

Effects of Water Level Fluctuation and Nutrient Levels on Wetland Plant Biological Integrity

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Abstract

Minnesota Pollution Control Agency (MPCA) has developed Plant IBI (Indices of Biological Integrity) to assess wetland ecological health since 1995. From the same year, six wetlands in southern Minnesota have been monitored by water and plant samplings in summers. Results from statistical analyses showed very high significant levels of correlations among plant, water quality, and water level.

Introduction

- Excessive nutrients have potential impacts on wetland water quality, and threaten wetland health.
- Wetland hydrology affects its vegetation distribution, species composition and productivity.
- Water quality affects wetland function and bioprocesses, while water level fluctuation affects wetland stability and coverage area.
- When the nutrient conditions and moisture contents change in wetlands, the stability of wetland ecosystem would be threatened.
- Hypothesis 1: wetland water characteristics have significant effects on plant IBI.
- Hypothesis 2: water level fluctuations significantly affect water chemical properties.
- Objectives: to interpret how water physical and chemical characteristics affect plant ecological integrity and wetland aquatic communities.

Figure 1. Locations of six MPCA monitoring sites.

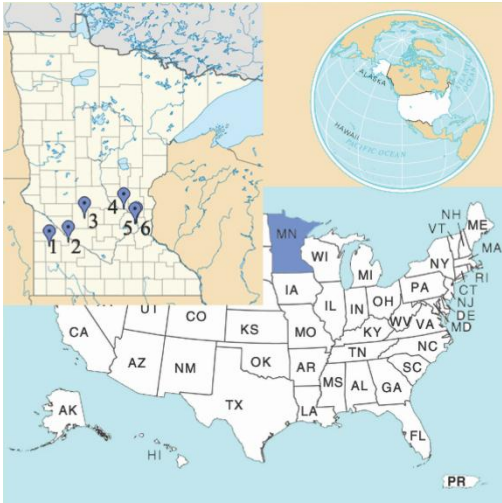


Table 1. Background Information of Study Sites

No.	Wetland ID	Landscape type	Managed water levels	Area (ha)	Estimated average depth (m)	Fish present
1	Prairie Marshes	Natural	No	13.93	0.9	Yes
2	Rohliks	Agricultural	No	56.03	0.9	No
3	Charlotte	Agricultural	No	22.53	0.9	Yes
4	Prairie	Natural	No	14.57	1.2	Yes
5	Wood	Urban	Yes	37.94	0.9	Yes
6	Legion	Urban	Yes	8.86	0.9	Yes

Materials and Methods

- Plant IBI scores are calculated based on ten community metrics to determine whether a wetland is impaired and the severity of impairment.
- Water samples were collected for physical and chemical property analyses: water temperature, turbidity, pH, conductivity, chloride, Kjeldahl nitrogen, total phosphorus, and dissolved oxygen.
- Automatic loggers have also been deployed to record hourly water levels since 2008.

1. Effects of Water Quality Conditions on Wetland Plant Biological Integrity

- Plant IBI scores were assessed 5 times for each wetland during 1995-2008 except two sites.
- Water quality data was sampled several times in every year when plant IBI scores were assessed for each site.
- Annual averages of water quality data were calculated to compare with plant IBI scores of certain years.
- Data from all six wetlands was put together and analyzed.
- Independent variables: water temperature, turbidity, pH, conductivity, Cl, Kjeldahl-N, TP and DO; Dependent variable: plant IBI.
- Statistical technique: multiple regression.

2. Effects of Water Level Fluctuations on Wetland Water Conditions

- Water quality data was collected 8 times at each wetland during 2008 and 2009 summers.
- Water level and temperature were recorded hourly in 2008 and 2009 summers.
- Monthly averages of water level data were calculated to compare with water quality data of certain months.
- Data from individual wetlands was separated and analyzed.
- Independent variable: water level; Dependent variables: water temperature, transparency, pH, conductivity, Cl, Kjeldahl-N, TP, DO.
- Statistical technique: simple regressions.

Results and Discussion

1. Multiple Regression

Plant IBI scores range from 0 to 100 with higher values indicating higher ecological integrity and diversity, and less human disturbance.

Full Model

ANOVA Significance = .034; $R^2 = .767$

Table 2. Coefficients (Full Model)

	Unstandardized coefficients		Standardized coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-49.047	81.547		-.601	.562
Temp.	-3.055	1.853	-.354	-1.649	.134
Turbidity	-4.652	2.434	-.545	-1.911	.088
pH	27.350	13.042	.803	2.097	.065
Cond.	-.052	.037	-.442	-1.430	.186
Cl	-.144	.333	-.165	-.432	.676
Kjeldahl-N	-3.639	16.555	-.084	-.220	.831
Total P	53.366	189.732	.123	.281	.785
DO	-1.454	2.532	-.178	-.574	.580

Table 3. Significance of Pearson Correlation Coefficients (Full Model)

	IBI	Temp	Turb	pH	Cond	Cl	N	TP	DO
IBI	.	.366	.079	.007	.125	.001	.349	.009	.026
Temp	.366	.	.173	.149	.017	.297	.188	.244	.115
Turb	.079	.173	.	.125	.111	.035	.021	.004	.163
pH	.007	.149	.125	.	.116	.044	.061	.226	.000
Cond	.125	.017	.111	.116	.	.410	.081	.396	.009
Cl	.001	.297	.035	.044	.410	.	.399	.000	.162
N	.349	.188	.021	.061	.081	.399	.	.057	.343
TP	.009	.244	.004	.226	.396	.000	.057	.	.433
DO	.026	.115	.163	.000	.009	.162	.343	.433	.

Reduced Model

ANOVA Significance = .000; $R^2 = .785$

Table 4. Coefficients (Reduced Model)

	Unstandardized coefficients		Standardized coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-43.509	44.506		-.978	.343
Temp.	-2.889	1.159	-.321	-2.494	.024
Turbidity	-4.991	1.141	-.543	-4.375	.000
pH	24.013	4.171	.709	5.757	.000
Cond.	-.048	.016	-.393	-3.018	.008

2. Simple Regressions

Water level: absolute elevation – vary from site to site.

Figure 2. Water level profiles.

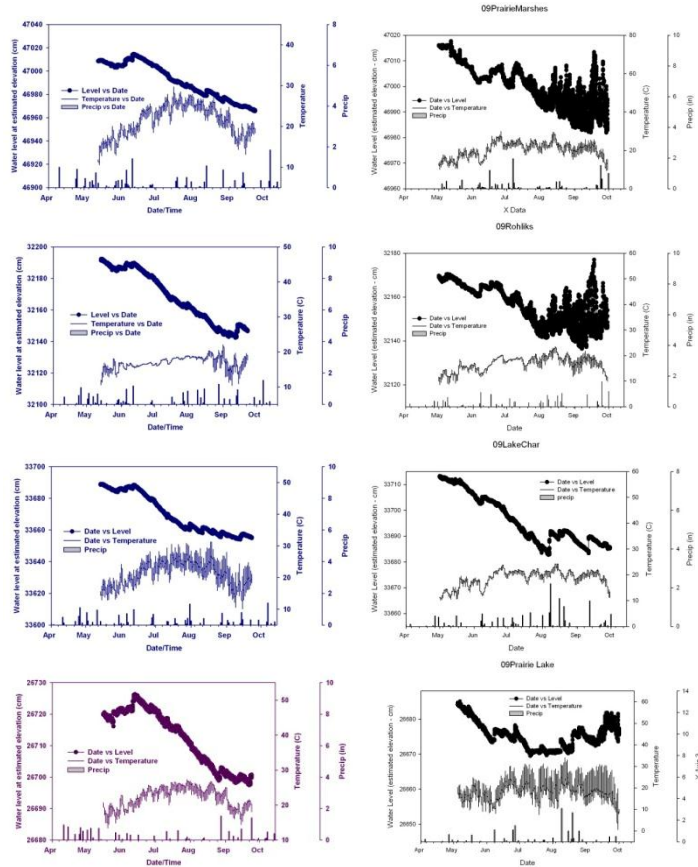


Table 5. Significance and R^2 of Simple Regressions

No.	Wetland ID	Landscape type	Value	Tran	pH	Cond	Cl	N	TP	DO
1	Prairie Marshes	Natural	Sig.	.024	.259	.031	.457	.820	.246	.721
			R^2	.671	.245	.638	.095	.009	.216	.028
2	Rohliks	Agricultural	Sig.	.143	.974	.057	.030	.004	.117	.705
			R^2	.376	.000	.638	.571	.769	.358	.031
3	Charlotte	Agricultural	Sig.	.590	.403	.017	.915	.004	.732	.901
			R^2	.062	.143	.710	.002	.775	.021	.003
4	Prairie	Natural	Sig.	.874	.183	.518	.383	.079	.440	.856
			R^2	.006	.323	.088	.129	.427	.102	.007
5	Wood	Urban	Sig.	.241	.366	.317	.259	.665	.379	.034
			R^2	.262	.165	.198	.206	.033	.131	.627
6	Legion	Urban	Sig.	.351	.606	.429	.072	.212	.928	.211
			R^2	.175	.057	.129	.442	.245	.001	.292

Conclusions

- Wetland water quality and nutrient level have significant effects on plant biological integrity.
- Due to the multicollinearity of water quality variables, the impacts of water quality on wetland health are very complicated.
- Water level fluctuation → nutrient levels → wetland vegetations.

Acknowledgement

The authors would like to thank the Minnesota Pollution Control Agency (MPCA) for sharing data. Special thanks goes to Mr. Mark Gernes from MPCA for his great help on the project.

References

- Euliss, N. H., Jr., LaBaugh, J. W., Fredrickson, L. H., Mushet, D. M., Laubhan, M. K., Swanson, G. A., et al. (2004). The wetland continuum: A conceptual framework for interpreting biological studies. *Wetlands*, 24(2), 448-458.
- Hanson, M. A., Zimmer, K. D., Butler, M. G., Tangen, B. A., Herwig, B. R., & Euliss, N. H., Jr. (2005). Biotic interactions as determinants of ecosystem structure in prairie wetlands: An example using fish. *Wetlands*, 25(3), 764-775.
- van der Valk, A. G., & Davis, C. B. (1978). The role of seed banks in the vegetation dynamics of prairie glacial marshes. *Ecology*, 59(2), 322-335.



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