Use of Aerial Light Detection and Ranging Survey to Support Restoration and Management Objectives for Mitigation Wetlands in Marquette, MI, USA

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Introduction

In 2011, the City of Marquette, MI and the Marquette County Conservation District constructed a series of four mitigation wetlands to fulfill a Michigan Department of Environment, Great Lakes, and Energy (EGLE) Division permit focused on restoring 4.17 acres of forested wetlands. Repeat quadrat vegetation sampling locations and hydrological monitoring equipment were previously established to monitor native and non-native species and to examine the hydrological connectivity between adjacent groundwater and surface water bodies.

The purpose of this study is:

- Generate a high-resolution digital elevation model (DEM) using a light detection and ranging (LiDAR) survey of four separate forested mitigation wetlands in Marquette, MI, USA;
- Use the DEM to integrate with existing hydrological and vegetation monitoring to inform management activities and improve restoration outcomes.

Study Area

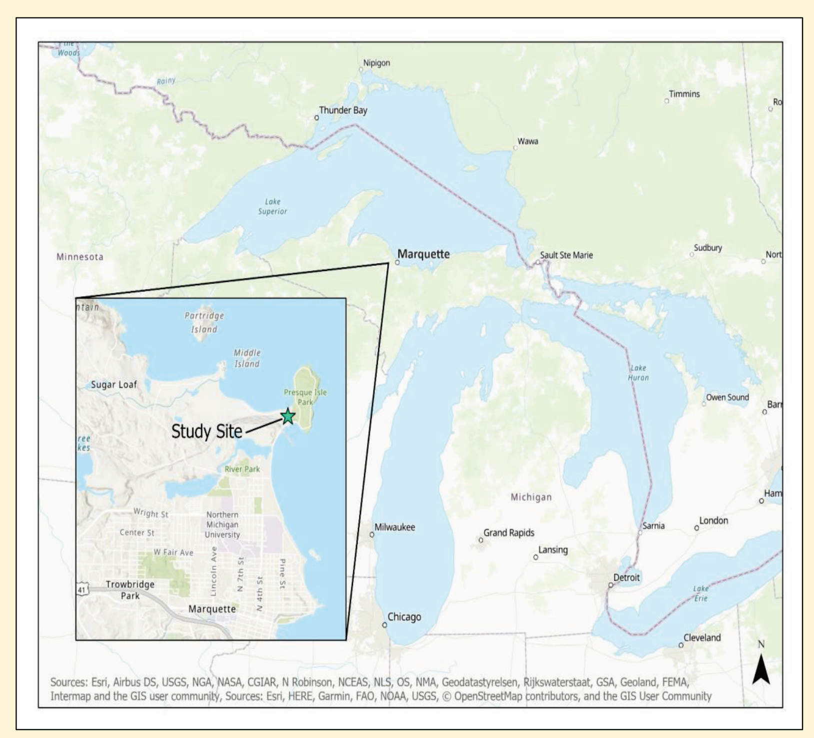

Figure 1. Wetland boundaries defined by the City of Marquette and USFWS NWI data overlaid on 2022 NAIP Imagery.

Methods

- A LiDAR survey flight was conducted over a 28.9-acre area that encompasses the 4.17 acres of mitigation wetlands, 4.94 acres of an existing palustrine emergent and shrub/scrub class wetland complex, and also includes urban, forested and non-woody land cover areas.
- A Zenmuse L1 Lidar sensor plus RGB sensor mounted on a DJI M300 RTK uncrewed aerial vehicle was used to collect LiDAR return data and visible light images at an altitude of 50 m using a 60% forward and 20% side overlap and three returns.
- Data were reconstructed into a point cloud using DJI Terra 3.6.6 and imported into ArcGIS Pro 2.6 to classify and extract points representing ground elevation.
- These ground elevation data were subsequently converted to a DEM with a spatial resolution of 0.5 m.
- A single-factor ANOVA and Tukey-Kramer test were performed in Excel to determine differences in TWI among the four mitigation wetlands.

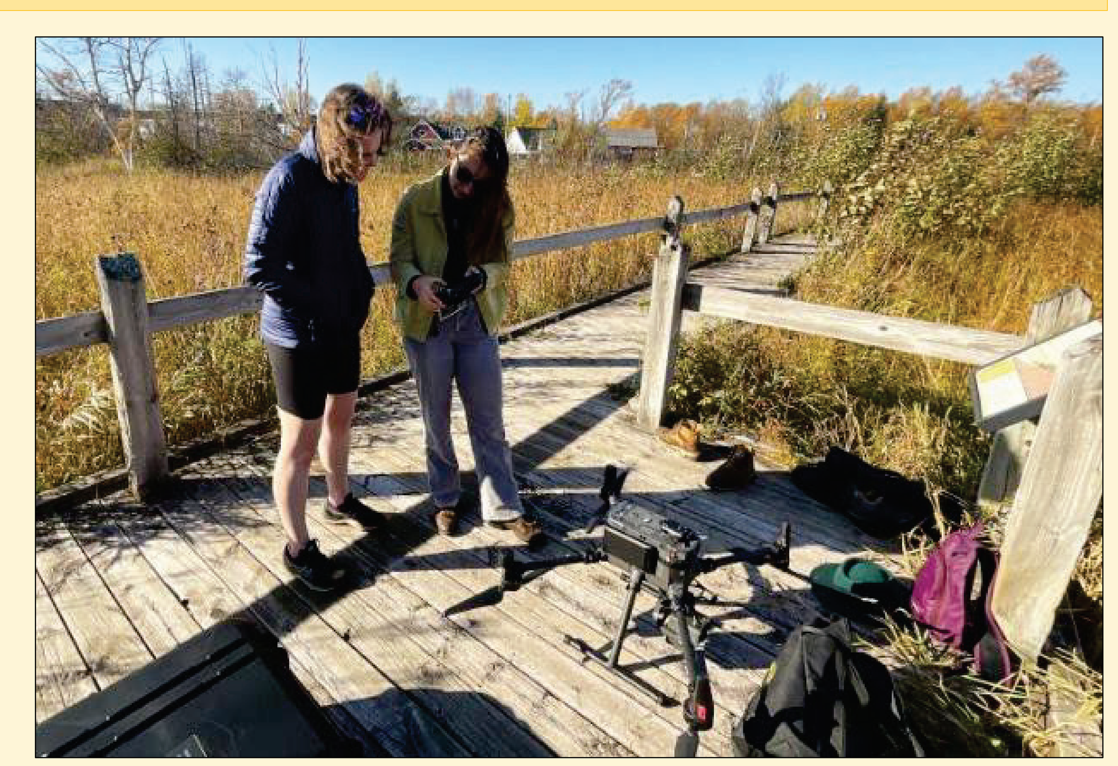

Figure 2. NMU students Mary Kelly and Rhayna Lillie program the UAV for the flight at the Presque Isle mitigation wetland area.

Results

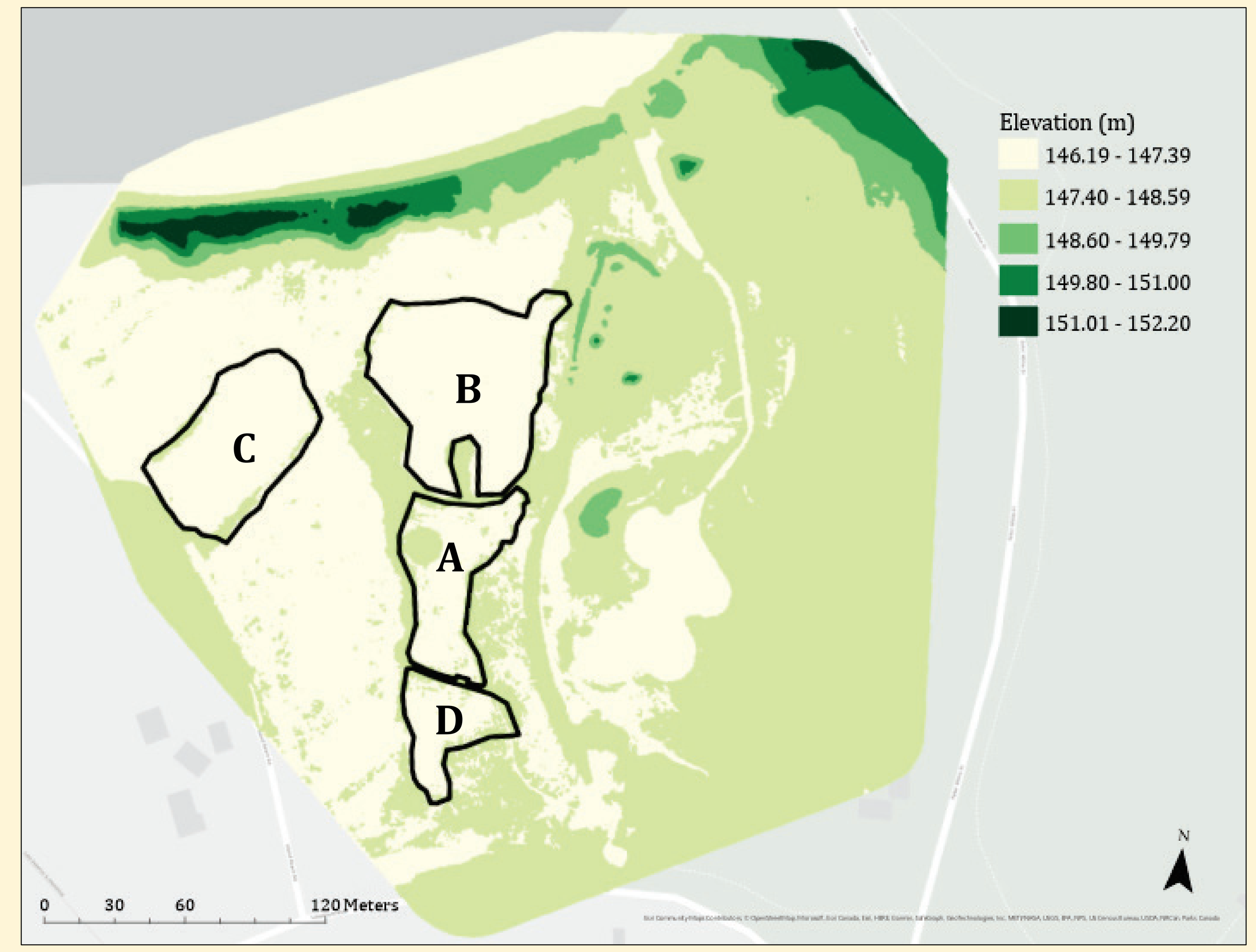

Figure 3. DEM of study area.

Figure 4. Topographic Wetness Index (TWI) of study area.

Table 1. Data table showing results of the single-factor ANOVA test.

Mitigation Wetland	Count	Sum	Average	Variance
A	10035	97853	9.75	39.10
B	20450	237419	11.61	34.24
C	14409	170624	11.84	39.06
D	5636	25021	4.44	17.73

My single-factor ANOVA analysis indicated that significant differences in TWI exist between wetlands. Subsequent Tukey-Kramer tests revealed that Wetland D had a statistically-significantly lower TWI than the other three wetlands (Table 2).

Table 2. Data table showing results of the Tukey-Kramer test.

Comparison	Abs. Mean Difference	Q Critical	P-Value	Null Hypothesis
A - B	1.86	3.63	> 0.05	Fail to reject
A - C	2.09	3.63	> 0.05	Fail to reject
A - D	5.31	3.63	< 0.05	Reject
B - C	0.23	3.63	> 0.05	Fail to reject
B - D	7.17	3.63	< 0.05	Reject
C - D	7.40	3.63	< 0.05	Reject

Discussion

- High TWI values are an indication of where water has a higher potential to either flow downslope or accumulate in low-lying areas. Low TWI values are in areas that have greater potential to contribute water to areas of steep slopes or low-lying areas.
- Water does not accumulate as easily in D because of its higher elevation and possibly due to dominant slope.
- Wetlands with lower TWI might potentially discourage species that require greater amounts of moisture and/or water depth. If management and invasive species are a concern, diversity of TWI might increase compositional diversity of wetlands and lessen their risk to certain invasive species.

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