Individual and Cross-Watershed Research

- Research from series of individual projects within Ohio and cross-watershed projects in Indiana, Michigan, and Ohio from 2006 to 2018

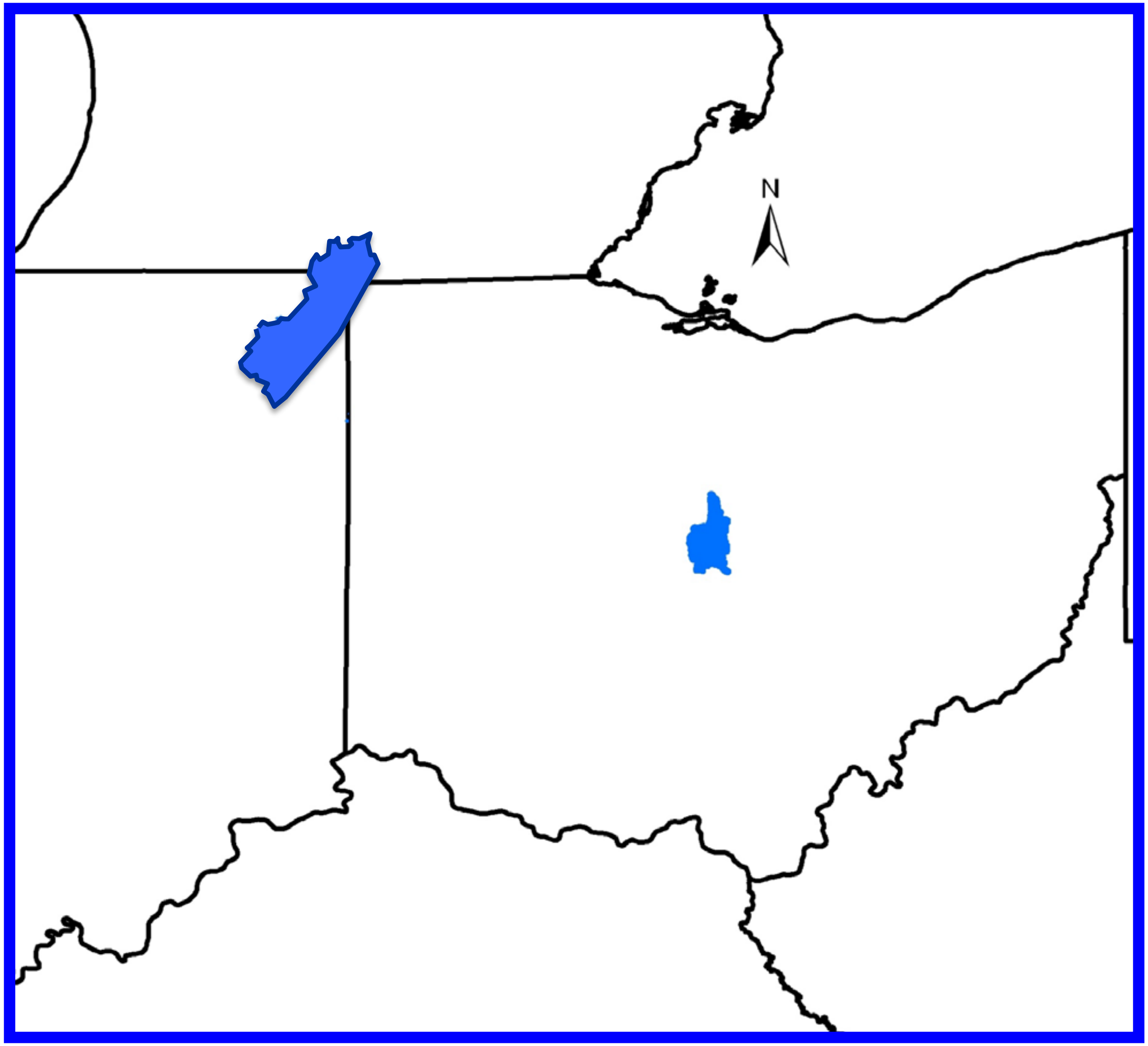
- Part of USDA Agricultural Research Service's Conservation Effect Assessment Project Watershed Assessment Study
  - Document ecological impacts of conservation practices within channelized agricultural headwater streams
  - Document biota-habitat relationships in agricultural headwater streams to predict what types of conservation practices provide the greatest benefits

St. Joseph River Watershed

- Located in northeast Indiana, south central Michigan, & northwest Ohio

Upper Big Walnut Creek

- Located in central Ohio



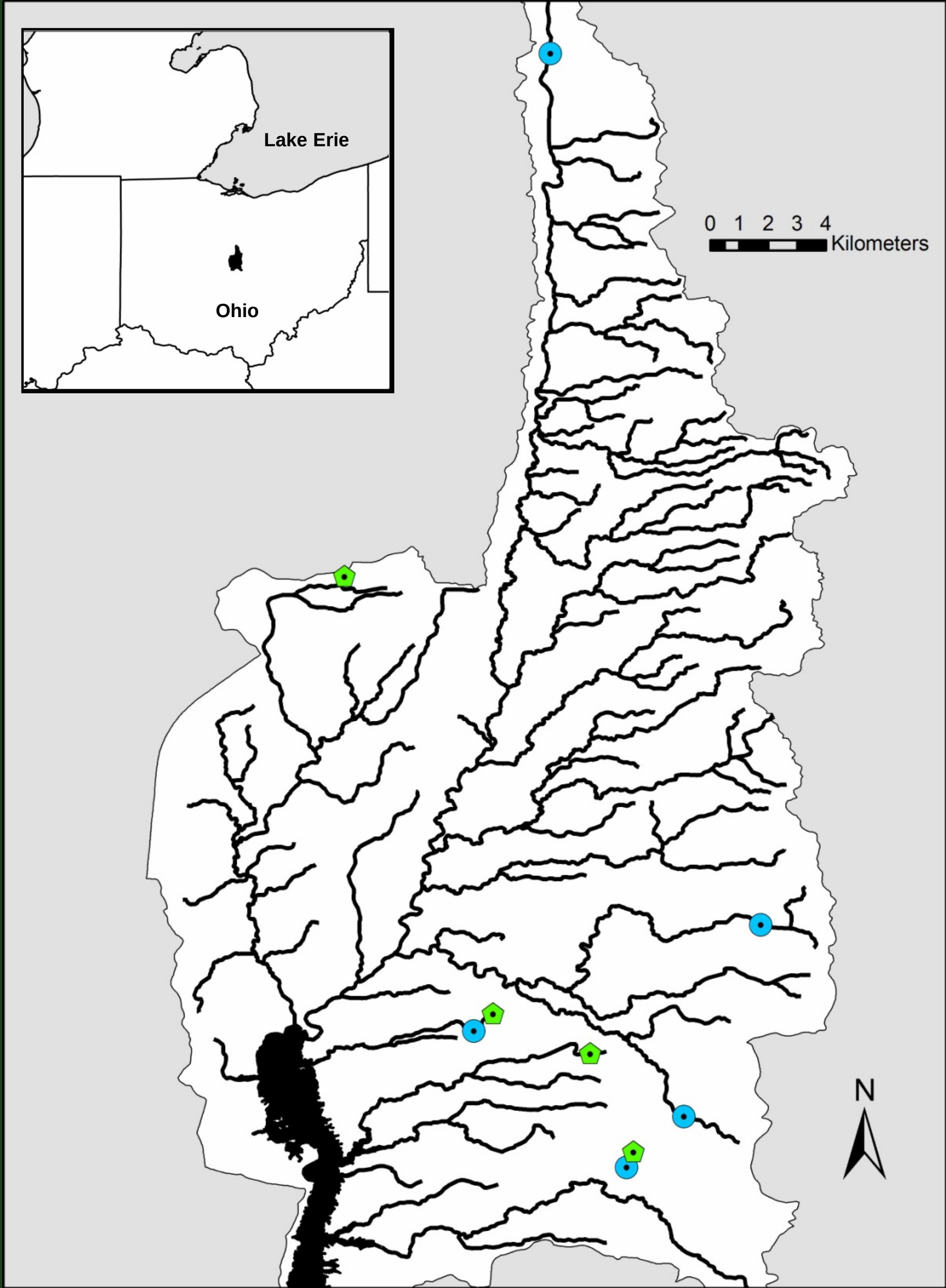

Saint Joseph River
Upper Big Walnut Creek

Spatiotemporal Trends

Does watershed size, year, and season influence pesticide mixtures?

- Five year study (2007 to 2011)
- Nine sites within seven headwater streams
  - 4 sites – small streams with mean watershed size 1.3 km^2
  - 5 sites – large streams with mean watershed size 4.2 km^2

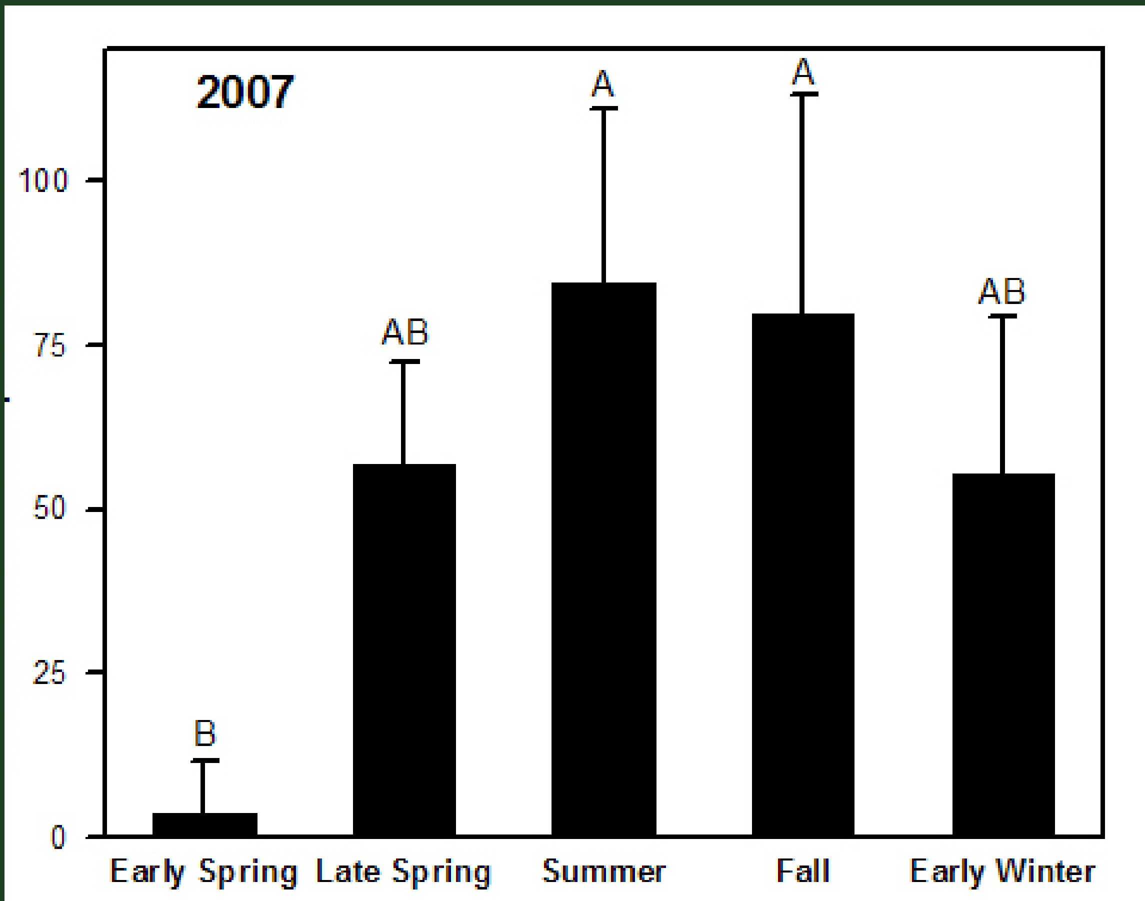
Smiley et al. 2014. Agriculture, Ecosystems, & Environment 193:83-95.

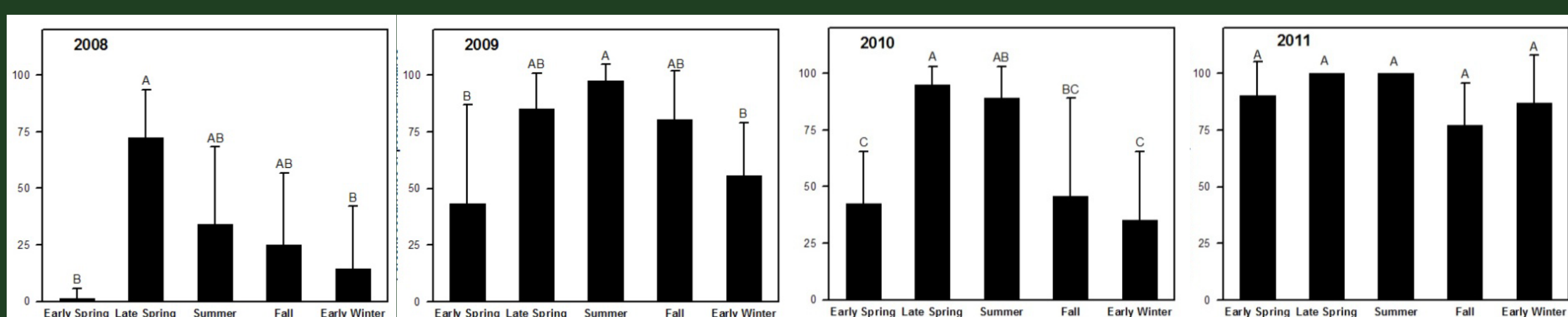


Frequency of Spatial and Temporal Variation

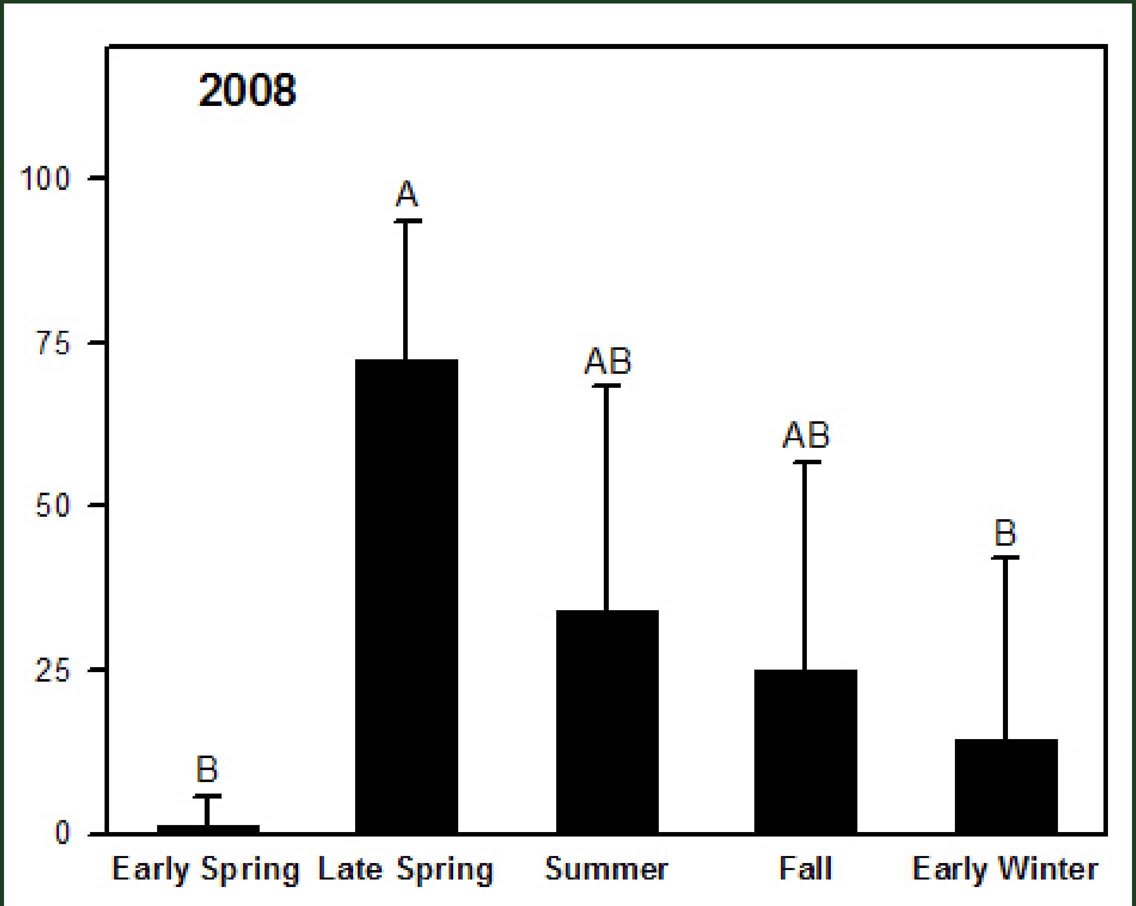
Response Variable	Spatial	Temporal
% Occurrence pesticide mixtures	No	**Yes (Year x Season)**
Composition 10 most frequent mixtures	No	**Yes (Year x Season)**
Number of pesticides	No	**Yes (Year x Season)**
Number of herbicides	No	**Yes (Year, Season)**
Number of fungicides	No	**Yes (Year x Season)**
Mixture concentration	No	**Yes (Year x Season)**
Max. mixture concentration	No	**Yes (Year x Season)**
% herbicide concentration	No	**Yes (Year x Season)**
% fungicide concentration	No	**Yes (Year x Season)**
% insecticide concentration	No	**Yes (Year x Season)**
Number of pesticide mixtures	No	**Yes (Year x Season)**
% occur herbicide mix.	No	**Yes (Year x Season)**
% occur herbicide-fungicide mix.	No	**Yes (Year x Season)**
% occur atrazine-metolachlor	**Yes (Stream size)**	**Yes (Year)**

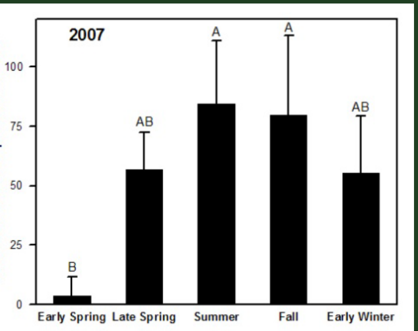
Percent Occurrence of Pesticide Mixtures

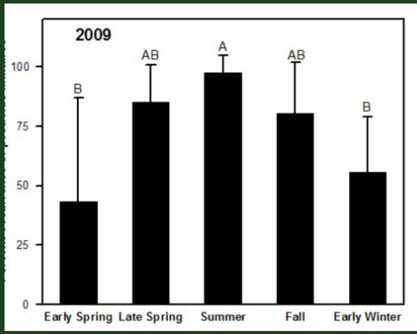


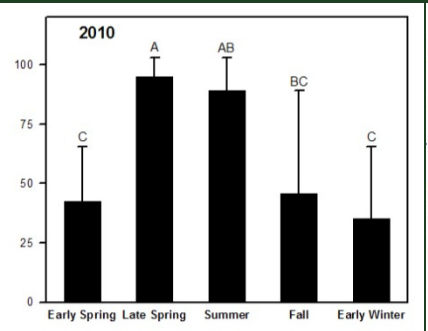


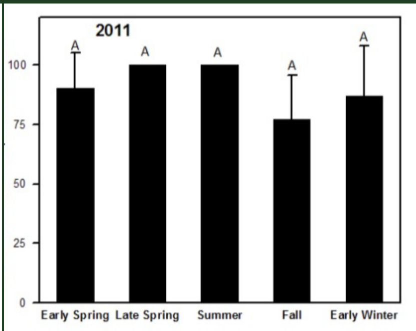
Percent Occurrence of Pesticide Mixtures



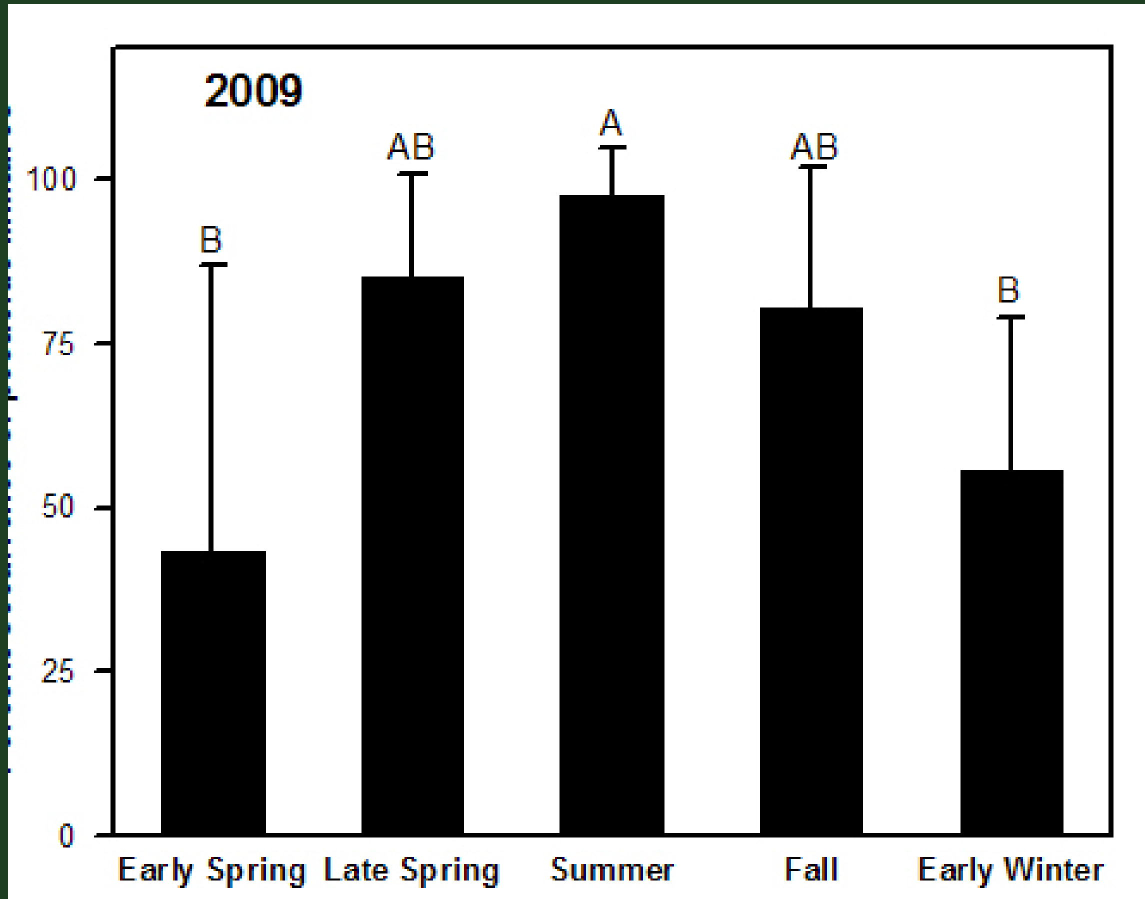


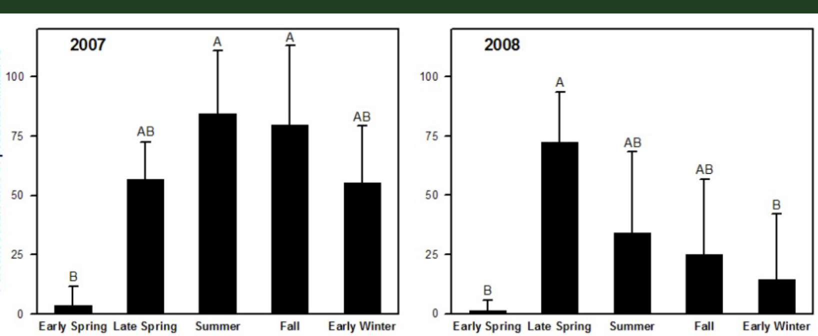


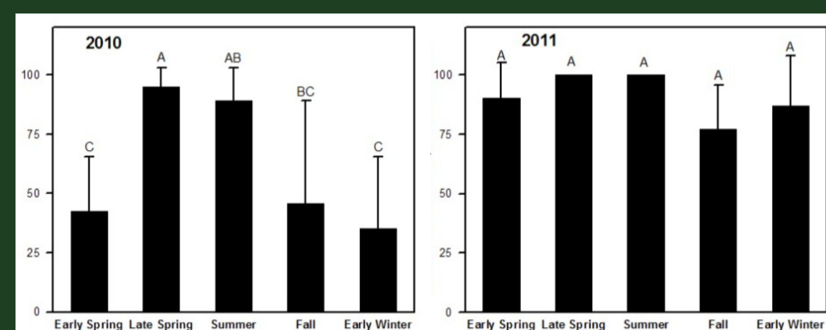




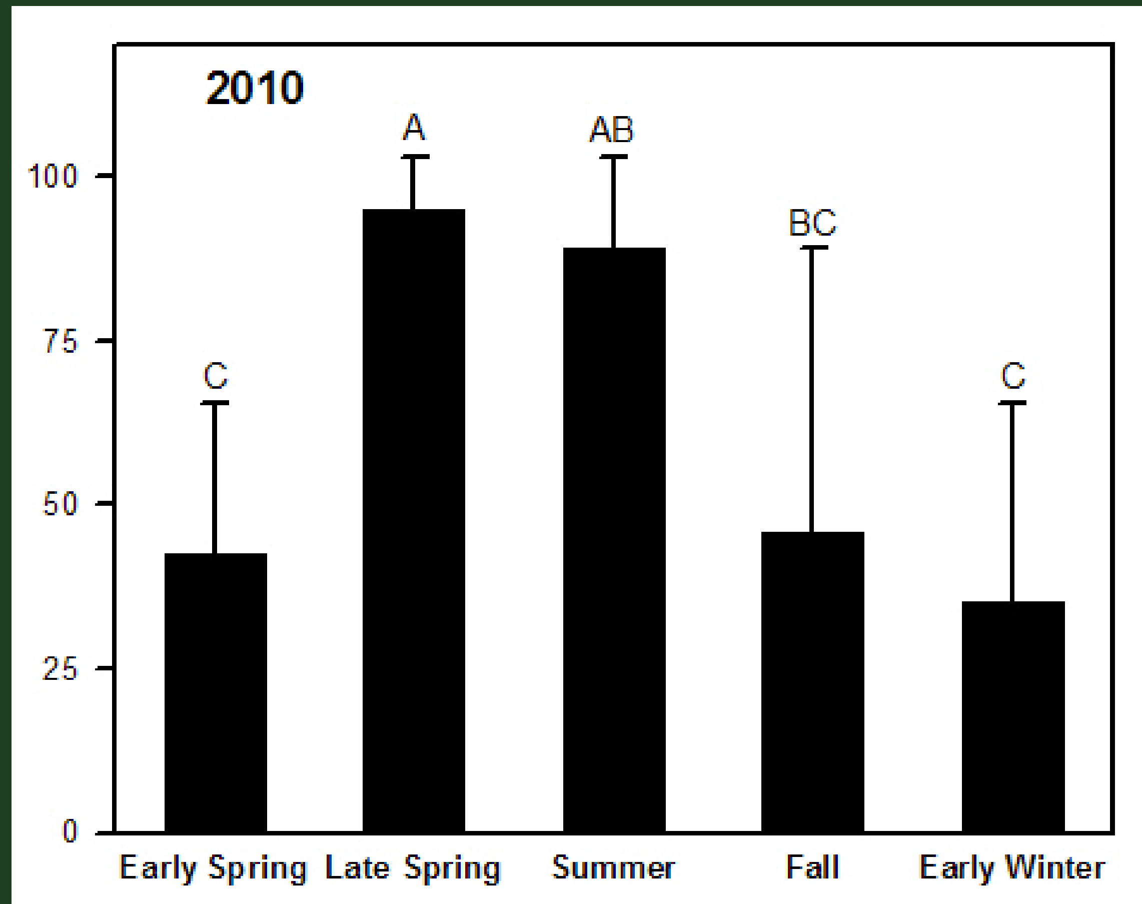
Percent Occurrence of Pesticide Mixtures

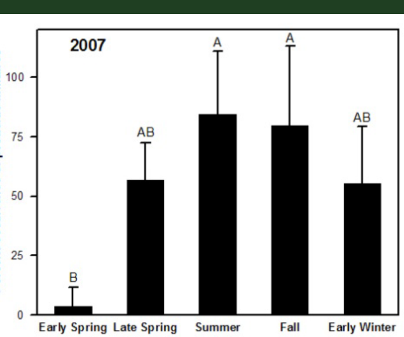


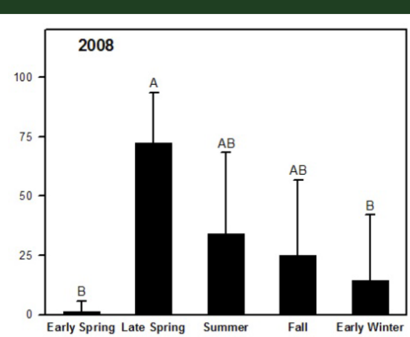


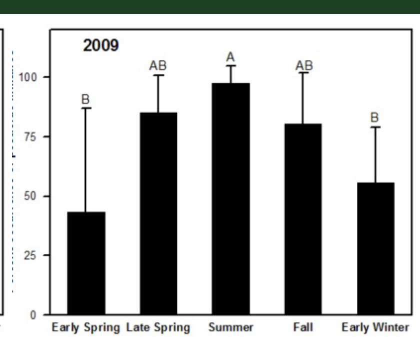


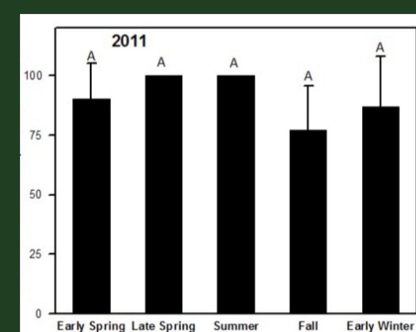
Percent Occurrence of Pesticide Mixtures



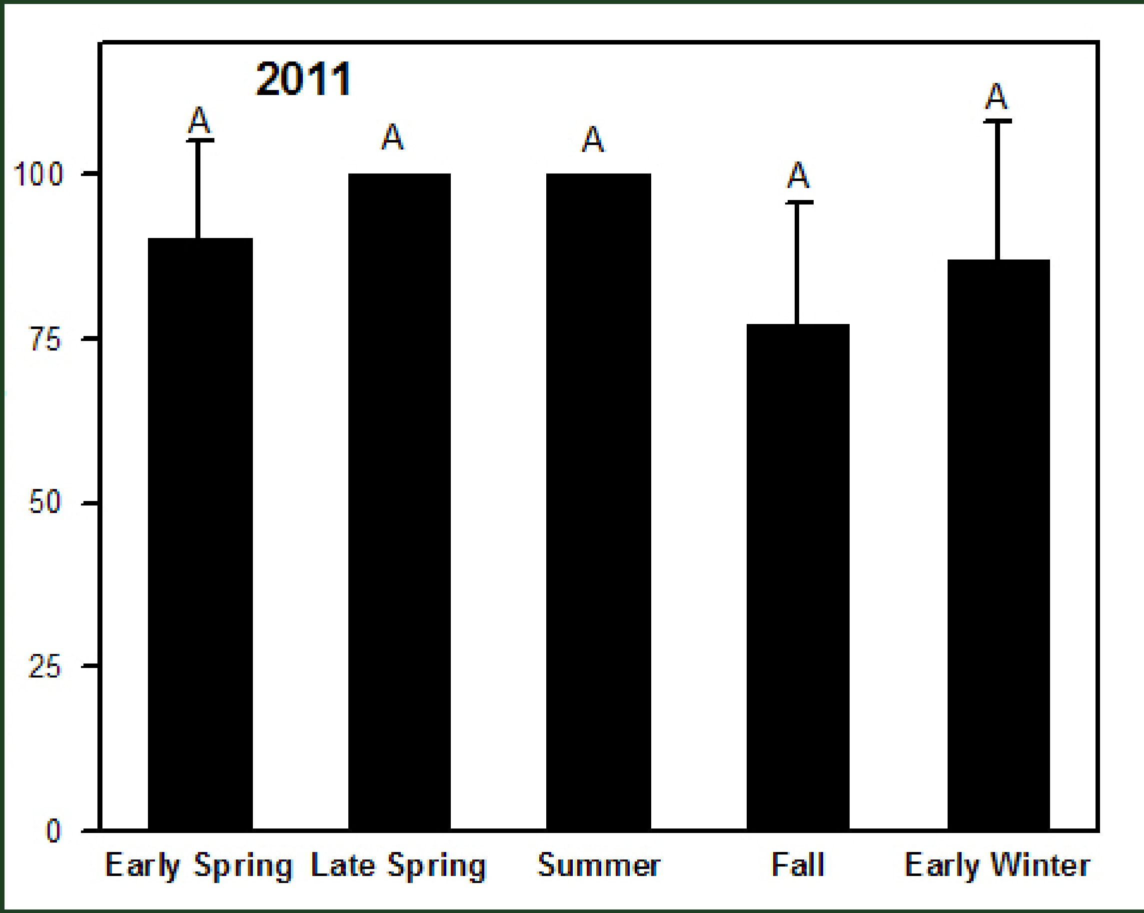


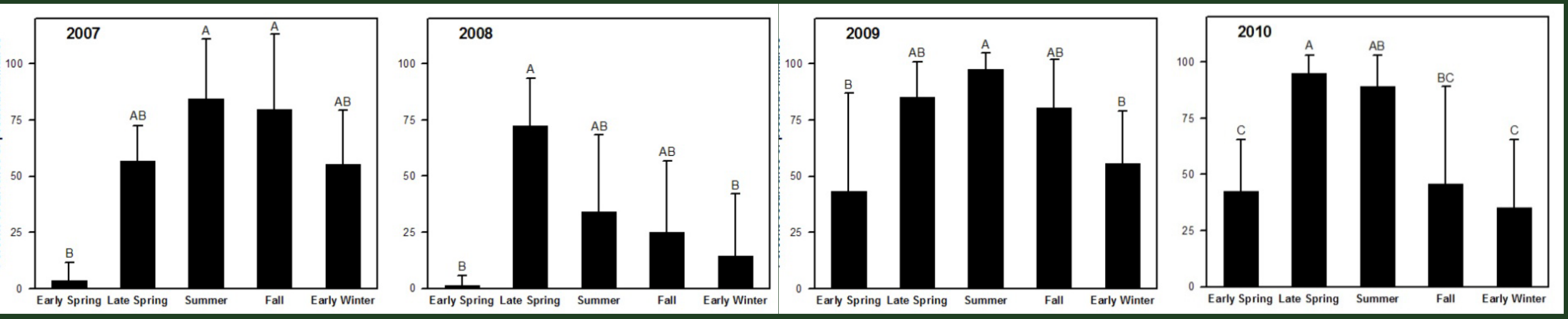






Percent Occurrence of Pesticide Mixtures

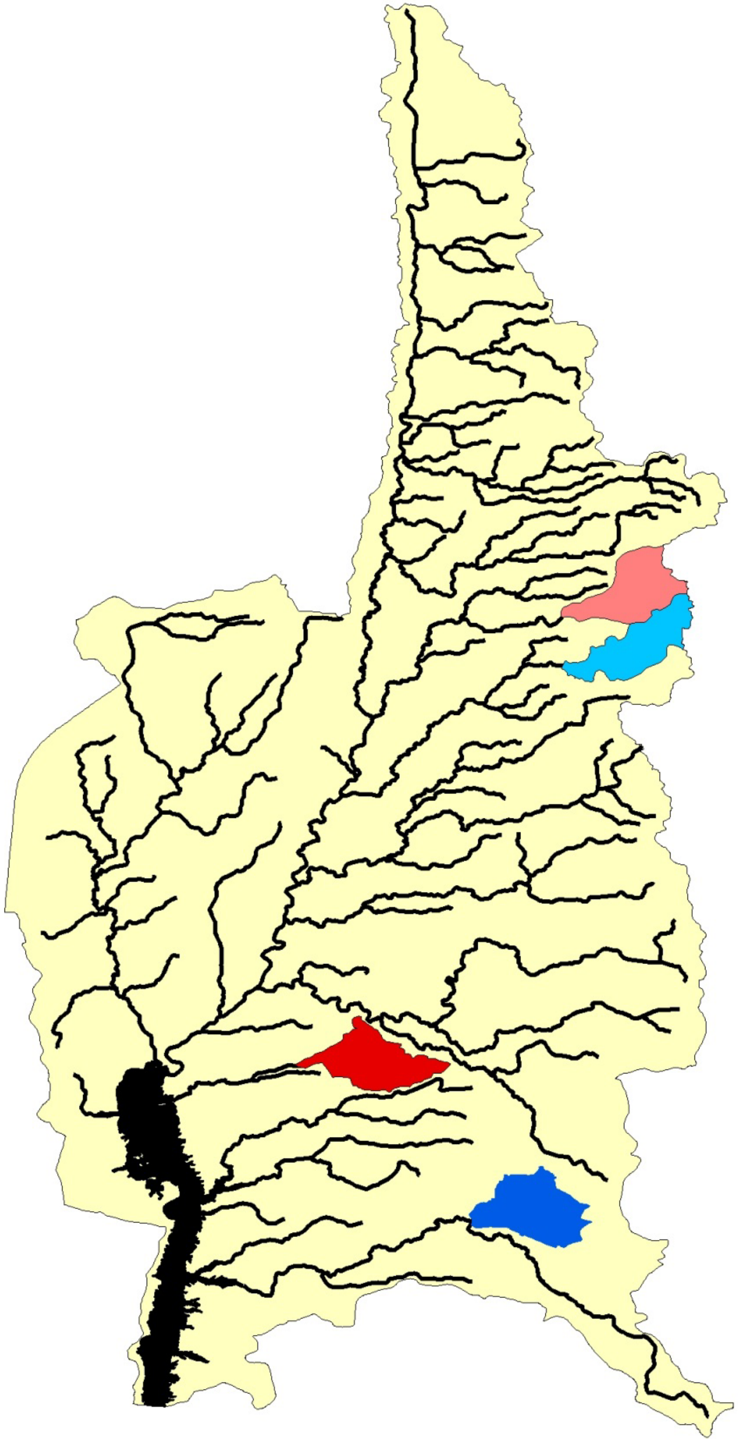


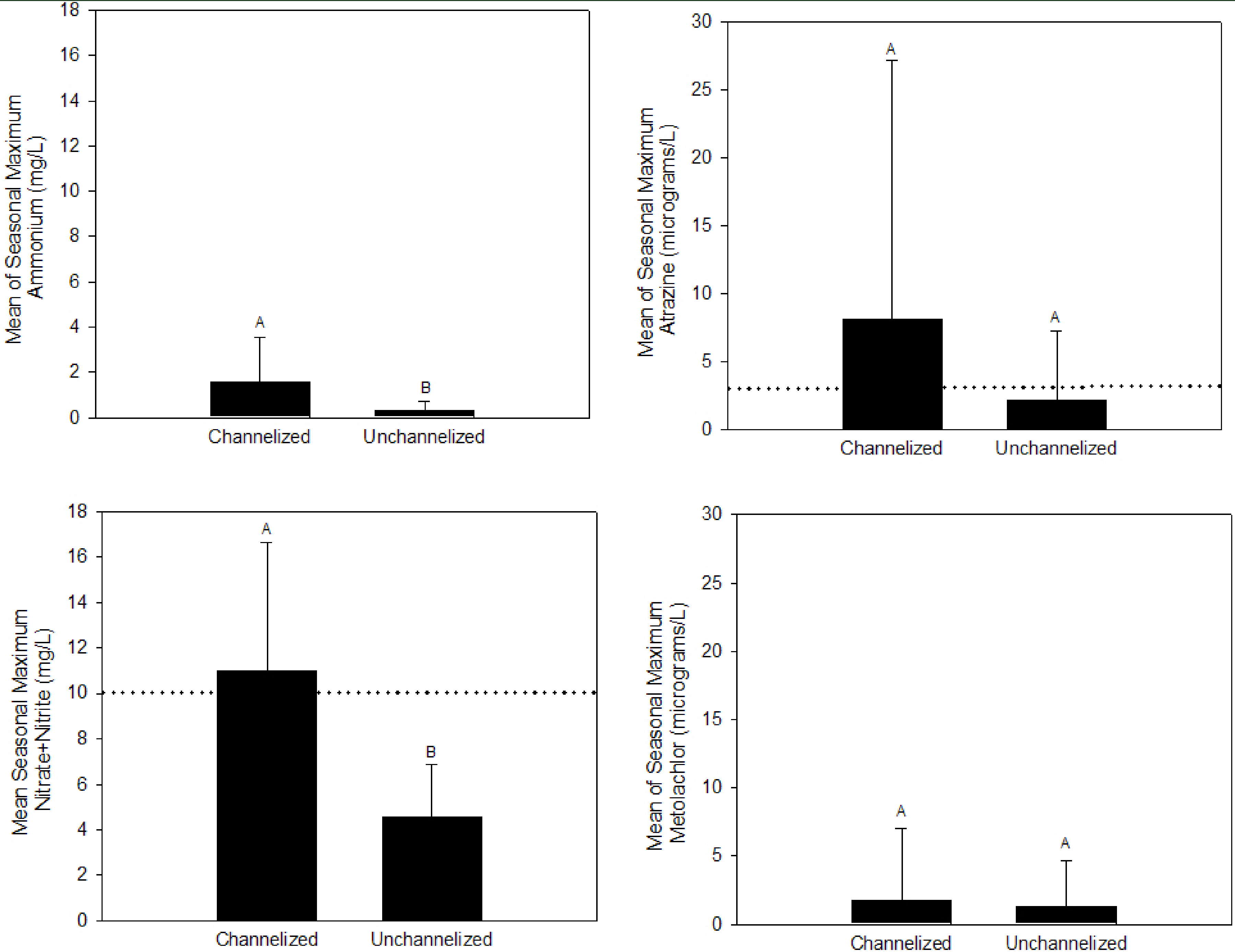


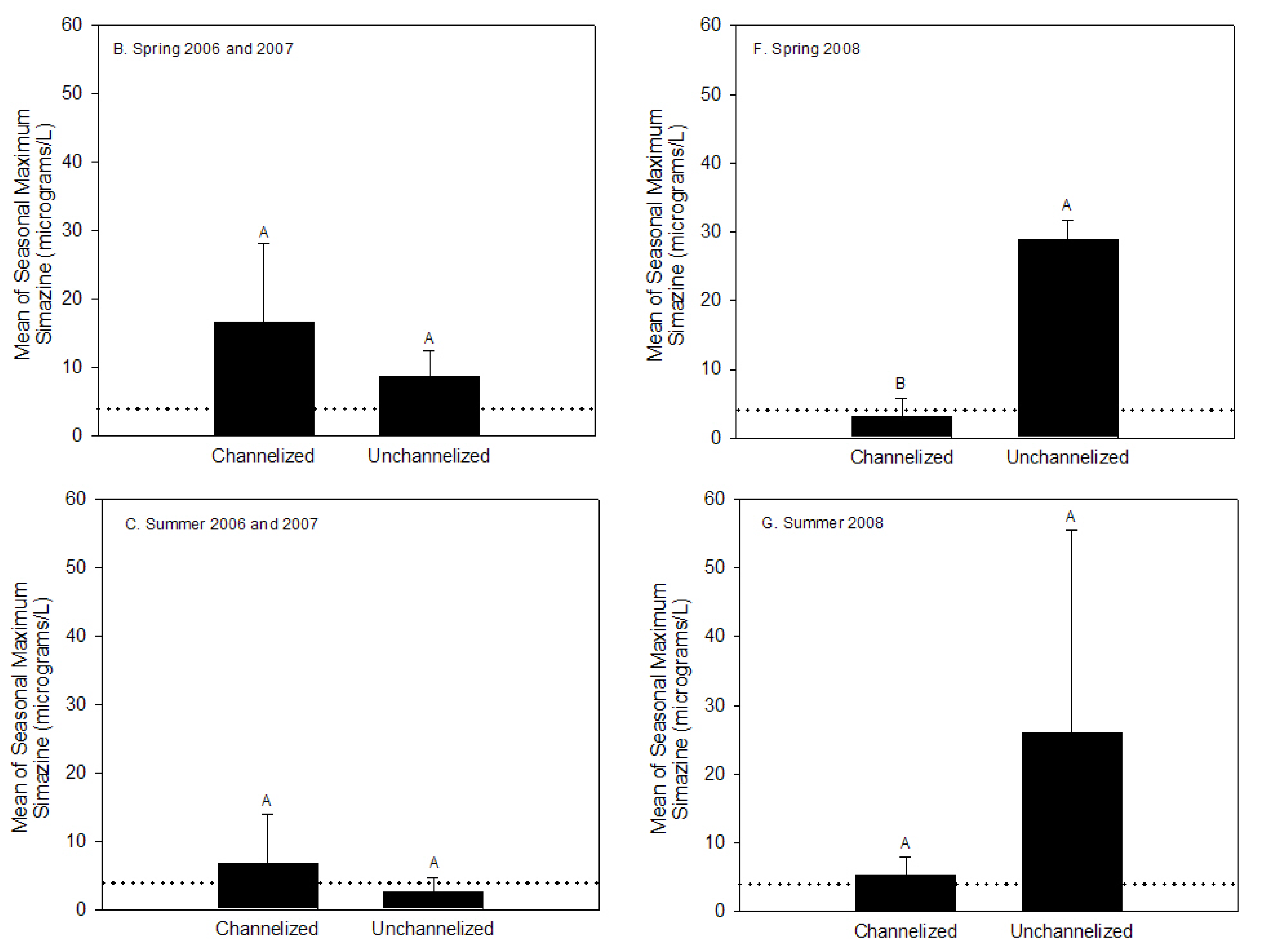
Does nutrient and pesticide concentrations differ between channelized and unchannelized agricultural headwater streams?

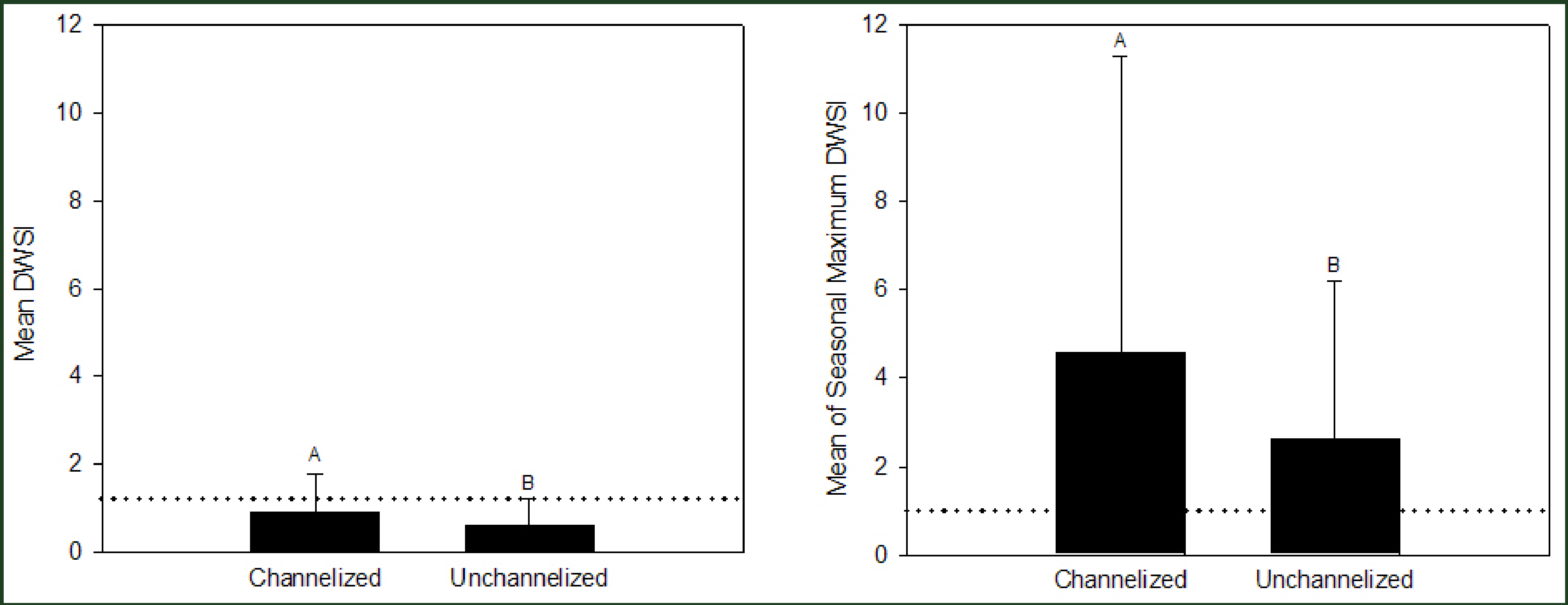
- Sampling two channelized and two unchannelized streams
- 4 km^2 watersheds
- Weekly grab samples from 2006 to 2008

Smiley et al. 2010. Journal of Water and Health 8: 577-592.




Mean of Seasonal Maximum Ammonium (mg/L)
0
2
4
6
8
10
12
14
16
18
A
B
Channelized
Unchannelized
Mean of Seasonal Maximum Atrazine (micrograms/L)
0
5
10
15
20
25
30
A
A
Channelized
Unchannelized
Mean Seasonal Maximum Nitrate+Nitrite (mg/L)
0
2
4
6
8
10
12
14
16
18
A
B
Channelized
Unchannelized
Mean of Seasonal Maximum Metolachlor (micrograms/L)
0
5
10
15
20
25
30
A
A
Channelized
Unchannelized


B. Spring 2006 and 2007
Mean of Seasonal Maximum Simazine (micrograms/L)
60
50
40
30
20
10
0
A
A
Channelized
Unchannelized
F. Spring 2008
Mean of Seasonal Maximum Simazine (micrograms/L)
60
50
40
30
20
10
0
A
B
Channelized
Unchannelized
C. Summer 2006 and 2007
Mean of Seasonal Maximum Simazine (micrograms/L)
60
50
40
30
20
10
0
A
A
Channelized
Unchannelized
G. Summer 2008
Mean of Seasonal Maximum Simazine (micrograms/L)
60
50
40
30
20
10
0
A
A
Channelized
Unchannelized



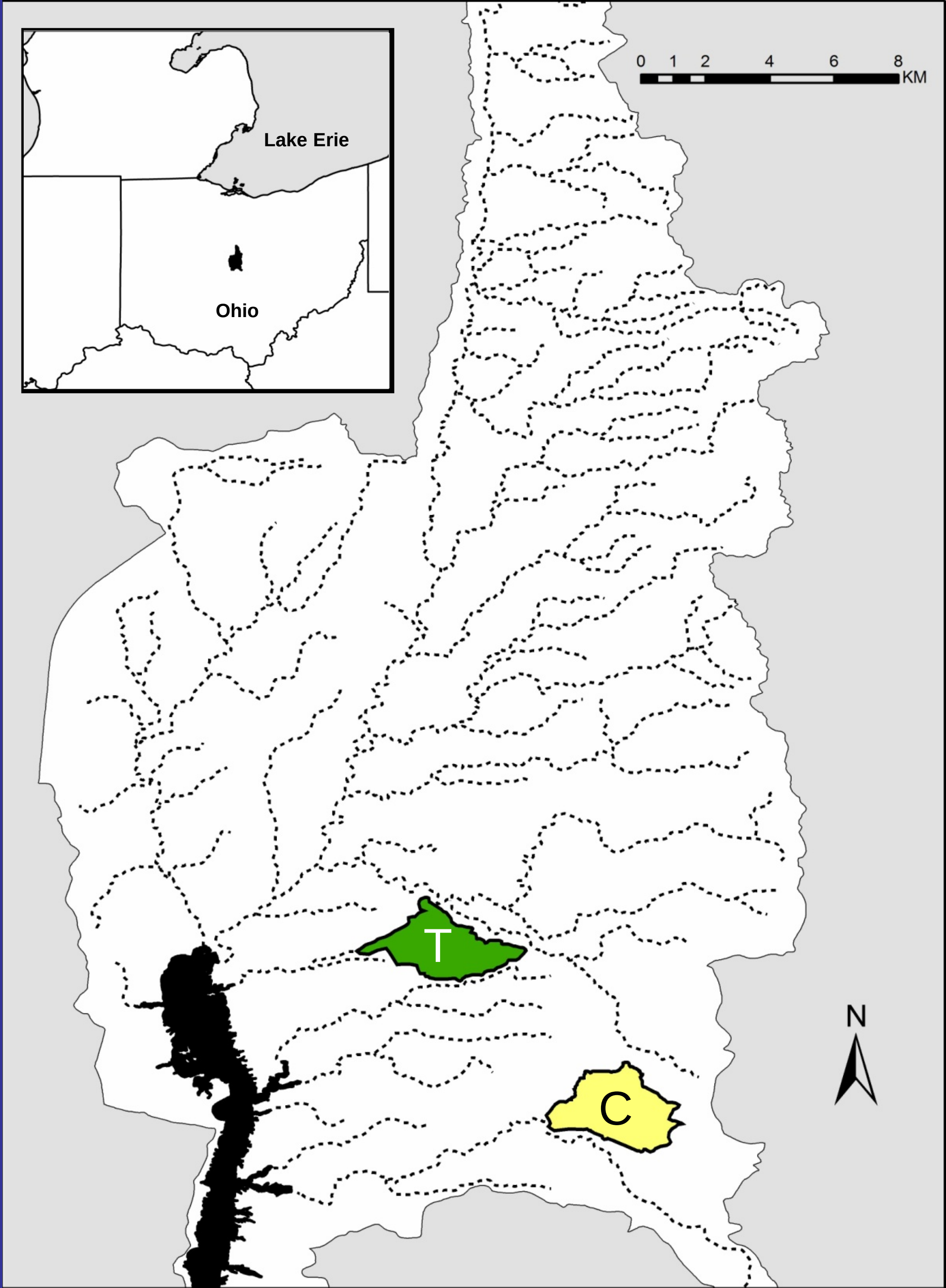
- Calculated nutrient-pesticide toxicity index derived through concentration addition model and US EPA drinking water standards
    - Calculated index with ammonium, nitrate-nitrite, alachlor, atrazine, metolachlor, simazine, and chlorothalonil

Effects of Conservation Practices

What is the effect of atrazine reduction practices on pesticides, pesticide mixtures, & fishes in channelized headwater streams?

- Six year study (2005 to 2010)
- One control and one treatment
- The adoption of ***pesticide management practices*** intended to reduce atrazine usage was promoted in treatment stream
- Reverse BACI design sampling 2 years with p.m. practices and 4 years without

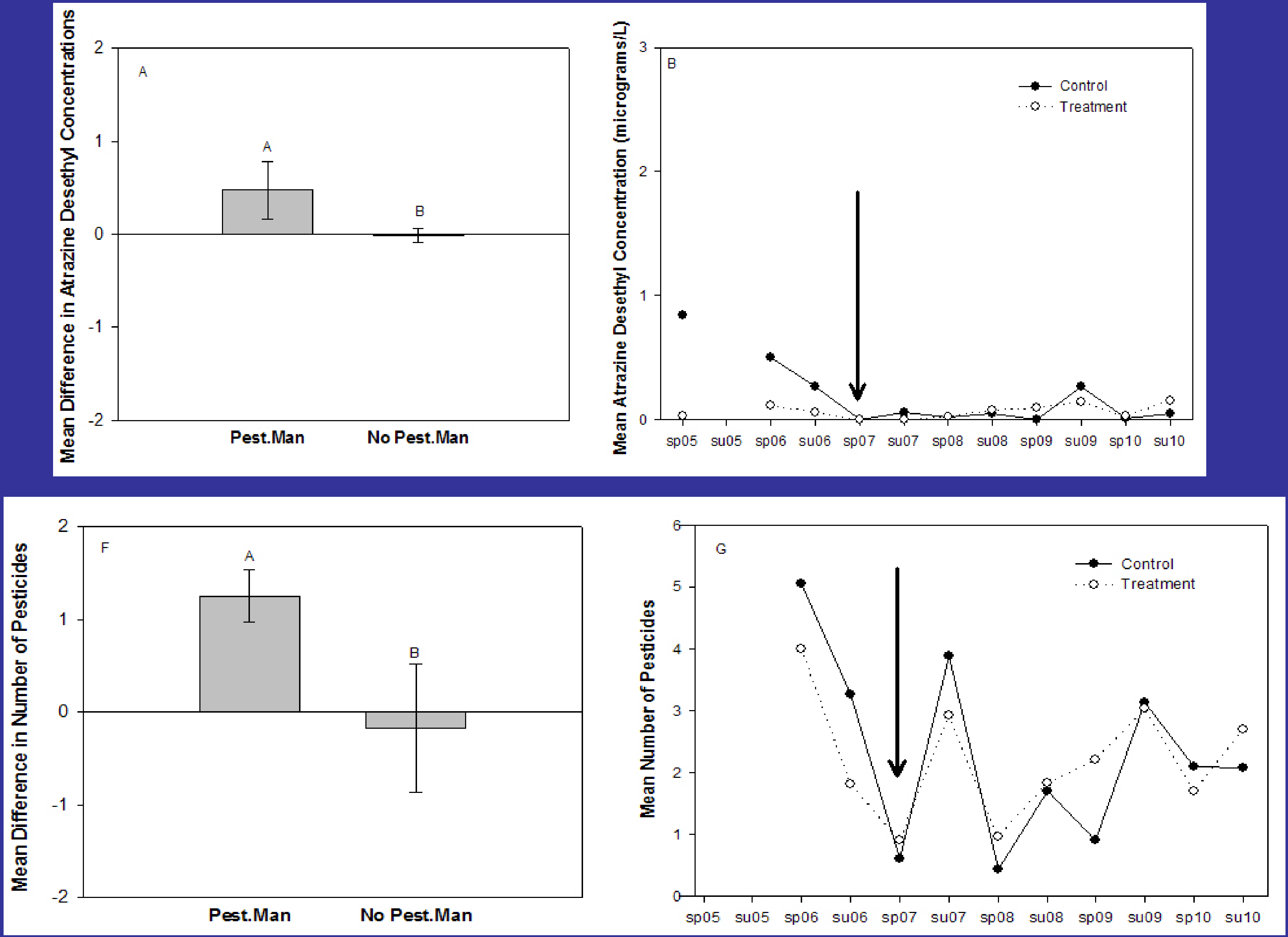
Smiley et al. 2012. Journal of Sustainable Watershed Science & Management 1:61-75.



Pesticide Results

Atrazine related variables	Pesticide Mixtures
Mean atrazine concentration	***Mean number of pesticides****
Mean atrazine desethyl concentration*	Number of mixtures
Maximum atrazine concentration	Number of atrazine-based mixtures
Maximum atrazine desethyl concentration	Number of simazine-based mixtures
Percent atrazine occurrence	Similarity in composition of mixtures
Percent atrazine desethyl occurrence*	Mean Acute Toxicity Hazard Index
	Max. Acute Toxicity Hazard Index
	Mean Chronic Toxicity Hazard Index
	Max. Chronic Toxicity Hazard Index

Atrazine Desethyl Concentrations & Number of Pesticides



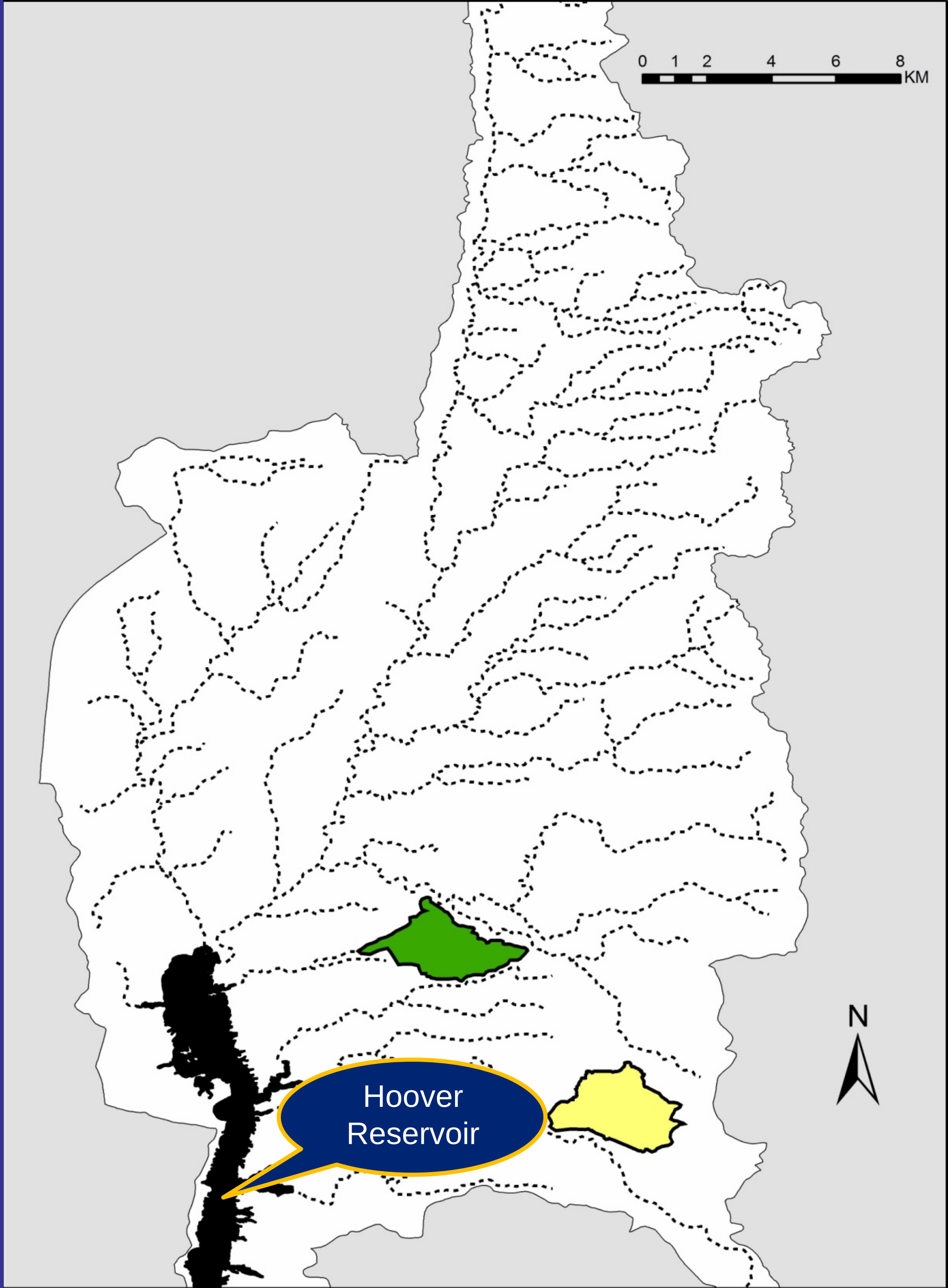
Fish Community Responses

No effects of pesticide management practices on fish biodiversity, abundance, and species composition

What factors have greatest influence on atrazine concentrations in a drinking water reservoir?

- Atrazine concentrations from Hoover Reservoir from 1985 to 2006

- Effects of atrazine reduction practices at spatial scale of 492 km2



King et al. 2012. Journal of Soil and Water Conservation 67: 416-424.

Number of RV with Greatest Coefficients and Effects

	# RV	Effect
May to June precipitation	5*	+
% adopting atrazine reduction practices	3**	-
% ha adopting other EQIP practices	0	
% ha corn	0	
% ha soybean	0	
% ha wheat	0	
Annual precipitation	0	

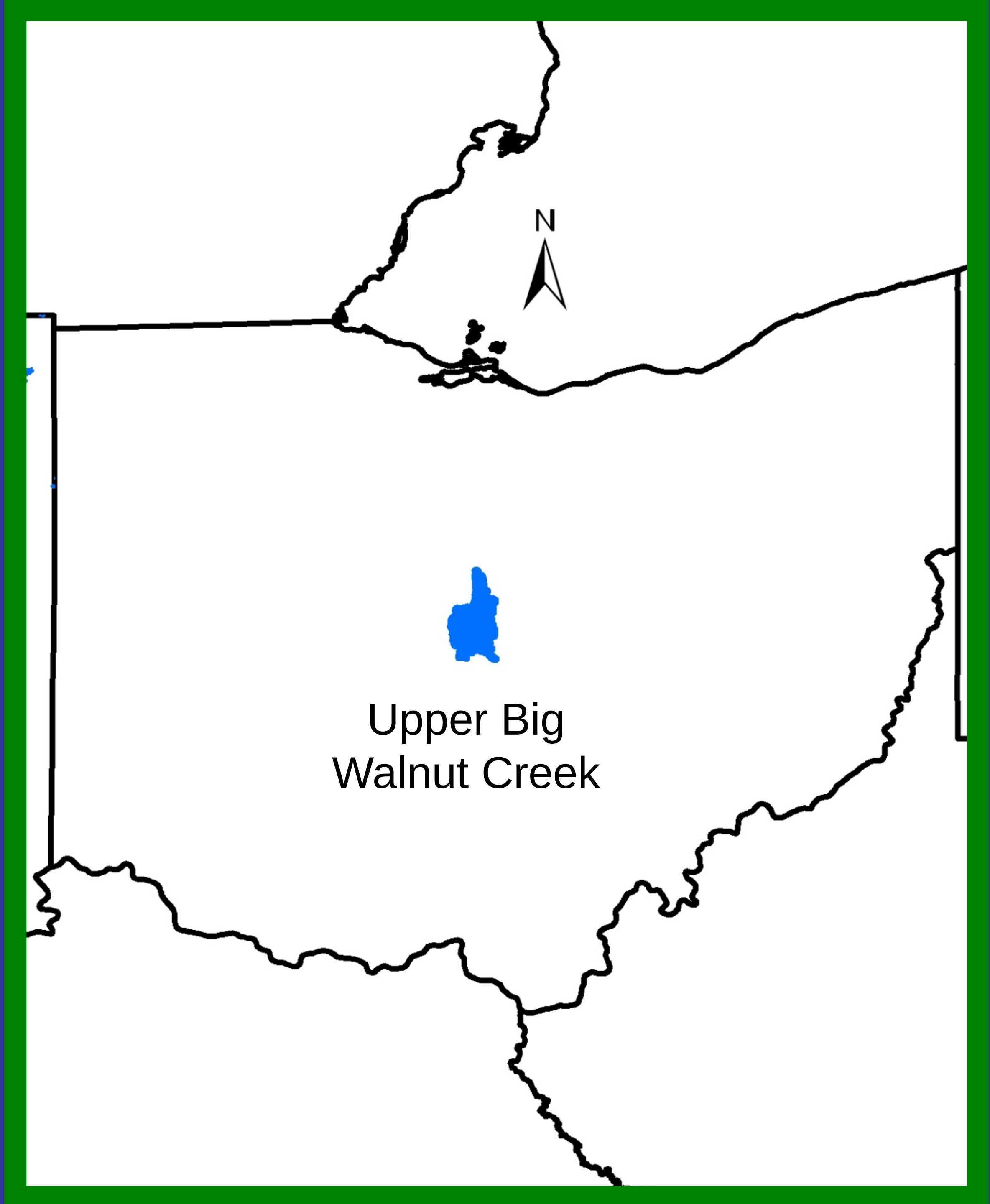
* Max, min, SD, 95%, post-application mean

** Mean, median, # months > 3ug/L

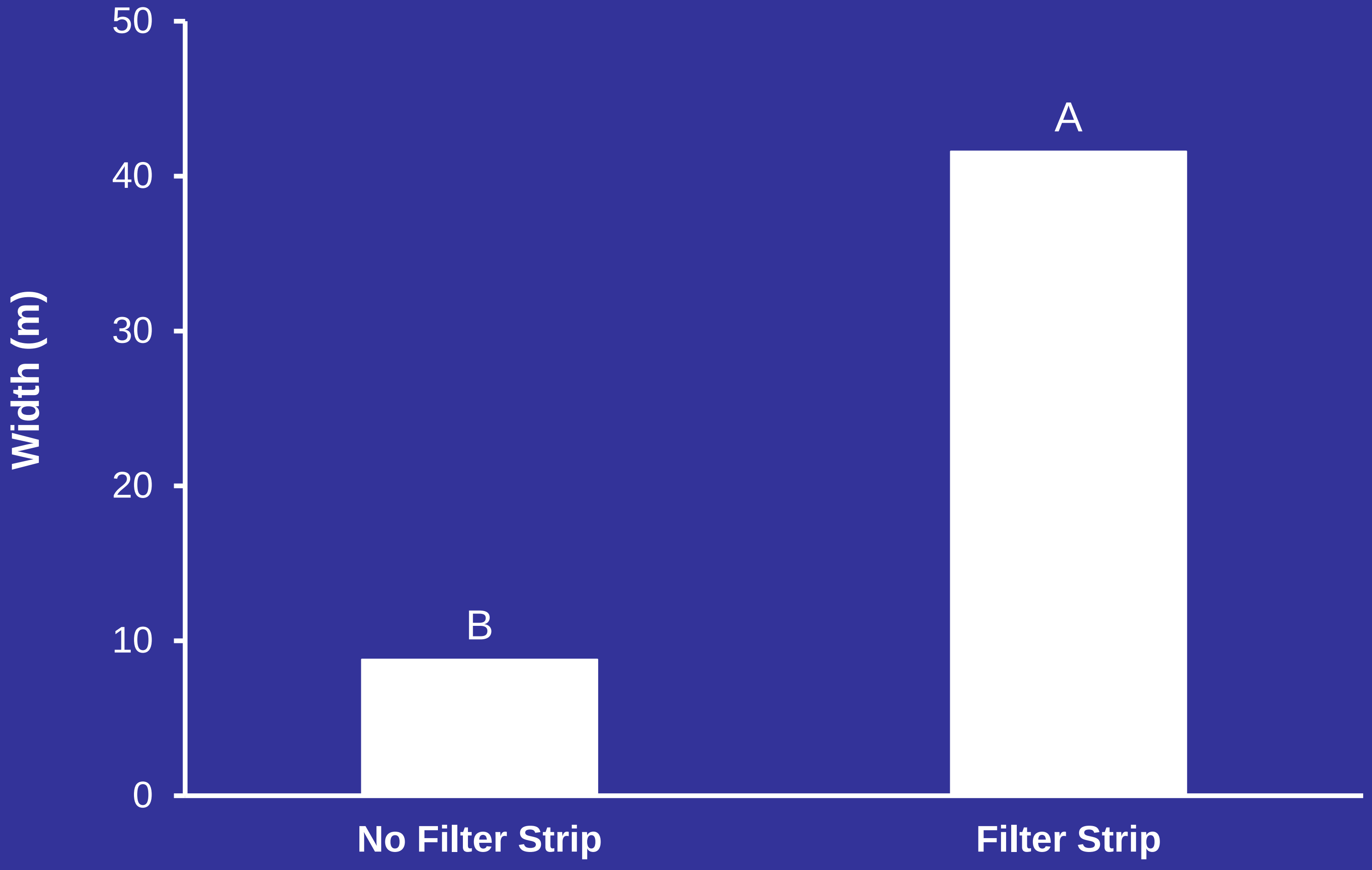
Is there a difference in physical habitat, water chemistry, and biota between channelized agricultural headwater streams with and without grass filter strips?

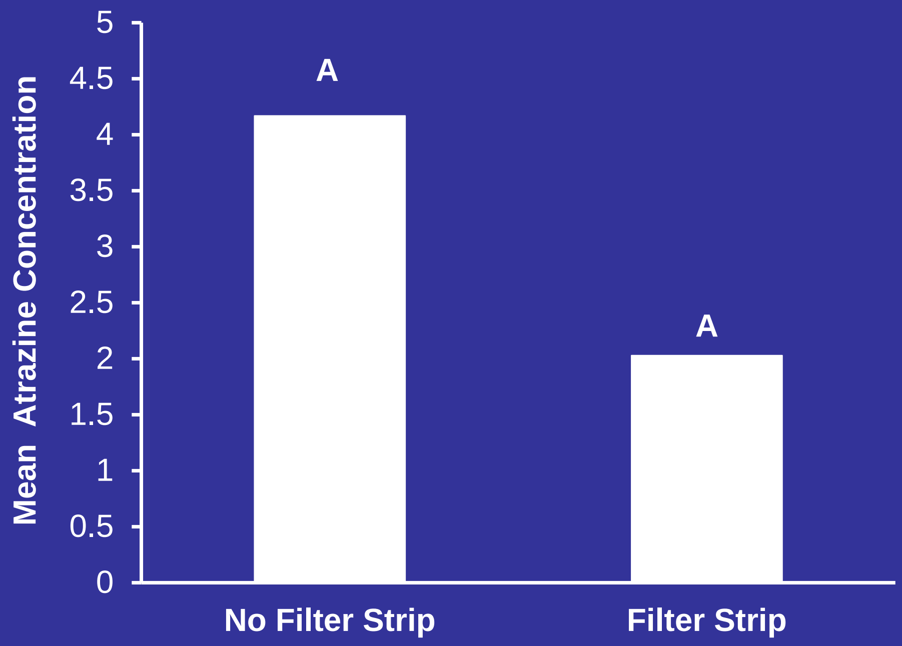
- 3 streams without filter strips
- 3 streams with filter strips
- 2006 to 2009

Smiley et al. 2011. Ecological Engineering 37: 1314-1323.

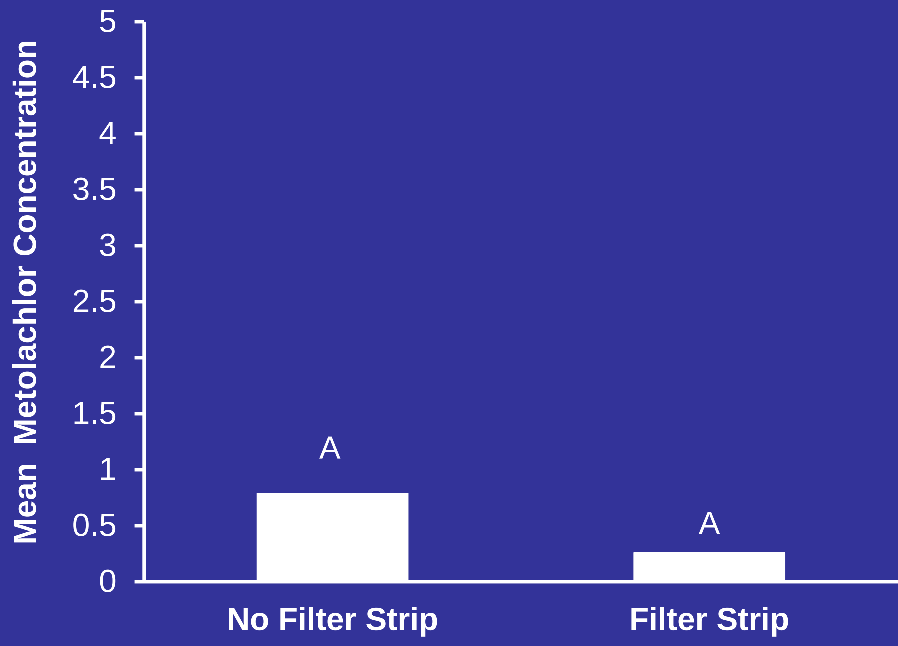


Riparian Width

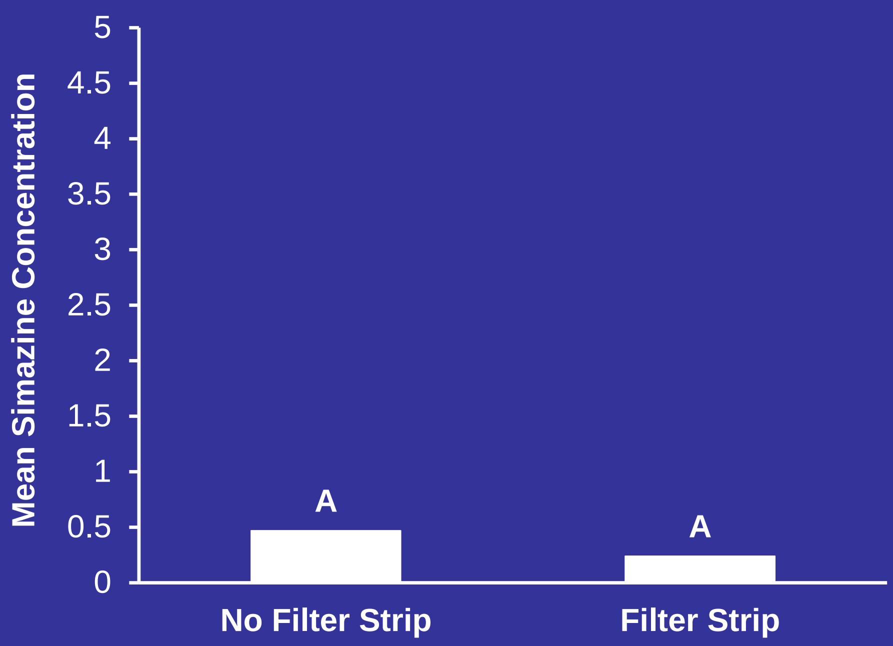




Mean Atrazine Concentration
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
A
A
No Filter Strip
Filter Strip



Mean Metolachlor Concentration
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
A
A
No Filter Strip
Filter Strip



Mean Simazine Concentration
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
A
A
No Filter Strip
Filter Strip

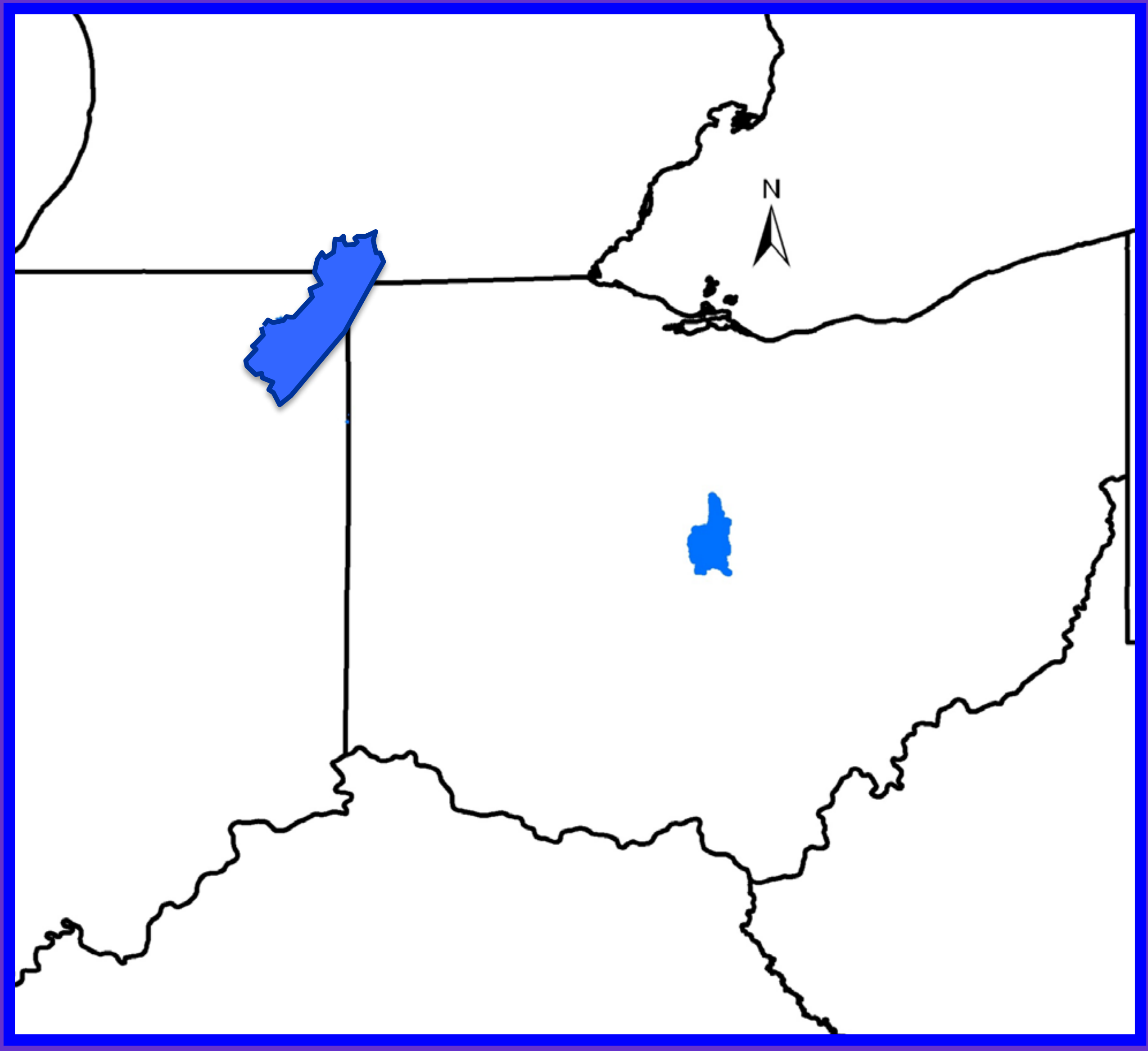
Other Results

No differences in riparian vegetative structure, geomorphology, instream habitat, physicochemical variables, fishes, and amphibians between streams with and without grass filter strips

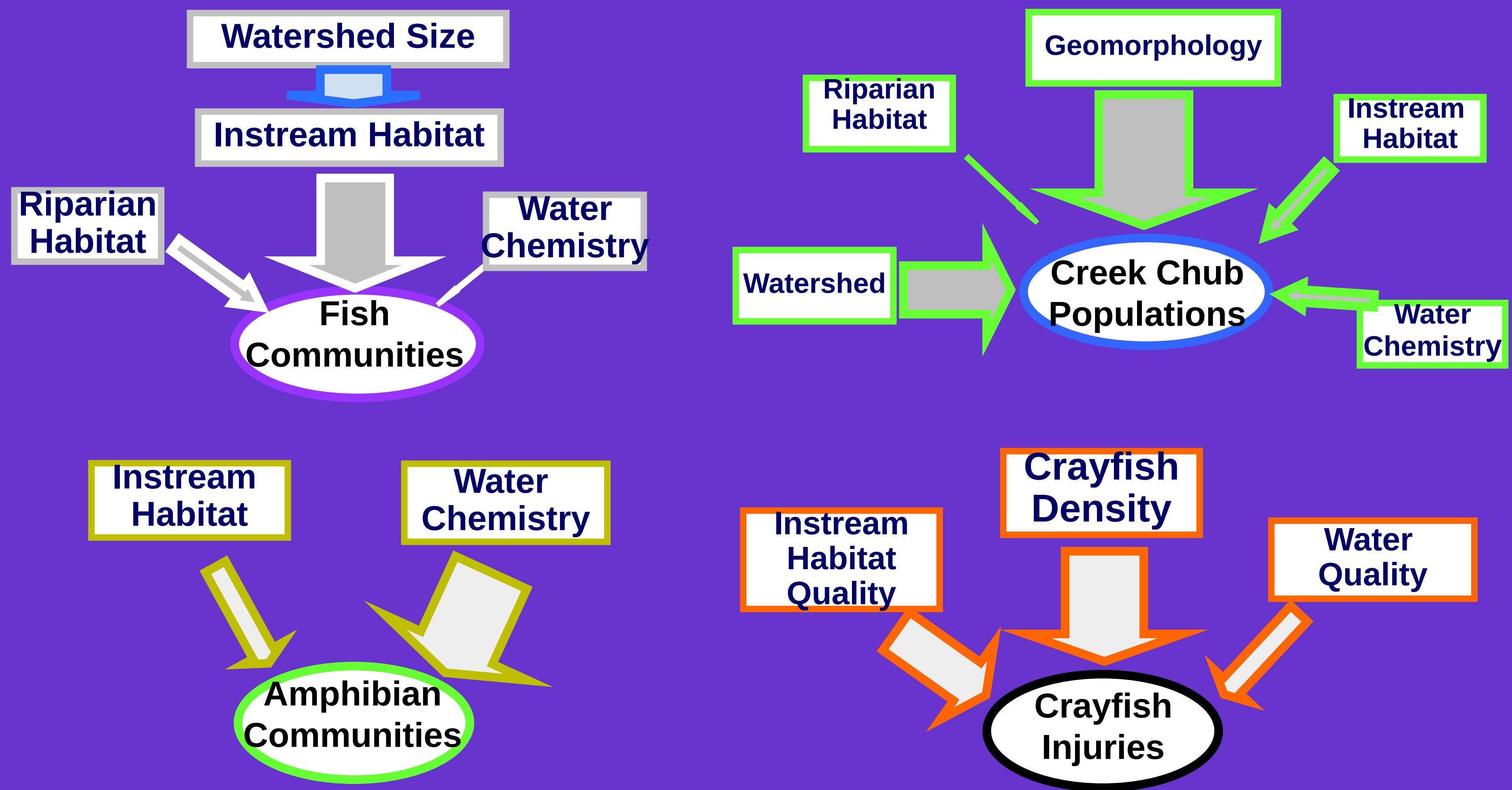
Biota-Habitat Relationships

What factors have greatest influence on the biota in agricultural headwater streams?

- Results from series of studies conducted in Saint Joseph River watershed and Upper Big Walnut Creek

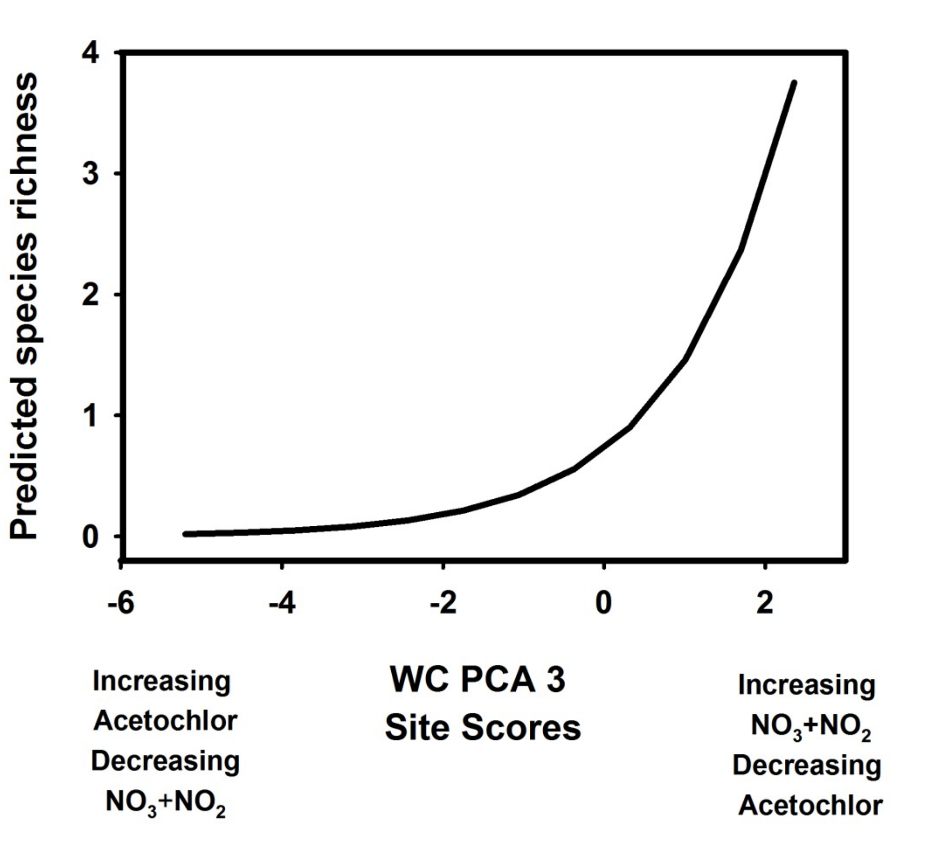


Biota-Habitat Relationships in CEAP Agricultural Headwater Streams in Indiana & Ohio (2005 to 2015)

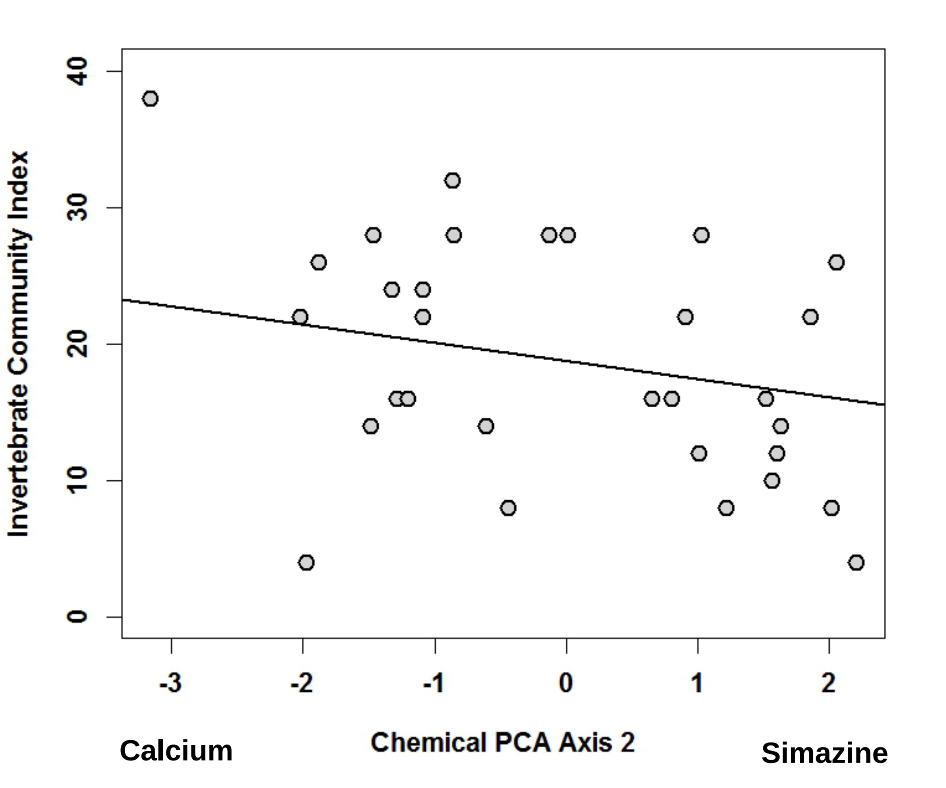


Smiley et al. 2008. Journal of Soil and Water Conservation 63: 218A-219A
Smiley et al. 2009. Ecohydrology 2: 294-302
Sanders et al. 2020. Journal of Environmental Quality
Smiley et al 2017. Northeastern Naturalist 24(sp8): 18-44
Jordan et al. 2016. Agriculture, Ecosystems, and Environment 230:87-97
Wood et al. 2020 Environmental Monitoring & Assessment 192:227

Relationships with Herbicide and Nutrient Gradients



Jordan et al. 2016. Agriculture, Ecosystems, and Environment 230:87-97



Shuman et al. 2020. Water, 12, 2976

Conclusions

- **Spatiotemporal Trends**
  - Pesticide mixtures exhibit greater temporal variation than spatial variation
  - Pesticide concentrations and toxicity of nutrient-pesticide mixtures differs between channelized and unchannelized streams
- **Effects of Conservation Practices**
  - No effect of atrazine reduction practices in 4 km2 watersheds with only 30% adoption in the watershed
  - Atrazine reduction practices reduce atrazine concentrations in 493 km2 watershed, but the effect of rainfall is greater
  - No effect of planting grass filter strips on pesticide concentrations
- **Biota-Habitat Relationships**
  - Fishes and crayfishes are most strongly influenced by physical habitat and amphibians are most strongly influenced by nutrients & pesticides
  - Trends in amphibian and macroinvertebrate diversity and abundance occur below acute and chronic toxicity levels of herbicides

Implications for Modeling

- Need go beyond modeling the impacts of individual pesticides and model the effects of pesticide mixtures
- Models need to incorporate annual and season variation
- Models should incorporate the effect of stream channelization
  - Consider exploring the effects of spatial variation, especially at larger watershed sizes
- Models should incorporate the effects of nutrients and physical habitat that may alter the observed effect of pesticides
- Model acute, chronic, and sublethal effects of pesticides

Acknowledgements

- USDA-ARS National Erosion Research Laboratory collaborators: J. Gonzalez, D. Smith, E. Pappas, C. Huang
- USDA-ARS Soil Drainage Research Unit collaborators: K. King, N. Fausey
- Purdue University Fort Wayne collaborators: R. Gillespie, M. Jordan, K. Sanders, T. Wood, T. Shuman
- Current and past personnel from the USDA-ARS Soil Drainage Research Unit, USDA-ARS National Erosion Research Laboratory, and Purdue University Fort Wayne assisted with field and laboratory work for Saint Joseph River and Upper Big Walnut Creek water chemistry and ecology research.
- Natural Resources Conservation Service and Local Soil and Water Conservation Districts in Indiana and Ohio
- We also are grateful to those landowners who gave permission to work on their property

Questions?

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