

A young girl with brown hair in a ponytail, wearing a yellow shirt and purple pants, is sitting on a white and red plastic cooler on a grassy bank. She is holding a yellow and blue fishing rod that extends over a body of water. The water is calm and reflects the surrounding greenery and a building in the distance. The scene is bright and sunny.

# Nutrient Criteria and Its Connection to Local Water Quality

Hypoxia in the Gulf of Mexico:  
Implications and Strategies for Iowa

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Ames, Iowa

# Nutrient Criteria and Its Connection to Local Water Quality



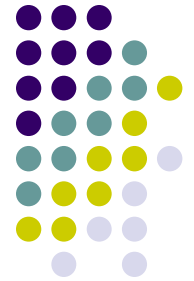
- Background
- Criteria Development
- Nutrient Reduction Goals and Examples
- Nutrient criteria and Gulf Hypoxia Goals

# Nutrient Criteria Milestones 1970-2000



- (1972, 1987) Federal Clean Water Act
- (1976) National Lake Nutrient Eutrophication Study
- (1980, 1990) Iowa Lakes Classification Studies
- (1998) U.S. EPA National Strategy for Development of Regional Nutrient Criteria
- (1998- present) Region 7 Nutrient Criteria RTAG
- (2000) U.S. EPA technical guidance for lakes/reservoirs, rivers/streams, estuaries/coastal areas

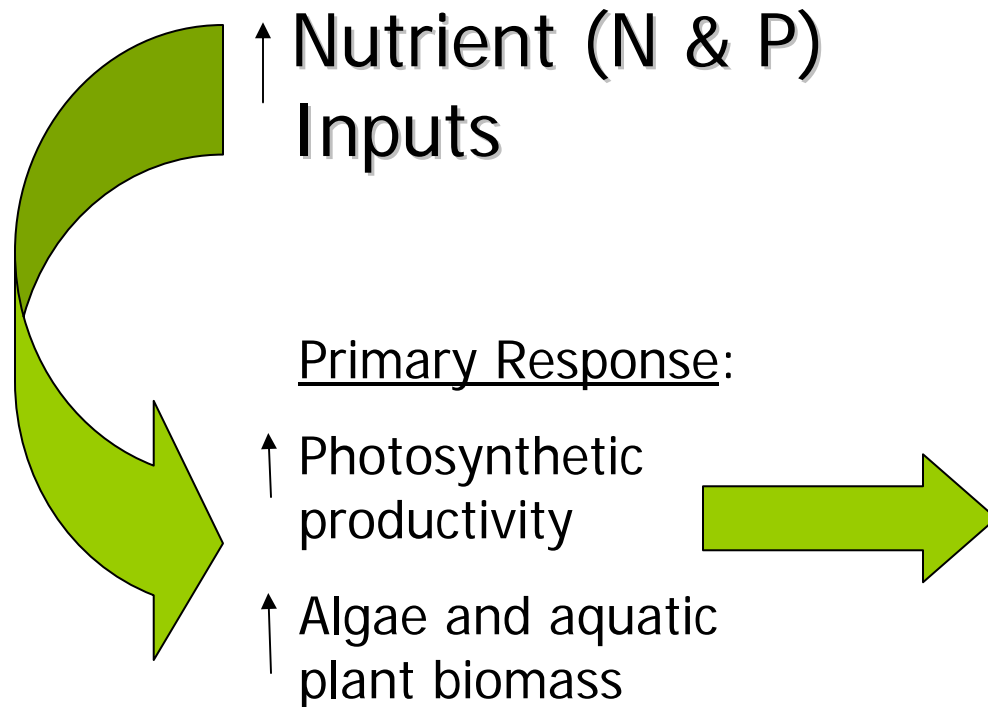
# Nutrient Criteria Milestones 2001-2008



- (2002) Iowa SF 2363 (state nutrient strategy requirement)
- (2004) Iowa nutrient budget
- (2006) Iowa nutrient criteria plan
- (2007) U.S. EPA policy memorandum (Benjamin Grumbles, Assistant Administrator, Office of Water)
- (2007-2008) Nutrient Science Advisors (NSA) committee recommendations



# Nutrient Enrichment\*

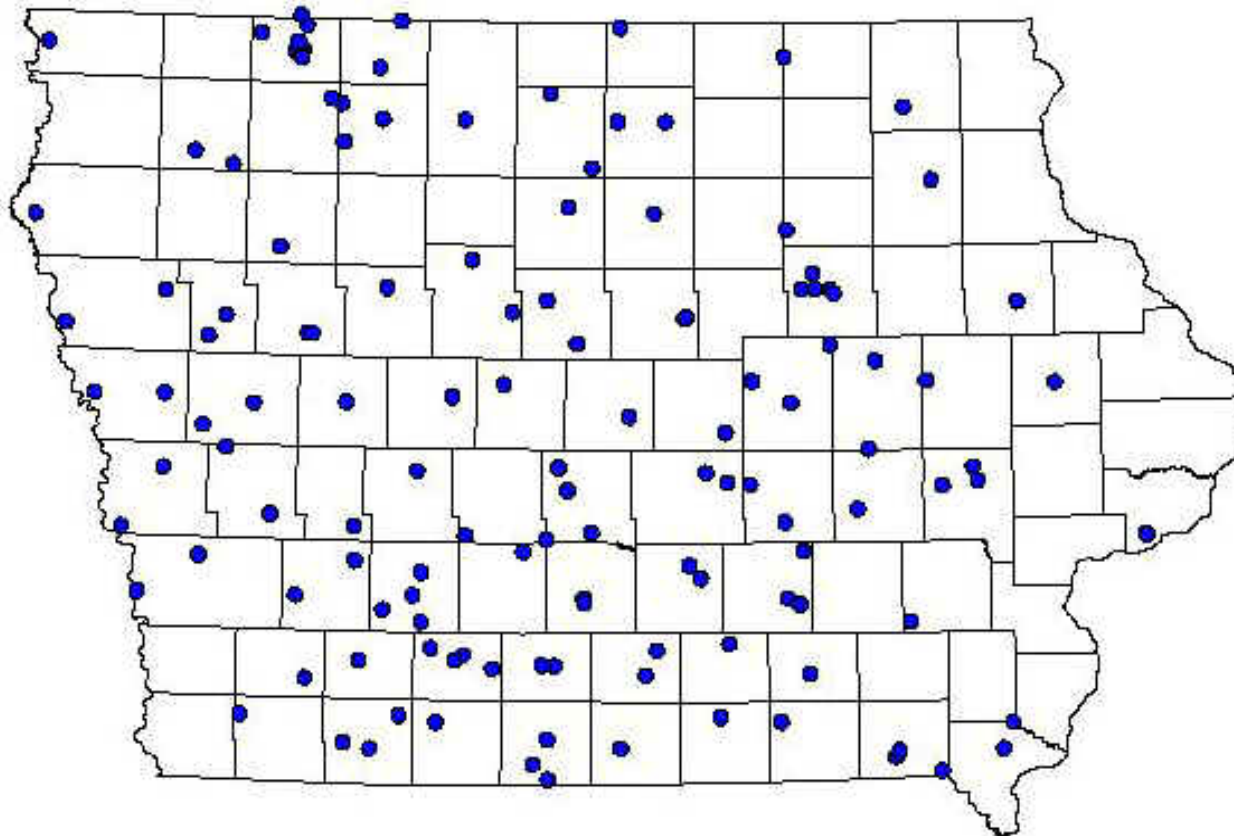
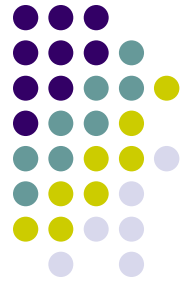


## Secondary Responses & WQ Impacts:

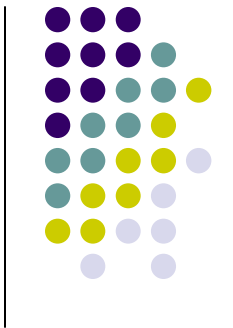
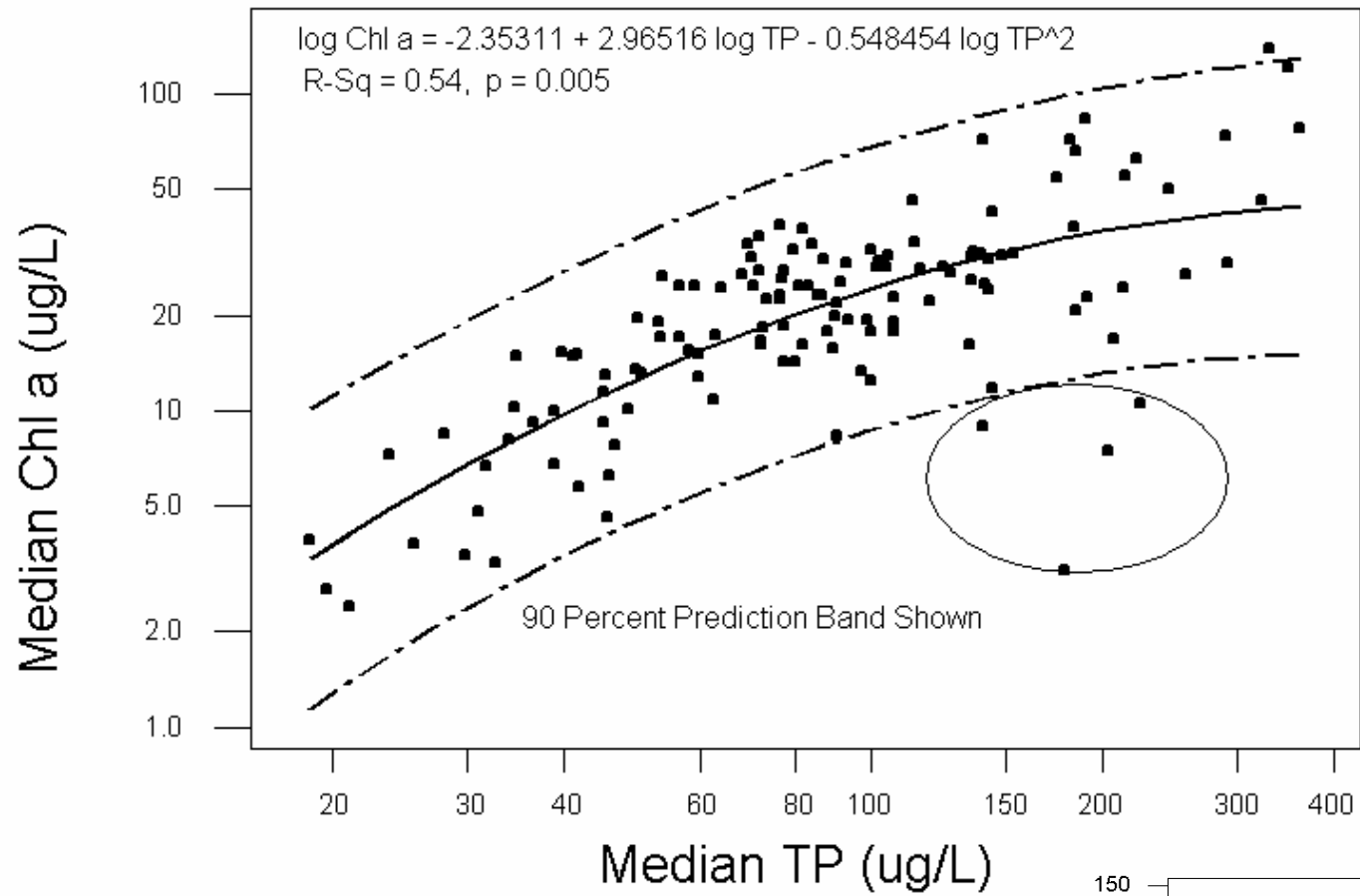
- ↓ Water clarity / Aesthetics
- ↑ D.O. flux / ↓ D.O. minima
- ↑ Rough fish
- ↓ Species diversity
- ↑ Habitat degradation
- ↑ Cyanobacteria / cyanotoxins
- ↑ Taste & odor compounds
- ↓ Water quality (e.g., pH, ammonia)

**\*potential responses to nutrient inputs when nutrient availability is limiting to algae and plants**

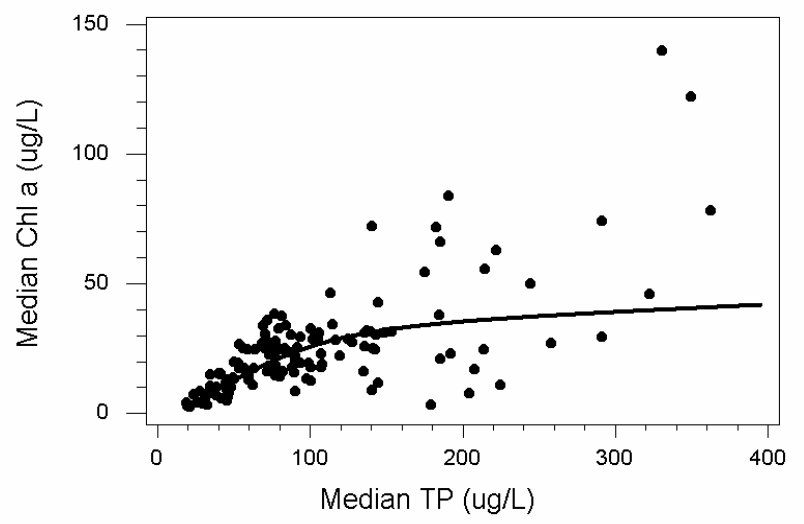
# Iowa's ambient lake monitoring program



- 131 lakes monitored 3 times during summer recreation season since 2000
- Wide variety of lakes – natural, impoundments, pits, flood control reservoirs



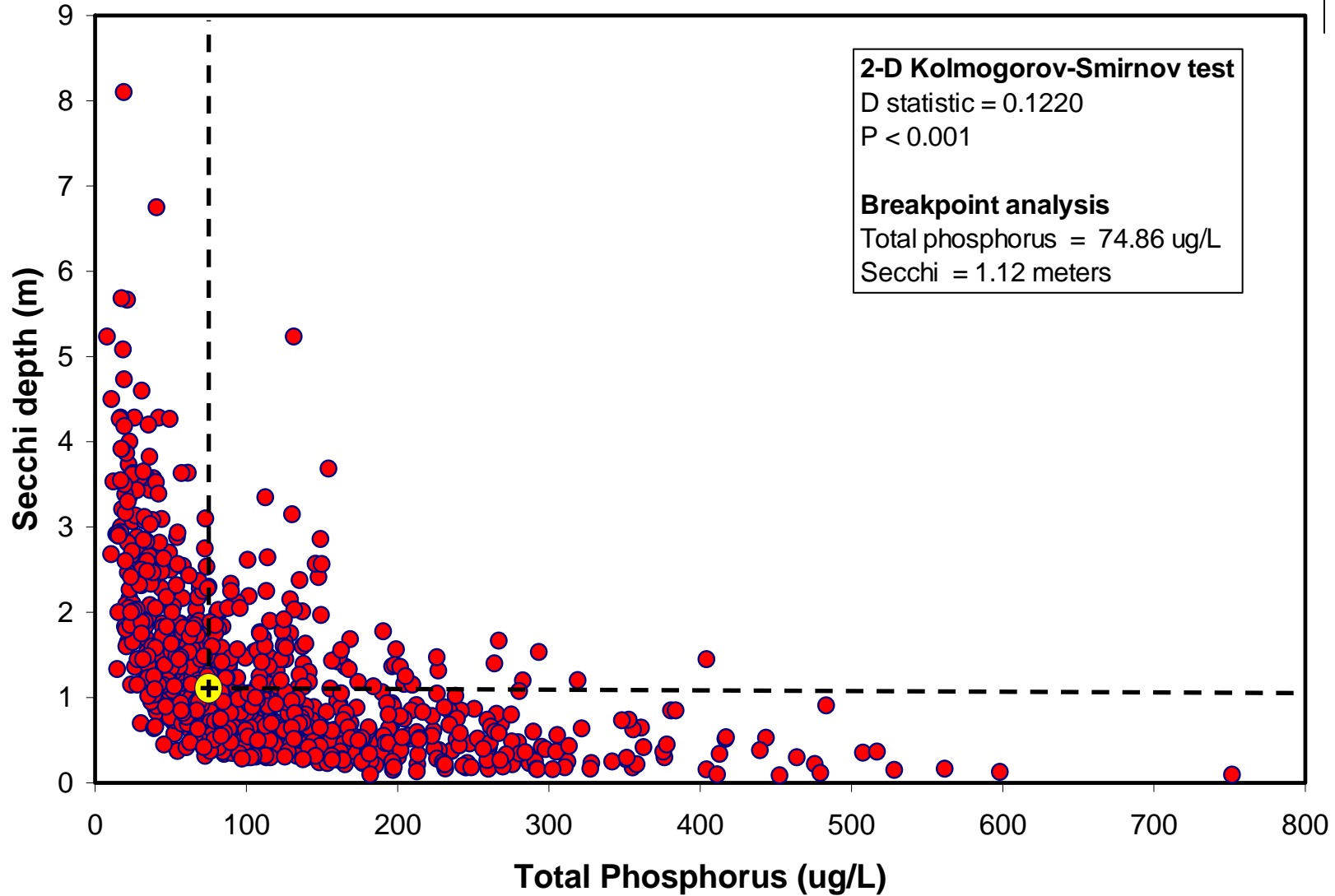
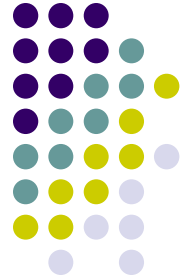
The quadratic equation line shown above is shown superimposed on the raw, untransformed data at right.



*(Jack Riessen, IDNR)*

# Secchi Disk Criterion

## Water quality breakpoint analysis





# Nutrient criteria

U.S. EPA guidance (2000):

- Focus on harmful impacts to aquatic ecosystems and water uses
- Consists of causal (nutrient, N & P) and response variables (e.g., chlorophyll a, secchi depth)
- Incorporate frequency & duration aspects

# Nutrient Benchmarks: Lakes



Source	Secchi Depth (meters)	Chlorophyll A (ug/L)	TP (ug/L)	TN (mg/L)	Sample Data Qualifications
U.S. EPA Lake & Reservoir Guidance (2000)	1.07 *	14.8 *	60 *	0.96 *	SD, ChIA, TP, TN medians from summer season except TN median (all seasons)
	1.9 **	14.4 **	45 **	1.18 **	
	1.1 ***	8.35 ***	35 ***	0.661 ***	
Region 7 RTAG (2007)	-	8	35	0.7	growing season mean, minimum 3 samples / year for 3 years
Iowa Nutrient Science Advisors (2008) **	1	25	35	0.9	SD & Chlorophyll A benchmarks met 75% during summer rec. season, TP & TN summer mean, minimum 3 samples / year for 3 years

\* Ecoregion 47, aggregate nutrient region VI; \*\* Ecoregion 52, aggregate nutrient region VII; \*\*\* Ecoregion 40, aggregate nutrient region IX.

\*\* Nutrient Science Advisors Class A Lake Nutrient Recommendations:

<http://www.iowadnr.com/water/standards/nutrients.html>



# Lake TMDL nutrient reduction targets:

Examples from recent TMDLs for algae and turbidity impairments

Lake	Year	Secchi Depth Target (m)	Chlorophyll A Target (ug/L)	Target TP (ug/L)	Target TP concentration % reduction	Phosphorus % Load Reduction
Blue Lake	2008	0.7	33	58	41	58
East Osceola	2008	0.7	33	72	76	71
Carter	2007	0.7	33	96	37	54
Five Island	2006	0.7	33	82	7	17
Cornelia	2006	Trophic State Index (TSI) = 65		63	13	28
Littlefield	2006			96	26	57
Trumbull	2006	0.7	33	96	64	64
Silver (Palo Alto)	2006	0.7	33	96	60	60-74*
Easter Lake	2005	0.7	33	68	24	40
Clear	2005	0.7	33	96	42	49
Swan	2005	0.7	33	96	80	36-52*
Mariposa	2004	0.7	33	96	60	81

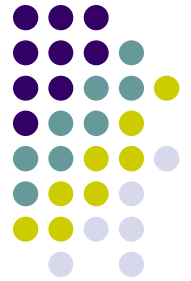
\* load reduction target is dependent upon degree to which in-lake loading is reduced.

# Lake Ahquabi



## A Restoration Success Story

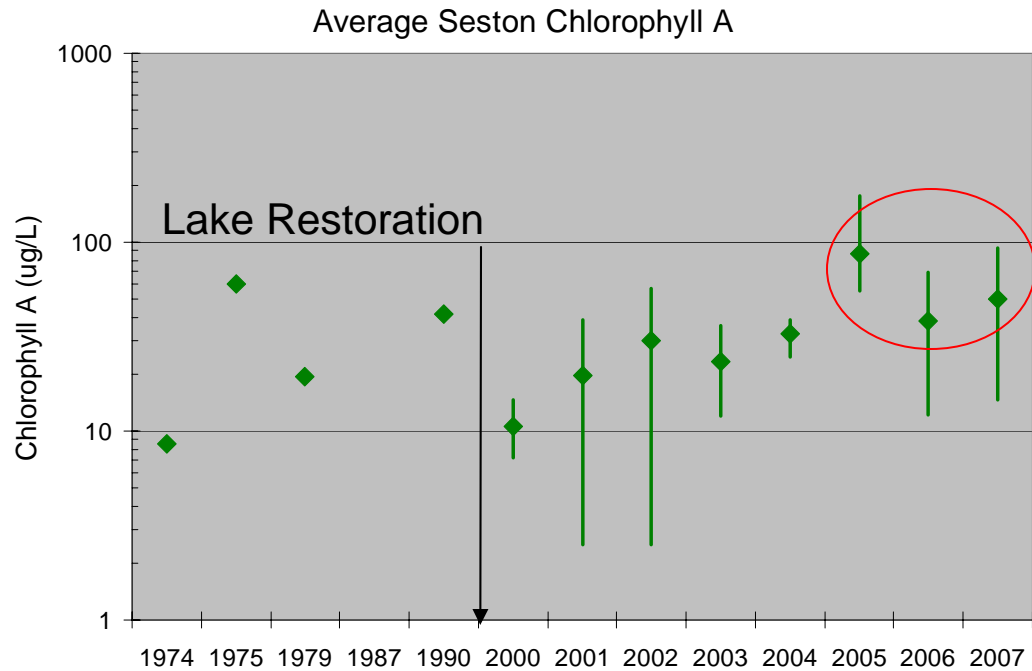
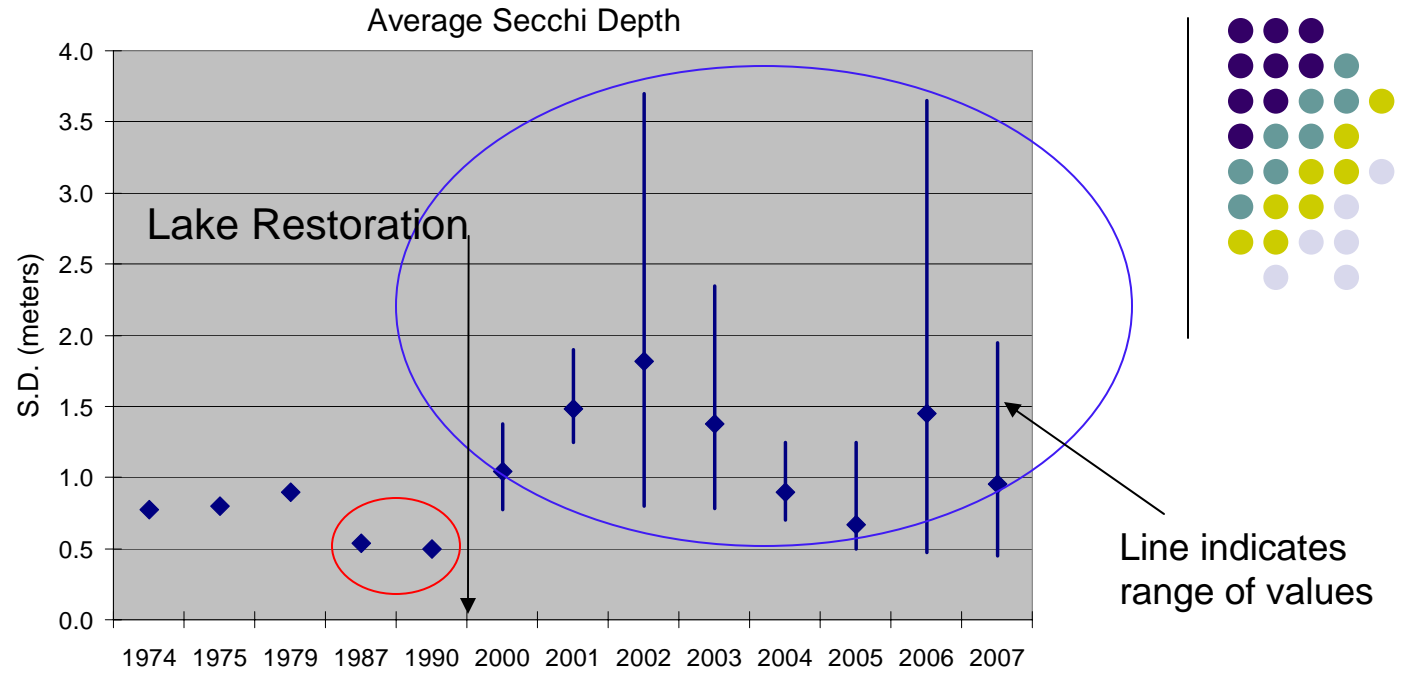
- ❑ late 80's-early'90s – severe water clarity & sedimentation problems
- ❑ state park / lake use substantially reduced
- ❑ restoration goal reduce sediment & nutrient (phosphorus) delivery by 50%
- ❑ lake / watershed work completed in 1997; total cost ~ \$4 million
- ❑ conservation practices for 95% cropland & pasture
- ❑ 2 sediment basins renovated, 3 new wetlands built
- ❑ In-lake work: sediment removal, fish habitat improvement, dam & spillway improvements
- ❑ post-restoration park use & fishing visits increased three-fold



# Lake Ahquabi

What do the data show?

~ 50-100% increase avg. secchi depth; 2000-2008 avg. > 1 m



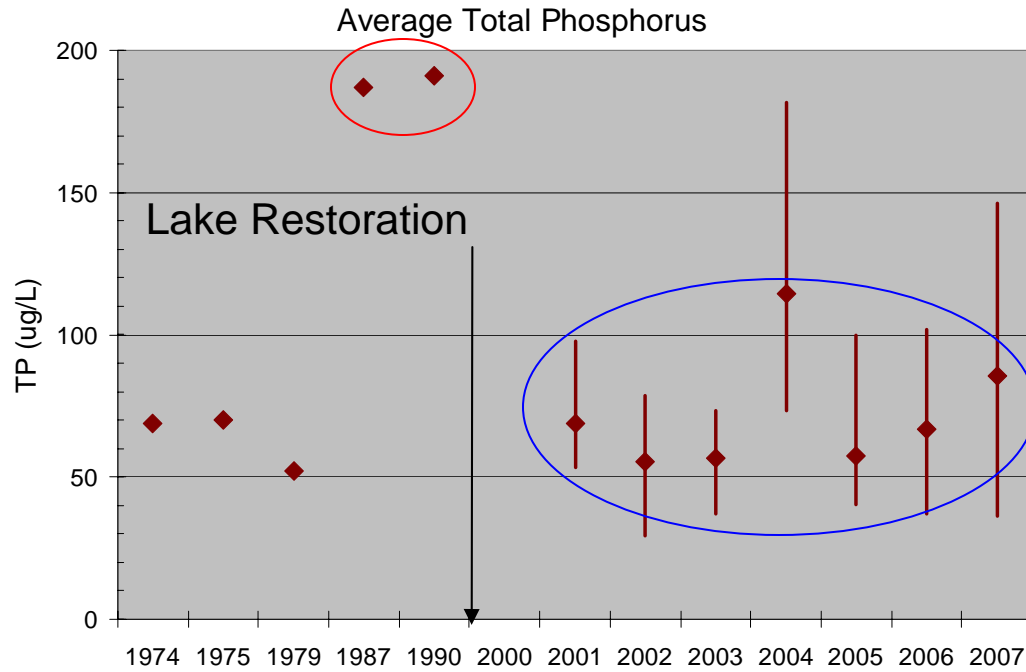
Increasing trend in chlorophyll levels?

Nuisance algal blooms in recent years



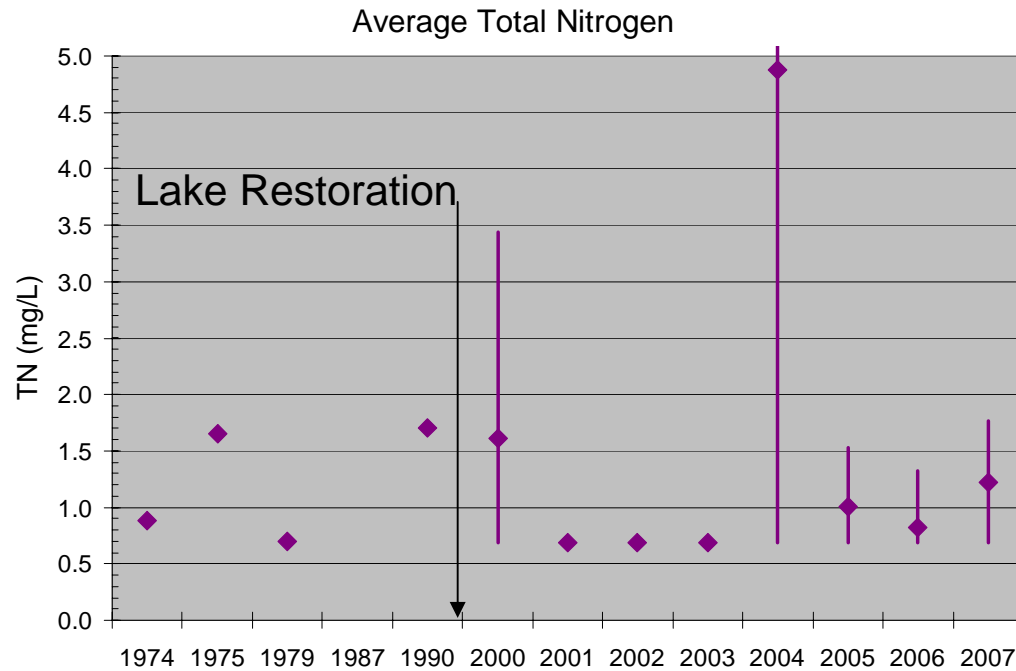
# Lake Ahquabi

## What do the data show?



**Approx.  
60% TP  
reduction**

No clear  
pattern in  
TN levels

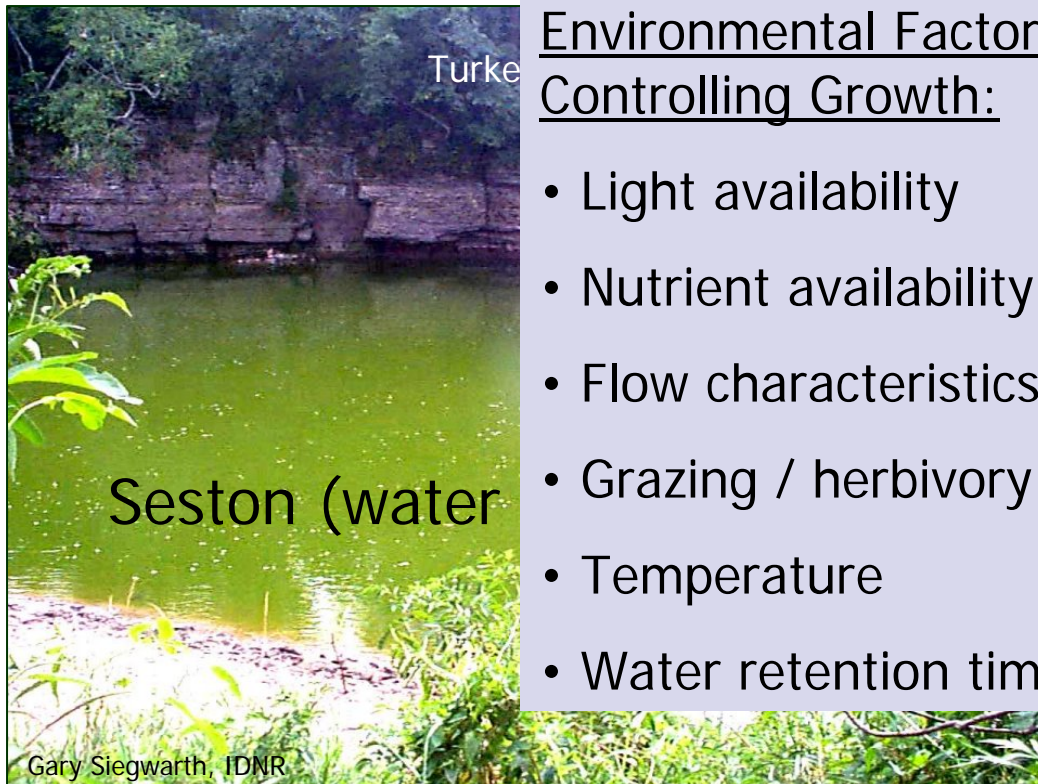


# Rivers and Streams

## Nutrients → Algae



2 Main Types of Growth:

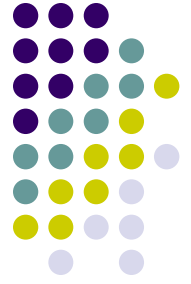


### Environmental Factors Controlling Growth:

- Light availability
- Nutrient availability
- Flow characteristics
- Grazing / herbivory
- Temperature
- Water retention time



# Nutrient TMDL North Fork Maquoketa River, Dubuque Co.



## Nutrient response targets:

Daily D.O. range < 10 mg/l

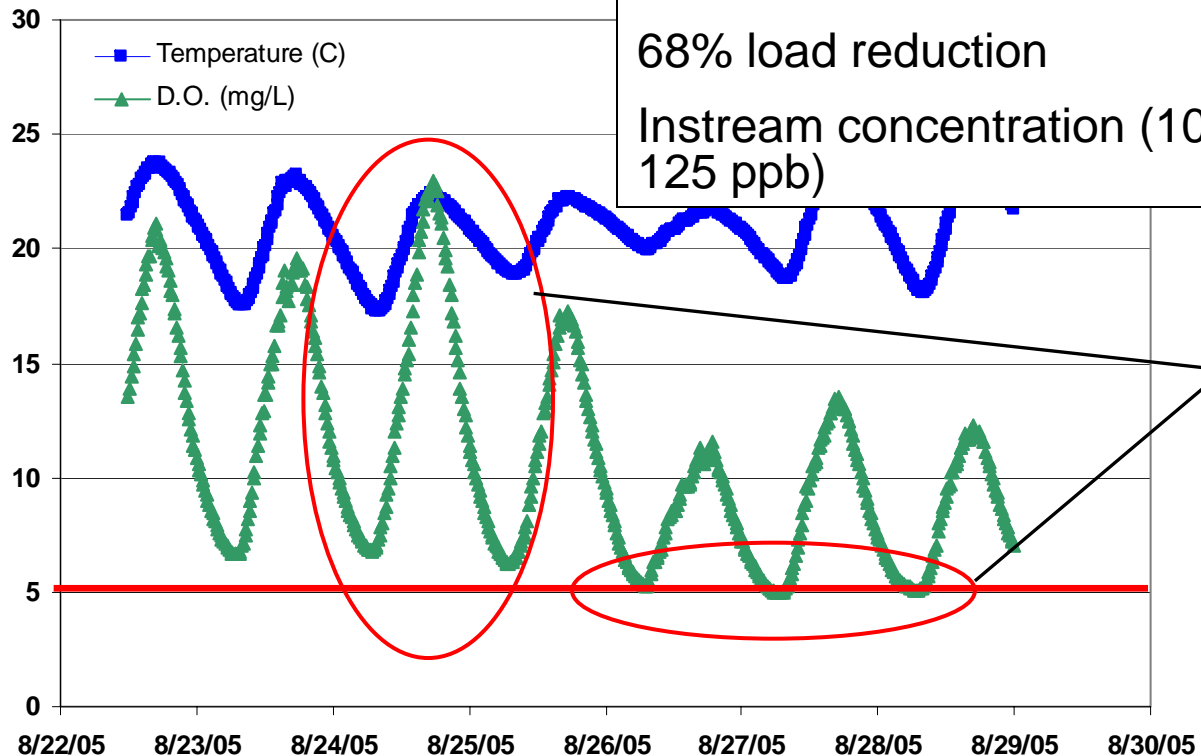
D.O. minima > 5 mg/L

Bottom algae reduced 33%

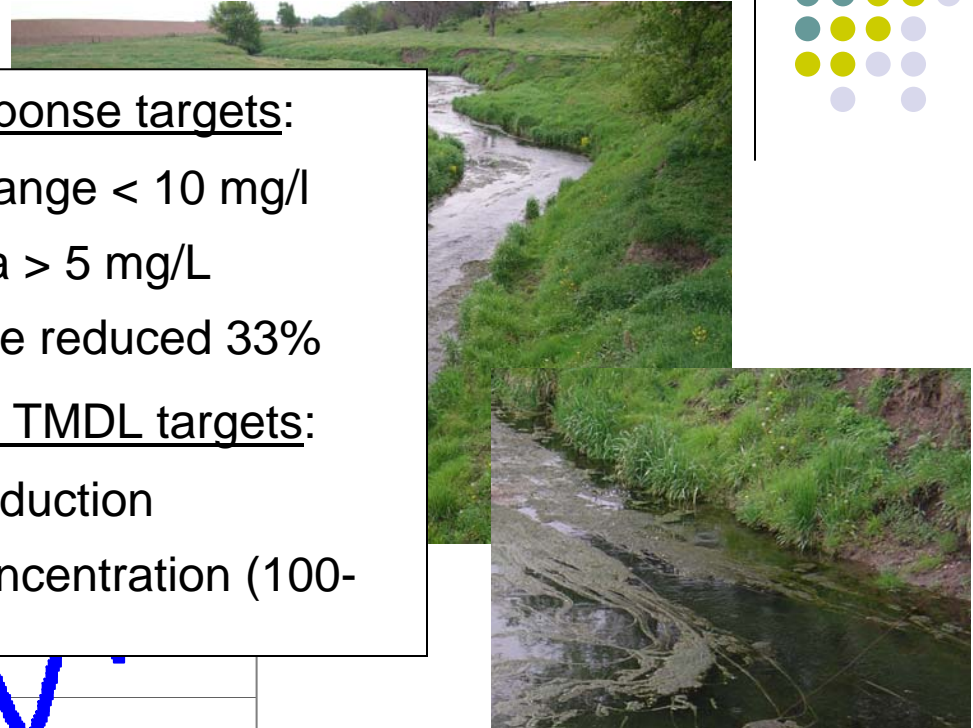
## Phosphorus TMDL targets:

68% load reduction

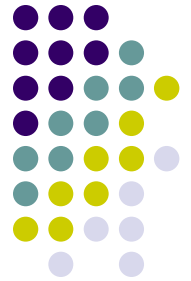
Instream concentration (100-125 ppb)



Problem: Low dissolved oxygen and excessive diurnal fluctuations combine with sedimentation and episodic ammonia toxicity problems resulting in impairment to benthic macroinvertebrate and fish assemblages.



# Midwestern Stream Nutrient – Biological Response Studies



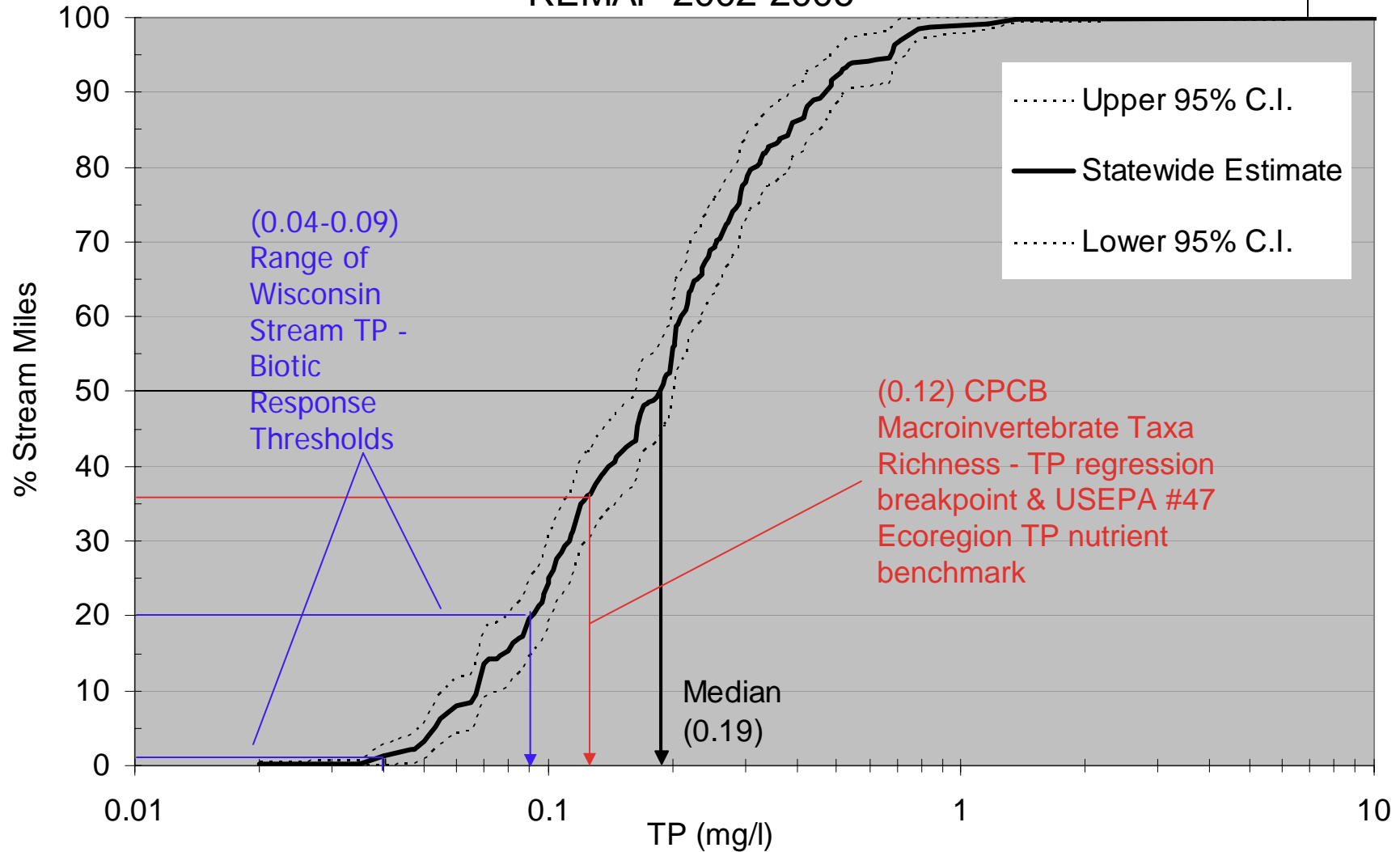
- IA, KS, MO, NE [Central Plains Center for Bioassessment (CPCB)  
D.H. Huggins, D. Baker et al. 2008 (in progress)] \*
- Illinois [Council on Food and Agricultural Research (CFAR), G.F.  
Czapar et al. 2007]
- Iowa [IDNR 2002-2006 probabilistic stream survey (REMAP) (in  
progress)]
- Minnesota [S. Heiskary, H. Markus, MPCA 2003]
- Wisconsin [D.M. Robertson et al., USGS & WDNR 2006]

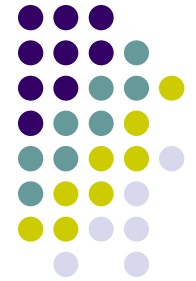
\* 2008 Annual Water Monitoring Conference:

[http://wqm.igsb.uiowa.edu/activities/conferences/conf\\_2008.htm](http://wqm.igsb.uiowa.edu/activities/conferences/conf_2008.htm)

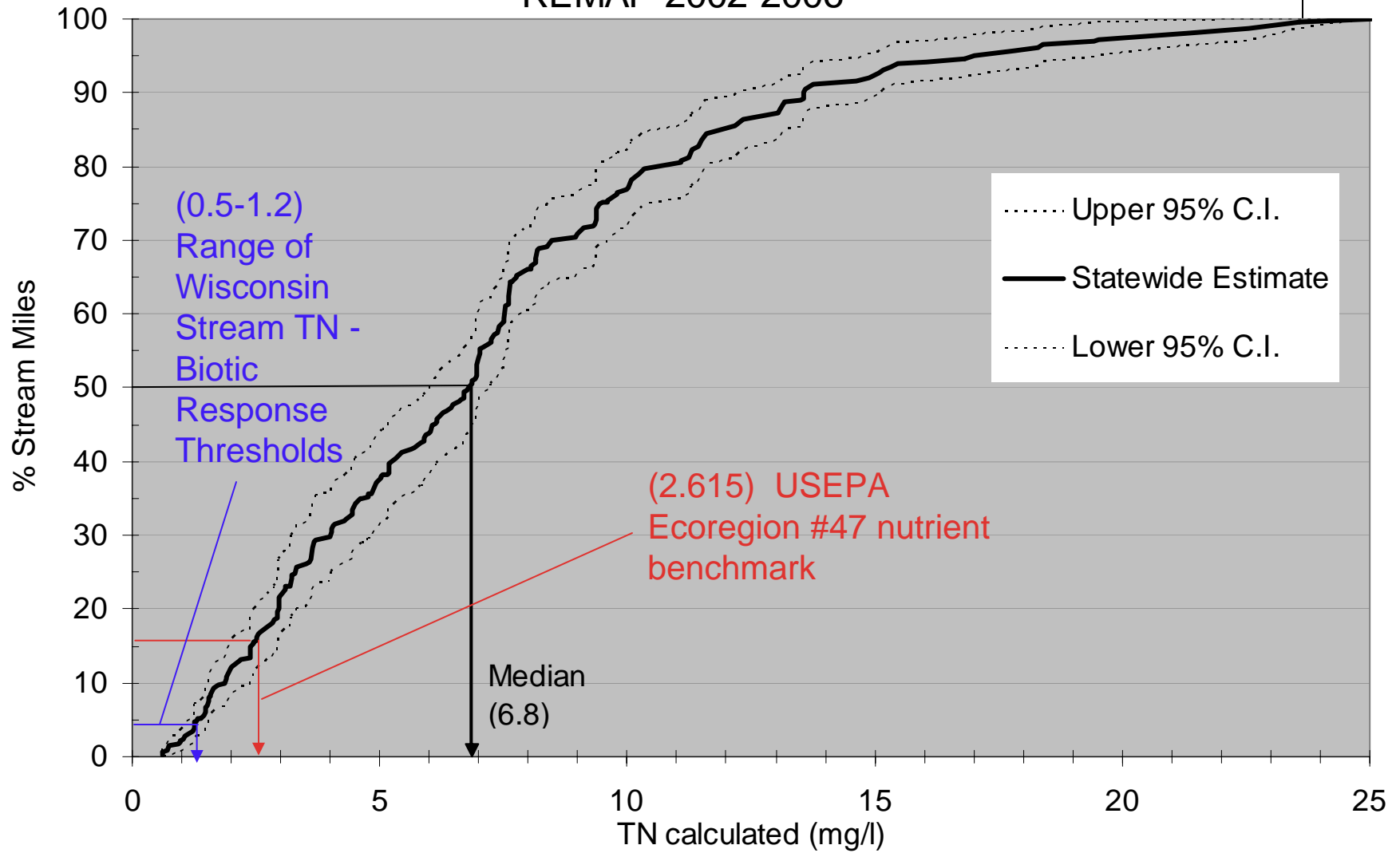


# Perennial River/Stream Total Phosphorus REMAP 2002-2006





# Baseflow Stream Total Nitrogen REMAP 2002-2006



# Springbrook Creek, Guthrie Co.



## 2005 baseflow sampling

median values (n=17)

TP = 0.08 mg/L

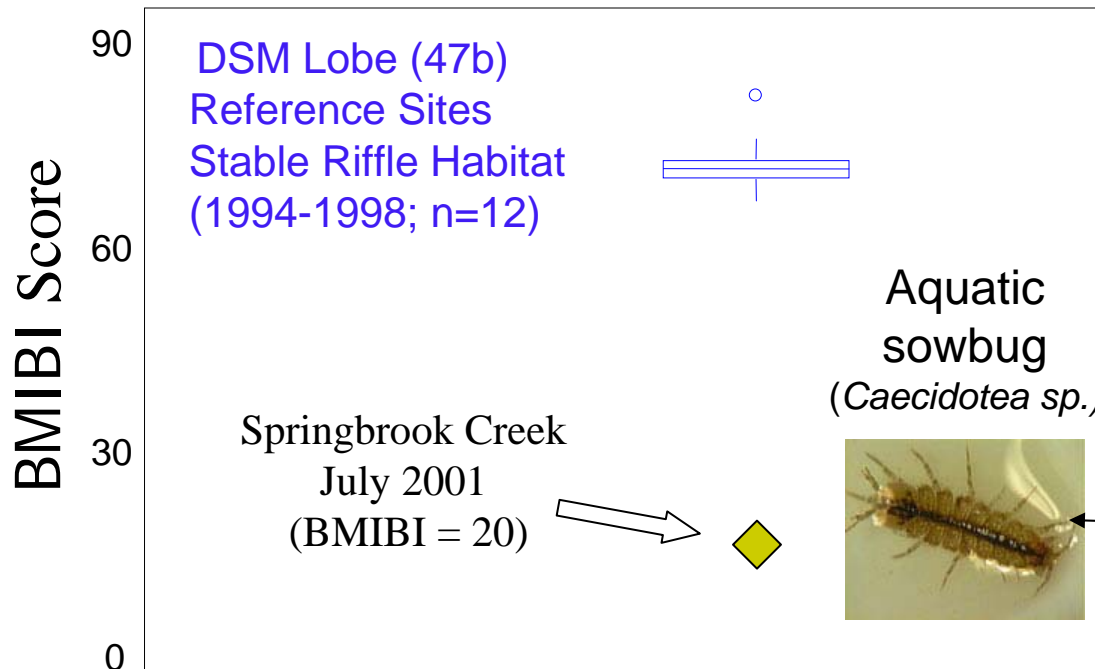
Diss. P = 0.06 mg/L

Nitrite+nitrate = 6.7 mg/L

TSS = 3 mg/L

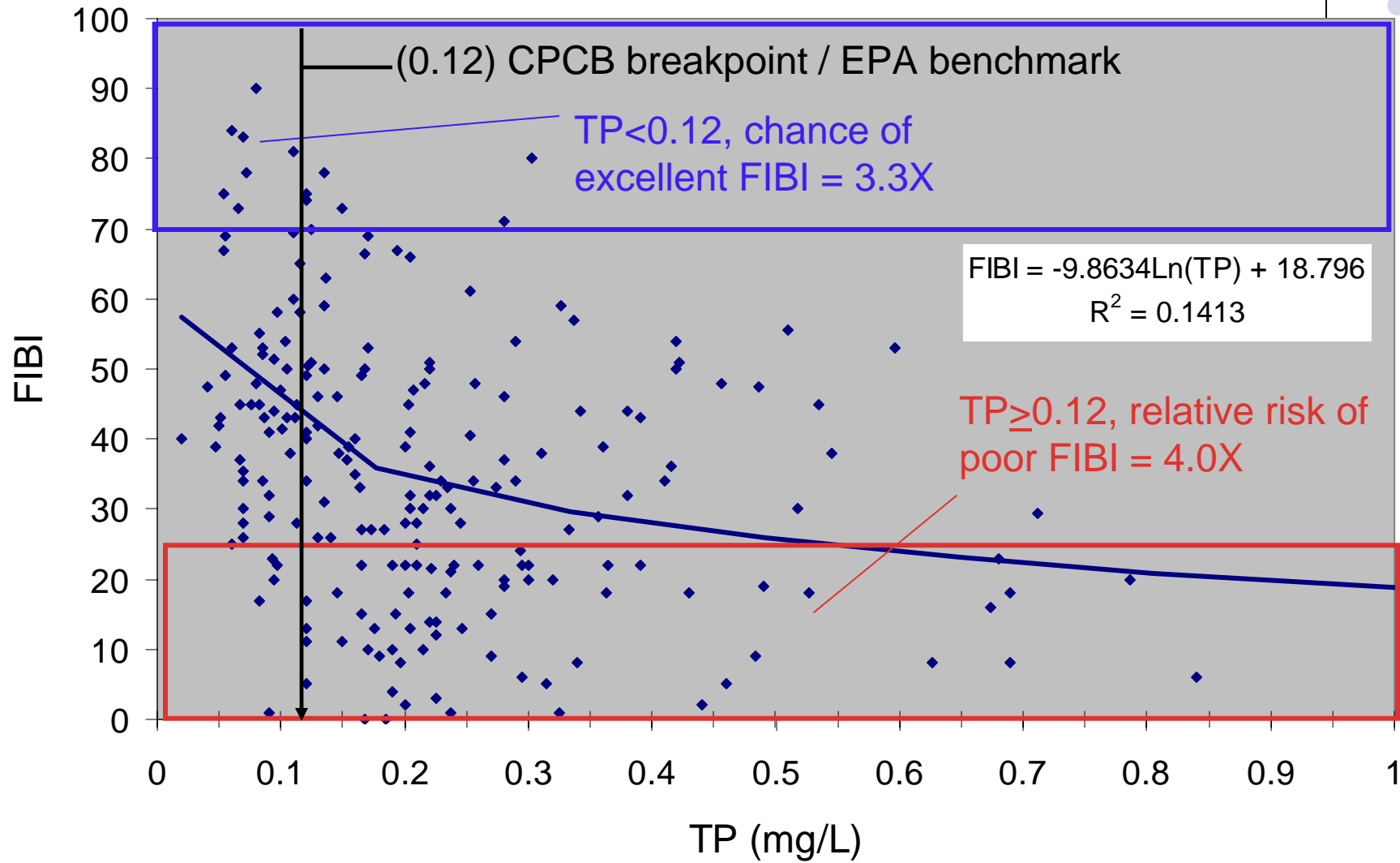


## Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI)





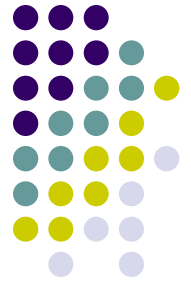
# Total Phosphorus vs. Fish Index of Biotic Integrity (FIBI) Iowa Perennial Rivers/Streams: REMAP 2002-2006



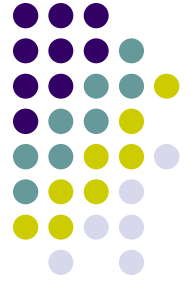
# How do nutrient criteria relate to Gulf Hypoxia goals?

## Considerations:

- Targets
  - Concentration (Nutrient Criteria) vs. Load (Gulf Hypoxia)
- Reduction strategies
  - Nutrient focus (N vs. P)
  - Timing (low flow vs. high flow)
  - Technologies / practices
- Prioritization of watersheds
  - Scale
  - Impairments



# Acknowledgements



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**Christopher Jones**, Des Moines Water Works

**Joe Larscheid**, Fisheries Research, Iowa Department of Natural Resources

**John Olson**, Watershed Monitoring & Assessment, Iowa DNR

**Michael Quist**, Natural Resource Ecology and Management, Iowa State University

**Peter Weyer**, Center for Health Effects of Environmental Contamination, Univ. of Iowa

**Tom Wilton**, Water Quality Assessment Section, Iowa DNR

