

Figure 1: Major lake and watershed factors affecting lake P retention. Shaded symbols indicate factors typically considered in P retention models whereas open symbols indicate additional factors specific to the present study. Dashed lines indicate inferred relationships, which cannot be tested with available data, but are otherwise discussed herein.

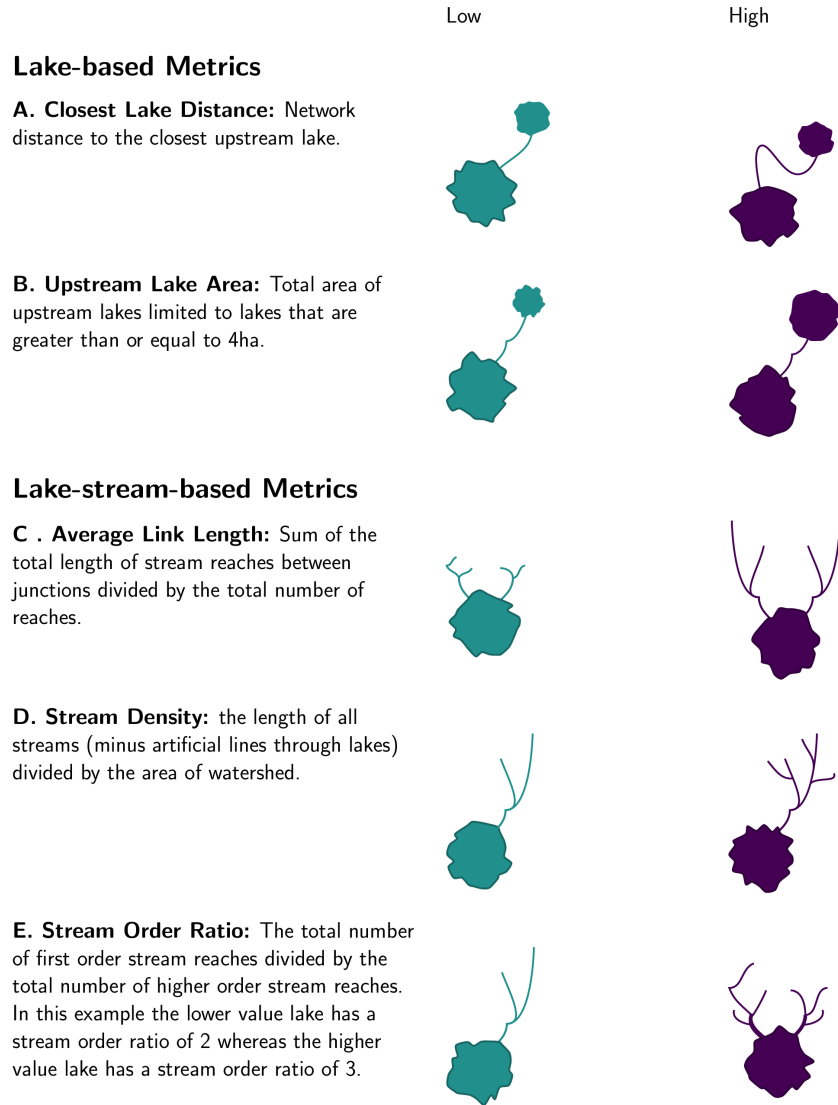


Figure 2: Connectivity metric definitions along with simplified examples of high and low value lakes that might arise from a binary classification. Both lake-stream-based and stream-based metrics are associated with restrictions on in-stream transport whereas stream-based metrics are associated with differences in transport of P from terrestrial runoff to streams. We use the term “first order stream” to describe a headwater stream.

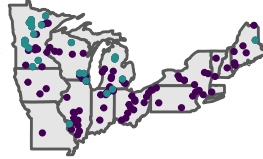
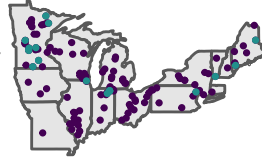
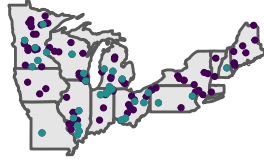


### A. SWS

Average  
link length

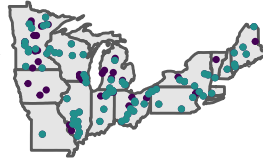
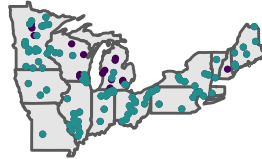
Closest  
lake distance

Stream  
density



Baseflow

Stream  
order ratio

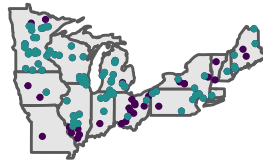
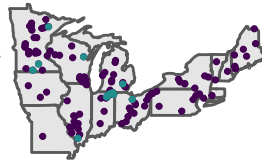
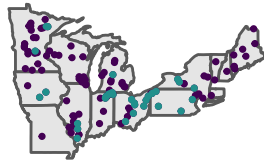


### B. WS

Average  
link length

Closest  
lake distance

Stream  
density



Upstream  
lake area

Baseflow

Stream  
order ratio

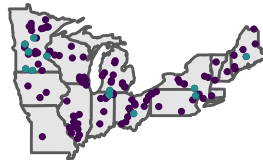
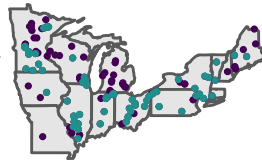
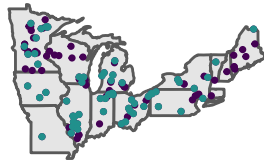


Figure 5: Locations of lakes of with different connectivity metric values at the (A) lake subwatershed and (B) lake watershed extent. Low valued lakes are represented by lighter (green) symbols, and high values lakes are represented by darker (purple) symbols. WS is the lake watershed extent. SWS is the lake subwatershed extent. Connectivity metrics are defined in Figure 2.

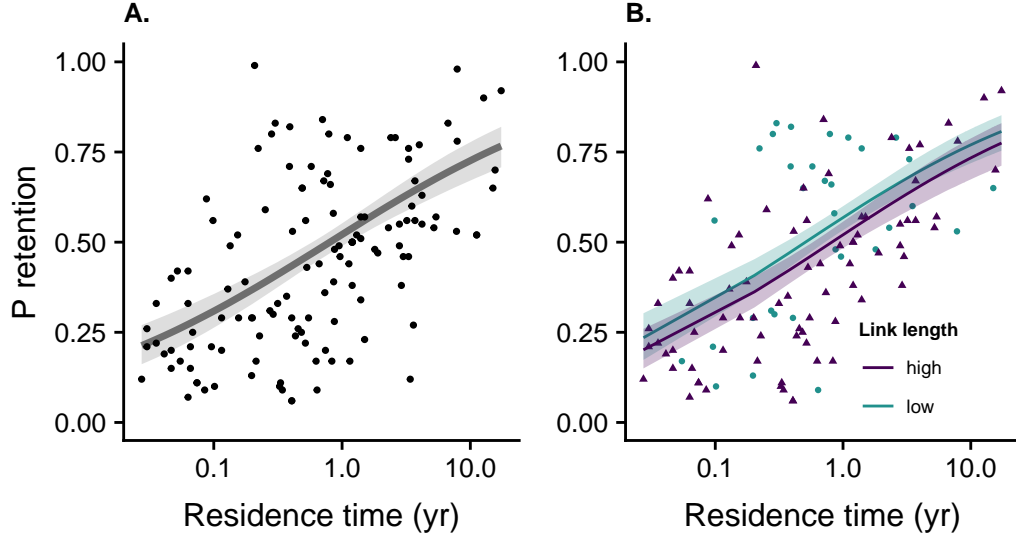


Figure 6: Residence time (yr) versus P retention for the NES dataset and the global model fit to the data ( $R^2 = 0.34$ ,  $n = 129$ ) where the solid line and shaded interval represents the median and central 95% interval estimates respectively (A). As above except that solid lines and shaded interval estimates represent hierarchical model fits to the data ( $R^2 = 0.41$ ,  $n = 129$ ) based on watershed average link length, which had the strongest association of any connectivity metric relative to P retention (B). Equations for these lines at median water residence time for low and high link length lakes are:  $R_p = 1 - (1 / (1 + 1.32 \tau^{0.4}))$  and  $R_p = 1 - (1 / (1 + 1.08 \tau^{0.4}))$  respectively.

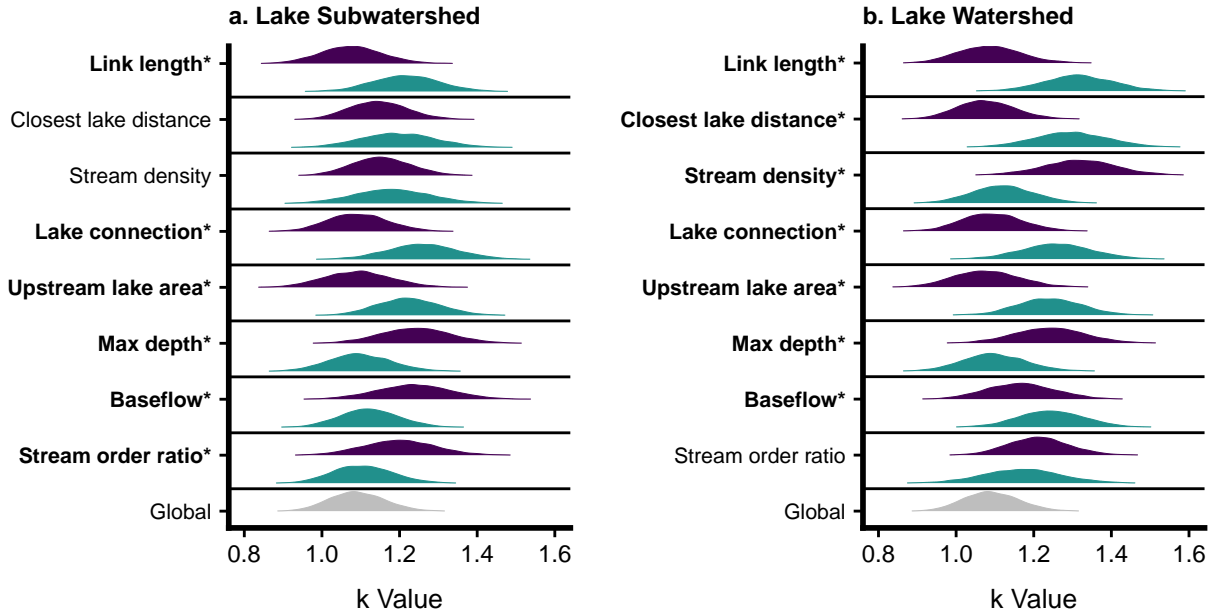


Figure 7: Distribution of the  $k$  parameter from Eq. 1 in lakes of differing connectivity, depth, or baseflow at the (A) lake subwatershed and (B) lake watershed extents. Lighter (green) lines indicate lakes with lower connectivity metrics values while darker (purple) lines indicate lakes with higher connectivity metrics values. For lake connection, lighter colored lines indicate lakes without upstream lakes. Connectivity metrics are defined in Figure 2. Labels associated with models where differences in  $k$  translated to significant differences in P retention are bolded and starred.