Modeling the Effects of Multiple Stressors on Stream Macroinvertebrate and Algal Metrics from Agricultural and Urban Watersheds

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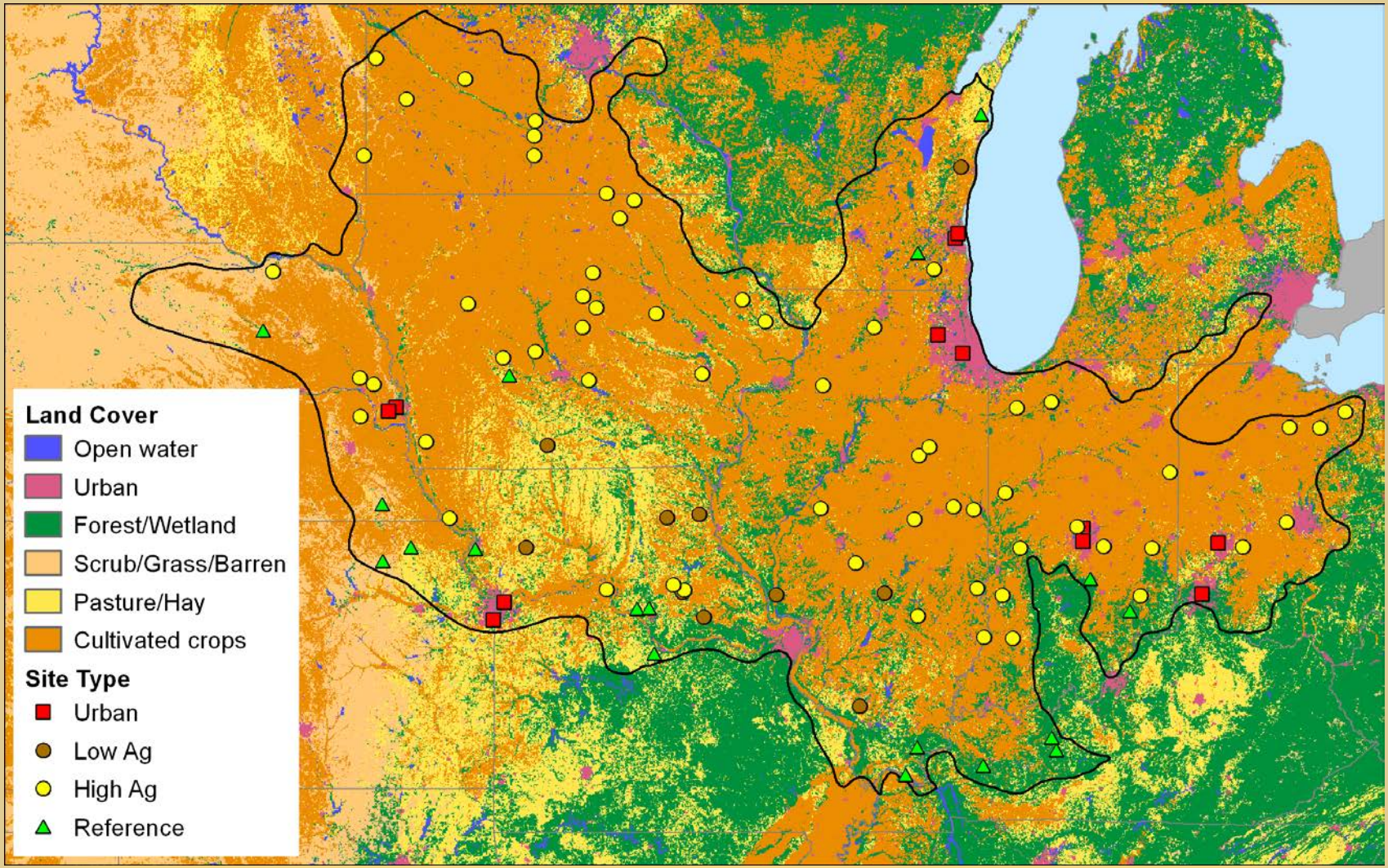
USGS – NAWQA

Study completed in collaboration with EPA NARS

U.S. Department of Interior
U.S. Geological Survey

98 Sites across 12 Midwestern States



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Boosted Regression Tree Models: **GIS**
R^2 = 0.86 (5 – 6 variables)

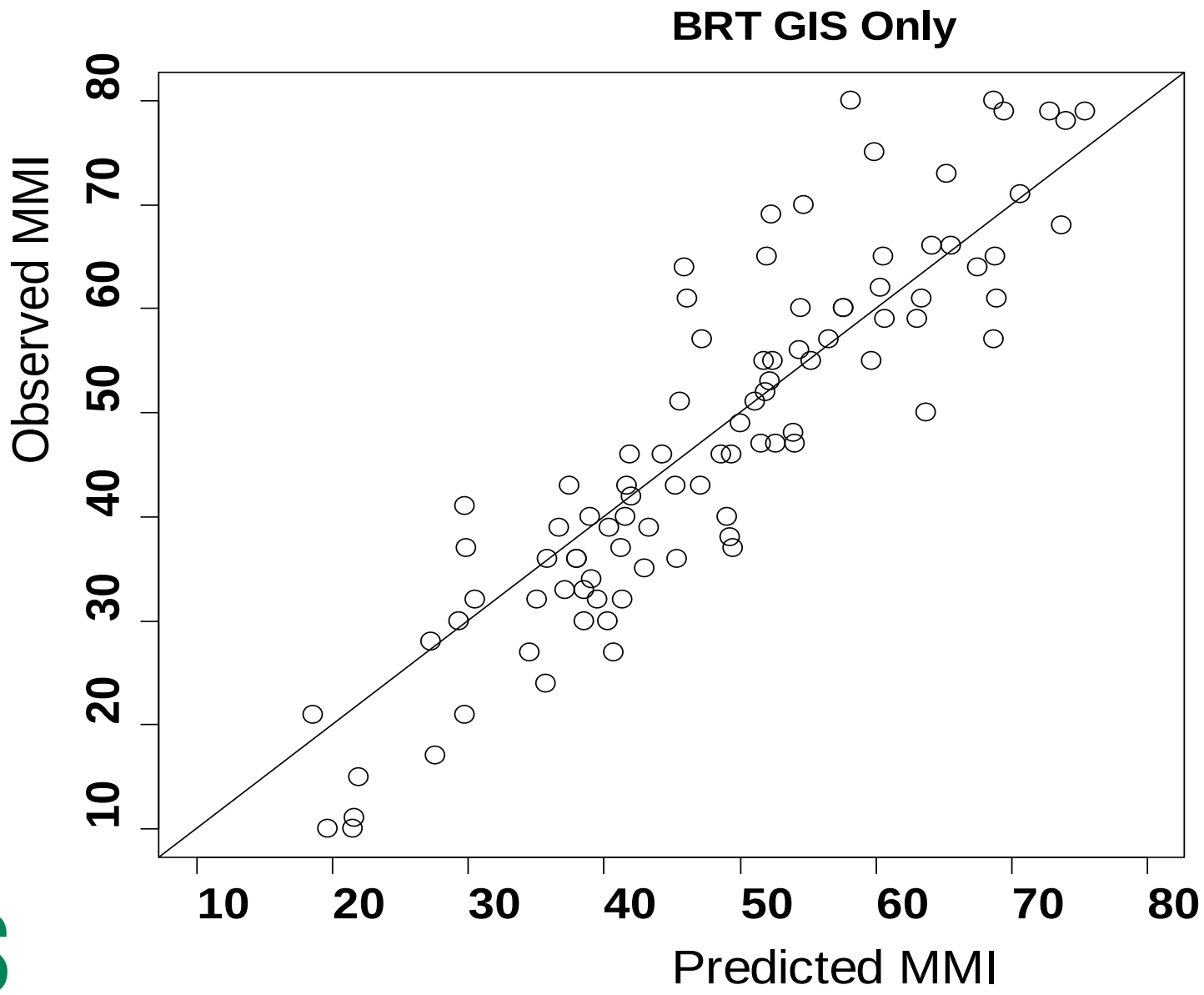
Unpublished; subject to revision

EPTR

Avg Tolerance of all Taxa: RichTOL

Richness of Intolerant Taxa: INTOL_RICH

MMI



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Boosted Regression Tree Models: Env.All
R^2 = 0.83 (6 – 7 variables)

	Model Statistic	GIS n = 46	Habitat n = 52	Nutrients n= 44	Contamin. n = 69	Env. All n = 34
EPTR	R^2	0.72	0.61	0.62	0.63	**0.73**
Avg Tolerance of all Taxa: RichTOL	R^2	0.77	0.86	0.57	0.36	**0.73**
Richness of Intolerant Taxa: INTOL_RICH	R^2	0.79	0.81	0.62	0.74	**0.66**
MMI	R^2	0.86	0.74	0.53	0.79	**0.87**

MMI	VI
Pyrethroid deg	24
Wet Width Med	14
Ammonia	13
Embedded-ness	13
Wet Width Var	13
d84 Substrate	11
Velocity	11

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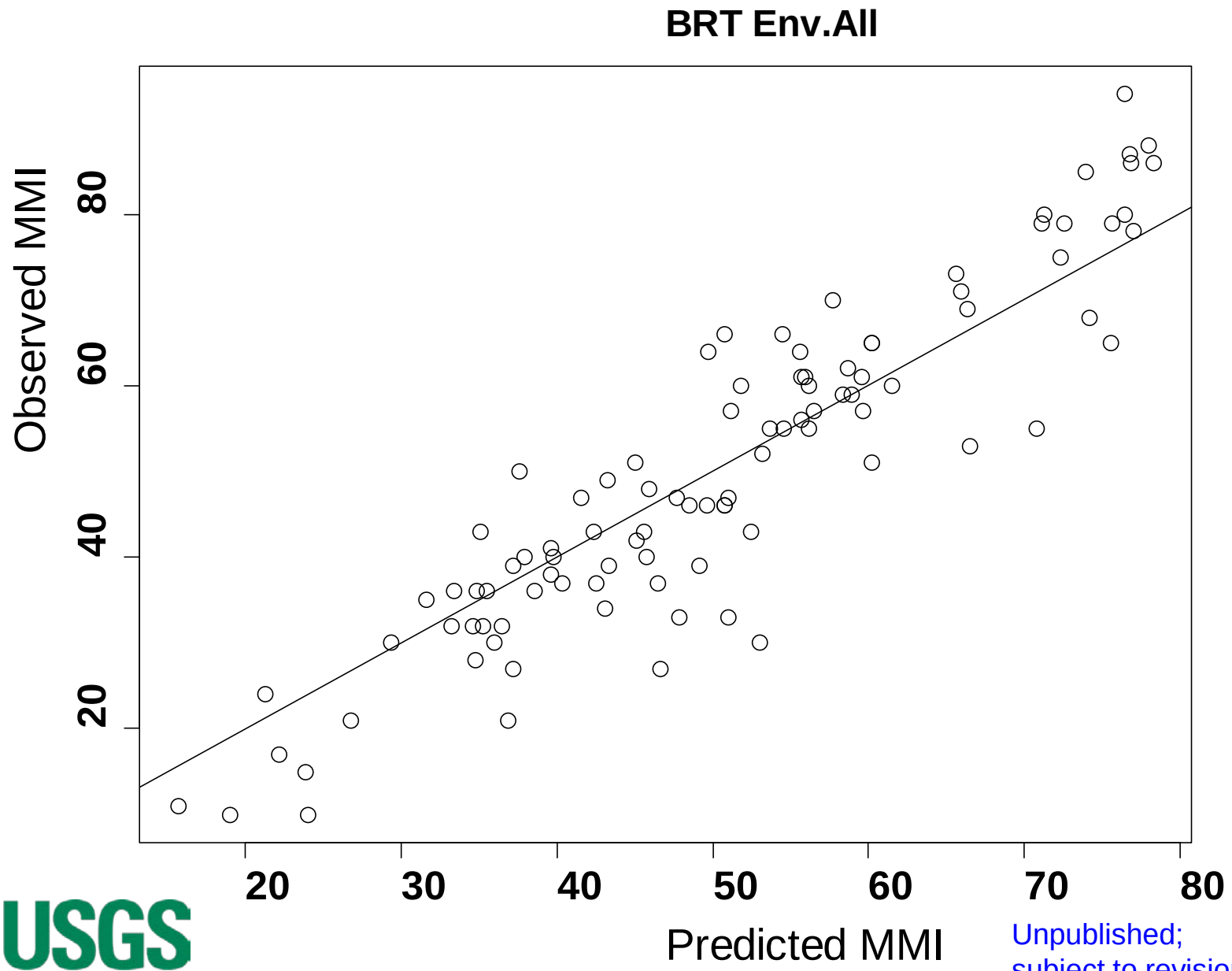
BRT Partial Dependency Plots for MMI: Env.All (R^2 = 0.87)



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Boosted Regression Tree Models:
GIS + Env.All R^2 = 0.95 (4 – 6 variables)

Unpublished; subject to revision	Model Statistic	GIS n = 46	Habitat n = 52	Nutrients n= 44	Contamin. n = 69	Env. All n = 34	GIS + Env n = 44
EPTR	R^2	0.72	0.61	0.62	0.63	0.73	0.74
		(5)	(6)	(5)	(4)	(6)	(6)
Ave Tolerance of all Taxa: RichTOL	R^2	0.77	0.86	0.57	0.36	0.73	0.85
		(6)	(6)	(5)	(4)	(6)	(6)
Richness of Intolerant Taxa: INTOL_RICH	R^2	0.79	0.81	0.62	0.74	0.66	0.83
		(6)	(6)	(5)	(3)	(6)	(4)
MMI	R^2	0.86	0.74	0.53	0.79	0.87	0.95
		(5)	(5)	(5)	(4)	(7)	(6)

22 total possible variables in GIS + Env –

9 were GIS Based – 8 Habitat, 4 Nutrients, 1 Contaminant

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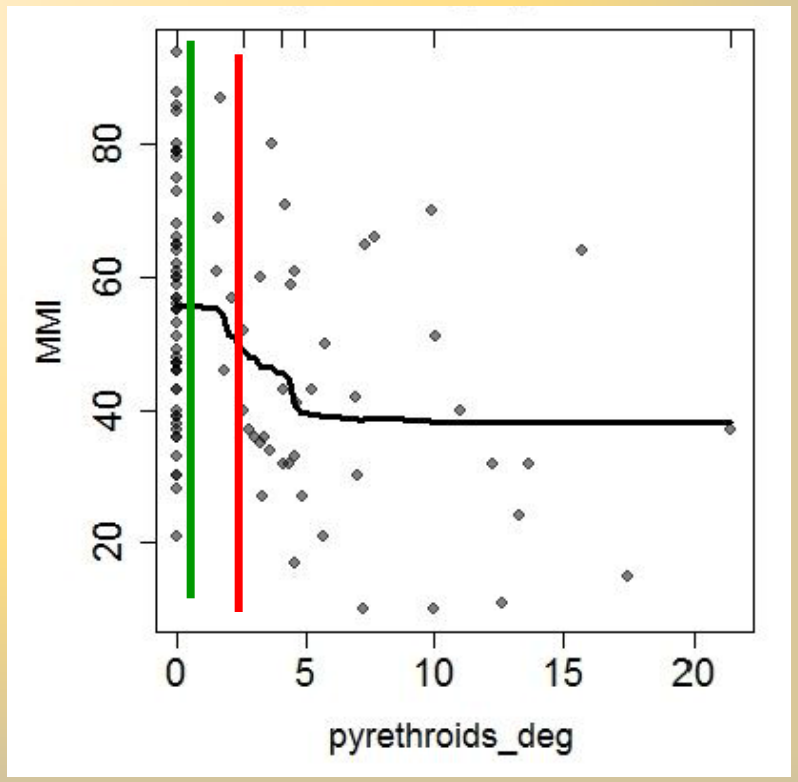
Photos: Society for Freshwater Sciences

How can we apply these results to sites?

- Pyrethroid degradates (contam.)
- Channel geometry (habitat)
- Ammonia (nutrient)
- Substrate (habitat)

Stressees

Pyrethroid degradates (POCIS)



Photos: Pete VanMetre USGS

Stressors

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Applying stressor breakpoints to sites

And some of best.

TSTAID	Shortname		WETWID_VAR	d84	pyrethroid_deg_sum	Mean Ammonia	MMI	# Above Upper Threshold
T03241500	OH_Massies		0.375	167.1	0.00	0.022	86	0
T394340085524601	IN_Sugar		0.429	50.8	0.00	0.026	86	0
T401849087161401	IN_Pine		0.229	182.3	1.61	0.015	87	0
T390033085300301	IN_Otter1		0.425	45.7	0.00	0.037	88	0
T03336645	IL_Mvermilion		0.143	124.3	0.00	0.031	94	1

Some of the worst sites,

T05575550	IL_Clear		0.071	1.0	6.35	0.028	10	3
T06610765	NE_LPapillon		0.159	1657.0	10.25	0.107	10	2
T06610785	NE_Wpapillon		0.224	0.7	24.66	0.099	11	3
T410133082465301	OH_Honey		0.100	0.1	27.36	0.212	15	4
Breakpoints	low		>0.40	>50	<1.0	<=0.02	<=36	
	medium		0.21-0.40	20-50	1.0-2.5	0.02-0.05	36-63	
	high		<0.21	<20	>2.5	>0.050	>63	

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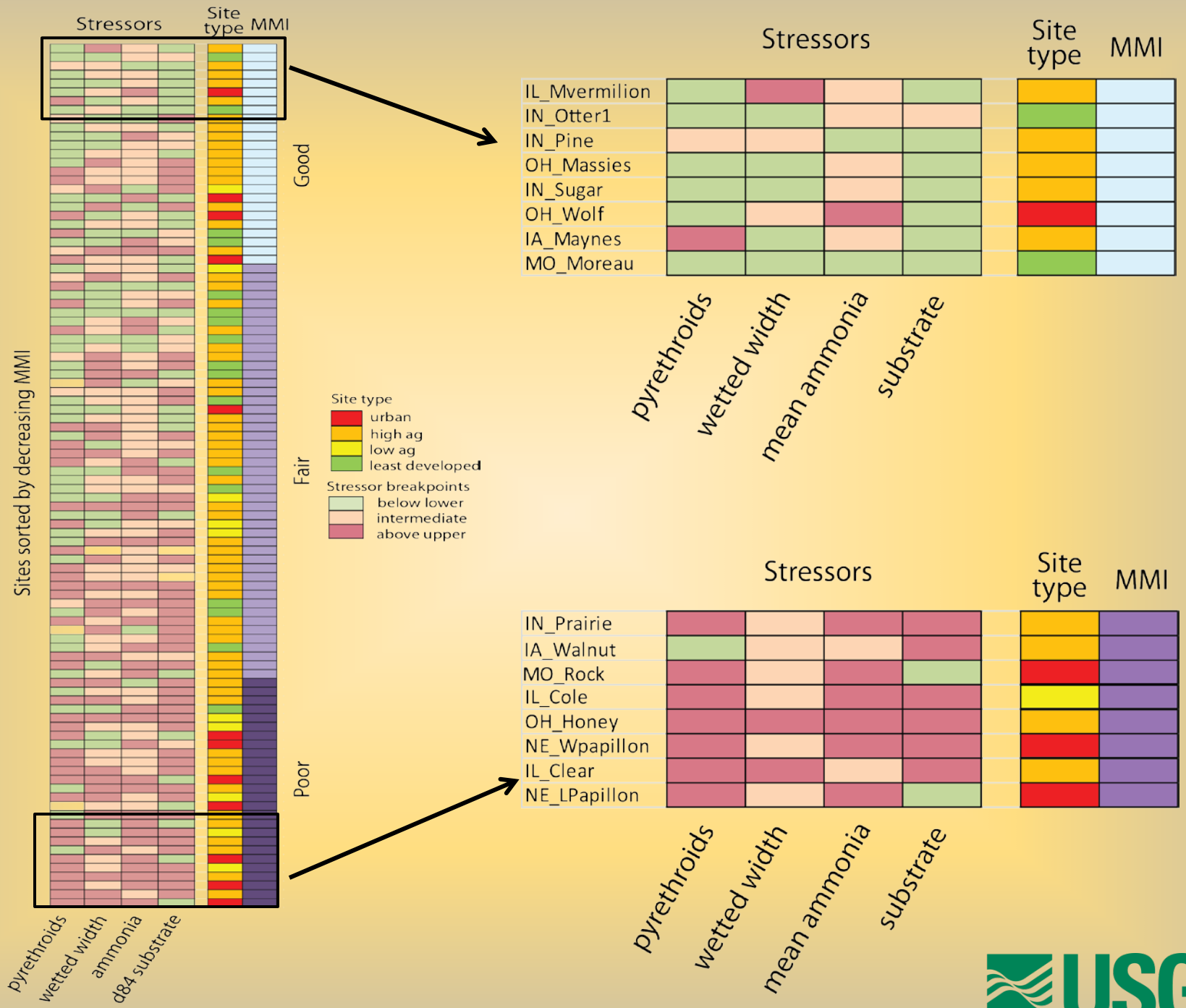
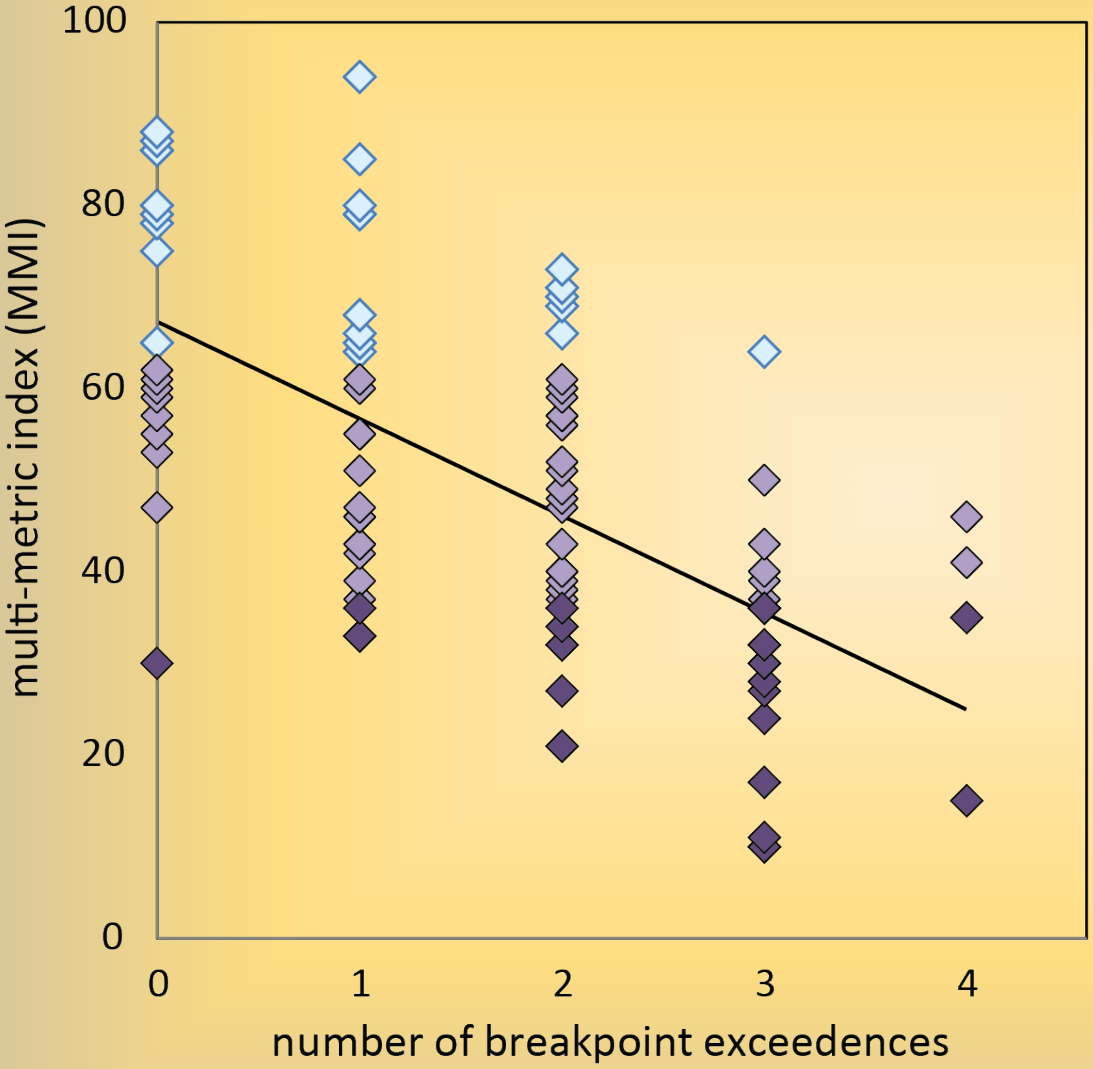

Stressors
Site type
MMI
Sites sorted by decreasing MMI
Good
Fair
Poor
pyrethroids
wetted width
ammonia
d84 substrate
Site type
urban
high ag
low ag
least developed
Stressor breakpoints
below lower
intermediate
above upper
Stressors
Site type
MMI
IL_Mvermilion
IN_Otter1
IN_Pine
OH_Massies
IN_Sugar
OH_Wolf
IA_Maynes
MO_Moreau
pyrethroids
wetted width
mean ammonia
substrate
Stressors
Site type
MMI
IN_Prairie
IA_Walnut
MO_Rock
IL_Cole
OH_Honey
NE_Wpapillon
IL_Clear
NE_LPapillon
pyrethroids
wetted width
mean ammonia
substrate
USGS

It might not be which stressor, but how many



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Photos: Pete VanMetre USGS

Now Algae Models

Boosted Regression Tree Models:
Algal Metrics

Algae Metrics	MSQA n = 98		
	R^2		VI
Pollution Tolerance 4 and 5 -- Less Tolerant	0.85	Percent Fines	30
		Temp Max 42 d	27
		Scrapper Rich	17
		Depth Max 42 d	16
		TP Med 42 d	10
High Phosphorus	0.80	TP Med 42 d	33
		Rip Disturbance	20
		Sulfon H conc	19
		Wet Width	15
		Susp. Sediment	13
Highly Motile	0.89	TP Med 42 d	24
		Velocity Avg.	23
		d84 Substrate	19
		Susp Sed 42 d	19
		Temp Max 42 d	15

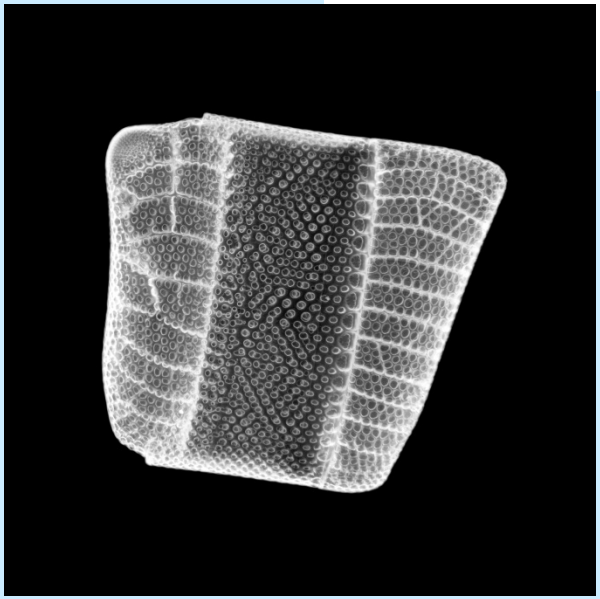

Photo: Picturepest

Unpublished; subject to revision

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Boosted Regression Tree Models:
Algal Metrics

Algae Metrics	MSQA n = 98			Per_fines > 0.50 n = 55		
	R^2		VI	R^2		VI
Pollution Tolerance 4 and 5 -- Less Tolerant	0.85	Percent Fines	30	0.93	Temp Max 42 d	29
		Temp Max 42 d	27		Stream Flow	21
		Scrapper Rich	17		Susp. Sediment	21
		Depth Max 42 d	16		Triazine Herb	16
		TP Med 42 d	10		Depth Avg.	13
High Phosphorus	0.80	TP Med 42 d	33	0.86	TP Med 42 d	29
		Rip Disturbance	20		Plant PTI 8-14	26
		Sulfon H conc	19		Susp. Sediment	25
		Wet Width	15		Triazine Herb	20
		Susp. Sediment	13			
Highly Motile	0.89	TP Med 42 d	24	0.96	TP Med 42 d	35
		Velocity Avg.	23		Time Critical D	23
		d84 Substrate	19		Susp. Sediment	23
		Susp Sed 42 d	19		Depth Avg.	19
		Temp Max 42 d	15			

Photo: Kurt Carpenter USGS

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Boosted Regression Tree Models:
Algal Metrics

Algae Metrics	MSQA n = 98			Per_fines > 0.50 n = 55			Per_fines < 0.50 n = 41		
	R^2		VI	R^2		VI	R^2		VI
Pollution Tolerance 4 and 5 -- Less Tolerant	0.85	Percent Fines	30	0.93	Temp Max 42 d	29	0.80	Depth Max 42 d	35
		Temp Max 42 d	27		Stream Flow	21		Temp Max 42 d	32
		Scrapper Rich	17		Susp. Sediment	21		Rip Canopy	15
		Depth Max 42 d	16		Triazine Herb	16		Triazine Herb	10
		TP Med 42 d	10		Depth Avg.	13		Scrapper Rich	8
High Phosphorus	0.80	TP Med 42 d	33	0.86	TP Med 42 d	29	0.73	Depth Max 42 d	35
		Rip Disturbance	20		Plant PTI 8-14	26		Fungicides	24
		Sulfon H conc	19		Susp. Sediment	25		TP Med 42 d	17
		Wet Width	15		Triazine Herb	20		Misc Herbicides	15
		Susp. Sediment	13					Sediment Herb	9
Highly Motile	0.89	TP Med 42 d	24	0.96	TP Med 42 d	35	0.89	Depth Max 42 d	83
		Velocity Avg.	23		Time Critical D	23		Fungicides	9
		d84 Substrate	19		Susp. Sediment	23		Misc Herbicides	8
		Susp Sed 42 d	19		Depth Avg.	19			
		Temp Max 42 d	15						

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Summary

Both Algae and Invert metrics had models above R^2 of 0.85 using instream stressor variables

Habitat (substrate and channel morph), Nutrients and Contaminants were important variables in both type of models

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Photos: Society for Freshwater Sciences (left); Kurt Carpenter (right)

Summary

Breaking all sites into two subgroups based on substrate (percent fines) increased the propensity for WQ and Contaminant variables to become more important in algal models

Photo: Society for Freshwater Sciences

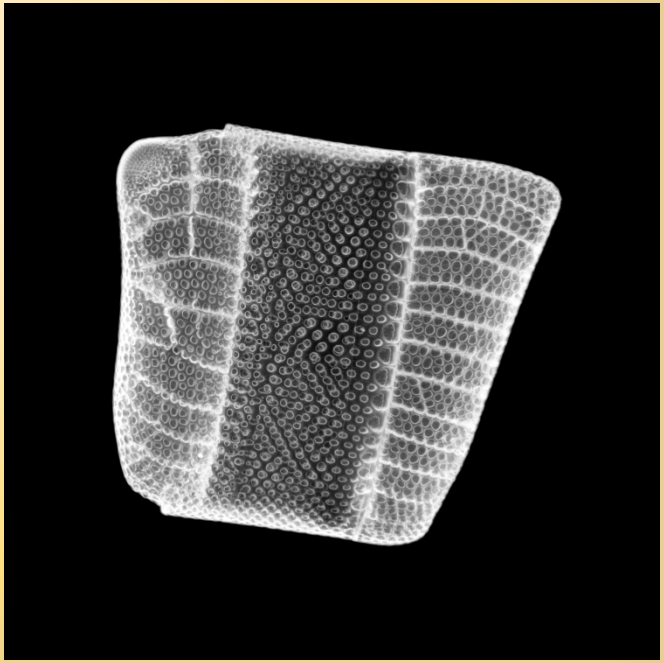

Photo: Picturepest

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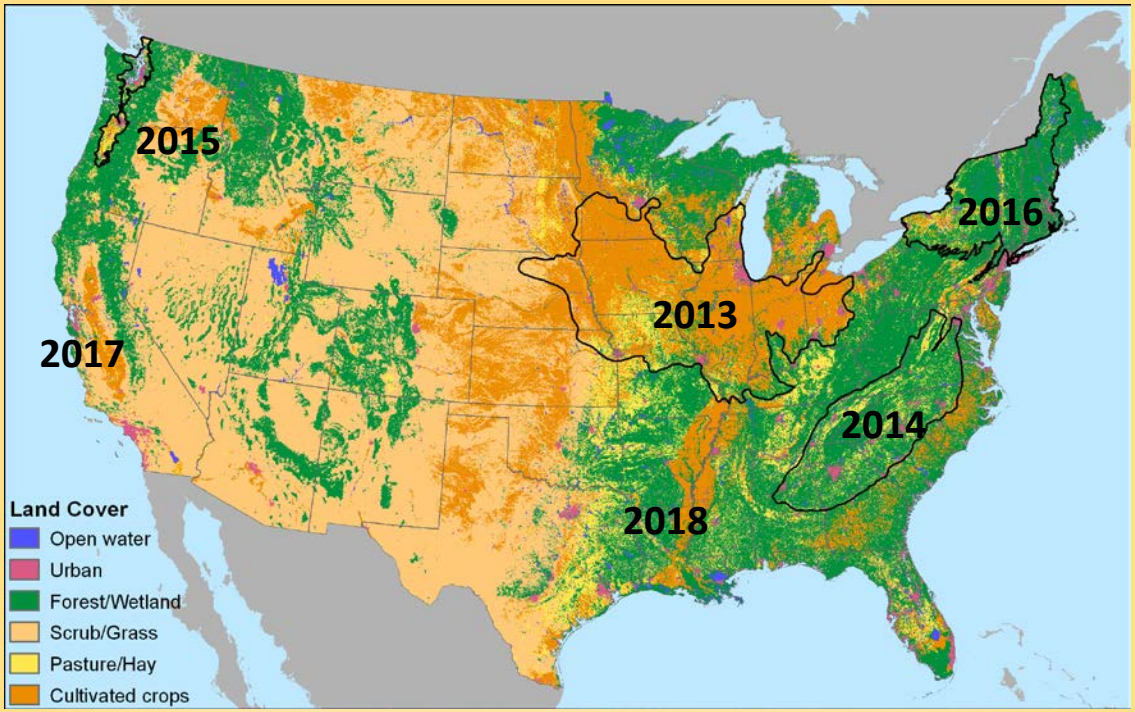
RSQA 2013-2018



- One region per year
- About 100 small streams per region
- Sampling during the Spring/Summer to capture expected high chemical occurrence

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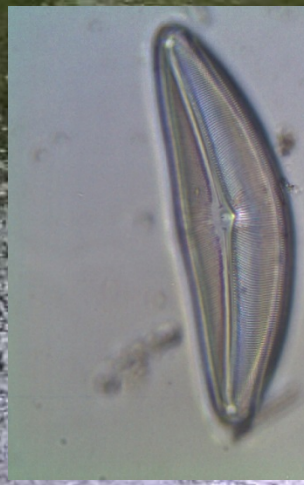
Thank you



Photos: Society for Freshwater Sciences