Restoration alters stream metabolism without affecting dissolved organic nutrients

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Introduction

Waller Creek Diversion Tunnel

The Waller Creek Diversion Tunnel diverts streamflow from Waller Creek into an underground tunnel to reduce flooding in downtown Austin, TX, USA. During high flow, floodwaters are diverted from the creek and into the tunnel, which dumps floodwaters into Lady Bird Lake. During base flow, water from Lady Bird Lake is pumped from the tunnel into the creek channel at the diversion tunnel, altering the water source in the creek.
The tunnel was expected to lead to better water quality and a "functioning creek ecosystem" (Waterloo Conservancy, 2023). We measure stream function as metabolic regime in Waller Creek. We expect that the difference in source water could significantly alter nutrient quality and quantity, which is measured to assess whether dissolved nutrients controls stream metabolism.

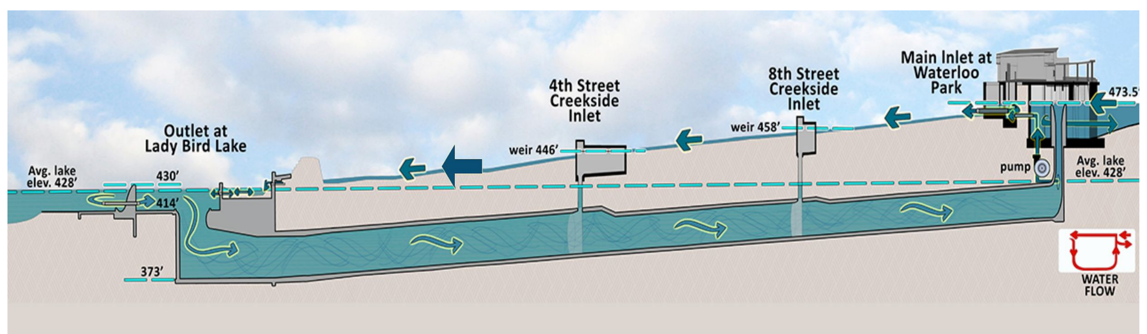

Figure 1: Waller Creek flood diversion tunnel

Dissolved organic matter (DOM) and stream metabolism

DOM is closely tied to hydrology patterns, tending to be more microbially derived during dry summers and terrestrially derived during rainy fall and spring months (Goldman et al., 2014). In urban streams these patterns may vary due to organics introduced by storm drains and leaky sewers and shift metabolic regimes of streams to more dominated by respiration.
We measured DOM in a heavily urbanized creek in Austin, TX, USA, across multiple seasons and upstream and downstream of the flood diversion tunnel that significantly alters creek hydrology. These results are compared to a rural reference creek, Bear Creek.

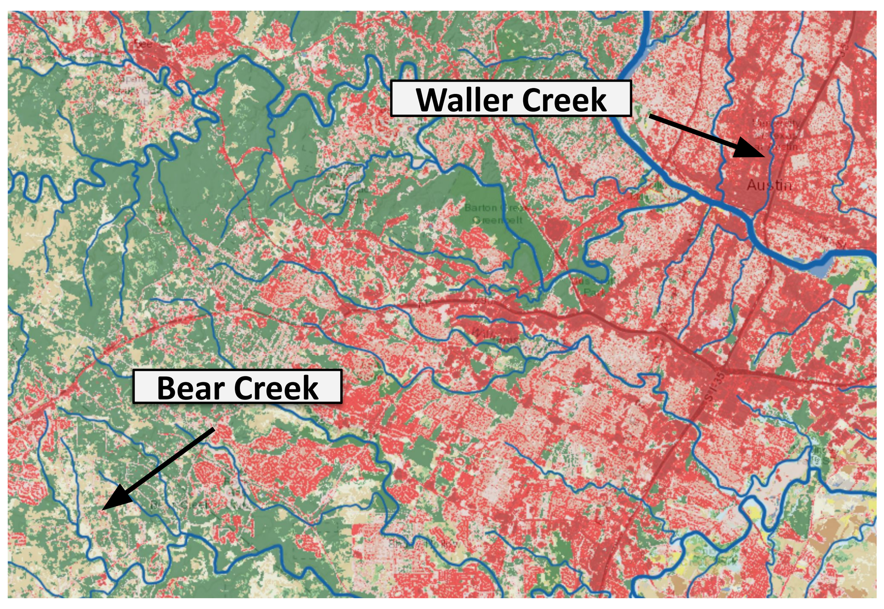

Figure 2: Land cover in Austin, TX, USA. Red indicates impervious cover.

Figures

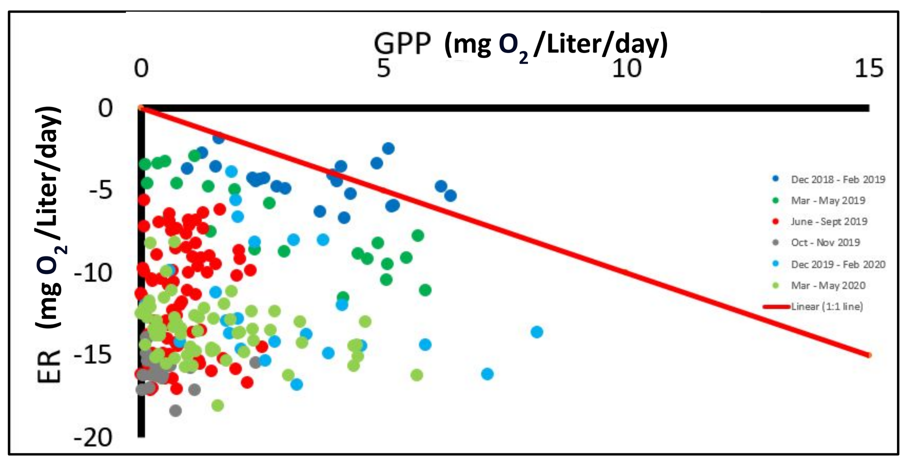

Figure 3: Upstream Waller Creek estimated ecosystem respiration and gross primary production

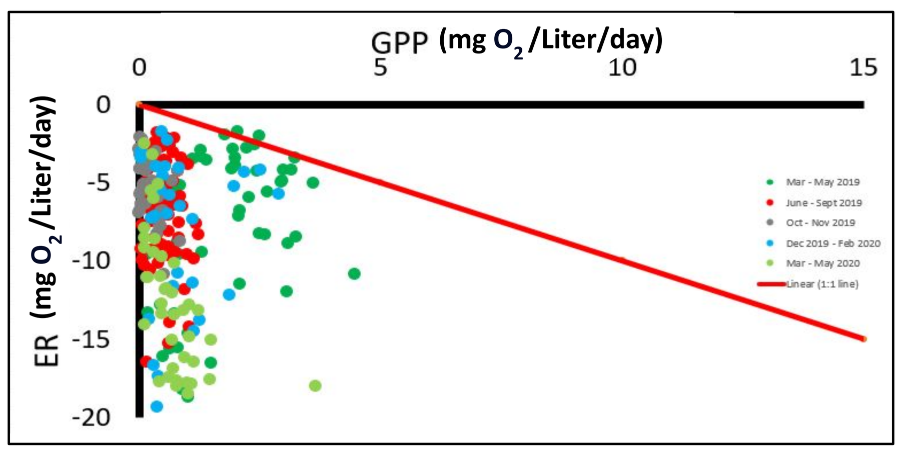

Figure 4: Downstream Waller Creek estimated ecosystem respiration and gross primary production

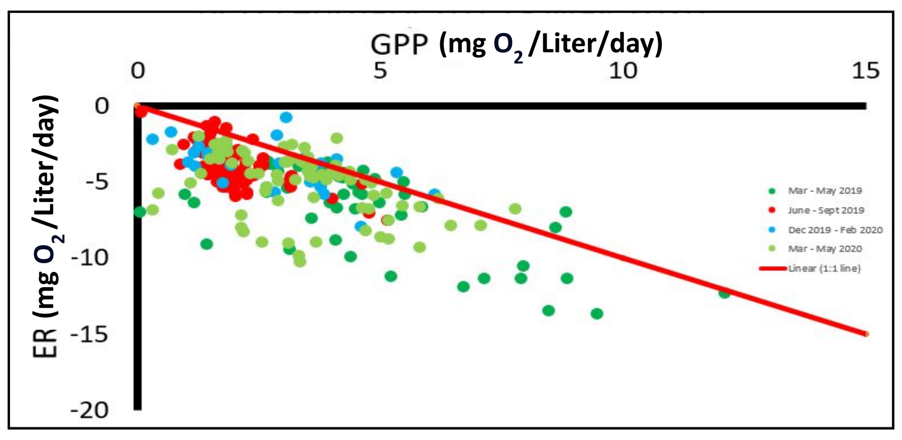

Figure 5: Bear Creek estimated ecosystem respiration and gross primary production

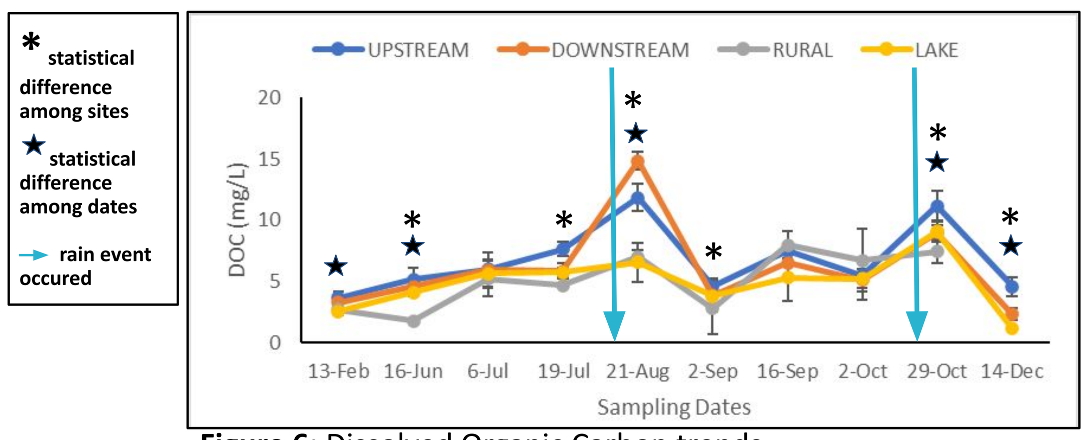

Figure 6: Dissolved Organic Carbon trends

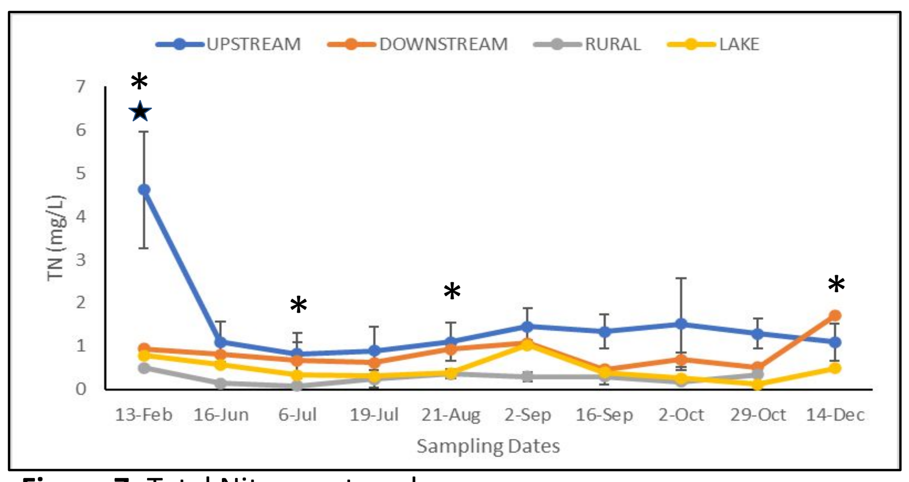

Figure 7: Total Nitrogen trends

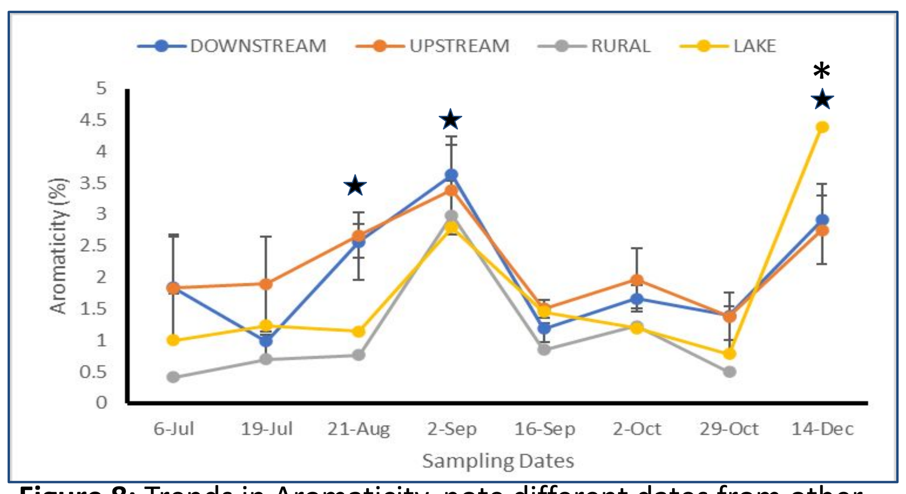

Figure 8: Trends in Aromaticity, note different dates from other samplings

Results and Discussion

Stream Metabolism

- The ratio of gross primary production (GPP) to ecosystem respiration (ER) was highest in the reference creek and lowest downstream of the tunnel.

Patterns in DOM

- The two largest spikes in DOC in Waller Creek occur after rain events, suggesting that storm drain input is important upstream and downstream of the diversion tunnel.
- Waller Creek upstream of the tunnel has intermittently and significantly higher TN values compared to other creeks sites, suggesting that recirculating water in the tunnel leads to levels of nitrogen similar to the reference creek.
- Rain events lead to significantly higher aromaticity in all creeks, although the increase in the reference creek was of lower magnitude than Waller Creek.

Conclusion

DOC and aromaticity of nutrients in Waller Creek are not the driver of differences in metabolic regime in Waller Creek upstream and downstream of the diversion tunnel. The Waller Creek diversion tunnel leads to an overall decrease in net ecosystem productivity, with relatively higher ER than GPP. This result does not appear to be related to DOM quality or quantity, and is likely due to reduced scouring that allows sediment build up that smothers algal production

Methods

Sample Site Description:

- 6 Waller Creek sample sites
  - 3 upstream of the diversion tunnel
  - 3 downstream of the diversion tunnel
  - 1 Lady Bird Lake sample site
  - 3 Bear Creek sample sites

Metabolism Data Collection:

- GPP and ER were estimated at the same locations using a single state, open channel approach

(Appling et al., 2018)

DOM Collection and Processing:

- 3 replicate samples collected at each site
- Filtered samples through a 0.45 micron filter
- Teledyne Tekmar total carbon analyzer
  - Dissolved Organic Carbon (DOC) measured in mg/L
  - Total Nitrogen (TN) measured in mg/L
- UV-spectrophotometry:
  - SUVa absorbance levels 254 nm/DOC (mg/L)

(Findlay & Parr 2017)

- Linear Mixed Effects models were used to assess statistical differences among dates, sites and interactions among dates and sites

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