Wetland Ecosystem Functions: Drivers, Evaluation, and Management Implications

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Urgency for understanding Alpine Wetlands

- Hydrological role of Mt. Wetlands poorly understood
  - BUT - "***many regions, changing P or melting snow & ice are altering hydrological systems, affecting water resources in terms of quantity and quality"*** (IPCC WGII Report, 2014)

- Wetlands have considerable assets from an ecosystem services perspective:
  - Mitigate downstream effects of extreme P through water retention & reduced flow velocity
  - Provide water back to ecosystems during periods of drought
  - Critical wildlife habitat
  - Improve water quality
  - Viable cost alternative to built infrastructure (e.g. levees, bypasses)

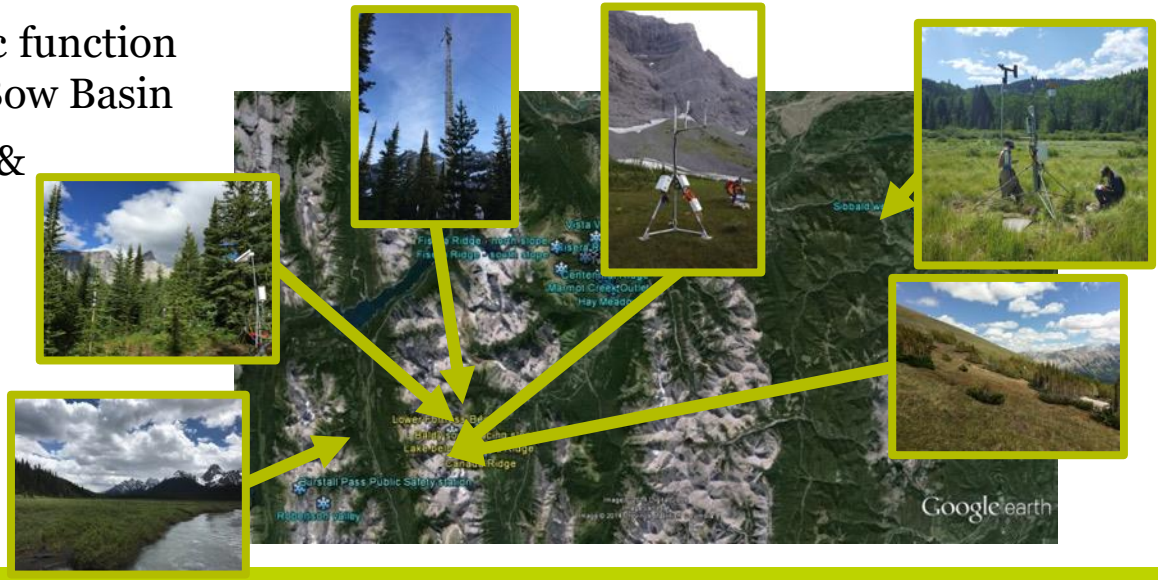
- Support successful wetland policy implementation through establishment of the ecohydrologic function of alpine wetlands

To address this urgency we must:

- Establish basic eco-hydrological function of alpine wetlands
  - Variation among types & elevation?
- Assess overall hydrological ***role*** in changing mountain environment → interactions with ecology
- Role:
  - of surrounding land use/physiography
  - of disturbance on ecohydrologic function of foothills wetlands in Upper Bow Basin
  - in flow regulation, biodiversity & assessment
- *MWF Wetland Theme* will expand understanding of natural variability in ecohydrologic function & water table stability

- Field based meas. programs
- Modelling
- Remote sensing

- 1º ecohydrologic processes
  - Response to disturbance
- GW, buffers & vegetation roles
- *Climate change & vegetation shifts*



Biodiversity & Hydrologic Functions Among Wetlands Along Landuse & Elevation Gradients

- Biodiversity & change with elevation
- Role of surrounding forests in regulating ET losses
- Upland-wetland hydrologic connections
- Controls (physical, ecological, climatic) on WUE

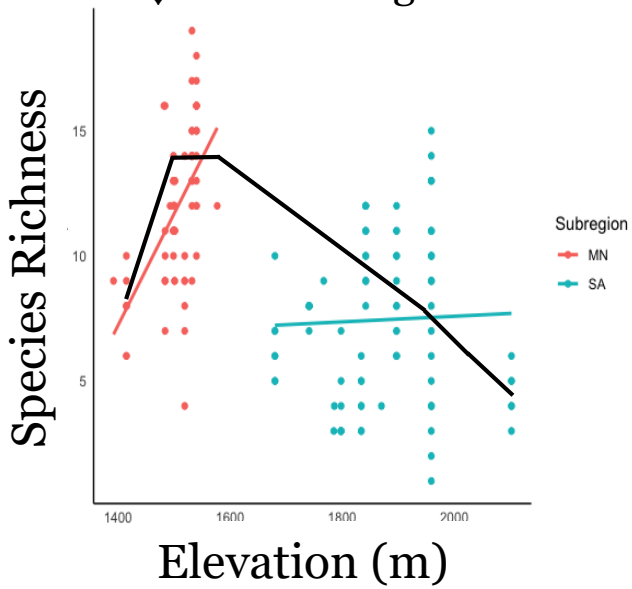
- **Intensive site installations…**
  - 3 wetland sites across an elevational gradient to evaluate atmospheric controls & hydrological connections across space / time

- **Synoptic site installations…**

Avian Community

- ***Char. mt. peatland biodiversity - what spp. using unmapped habitats & importance for regional diversity***
  - ***Elevation or natural sub-region?***

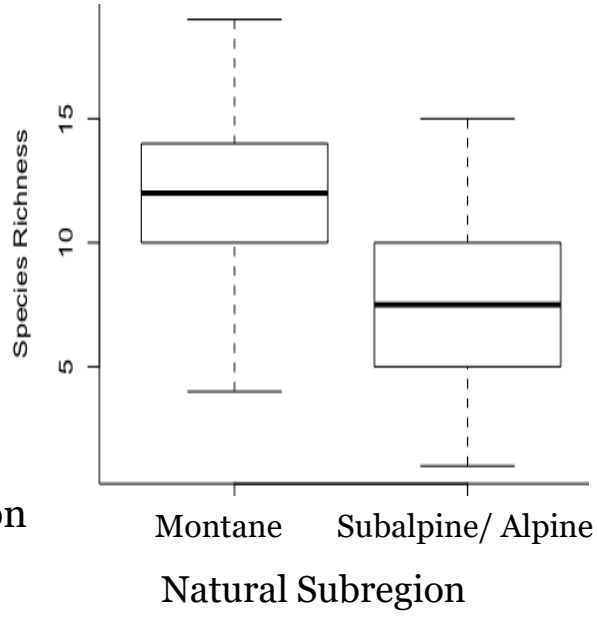
- Spp. richness highest at ~1500m
  - ↓ w increasing elevation



- Natural subregion is a stronger predictor of spp richness compared to elevation
  - Birds responding more to veg. types associated with relatively homogenous Natural Subregion

NOT

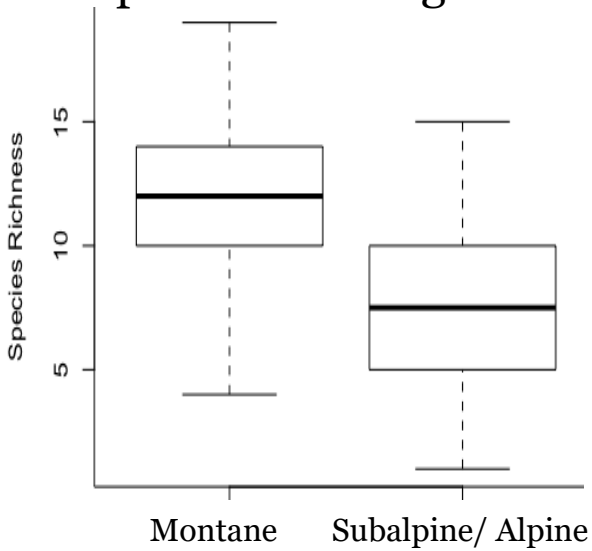
with climate variables that change linearly with elevation



Plant Community

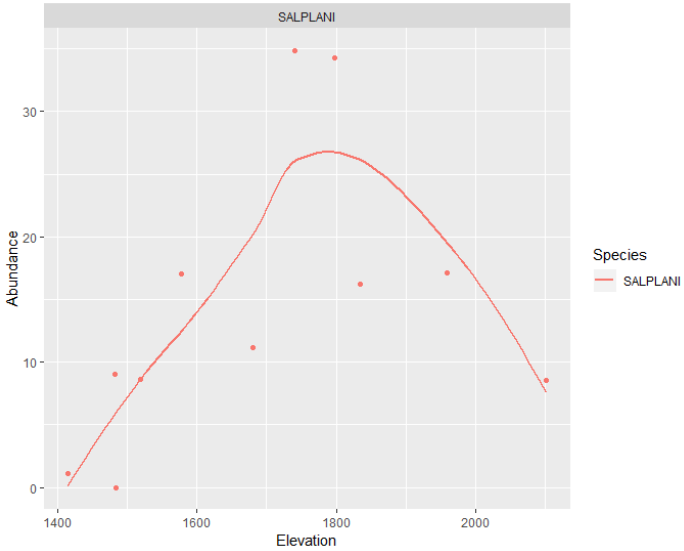
Veg. composition as function of elevation/climate?

- Site elevations significantly related to differences in vegetation spp composition among sites



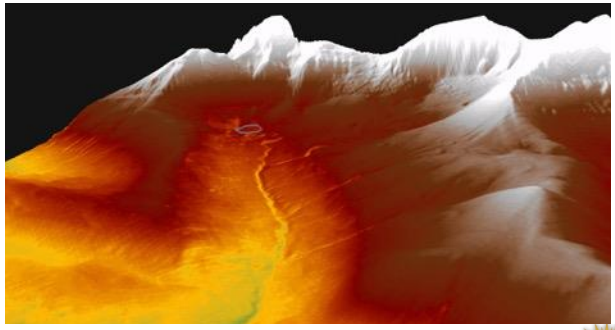
Optimal elevation for different spp.?

- Elev. niche plot curves for each Spp. →LOESS
  - Spp. abundances changes along elevation gradient
- Distribution of different vascular plants & ID habitat optimum elevation
  - Each vascular Spp. has a different optimum



Process Ecohydrology

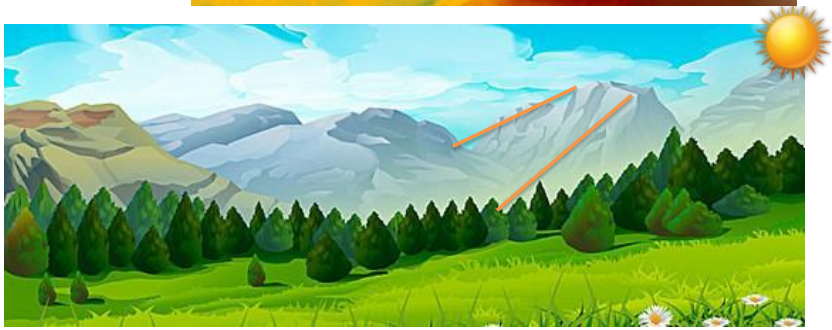
Process-based Understanding of Wetland Functions



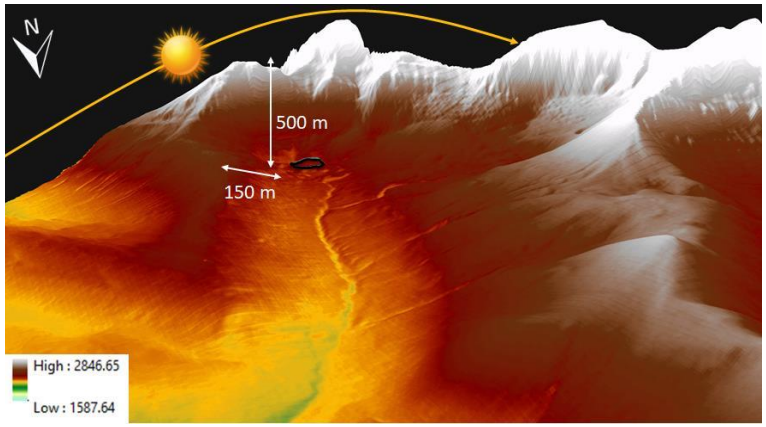
- Individual wetlands to the sub-basin level
- Sensitivity of wetland functions to surrounding land use at multiple scales

- **Alpine environmental variables:**
- Topography, aspect, slope, and elevation

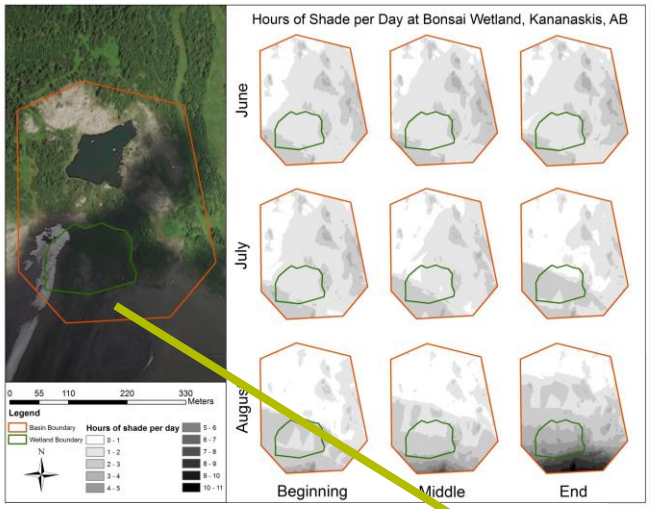
  →isolated microclimates due to limitations in light and available energy (i.e. resulting in horizon shadows).



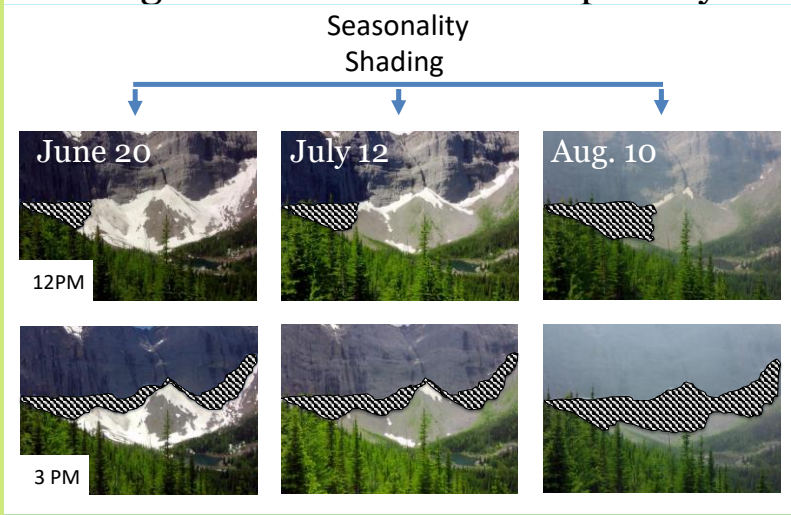
Process-based Understanding of Wetland Functions



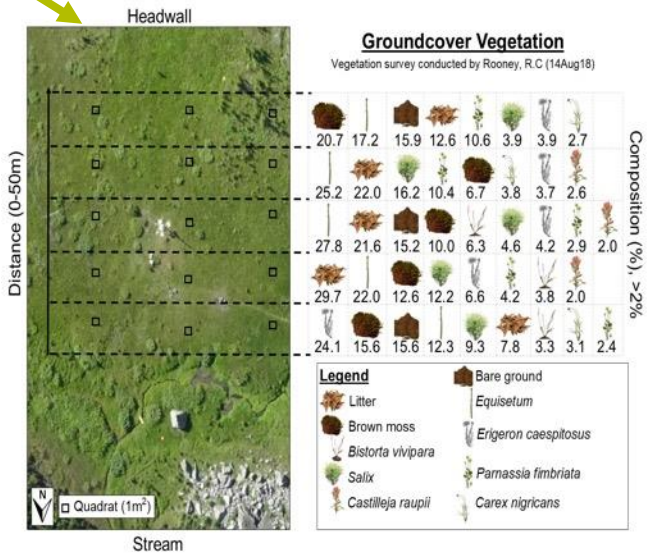
- June and July ~3 hours of shade per day
- August ~8 hours of shade per day



- … strong influence on microclimate
- Evident in WUE?

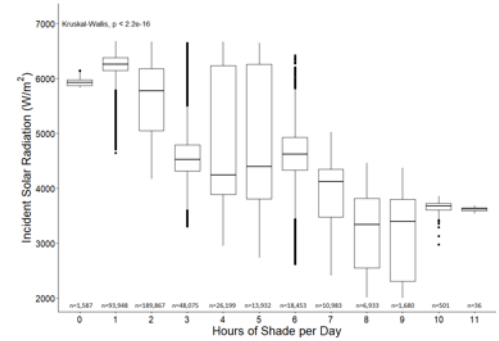


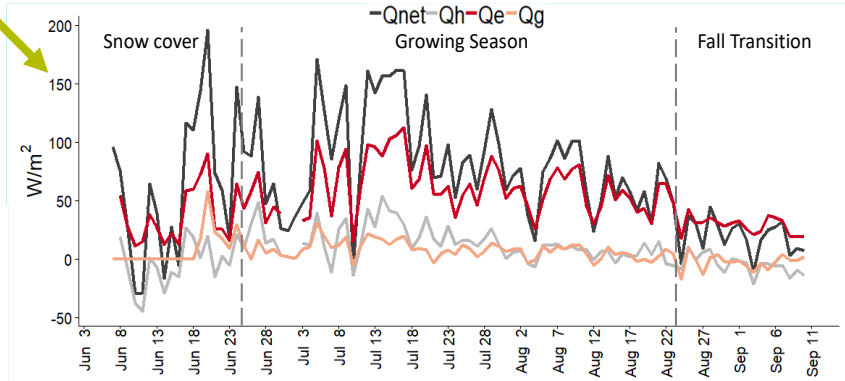
- Patterns in veg. seem controlled by headwall shadows…

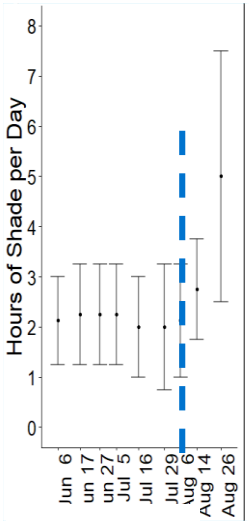


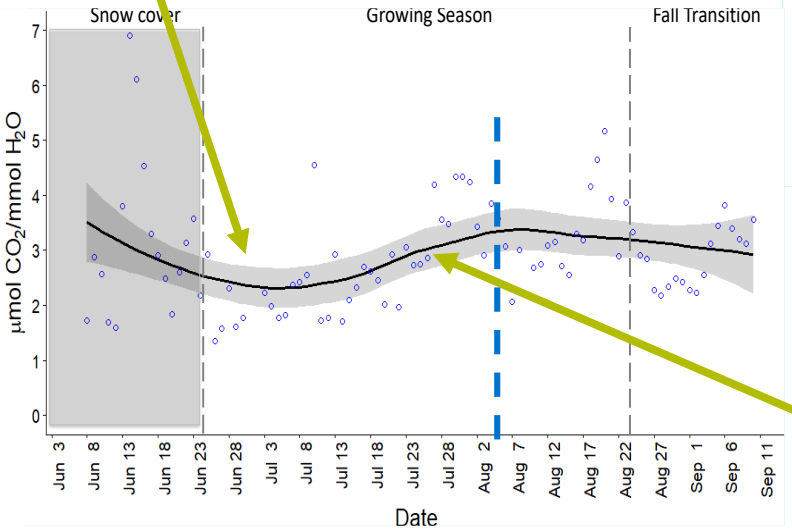
Process-based Understanding of Wetland Functions

- ***Shading*** – significantly decreases daily available energy during peak season
  - Early season peak in Avail. Energy
- WUE - links P/S to water use
  - WUE: Peak in ET prior to peak in productivity





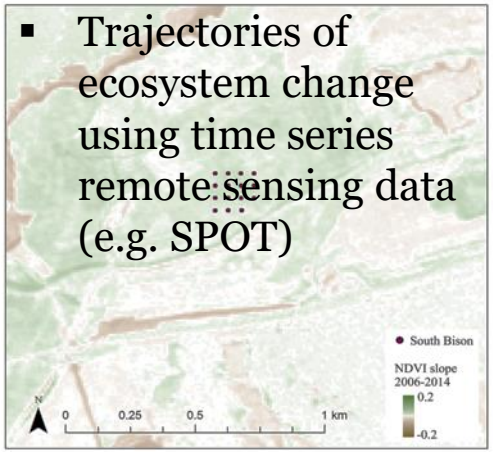




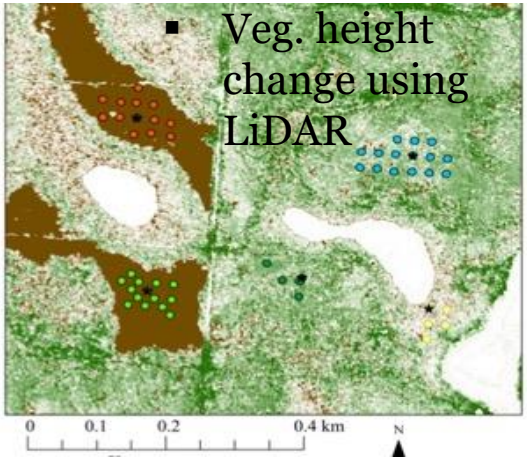
- P/S dominant regulator of seasonal variations in WUE
- Snow free: Higher WUE
  - Reduction in radiation – affects E before P/S

Map Wetlands & Collect Multi-Spectral Imagery

- Develop remotely sensed indicators of wetland ecohydrologic function
- Land-use impacts (ATV roads, logging, cutlines) – evaluated (Field/Modelling) to assess:
  - Sensitivity of wetlands to up-slope disturbance
  - Edge effects on Forest ET
- Veg/water indices (thermal bands), Spp. composition, biomass estimation, canopy structure, & topography from UAV, Satellites + field data → assess/detect effects of disturbance features on wetland & forest ecohydrological health



- Trajectories of ecosystem change using time series remote sensing data (e.g. SPOT)

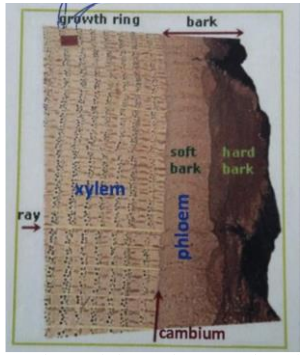


- Veg. height change using LiDAR

- Inform how to protect wetland ecohydrological processes
  - Which processes? Internal/External?
  - How far out?
  - How sensitive?

Wetland Change & Disturbance

- Historical/spatial ranges in responses to landscape & climatic disturbances
- Wood anatomy → wetland plant-climate interactions across elevation gradient



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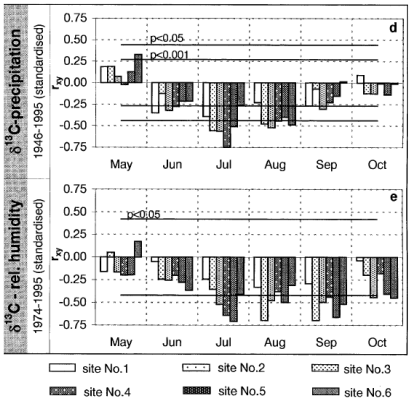
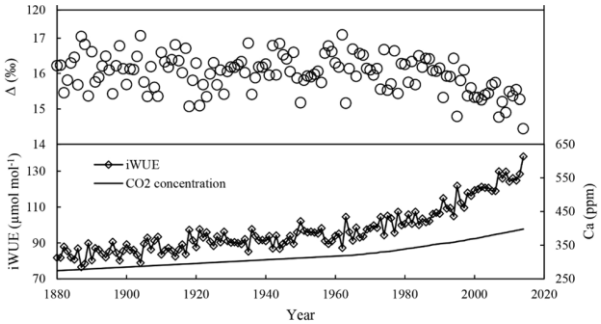


Treydte et al. 2001. Tellus B, 53(5): 593-611.

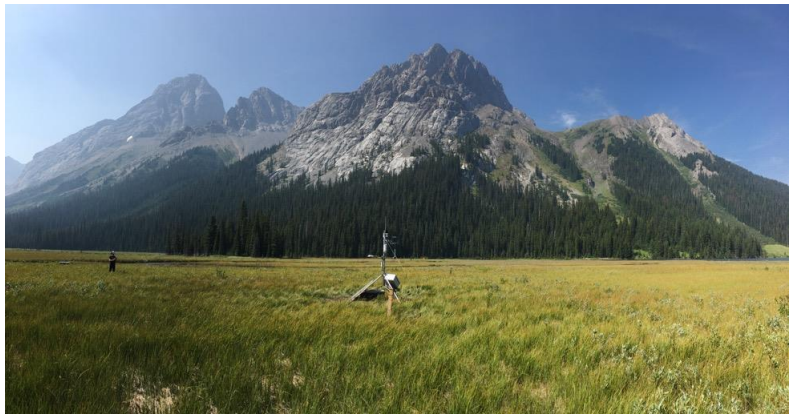


Weiwei et al. 2018. Scientific Reports, 8(1): 308.

- Wood anatomy (ex. Size/distribution of conducting vessels/growth ring) + chem. comp. of cell tissues (ex. C13-signal) - related to local climate & other stresses → reconstruct past environmental/climatic conditions
- Relate wood anatomy to snow depth measured → reconstruct snow depths
- iWUE across elevation & disturbance gradients (using delta C-13)

Summary & Next Steps

- Vegetation change responds to climatic gradients in elevation
- Avian populations respond more to community scale changes – not elevation driven gradients
  - Lag in response of avian populations to climatic change
- Microclimatic controls on wetland water use can be over-ridden by radiative effects
- Productivity peaks quickly after snowmelt



- Based on intensive sites work towards establishing disturbance indicators
  - Test sensitivity at synoptic sites
- Establish baseline of climatic vs landuse change disturbance effects on wetland health and water use
- Build on this baseline w R/S approaches to detect disturbance effects on wetlands at large scales
- Recommendations on buffer management

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