National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

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LAKES 101

Biocriteria Development for Lakes: Merging multimetric & multivariate approaches to develop trial biocriteria for phytoplankton and macroinvertebrates in lakes

Presented by

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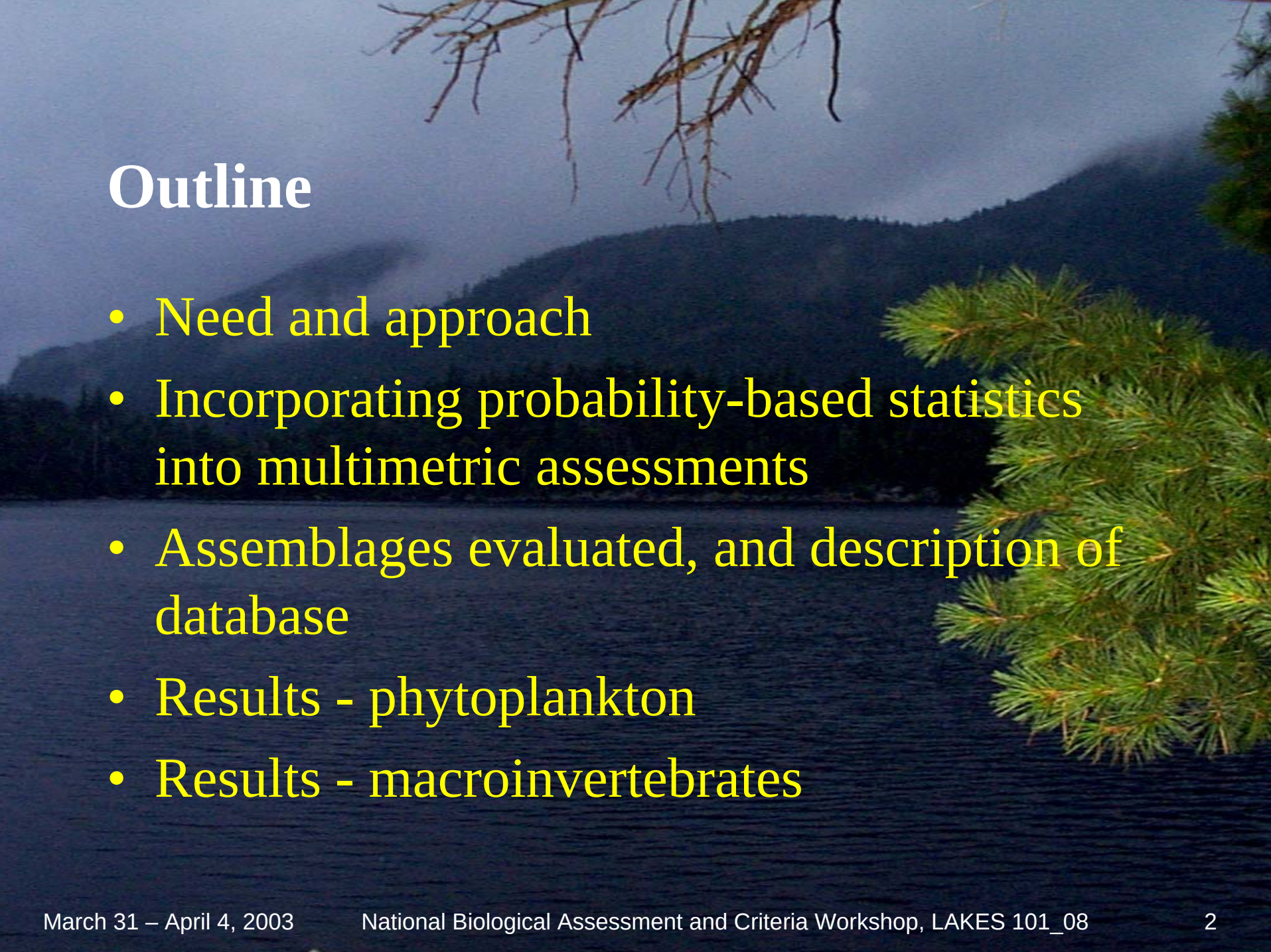


Outline

- Need and approach
- Incorporating probability-based statistics into multimetric assessments
- Assemblages evaluated, and description of database
- Results - phytoplankton
- Results - macroinvertebrates

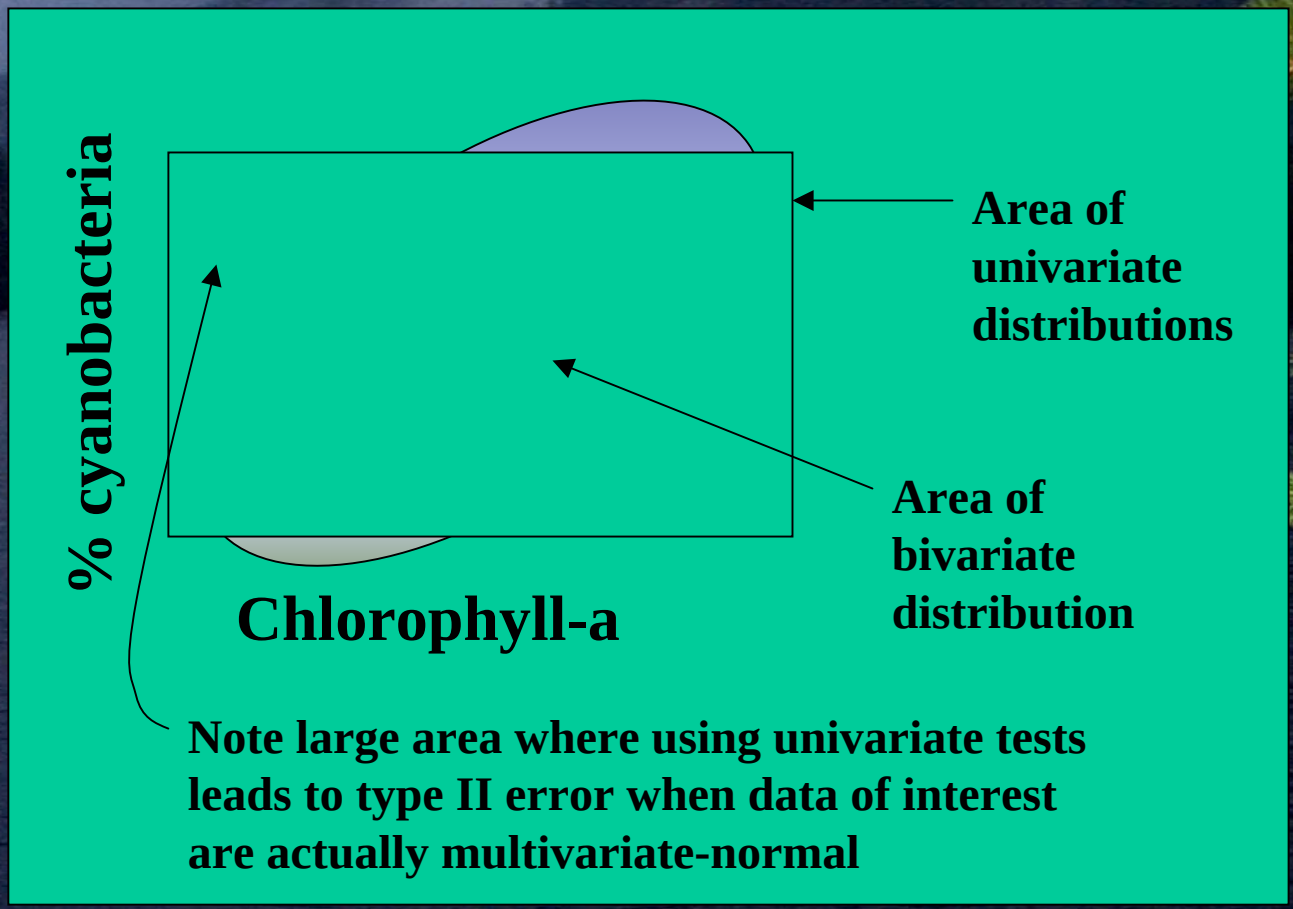
Need and approach

- VT's 2000 WQS revision established regulator requirement for quantitative biocriteria for use in assessment and listing.
- VT uses the standard reference-based multimetric approach, but it is...
- Validated using probability-based statistics.

Incorporating probability-based statistics into multimetric assessments

- Multivariate methods
- Commonly used techniques like T-tests and ANOVA, but mathematically extended to multiple metrics
- Address simultaneous joint variation in multiple metrics
- Controls for experiment-wise error

Controlling experiment-wise error using multivariate-normal data



Assemblages evaluated, and description of database

- 40+ lakes
- Assessed for trophic parameters (S.D., cha), phytoplankton, macrophytes, bugs.
- Lakes range widely in alkalinity, size, depth, trophic status, and level of disturbance.
- Large number of candidate metrics produced from VTDEC biomonitoring database - also several ‘new’ metrics developed for lakes

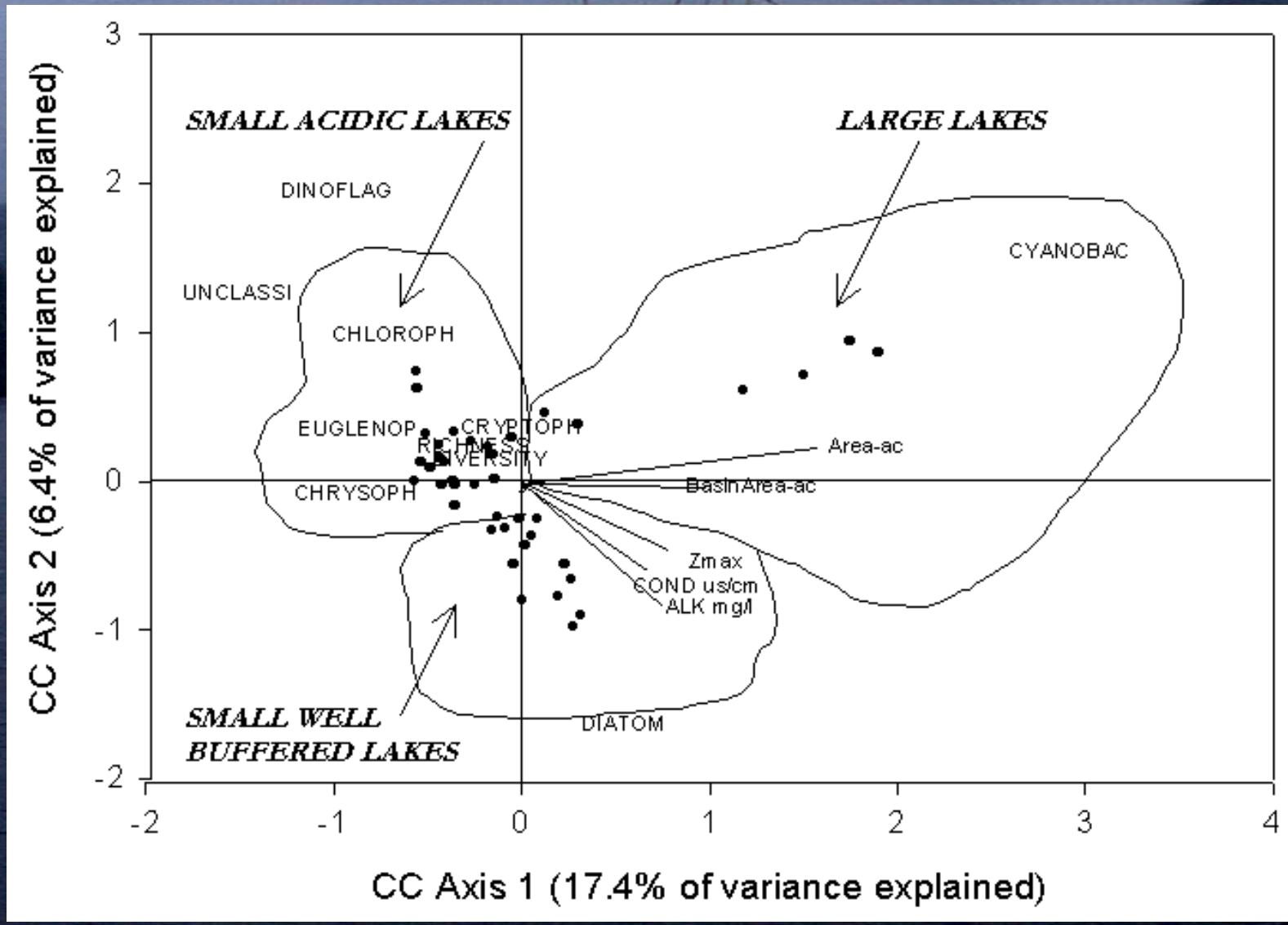
Multivariate methods used in this project

- Canonical Correspondence Analysis (CCA)
- Multivariate ANOVA (MANOVA)
- Discriminant Function Analysis (DFA)

Classification approach

- Use CCA to infer the existence of lake classes, which appear to be influenced by environmental variables
- Use DFA to generate algorithms permitting calculation of a lake's membership to a group
- Verify that biometrics actually vary w/ classes

Classification Approach - CCA

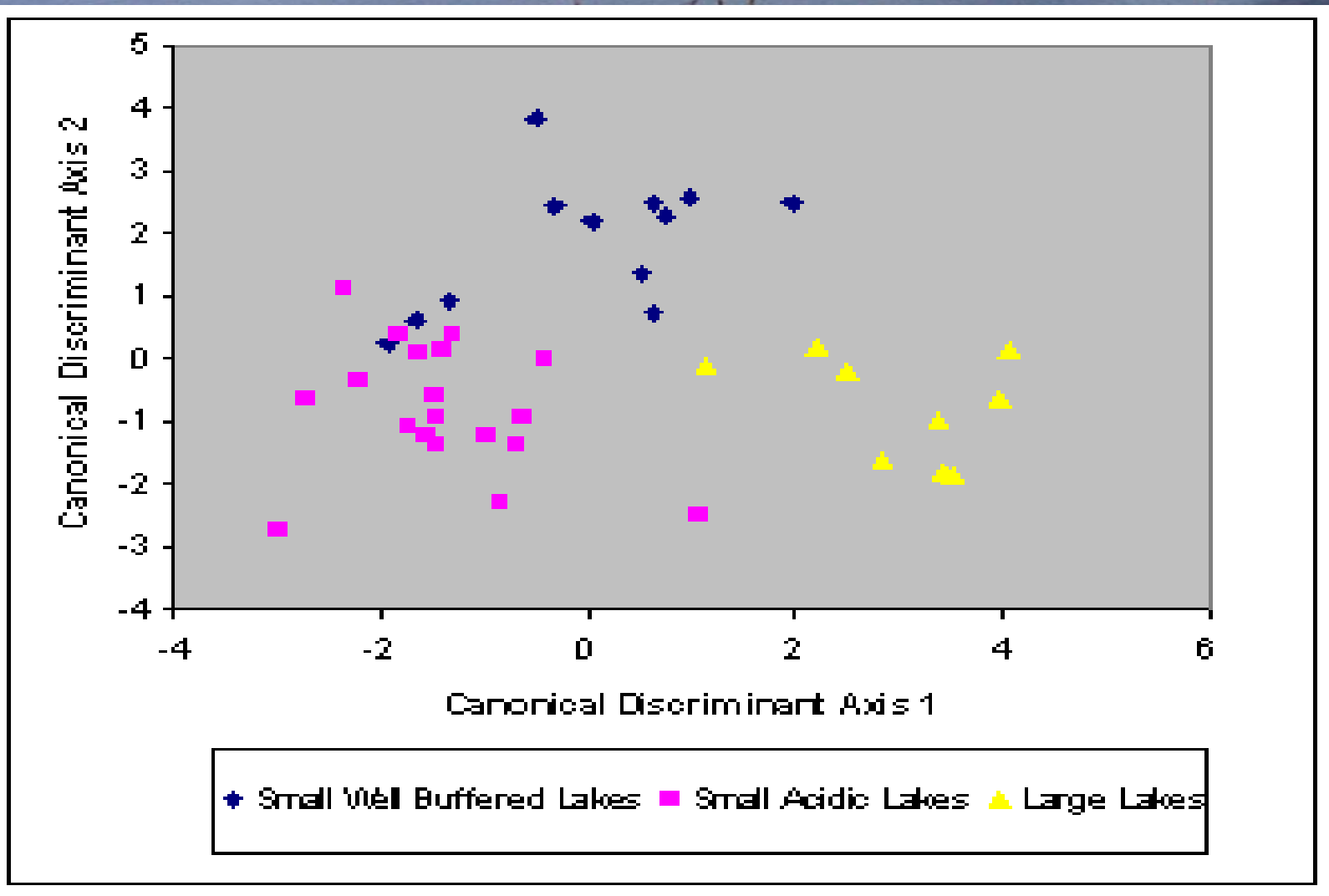


Discriminant function analysis

Create equations based on:

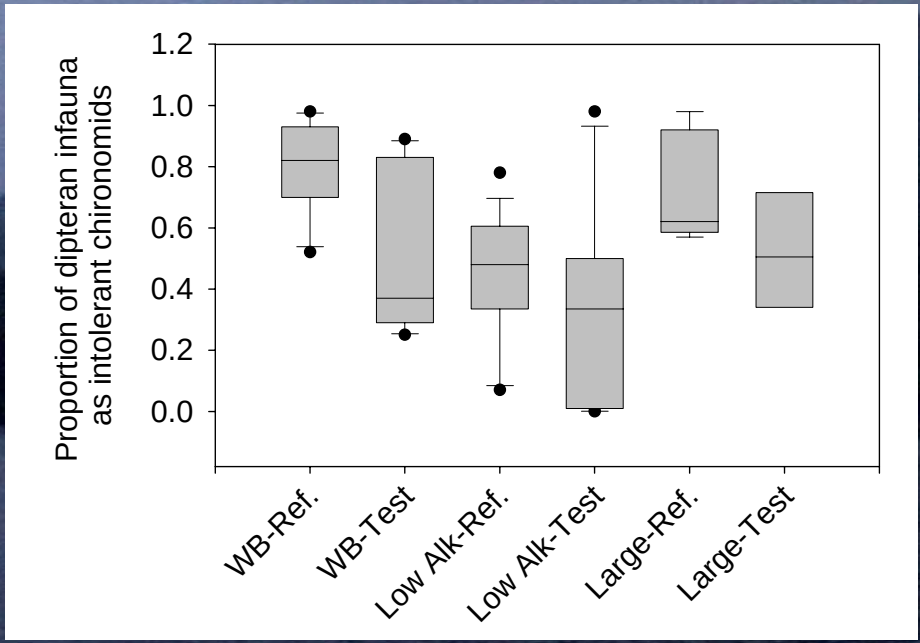
- Lake Area (ac)
- Basin area (ac)
- Basin/Lake Area Ratio
- Maximum depth (m)
- Alkalinity (mg/l)
- Conductivity (*u*S/cm)

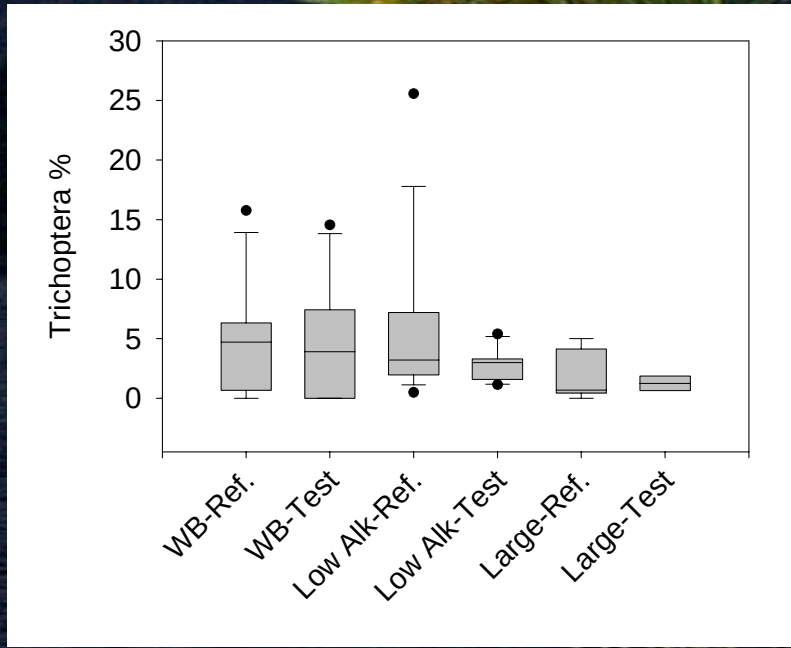
Discriminant function analysis



p=0.001 Overall error rate 15%

Metric selection / scoring procedure





Index development followed standard procedures. The above figures pertain to macroinvertebrates and are for illustrative purposes.

Metrics selected

- Total density, % *Aphanizomenon spp.*, *Anabaena spp.*, *Microcystis spp.* by volume +

- for Small, Well Buffered Lakes:
  - % chrysophytes by density

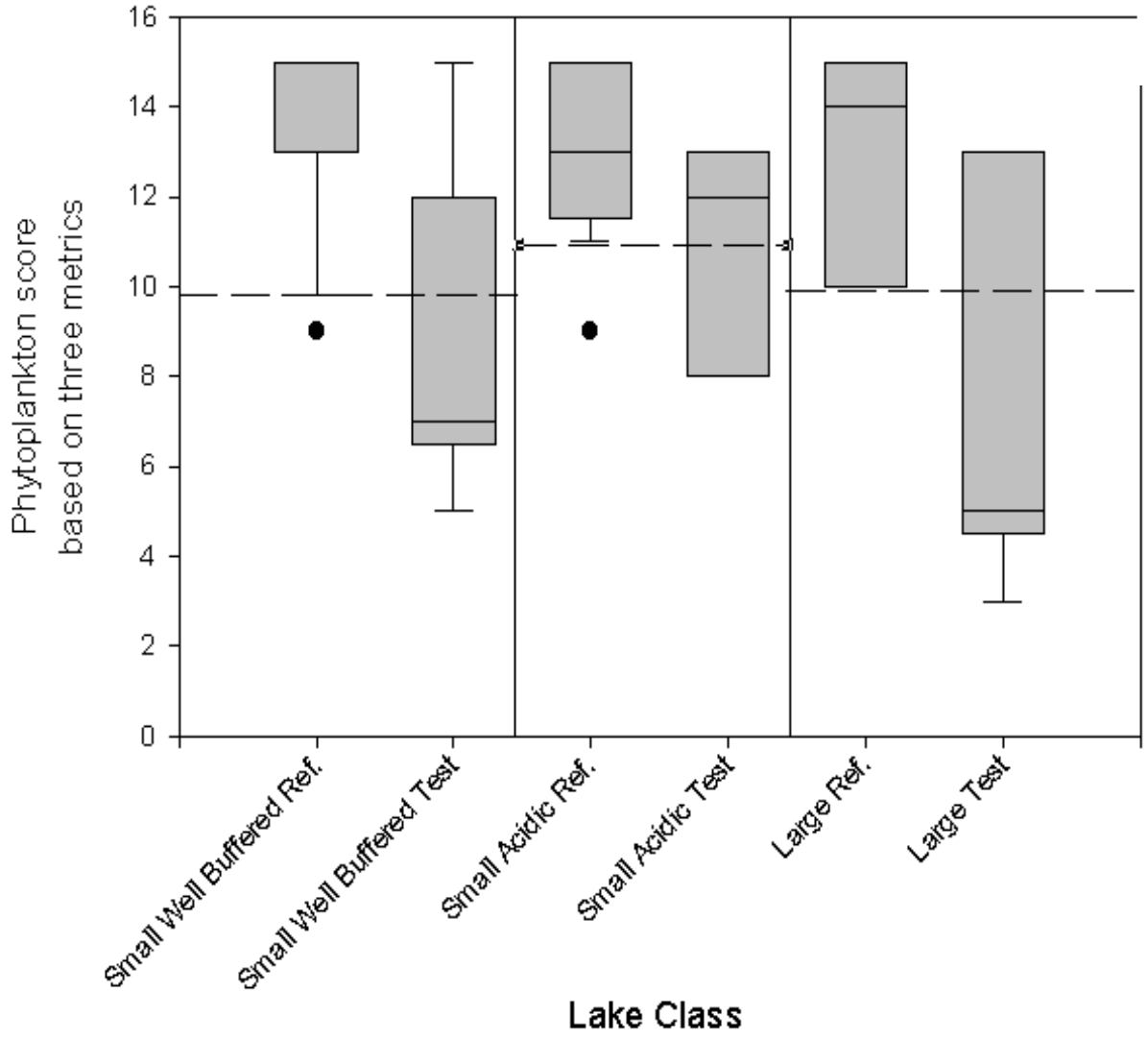
- for Small, Acidic Lakes:
  - % cryptophytes by volume

- for Large Lakes:
  - % diatoms by density

Verification of selected metrics using manova

- Use MANOVA to test that the variation observed across classes and between reference and test lakes is statistically significant
- Results:
  - No sig. variation attributable to interaction
    - $p=0.806$
  - Sig. variation attributable to lake class
    - $p<0.001$
  - Sig. variation attributable to reference status
    - $p=0.022$

Box plots of final phytoplankton scores



Proposed Designation

Macroinvertebrate community meets expected reference condition for this lake type

Macroinvertebrate community deviates significantly from expected reference condition for this lake type

Macroinvertebrates

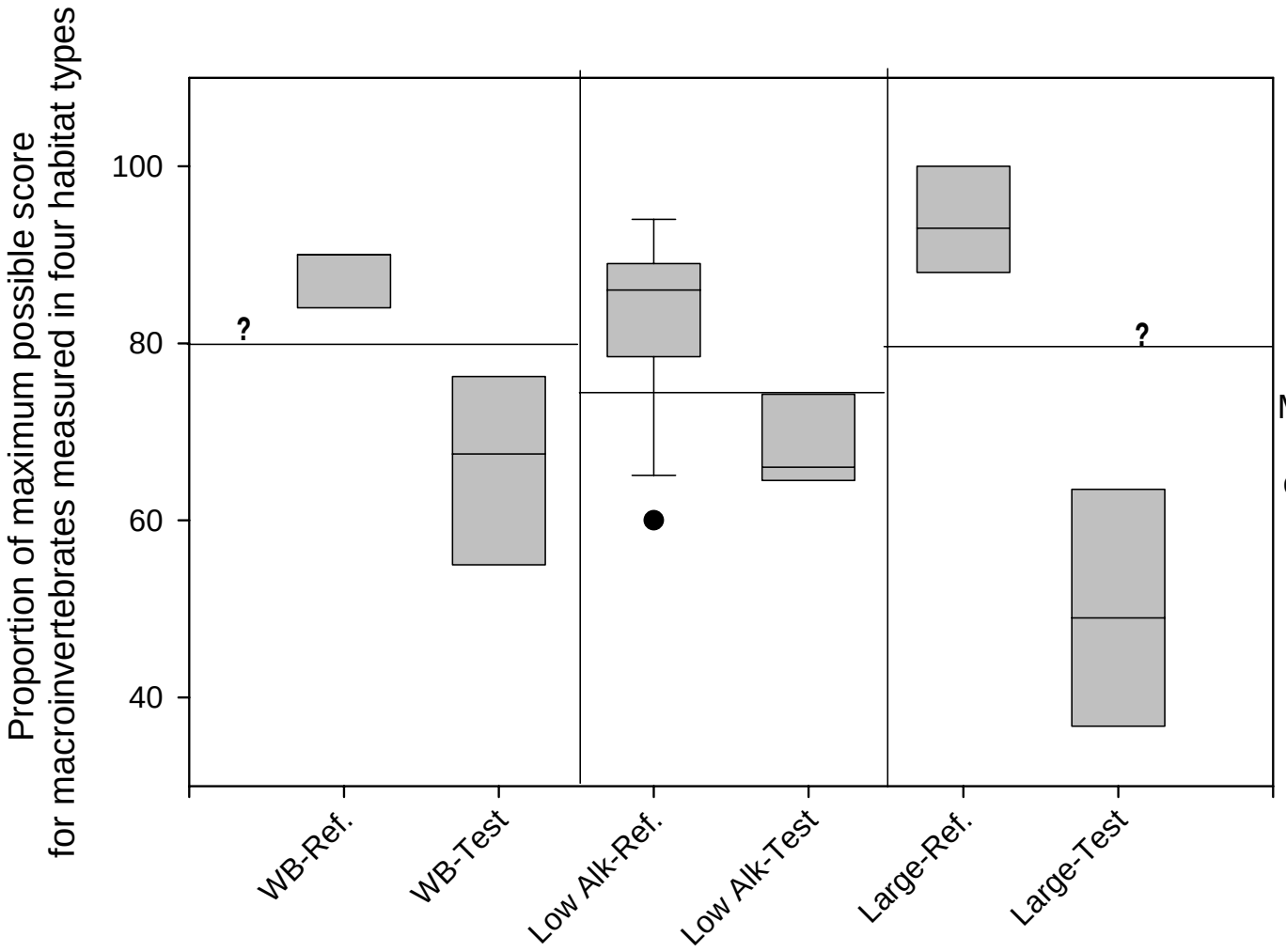
- Five habitats assessed
  - rocky littoral (kick net),
  - muddy littoral (kick net),
  - littoral macrophytes (sweep net),
  - sublittoral (Ekman grab),
  - profundal (Ekman grab).
- Classification derived using the phytoplankton metrics was re-verified for macroinvertebrates and retained.
- Index development again followed standard procedures, and was then verified using MANOVA.

Macroinvertebrate metric summary -

	Lake class		
Habitat	Small low-alkalinity	Small well buffered	Large
Rocky littoral	2	1	4
Muddy littoral	0	2	2
Macrophyte	2	2	2
Sublittoral	2	3	3
p for MANOVA	0.009	0.04	0.026

- For each lake class, between 6 and 11 metrics comprise the macroinvertebrate index.
- Structural and functional aspects

Box plots of final macroinvertebrate scores



Proposed Designation

Macroinvertebrate community meets expected reference condition for this lake type

Macroinvertebrate community deviates significantly from expected reference condition for this lake type

What about the profundal zone??

- Reference, test, and impaired lakes all showed wide ranges in dipteran community structure (richness and diversity).
- Some reference lakes were devoid of profundal community.
- Some impaired lakes had maximum richness/diversity values (intermediate disturbance).
- Mostly unusable data for the purpose of generating lake biocriteria based on these data.

Macroinvertebrates – Impairment types

- Flow regulation - depression in rocky-littoral metrics, and in macrophyte-bed community metrics.
- Eutrophication – alterations to the dipteran and crustacaea-mollusca communities.
- Cumulative impact – several lakes show alterations which are most appropriately pinned to ‘cumulative stresses.’
- Acidity – signal of acidification effects in low alkalinity lakes is present, albeit weak.

Summary:

- VT's bioassessment system is comprised of:
  - Classification scheme
    - error-quantified
    - equations to allocate lakes to a class
  - Phytoplankton
    - 5 metrics
    - vary by lake type
  - Macroinvertebrate Index
    - 6-11 metrics
    - vary by lake type

- **MACROINVERTEBRATE METRIC LISTS**

Metric selection / scoring procedure

- Untransformed data
- Box plots to visualize distributions
- Correlation matrix (non-parametric) to weed out redundant metrics
- Calculation of interquartile coefficients
- Retain metrics explaining greatest separation between classes and providing largest discrimination of reference vs. impaired status

Macroinvertebrates - Well buffered lakes

- Eight metrics
- RL: COTE/COTE+remaining dipterans
- ML: VT Hilsenhoff BI, taxa richness
- MAC: % tanytarsus, chironomid richness
- SL: % in top 3 dominant communities, % collector filt., % dipterans as intolerant chironomids
- Model indicates significant separation between reference and test/imp. lake scores:
  - Wilks' $\lambda = 0.278$, $F = 4.54$, $p=0.04$

Macroinvertebrates - Low alkalinity lakes

- Six metrics
- RL: %crustacaea-mollusca, % dipterans as intolerant chironomids
- ML:none
- MAC: crustacaea-mollusca R, taxa richness
- SL: % tanytarsus, % dipterans as intolerant chironomids
- Model indicates significant separation between reference and test/imp. lake scores:
  - Wilks' $\gamma = 0.237$, $F = 11.77$, $p=0.009$

Macroinvertebrates - Large lakes

- Eleven metrics
- RL: % top dominant taxa, % ephemoptera, % coll. gath., % crustacaea-mollusca
- ML: VT Hilsenhoff BI, % chironomids
- MAC:taxa richness, chironomid R
- SL: % coll. filt., chironomid R, % dipterans as intolerant chironomids
- Model indicates significant separation between reference and test/imp. lake scores:
  - Wilks' $\lambda = 0.121$, $F = 9.36$, $p = 0.026$