Effect of lakeshore development on oligotrophic lakes in northeastern Vermont

Eric Howe, Leslie Matthews, Kellie Merrell & Susan Warren

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Water Quality Division

NEAEB 2007

Presentation outline

- Background: land use changes
- Need for study
- Project objectives
- Methods
- Results
- Conclusions
- What's up next

Land use changes in Vermont

Pre-1850s

Land use changes in Vermont

Pre-1850s

1880s

Land use changes in Vermont

Pre-1850s

1880s

1920s

Land use changes in Vermont

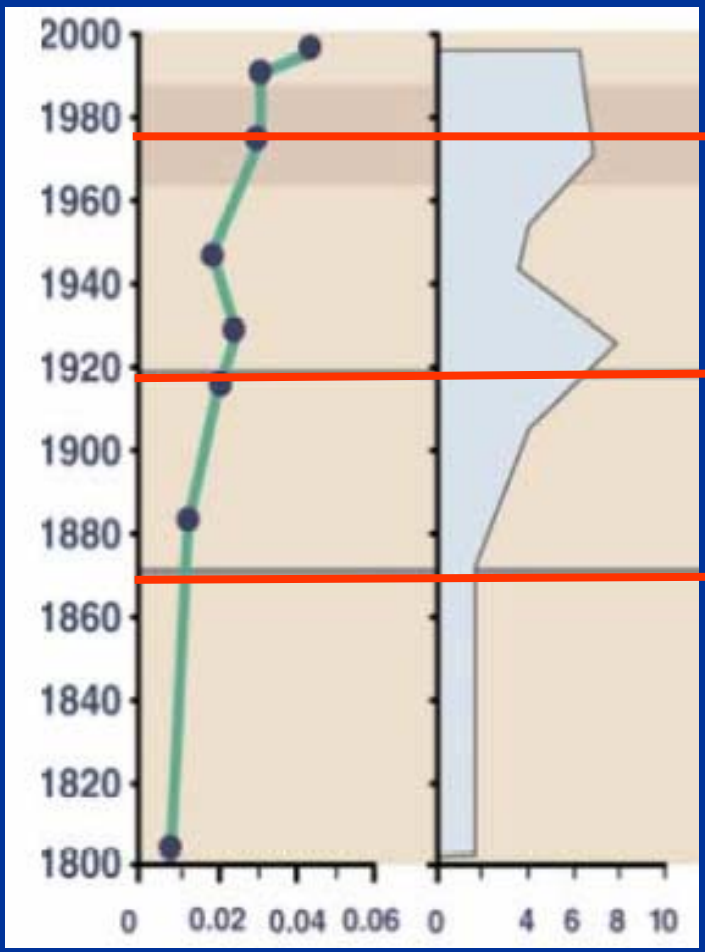
Pre-1850s

1880s

1920s

1980s

Land use changes



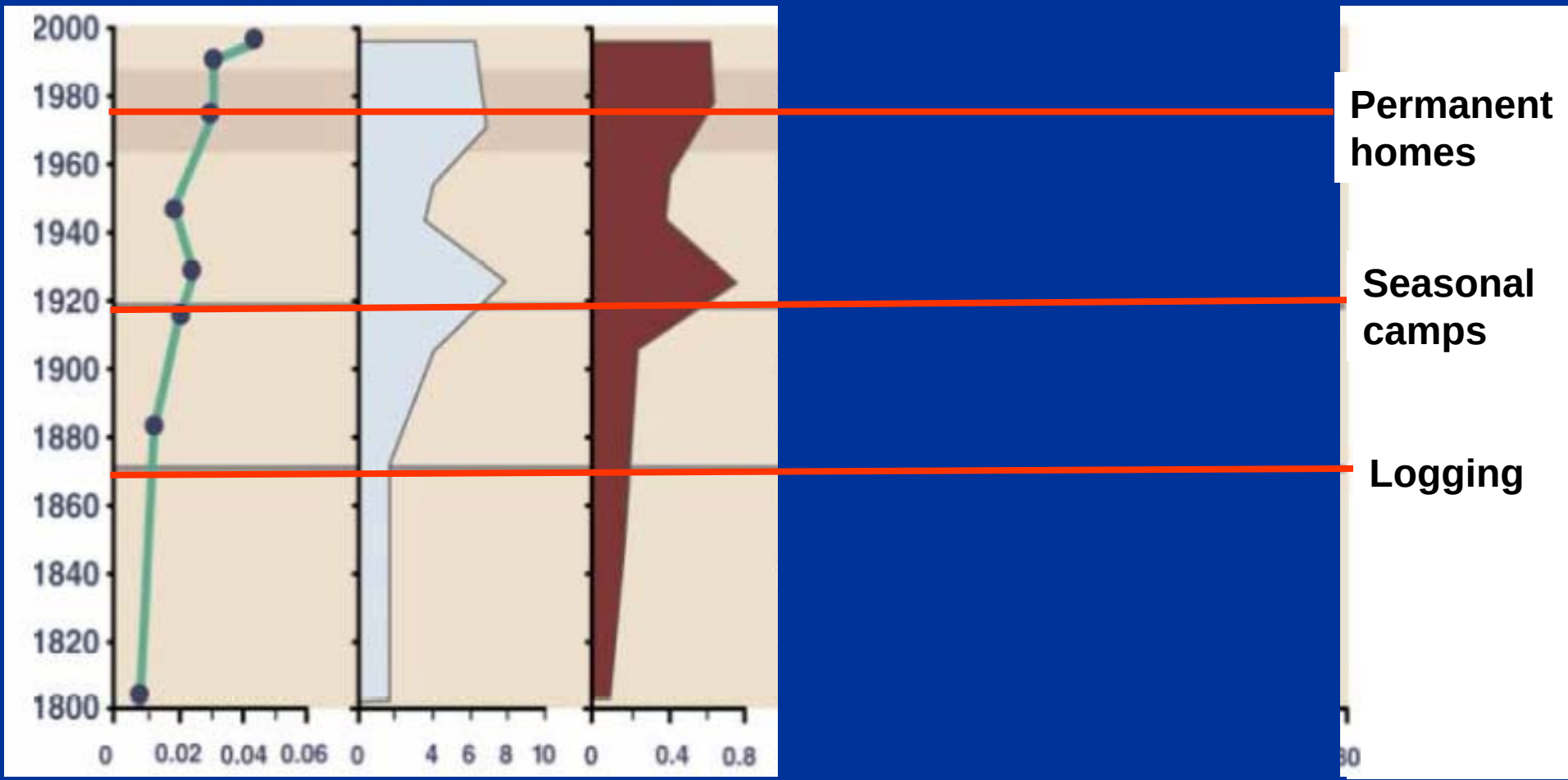
Permanent homes

Seasonal camps

Logging

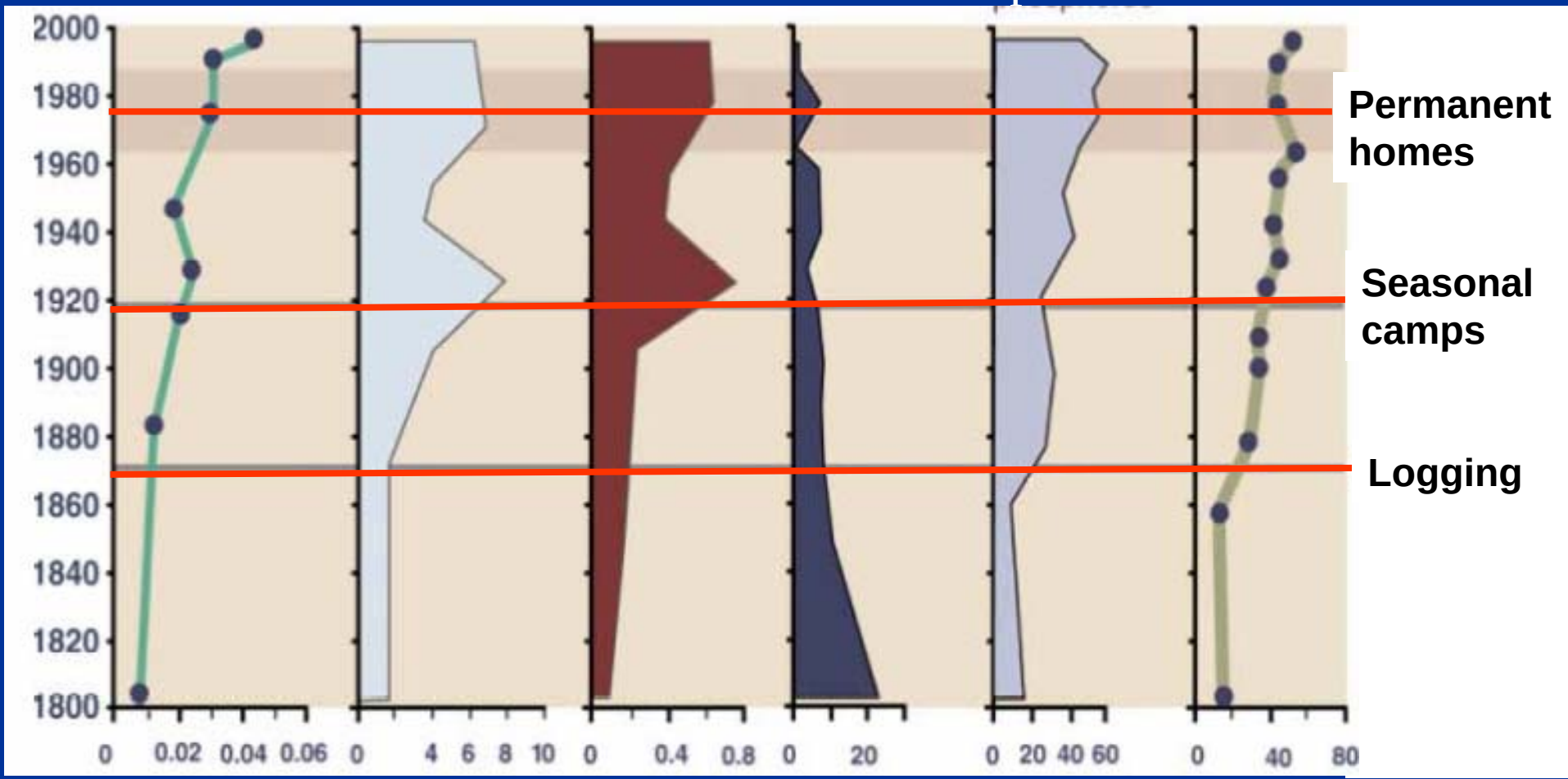
Garrison & Wakeman (2000)

Land use changes



Garrison & Wakeman (2000)

Land use changes



Garrison & Wakeman (2000)

Need for Study

- Several studies in Wisconsin
  - Jennings et al. 2003, Emmons et al. 1999, others
  - Found significant effects of shoreline development for macrophytes, woody debris, fishes, birds, frogs

- None to date in Vermont!
  - No shoreline buffer laws in Vermont
  - Same response to shoreline development as Wisconsin lakes?

Study Objectives

1. Measure the affect of shoreland development on lentic littoral systems.

Study Objectives

1. Measure the affect of shoreland development on lentic littoral systems.

2. Enhance lake assessment protocols: quantitative method to assess littoral zone habitat health.

Study Objectives

1. Measure the affect of shoreland development on lentic littoral systems.

2. Enhance lake assessment protocols: quantitative method to assess littoral habitat health.

3. Develop a quantitative aquatic plant biotic index.

4. Collect Vermont specific information for outreach & mitigation

Study Objectives

1. Measure the affect of shoreland development on lentic littoral systems.

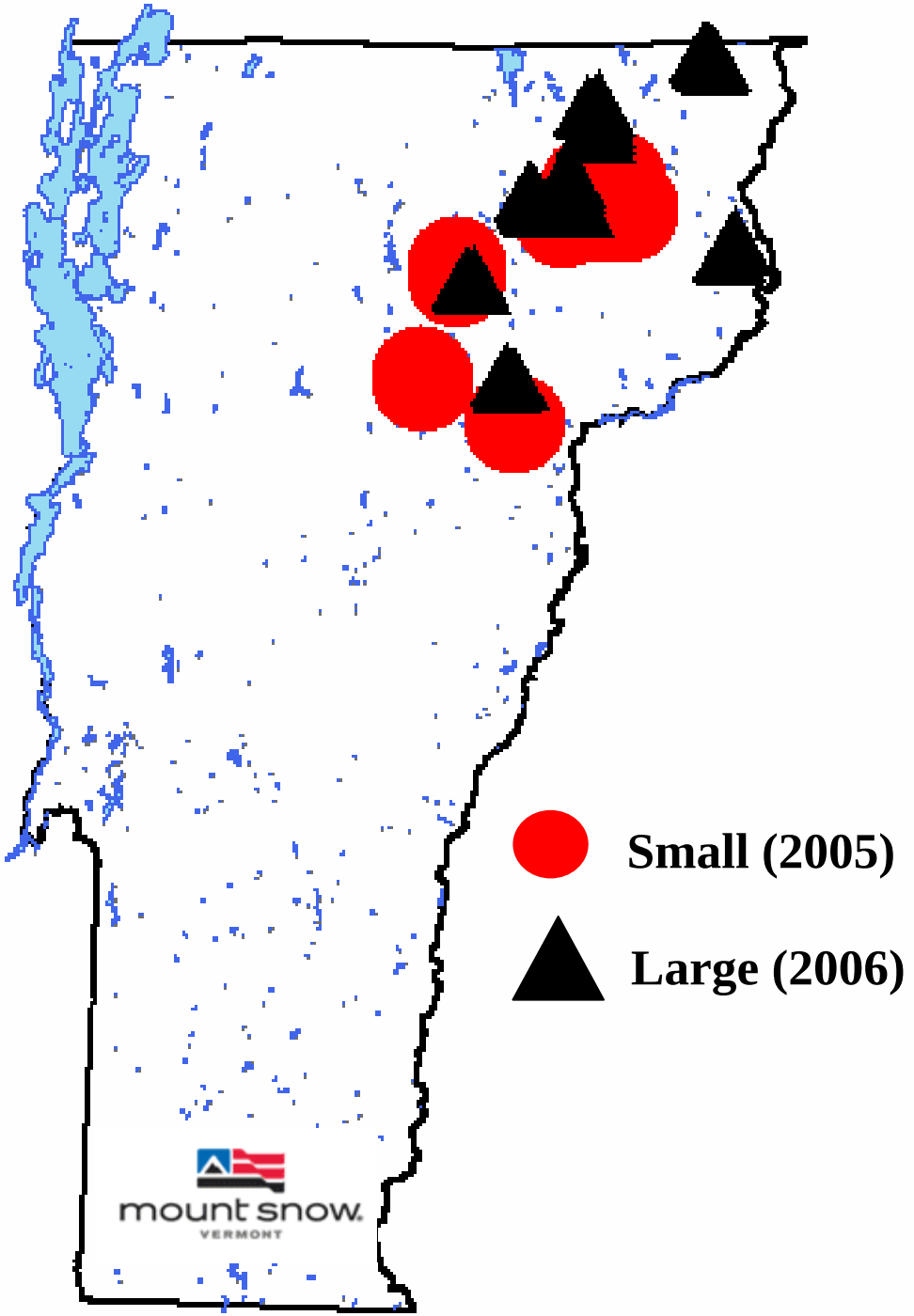
2. Enhance lake assessment protocols: quantitative method to assess littoral zone habitat health.

3. Develop a quantitative aquatic plant biotic index.

4. Collect Vermont specific information for I&E to augment findings in peer review literature & other states.

Presentation outline

- Background: land use changes
- Need for study
- Project objectives
- Methods
- Results
- Conclusions
- What's up next



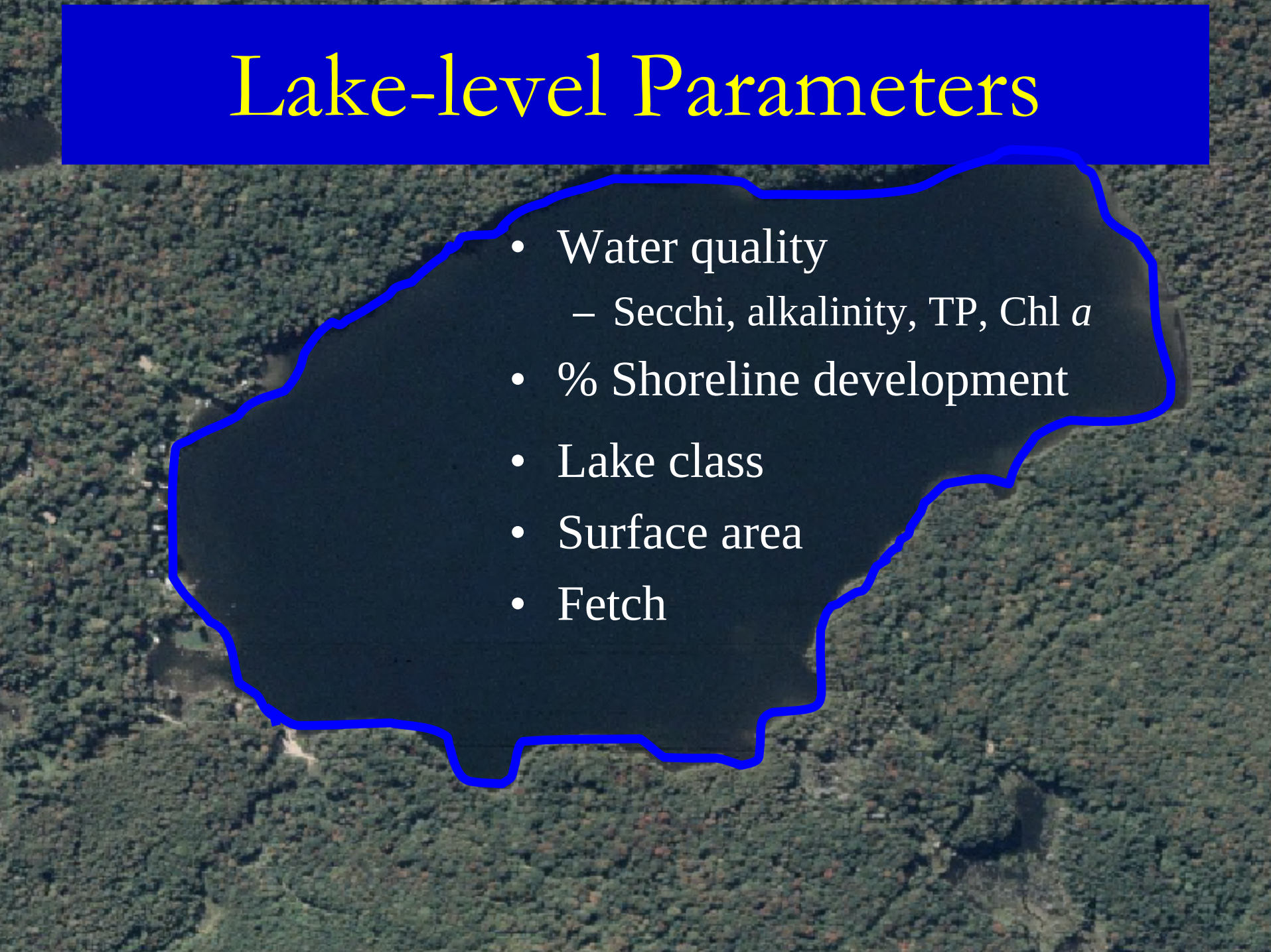
Study sites

- Oligotrophic lakes in NE Kingdom
- Small lakes < 50 ha
- Large lakes > 200 ha
- Alkalinity ~ 35 mg $CaCO_3$ /liter
- No winter drawdown
- Minimal impact by non-natives

Methods

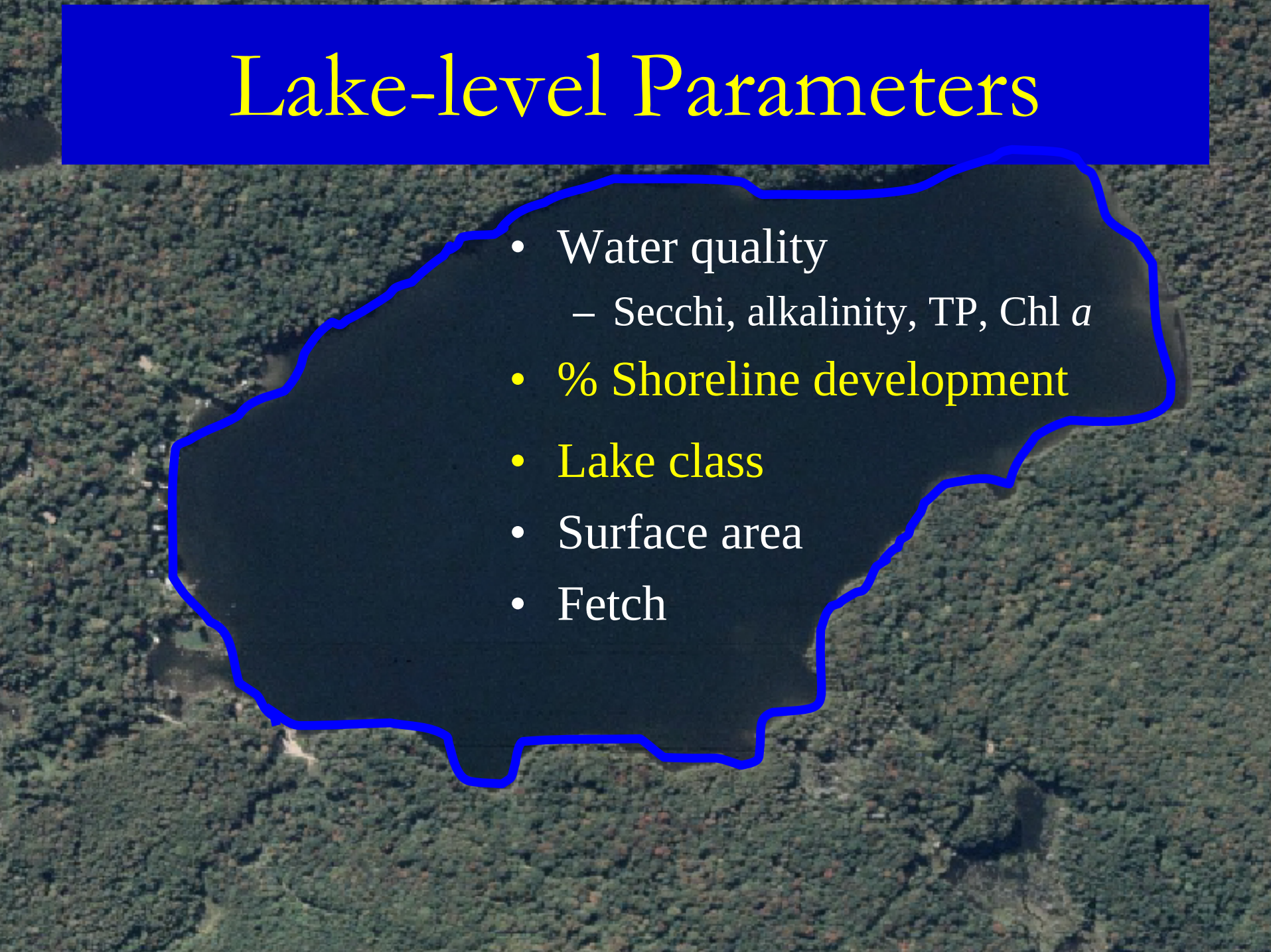
- Data collection at 3 scales
  - Lake-level
  - Site-level
  - Plot-level
- Modeled survey methods after studies in Wisconsin, Maine, & Quebec
  - Jennings et. al 2003, Emmons et. al 1999, Ness M.S. thesis (Maine)

Lake-level Parameters



- Water quality
  - Secchi, alkalinity, TP, Chl *a*
- % Shoreline development
- Lake class
- Surface area
- Fetch

Lake-level Parameters



- Water quality
  - Secchi, alkalinity, TP, Chl *a*
- % Shoreline development
- Lake class
- Surface area
- Fetch

Site-level Parameters

- Riparian vegetation
- Littoral shading
- Coarse woody debris
- Slope (edge of water to 2m depth)

Site-level Parameters

- Riparian vegetation
- Littoral shading
- Coarse woody debris
- Slope (edge of water to 2m depth)

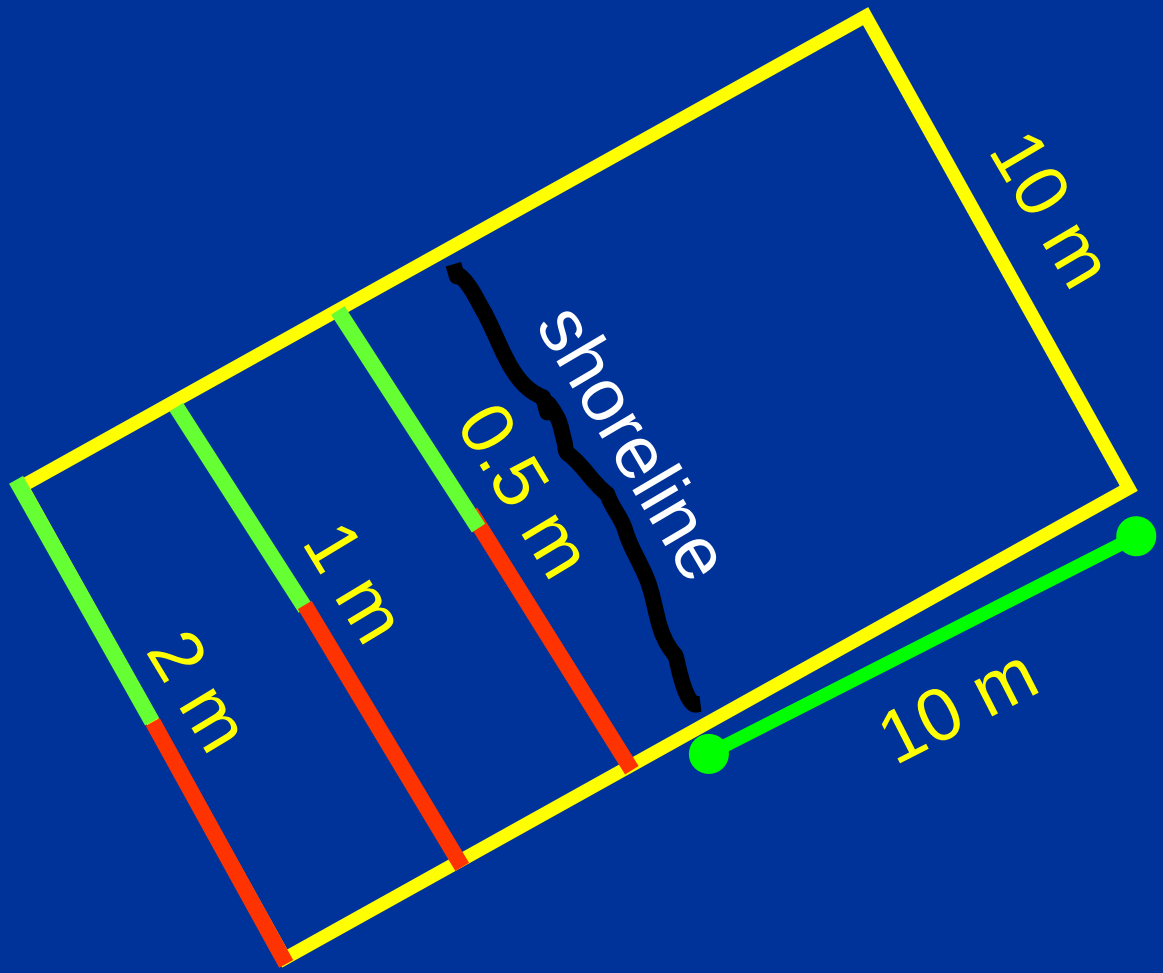
Plot-level Parameters

- Sediment structure
  - type
  - % embeddedness
  - % carbon
- Allochthonous
  - fine, med woody debris
  - leaf litter
- Biota
  - macrophyte structure, aufwuchs, microalgae
  - fish, snail, crayfish, mussel presence

Plot-level Parameters

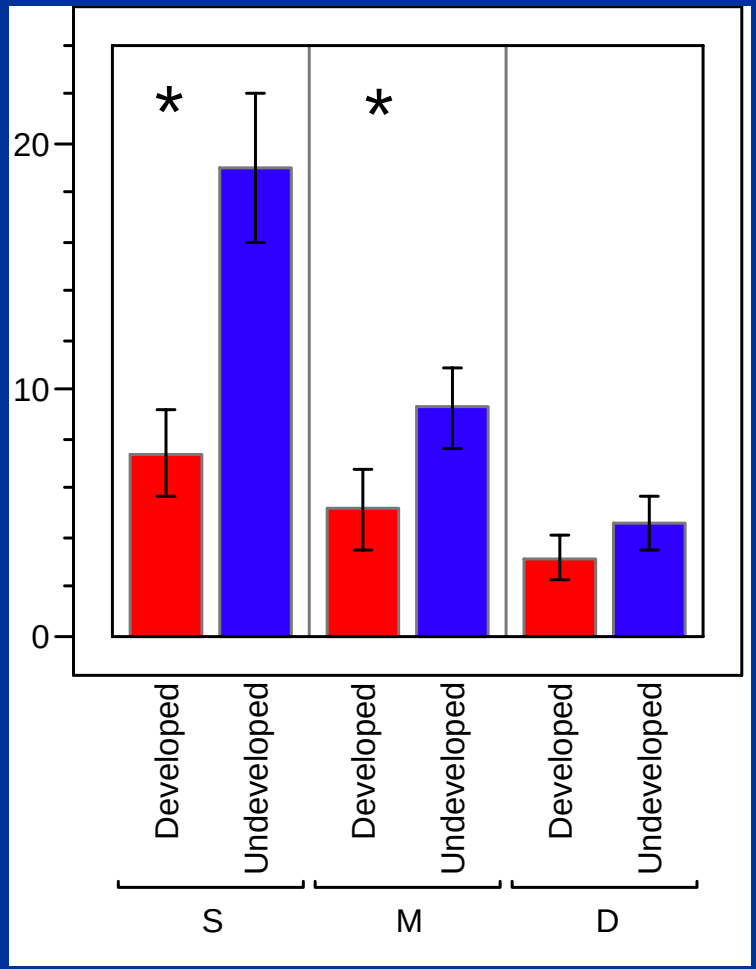
- Sediment structure
  - type
  - % embeddedness
  - % carbon
- Allochthonous
  - fine, med woody debris
  - leaf litter
- Biotic
  - macrophyte structure, aufwuchs, microalgae
  - fish, snail, crayfish, mussel presence

Results
Plot-level

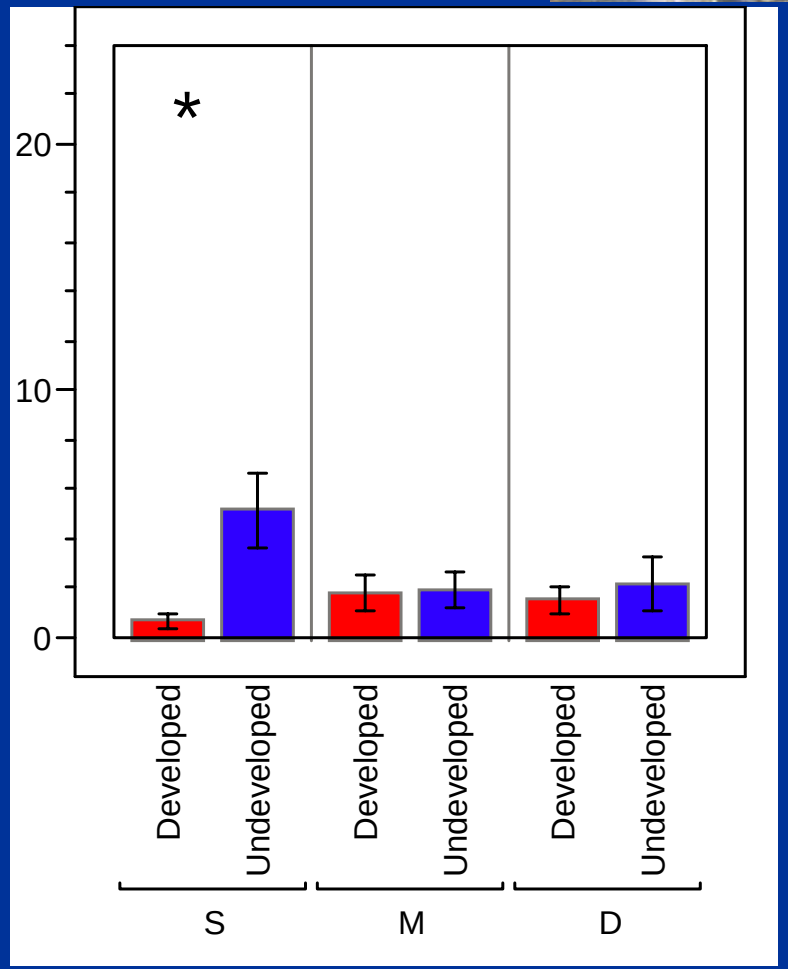


Fine Woody Debris % Cover

Small oligotrophic

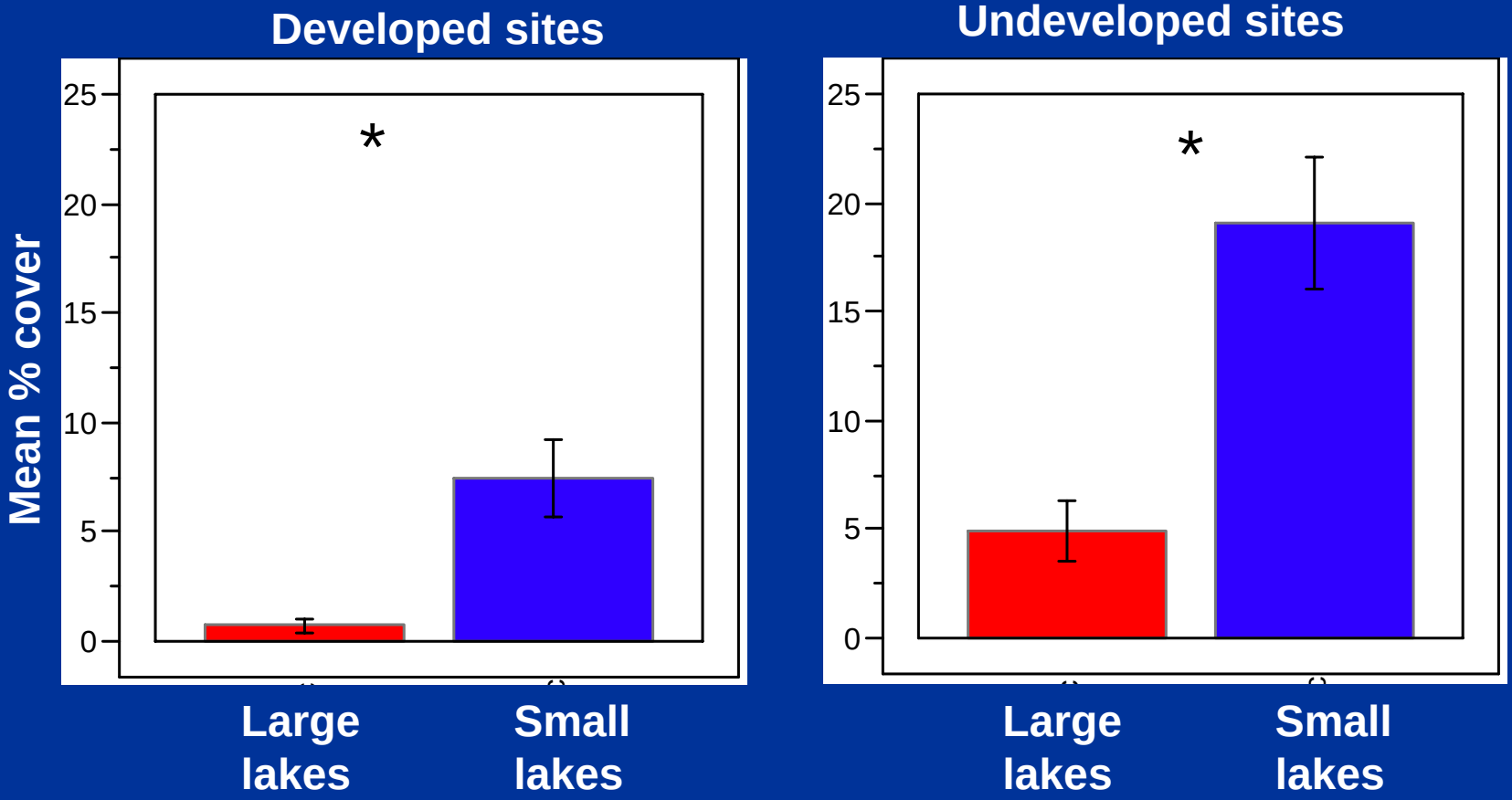


Large oligotrophic



* $p < 0.05$

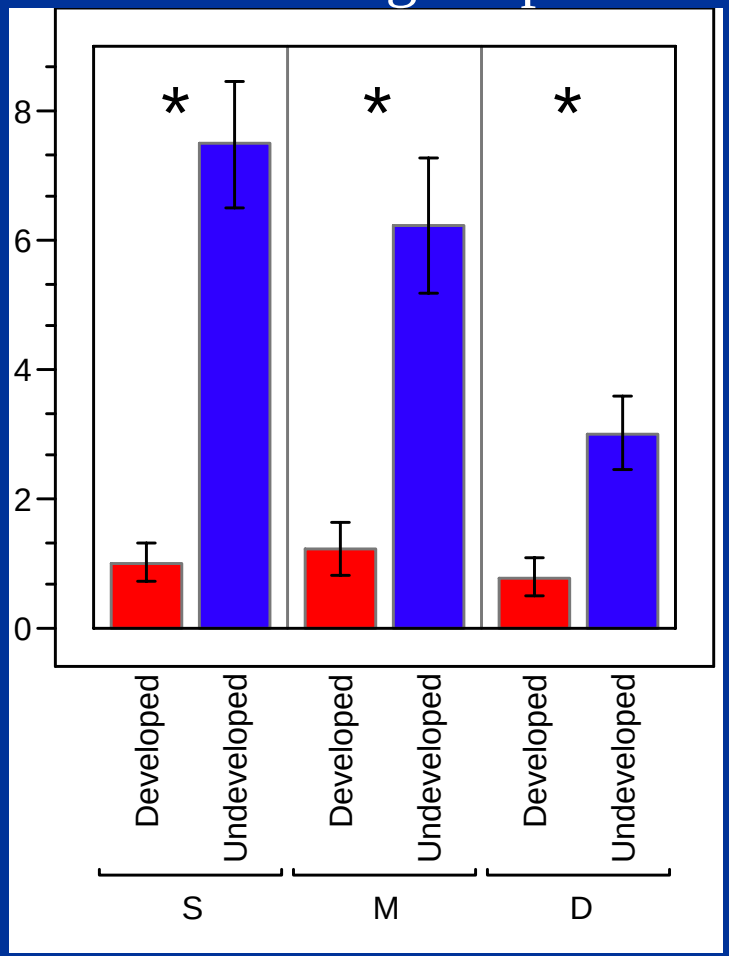
Mean % Cover Fine Woody Debris, Shallow transects



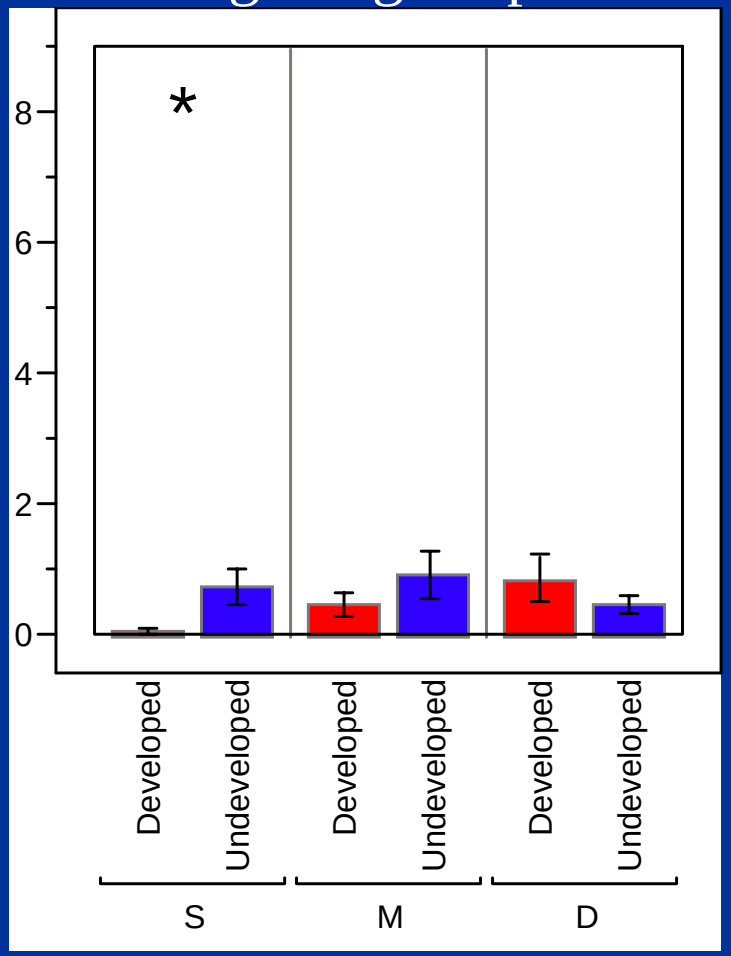
* $p < 0.05$

Medium Woody Debris % Cover

Small oligotrophic

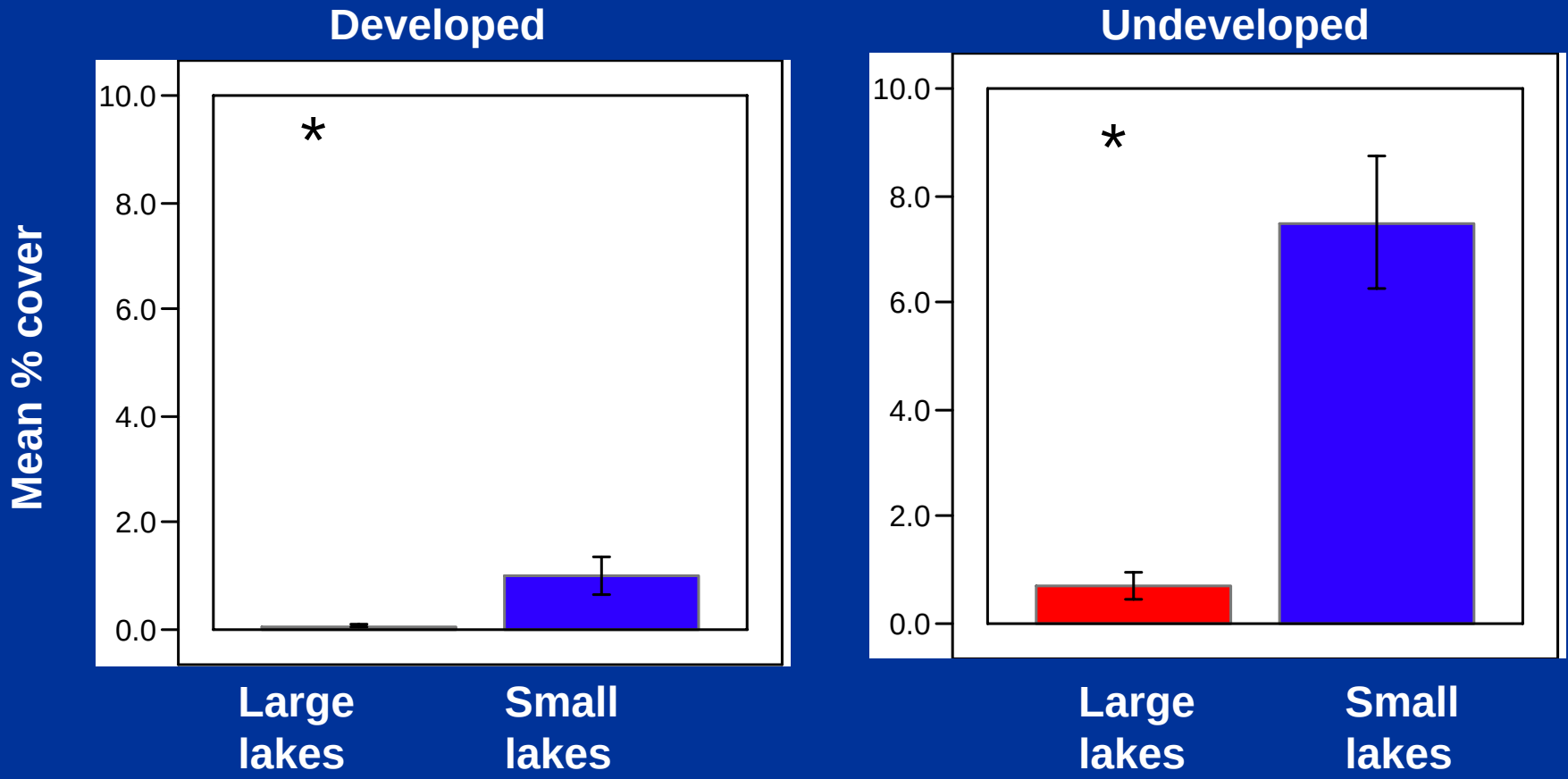


Large oligotrophic



* $p < 0.05$

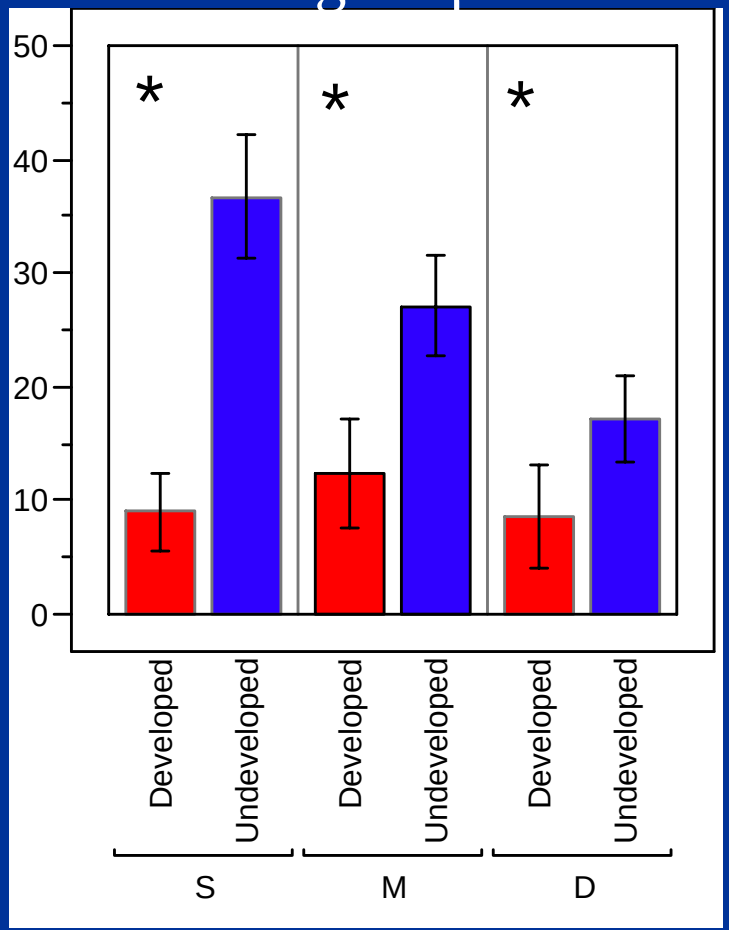
Mean % Cover Medium Woody Debris, Shallow transects



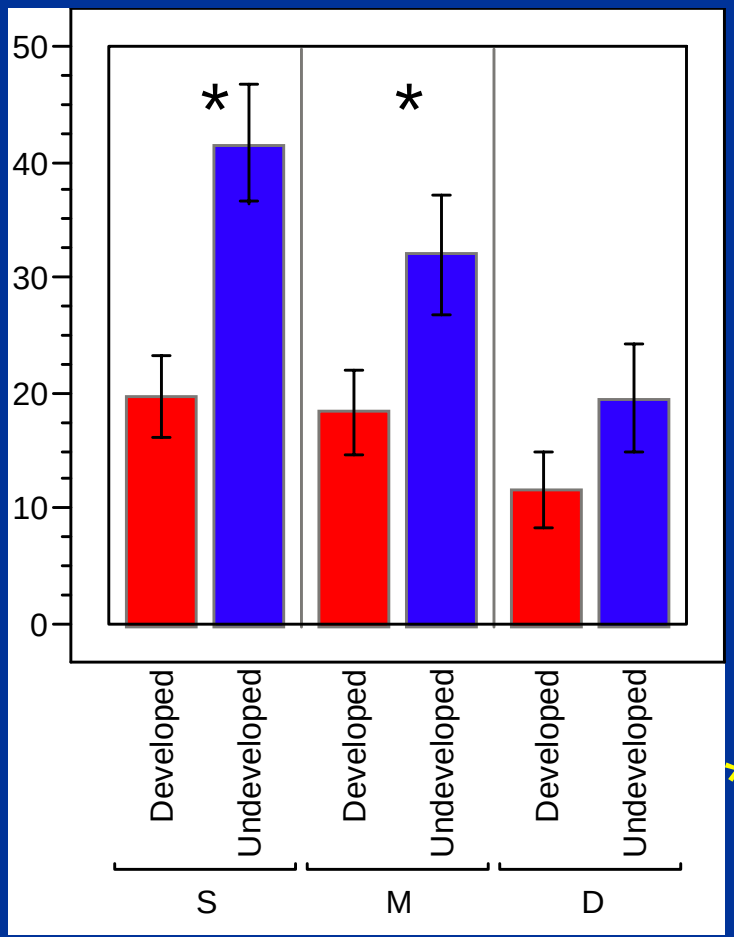
* $p < 0.05$

Mean % Cover Aufwuchs

Small oligotrophic



Large oligotrophic



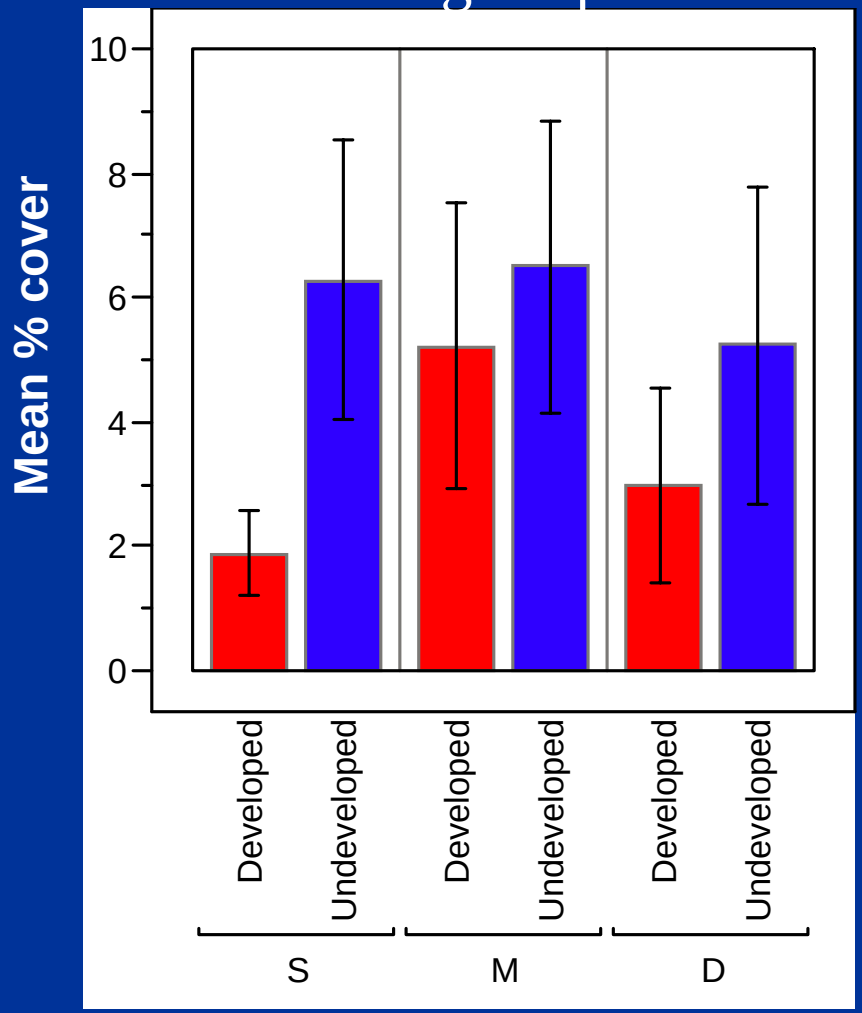
* $p < 0.05$

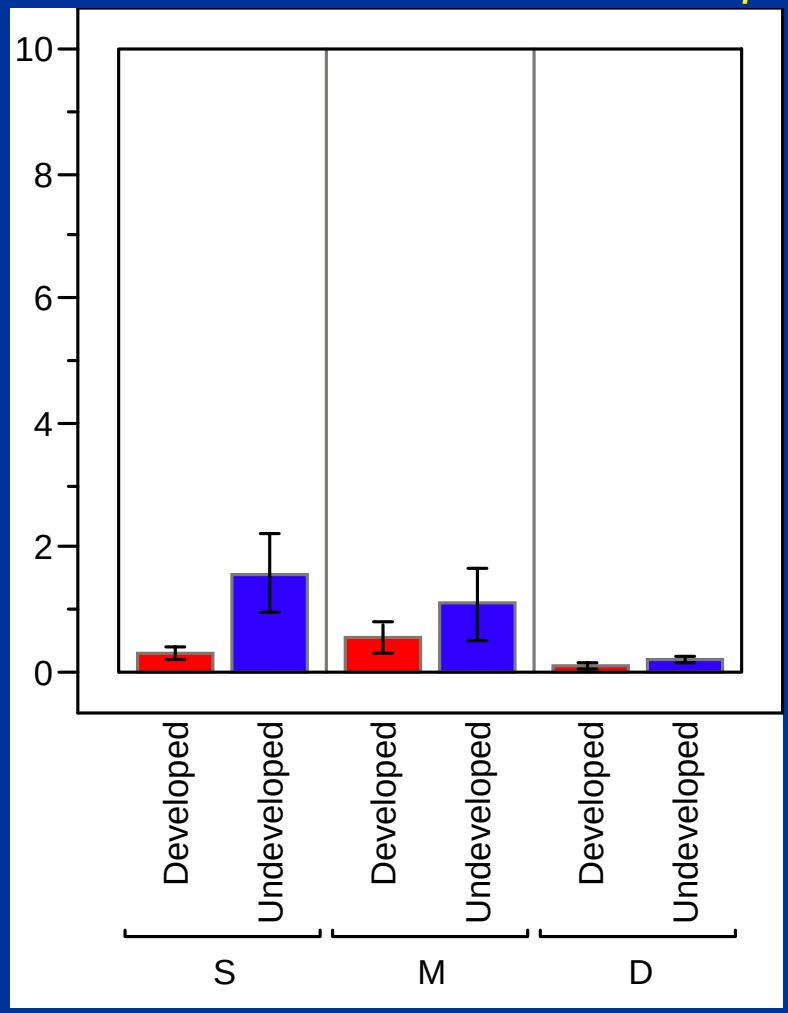
Deciduous Leaf Litter Mean % Cover

Small oligotrophic

Large oligotrophic

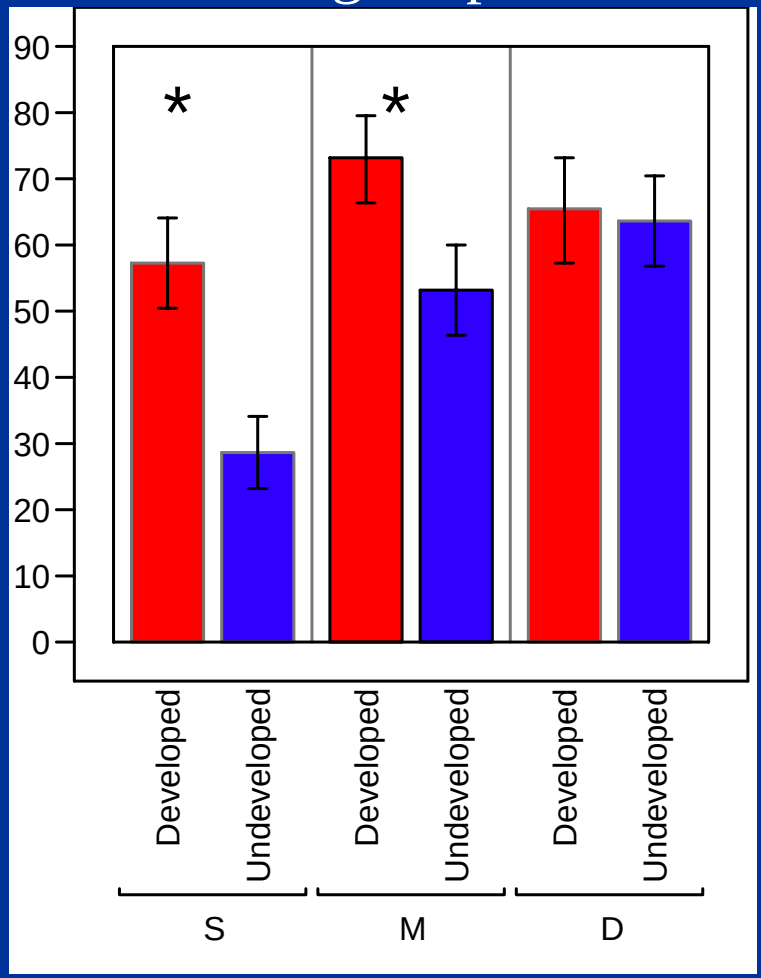
* $p < 0.05$



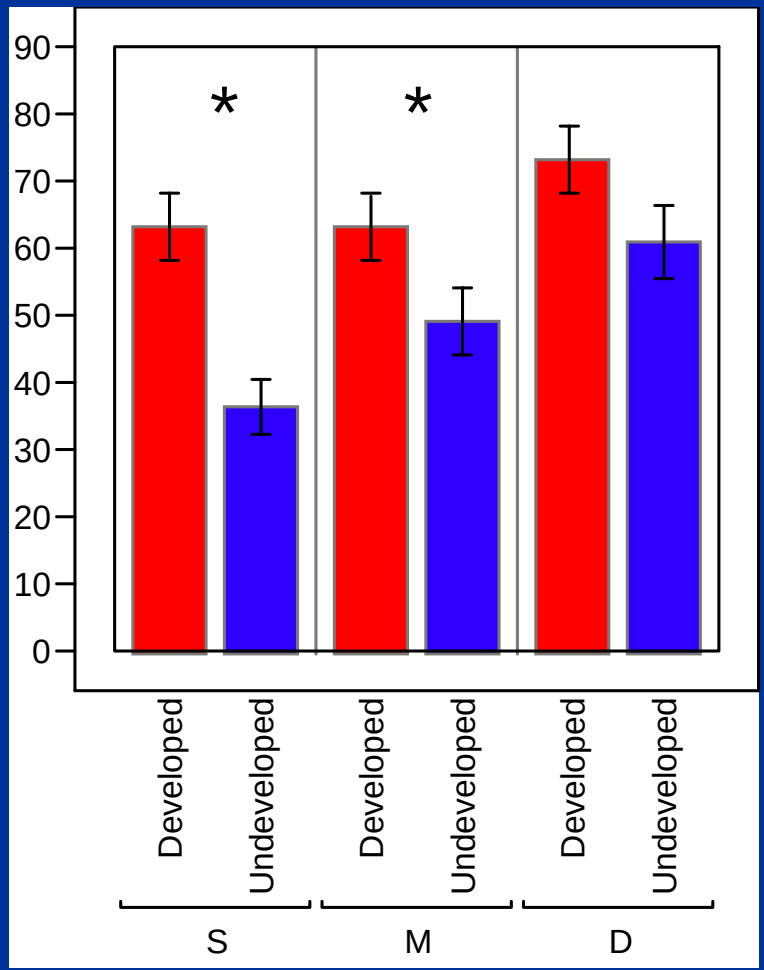


Mean % Sediment Embeddedness

Small oligotrophic



Large oligotrophic



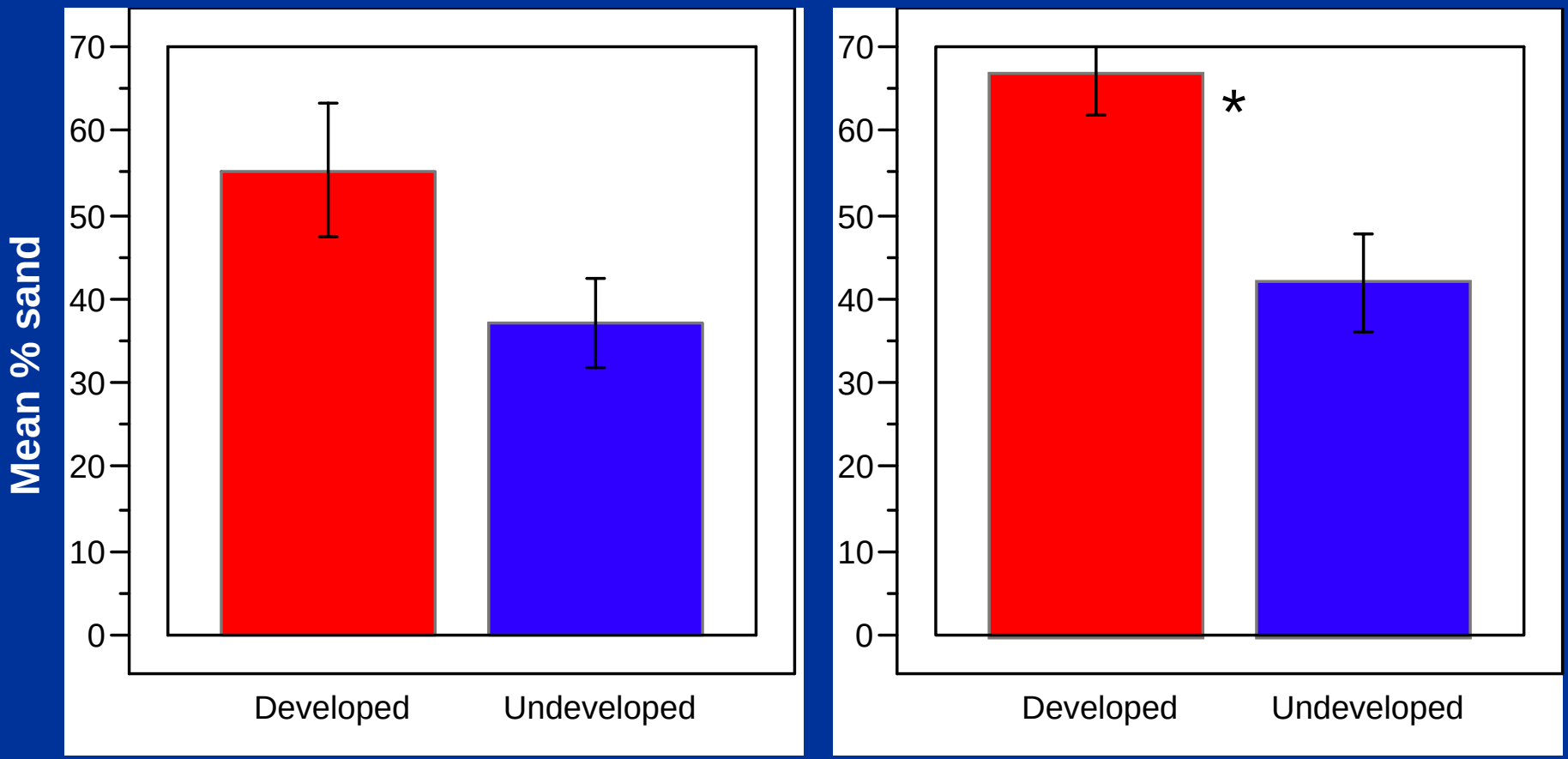
* $p < 0.05$

Mean % Sand at Shallow Transect (0.5 m)

Small oligotrophic

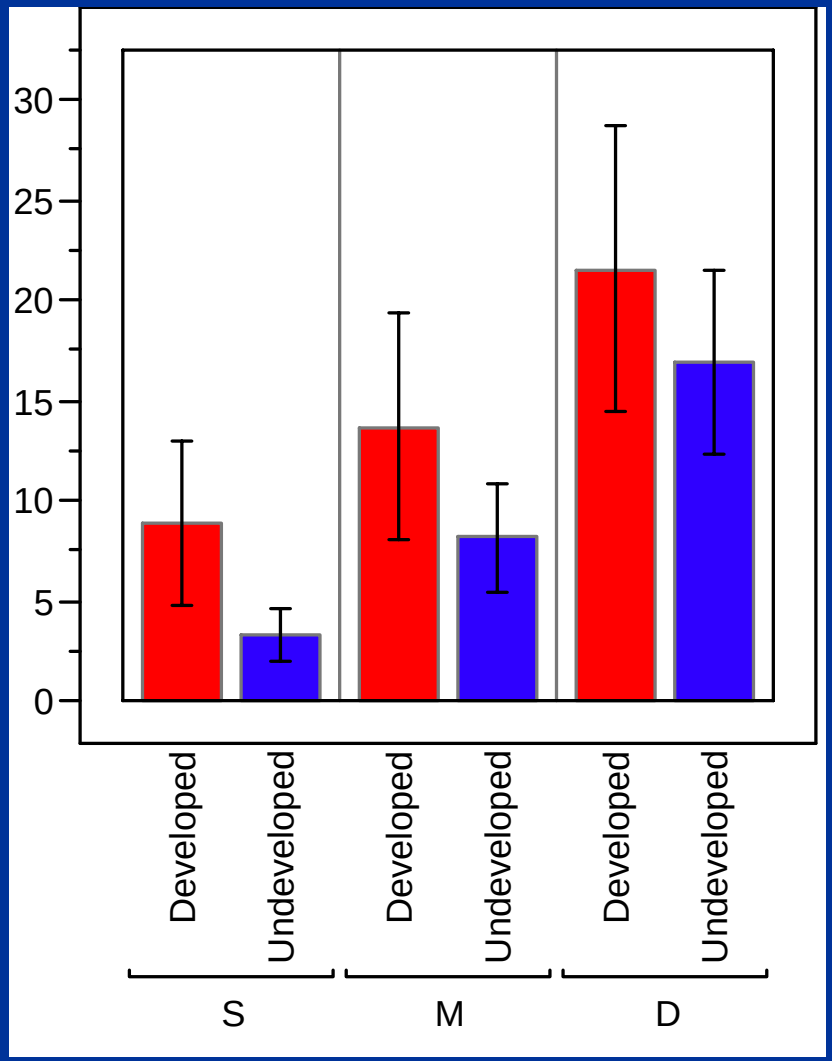
Large oligotrophic

* $p < 0.05$

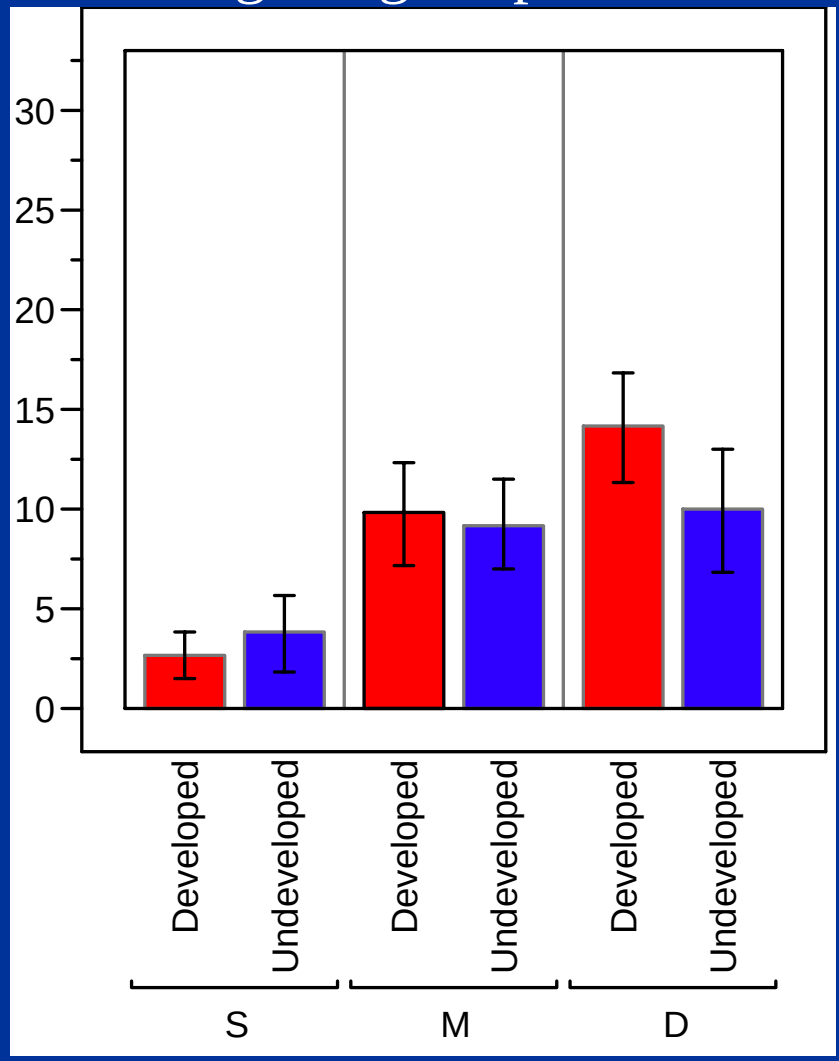


Aquatic Macrophyte Mean % Cover

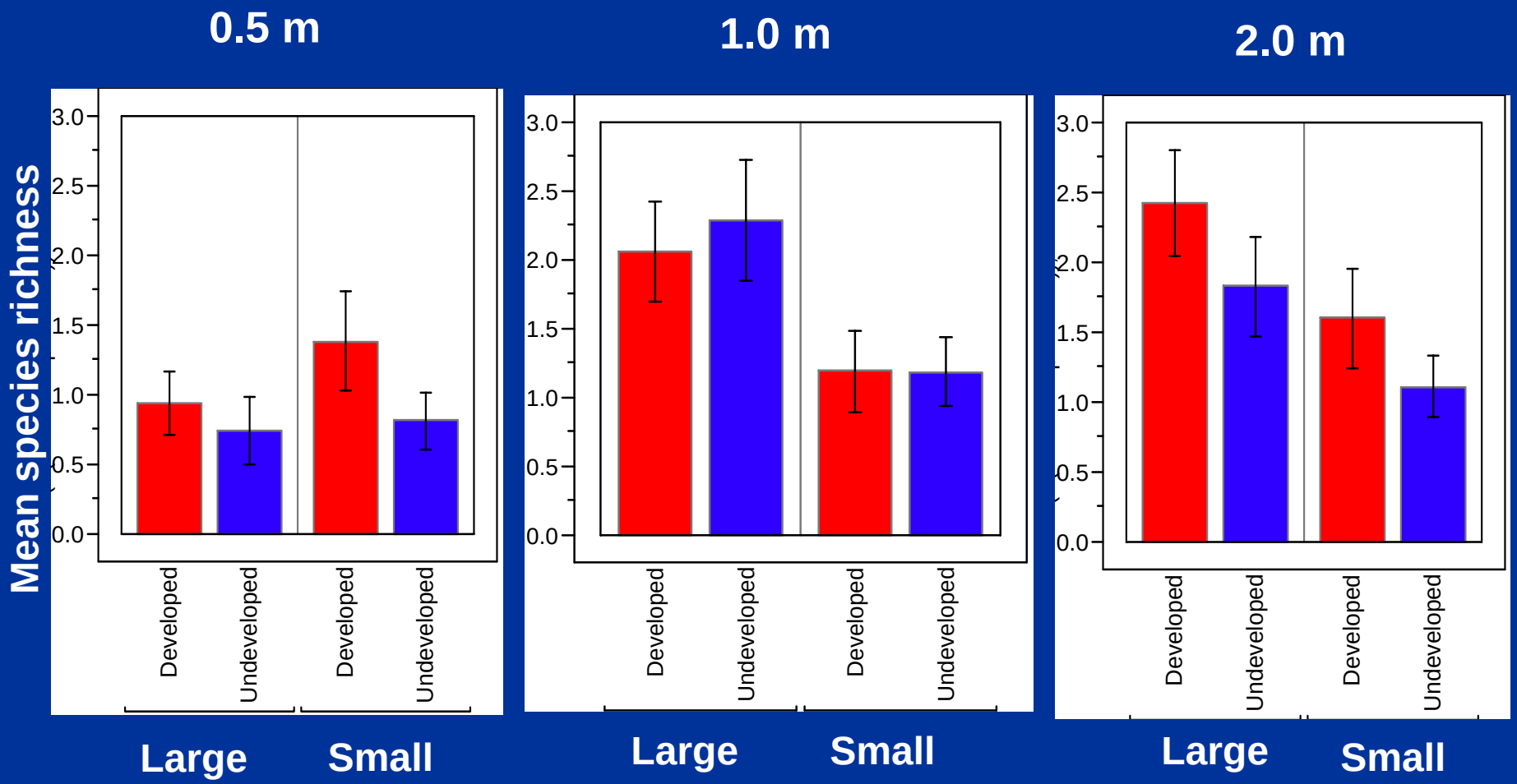
Small oligotrophic



Large oligotrophic



Macrophyte species richness



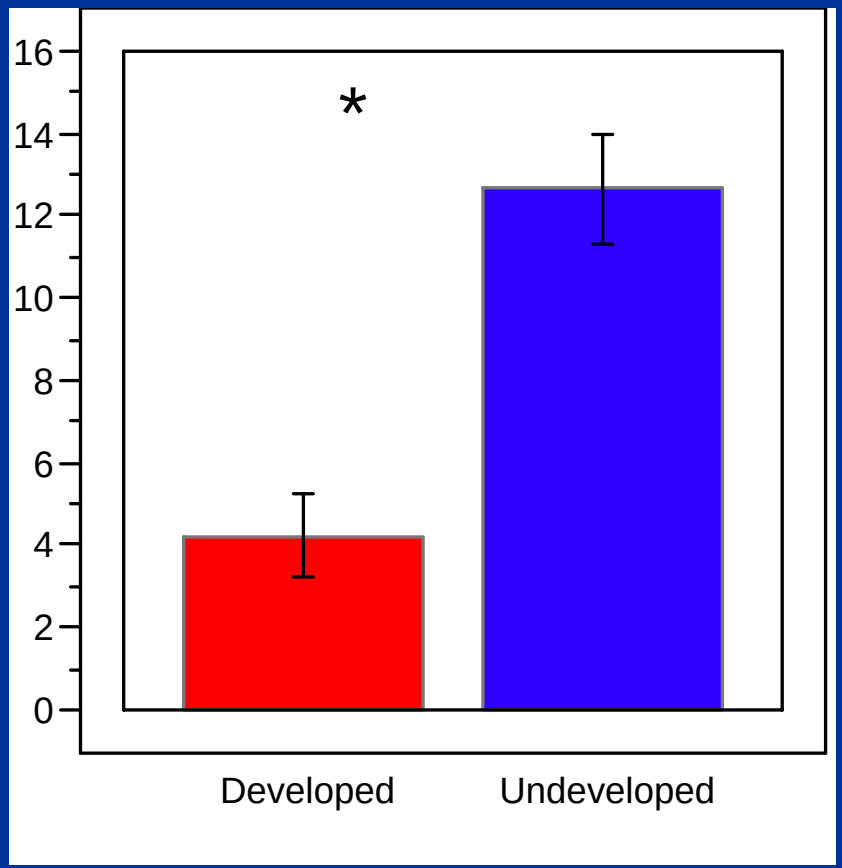
Site-level Results

- Riparian vegetation
- Littoral shading
- Coarse woody debris

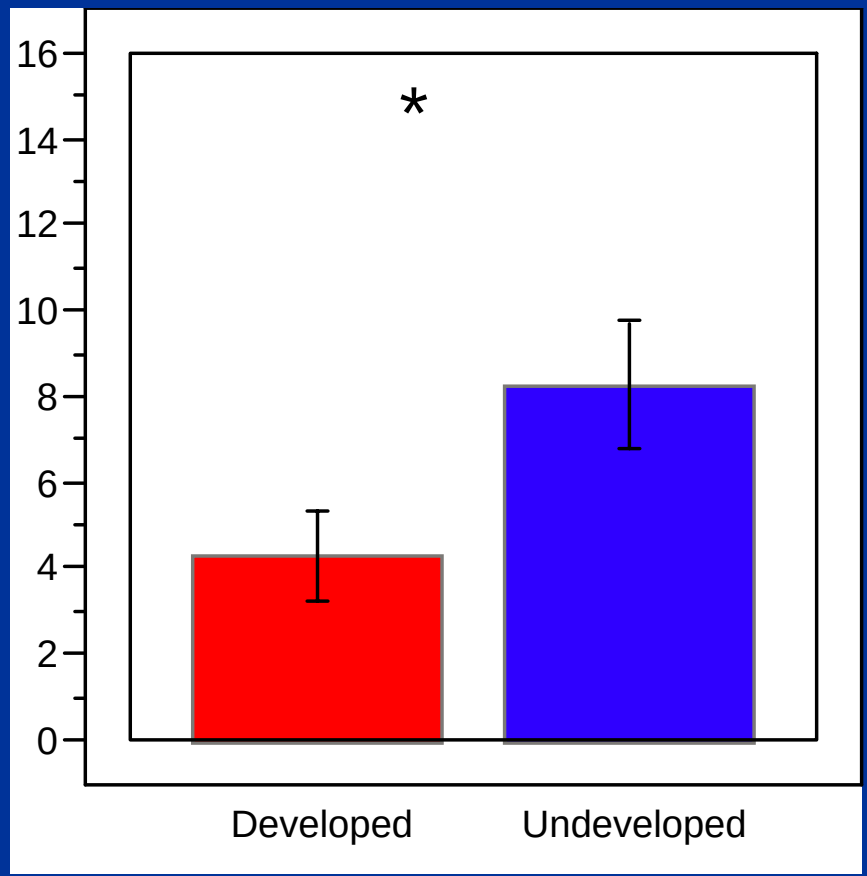
Mean # Coarse Woody Debris

(> 10 cm diameter)

Small oligotrophic

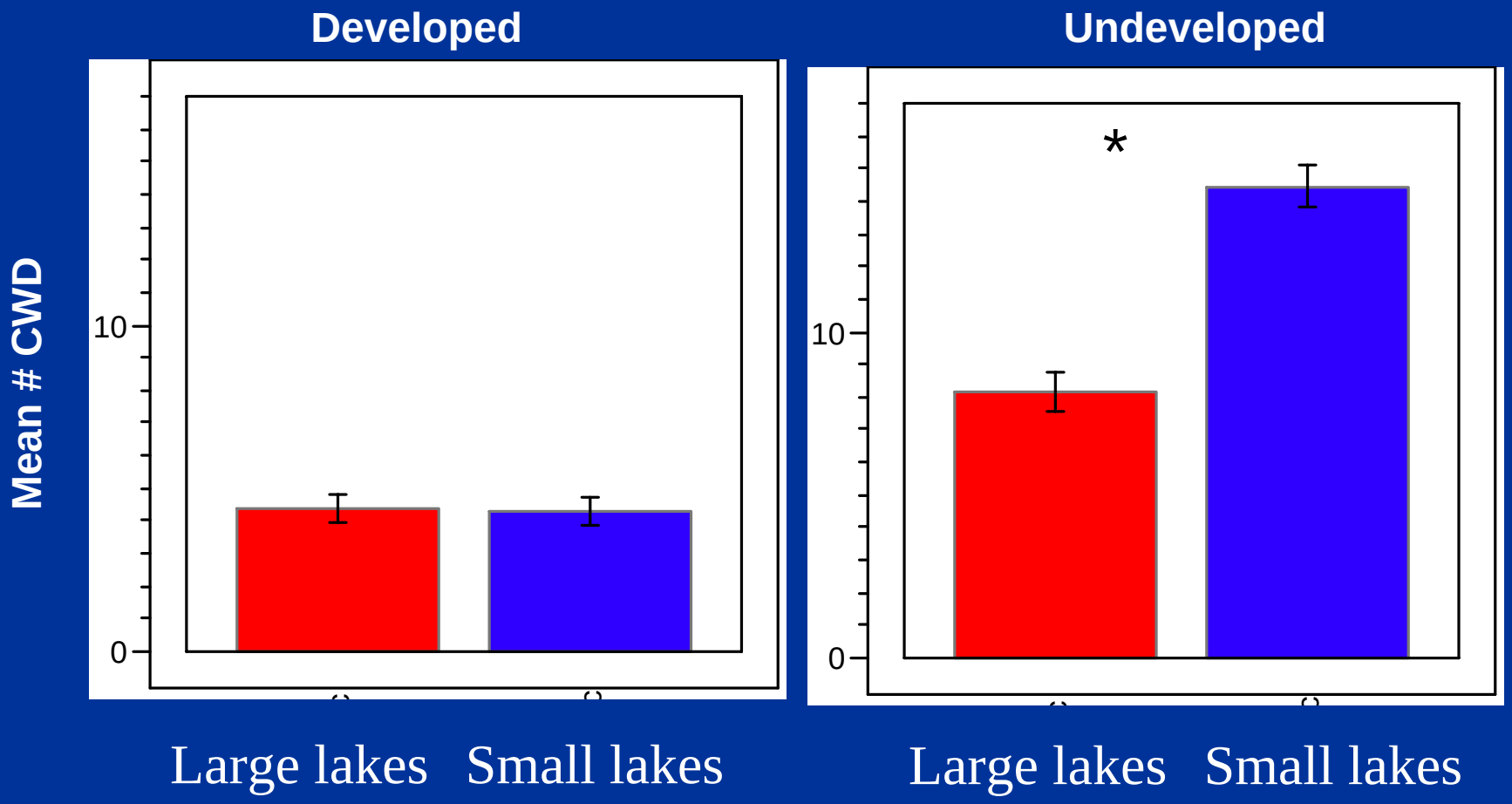


Large oligotrophic



* $p < 0.05$

Mean # Coarse Woody Debris

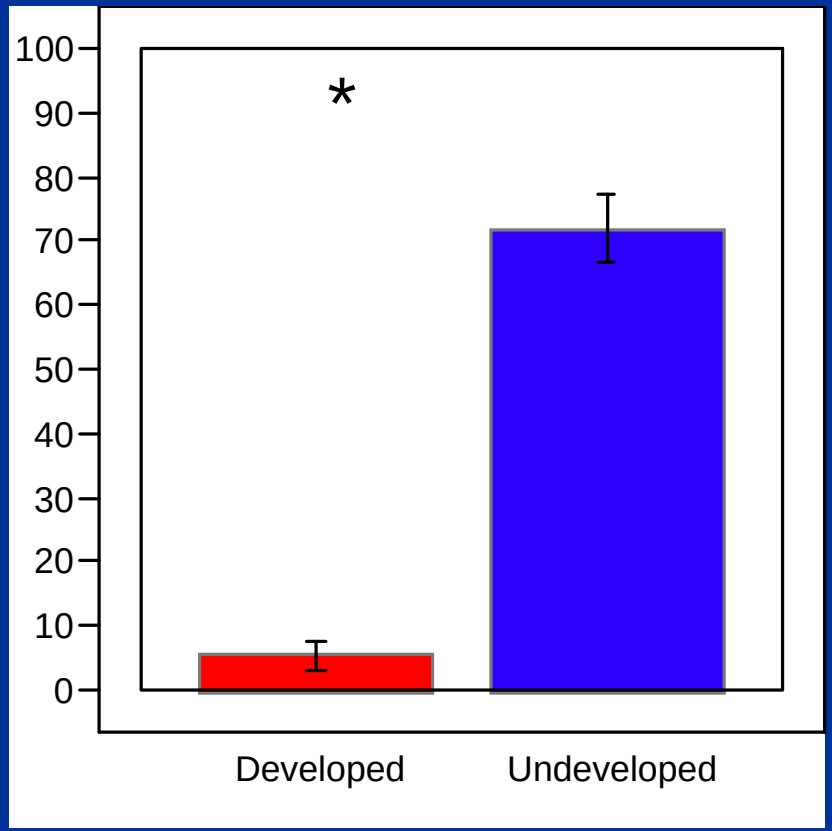


* $p < 0.05$

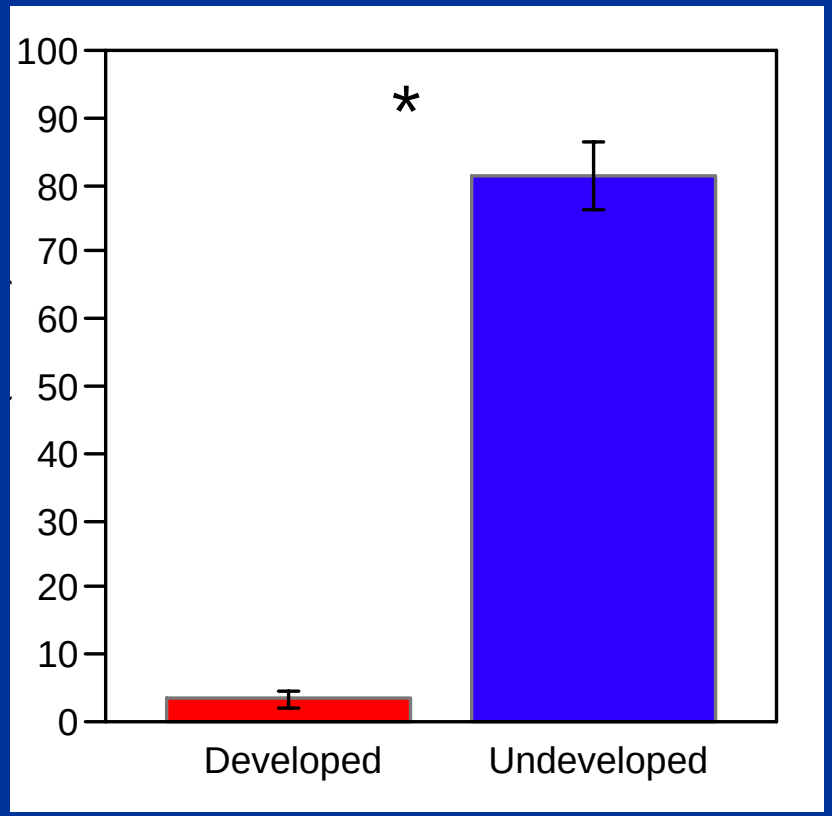
Riparian Shoreline Vegetation, % Trees

* $p < 0.05$

Small lakes



Large lakes



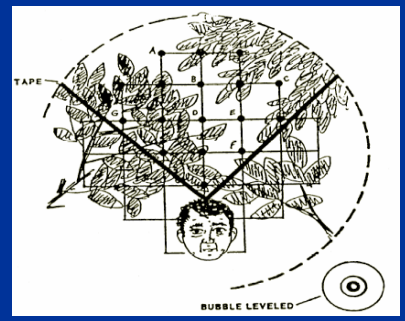
Riparian Shading

Small lakes

Large lakes

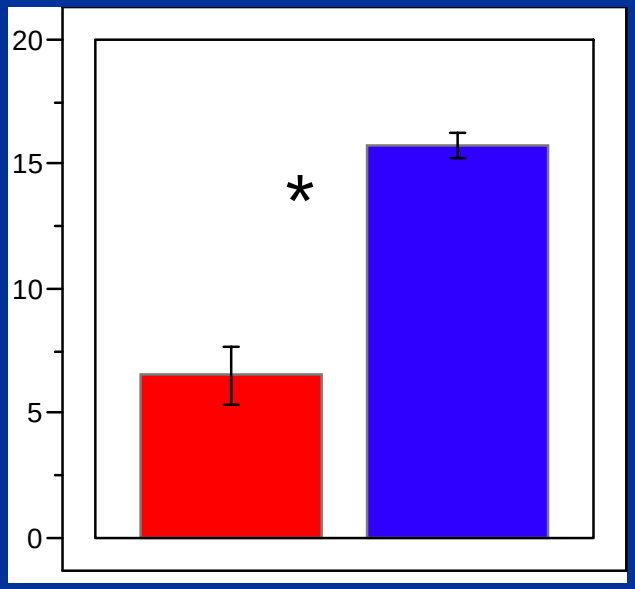
* $p < 0.05$

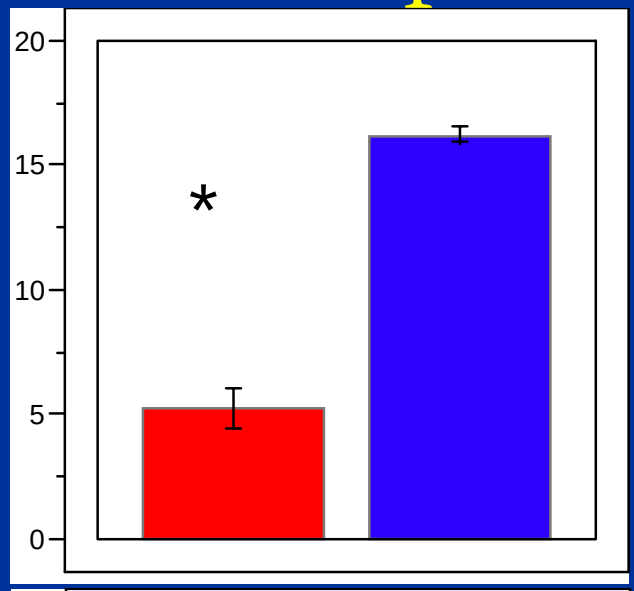
1 m densiometer

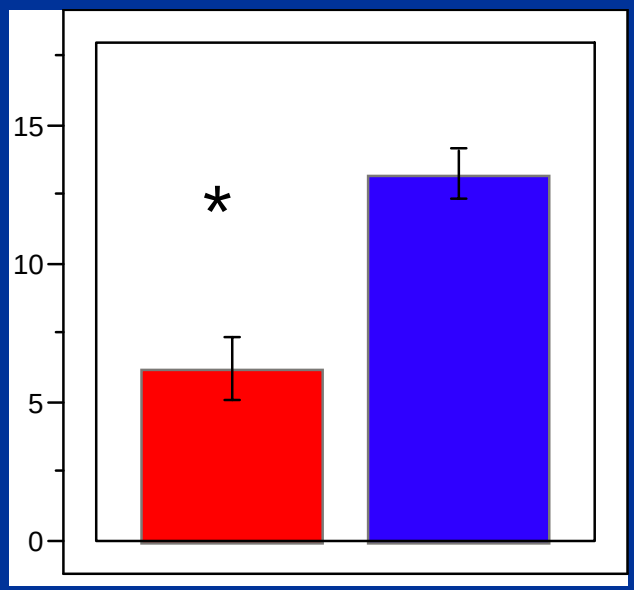


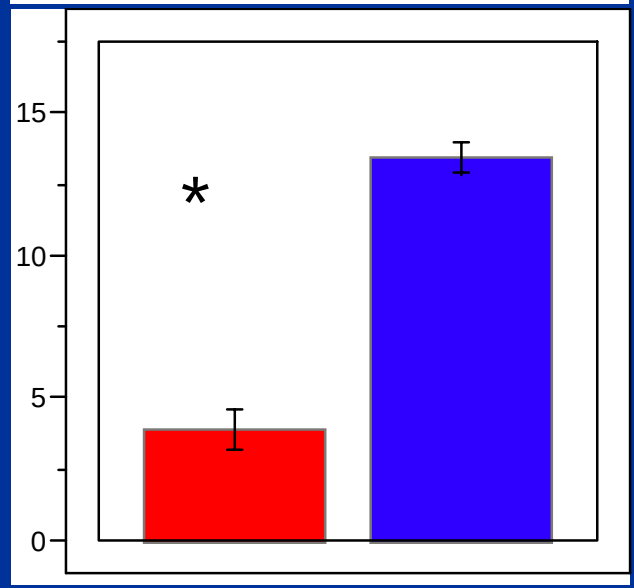
5 m densiometer

Mean densiometer reading (max = 17)





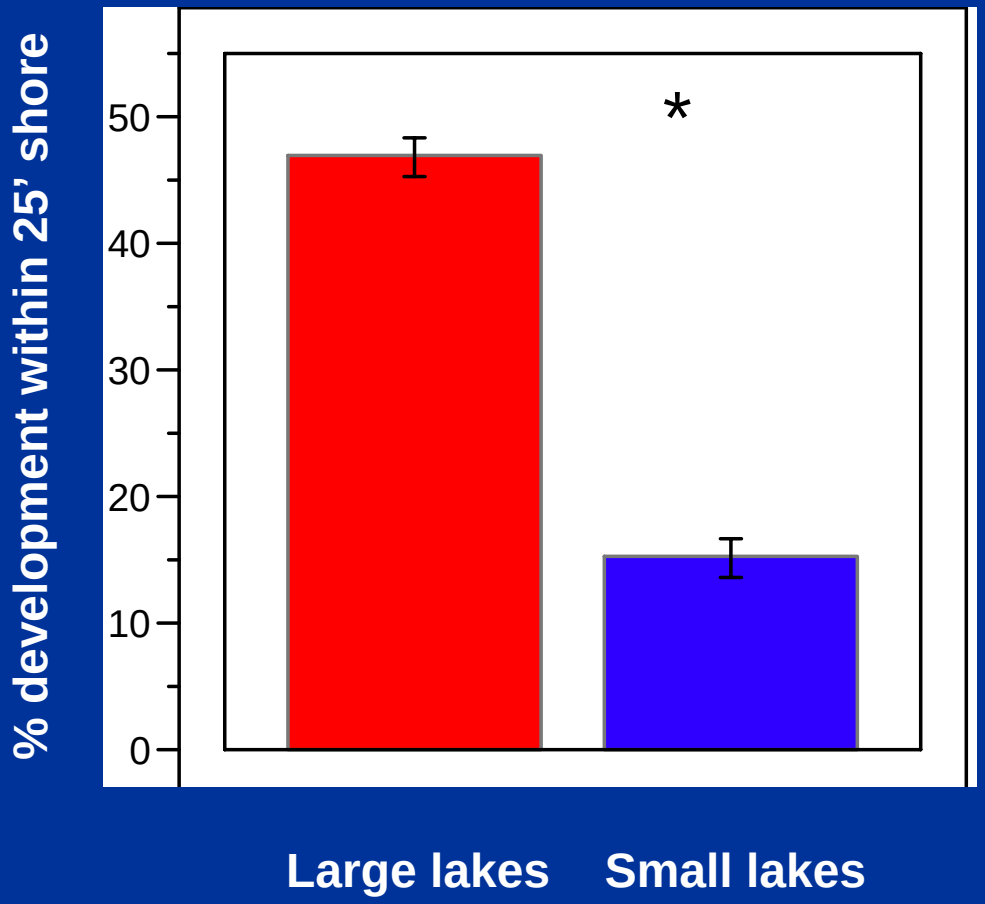


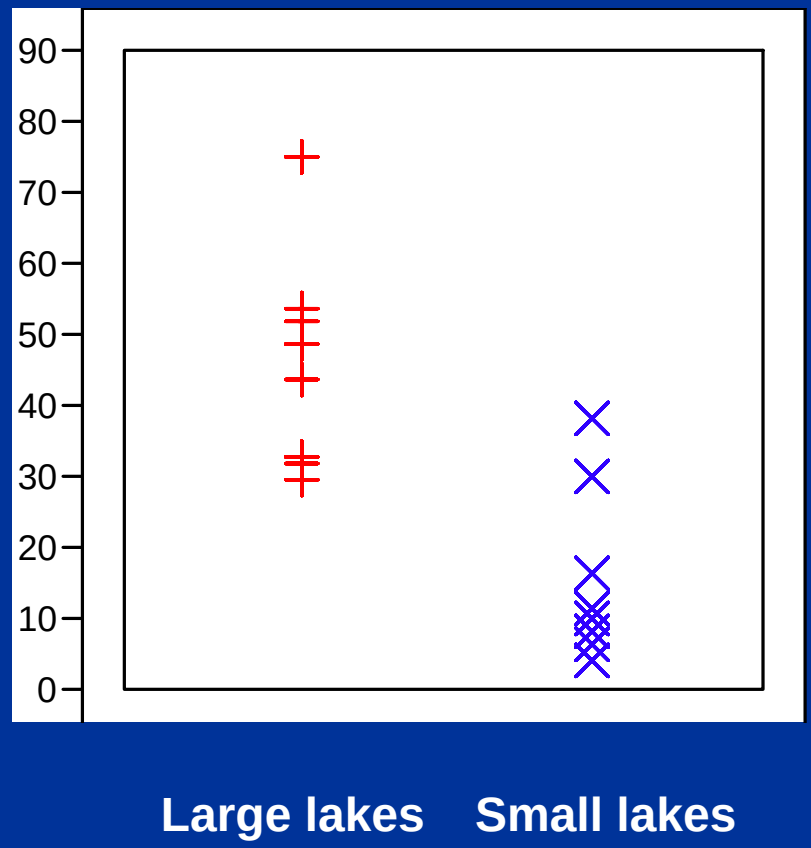


Developed Undeveloped

Developed Undeveloped

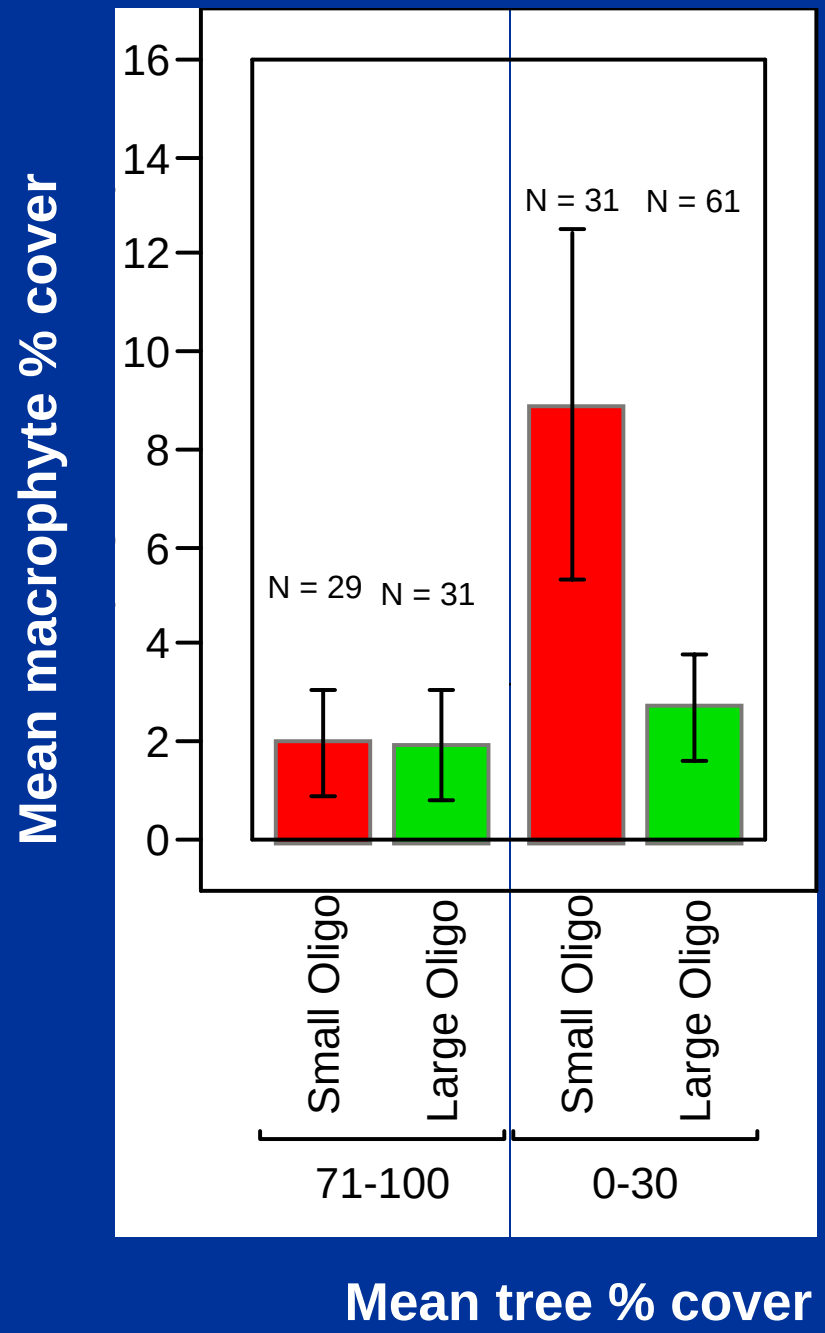
% Shoreline development within 25’ of water line





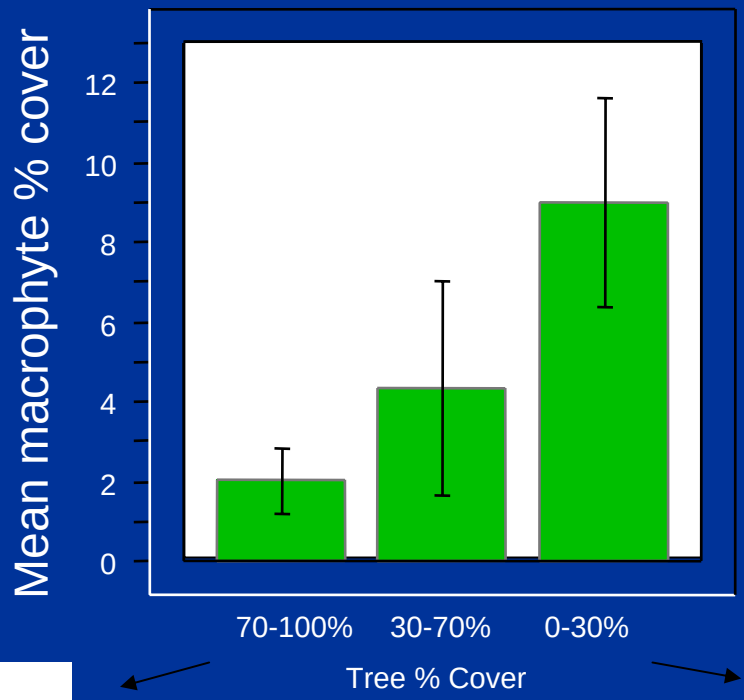
* $p < 0.05$

Mean macrophyte % cover by lake class within tree % cover



- discarded 30-70% tree cover category due to low sample size

More Aquatic Plant Diversity in Oligotrophic Lakes



Fewer Trees

Chara sp.
Equisetum fluviatile
Najas flexilis
Potamogeton amplifolius
Potamogeton gramineus
Potamogeton praelongus
Vallisneria americana

Chara sp.
Najas flexilis
Nymphaea odorata ssp. Odorata
Potamogeton amplifolius
Potamogeton gramineus
Sparganium sp.

Chara sp.
Eleocharis acicularis
Elodea canadensis
Elodea sp.
Equisetum fluviatile
Megalodonta beckii
Myriophyllum sp.
Myriophyllum spicatum
Najas flexilis
Najas sp.
Nitella sp.
Nymphaea odorata ssp.Odorata
Nymphaea sp.
Potamogeton amplifolius
Potamogeton epihydrus
Potamogeton gramineus
Potamogeton sp.
Vallisneria americana

***red indicates found only in low % tree cover**

Presentation outline

- Background: land use changes
- Need for study
- Project objectives
- Methods
- Results
- Conclusions
- What's up next

Conclusions about shoreline development on Vermont oligotrophic lakes

- Lake-level
  - Increased shoreline development with lake size
  - ⇨ Limits shoreline access for wildlife

Conclusions about shoreline development on Vermont oligotrophic lakes

- Lake-level
  - Increased shoreline development with lake size
  - ⇨ Limits shoreline access for wildlife
- Site-level
  - Switch from tree- to lawn-dominated shoreline
  - Decreased shading of shallow waters
  - ⇨ Leads to increased water temps, productivity
  - Decreased coarse woody debris
  - ⇨ Leads to loss of habitat for fish, wildlife, & macroinverts

Conclusions about shoreline development on Vermont oligotrophic lakes

- Plot-level
  - Decreased fine, medium woody debris
  - Decreased deciduous leaf litter
  - Decreased aufwuchs
  - More sediment embeddedness
  - More sand/gravel

⇨ less organic matter available in benthos

⇨ less food/habitat available for macroinverts, fish, wildlife

Presentation outline

- Background: land use changes
- Need for study
- Project objectives
- Methods
- Results
- Conclusions
- What's up next

What's Up Next: More Surveys!

- Mesotrophic
  - 2007 & 2008
- Eutrophic
  - 2008
- Fish surveys

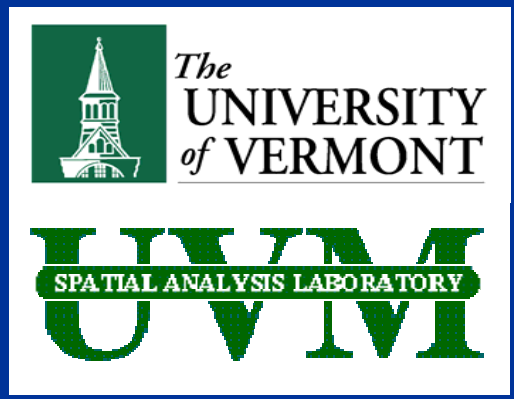
What's Up Next: Data Analyses!

- Explore Information-Theoretic Approach
  - Model selection theory
  - Parameter influences on response variables
  - Multivariate analyses
- Explore policy & outreach options
  - Working with Marjan van den Belt & Mediated Modeling @ UVM
- Develop a macrophyte biotic index specific to Vermont
- Publish!

Collaborators

UVM Spatial Analysis Lab

- David Capen
- Sean Macfaden
- Britt Haselton



Field & Expert Advice Contributors

Neil Kamman, Ginny Garrison, Lindsay Harris, Amy Shedrick, Rich Langdon, Brian Duffy, Steve Fiske, Jim Kellogg & Sarah Wheeler

Funding

Northeastern States Research Cooperative

EPA Water Quality Monitoring


Questions?