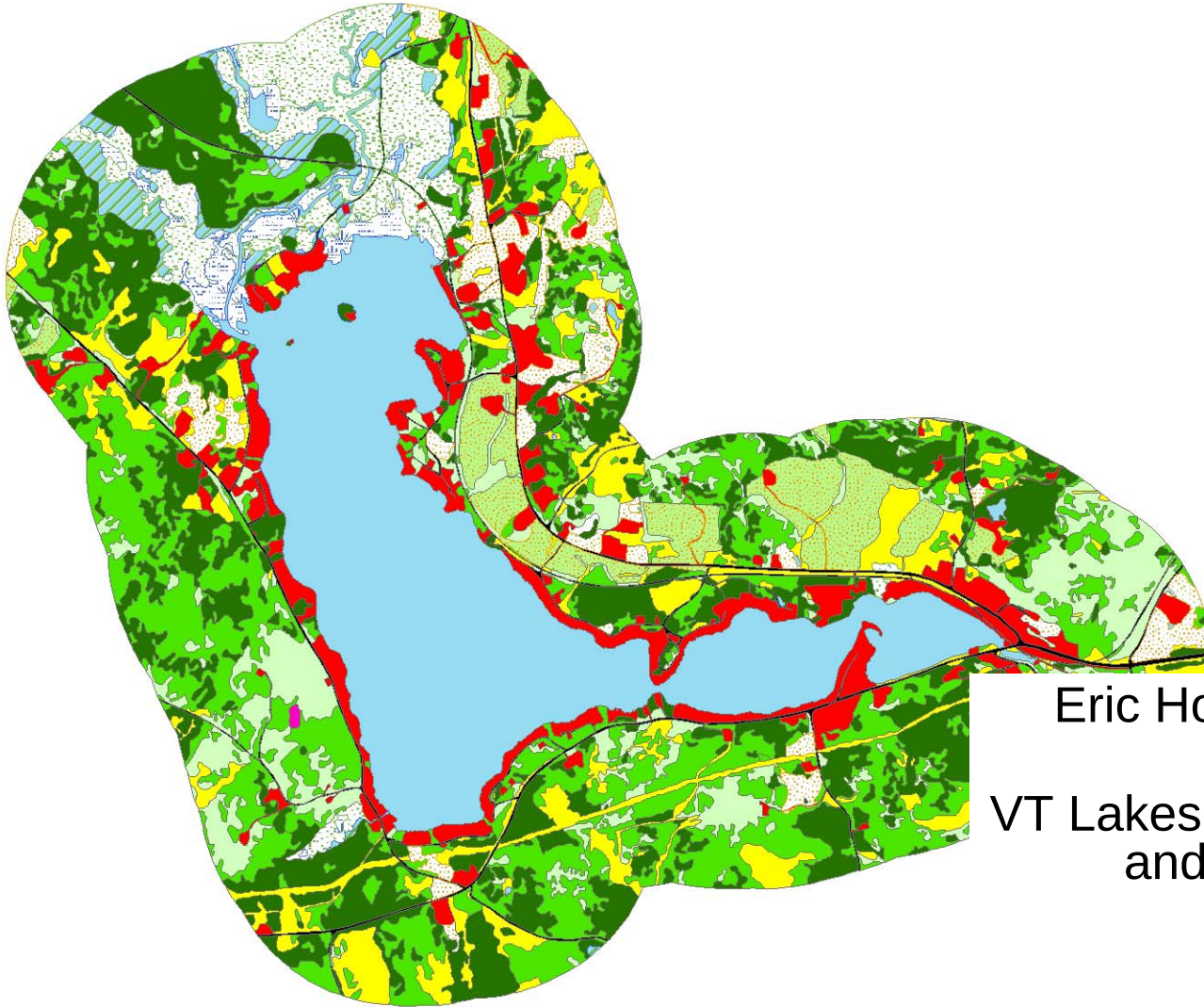


US EPA ARCHIVE DOCUMENT

How much lakeshore development can a lake sustain?



Eric Howe, Kellie Merrell and
Susan Warren
VT Lakes and Ponds Management
and Protection Section

NEAEB 2009

We know unbuffered lakeshore development:

- Destabilizes shorelines



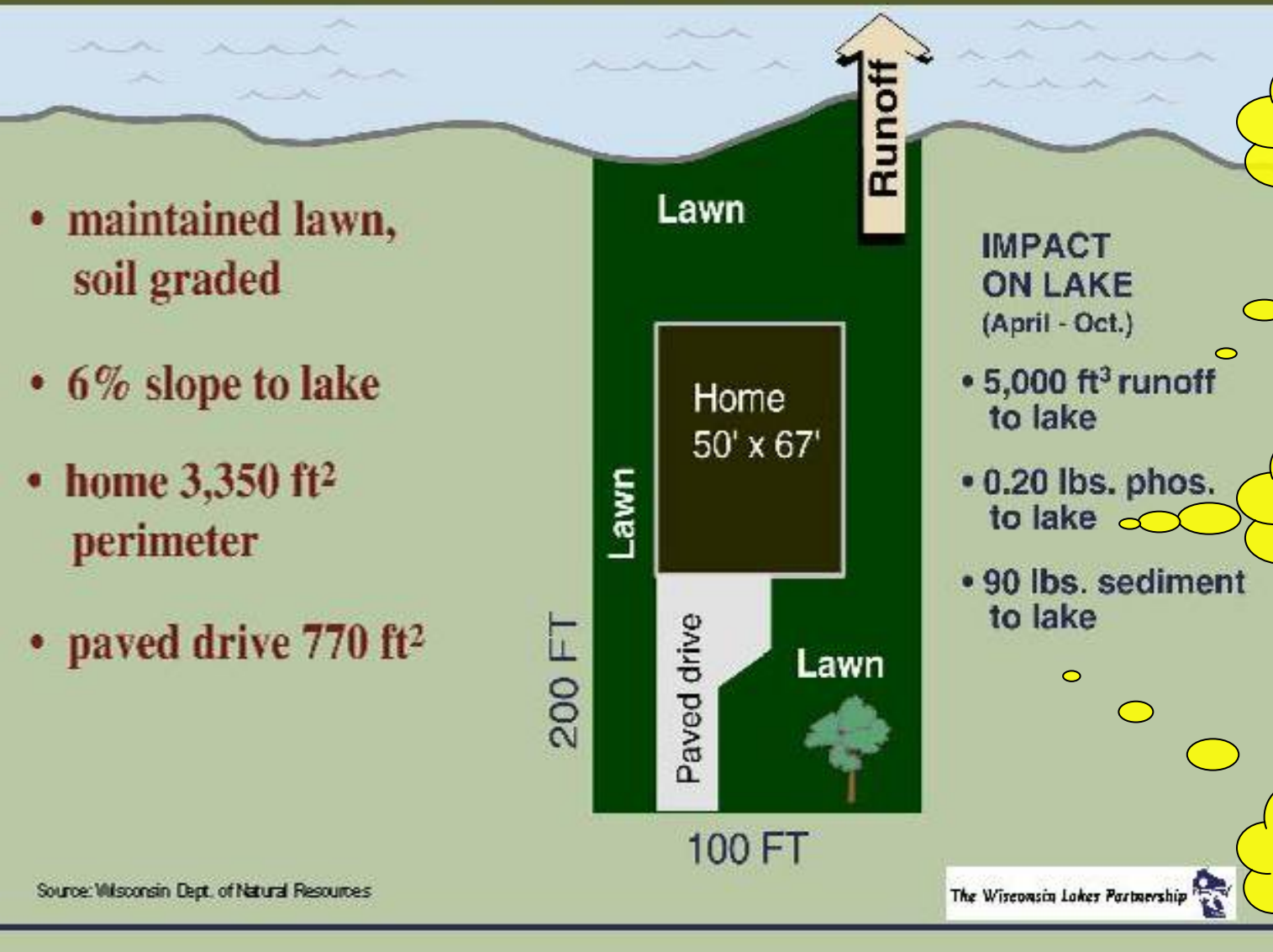
We know unbuffered lakeshore development:

- Destabilizes shorelines
- Increases nutrient loading





1990s development – Apr.-Oct. phosphorus/sediment runoff model



Modern development contributes more phosphorus and sediment than a forested site

We know unbuffered lakeshore development:

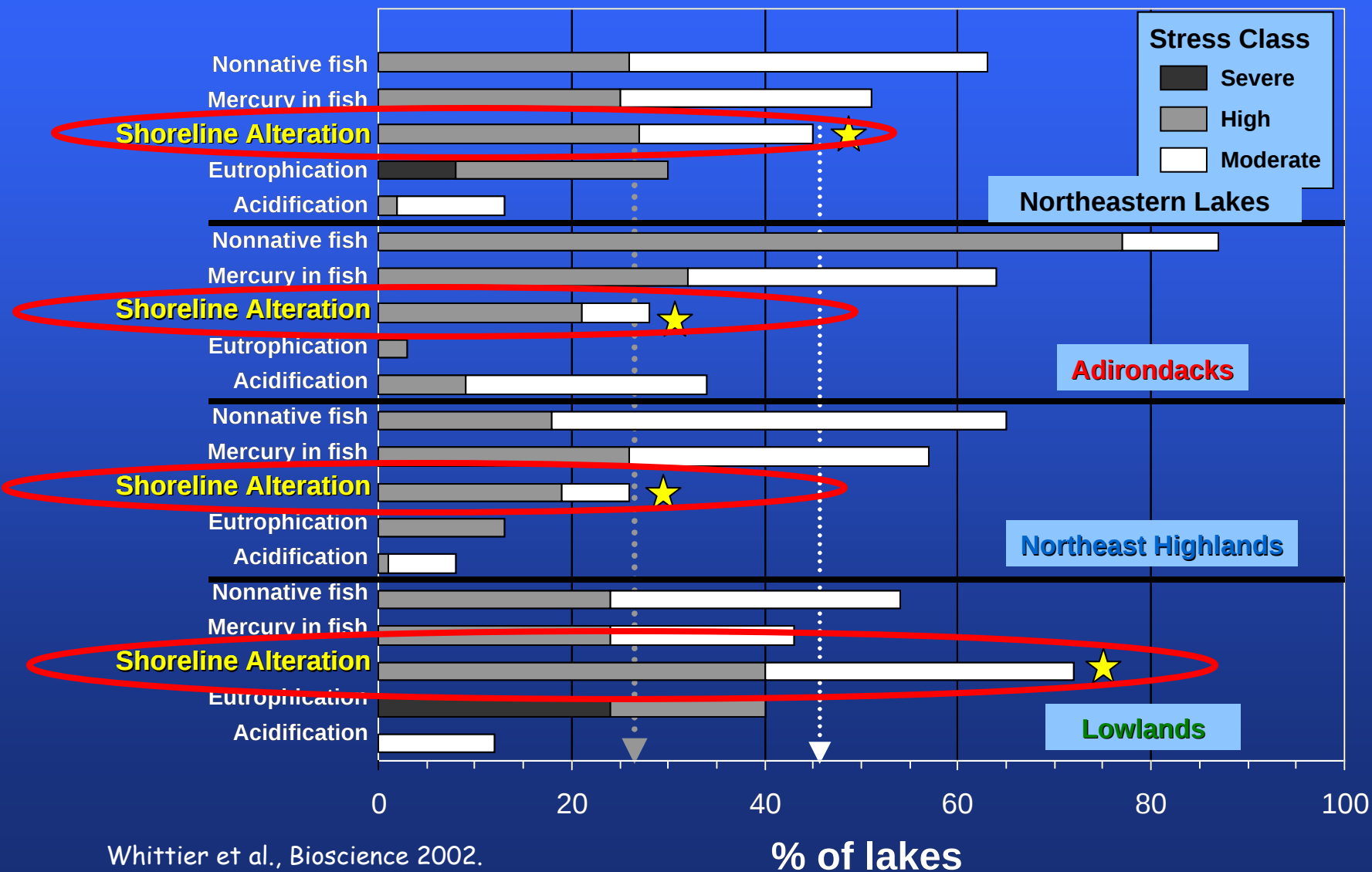
- Destabilizes shorelines
- Increases nutrient loading
- Simplifies habitat





We know this stressor to lakes is widespread

Comparison of Extent and Severity of Stressors in Northeastern Lakes





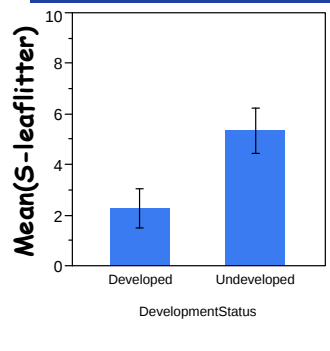
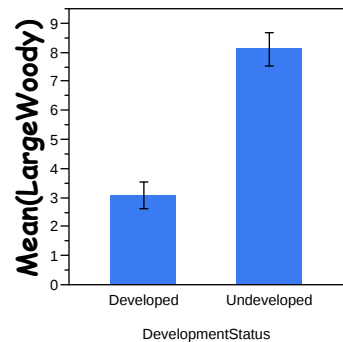
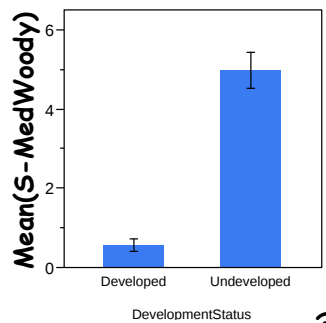
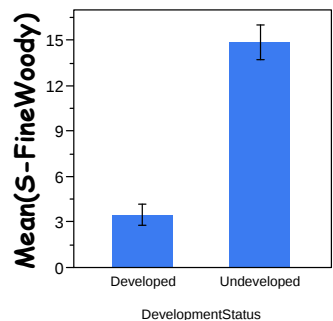
IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

The result of removing the vegetated buffer
& increasing impervious surface area



IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

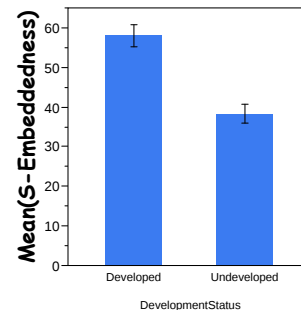
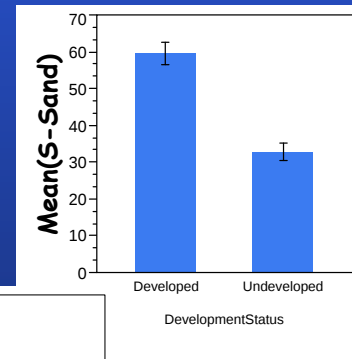
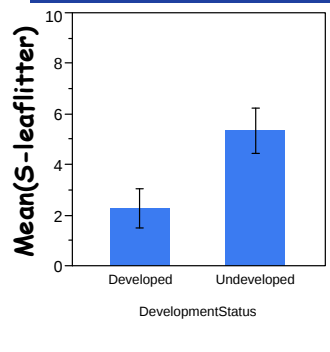
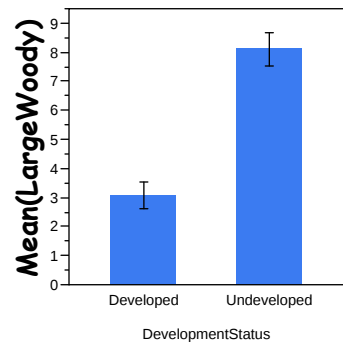
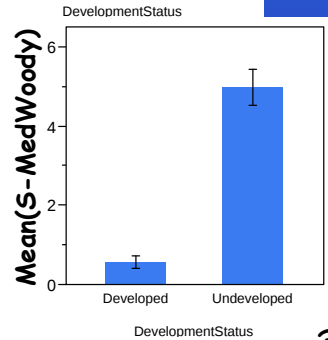
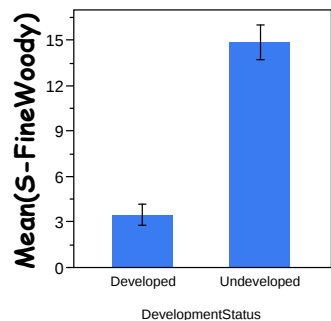
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IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

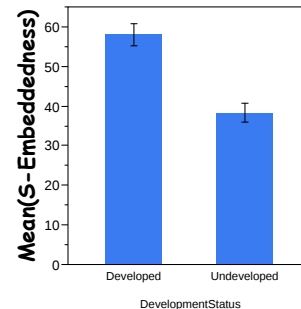
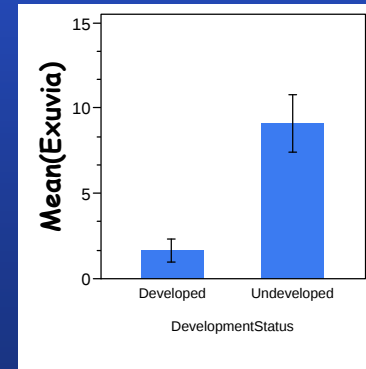
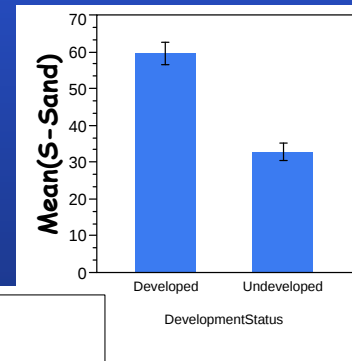
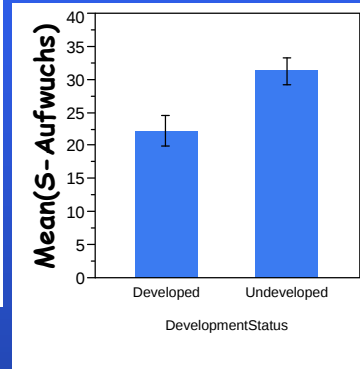
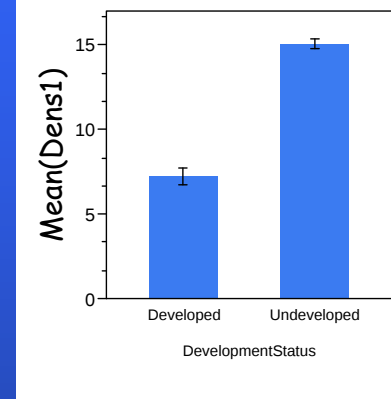
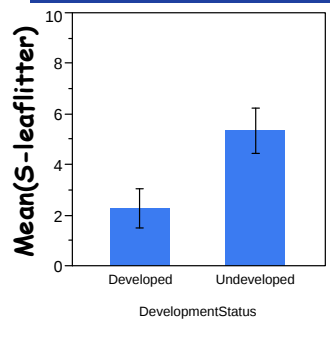
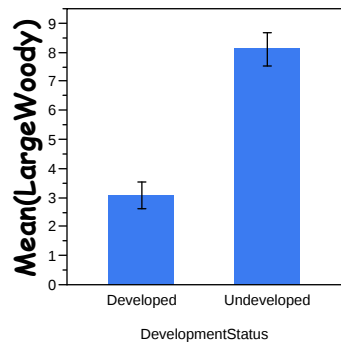
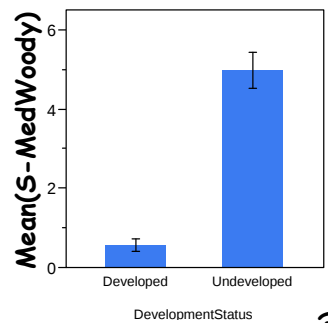
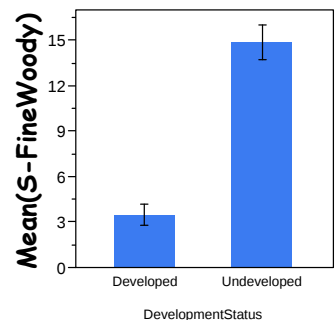
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IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

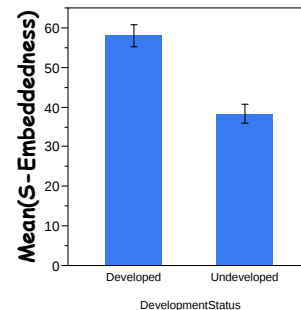
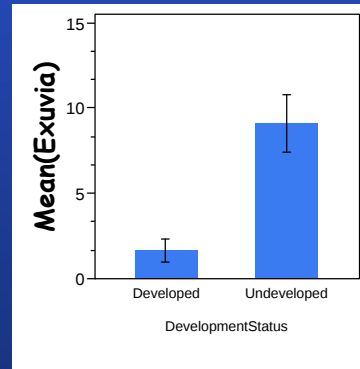
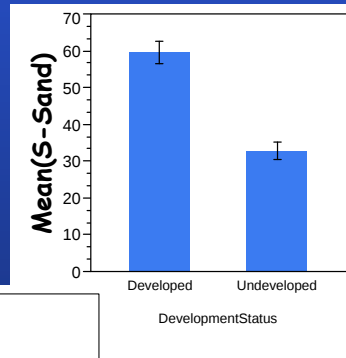
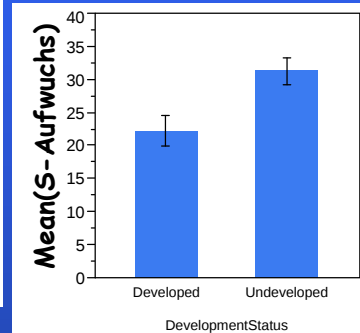
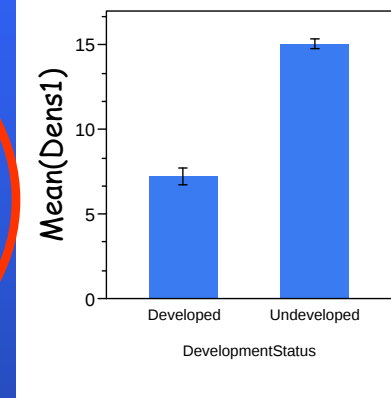
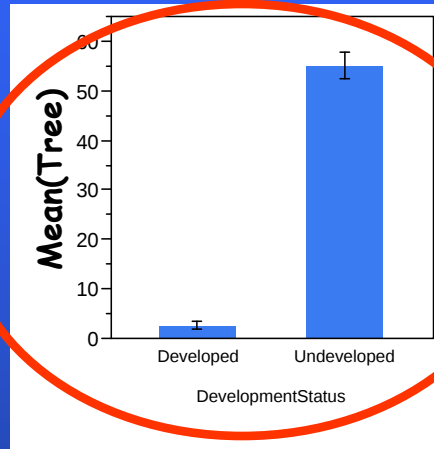
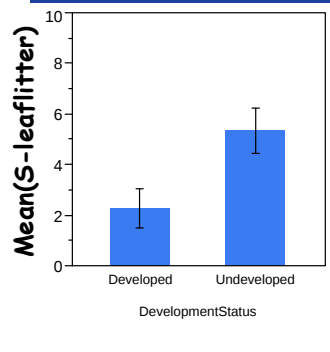
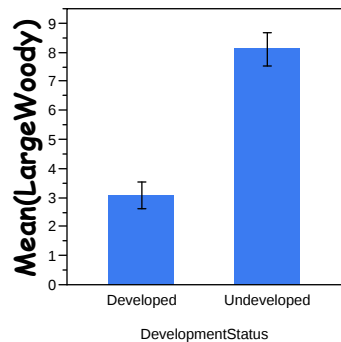
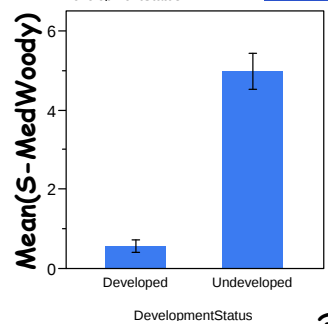
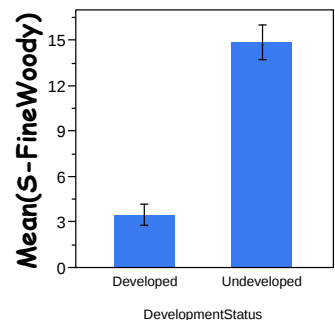
The result of removing the vegetated buffer & increasing impervious surface area





IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

The result of removing the vegetated buffer & increasing impervious surface area



But, how much can a lake sustain?

Resilience may vary from lake to lake

- Extent and intensity of existing lakeshore development
- Flushing rate
- Shoreline Development Index (lake shape)
- Mean depth/extent of littoral area
- Watershed nutrient loadings

Management and regulation?

Vermont has narrative standards based on Qualitative observations

Aquatic Biota, Wildlife, and Aquatic Habitat:

Change from the natural condition limited to
none, **minimal, minor, or moderate** impacts
from human activity

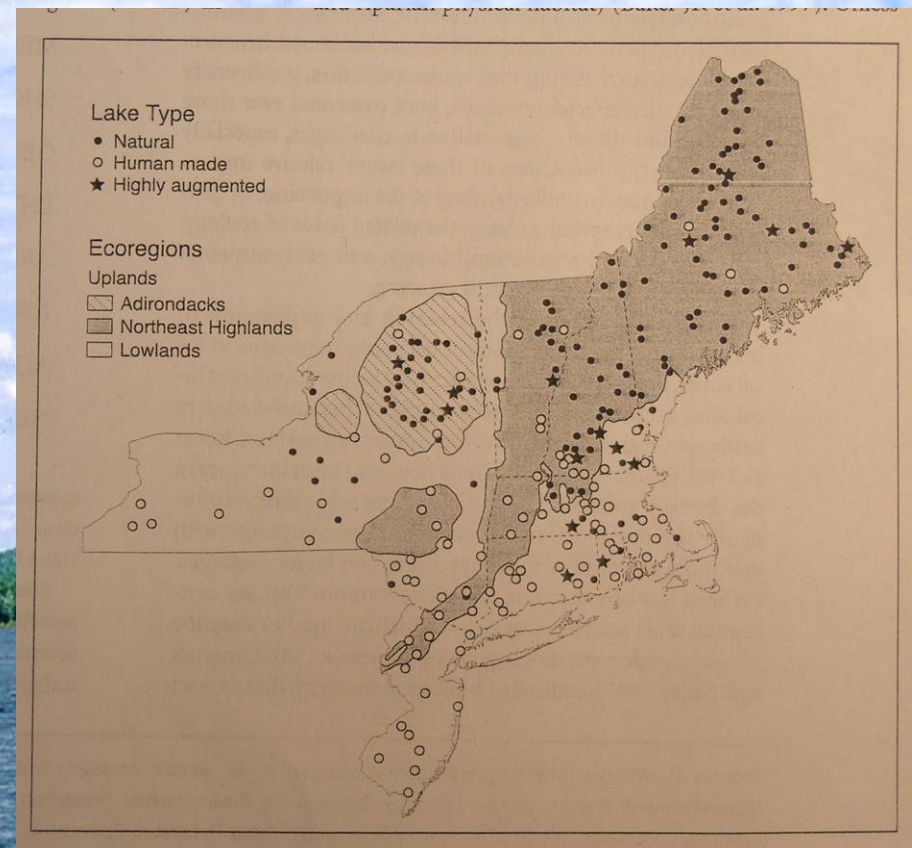
Level varies with Classification

What Quantitative
standards can we use?



EPA has lead the way
toward determining a
threshold

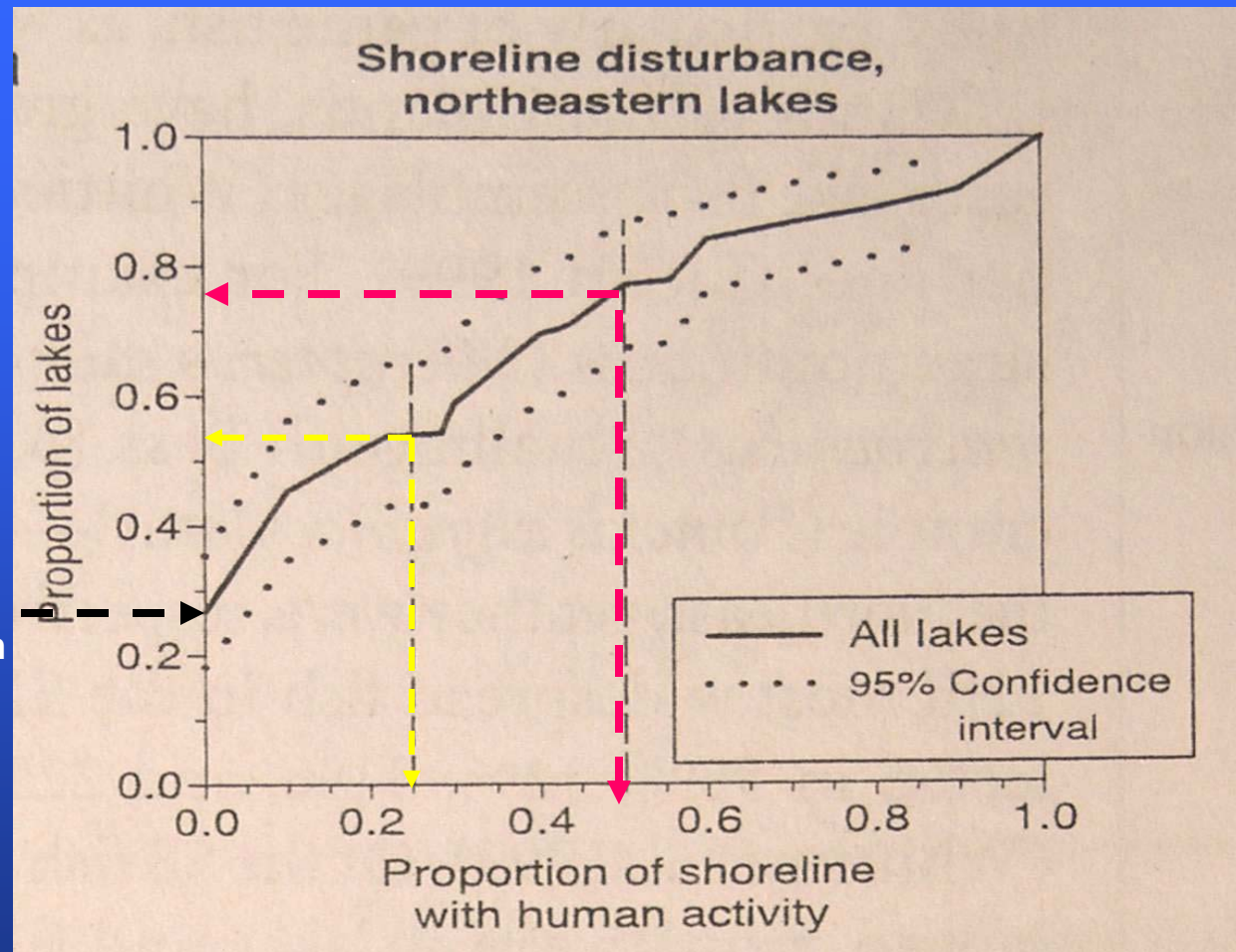
Spatially-Balanced Probability Sample (n=350) Represents 11,088 lakes in the Northeastern U.S.A.



Whittier, Paulsen, Larsen, Petersen, Herlihy and Kaufmann. 2002. Indicators of Ecological Stress and their extent in the population of Northeastern Lakes. *BioScience* 52(3):235-247



Lake Population CDF's



27% - No Human Activities

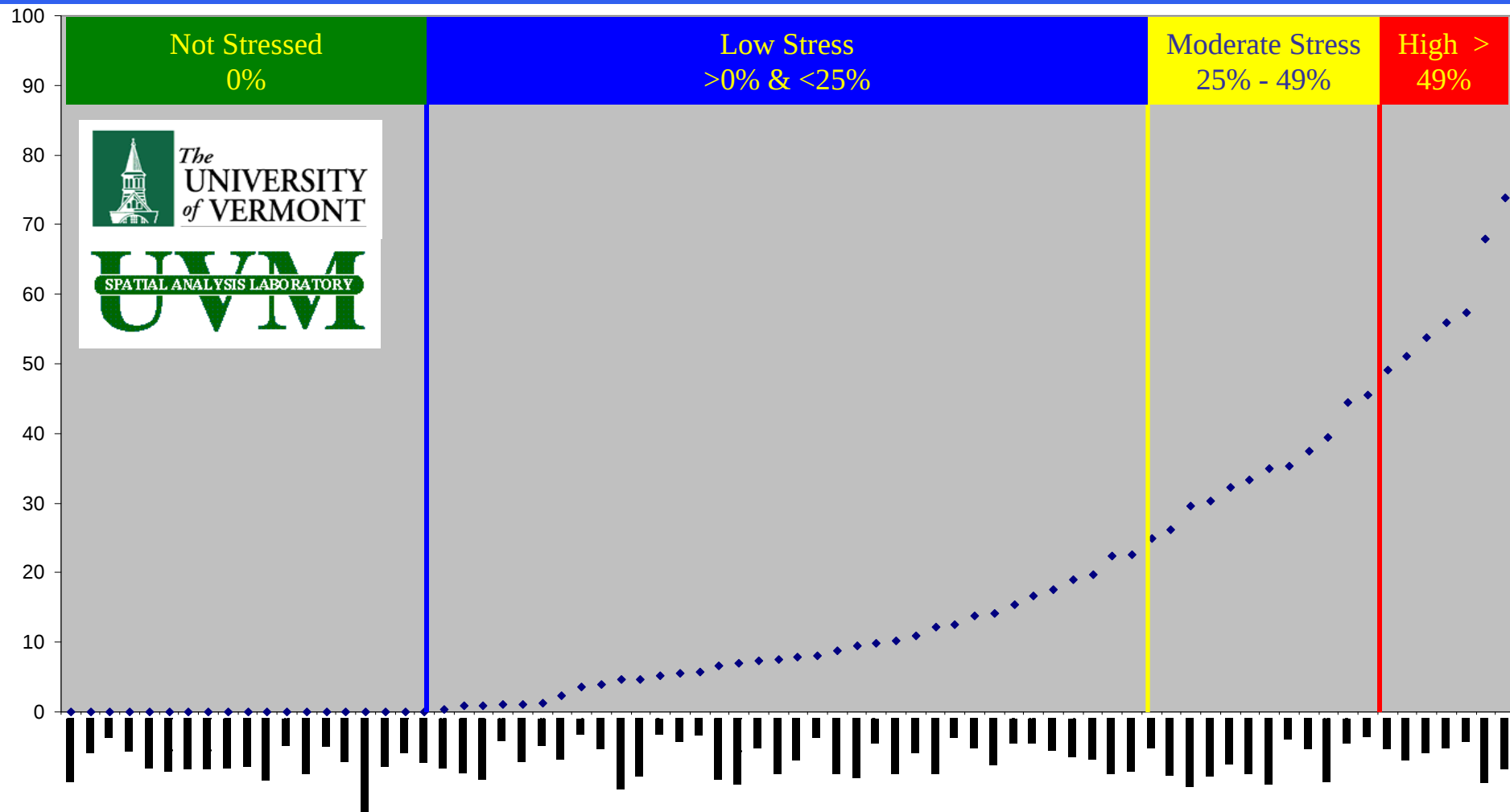
Moderate Stress, High Stress

Whittier, Paulsen, Larsen, Petersen, Herlihy and Kaufmann. 2002. Indicators of Ecological Stress and their extent in the population of Northeastern Lakes. *BioScience* 52(3):235-247



Applying EPA's thresholds to Vermont

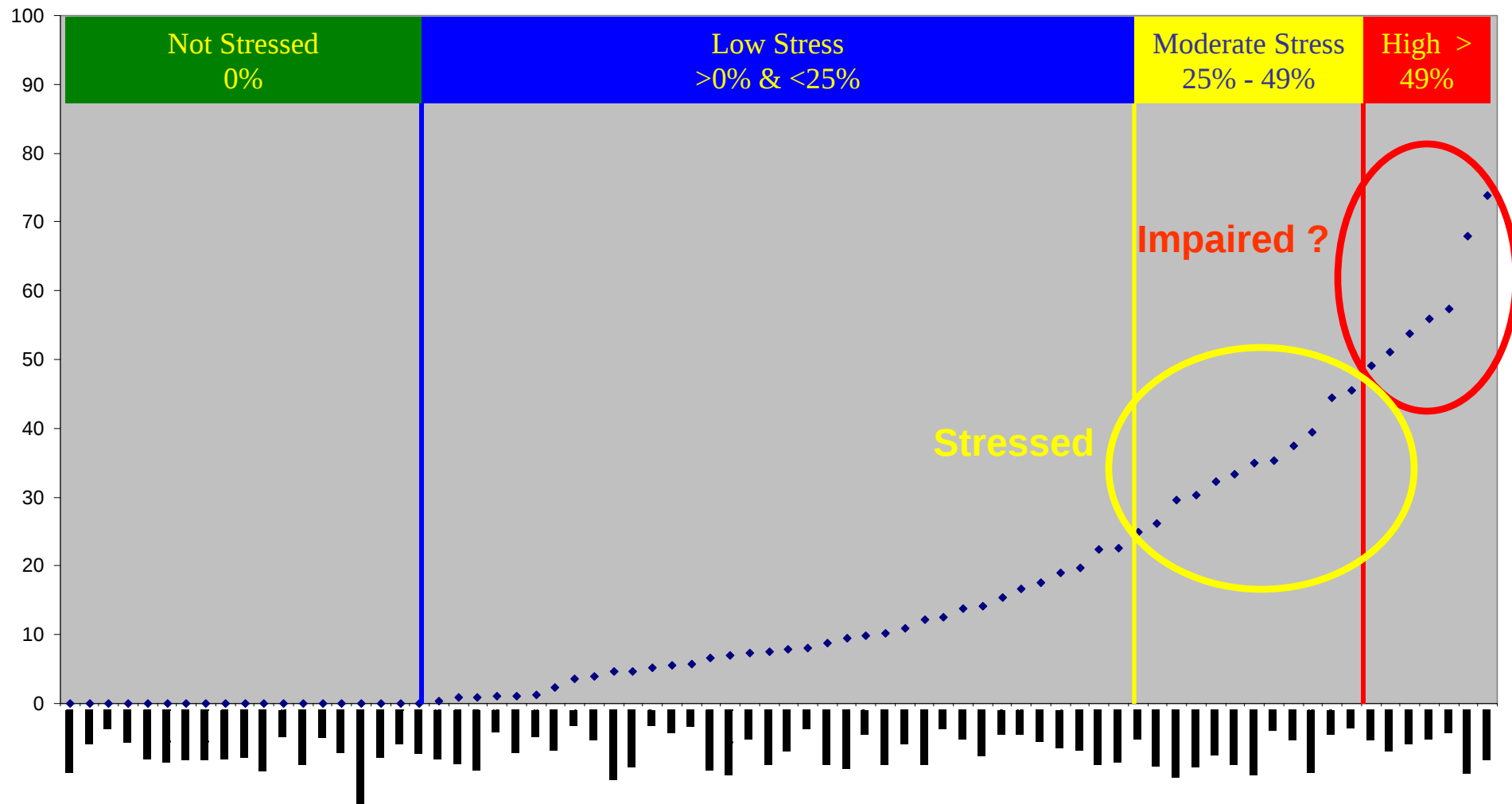
% of shore developed w/in 25' of shoreline, Using 74 UVM mapped lakes using 2003 aerial photos





Potential Stressed and Impaired Lakes (VTWQS)

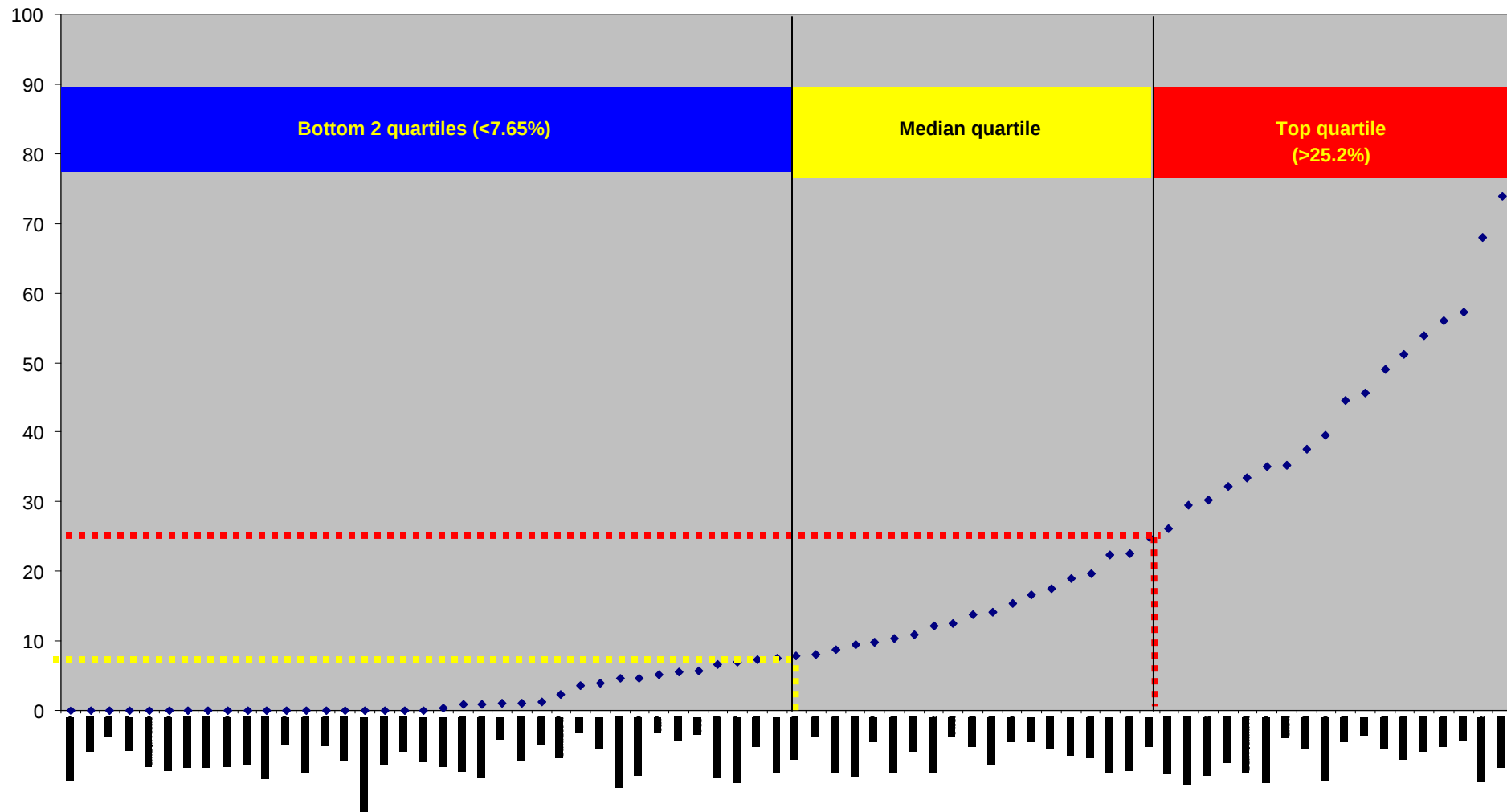
Use as threshold in future management objectives?





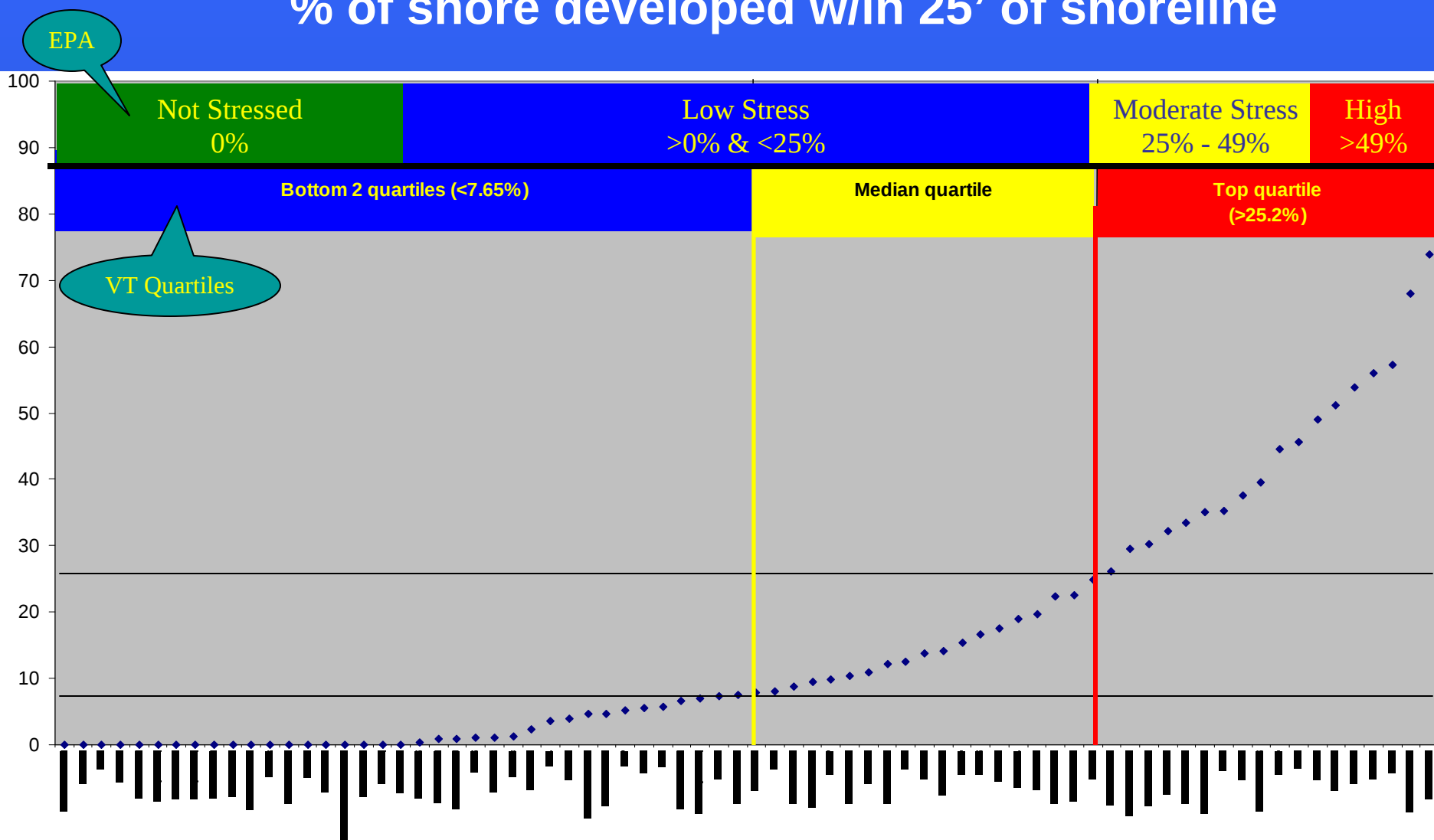
Instead of using EPA's thresholds, use their approach

% of shore developed w/in 25' of shoreline



Different thresholds tailored to VT lakes

% of shore developed w/in 25' of shoreline



A green frog is sitting in a shallow stream with a rocky bed. Above the frog is a large, light blue thought bubble containing text. Three smaller, light blue circles lead from the frog to the main thought bubble.

But are these valid
thresholds of how much
lakeshore development
a lake can sustain?

Hypothesis

- When lakewide development gets to a certain threshold, we'll see changes in our habitat parameters measured at undeveloped reference sites.

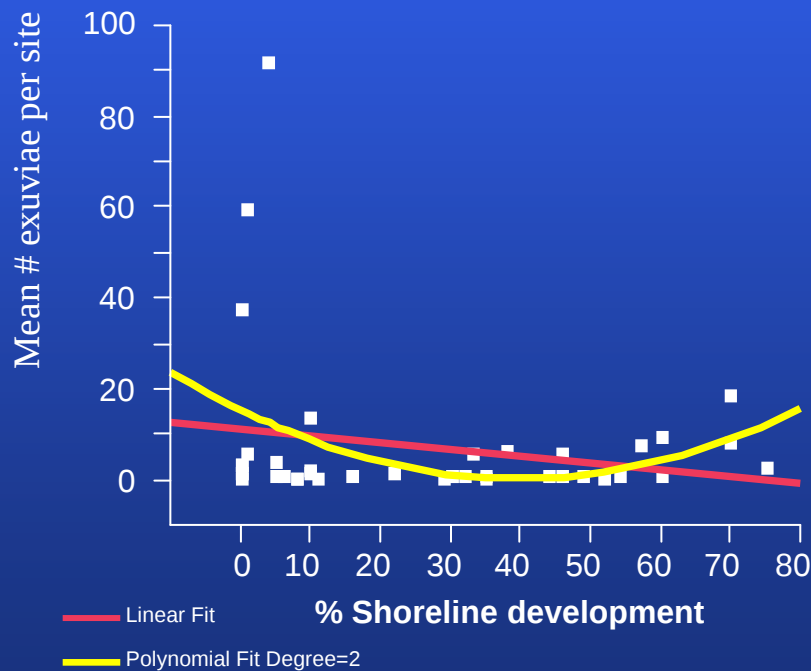
Is there a development threshold?

**Mean # odonate exuviae at undeveloped sites by %
shoreline development**



Is there a development threshold?

Mean # exuviae at undeveloped sites by % shoreline development



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	1245.844	622.922	2.1341
Error	37	10799.756	291.885	
C. Total	39	12045.600		

Prob > F
0.1327

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	8.57	4.369538	1.96	0.0573
Mean(Development25Feet)	-0.254	0.13174	-1.91	0.0641
(Mean(Development25Feet)-26.55)^2	0.009	0.005909	1.61	0.1153

Is there a development threshold?

Other parameters examined:

- Aquatic woody habitat
 - Fine, medium, coarse
- Macrophytes
- Substrate characteristics
 - Sand, embeddedness

Is there a development threshold?

Other parameters examined:

- Aquatic woody habitat
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**NO OBSERVED
THRESHOLDS**

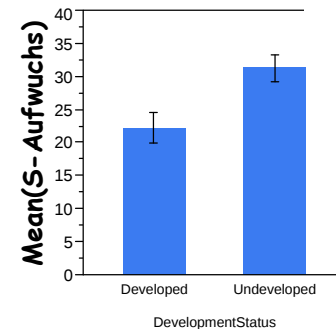
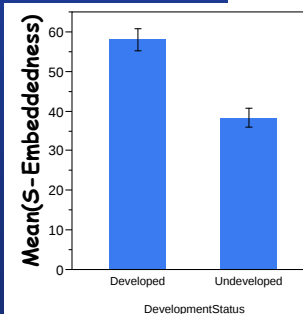
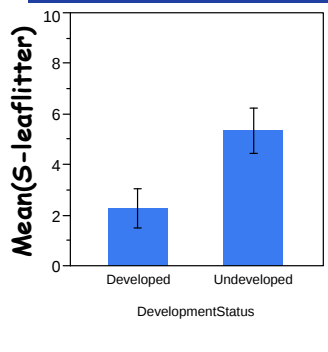
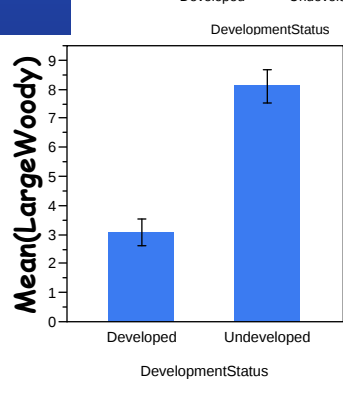
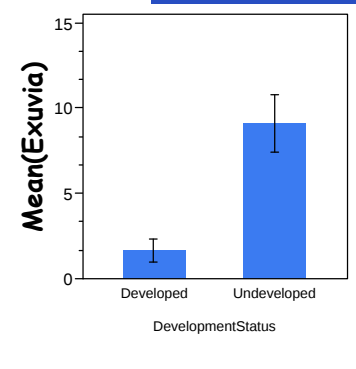
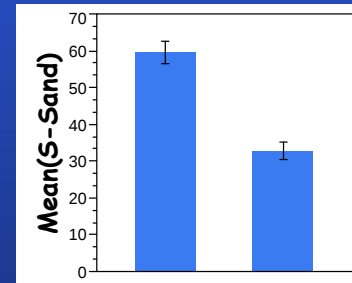
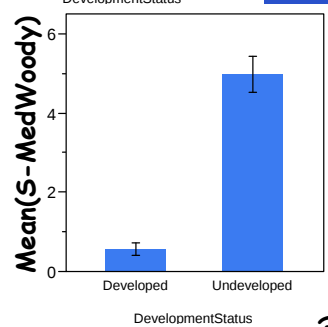
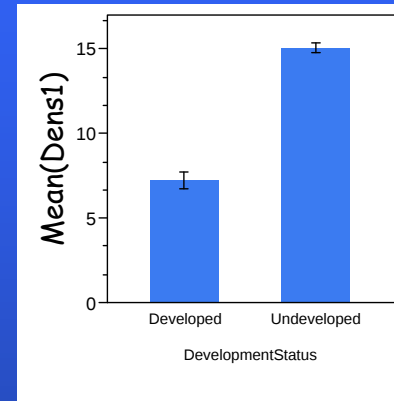
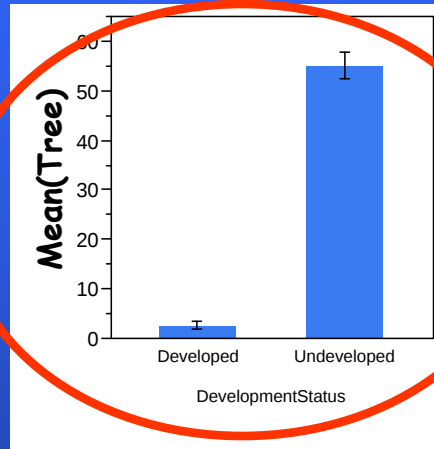
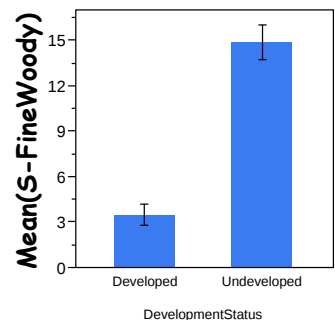
Hypothesis not supported

- No observed threshold limit
- Our littoral habitat response variables are truly a function of treed shores



IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

The result of removing the vegetated buffer & increasing impervious surface area

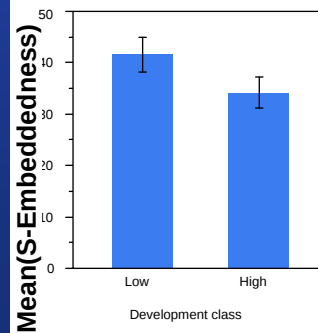
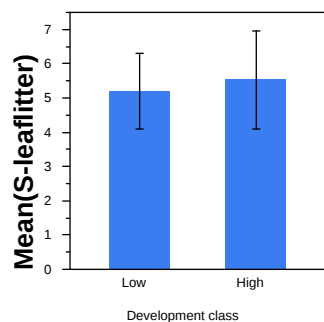
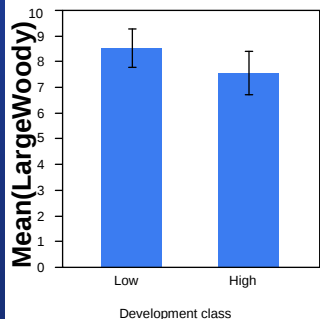
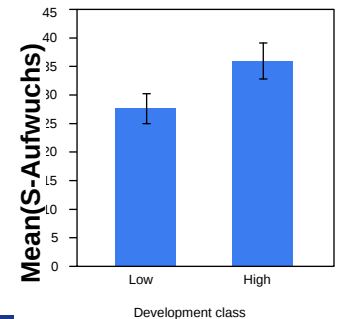
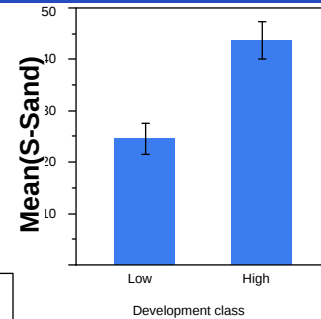
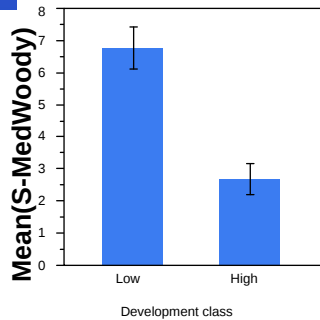
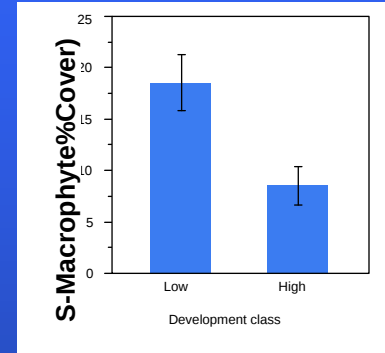
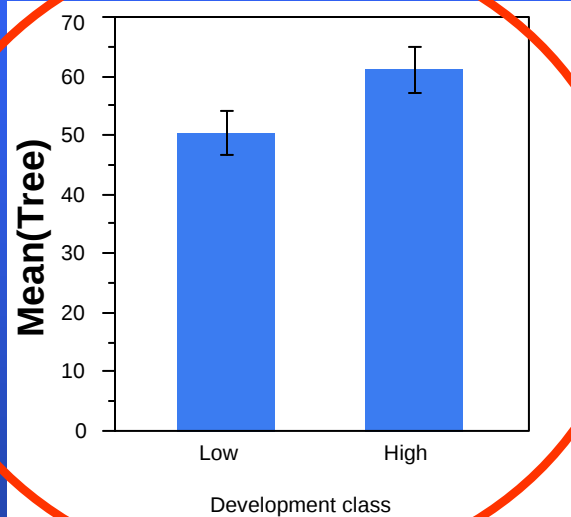
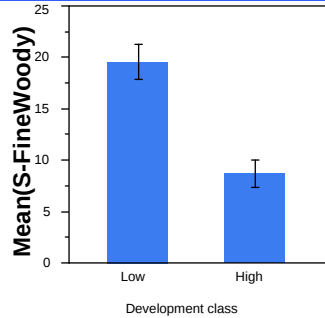


Hypothesis not supported

- No observed threshold limit
- Our littoral habitat response variables are truly a function of treed shores
- Narrowly treed shorelines on highly developed lakes can provide refugia

IMPACTS OF DEVELOPMENT ON AQUATIC HABITAT

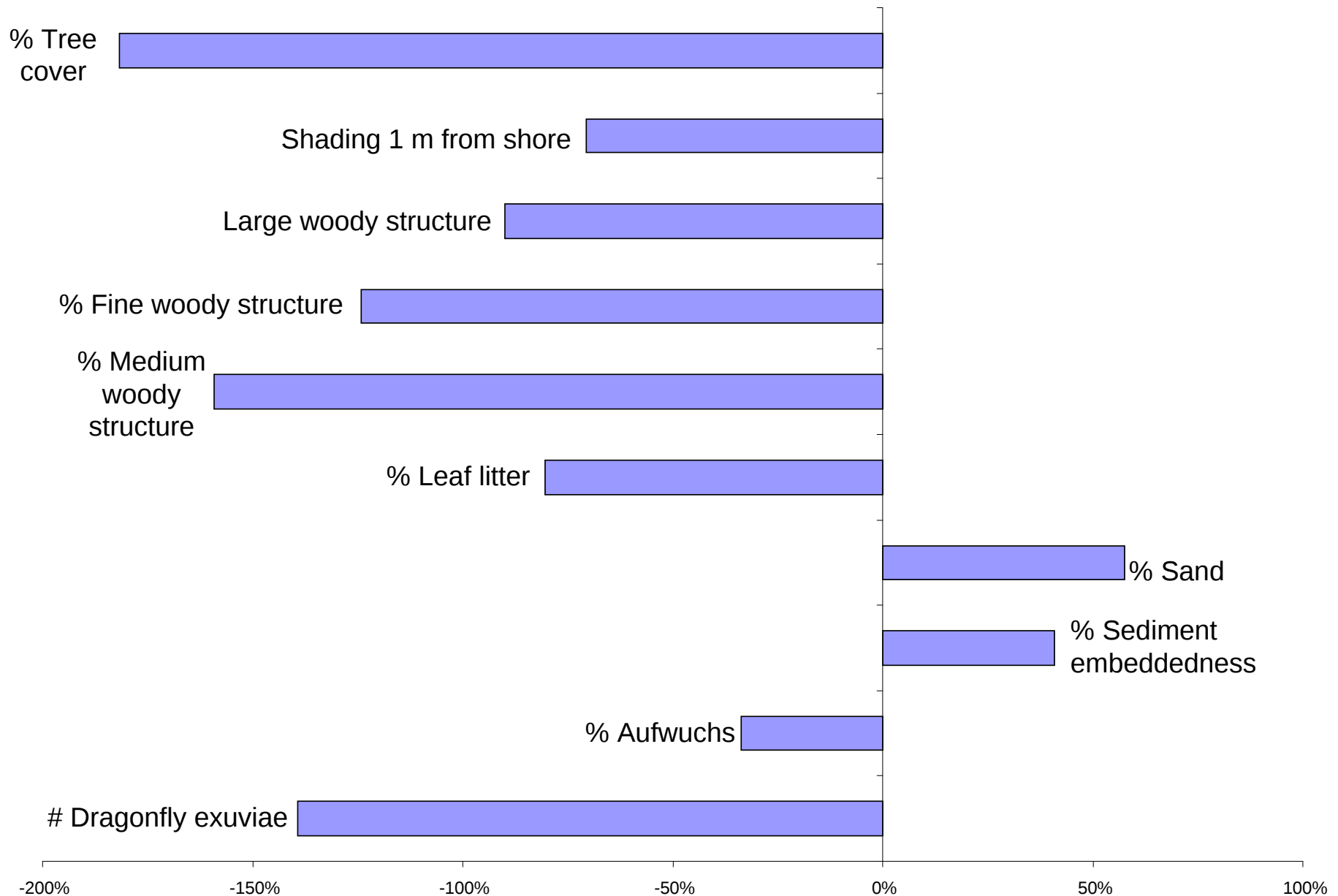
Conditions at undeveloped sites at low and high levels of shoreline development (25%)



So, we've got findings
indicating that at the site
level there are big changes
in littoral habitat



Relative Percent Difference of Unbuffered Developed Sites From Reference Condition



How to answer the
question:

“How much
development can a lake
sustain?”



How to answer the question:

“How much development can a lake sustain?”

- Develop a sampling program to capture lakewide affect on specific species and/or community

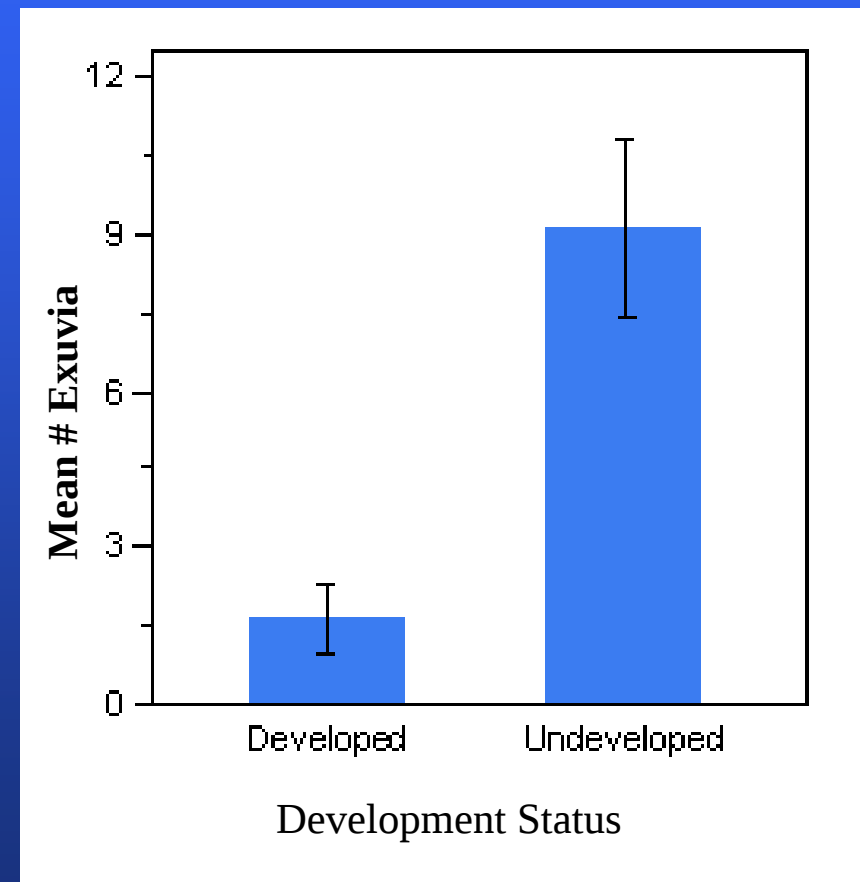
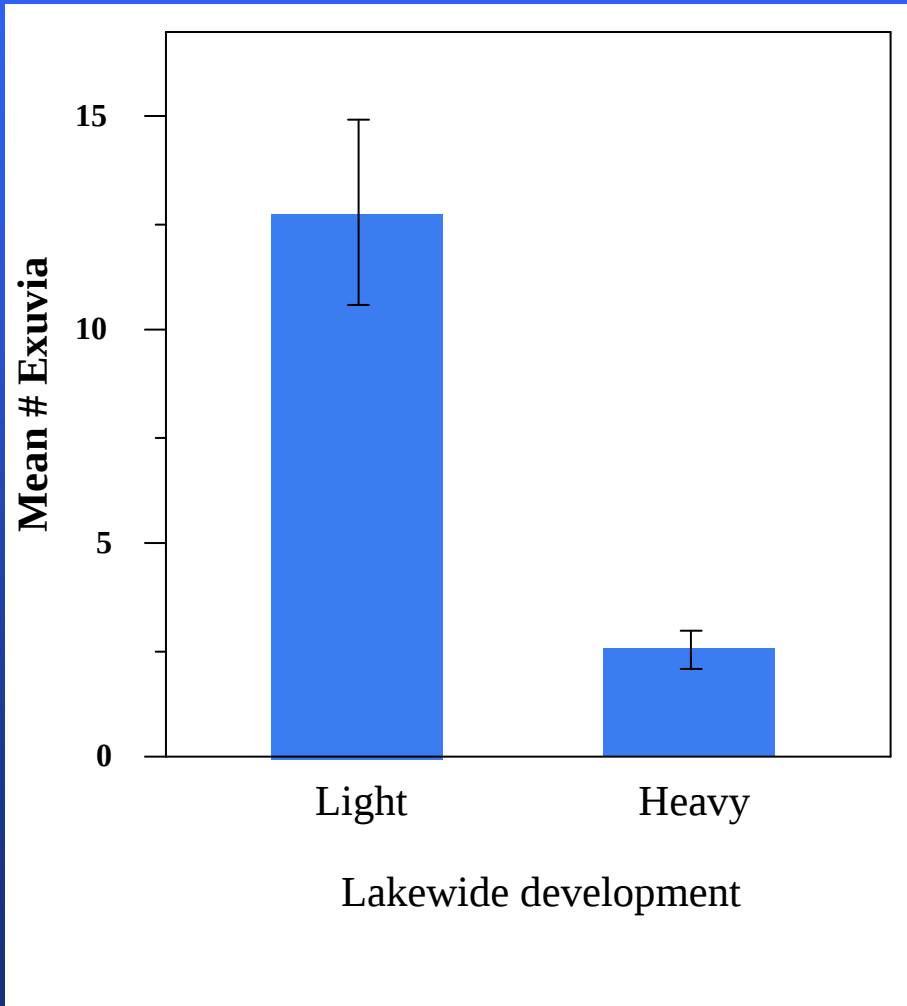


How to answer the question:

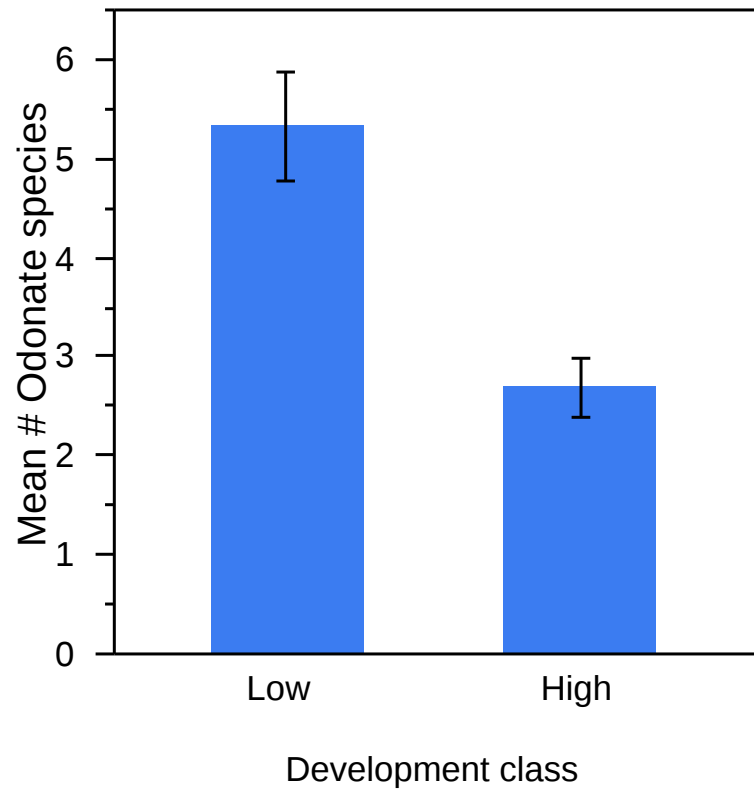
“How much development can a lake sustain?”

- Develop a sampling program to capture lakewide affect on specific species and/or community
- Choose indicator species with life histories linked to the reference condition of the littoral and riparian habitats
 - Odonates, amphibians
 - Directly use aquatic and terrestrial habitats
 - Spawning fishes
 - Direct use of aquatic habitat
 - Indirectly affected by terrestrial land use

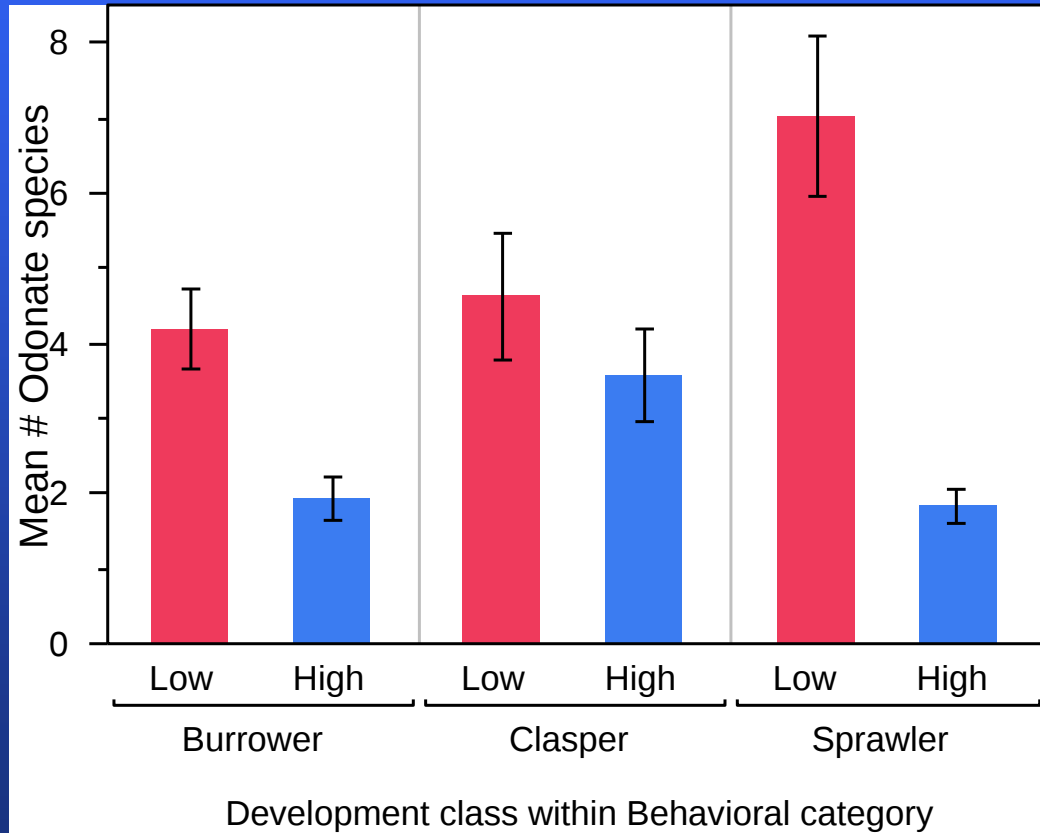
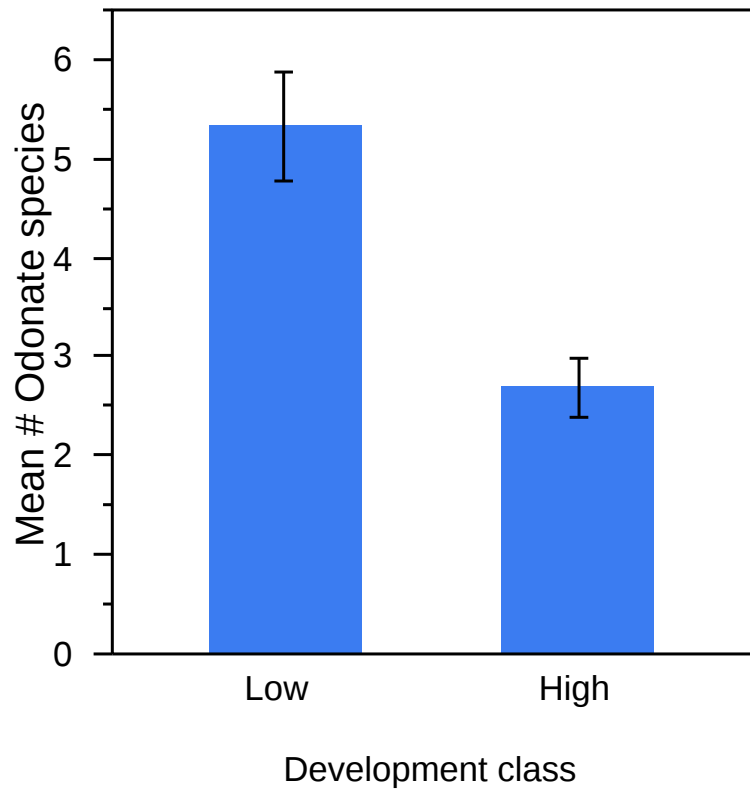
Odonates as an indicator species?



Odonates as an indicator species?



Odonates as an indicator species?



How to answer the question:

“How much development can a lake sustain?”

- Develop a sampling program to capture lakewide affect on specific species and/or community
- Choose indicator species
- Select lake classes carefully
 - Sample size is important to identify the trends!

How to answer the question:

“How much development can a lake sustain?”

- Develop a sampling program to capture lakewide affect on specific species and/or community
- Choose indicator species
- Select lake classes carefully
- Explore alternative statistical techniques
 - Principal Components Analysis & linear regression?

Collaborators

UVM Spatial Analysis Lab

- David Capen
- Sean MacFaden
- Britt Haselton



Field & Expert Advice Contributors

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

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Northeastern States Research Cooperative

VT Fish & Wildlife

EPA Water Quality Monitoring



Questions?

