



Nearshore Fish and Wildlife Habitat: Human Impacts, Obvious Remedies, Difficult Choices

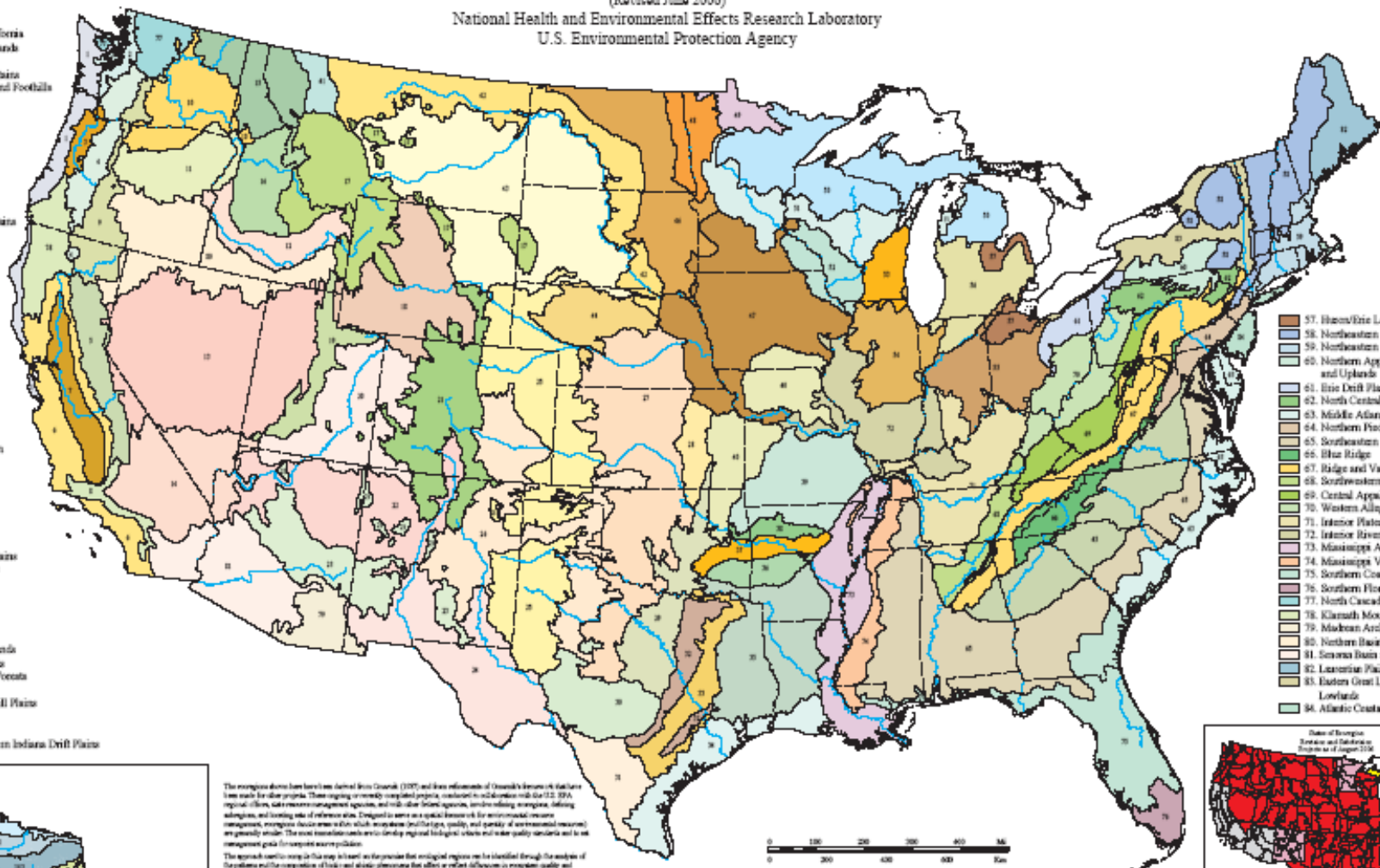
Paul Cunningham
Bureau of Fisheries Management

National Ecoregion Framework

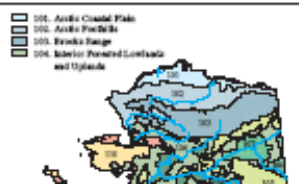
Level III Ecoregions of the Continental United States

(Revised June 2006)
 National Health and Environmental Effects Research Laboratory
 U.S. Environmental Protection Agency

- 1. Coast Range
- 2. Puget Lowland
- 3. Willamette Valley
- 4. Cascade
- 5. Sierra Nevada
- 6. Southern and Central California Chaparral and Oak Woodlands
- 7. Central California Valley
- 8. Southern California Mountains
- 9. Eastern Cascade Slopes and Foothills
- 10. Columbia Plateau
- 11. Blue Mountains
- 12. Snake River Plain
- 13. Central Basin and Range
- 14. Mojave Basin and Range
- 15. Northern Rockies
- 16. Idaho Batholith
- 17. Middle Rockies
- 18. Wyoming Basin
- 19. Wasatch and Uinta Mountains
- 20. Colorado Plateau
- 21. Southern Rockies
- 22. Arizona/New Mexico Plateaus
- 23. Arizona/New Mexico Mountains
- 24. Chihuahuan Deserts
- 25. High Plains
- 26. Southwestern Tablelands
- 27. Central Great Plains
- 28. Flint Hills
- 29. Cross Timbers
- 30. Edwards Plateau
- 31. Southern Texas Plains
- 32. Texas Blackland Prairies
- 33. East Central Texas Plains
- 34. Western Gulf Coastal Plain
- 35. South Central Plains
- 36. Ouachita Mountains
- 37. Arkansas Valley
- 38. Boston Mountains
- 39. Ozark Highlands
- 40. Central Irregular Plains
- 41. Canadian Rockies
- 42. Northwestern Glaciated Plains
- 43. Northwestern Great Plains
- 44. Nebraska Sand Hills
- 45. Piedmont
- 46. Northern Glaciated Plains
- 47. Western Corn Belt Plains
- 48. Lake Agassiz Plain
- 49. Northern Minnesota Wetlands
- 50. Northern Lakes and Forests
- 51. North Central Hardwood Forests
- 52. Driftless Area
- 53. Southwestern Wisconsin Till Plains
- 54. Central Corn Belt Plains
- 55. Eastern Corn Belt Plains
- 56. Southern Michigan/Northern Indiana Drift Plains



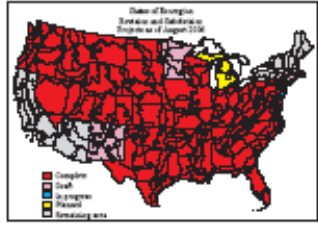
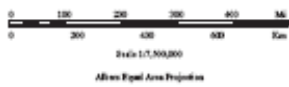
- 57. Huron/Erie Lake Plains
- 58. Northeastern Highlands
- 59. Northeastern Coastal Zone
- 60. Northern Appalachian Plateau and Uplands
- 61. Erie Drift Plain
- 62. North Central Appalachians
- 63. Middle Atlantic Coastal Plain
- 64. Northern Piedmont
- 65. Southeastern Plains
- 66. Blue Ridge
- 67. Ridge and Valley
- 68. Southwestern Appalachians
- 69. Central Appalachians
- 70. Western Allegheny Plateau
- 71. Interior Plateau
- 72. Interior River Valleys and Hills
- 73. Mississippi Alluvial Plain
- 74. Mississippi Valley Loess Plains
- 75. Southern Coastal Plain
- 76. Southern Florida Coastal Plain
- 77. North Carolinian
- 78. Klamath Mountains
- 79. Madras Archipelago
- 80. Northern Basin and Range
- 81. Sonoran Basin and Range
- 82. Laurentian Plains and Hills
- 83. Eastern Great Lakes and Hudson Lowlands
- 84. Atlantic Coastal Plain Interiors



- 100. Arctic Coastal Plain
- 101. Arctic Foothills
- 102. Brooks Range
- 103. Interior Forested Lowlands and Uplands

The ecoregions shown here have been derived from Omernik (1975) and have refinements of Omernik's system which have been made for other projects. These changes are mostly conceptual projects, consistent with the U.S. EPA regional, state, and resource management agencies, and with other federal agencies, and/or existing agencies, defining subregions, and listing sets of reference sites. Designed to serve as spatial baselines for environmental resource management, ecoregion boundaries are often subject to change (in type, quality, and number of environmental resources) as agencies evolve. The most immediate such revision is ongoing regional biological values and water quality standards and is an ongoing goal for improved water pollution.

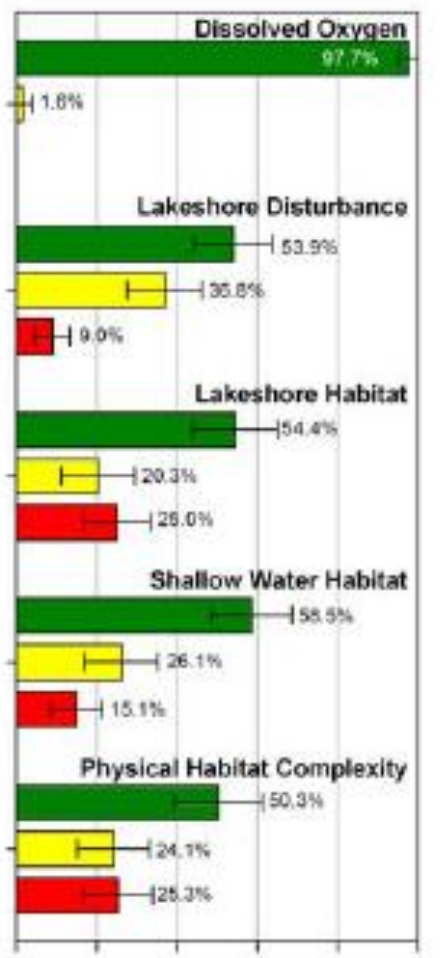
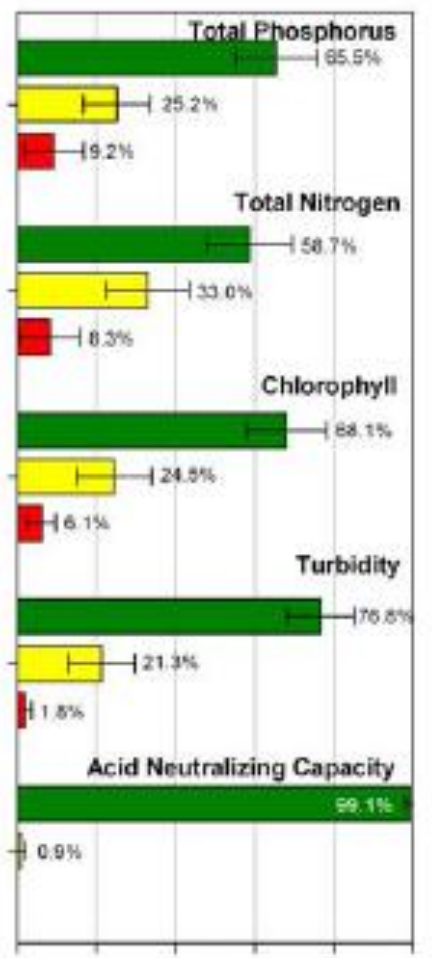
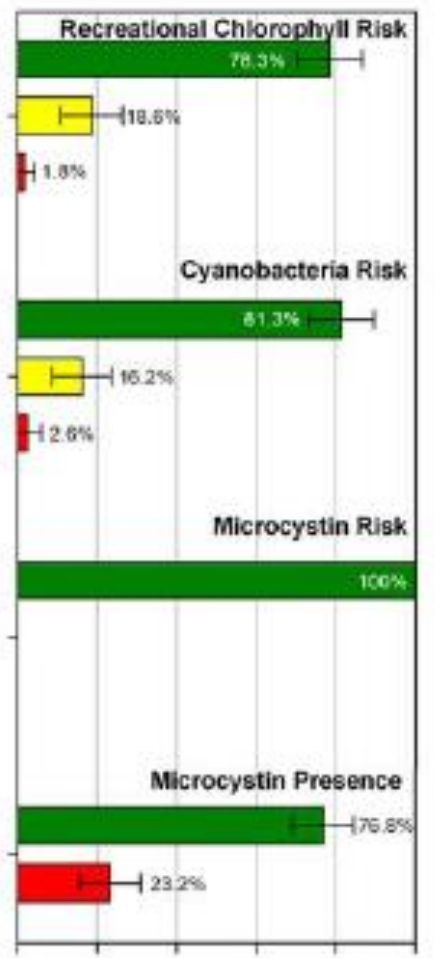
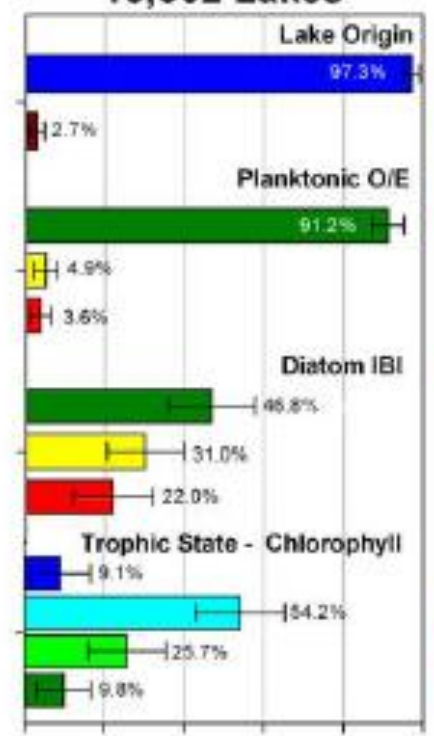
The approach used to map this map is based on the premise that ecoregions can be identified through the analysis of the patterns and the responses of biotic and abiotic phenomena that affect or reflect differences in resource quality and usage (Omernik 1987; Omernik 1989). These differences include geology, geomorphology, vegetation, climate, soils, land use, and hydrology. The relative importance of each characteristic varies from one ecoregion to another depending on the hierarchical level. Because of possible confusion with other meanings of terms for different levels of regional regions, a 30-year ecoregion classification scheme has been adopted for this effort. Level II is the coarsest level, consisting of 69 ecoregions; 11 ecoregions, where a Level II level is not defined, are subdivided into 111 ecoregions (Level III) in the Americas only.



Context is Critical



Upper Midwest 15,562 Lakes



Percentage of Lakes

For Lake Origin:
 Natural (Blue) Man-Made (Red)

For Plankton O/E
 < 20% Taxa Loss (Green) 20-40% Taxa Loss (Yellow) > 40% Taxa Loss (Red)

For Diatom IBI:
 Good (Green) Fair (Yellow) Poor (Red)

For Trophic State - Chlorophyll
 Oligotrophic (<= 2 ug/L) (Blue) Mesotrophic (>2-7 ug/L) (Cyan)
 Eutrophic (>7 to 30 ug/L) (Light Green) Hypereutrophic (> 30 ug/L) (Dark Green)

Percentage of Lakes

Low Risk (Green) Present (Red)
 Moderate Risk (Yellow) Absent (Green)
 High Risk (Red)

Percentage of Lakes

Good (Green)
 Fair (Yellow)
 Poor (Red)

Percentage of Lakes

Good (Green)
 Fair (Yellow)
 Poor (Red)

Wisconsin's Ecoregions



Northern Lakes and Forests

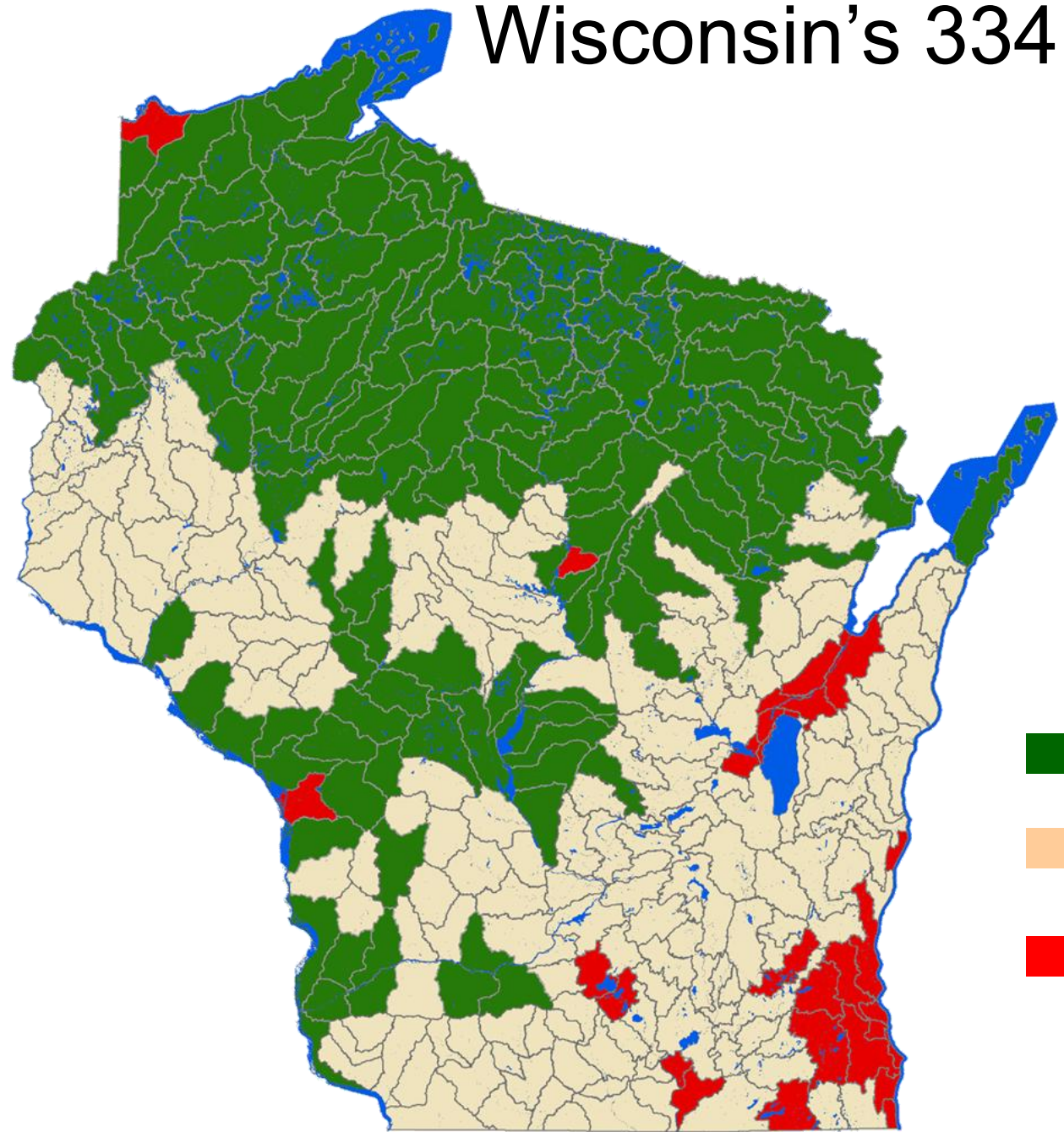
North Central Hardwood Forests




Driftless

**Southeastern
Till Plains**

Omernik, J.M. 1987.
Ecoregions of the
conterminous United
States.

Wisconsin's 334 Watersheds

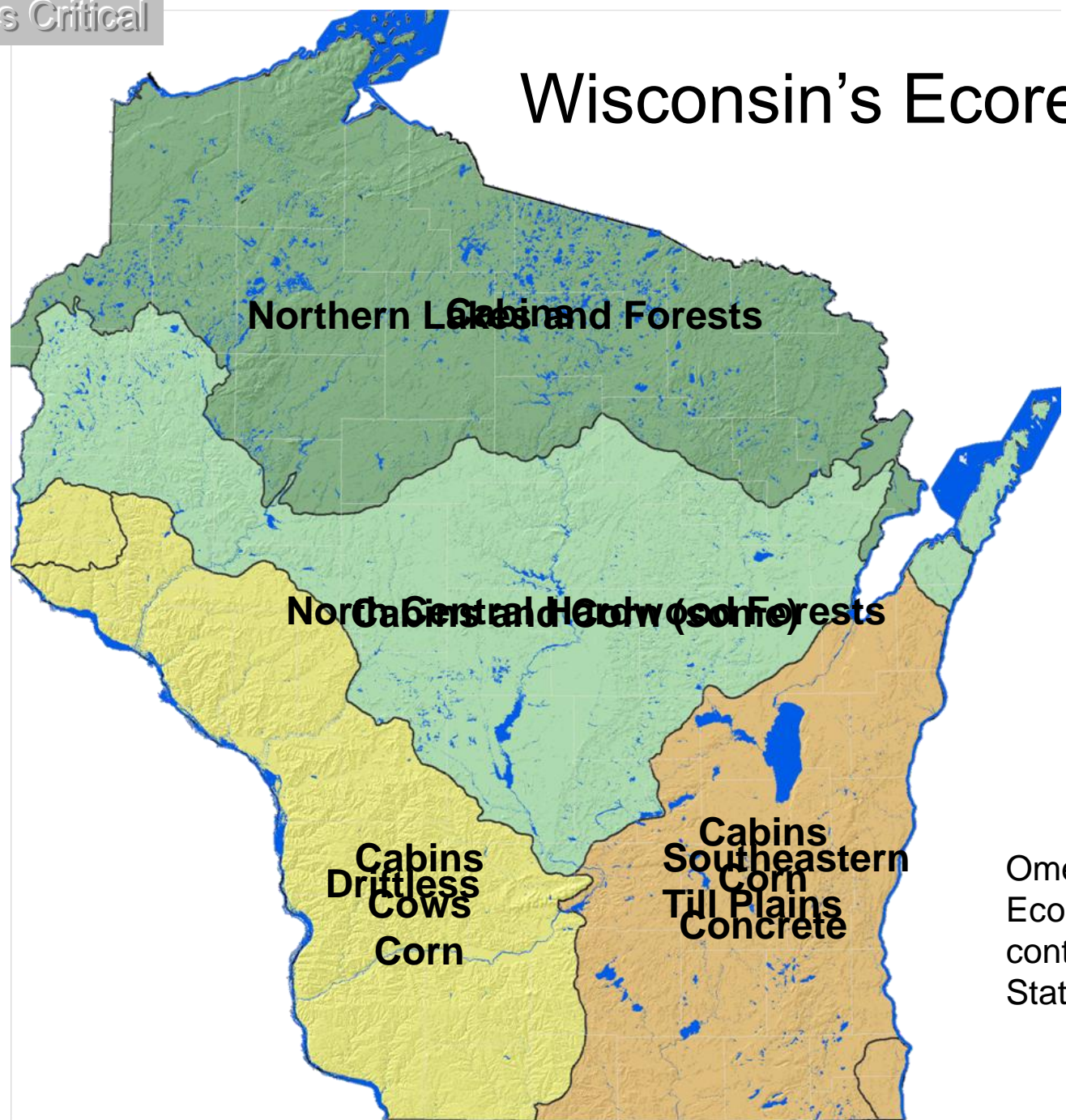


-  Forested, < 8% Urban and < 50 % Agriculture
-  Agriculture, > 50 Ag.
-  Urban, > 8% Urban.

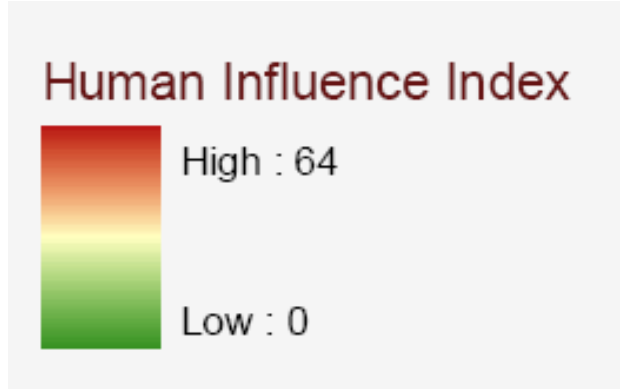
A 3-dimensional view of population density, 1990.



Wisconsin's Ecoregions

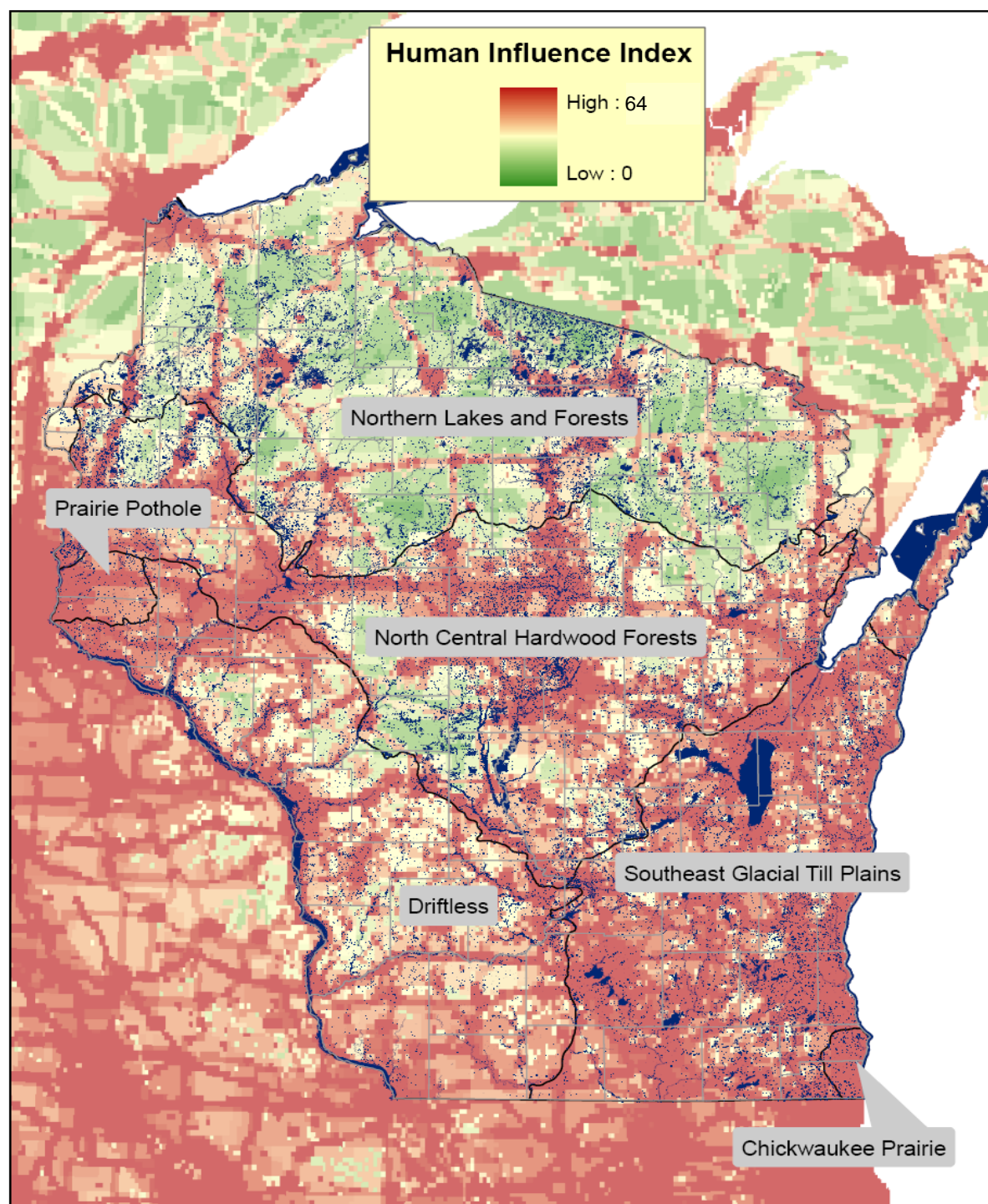


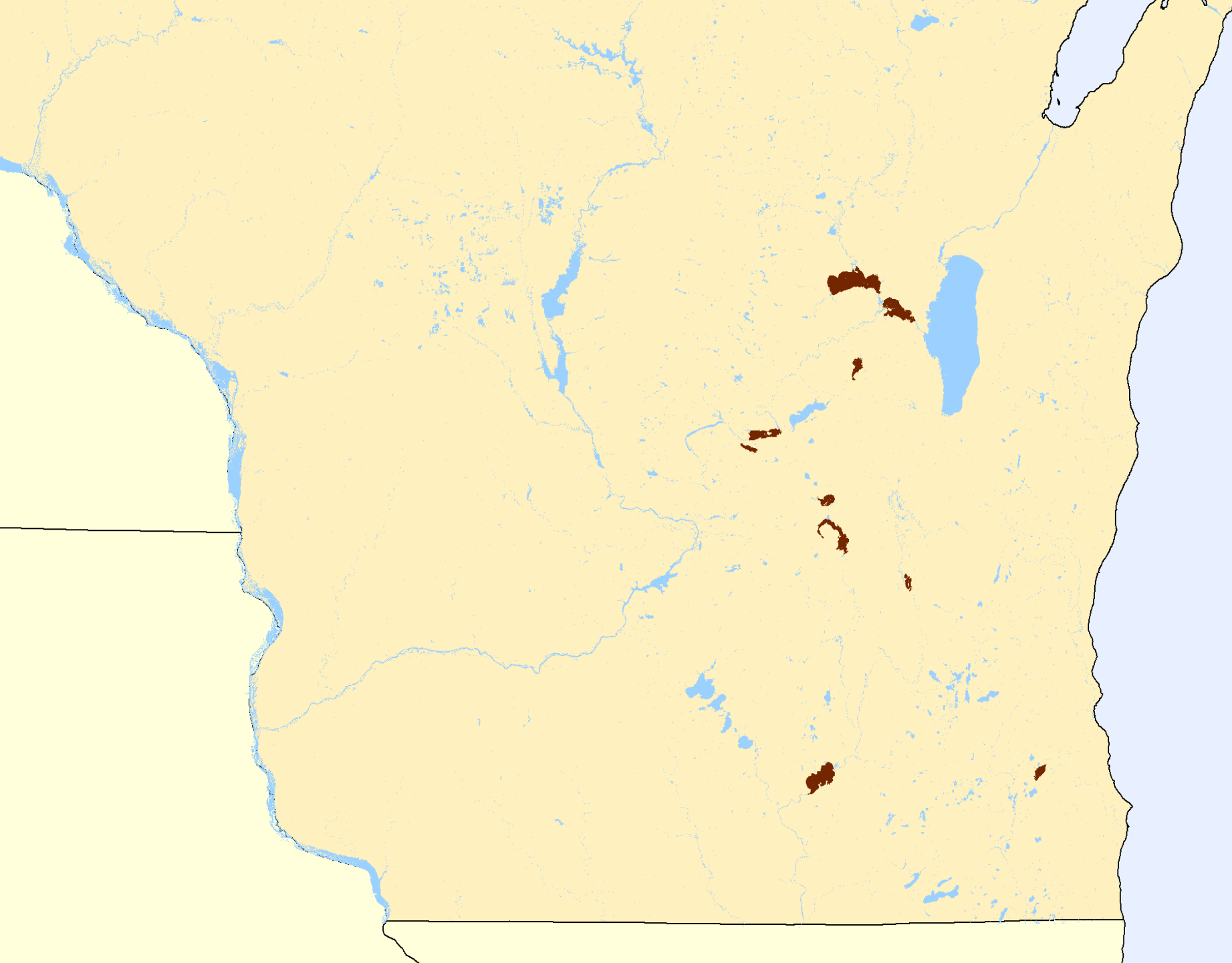
Omernik, J.M. 1987. Ecoregions of the conterminous United States.



The Human Influence Index

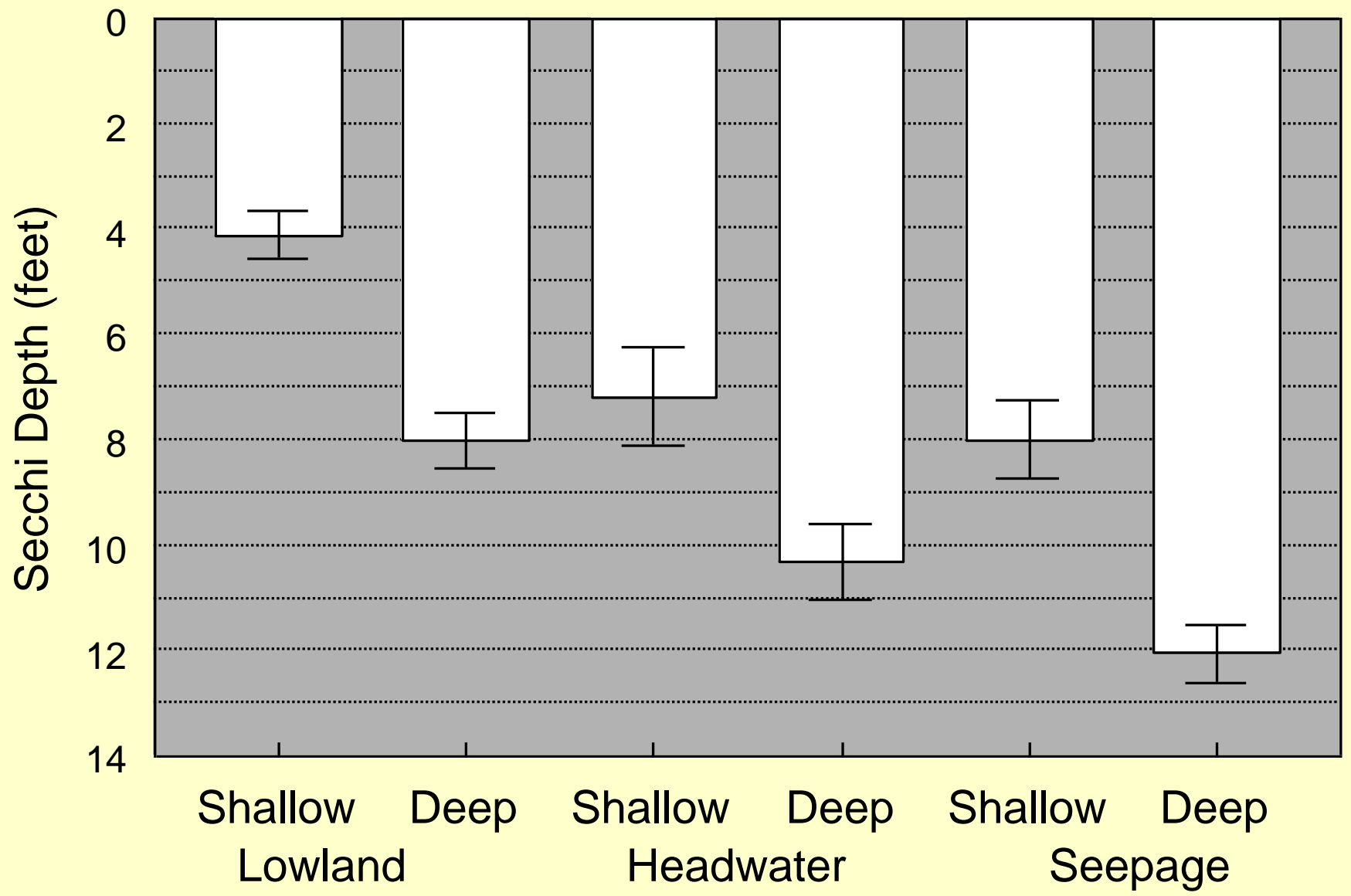
The Human Influence Index (HII) is a measure of direct human influence on terrestrial ecosystems using the best available data sets on human settlement (population density, built-up areas), access (roads, railroads, navigable rivers, coastline), landscape transformation (land use/land cover) and electric power infrastructure (nighttime lights). HII values range from 0 to 64. Zero value represents no human influence and 64 represents maximum human influence possible using all 8 measures of human presence.





Summer Secchi Depth

Mean and 95% Confidence Interval (n=920)

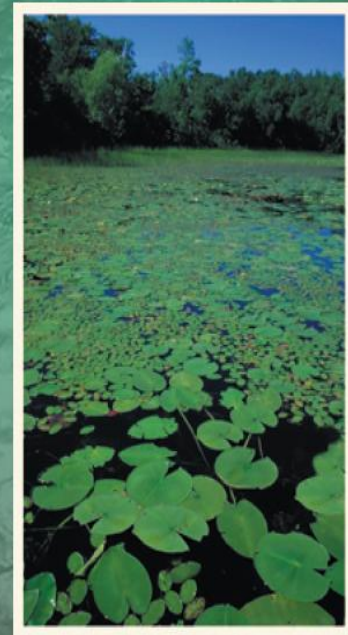


Shallow Lakes



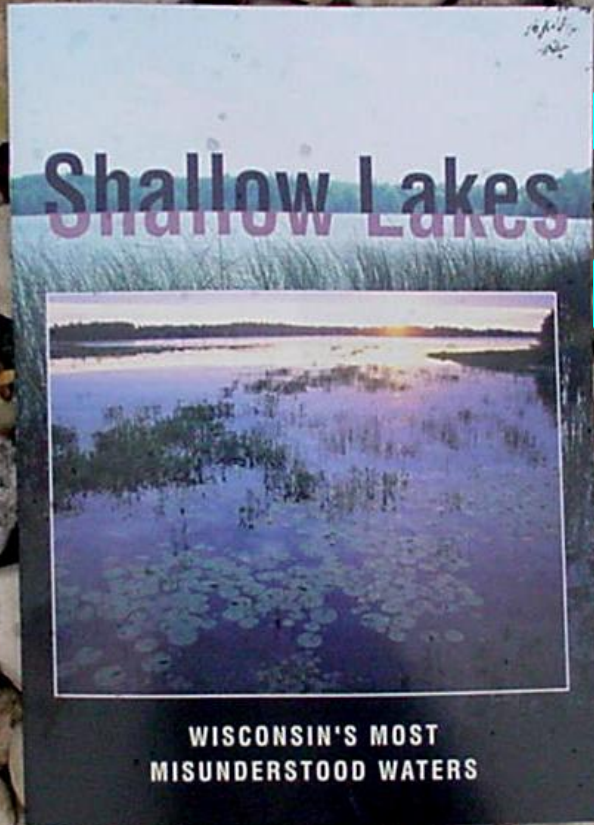
WISCONSIN'S MOST
MISUNDERSTOOD WATERS

SHALLOW LAKES



HOPE FOR MINNESOTA'S TROUBLED WATERS

SHALLOW LAKE : NON-STRATIFIED, < 7 m DEEP, > 4 ha



✓ > One third of WI lake acres, > 300k ac

✓ WI's largest , Winnebago @ 137,708 ac

✓ Large littoral zone area(>50%criteria)

✓ Aquatic plants = Heart of ecosystem

✓ Exist in turbid or clear water state

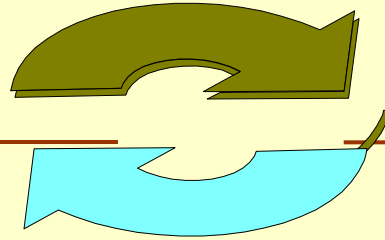
✓ Water column stays mixed

✓ User expectations often unrealistic

Stable States in Shallow Lakes

Clear State

- clear water
- low algal biomass
- high macrophyte biomass
- Piscivores dominate



Turbid State

- murky water
- high algal biomass
- sparse macrophytes
- Planktivores/benthivores dominate

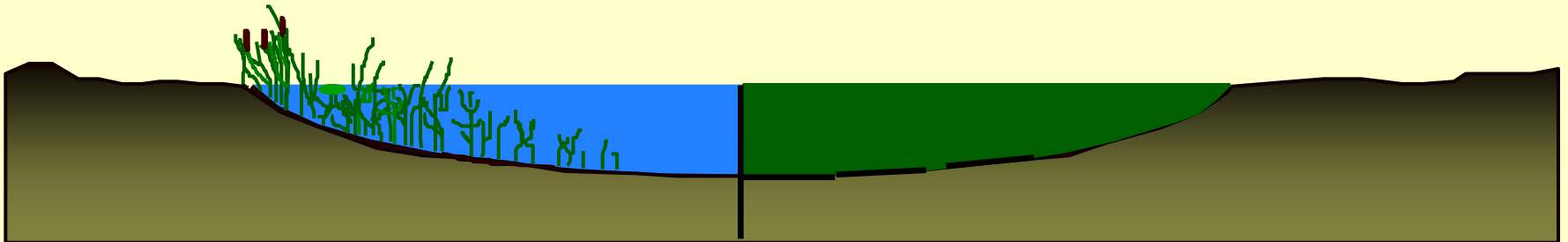




Photo Courtesy of MNDNR



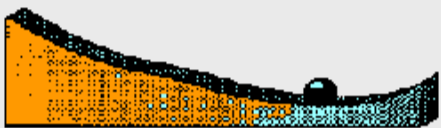
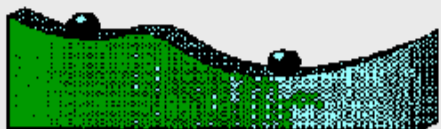
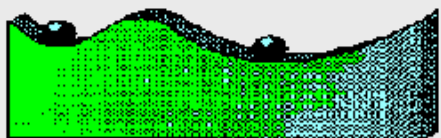
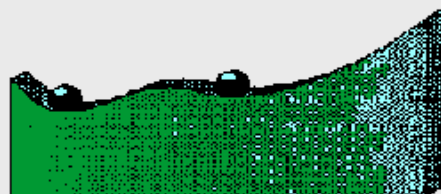
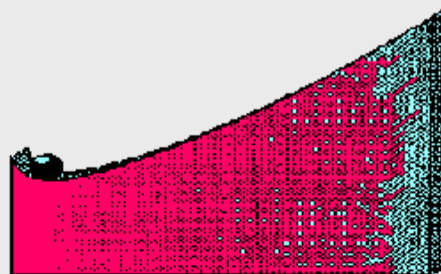
Shallow Lake Ecology

(From Scheffer et al. 1993)

**NUTRIENT
POOR**



**NUTRIENT
RICH**



CLEAR

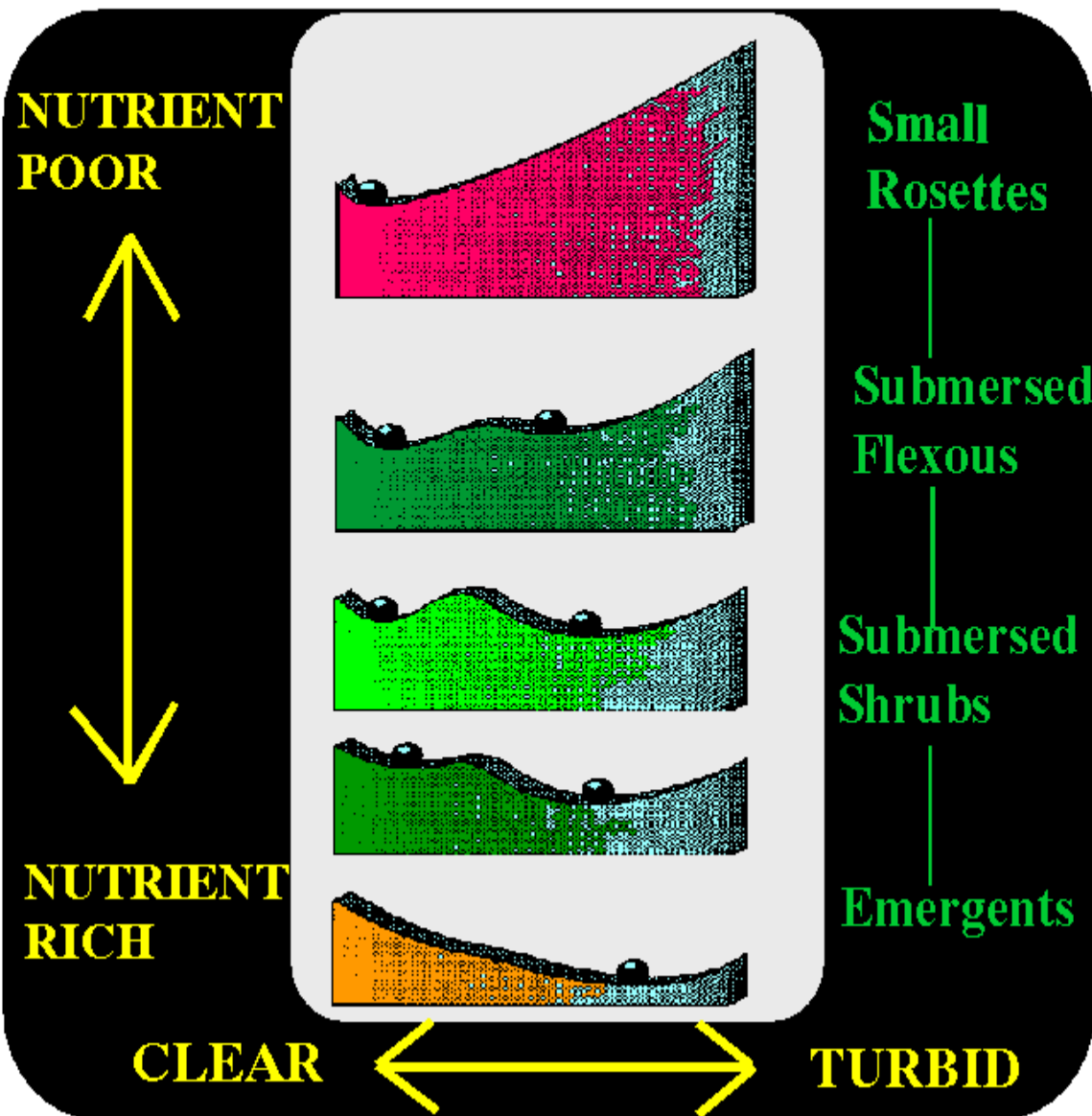


TURBID

Shallow Lake Ecology

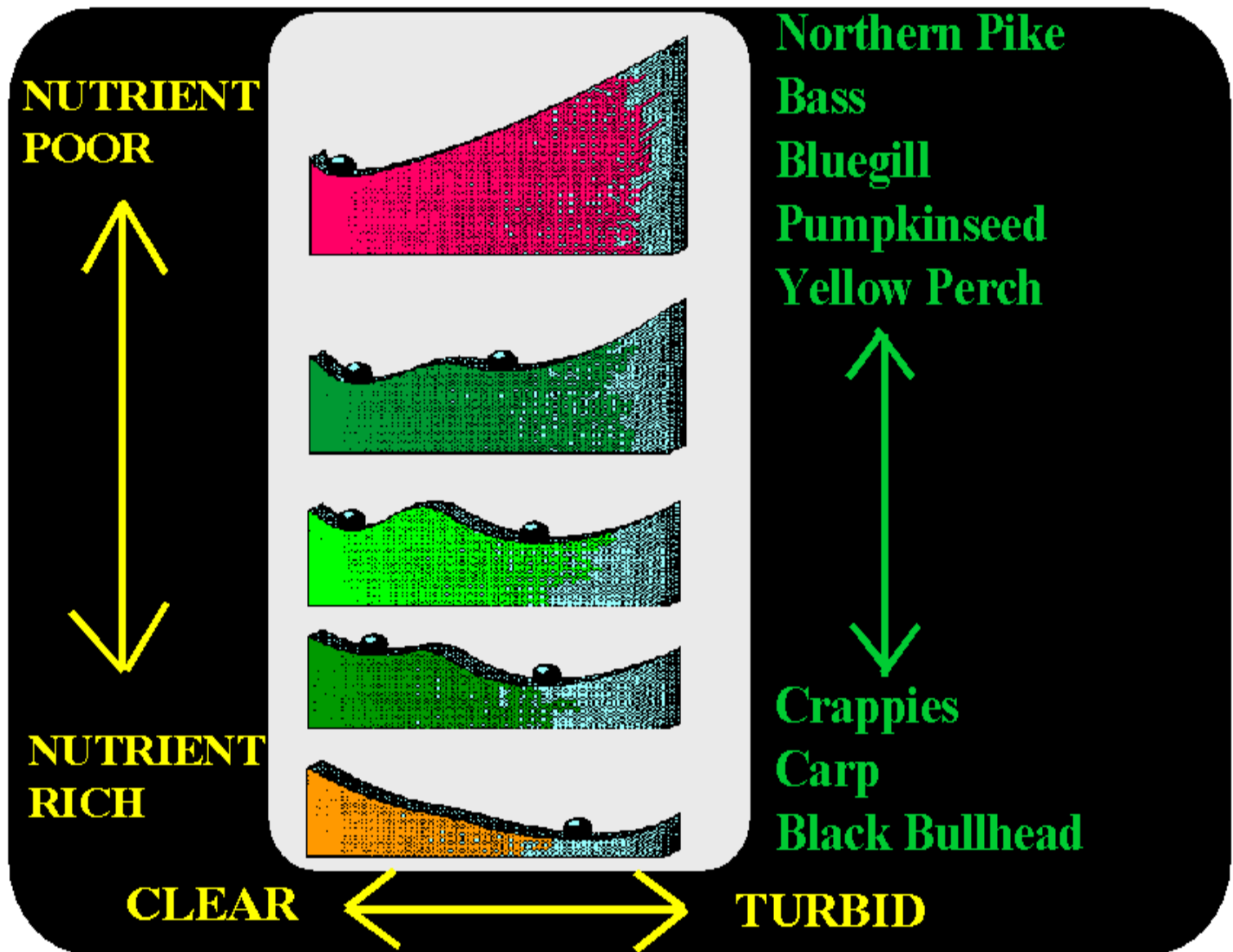
(From Scheffer et al. 1993)

Plants



Shallow Lake Ecology

(From Scheffer et al. 1993)



Thresholds



Bioturbation





Photo: Mike DeVries, The Capital Times, 5 July 2007

Total phosphorus concentration (micrograms per litre)

25

50

100

1000

Alternative states of plant or plankton dominance

Clear water
Unique
dominance
by plants

Clear water, dominance by taller plants, stabilised by buffers

Clear water with
sparser plants

PLAN

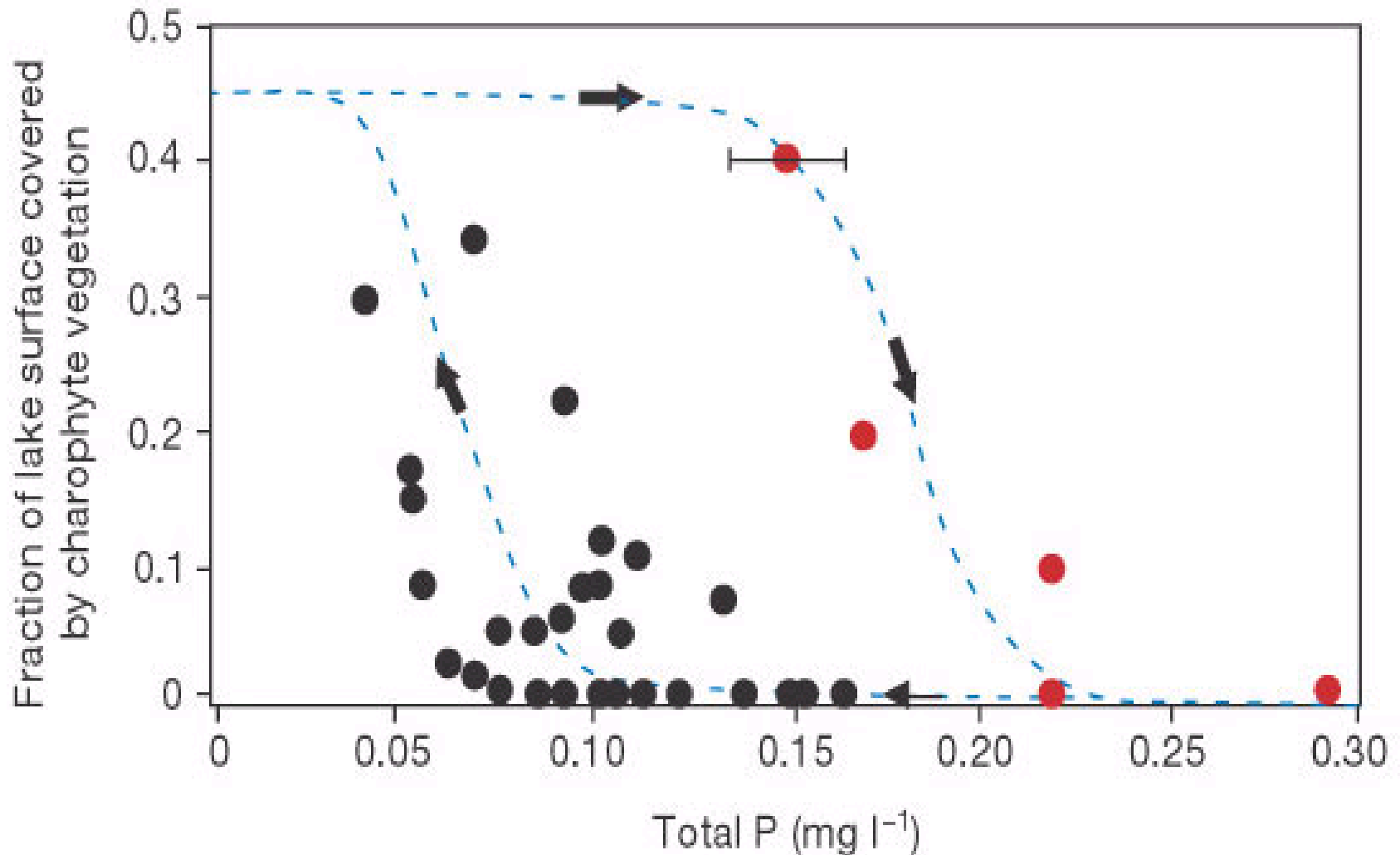
FORWARD SWITCHES

Mechanical cutting.
Boat damage.
Herbicide use or accidental runoff.
Heavy grazing by high density of native or introduced species.
Raising of the water level to place plants at lower light intensities.

Turbid water, dominance

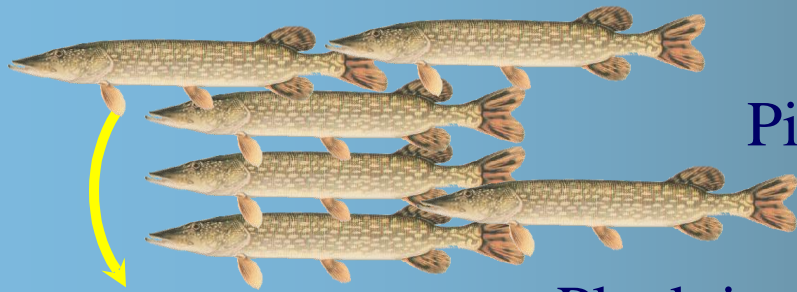
PHYTOPLANKTON

- Destruction of zooplankton activity by pesticides or toxins.
- Reduction of piscivorous fish to zooplanktivorous fish ratio by deoxygenation in summer/winterkill.
- Overfishing of large fish so that small size classes are favoured.



Hysteresis in the response of charophyte vegetation in the shallow Lake Veluwe to increase and subsequent decrease of the phosphorus concentration. Red dots represent years of the forward switch in the late 1960s and early 1970s. Black dots show the effect of gradual reduction of the nutrient loading leading eventually to the backward switch in the 1990s.

Clear-water State



Piscivores



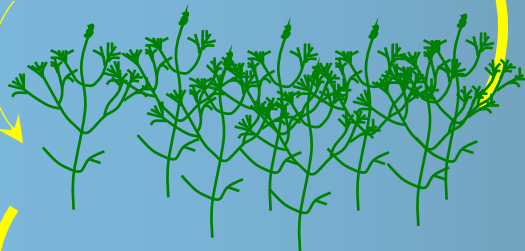
Planktivores/Benthivores



Zooplankton grazing



Algae biomass

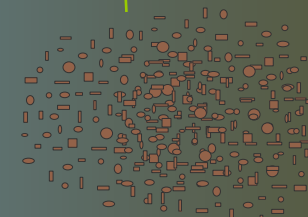
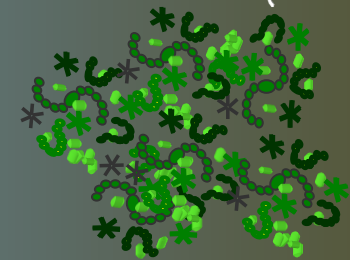


Aquatic plant biomass



Sediment Resuspension

Turbid-water State



Biomaniipulation

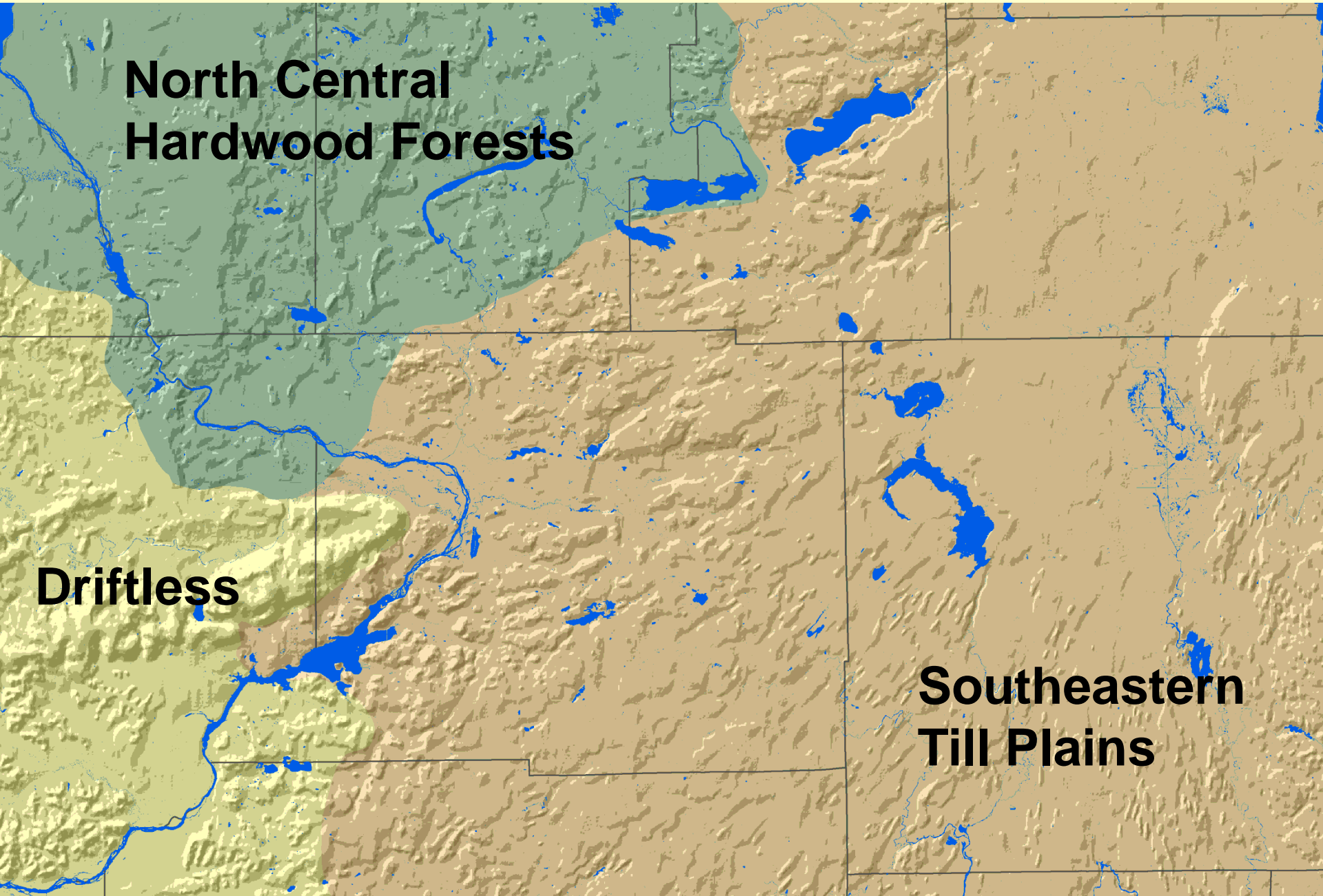


Cladocerans, or water fleas “vacuum” the algae from lake water. When they are abundant, the water is more clear.

If conditions are unfavorable, i.e. zooplanktivorous fish like bluegill are abundant, refuge absent, the lake water remains turbid from algae.



Park Lake as an Example



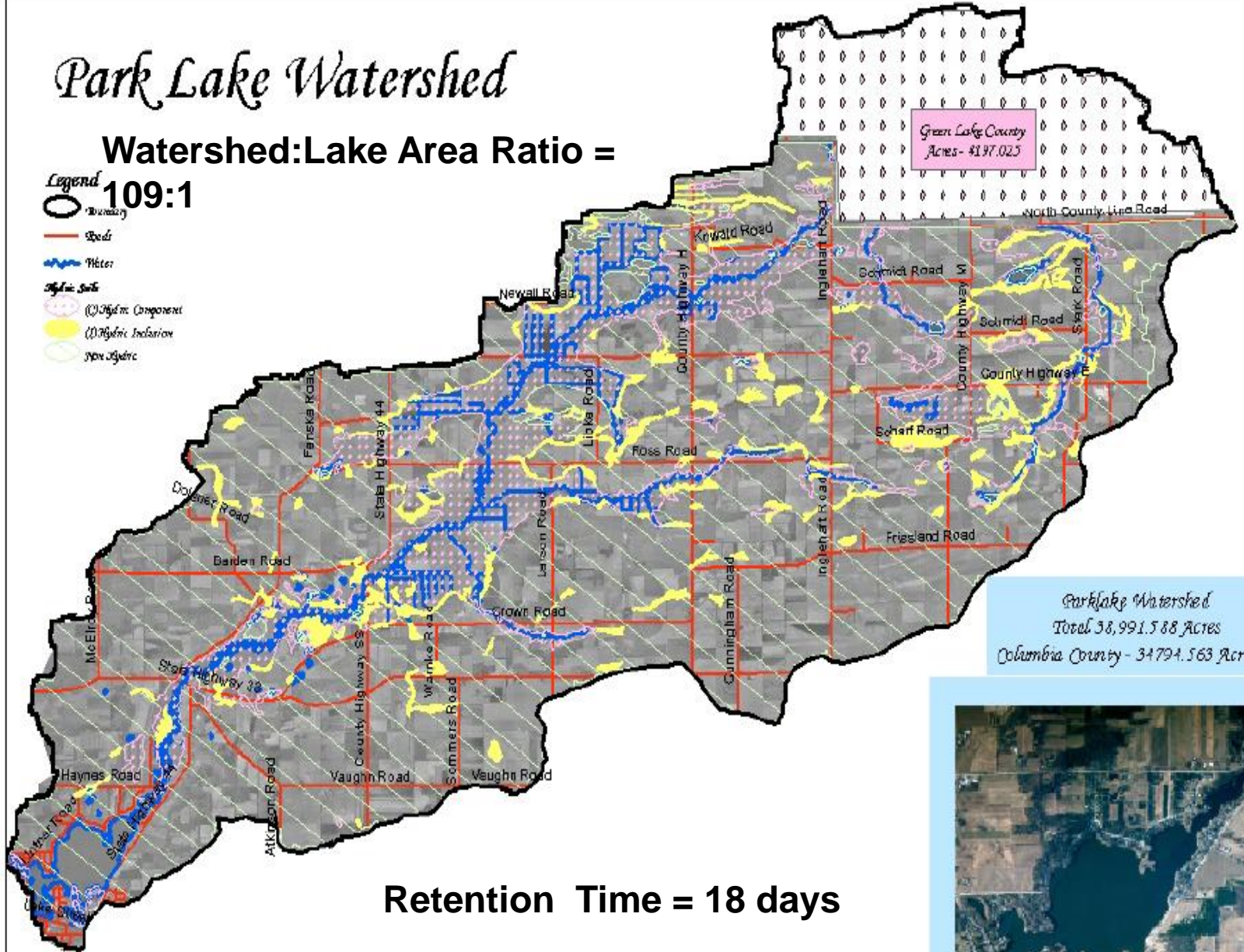
Park Lake Watershed

Watershed:Lake Area Ratio =

109:1

Legend

-  Boundary
-  Road
-  Water
- Hydroic Soils**
-  (C)Hydroic Component
-  (I)Hydroic Inclusion
-  Non Hydroic



Park Lake Watershed
 Total 38,991.588 Acres
 Columbia County - 34,794.563 Acres

Retention Time = 18 days



Map created by: Greg Johnson
 Columbia County and Water Conservation Department
 Scott Collins, Director
 2002 Digital Ortho provided by
 Land Information Department
 Kristen Anderson, Director

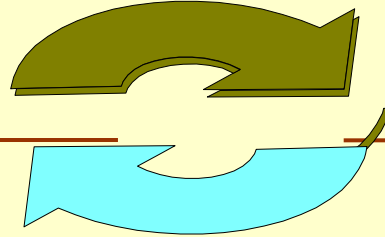


Park Lake as an Example

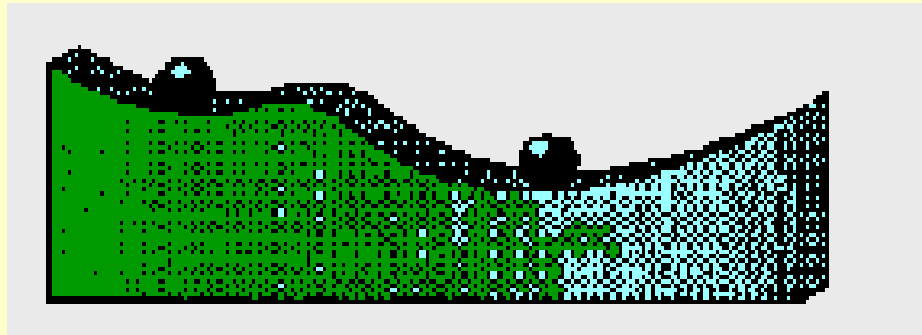
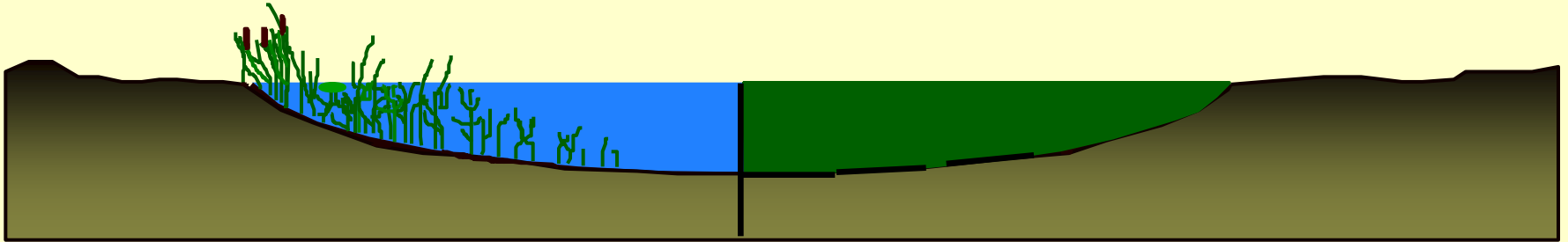


Park Lake

Clear State



Turbid State



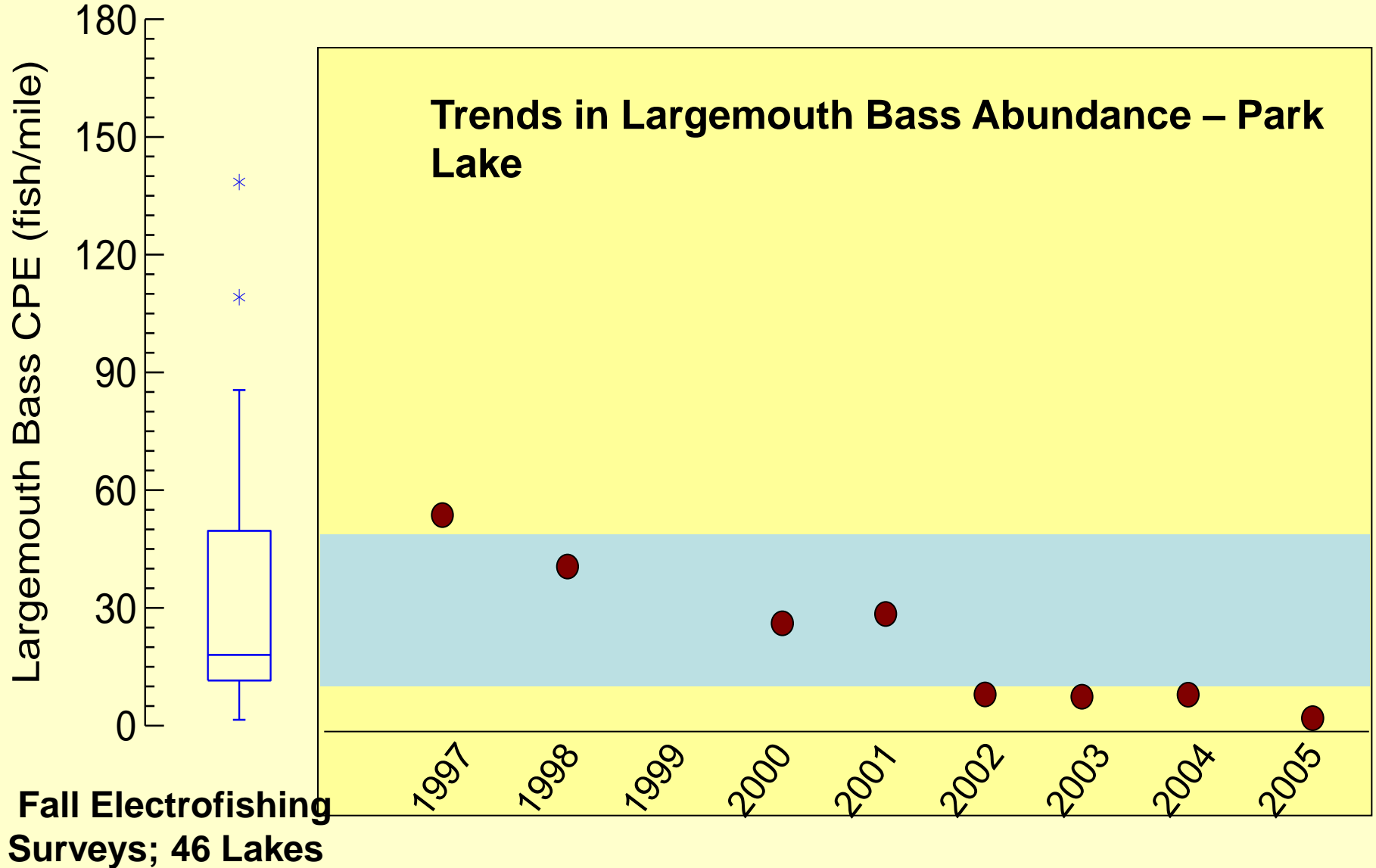
1978, SAV= 11 species

2001, SAV=2 species

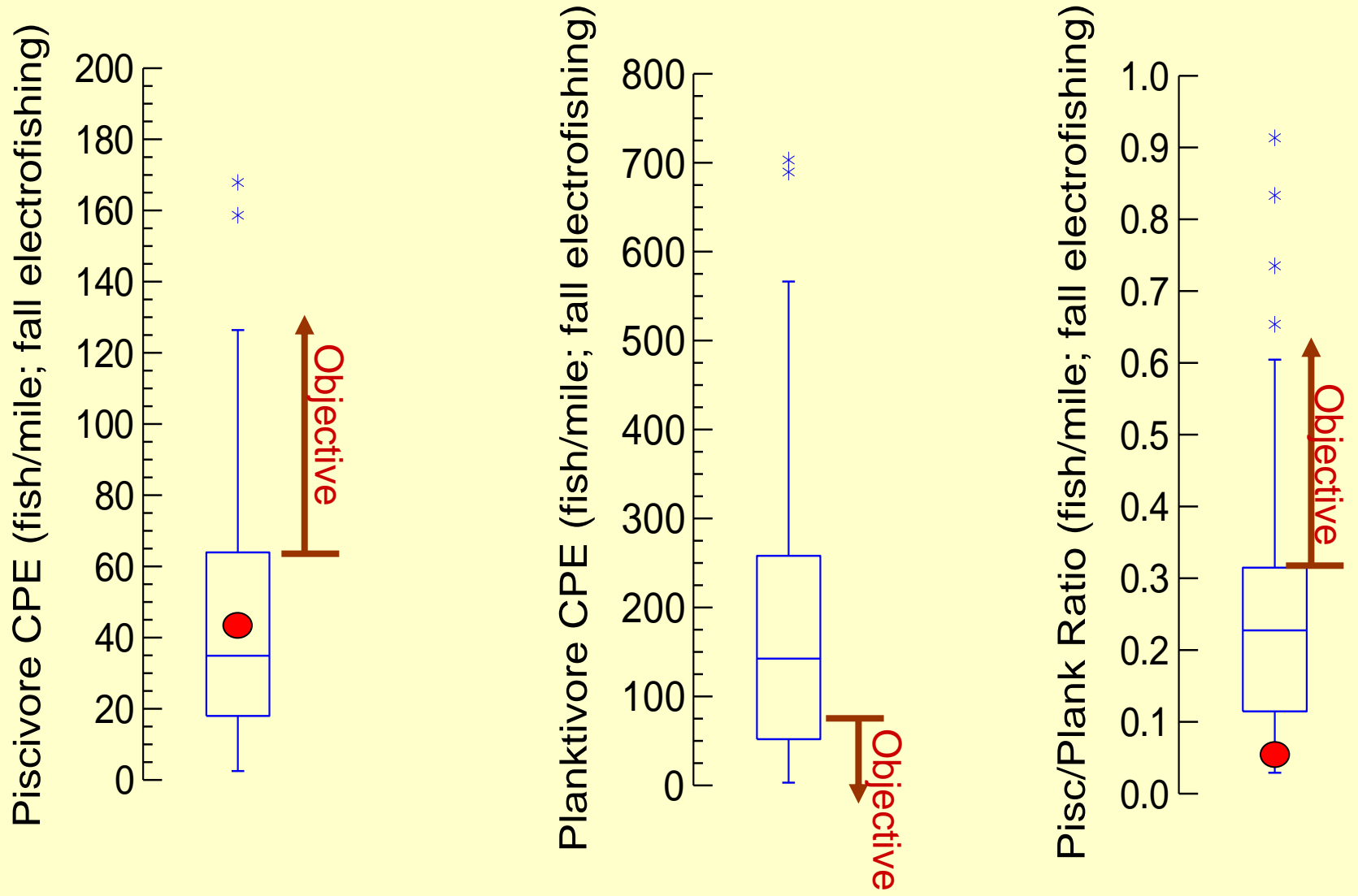
1998, SAV=10 species

Fish Community: Assessment by Analogy

Inter-quartile ranges are benchmarks for quick evaluations of survey data. Catch rates within the inter-quartiles = **normal** for Class 3 lakes. Catch rates outside the inter-quartiles = **unusual**.

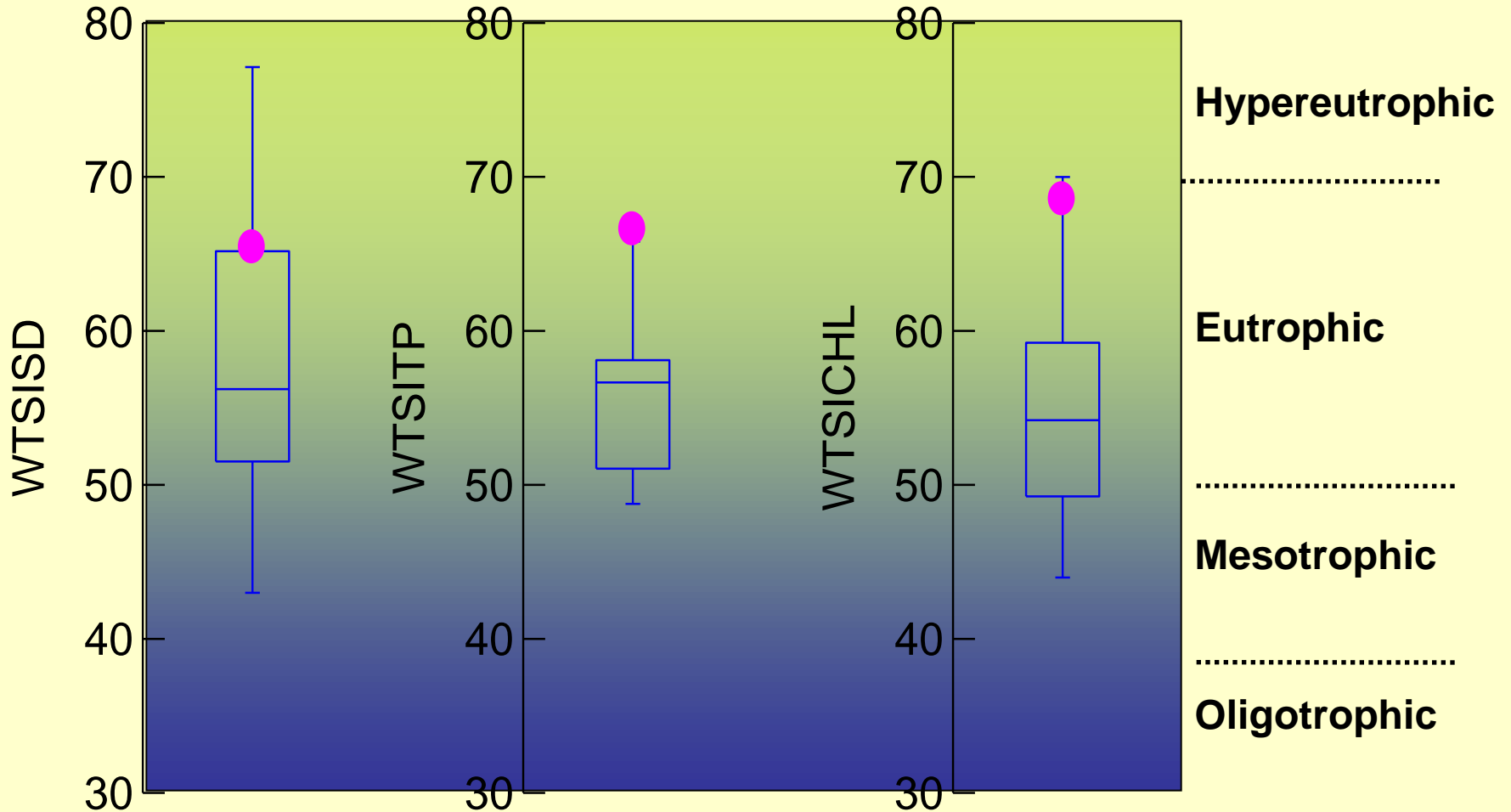


Fish Community Objectives: Biomanipulation of Park Lake



● = Park Lake's Current Condition

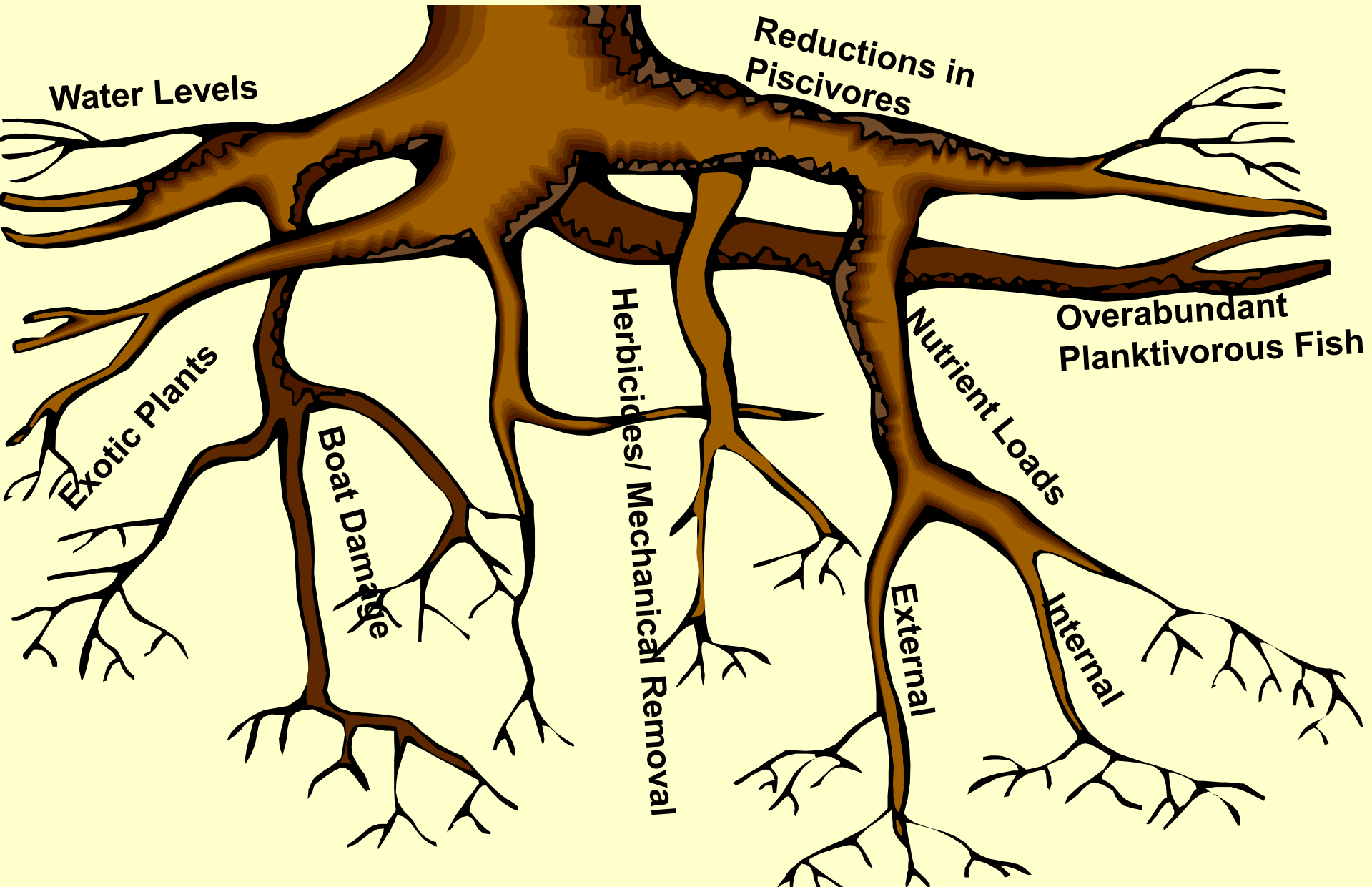
Example: Trophic State Indices



Box plots: Shallow lowland drainage lakes in Southern Wisconsin

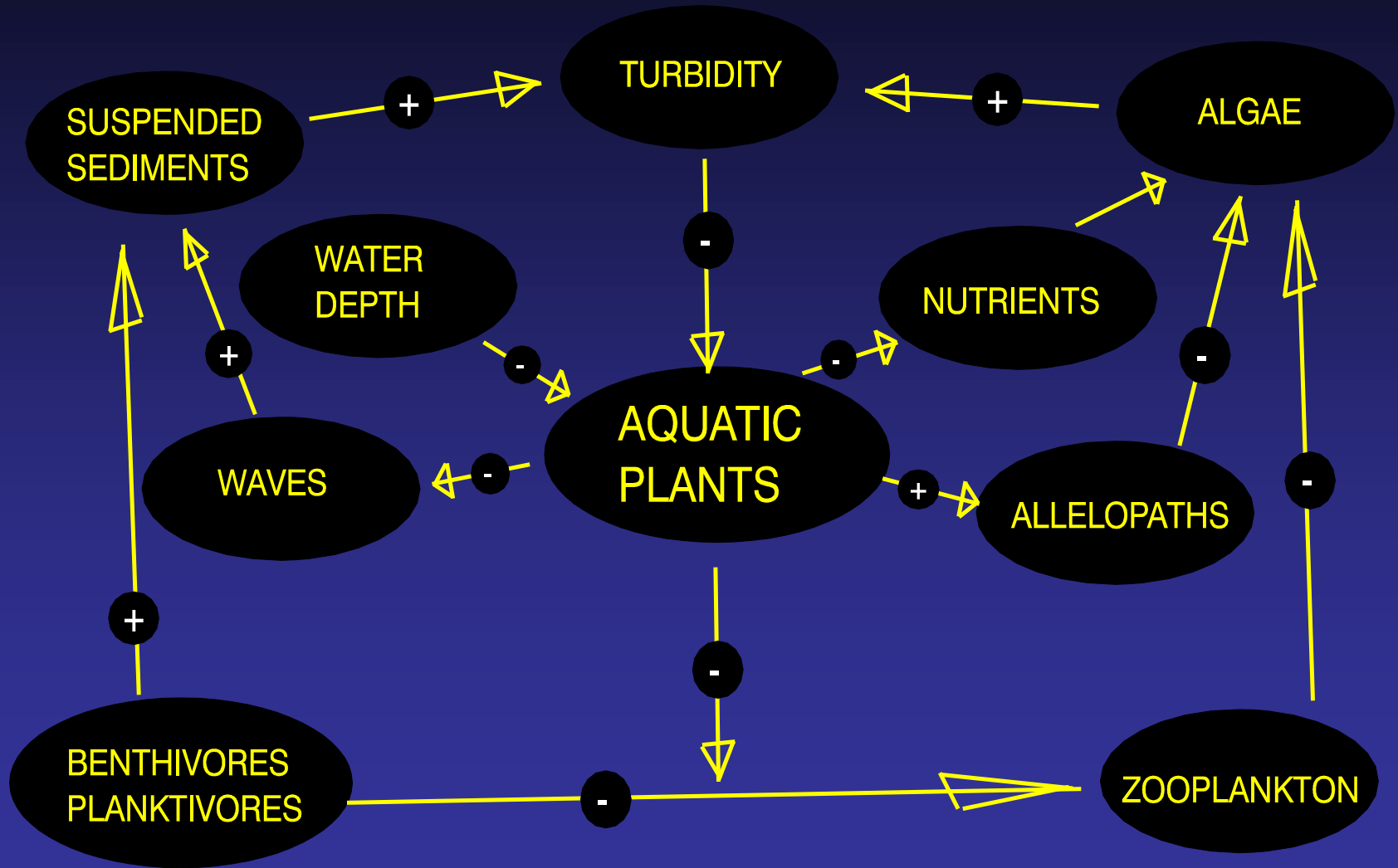
● 2001-2004 (mean) Park Lake TSI values (summer)

What is the root problem/cause of Park Lake's Degradation?



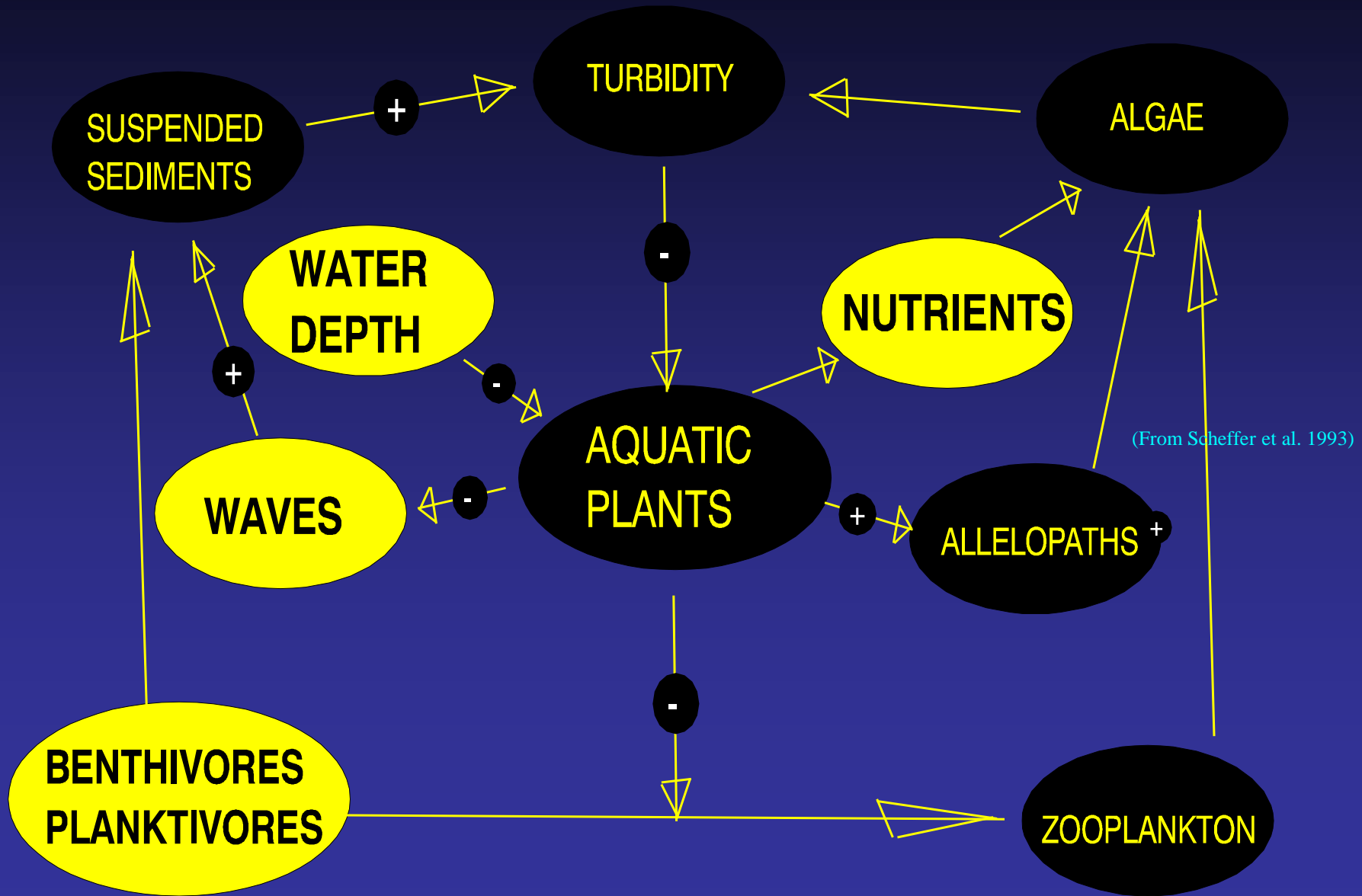
Shallow Lake Ecosystems

A Conceptual Model (From Scheffer et al. 1993)



Shallow Lake Ecosystems

A Conceptual Model



Management Tools

**BENTHIVORES
PLANKTIVORES**

**WATER
DEPTH**

WAVES

NUTRIENTS



Management Tools

**BENTHIVORES
PLANKTIVORES**



**SPOT TREATMENTS
CHEMICAL RECLAMATION
COMMERCIAL HARVEST
STOCK PISCIVORES
PROTECT PISCIVORES**

Biomanipulation



(Commissioner Philo Hoy,
1876)

“When you can go with hook and line and bag ten pound specimens of that most desirable fish, the carp, then you will feel like thanking the men who have so persistently persevered in investigating every condition that can secure benefits so great.”

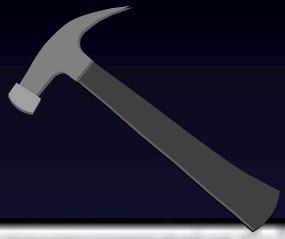


(General Edwin E. Bryant, President of the Wisconsin Fisheries Commission, 1901)

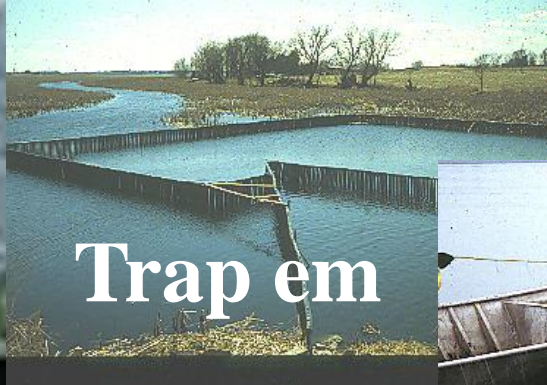
“ The greatest trouble we have in some of our lakes in Wisconsin is that the carp have got in there. I do not know of a fisherman in Wisconsin that would catch one if he could, and I never heard of one being eaten either by anybody in the circle of my acquaintance... Within a radius of five miles of Madison there are billions of carp. Every fisherman sees them, curses them, and refuses to catch them. ”

“Advances” in Fisheries Management





Hammering Carp



Contract Removal

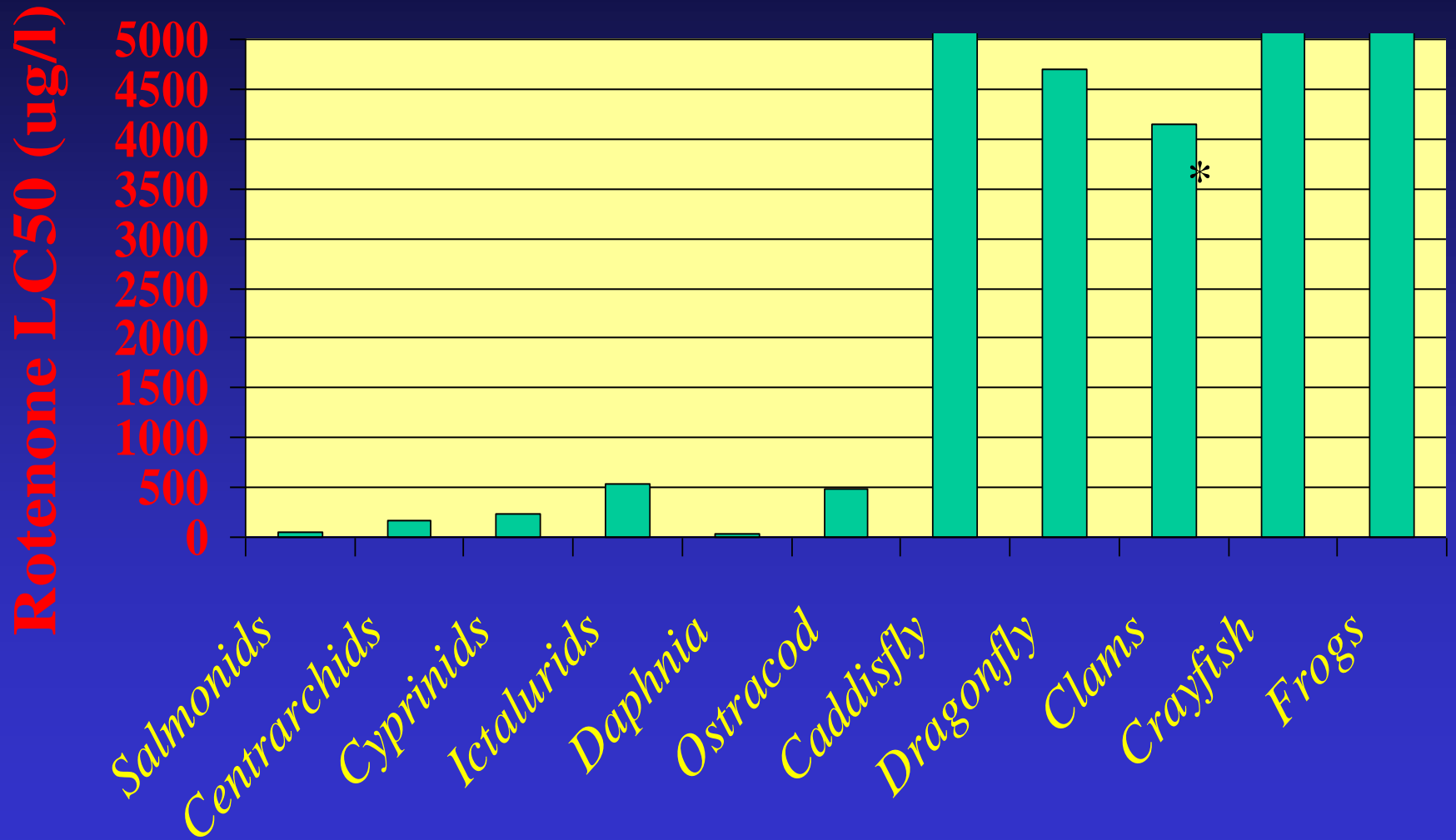


Rotenone



Toxicity of Rotenone

Laboratory Tests; 24 hr LC₅₀



* 96 hour LC₅₀

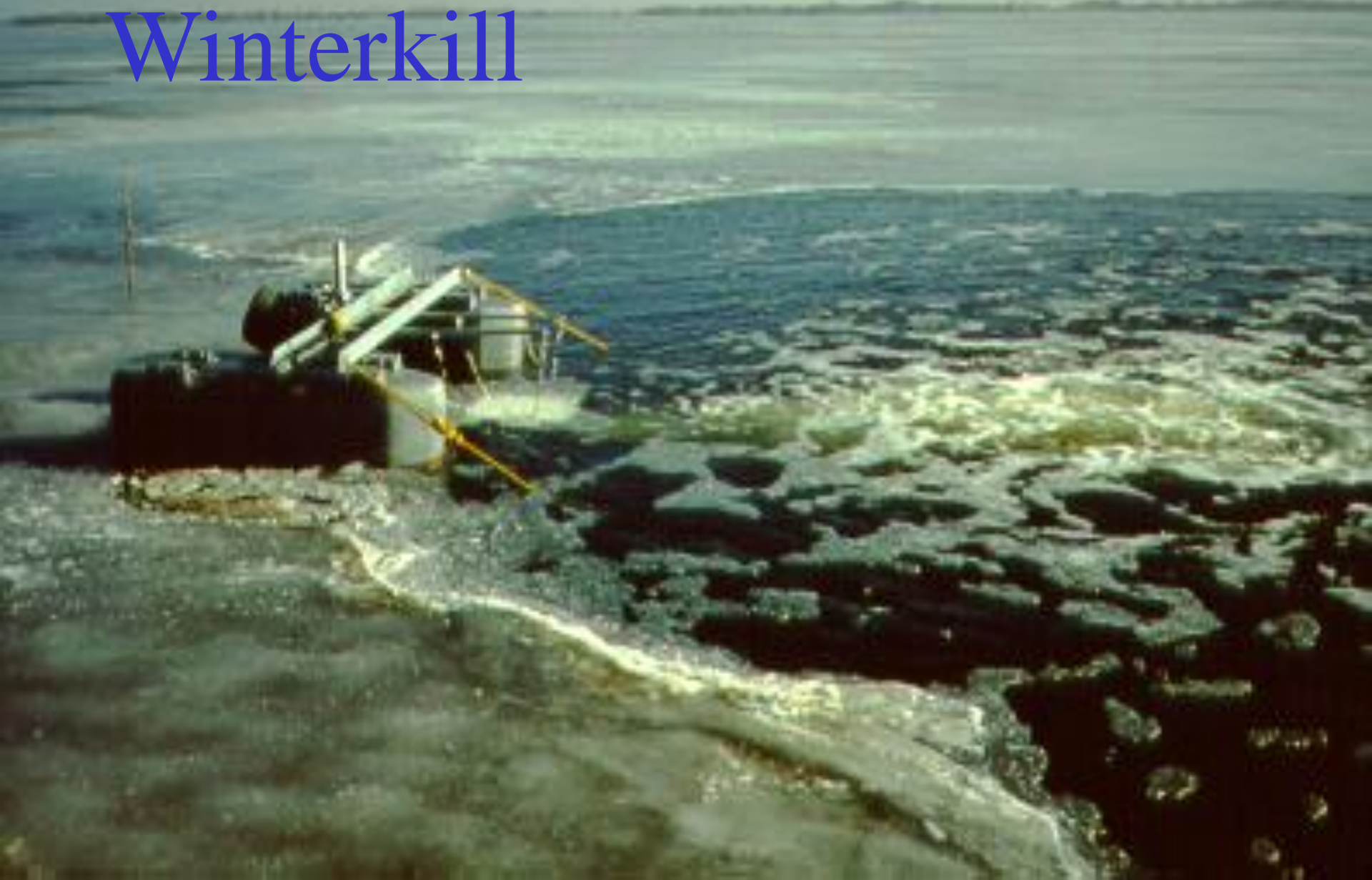
Fry Stocking



Fry Stocking



Aeration to Prevent Winterkill



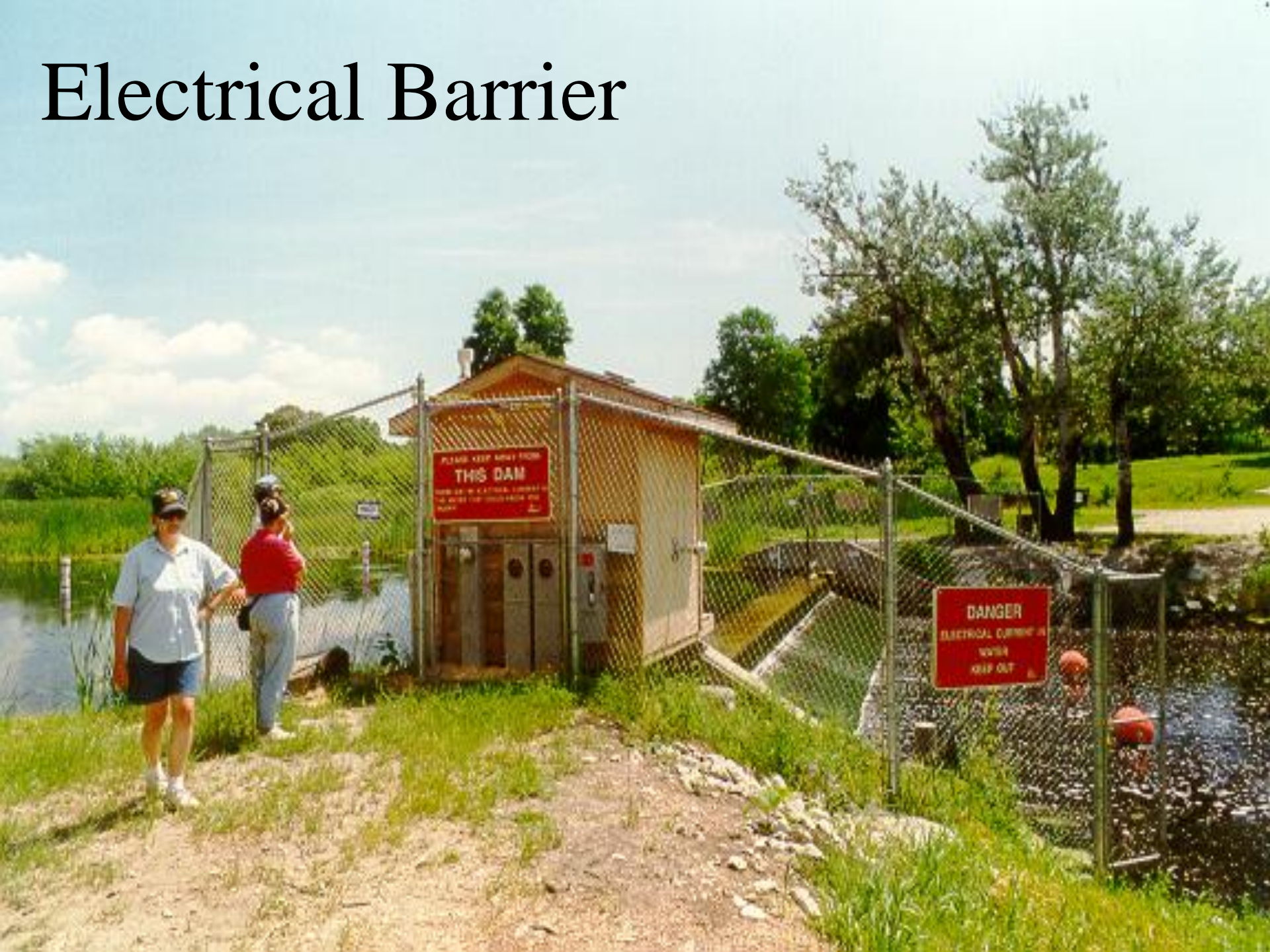
Aeration - Refuge Area





Physical

Electrical Barrier



Management Tools

**BENTHIVORES
PLANKTIVORES**



**PROTECT PISCIVORES
STOCK PISCIVORES
COMMERCIAL HARVEST
CHEMICAL RECLAMATION
SPOT TREATMENTS**

**WATER
DEPTH**



**LONG-TERM LEVELS
DRAWDOWN**

WAVES



NUTRIENTS



HIGH WATER LEVELS DESTROY HABITAT

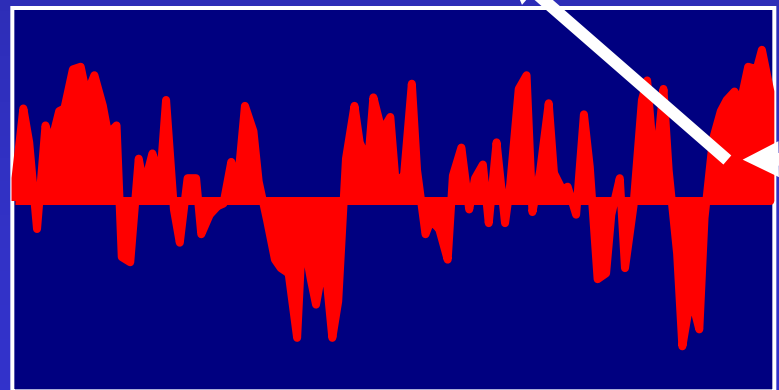
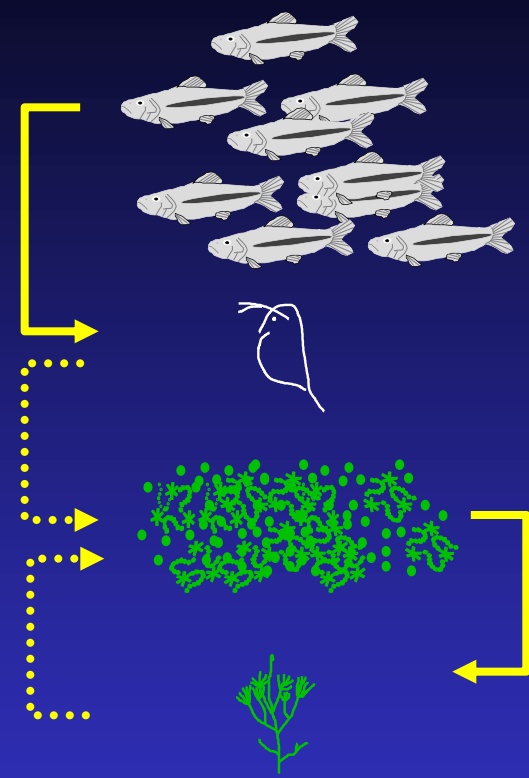
NOW



Clear-water state



Turbid-water state



Increased water depth

Management Tools

**BENTHIVORES
PLANKTIVORES**

**PROTECT PISCIVORES
STOCK PISCIVORES
COMMERCIAL HARVEST
CHEMICAL RECLAMATION
SPOT TREATMENTS**

**WATER
DEPTH**

**DRAWDOWN
LONG-TERM LEVELS**

WAVES

**TEMPORARY BREAKWATERS
BARRIER ISLANDS
BOATING RESTRICTIONS**

NUTRIENTS

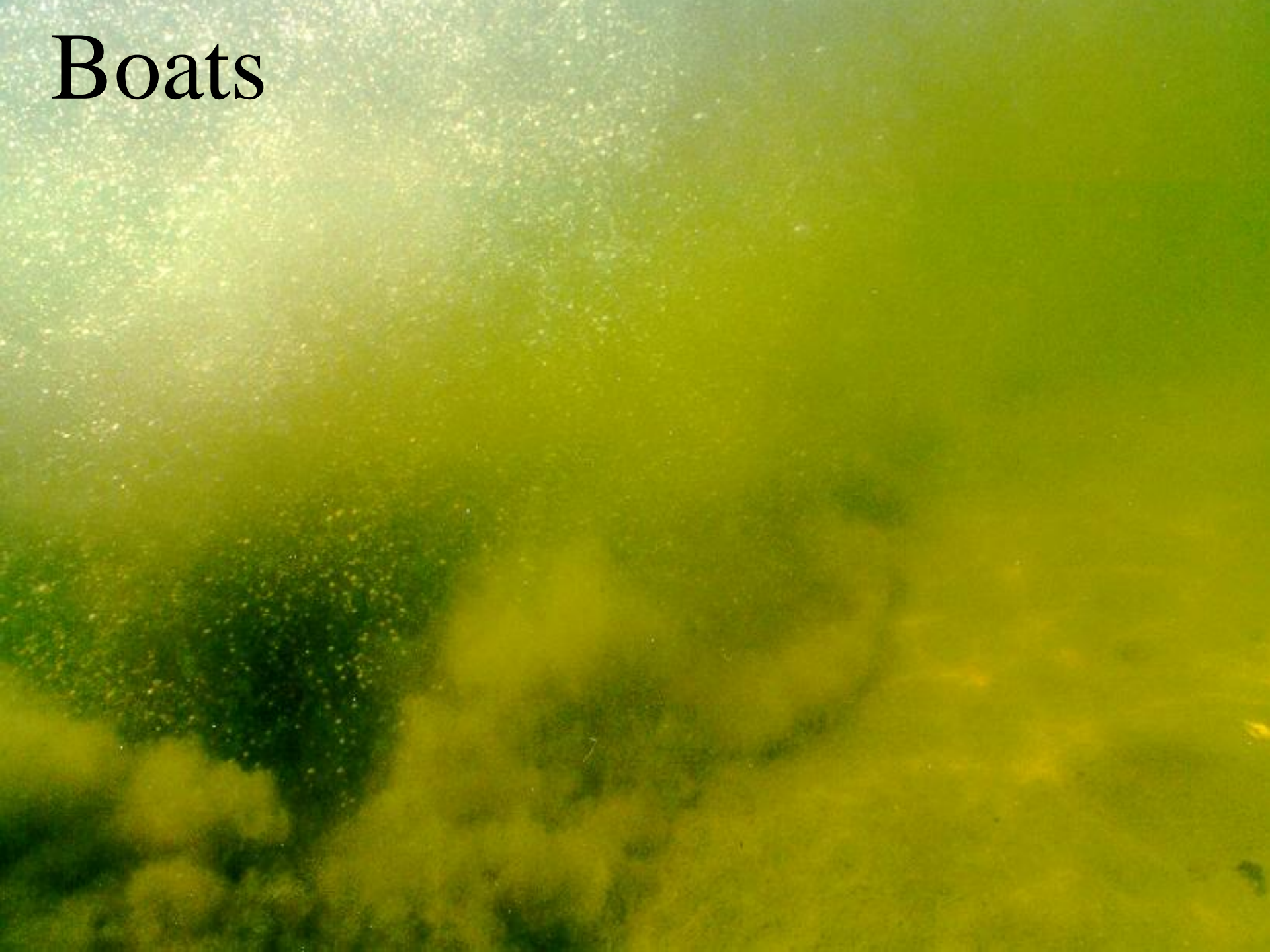
Boats





IF MOM ONLY KNEW

Boats

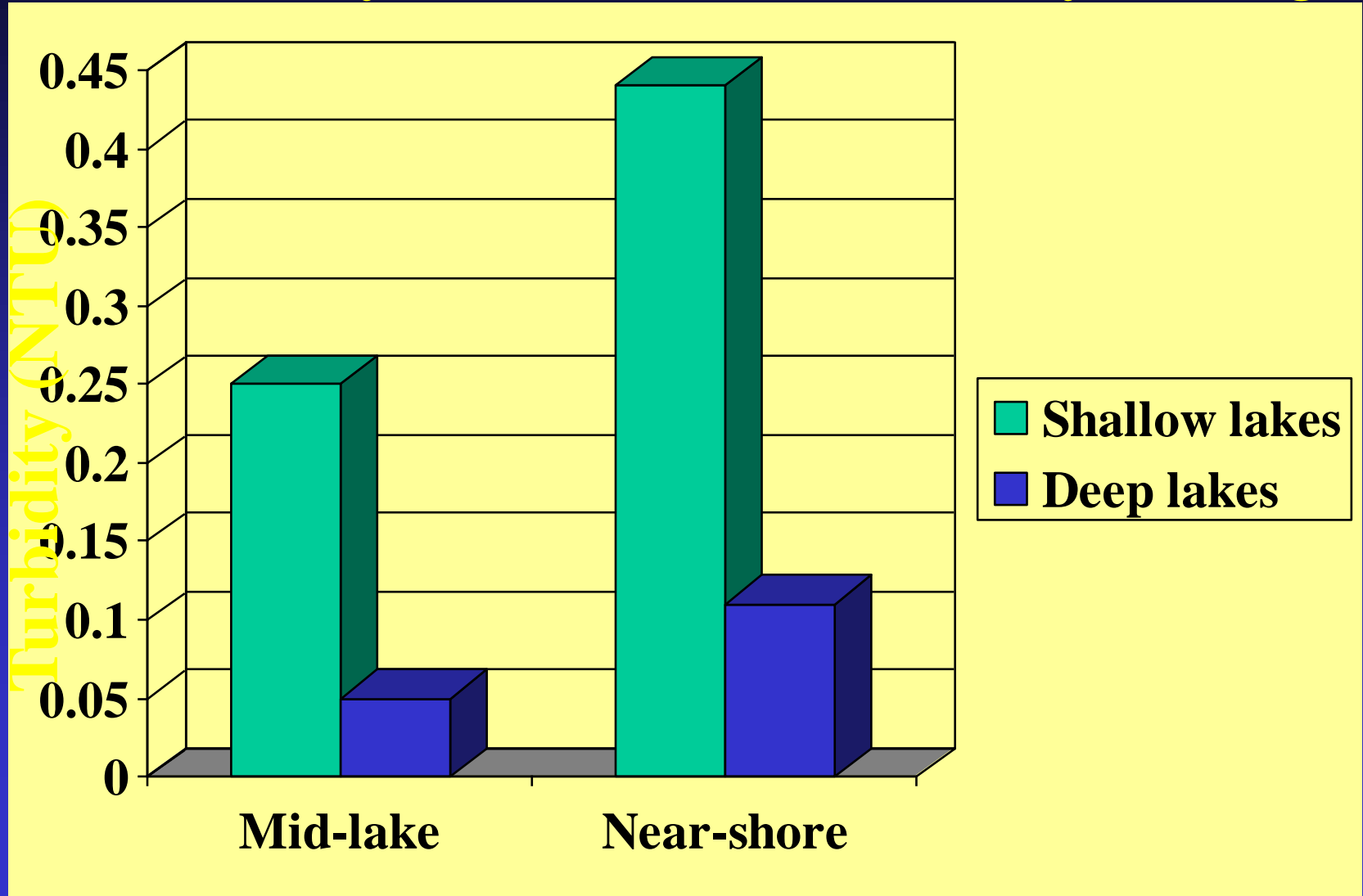


Boats

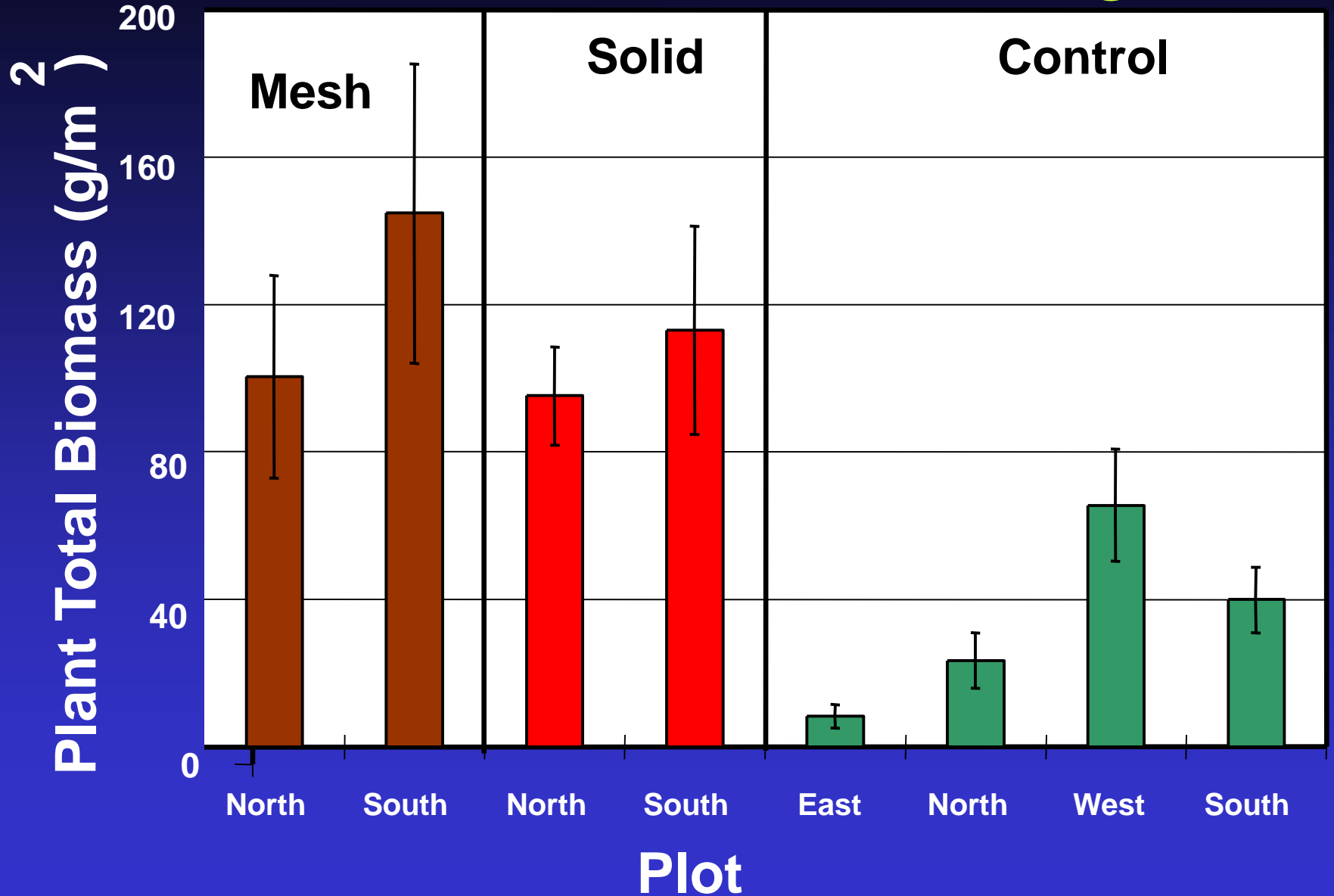


Boating

Weekday to Weekend Turbidity Change



Plant Growth - Boating



Management Tools

**BENTHIVORES
PLANKTIVORES**

**PROTECT PISCIVORES
STOCK PISCIVORES
COMMERCIAL HARVEST
CHEMICAL RECLAMATION
SPOT TREATMENTS**

**WATER
DEPTH**

**DRAWDOWN
LONG-TERM**

WAVES

**LEVELS
TEMPORARY BREAKWATERS
BARRIER ISLANDS
BOATING RESTRICTIONS**

NUTRIENTS

**EXTERNAL LOADS
NUTRIENT INACTIVATION**

External Nutrient Loads

BMPs
Buffers
Settling basins
Flow diversion



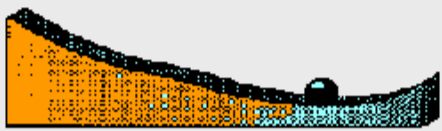
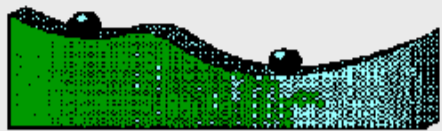
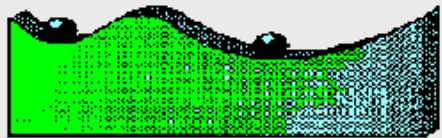
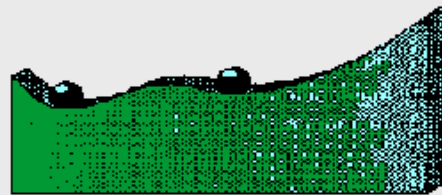
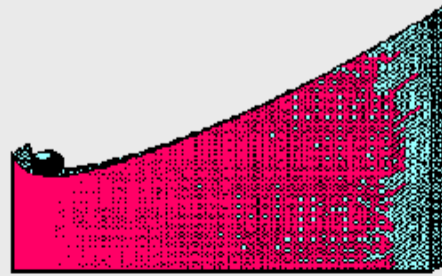
Shallow Lake Ecology

(From Scheffer et al. 1993)

**NUTRIENT
POOR**



**NUTRIENT
RICH**



Protection

CLEAR



TURBID

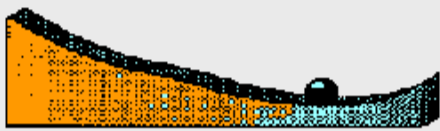
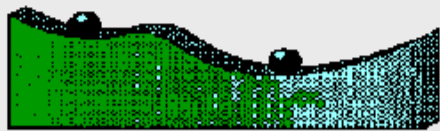
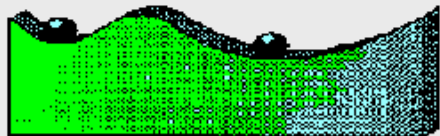
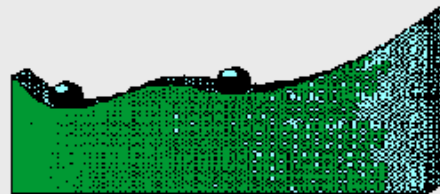
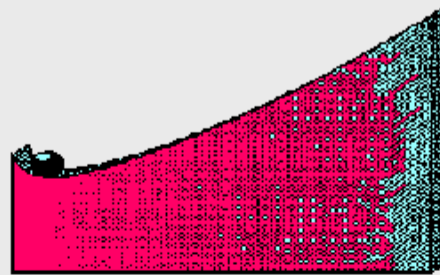
Shallow Lake Ecology

(From Scheffer et al. 1993)

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POOR**



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RICH**



Protection

**Restorations
Work**

CLEAR



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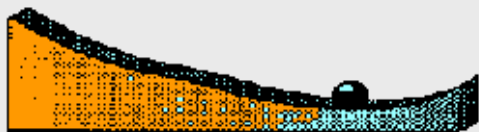
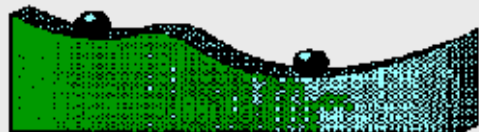
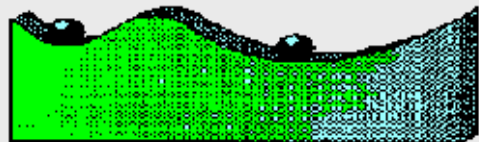
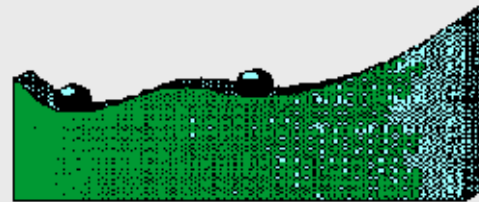
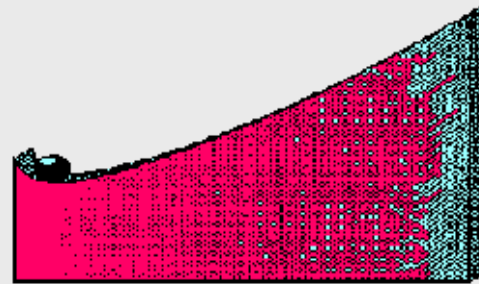
Shallow Lake Ecology

(From Scheffer et al. 1993)

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POOR**



**NUTRIENT
RICH**



Protection

Restorations
Work

Restorations
Fail

CLEAR



TURBID

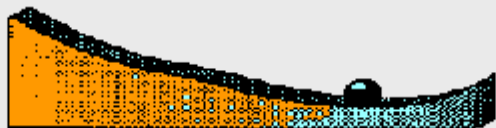
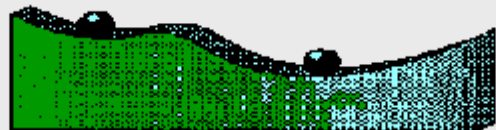
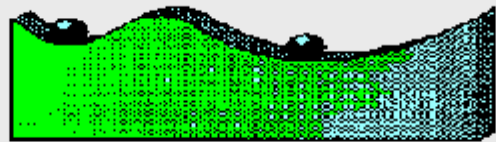
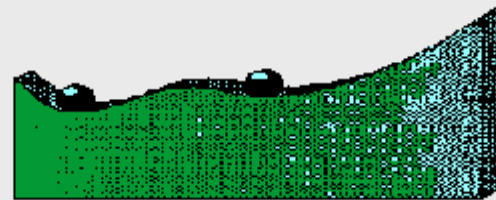
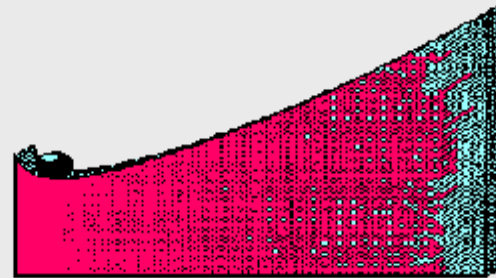
Shallow Lake Ecology

(From Scheffer et al. 1993)

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RICH**



Thunder Lake
Big Muskego
Rush Lake
Lake Puckaway
Fox Lake
Beaver Dam Lake
Sinnissippi Lake
Lake Koshkonong

CLEAR

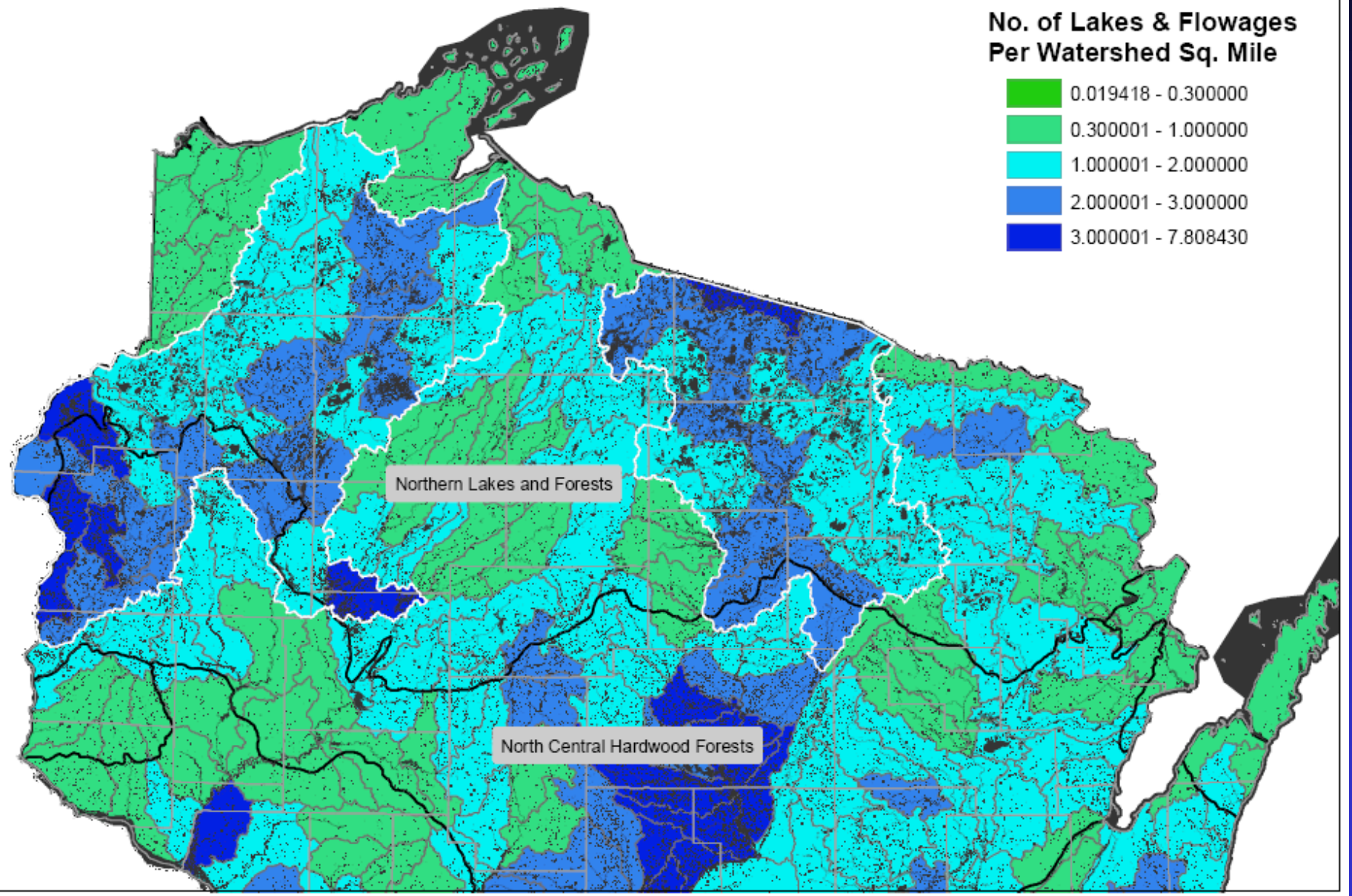
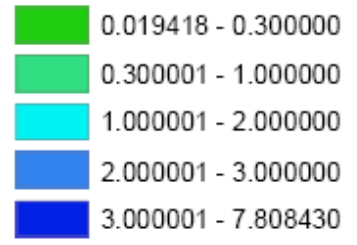


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Level III Ecoregions and Watersheds of Wisconsin

Number of Lakes/Ponds/Flowages/Watershed Sq. Mile

No. of Lakes & Flowages
Per Watershed Sq. Mile



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Domestication of Wisconsin Lakes

Courtesy of MN DNR

Comparisons of Undeveloped and Developed Shorelands, Northern Wisconsin



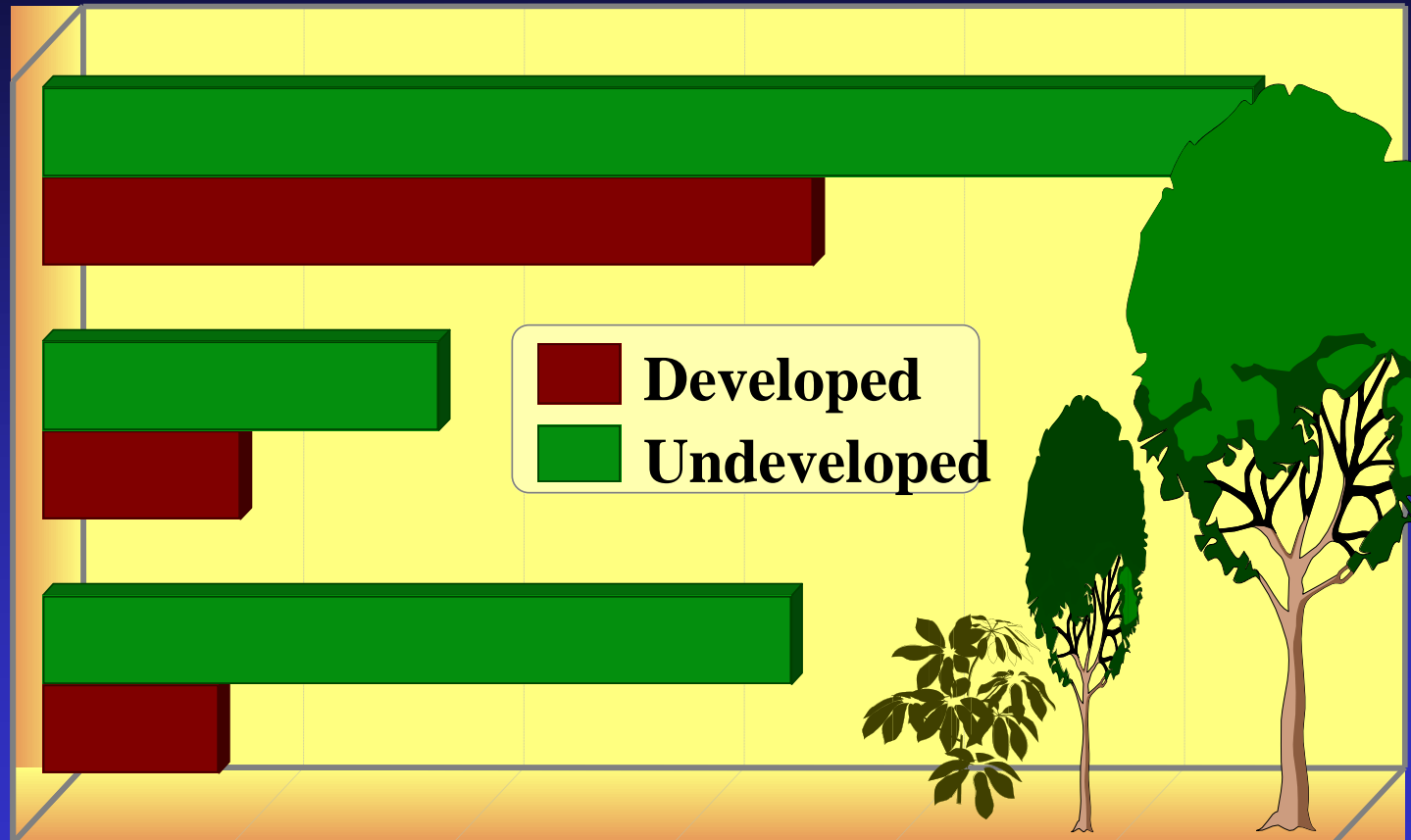
Joan Elias & Mike
Meyer

What's Happened To Shoreland Plant

Canopy

**Understor
y**

Shrub

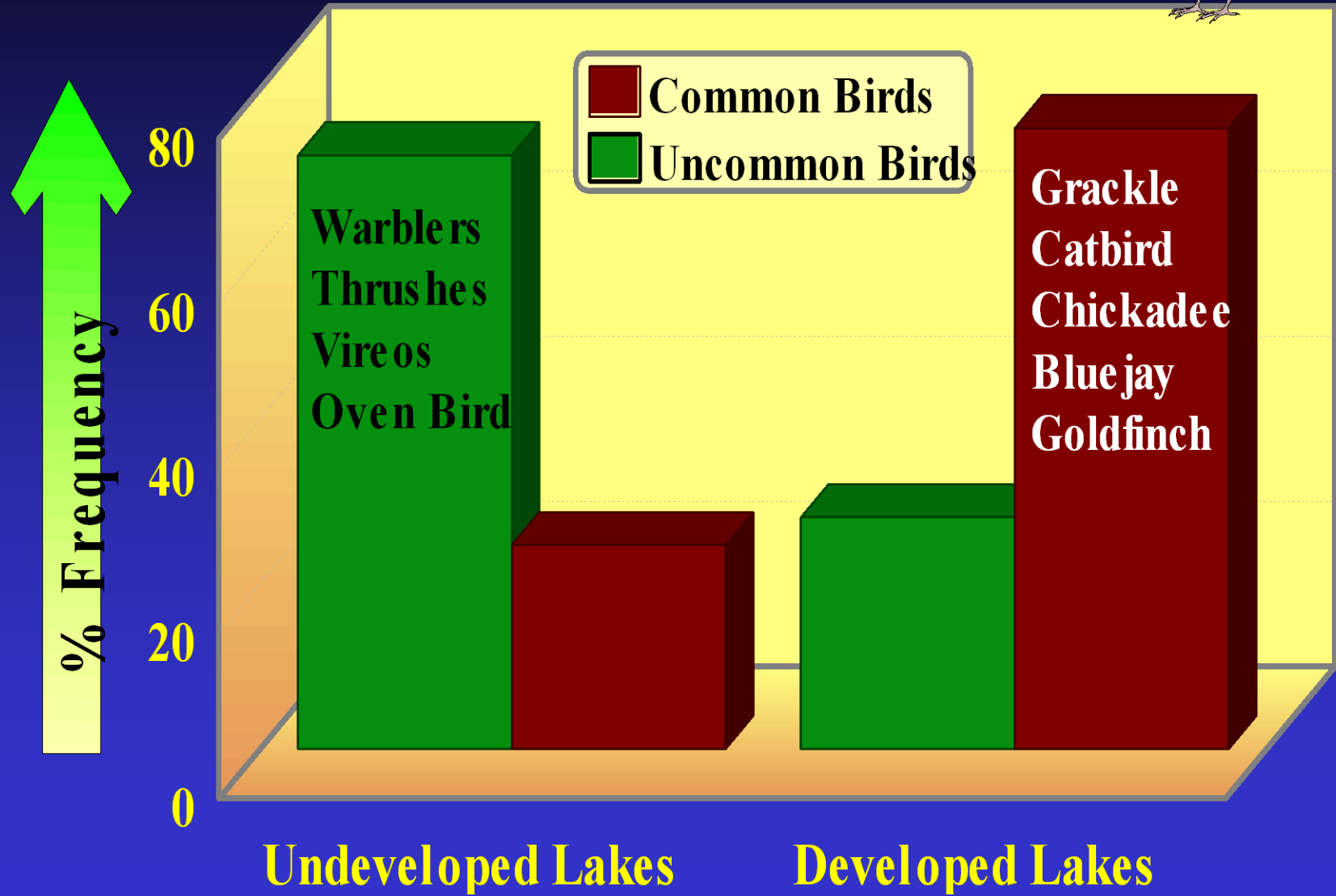
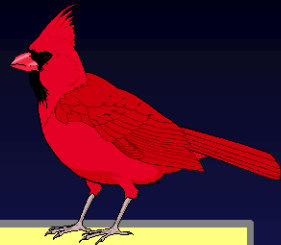


0 10 20 30 40 50 60

**Elias and Meyer, in
Prep.**

% Plant Cover

What's Happened To Songbirds?



Consequences of Lakeshore Development on Emergent and Floating-Leaf Vegetation Abundance



Radomski and Goeman, 2001

Consequences of Lakeshore Development on Emergent and Floating-Leaf Vegetation Abundance



- Developed shores had less aquatic vegetation
- For each lake lot, 2/3rds of the emergent and floating-leaf vegetation was lost
- Minnesota has lost 20-28% of this vegetation

Radomski and Goeman, 2001

Impacts of Lakeshore Development on Tree-falls in North Temperate Lakes

Christensen et al. 1996

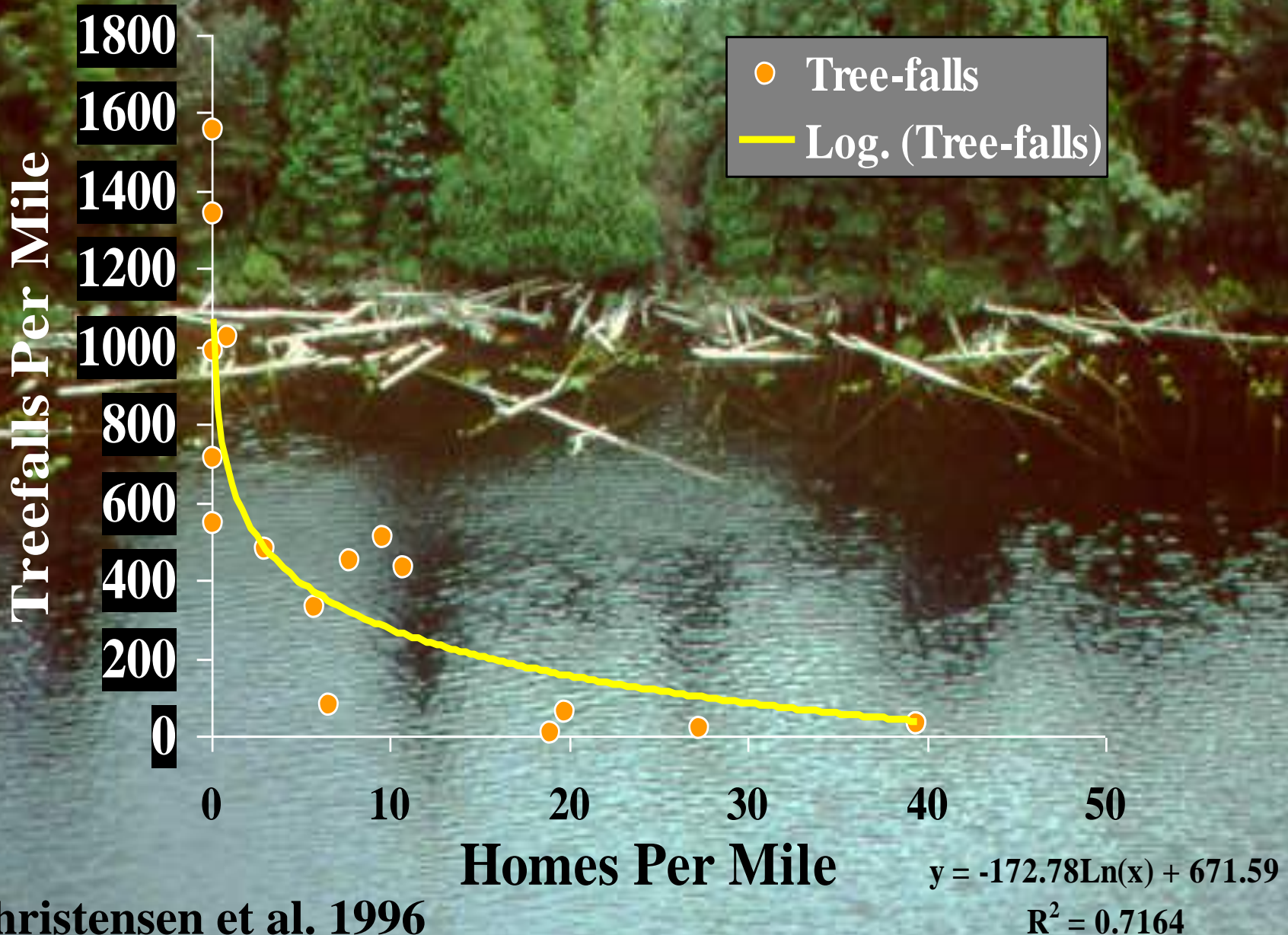


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Impacts of Development on Tree-falls



Christensen et al. 1996

Development Impacts on Fish Growth and Production



Schindler et al. 2000

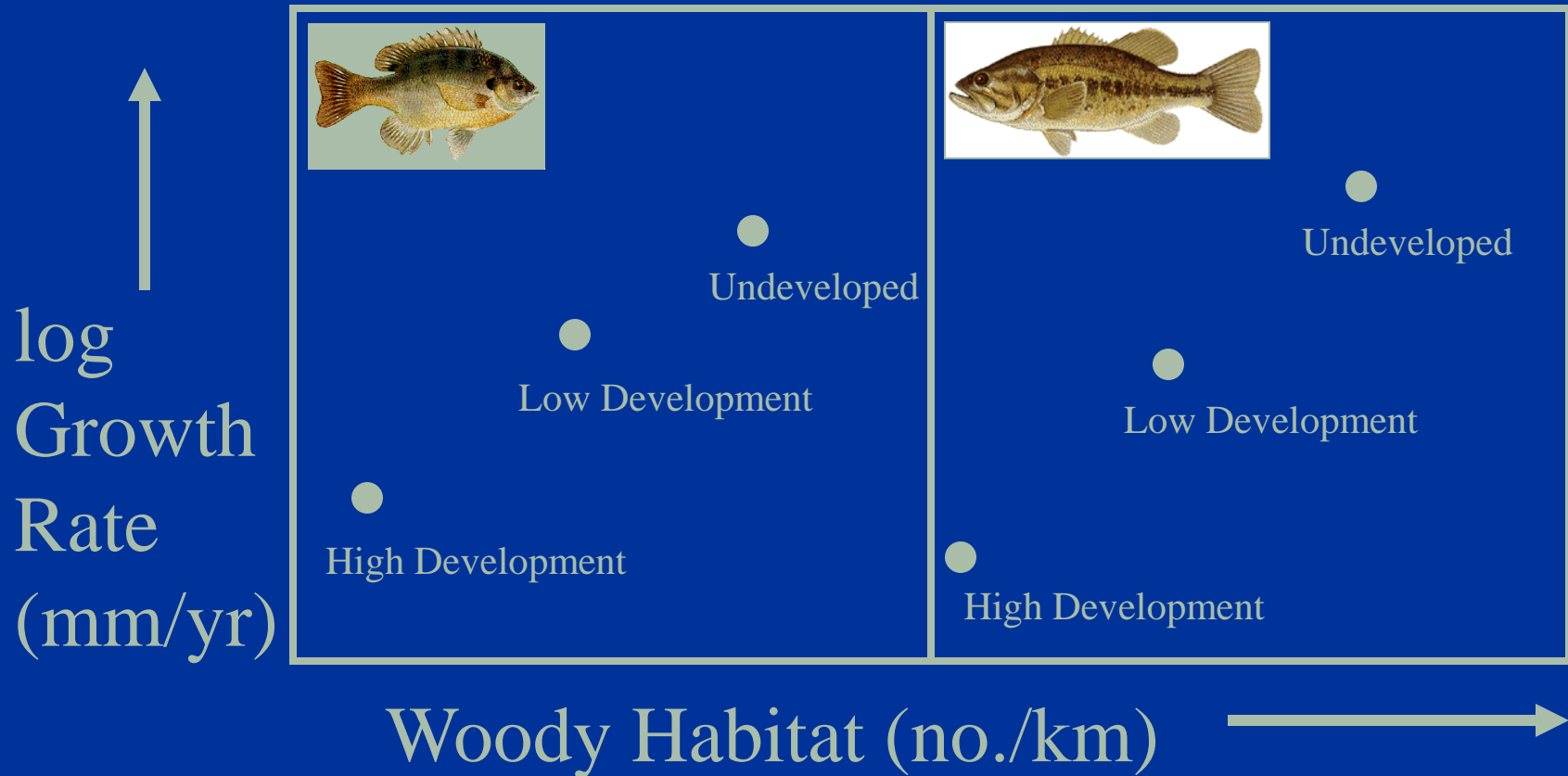


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Fish grow ~3X faster in lakes with lots of woody habitat



From Schindler et al. 2000



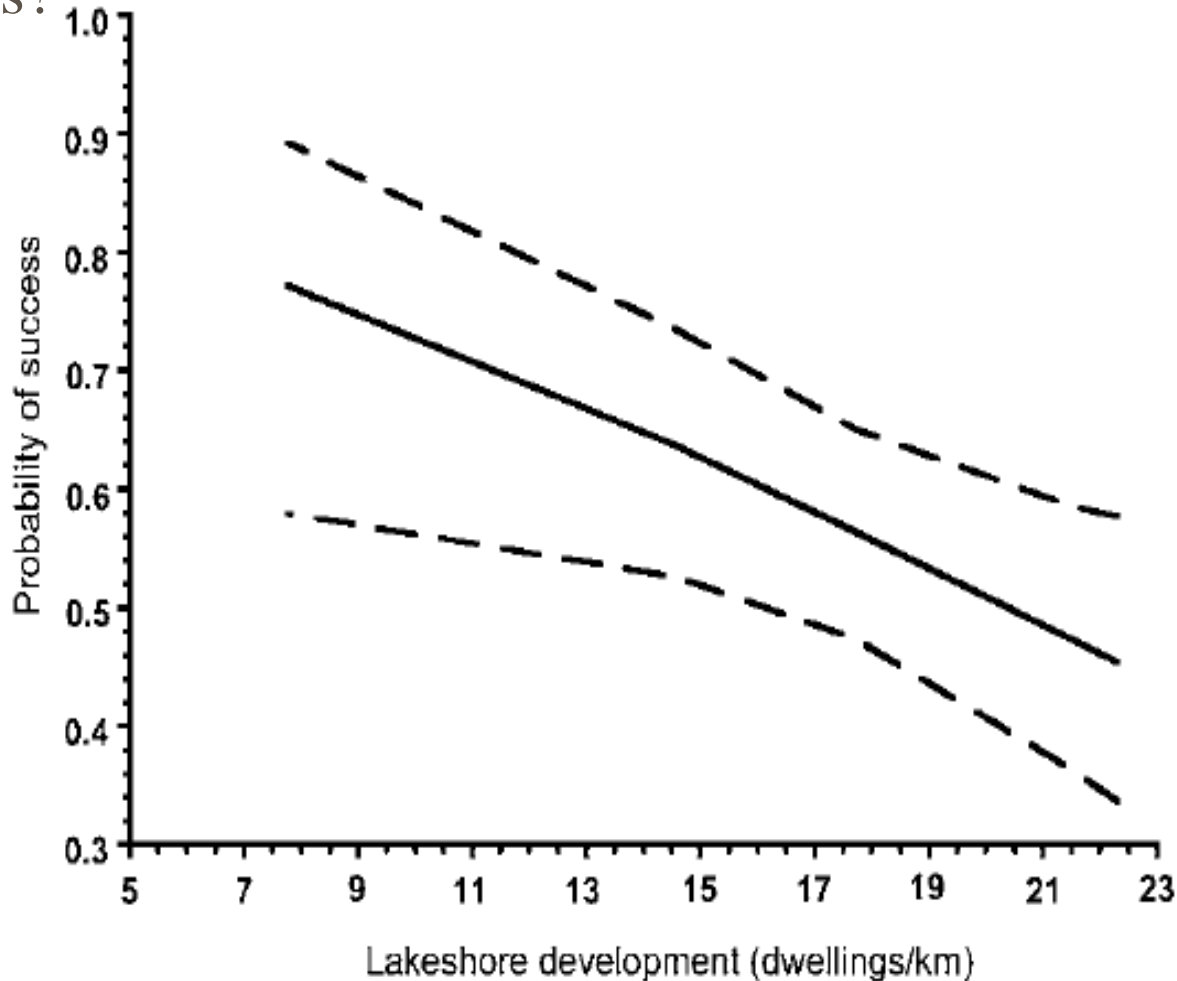
Department of Fisheries and Wildlife

Preserving our past...Creating our future

MICHIGAN STATE
UNIVERSITY

TYLER WAGNER, AARON K. JUBAR, AND MARY T. BREMIGAN

Can Habitat Alteration and Spring Angling Explain Largemouth Bass Nest Success?



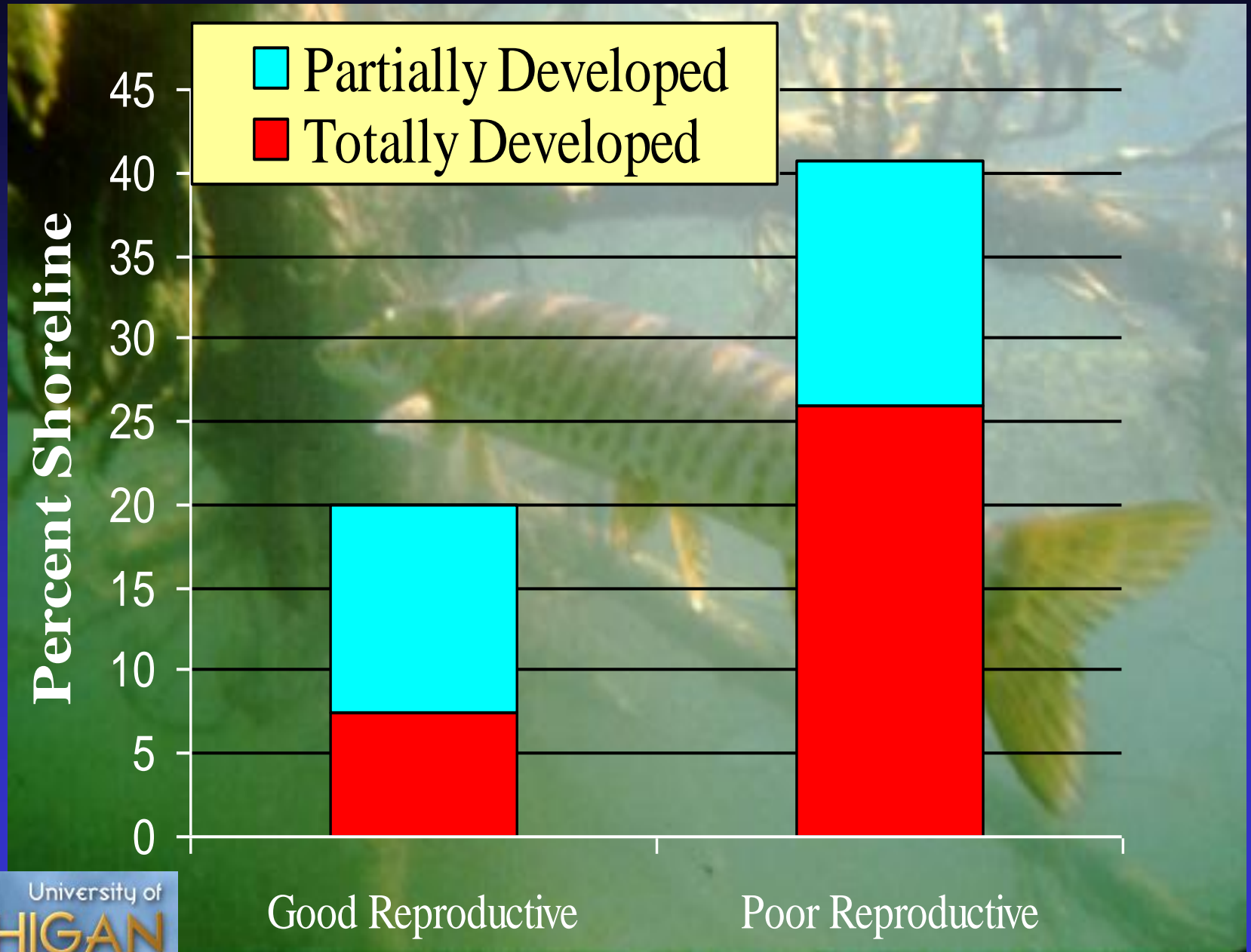
Lake Characteristics Influencing Spawning Success of Muskellunge



Rust et al.,

University of
MICHIGAN

Lake Characteristics Influencing Muskellunge Reproduction



Improve Water Clarity

Fish and Wildlife Habitat

Hold Sediments

Nutrient Cycling

Invertebrates

Aesthetics





Effects of Pier Shading on Near-Shore Aquatic Habitat

Researchers:

Paul Garrison, DNR

Dave Marshall, DNR

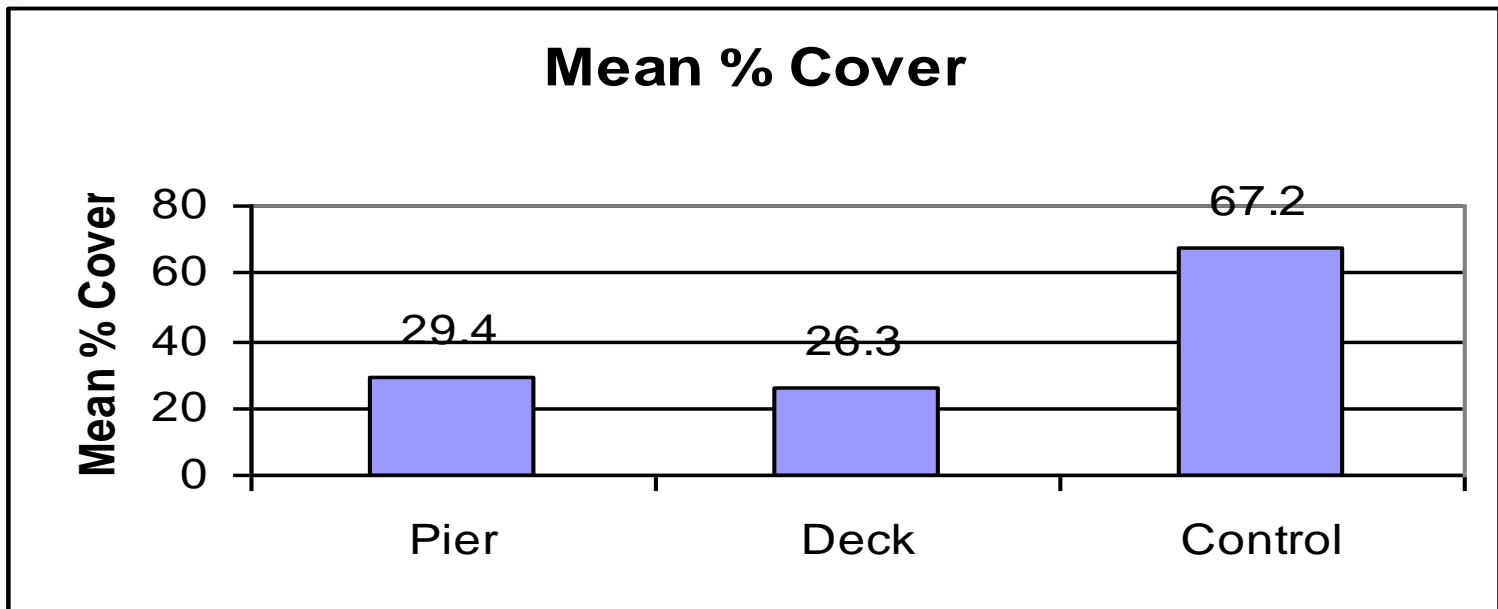
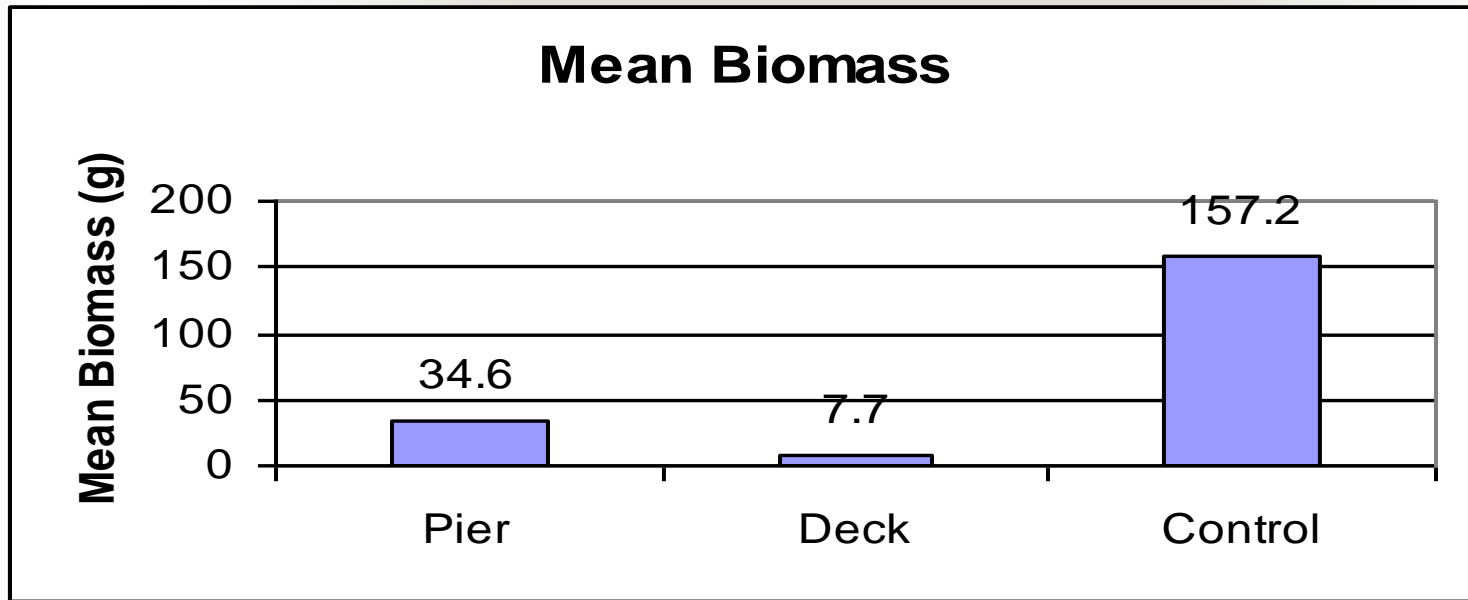
Laura Stremick-Thompson, DNR

Patricia Cicero, Jefferson County LWCD

Paul Dearlove, Lake Ripley Mgmt. Dist.

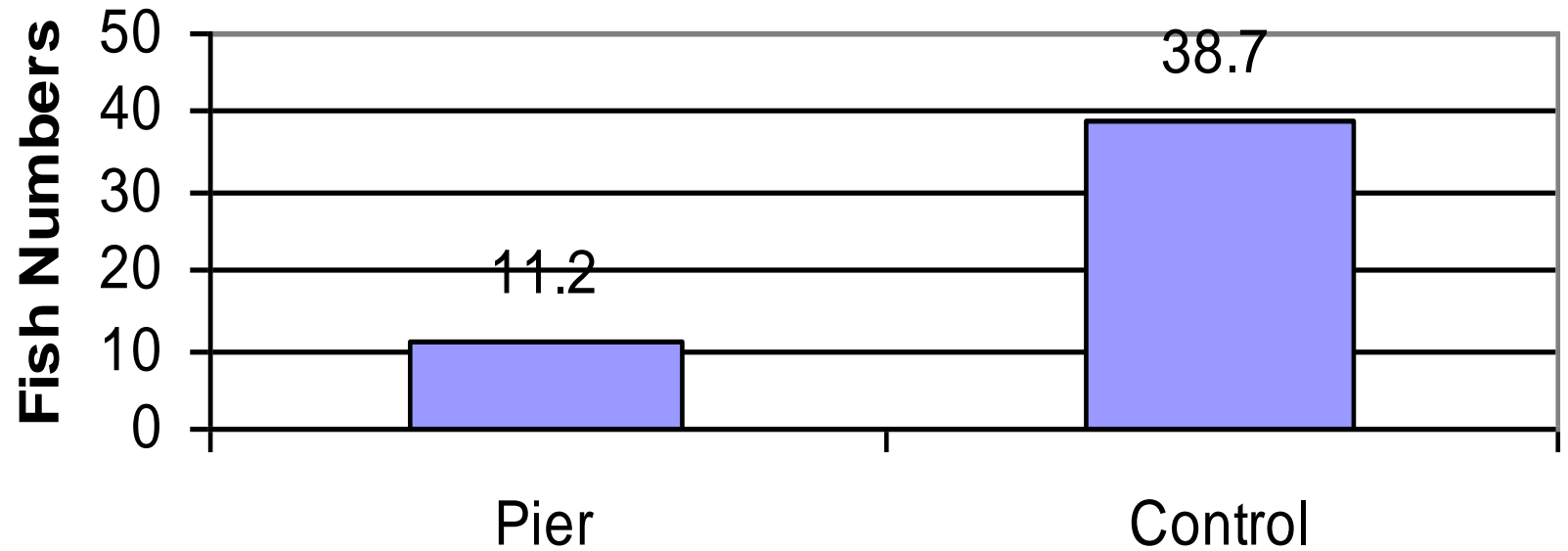


Ecological Effects of Piers on Aquatic Plants



Ecological Effects of Piers on Fish

Mean Catch Rates



Habitat Changes With Lakeshore Development

Shrub layer at lake-forest edge

Bank cover

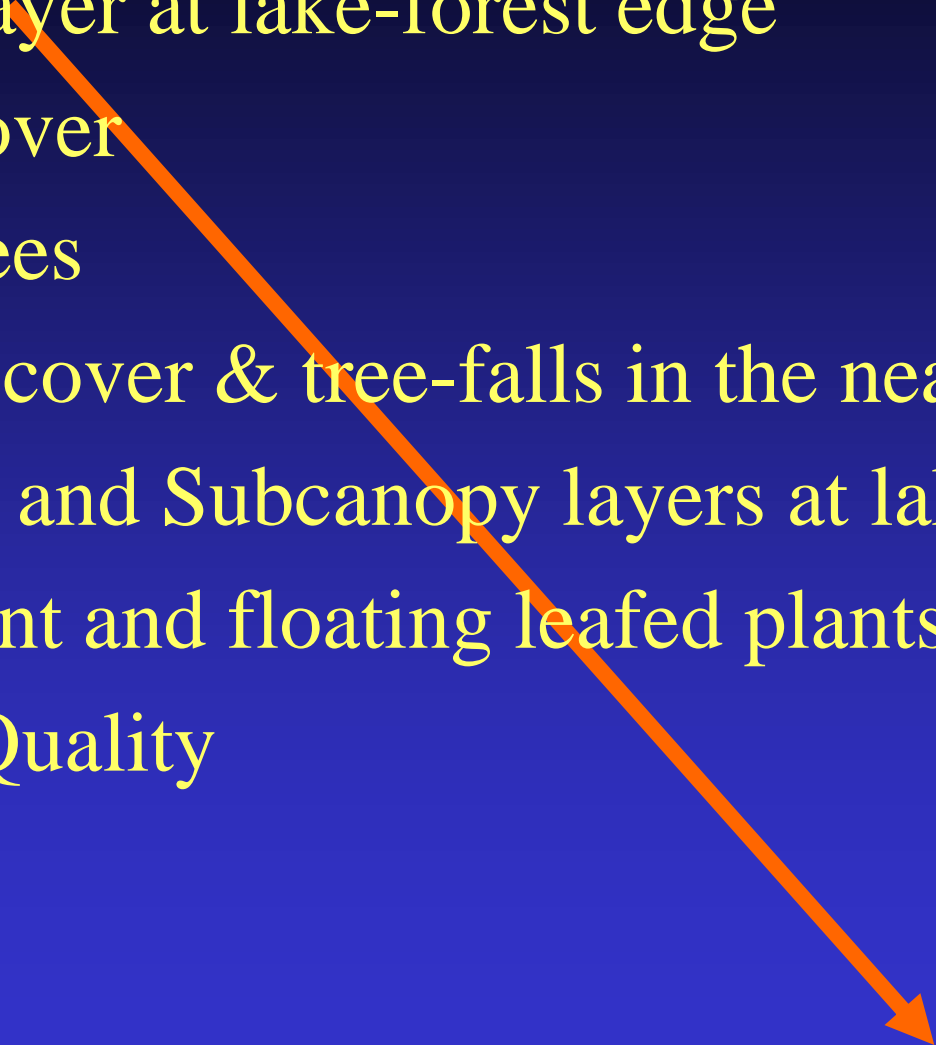
Snag trees

Woody cover & tree-falls in the nearshore

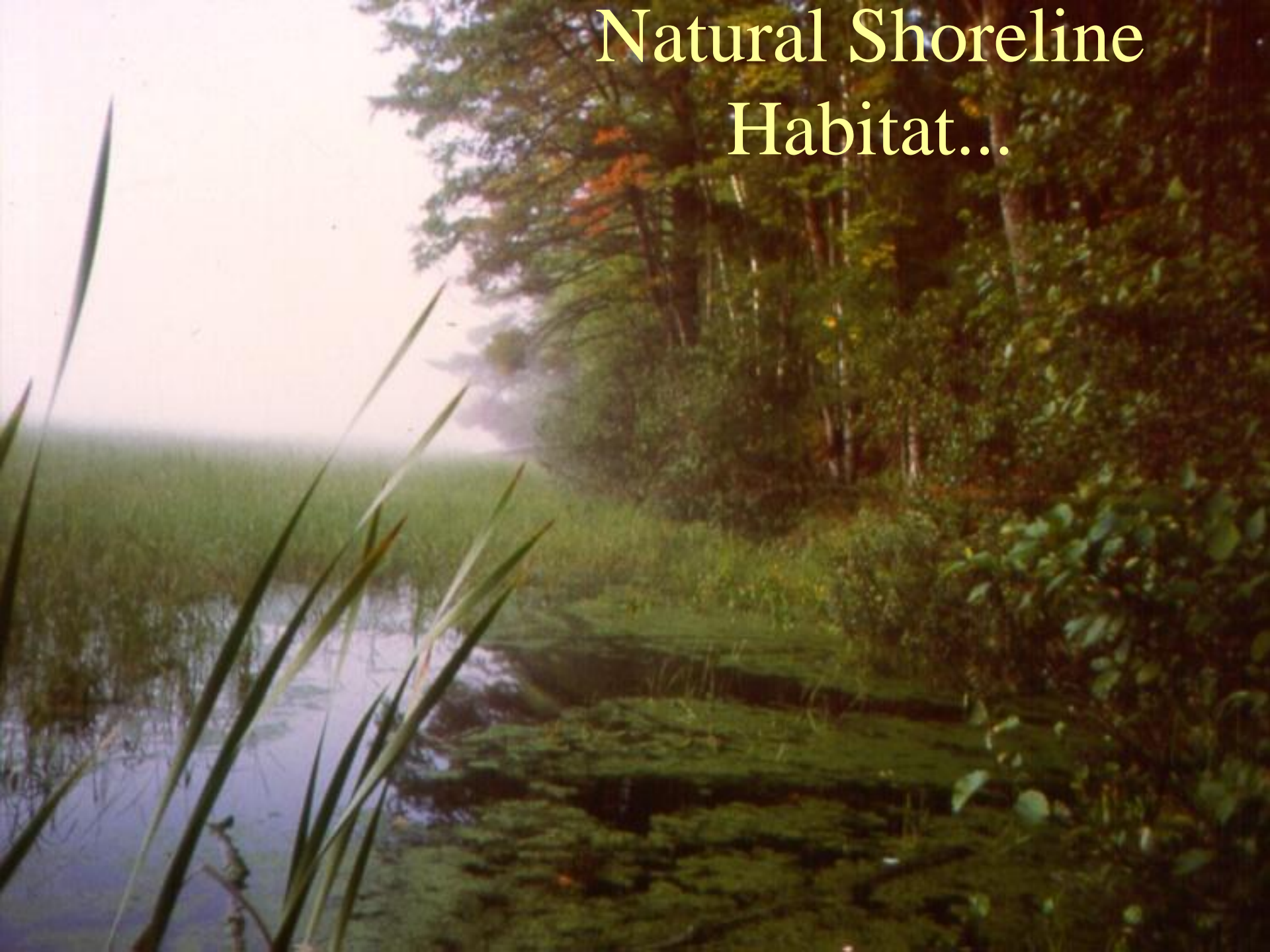
Canopy and Subcanopy layers at lake-forest edge

Emergent and floating leafed plants

Water Quality



Natural Shoreline Habitat...





Going, ...



Going, ...



Going,

...

Gone.....



Well it Doesn't
Have to Be That
Way!







The Remedies seem obvious and the stakes are great

Lake Tomahawk, Oneida County



Tale of Two Bays