Response of a small mountain river to a sediment pulse tracked using sub-canopy UAV surveys

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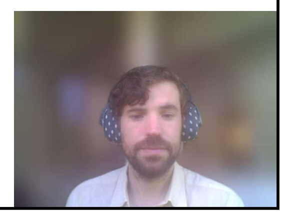
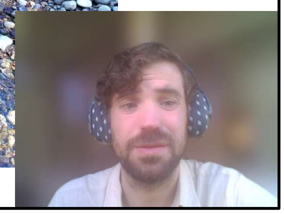


Hello everyone, I'm Conor McDowell a PhD student at UBC, and on behalf of my collaborators, Carina Helm and Dave Reid from Hatfield Consultants and Marwan Hassan from UBC, I'd like to present to you some work we've been doing tracking the response of a small mountain river to a sediment pulse with UAVs

East Creek, British Columbia

- Narrow (~3m wide) supply-limited forested river reach
- Monitored since 2003
- in 2018, upstream culvert was replaced with a bridge releasing a pulse of sediment



Our study site is East Creek, a small mountain stream in British Columbia just East of Vancouver.

It is a narrow, forested reach, with a precipitation dominated hydrograph, that has been partially cut off from upstream sediment supply since the 70s.

We've been monitoring the reach since 2003, so we have a lot of information about its historical morphodynamics

In 2018, those morphodynamics changed, as a culvert immediately upstream was replaced with a bridge, releasing a pulse of sediment.

On the left, here, you can see a picture of the upstream culvert, this is taken looking upstream. On the right, you can see the bridge that replaced it, taken from about the same spot. Notice the built-up slope and rip-rap. That wedge of sediment trapped behind it was made available to the downstream reach.

Research Question

1. What is the geomorphic response of the channel to the sediment pulse released by the bridge installation?
   - Sediment storage, where available, but channel morphology persists!

Upper reach is a narrow rapid section, downstream reach is a wider pool-riffle section

I'm going to oversimplify the channel here, but broadly you can split the study reach in two. Upstream, as you can see in the photo on the left, there is a narrow, about 50m long, channel segment with a relatively featureless bed. Further downstream, as you see on the right, the channel gets a bit wider, and has notable, if suppressed, topographic features that can store sediment.

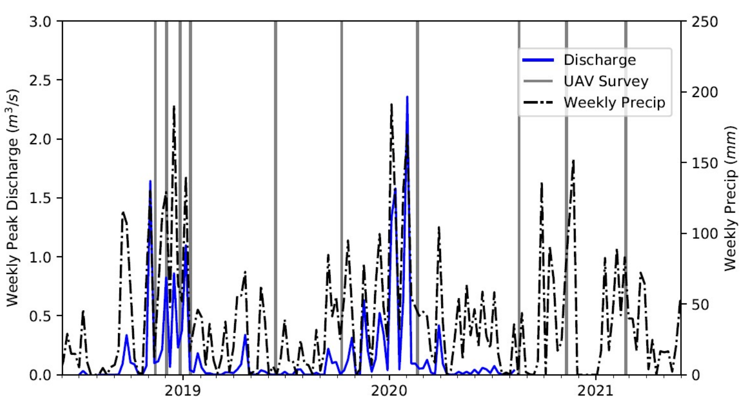
So the question we hope to answer is, what is the geomorphic response of the channel to the sediment pulse released by the bridge installation? How will the channel, and its features, change?

The answer to this question is important because can inform how SMRs might respond to the changes in sediment supply we expect from climate change or similar engineering endeavors. This has important implications for channel habitats and flooding risks.

And to spoil it for y'all, we observed aggradation in segments of the channel that has stored sediment in the past, and after a large pulse like this, the channel features remain in place!

Methods

1. Conducted 12 UAV surveys between summer 2018 – summer 2021
2. Surveys were flown beneath the canopy at 2-4 m altitude.
3. Built DEMs using Metashape and CloudCompare
4. Georeferenced DEMs using 78 XS pins and 50-150 surveyed control points



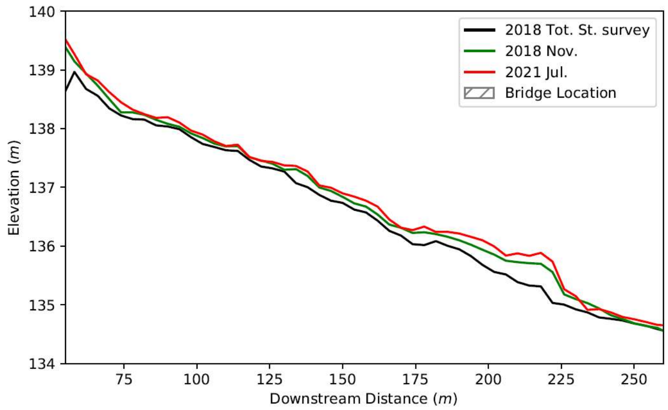
So to track channel response to the pulse, we conducted 12 UAV surveys between the summer of 2018 and summer of 2021. We flew adhoc surveys after large rain events and once during each low-flow summer. The surveys were more frequent immediately after the installation.

Because the stream was forested, these surveys were flown at 2-4 m altitude, as you can see on the photo on the right (the drone is in the middle of the channel here)

We then build DEMs from drone imagery using metashape and cloudcompare and georeferenced those DEMs using 78 cross-section pins and 50-150 control points (depending on the survey).

Results

1. Approx. 140 m^3 of sediment was added to storage in the reach after bridge installation
   - 80 m^3 was stored during the first event – 110 m^3 during the first year
   - 100 m^3 was stored in the downstream riffle-pool section, only 40 m^3 was stored upstream
2. A channel-spanning logjam formed during the first event and remained throughout



We observed that approximately 140m3 of sediment was added to storage in the reach after bridge installation. For context, prior to the bridge, we regularly observed 1m3 of upstream supply, so this event was about 100x bigger than normal.

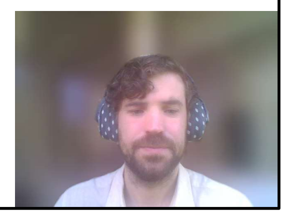
Most of the storage and transport happened immediately after the bridge was installed. Over half of sediment was stored during the first event and 80% of it during the first year.

As you can see in the longitudinal profile here, Most of the sediment storage occurred downstream in the wider section with features that can store sediment. Some of the furthest upstream changes were constructed during bridge installation, but the narrow featureless section only experienced minimal change.

You might notice the large hump about 225 m downstream, that was caused by a channel-spanning logjam that formed during the first event and is still there today. There is almost no sign of downstream transport past the logjam, so the large sediment wedge that formed trapped most of the sediment.

Results

3. Channel features remained despite sediment supply 100x greater than average

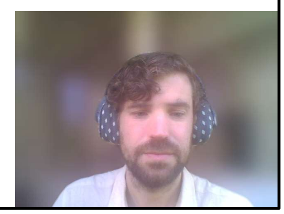


Still despite 100x the normal upstream supply, and a logjam, the channel features remained mostly the same. Photos on the left were taken upstream of the logjam from before the bridge installation, photos on the right were from the same places 2 years after.

You can see that storage features like bars enlargened, and the bed became looser, but there was little or no rearrangement of channel features

Implications

1. Channel morphology was able to absorb a large sediment supply event
   - Areas that had storage zones trapped most of the sediment with little to no rearrangement
   - Areas that had little room for storage passed sediment, with little geomorphic impact
2. UAV surveys had some limitations:
   - Flying was tricky, some blind spots (vegetation, wood, bank cover, deep/active water)
   - Uncertainties were large compared to event-scale changes
     - Survey every year after the first event



So some take home messages here:

First, from a geomorphic perspective:

Channel morphology was able to absorb a large sediment supply event. Areas that had storage zones trapped most of the sediment with little to no rearrangement. Areas that had little room for storage passed sediment, with little geomorphic impact

Second: some insights on the method:

The UAV surveys worked in this context, however:

Flying was tricky, we crashed a couple drones dodging trees and there were some blindspots caused by…

Uncertainties were large compared to event-scale changes

- If we did this again, I’d recommend surveying every year after the first event or two, because the changes were too small to confidently capture.

Thank you

If you have questions or want to speak further:

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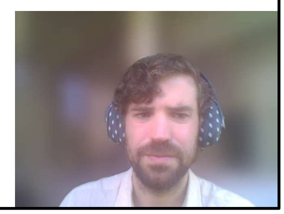

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