Collaborating to reclaim well pads into peatlands through partial removal: Design and implementation of field strategies for monitoring hydrology

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Collaborators

Civil earthworks, permitting, expertise

Alberta Environment and Parks

Associated Environmental

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Background

- Peatlands:
  - 40 cm organic soil
  - Water table at or near surface
  - Water regulation, C sequestration, habitat

- *“equivalent land capability”*
  - Commonly reclaimed as upland forests

Image: NAIT Centre for Boreal Research

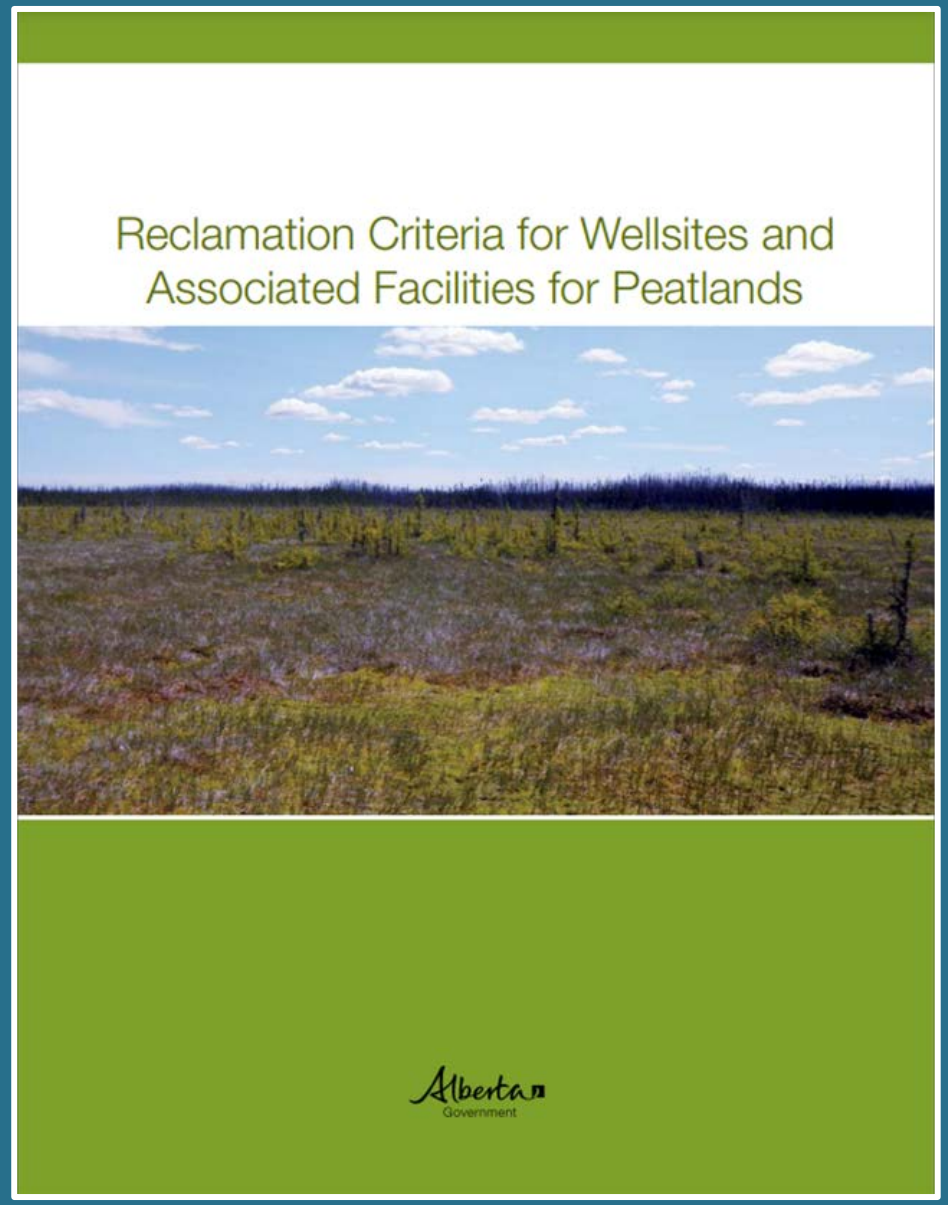
Peatland Criteria

- 2015, 2017

- Vegetation:
  - Self-sustaining, peat accumulating

- Landscape assessments:
  - Moisture regime (P/F):
    - Moist for full season
    - 1-10 cm ponding in the spring

    - *Necessary to support peatland vegetation*



Peatland Restoration

- Removal or inversion + moss introduction
  - Organic substrate at surface
  - Moss layer transfer
- Promising for bog initiation
- Limitations
  - Expensive
  - Not optimized for fens (true mosses)

Image: NAIT Centre for Boreal Research

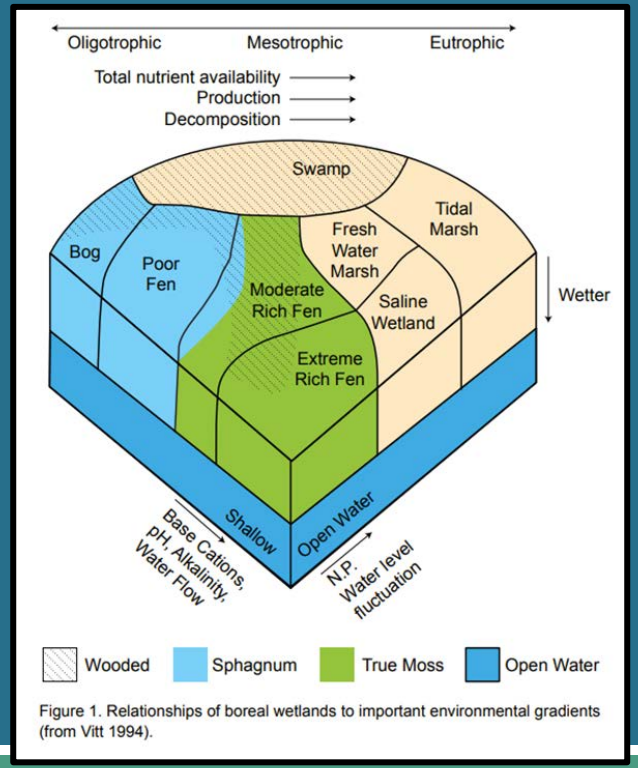
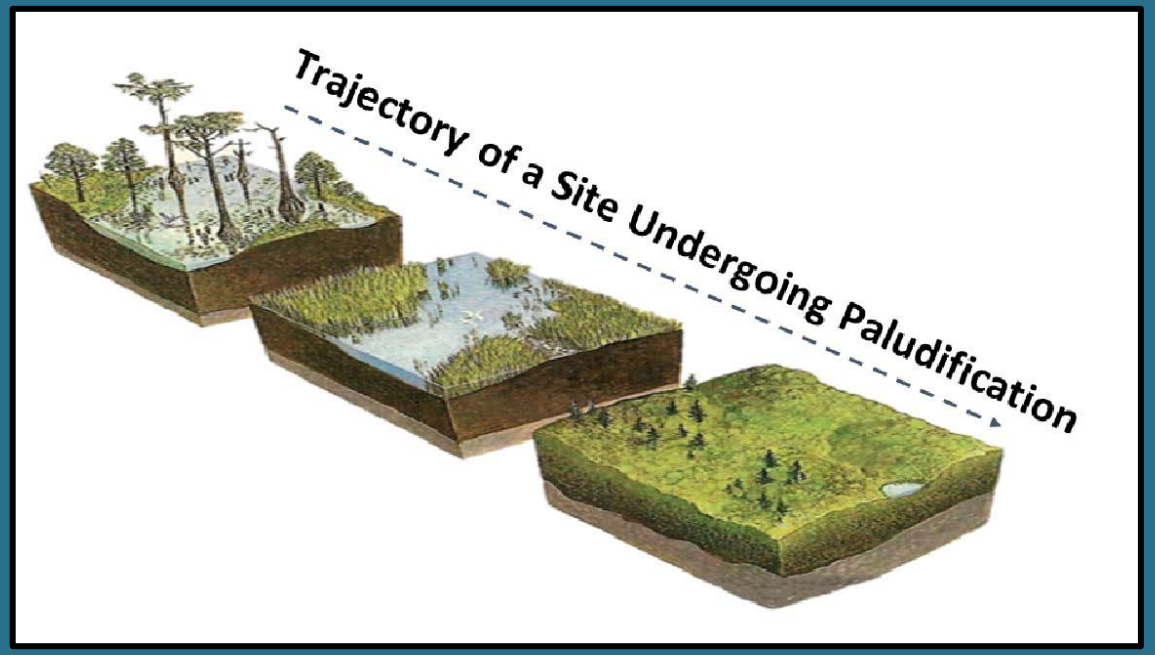


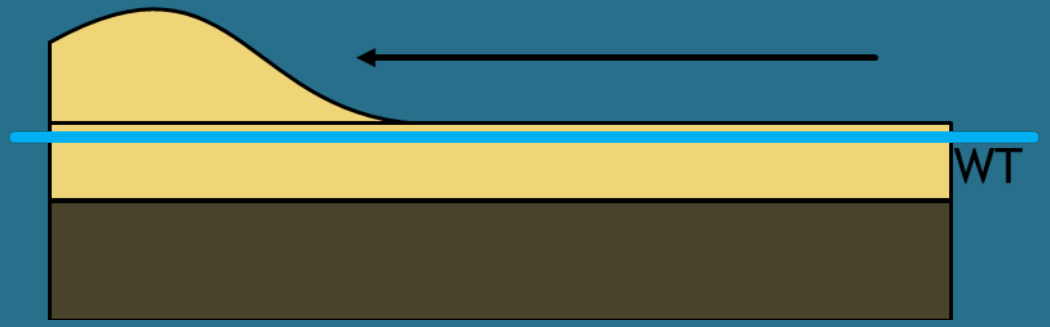
Figure 1. Relationships of boreal wetlands to important environmental gradients (from Vitt 1994).

Figure: Peatland Criteria

Partial Removal

- Paludification
  - Saturation of formerly dry mineral soils
- Partial removal + moss introduction
  - ‘Fast tracking’ succession
  - Direct contact with nutrient-rich mineral fill
- To date - small scale:
  - Sustained water availability when elevation closely matched to peatland water table
- Full scale?





Study Site

Partial Removal Process

Images: NAIT Centre for Boreal Research

Moss Layer Transfer

Images: NAIT Centre for Boreal Research

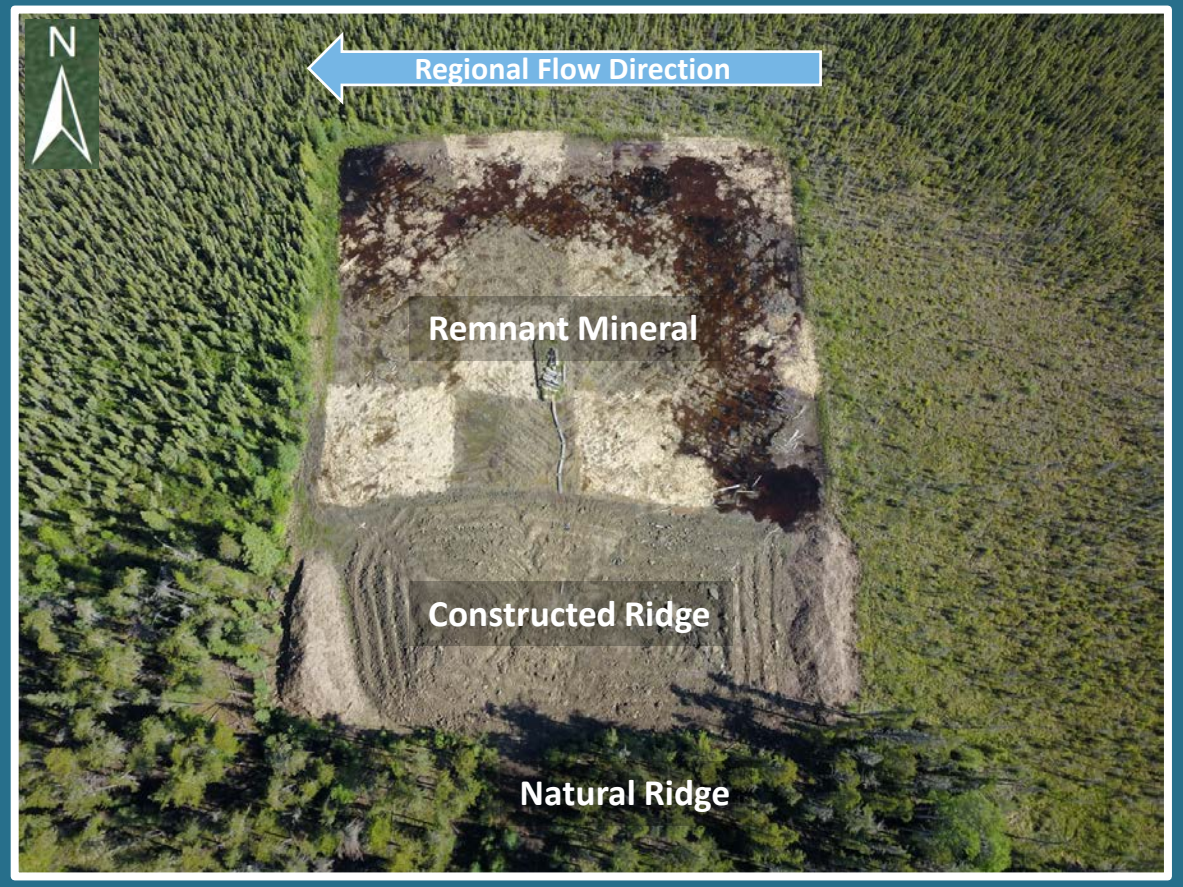
- Mulching

Objectives

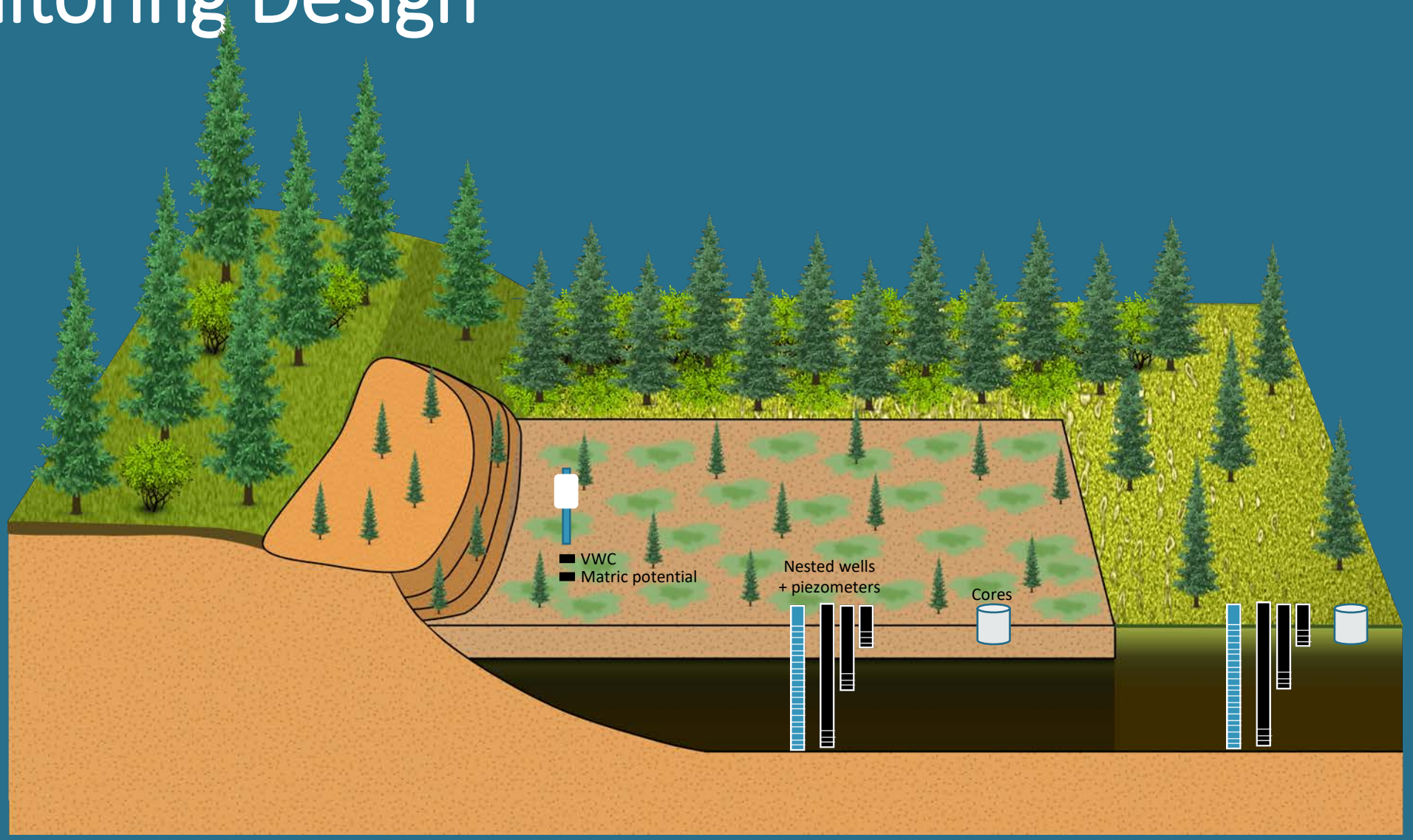
1. Hydrophysical characterization
   - Cores (lab)
   - Slug tests (field)

2. Hydrological connectivity
   - Water table
   - Hydraulic gradients

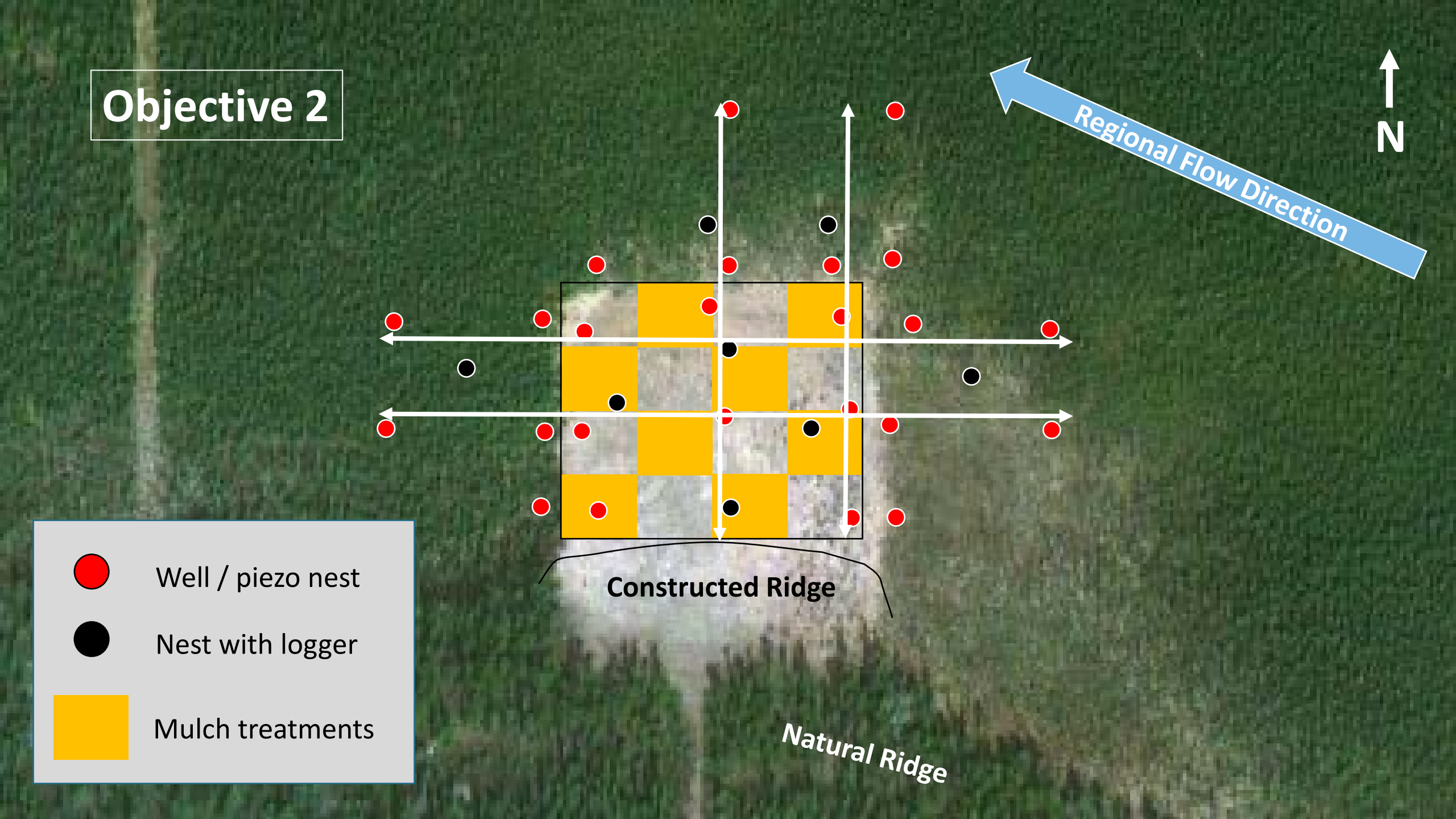
3. Water availability to mosses
   - VWC (storage)
   - Matric potential (availability)



Monitoring Design



M. McKinnon (made with the Health Canada CSM Tool)


Objective 2
Regional Flow Direction
N
Constructed Ridge
Natural Ridge
Well / piezo nest
Nest with logger
Mulch treatments

Objective 3

Regional Flow Direction

N

Soil sensor station

Nest with logger

Mulch treatments

Constructed Ridge

Natural Ridge

Hydrophysical Characterization

- Loamy sand
  - Low water storage capacity

- Low organic matter within the remnant mineral fill
  - Further implications for water storage

	Bulk Density (g/cm^3)	Total Porosity (%)	Organic Matter (%)	Clay (%)	Silt (%)	Sand (%)
Upgradient peatland	0.05	97	95.3			
Mineral pad	1.57	38	2.1	3.0	15.7	81.3
Downgradient peatland	0.08	95	90.6			

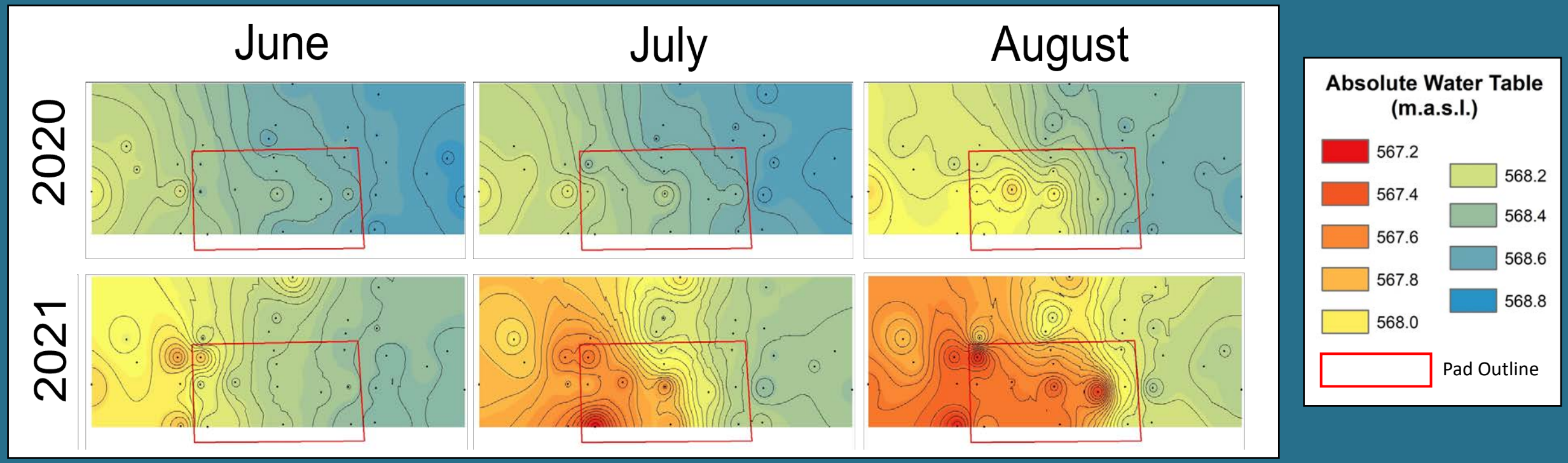
Hydraulic Conductivity

- Maximum flow rate
- Maximum flow rate through mineral is two orders of magnitude lower than adjacent peatlands
  - Semi-impermeable barrier to flow
- Maximum flow rate significantly higher in the upgradient peatland at all depths
  - Pad: compaction
  - Downgradient: peat ‘collapsing’

Units: cm/day

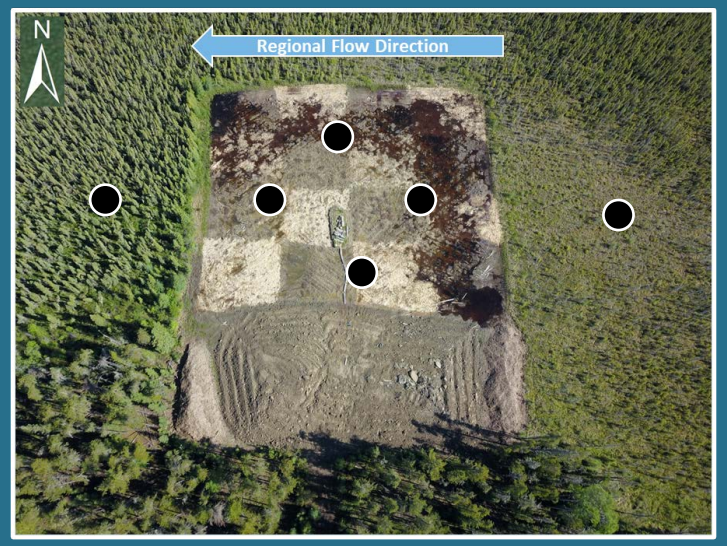
Flow Paths

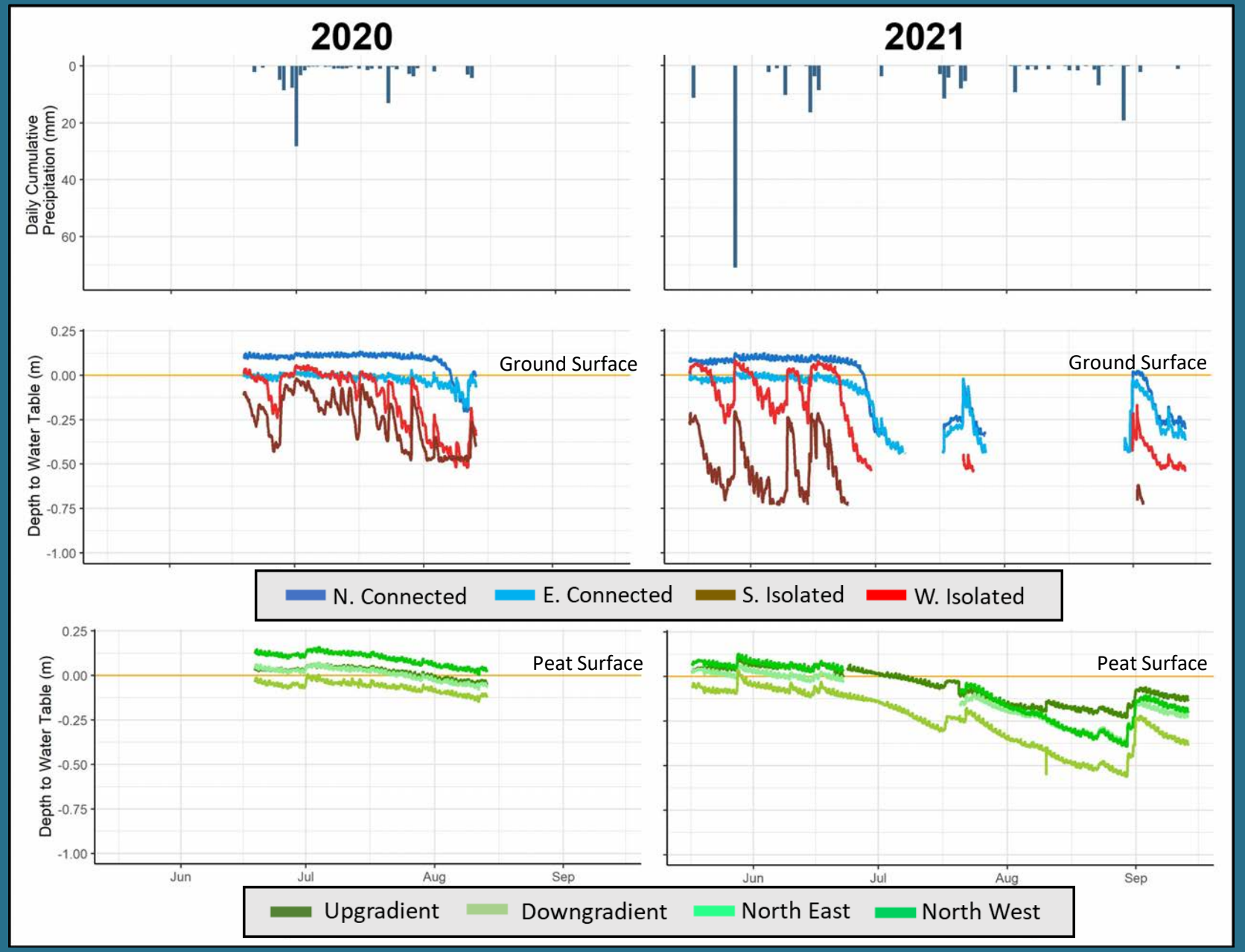
- Restrictions on flow through/under the remnant pad resulting in preferential flow
  - Poor connectivity across pad



Water Table Dynamics

- Better regulated upgradient
- Poorly regulated in isolated areas

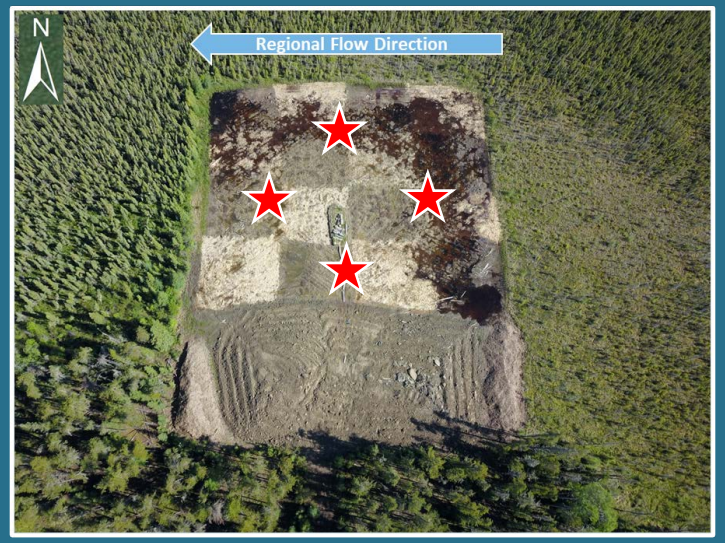


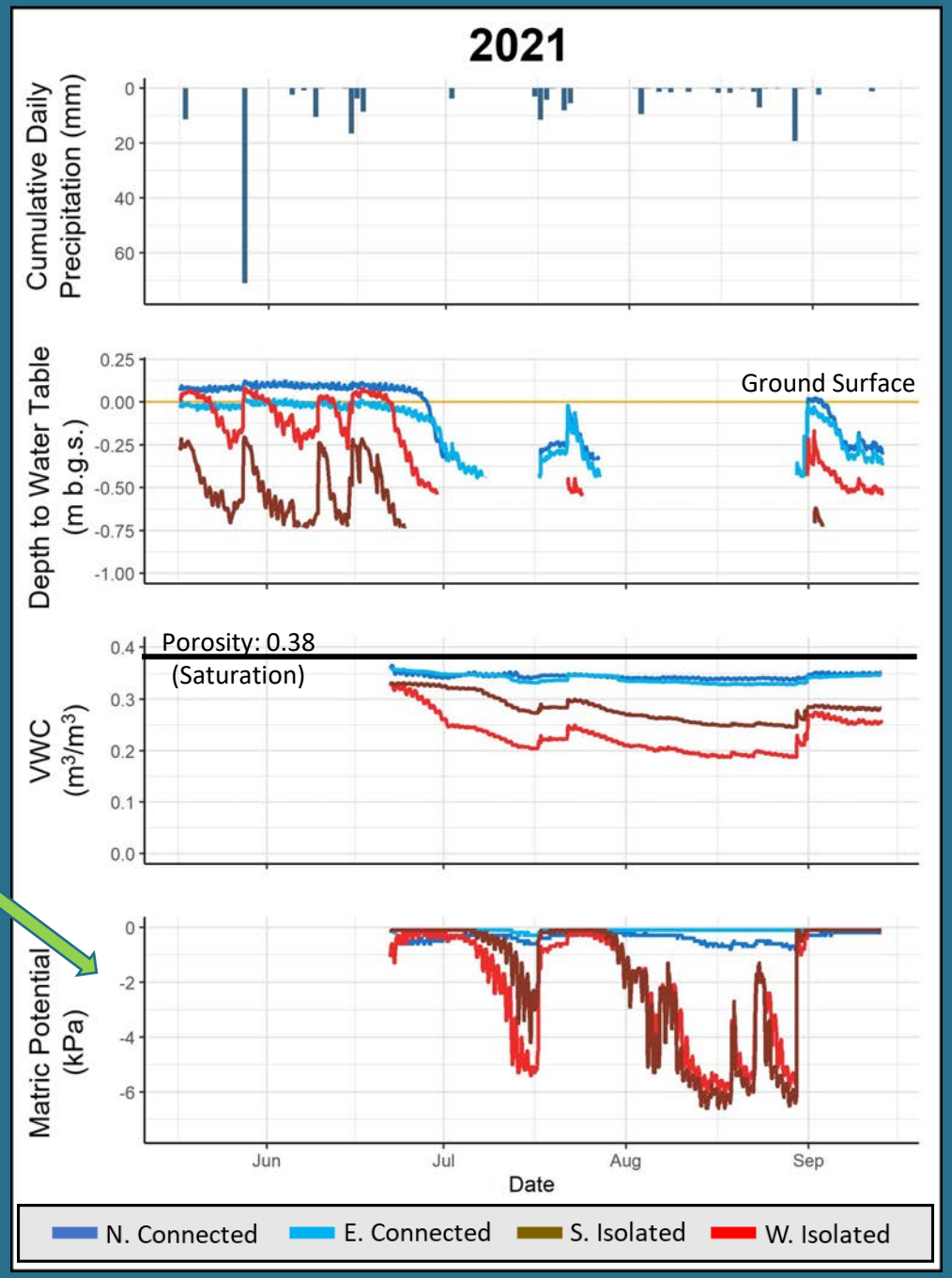


Soil Moisture Dynamics

- Consistently saturated along upgradient edge
- Soil moisture closely controlled by precipitation inputs in isolated areas

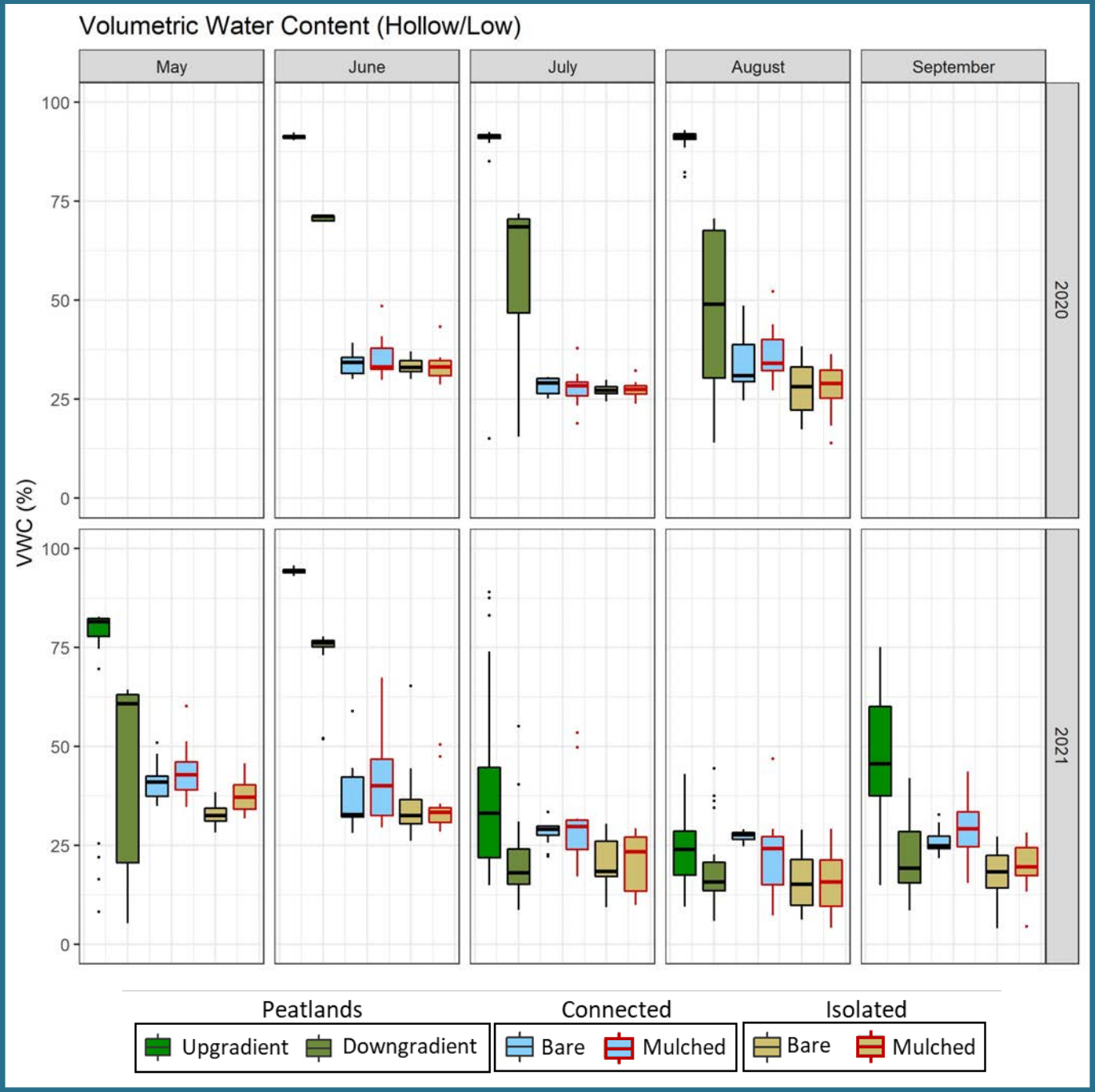
- Water stress: more negative than -10 kPa
  - Loamy sand: ~15% VWC
  - Clay: ~50% VWC





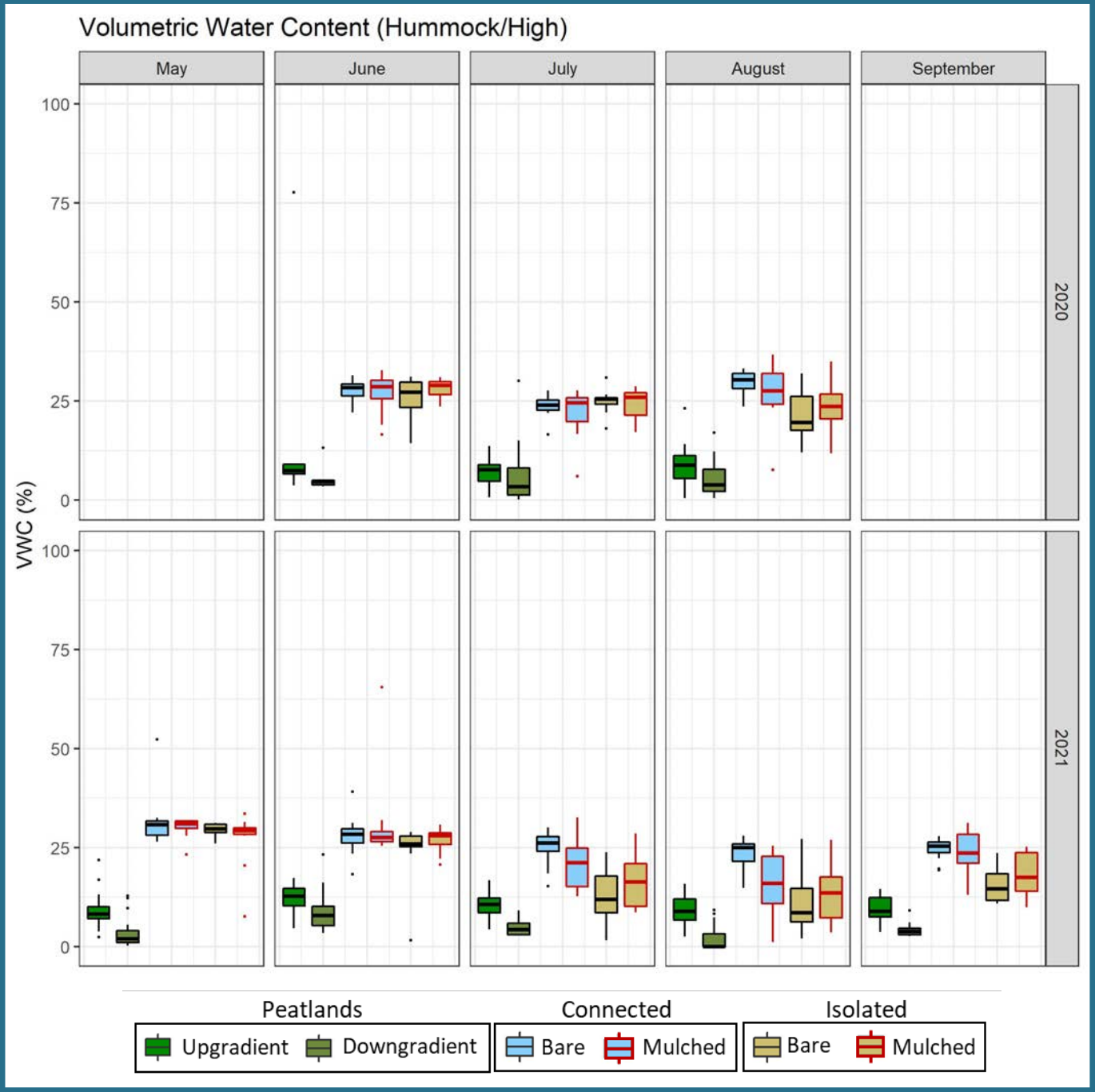
Spatial Variability: VWC (Low)

- Wet year (2020):
  - Low points on pad drier than peatland hollows
    - Mulching: variable effect
- Dry year (2021):
  - Low points drier than hollows early on
  - More comparable to hollows later on
    - Mulching: variable, more distinct effect



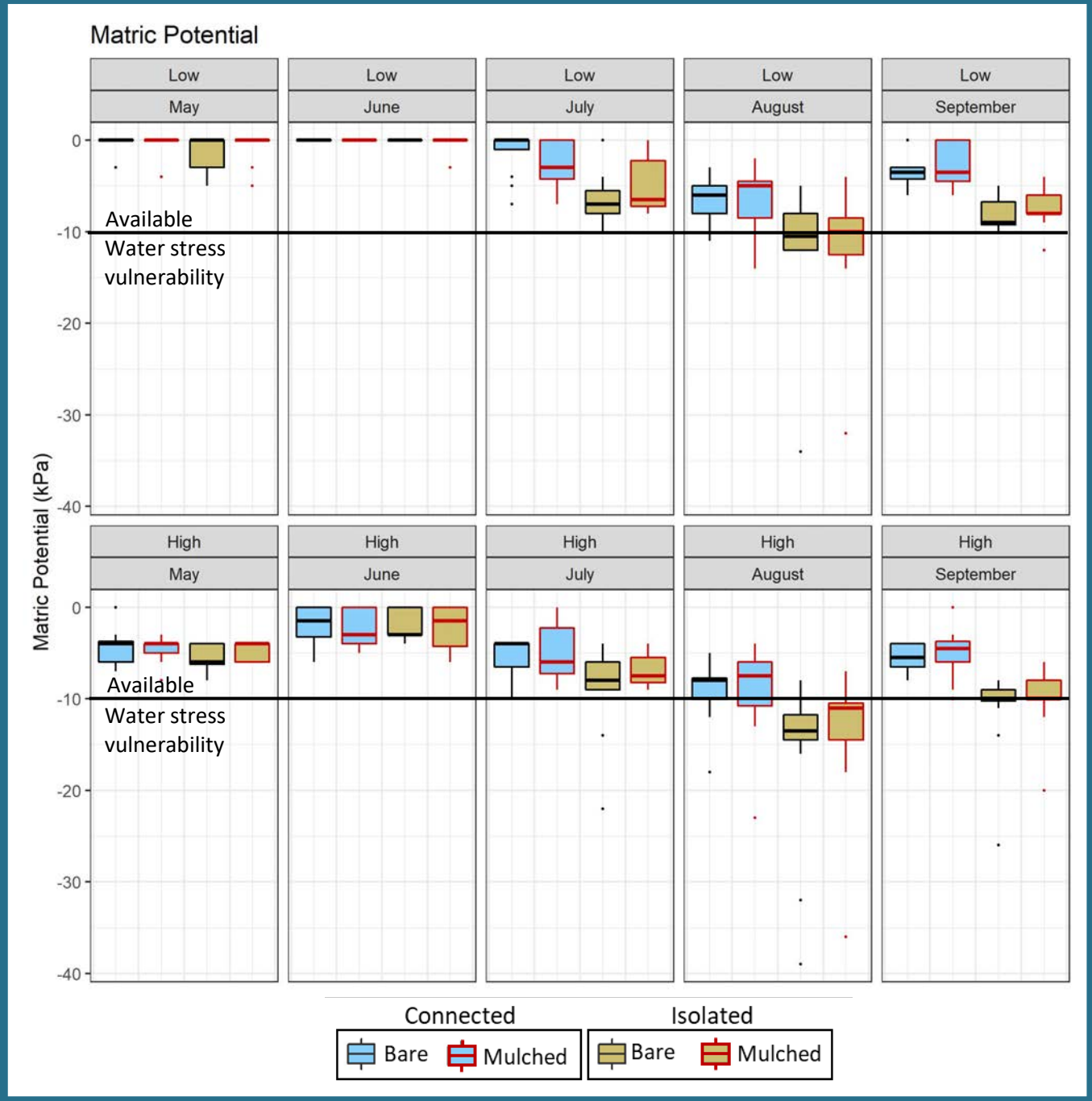
Spatial Variability: VWC (High)

- Wet year (2020):
  - High points on pad consistently wetter than hummocks in adjacent peatlands
- Dry year (2021):
  - Similar trend as in 2020



Spatial Variability: Water Availability

- Maintenance of near-saturated conditions in early season
- Potential water stress at high and low points by late season
  - At or below -10 kPa indicator
  - More pronounced in isolated areas



Conclusions & Recommendations

- Hydrological connectivity between the adjacent peatland and upgradient edge of the remnant mineral pad minimized risk of water stress
- Hydrological isolation of interior & downgradient areas of the remnant mineral pad
  - Vulnerability to water stress in the mid- to late-season

Preliminary Monitoring Considerations

- Pending comparison against detailed vegetation surveys (2024)

- Landscape assessments
  - Hydrology:
    - Proximity of water table to surface (PVC wells; emphasis on late season)
      - Within 5 cm ideal – may not be critical

    - VWC (handheld probe; emphasis on late season)
      - VWC matching -10 kPa indicator threshold varies by soil texture (retention characteristics)
        - Loamy sand ~15%
        - Sand ~20%
        - Clay ~50%

Thanks!

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