Controls on streamflow intermittence in the Colorado Front Range

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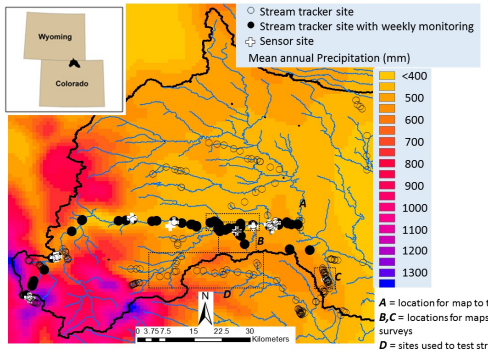
STREAMTRACKER
Community Powered Stream Monitoring

ECOSYSTEM SCIENCE AND SUSTAINABILITY
COLORADO STATE UNIVERSITY

COLORADO FRONT RANGE STREAMS

The study area is the upper Cache la Poudre basin on the east slope of the Rocky Mountains in northern Colorado. The climate is primarily semiarid, with mean annual precipitation ranging from 400-1400 mm. Elevation ranges from 1500-4100 m, with intermittent winter snow at low elevations and persistent winter snow at high elevations.



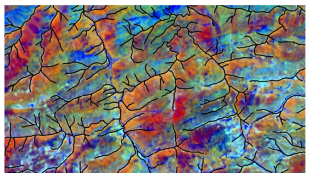
A = location for map to the right
B,C = locations for maps of field surveys
D = sites used to test stream type prediction model

MONITORING INTERMITTENCE

PRESENCE/ABSENCE OF STREAMFLOW

Crowd-sourced visual observations

Light sensors modified to detect flow presence



Landsat change detection, air photos

STAGE/DISCHARGE

Staff gauge, capacitance rod
Salt dilution discharge

QUESTIONS

We used these different types of observations to address the following questions:

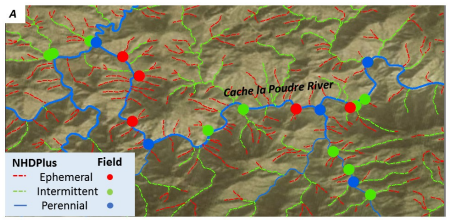
SPATIAL: How do observed stream types compare to GIS data products? Can we reconstruct spatial patterns of streamflow with remotely sensed imagery?

TEMPORAL: When and where do streams flow? Can we reconstruct temporal patterns of intermittence using the Landsat record?

CONTROLS: How do different watershed variables relate to intermittence, and can we predict stream type using these variables?

SPATIAL PATTERNS OF INTERMITTENCE

Comparison to National Hydrography Dataset (NHDPlusV2) at points



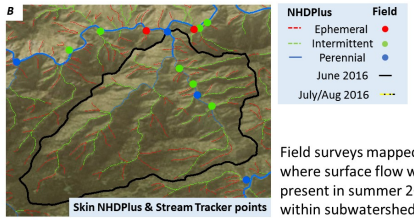
Segment of stream tracker points along the Cache la Poudre River. Field classifications are from ~weekly observations May-Sept 2017.

- Ephemeral = no flow observed;
- Intermittent = flow observed at least once;
- Perennial = always flowing.

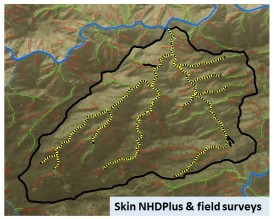
Type	Field sites	NHDPlus class match	NHDPlus flowlines not observable
Ephemeral	7	43%	105
Intermittent	22	73%	79
Perennial	19	37%	1
Total	48	60%	185

We monitored tributaries intersecting the main highway along the Cache la Poudre River. Most of these were near an NHD flowline, for which 60% of stream type classes matched observations. Many NHD flowlines were not observed in the field because of vegetation or other cover or because the channel was not present.

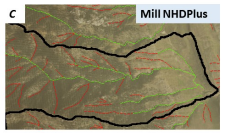
Spatial patterns from field mapping

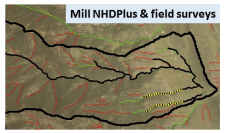


Field surveys mapped where surface flow was present in summer 2016 within subwatersheds.



In the higher elevation burned watershed (Skin), where outlet flow has been perennial, channel length with flow was similar throughout the summer, with fewer flowing channels than mapped in NHDPlus.



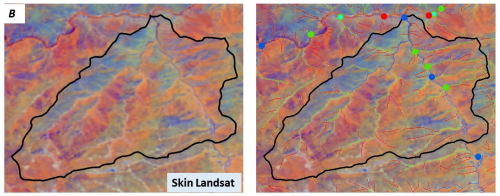


In the lower elevation unburned watershed (Mill), where outlet flow is intermittent, channel length with flow decreased dramatically over the summer.

Spatial patterns from Landsat

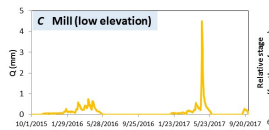
Image of the change in tasseled-cap indices from Landsat 6/8/17-8/27/17 picks up differences along the channel network.

Δbrightness
Δgreenness
Δwetness

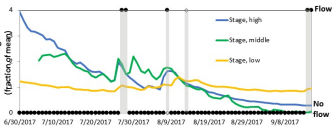


Cyan = both greenness and wetness increased

TEMPORAL PATTERNS OF INTERMITTENCE

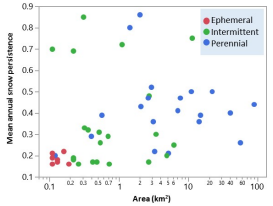


Mill Creek flows seasonally in the winter, with peak flow during snowmelt. Mill had no flow during the time period shown to the right.



Streams with large enough drainage area and high enough precipitation retain flow through the summer. Others flow only briefly after summer rains, which tend to cover only small areas.

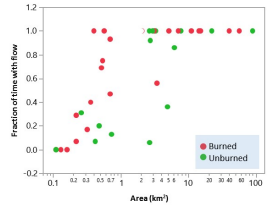
CONTROLS ON INTERMITTENCE



Variable	R^2 with flow fraction
ln(Area)	0.47*
Snow Persistence	0.34*
Slope	0.18*
Temperature	0.10*
ln(precipitation)	0.13*
Aspect	0.06

*α<0.05

For weekly stream tracker points, the fraction of time with flow correlates best with drainage area and snow persistence, the fraction of time from Jan-Jun with snow present.



Fraction of time with flow also tends to be higher for streams affected by the 2012 High Park Fire compared to unburned areas with similar drainage areas.

Prediction: A partition analysis model using area, slope, and snow persistence predicts 83% of flow classes correctly. On a test set of stream points (D in location map), this model predicts 76% of stream types correctly.

A partition analysis model using the Landsat indices for the images to the left is 80% correct for 6/8/17 and 84% correct for 8/22/17.

KEY FINDINGS/REMAINING QUESTIONS

- **SPATIAL:** NHD maps higher drainage density than observed in the field
  - Questions: How can we map more of the drainage network efficiently? Can we develop Landsat-based flow mapping models that are transferable between locations and dates?
- **TEMPORAL:** Most streams in the study area are intermittent, with flow during winter and spring and occasionally after summer rains
  - Question: How frequently do we need to measure flow to characterize intermittence accurately?
- **CONTROLS:** Likelihood of perennial flow increases with snow persistence and the log of drainage area
  - Question: How can we to analyze geologic controls on streamflow across a large area?

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Thank you to all who contributed stream observations

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