NSAC Progress

(Nutrient Science Advisory Committee)

Presented by Paul Terrio, USGS

Nutrient Science Advisory Committee

2016 NLRS Framework:

http://www.epa.illinois.gov/topics/water-quality/watershed-management/excess-nutrients/nutrient-loss-reduction-strategy/index

NSAC Charge:

- Make recommendations to Illinois EPA regarding numeric river and stream eutrophication water quality standards
- Consider whether standards should vary spatially or by other classification factors
- Consider need to obtain EPA approval in recommendations

NSAC Progress

(Nutrient Science Advisory Committee)

Presented by Paul Terrio, USGS

Dr. Todd Royer, Indiana University, Chair

Dr. Candice Bauer, U.S. Environmental Protection Agency, Region 5

Dr. Doug McLaughlin, National Council for Air and Stream Improvement

Dr. Christopher Peterson, Loyola University

Paul Terrio, U.S. Geological Survey

Dr. Matt Whiles, Southern Illinois University

United States Environmental Protection Agency

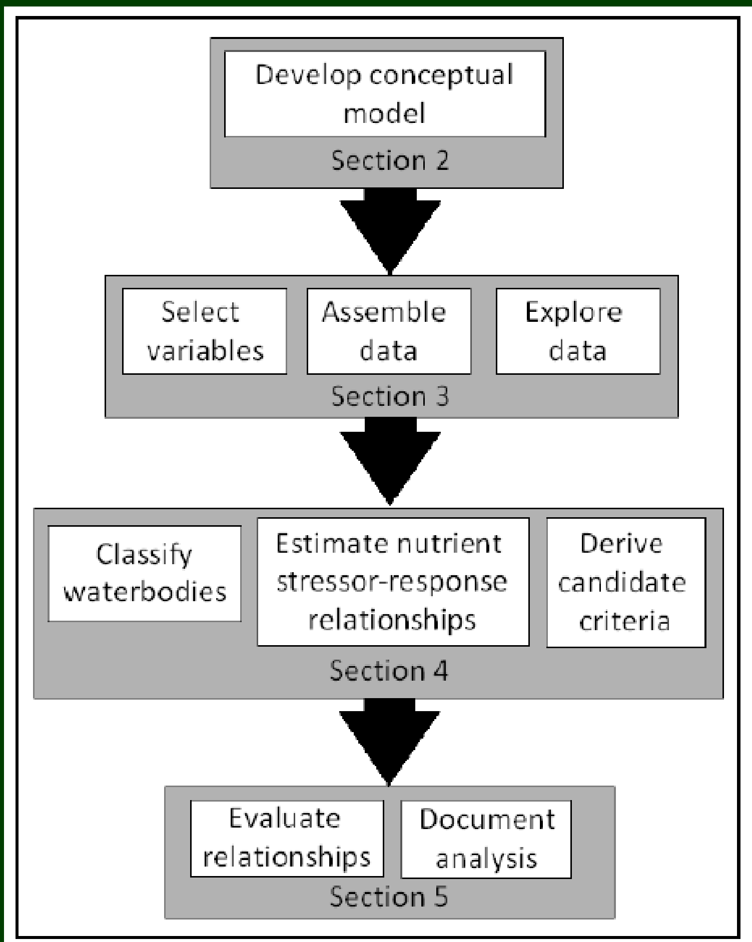
Office of Water

Mail code 4304T

EPA-820-S-10-001

November 2010

Using Stressor-response Relationships to Derive Numeric Nutrient Criteria



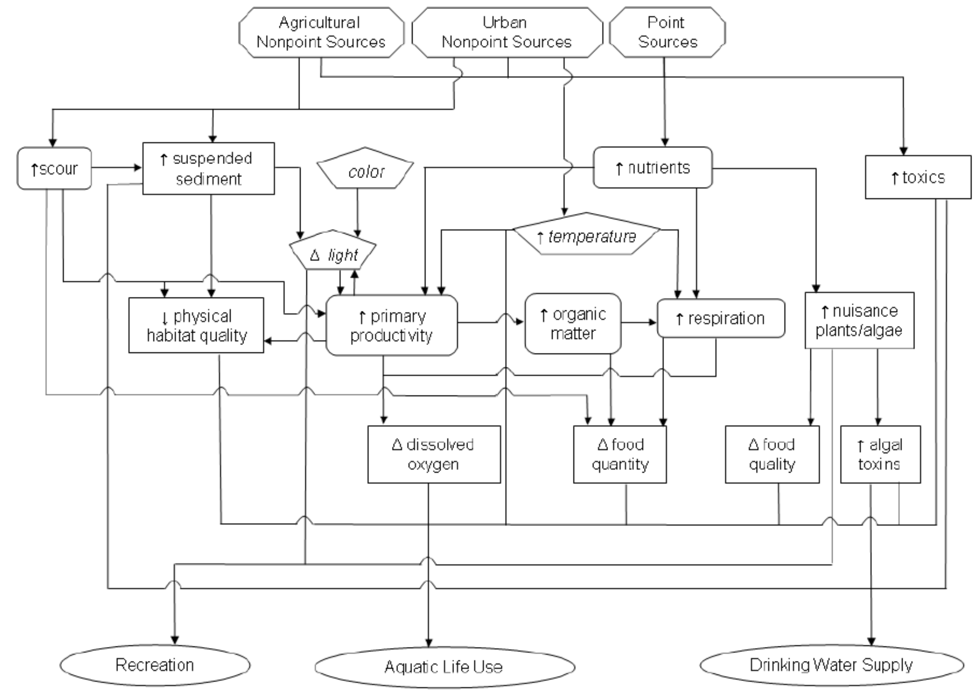
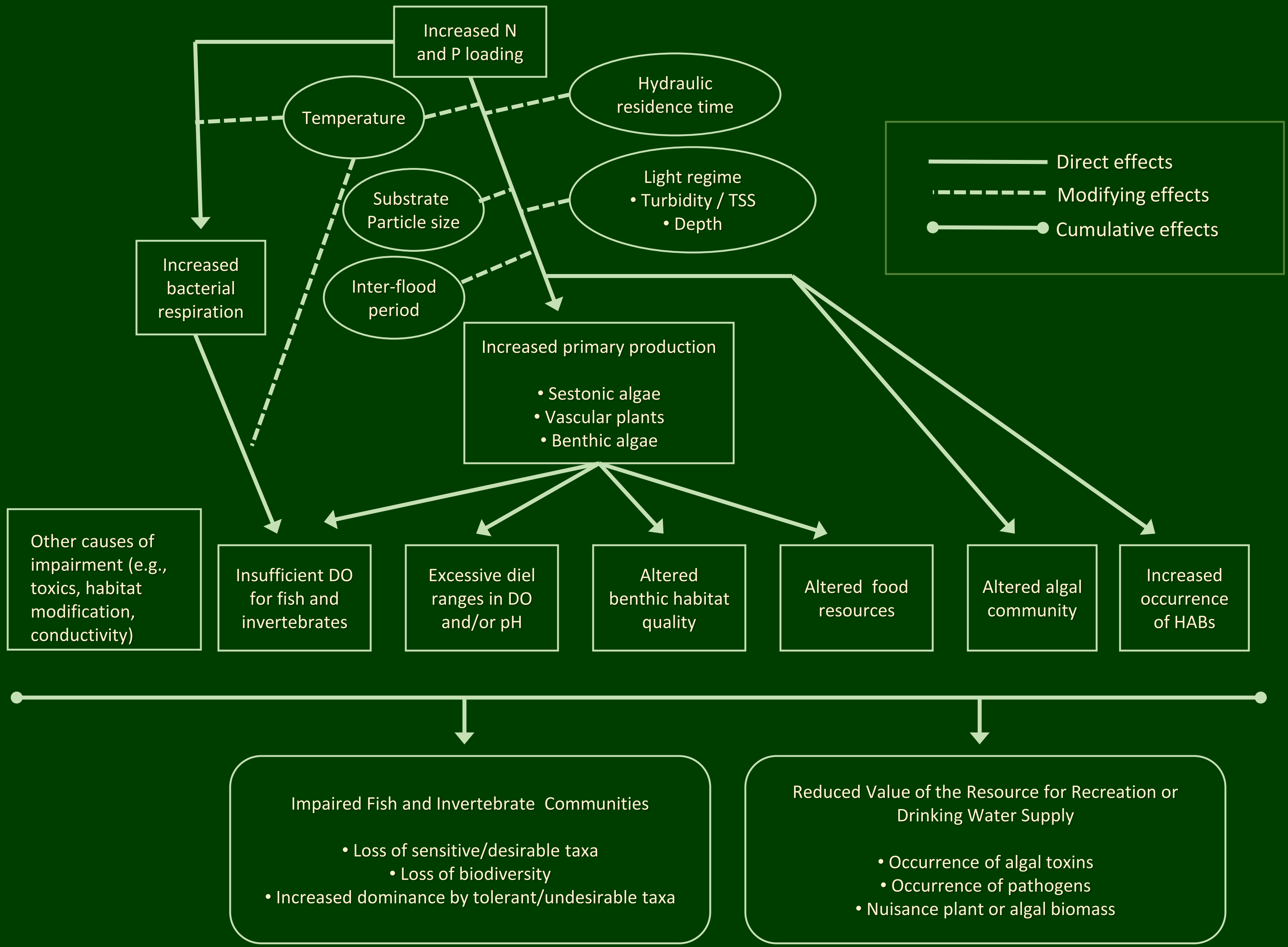
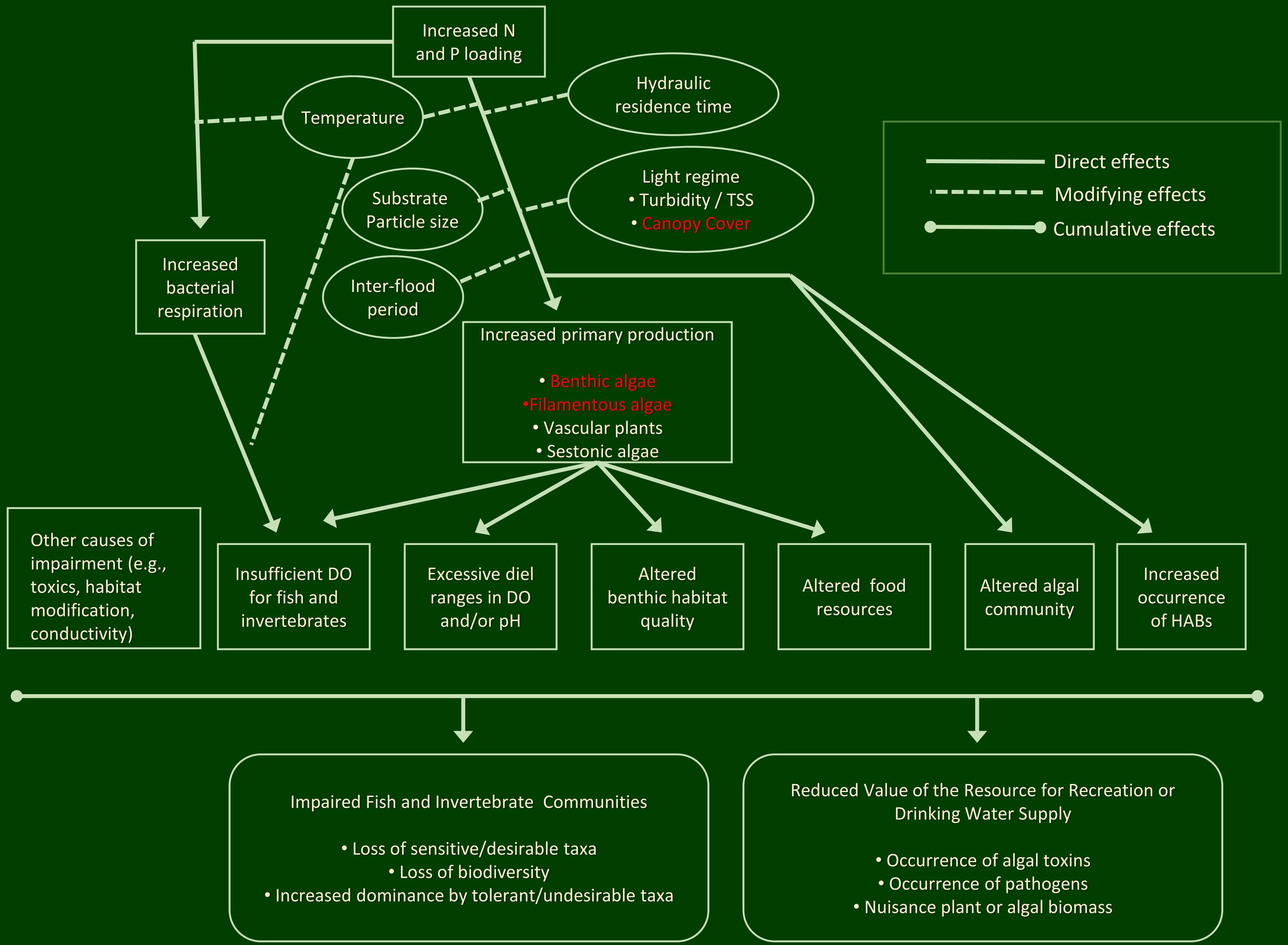


Figure 2-2. Conceptual model diagram for streams. See text for explanation of shapes and symbols.

Conceptual Model: Non-Wadeable Rivers



Conceptual Model: Wadeable Rivers



EPA United States Environmental Protection Agency — Office of Water, Mail Code 4305T — EPA-820-F-13-039, September 2013

Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters

… OR what NSAC calls "combined criteria"

These guiding principles apply when states wish to rely on response parameters to indicate that a designated use is protected, even though a nitrogen and/or phosphorus level is/are above an adopted threshold. If a state prefers to apply causal and response parameters independently, the principles in II.C will not apply.

States interested in this approach should have a biological assessment program that confidently measures biological responses and other nutrient-related response parameters through a robust monitoring program to account for temporal variability to document the effects of nutrient pollution. This will allow the

Example: Minnesota River Eutrophication Standards (combined criteria example)

A. Eutrophication standards are compared to data averaged over the summer season or as specified in subpart. 4.
Exceedance of the total phosphorus and either sestonic chlorophyll-a, biochemical oxygen demand (BOD5), diel dissolved oxygen flux or pH standard is required to indicate a polluted condition for assessment and implementation purposes.

Criteria consist of TP and four response indicators (chl *a*, DO flux, BOD_5 and pH):

Ecoregion	TP (µg/L)	Chlorophyll a (µg/L)	Daily DO flux (mg/L)	BOD_5 (mg/L)	pH
North	50	7	3	1.5	CW: 6.5-8.5 WW: 6.5-9.0 (From MN WQS)
Central	100	18	3.5	2	
South	150	35	4.5	3	

Other Midwest Nutrient Criteria

- Minnesota Eutrophication Standards
  - Weighed multiple lines of evidence including stressor-response based and reference-based
  - Includes values for western Corn Belt ecoregion
- Wisconsin TP criteria
  - Stressor-response based
  - Lacks Corn Belt ecoregion
- No EPA-approved numeric standards
  - IN, IA, MO, OH

Lines of Evidence Weighed by NSAC for Illinois Rivers and Streams

- IEPA / IDNR Data
  - Stressor-response analyses
  - Statistical distribution analyses
  - Modeled reference conditions
- Stressor – Response data from Literature
  - Conclusions from Council on Food and Agricultural Research (C-FAR) funded work in Illinois streams
  - TetraTech and other analyses
- Reference/Background Nutrient estimates from Literature

Lines of Evidence

- **IEPA Data**
- Reference/Background Nutrient estimates from Literature
- Conclusions from Council on Food and Agricultural Research (C-FAR) funded work in Illinois streams
- Stressor – Response data from Literature

Analyses of Illinois EPA Data

- Conducted updated analyses of Illinois EPA dataset with EPA-funding (assistance from Tetra-Tech)
- NSAC used a portion of available Illinois EPA dataset:
  - 2006-2015
  - Included sites from ambient network and intensive basin surveys
  - Parameters included:
    - TP/TN
    - Sestonic chl a (measure of water column algae)
    - Continuous dissolved oxygen (DO)
    - Macroinvertebrate and fish indexes of biological integrity
    - QHEI (measure of habitat quality)
    - Other Water quality measures (turbidity, temperature, etc.)

Analyses of Illinois EPA Data

- Focused on stressor-response relationships:
  - Nutrients vs. Chl a/DO min/DO avg/DO flux
  - Nutrients vs. mIBI/macroinvert metrics/fIBI
  - Chl a/DO vs. mIBI/macroinvert metrics/fIBI
- Analyzed relationships in different ways:
  - Statewide vs. Aggregate Nutrient Ecoregions vs. Level 3 ecoregions vs. major river basin
  - Watershed area
  - All stream orders vs. 3 stream order groupings
  - All sites vs. high QHEI vs. high IBI sites

- Some support for conceptual model, but in virtually all cases the stressor-response models had low predictive power with R^2 values less than 0.35

Limitations

- IEPA monitoring program was not specifically developed to support nutrient criteria development
- Data collection is not developed in a probabilistic design
- Lack data on periphyton (benthic algae) in Illinois streams
- Some analyses excluded sites that did not include continuous DO, resulting in decreased sample size

Lines of Evidence

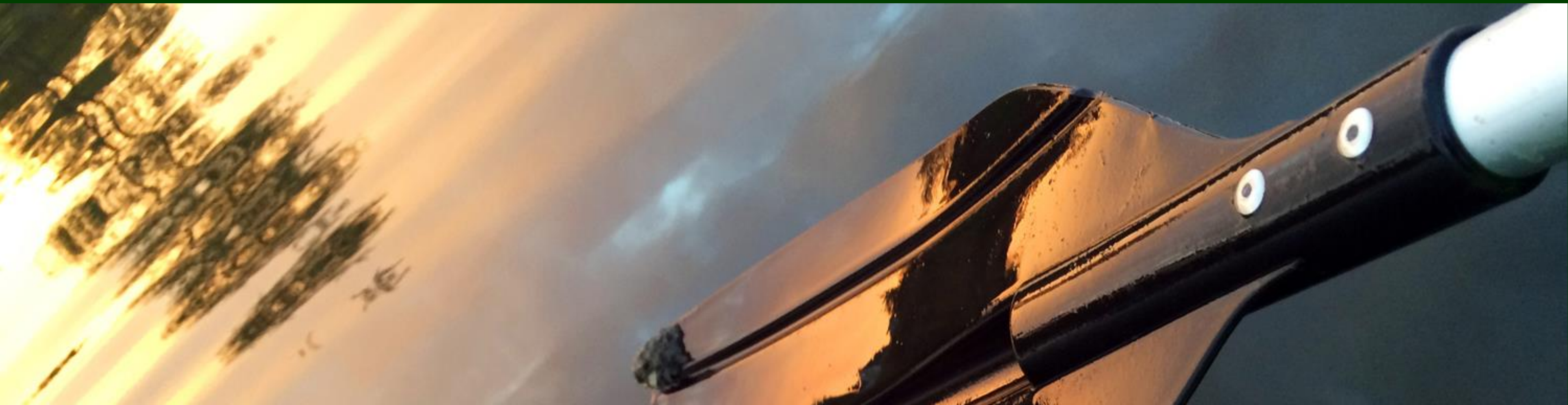
- IEPA Data
- **Reference/Background Nutrient estimates from Literature**
- Conclusions from Council on Food and Agricultural Research (C-FAR) funded work in Illinois streams
- Stressor – Response data from Literature

Background Nutrient Concentrations from USEPA (2001) and IEPA dataset (2017)

Statistical Distribution Sources	Ecoregion 6* TP (ug/L)	Ecoregion 9* TP (ug/L)	Ecoregion 6 TN (ug/L)	Ecoregion 9 TN (ug/L)
25^{th} USEPA (annual)	76	37	2180	690
25^{th} IEPA data (seasonal)	90	130	2100	900
25^{th} IEPA data (annual)	80	120	2400	900
75^{th} IEPA Minimally Disturbed Sites (seasonal; n=104)	160	110	5600	1100
75^{th} IEPA Minimally Disturbed Sites (annual; n=92)	160	110	6400	1100
75^{th} IEPA Attaining mIBI Sites (seasonal)	190	200	6000	1500
75^{th} IEPA Attaining mIBI Sites (annual)	190	200	6100	1600

Modeled Reference Nutrient Concentrations from Literature and IEPA dataset (2017)

Modelled Reference Sources	Ecoregion 6* TP (ug/L)	Ecoregion 9* TP (ug/L)	Ecoregion 6 TN (ug/L)	Ecoregion 9 TN (ug/L)
IEPA data (annual)	190	50	1600	500
Dodds and Oakes	23	31	215	370
Smith et al.	54	48	355	150
Robertson EPZ 1 and 2 and ENZ 3*	100	40	1480	1480



Lines of Evidence

- IEPA Data
- Reference/Background Nutrient estimates from Literature
- **Conclusions from Council on Food and Agricultural Research (C-FAR) funded work in Illinois streams**
- Stressor – Response data from Literature

Assessment of Chlorophyll-*a* as a Criterion for Establishing Nutrient Standards in the Streams and Rivers of Illinois

Todd V. Royer* Indiana University
Mark B. David, Lowell E. Gentry, Corey A. Mitchell, and Karen M. Starks University of Illinois at Urbana-Champaign
Thomas Heatherly II and Matt R. Whiles Southern Illinois University

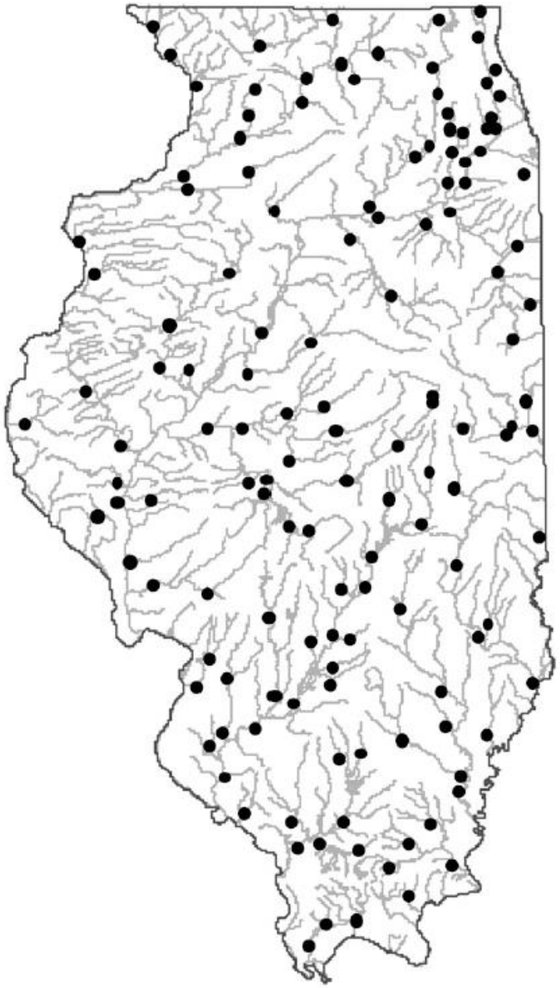


Fig. 1. Map of Illinois showing the major river networks and the distribution of the 138 sites used for the study.

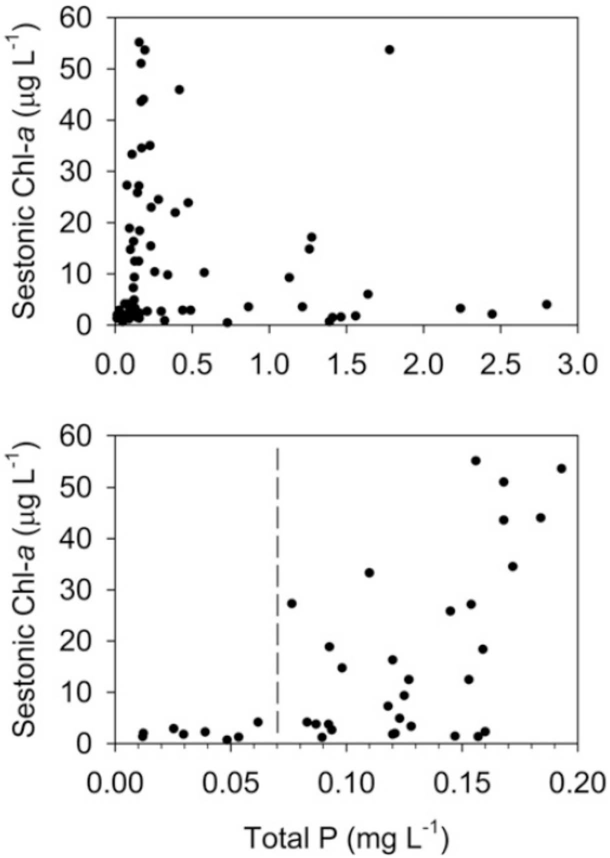


Fig. 4. Relationship between total P and sestonic chlorophyll-*a* (chl-*a*) concentrations during the 2004 low-discharge survey using all sites (upper panel), and only sites with an open canopy (<25%) and total P concentrations of <0.2 mg L^{-1} (lower panel; $n = 38$). The dashed vertical line indicates an apparent threshold value of 0.07 mg L^{-1} total P.

Lines of Evidence

- IEPA Data
- Reference/Background Nutrient estimates from Literature
- Conclusions from Council on Food and Agricultural Research (C-FAR) funded work in Illinois streams
- **<u>Stressor – Response data from Literature</u>**
  - **Compilation in progress**

Wadeable Streams (small) :

Statistical distributions / Modeled reference conditions

Statistical Distribution Sources	Ecoregion 6* TP (ug/L)	Ecoregion 9* TP (ug/L)	Ecoregion 6 TN (ug/L)	Ecoregion 9 TN (ug/L)
25^{th} USEPA (annual)	76	37	2180	690
25^{th} IEPA data (seasonal)	90	130	2100	900
25^{th} IEPA data (annual)	80	120	2400	900
75^{th} IEPA Minimally Disturbed Sites (seasonal; n=104)	160	110	5600	1100
75^{th} IEPA Minimally Disturbed Sites (annual; n=92)	160	110	6400	1100
75^{th} IEPA Attaining mIBI Sites (seasonal)	190	200	6000	1500
75^{th} IEPA Attaining mIBI Sites (annual)	190	200	6100	1600

Non -wadeable Streams (medium-large):

Stressor-response based supported by data outside of Illinois

Numeric Target Evaluation Worksheet

Step 1. Enter variable names and description, and then paste data into columns C

Note: Paired observations are required (no blanks) and data must have fewer than 3000 records

For scroll bar to work for chart, data values must be >1 (i.e., modify original units if necessary).

TetraTech source data file: stressResponse_R1.rda exported to stressResponse_dbm.xlsx

Candidate Response Variable (enter name, description):

Name:	chlac.seas
Description:	growing season geometric mean sestonic chlorophyll a, all site-years, strea including data extracted and analyzed after 28-day holding time.

Candidate Causal Variable (enter name, description):

Name:	TP.seas
Description:	growing season geometric mean total phosphorus, all site-years, stream or

Other data/variable notes:

each data pair represents the growing season geometric mean for a single site in a single year.

		Candidate Response	Candidate Cause
	Name:	chlac.seas	TP.seas
StaYear	Units:	ug/L	ug/L
AD-02_2009	175919	2.11087847	175.91889
AD-02_2014	####	4.27	102.76796
AD-04_2009	####	1.57	218
AD-20_2009	####	1.460499199	192.6427
AJ-10_2005	93670	7.120501611	93.669632
AT-05_2005	63388	17.69745744	63.387696
AT-05_2010	90475	13.51584787	90.474723
AT-06_2005	82301	55.03953792	82.301284
AT-06_2006	####	10.40621588	146.20728
AT-06_2007	66350	7.288689869	66.349764
AT-06_2008	112020	19.20862941	112.01999
AT-06_2009	141746	9.288391445	141.74624
AT-06_2010	####	9.643371779	139.44647
AT-06_2011	179163	10.02692868	179.16333
AT-06_2012	130412	30.46583068	130.41178
AT-06_2013	####	17.31207061	200.79471
AT-06_2014	181271	14.64872668	181.27112
ATF-03_2005	87132	77.49658057	87.132084
ATF-03_2010	####	22.36789619	165.86649
ATF-08_2005	107533	9.743715924	107.5327
ATF-08_2010	68920	0.922973604	68.919632
ATFJ-01_2005	90277	8.968946426	90.27735
ATG-03_2005	####	8.046185602	142.66941
ATG-03_2006	####	5.839485375	292.93872
ATG-03_2008	####	3.092657259	307.88127
ATG-03_2009	####	15.37549238	342.05754
ATG-03_2010	####	3.573171219	368.7773
ATG-03_2011	254117	5.293214778	254.11745
ATG-03_2012	510751	2.424838295	510.75057
ATG-03_2013	####	5.470662344	300.40239
ATG-03_2014	129557	3.66568324	129.55716
B-03_2011	####	8.34	308
B-06_2005	####	107.4374978	154.6002

Calculated Summary Statistics

	chlac.seas	TP.seas
	ug/L	ug/L
Mean	30.9	262.9
SD	34.6	377.4
CV	1.12	1.44
Min	0.364	28.699
Median	19.859	187.263
Max	270	8320
# Data Pairs	707	707

Step 2. Adjust Both Candidate Response and Candidate Causal Variable Scroll Bars To Evaluate Numeric Targets

Candidate Response Variable

chlac.seas	Units
30	ug/L
240	# exceeding target

Step 2a. Candidate Response Variable Scr

Candidate Causal Variable

TP.seas	
115	ug/L
569	# exceeding target

Step 2b. Candidate Causal Variable Scroll

Step 3. Examine Results

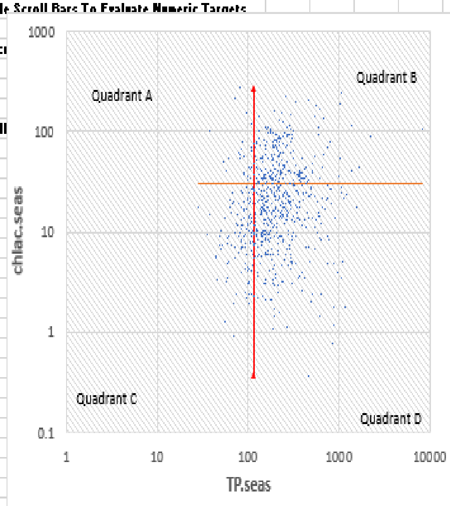
a. 2 x 2 Matrix (cells show # of data pairs)

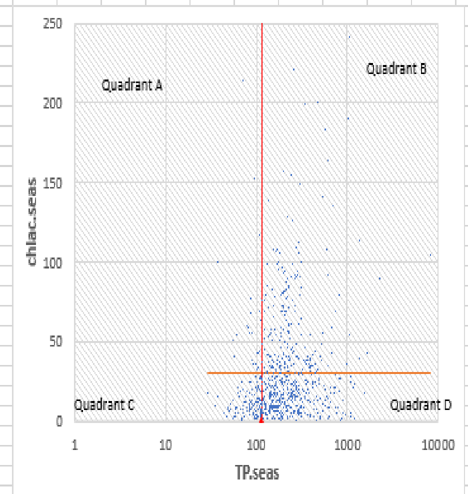
		TP.seas		
		attained	not attained	Total
chlac.seas	not attained	24	216	240
	attained	114	351	465
	Total	138	567	705

indicates agreement between candidate causal and res

indicates disagreement between candidate causal and

View another chart --------- Same data, alternative display using linear y axis





b. Predictive Performance Su

		Definitions
Prevalence (%)	34	The proportion of all response observations that exceed (i.e., do not attain, do not meet) the target.
Agreement/Non-errors (100% reflects perfect agreement)		
Accuracy (%)	57	The average of Sp and Se.
Specificity (Sp, %)	25	The proportion of data pairs that agree when the candidate response variable meets the target (i.e., Quad. C/(Quad. C + Quad. D)*100).
Sensitivity (Se, %)	90	The proportion of data pairs that agree when the candidate response variable does not meet the target (i.e., Quad. B/(Quad. A + Quad. B)*100).
Errors/Disagreement (0% reflects perfect agreement)		
1-Se (%)	10	The proportion of data pairs that disagree when the candidate response variable meets the target (i.e., 100 - [Quad. C/(Quad. C + Quad. D)*100]).
1-Sp (%)	75	The proportion of data pairs that disagree when the candidate response variable does not meet the target (i.e., 100 - [Quad. B/(Quad. A + Quad. B)*100]).
NPE (%)	17	The "negative predictive error" (NPE) is the proportion of data pairs that disagree when the candidate causal variable meets its target (i.e., 100 - [Quad.A/(Quad. A + Quad. C)*100)]
PPE (%)	62	The "positive predictive error" (PPE) is the proportion of data pairs that disagree when the candidate causal variable does not meet its target (i.e., 100 - [Quad. D/(Quad. B + Quad. D)*100)]

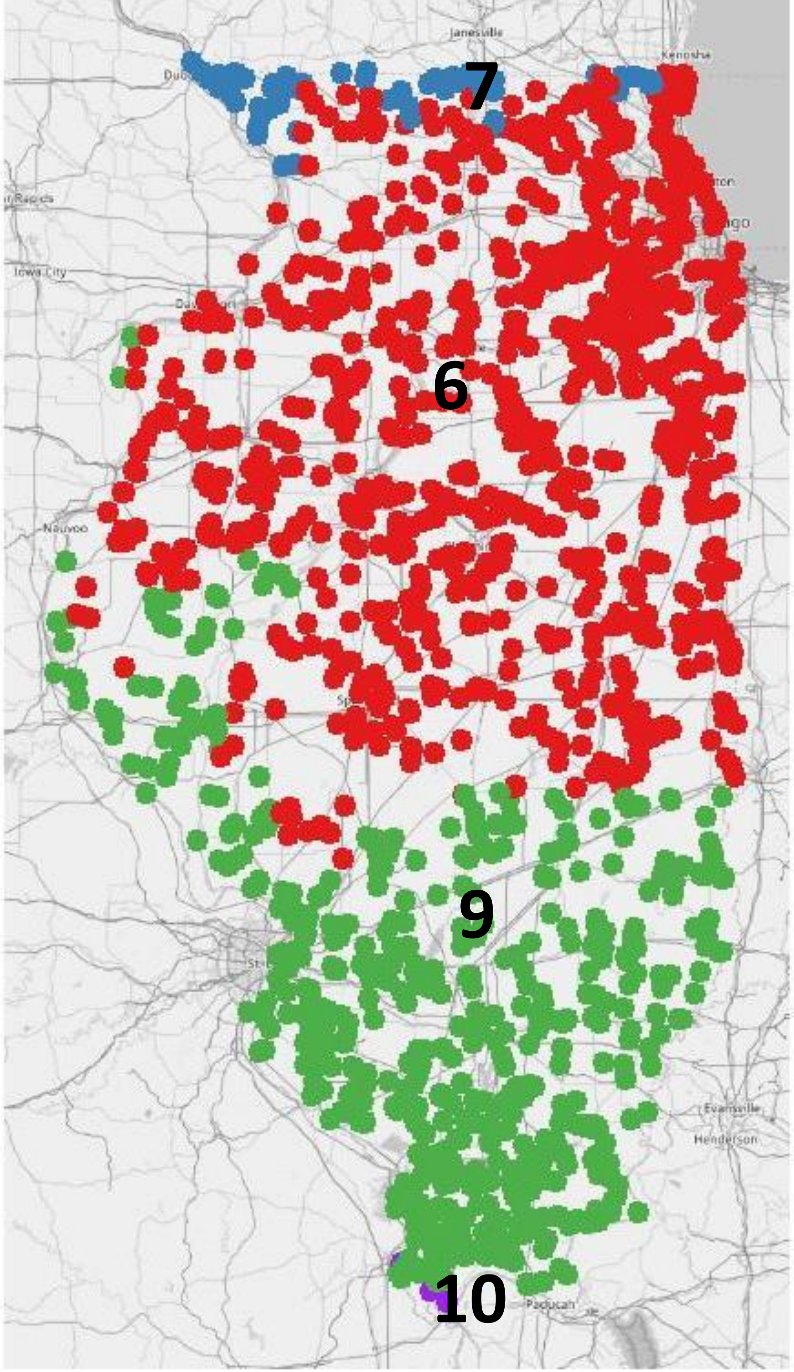
For threshold lines on chart

		min	max
	TP.seas	28.699	8320
	chlac.seas	0.364005494	270
target for	chlac.seas	30	30
target for	TP.seas	115	115

- Finalizing criteria recommendations (May?)
- Drafting report (September?)

Thank you…..stay tuned.

Nutrient Ecoregions in Illinois



Conclusions from C-FAR work

- Benthic algae saturation threshold for dissolved phosphorus in laboratory experiments occurred at ~25ug/L SRP – consistent with other literature (Hill and Fanta 2007)
- Statewide survey of 53 streams for nutrients, habitat, and macroinvertebrate measures observed that both habitat and nutrients (nitrogen and phosphorus) affected measures of macroinvertebrate health (Heatherly et al. 2007)
- Statewide 2004 low-flow survey observed possible increase in sestonic algae in open-canopied sites with TP > ~70 ug/L (Royer et al. 2008)