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
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