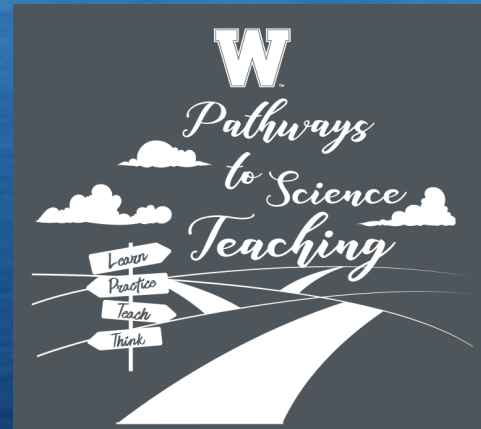


# Preparing Preservice Teachers to Engage in NGSS Science and Engineering Practices: *The Pathways to Science Teaching Program*

Heather L. Petcovic, Steven Bertman, Lauri E. Davis, Stephen Kaczmarek, Kevin Koch, Valerie Long, and R. Paul Vellom

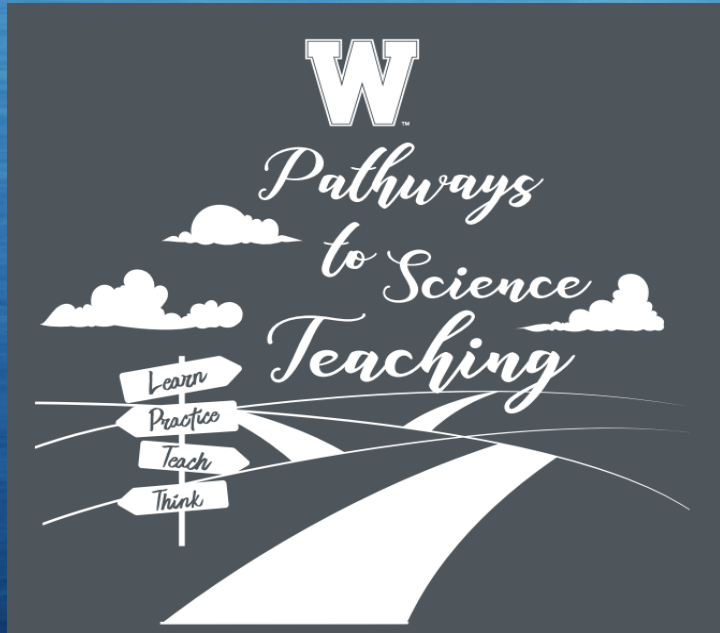


**WESTERN  
MICHIGAN  
UNIVERSITY**



This work is supported by the National Science Foundation under Grant No. GEO-1701007. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

# *Why Pathways to Science Teaching?*

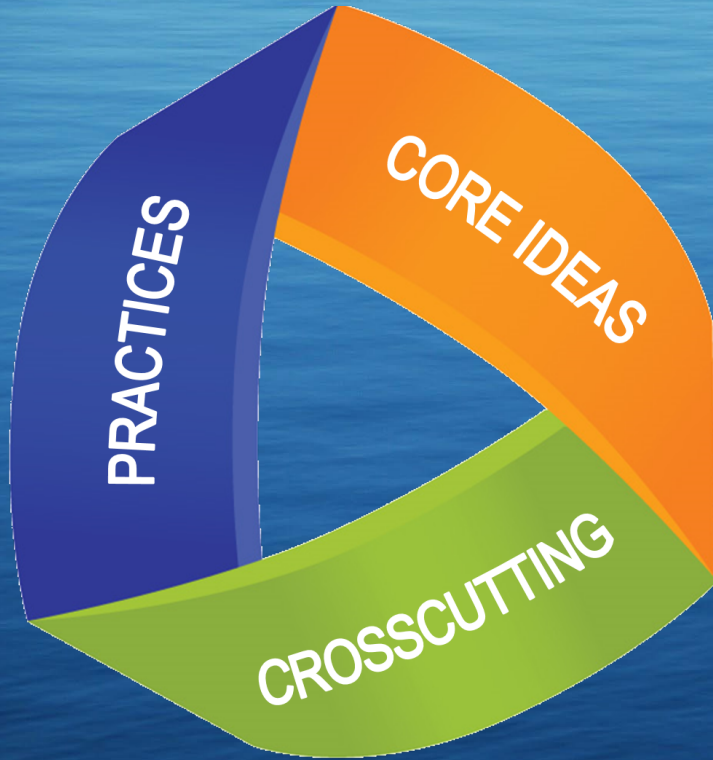


Diverse and well-prepared K-12 teachers are critical to expanding participation in the geoscience workforce

*Pathways* is an NSF GeoPATHS project aimed at:

1. Preparing diverse students to become K-12 science teachers
2. Engaging future teachers in authentic research and teaching science to youth
3. Enhancing identity of preservice teachers as both geoscientists and as educators

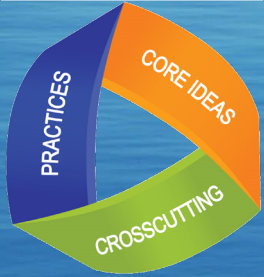
# Why *Pathways to Science Teaching*?



- Next Generation Science Standards emphasize three dimensions of science
- BUT, engaging in science and engineering practices is often lacking in teacher preparation programs
- *Pathways* emphasizes:
  - Science and Engineering Practices
  - Nature of Science
  - Identity as geoscientist and teacher



# Why *Pathways to Science Teaching*?



<https://www.nextgenscience.org/three-dimensions>

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

A 10 week summer program themed around water quality:

- Week 1: Meet local water quality stakeholders
- Weeks 2-5: Design and conduct water quality research
- Weeks 6-9: Teach youth in summer camps themed around water quality
- Week 10\*: Communicate results (\*BONUS - present at national conference)

# Who were *Pathways* participants?

Three cohorts, total of 23 participants

- 10 secondary science education, 6 elementary education, 7 science majors
- 16 women, 10 underrepresented in science teaching by gender
- 9 students of color (Black/African American, Asian, Hispanic, 2+ races)
- 2 LGBTQ+, 2 Military veterans, 1 with disability
- Half attended community college, 6 first generation college

Cohort 1: 2018



Cohort 2: 2019



Cohort 3: 2020 2021





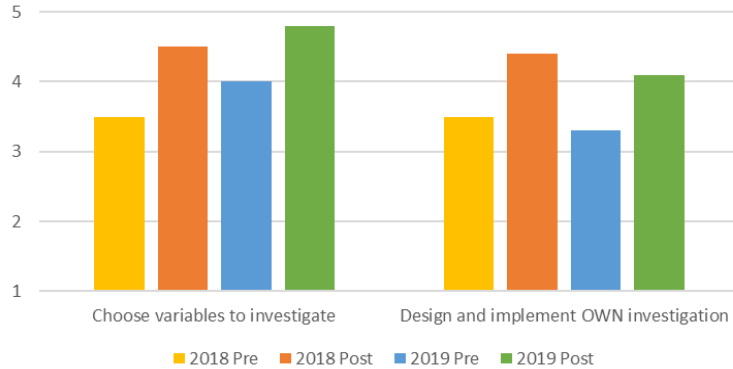
# How did we measure program success?

Project goal – data measures participants'	Data source	When collected
Understanding of the nature of science (NOS) and scientific inquiry (NOSI)	SUSSI (Liang et al., 2006; 2008)	First day of program, at transition, last day of program
Knowledge of and comfort with using NGSS science and engineering practices in the classroom	SIPS (Hayes et al, 2016)	First day of program, at transition, last day of program
Identity as a scientist and as a teacher	Survey developed by SAMPI	First day of program, at transition, last day of program
General experiences, most and least impactful parts of the program, suggestions for improvement	Individual participant interview	Last day of program

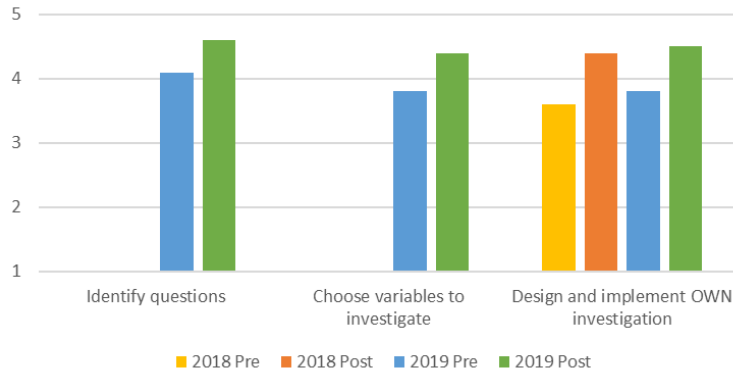
Evaluation conducted by SAMPI at WMU

# How did we impact participants' SEPs?

Comfort with NGSS SEP



Comfort helping youth with NGSS SEP

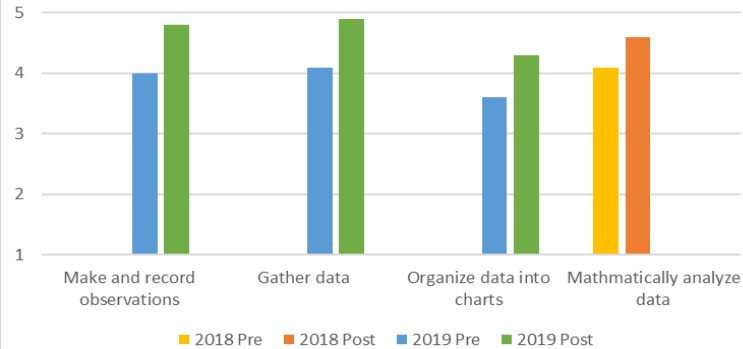


Preservice teachers designed their own water quality investigations and had youth design and conduct investigations.

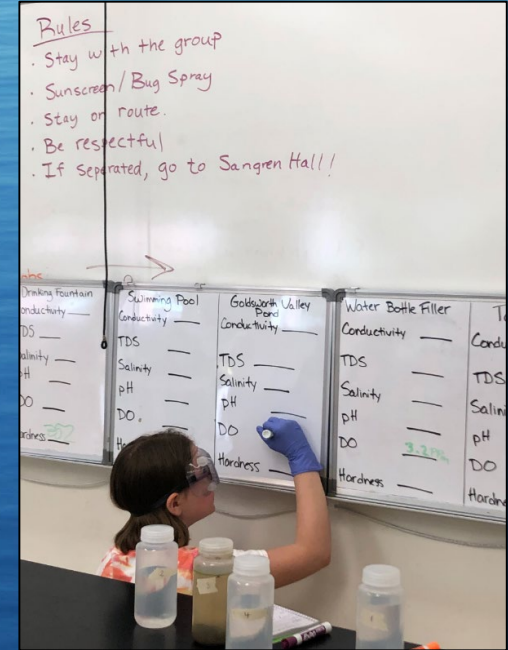
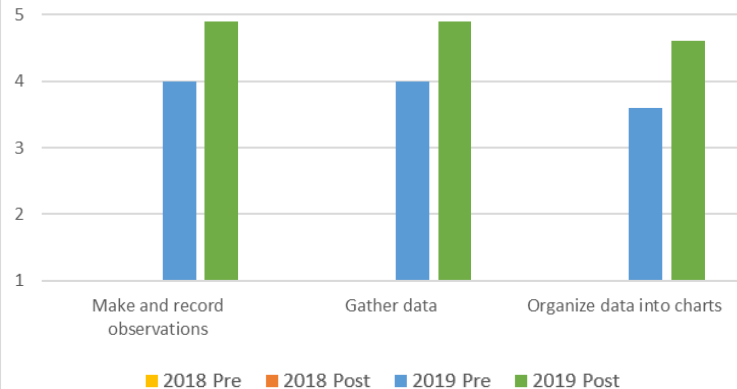


# How did we impact participants' SEPs?

Comfort with NGSS SEP



Comfort helping youth with NGSS SEP

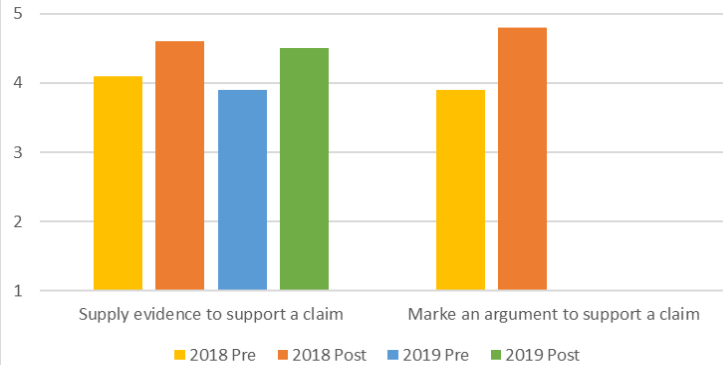


2019 Cohort emphasized recording, gathering, and analyzing data.

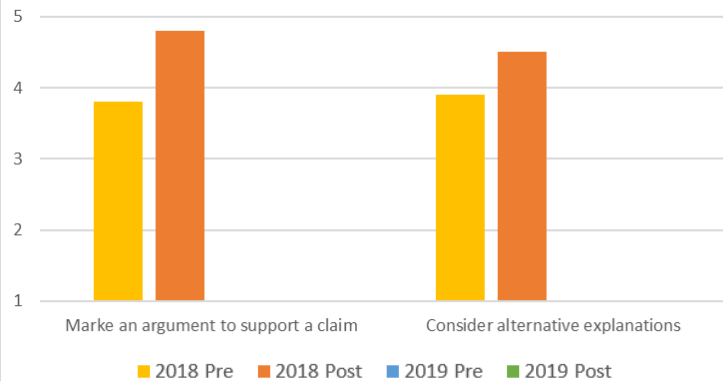


# How did we impact participants' SEPs?

Comfort with NGSS SEP



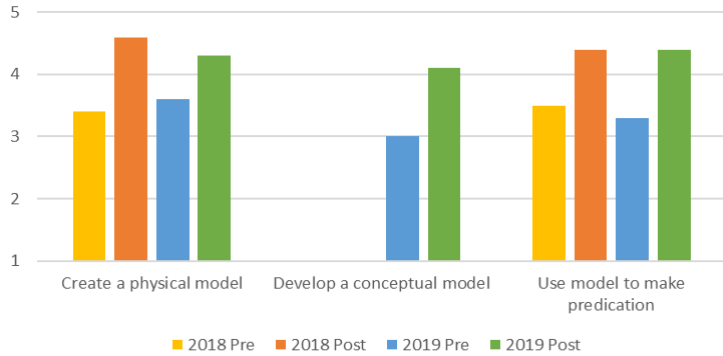
Comfort helping youth with NGSS SEP



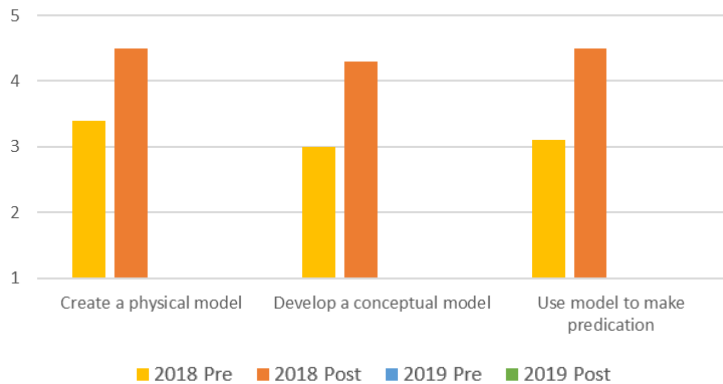
All cohorts gained experience in using evidence to support claims; 2018 cohort emphasized argumentation.

# How did we impact participants' SEPs?

Comfort with NGSS SEP



Comfort with helping youth with NGSS SEP



All cohorts created and used models; 2018 cohort emphasized models



# How did we impact participants' SEPs?

"We focused a lot on scales and models so we were able to use water cycle models and other models we had on campus." -2018

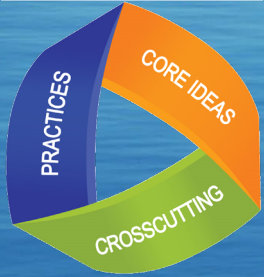
"models ... represent big picture concepts." -2019

"They [the NGSS] reflect what scientists are actually doing in the field" -2019

"The practices stress finding solutions for problems and that is a big part of geoscience careers." -2018

"With real life research in my pocket, I feel I can provide students with a more complete experience by modeling conditions that we came across in the field, such as open ended discovery." -2018

# Impact of *Pathways to Science Teaching*



<https://www.nextgenscience.org/three-dimensions>

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
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A 10 week summer program themed around water quality:

- Week 1: Meet local water quality stakeholders
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- Weeks 6-9: Teach youth in summer camps themed around water quality
- Week 10\*: Communicate results (\*BONUS - present at national conference)



# Want to hear more?

## Engaging Youth in NGSS Science and Engineering Practices in Water Science Summer Camps (153-1)

Clare Bunton, Jovaughn Carver, Kathy Garneau, Keelin A. Markou, Diamond Norlien, Cora Paul, Brianna Salome, Heather Petcovic, Lauri E. Mackelburg-Davis, Valerie Long, Paul Vellom, Kevin Koch



### Project Purpose

The Pathways to Science Teaching Program provided undergraduate science and preservice educators with authentic research and hands-on science teaching experiences. In the first 5 weeks of the 10-week summer program, preservice educators conducted research on water quality in the Kalamazoo River watershed, Kalamazoo County, Michigan. The first 5 weeks were focused on preparing lesson plans and educating 10th-grade summer campers about water quality using research the group conducted. Lesson plans used a "5E" design (Bybee et al., 2006), were based on NGSS standards used in "5E" design (Bybee et al., 2006), and highlighted careers in earth and environmental science.

### Project Context

Preservice educators designed and led three summer camps on water quality over two weeks in summer 2021.

**What's in Your Water?**  
Week 1, 5am-8am  
Day 1: Expansion of the water cycle  
Day 2: Human impact on water quality  
Day 3: View of macroinvertebrates in stream water quality  
Day 4: Water filtration  
Day 5: Preservice week challenge results

**Water in, Water Out**  
Week 2, 8am-12pm  
Day 1: Water quality and the water cycle  
Day 2: Water quality and the water cycle  
Day 3: Aquifers and human impacts  
Day 4: Aquifers and human impacts  
Day 5: Macroinvertebrates in stream water quality  
Day 6: Revolving week challenge results

### Project Outcomes

Throughout the two weeks of camps, there was water quality in the preservice educators' stations to connect with the campers, along with gaining a better understanding of how to keep the campers involved and engaged. During the preservice educators' stations, the preservice educators gained first-hand experience in scientific practices such as asking inquiry, developing questions, and conducting research. They were successful in translating these experiences into lesson plans for the summer camps. Lesson plans focused on water quality, including water quality, analyzing and interpreting data, communicating, and planning and carrying out investigations. By the end of each week, the campers had learned to become more about water and had a newfound appreciation for our freshwater resources.

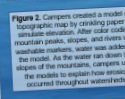


This work is supported by the National Science Foundation under Grant No. GEO-171007. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

### Developing and Using Models



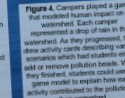
**Figure 1.** Campers were introduced to a variety of models, including a groundwater model, and were asked to gather and use evidence to create their own models to help explain water quality features and processes. Students used models to create predictions and support their arguments, demonstrating the ability to explain their understanding of the phenomenon.



**Figure 2.** Campers created a model of a landscape, map by creating layers to simulate elevation. After color coding mountain peaks, slopes, and rivers with the model. As the water ran down the slope of the model, campers used the model to explain how elevation occurred throughout watersheds.

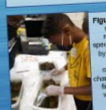


**Figure 3.** Campers created models out of local resources, using the evidence they gathered. Students had the opportunity to modify or change their model. In the "before" model, campers used the "before" model to show their understanding of the relationships among variables that contribute to the natural or disturbed system of observable or unobservable factors.



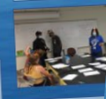
**Figure 4.** Campers played a game that involved human impact on a watershed. As they progressed, they actively made decisions about water quality and how it affected the watershed. When they finished, students were able to explain how each game model contributed to the pollution of water resources.

### Analyzing and Interpreting Data



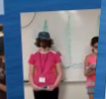
**Figure 5.** Campers gathered and recorded information about where to find local clean water sources, and how to determine whether water is clean, and how to filter water. They gathered water information each day while at camp. 3.A. Campers from evaluated which information was the most essential for their understanding. 3.B. Campers created a model to help explain the phenomenon.

### Engaging



**Figure 6.** Campers gathered and recorded information about where to find local clean water sources, and how to determine whether water is clean, and how to filter water. They gathered water information each day while at camp. 3.A. Campers from evaluated which information was the most essential for their understanding. 3.B. Campers created a model to help explain the phenomenon.

### Constructing

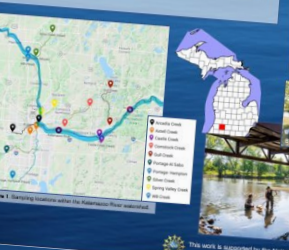


**Figure 7.** Campers gathered and recorded information about where to find local clean water sources, and how to determine whether water is clean, and how to filter water. They gathered water information each day while at camp. 3.A. Campers from evaluated which information was the most essential for their understanding. 3.B. Campers created a model to help explain the phenomenon.

### Introduction

Human activity can have detrimental effects on freshwater ecosystems (Zhang, 2020). Factors that influence it, it is necessary to properly manage this resource. Stream health can be assessed in various ways, including macroinvertebrate populations (EPA, 2013), chemical constituents, and the habitat structure surrounding the water source. Macroinvertebrates contribute to chemically untreated freshwater ecosystems, including non-point agricultural, industrial, and urban runoff (EPA, 2017). Along the Kalamazoo River watershed, the Kalamazoo River watershed is a major source of non-point agricultural and urban runoff (EPA, 2017). Along the Kalamazoo River watershed, the Kalamazoo River watershed is a major source of non-point agricultural and urban runoff (EPA, 2017). Along the Kalamazoo River watershed, the Kalamazoo River watershed is a major source of non-point agricultural and urban runoff (EPA, 2017).

- More human impact on the land use along a river results in a greater decrease of macroinvertebrates biodiversity.
- More human impact on land use along a river results in a greater decrease of pollution-sensitive macroinvertebrates.
- More human impact on land use along a river will increase observed changes in pH and conductivity.



**Figure 1.** Sampling locations along the Kalamazoo River watershed.

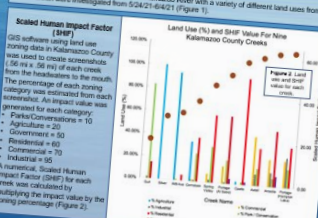
### Obtaining, Evaluating, and Communicating Information

## Talking SHIF: Human Impact on Creek Health (59-24)

Cora Paul, Clare Bunton, Jovaughn Carver, Kathy Garneau, Keelin A. Markou, Diamond Norlien, Brianna Salome, Steve Bertman, Steve Kaczmarek, Heather Petcovic, Lauri E. Mackelburg-Davis

### Methods

The river health of nine tributaries of the Kalamazoo River with a variety of different land uses from rural to urban were investigated from 2014-2017 (Figure 1).



**Figure 2.** Percentage of each stream category for each watershed. The chart shows the percentage of each stream category for each watershed, including Agriculture, Commercial, Residential, and Industrial.

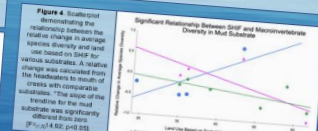
### Water Chemistry

Two PC40 multi-parameter meters (Aqua) were used to determine average pH (pH), conductivity (microSiemens/cm), salinity (ppt), and temperature (°C) (Figure 3).

### Macroinvertebrates

Standardized samples (40L) of each tributary substrate (gravel, sand, silt, and rock) were collected by dragging a 43 m long net. Individual species were identified and counted as follows: 1-10 individuals = 1; 11-20 individuals = 2; 21-30 individuals = 3; 31-40 individuals = 4; 41-50 individuals = 5; 51-60 individuals = 6; 61-70 individuals = 7; 71-80 individuals = 8; 81-90 individuals = 9; 91-100 individuals = 10.

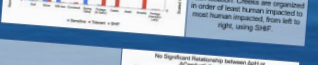
### Results



**Figure 4.** Scatter plot showing the relationship between the number of sensitive macroinvertebrates found at the mouth and headwaters of nine Kalamazoo County creeks. The plot shows the relationship between the number of sensitive macroinvertebrates found at the mouth and headwaters of nine Kalamazoo County creeks.



**Figure 5.** Graph demonstrating the total number of sensitive and intolerant macroinvertebrates found at the mouth and headwaters of nine Kalamazoo County creeks. The graph shows the total number of sensitive and intolerant macroinvertebrates found at the mouth and headwaters of nine Kalamazoo County creeks.



**Figure 6.** Graph demonstrating the change in pH and the change in conductivity for nine Kalamazoo County creeks in order of increasing human impact. The graph shows the change in pH and the change in conductivity for nine Kalamazoo County creeks in order of increasing human impact.

### Conclusions

There is no statistically significant relationship between land use along a creek and change in macroinvertebrate biodiversity in great and small watersheds. There is a significant relationship between land use along a creek and change in macroinvertebrate biodiversity in small watersheds ( $p < 0.05$ ).

A higher number of sensitive macroinvertebrates are found in a number of small watersheds. A higher number of intolerant macroinvertebrates are found in a number of small watersheds. Together these data suggest a relationship between human pollution-sensitive organisms and increased abundance of tolerant organisms with human impacted land use.

Future studies would benefit by replicating sampling at rivers and a more thorough evaluation of land use, possibly by using remotely sensed satellite data. By extending the area studied into other watersheds, a greater range of human impact would be provided.



**Figure 7.** Photo of campers and educators at a sampling site.

### References & Acknowledgements

References are available on request. Thank you to the landowners who gave us access to their land in order to conduct research. Thank you to the students who volunteered at the background information necessary to conduct the research project.

Tuesday, 11-1

Sunday, 4-6