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Management of hydro-biogeochemical connectivity of geographically isolated wetlands to reduce the risk of eutrophication of Lake Winnipeg

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Lake Winnipeg – a transboundary water resource that is the 10th largest freshwater lake in the world – was recently listed as the most threatened lake in the world due to eutrophication. Its watershed has experienced amongst the highest geographically isolated wetland (GIW) drainage rates in the world, leading to increased nutrient loads to remaining wetlands and downstream streams and lakes. GIWs are surrounded by uplands – and thus collect and store water from the surrounding landscape during snowmelt or storm events, and filter nutrients before slowly returning water to the water cycle. When drained, GIWs become connected to downstream flows and nutrients move unimpeded from and through them to downstream waters. Therefore, effective GIW management strategies can reduce nutrient loads to regional surface water bodies in the Lake Winnipeg watershed. But, how do we prioritize wetland protection and restoration efforts? We know that hydrologic connections to GIWs vary in length and timing, and hypothesize that long and slow hydrologic connections to a GIW have higher potential for P retention, while short and fast hydrologic connections to a GIW have lower potential for P retention along the flow path, leading to higher P concentrations within the GIW. We test these hypotheses in a watershed that drains into the North Saskatchewan River and ultimately to Lake Winnipeg. Using a novel model that quantifies the continuum of time and length variations of subsurface-surface hydrological connections to each GIW, we explore the relationship between length and time and time of hydrologic connection to a GIW and nutrients in the GIW. We found that GIWs are not always "isolated" islands – rather, they are connected to other surface waters in diverse ways. GIWs with no modeled surface or subsurface hydrological connections had the lowest nutrient concentrations and algal biomass. Recharge GIWs have lower concentrations of nutrients than discharge wetlands. Discharge GIWs with longer (slower) connections removed more nutrients along flow path to the wetland than discharge GIWs with shorter (faster) connections. Based on our findings, GIWs with long and slow hydrological connections have the highest potential for retaining phosphorus and therefore reducing eutrophication of downstream waters, and therefore should be prioritized in wetland protection and restoration strategies.