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Supplementary material

Appendix 1

Development of GIS data layers

Water Depth

We developed a dynamic bathymetry map for the wetland complex using water depth measurements collected at systematically placed point locations (n = 694). Depth measurements (± 1 cm) were taken from a canoe in open water or on foot in flooded vegetation using a steel measuring tape and GPS unit. Lake level at the water control structure was recorded concurrent with depth measurements using a data logger (TruTrack model WT-HR 1000, Christchurch, NZ), which allowed depth values to be adjusted for changes in mean water level. Inverse-distance weighted (IDW) interpolation of depth values was performed in ArcGIS to rasterize the data. Changes in depth of open water in the main body of the lake were nearly 1:1 with changes at the control structure, while fluctuations in flooded sedge habitat and small ponds were proportional to water level at a lower ratio. Thus, depth maps were temporally dynamic and represented current water conditions for each resight survey session.

Open Water and Emergent Vegetation

We used National Agriculture Imagery Program (NAIP) aerial orthoimagery to create open water and open water-emergent vegetation edge density rasters for the study area. Imagery was available over the study area for the summers of 2005, 2009, 2011 and 2013. Change detection revealed no significant changes in open water vs. emergent vegetation coverage during this time period, so we used the 2009 image to create open water (%) and edge density (km km^{-2}) rasters to represent all study years. A histogram density slice was applied to the near-infrared (NIR) band in the image to separate open water and vegetation features, with boundaries converted to spatial lines to estimate edge densities. Additional details on these procedures are available in O'Neil et al. (2014).

Submergent Aquatic Vegetation

Aquatic vegetation surveys occurred on the study site each summer. Surveys were conducted at random 5 × 5 m plots on the study site, and SAV ordinal rank order cover classes were recorded (Daubenmire 1959). We used the % bare substrate class (100% minus the percentage of SAV canopy cover) to represent vegetation cover and to account for the ordinal nature of SAV cover classes. We used ArcGIS Geostatistical Analyst (ArcGIS 10.1, Esri Inc., Redlands, CA, USA) to apply a kriging interpolation model to the bare substrate canopy cover measurements for each year of the study. Ordinary kriging was used to predict bare substrate canopy cover at unmeasured locations when no relationship between water depth and SAV was detected. If SAV was significantly correlated with water depth (β coefficient for water depth $\neq 0$, $\alpha = 0.05$), we applied a universal cokriging model (Stein et al. 1991) using water depth values as a covariate to model the non-stationary process. For each kriging model, we used the Geostatistical Wizard tool in ArcGIS Geostatistical Analyst to optimize model parameters based on minimizing the mean-squared prediction error.

Fetch

Fetch, the distance wind can travel unobstructed over water (Rohweder et al. 2008), was estimated using methods from Finlayson (2005). Based on prevailing wind directions from the nearest reporting weather station (Dillon, MT; Western Regional Climate Center, http://www.wrcc.dri.edu/climatedata/climtables/westwinddir/), we applied a weighted fetch model to winds ranging from SSE (150°) to W (270°), ensuring that S and SSW aspects receiving the highest weights (0.32 and 0.24, for 180° and 195°, respectively) and the sum of all weights was 1. The resulting model was a raster where each pixel value was the weighted fetch, in distance (km).

References

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