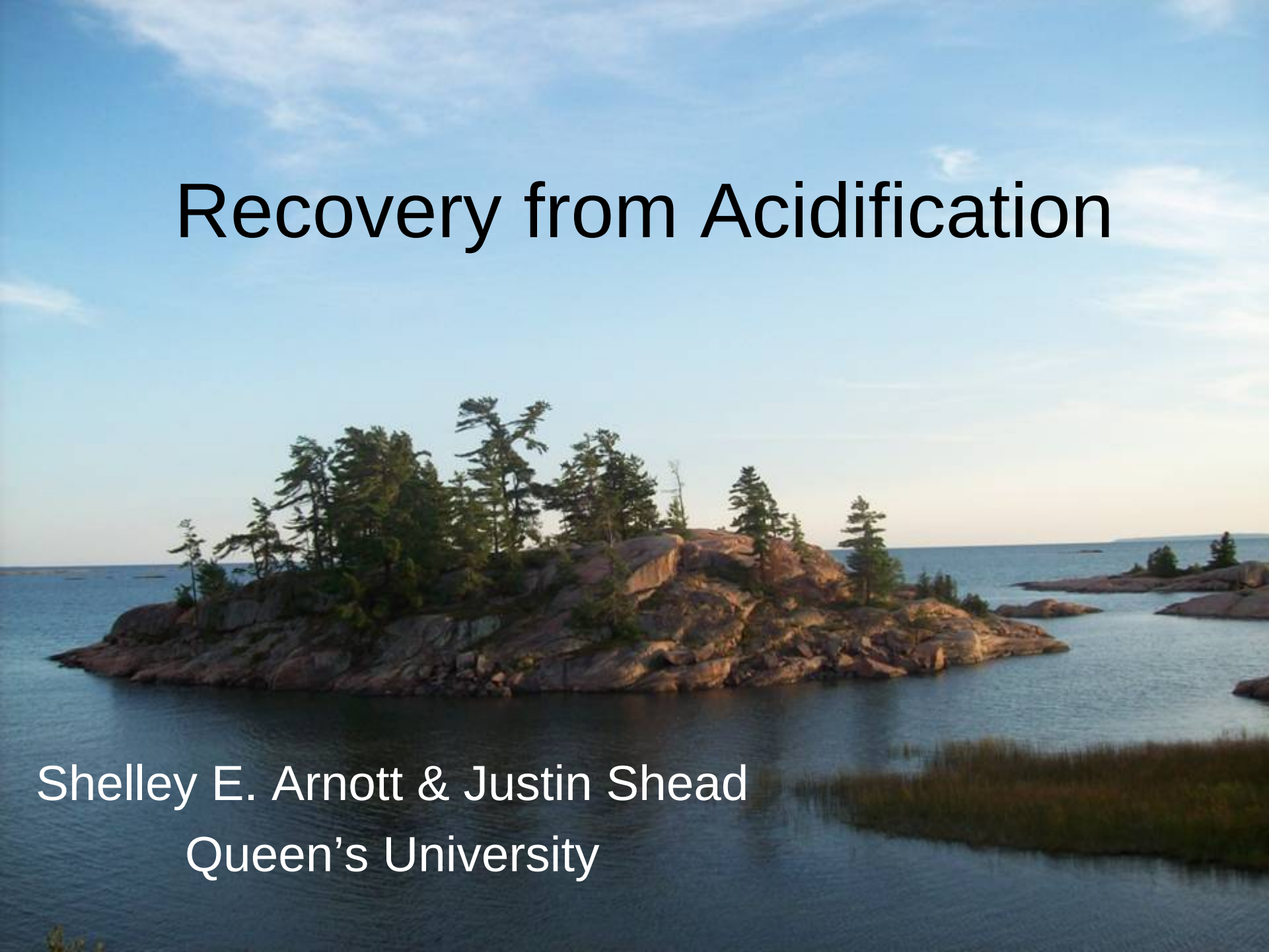
Recovery from Acidification



Shelley E. Arnott & Justin Shead
Queen's University

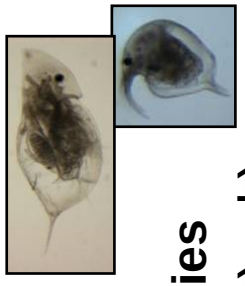
Regional Acidification

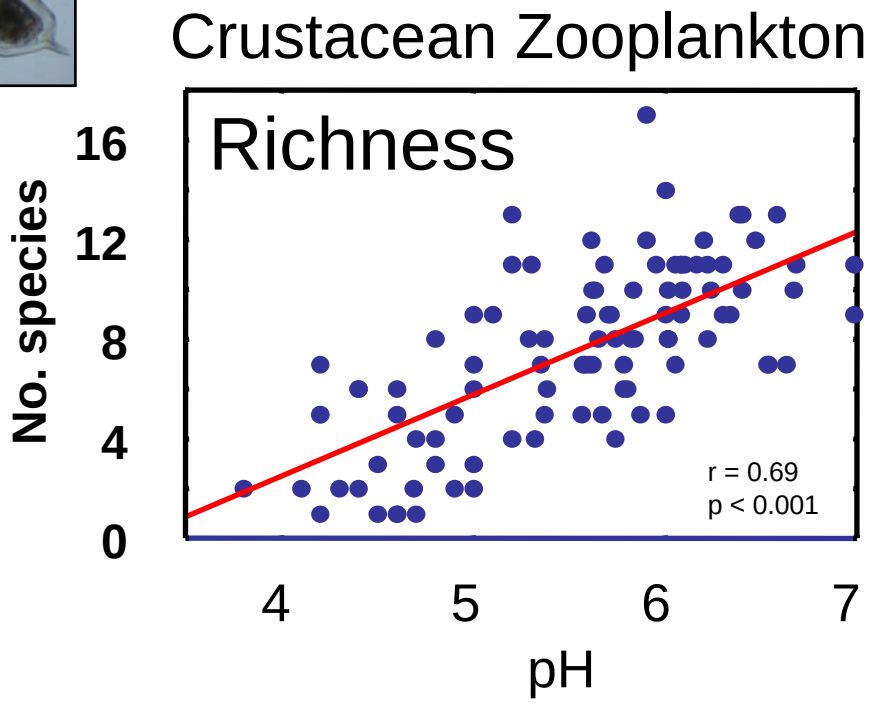
- S and N emissions from industrial activities
- Large impact in N. Am and Europe
- Recent issue in China
- Affects terrestrial and aquatic ecosystems

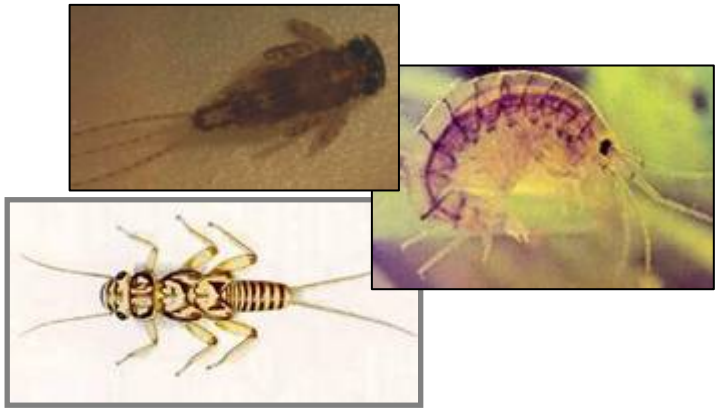
Sudbury has long been one of the world's largest nickel producers

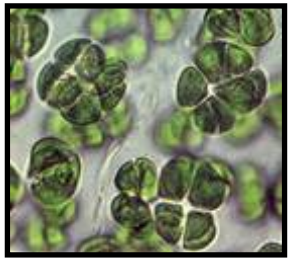
Thousands of hectares of land were damaged

Acidification of Aquatic Ecosystems

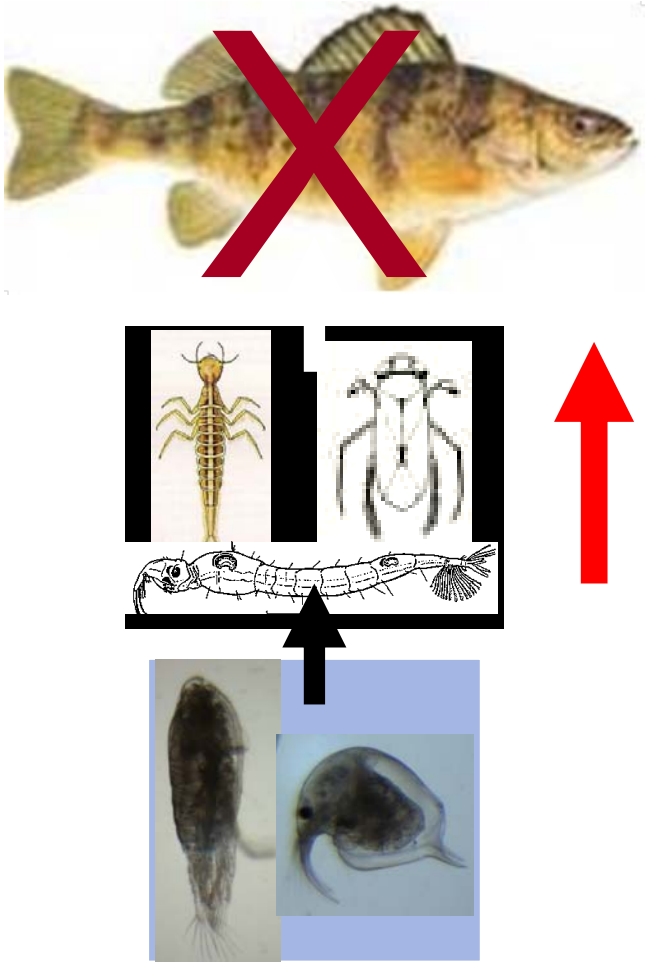


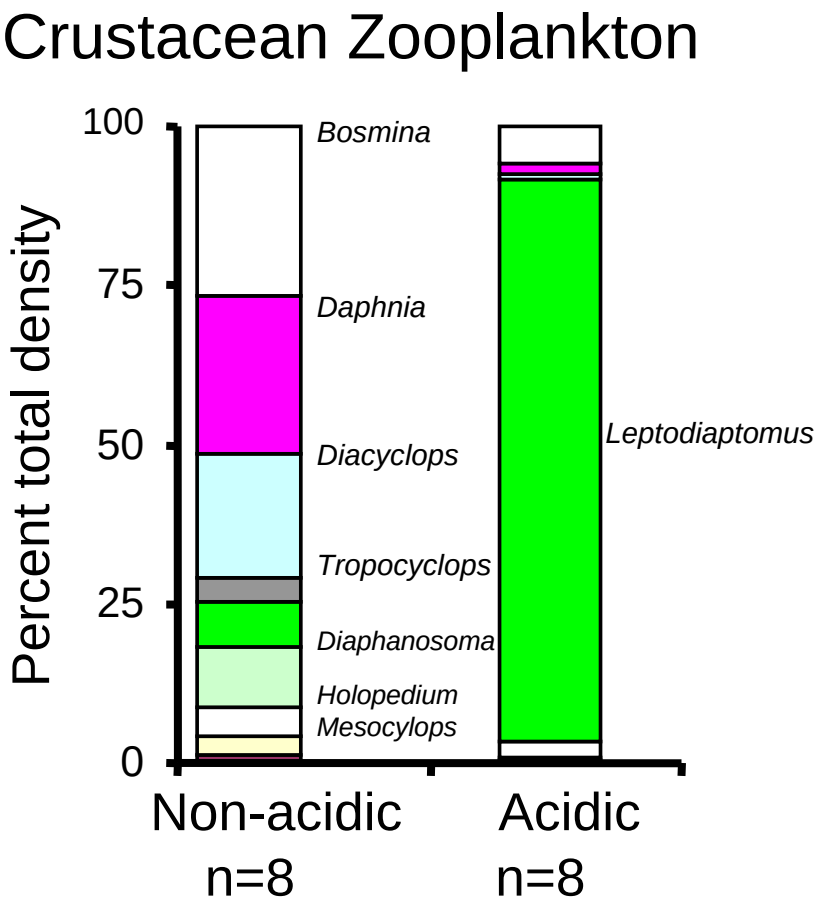




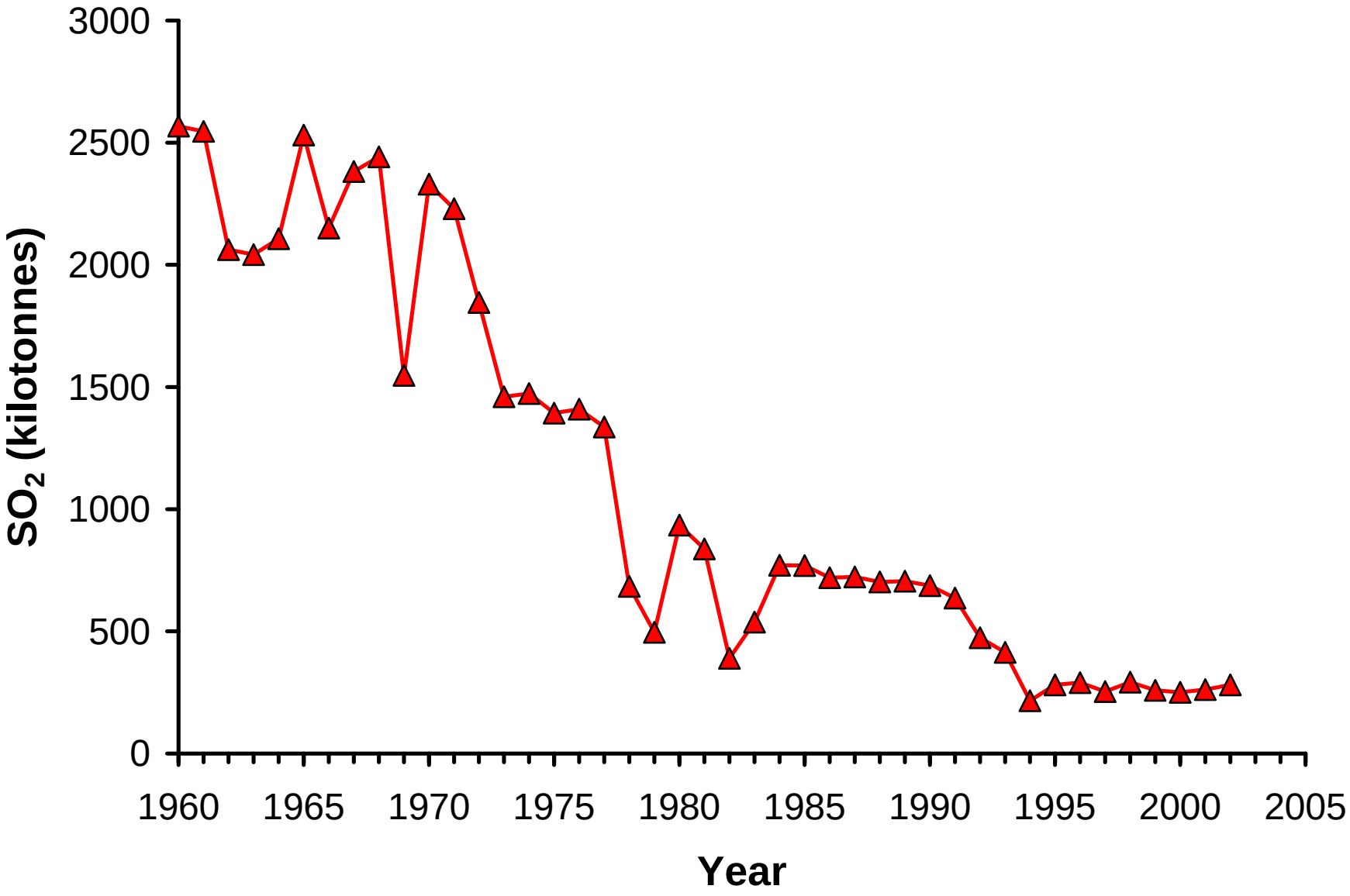


Food Web Changes with Acidification

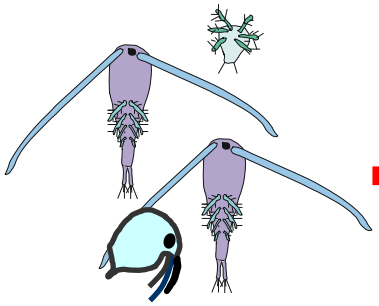




Reductions in Sudbury Smelter Emissions



Biological Recovery: A conceptual Model



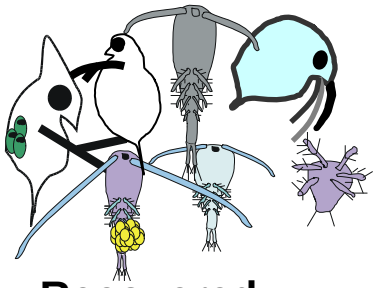
Acid-damaged community

Arrival of species

- Overland
- Resting eggs

Growth and survival of species

- Abiotic conditions
- Competition
- Predation

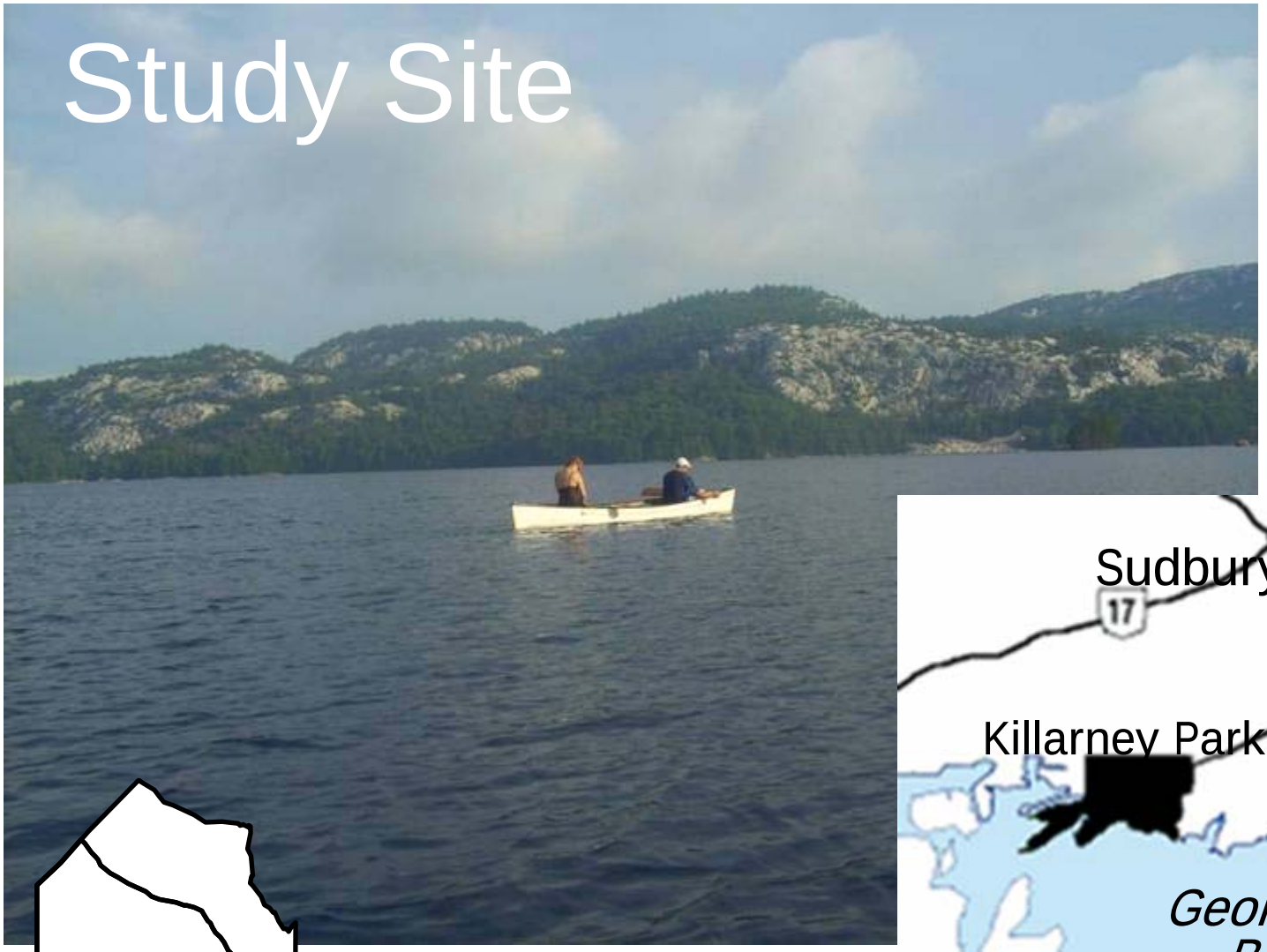


Recovered community

Questions

- Is there chemical recovery?
- Is there biological recovery?
- What controls biological recovery?
  - Dispersal
  - Local environmental conditions

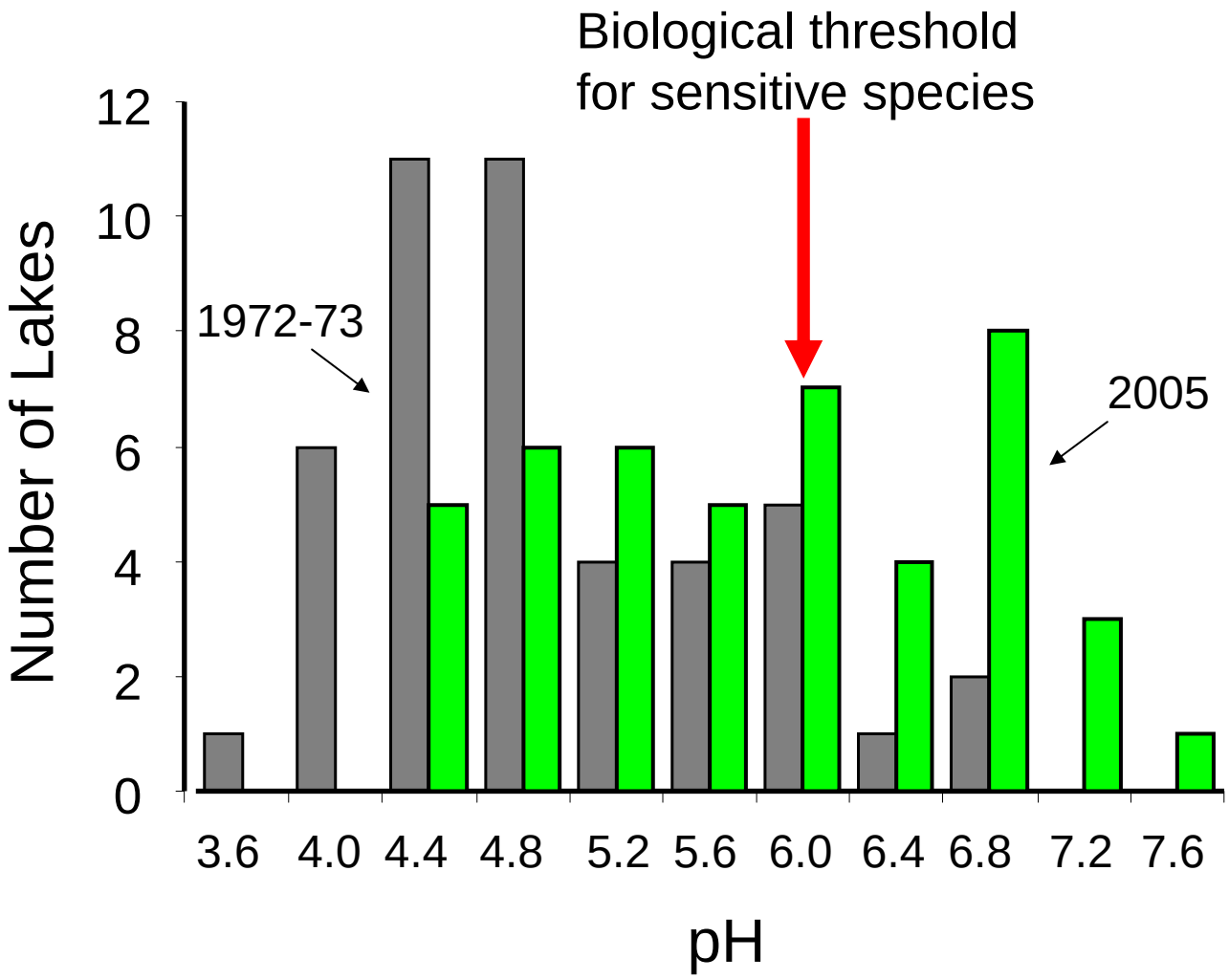
Study Site



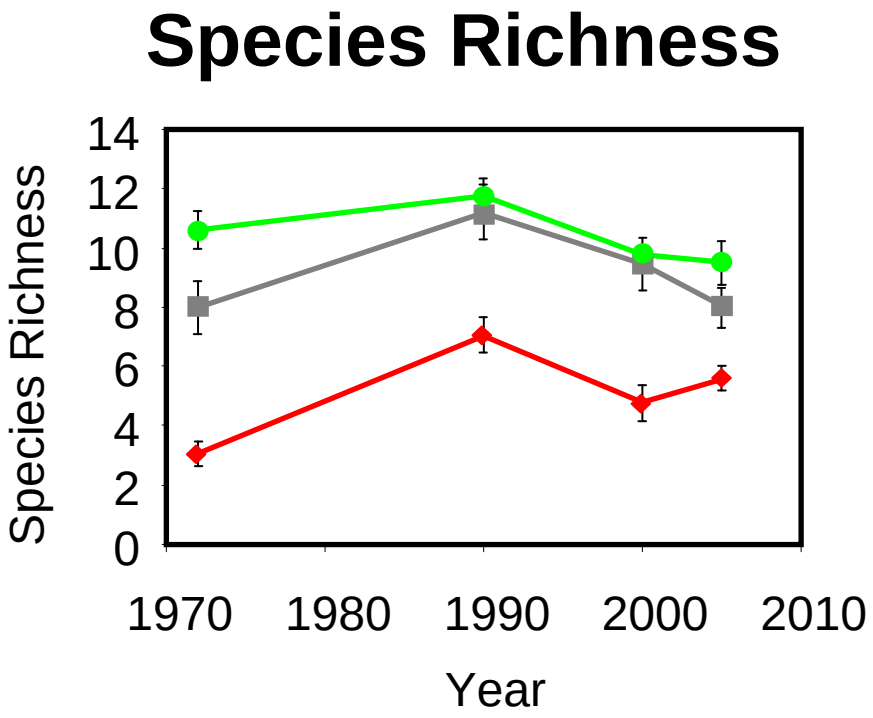
Survey dates:
1970s
2005

Killarney Provincial Park

Recovery of lake water pH



Zooplankton Recovery

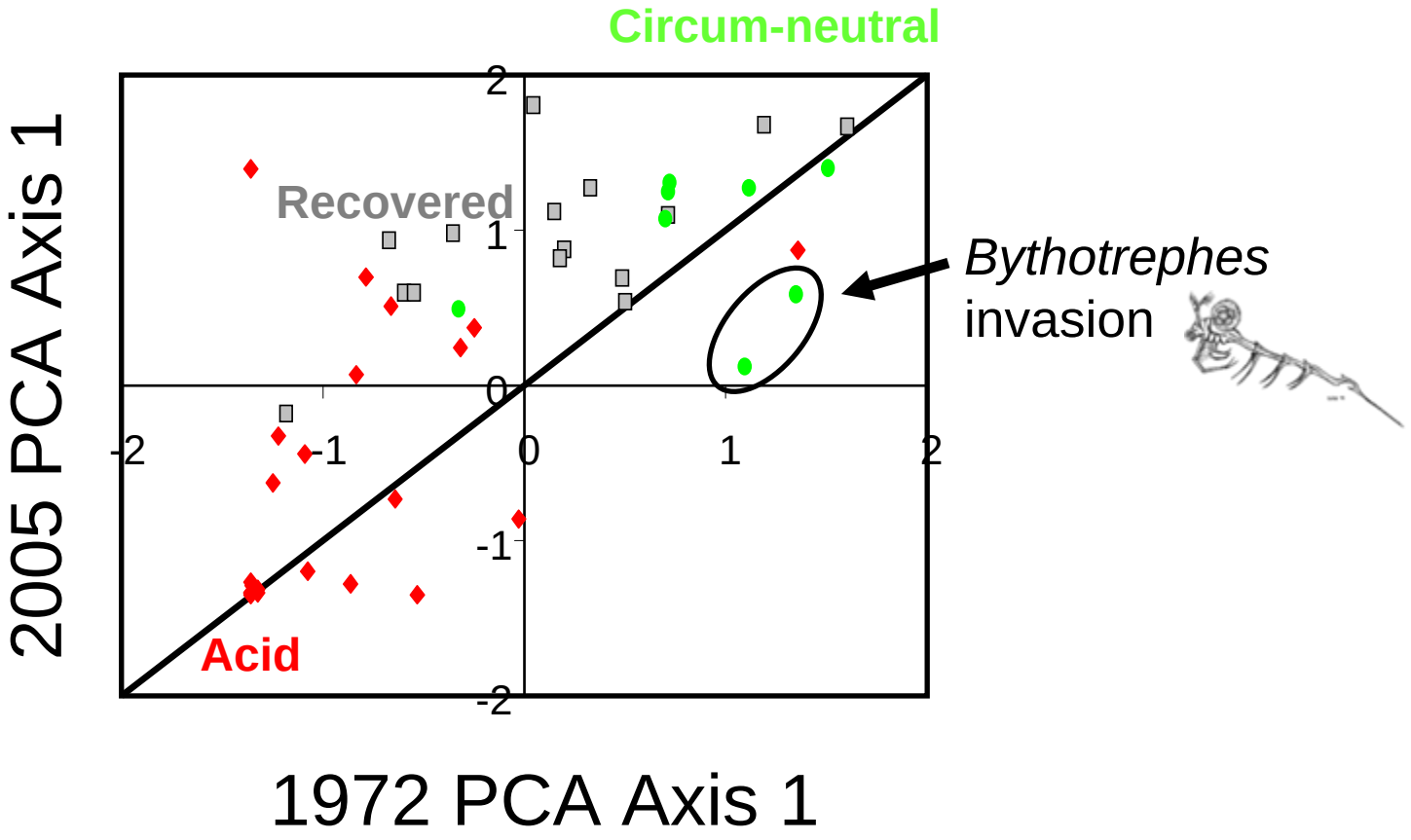


Circum-neutral lakes: pH historically > 6

Recovering lakes: current pH > 6

Acid lakes: pH < 6

Community Composition



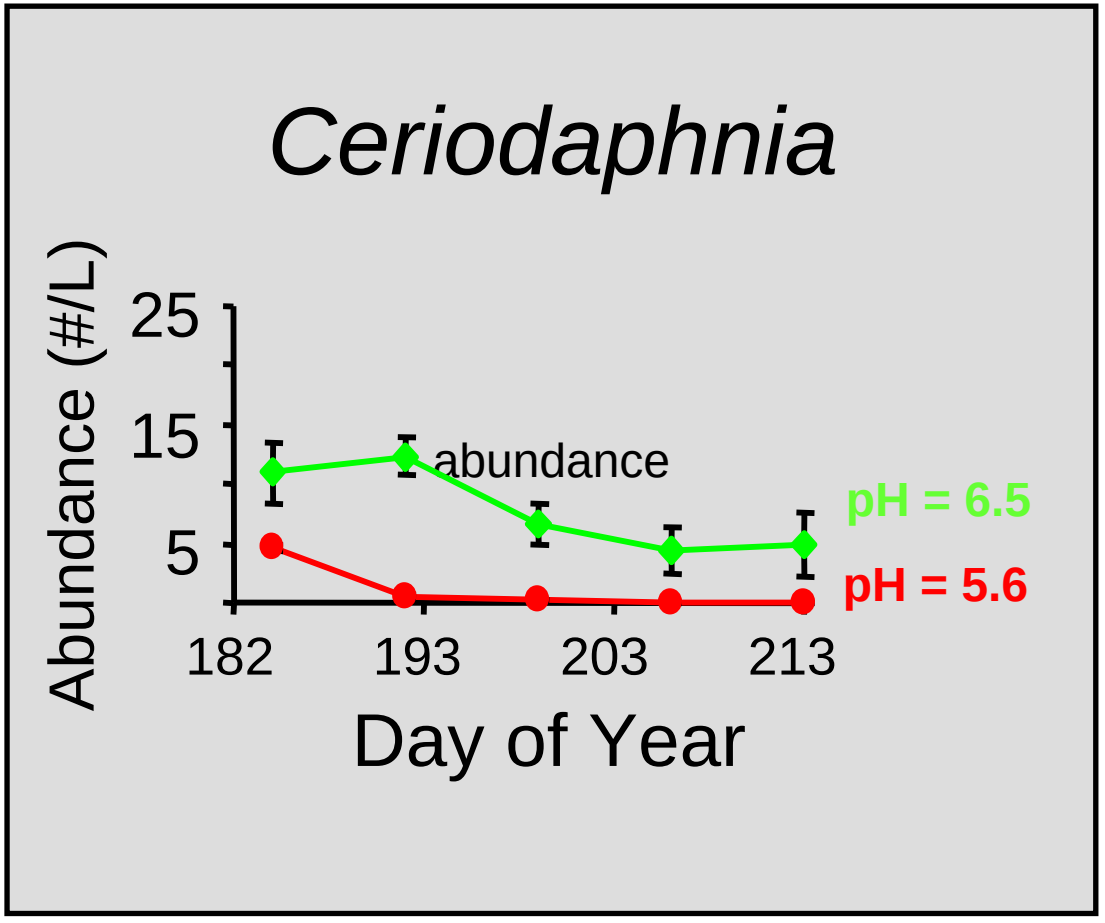
Recovery Summary

- Chemical recovery in many lakes
  - Many lakes still below pH 6
- Weak evidence of biological recovery
  - Lakes with pH > 6
    - Species richness slightly lower than circum-neutral lakes
    - Community composition moving toward circum-neutral
  - Acid lakes
    - Weak increasing trend in richness
    - No general trend toward community composition recovery

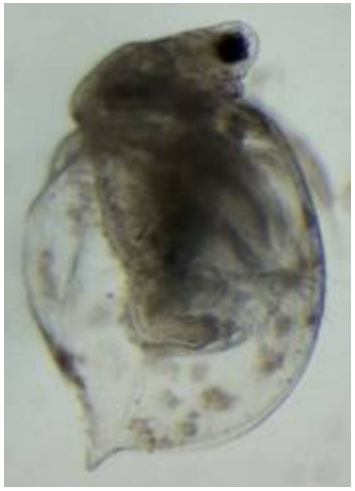
Factors Controlling Biological Recovery

- Water acidity
- Biotic interactions
  - Zooplankton
  - Macroinvertebrate predators
- Dispersal limitation

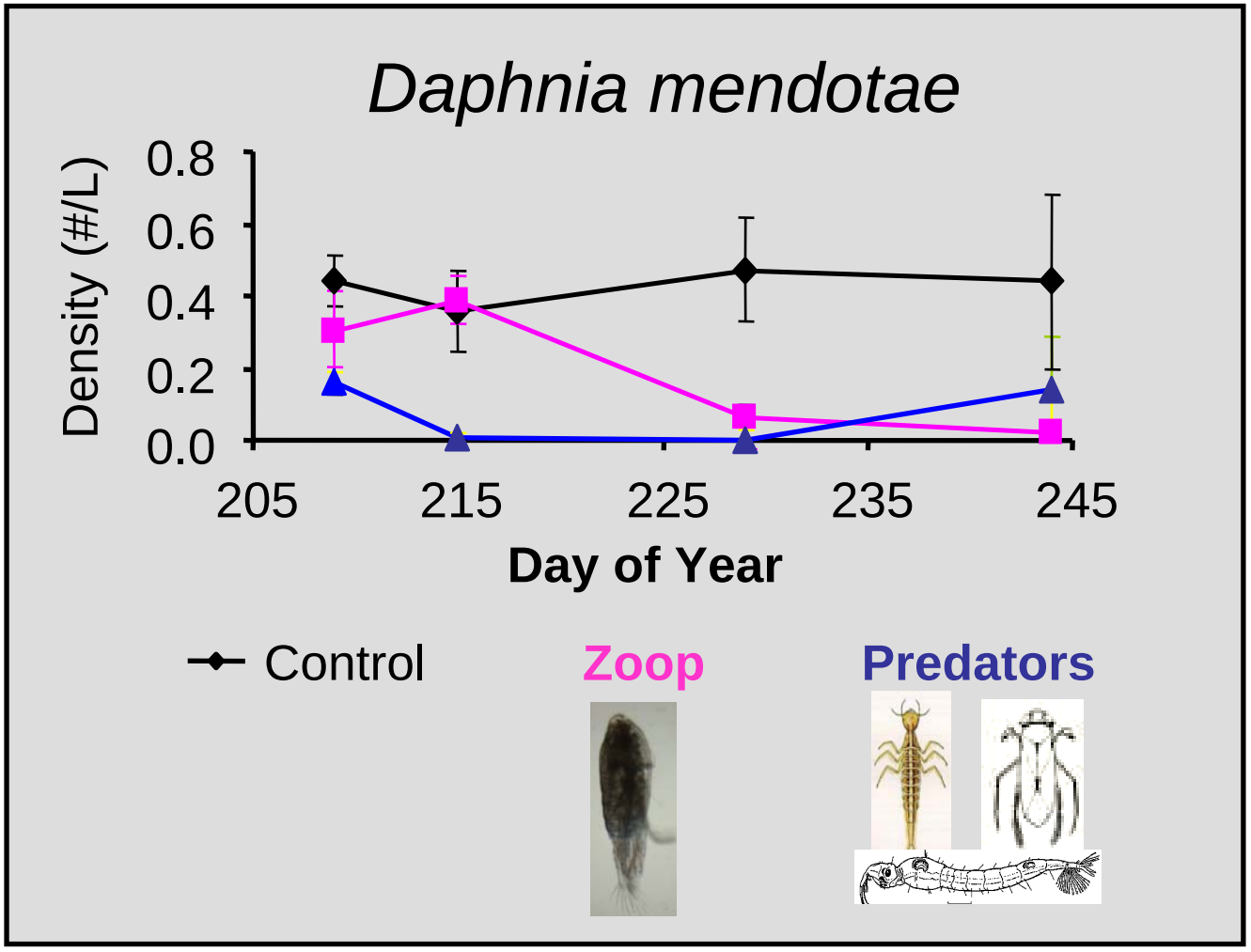
Lake Water Acidity



Ceriodaphnia & *Daphnia* recovery limited by lake water pH

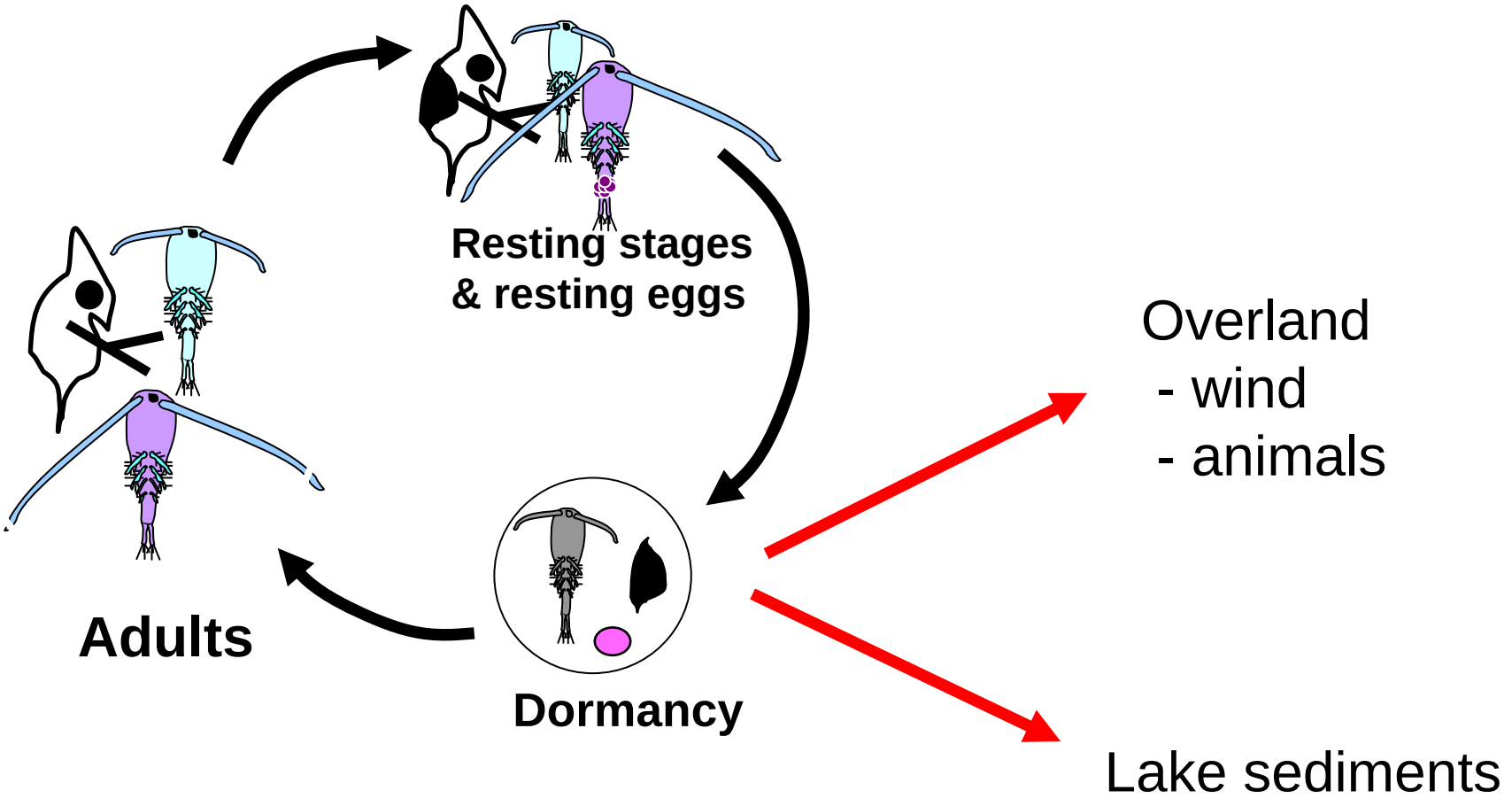


Biotic Interactions

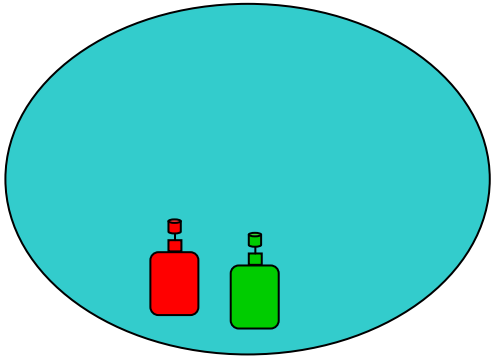


- *Daphnia mendotae*
- *Daphnia pulex*
- *Diacyclops*
- cyclopoid copepodids

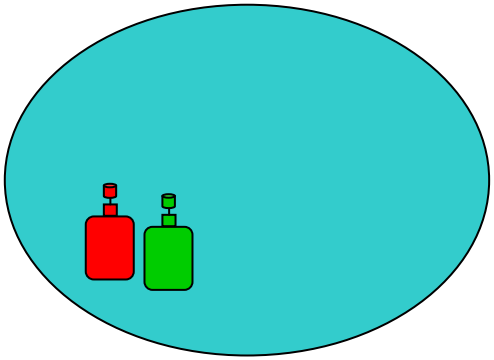
Dispersal


Resting stages
& resting eggs
Adults
Dormancy
Overland
- wind
- animals
Lake sediments

Reciprocal Transplant of Resting Eggs



Carlyle Lake
- recovered



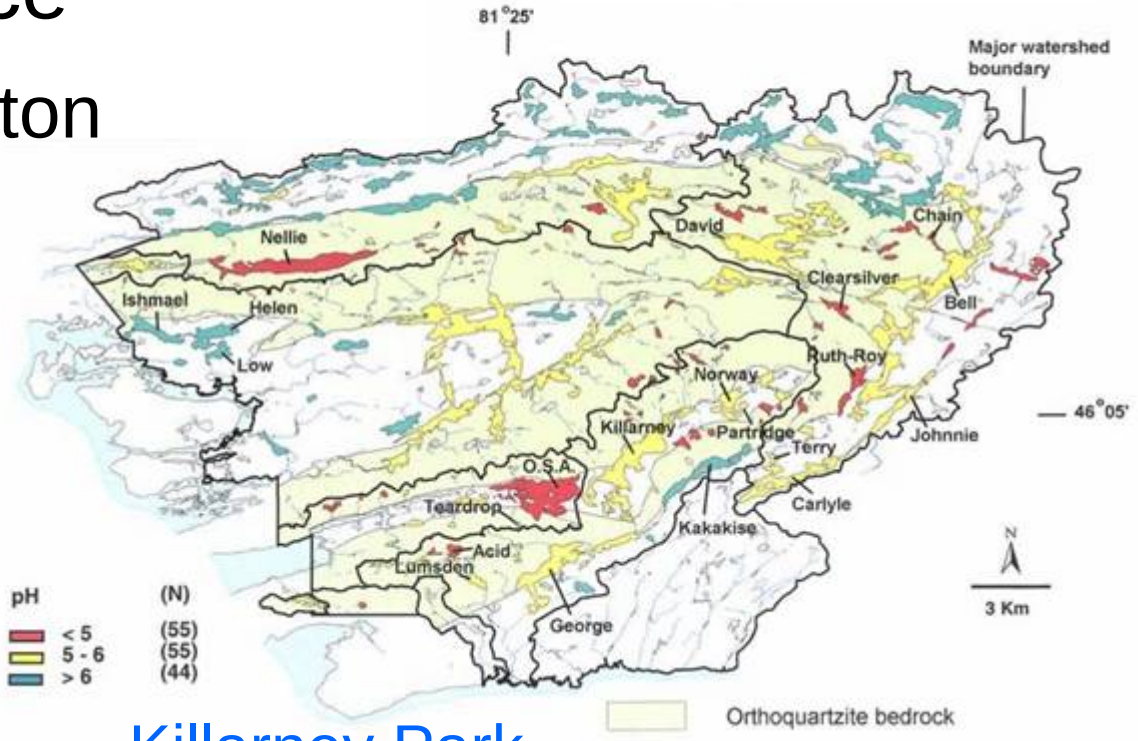
Swan Lake
- Not recovered

- 12 species emerged from Swan Lake sediments
- 4 species emerged from Carlyle Lake but not Swan Lake sediments
- Emergence for several species was lake-dependent

Factors Limiting Recovery

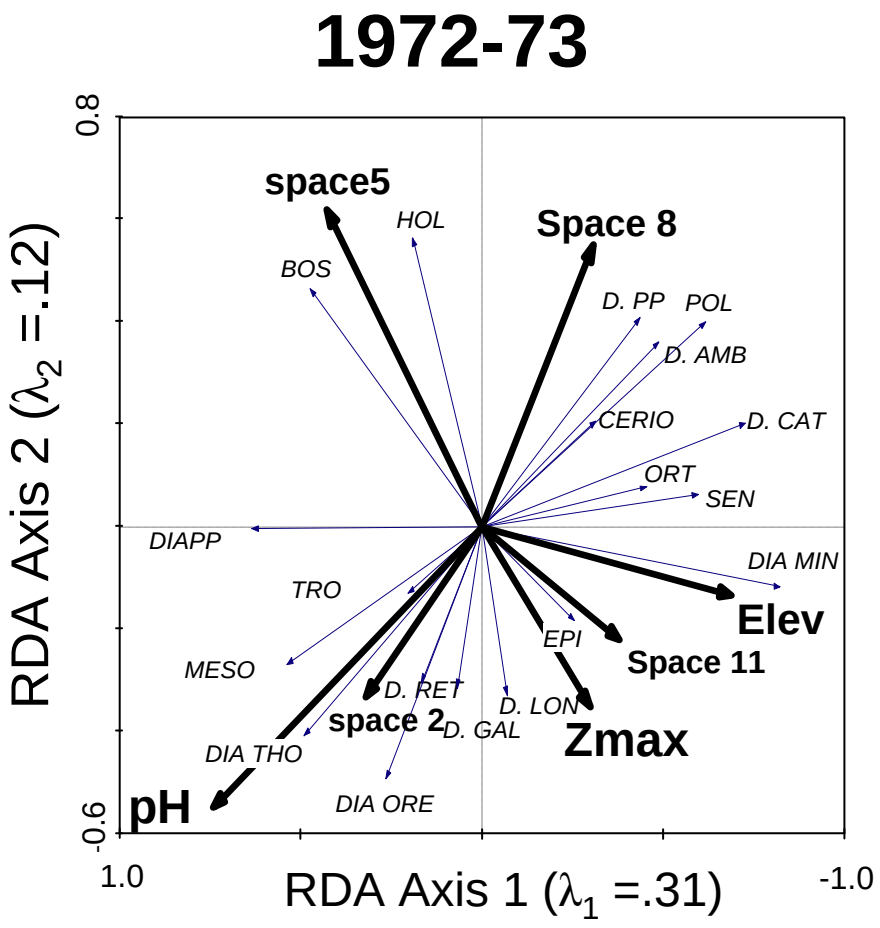
- Lake water pH
- Biotic Resistance
  - Local zooplankton
  - Invertebrate predators
- Dispersal

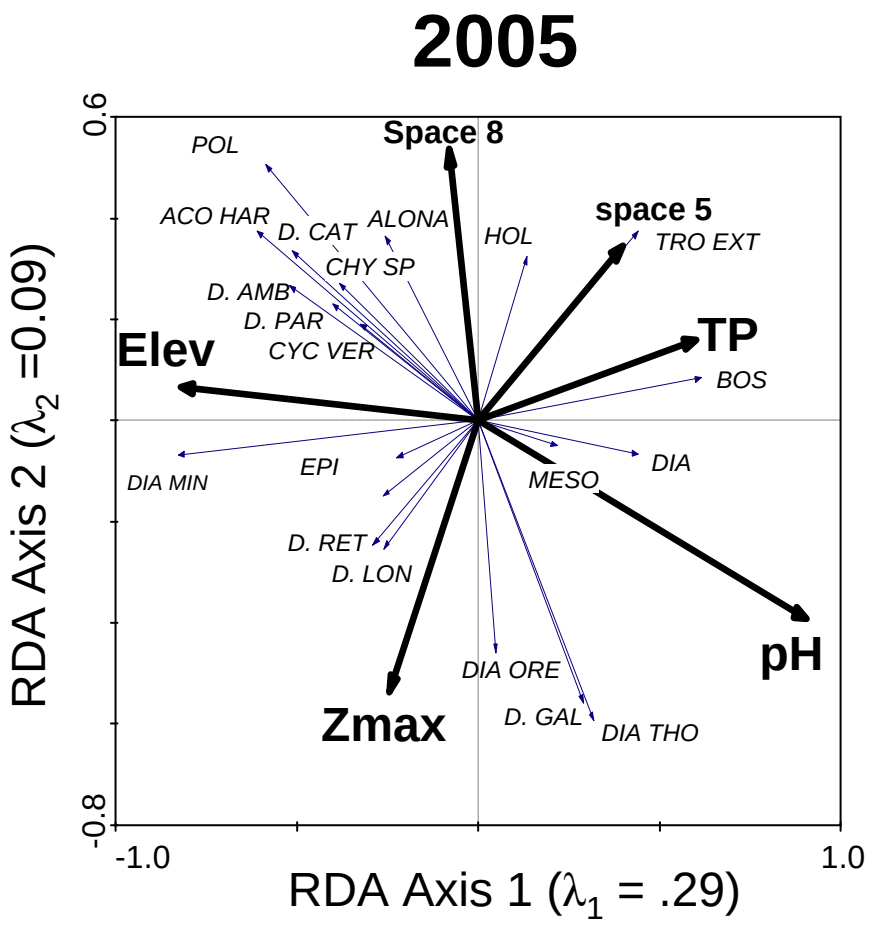
Surveys: 1970s
2005



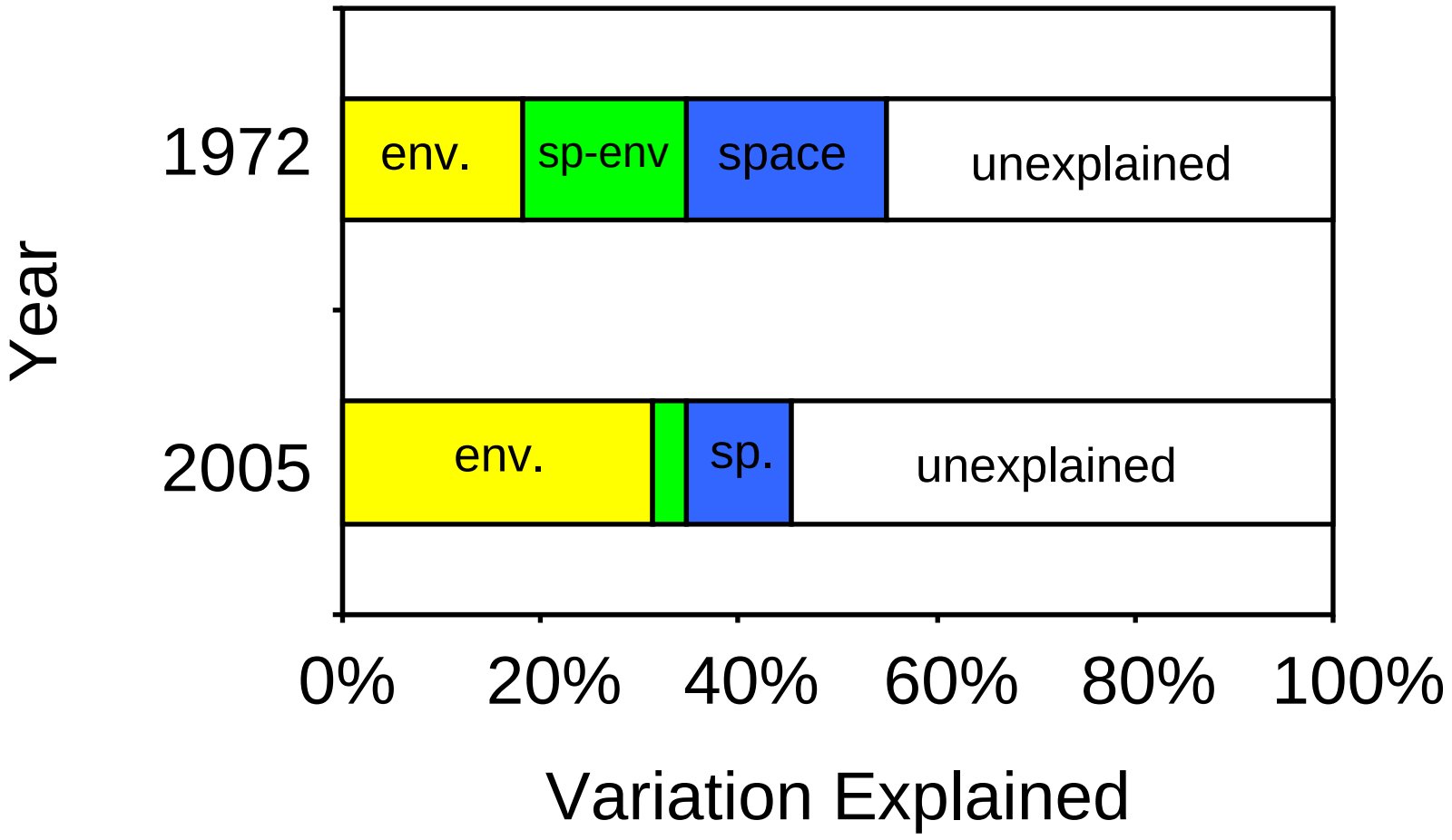
Killarney Park

Relative Role of Dispersal and Environmental Factors Killarney Park Zooplankton





Role of Space and Environment



Summary

- Evidence of some chemical recovery
- Limited biological recovery
- Factors limiting biological recovery
  - Lake water pH
  - Biotic resistance
    - Local zooplankton
    - Invertebrate predators
  - Dispersal
    - May be dispersing from resting eggs in sediment

Acknowledgements

- NSERC
- Queen's University
- Laurentian University
- Sigma Xi
- MEC
- Cooperative Freshwater Ecology Unit
- Killarney Park
- Ontario Ministry of Environment
- Ontario Ministry of Natural Resources
- INCO

Angela Strecker
Jessie Binks
Alison Jackson
Dave Hasek
Paige Olmsted
Alison Derry
Liz Hatton