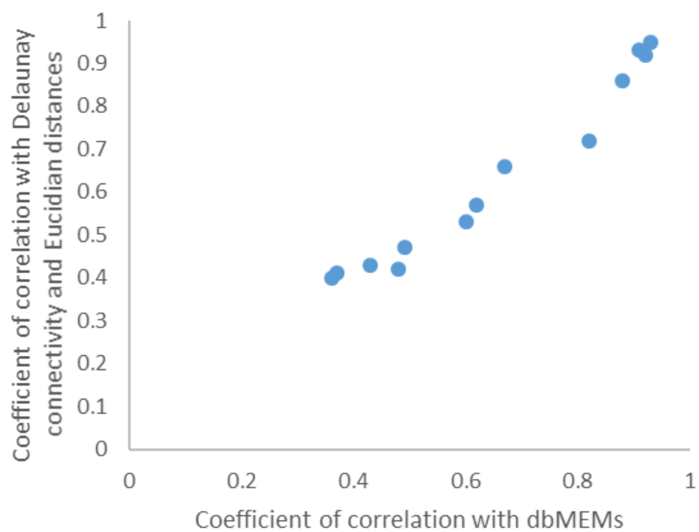
Supplementary Material

We tested different connectivity and edge weighting matrices to examine the effect of this choice on our results and ensure that our conclusions are not sensitive to the different ways to build MEMs. To do so, we built general Moran Eigenvectors Maps (MEMs) using 4 contrasting weighting functions (Delaunay and Gabriel connectivity matrix combined with Euclidean and Power function for distance matrix), and compared the variance explained in a subset of variables to the amount of variance explained by the distance-based MEMs (dbMEMs) used in the main text. We used a subset of response variables because these are extremely time-consuming analyses for that many sites, and we wanted to conduct our test on variables for which we had the identical number of observations. These variables include N deposition, SO4 deposition, Runoff, Baseflow, Mean annual precipitation, Mean annual temperature, Catchment slope, as well as percent Urban, Agriculture, Pasture, Evergreen, Mixed forest, Wetlands and Forested wetlands coverage in catchments.

We quantified the amount of variation explained in geographic variables by the first 2 axis of a redundancy analysis (RDA), which included MEMs as predictors and the above geographic response variables. Supplementary figure 1 shows the proportion of variance explained in the response variables using MEMs based on a Delaunay connectivity and Euclidean distance matrices *vs* that explained by dbMEMs (based a Minimum spanning tree (MST) connectivity matrix and a truncation of the Spatial weighing matrix (Euclidean distances), as used in the main text).



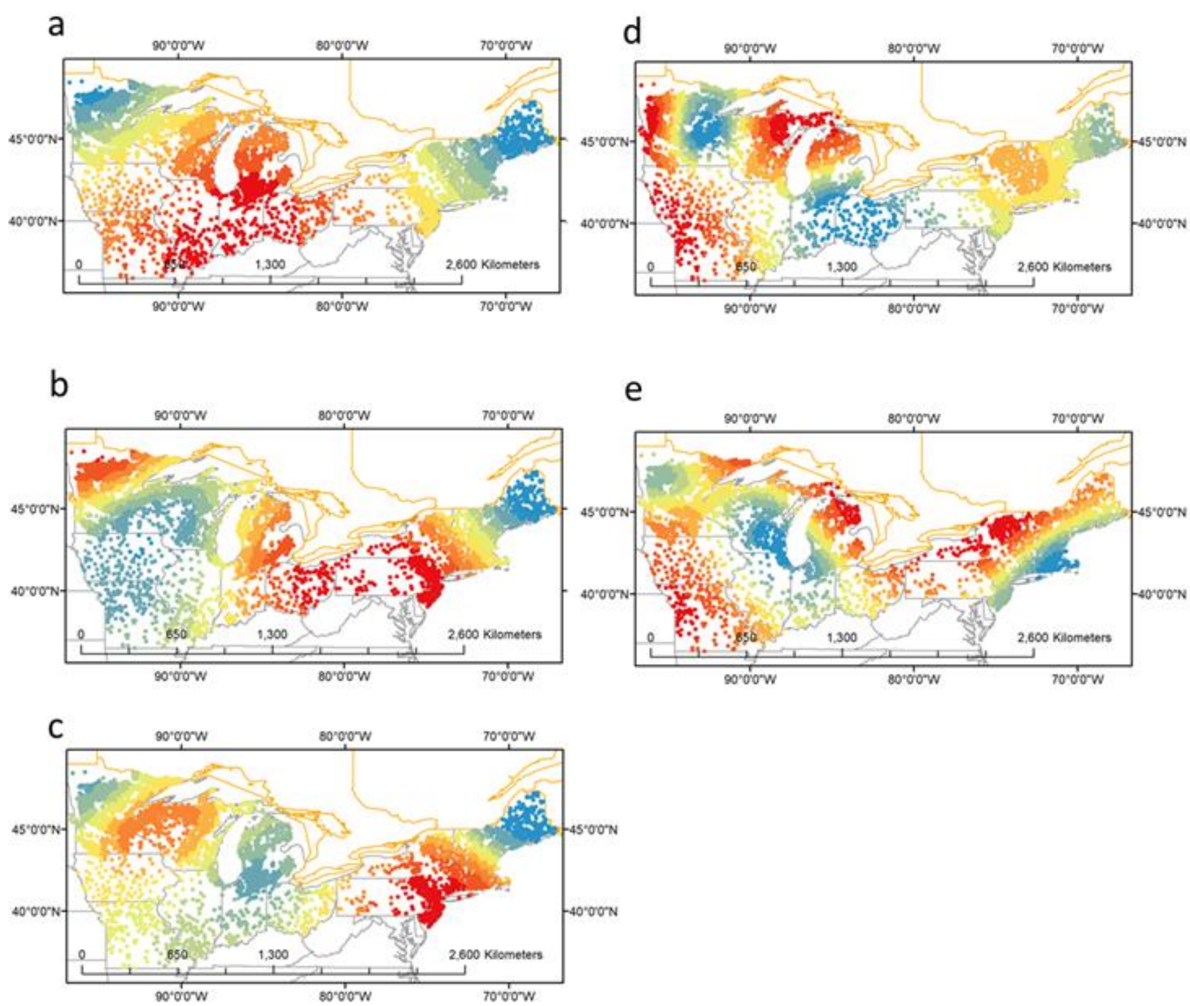
Supplementary figure 1. Comparing the variation explained in geographic response variables by dbMEMs vs MEMs built with a Delaunay connectivity matrix and Euclidean distances.

The r^2 for this relationship is 0.96 (Supp. Fig. 1). Supplementary table 1 shows the concordance of the variance explained in response variables using different combinations of connectivity matrices and edge weighting matrices. In other words, this table shows the r^2 of the above relationship, done for each possible combination of connectivity and distance matrices. This analysis demonstrates that our results are robust. Our main conclusions rely on the strength of spatial relationships among different climate, landscape, and lake variables, and the strength of the spatial structure estimated in these variables was only slightly affected by the choice of the weighting matrix.

Supplementary table 1. Concordance in the proportion of variation explained in geographic response variables by MEMs built with different connectivity and distance matrices. "MST Euclidean" corresponds to the combination of matrices used in dbMEMs.

	MST Euclidian.	*Delaunay Euclidian.*	*Gabriel Euclidian.*	*Delaunay power.*	*Gabriel power*
MST euclidian					
Delaunay euclidian	*0.96*				
Gabriel euclidian	*0.84*	*0.95*			
Delaunay power	*0.96*	*0.99*	*0.95*		
Gabriel power	*0.84*	*0.95*	*1*	*0.95*	

Appendix 2. Additional dbMEMs explaining significant amounts of variation in ecosystem variables. MEMs are shown in decreasing order in terms of spatial structure. dbMEM # 2,4,5, 7 and 8 (see Table 1) are shown. For each panel, the colors represent the amplitude of the dbMEM's sine wave, the "S-value", at each site. Sites with a similar S-value color are the most similar to each other, and red vs blue values are inversely correlated.



Appendix 3. Relationships of Moran Eigenvector Maps with contrasting spatial structure and climate, landscape and lake ecosystem properties. All MEMs explaining at least two percent of the variation in ecosystem variables are shown. See Table 1 legend for complete legend.

Variable	MEM #																	Cumulative
	Latitude	Longitude	1	2	3	4	5	6	7	8	9	10	11	13	14	15	18	
Mean annual precipitation	0.07		0.82					0.02										**0.91**
Mean annual temperature	0.91		0.02															**0.93**
Runoff		0.88			0.02			0.02										**0.92**
SO4 deposition	0.68		0.1			0.02		0.04	0.04									**0.88**
Mixed forest	0.11	0.21			0.29			0.13									0.02	**0.76**
N deposition	0.03	0.28			0.18			0.27	0.04					0.02				**0.82**
Evergreen	0.31	0.22						0.1		0.02	0.02							**0.67**
Agriculture			0.05	0.14	0.31			0.1		0.02								**0.62**
Baseflow					0.35			0.21		0.04								**0.6**
Forested wetlands					0.41			0.07										**0.48**
Urban	0.22						0.04	0.11	0.02	0.06		0.04						**0.49**
Wetlands	0.33				0.05					0.03						0.02		**0.43**
Pasture				0.04	0.26			0.04							0.02			**0.36**
TP	0.12	0.18				0.04		0.02		0.05								**0.41**
Chl a					0.19	0.04	0.05	0.03										**0.31**
Catchment slope		0.04	0.27					0.02		0.04								**0.37**
Secchi depth	0.05	0.05		0.02	0.18		0.03											**0.33**
TN		0.11		0.09			0.03	0.04		0.03			0.02					**0.32**
Lake depth (max)							0.07	0.02										**0.09**
Lake area	0.05						0.03											**0.08**
Lake perimeter							0.03											**0.03**
Watershed area	0.01																	**0.01**
Approximate MEM wavelength (km)			3200	1600	1400	1100	1000	800	700	600	550	500						