Investigating the Hydrological Connectivity of Forested Mitigation Wetlands Between 2019 - 2021 in Marquette Michigan, USA

Connor O'Loughlin[1], Matthew Van Grinsven[1], Katy Robinson[2] Emma Waatti[1], Madeline O'Donnell[3]

[1]Northern Michigan University Dept. of Earth, Environmental & Geographical Sciences, [2]USDA Natural Resource Conservation Service, [3]Marquette County Conservation District

ID: 1993

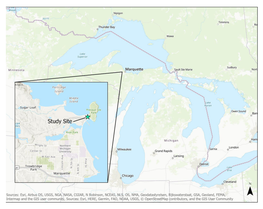
Introduction

Since 2011 the City of Marquette and the Marquette County Conservation District have been working on a mitigation project to fulfill a Michigan Department of Environment, Great Lakes, and Energy permit to restore 2.1 acres of forested palustrine wetlands located on a tombolo just north of Marquette, MI (Figure 1). While there are no connecting channels that would permit surface water exchange between Lake Superior and the mitigation wetlands, these wetlands nevertheless may function similar to other barrier protected coastal wetlands in the Great Lakes. There is a single coastal dune separating this mitigation wetland complex from Lake Superior. The overall of objective of this study was to investigate the hydrological connectivity between the atmosphere, Lake Superior, and 3 mitigation wetlands.

Methods

- The Modified Hargreaves-Samani equation (Droogers & Allen 2002) was used to estimate daily potential evapotranspiration (PET; Figure 3).
- Daily water stress (Figure 4) was estimated cumulatively – for the duration of the growing season – by subtracting daily PET estimates from daily accumulated precipitation observations (Figure 2).
- Data loggers (Onset Hobo U20L) were deployed in monitoring wells and used to record wetland water level observations every 30-minutes during 2021 (Figure 5). A differential level survey was conducted to reference the elevation (AMSL) of each monitoring wells to a local pre-established datum control point.
- Lake Superior water level observations were retrieved from the master monitoring gauge in Marquette, MI (NOAA-GLERL; Figure 6), and local sub-hourly meteorological observations (Figure 2) were retrieved from MesoWest and used to compare with wetland water level observations.

Figure 1. Study area location relative to the Great Lakes region and the City of Marquette (below), and the mitigation wetland study site boundaries (left).



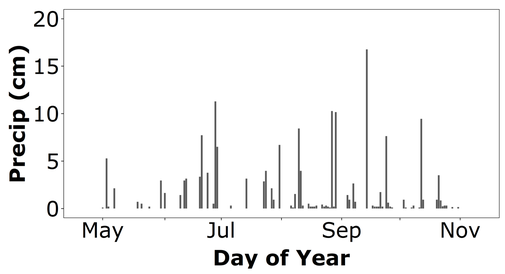


Figure 2. Daily accumulated precipitation (Precip; cm) observations for 2021.

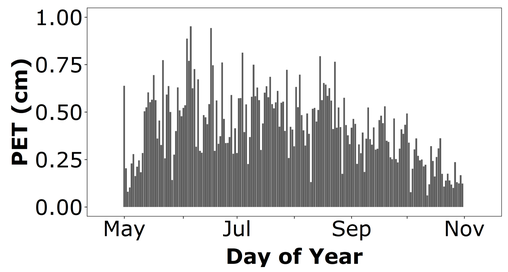


Figure 3. Daily potential evapotranspiration (PET; cm) estimates for 2021.

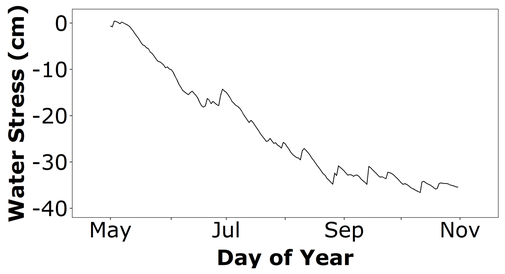


Figure 4. Daily water stress (cm) estimated cumulatively as Precip – PET for 2021.

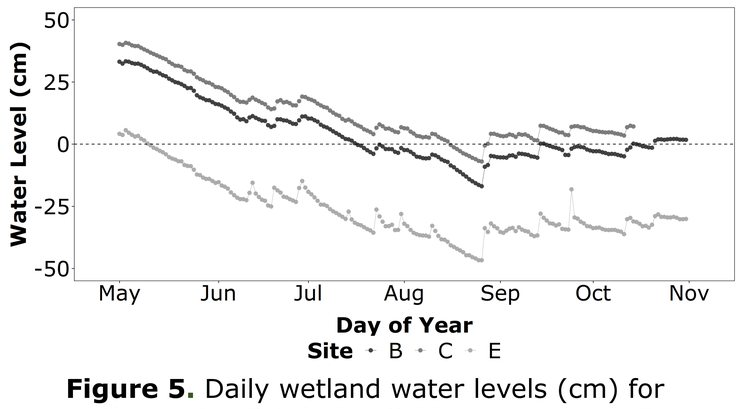


Figure 5. Daily wetland water levels (cm) for wetland sites B (black), C (dark gray), and E (light gray) observation relative to the wetland soil surface (dashed) for 2021.

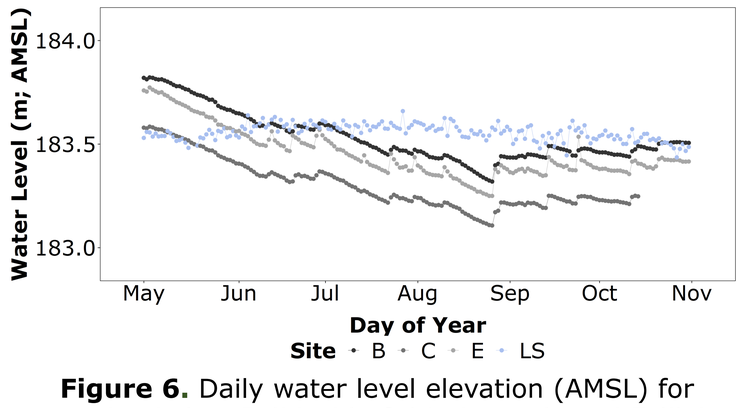


Figure 6. Daily water level elevation (AMSL) for wetland sites B (black), C (dark gray), and E (light gray); and for Lake Superior (blue) during 2021.

Results

- Wetland water levels were immediately responsive to episodic precipitation events during the growing season (Jun 1– Sep 1; Figures 2 & 5).
- Higher rates of wetland water level drawdown during the growing season coincide with the periods of higher PET (Figures 3 & 5).
- Wetland water levels (AMSL) of all 3 mitigation wetlands were above the elevation of Lake Superior (AMSL) on May 1, and on average maintained a mean elevation of 3.6 cm (± 5.1 cm) higher than Lake Superior between May 1st - June 1st (Figure 6).
- Wetland water levels (AMSL) of all 3 mitigation wetlands were below the elevation of Lake Superior (AMSL) for the majority of the growing season, and on average maintained a mean elevation of 18.2 cm (± 6.8 cm) lower than Lake Superior between June 1st – September 1st (Figure 6).

Literature Cited

Droogers, P., Allen, R.G. Estimating Reference Evapotranspiration Under Inaccurate Data Conditions. *Irrigation and Drainage Systems* **16,** 33–45 (2002)

Discussion

The water level elevation (AMSL) of all three mitigation sites was below the elevation of Lake Superior (AMSL) for the majority of the growing season (Figure 6). This indicates that Lake Superior water was directly contributing water to these wetlands via groundwater exchange during the growing season.

Seasonal rates of drawdown in each mitigation wetland (Figure 5) closely resemble the estimated cumulative water stress (Figure 4). This indicates these mitigation wetlands were also directly responsive to meteorological inflows (precipitation; Figure 2) and outflows (PET; Figure 3).

Conclusion

The water level elevation of these mitigation wetlands were below the elevation Lake Superior for an average 174 days during 2021 (Figure 6) indicating Lake Superior is likely contributing water via groundwater exchange underneath the singular barrier dune located on the northern boundary (Figure 1).