Water Quality Analysis of the Lamprey River Watershed

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URC Poster and report

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Motivation

Good water quality is important for the ecosystem and human health. The Lamprey River was designated as a National Wild and Scenic River on the basis of its outstandingly remarkable scenic, recreational, geologic, fish and wildlife, and historical resources, which all depend on its water quality. The Lamprey River flows into the Great Bay Estuary, which is suffering from excess suspended solids and nutrient loading. It is also a major water source for residents living in the watershed and the University of New Hampshire. This study seeks to characterize the phosphorus and heavy metal levels of the Lamprey River.

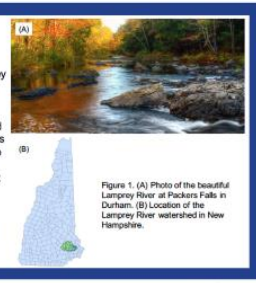

Figure 1. (A) Photo of the beautiful Lamprey River at Packers Falls in Durham. (B) Location of the Lamprey River watershed in New Hampshire.

Spatial Analysis

- Location information and average concentrations before and after 2000 of parameters with the most measurements were imported into QGIS.
- Exceedances of phosphorus were found at 7 locations before 2000; the one close to Epping was very high (0.09 mg/L). After 2000, only 2 locations exceeded the NHDES standard, and the maximum (0.04 mg/L) was close to the standard (0.035 mg/L).
- Prior to 2000, exceedances of aluminum were found at numerous locations; after 2000 only 1 exceedance was found.
- Before 2000, numerous exceedances of zinc and copper were found especially in the upper watershed; after 2000, no exceedances were found.

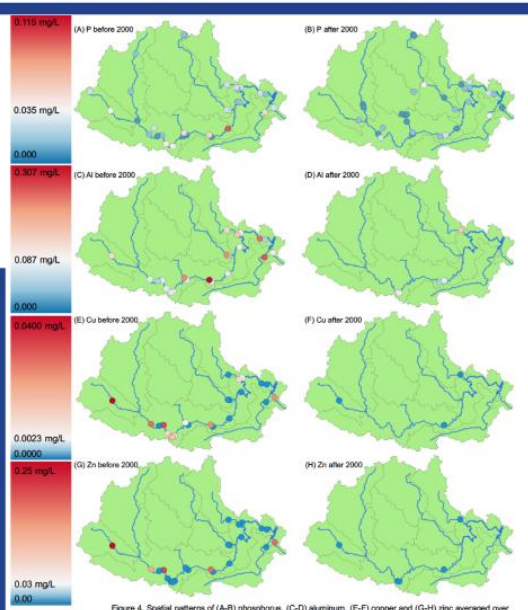

Figure 4. Spatial patterns of (A-B) phosphorus, (C-D) aluminum, (E-F) copper and (G-H) zinc averaged over all measurements (A,C,E, G) before 2000 and (B, D, F, H) after 2000.

Data Summary

- Historical water quality grab sample measurements for 112 stations in the Lamprey River watershed were downloaded from the NH Department of Environmental Services (DES) Environmental Monitoring Database via the OneStop Mapper.
- Only freshwater samples were used in this study. Outliers of iron and zinc were excluded.
- Exceedances were assessed by comparison with New Hampshire guidelines
  - For dissolved heavy metals, chronic Water Quality Criteria for Toxic Substances (Env-Wq 1703.21) were used.
  - For total phosphorus, standards were recommended by NHDES (Interpreting VRAP Water Quality Monitoring Parameters, 2011).
- Phosphorus concentrations did not change seasonally, but phosphorus flux was highest in spring
- Most heavy metal measurements occurred in summer and fall. Very few dissolved samples of cadmium, chromium, iron, mercury and nickel have been obtained.

Parameter	Total Count	Average (mg/L)	NHDES Standard (mg/L)	Percentage Exceedance	Number of Measurements Before 2000	Number of Measurements After 2000	Number of Exceedances Before 2000	Number of Exceedances After 2000	Percentage Exceedance Before 2000	Percentage Exceedance After 2000
Phosphate	2272	0.00709	0.0120	6.34%	57	2107	6	138	0.26%	6.07%
Phosphorus	2269	0.02528	0.0350	13.75%	291	1897	61	251	2.69%	11.06%
Aluminum	165	0.10513	0.0870	31.52%	133	32	41	11	24.85%	6.67%
Cadmium	13	0.00025	0.0002	15.38%	13	0	2	0	15.38%	0.00%
Chromium	13	0.01000	0.0110	0.00%	13	0	0	0	0.00%	0.00%
Copper	141	0.01089	0.0023	52.48%	131	10	73	1	51.77%	0.71%
Iron	13	0.61454	1.0000	0.00%	12	0	0	0	0.00%	0.00%
Lead	133	0.00376	0.0650	0.00%	121	12	0	0	0.00%	0.00%
Mercury	5	0.00000	0.0008	0.00%	1	4	0	0	0.00%	0.00%
Nickel	18	0.00417	0.0133	11.11%	13	5	2	0	11.11%	0.00%
Zinc	157	0.18265	0.0300	25.48%	134	22	40	0	25.48%	0.00%

Table 1. Summary of measurements for each parameter, including total number of measurements, average parameter value, NHDES standard and exceedances

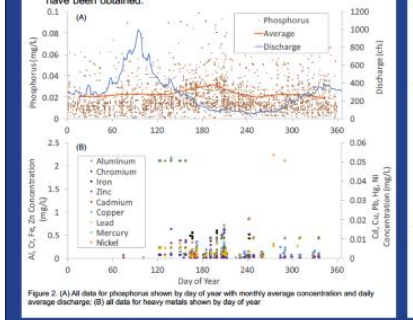

Figure 2. (A) All data for phosphorus shown by day of year with monthly average concentration and daily average discharge; (B) all data for heavy metals shown by day of year

Temporal Analysis

- Each parameter and its standard were plotted over time. JMP was used to test the significance of the trend line slope.
- In general, the average annual concentration of phosphorus did not exceed the New Hampshire standard. Freshwater phosphorus and phosphate concentrations did not increase over time.
- Most heavy metals either decreased over time, or never exceeded the New Hampshire standard.

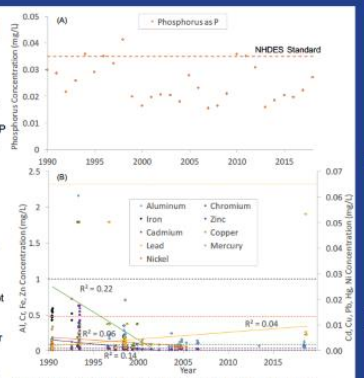

Figure 3. Time series of (A) annual average total phosphorus concentration and its recommended standard; (B) heavy metal measurements for all sites with their standards (dashed lines) and trend lines (solid lines) if the concentration changes over time ($p < 0.05$).

Conclusions

- The Lamprey River occasionally exhibits high phosphorus and heavy metal concentrations, in portions of the watershed that are more developed. Heavy metal concentrations have decreased over time, while phosphorus levels may be increasing.
- Overall the surface water quality of the Lamprey River watershed is high, and it is suitable for recreational purposes.
- Despite the generally high water quality, continued management of the watershed is critical. Possible actions include industrial permitting; developing TMDL for the portions of the Lamprey River that are impaired for aluminum, cadmium, copper, lead, mercury and nickel; and reducing storm water runoff.

Acknowledgements

I would like to thank Anne Lightbody and the Lamprey River Advisory Committee for their guidance and advice. I would also like to thank all the people and organizations that collected water quality data, and the NHDES for making it available.

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October 28, 2019

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Motivation

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- The Lamprey River was designated as a National Wild and Scenic River on the basis of its outstandingly remarkable scenic, recreational, geologic, fish and wildlife, and historical resources, which all depend on its water quality.
- It is also a major water source for residents living in the watershed and the University of New Hampshire.

(A)

(B)

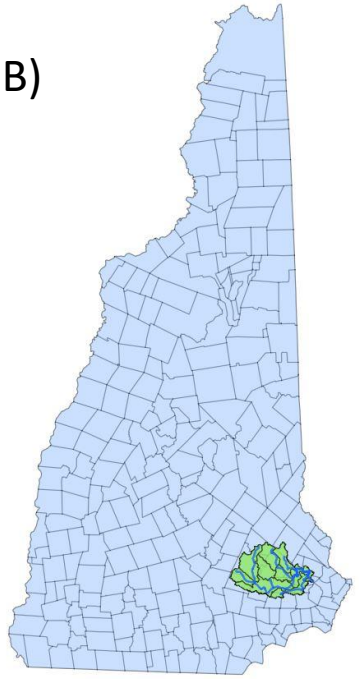

Figure 1. (A) Photo of the beautiful Lamprey River at Packers Falls in Durham; (B) location of the Lamprey River watershed in New Hampshire.

Data Summary

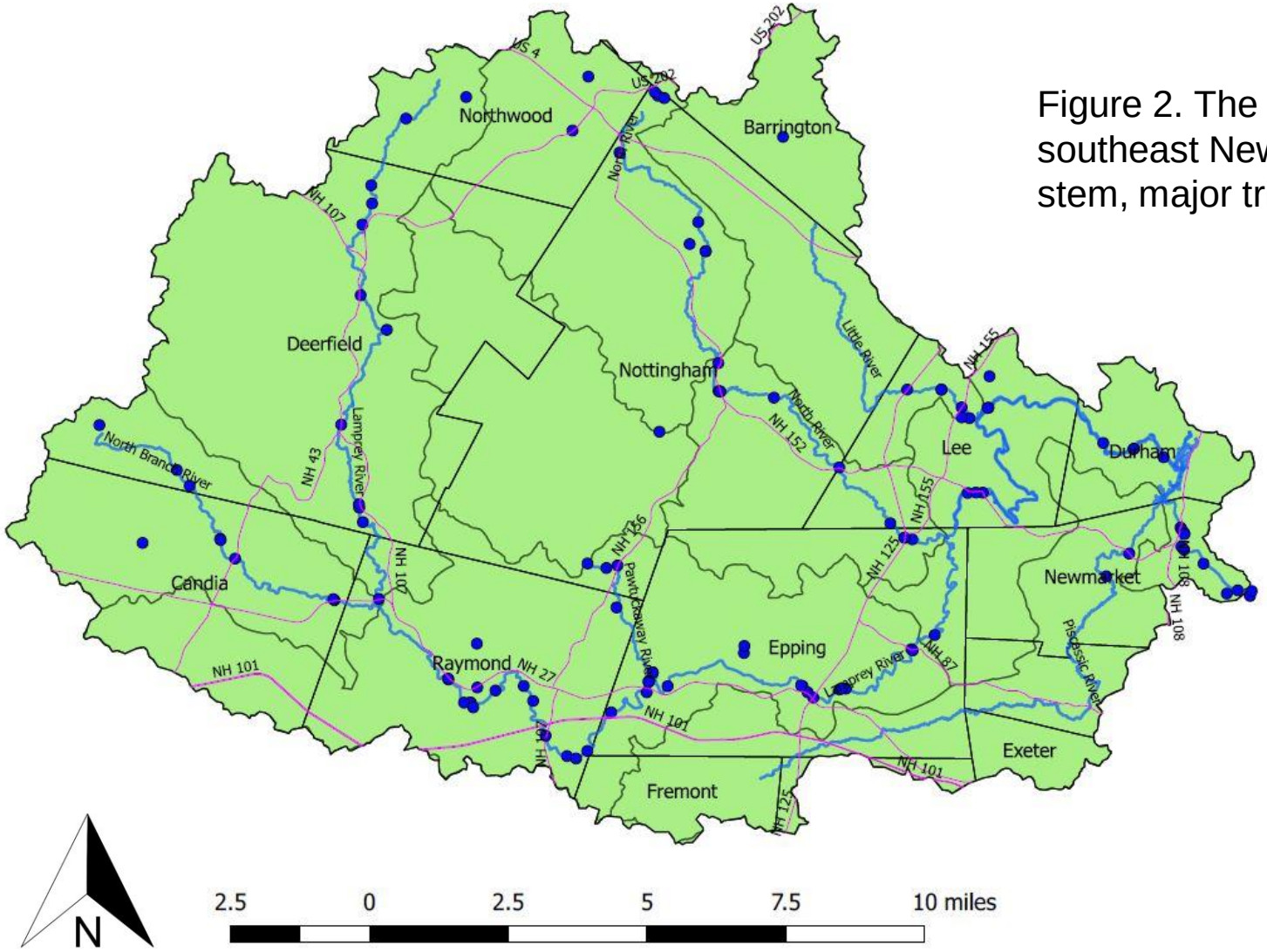

Figure 2. The Lamprey River watershed in southeast New Hampshire showing the main stem, major tributaries, and sampling locations.

Parameter	Total Count	Number of Stations	Average (mg/L)	NHDES Standard (mg/L)	Percentage Exceedance	Number of Measurements Before 2000	Number of Measurements After 2000	Percentage Exceedance Before 2000	Percentage Exceedance After 2000
Phosphorus	2269	59	0.0236	0.035	13.75%	291	1897	19.93%	12.70%
Aluminum	165	26	0.1051	0.087	31.52%	133	32	30.83%	34.38%
Zinc	157	25	0.1827	0.03	25.00%	134	22	29.10%	
Copper	141	25	0.0109	0.0023	51.77%	131	10	54.96%	10.00%
Lead	133	26	0.0038	0.065		121	12		
Nickel	18	12	0.0042	0.0133	11.11%	13	5	11.11%	
Cadmium	13	11	0.0003	0.0002	15.38%	13		15.38%	
Chromium	13	11	0.0100	0.011		13			
Iron	13	10	0.6145	1		12			
Mercury	5	4	<0.0001	0.0008		1	4		

Table 1. Summary of measurements for each solute, including the total number of measurements, average concentration over the period of record, NHDES standard, number of measurements before and after 1/1/2000, and percentage of exceedances before and after 1/1/2000.

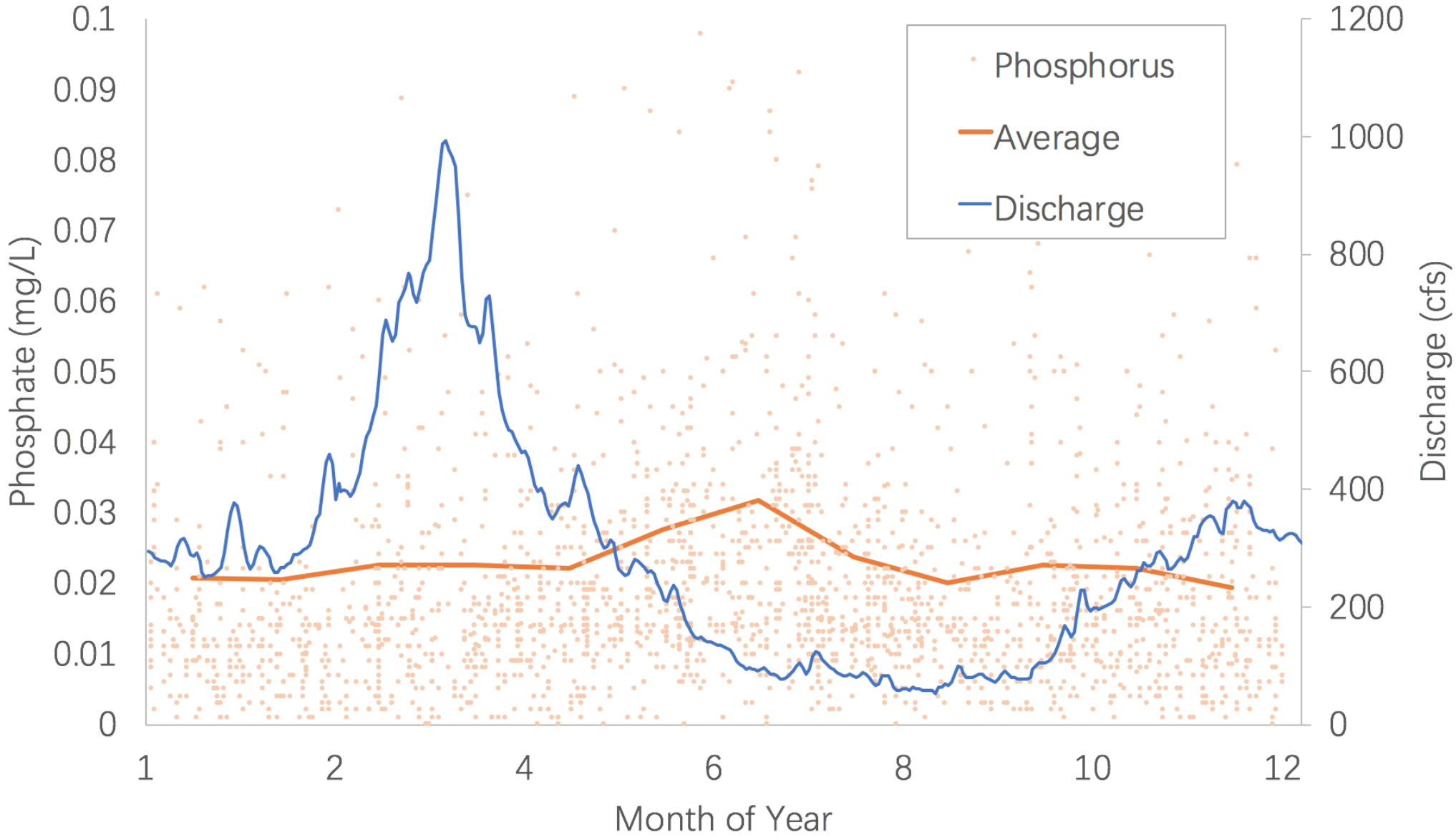

Figure 3. All data for phosphorus shown by day of year with monthly average concentration and daily average discharge

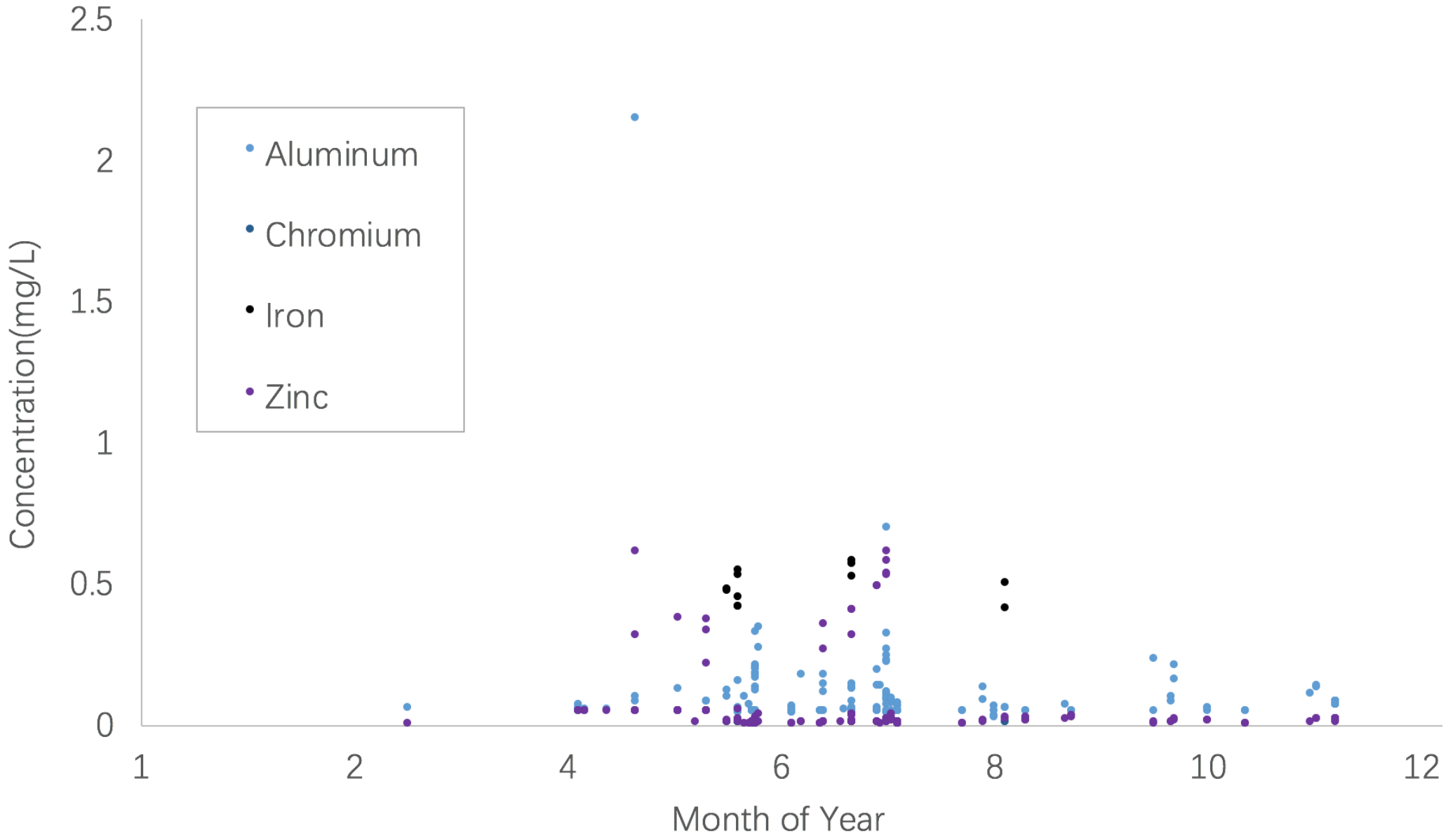

Figure 4. All data for aluminum, chromium, iron, and zinc shown by day of year

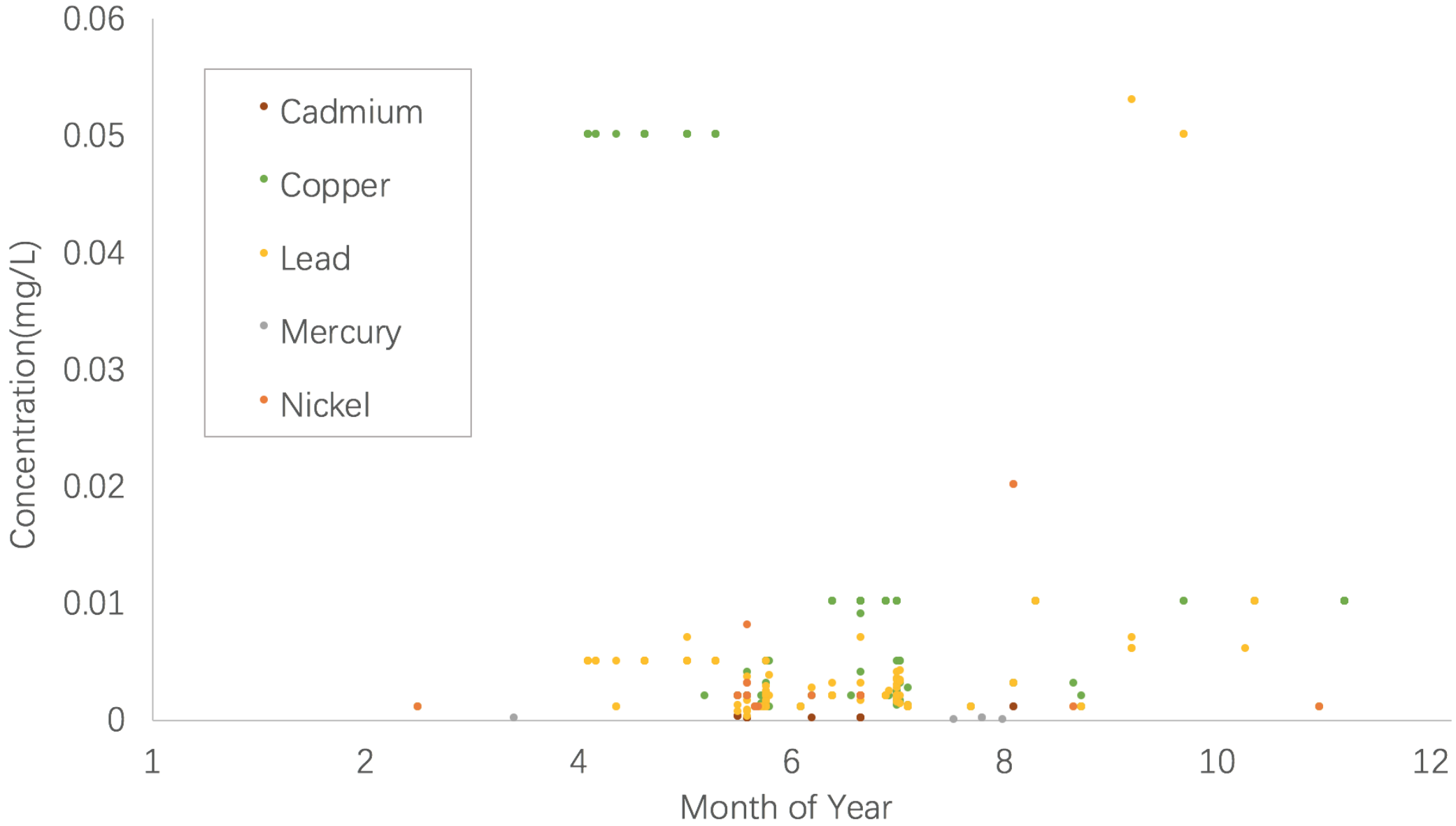

Figure 5. All data for cadmium, copper, lead, mercury, and nickel shown by day of year

Temporal Analysis

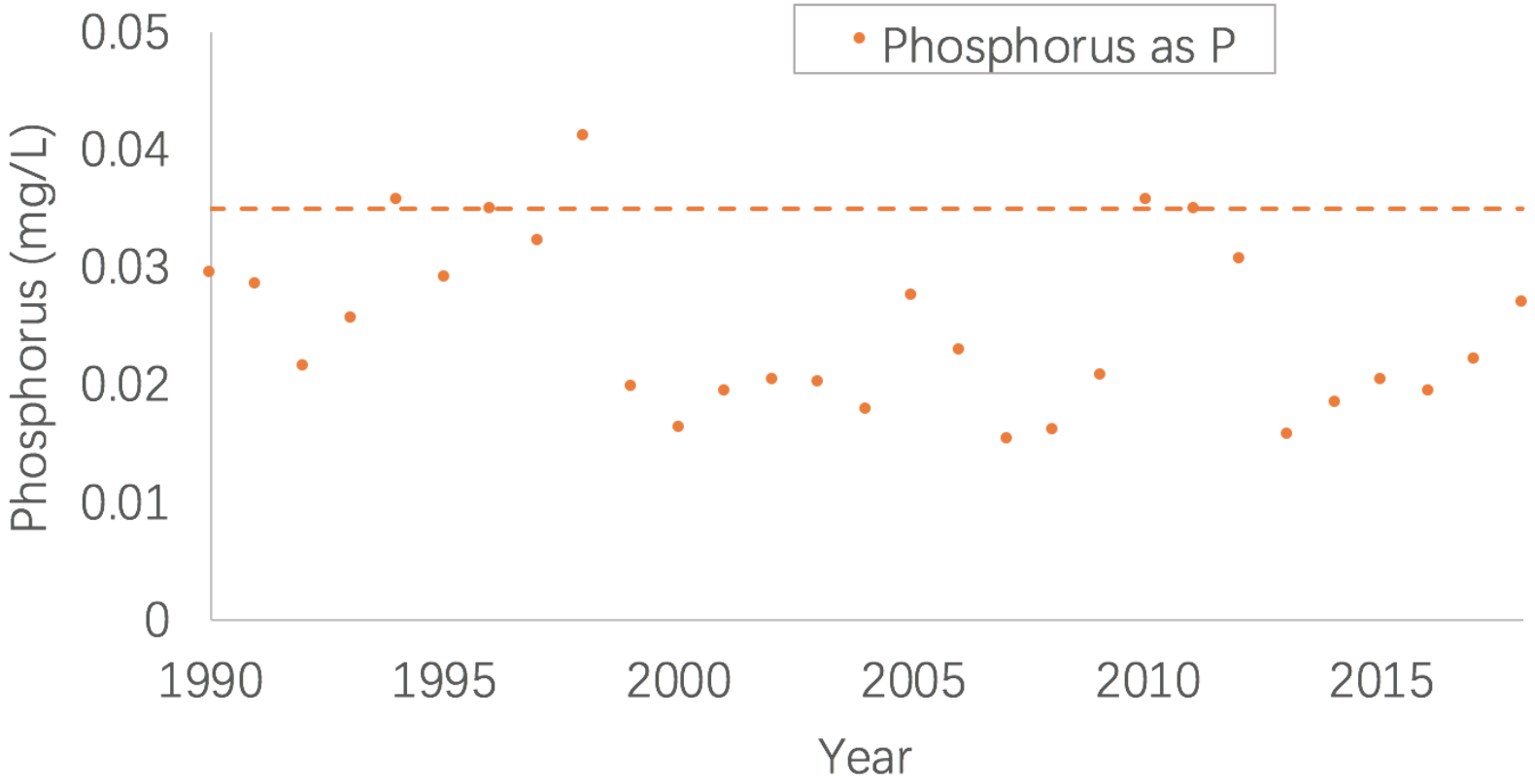

Figure 6. Time series of annual average total phosphorus concentration and its recommended standard

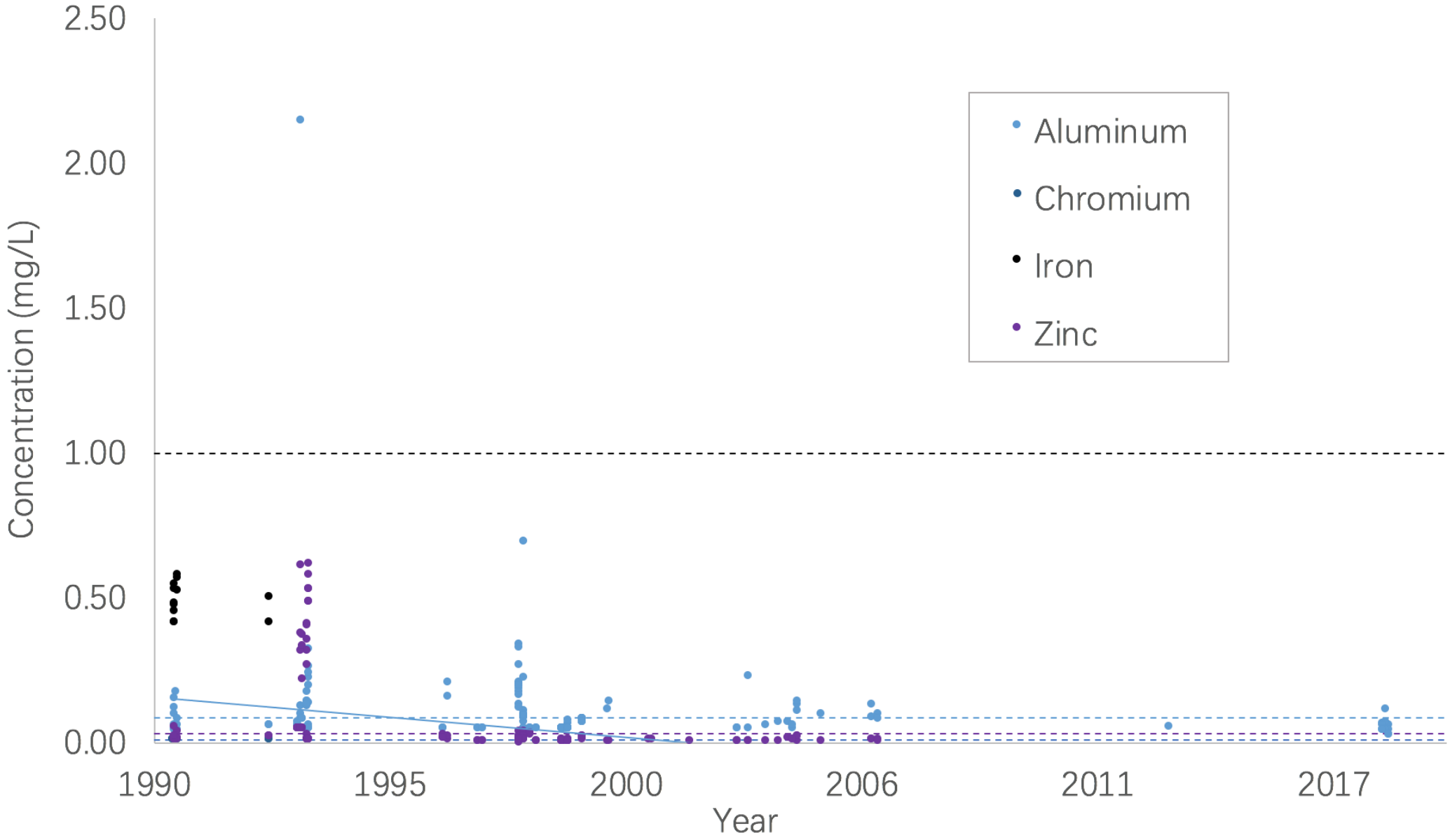

Figure 7. Time series of aluminum, chromium, iron and zinc concentrations for all sites with their standards (dashed lines) and trends (solid lines) if the concentration changes over time ($p<0.05$)

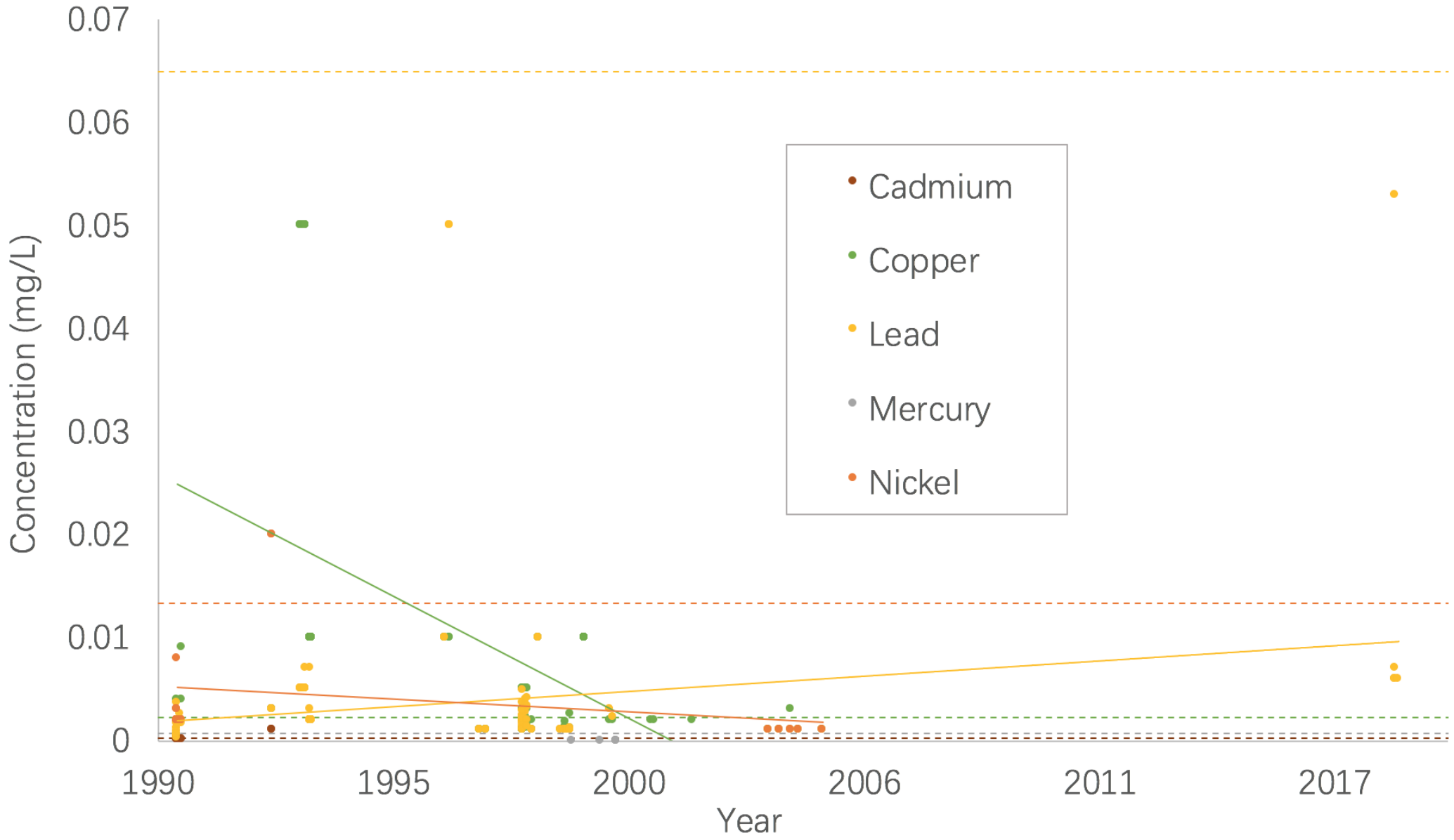

Figure 8. Time series of cadmium, copper, lead, mercury, and nickel concentrations for all sites with their standards (dashed lines) and trends (solid lines) if the concentration changes over time ($p<0.05$)

Spatial Analysis

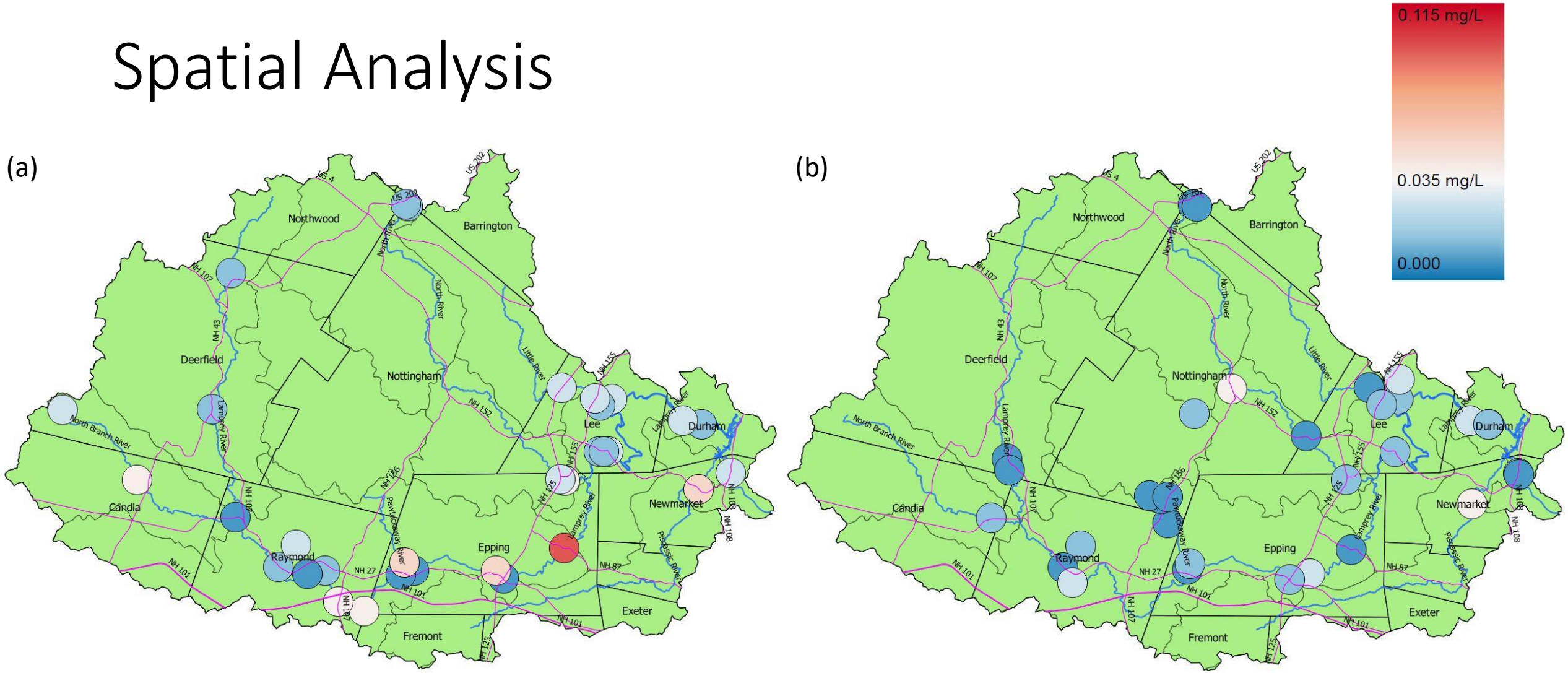

Figure 9. Spatial patterns of phosphorus averaged measurements (a) before and (b) after 1/1/2000

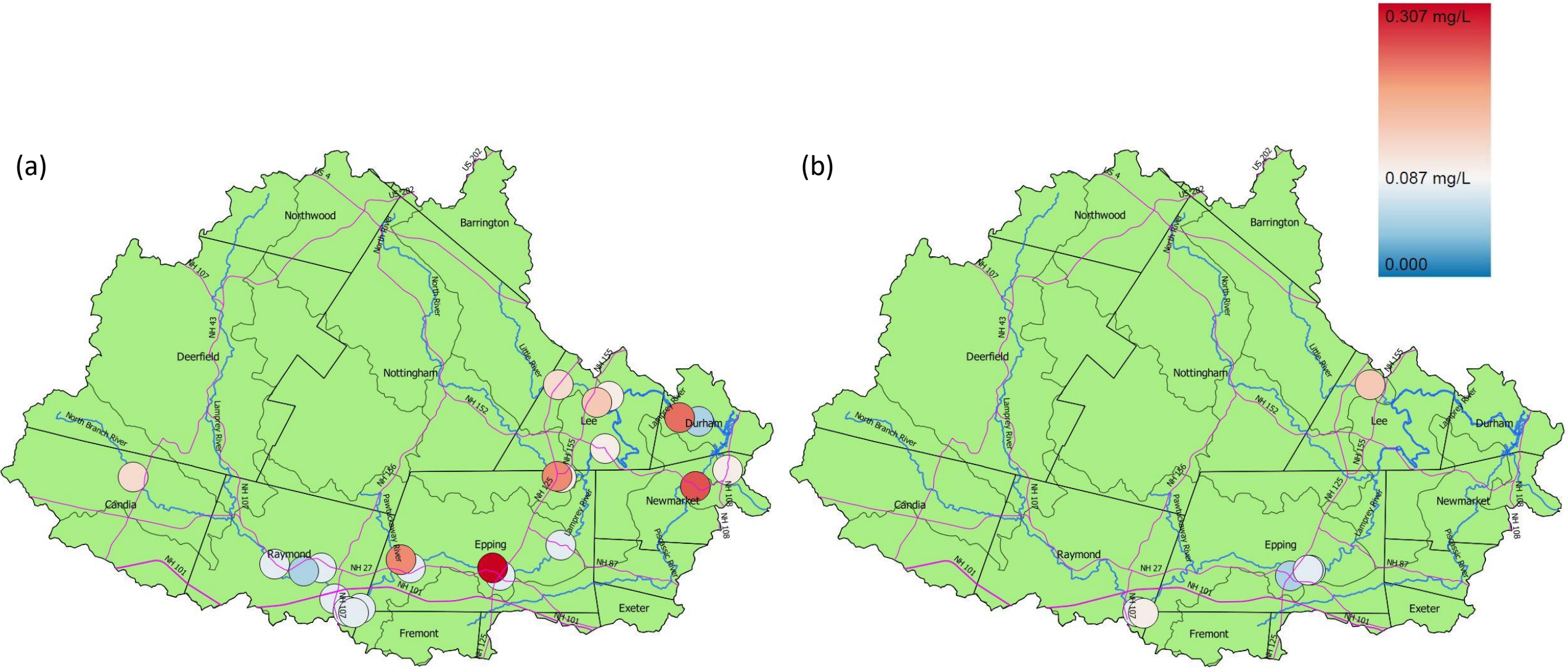

Figure 10. Spatial patterns of aluminum averaged measurements (a) before and (b) after 1/1/2000

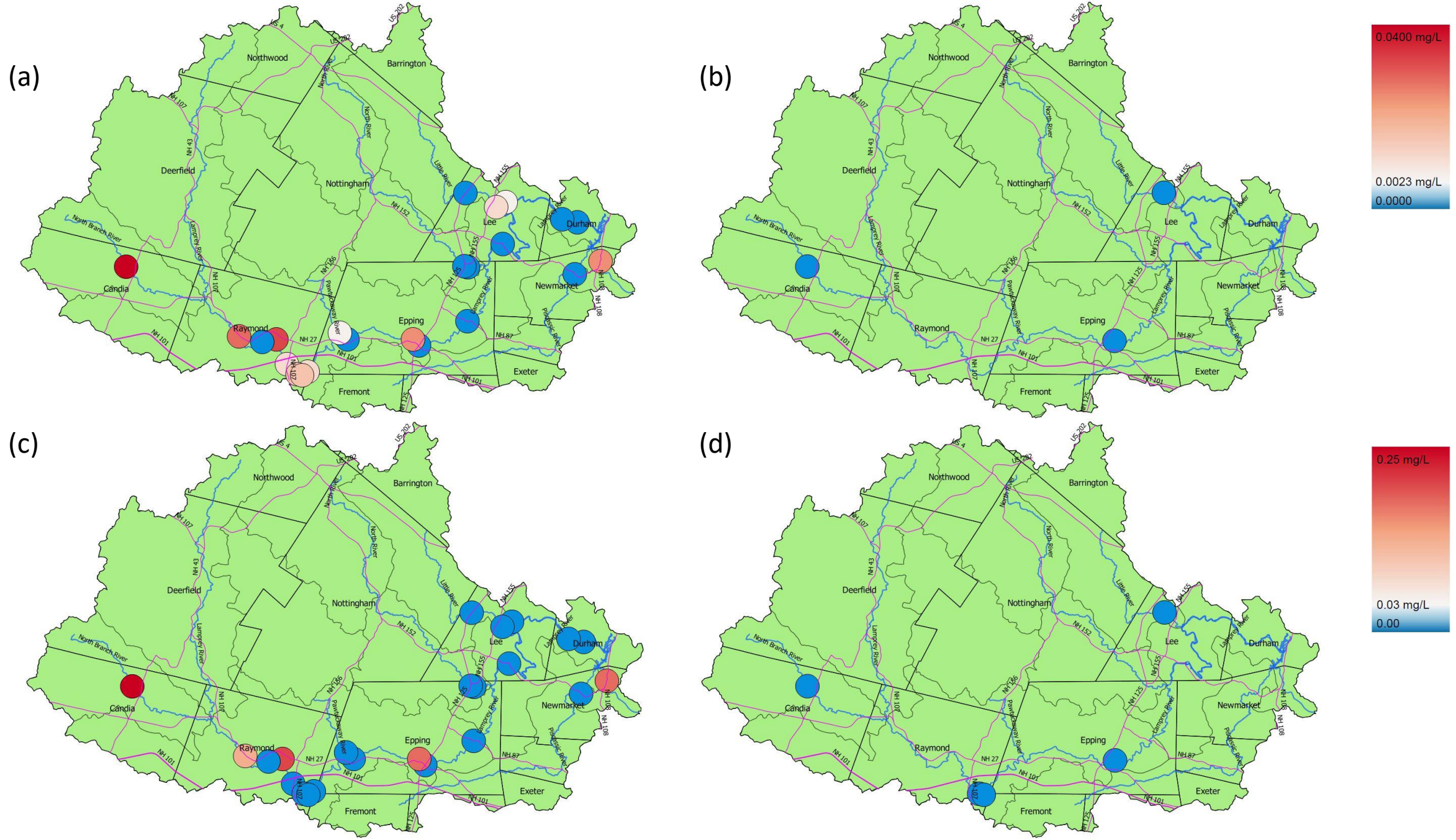

Figure 11. Spatial patterns of (a, b) copper and (c, d) zinc averaged measurements (a, c) before and (b, d) after 1/1/2000

Conclusions

- Overall the surface water quality of the Lamprey River watershed is high, and it is suitable for recreational purposes. However, the Lamprey River occasionally exhibits high phosphorus and heavy metal concentrations. Heavy metals exceedances occurred in portions of the watershed that are more developed or have a legacy of industrial activity.
- Conclusions about heavy metal levels are limited by a lack of regular monitoring data for the water column and deposited sediment. In addition, isolated grab samples cannot capture fluxes during storms, even though those short-duration events may drive annual loads.
- Frequent phosphorus monitoring is recommended in spring and summer to recognize conditions that could promote algal blooms in embayments and impoundments.

Thank You!