Measuring the effects of lakeshore development on littoral habitat and macroinvertebrates

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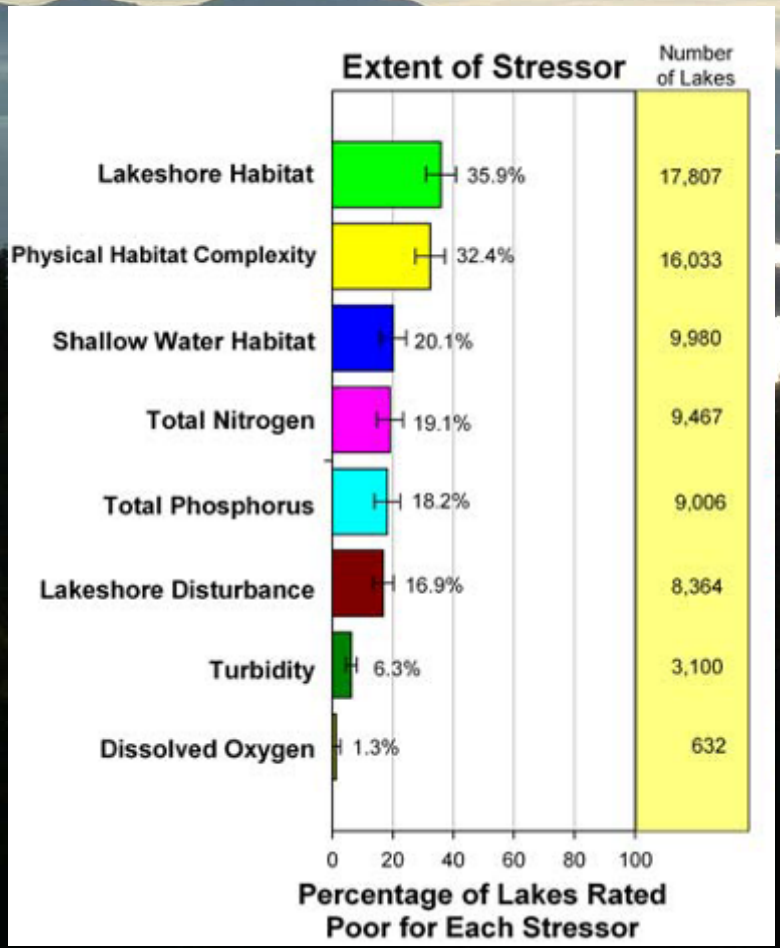
Lakeshore Residents Convert Natural Vegetation to Lawn and Impervious Surfaces

Removal of Lakeshore Vegetation 'Lakeshore Habitat' is the most widespread stressor to the nation's lakes

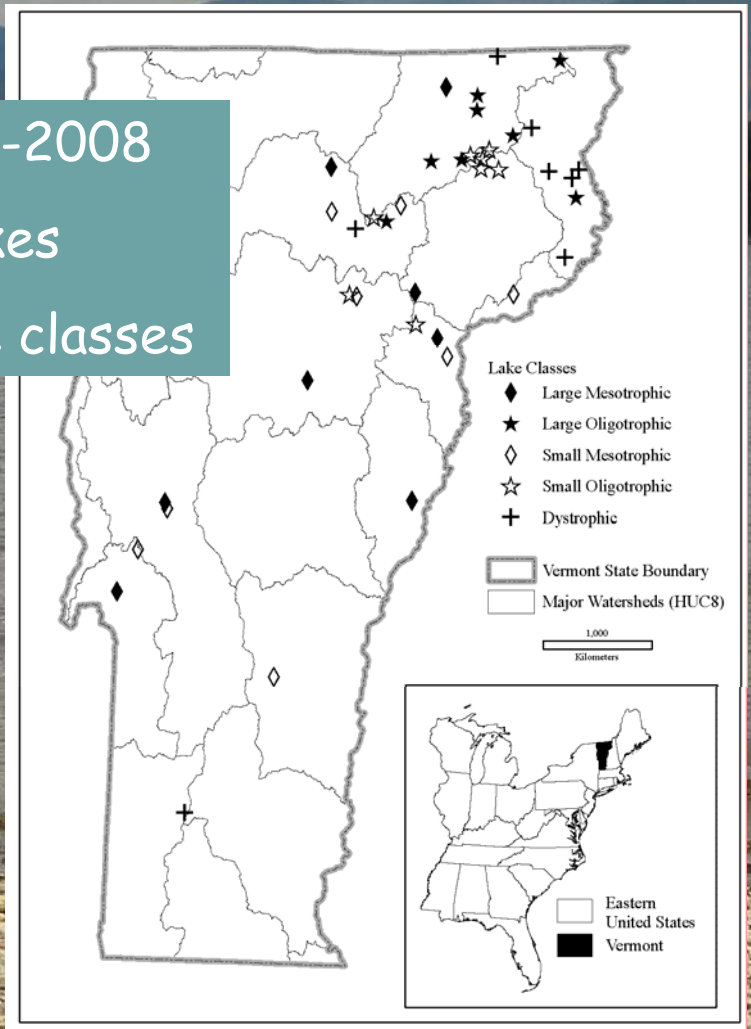


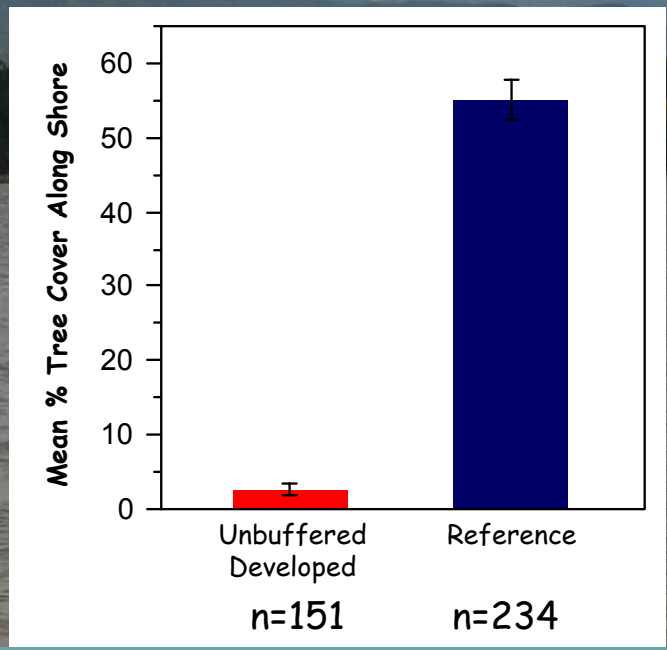
"Of the stressors included in the NLA, poor lakeshore habitat is the biggest problem in the nation's lakes; over one-third exhibit poor shoreline condition."

U.S. EPA, 2009. National Lakes Assessment, Draft Collaborate Survey of the Nation's Lakes

Vermont study found that unbuffered lakeshore development significantly changes aquatic habitat and biota

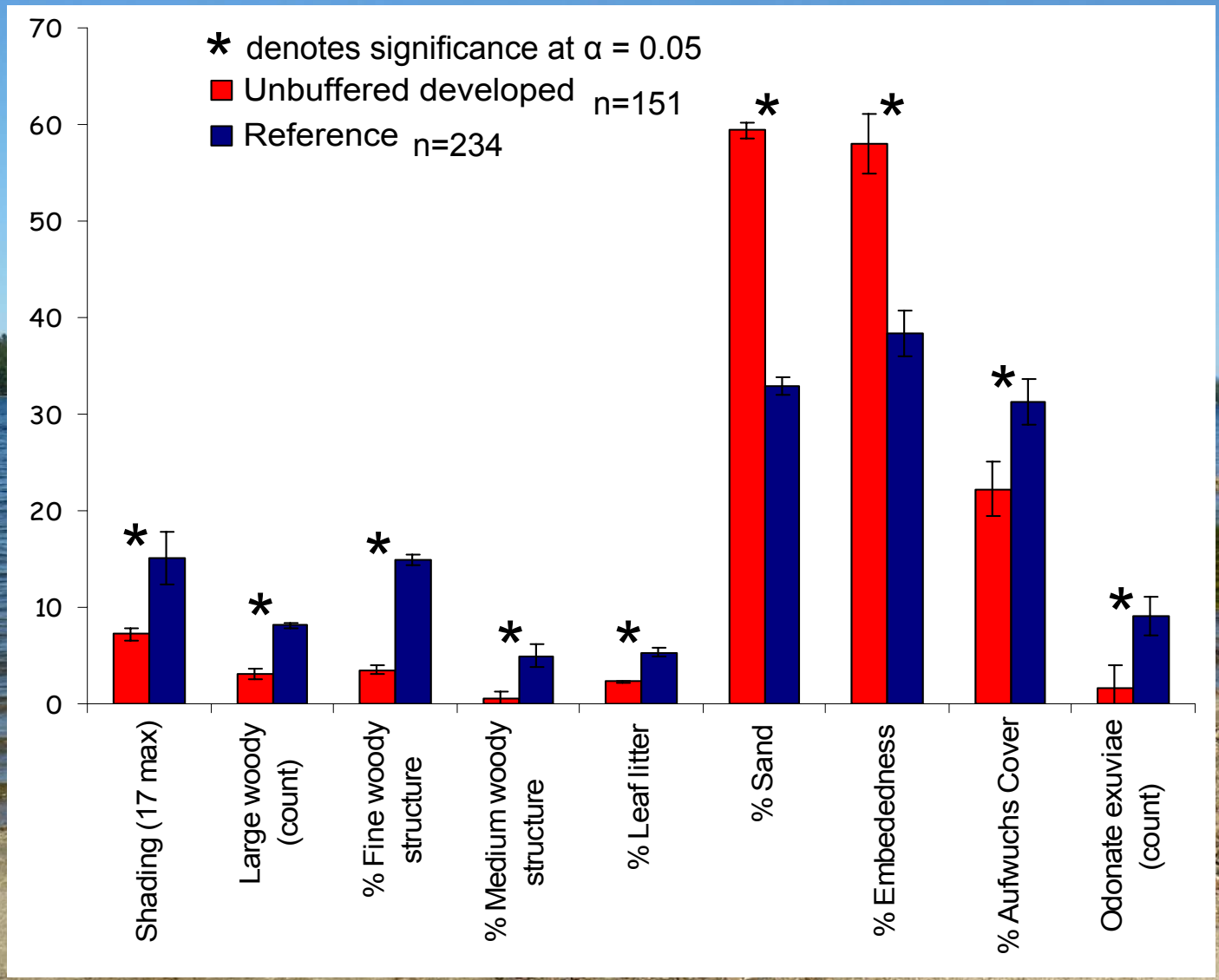
- 2005-2008
- 40 lakes
- 5 lake classes





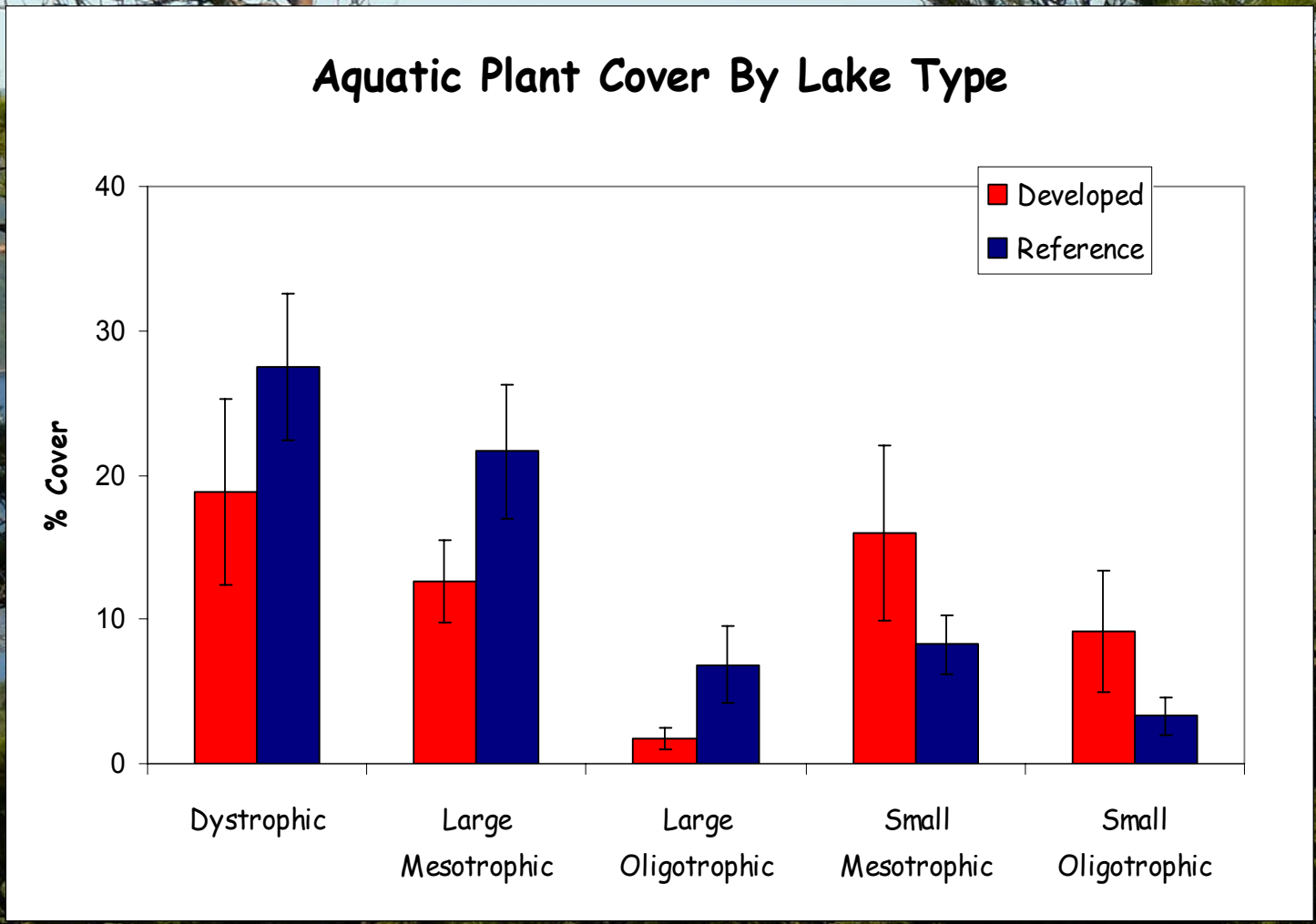
Compared developed sites without trees along the shore to reference sites

Removal of Lakeshore Vegetation Results in the Simplification of Littoral Habitat

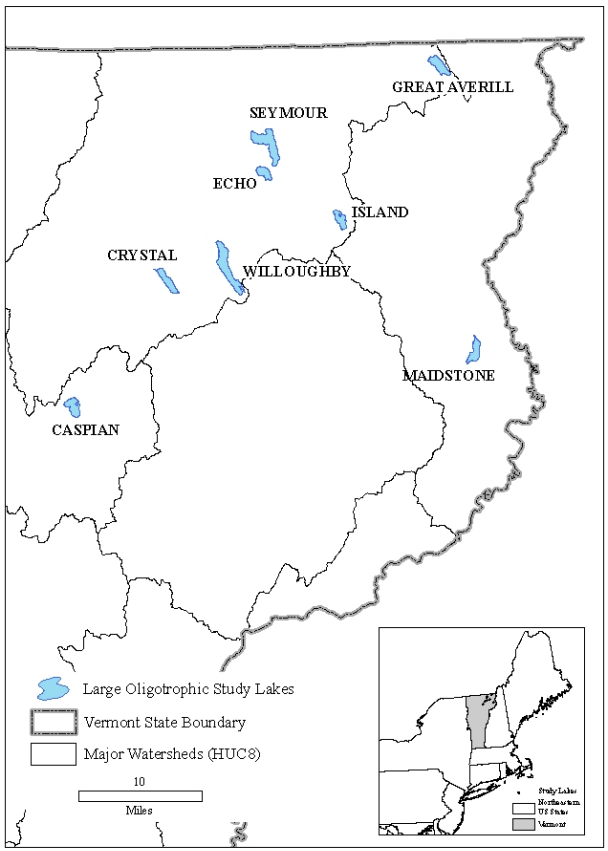


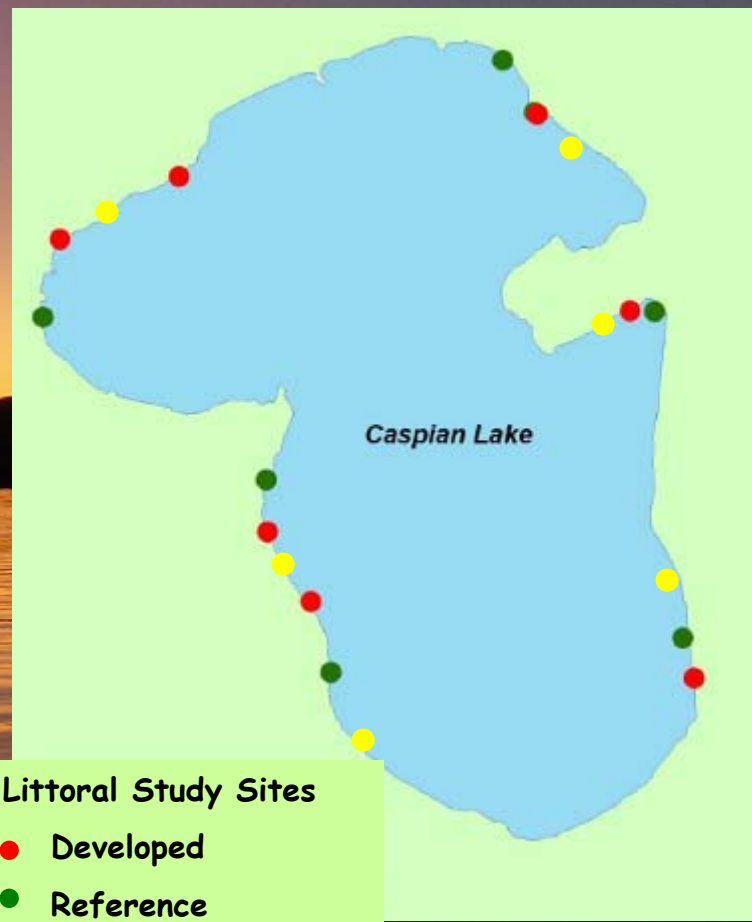
Statistically significant changes from the reference condition were found regardless of lake class

Removal of Lakeshore Vegetation Results in Changes in Aquatic Plant Cover which Varied with Lake Class



2009 Sampled 48 Buffered Developed Sites at the 8 Large Oligotrophic Lakes





Example Reference Condition Lakeshore Sites

Large Oligotrophic Lake Class

Example Reference Condition Lakeshore Sites

Large Oligotrophic Lake Class

Example Reference Condition Lakeshore Sites

Large Oligotrophic Lake Class

Example Unbuffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

Example Unbuffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

Example Unbuffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

Example Unbuffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

Example Buffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

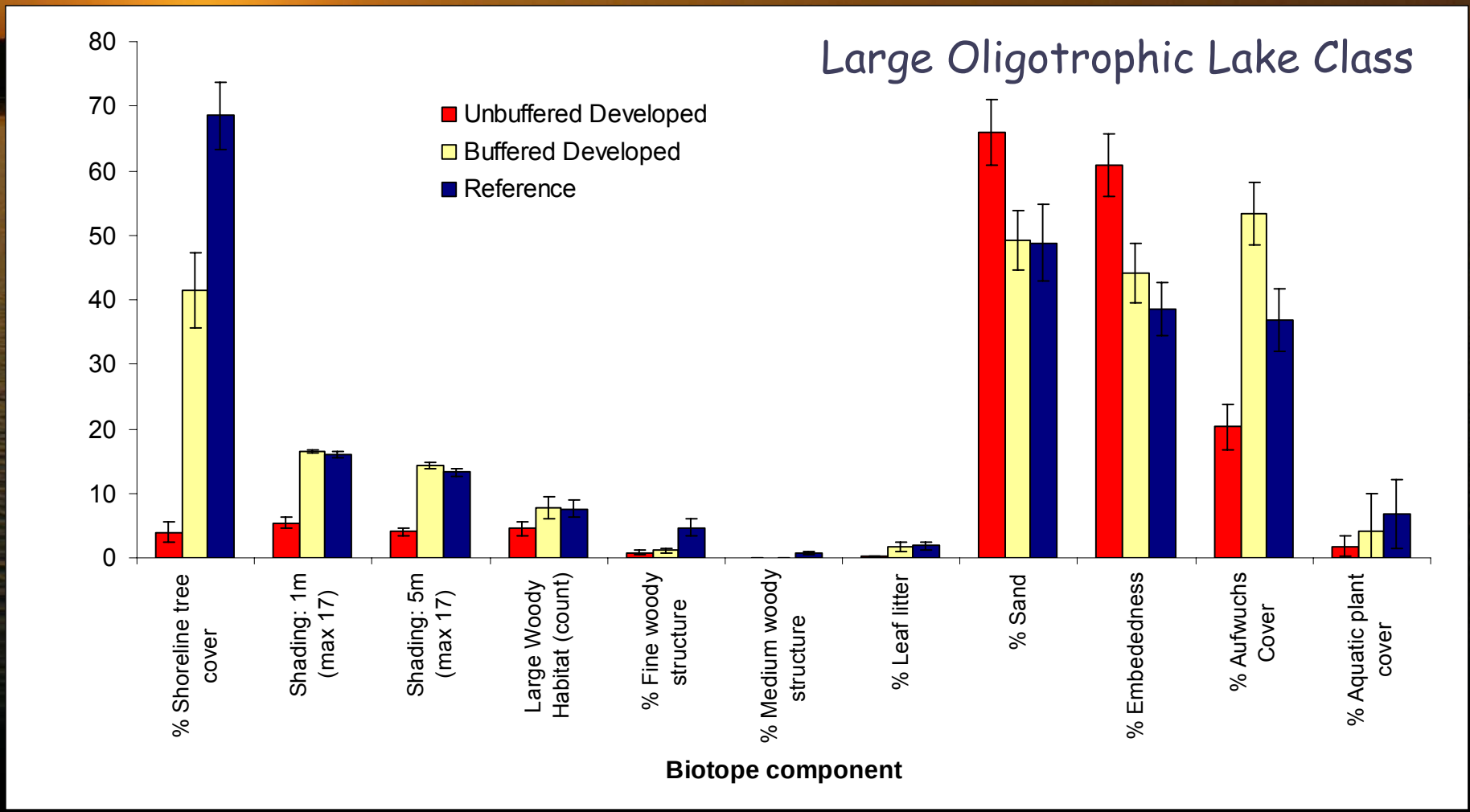
Example Buffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

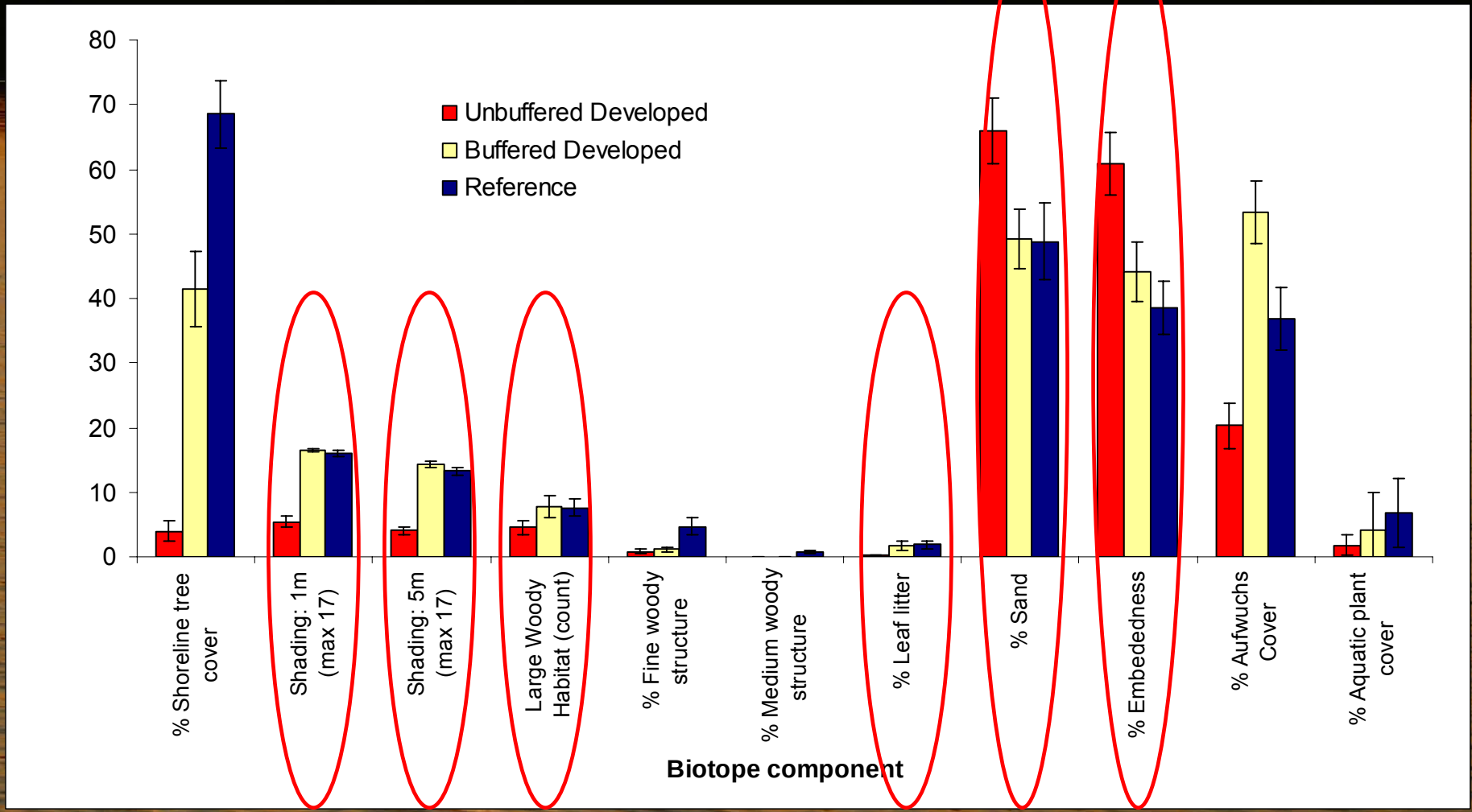
Example Buffered Developed Lakeshore Sites

Large Oligotrophic Lake Class

Buffered Developed Sites More Like Reference Sites



These 6 littoral habitat parameters retained their reference condition off buffered developed sites



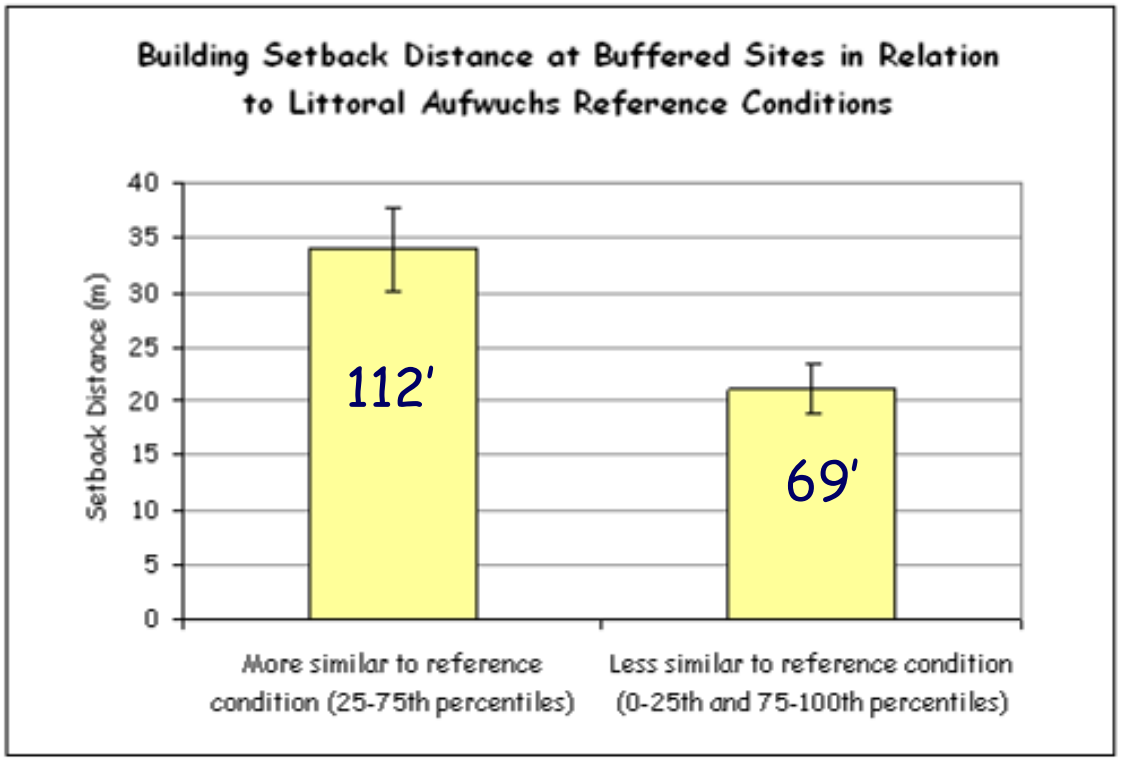
No change to the following littoral habitat parameters: shading, large woody stucture, leaf litter, sand and embeddedness, were achieved when the lakeshore property:

- IMMEDIATE SHORELINE (*viewed from lake in summer*):
  - Trees (≥15') made up at least 40% of the vegetation
  - Shrubs made up at least 20%
  - Ground cover made up no more than 20%
- The width of the intact buffer was
  - 9m (30') at it's widest
  - 7m (23') overall
  - 5m (16') at it's narrowest
- Main structures were set back an average of 20m (66')
- Closest structures were set back an average of 17.5 m (57')

No change to the following littoral habitat parameters: shading, large woody stucture, leaf litter, sand and embeddedness, were achieved when the lakeshore property: (Continued)

- 25'X25' RIPARIAN PLOT (*viewed knee height in late fall*):
  - Duff and natural grasses/ferns made up 60-80%
  - Tree trunks 10%
  - Shrubs 15%
  - Lawn/flower beds less than 10%
- >30 saplings (<2' diam) in 25'X25' riparian plot
- <5% of the 25'X25' riparian plot was impervious
- Maintained the minimum of 12 DBH points allowed by Maine's shoreland protection act

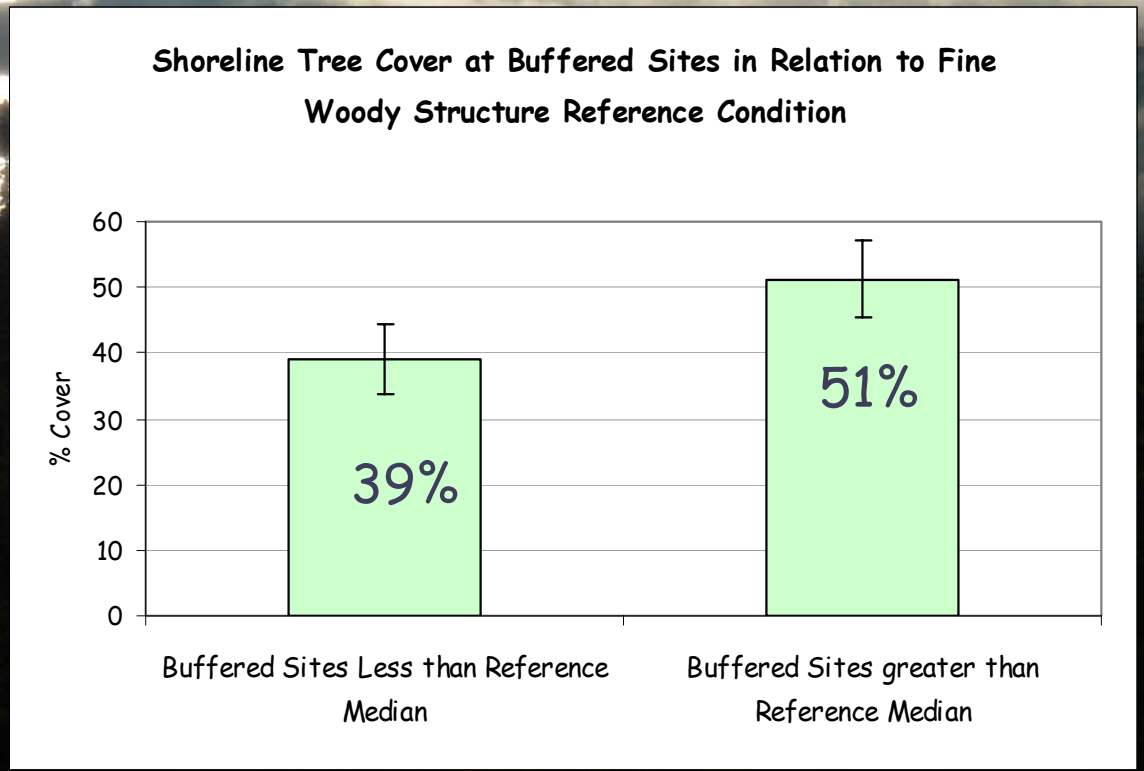
No change to aufwuchs was achieved when the lakeshore property met the additional criteria of:



- Main structures were set back an additional 14m back (34m or 112')

No change to fine woody structure was achieved when the lakeshore property met the additional criteria of:

- Trees (>15') made up an additional 10% more of the immediate shoreline (for a total of 50%)



It is possible to develop a lakeshore and protect aquatic habitat

- It simply requires maximizing the retention of natural vegetation and setting impervious surfaces back from the lakeshore

The 2009 sampling effort also entailed collecting macroinvertebrate samples from the original unbuffered and reference sandy and rocky littoral sites, the dominant habitat types in these lakes.

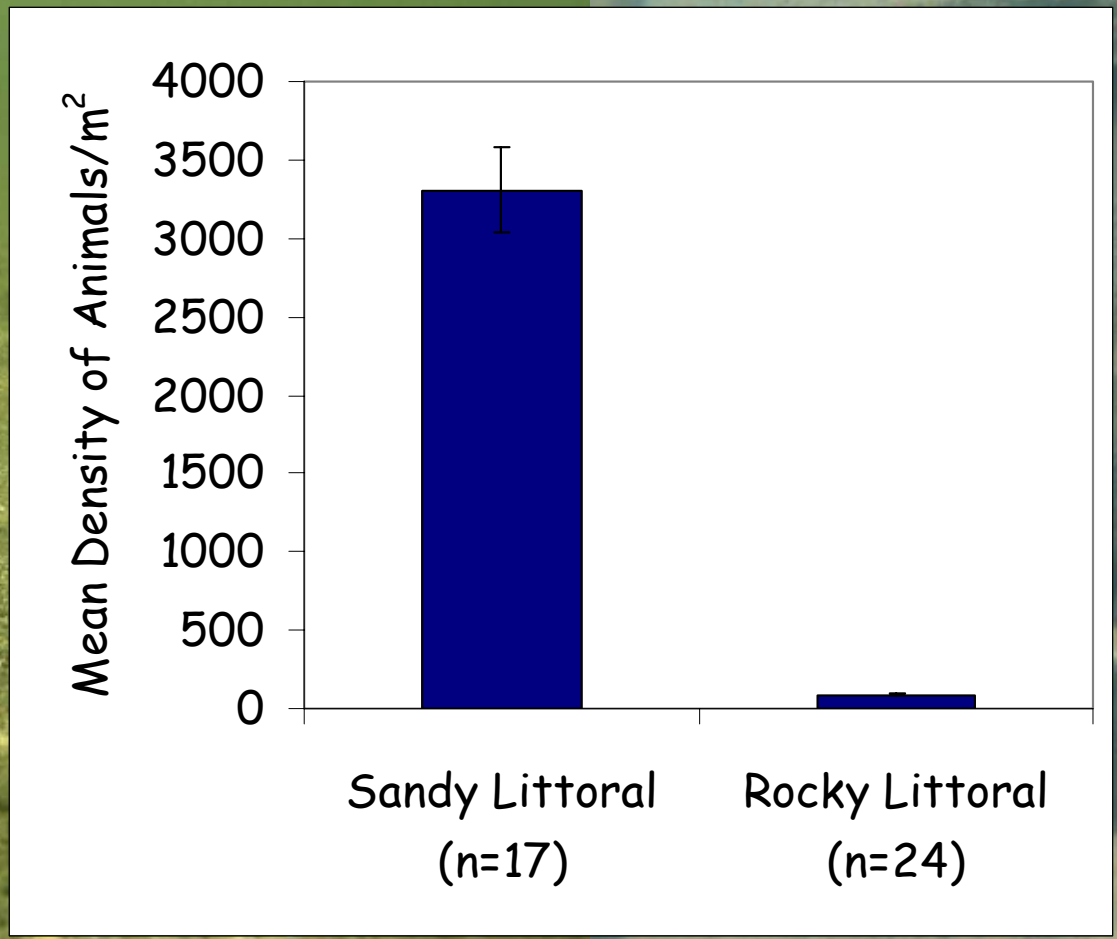
2009 Macroinvertebrate Sampling

- 8 Large Oligotrophic Lakes
- Unbuffered Developed and Reference Sites
- Rocky and Sandy Sites
- 0.5 m depth

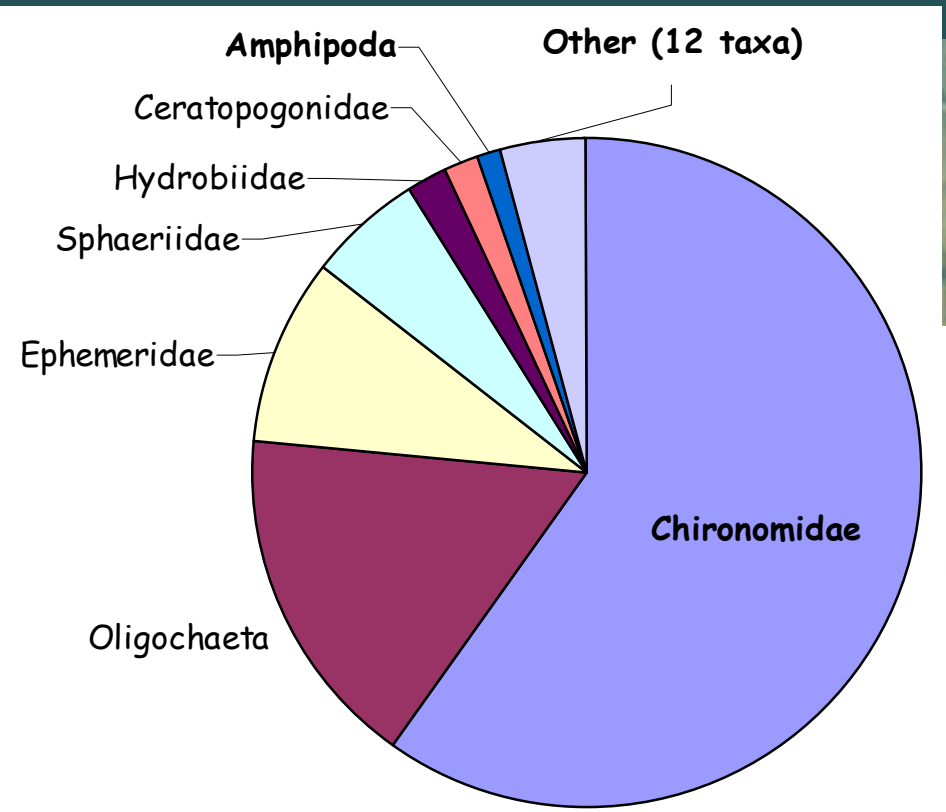
De Susa, S., Pinel-Alloul, B. and Cattaneo, A. 2008. Response of littoral macroinvertebrate communities on rocks and sediments to lake residential development. Can. J. Fish. Aquat. Sci. 65: 1206 – 1216.

Levey, R. and Fiske, S. 1996. Survey of the shale and cobble zone macroinvertebrate communicty, 1995. Vermont Agency of Natural Resources, Waterbury, VT. 37 p.

Reference Site Macroinvertebrate Densities Differed With Substrate Type

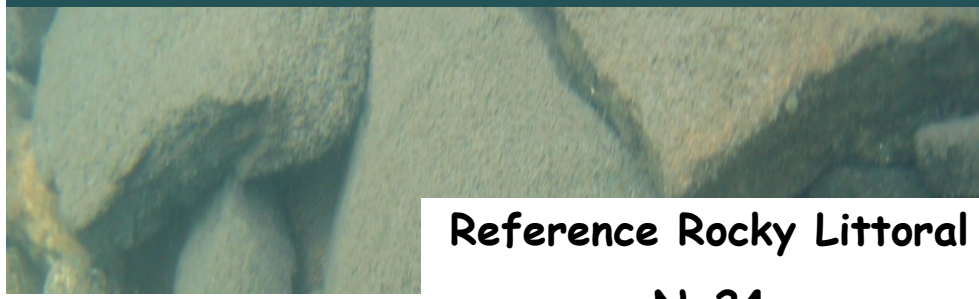


Reference Macroinvertebrate Communities Differed with Substrate



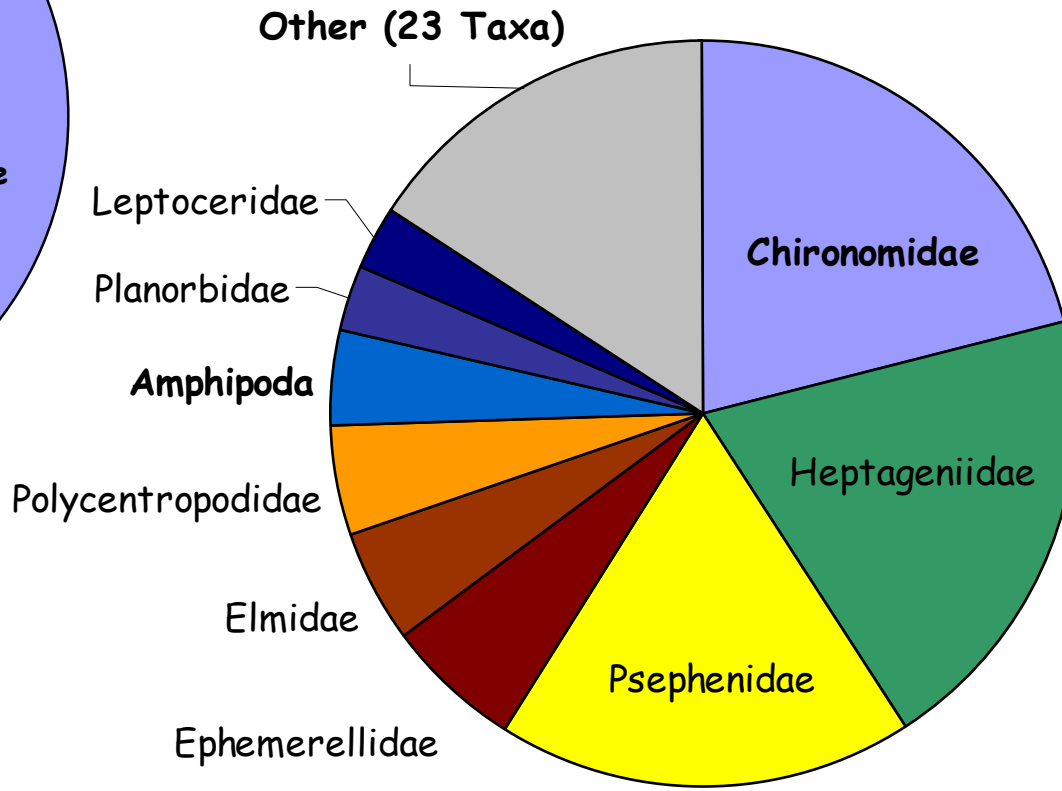
Reference Sandy Littoral

N=17

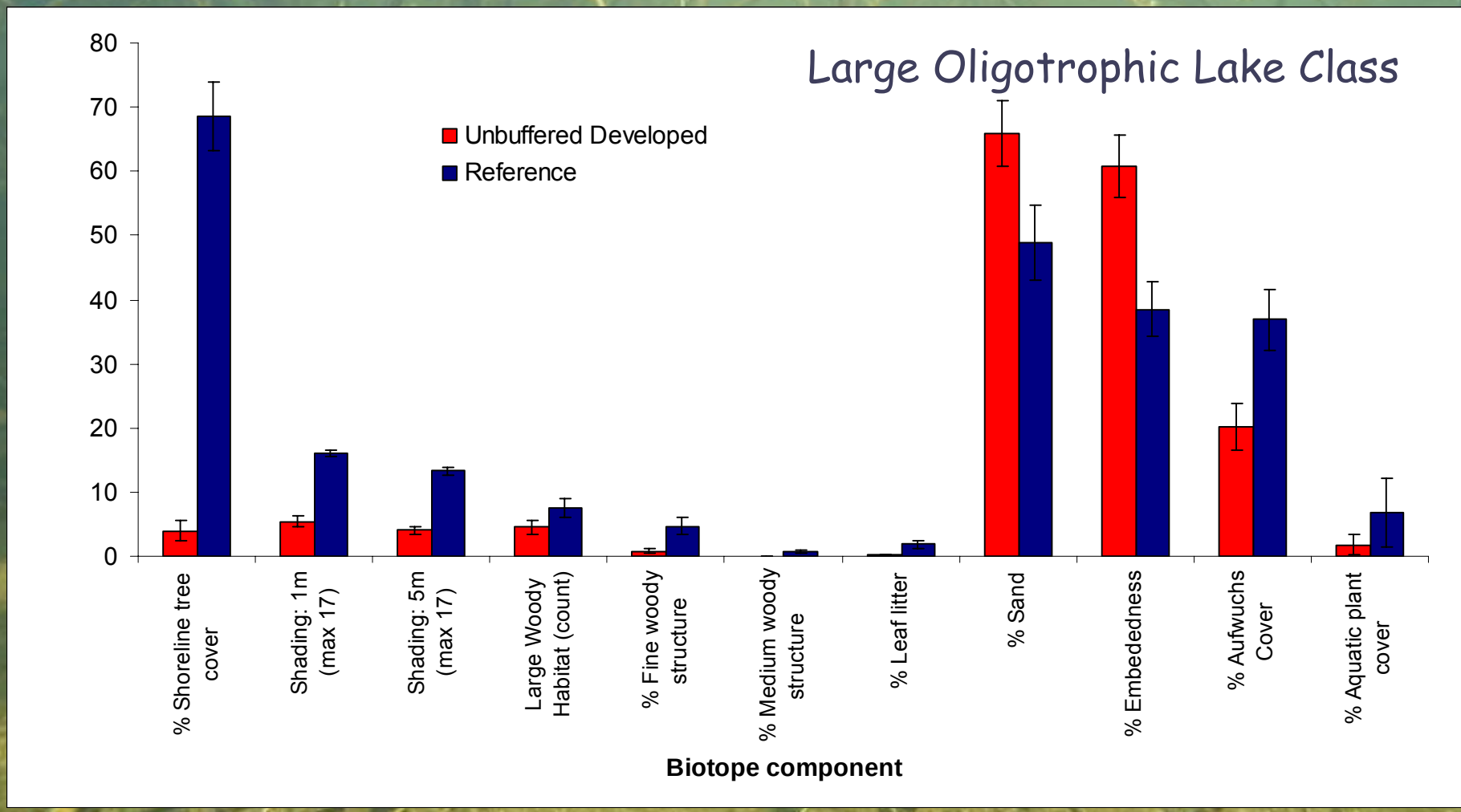


Reference Rocky Littoral

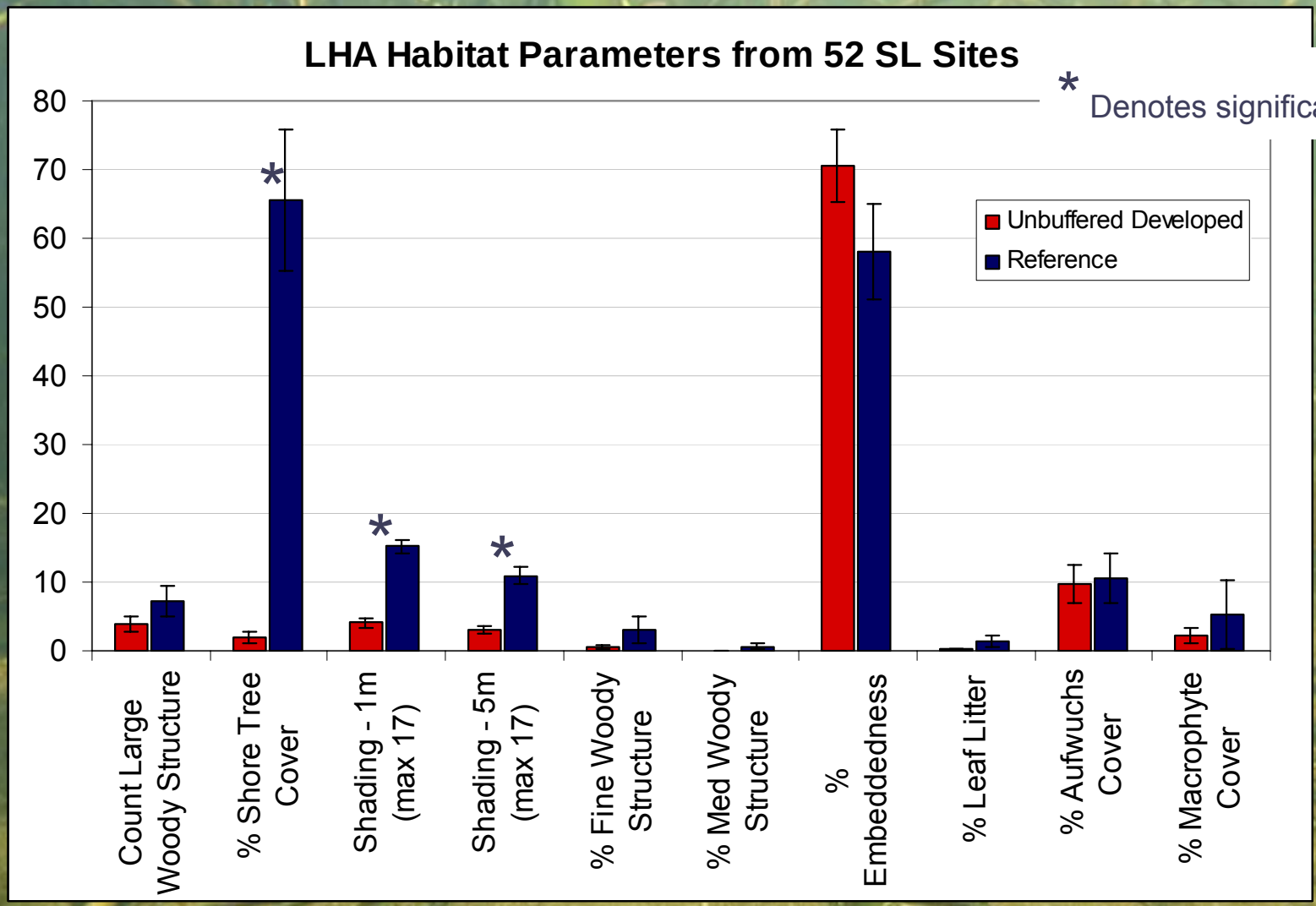
N=24



Do Macroinvertebrate Densities and Community Structure Change With Changes in Littoral Habitat Caused by Unbuffered Lakeshore Development?



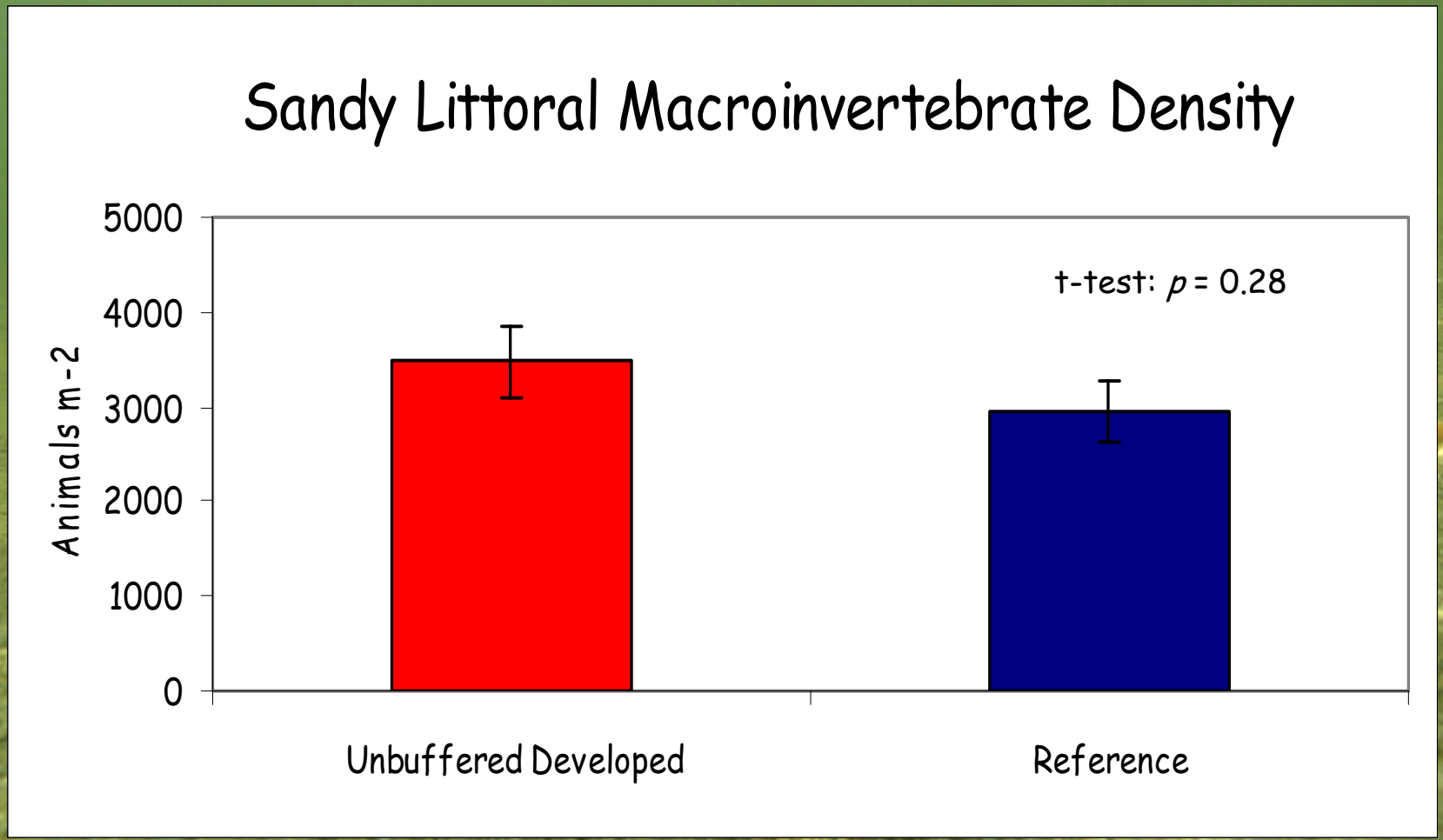
For Sandy Sites Sampled, the Only Littoral Habitat Parameter that Significantly Differed From the Reference Sites was Shading



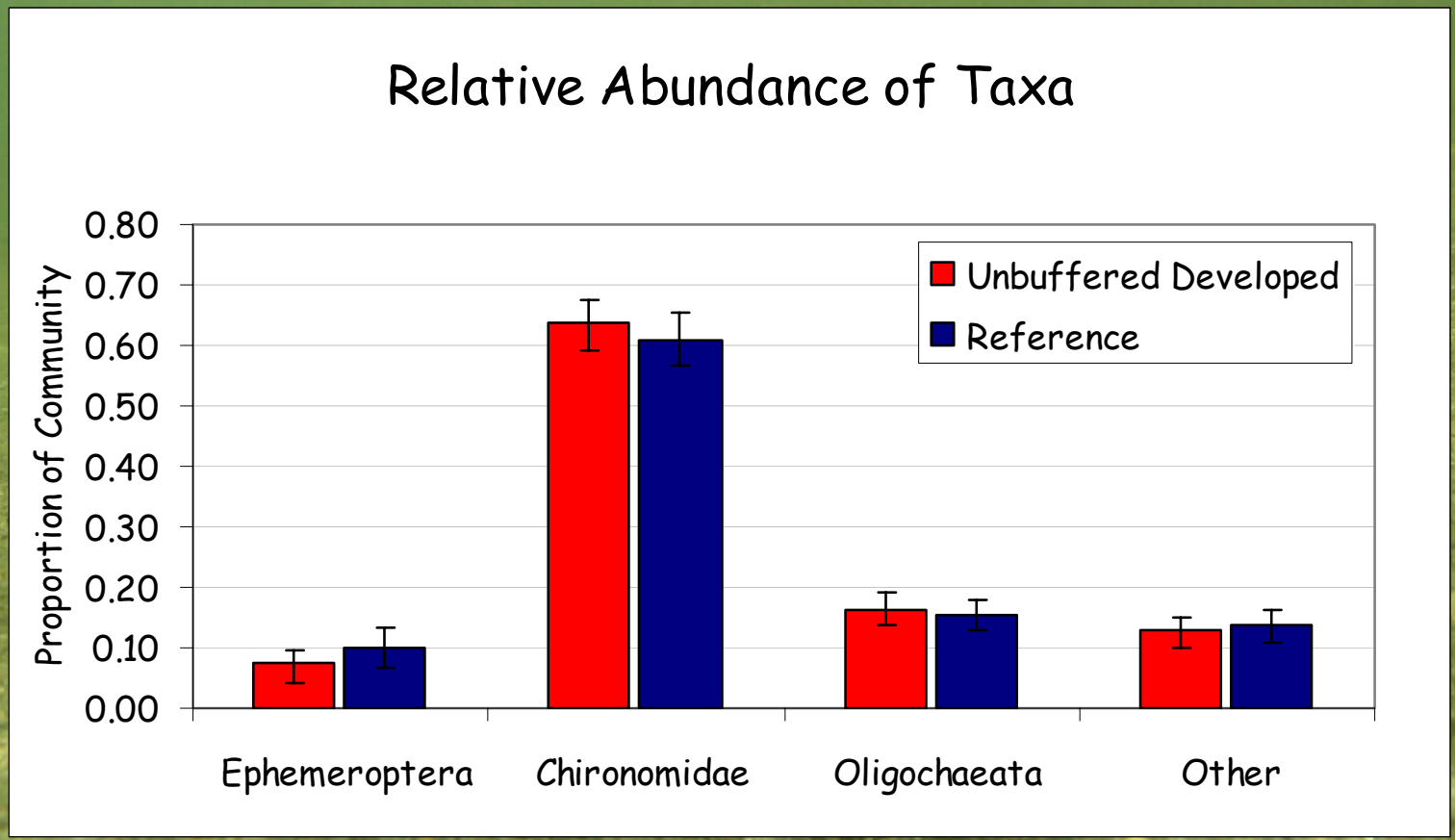
Unbuffered Developed (n=35)

Reference (n=17)

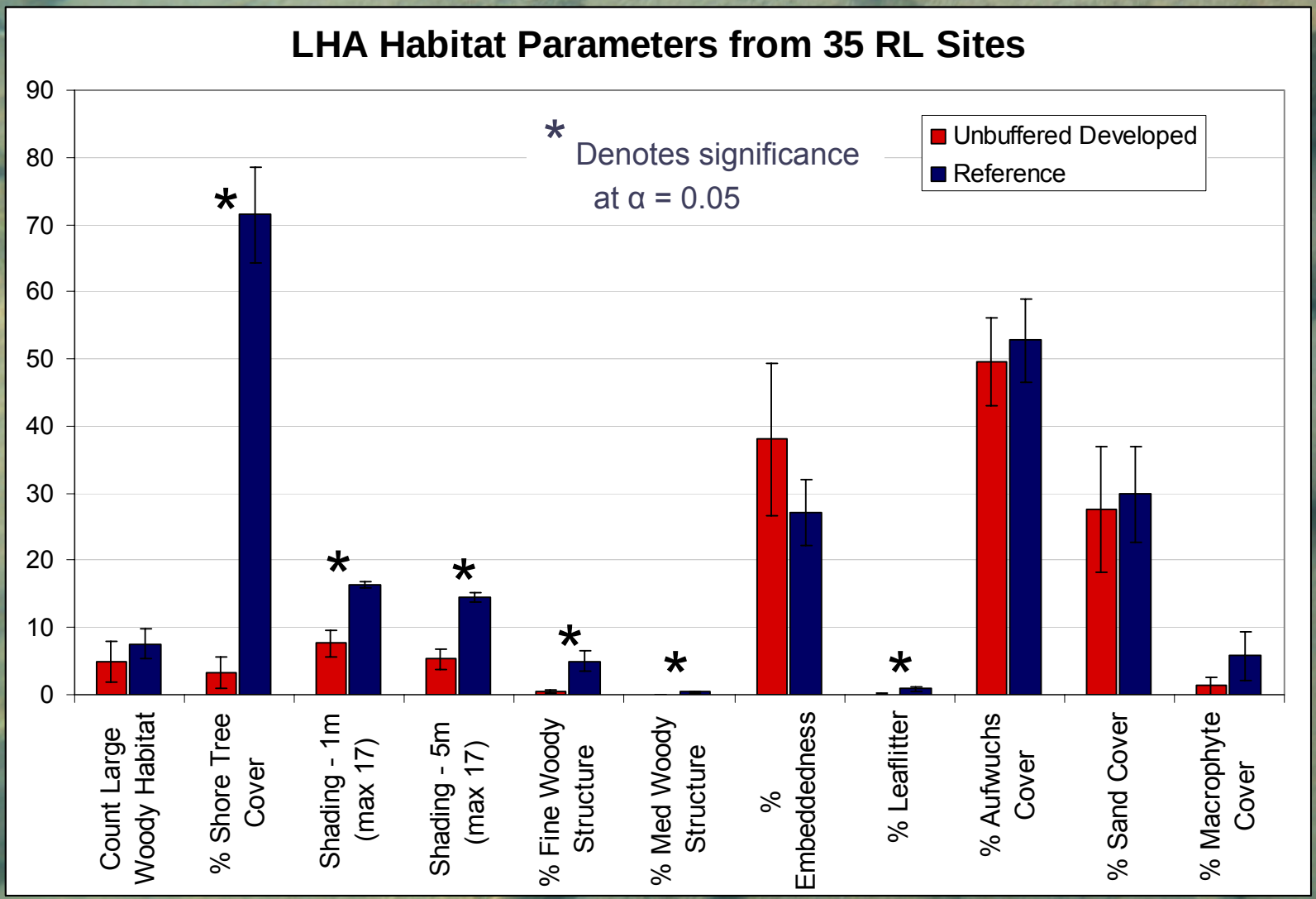
When Shading Was the Only Littoral Habitat Characteristic Changed by Development, No Significant Change in Macroinvertebrate Densities at Sandy Sites Was Found



When Shading Was the Only Littoral Habitat Characteristic Changed by Development, No Significant Change in the Macroinvertebrate Community at Sandy Sites was Found



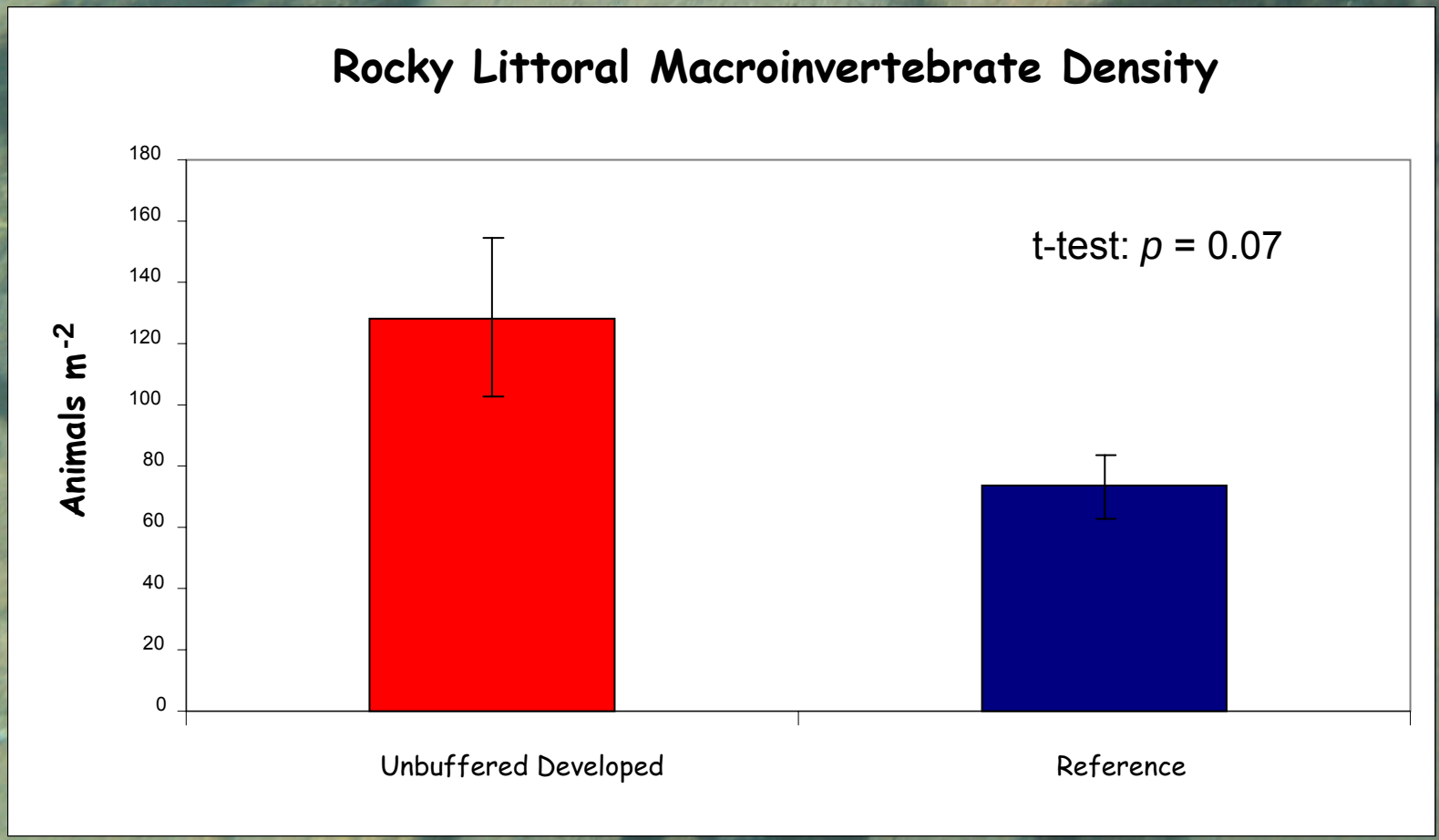
For Rocky Sites Sampled, the Only Littoral Habitat Parameters that Significantly Differed From the Reference Sites were Shading, Leaf Litter, Fine and Medium Woody Structure



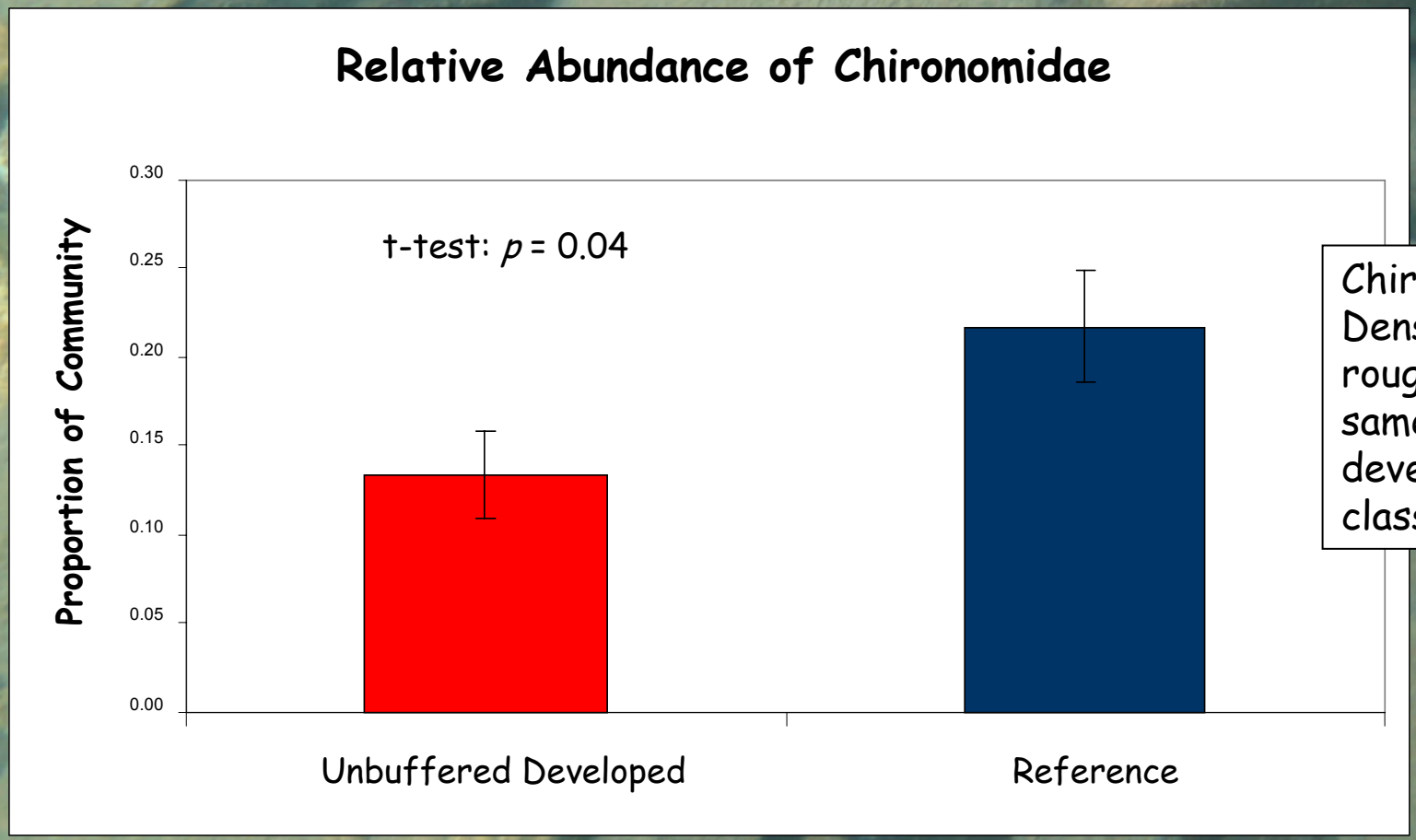
Unbuffered Developed (n=11)

Reference (n=24)

At Unbuffered Developed sites; where shading, leaf litter, fine and medium woody structure was reduced, the density of macroinvertebrates was greater



At Unbuffered Developed sites; where shading, leaf litter, fine and medium woody structure was reduced, the community structure of macroinvertebrates was altered



Chironomidae Densities were roughly the same between development classes: ~15 m^{-2}

Macroinvertebrates as Bioindicators?

- Substrate type defined the community structure as well as overall densities
- Sensitivity to development was not adequately tested at sandy sites, since developed sites sampled only significantly differed from reference sites in littoral shading
- Localized enrichment increased densities and shifted the community structure at unbuffered developed rocky sites compared to reference rocky sites (Littoral shading, % leaf litter, % fine and medium woody structure were significantly different)

Incorporating Littoral Habitat and Biomonitoring into Routine Lake Monitoring

The Clean Water Act affords the use of aquatic habitat and biotic indicators to determine if designated uses are attainable, to what extent they are supported, and to evaluate the effect of pollutant sources and their controls on water quality.

Results from this study suggest that habitat and biotic indicators should be developed and standardized to expand routine lake monitoring into the littoral zones of lakes.

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