Biotic Index (FSBI)
  - % Intolerant (partial cut, post-harvest)

(indicates treatment and phase where significant changes were observed)

Filling the measurement gap…

"…the hydrological community is becoming more and more removed from process understanding based on direct field investigations."

R. Sidle, 2006, *HPToday*

[Peakflow questions cannot be resolved using statistics alone… a process-based modeling approach is needed]

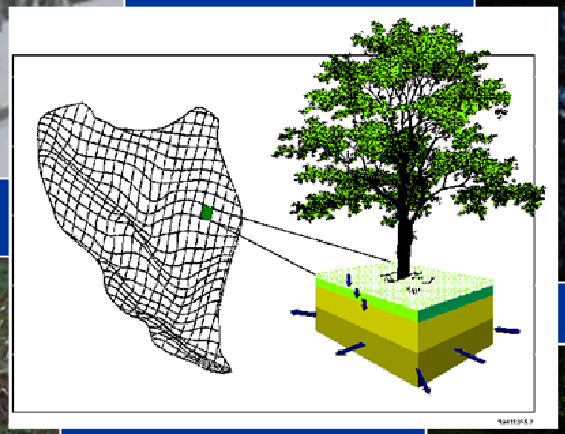
G. Grant, 2004

"Mon Ami, Fieldwork is always painful!"

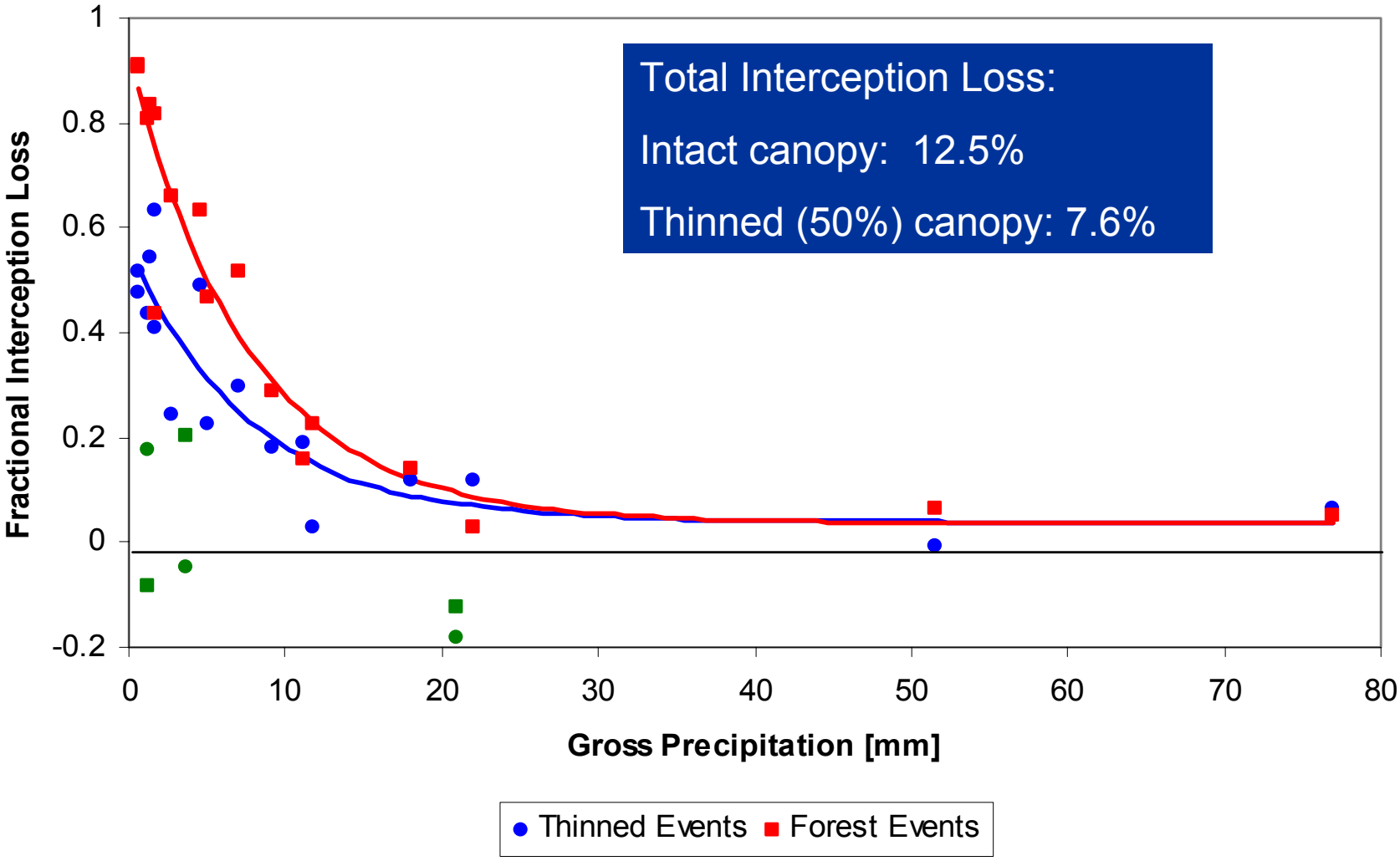
Y. Alila, 2004

Opening up the Black Box

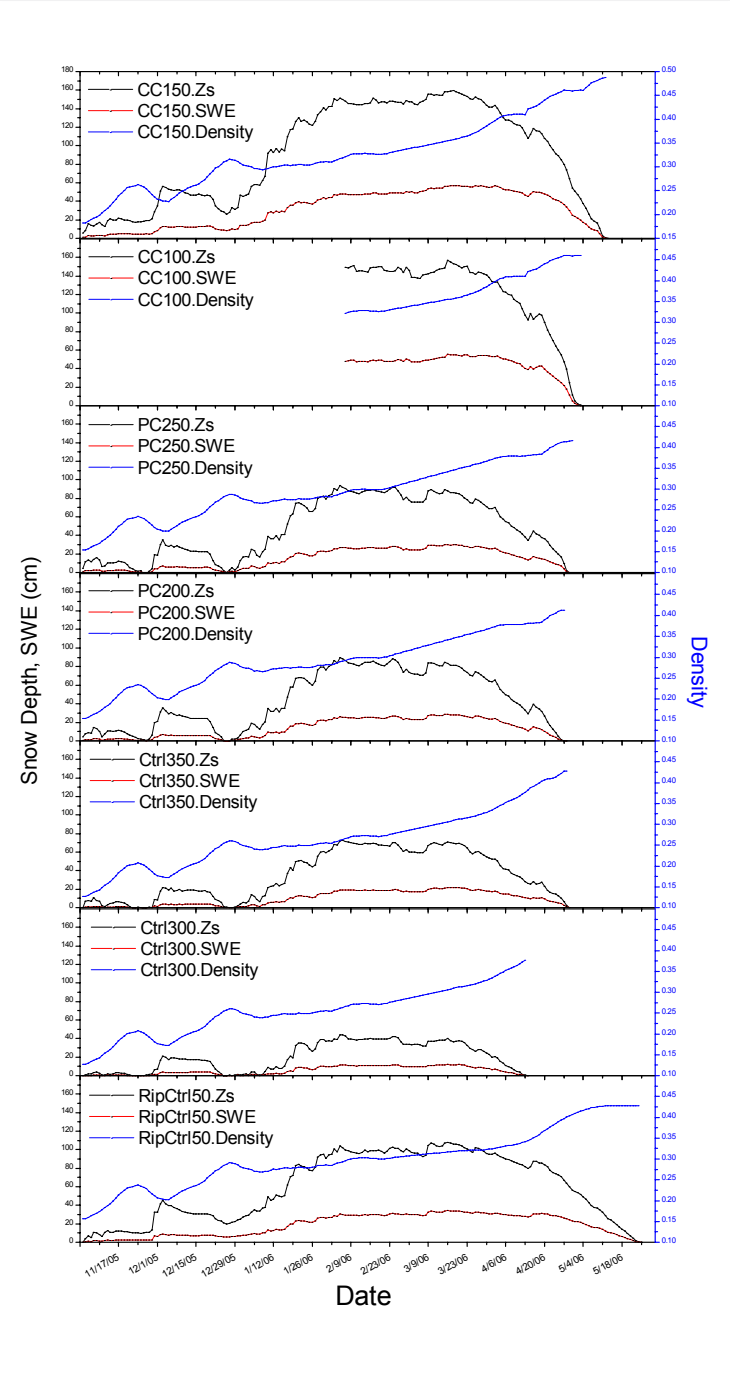
Process Investigations



Fractional Interception Loss



Snow Cover by Treatment



Clearcut

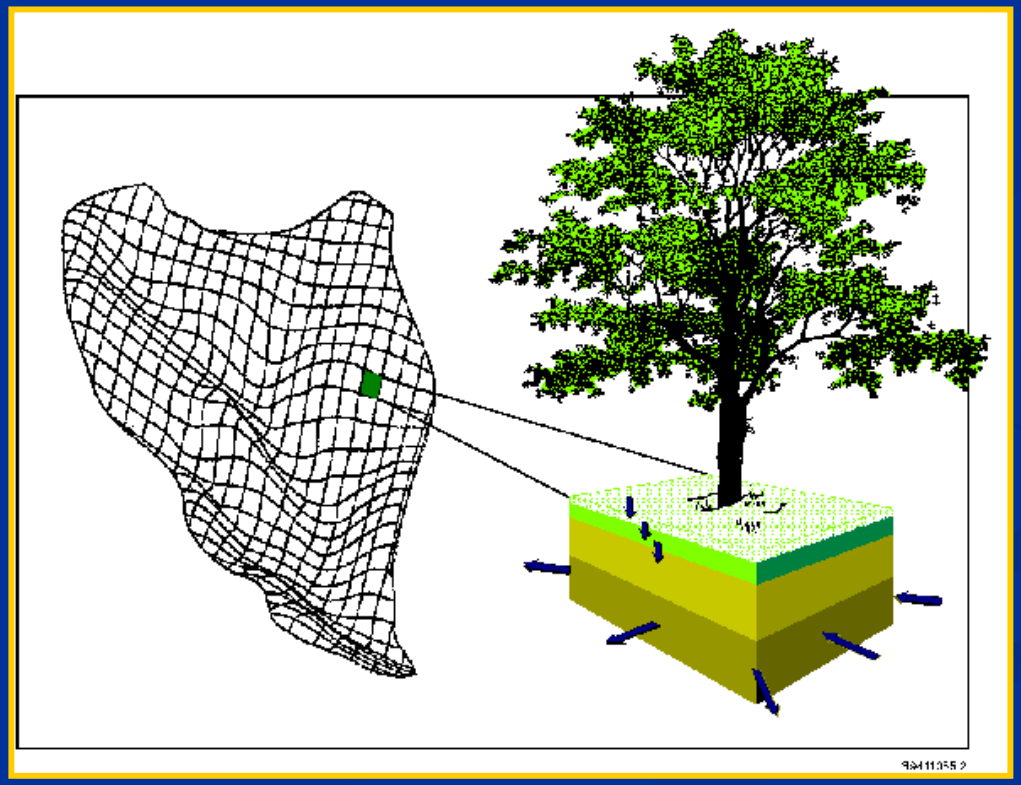
Partial cut

Forest

Methods – Numerical Modeling

Distributed Hydrology Soil Vegetation Model (DHSVM)

Approach: Use well-validated numerical model to assess alternative land-use and climatic scenarios



Modeling Investigations

- How will water balance and peak flows change as a result of:
  - Road density and configuration ?
  - Harvest pattern ?
  - Sub-basin synchronicity ?
  - Climatic shifts ?

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Manuscripts soon to appear in Headwaters Special Issue of Forest Science

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