

Exploring the Sensitivity of Watershed Hydrology to Land Cover and Climate Change: Results from an Experimental Watershed Spanning the Rain-Snow Transition Zone

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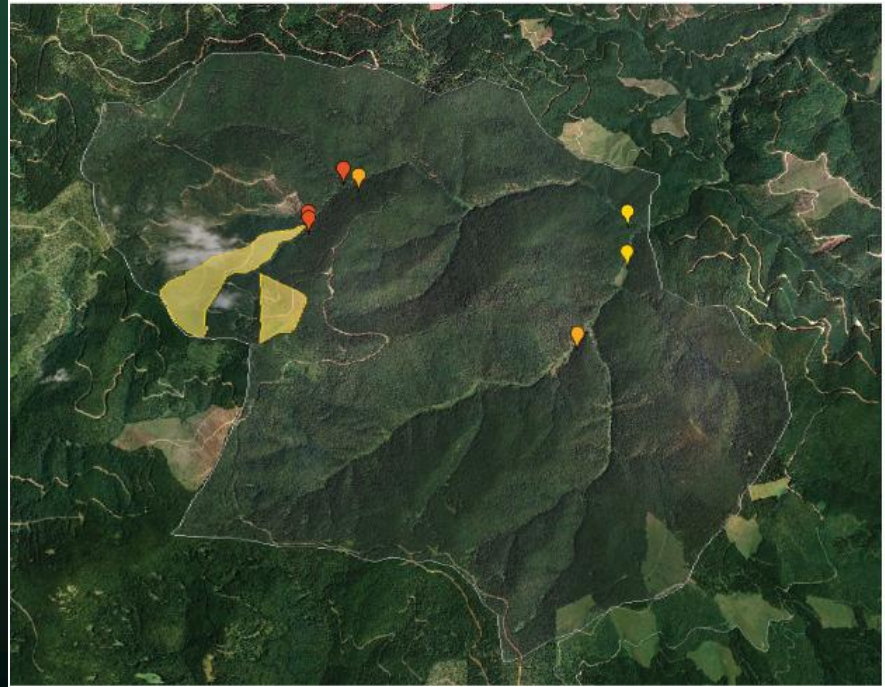
Objective and Questions

- Develop a holistic understanding of the hydrologic future in the interior Pacific Northwest
- Question: How are flow regimes in a watershed spanning the rain/snow transition zone expected to change?
 - Due to climate change?
 - Due to forest harvest and regeneration?
 - Across scales? (1st to 4th order watersheds)
 - Similarities and differences?

Land Cover Change

Many Experimental Forest Studies:

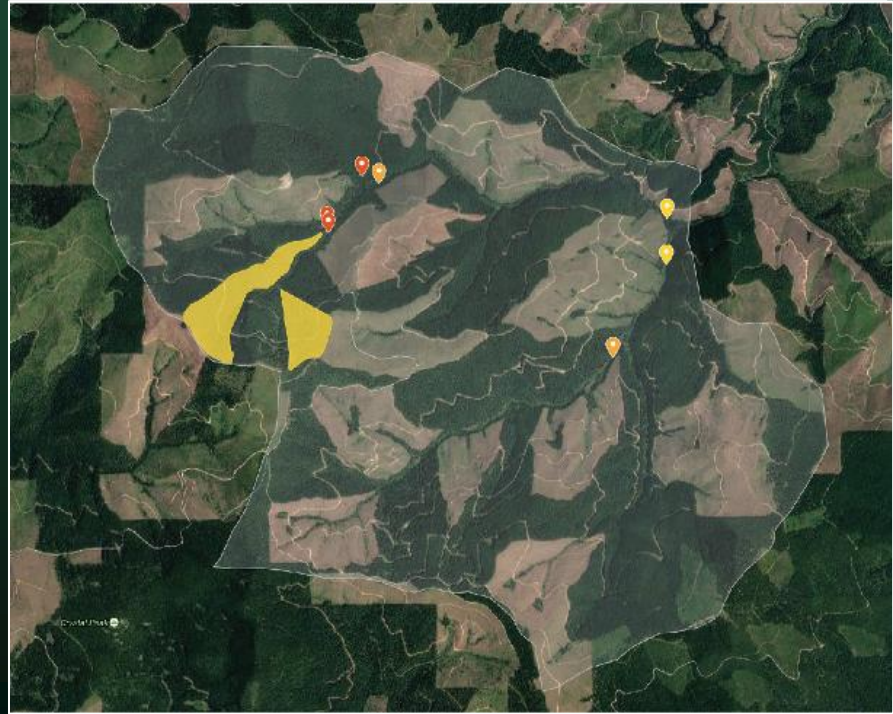
- Discrete Impact →
Forest
Regeneration
- 50 -100% harvest
- Low age diversity



Land Cover Change

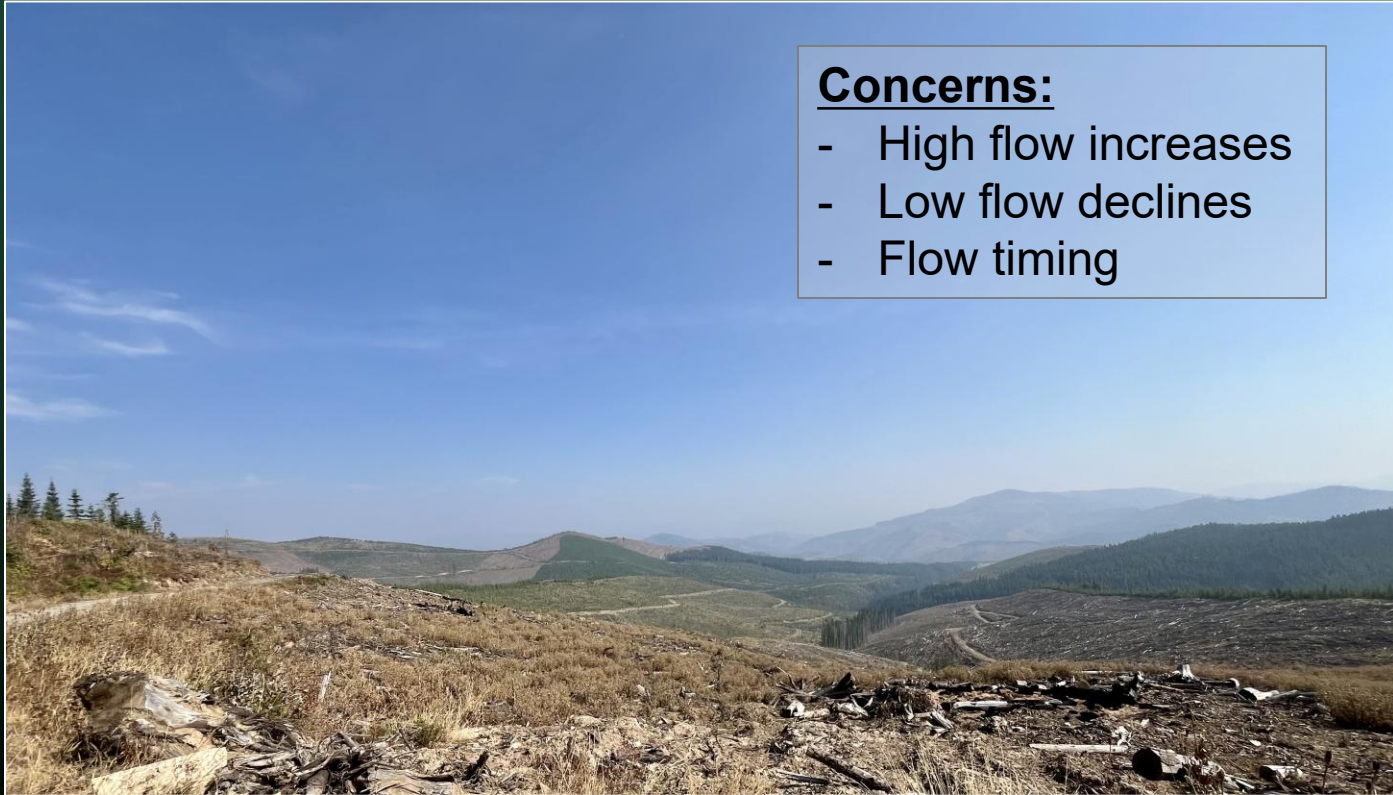
Working Forests:

- Successive Disturbance → Continuous Regeneration



Age diversity generally increases with scale

Land Cover Change on Private Forestland

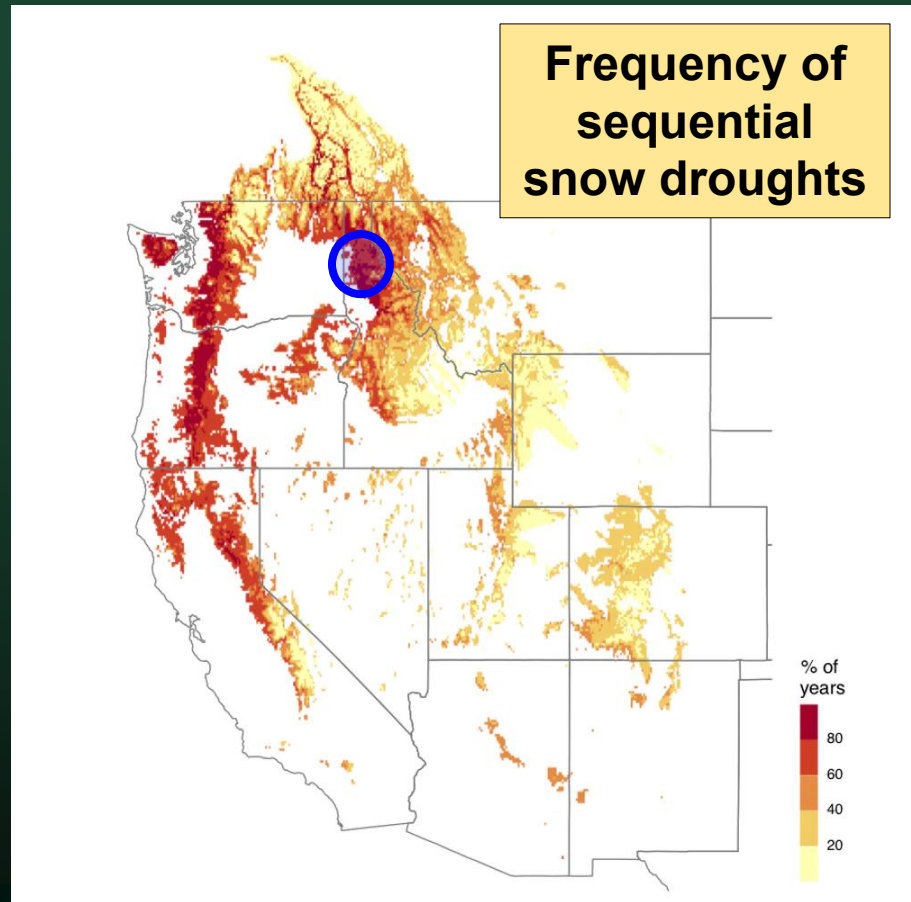


Concerns:

- High flow increases
- Low flow declines
- Flow timing

Climate Change

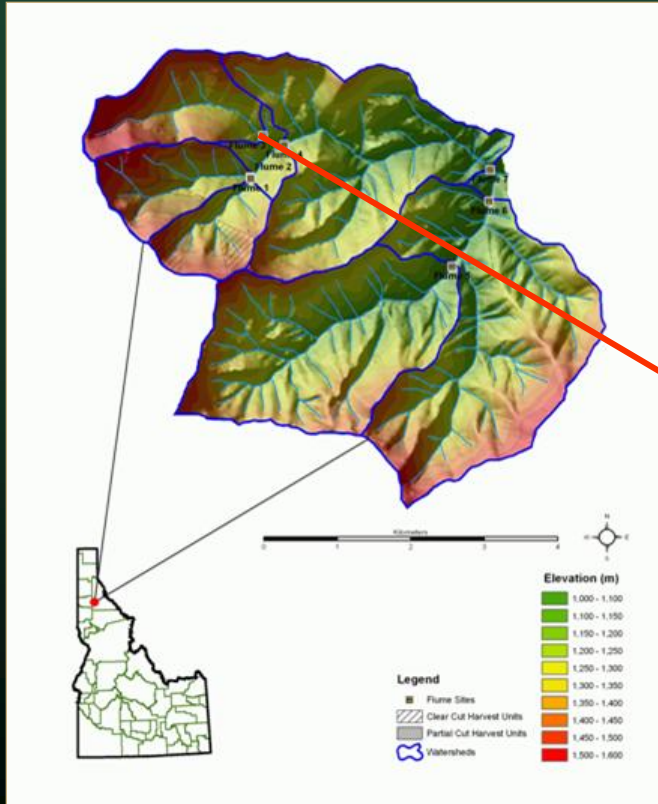
- Patterns of snow metrics are all similar:
 - Successive snow droughts
 - Rain:snow ratio
 - Peak snow depth
 - Melt timing
- Declining low flows...



Marshall, A. M., J. T. Abatzoglou, T. E. Link, and C. Tennant. 2019. Projected changes in interannual variability of peak snowpack amount and timing in the western United States. *Geophysical Research Letters*, 46(15), 8882-8892. <https://doi.org/10.1029/2019GL083770>.

Mica Creek Experimental Watershed

v. 1.0



Location:

N. Central Idaho

Climate:

- Continental/Maritime
- Transitional Snow Zone



Site Characteristics

- Size
 - 27 km²
- Elevation
 - 1000-1625 m
- Precipitation
 - 1440 mm/yr
- Vegetation:
 - ~80 yr Mixed conifers
- Active Forest Management
 - Diversity of age classes

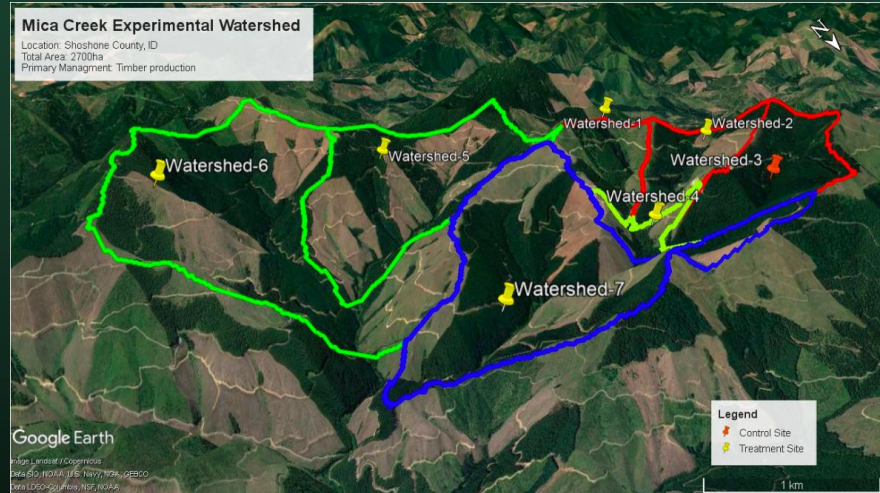


Image courtesy of C. Deval

Mica Creek: Data collection



Soil properties



Soil moisture

Flow, chemistry & isotopes



Distributed
Hydro-
meteorology



Throughfall



Sap Flux



Snowpack properties



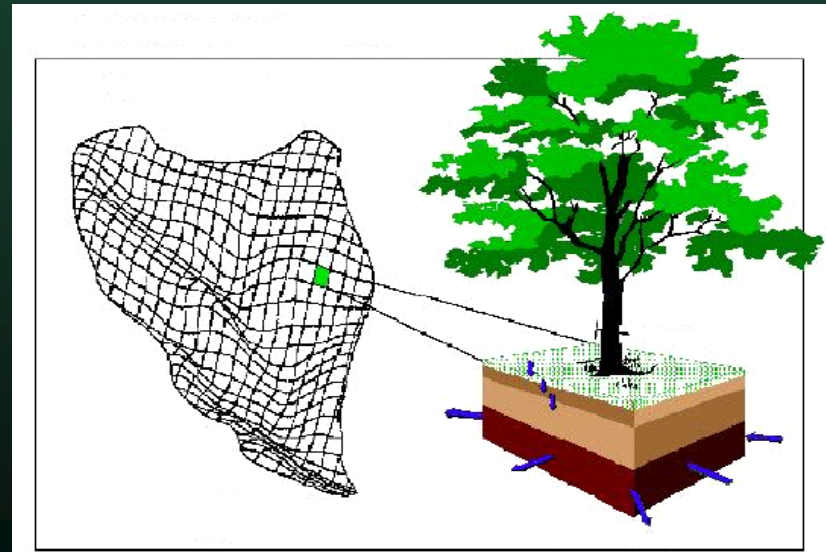
Reducing the
Potential for
Equifinality

Simulation Approach:

Physically-Based, Virtual Experimental Watershed

- Distributed Hydrology Soil Vegetation Model (**DHSVM**)
- Detailed Internal Watershed Data
 - Parameterization
 - Validation
 - Du et al., 1994 & 1996
- Quasi Monte-Carlo Parameterization
- Simulate Alternative Futures

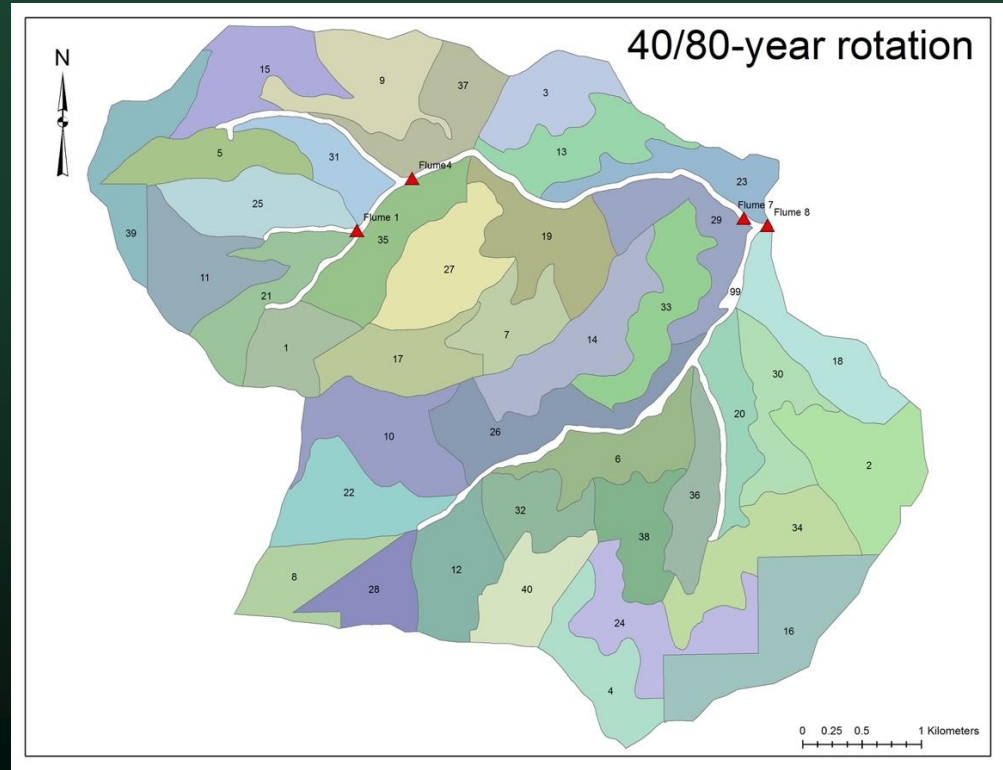
DHSVM schematic



(Wigmosta, 1994)

Simulated Harvest Units

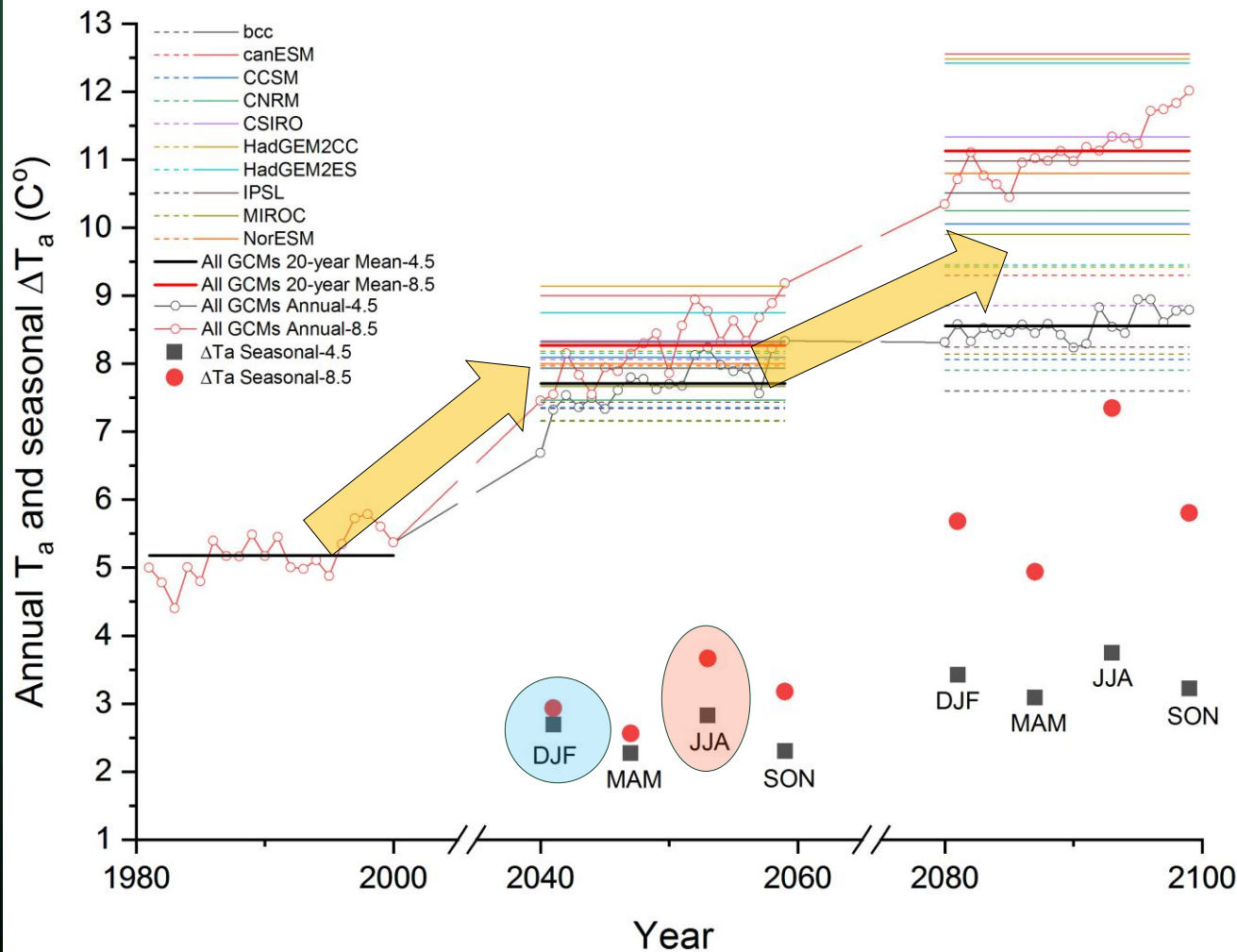
- 40 yr rotation ...
- ~2.5% per year
 - Higher than in practice



Projected Temperatures

AR5, RCP 4.5 & 8.5

- Warmer
- Less in winter
- High uncertainty

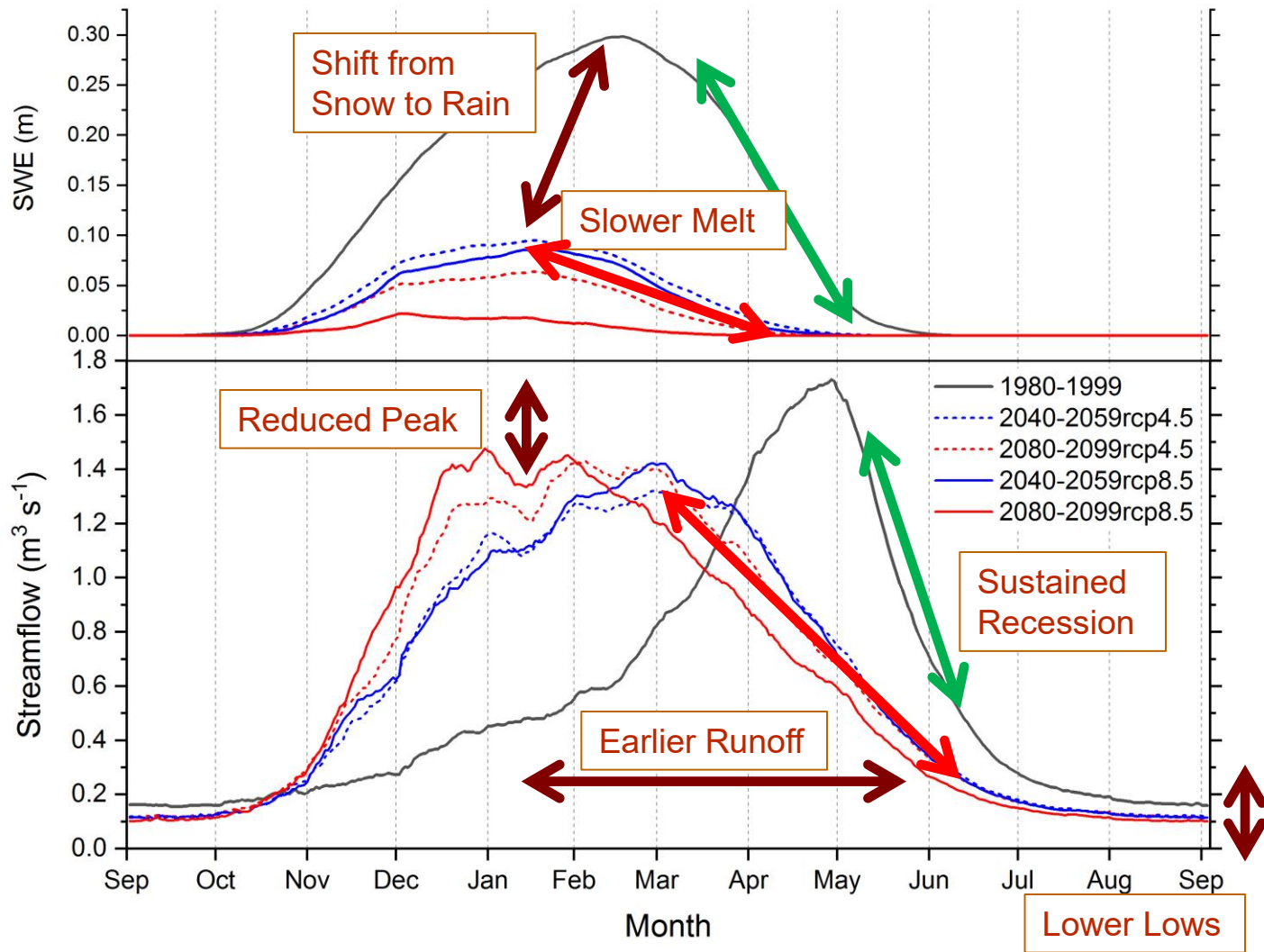


- Annual increase
- Wetter winters
- Drier summers

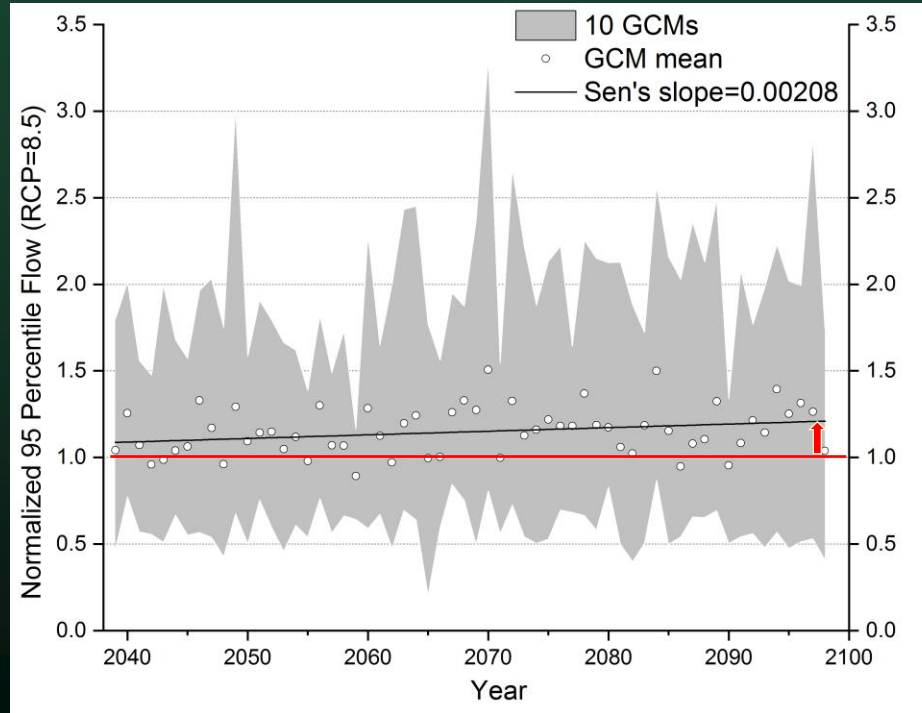
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- Figure 1 consists of two panels. The top panel is a line graph showing Annual (m year⁻¹) and Seasonal (normalized) Precipitation from 1980 to 2100. The y-axis ranges from 0 to 2. The x-axis shows years from 1980 to 2100, with a break between 2000 and 2040. The graph displays data for various GCMs (bcc, canESM, CCSM, CNRM, CSIRO, HadGEM2CC, HadGEM2ES, IPSL, MIROC, NorESM) and their 20-year means. The bottom panel is a scatter plot showing Seasonal (normalized) precipitation for DJF, MAM, JJA, and SON from 2040 to 2100. The y-axis ranges from 0 to 2. The x-axis shows years from 2040 to 2100, with a break between 2060 and 2080. The plot shows data for various GCMs and their 20-year means, with a legend indicating the seasonal means and the 8.5°C scenario.

Projected Snow and Streamflow

10 GCM ensemble



95th Percentile Flows RCP 8.5



Baseline: 1980- 2000

*preliminary
simulations

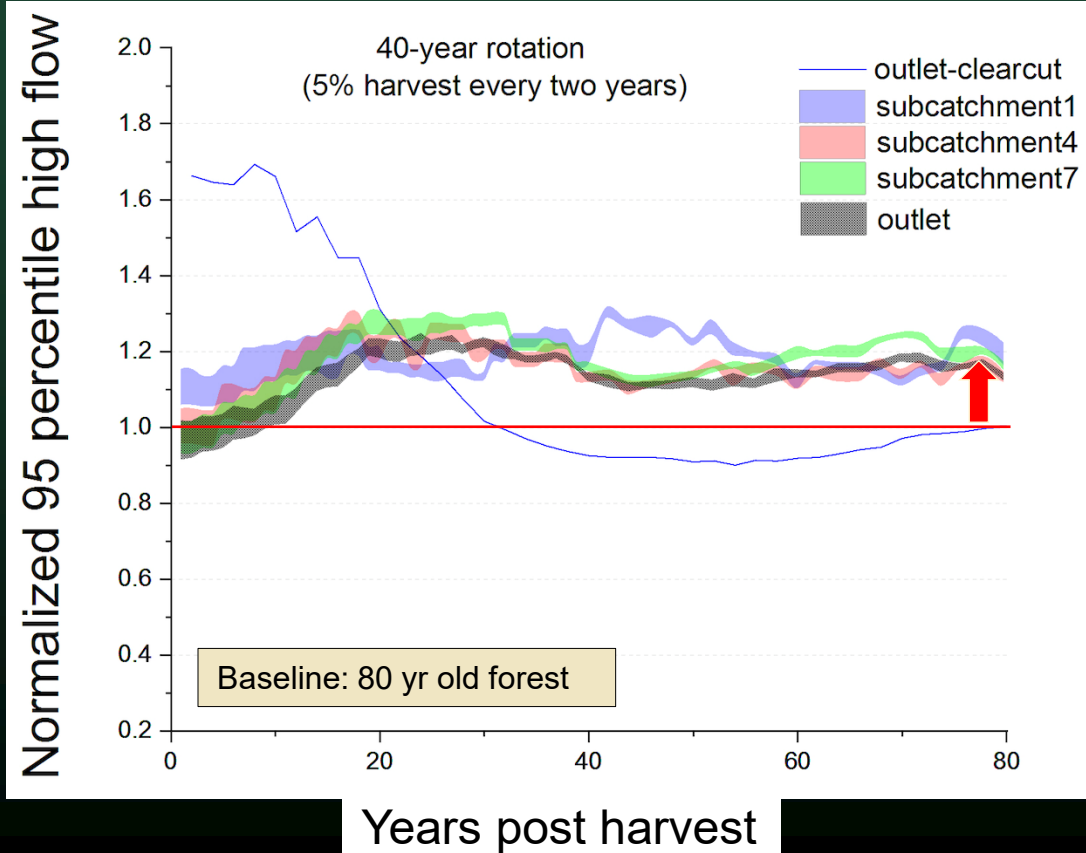
**Slight
Increasing
trend**

**Rain-on-snow
declining?**

Musselman et al., 2018

95th Percentile Flows

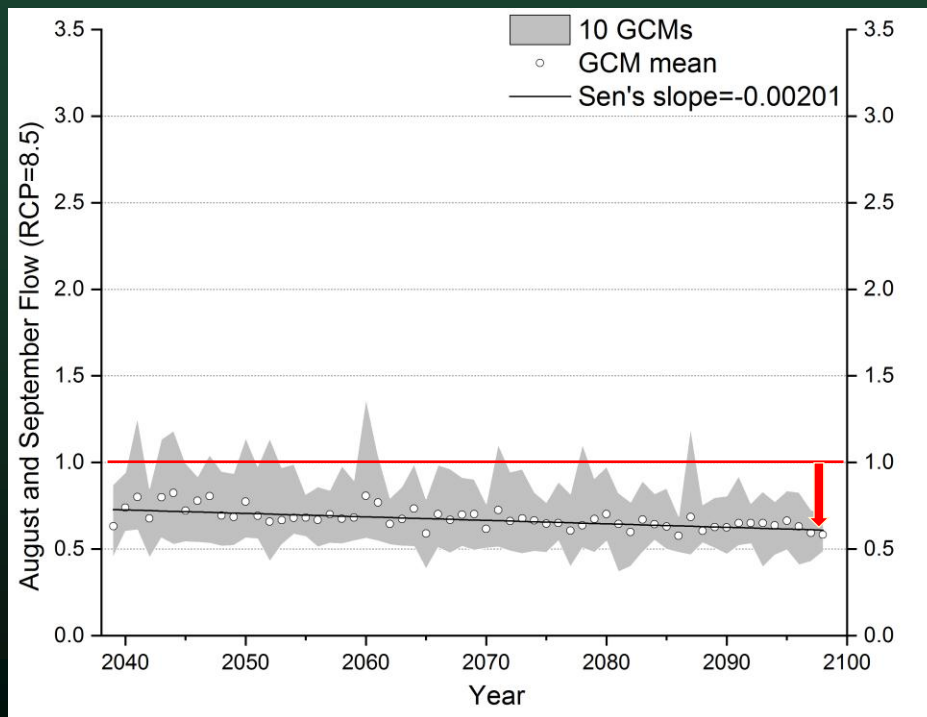
Land Cover Change



**Sustained
increases
at
larger
scales**

Aug - Sep Low Flows

RCP 8.5



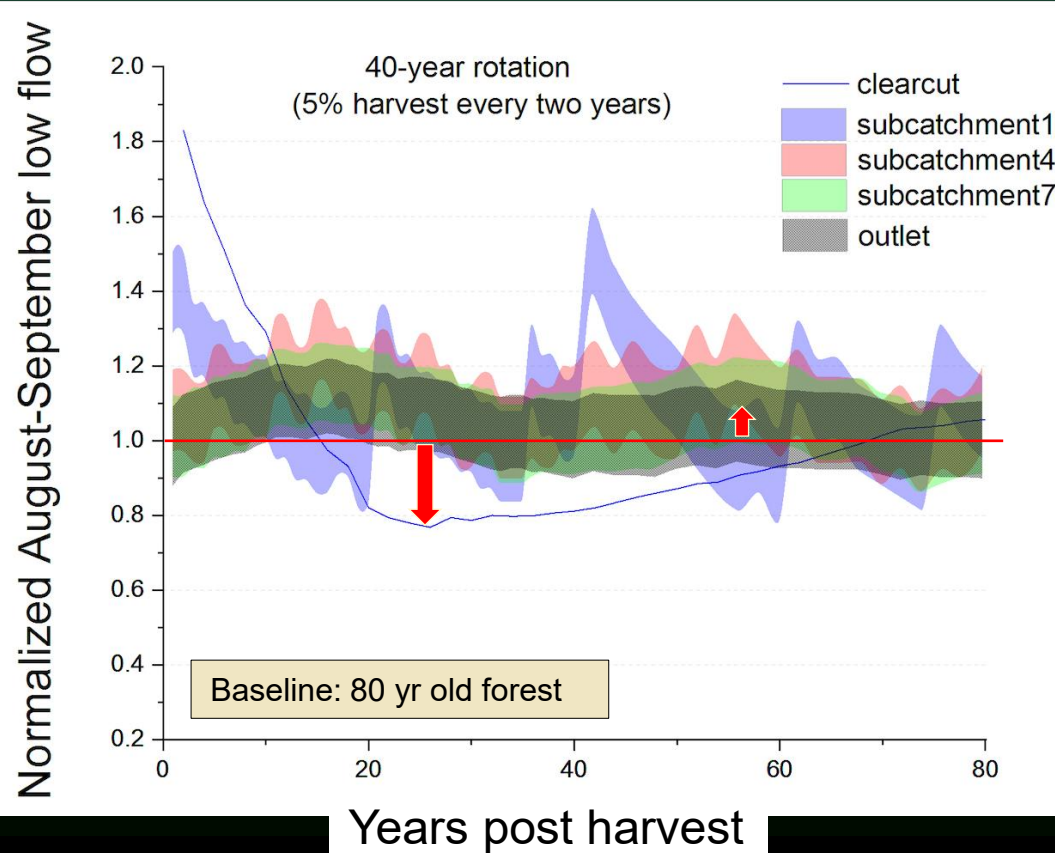
**Decreasing
trend**

Baseline: 1980- 2000

*preliminary
simulations

Aug – Sep Low Flows

Land Cover Change



Large Scales:
May slightly
offset climate
effects

Small Scales:
May offset or
exacerbate
climate effects

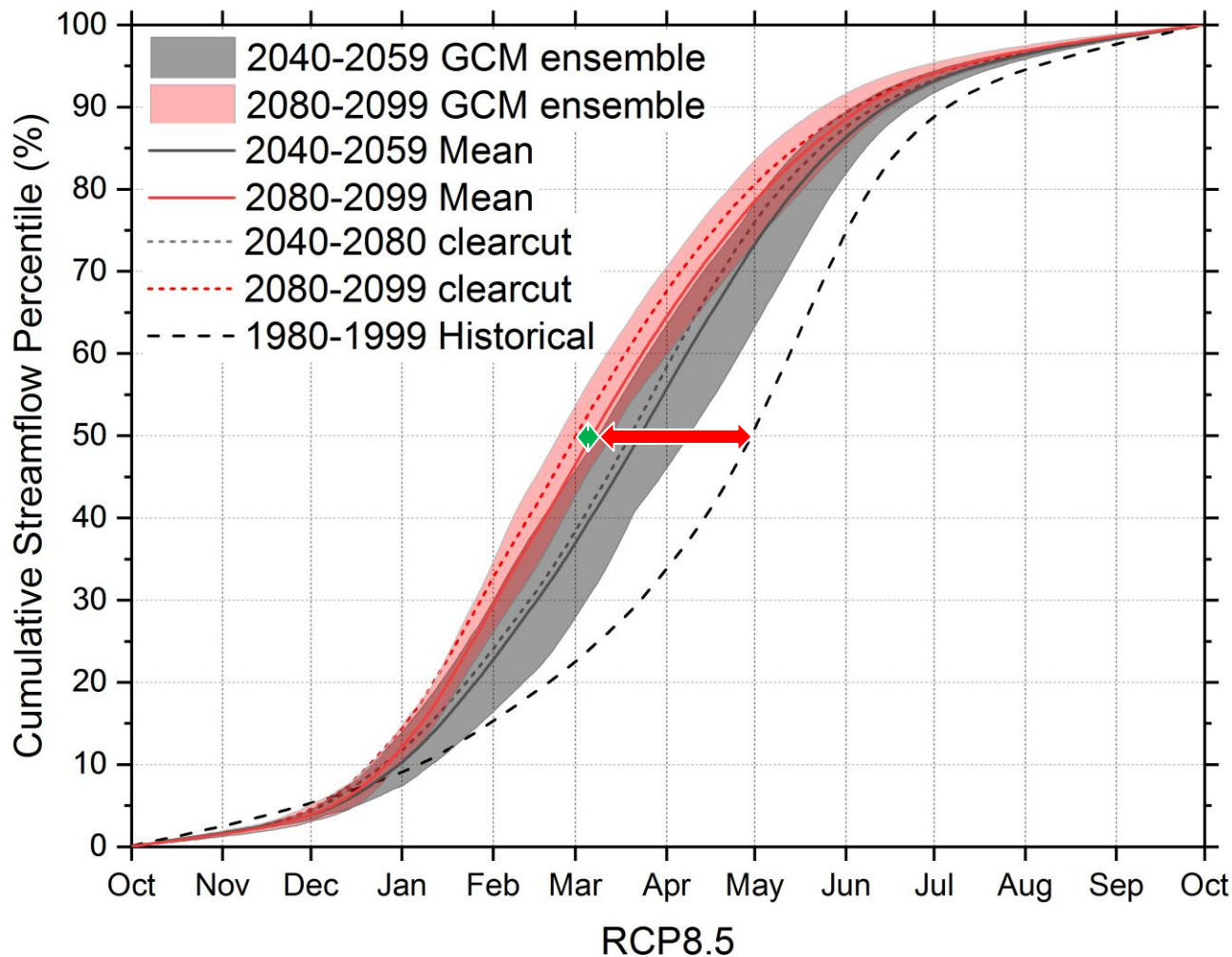
Depends on age

Land + Climate
Effect:

Cumulative Streamflow

Harvest
Effect is Minimal
Compared to Climate

- Based on 100%
Harvest!

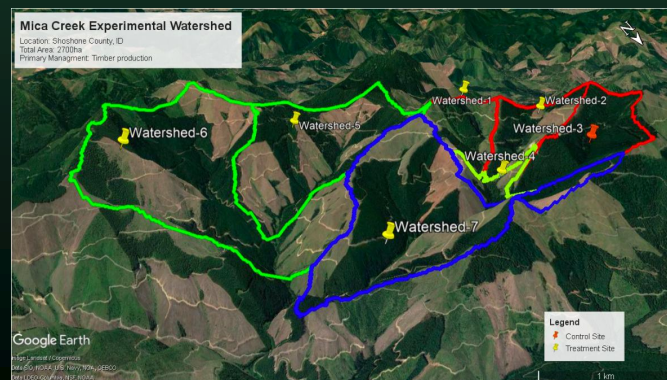


Summary

- Profound climate-driven flow regime changes are underway
 - Across all scales
 - Expected to slow in late century
- Climate changes have larger effects on timing
- Land cover changes have larger effects on flows
 - Harvest effects on flows **diminish or reverse as scale increases**
 - Reduces or exacerbates climate effects

Future Directions:

- Role of microclimate and snowpack variations
- Shifting lowflows and stream temperatures
- First update the watershed!



An aerial photograph of a mountainous region, likely a watershed, with a network of rivers and streams. The terrain is covered in green vegetation, with some areas of brown and tan, possibly indicating cleared land or different vegetation types. White contour lines are overlaid on the map, showing the elevation of the land. The text is centered within a white rectangular border.

Toward Mica v. 2.0...

**From Paired Watershed Experiment
to
Research Basin**

Site Access Improvements



Core Meteorological Monitoring Improvements

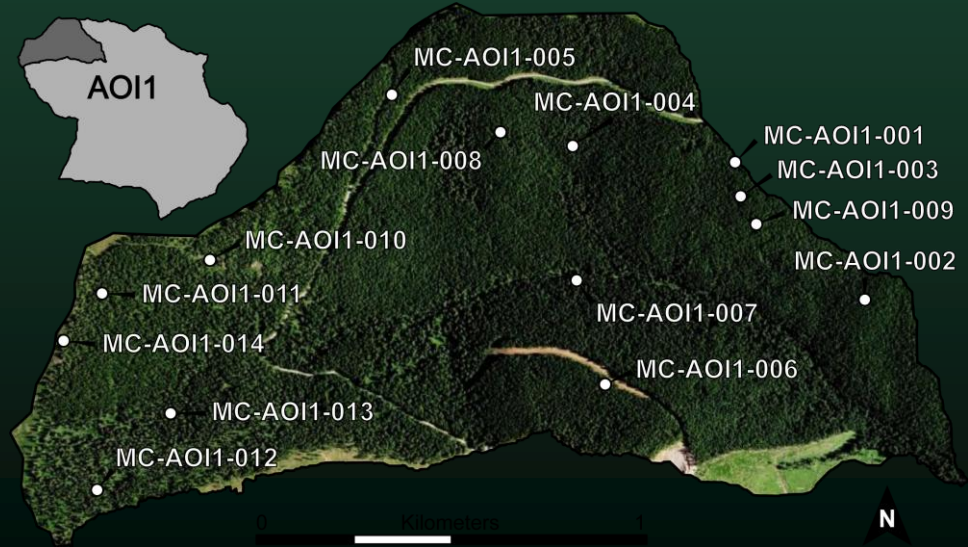


Core Gauging Stations Improvements



Expanded Subsurface Characterization

(Lohse & Patton, ISU)



Detailed Regeneration Monitoring



Thank You!

Questions?



University of Idaho

