Beetle Impacts on Runoff Timing and Volume at the Watershed Scale

What do we see when we measure what comes out at the bottom of a watershed?

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Beetle Impacts on Runoff Timing and Volume

- The few watershed-scale studies from past bark beetle infestations
- Forest-harvest experiments as analog for beetle infestations
- Watershed-scale studies of runoff from ongoing MPB infestation in Colorado & Wyoming
- Potential reasons for the lack of clear hydrologic response with ongoing MPB infestation

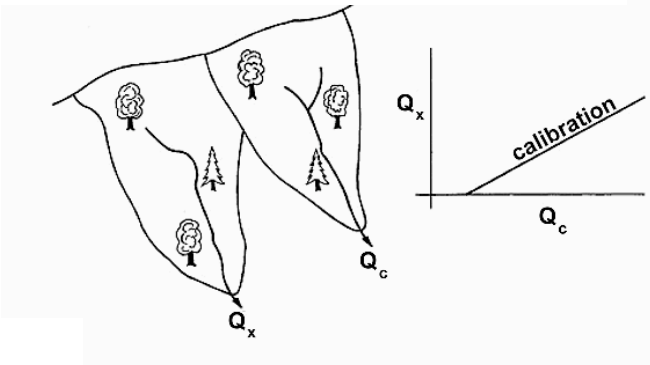
First-order expectations from process studies

- **Overall runoff volume (yield) may increase** as greater snowpacks accumulate, plus lower transpiration
- **Runoff timing may shift earlier** as snowpack subjected to greater melt forcings
- **Higher peak flows** due to both of the above

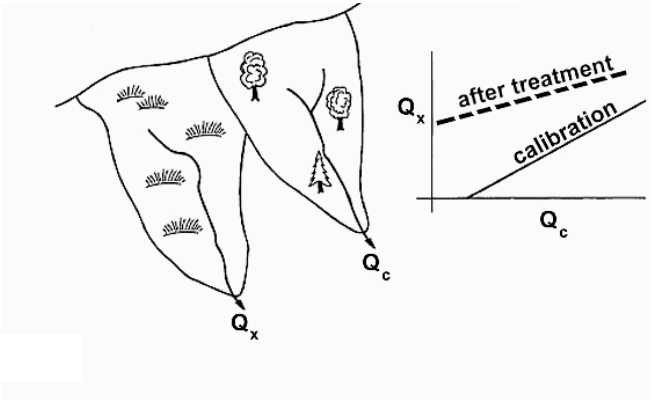
Inferring runoff changes – two approaches

Paired–watershed

Calibration across watersheds

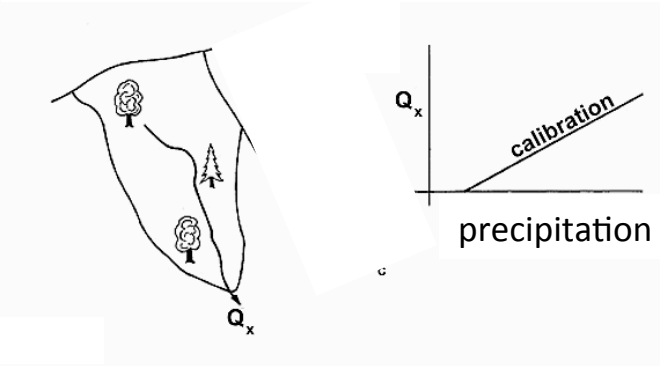


Post-treatment period



Single watershed

Calibration with basin precipitation



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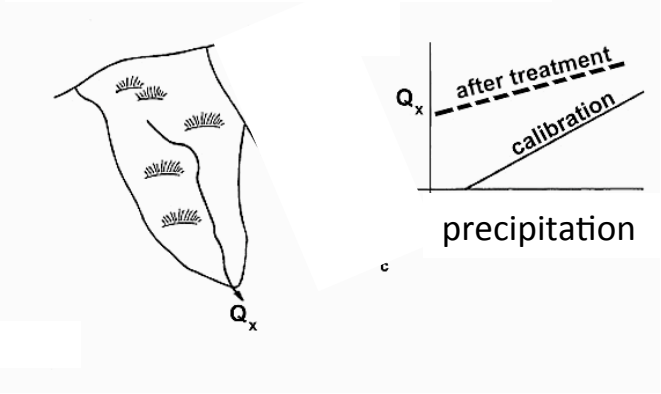


1940s spruce beetle outbreak in NW Colorado

- Most mature Englemann spruce and lodgepole pine killed across White River Plateau, 1941-1946
- Love (1955) compared beetle-affected White River flows with unaffected Elk River flows
- Inferred a **14% increase** in yield during infestation, and **22% increase** post-infestation
- Attributed increase to reduced interception and transpiration

1940s spruce beetle outbreak in NW Colorado

- Bethlahmy (1974, 1975) revisited Love's work and **confirmed increased yield (+15%)** persisting for ~25 years post-infestation in White River
- Also **16% yield increase** in beetle-impacted Yampa River basin
- Attributed persisting hydrologic effects to lack of forest regrowth in many areas (see photo)

1970s MPB outbreak in SW Montana

- Potts (1984) analyzed Jack Creek flows, where 35% of "total timber" killed
- Inferred following hydrologic changes:
  - **15% increase** in total yield
  - **2-3 week advance** in runoff peak
  - 10% increase in low flows
  - Little change in peak flows
- Ascribed these changes to reduced transpiration, alteration of snow accumulation and melt, and soil moisture changes

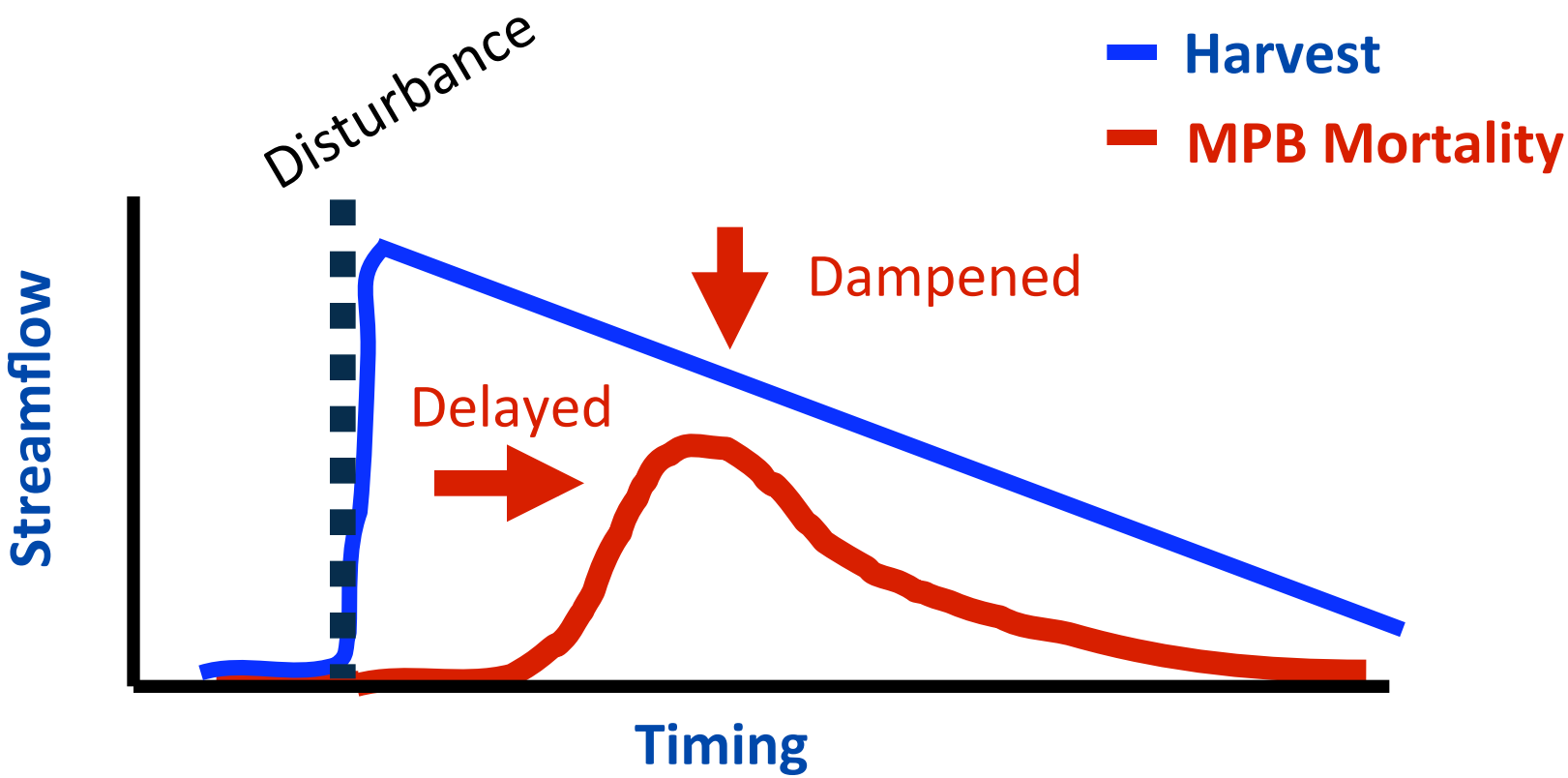
Forest harvest experiments as analog for beetles

- Fool Creek, CO (Fraser Exp. Forest): 50% basal area removed, **30% increase** in yield, hydrologic recovery after ~60 years
- Bosch and Hewlett (1982) reviewed 94 studies of hydrologic changes following vegetation removal
  - *No detected change* under 20% canopy removal, or under 20" annual precipitation
  - In the several studies from interior West forests, yield **increased 20% to >100%**

Forest harvest experiments as analog for beetles

- Why forest harvest may not be an appropriate analog for beetle impacts on hydrology:
- *Canopy and woody material removed instantaneously*
- *Removal of/damage to understory vegetation*
- *Compaction of soils by harvesting equipment*

Forest harvest vs. Beetle mortality – conceptual model



Model by Elder, Hubbard, and Rhoades (USFS RMRS) – based on Fraser observed harvest response, and hypothesized MPB response

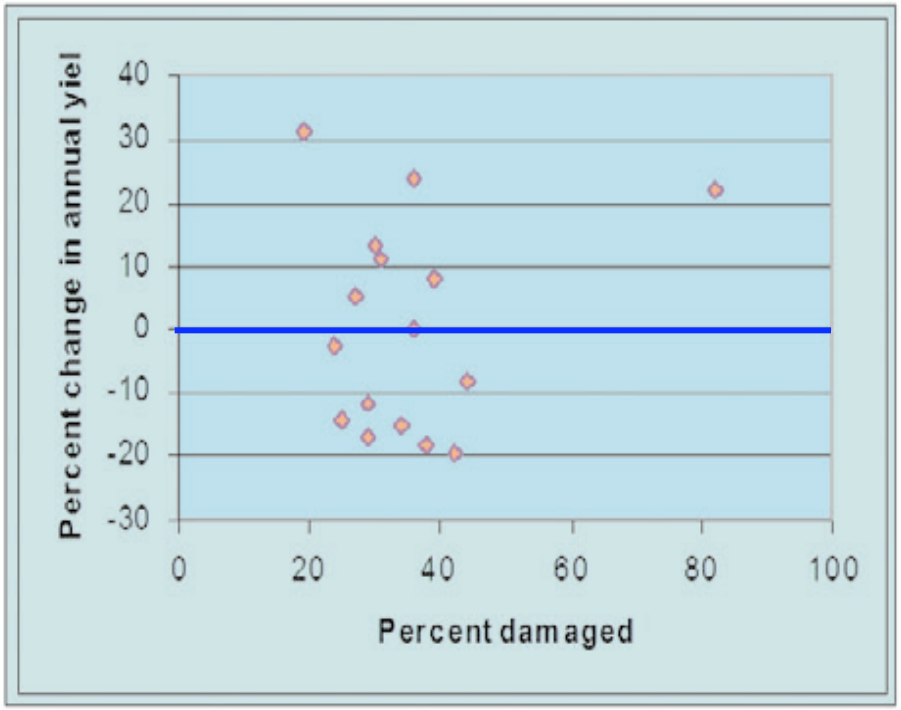
Ongoing MPB infestation in CO & WY

Williams Fork Mountains, north-central Colorado

Photo courtesy of USGS

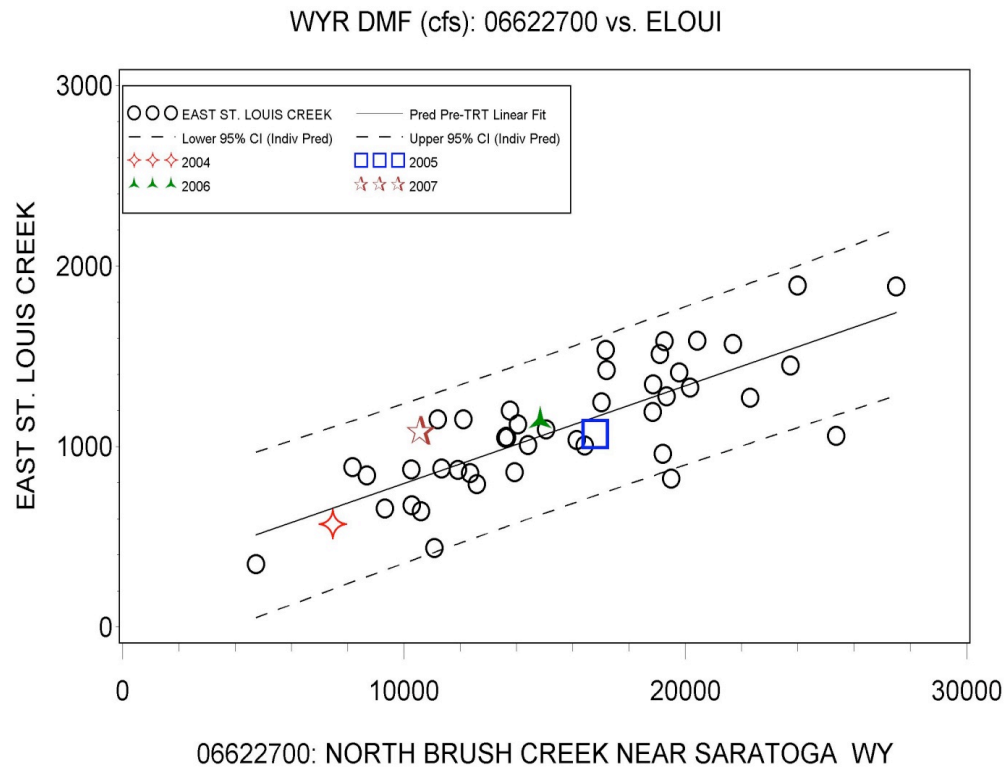
Ongoing MPB infestation in CO & WY

- **STUDY #1:** Stednick and Jensen (2007) paired **16 MPB-affected watersheds in W. CO, S. WY** with unimpaired watersheds
- Found variable yield responses, with **more *decreases* than increases**
- Understory - important factor?



Ongoing MPB infestation in CO & WY

- **STUDY #2: Fraser Exp. Forest** – flow changes in E. St. Louis Creek vs. North Brush Creek, WY (Elder et al, unpublished)
- After onset of MPB (2004-2007), flow relationship **still within the envelope of past variability** (dashed lines)
- 2007 – North Brush Creek hit by MPB, so no more control



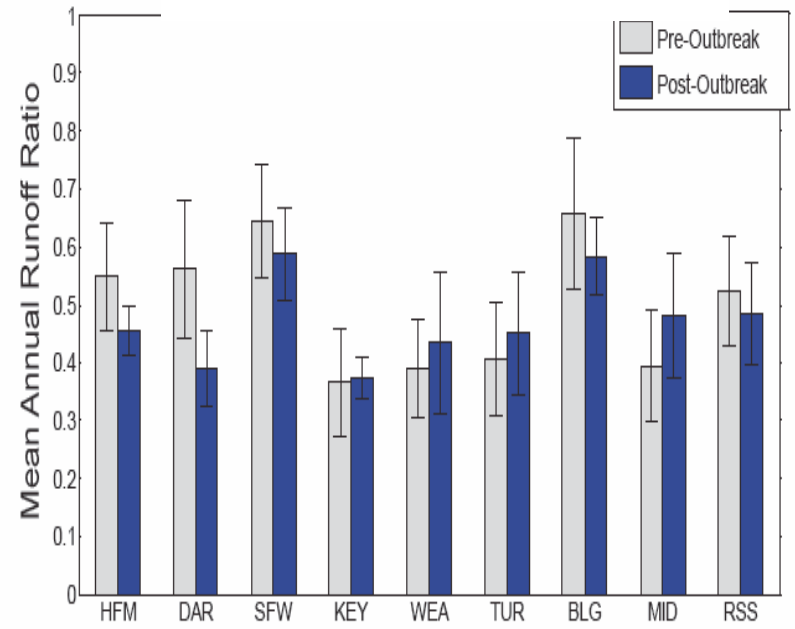
Pre-TRT = data up through 2003

Ongoing MPB infestation in CO & WY

- **STUDY #3:** Brooks, Somor et al. assessed runoff:precip ratio in **8 beetle-affected watersheds in western CO**
- Runoff ratio for post-infestation period **showed highly variable response**
- Indications that local climate factors (warming) may be overriding the vegetative response

Decrease: 4 watersheds

Increase: 4 watersheds



9th watershed (relatively uninfested) also **decreased**

Ongoing MPB infestation in CO & WY

- **No studies** have systematically examined potential shifts in ***runoff timing*** from current infestation
- However, earlier runoff has been detected and attributed to *other* causes for some or all of this region:
  - Regional spring warming (Clow 2010)
  - Dust-on-snow (Painter, Deems, et al.)
- Also, lower-flow years (2000-2004; 2006-2008) are strongly associated with earlier runoff regardless of other factors

Why is the watershed-level hydrologic response to the current MPB infestation not conforming to expectations?

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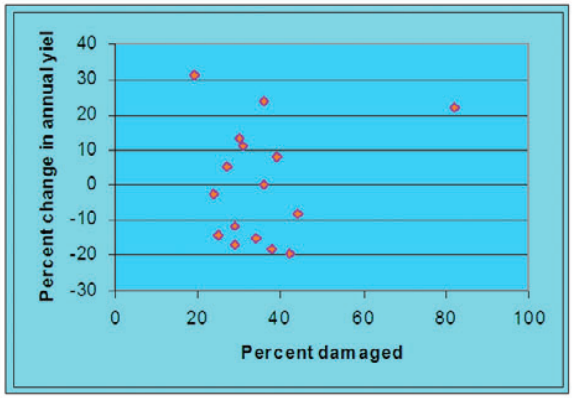

- Previous beetle studies occurred in different forest types (spruce-fir) or climates (western MT)
- Forest harvesting may be poor analog for beetle infestation
- Understory response was under-appreciated; may take up "slack" in transpiration

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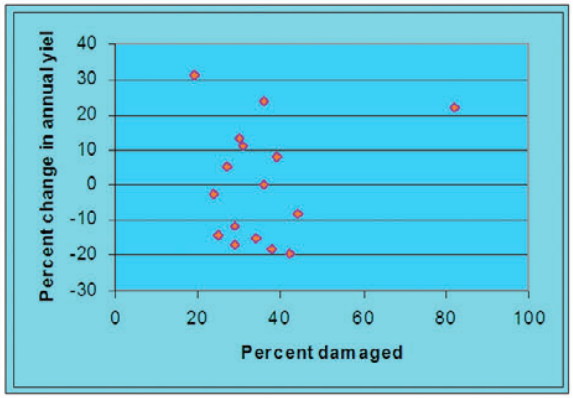

- A yield response may yet emerge from noise of variability (lag model of response)
- Warming climate and low precip in much of 2000s may have damped/obscured the vegetation-driven response
- Impacts of dust-on-snow also may be altering precip-flow relationships, making detection difficult

Lessons for Utah watersheds?

- Beetle infestation does not necessarily lead to significant changes in runoff characteristics
- However, spruce forests may be more prone to runoff changes than lodgepole due to higher precip and runoff efficiency
- Salvage harvest may cause changes in runoff greater than initial effects of infestation
- Identifying control watersheds and climate data for establishing baselines will facilitate monitoring of impacts
- But warming and dust-on snow may confound detection of beetle signal in runoff