A multi-variate method for analyzing water quality in Sardis Lake

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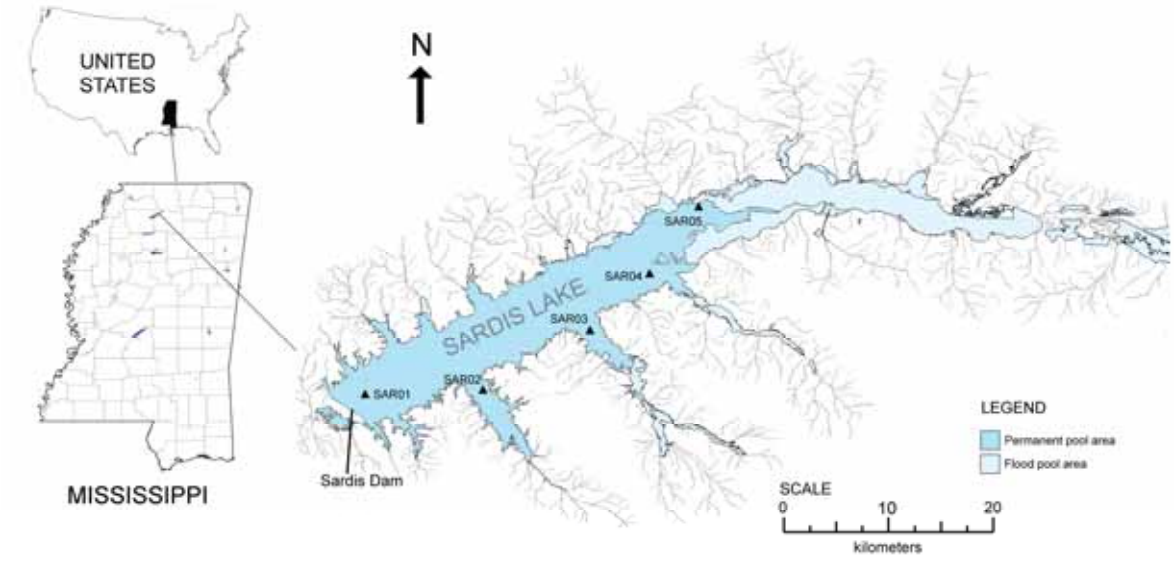
Large Water Quality Datasets

- The challenge: to use existing water quality datasets for more than just compliance monitoring
  - Hundreds of samples
  - Several times per year
  - Several water depths
  - Difficult to interpret
- The solution: a method of data treatment and multivariate statistical analysis

Sardis Lake, northern Mississippi

- Data collected about quarterly, nine years between 1994 and 2004; compliance sampling
- National Lakes Assessment Program
- 4400 ha (11,000 acres)
- Yazoo River Basin
- Flood control, Sardis Dam
- Swimming, boating, fishing, hunting

Sardis Lake



Monitoring Sites

Monitoring Site	Location Description	Latitude	Longitude
SAR01	Center line of lake near Sardis Dam	34N 24' 54.5"	89W 47' 9.8"
SAR02	Embayment near Clear Creek landing public use area	34N 25' 13.2"	89W 42' 42.7"
SAR03	Embayment off an unnamed road off County Road 102 in College Hill	34N 27' 24.1"	89W 38' 38.4"
SAR04	Embayment near Hurricane landing public use area	34N 29' 26.6"	89W 36' 18.1"
SAR05	Below Highway 7 at upstream end of the Sardis Lake	34N 31' 52.7"	89W 34' 31.1"

Sample Data Summary

			Temporal Distribution			Spatial Distribution		
Parameter	Temporal + Spatial		Season	Mean	SD	Monitoring Station	Mean	SD
COD	Mean	15.2	Fall	14	7.8	SAR01	15	8.4
(mg/L)	SD	6.7	Winter	16	5.2	SAR02	17	6.1
	Std. Skewness	4.698	Spring	16	6.5	SAR03	11	1.6
	Std. Kurtosis	2.119	Summer	15	6.9	SAR04	15	5.2
						SAR05	19	8.1
Total Alkalinity	Mean	20.1	Fall	19.2	4.7	SAR01	18.5	5.1
(mg/L)	SD	4.8	Winter	15.7	3.9	SAR02	19.1	3.8
	Std. Skewness	0.835	Spring	17.5	5.9	SAR03	19.4	3.1
	Std. Kurtosis	2.79	Summer	22.5	2.9	SAR04	22.0	2.9
						SAR05	27.7	6.3

Principal Component Analysis

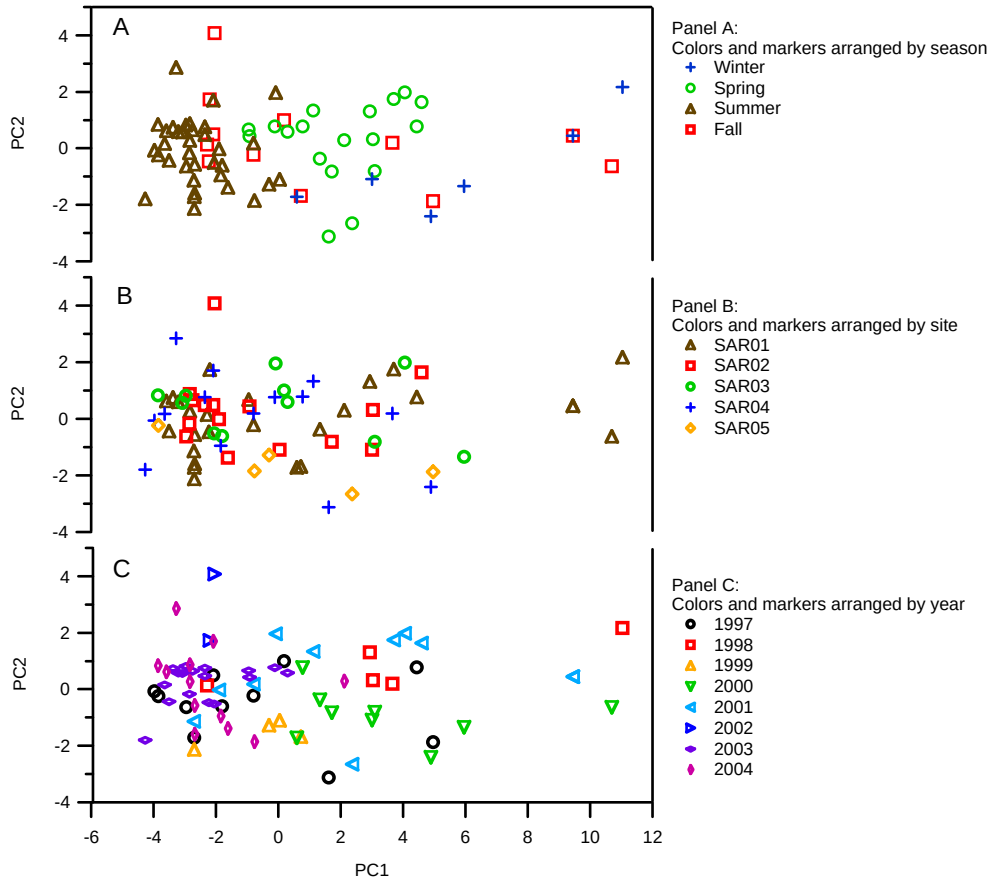
- Multivariate statistical method
- Used when datasets where numerous types of measurements are made on each individual in a sample population
- PC scores contain integrated information from all of the variables
- Reduces number of variables of large datasets without significant loss of information
- Exploratory method

Spearman's Rank Correlations

	COD	Total Alkalinity	TSS	Nitrogen, Ammonia	Nitrogen, TKN	Nitrogen, NO_2 + NO_3	Total Phosphorous	TOC	Total Hardness	Total Chloride	Turbidity
COD	1.000										
Total Alkalinity	-0.023	1.000									
TSS	-0.025	**-0.271***	1.000								
Nitrogen, Ammonia	0.210	**-0.519****	**0.368****	1.000							
Nitrogen, TKN	-0.185	**-0.253***	**0.305****	0.011	1.000						
Nitrogen, NO_2 + NO_3	0.029	**-0.280***	**0.418****	**0.319****	**0.290***	1.000					
Total Phosphorous	0.075	-0.189	**0.512****	**0.312****	**0.239***	**0.314****	1.000				
TOC	0.120	0.201	**-0.249***	**-0.234***	0.066	0.075	**-0.258***	1.000			
Total Hardness	0.130	**0.774****	**-0.250***	**-0.313****	-0.186	**-0.272***	-0.085	**0.279***	1.000		
Total Chloride	0.111	-0.219	**0.587****	**0.410****	0.065	**0.314****	**0.558****	**-0.312****	0.002	1.000	
Turbidity	0.075	**-0.547****	**0.737****	**0.429****	**0.360****	**0.554****	**0.701****	**-0.245***	**-0.405****	**0.606****	1.000

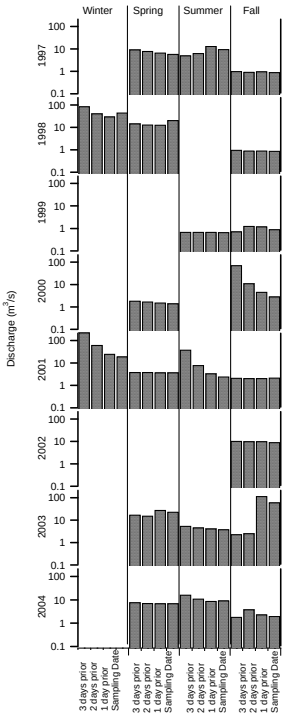
Principal Components on 9 Water Quality Parameters

Parameter	Communality	Factor Loadings[b]		
		PC1	PC2	PC3
COD	0.811	0.007	-0.108	**0.894**
Total Alkalinity	0.558	**-0.596**	-0.372	-0.254
TSS	0.691	**0.783**	-0.102	-0.261
Nitrogen, Ammonia	0.615	**0.746**	-0.033	0.239
Nitrogen, TKN	0.783	0.268	**0.783**	-0.314
Total Phosphorous	0.554	**0.737**	0.040	0.098
TOC	0.661	-0.453	**0.617**	0.275
Total Chloride	0.620	**0.687**	-0.372	-0.104
Turbidity	0.873	**0.909**	0.197	0.084
Eigenvalue		3.643	1.332	1.191
% of Variance		40.5	14.8	13.2

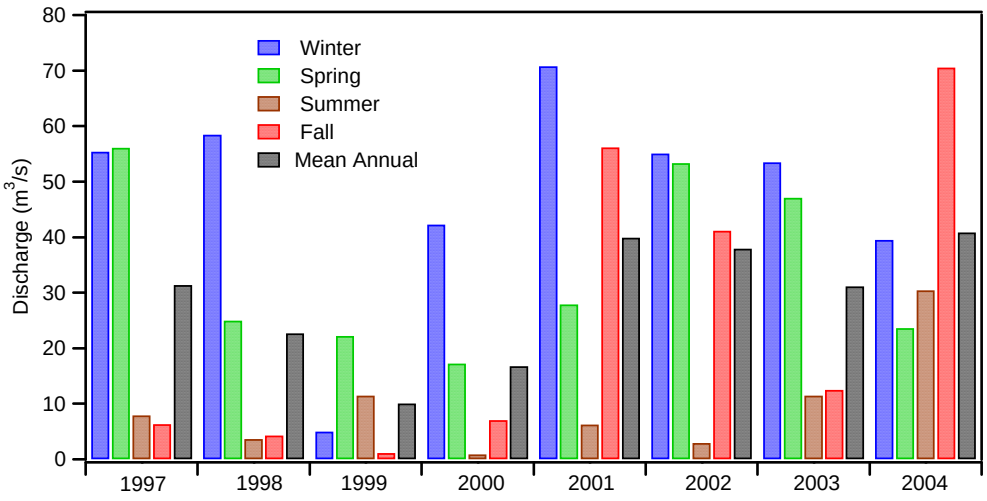


Discharges into Sardis Lake

- Represented by USGS gauge station at Little Tallahatchie River at Etta
- Indicators of stormwater runoff into lake
- Equilibrium of water quality parameters were perturbed when flow variations occurred



Little Tallahatchie River Flows



Conclusions

- Water quality patterns in Sardis Lake can be determined with only nine parameters: COD, Alkalinity, TSS, Ammonia, TKN, Phosphorus, TOC, Chloride, Turbidity
- Water quality as a whole was most steady in the summer, and least steady when affected by stormwater runoff (temporal variations)
- The five monitoring stations exhibited similar water quality to each other (little spatial variations)

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Lim, K.Y., Surbeck, C.Q., 2011. A multi-variate methodology for analyzing pre-existing lake water quality data. *Journal of Environmental Monitoring* 13, 2477-2487.