Dynamic connectivity in small, forested wetlands controls runoff in aspen-dominated catchments of the sub-humid Boreal Plains

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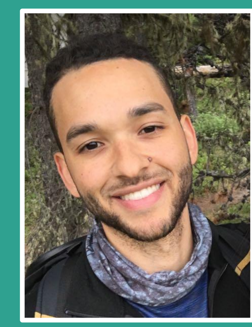

Background

- Hydrological functioning of sub-humid systems (P-ET ≈ 0) is susceptible to climate change [1].
- Boreal Plains feature highly variable climate [2] and contrasting hydrologic response areas of low relief [3].
- Aspen catchments on coarser substrates have low and variable runoff (high transpiration and storage [4]), and role of hillslope-valley connectivity and climate in controlling runoff is not well-established.
- Understanding of runoff processes is required for landscape management of often contrasting needs now and in the future.

Aims

- Determine runoff mechanism and runoff dynamics across dry to wet periods climate cycles (>15 years).
- Identify role of climate and storage distribution in promoting or inhibiting runoff.

Methods

- Hydro-meteorological surveying across 19 years in strategically-placed wells, piezometers, met. stations and a discharge site.
- Rigorous assessment of sub-surface stratigraphy as proxy for storage and to delineate potential barriers to (sub)surface flow.

Ongoing work

- Assessment of wetland ET as control on storage and saturated area maintenance.
- Identification of potential impacts on adjacent upland forests (tree water sourcing and productivity).

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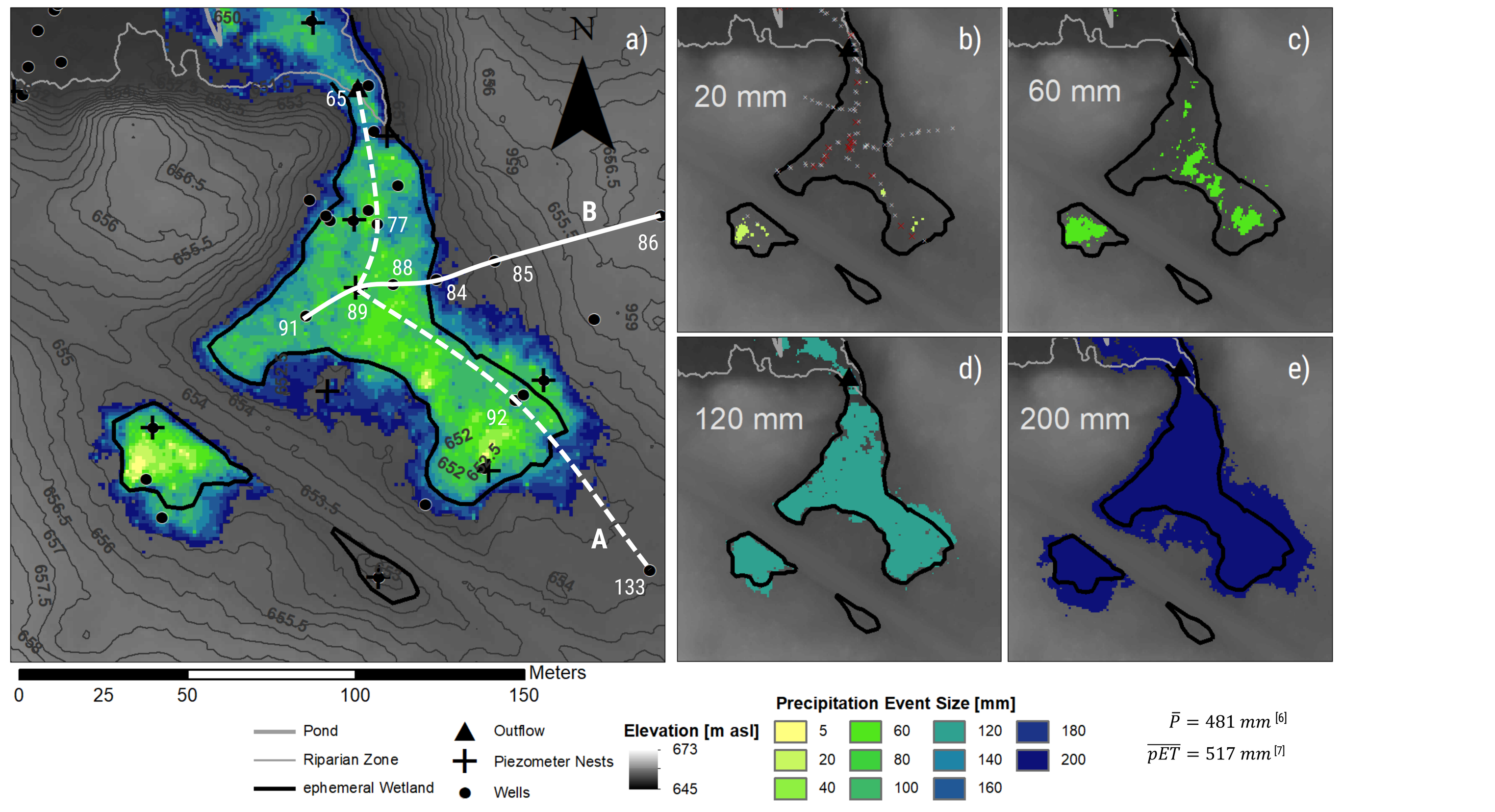
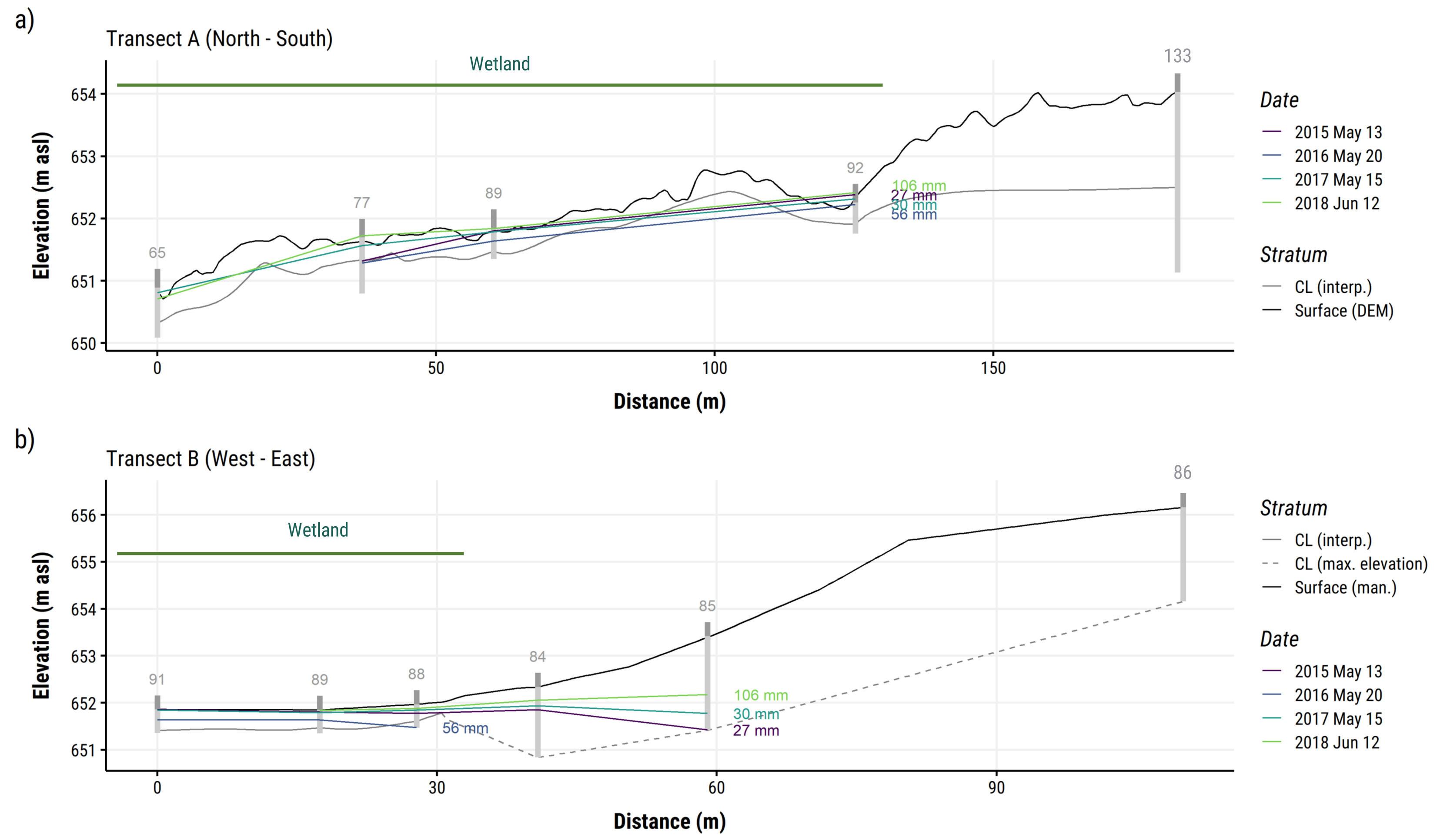
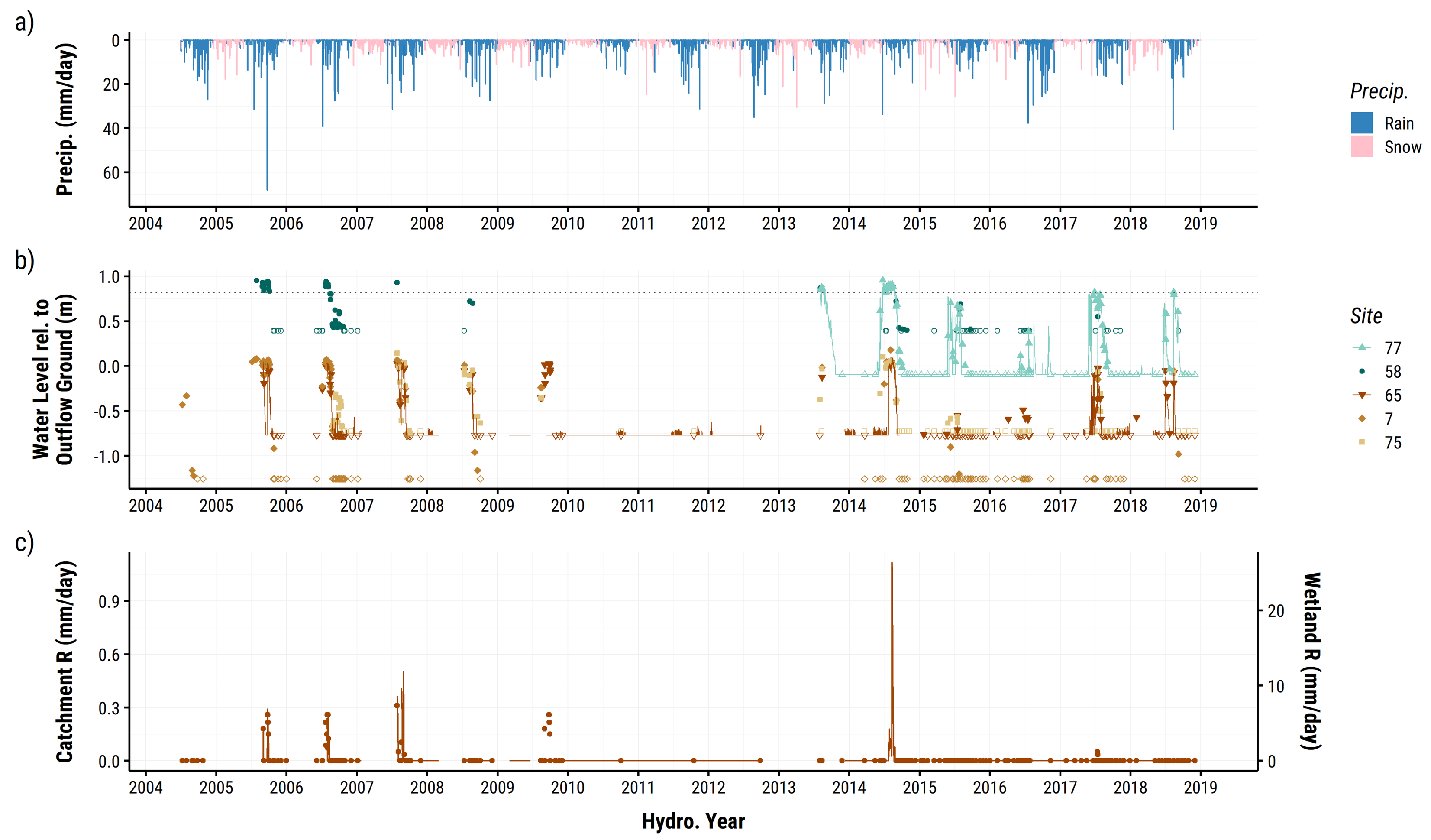


F1. Estimated extent of surface saturated areas (SSA) in response to P. Storage estimated from the soil surface to a low conductivity clay layer (cf. **F3**, $K_s < 10^{-8}$) at an average porosity of $n_e = 0.2$. Panel b) shows surveyed SSA (red) along transects (grey crosses) after 28 mm P.



F2. Water levels in response to P (15-day totals), topography and sub-surface morphology (clay layer; $K_s < 10^{-8}$) along A and B (cf. **F1**). When dry, 56 mm did not cause responses beyond the wetland (B, 91 to 88). Flow into uplands were common, while hillslope contributions rare. Interactions with regional groundwater were not observed.



F3. Precipitation (a), wetland water levels (b) and runoff. Open symbols are dry wells. Runoff initiated mid-wetland (77) can disappear into storage before reaching outflow (65). 2014 featured surface-near ice (< 30 cm depth) by mid-May, and produced runoff at only 334 mm/year. By contrast, 2016 (one of the wettest of the previous 20 years; 537 mm) did not generate runoff, and ice was below 40 cm late April.

Outcomes:

- **Runoff was low,** infrequent between years and intermittent within years. It was **exclusively generated in the wetland (4 % total catchment area) as saturation excess flow** and did not correlate with annual or seasonal precipitation totals.
- Storage varied within the wetland, and contrasted considerably between wetland and upland hillslopes.
- Sub-surface topography imposed thresholds on groundwater connectivity in the wetland.
- Available storage and surface-near ice controlled saturated area formation and connectivity; the wetland saturated top-down, not bottom-up.
- Hillslope-wetland (valley) connectivity was rare, and groundwater gradients indicated flow into hillslopes.
- Hillslopes may contribute groundwater in response to rare, large P events (> 100 mm), and potentially via surface runoff in exceptionally wet years.

Take-home:

The dynamic nature of storage and connectivity allowed for runoff generation under a range of climatic conditions (**i.e. highest runoff during dry year**) and groundwater flow into adjacent hillslopes.

Low-storage areas, such as the wetland, are disproportionately important for runoff in aspen-dominated catchments with large storage and transpiration.

Small, forested wetlands hence may be crucial in maintaining downslope and adjacent systems in the future under altered hydrometeorological regimes expected for the Boreal Plains [8].

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Photography encouraged