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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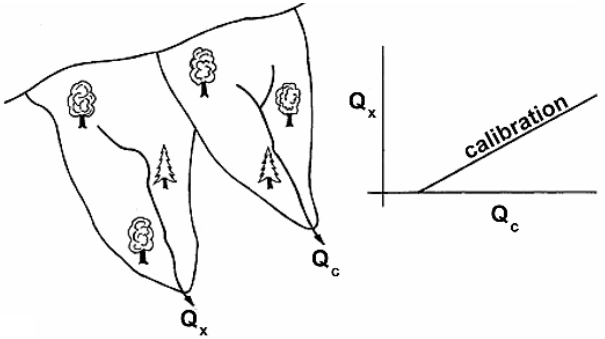
General expectations from process studies

- **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

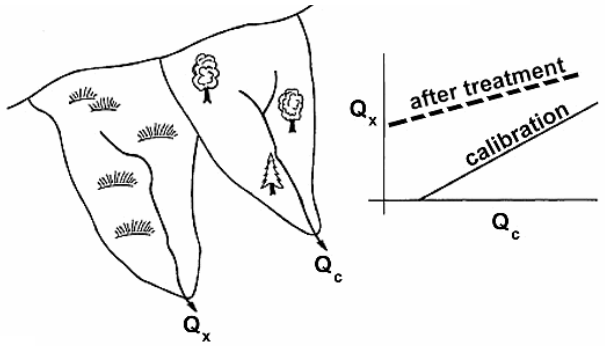
Inferring runoff changes – two approaches

Paired–watershed

Calibration across watersheds

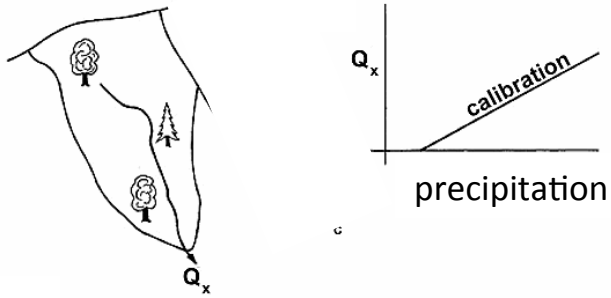


Post-treatment period

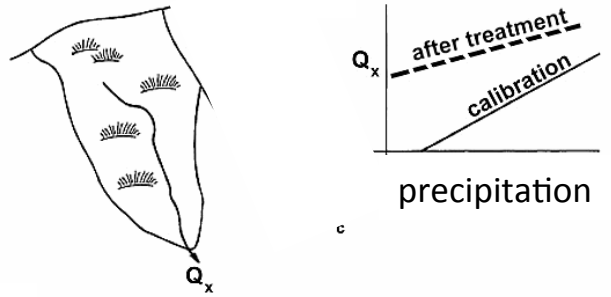


Single watershed

Calibration with basin precipitation



Post-treatment period



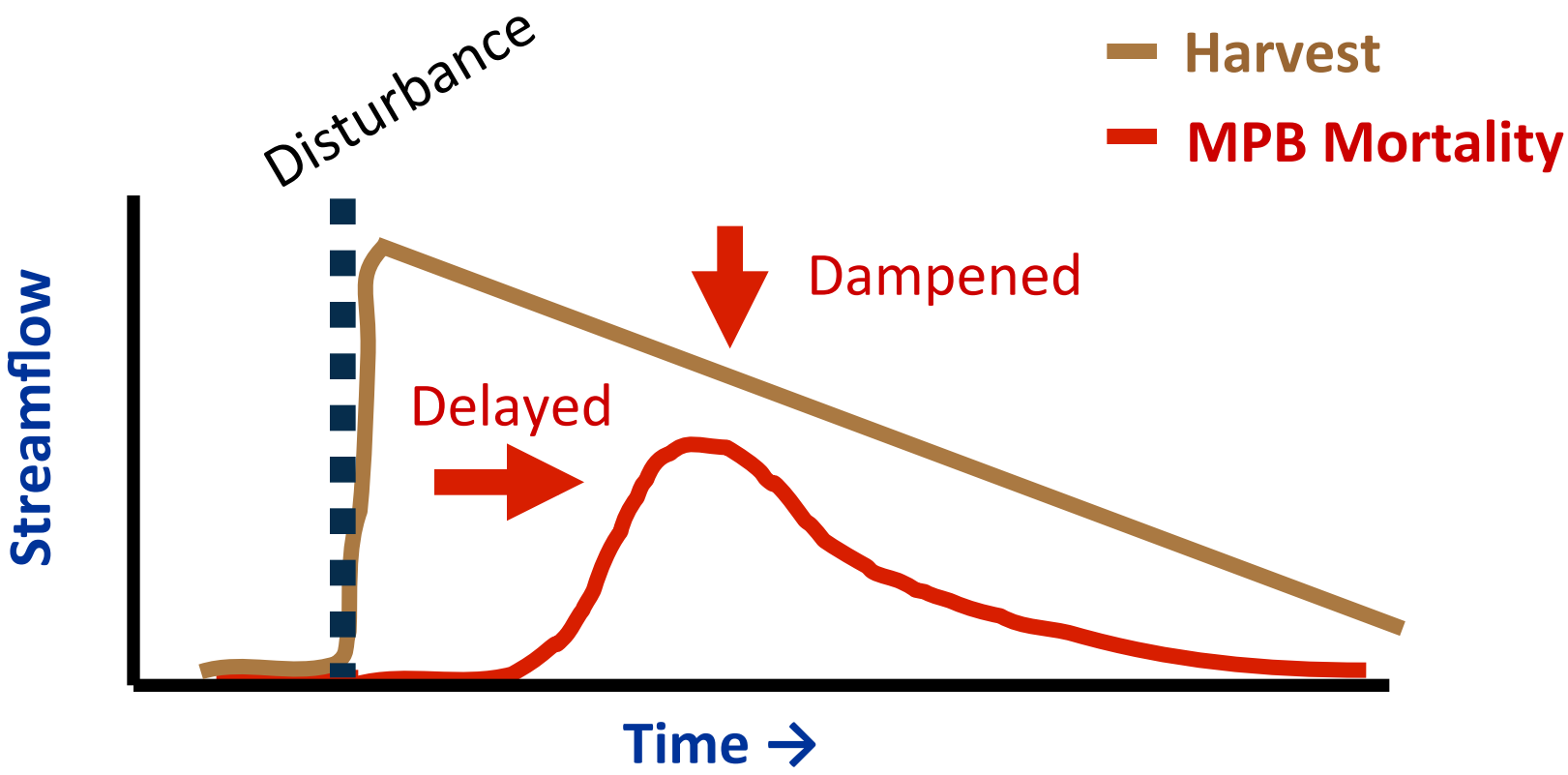
Forest harvest experiments as analog for beetles

- 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

1940s spruce beetle outbreak in NW Colorado

- Love (1955) compared beetle-affected White River flows with unaffected Elk River flows
- Inferred a **14% increase** in runoff during infestation, and **22% increase** post-infestation

- Bethlahmy (1974, 1975) **confirmed increased yield (+15%)** persisting for ~25 years post-infestation in White River
- Attributed persistence of runoff change to lack of forest regrowth in many areas (see photo)

Most mature spruce and lodgepole were killed across the White River Plateau

-> Expectation for San Juans: more runoff

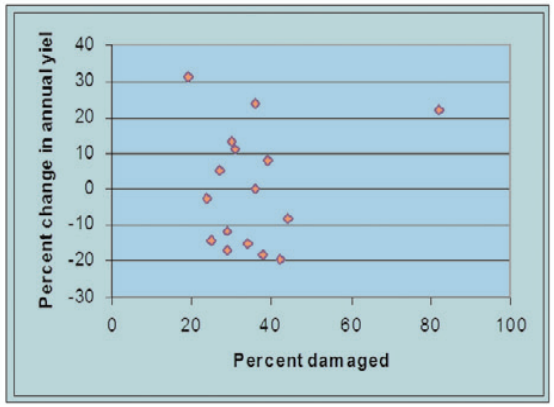
The 2000s MPB infestation in Colorado

Williams Fork Mountains, north-central Colorado

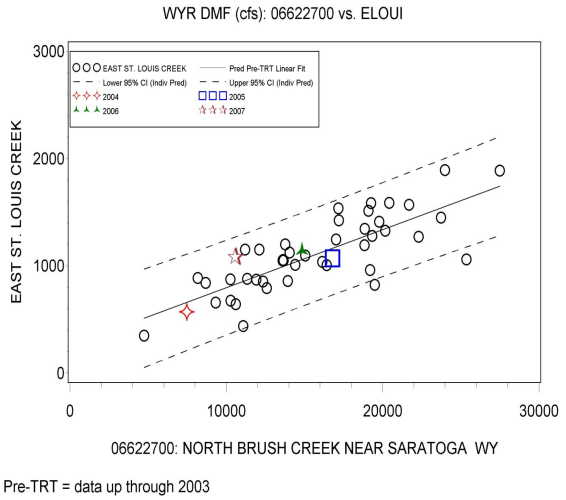
Photo courtesy of USGS

Runoff studies from the 2000s MPB infestation

- Stednick and Jensen (2007) – 16 paired watersheds; ***variable runoff responses, with more decreases than increases***



- Elder et al., Fraser Experimental Forest – one paired watershed, ***no changes in runoff beyond prior range of variability***



- Brooks, Somor et al. - runoff:precip ratio in 8 beetle-affected watersheds ***did not consistently change***

-> Expectation for San Juans: Unclear

What about the *timing* and size of peak flows?

- **No studies** have systematically examined potential shifts in ***runoff timing*** **and** ***peak flows*** at the basin or watershed scale from current MPB infestation
- Stand-level studies show one week earlier initiation of snowmelt due to additional tree litter but unclear if those impacts scale up
- Earlier runoff in western Colorado in recent decades has been attributed to *other* causes:
  - Regional spring warming (Clow 2010)
  - Dust-on-snow (Painter, Deems, et al.)
- Recent lower-flow years (2000-2004; 2006-2008) are strongly associated with earlier runoff regardless of other factors

Lessons from the MPB infestation regarding runoff

- **Scale matters**—what happens at the tree/stand scale may not represent larger scales
- **Forest type matters** – spruce/fir is higher, colder, snowier wetter than lodgepole – so will be affected more?
- **Disturbance matters** - forest harvesting may not be good analog for beetle infestation; spruce beetle causes higher mortality than MPB
- **Understory matters** – Understory vegetation and surviving canopy trees can take up "slack" in water use
- **Variability matters** – Year-to-year variation in snowpack, etc., is much greater than potential impacts

More considerations about runoff changes

- 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
- A water yield response may yet emerge from noise of variability

What to expect for San Juan watersheds?

- MPB: Widespread tree mortality in CO lodgepole forests has *not* led to consistent changes in runoff characteristics
- However, *spruce-fir* forests are likely more prone to post-beetle runoff changes due to higher precipitation and greater loss of LAI
- **So we might expect higher runoff and earlier peak flows from San Juan watersheds with high spruce mortality**

What to expect for San Juan watersheds?

- Identifying control watersheds and climate data for establishing baselines will facilitate monitoring of impacts
  - Warming temperatures and dust-on-snow may confound detection of "beetle signal" in runoff
- Salvage harvest can cause changes in runoff greater than effects of infestation