Invasive Aquatic Plants: Impacts to Fisheries and Aquatic Resources

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My Background

- PhD in plant ecology
- Transitioned to a weed scientist with USACE
- Worked on invasive and native aquatic plant biology, ecology, and management for 42 years
- One gross of published papers

What's an Invasive Aquatic Plant?

- A nonnative aquatic plant that causes environmental, economic, or aesthetic harm
- i.e., a nonnative aquatic weed
    - Eurasian watermilfoil
    - Hydrilla
    - Brazilian waterweed
    - Curlyleaf pondweed

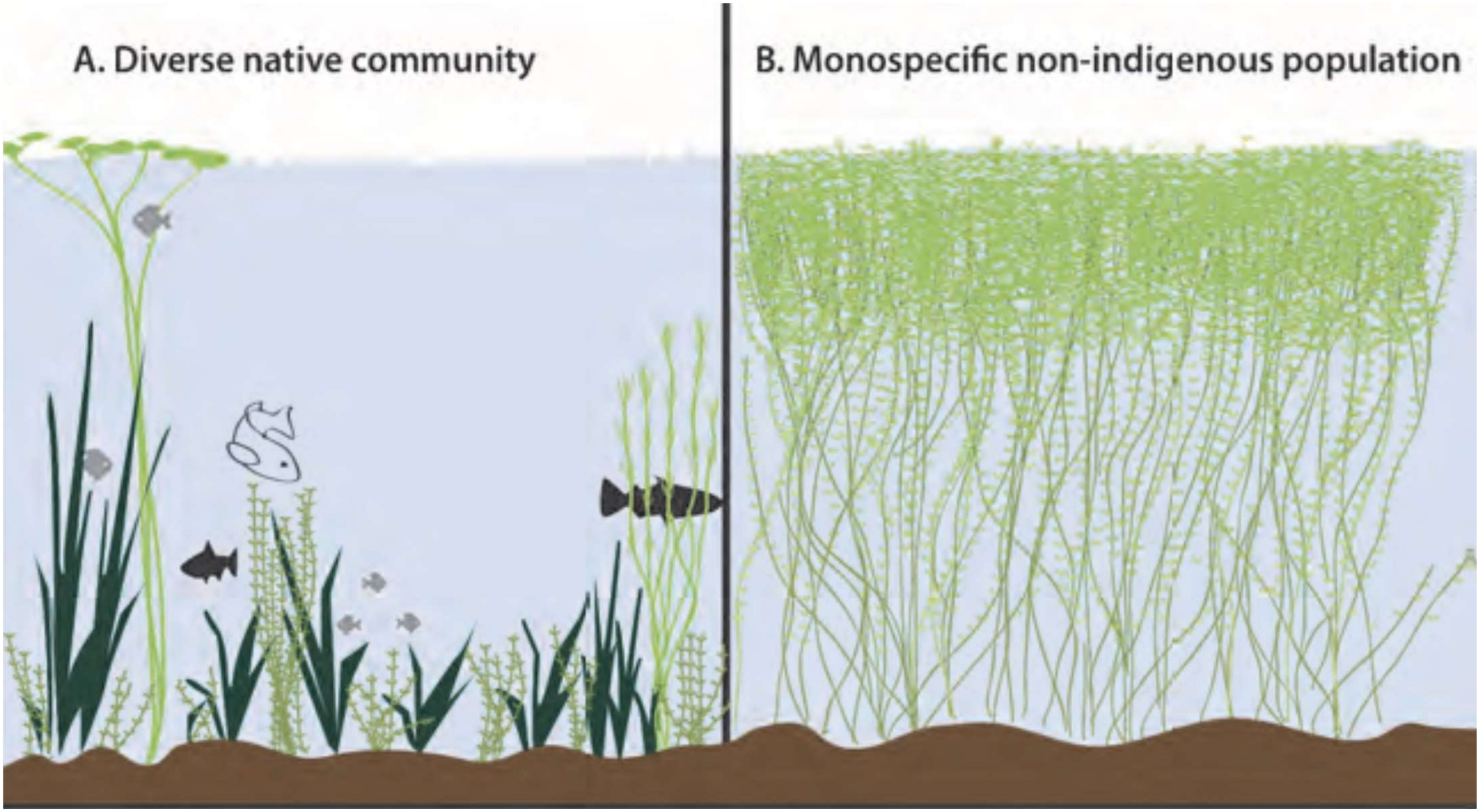
Economic Impacts of Invasive Plants

- Commercial and Recreational Navigation
- Hydropower
- Irrigation
- Drinking water
- Flood Control
- Spread of insect-borne diseases
- Recreational impairment
- Property value
- Human health

Ecological Effects of Invasive Plants

- Degradation of water quality
- Reduction in species diversity
- Suppresses native plant species
- Potential impacts on endangered species
- Alters animal communities
    - Fish
    - Macroinvertebrates
- Alters ecosystem services

Native vs Invasive Canopy Structure



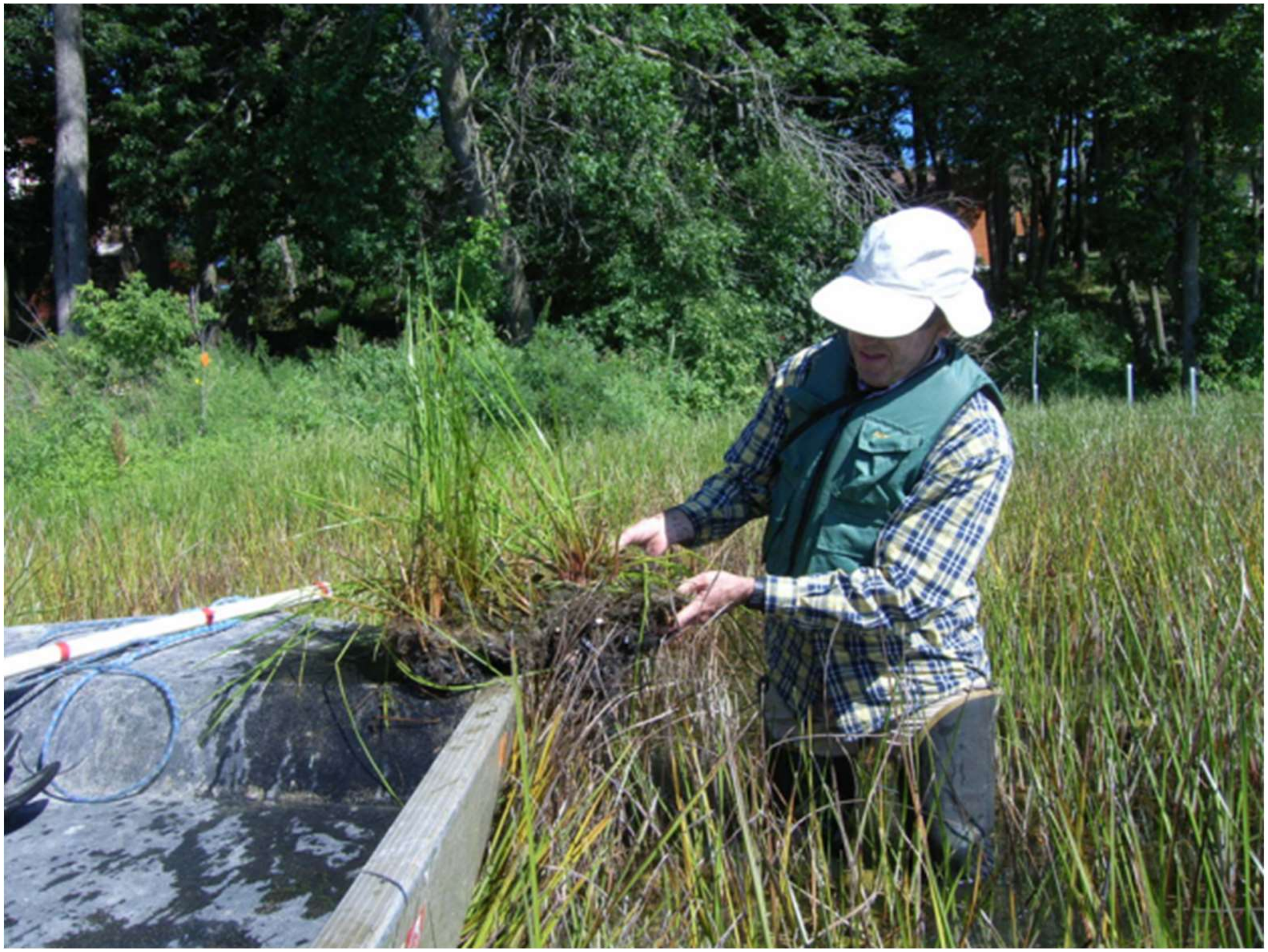
Structure of Invasive vs Native Plants

Under-
water
photos,
Lake
George,
NY by
author

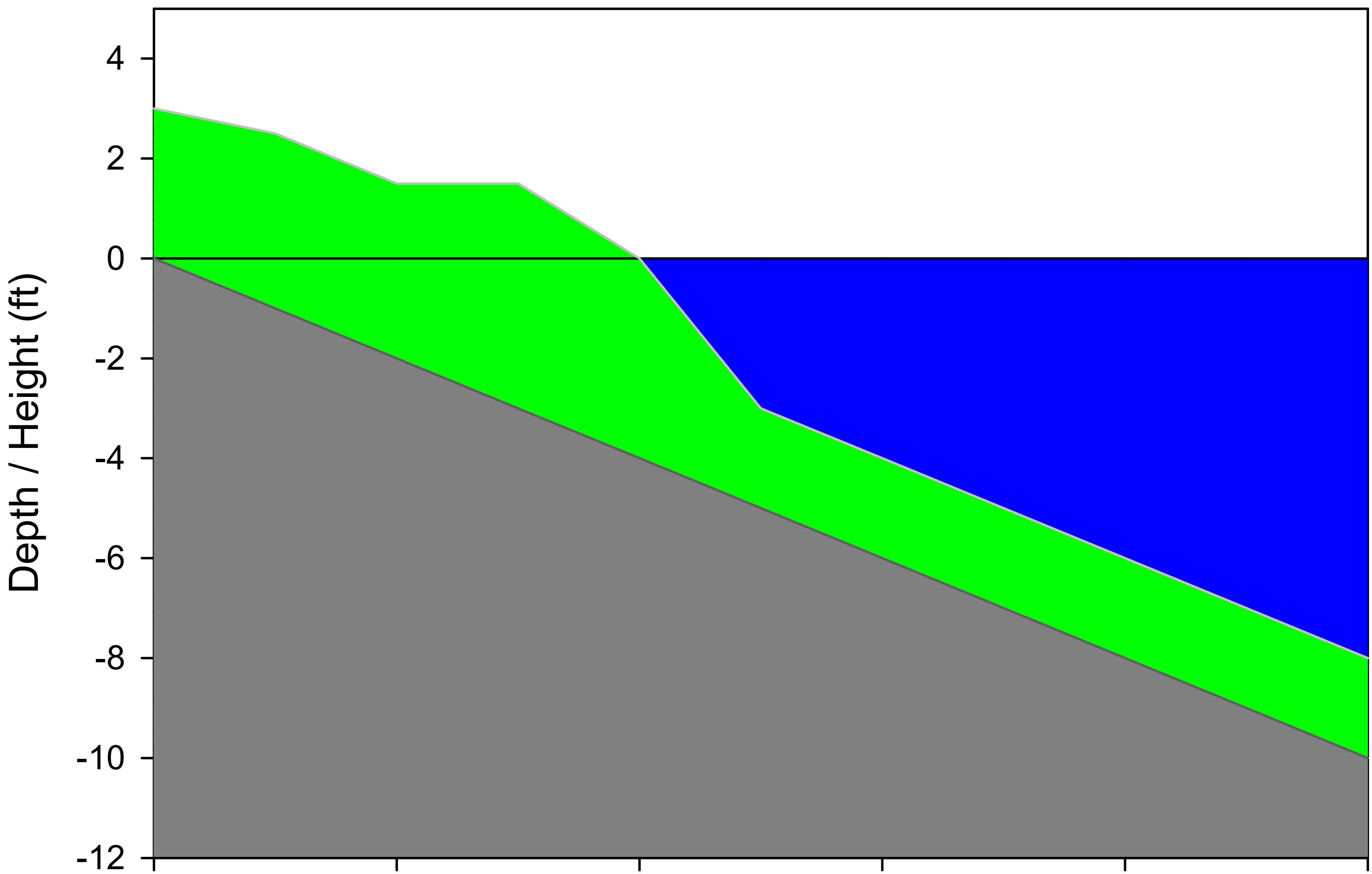
Ecosystem Engineer

- Physical ecosystem engineers are organisms that directly or indirectly control the availability of resources to other organisms by causing physical state changes in biotic or abiotic materials.
- Physical ecosystem engineering by organisms is the physical modification, maintenance, or creation of habitats.

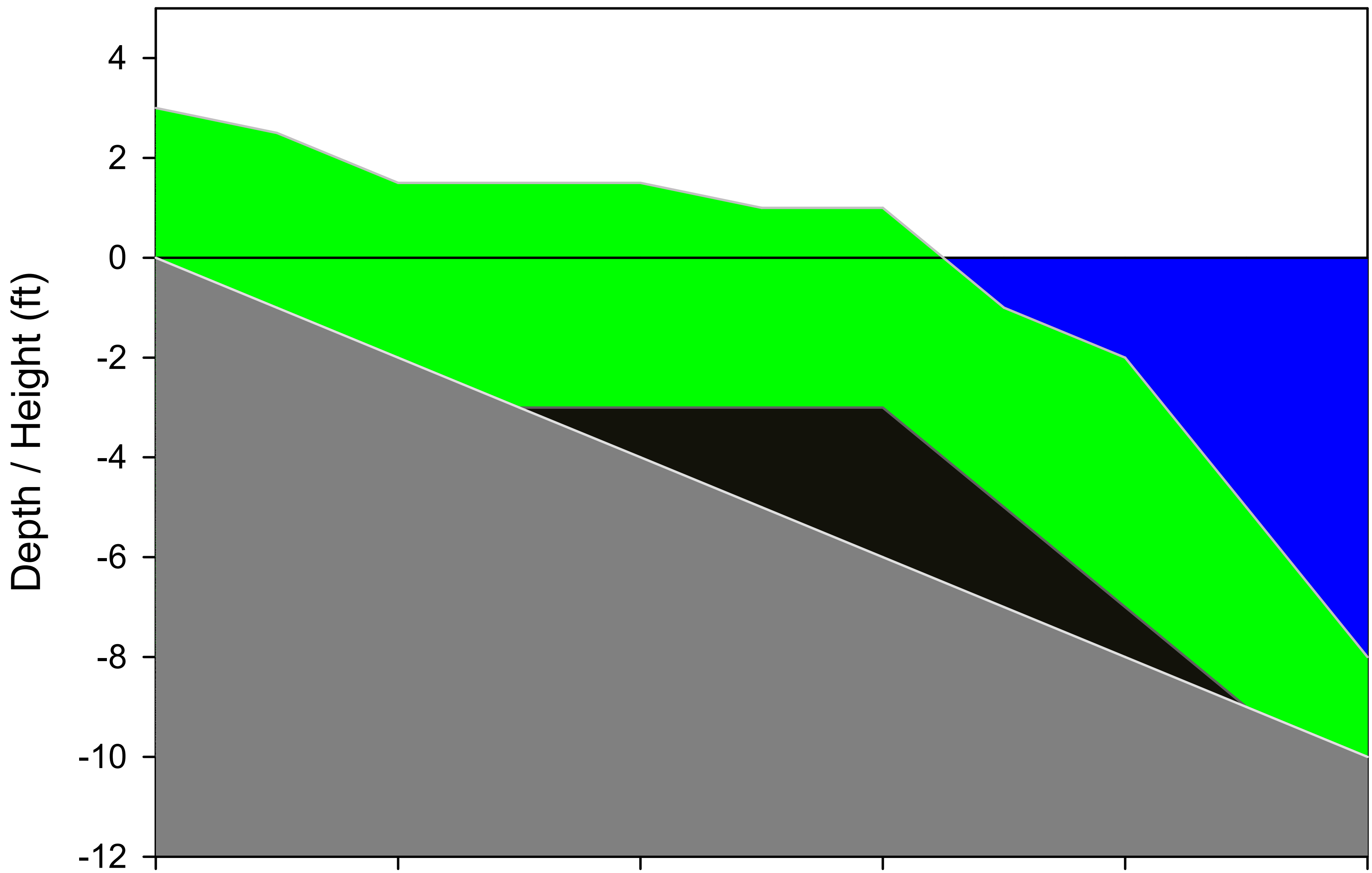
Flowering Rush: A Mat Former – and Ecosystem Engineer?



Profile of Flowering Rush Growth with Depth



Profile of Flowering Rush with Deposition



Invasive Plants and Water Quality

- Nutrient pump of phosphorus from sediment to water column
- Decomposition releases nutrients
- Reduced oxygen, pH shift can allow release of nutrients from sediment

Submersed Plants and Dissolved Oxygen

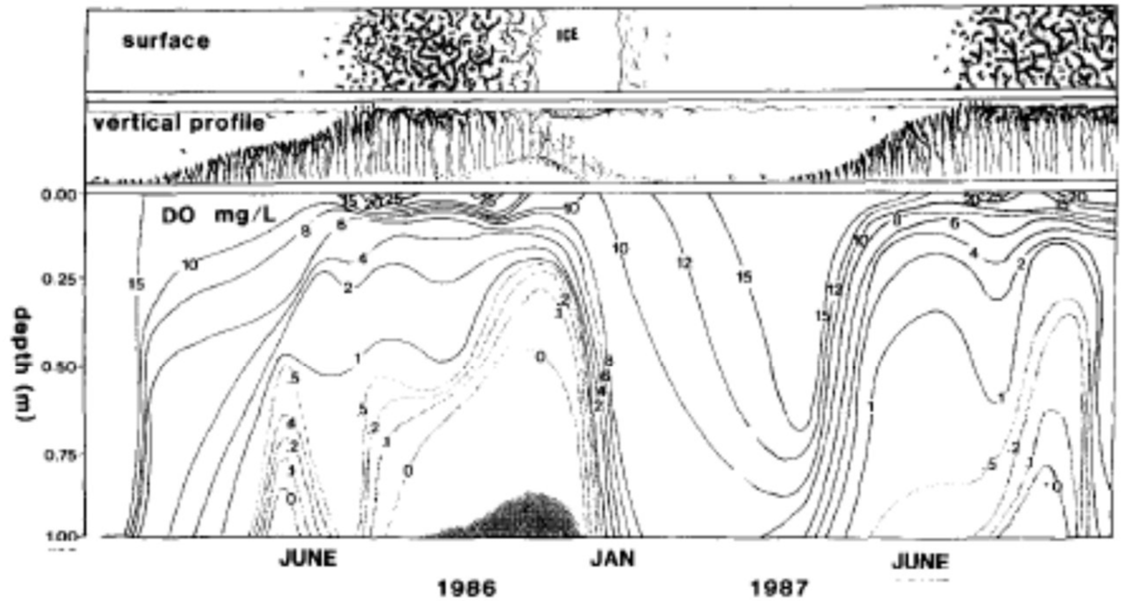


Fig. 7. Dissolved oxygen (mg l^{-1}) isopleths in a dense mixed stand of *C. demersum* and *M. exalbescens* in Bull Lake from March 1986 to December 1987. The stippled area represents the bottom of the lake during summer low water.

While not as severe, submersed plants also create anoxia or hypoxia in dense canopies, particularly near the bottom

Combined with pH swings from photosynthesis, this will encourage flux of P.

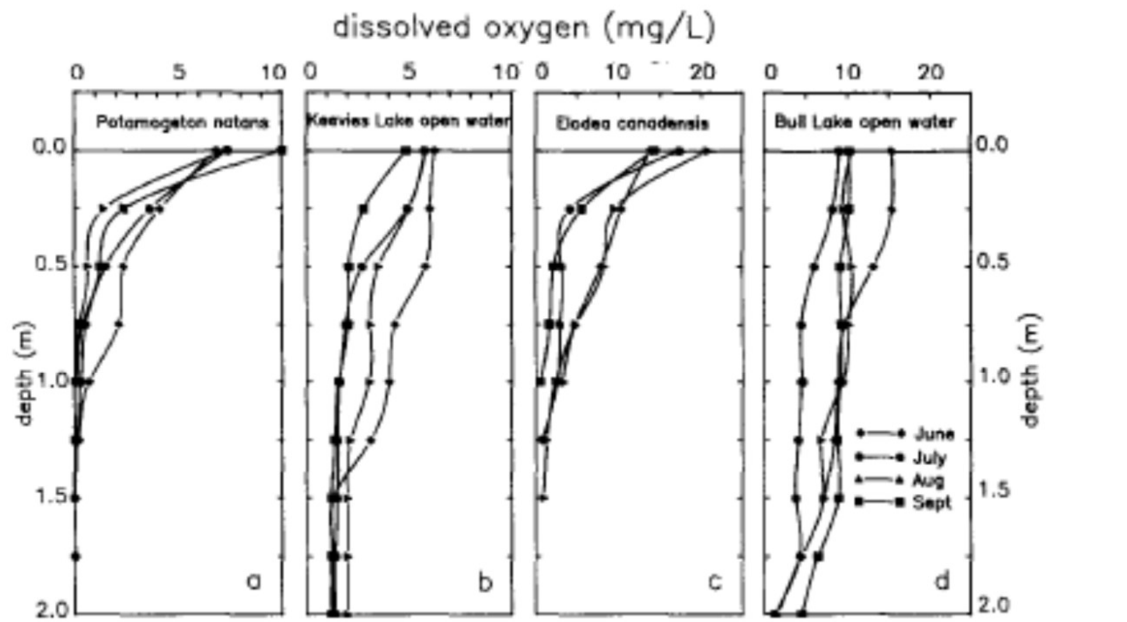


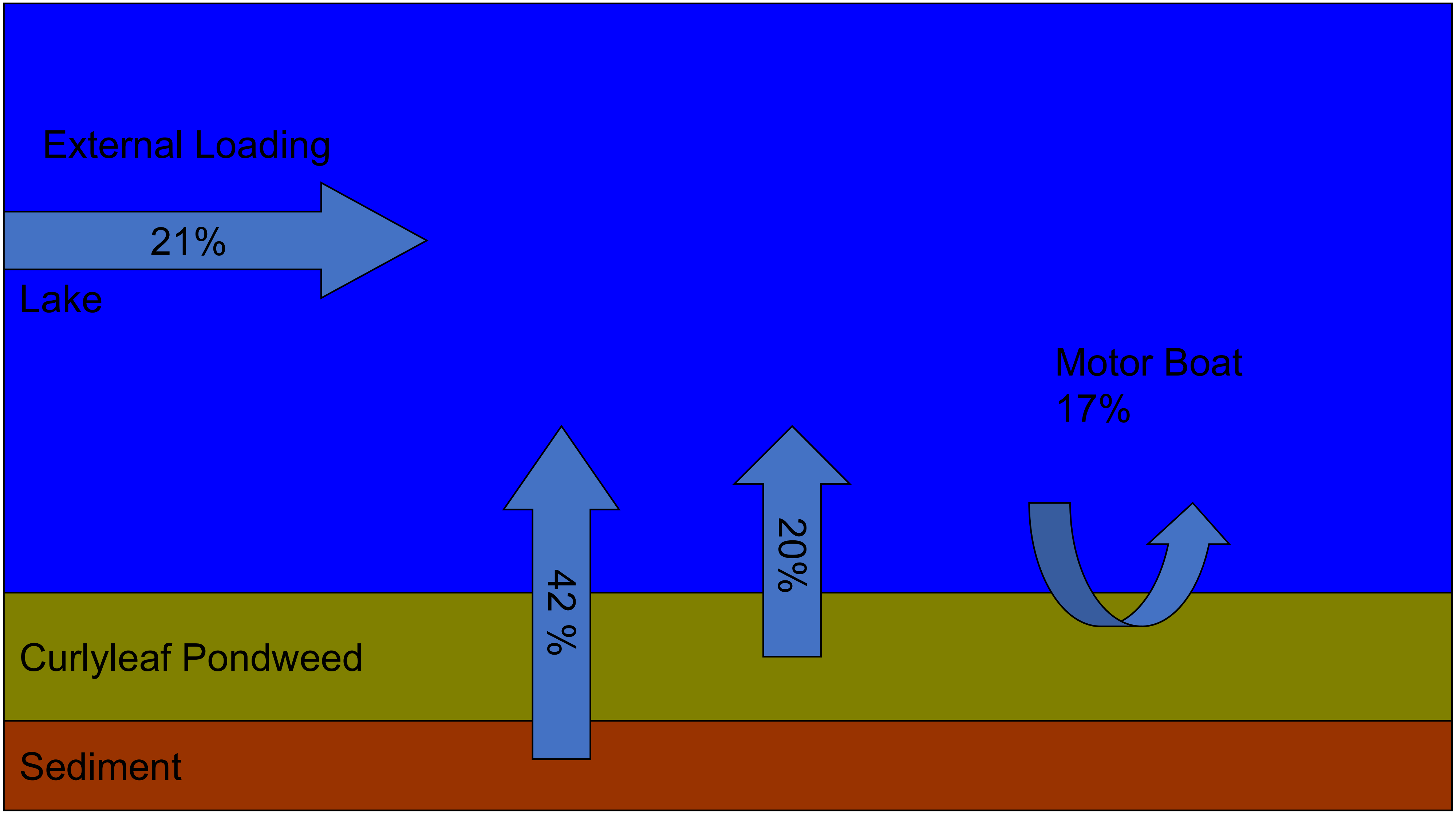
Fig. 5. Mean dissolved oxygen by depth ($n \geq 15$) during June through September, 1986–1987 for: (a) *P. natans* sites in Keevies Lake; (b) open-water sites in Keevies Lake; (c) *E. canadensis* sites in Bull Lake; (d) open-water sites in Bull Lake.

Frodge et al. 1990

USDA

Phosphorus Loading

James et al. 2001



P Release with High pH

- At neutral pH and oxygenation, SRP flux from sediments to water is minimal
- Even with an oxygenated overlying water, elevated pH will allow SRP flux from sediment

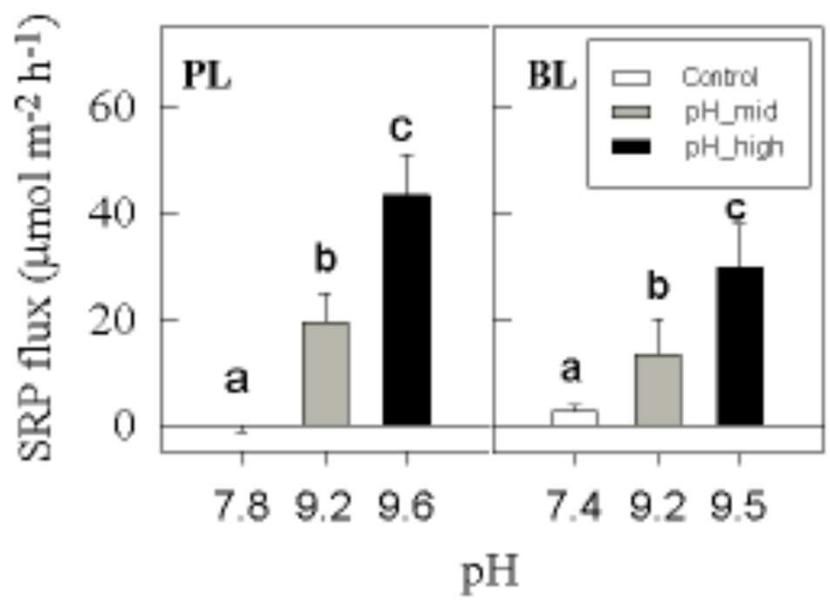


Fig. 2. Experimental pH effects on SRP flux rates from sediments at Powerline (PL) and Budds Landing (BL). Error bars are the standard errors. Two-way ANOVA was used to test the pH effects on SRP release at both sites. With elevation in the experimental pH, SRP fluxes were significantly different at each site ($P < 0.01$), but nonsignificantly different between stations ($P > 0.05$). Different letters are used to show significant difference.

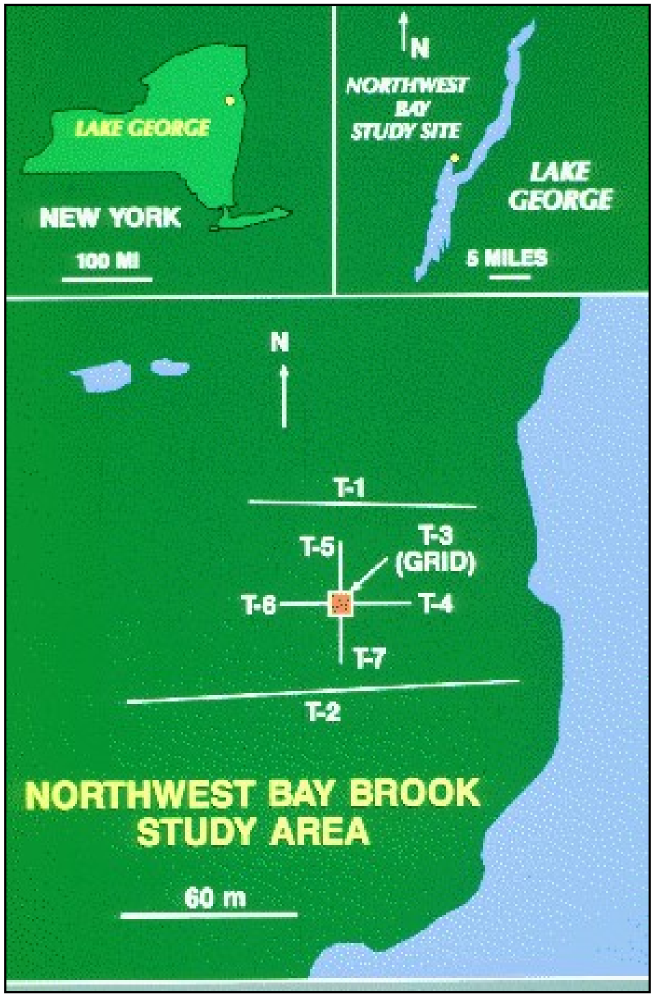
USDA

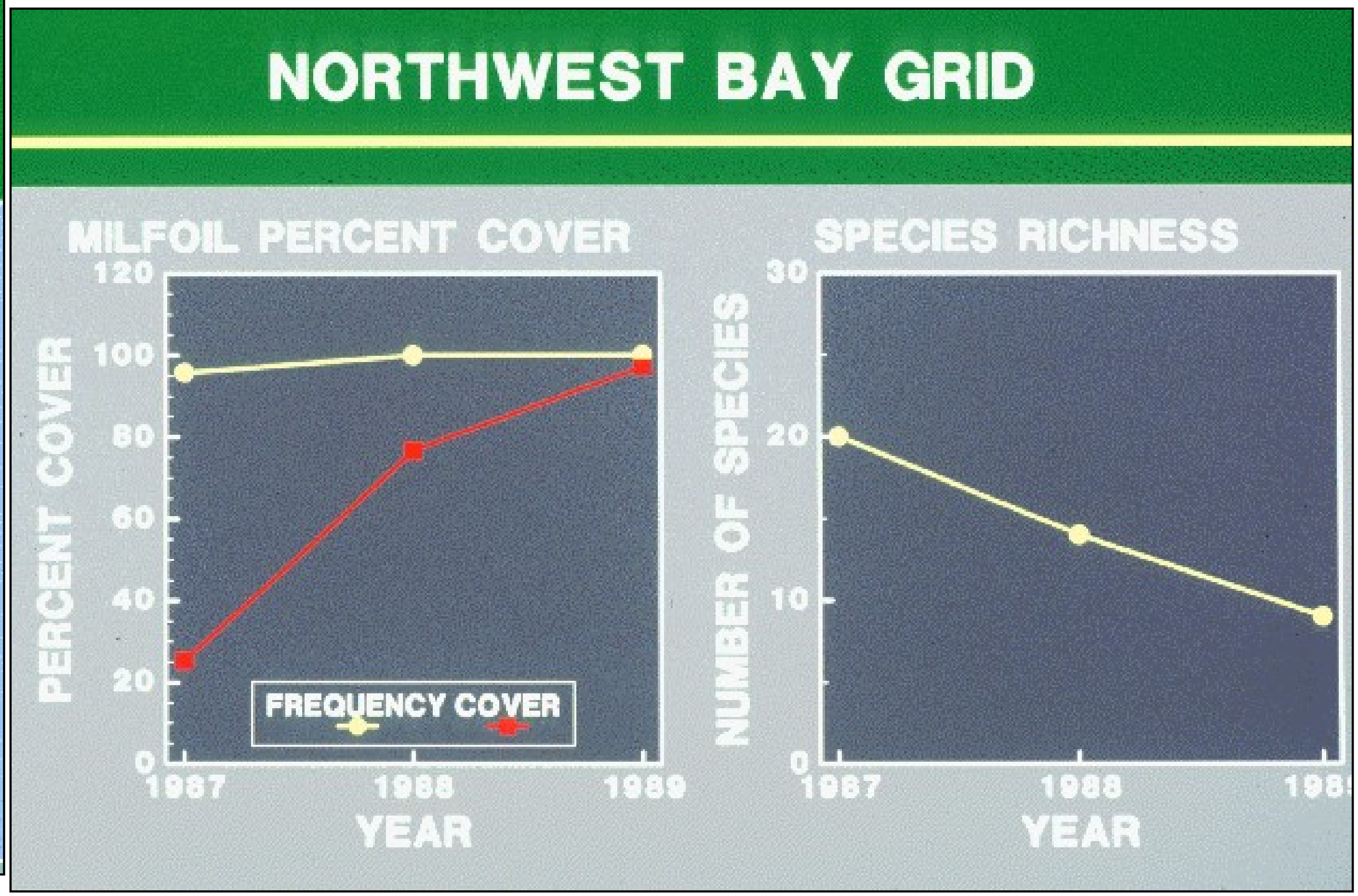
Gao et al. 2012

Impacts of Invasion on Native Plants

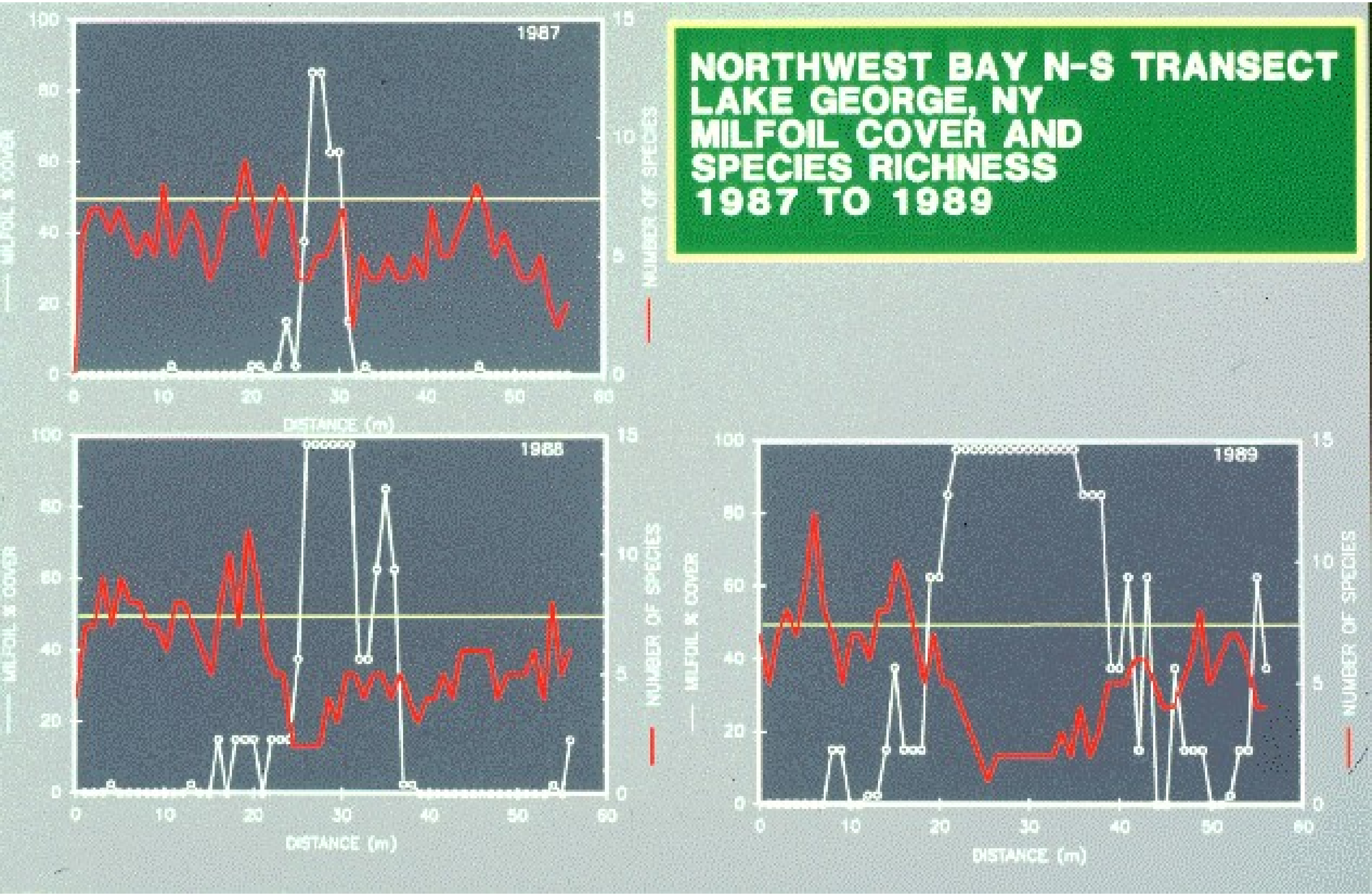
- Permanent grid and transects in Lake George, NY in 3 to 5 m water depth
- Plant cover assessed every year in July from 1987 to 1989

Eurasian watermilfoil vs. Native Plants

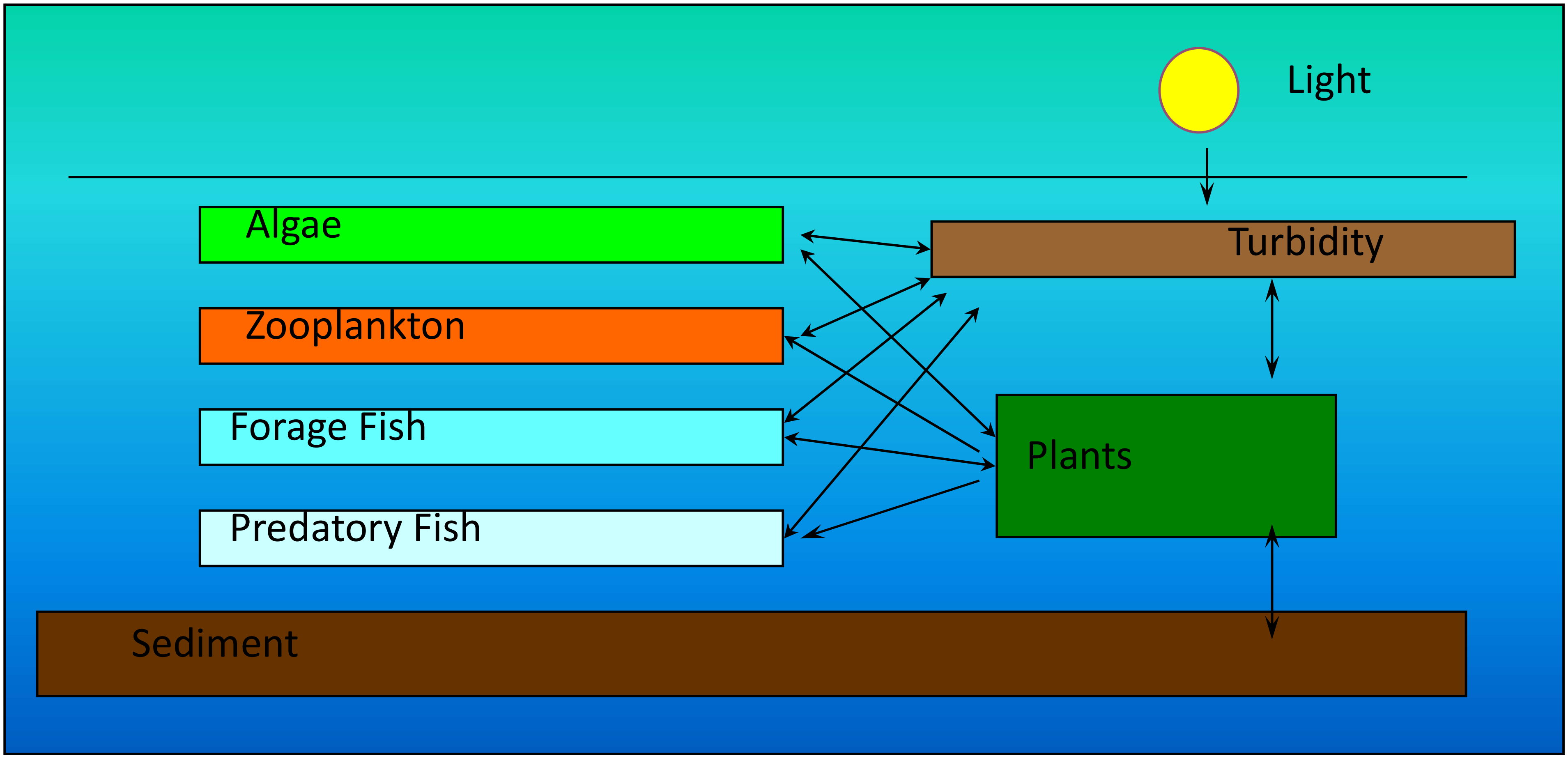




Eurasian watermilfoil and Diversity



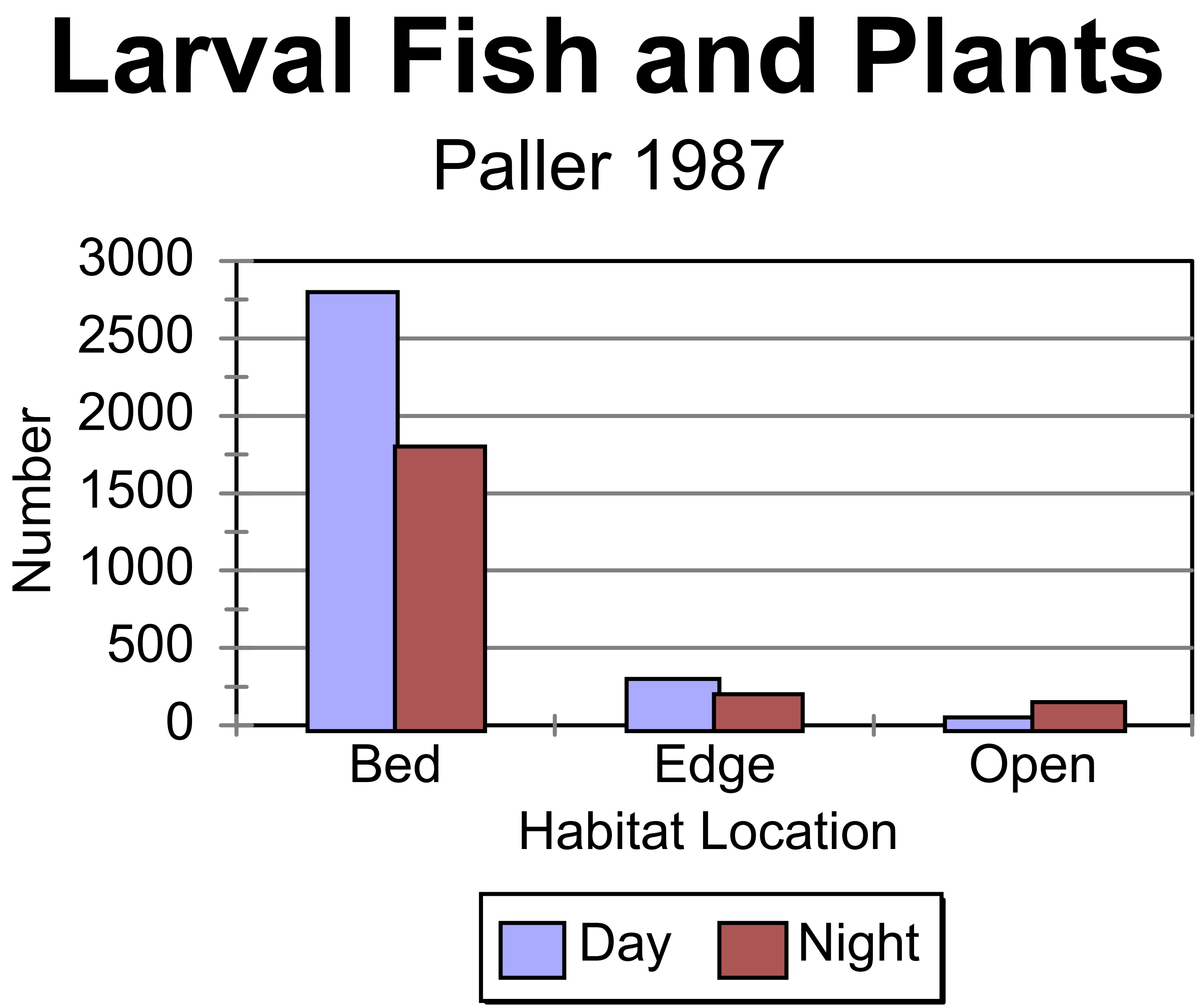
Littoral zone population dynamics are a complex web of weak interactions of biotic communities and environment



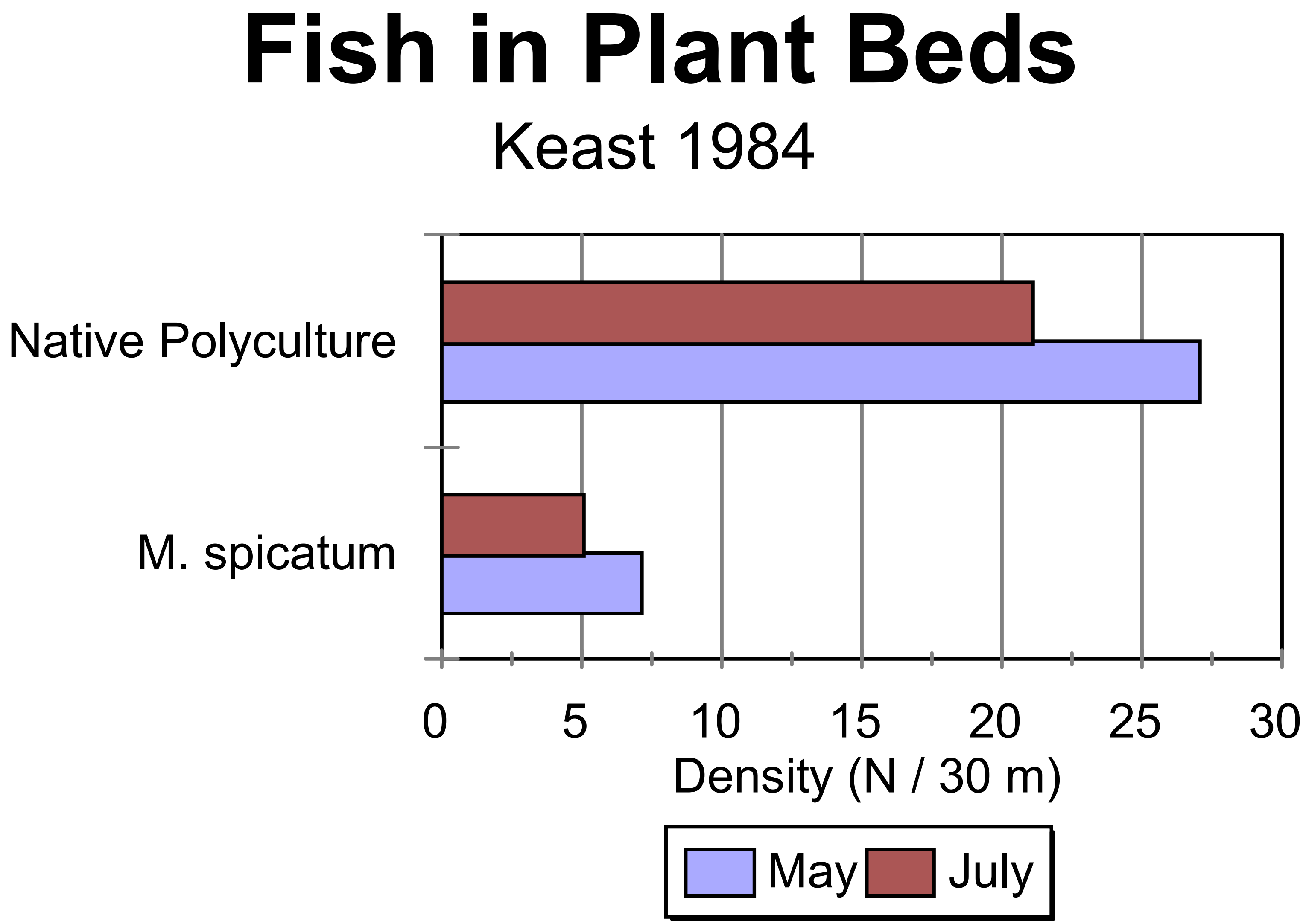
Invasive Plants and Fish

- Alter predator/prey balance
- After time, produces large numbers of stunted, underfed fish

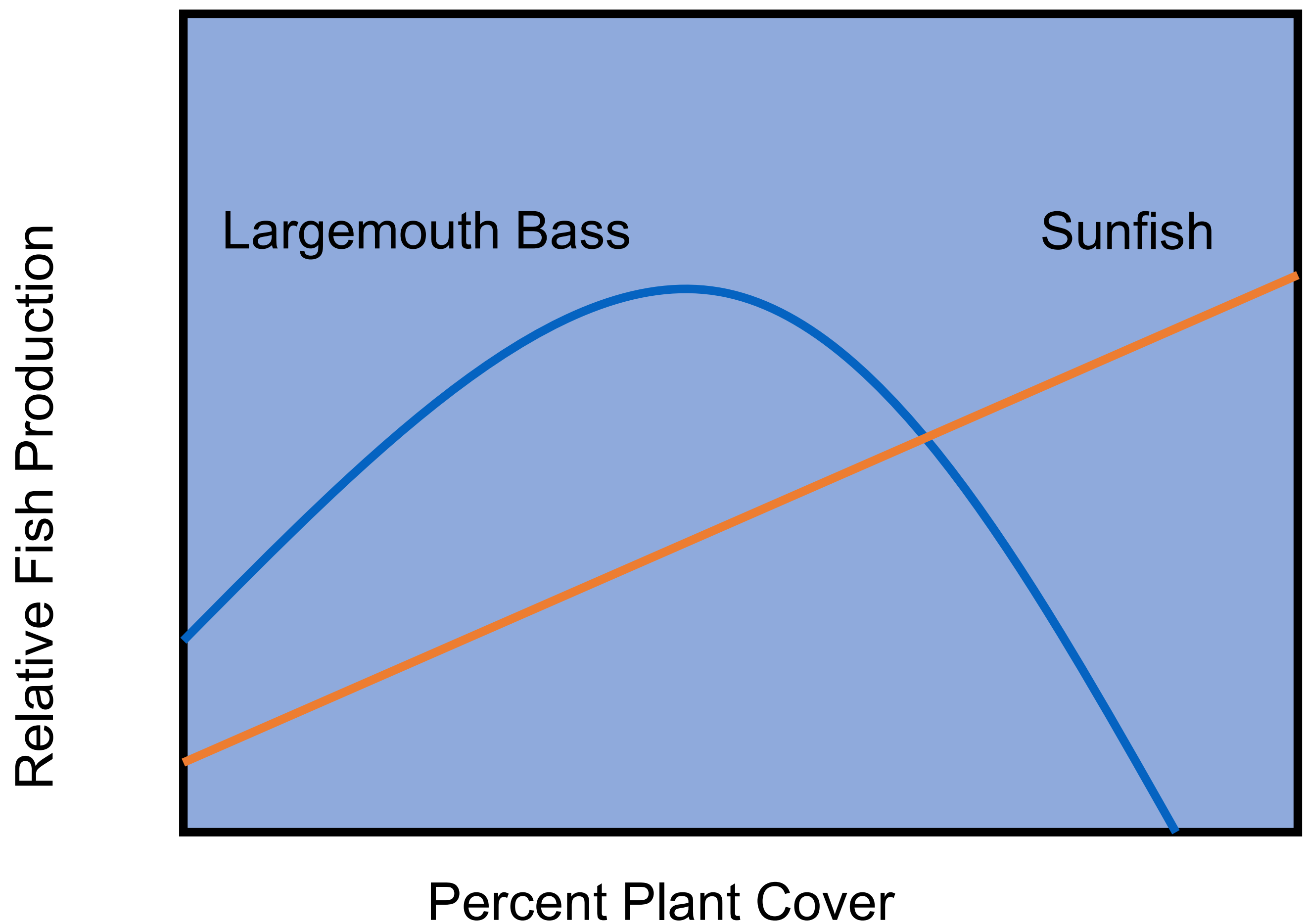
Larval Fish and Plants



Fish Use of Plant Beds



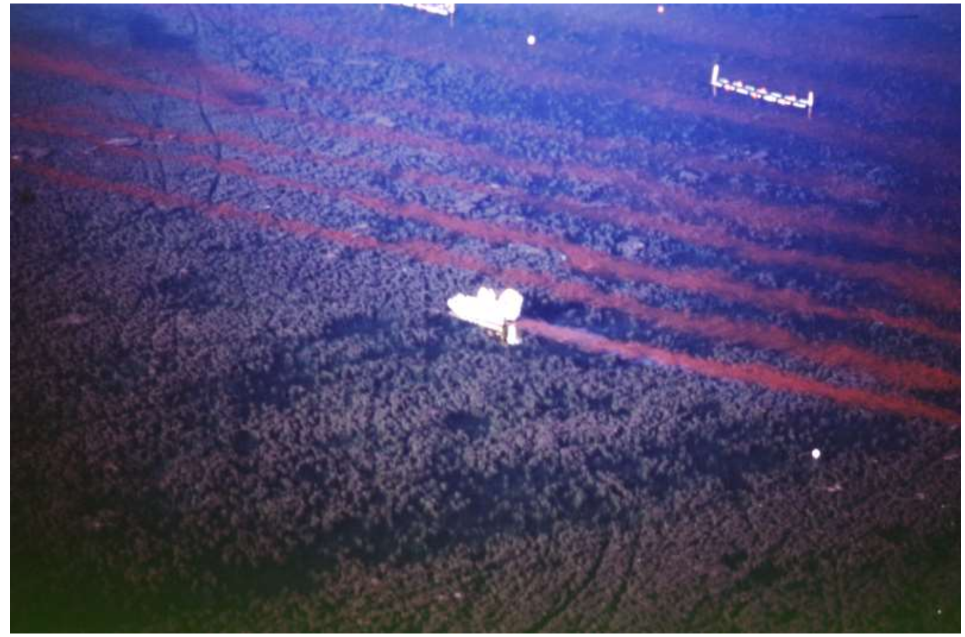
Aquatic Plants and Predator/Prey Balance



Predatory Fish Attracted to Edge of Plant Bed

Large Acreage of Topped-out Invasive Aquatic Plants

Hydrilla in Lake Guntersville AL circa 1992. Water depth is 12’.



Fluorescent dye treatment on Lake Minnetonka circa 1997 on bed of Eurasian watermilfoil. Water depth is 10’.

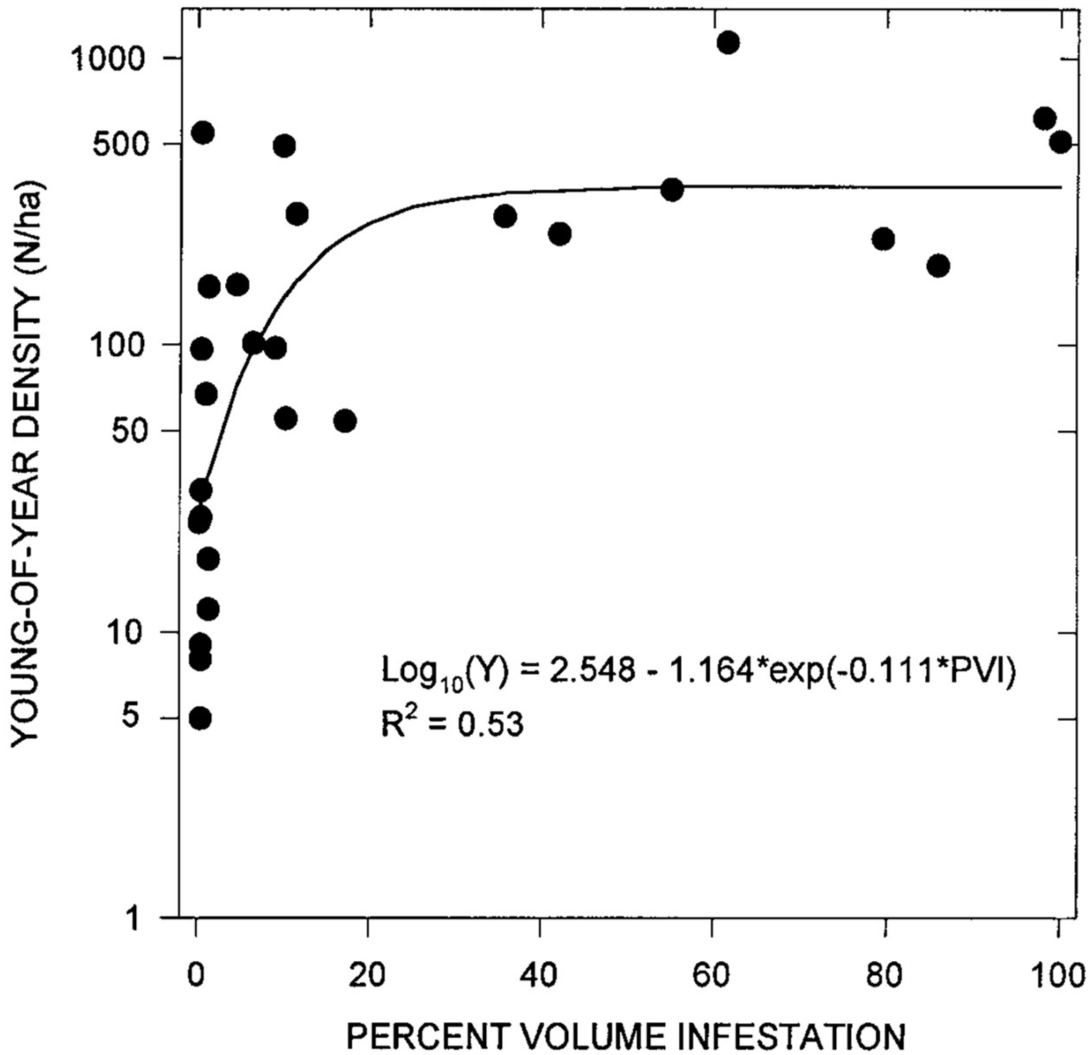
The View from the Surface

The View Underneath

Plant Volume and YOY Fish Density

Figure 1. The relation between young-of-year largemouth bass density and percent volume infestation of aquatic plants in Florida lakes greater than 54 ha. Line represents least-squares non-linear regression.

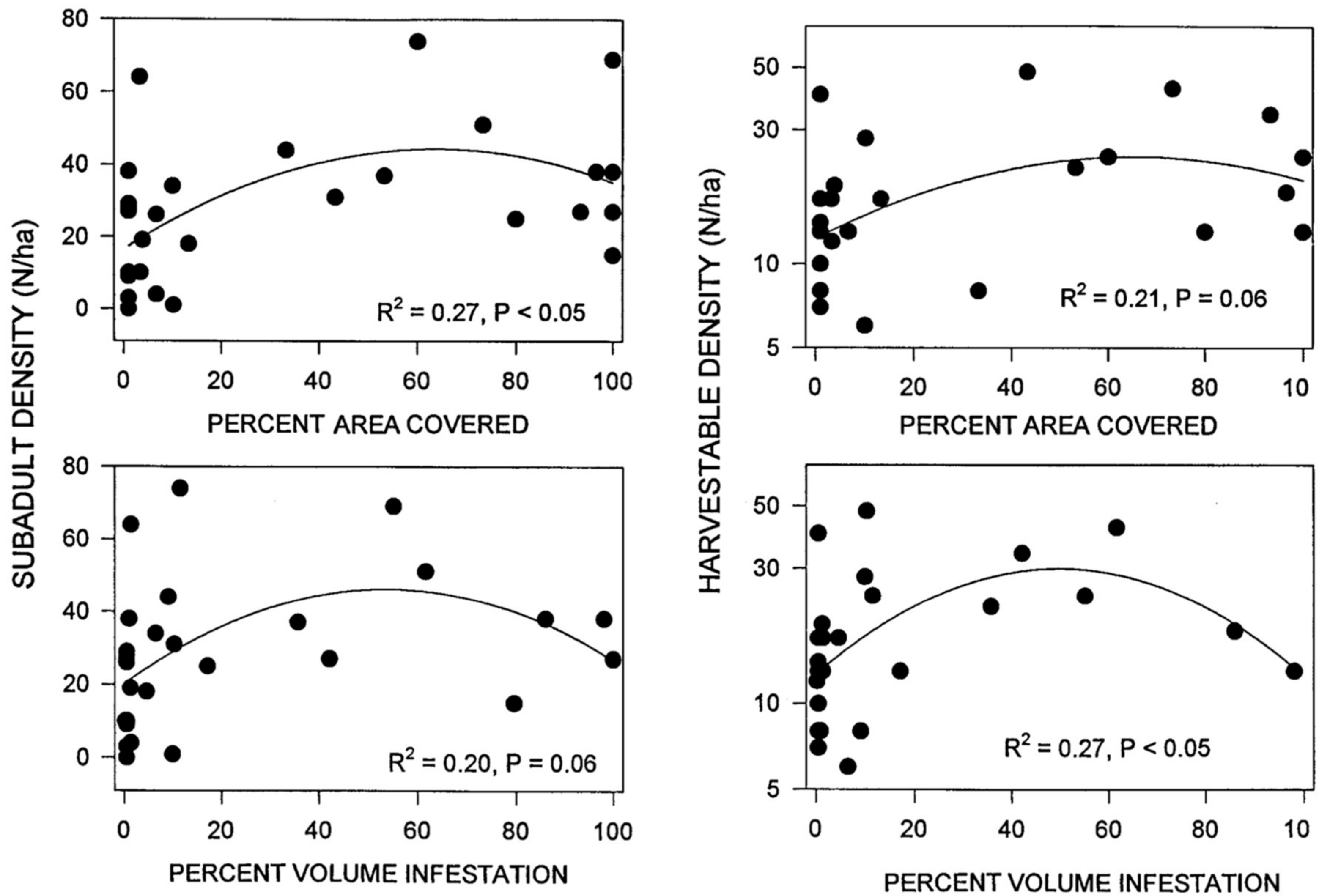
J. Aquat. Plant Manage. 34: 43-47



Subadult and Adult Bass

Figure 2. The relations between subadult and harvestable largemouth densities and percent area covered and percent volume infestation of aquatic plants in Florida lakes greater than 54 ha. Lines represent second-degree parabolic regressions.

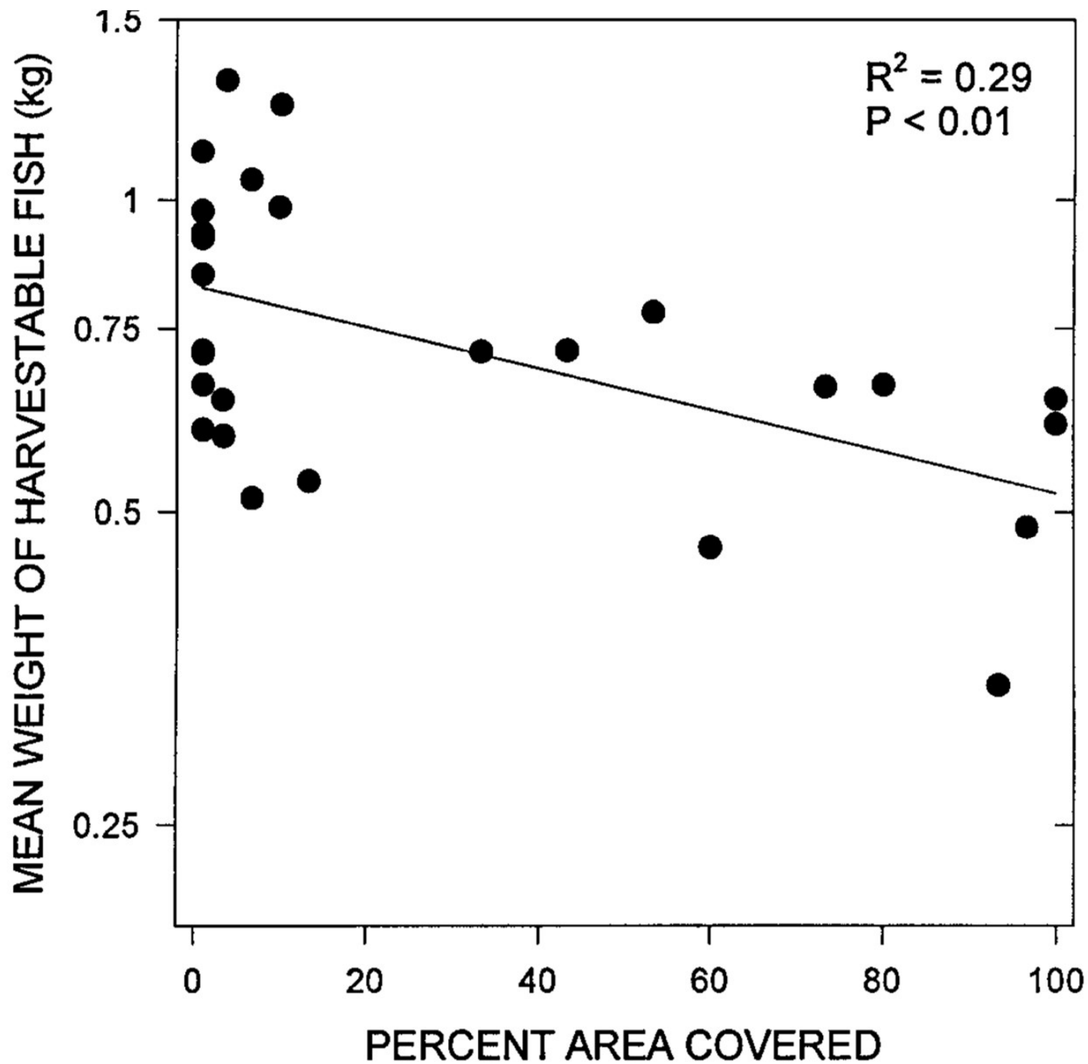
J. Aquat. Plant Manage. 34: 43-47



Plant Percent Cover and Harvestable Weight

Figure 3. The relation between mean weight of harvestable largemouth bass
and percent area covered of aquatic plants in Florida lakes greater than 54 ha.

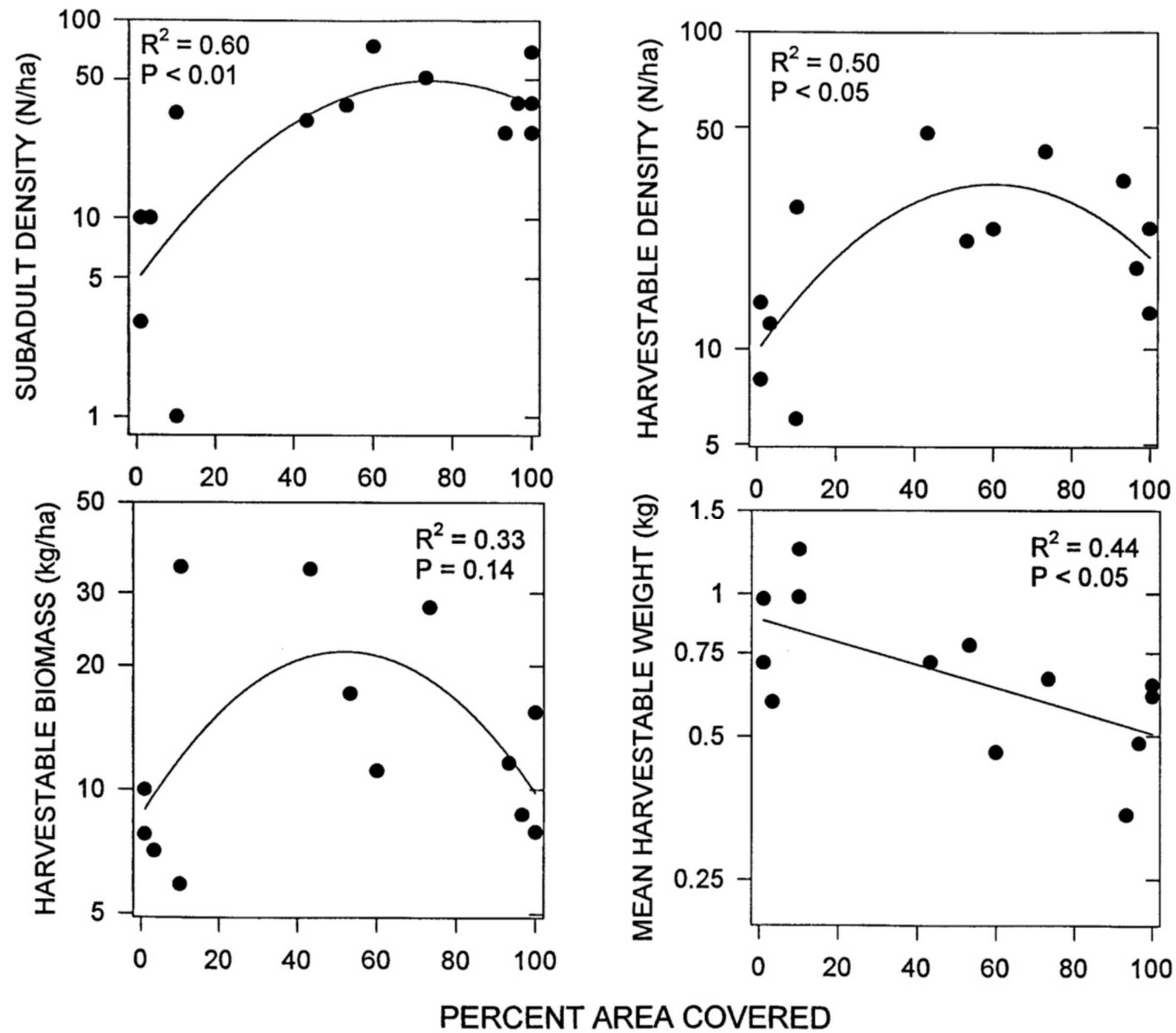
J. Aquat. Plant Manage.
34: 43-47



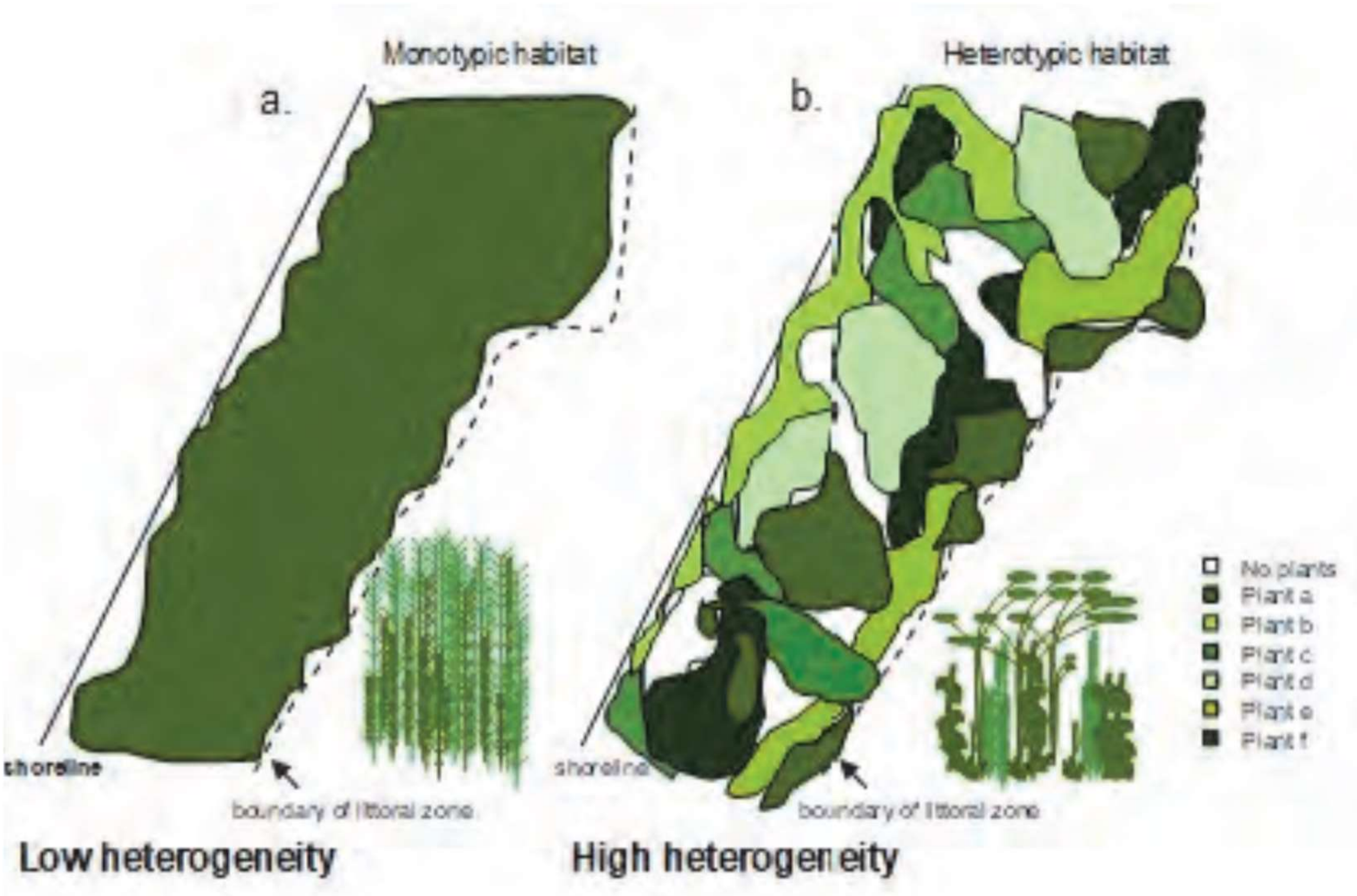
Fish Density and Weight vs Percent Cover

Figure 4. Relations between largemouth bass subadult density, adult density, adult biomass and mean harvestable weight, and percent area covered of
aquatic plants in Florida lakes greater than 116 ha. Lines represent second-degree parabolic or linear regressions.

J. Aquat. Plant Manage.
34: 43-47

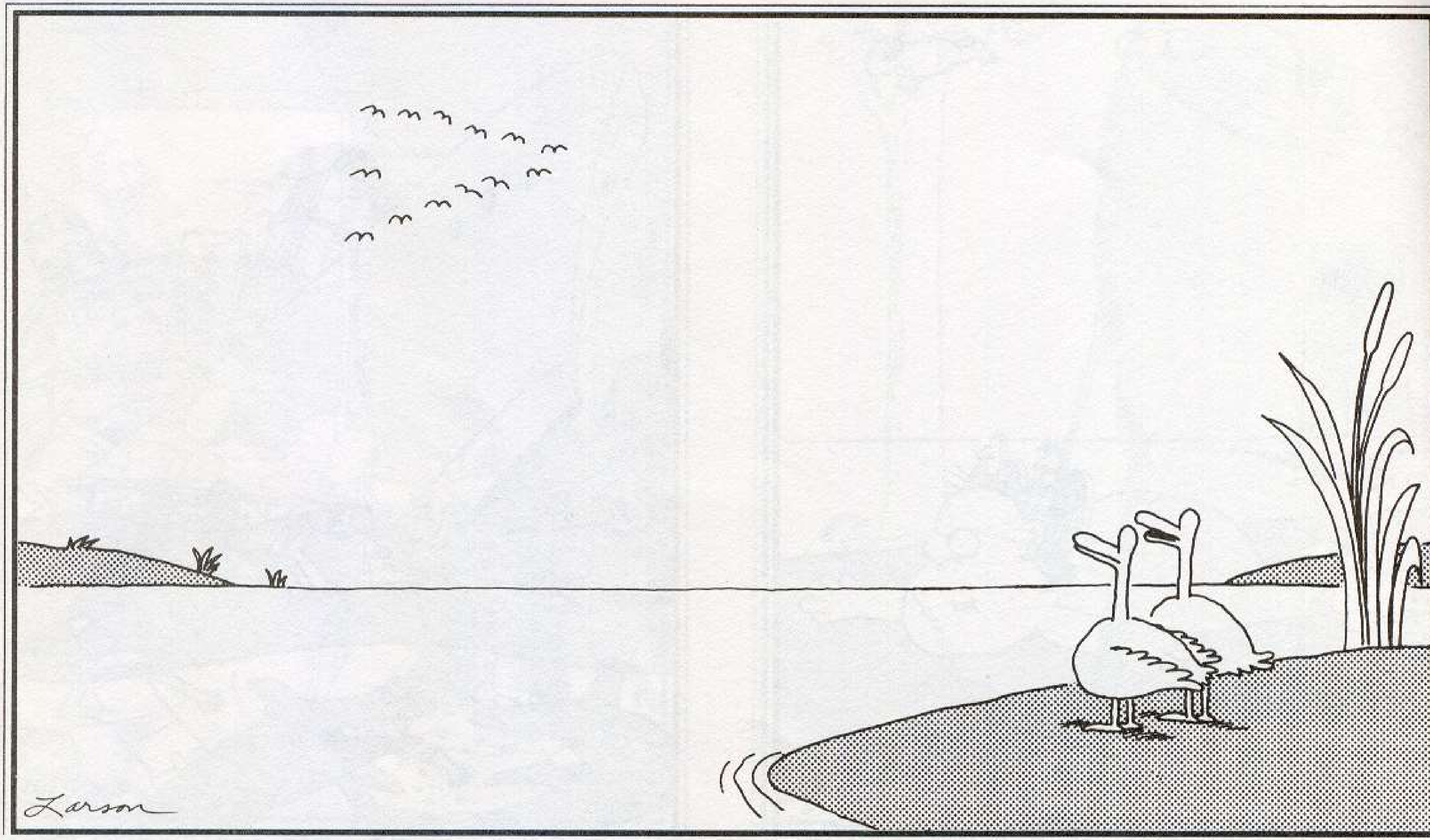


Optimal Habitat for Fish



Eric Dibble:
"However, the "optimal" habitat that provides a beneficial environment for most animal populations is one that contains a large diversity of native plants."
AERF BMP 2020

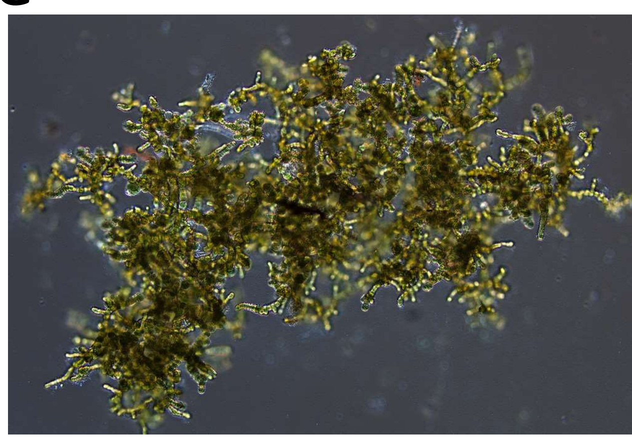
Invasive Aquatic Plants and Birds



"I just can't tell from here. … That could either be our flock, another flock, or just a bunch of little m's"

Avian vacuolar myelinopathy

- Bald Eagle contract avian vacuolar myelinopathy from eating coots
- Coots eat hydrilla covered in the cyanobacterium *Aetokthonos hydrillicola* which grows on the hydrilla



Avian Vacuolar Myelinopathy

- Pathways to Bald Eagle
  - Coots
  - Turtles
  - Grass carp
- Susan Wilde, U GA

Shallow Lake Alternate Stable States

Reduced resuspension

Macrophyte growth

Increased sedimentation

Reduced TSS loading

Benthivorous omnivorous fish
High TSS loading
High nutrient loading
Catastrophic events

Turbid State

High turbidity
Low transparency
Little or no plant growth

Clear State

Abundant plant growth
Low turbidity
High transparency

Lakes without Plants

- Turbid
- Poor fish recruitment
- Little structure for fishing
- Unstable sediment

Shallow Lakes: High Transparency Occurs over a Broad Range of TP

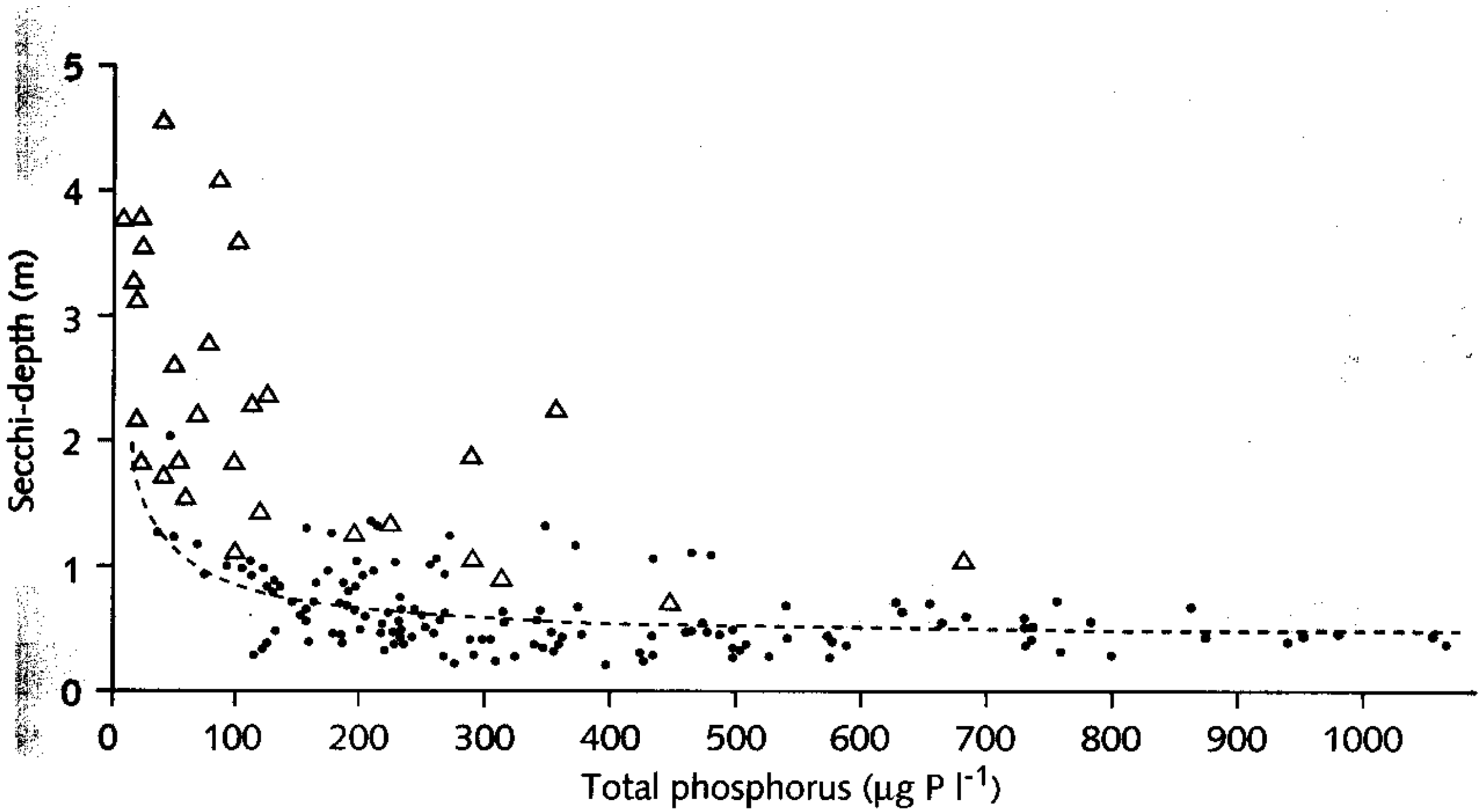
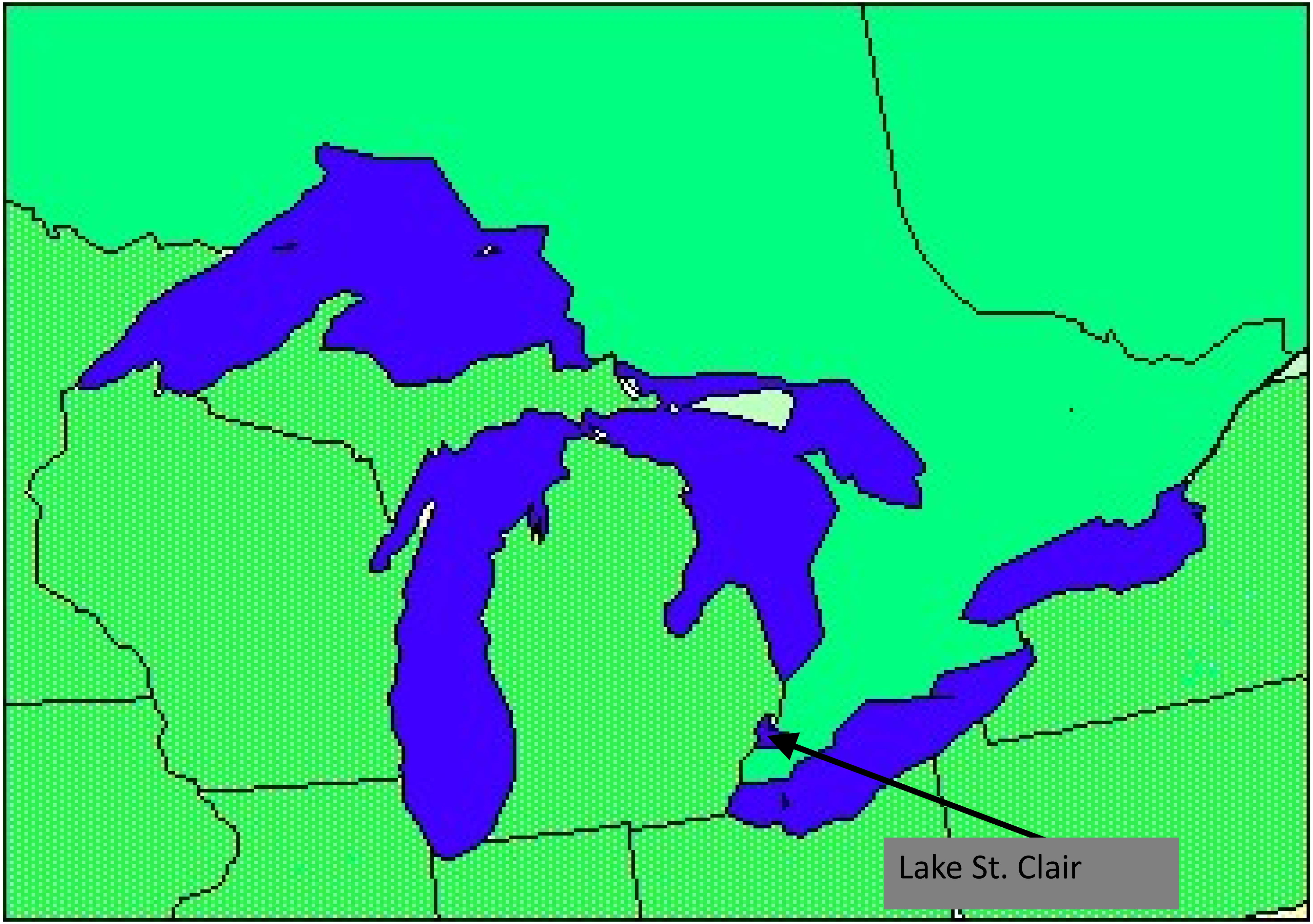
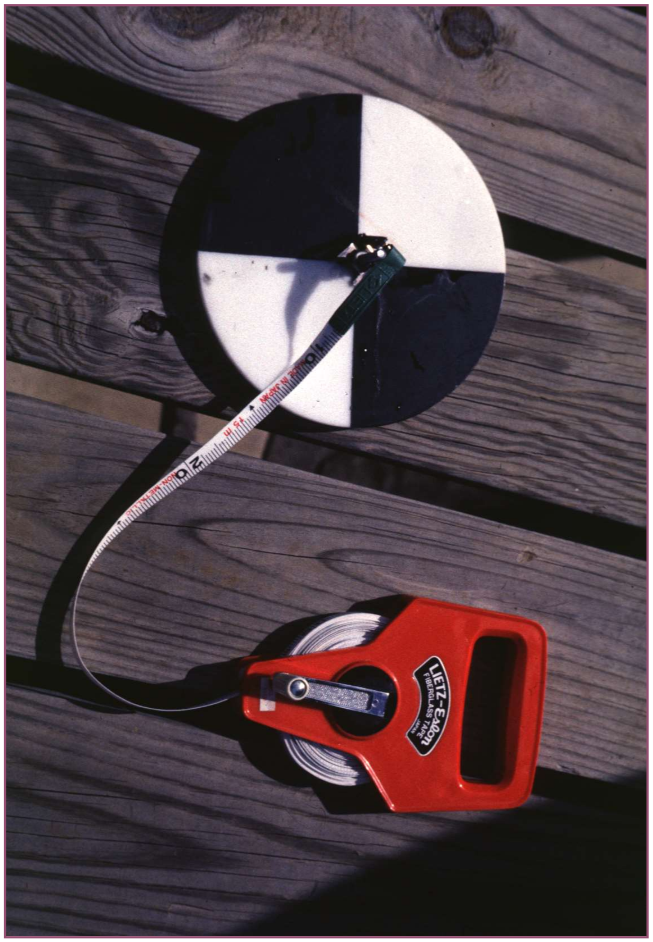


Figure 2.3: *Summer mean transparency ('secchi-depth') in relation to lake water total-P for shallow Danish lakes with high cover of submerged vegetation (triangles) and lacking such vegetation (small dots).*

Meijer 2000

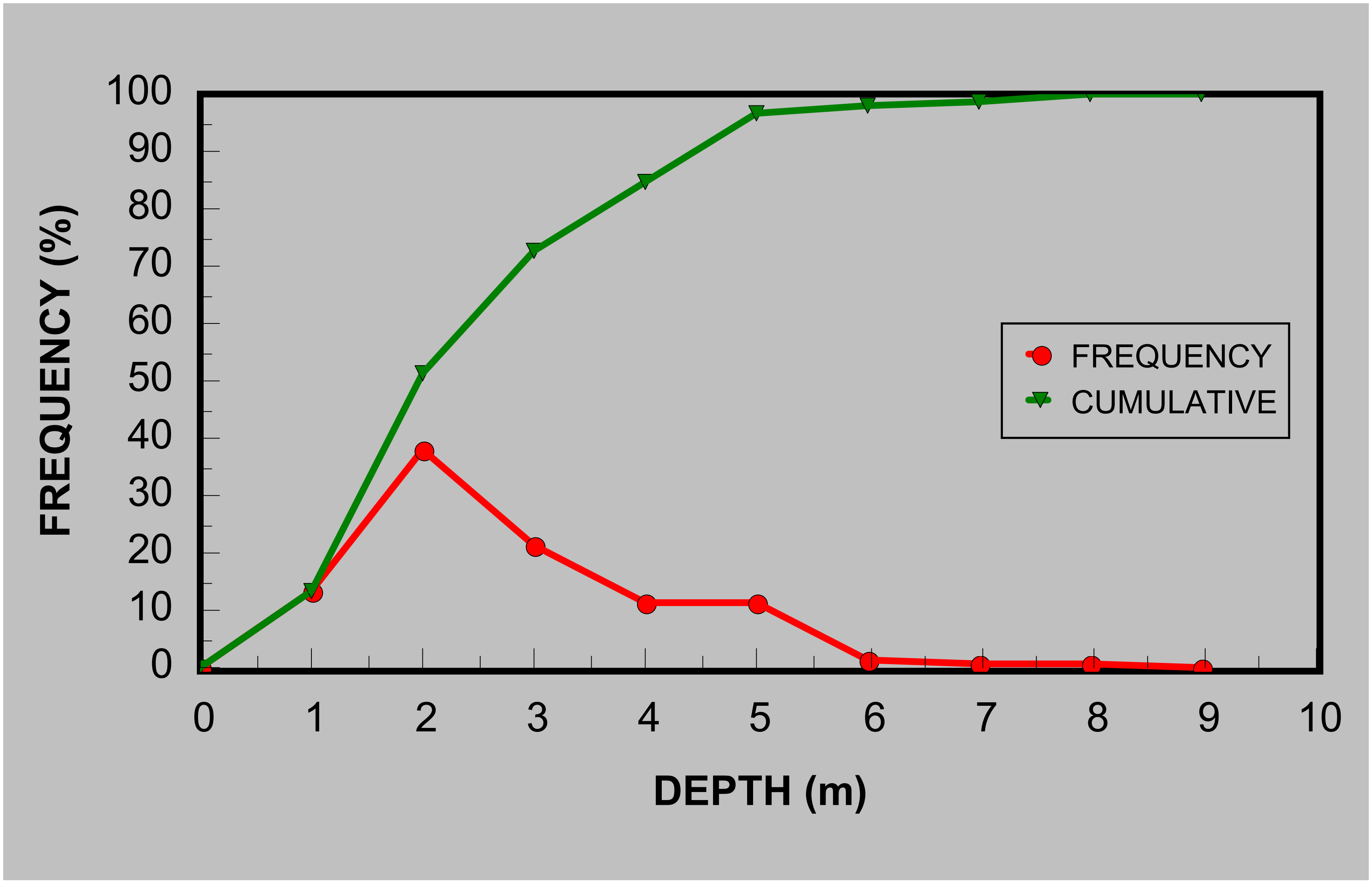

Lake St. Clair

Changes in Water Clarity

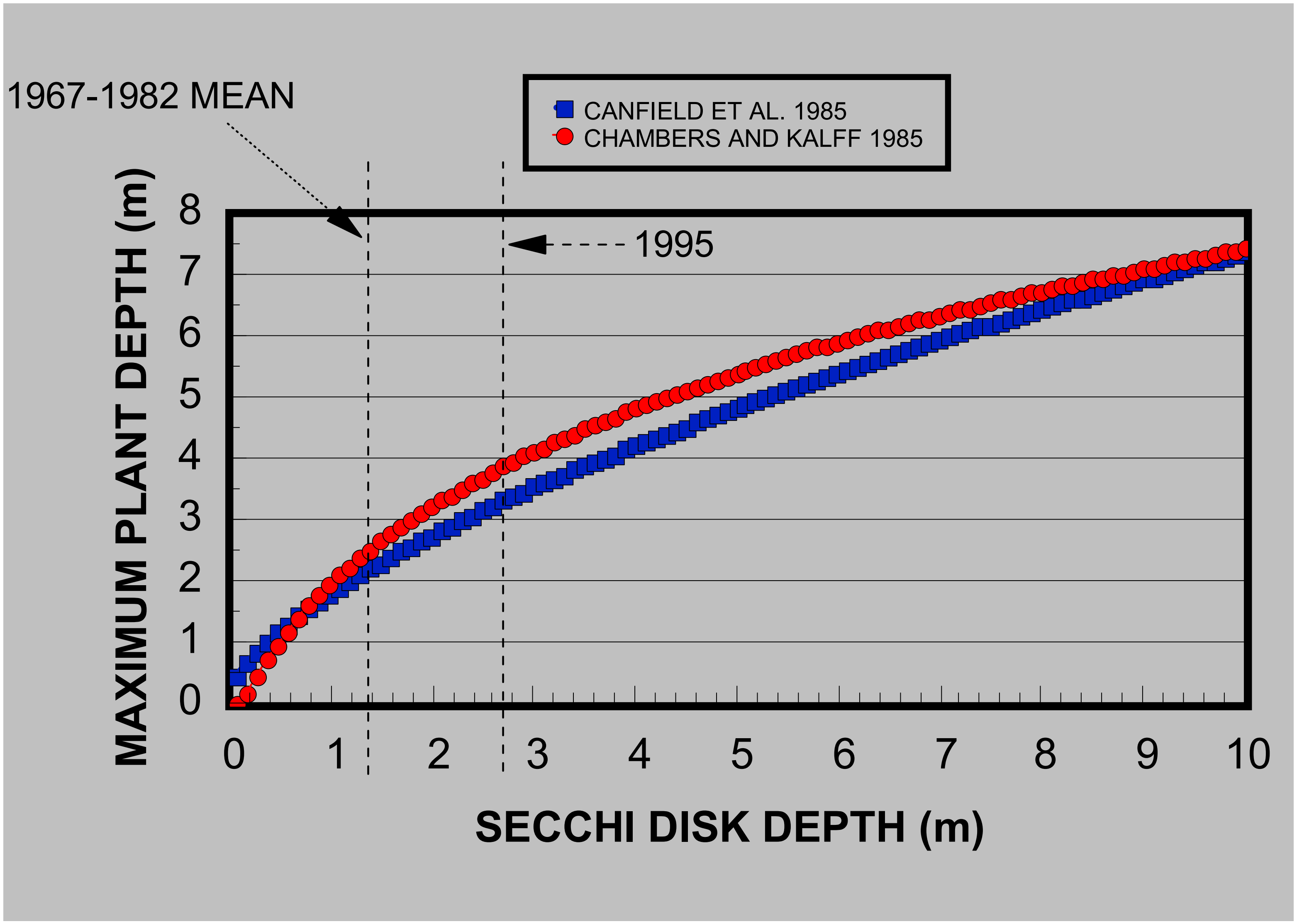


- Water clarity has increased dramatically in last 20 years
- Change appears to be mediated by introduction of zebra mussel
- Lake now has vegetated littoral area of about 1,000 km^2

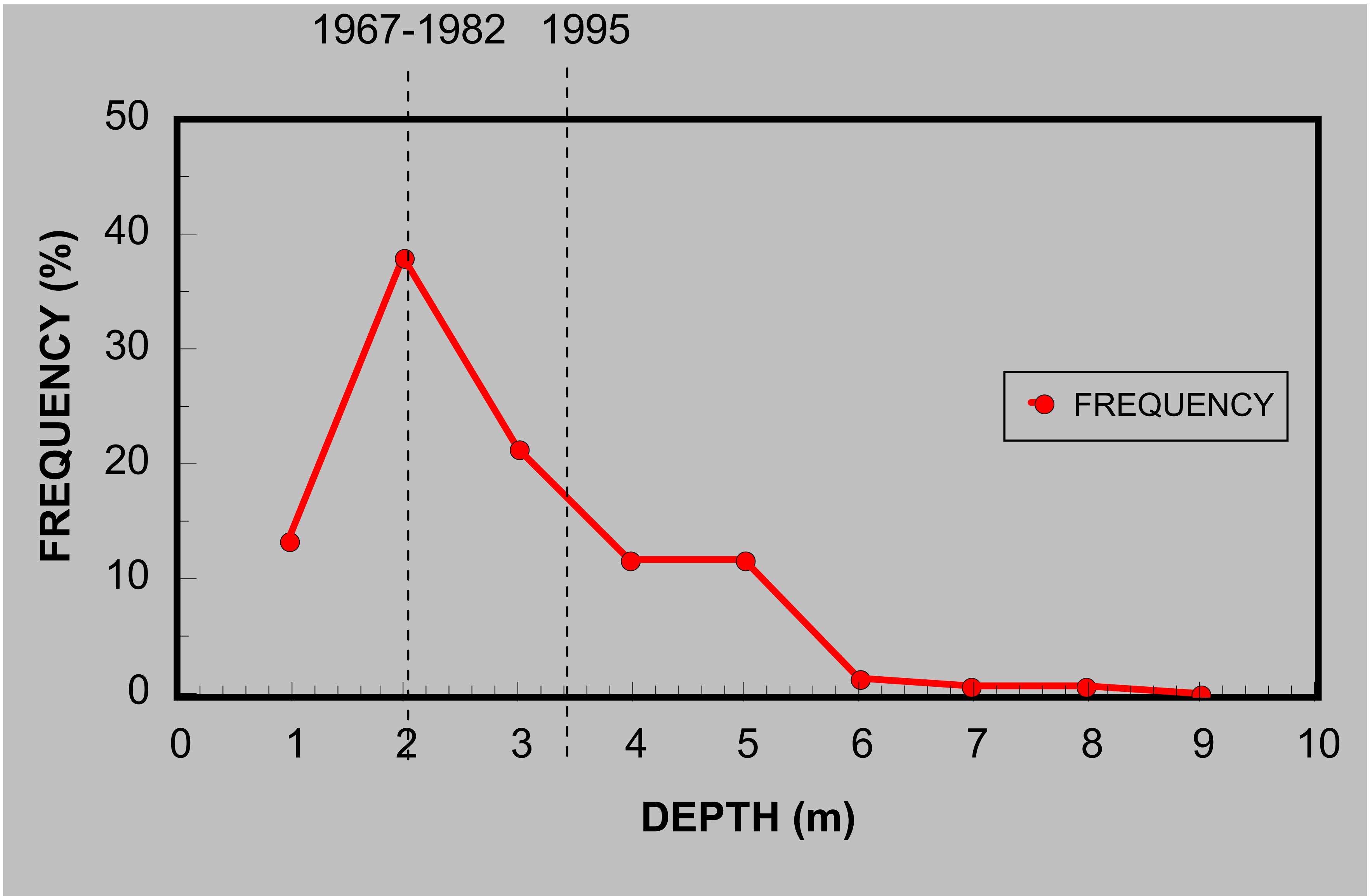
Depth Profile for Lake St. Clair



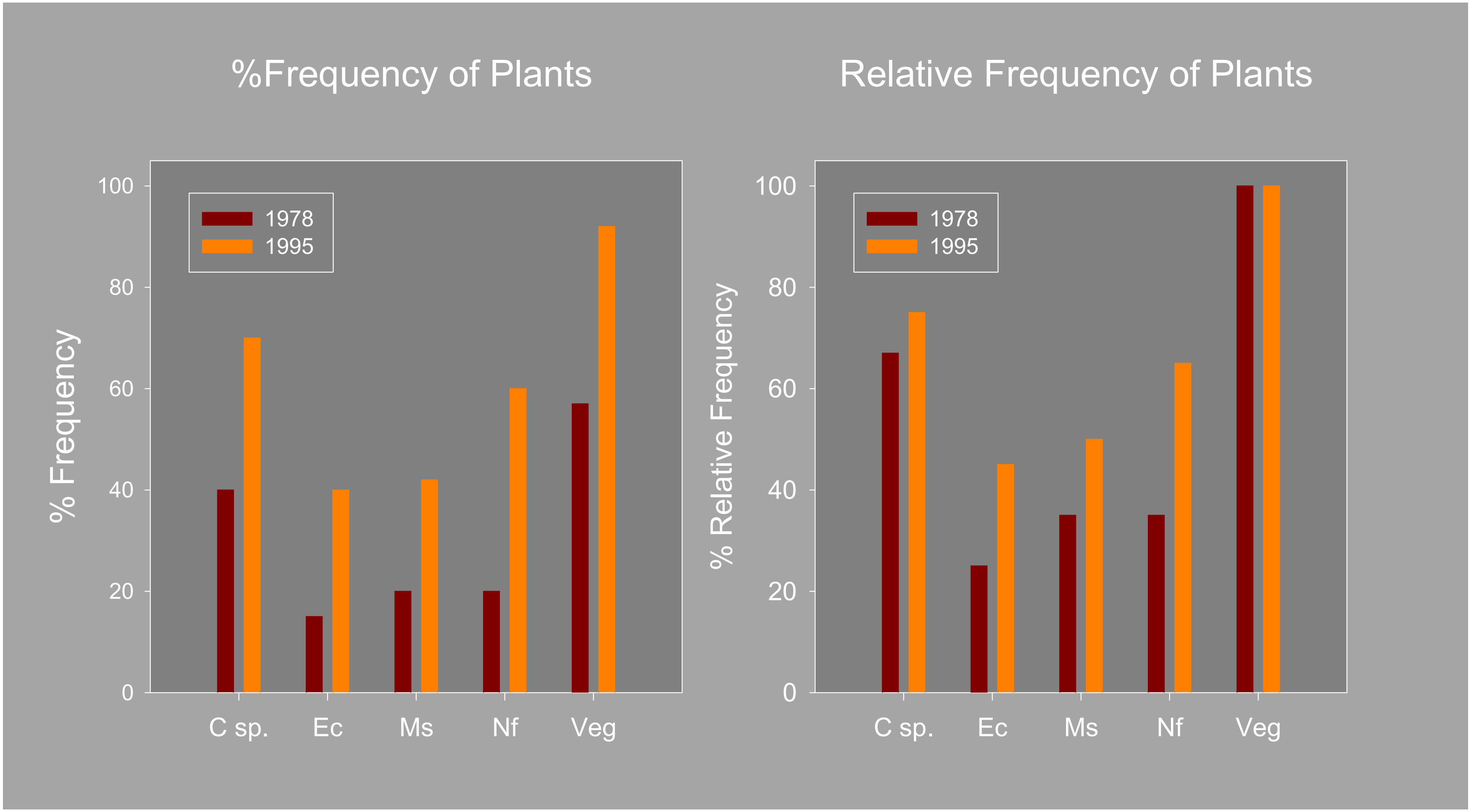
Secchi Disk Depth for Lake St. Clair



Predicted Depth of Plants in Lake St. Clair



Change in Aquatic Plant Community

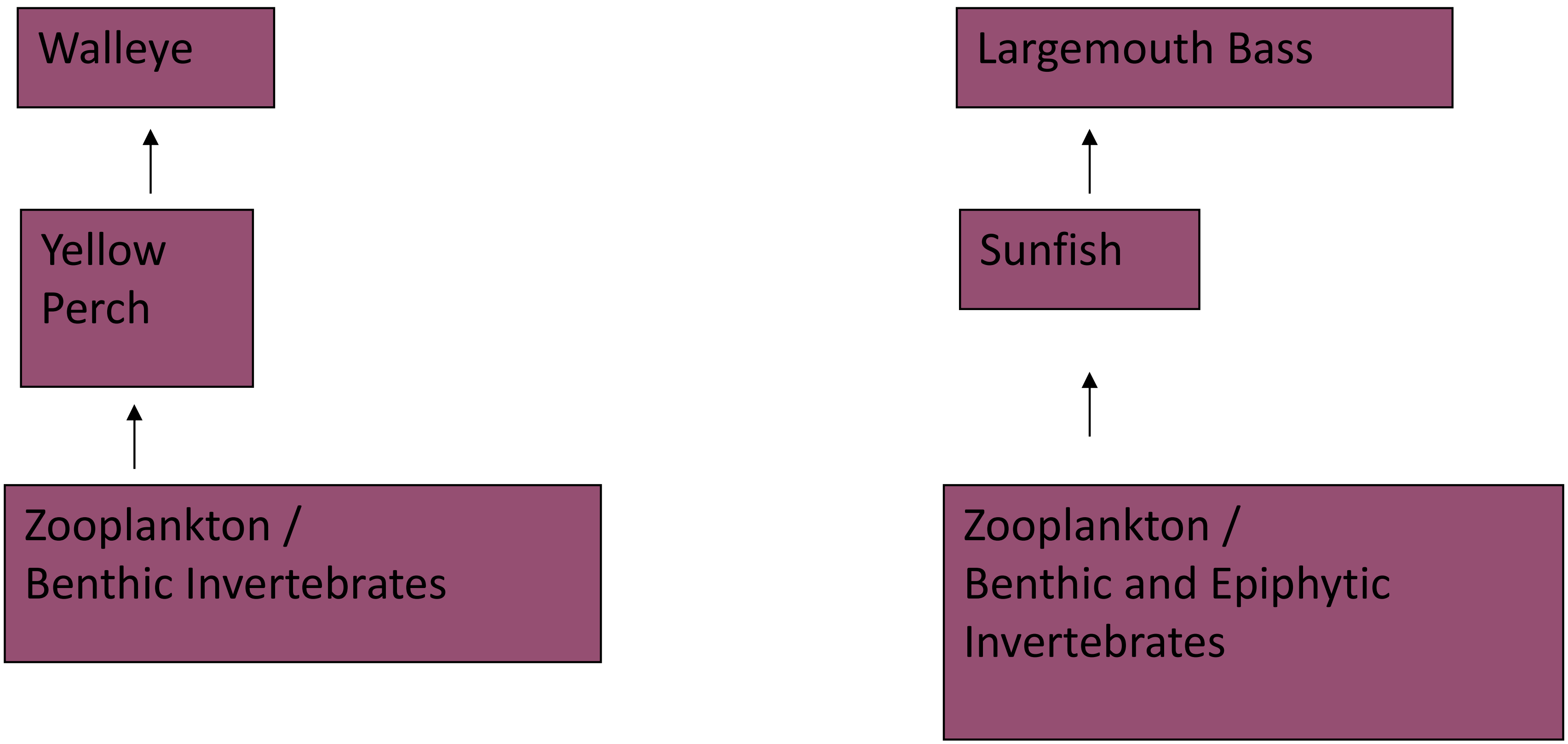


USGS Data. C sp., Chara; Ec, Elodea canadensis; Ms, Myriophyllum spicatum; Nf, Najas flexilis; Veg, vegetated.

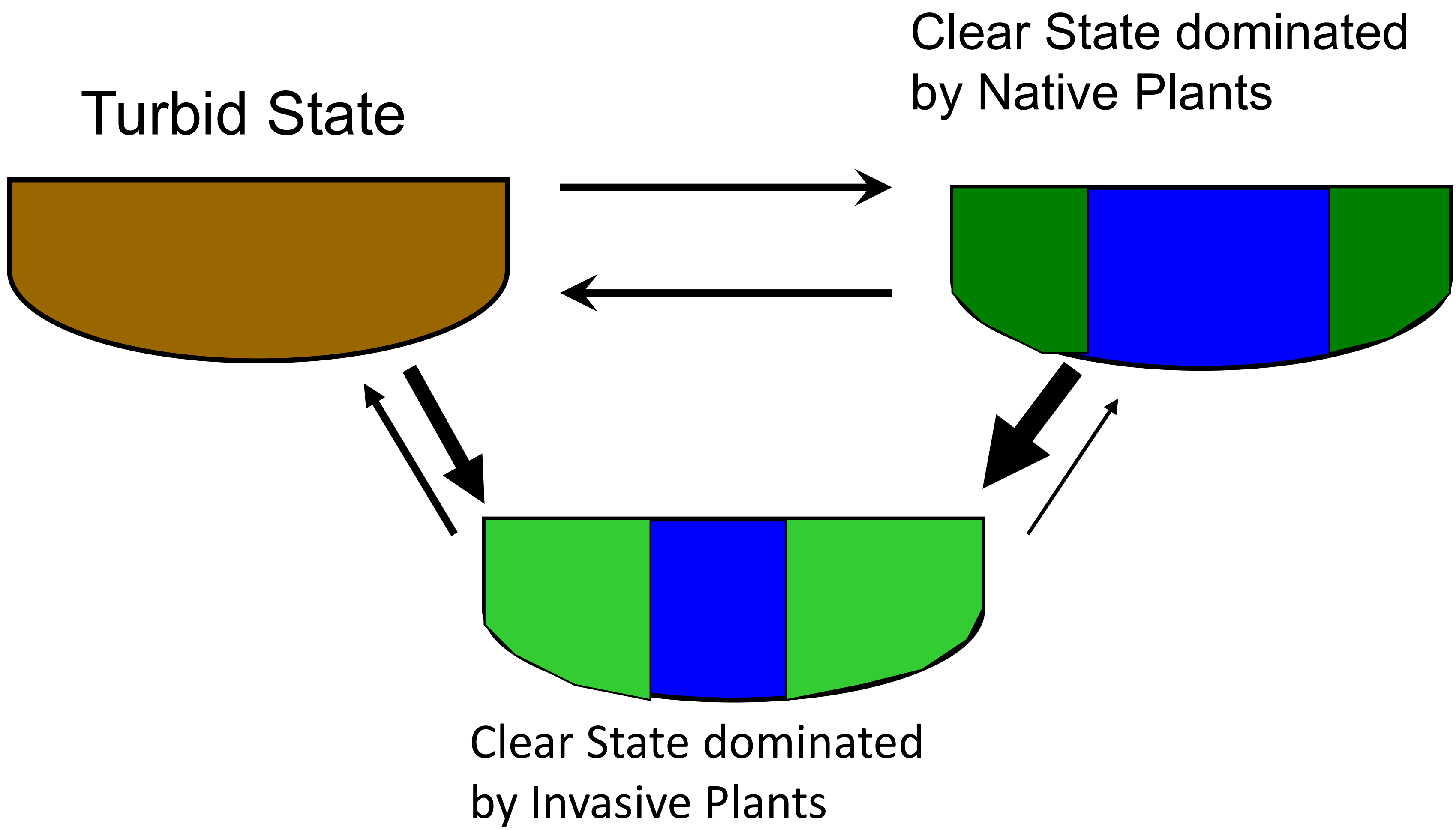
Dominant Trophic Structure

Pre-1970
Pelagic

Post-1995
Littoral



Three Stable States?



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Northern Pike in Western Ontario

Rainbow Trout in South Island New Zealand, 2018