

# **Impacts of Trophic State on the Composition of Algae Assemblages of the Harpeth River in Middle Tennessee**

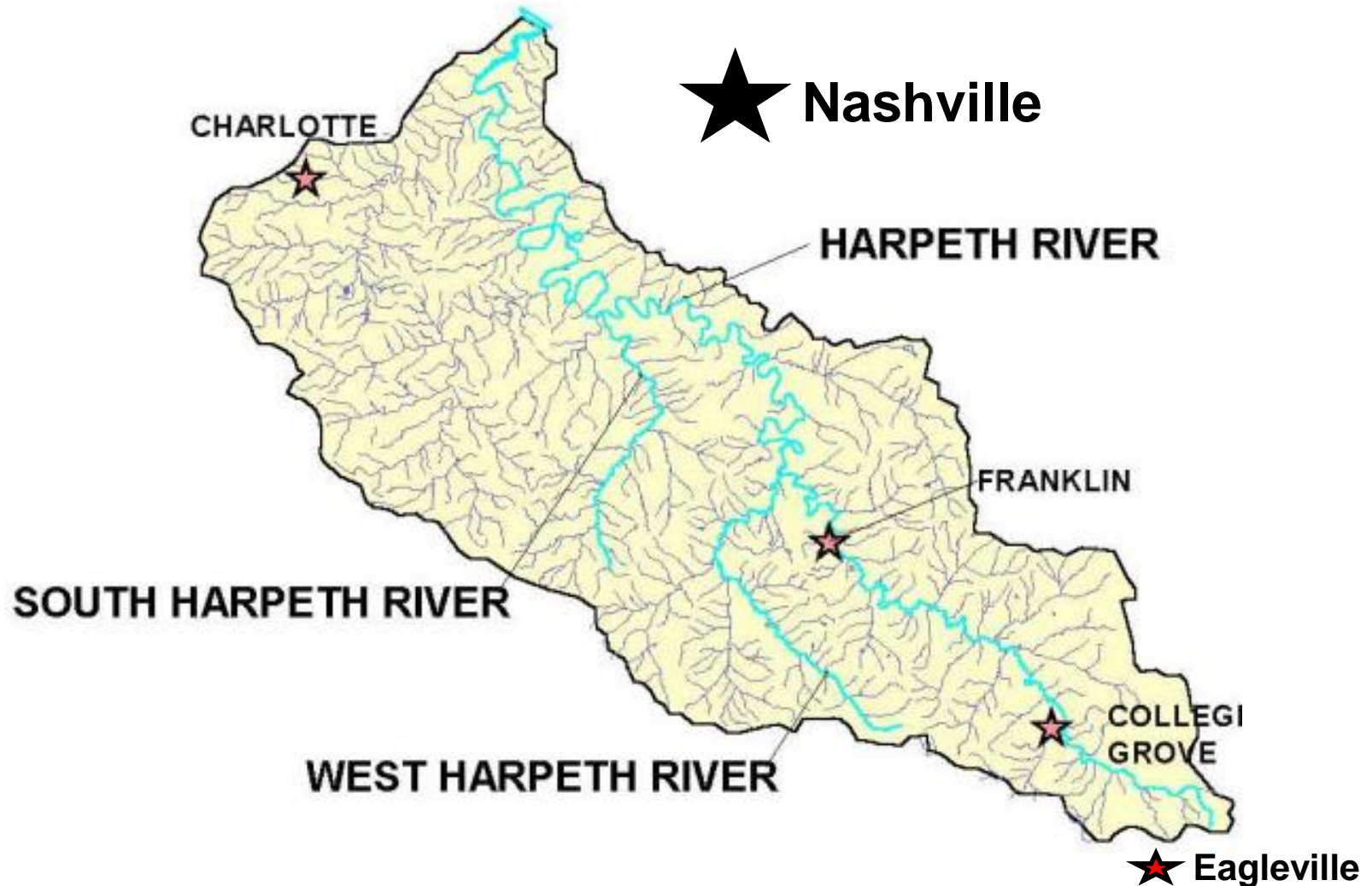
**Jefferson Lebkuecher, Sandra Bojic, Cooper Breeden, Samantha Childs, Mathew Evans, Bailey Hauskins, Zach Irick, Josh Kraft, Jonathan Krausfeldt, and Nicole Santoyo**

**Department of Biology, Austin Peay State University  
Clarksville, TN 37044**



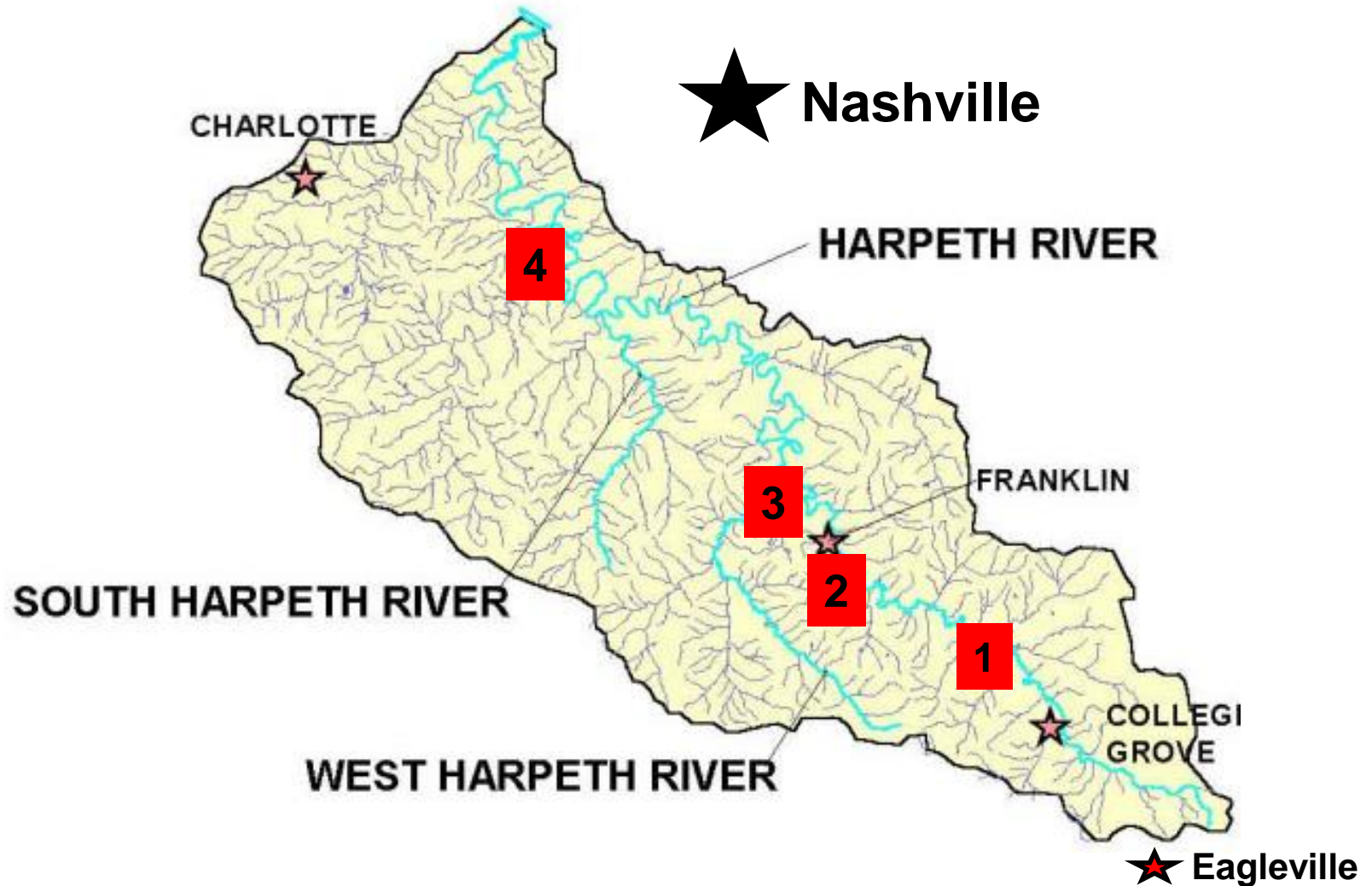
# The Harpeth River

- flows northwest 185 km from its source near Eagleville, TN.
- enters the Cumberland River northwest of Nashville, TN.



# Methods

- sampled 4 river sites on Oct 30, 2017.

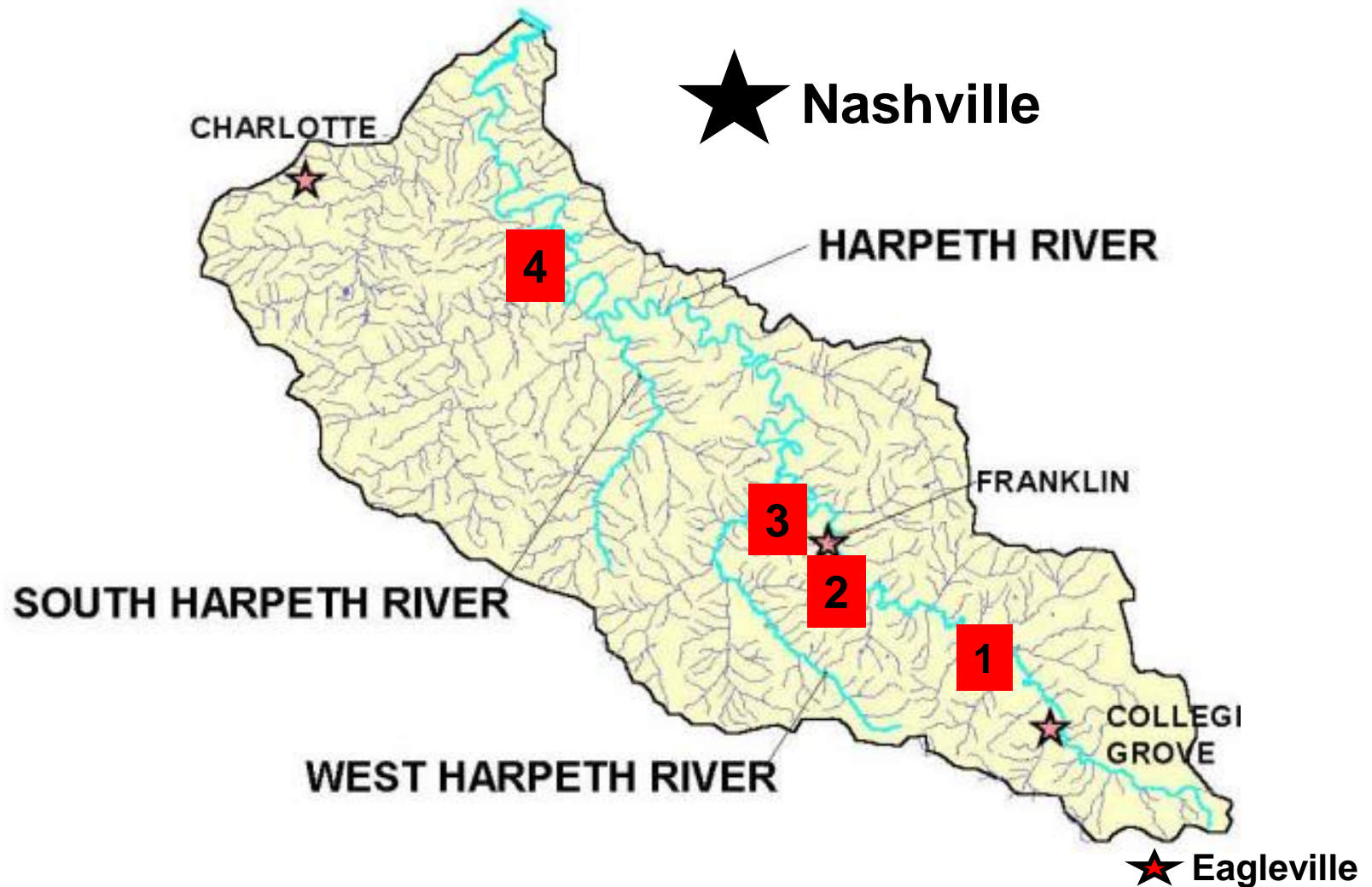




- site 1 is located 12 km east-southeast of Franklin, TN

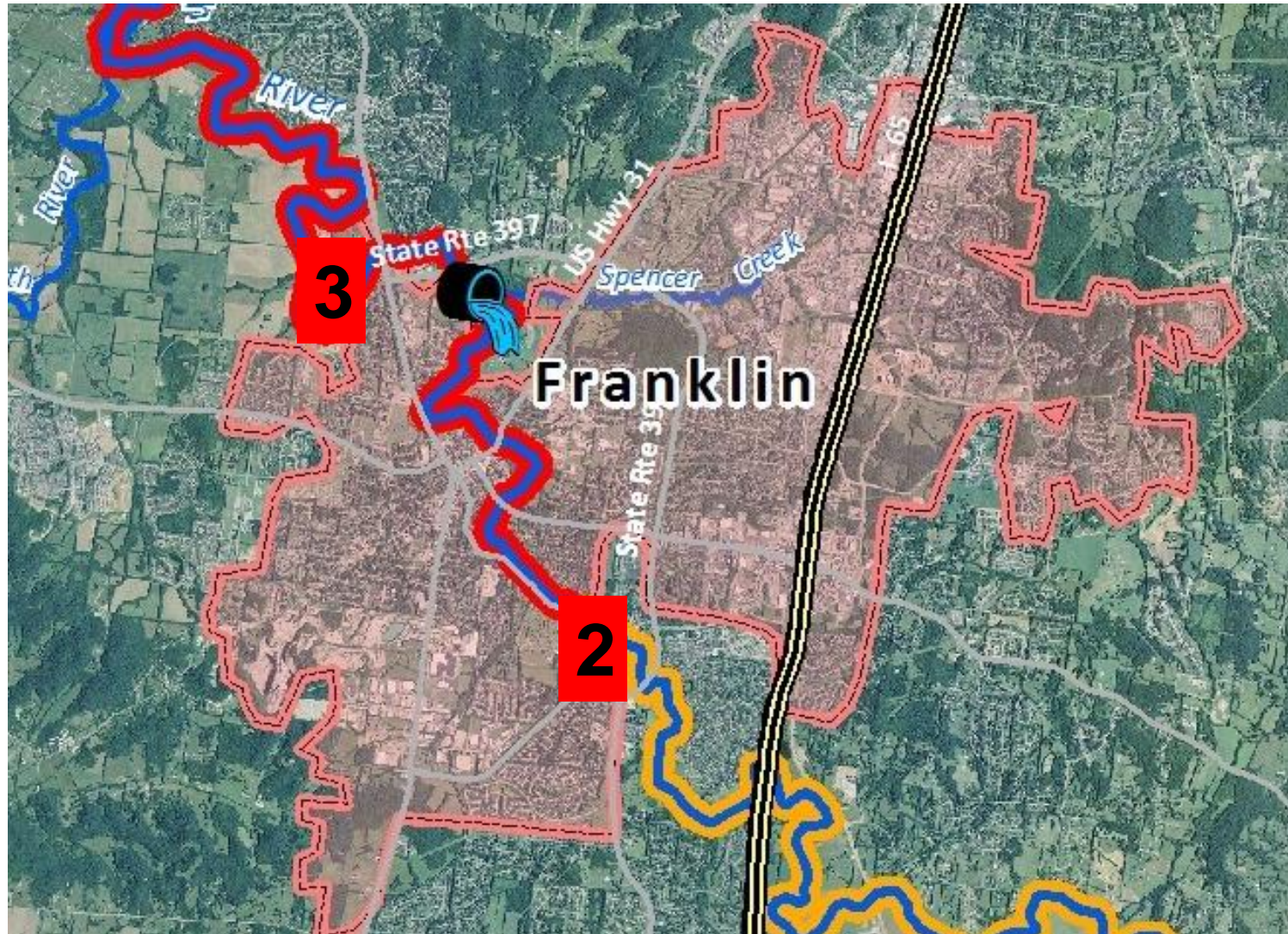


- site 2 is located in southeast Franklin.

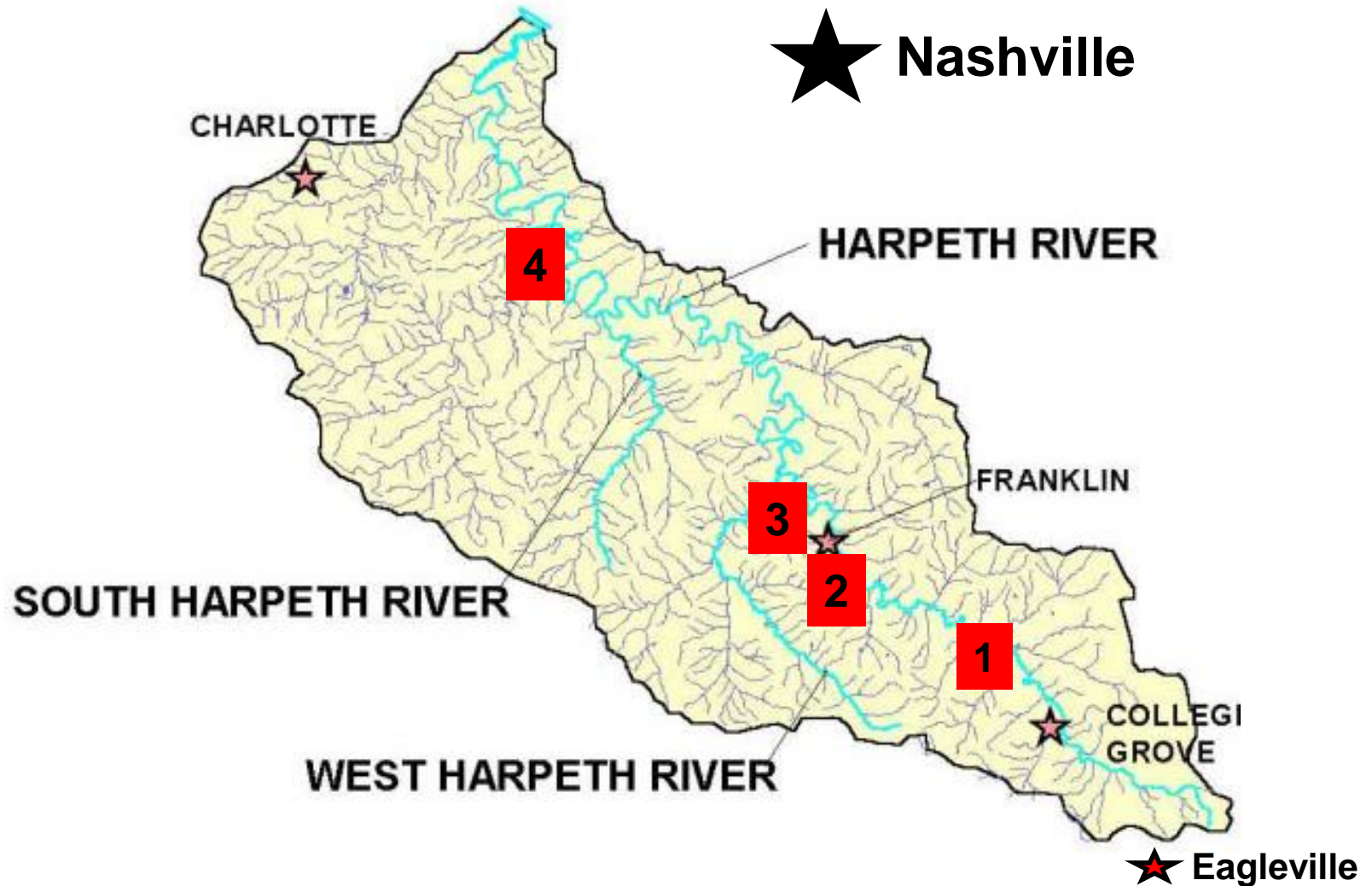




- site 3 is located in west Franklin.
- 5 km downstream the Franklin Wastewater Treatment Facility.



- site 4 is located:
  - 15 km north-northwest of Franklin.





- site 4 is located:
  - 15 km north-northwest of Franklin.
  - 100 m downstream of Hwy 100 bridge at the Harpeth River State Park canoe access point.





## [Total phosphorous]

- were determined from water samples collected 5 cm below the surface.



Site 2



# Periphyton characteristics

- were determined from cobbles removed from 4 replicate plots (0.25 m<sup>2</sup>) established 1.25 m apart at each site.



Site 3



# Periphyton characteristics

- were determined from cobbles removed from 4 replicate plots (0.25 m<sup>2</sup>) established 1.25 m apart at each site.
- included:
  - AFDM of benthic organic matter.



# Periphyton characteristics

- were determined from cobbles removed from 4 replicate plots (0.25 m<sup>2</sup>) established 1.25 m apart at each site.
- included:
  - AFDM of benthic organic matter.
  - [chl *a*].





# Algae composition

- determined from algae scraped from cobbles and preserved in 1 % glutaraldehyde.



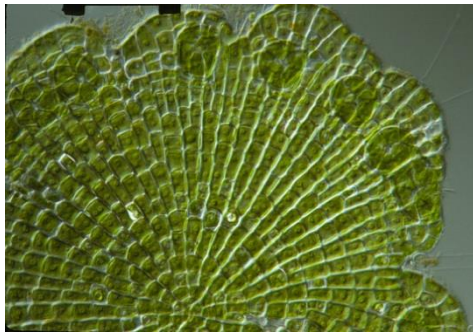
Site 4

# Soft algae

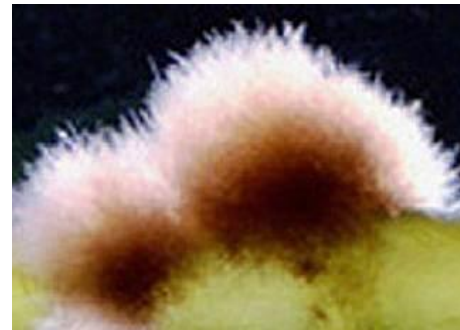
- were identified using a gridded microscope slide until > 800 units/site were tallied.
- 1 unit = 1 unicell; 1 colony; 10  $\mu\text{m}$  of length of a filament.



*Cryptomonas erosa*



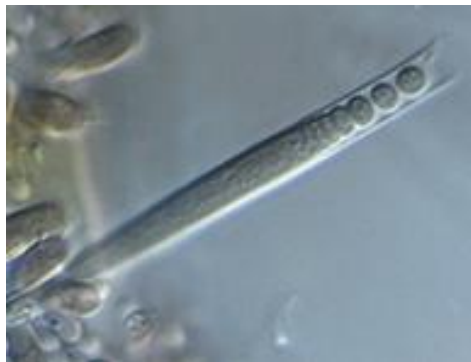
*Coleochaetae orbicularis*



*Audouinella violacea*



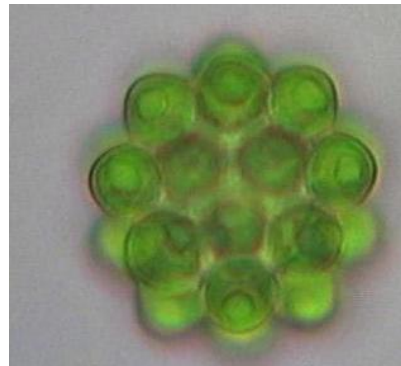
*Oocystis lacustris*



*Chamaesiphon confervicola*



*S. quadriculata*



*Coelastrum microporum*



*Ankistrodesmus falcatus*



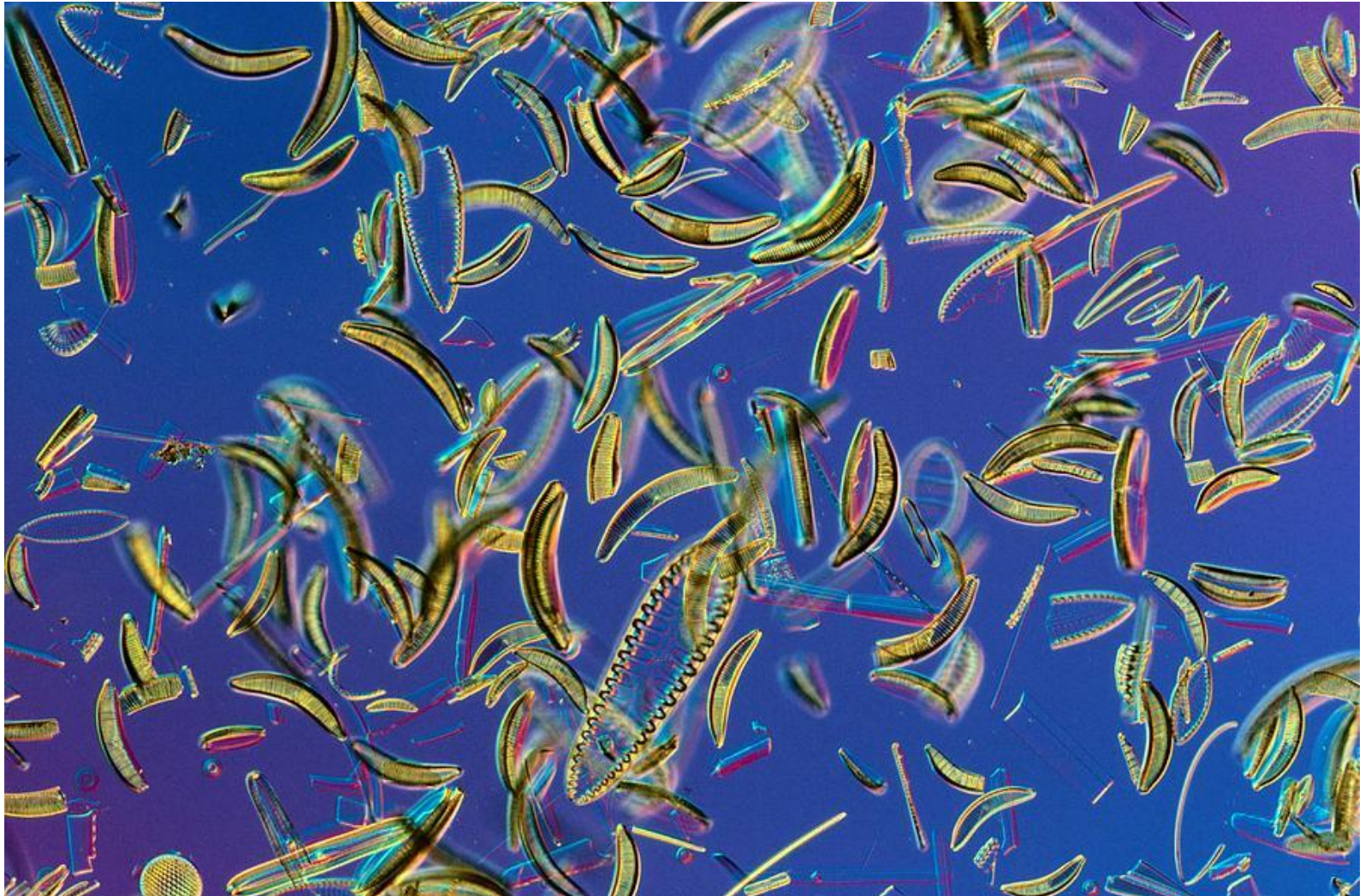
# Diatoms

- were cleaned (in 2.6 % sodium hyperchlorite) and mounted onto glass slides.



# Diatoms

- were cleaned (in 2.6 % sodium hyperchlorite) and mounted onto glass slides.
- > 200 taxa/site were identified and tallied.





# Results

## [Total Phosphorus] of water samples

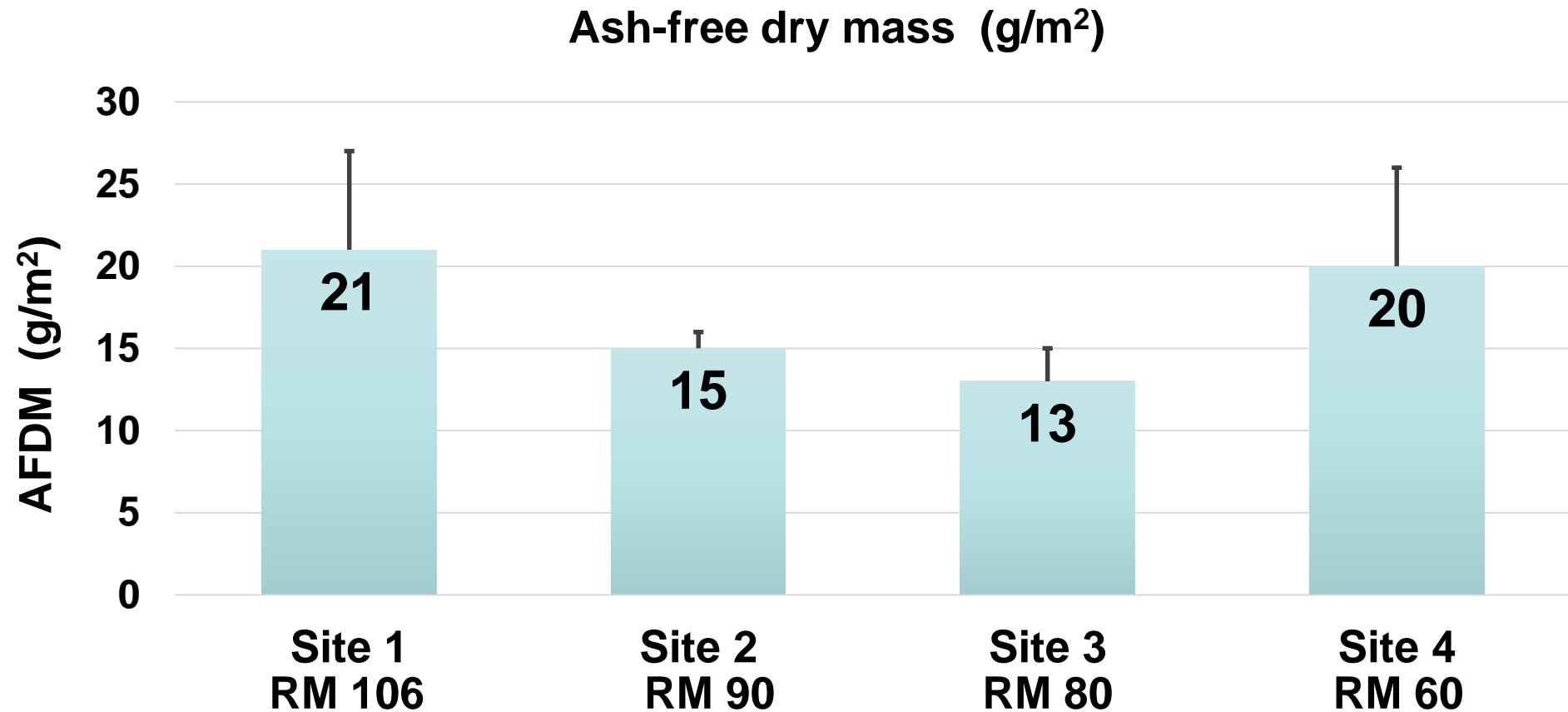
- are above threshold values which designate eutrophic conditions ( $75\text{ }\mu\text{g/L}$ ) at all sites.
- greatest at site 3 located 5 km downstream of the wastewater treatment plant.

[Total Phosphorus] ( $\mu\text{g/L}$ ) of Water



## [AFDM]

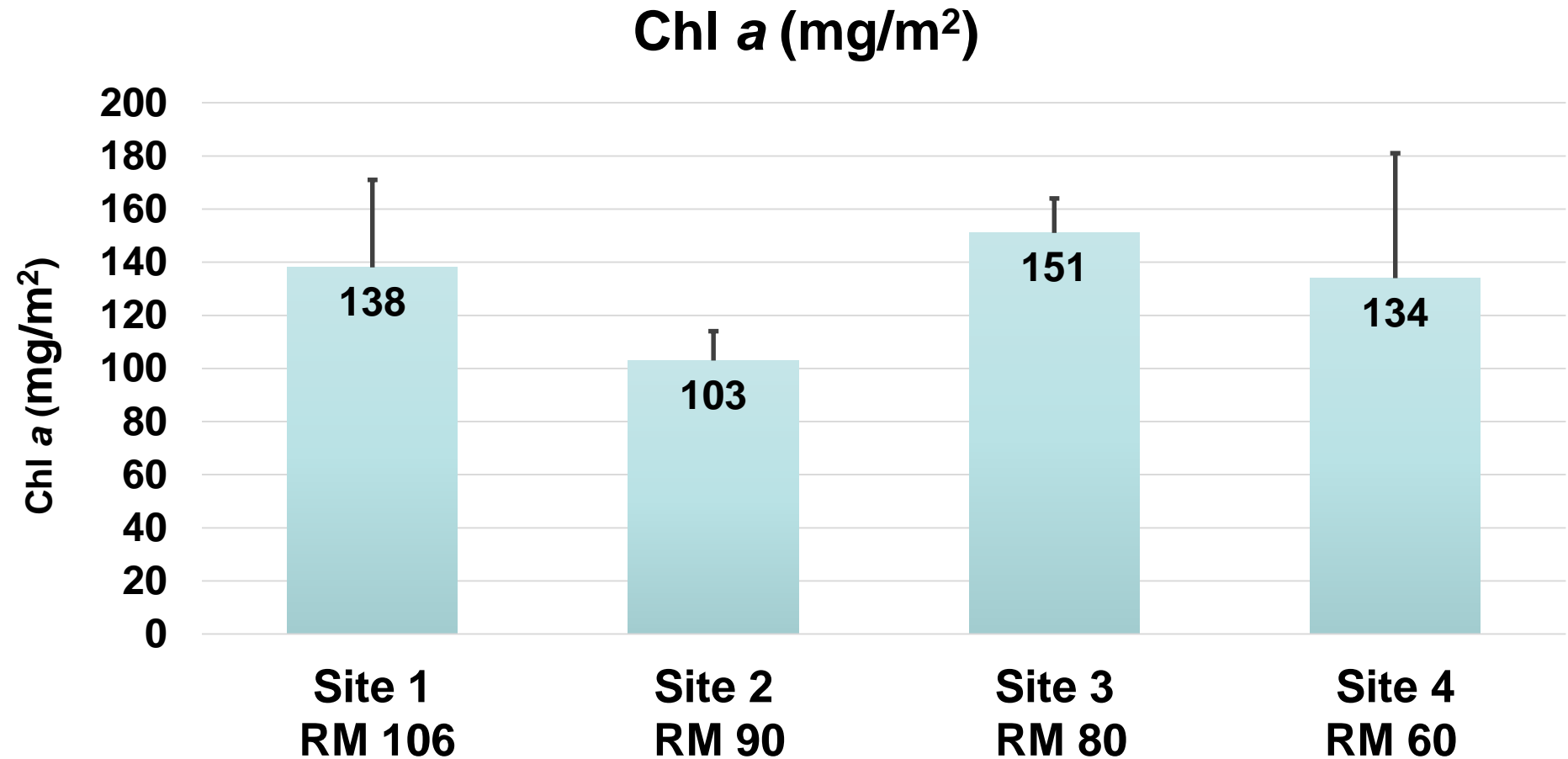
- are > than the threshold value (10 g/m<sup>2</sup>) used to designate sites as eutrophic.
- not significantly different.





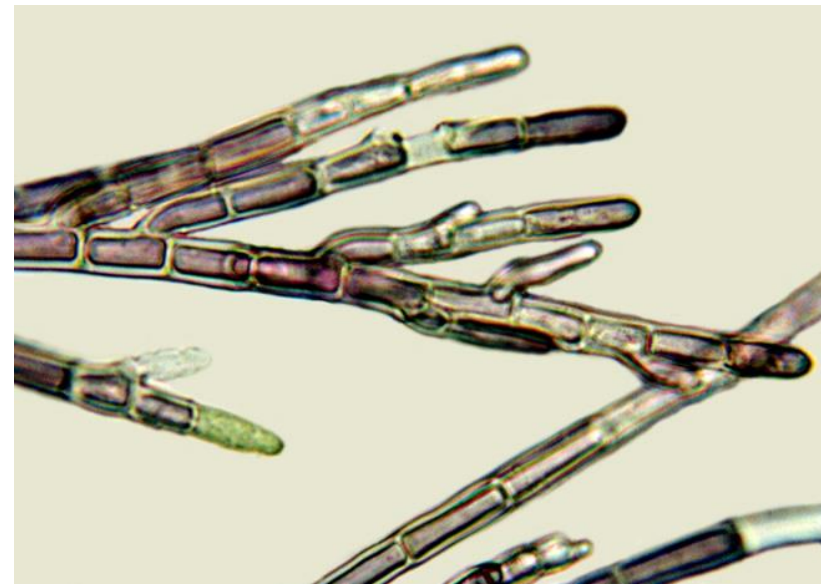
## Periphyton [chl *a*]

- are > than the threshold value (70 mg/m<sup>2</sup>) used to designate sites as eutrophic.
- not significantly different.



# Soft-algae taxa

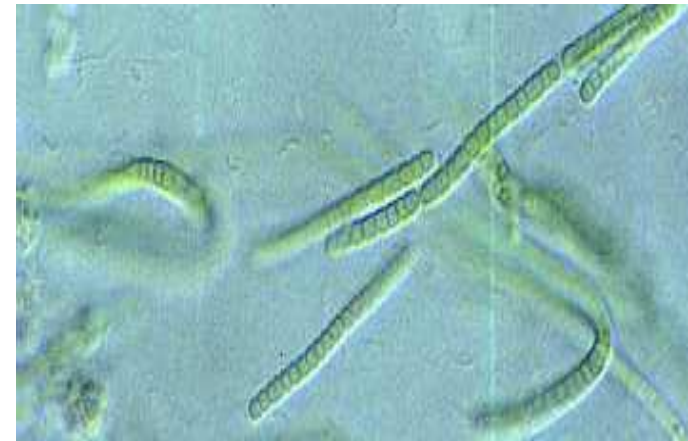
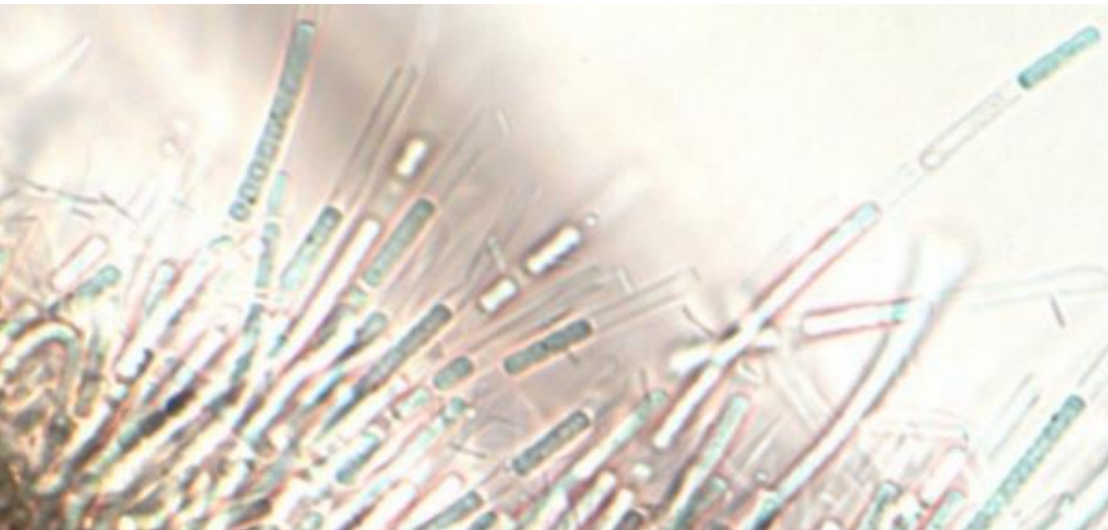
- 92 taxa were identified and % composition at each site determined.
- most abundant overall were:
  - *Audouinella hermannii* (16 %)
    - due to high abundance at the 3 lowermost sites.
    - an indicator of eutrophic conditions.



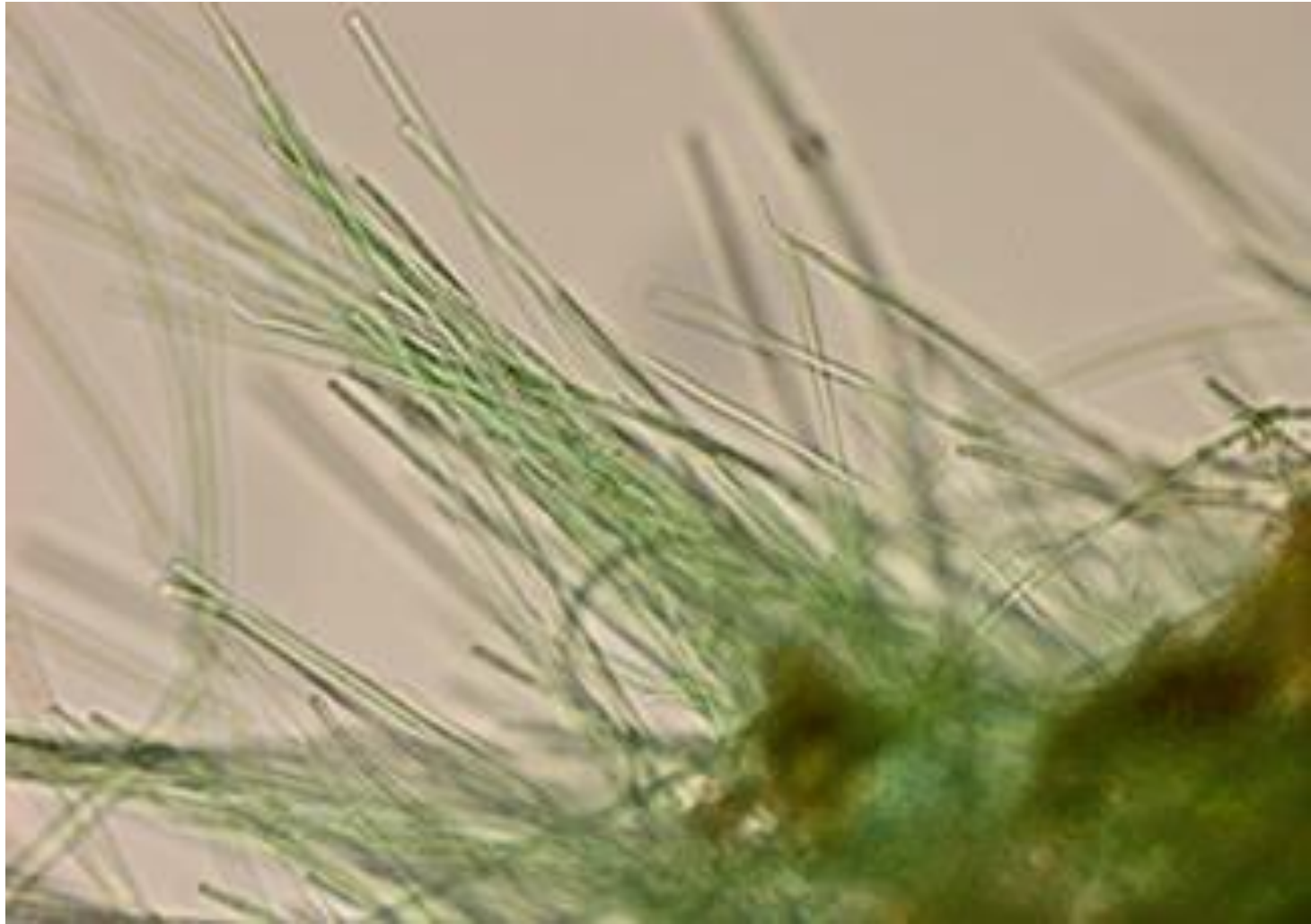


# Soft-algae taxa

- 92 taxa were identified and % composition at each site determined.
- most abundant overall were:
  - *Audouinella hermannii* (16 %)
    - due to high abundance at the 3 lowermost sites.
    - an indicator of eutrophic conditions.
  - *Leptolyngbya fovularum* (11 %)



- *Phormidium diguettii* (10 %)
  - the most abundant taxon at site 1.
  - abundant in oligotrophic and mesotrophic conditions.





- numerous taxa were identified not previously known to occur in TN:

- *Chilomonas* sp.
- a nonphotosynthetic Cryptophyta.



- *Paulinella chromatophora*
  - Rhizaria supergroup, Phylum Cercozoa.
  - has primitive, cyanobacteria-like chloroplasts.

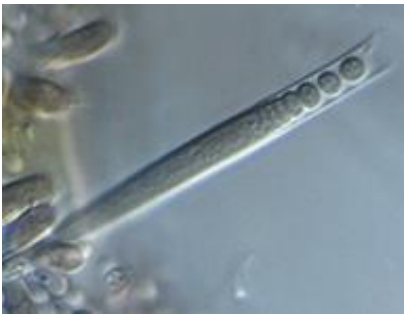




# Algae Trophic Index (ATI)

- calculated to evaluate the impact of trophic state.

$$\text{ATI}_{\text{site}} = \frac{\sum_{\text{all taxa}} [\text{a taxon's abundance} \times \text{taxon's trophic indicator value}]}{\text{total no. of algae}}$$

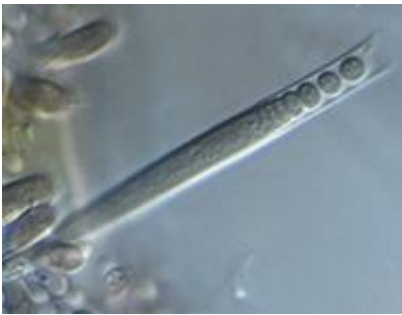


# Algae Trophic Index (ATI)

- calculated to evaluate the impact of trophic state.

$$ATI_{\text{site}} = \frac{\sum_{\text{all taxa}} [\text{a taxon's abundance} \times \text{taxon's trophic indicator value}]}{\text{total no. of algae}}$$

- trophic indicator value
  - = abundance-weighted average for chl *a* for taxa in middle TN streams (Grimmett and Lebkuecher 2017, J. Freshwater Ecology).
  - if a species is more abundant at sites with high [chl *a*], that sp. has a high trophic indicator value.

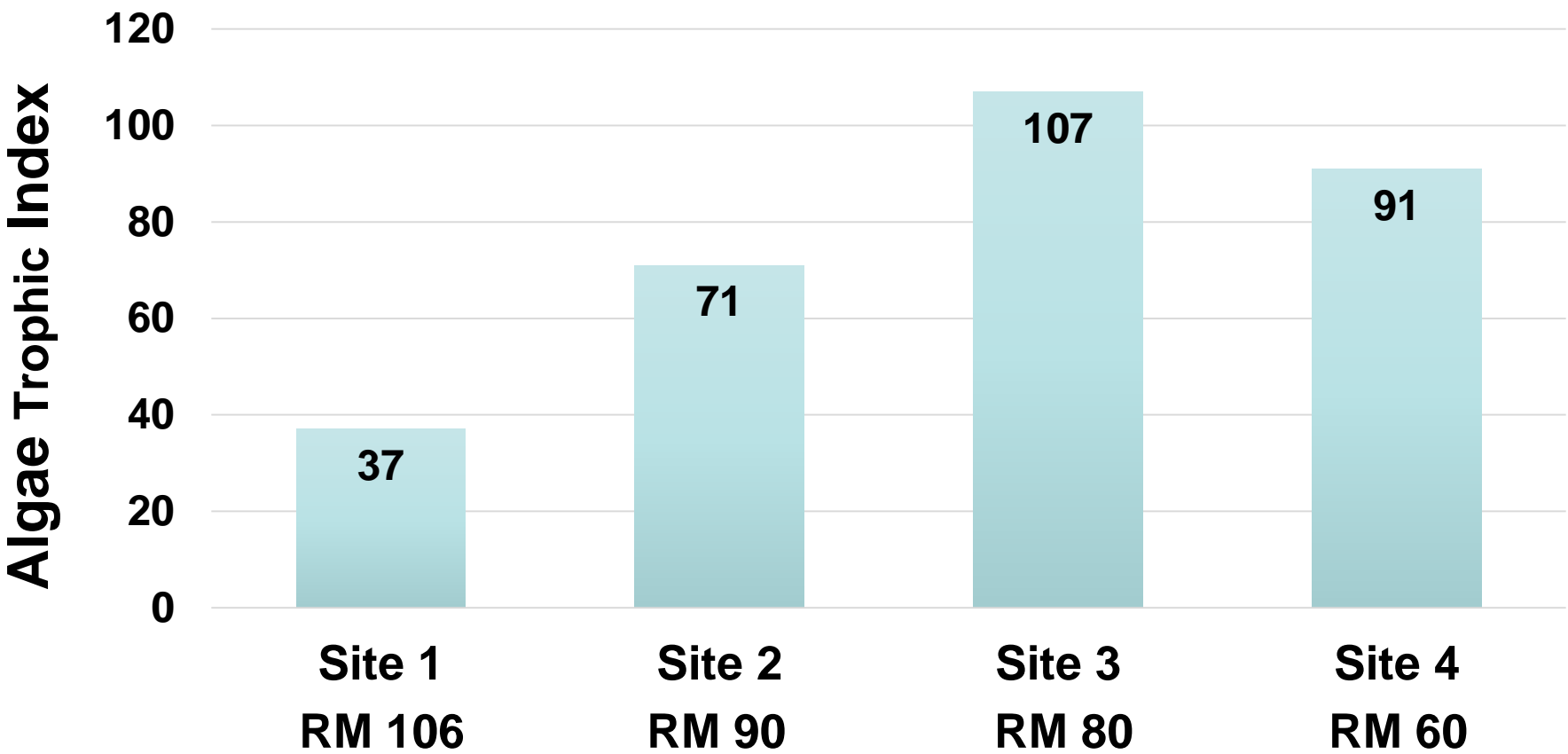




ATI values for the assemblages

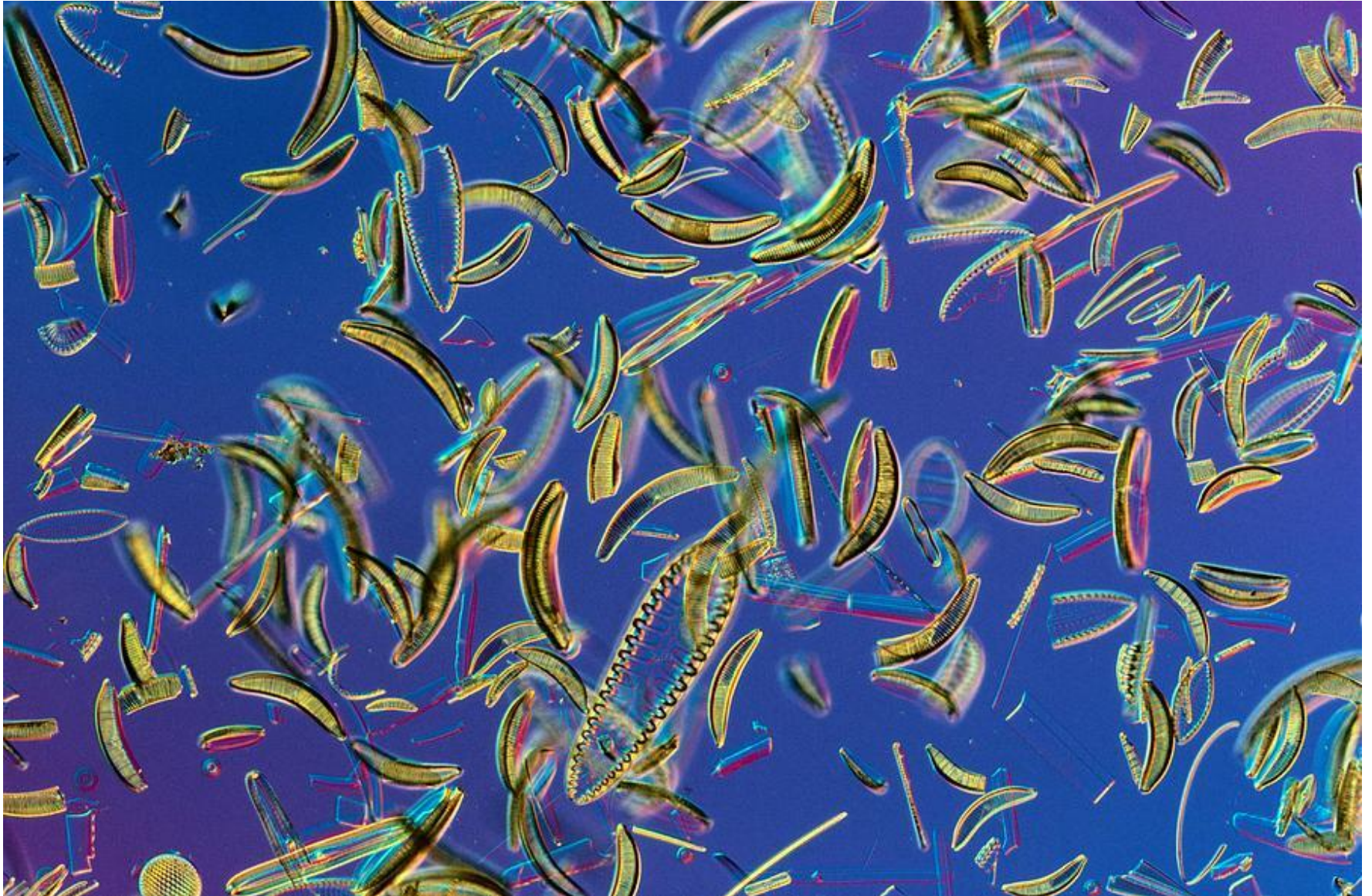
- indicate that site 3 is most impacted by nutrient enrichment.

**Algae Trophic Index**



# Diatoms

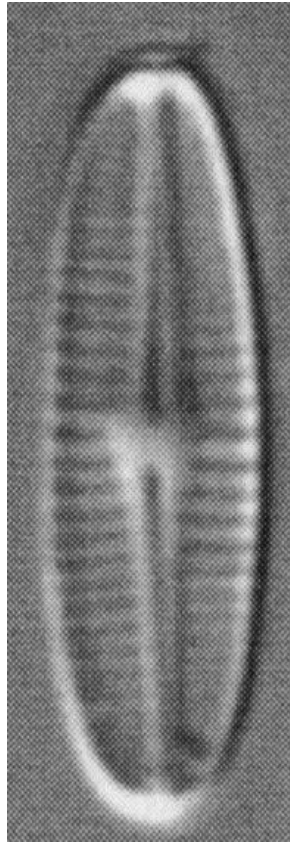
- 94 diatom taxa were identified and % composition determined for each site.





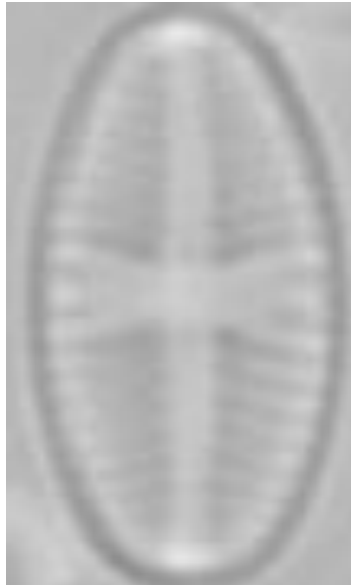
# Diatoms

- 94 diatom taxa were identified and % composition determined for each site.
- most abundant overall were:
  - *Achnanthes rivulare* (10.4 %)
  - common throughout SE U.S.



# Diatoms

- 94 diatom taxa were identified and % composition determined. for each site.
- most abundant overall were:
  - *Achnanthes rivulare* (10.4 %)
    - common throughout SE U.S.
  - *Navicula minima* (7.6 %)
    - indicator of eutrophic habitats.





# Diatoms

- 94 diatom taxa were identified and % composition determined. for each site.
- most abundant overall were:
  - *Achnanthes rivulare* (10.4 %)
    - common throughout SE U.S.
  - *Navicula minima* (7.6 %)
    - indicator of eutrophic habitats.
  - *Cymbella affinis* (6.8 %)
    - most abundant at site 1.
    - more abundant in oligotrophic and mesotrophic water.



# Pollution Tolerance Index for Diatom Assemblages (PTI)

- calculated to determine impact of trophic state.
- used to infer trophic state of stream sites.

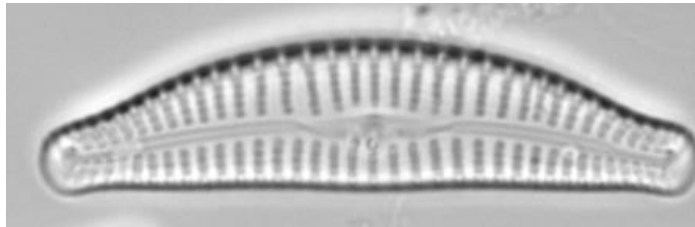




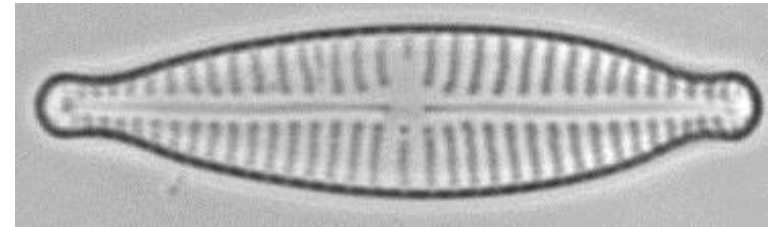
$$PTI = \frac{\sum_{\text{all taxa}} [\text{taxon's abundance} \times \text{the taxon's trophic-indicator value}]}{\text{total no. of diatoms}}$$

- Trophic-indicator values range from 4 to 1.

*Cymbella affinis* = 4  
(in oligotrophic water)



*Gomphonema parvulum* = 1  
(in eutrophic water)

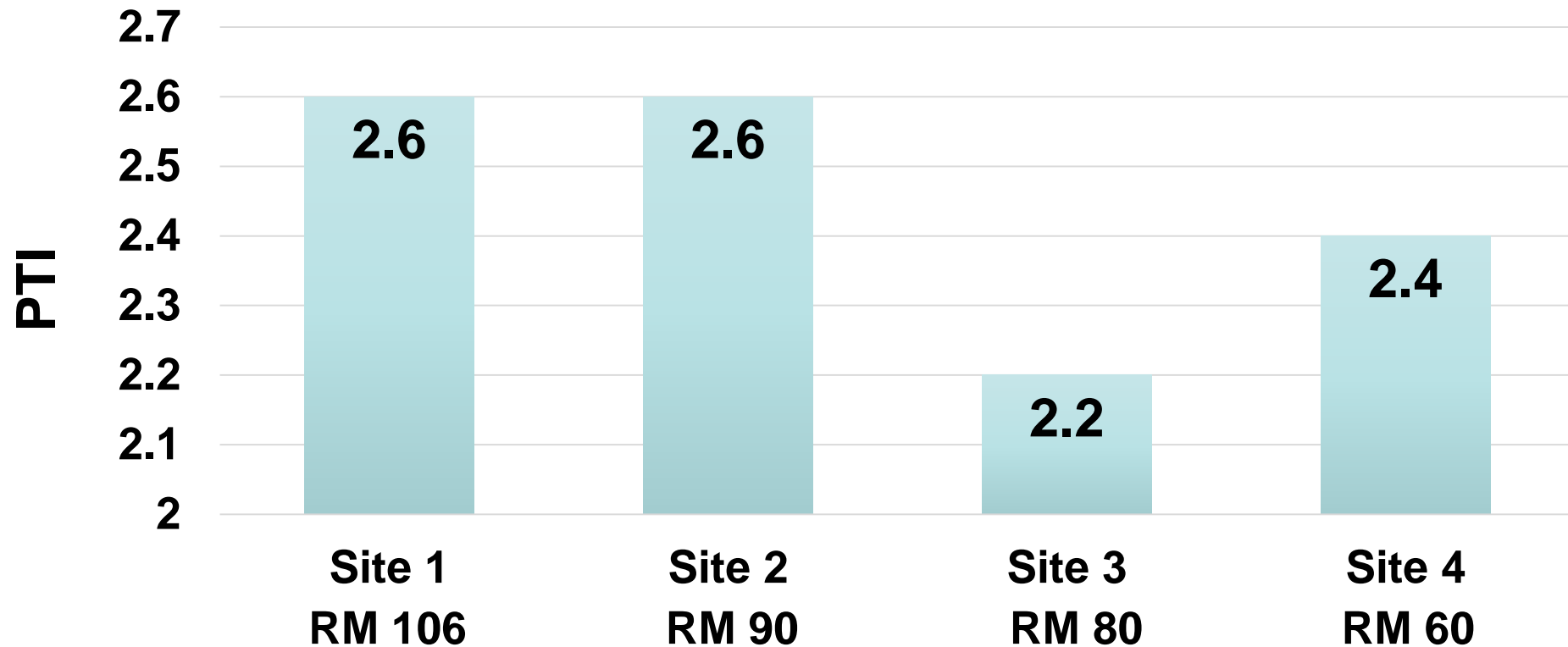


PTI

- ranges from 4 to 1.
- sites w/ numerous taxa w/ low trophic indicator values have low PTI values.

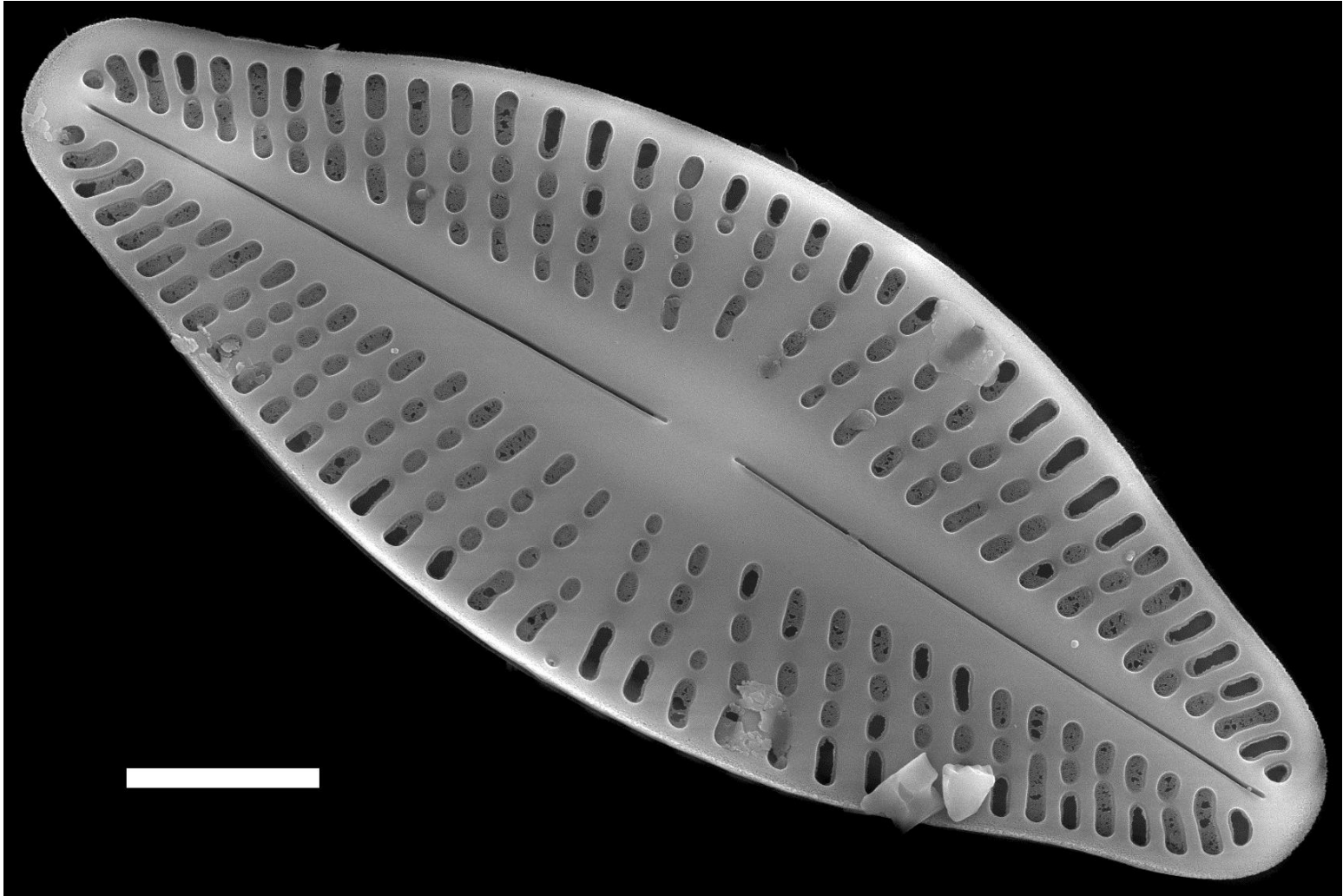
## Values for the PTI

- $\leq 2.6$  indicate eutrophic environments.
- indicate:
  - the sites are impacted by nutrient enrichment.
  - site 3 is the most nutrient impaired.



# Motile diatoms

- have a raphe (longitudinal slit in glass wall).



*Karia cleve*, scanning electron micrograph, 1000 X



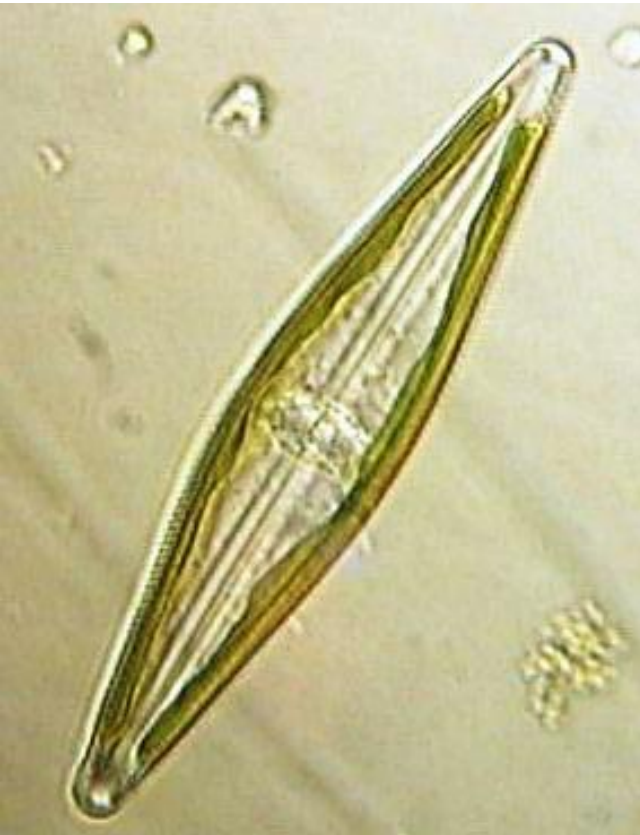
# Motile diatoms

- have a raphe (longitudinal slit in glass wall).
- able to avoid being buried by sediments.
- abundant at sites covered w/ sediments.



# Siltation Index

= % motile diatoms of the genera *Navicula*, *Nitzschia*, *Surirella*.



*Navicula*



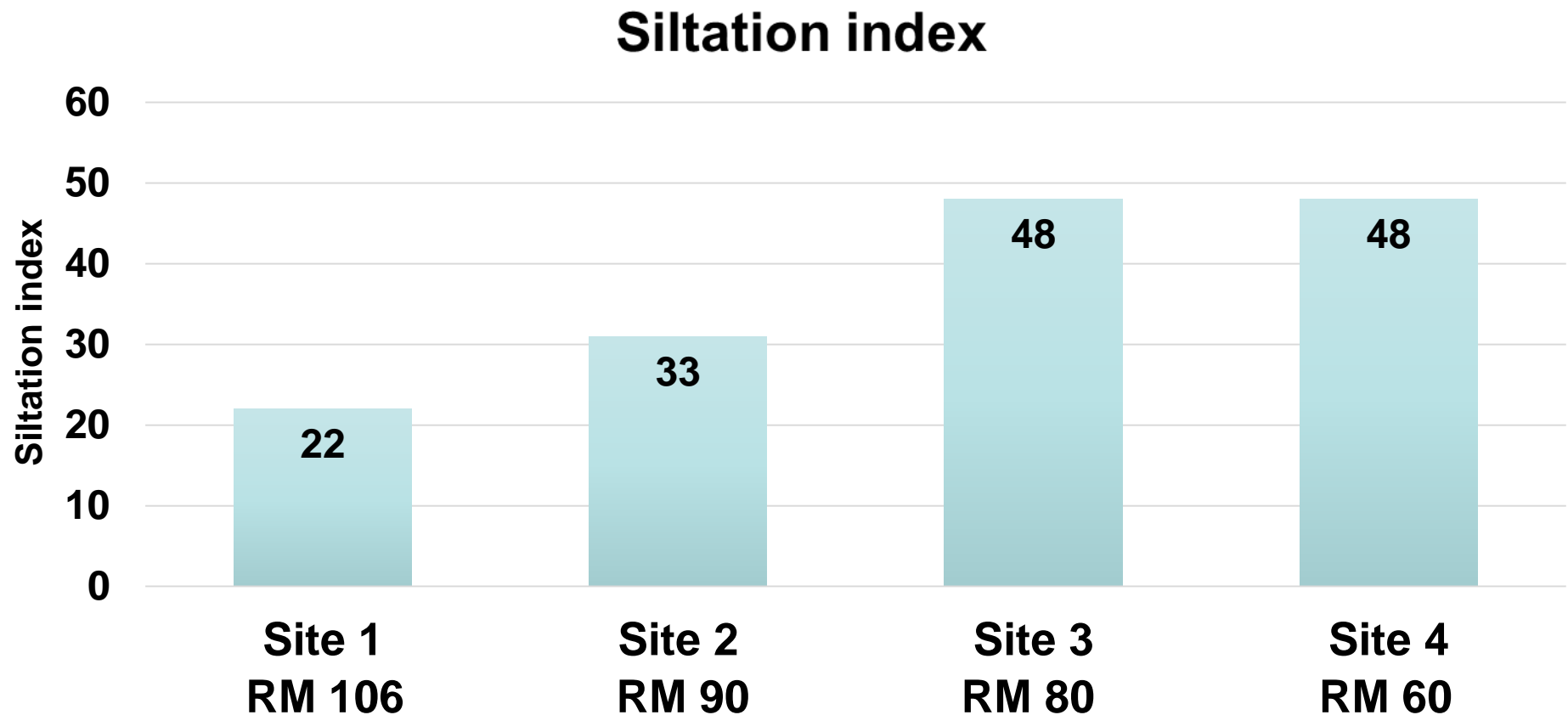
*Nitzschia*



*Surirella*

# Values for the Siltation Index

- > 40 indicate a negative impact of excessive sediments.
- are greatest for sites 3 and 4.
- indicate that siltation negatively impacts water quality.





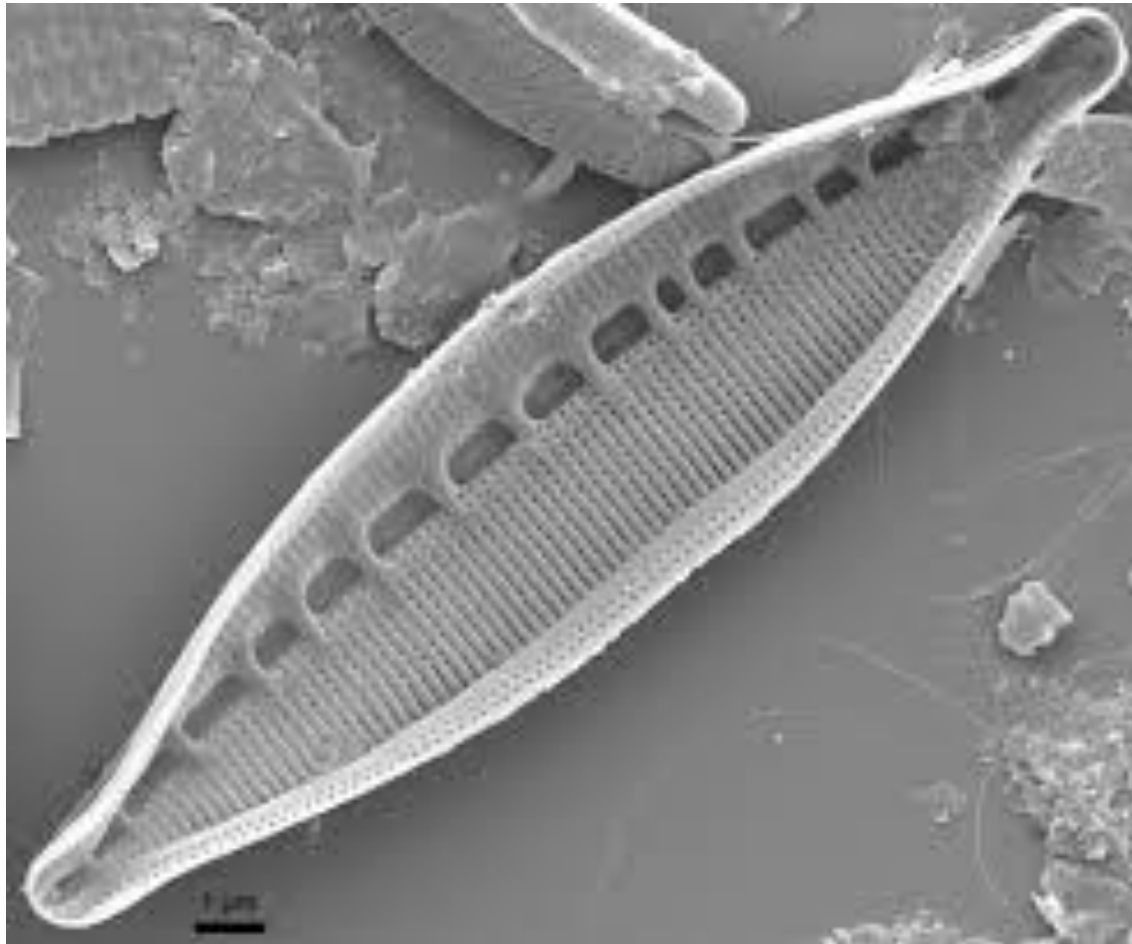
# Organic pollution

- results from erosion of organic soil, input of manure or sewage, and overgrowth of algae.



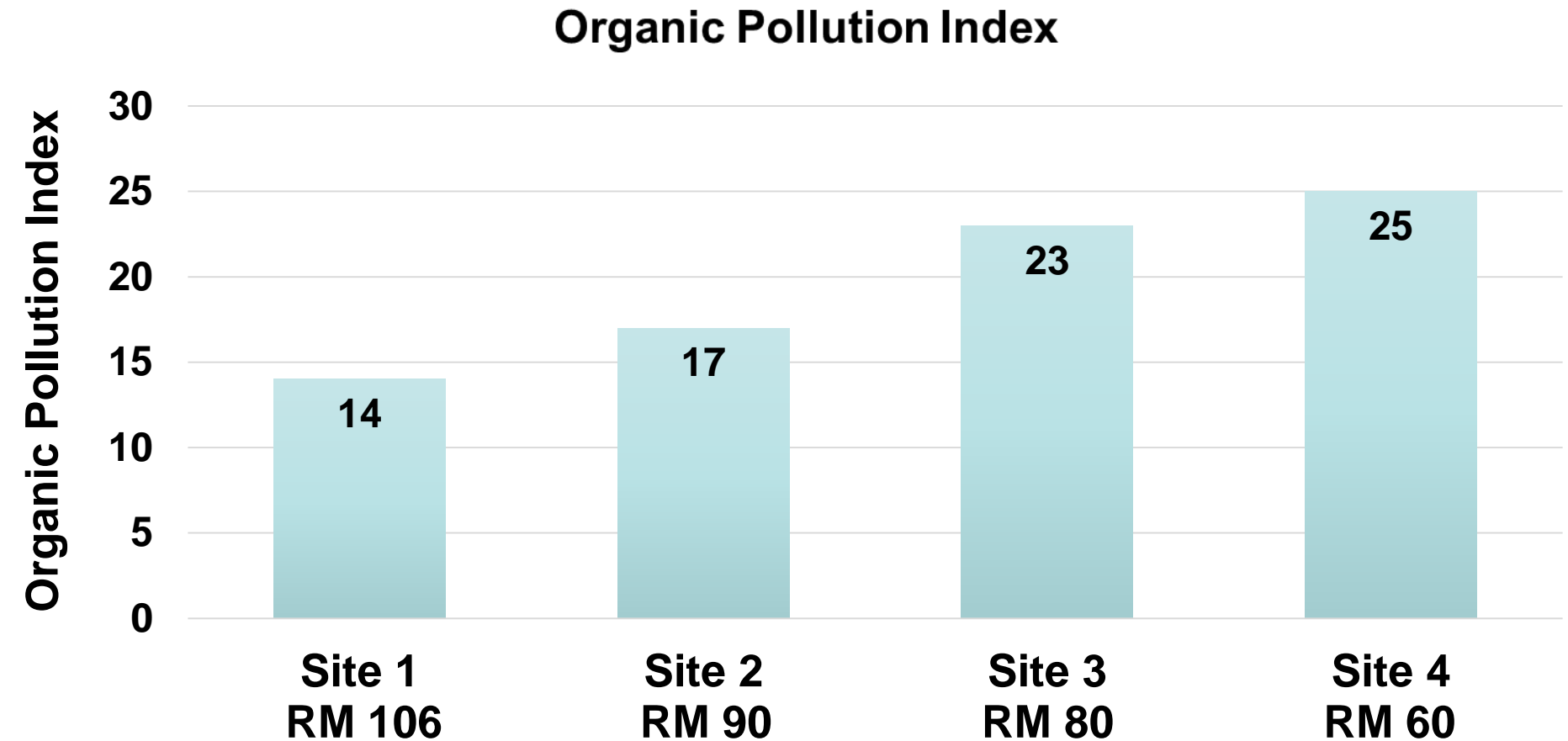
# Organic Pollution Index

= % of diatoms tolerant of organic pollution (includes many *Nitzschia* sp.).



# Values for the Organic Pollution Index

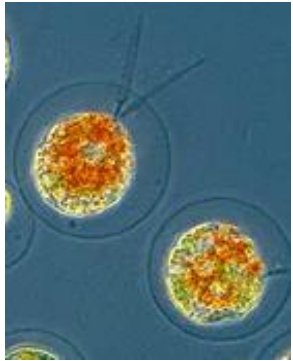
- > 20 suggest a negative impact of high [organics].
- sites 3 and 4 are negatively impacted by high [organics].





# Conclusions

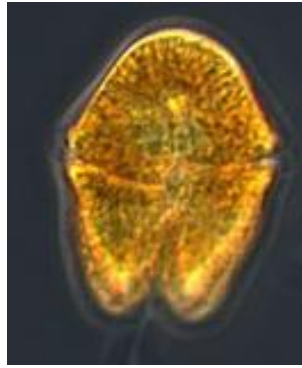
- 186 taxa of algae were identified and % composition determined.



*Haematococcus*



*Staurastrum*



*Gymnodinium*



*Synura*



*Chroococcus*



*Bulbochaetae*



*Cosmarium*



*Phacus*

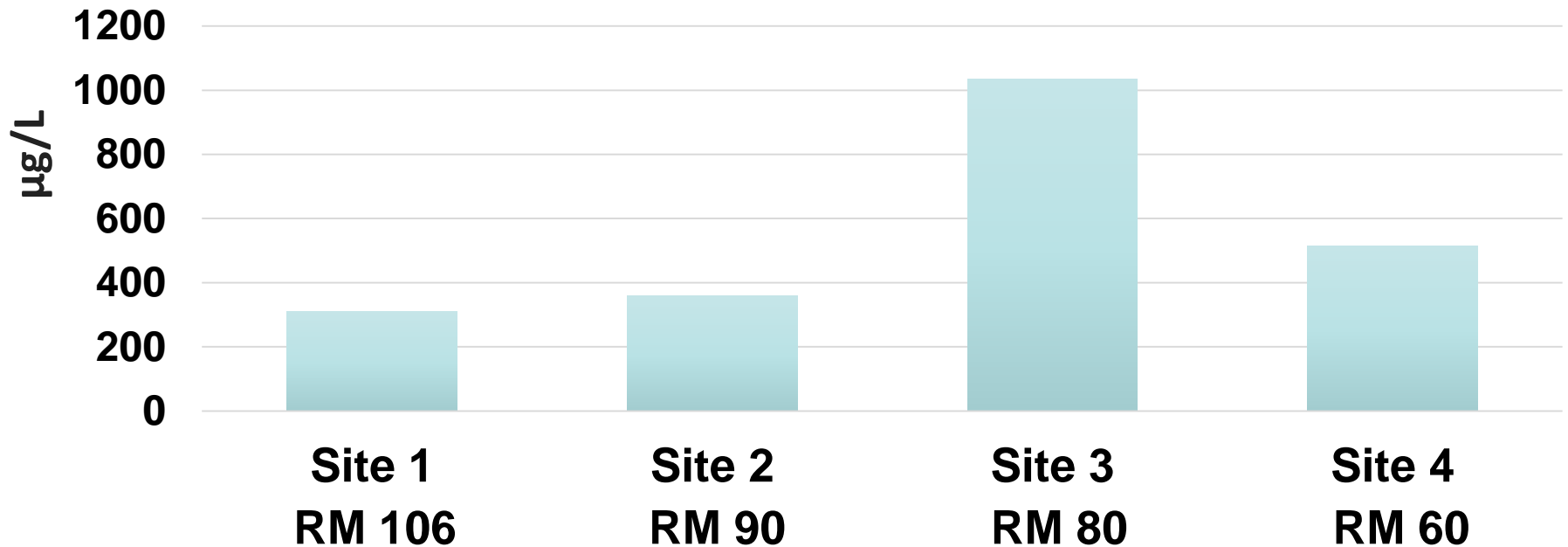


*Colacium*

# Conclusions

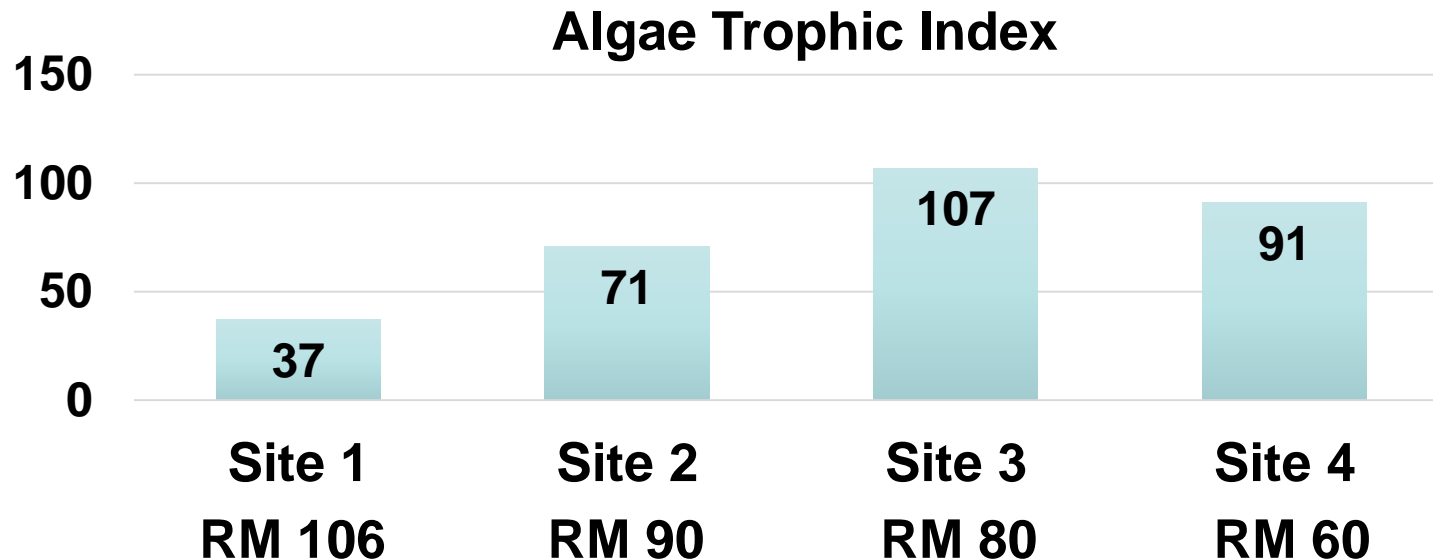
- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
  - site 3:
    - greatest [TP].

[Total Phosphorus] ( $\mu\text{g/L}$ ) of Water



# Conclusions

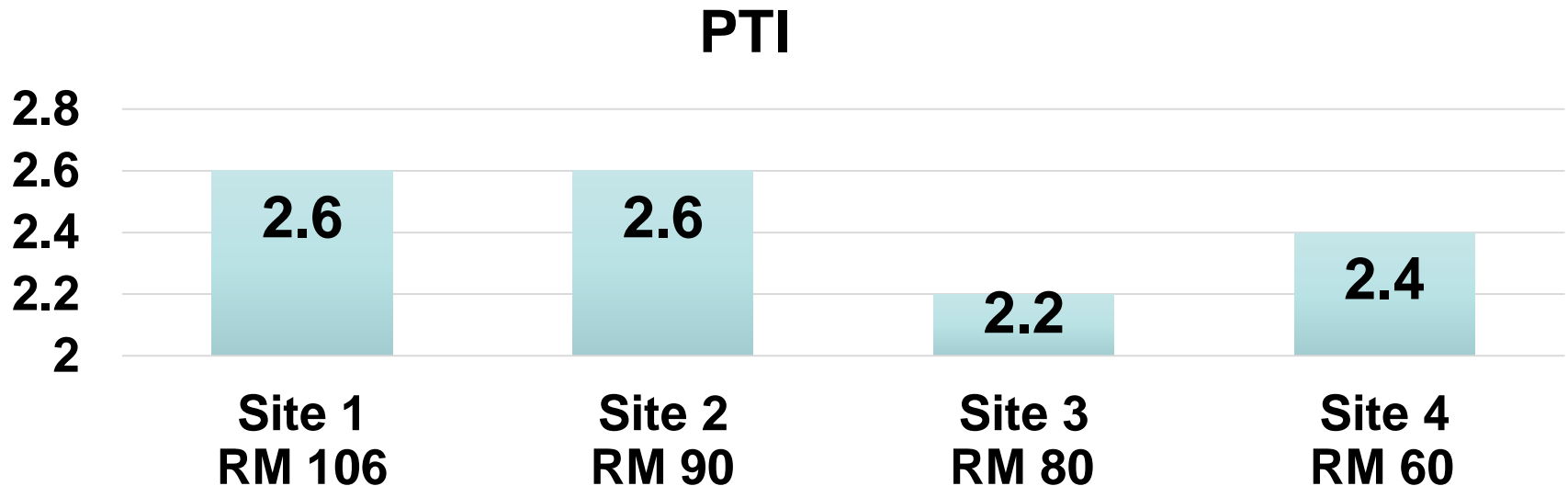
- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
  - site 3:
    - greatest [TP].
    - greatest ATI value.



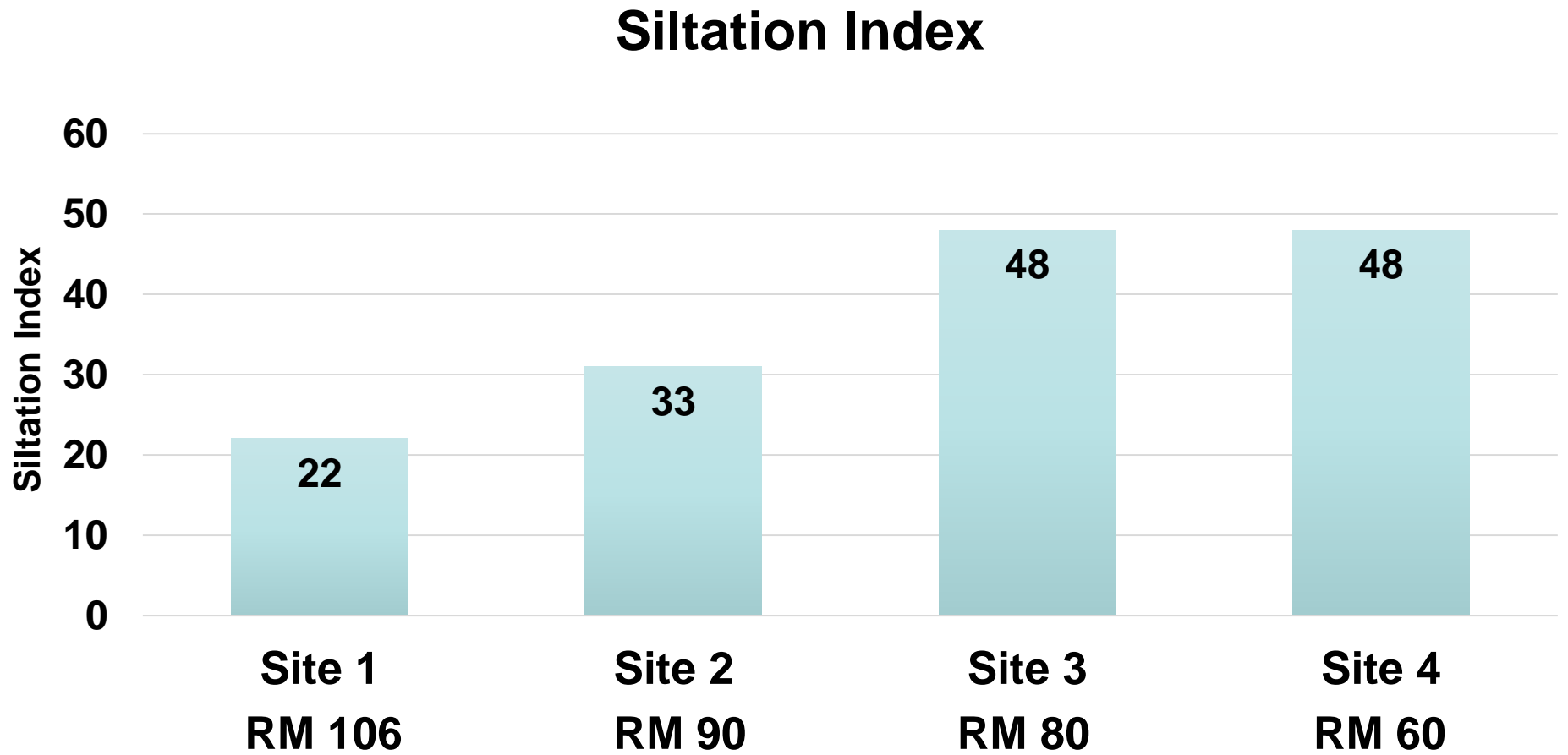


# Conclusions

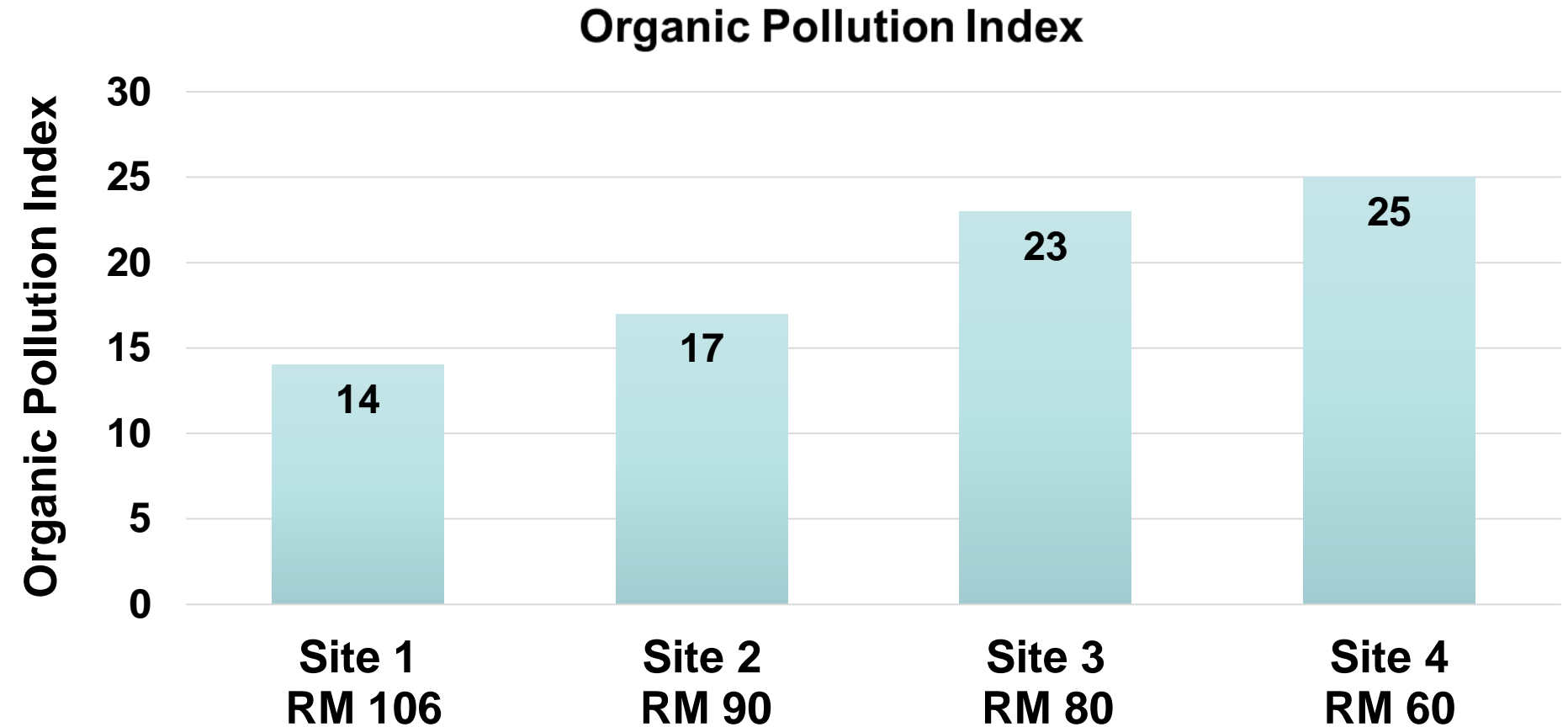
- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
  - site 3:
    - greatest [TP].
    - greatest ATI value.
    - lowest PTI value.



- sites 3 and 4:
  - greatest Siltation Index values.



- sites 3 and 4:
  - greatest Siltation Index values.
  - greatest Organic Pollution Index values.





# Acknowledgements

- Funding was provided by:
  - The Harpeth Conservancy.
  - Biology Department of Austin Peay State University

