Linking the Agricultural Landscape of the Midwest to Stream Health with Structural Equation Modeling.

AUTHORS

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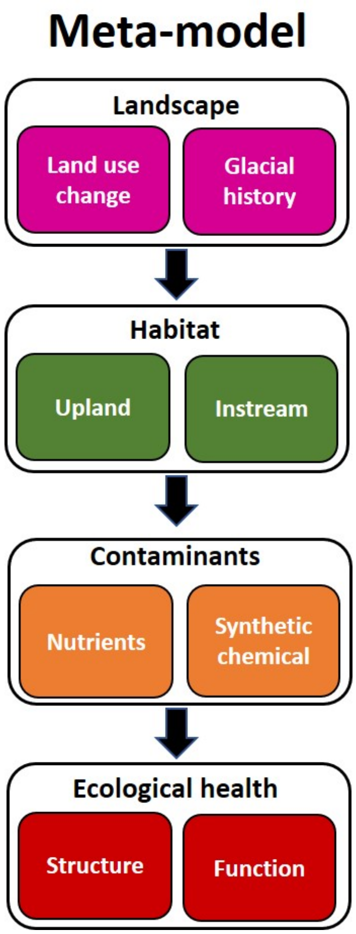

Figure S1. Portrayed in a “meta-model” generalizing how landscape structure and land-use change transmit effects through a hierarchical network culminating in alterations to ecological health. Figures 1- 4 expand in detail results from the Midwest Steam Quality Assessment. Boxes depict types of variables important to midwestern streams and arrows show the spatial- temporal relationships among variables. Glacial history is indicated by the variable Sand Content in Soil in subsequent models.

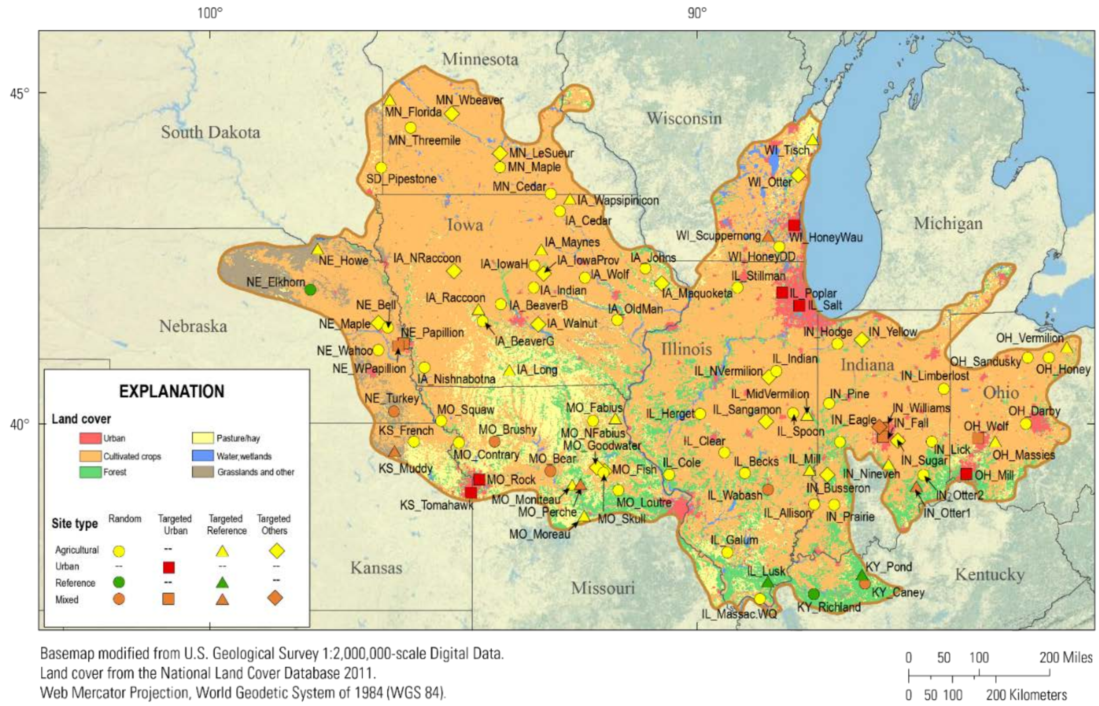

Figure S2. Map of the 100 sites sampled in the Midwestern Stream Quality Assessment (MSQA) in 2013 and corresponding land uses. Two of the 100 streams sampled for water quality were dropped from this analysis: the ecological survey was not done at one stream because of excessive depth (all streams were sampled using wading protocols), and the other stream was considered an outlier on the basis of basin size (>6,000 km^2) and its location on the far western edge of the region. Source: https://webapps.usgs.gov/RSQA/#!/region/MSQA.

Table S1. Variable definitions and why they were selected to be included in the structural equation models. Note: other variables were also considered for the model, see text for a discussion on why variables were not included in the models.

Variable	*Type of variable*	*Why used*	*Predicted effects on ecology*	*Transformation*
		Land use[a]		
Agricultural Land Use	Predictor	A study design element to assess the effects of agricultural and urban land uses on stream ecosystems.[4]	Indirect (-)	NT
Urban Land Use	Predictor	A study design element to assess the effects of agricultural and urban land uses on stream ecosystems.[4]	Indirect (-)	NT
		Natural landscape[a]		
Sand Content in Soil	Covariate[b]	Identified as an important variable in a previous investigation.[11] Also, this quality of soil was correlated with glacial history, which has been shown to be an important landscape factor in previous assessments of ecological integrity in the Midwest..[17, 56, 58]	Indirect	NT
Basin Area	Covariate[b]	*Posteriori* variable added to scale the influence of other variables that can be influenced by the size of river or stream or the location within the stream network of the sample location.	Indirect	$Log_{10}(X)$
		Upland[a]		
Channel Erosion	Stressor	A metric that determines the proportion of stream sediment comprised of either surface soil from the upland or in channel deposits of sediment. This metric has been modified from Gellis et al.[16] in that percent surface derived sediment is subtracted from 1 to describe the proportion of sediment that was derived from the channel. [16]	Indirect (-)	$Log_{10}(X+1)$
Percent Riparian Area as Forest	Stressor	Many variables related with riparian condition were identified as important predictors of stream condition. This predictor was selected to represent riparian factors that could affect water quality and ecological integrity and to simplify the number of predictors considered in the model. [10-12]	Direct (+) and mediator of land-use effects	NT
		Habitat[a]		
Percent Riparian Canopy Cover	Stressor	Many variables related with riparian condition were identified as important predictors of stream condition. This predictor was selected to represent riparian factors that could affect water quality and ecological integrity and to simplify the number of predictors considered in the model. [10-12]	Direct (+)	Arcsin(sqrt(X/100)
Relative Bed Stability	Stressor	d84 and percent fines were used by other investigators. We chose to use Relative Bed Stability as descriptive of both these other predictors to reduce the number of predictors in the model. Related to fish, invertebrates, and algal communities. [10-12]	Direct (+)	$X^{(1/4)}$
Maximum Temperature	Stressor	Found to limit algal communities. [10]	Direct (-)	NT
		Synthetic chemicals[a]		
Bifenthrin in Sediment	Stressor	Found to limit invertebrate communities. [21, 22]	Direct (-)	$Log_{10}(X+1)$
Imidacloprid	Stressor	Detected broadly in the ecoregion at levels thought to cause effects to invertebrate communities. [15]	Direct (-)	$Log_{10}(X+1)$
Pyrethroid Degradates in Water	Stressor	Found to limit invertebrate communities. [11]	Direct (-)	$Log_{10}(X+1)$
Sum of Triazine Herbicides	Stressor	Found to limit algal communities. [10]	Direct (-)	$Log_{10}(X+1)$
		Nutrients[a]		
Ammonia	Stressor	Found to limit invertebrate communities. [11]	Direct (-)	$Log_{10}(X+1)$
Total Nitrogen	Stressor	Found to affect fish, invertebrate, and algal communities. [10-12]	Context dependent direct effects	$Log_{10}(X)$
Total Phosphorus	Stressor	Found to affect fish and algal communities. [10, 12]	Context dependent direct effects	$Log_{10}(X)$

a- Class within which variables are nested for developing total effects. b- Indicates variables not included in the total effects class for which it is listed, rather it is treated as a covariate. NT-Not transformed.

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Table S2. Estimates of regression coefficients (standardized path coefficients) and covariances for the structural equation model of the relationships between stressors in streams of the Midwestern United States.

Response	*Predictor*	*Standardized Path Coefficient*	*Standard Error*	*Z-score*	*p-value*	R^2
		Regressions				
Agricultural Land Use	Sand Content in Soil	0.18	0.093	1.954	0.051	0.07
	Basin Area	0.19	0.068	2.795	0.005	
Urban Land Use	Sand Content in Soil	-0.21	0.079	-2.599	0.009	0.04
Total Phosphorus	Sand Content in Soil	-0.31	0.078	-4.039	0.000	0.37
	Agricultural Land Use	0.25	0.137	1.843	0.065	
	Urban Land Use	0.23	0.142	1.618	0.106	
	Percent Riparian Area as Forest	-0.32	0.087	-3.648	0.000	
	Relative Bed Stability	-0.17	0.097	-1.745	0.081	
Total Nitrogen	Agricultural Land Use	0.91	0.097	9.415	0.000	0.57
	Urban Land Use	0.54	0.135	3.984	0.000	
	Relative Bed Stability	-0.24	0.067	-3.623	0.000	
Ammonia	Basin Area	-0.47	0.099	-4.720	0.000	0.30
	Percent Riparian Area as Forest	-0.33	0.093	-3.524	0.000	
Percent Riparian Area as Forest	Agricultural Land Use	-0.47	0.160	-2.960	0.003	0.15
	Urban Land Use	-0.48	0.140	-3.431	0.001	
Percent Riparian Canopy Cover	Basin Area	-0.32	0.086	-3.742	0.000	0.35
	Percent Riparian Area as Forest	0.47	0.077	6.129	0.000	
Maximum Temperature	Sand Content in Soil	-0.33	0.074	-4.489	0.000	0.28
	Basin Area	0.28	0.100	2.761	0.006	
	Percent Canopy	-0.25	0.105	-2.384	0.017	
Relative Bed Stability	Urban Land Use	0.21	0.098	2.165	0.030	0.35
	Percent Riparian Area as Forest	0.47	0.082	5.771	0.000	
	Channel Erosion	-0.28	0.088	-3.134	0.002	
Channel Erosion	Sand Content in Soil	-0.52	0.078	-6.608	0.000	0.56
	Urban Land Use	-0.66	0.101	-6.501	0.000	
Sum of Triazine Herbicides	Sand Content in Soil	-0.24	0.082	-2.875	0.004	0.26
	Agricultural Land Use	0.50	0.094	5.381	0.000	
Imidacloprid	Sand Content in Soil	-0.12	0.075	-1.589	0.112	0.36
	Agricultural Land Use	0.31	0.129	2.382	0.017	
	Urban Land Use	0.74	0.115	6.400	0.000	
Pyrethroid Degradates in Water	Agricultural Land Use	0.21	0.103	2.057	0.040	0.21
	Urban Land Use	0.33	0.145	2.264	0.024	
	Bifenthrin in Sediment	0.33	0.119	2.740	0.006	
Bifenthrin in Sediment	Agricultural Land Use	0.34	0.113	3.026	0.002	0.16
	Urban Land Use	0.46	0.133	3.453	0.001	
	Relative Bed Stability	-0.25	0.073	-3.376	0.001	
		Covariances[1]				
Agricultural Land Use	Urban Land Use	-0.68	0.085	-8.020	0.003	
Total Phosphorus	Total Nitrogen	0.29	0.097	3.013	0.003	
Imidacloprid	Pyrethroid Degradates in Water	0.27	0.097	2.750	0.006	

[1]Variables with covariances are not response or predictor variables, they are covariates. Fit statistics: Model converged normally after 43 interactions. Robust chi-square = 65.368, p-value = 0.328, df = 61, n = 90, Satorra-Bentler correction factor =0.986, Comparative Fit Index = 0.994, Relative Noncentrality Index = 0.994, Robust Root Mean Square Error of Approximation =0.028 (90% confidence interval (0.000-0.071), Standardized Root Mean Square Residual = 0.070, Incremental Fit Index = 0.994

Table S3. Estimates of regression coefficients (standardized path coefficients), covariances, and latent construct and variables for the structural equation model of the relationships between stressors and algal communities in streams of the Midwestern United States.

Response	*Predictor*	*Standardized Path Coefficient*	*Standard Error*	*Z-score*	*p-value*	R^2
		Regressions				
Agriculture Land Use	Sand Content in Soil	0.20	0.09	2.311	0.021	0.08
	Basin Area	0.19	0.07	2.842	0.004	
Urban Land Use	Sand Content in Soil	-0.22	0.07	-2.985	0.003	0.05
Total Phosphorus	Sand Content in Soil	-0.32	0.08	-4.273	0.000	0.38
	Agriculture Land Use	0.31	0.13	2.331	0.020	
	Urban Land Use	0.31	0.14	2.191	0.028	
	Percent Riparian Area as Forest	-0.29	0.09	-3.387	0.001	
	Relative Bed Stability	-0.18	0.09	-1.961	0.050	
Percent Riparian Area as Forest	Agriculture Land Use	-0.48	0.15	-3.259	0.001	0.15
	Urban Land Use	-0.53	0.14	-3.91	0.000	
Percent Riparian Canopy Cover	Basin Area	-0.31	0.09	-3.504	0.000	0.36
	Percent Riparian Area as Forest	0.49	0.08	6.517	0.000	
Maximum Temperature	Sand Content in Soil	-0.36	0.07	-4.973	0.000	0.30
	Basin Area	0.29	0.10	2.953	0.003	
	Percent Riparian Canopy Cover	-0.24	0.10	-2.322	0.020	
Relative Bed Stability	Urban Land Use	0.26	0.09	2.737	0.006	0.36
	Percent Riparian Area as Forest	0.46	0.08	5.794	0.000	
	Channel Erosion	-0.28	0.09	-3.033	0.002	
Channel Erosion	Sand Content in Soil	-0.51	0.08	-6.597	0.000	0.58
	Urban Land Use	-0.69	0.09	-7.813	0.000	
Sum of Triazine Herbicides	Sand Content in Soil	-0.31	0.08	-3.997	0.000	0.27
	Agriculture Land Use	0.49	0.09	5.463	0.000	
Algae Latent Variable	Total Phosphorus	-0.36	0.13	-2.756	0.006	0.56
	Sum of Triazine Herbicides	-0.26	0.13	-2.029	0.042	
	Maximum Temperature	-0.35	0.09	-3.8	0.000	
	Percent Riparian Canopy Cover	0.17	0.10	1.647	0.099	
		Covariances[1]				
Agriculture Land Use	Urban Land Use	-0.70	0.08	-8.592	0.000	
Total Phosphorus	Sum of Triazine Herbicides	0.37	0.08	4.505	0.000	
		Algae Community Health (Latent Variable)[2]				
	Biological Condition Grp[3] 2	0.70	0.08	9.068	0.000	0.49
	Biological Condition Grp 3	0.76	0.08	9.723	0.000	0.58
	Biological Condition Grp 4	-0.49	0.13	-3.887	0.000	0.24

[1]Variables with covariances are not response or predictor variables, they are covariates. [2] Latent variables are described by indicator variables which are listed below the named construct above. The latent construct and individual indicators are predicted by the structural equation model; thus, both the construct and the indicators have R^2. [3]Relative Abundance of Biological Condition Gradient Group. The model converged normally after 32 interactions. Robust chi-square = 63.215, p-value = 0.330, df = 59, n = 93, Satorra-Bentler correction factor = 1.018, Comparative Fit Index = 0.988, Relative Noncentrality Index = 0.988, Robust Root Mean Square Error of Approximation = 0.028 (90% confidence interval = 0.000-0.072), Standardized Root Mean Square Residual = 0.073, Incremental Fit Index = 0.989

Table S4. Estimates of regression coefficients (standardized path coefficients) and covariances for the structural equation model of the relationships between stressors and invertebrate communities in streams of the Midwestern United States.

Response	*Predictor*	*Standardized Path Coefficient*	*Standard Error*	*Z-score*	*p-value*	*R^2*
		Regressions				
Agricultural Land Use	Sand Content in Soil	0.18	0.09	2.017	0.044	0.07
	Basin Area	0.19	0.08	2.381	0.017	
Urban Land Use	Sand Content in Soil	-0.21	0.08	-2.627	0.009	0.04
Total Nitrogen	Agricultural Land Use	0.92	0.09	10.034	0.000	0.59
	Urban Land Use	0.56	0.13	4.432	0.000	
	Relative Bed Stability	-0.26	0.07	-3.965	0.000	
Ammonia	Basin Area	-0.43	0.11	-4.069	0.000	0.23
	Percent Riparian Area as Forest	-0.25	0.10	-2.474	0.013	
Percent Riparian Area as Forest	Agricultural Land Use	-0.47	0.14	-3.362	0.001	0.15
	Urban Land Use	-0.48	0.13	-3.624	0.000	
Relative Bed Stability	Urban Land Use	0.21	0.09	2.391	0.017	0.35
	Percent Riparian Area as Forest	0.47	0.08	5.901	0.000	
	Channel Erosion	-0.28	0.09	-3.238	0.001	
Channel Erosion	Sand Content in Soil	-0.52	0.08	-6.547	0.000	0.56
	Urban Land Use	-0.66	0.10	-6.454	0.000	
Pyrethroid Degradates in Water	Agricultural Land Use	0.19	0.10	1.898	0.058	0.22
	Urban Land Use	0.30	0.14	2.138	0.032	
	Bifenthrin in Sediment	0.35	0.12	2.976	0.003	
Bifenthrin in Sediment	Agricultural Land Use	0.34	0.09	3.680	0.000	0.16
	Urban Land Use	0.46	0.13	3.532	0.000	
	Relative Bed Stability	-0.25	0.07	-3.581	0.000	
Multi-metric Index of Macroinvertebrate Community	Percent Riparian Area as Forest	0.28	0.08	3.506	0.000	0.40
	Total Nitrogen	0.25	0.08	2.915	0.004	
	Ammonia	-0.27	0.07	-3.872	0.000	
	Channel Erosion	-0.26	0.09	-2.992	0.003	
	Pyrethroid Degradates in Water	-0.43	0.08	-5.387	0.000	
		Covariances[1]				
Agricultural Land Use	Urban Land Use	-0.68	0.08	-8.254	0.000	

[1]Variables with covariances are not response or predictor variables, they are covariates. The model converged normally after 28 interactions. Robust chi-square = 35.930, p-value = 0.566, df = 38, n = 90, Satorra-Bentler correction factor = 0.980, Comparative Fit Index = 1.000, Relative Noncentrality Index = 1.008, Robust Root Mean Square Error of Approximation = 0.000 (90% confidence interval (0.000-0.067), Standardized Root Mean Square Residual = 0.052, Incremental Fit Index = 1.007

Table S5. Estimates of regression coefficients (standardized path coefficients) and covariances for the structural equation model of the relationships between stressors and fish communities in streams of the Midwestern United States.

Response	*Predictor*	*Standardized Path Coefficient*	*Standard Error*	*Z-score*	*p-value*	R^2
		Regressions				
Agricultural Land Use	Sand Content in Soil	0.19	0.09	2.159	0.031	0.07
	Basin Area	0.19	0.08	2.432	0.015	
Urban Land Use	Sand Content in Soil	-0.22	0.07	-3.050	0.002	0.05
Percent Riparian Area as Forest	Agricultural Land Use	-0.41	0.16	-2.581	0.010	0.11
	Urban Land Use	-0.49	0.15	-3.288	0.001	
Relative Bed Stability	Agricultural Land Use	0.28	0.13	2.234	0.025	0.39
	Urban Land Use	0.49	0.14	3.648	0.000	
	Percent Riparian Area as Forest	0.48	0.08	6.303	0.000	
	Channel Erosion	-0.28	0.10	-2.917	0.004	
Channel Erosion	Sand Content in Soil	-0.52	0.08	-6.325	0.000	0.59
	Urban Land Use	-0.70	0.09	-7.628	0.000	
Multi-metric Index of Fish Community	Sand Content in Soil	0.28	0.08	3.616	0.000	0.46
	Relative Bed Stability	0.43	0.06	6.733	0.000	
	Percent Riparian Area as Forest	0.30	0.06	4.747	0.000	
		Covariances[1]				
Agricultural Land Use	Urban Land Use	-0.73	0.07	-10.859	0.000	

[1]Variables with covariances are not response or predictor variables, they are covariates. The model converged normally after 30 interactions. Robust chi-square = 6.615, p-value = 0.882, df = 12, n = 91, Satorra-Bentler correction factor = 0.950, Comparative Fit Index = 1.000, Relative Noncentrality Index = 1.023, Robust Root Mean Square Error of Approximation = 0.000 (90% confidence interval (0.000-0.051), Standardized Root Mean Square Residual = 0.036, Incremental Fit Index = 1.021

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Table S6. Direct, indirect, and total effects (standardized path coefficients) of each predictor of algal, invertebrate, or fish communities observed in streams of the Midwestern United States.

	Response variables								
Predictor Variable	Algae Latent Variable			Macroinvertebrate Multi-metric			Fish Multi-metric		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Agricultural Land Use		-0.25	-0.25		0.03	0.03		-0.12	-0.12
Urban Land Use		0.15	0.15		-0.18	-0.18		0.11	0.11
Sand Content in Soil		0.29	0.29		0.20	0.20	0.28	-0.04	0.24
Basin Area		-0.23	-0.23		0.05	0.05		-0.02	-0.02
Percent Riparian Area as Forest		0.29	0.29	0.28	0.07	0.35	0.30	0.21	0.50
Channel Erosion		-0.02	-0.02	-0.26	0.01	-0.26		-0.12	-0.12
Relative Bed Stability		0.08	0.08		-0.03	-0.03	0.43		0.43
Percent Riparian Canopy Cover	0.17	0.08	0.25						
Maximum Temperature	-0.35		-0.35						
Total Phosphorus	-0.36	-0.10	-0.46						
Sum of Triazine Herbicides	-0.26	-0.14	-0.39						
Total Nitrogen				0.25		0.25			
Ammonia				-0.27		-0.27			
Pyrethroid Degradates in Water				-0.43		-0.43			
Bifenthrin in Sediment					-0.15	-0.15			

Table S7. Covariance matrix and means used to estimate the structural equation model relations among variables of stream condition in the Midwestern United States.

	Ag Land Use	Urb Land Use	Total P	Total N	NH_4	% Rip. as Forest	% Canopy	Temp.	RBS	Erosion	Herbicides	Imidacloprid	Pyrethroid Degradates	Bifenthrin	Sand Content	Basin Area
Ag Land Use	0.954															
Urb Land Use	-0.649	0.933														
Total P	0.123	0.121	1.049													
Total N	0.599	-0.155	0.425	0.998												
NH4	-0.16	0.162	0.125	-0.06	1.037											
% Rip. as Forest	-0.142	-0.147	-0.403	-0.368	-0.188	0.99										
% Canopy	-0.243	0.125	-0.205	-0.338	0.037	0.504	0.958									
Temp.	-0.017	-0.047	0.102	-0.043	0.169	-0.061	-0.315	0.919								
RBS	-0.225	0.281	-0.287	-0.319	-0.087	0.41	0.251	-0.026	0.993							
Erosion	0.376	-0.525	0.111	0.137	0.071	0.086	-0.102	0.239	-0.345	0.973						
Herbicides	0.418	-0.329	0.342	0.123	0.03	0.118	0.029	0.167	-0.075	0.301	0.952					
Imidacloprid	-0.238	0.522	0.242	-0.094	0.123	0.039	0.194	0.101	0.282	-0.273	0.21	1.013				
Pyrethroid Degradates	0.02	0.209	0.265	0.2	0.016	-0.146	0.024	0.002	-0.119	-0.075	0.181	0.379	1.009			
Bifenthrin	0.087	0.144	0.186	0.329	0.026	-0.231	-0.016	0.018	-0.196	-0.035	0.092	0.157	0.416	1.011		
Sand Content	0.192	-0.202	-0.321	0.118	-0.091	-0.069	-0.001	-0.333	-0.015	-0.382	-0.191	-0.281	-0.178	-0.002	1.037	
Basin Area	0.253	-0.101	0.232	0.214	-0.4	-0.158	-0.384	0.335	-0.01	-0.051	0.166	0.108	0.005	0.052	0.069	0.989
Means	0	-0.012	-0.005	0.002	-0.006	0.013	0.008	0.038	-0.02	0.034	0.014	-0.03	-0.002	-0.021	0.001	-0.019

Ag Land Use=Agricultural Land Use, Urb Land Use=Urban Land Use, Total P=Total Phosphorous, Total N=Total Nitrogen, NH4=Ammonia, % Rip. as Forest=Percent Riparian Area as Forest, % Canopy=Percent Riparian Canopy Cover, Temp.=Maximum Temperature, RBS=Relative Bed Stability, Erosion=Channel Erosion, Herbicides=Sum of Triazine Herbicides, Pyrethroid Degradates=Pyrethroid Degradates in water, Bifenthrin=Bifenthrin in Sediment, Sand Content=Sand Content in Soil.

Table S8. Covariance matrix and means used to estimate the structural equation model of stressor effects to algal communities in streams of the Midwestern United States.

	BCG Grp 2	BCG Grp 3	BCG Grp 4	Agriculture Land Use	Urban Land Use	Total Phosphorus	Riparian Forest Area	Percent Riparian Canopy	Maximum Temperature	Relative Bed Stability	Channel Erosion	Sum of Triazine Herbicides	Sand Content	Basin Area
BCG Grp 2	1.013													
BCG Grp 3	0.513	1.028												
BCG Grp 4	-0.309	-0.433	1.031											
Agriculture Land Use	-0.211	-0.052	0.211	1.004										
Urban Land Use	0.119	0.002	-0.200	-0.729	1.036									
Total Phosphorus	-0.437	-0.353	0.210	0.109	0.127	1.018								
Riparian Forest Area	0.187	0.166	-0.142	-0.107	-0.186	-0.395	1.003							
Percent Riparian Canopy	0.185	0.319	-0.125	-0.204	0.062	-0.198	0.530	0.995						
Maximum Temperature	-0.282	-0.406	0.200	-0.021	-0.033	0.098	-0.073	-0.328	0.898					
Relative Bed Stability	0.166	0.131	-0.248	-0.268	0.338	-0.273	0.385	0.220	-0.022	0.998				
Channel Erosion	-0.251	-0.289	0.218	0.423	-0.599	0.106	0.102	-0.047	0.217	-0.385	1.024			
Sum of Triazine Herbicides	-0.375	-0.250	0.240	0.430	-0.373	0.336	0.126	0.083	0.144	-0.104	0.360	0.994		
Sand Content	0.258	0.379	0.010	0.220	-0.229	-0.319	-0.059	-0.010	-0.315	-0.030	-0.364	-0.202	1.032	
Basin Area	-0.348	-0.225	0.139	0.284	-0.141	0.220	-0.163	-0.380	0.332	-0.040	-0.019	0.170	0.088	0.995
Means	-0.013	0.011	-0.01	-0.01	0.018	-0.009	0.002	-0.031	0.052	-0.004	-0.007	-0.034	0.016	-0.017

BCG Grp= Relative Abundance of algae in a Biological Condition Gradient Group, Riparian Forest Area= Percent Riparian Area as Forest, Percent Riparian Canopy= Percent Riparian Canopy Cover, Sand Content=Sand Content in Soil.

Table S9. Covariance matrix and means used to estimate the structural equation model of stressor effects to invertebrate communities in streams of the Midwestern United States.

	Agricultural Land Use	Urban Land Use	Total Nitrogen	Ammonia	% Rip. as Forest	RBS	Channel Erosion	Pyrethroid Degradates in Water	Bifenthrin in Sediment	Macroinvertebrate Multi-metric	Sand Content in Soil	Basin Area
Agricultural Land Use	0.954											
Urban Land Use	-0.649	0.933										
Total Nitrogen	0.599	-0.155	0.998									
Ammonia	-0.16	0.162	-0.06	1.037								
Percent Riparian Area as Forest	-0.142	-0.147	-0.368	-0.188	0.99							
Relative Bed Stability	-0.225	0.281	-0.319	-0.087	0.41	0.993						
Channel Erosions	0.376	-0.525	0.137	0.071	0.086	-0.345	0.973					
Pyrethroid Degradates in Water	0.02	0.209	0.2	0.016	-0.146	-0.119	-0.075	1.009				
Bifenthrin in Sediment	0.087	0.144	0.329	0.026	-0.231	-0.196	-0.035	0.416	1.011			
Macroinvertebrate Multi-metric	0.147	-0.125	0.03	-0.368	0.285	0.294	-0.19	-0.412	-0.272	1.024		
Sand Content in Soil	0.192	-0.202	0.118	-0.091	-0.069	-0.015	-0.382	-0.178	-0.002	0.346	1.037	
Basin Area	0.253	-0.101	0.214	-0.4	-0.158	-0.01	-0.051	0.005	0.052	0.246	0.069	0.989
Means	0.000	-0.012	0.002	-0.006	0.013	-0.02	0.034	-0.002	-0.021	0.048	0.001	-0.019

% Rip. As Forest=Percent Riparian Area as Forest, RBS=Relative Bed Stability

Table S10. Covariance matrix and means used to estimate the structural equation model of stressor effects to fish communities in streams of the Midwestern United States.

	Agricultural Land Use	Urban Land Use	Percent Riparian Area as Forest	Relative Bed Stability	Channel Erosion	Multi-metric Index of Fish Community	Sand Content in Soil	Basin Area
Agricultural Land Use	0.970							
Urban Land Use	-0.753	1.055						
Percent Riparian Area as Forest	-0.054	-0.179	0.965					
Relative Bed Stability	-0.213	0.354	0.332	0.953				
Channel Erosion	0.428	-0.612	0.108	-0.388	1.046			
Multi-metric Index of Fish Community	-0.043	0.011	0.427	0.519	-0.232	0.980		
Sand Content in Soil	0.199	-0.234	-0.038	-0.002	-0.376	0.276	1.039	
Basin Area	0.281	-0.144	-0.159	-0.031	-0.020	-0.089	0.084	1.015
Means	0.001	0.027	-0.018	-0.017	-0.008	0.029	0.013	-0.019

Table S11. Median variable values for sites classified on glacial history.

Variable	Pre-Wisconsin	Late-Wisconsin
Channel Erosion	0.75	0.60
Surface Erosion	0.25	0.40
Percent Riparian Canopy Cover	38.00	37.00
Imidacloprid	31.16	41.91
Sum of Triazine Herbicides	933.47	470.06
Pyrethroid Degredates	2.84	0.00
Bifenthrin in Sediment	0.00	0.08
Maximum Temperature	30.04	29.45
Total Phosphorus	0.17	0.08
Total Nitrogen	2.90	3.96
Ammonia	0.03	0.02
Relative Bed Stability	0.04	0.25
MMI_FISH	53.80	61.40
MMI_INSECTS	38.74	51.29
BC_2.RelAbun	0.05	0.06
BC_3.RelAbun	0.26	0.33
BC_4.RelAbun	0.21	0.18
Urban Land Use	5.29	6.95
Agriculture Land Use	73.41	81.48
Sand Content in Soil	12.67	24.86
Percent Riparian Area as Forest	24.68	19.15
Basin Area	148.76	255.64
Base Flow Index	24.69	40.79
Basin Slope	4.54	1.87
Row Crops	57.83	74.44

BC= Biological Condition Group, RelAbun=Relative abundance.

Table S12. Summary statistics based on raw data values of each variable used in the structural equation modeling.

Variable	Median	Range
Channel Erosion (%)	0.71	0.00-1.00
Surface Erosion (%)	0.29	0.00-1.00
Percent Riparian Canopy Cover (%)	41	0-96
Imidacloprid (ng/POCIS)[1]	41.9	0.0-2855.9
Sum of Triazine Herbicides (ng/L)	723.3	49.1-3404.9
Pyrethroid Degredates (ng/POCIS)[1]	1.61	0.0-27.4
Bifenthrin in Sediment (% of likely effects benchmark)[1]	0.00	0.00-1.29
Maximum Temperature (°C)	29.78	19.85-45.47
Total Phosphorus (mg/L)	0.12	0.01-1.32
Total Nitrogen (mg/L)	2.90	0.11-31.30
Ammonia (mg/L)	0.03	0.00-0.87
Relative Bed Stability	0.07	0.00-6.71
MMI_FISH (score)	57.6	23.1-84.7
MMI_INSECTS (score)	44.06	6.4-87.0
BC_2.RelAbun (%)	0.06	0.00-0.68
BC_3.RelAbun (%)	0.30	0.07-0.91
BC_4.RelAbun (%)	0.20	0.01-0.61
Urban land use (%)	6.04	1.98-99.56
Agriculture land use (%)	74.8	0.05-95.27
Sand Content in Soil (%)	16.49	2.58-78.37
Riparian Area as Forest (%)	25.8	0.00-100.00
Basin Area (km^2)	164.47	3.47-2232.89
Base Flow Index (% of base flow to total streamflow)	32.49	7.00-6.38
Basin Slope (%)	2.67	0.57-11.71
Row Crops (%)	62.91	0.00-95.27

[1]-See more details in Moran et al. (2011)[21] and Nowell et al. (2018)[13]. MMI=Multi-metric Index, BC=Biological Condition Group, RelAbund=Relative abundance.