A *Limnological Yardstick* based on phosphorus limitation

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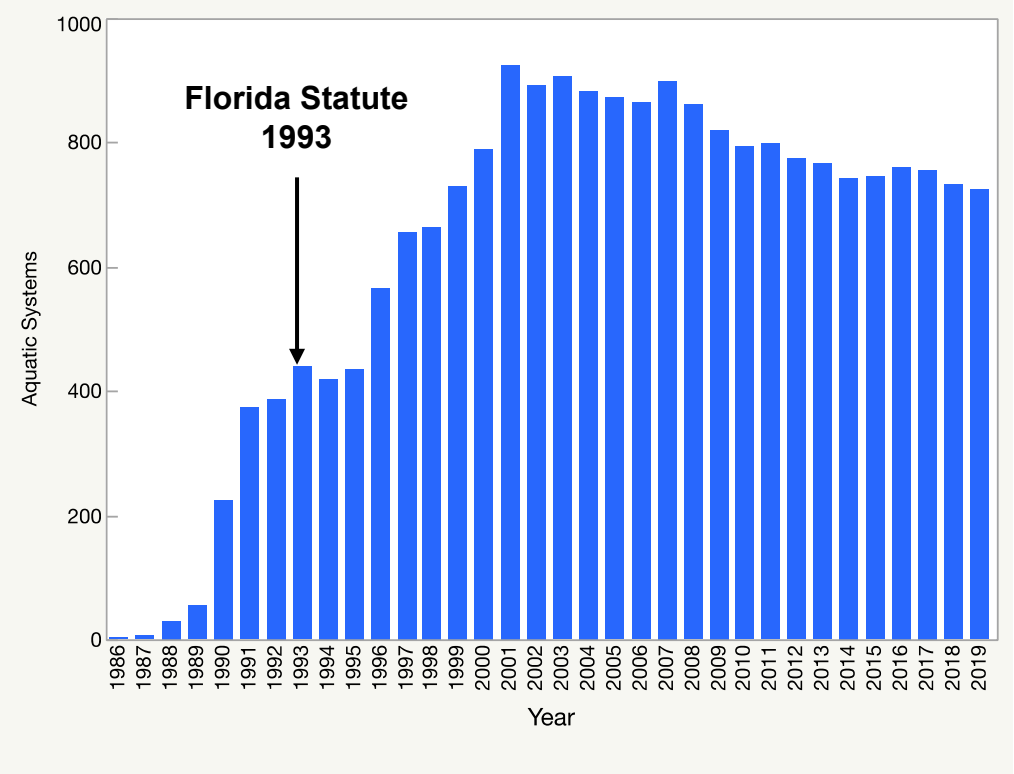
Florida
LAKE WATCH
CITIZEN SCIENCE SINCE 1986

Florida LAKEWATCH Mission Statement

Work with Citizen Scientists for the purpose of monitoring Florida's aquatic ecosystems to provide:

Research-quality data (Research)
Student training (Teaching)
Public education (Extension)

All with respect to water quality and aquatic systems management.



Data Comparison Studies

Canfield, D. E. Jr., C. D. Brown, R. W. Bachmann, and M. V. Hoyer. 2002. Volunteer lake monitoring: testing the reliability of data collected by the Florida LAKEWATCH program. Lake and Reservoir management 18: 1-9.

Hoyer, M. V., N. Wellendorf, R. Frydenborg, D. Bartlett, and D. E. Canfield, Jr. 2012. A comparison between professionally (Florida Department of Environmental Protection) and volunteer (Florida LAKEWATCH) collected trophic state chemistry data in Florida. Lake Reservoir Management. 28: 277-281.

Hoyer, M. V., and D. E. Canfield Jr. 2021. Volunteer collected water quality data can be used for science and management. Lake and Reservoir Management. 37:235-245..

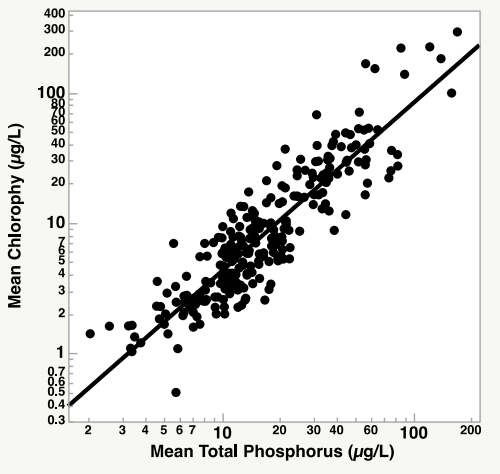
Trophic State Concept: Einar Naumann (1919, 1929)

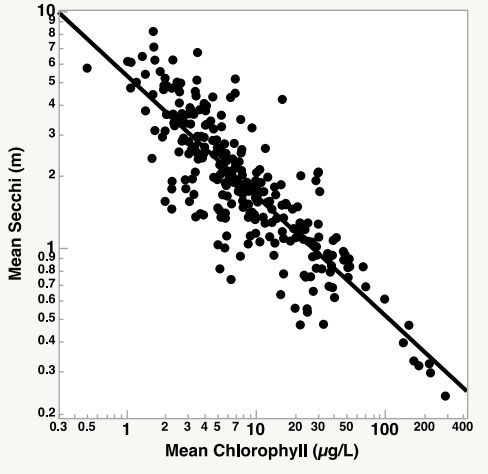
- **The amount of algae (production) in a lake is determined by several factors, primarily by the concentration of <u>phosphorus and nitrogen.</u>**
- **Regional variations in algal production correlate with the geological structure of the watershed with lakes in agricultural, calcareous regions being greener than lakes in forested, granitic watersheds.**
- **The amount of production in a lake affects lake biology as a whole.**
- **There are certain evolutionary (ontological) connections between lakes of the various types; lakes become more productive as they age.**

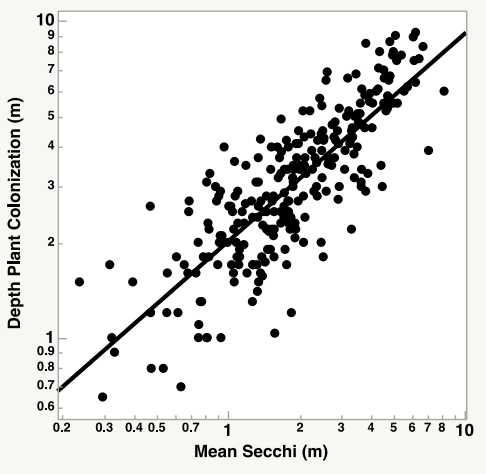
Chain of Trophic State Models Based on Phosphorus Limitation

Phosphorus Loading Model = TP
Phosphorus vs Chlorophyll Model = CHL
Chlorophyll vs Secchi Model = Secchi
Secchi vs Plant Colonization Model = MDC

$$TP = L/z\,(\sigma+r)$$







Factors Other Than Phosphorus Can Limit Algal/Plant Production

While Naumann's classification system was based on algal/plant production he understood factors other than nutrients could limit production (temperature, light, calcium, humic content, iron, pH, oxygen, and carbon dioxide)

The Florida Situation:

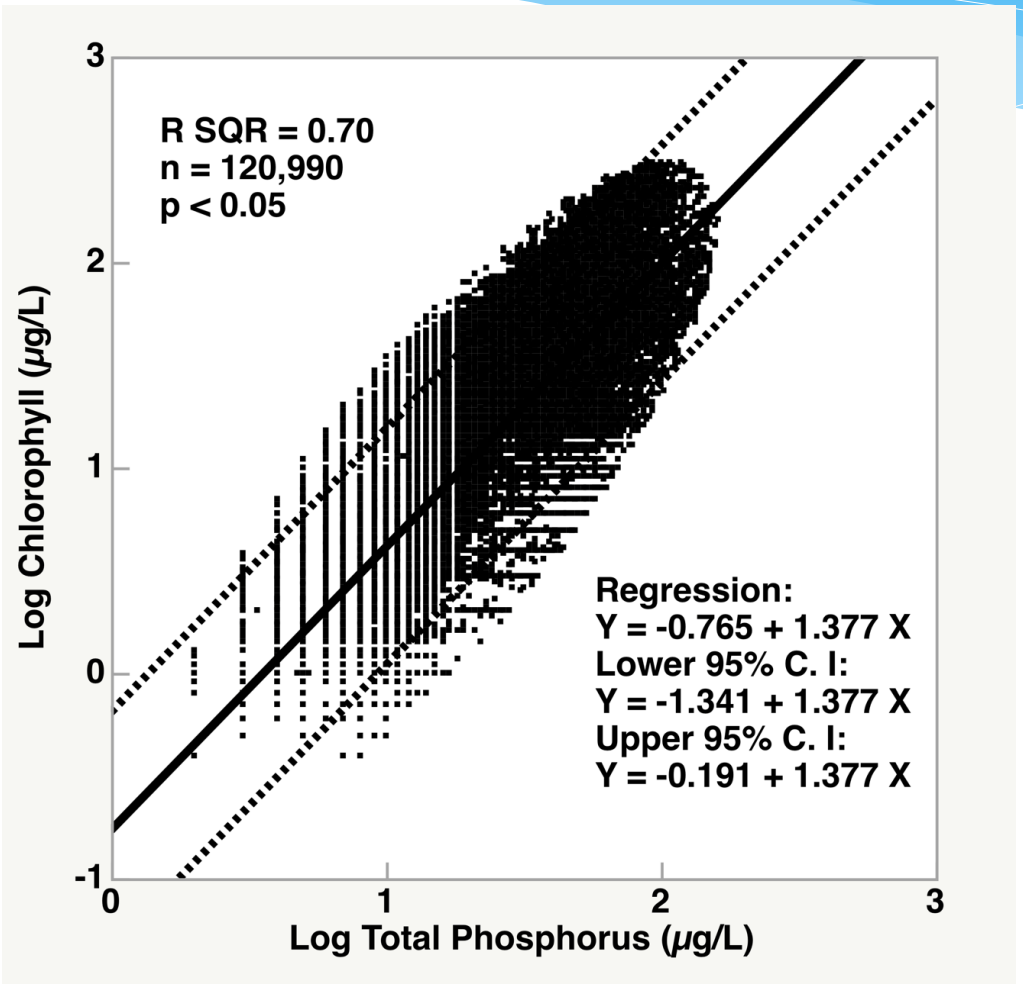
Nitrogen TN:TP < 10
Color > 40 Pt-Co Units

Non-Algal Suspended Solids
Flushing Rate
Zooplankton Grazing

Summary statistics for 388 Florida LAKEWATCH lakes > 15 Year of Data

Lake Type	Parameter	Lakes	Mean	Min	Max
Colored	Years	135	22.3	15	35
35%	TP	135	49	7	242
	TN	135	1145	245	3435
	CHL	135	23	3	164
	Secchi	135	1.1	0.3	3.1
	Color	135	110	40	484
	N:P	135	38	7	139
Clear P-Limited	Years	245	21.6	15	35
63%	TP	245	22	5	184
	TN	245	788	112	3092
	CHL	245	16	2	142
	Secchi	245	2.3	0.4	6.9
	Color	245	17	2	40
	N:P	245	52	13	796
Clear N-Limited	Years	8	25.6	15	29
2%	TP	8	244	72	347
	TN	8	1790	493	2387
	CHL	8	85	16	122
	Secchi	8	0.7	0.5	1.1
	Color	8	23	20	26
	N:P	8	8	7	10

Limnological Yardstick Model

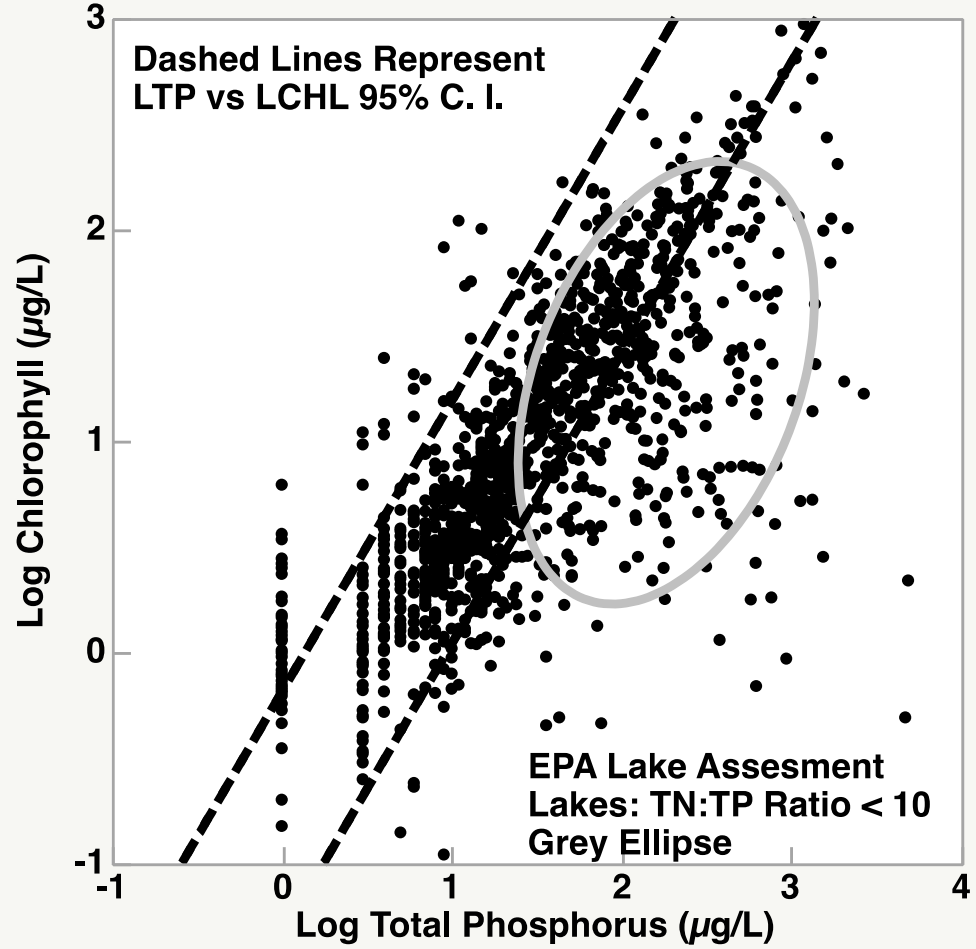


Phosphorus limited lakes with > 15 years of data (15-35 years):

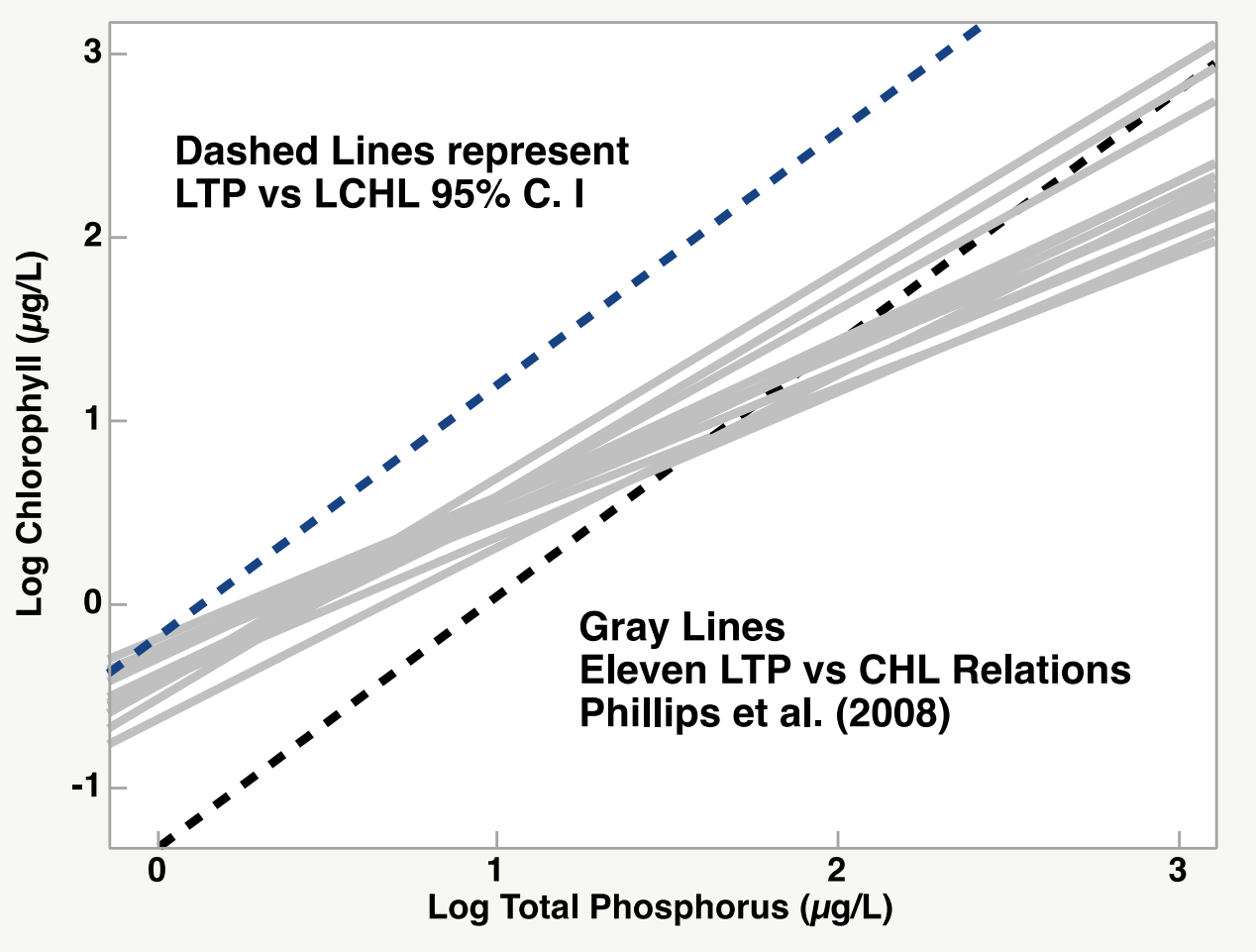
Color:
Lake < 40 Pt-CO

Nitrogen/Phosphorus:
Lakes > 10 N/P

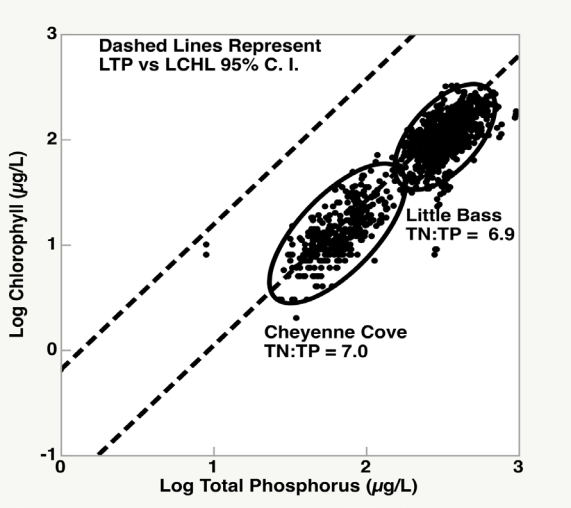
Limnological Yardstick: 2007 EPA Lake Assessment Data

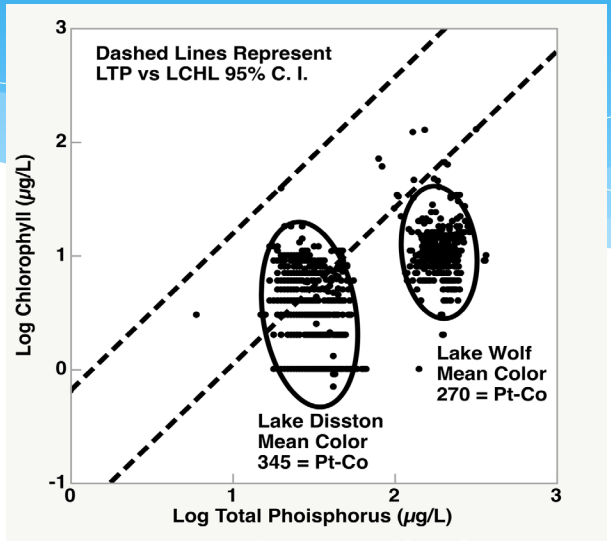


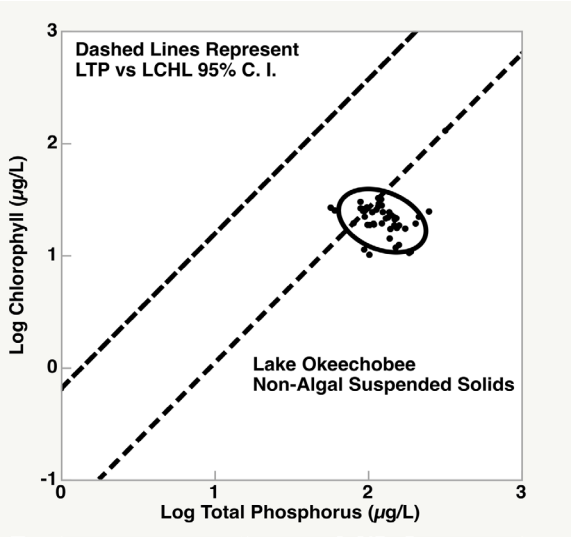
Limnological Yardstick: Published LTP vs CHL Relations

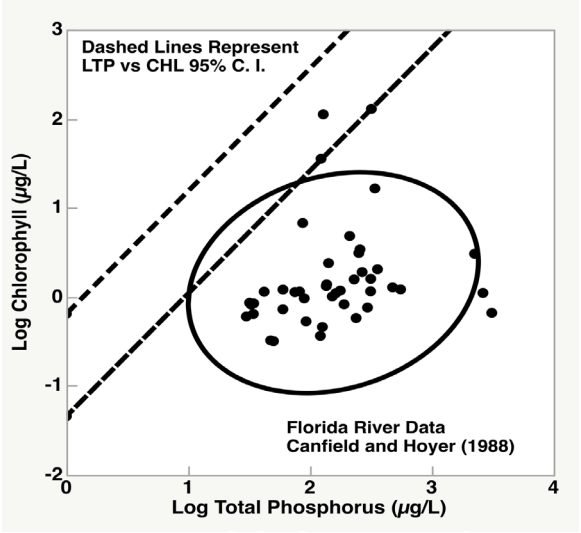


Additional Limiting Factors: Nitrogen, Color, Suspended Solids, Flushing Rate









Trophic State Classification vs Eutrophication

Defining Lake Trophic State is a static exercise, placing a lake somewhere along Naumann's gradient of lake production from low production (oligotrophic) to high production (eutrophic)

Eutrophication is the movement from a lower trophic state to a higher trophic state

Oligotrophication is the movement from a higher trophic state to a lower trophic state

Trophic State Index: Carlson (1977)

Table 1. Completed trophic state index and its associated parameters.

TSI	Secchi disk (m)	Surface phosphorus (mg/m^3)	Surface chlorophyll (mg/m^3)
0	64	0.75	0.04
10	32	1.5	0.12
20	16	3	0.34
30	8	6	0.94
40	4	12	2.6
50	2	24	6.4
60	1	48	20
70	0.5	96	56
80	0.25	192	154
90	0.12	384	427
100	0.062	768	1183

rophyll, or total phosphorus. The computational forms of the equations are

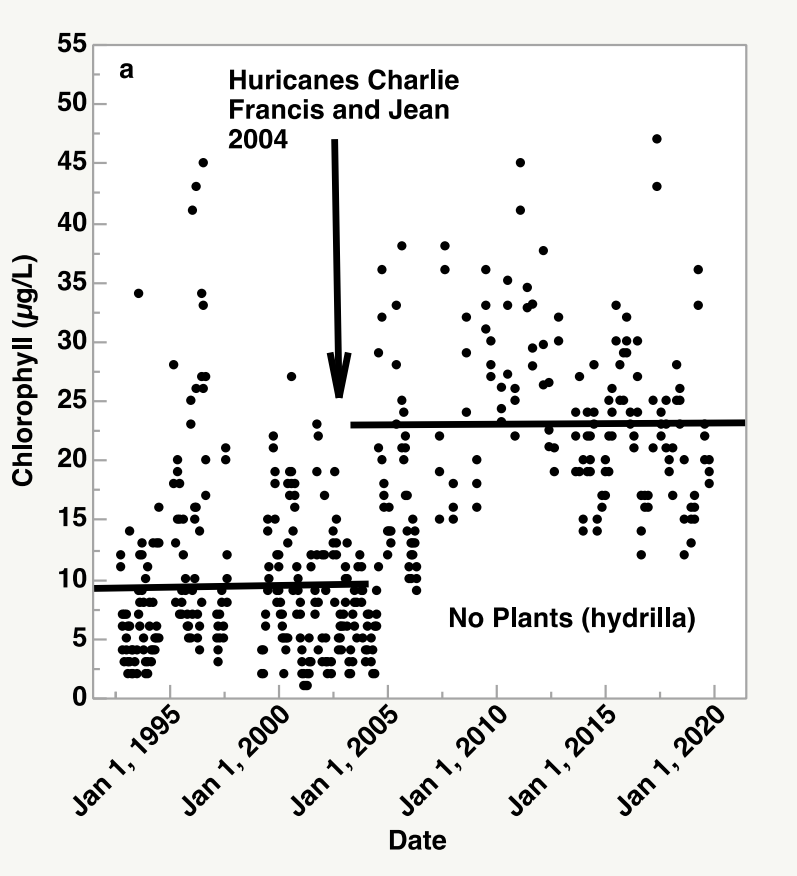
$$\mathrm{TSI(SD)} = 10\left(6 - \frac{\ln \mathrm{SD}}{\ln 2}\right), \qquad (11)$$

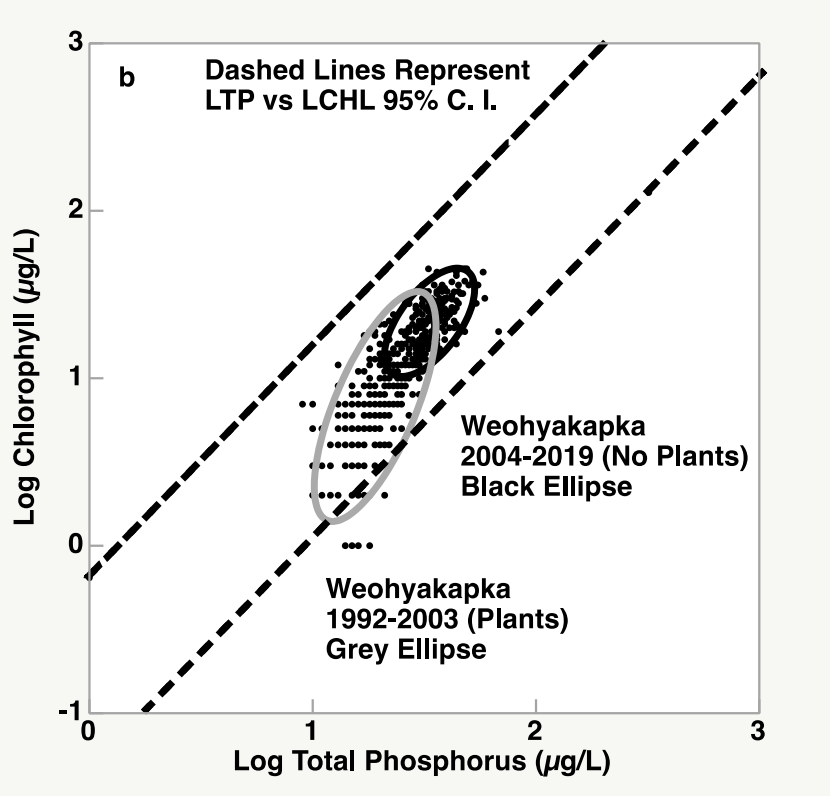
$$\mathrm{TSI(Chl)} = 10\left(6 - \frac{2.04 - 0.68 \ln \mathrm{Chl}}{\ln 2}\right), \qquad (12)$$

and

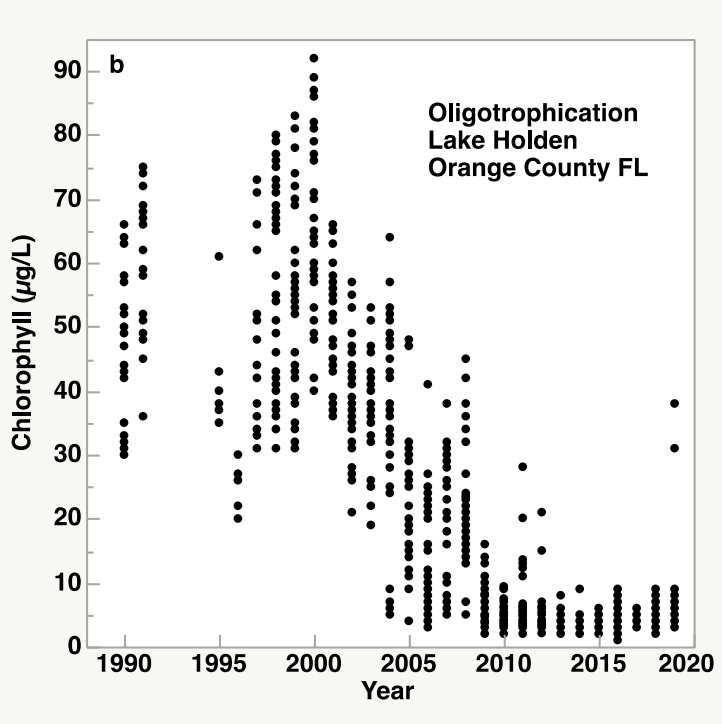
$$\mathrm{TSI(TP)} = 10\left(6 - \frac{\ln \frac{48}{\mathrm{TP}}}{\ln 2}\right). \qquad (13)$$

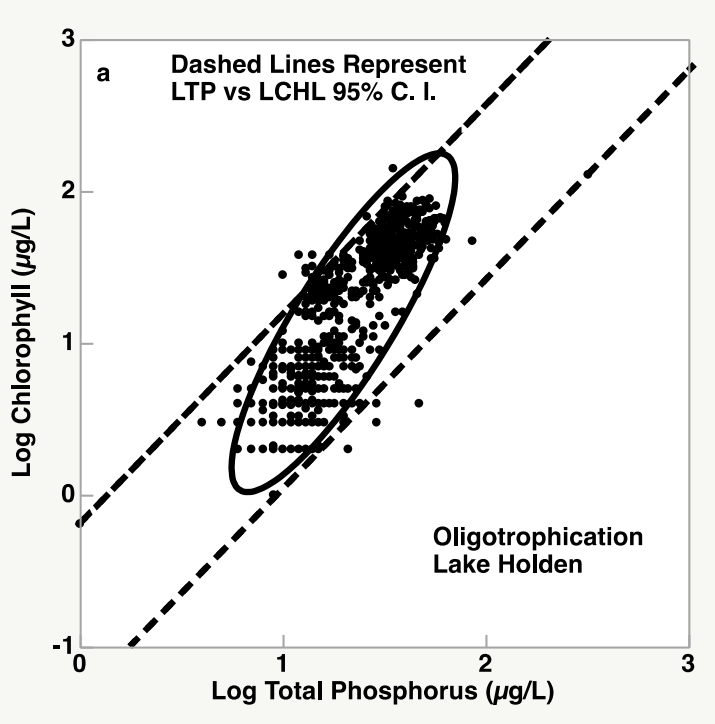
Trophic State Assessment: Lakes With Aquatic Macrophytes





Phosphorus Management With Alum: Oligotrophication





Merriam-Webster Dictionary

Yardstick: a standard for making a critical judgment: "*criterion measured by the yardstick of her first book was a great success*"

Questions?