How Low Will They Go?

The response of headwater streams in the Oregon Cascades to the 2015 drought

Sarah Lewis, Anne Nolin, Laura Hempel, John Selker,
Cara Walter, Clement Roques - *Oregon State University*
Gordon Grant - *USFS PNW Research Station*
Anne Jefferson - *Kent State University*

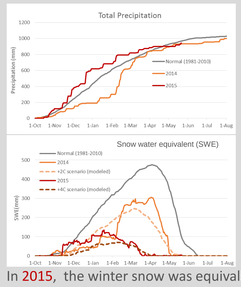
Funded by NSF #1551483-EAR and USDA Forest Service PNW Research Station

A landscape laboratory

High Cascade & Western Cascade Terrains

+

A very warm winter



In 2015, the winter snow was equivalent to a 4°C climate warming scenario.

=

A glimpse into the future of Oregon streamflows?

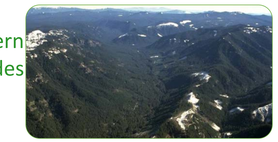
- The 2015 drought represents a unique opportunity **to test fundamental hypotheses of mountain streams** response to anticipated and dramatic changes in amount and timing of recharge.
- Specifically, how do headwater streams respond to low recharge in terms of l**ate summer flow and extent of channel network?**
- As the summer progressed, **flows did not reach record lows**. What can this tell us about the hydrogeologic landscape?

Spring-fed or Surface Flow? Contrasting Hydrogeologic Regimes

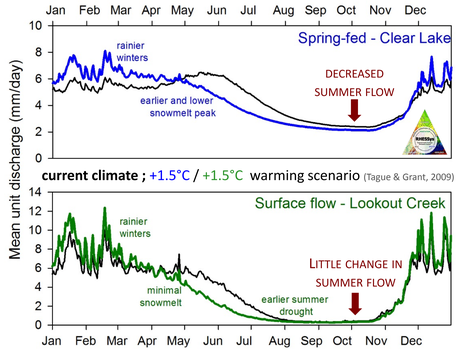
High Cascades

Precipitation infiltrates into young lava flows and emerges much later at large springs. Spring-fed streams have muted winter peaks and sustained baseflow.

Western Cascades

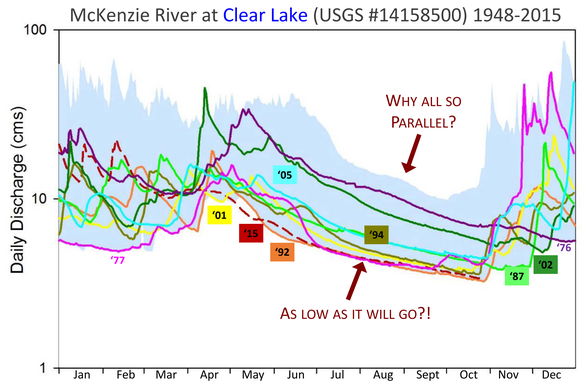


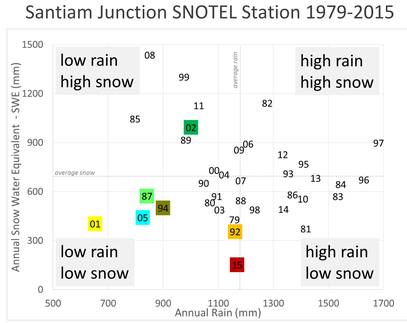
Precipitation and snowmelt run off hillslopes directly and rapidly to stream channels. Surface flow streams have flashy winter floods and summer drought.



PROJECT HYPOTHESIS: Summer flow in spring-fed streams will be *more sensitive* to climate warming

Regional Lows Not as Low as Predicted?!



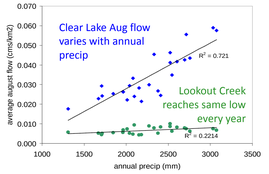


Summer flow is influenced by:
- magnitude of winter precipitation
- timing of last recharge pulse
- previous year's low flow
- when it starts raining in the fall

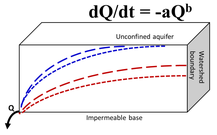
WHAT ABOUT SEQUENCING OF DROUGHT YEARS?

How Big *is* the High Cascade Aquifer?

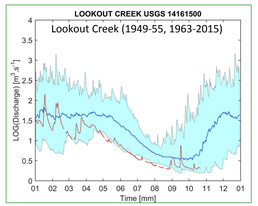
- Why didn't the spring-fed streams reach record lows this year?
- Is the High Cascade aquifer even larger than we previously thought?



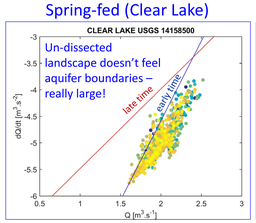
$$dQ/dt = -aQ^b$$



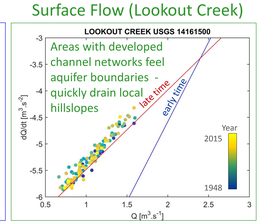
Using a reference case scenario early- and late- time solutions to the Bousinesq Equation for the draining of an unconfined aquifer:
(Brutsaert & Nieber, 1977; Rupp & Selker, 2005)



Spring-fed (Clear Lake)

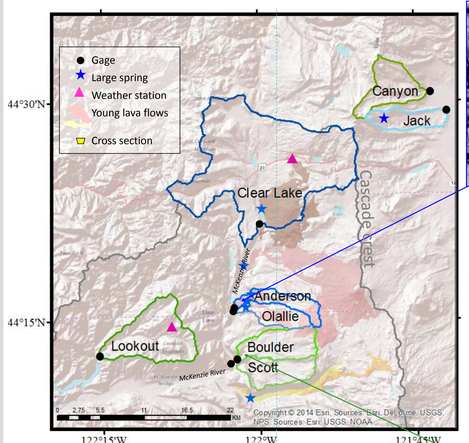


Surface Flow (Lookout Creek)



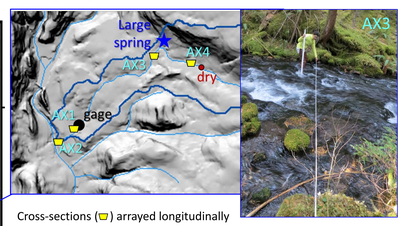
Clear Lake still has plenty of water to give, even at the end of the summer, while Lookout Creek exhausts its storage every year.

★ Study Watersheds

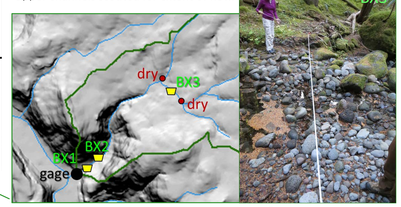


Spring-fed (blues) & surface flow (greens) study watersheds in the McKenzie & Deschutes Basins, Oregon

Spring-fed, Anderson Creek (19 km²)



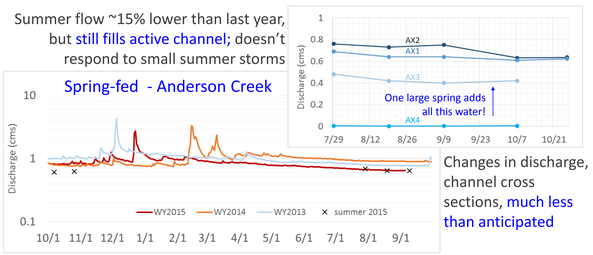
Cross-sections (▽) arrayed longitudinally measure flow, temp, wetted width/depth, & photos to supplement long-term gages. Upper channels scouted for extent of flow.



Surface Flow, Boulder Creek (33 km²)

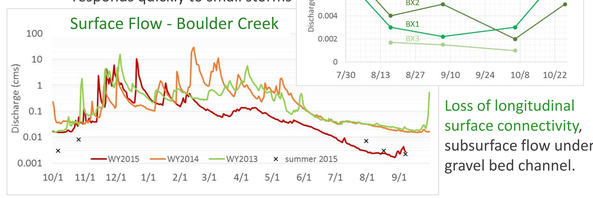
Small Watershed Streamflow Measurements

Summer flow ~15% lower than last year, but still fills active channel; doesn't respond to small summer storms



Changes in discharge, channel cross sections, much less than anticipated

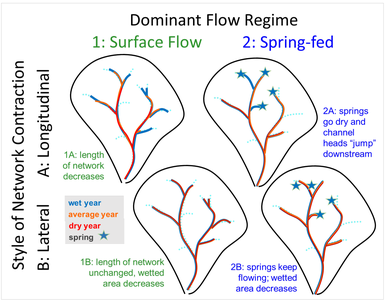
Order of magnitude lower than last year, is COLD (deep source for baseflow?); responds quickly to small storms



Loss of longitudinal surface connectivity, subsurface flow under gravel bed channel.

Stream Network Contraction

PROJECT HYPOTHESIS: Surface flow and spring fed systems network will have different styles of accommodating decreasing flow.



Data analysis underway! Some early observations:
- Little to no longitudinal contraction observed due to lack of change in discharge over study period?
- Surface fed: channels "V" shaped, width changes with flow; spring fed: channels are rectangular and relatively insensitive to changes in width.

Preliminary Synthesis

- We expected record low flows given the low snow, warm winter of 2015, equivalent to a 4°C warming scenario.
- All of our small watersheds recorded the lowest flows we've seen, but networks experienced little to no longitudinal contraction over the summer recession.
- Flows across the region approached, but only rarely and briefly exceeded, record lows.
- The High Cascade aquifer must be very, very large.
- 2016 is predicted to be another warm winter with year of average precipitation. How low might the streams go next summer?