Shallow Lake Ecology and Management

Todd Call
Shallow Lakes Program

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Two Concepts to Take Away

- Shallow lakes can exist in two states
  - Clear Water (Preferred for wetland wildlife)
  - Turbid Water
- Fish and nutrients are the primary drivers that determine the state

Presentation Topics

- Physical Characteristics of Shallow Lakes
- Shallow Lake Ecology
  - Two Stable States
- Managing Shallow Lakes
  - Why
  - How
- Local Management Examples

What is a Shallow Lake?

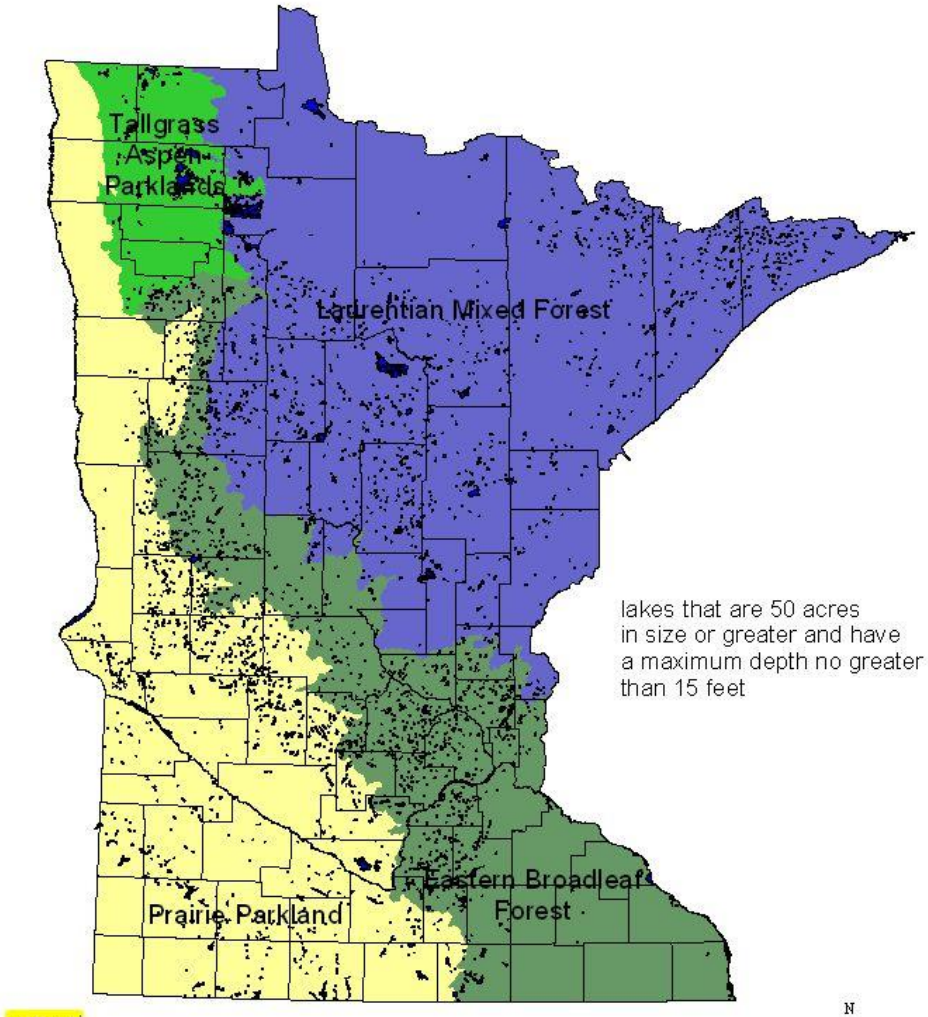
Water column is mixed

Aquatic plants over the entire lake

50 acres or greater in size

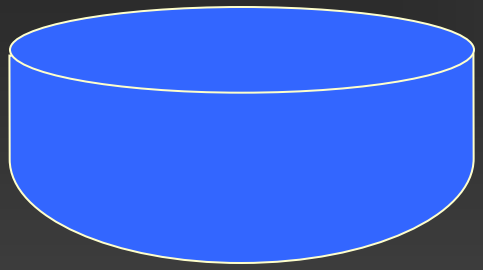
Less than 15 feet deep

Shallow Lakes in Minnesota

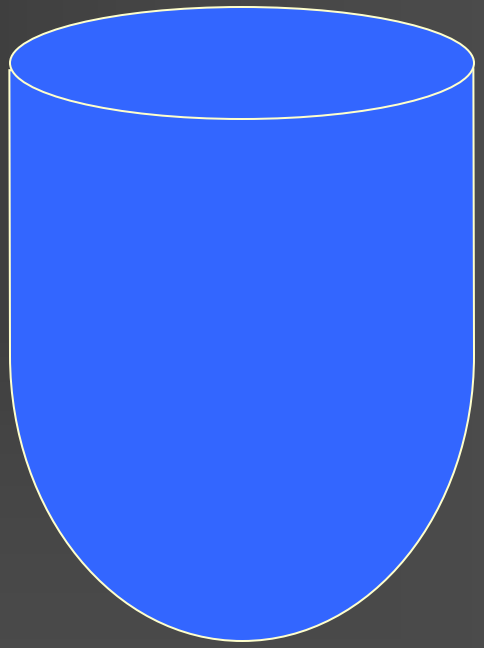


lakes that are 50 acres in size or greater and have a maximum depth no greater than 15 feet

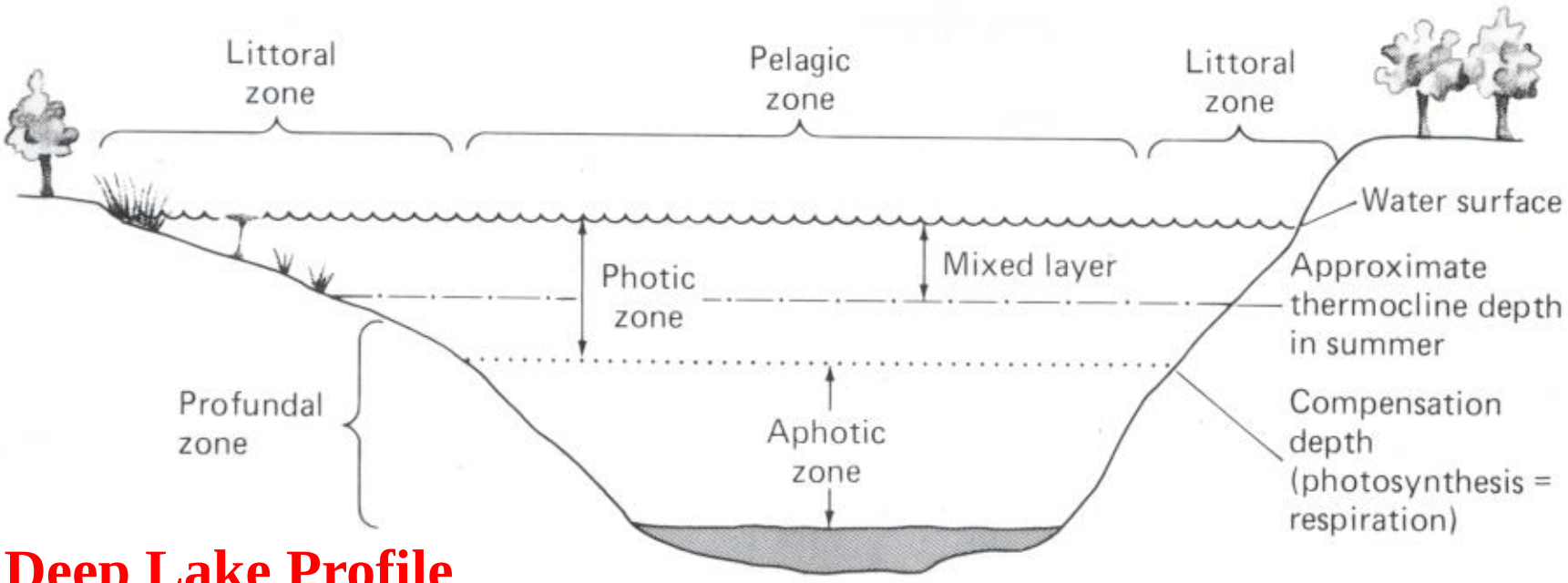
Shallow Lake



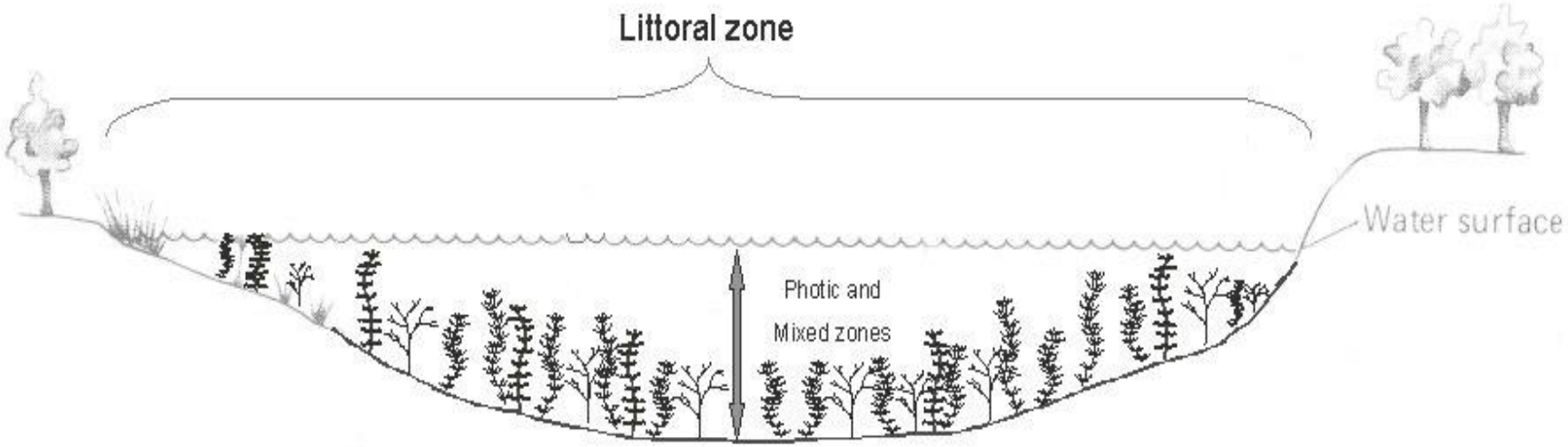
Deep Lake



How are shallow lakes different from deep lakes



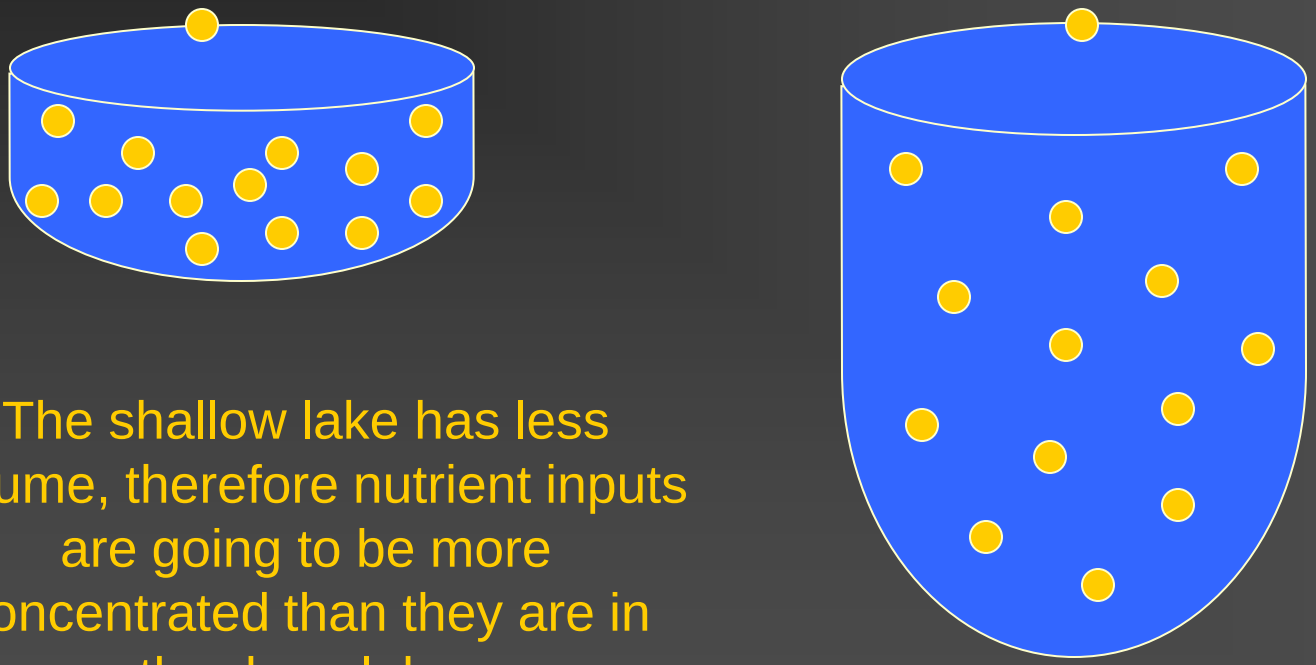
Deep Lake Profile



Shallow Lake Profile

Both lakes have the same watershed, the same surface acres, the only difference is depth. One lake is shallow, the other deep.

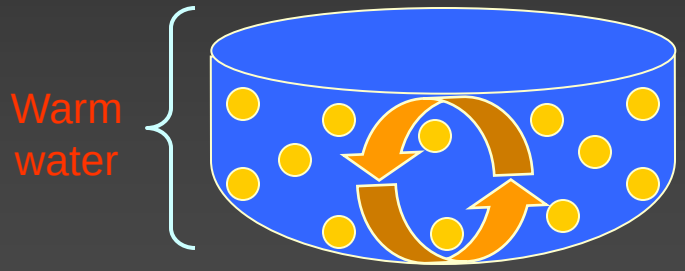
nutrients from watershed

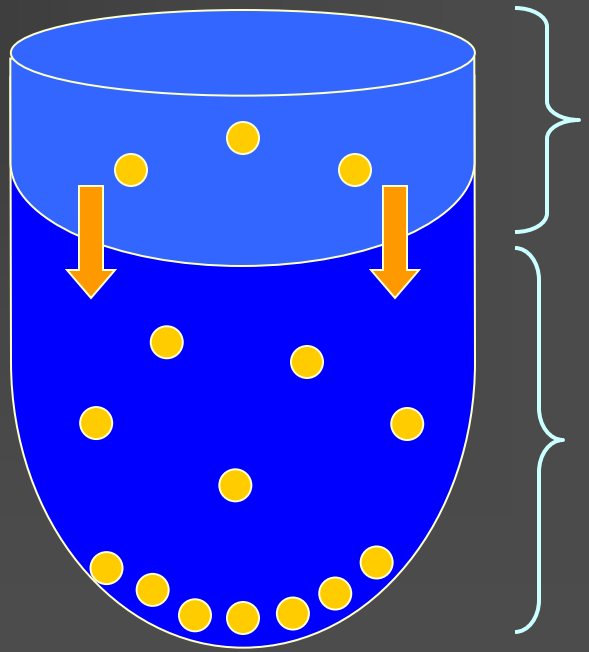


The shallow lake has less volume, therefore nutrient inputs are going to be more concentrated than they are in the deep lake.

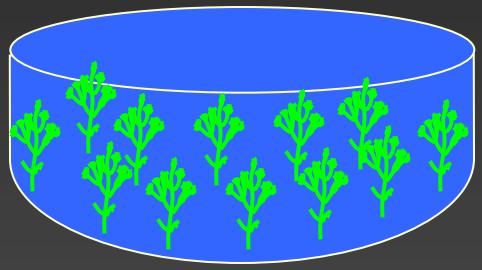
Sunlight warms the entire water column in a shallow lake, therefore the water can mix with the bottom sediments all summer long. Waves caused by wind can also turn to the bottom of shallow lakes and stir up sediments. These sediments contain nutrients which are mixed into the water and used by aquatic plants or algae.

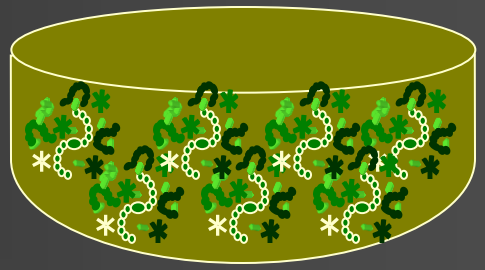
Because only the top layer of water is warmed by the sun in a deep lake, this top layer of water does not mix with the cooler deep water. Waves action also only impacts the upper layer of water. This separation allows nutrients to settle to the bottom of the lake. These nutrients are not available to plants and algae growing in the upper layers of water.



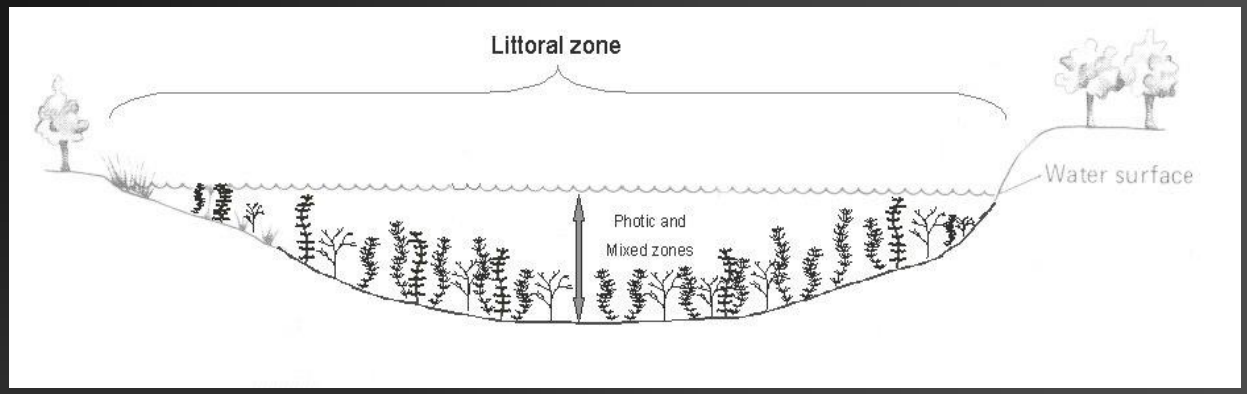


All of the nutrients in shallow lakes, plus availability of light means that something will have to grow. That something will be either rooted aquatic plants or algae.





In summary…



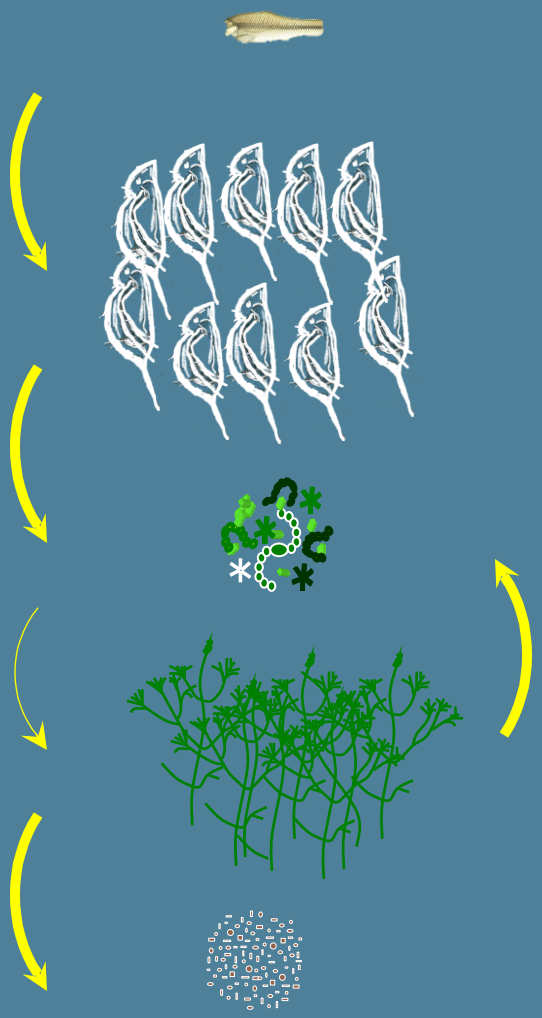
- Constant exchange of nutrients between sediments and water column
- Less capacity to buffer external nutrient loading
- Can winter kill often
- Wind effects can be substantial
- Complex interactions between plants, fish, nutrients and invertebrates
- May switch between clear-water and turbid-water states

Shallow lakes exhibit two alternative stable “states”

Clear-water Condition

Turbid Condition

Clear-water State



Fish

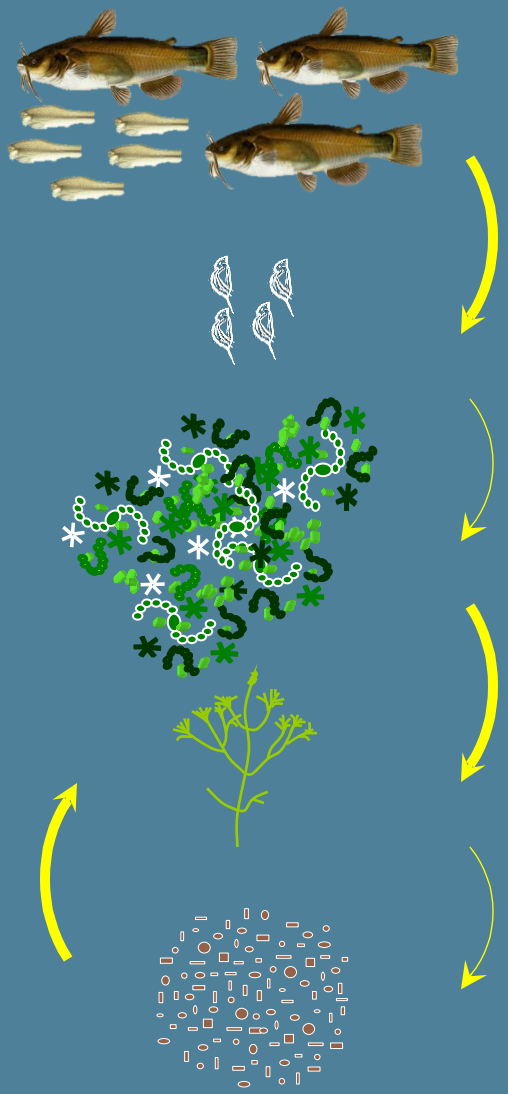
Zooplankton grazing

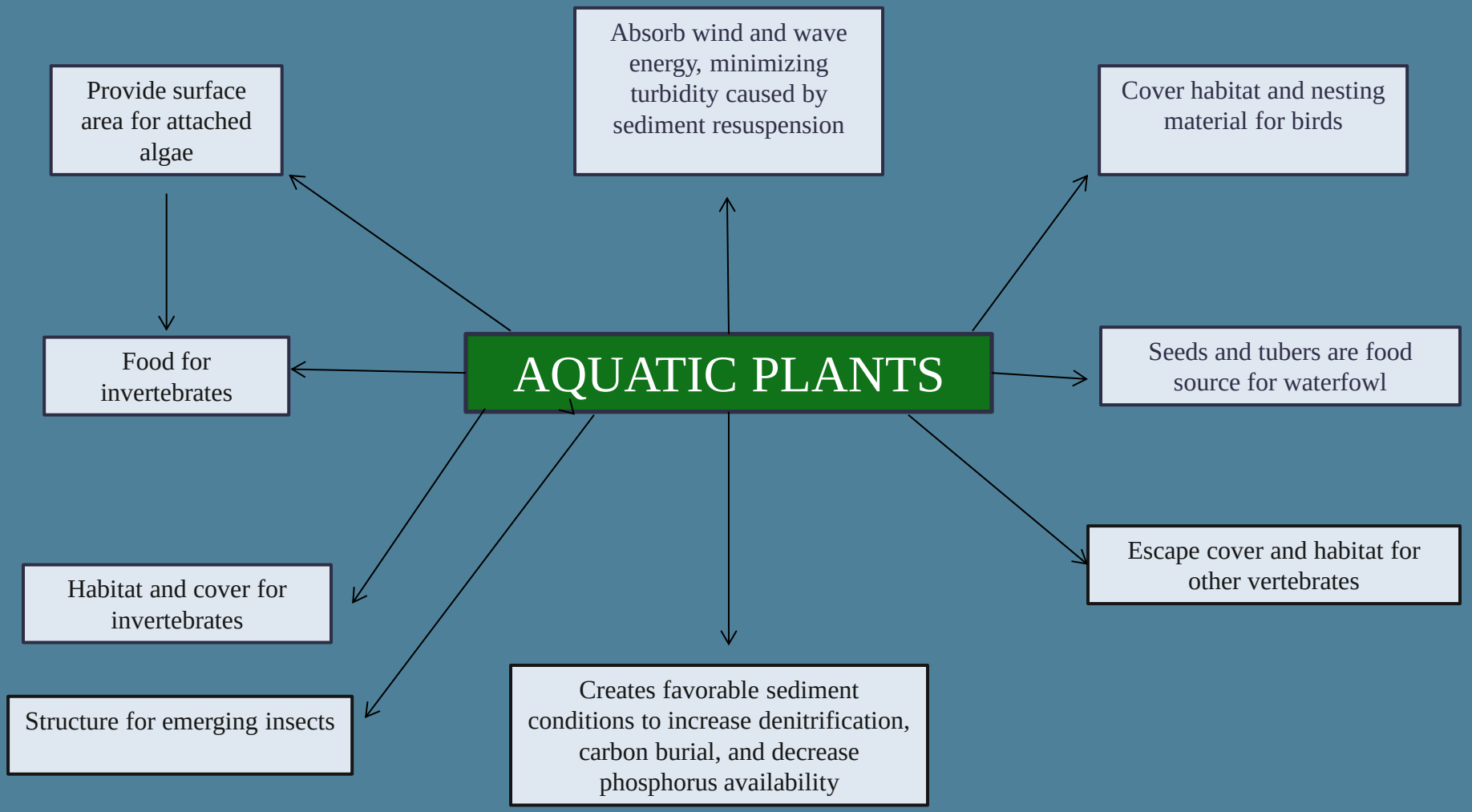
Phytoplankton biomass

Macrophyte biomass

Sediment Resuspension

Turbid-water State




AQUATIC PLANTS
Absorb wind and wave energy, minimizing turbidity caused by sediment resuspension
Provide surface area for attached algae
Cover habitat and nesting material for birds
Food for invertebrates
Seeds and tubers are food source for waterfowl
Habitat and cover for invertebrates
Escape cover and habitat for other vertebrates
Structure for emerging insects
Creates favorable sediment conditions to increase denitrification, carbon burial, and decrease phosphorus availability

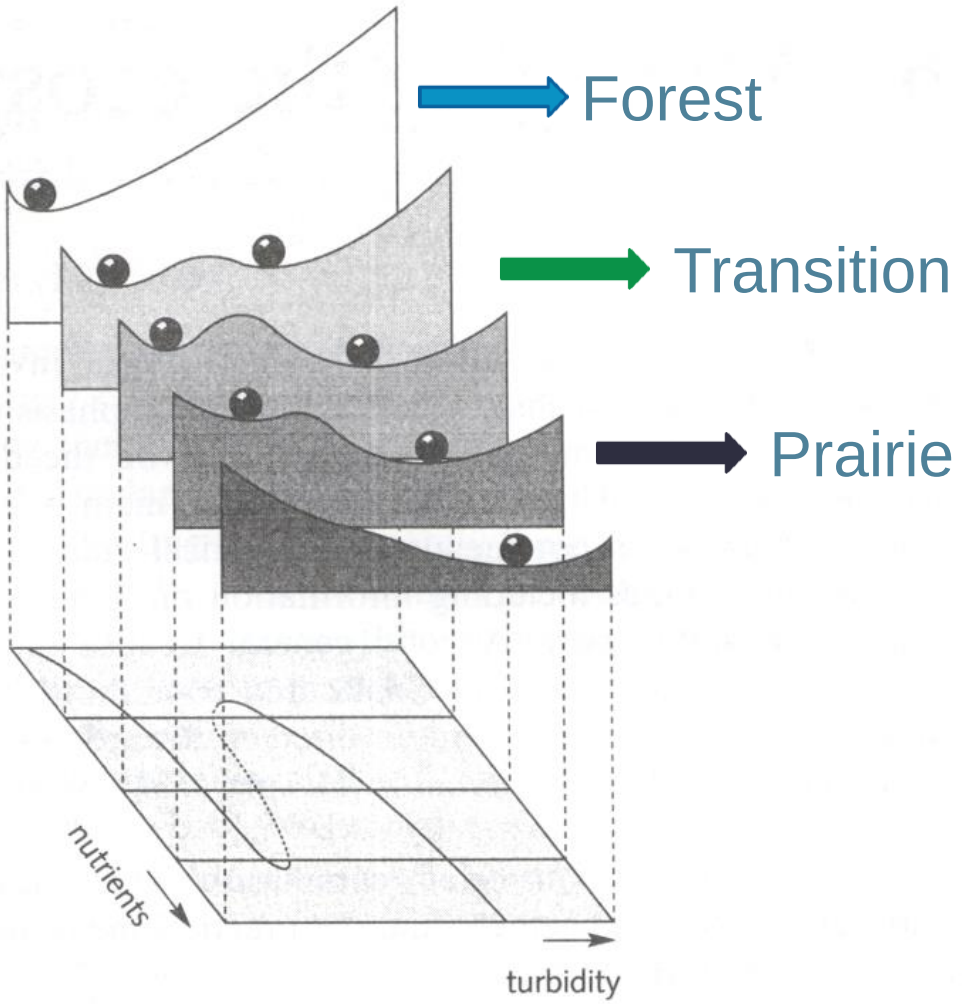


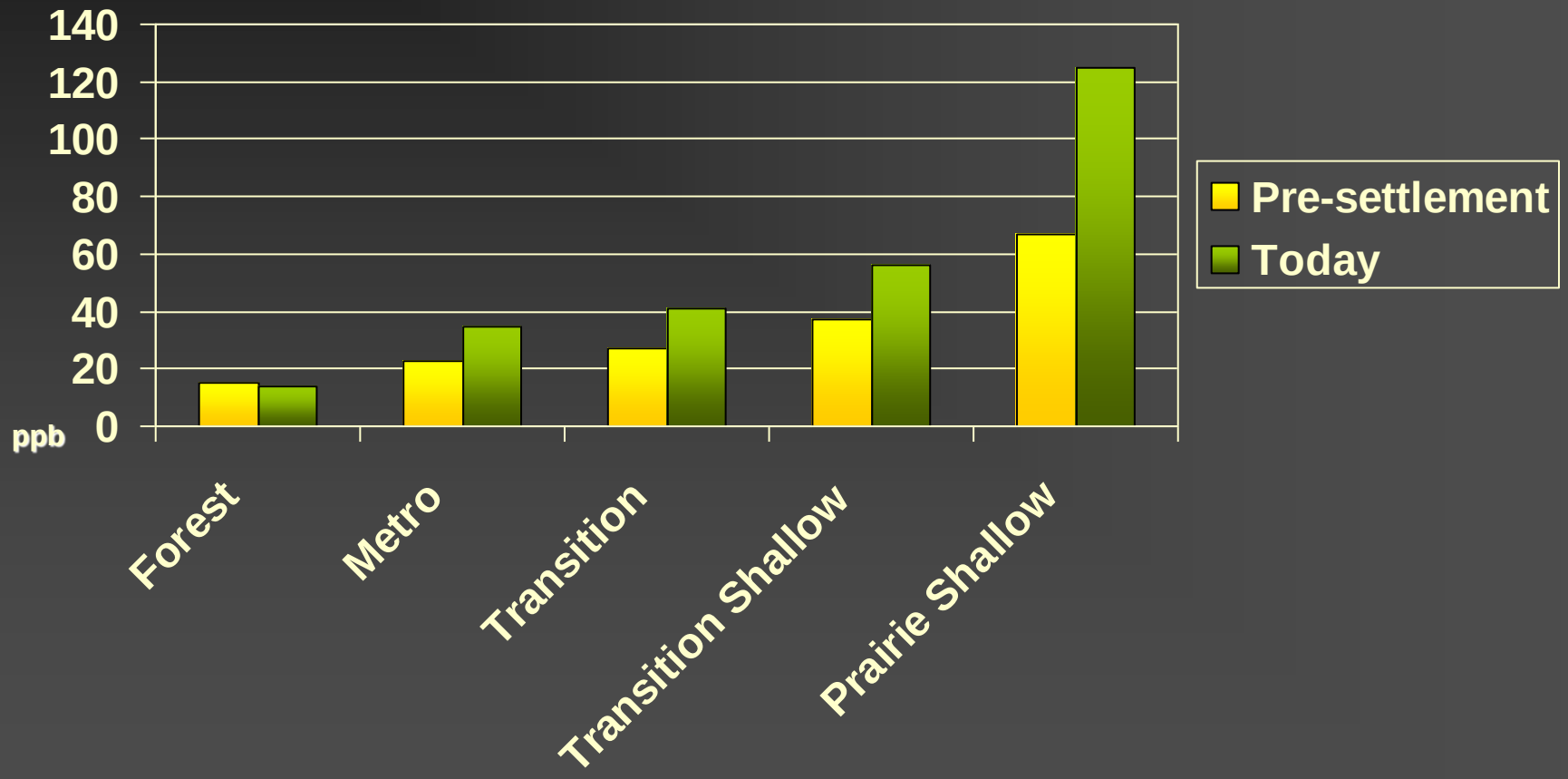
Fig. 6.1 'Marble-in-a-cup' representation of stability at five different levels of nutrient loading. The minima correspond to stable equilibria, tops to unstable breakpoints (see text). Modified from Scheffer (1990).

Issues That Impact Shallow Lakes

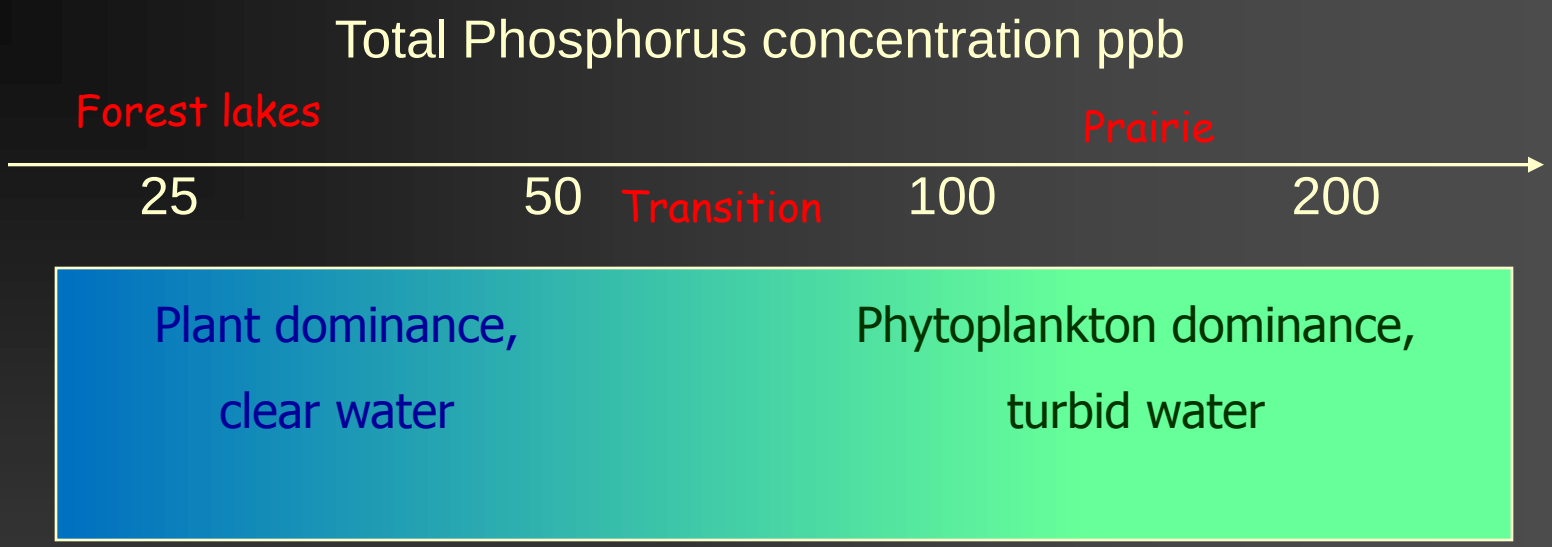
- Nutrient loading
  - Watershed\Land Use Practices
  - Internal Loading
  - Historical Legacy
- Unbalanced fish populations
  - Planktivores
  - Benthivores
- High water levels
  - Altered hydrology
  - Precipitation
  - Blocked outlets

Total Phosphorus

Pre-settlement vs. Today (all lakes)



Adapted from PCA Data



Difficulty of maintaining clear water

Unbalanced Fish Populations

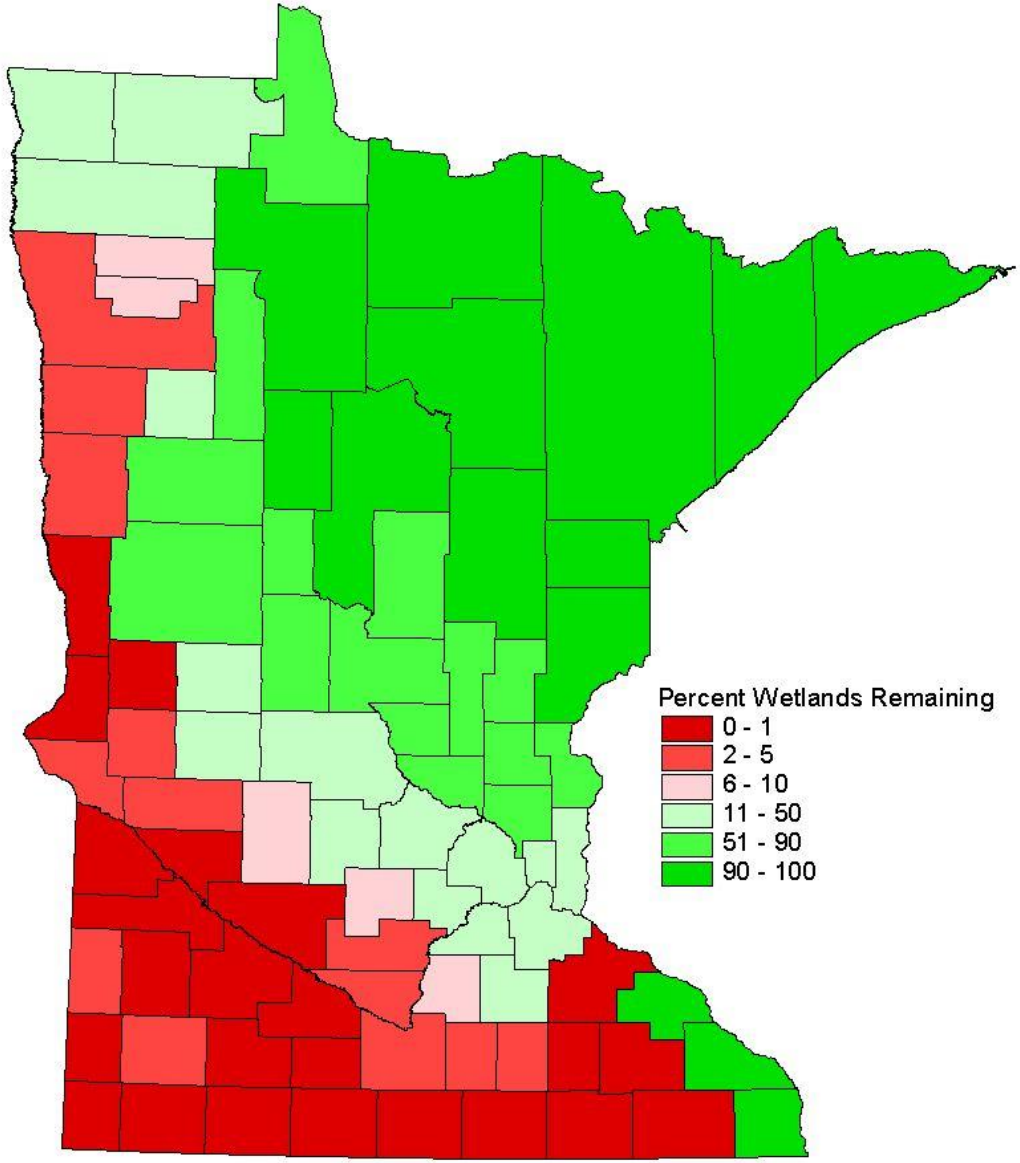

Black Bullhead


Fathead Minnow

Common Carp

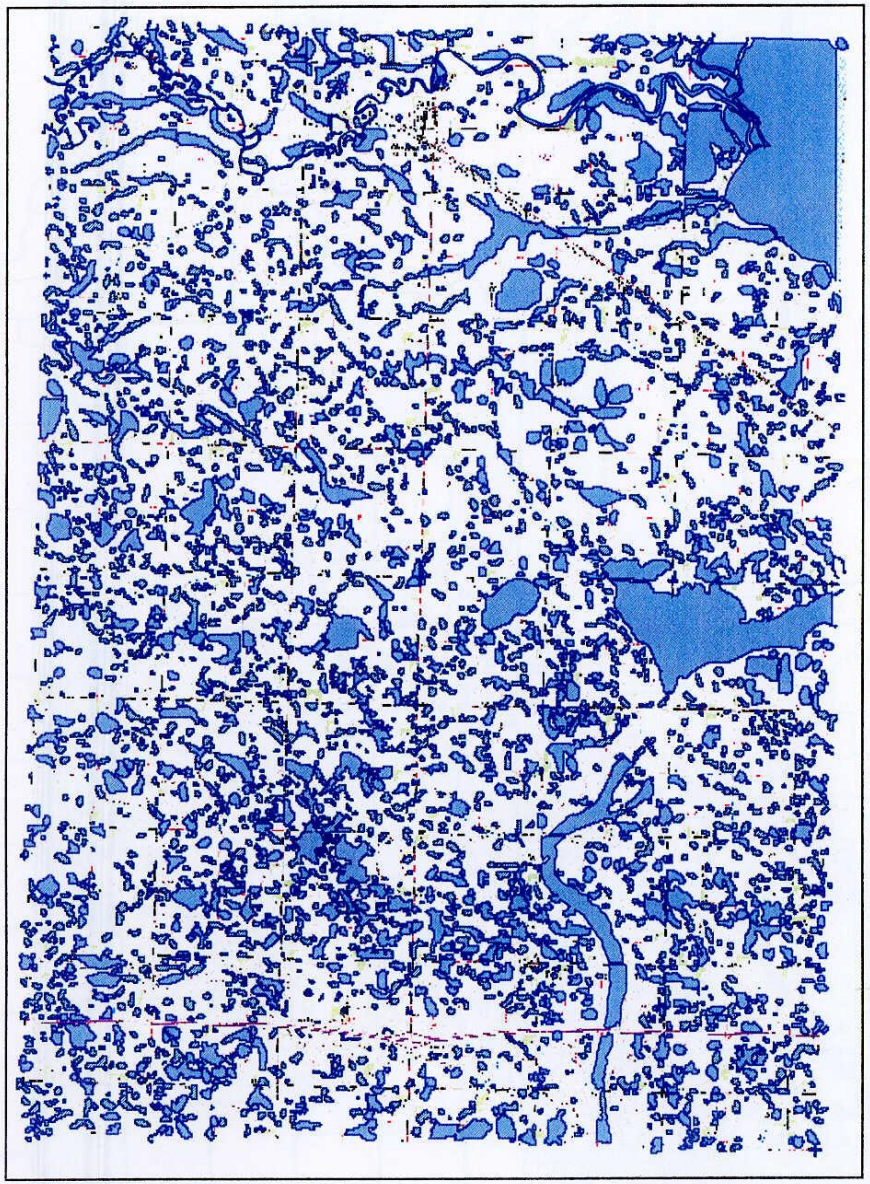
High Water Levels

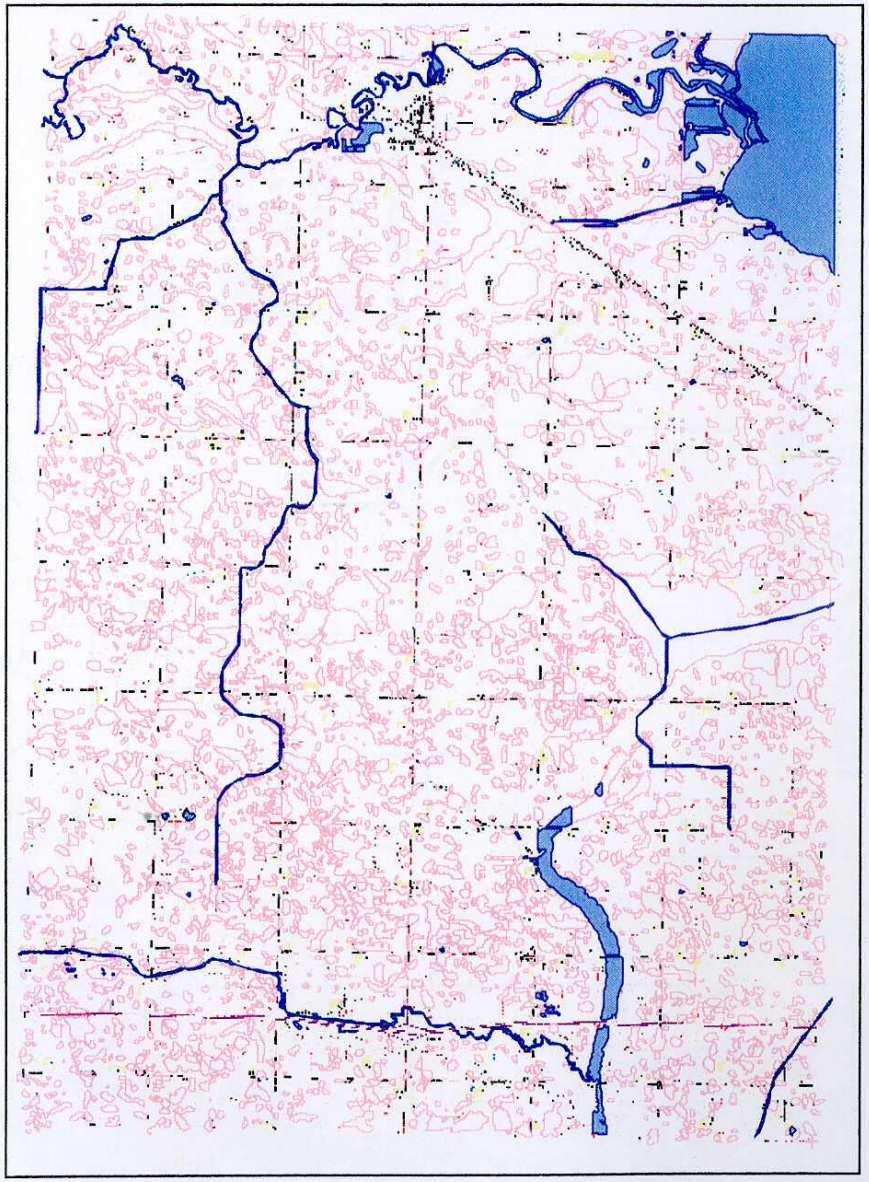
Minnesota Wetland Status



Source: Anderson , J and W. Craig, 1984. Growiing energy crops on Minnesota's wetlands: the land use perspective. U. of Minn. Center for Urban and Regional Affairs, Publ. CURA 84-3.

150 Years of Wetland Drainage in Minnesota



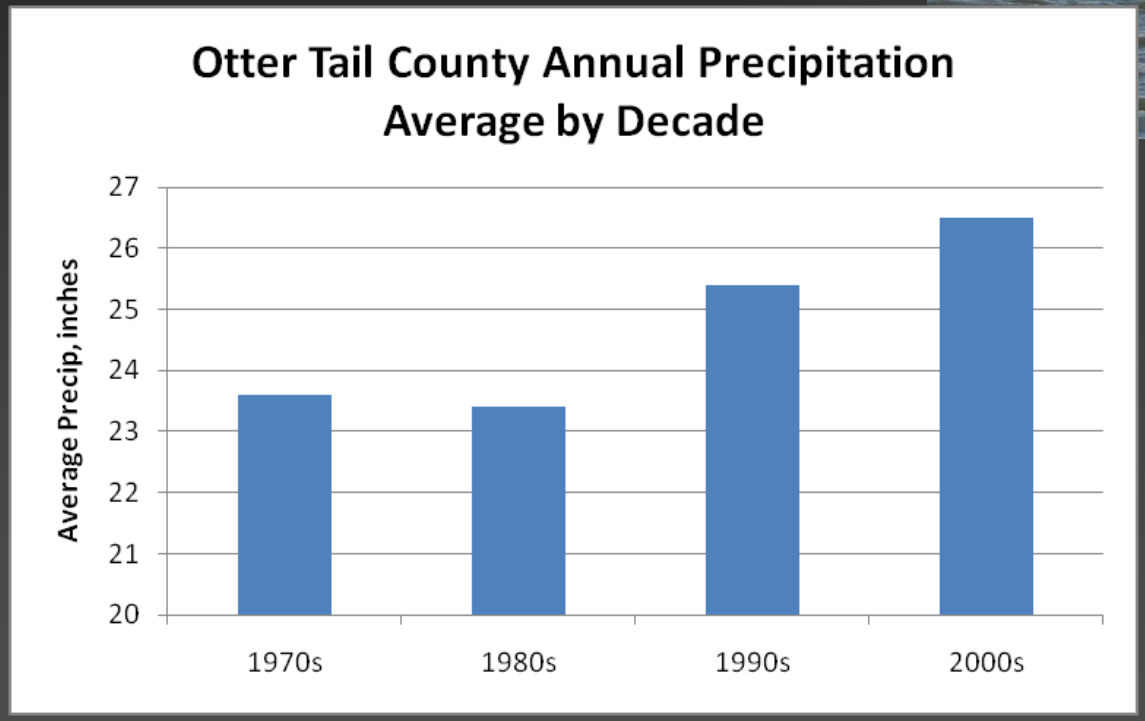


Circa 1844

50 mi^2 of Jackson County

Circa 1994

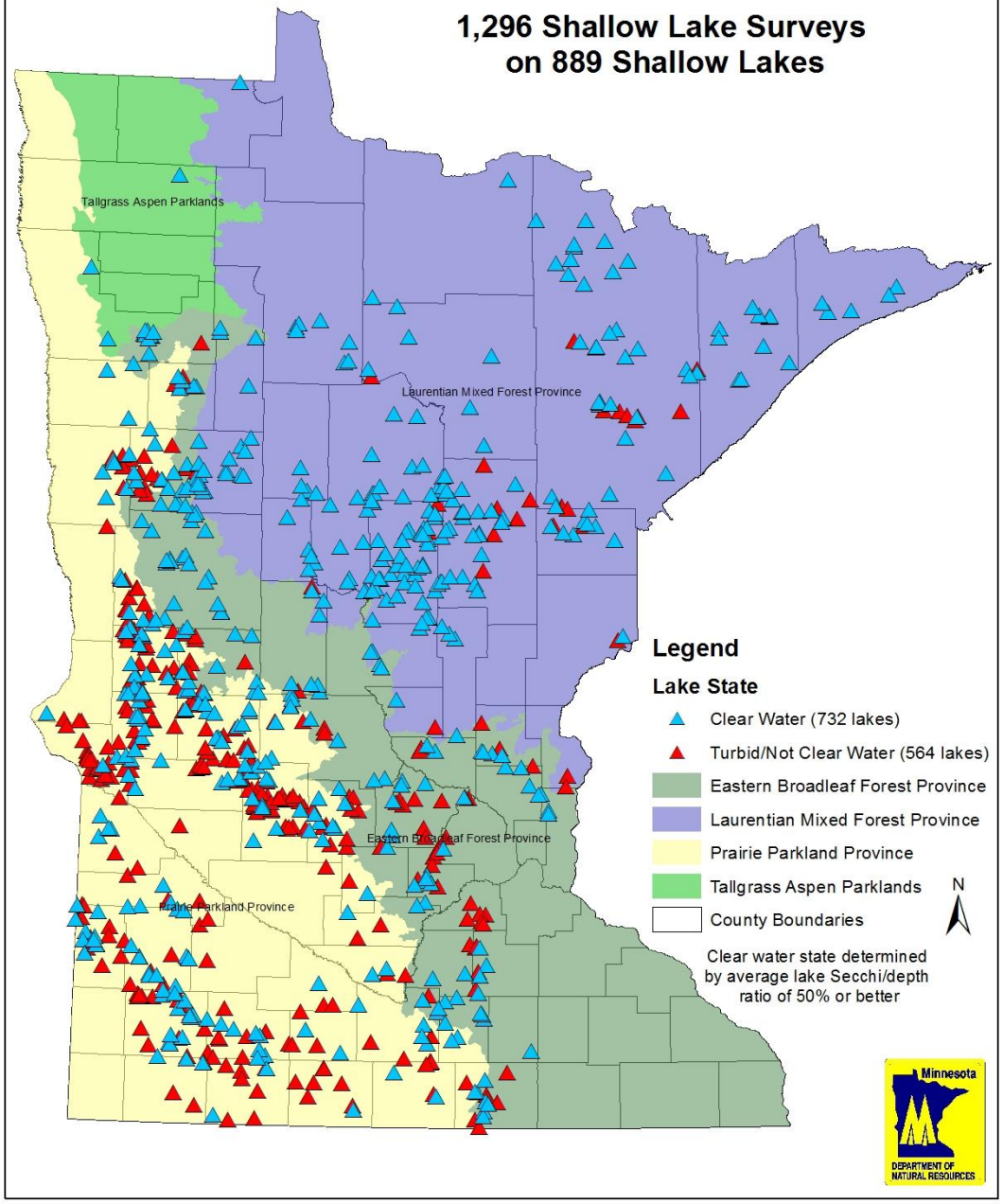
High Water Levels



Summarized from data from
Minnesota State Climatology Office


Blocked outlet channels

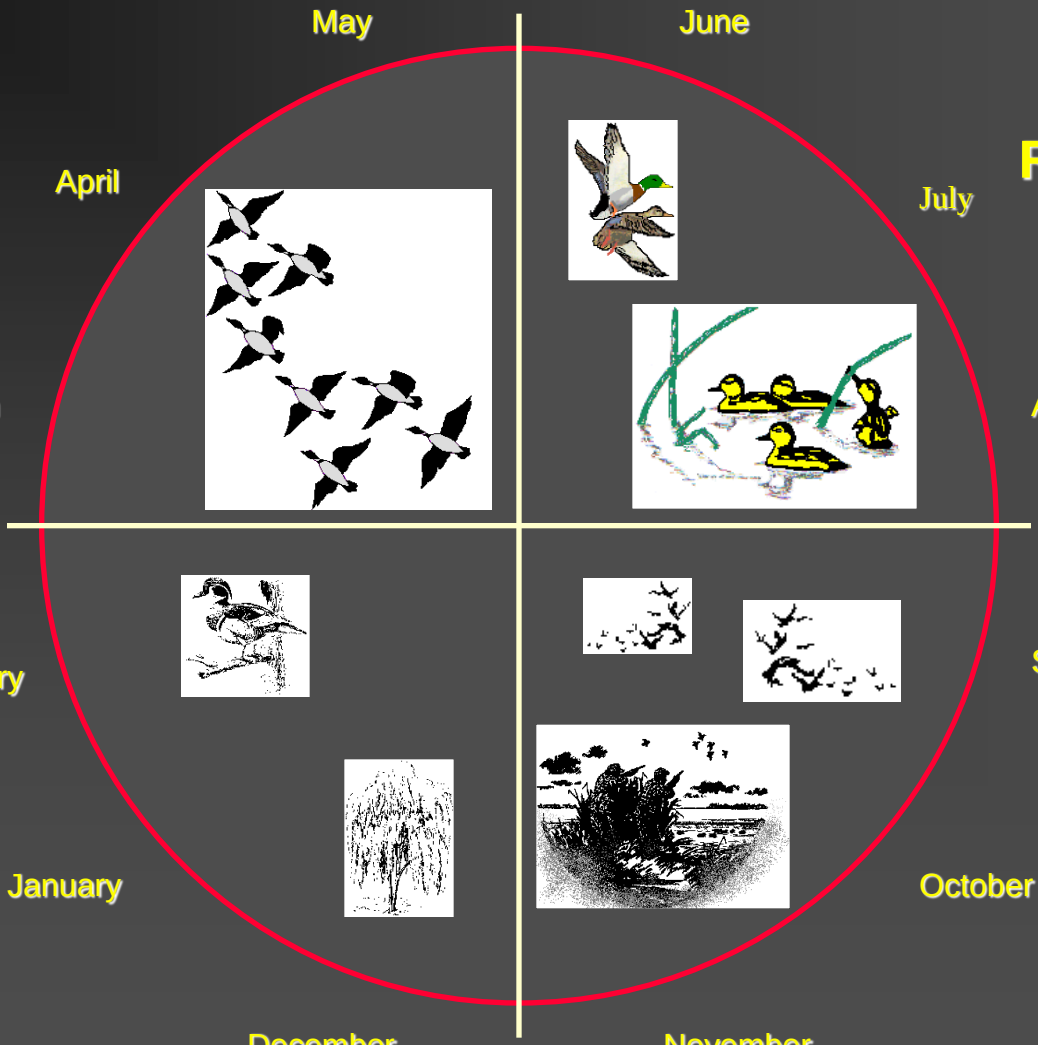
Shallow Lake Surveys 2002 - 2012



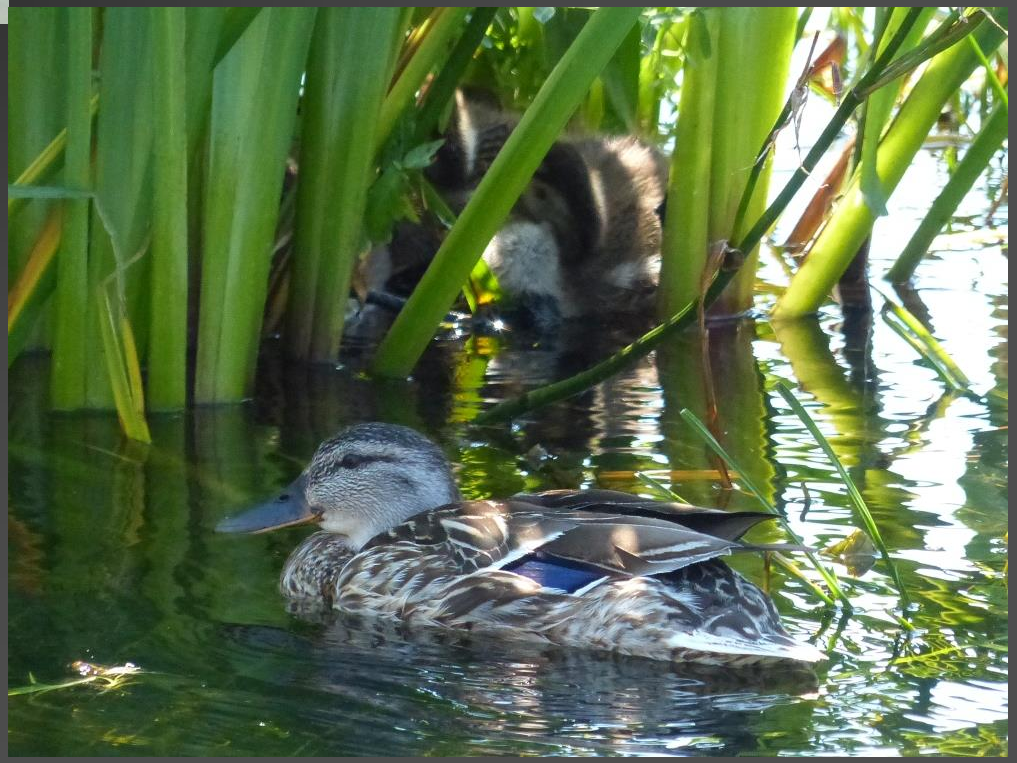
Why does the DNR want to manage shallow lakes for the clear water state?

- Maintain or improve wetland wildlife habitat especially for both migrating and breeding waterfowl.
  - Plants provide food
    - Seeds
    - Tubers
  - Plants provide cover and nesting material
  - Invertebrates provide needed protein and calcium
- Maintain or improve water quality

Annual Cycle for Waterfowl



Nesting and cover habitat



Seeds and tubers

Invertebrates

- Invertebrates contain up to 72% protein
- Excellent source of calcium
- Provide a complete range of essential amino acids
- Rapidly digested compared to plant material
- Efficient conversion of animal proteins to eggs and feathers




Importance of Invertebrates to Life History Stages of Ducks

- Egg-Laying
  - Energetically expensive
  - Protein and calcium requirements
  - Needed reserves for incubation
- Foods for Ducklings
  - 85-95% of diet of Class 1 ducklings
- Molting
  - Protein needed for feather production













Management Tools

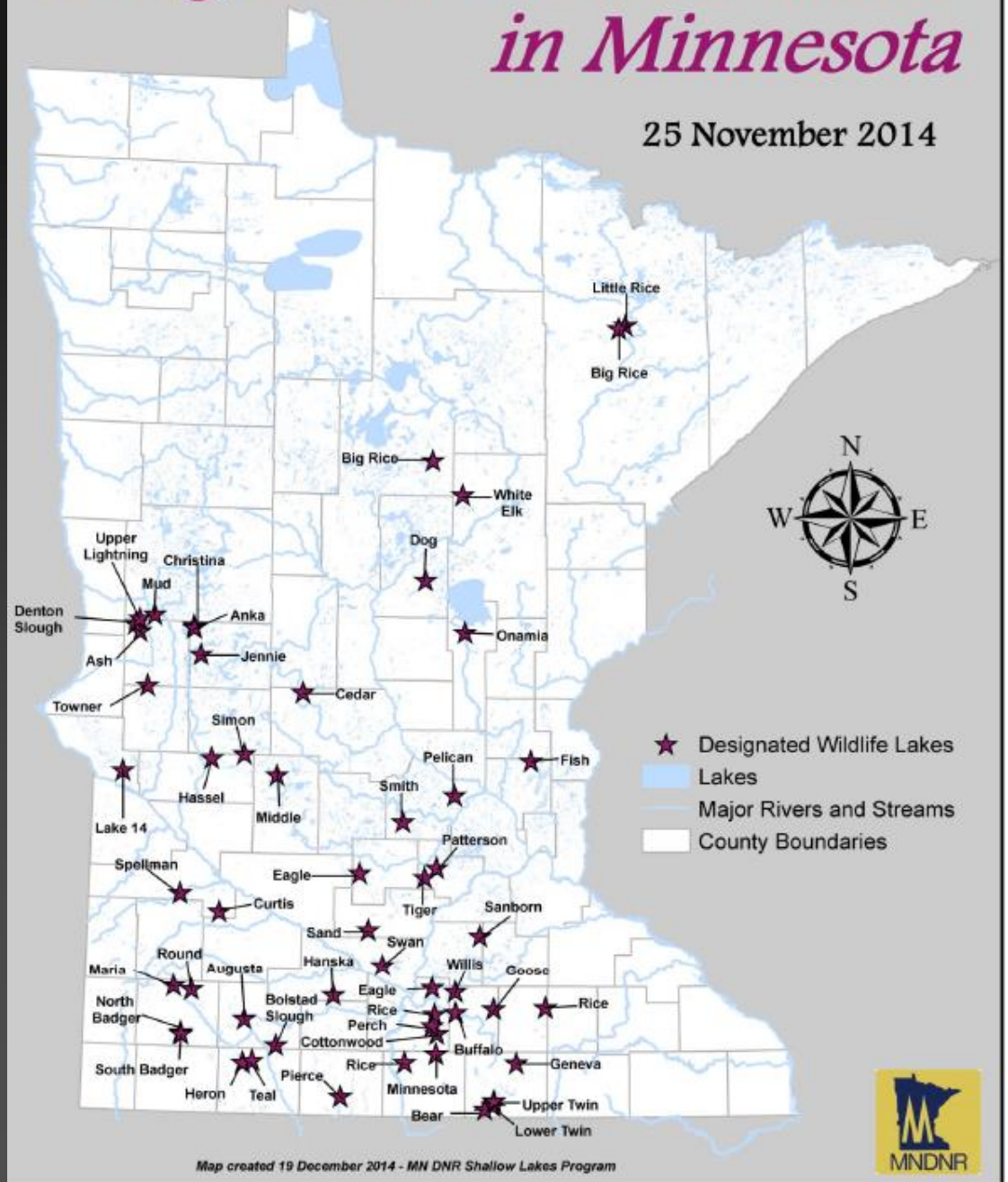
- Maintenance
  - **Protect lakes in good condition**
  - Outlet management
- In-lake management
  - Drawdowns
  - Fish community re-structuring
    - Rotenone treatments
    - Winter drawdowns
    - Fish barriers
  - Surface water use restrictions
- Watershed Management
  - Wetland Restoration
  - Grassland \Cover
  - Conservation easements\acquisition

Minnesota Shallow Lake Summary

	Lake Condition	Underlying nutrient Levels and landscape impacts	Management Approach
 Forest	Clear	Low	Focus on protection and outlet management for wild rice
 Transition	Clear or Turbid	Inter-mediate	May be needed-lakes usually respond well to management
 Prairie	More likely turbid	High	Aggressive management needed-difficult to maintain aquatic plants

Designated Wildlife Lakes in Minnesota

25 November 2014



Map created 19 December 2014 - MN DNR Shallow Lakes Program

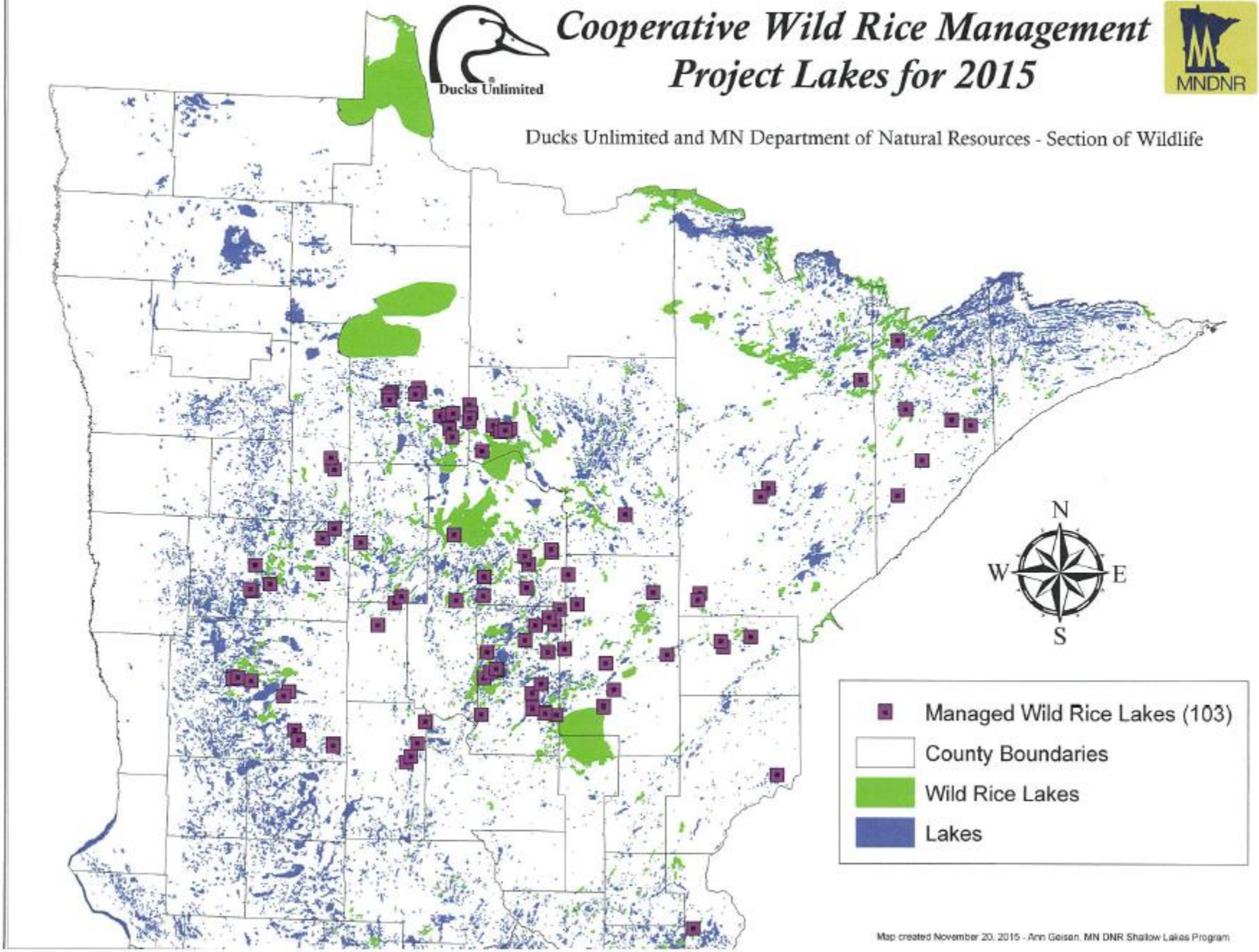

Outlet Maintenance

Cooperative Wild Rice Management Project Lakes for 2015

Ducks Unlimited

MNDNR

Ducks Unlimited and MN Department of Natural Resources - Section of Wildlife

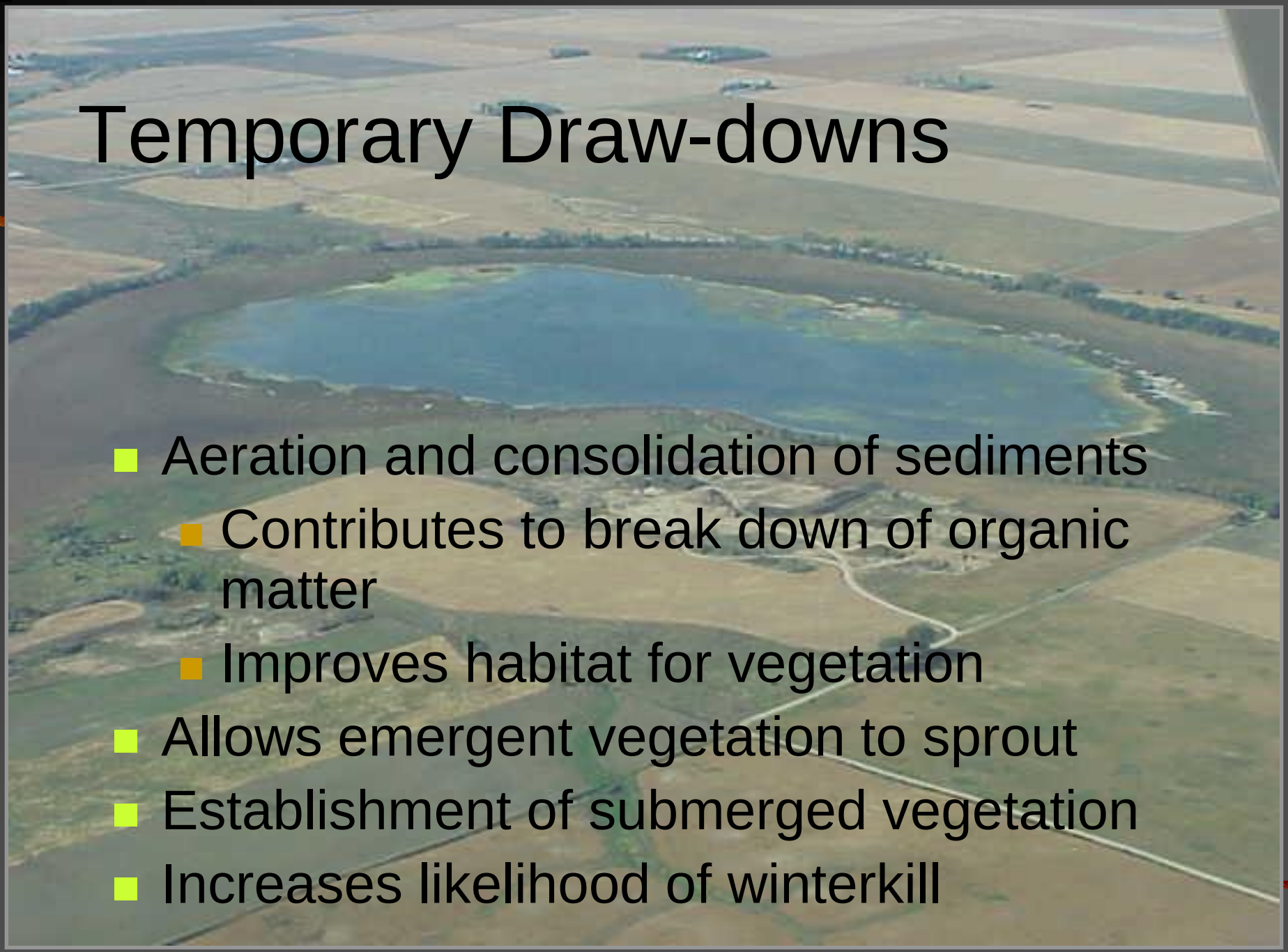


Map created November 20, 2015 - Ann Geisen, MN DNR Shallow Lakes Program

Drawdowns

- In-lake management
- Temporary lowering of water levels
- Enhance winterkill of fish
- Re-establish aquatic vegetation
- Quickly and effectively mimic droughts

Temporary Draw-downs



- Aeration and consolidation of sediments
  - Contributes to break down of organic matter
  - Improves habitat for vegetation
- Allows emergent vegetation to sprout
- Establishment of submerged vegetation
- Increases likelihood of winterkill

Water Level Drawdowns

- Our most effective management tool, like "shock therapy" for shallow lakes
- Requires the installation of a water control structure and downstream improvements
- Requires legal authority through Wildlife Lake Designation or MS103G.408
  - Management Plan and Public Hearing

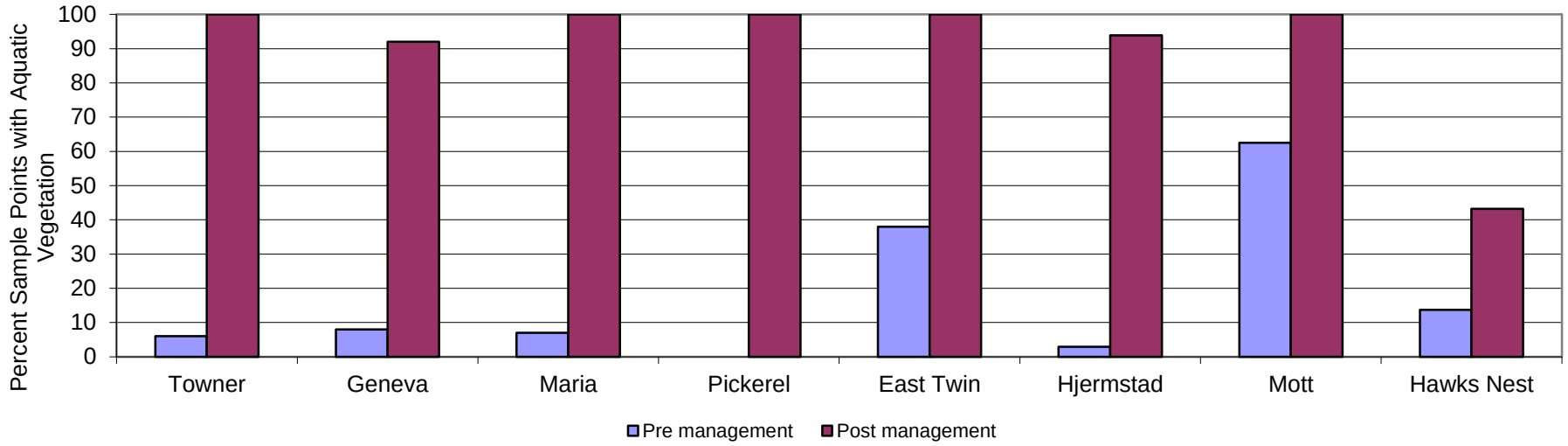
DRAWDOWN STRATEGY

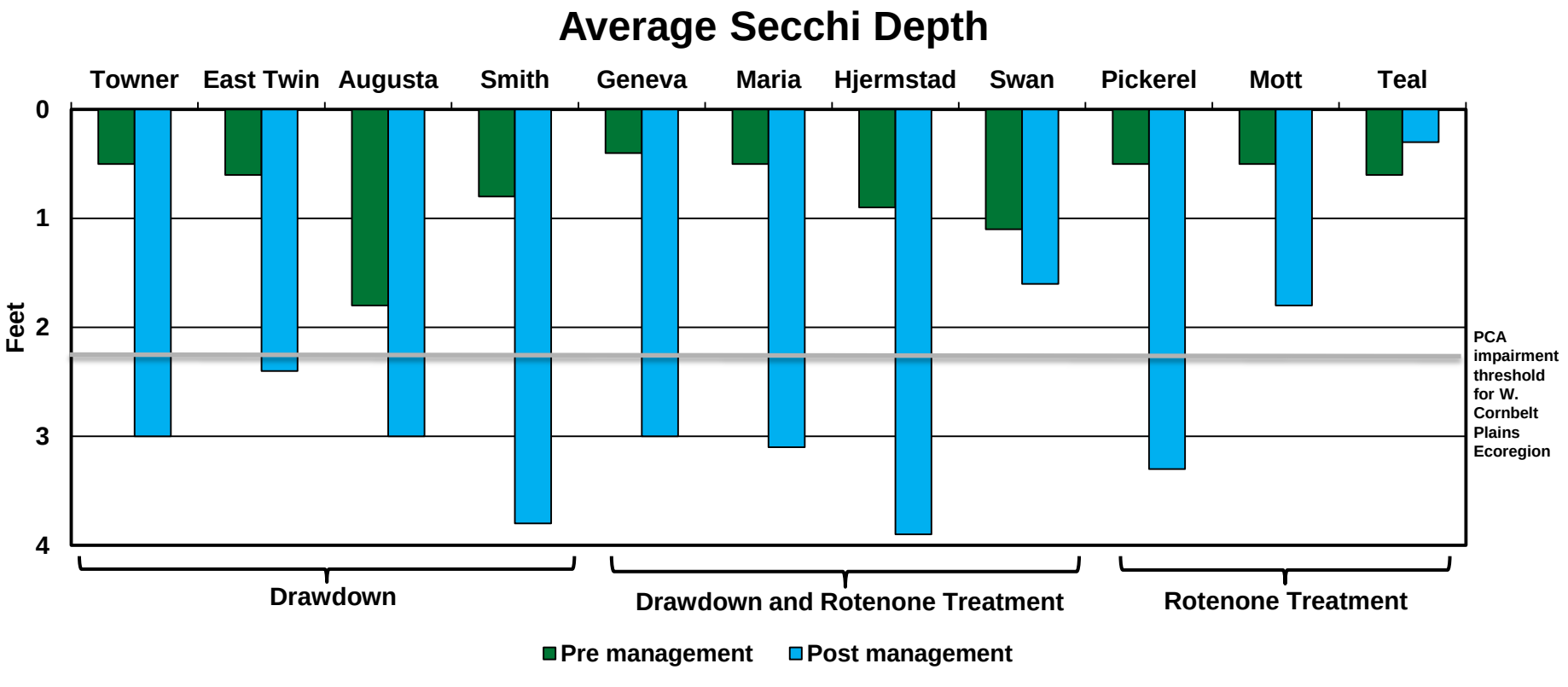
Frequency

Intensity

Timing

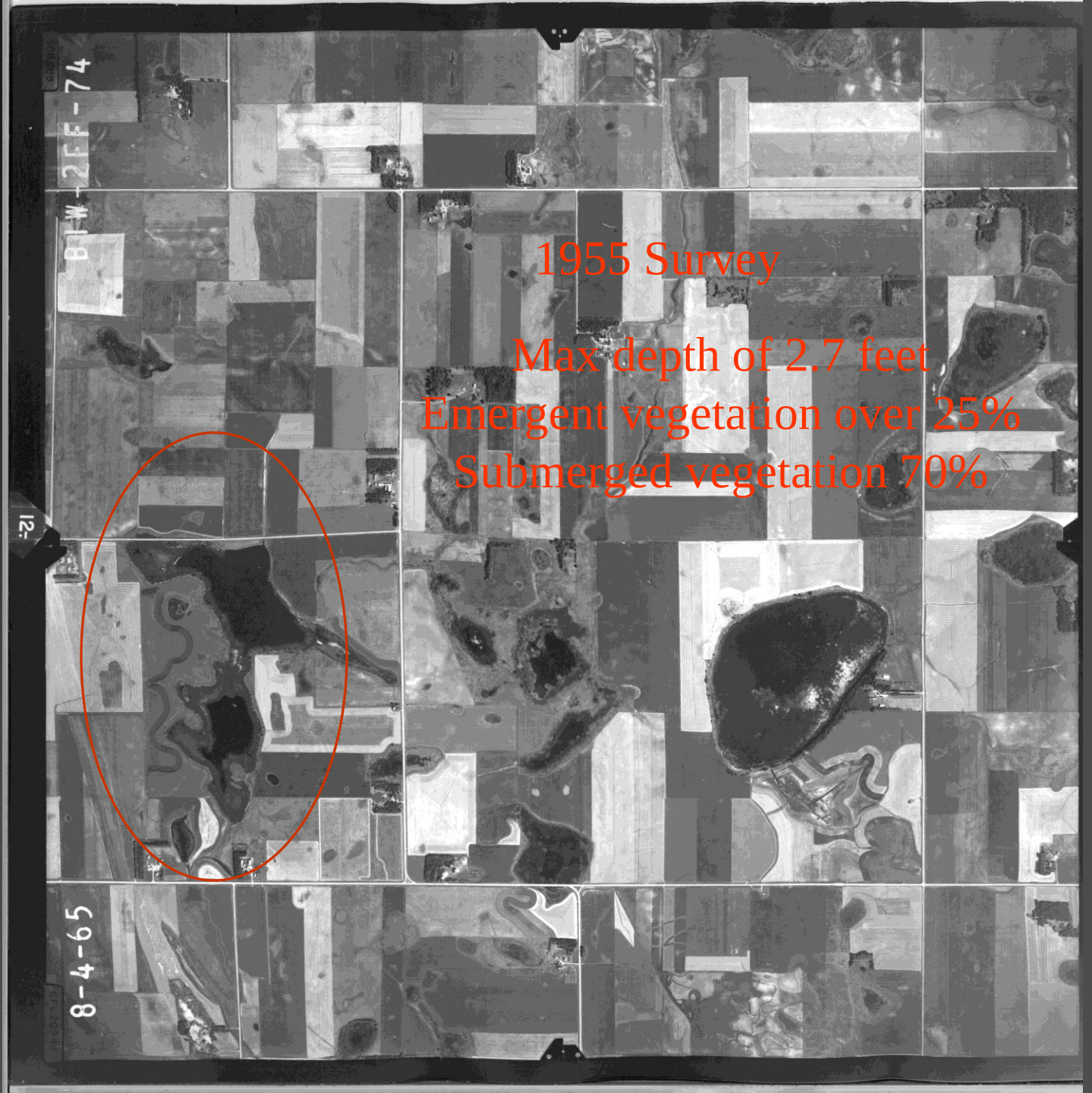
Rotenone Treatments


Percent Sample Points with Aquatic Vegetation
100
90
80
70
60
50
40
30
20
10
0
Towner
Geneva
Maria
Pickerel
East Twin
Hjermstad
Mott
Hawks Nest
Pre management
Post management


Average Secchi Depth
Towner
East Twin
Augusta
Smith
Geneva
Maria
Hjermstad
Swan
Pickerel
Mott
Teal
Feet
0
1
2
3
4
PCA impairment threshold for W. Cornbelt Plains Ecoregion
Drawdown
Drawdown and Rotenone Treatment
Rotenone Treatment
Pre management
Post management

MANAGEMENT EXAMPLES


Denton Slough
Kube-Swift WMA
Grant County
135 acres


1955 Survey
Max depth of 2.7 feet
Emergent vegetation over 25%
Submerged vegetation 70%
8-4-65


Denton Slough
DOW# 26030300
Grant County
July 21, 2011 Lake Survey
Vegetation and Depth
Access
4.50 4.50 4.50 4.75 4.00 3.50 4.25
3.50 4.25 4.25 4.75 5.25 5.25 5.00
5.00 5.50 5.25
5.00 5.50 5.50 4.75
4.00 5.00 5.00 5.25 4.25
3.25 4.50 4.50 4.50 4.50 4.50 3.50
4.75 4.25 3.75
4.00 4.25 4.75 3.75
3.00 5.00 5.00 4.75
3.25 4.75 5.00 5.00
4.50 5.00 4.75 4.75
4.00 3.50 4.25
4.00 4.50
4.50
Wildlife Lake Survey Results
N
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged / Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2010 FSA Orthophoto
600 300 0 600
Feet


Minnesota
DEPARTMENT OF
NATURAL RESOURCES
Ducks Unlimited


Fall 2011


Spring 2012


September 2012


3.1
1.60
1.50

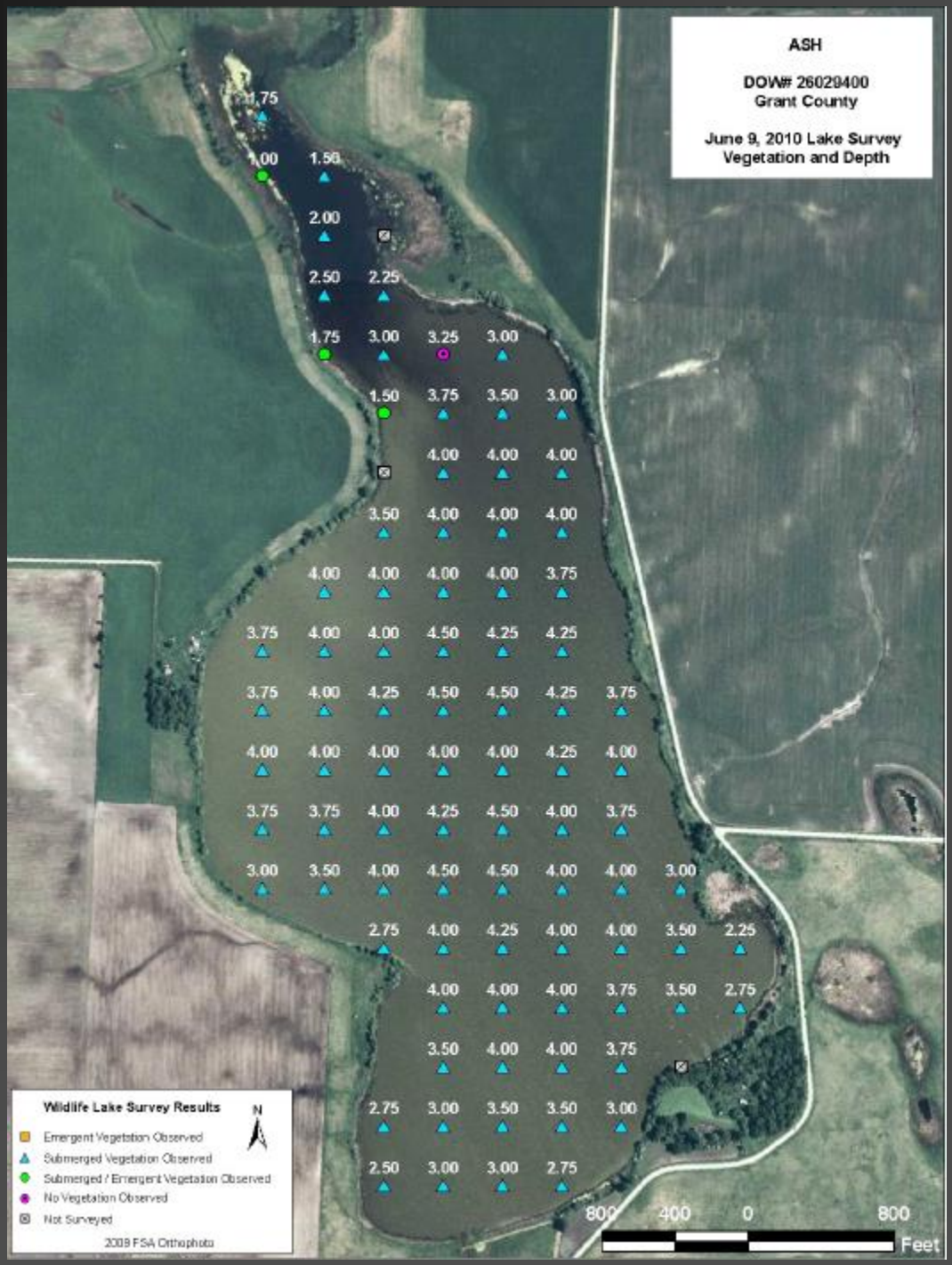

Denton Slough
DOW# 26030300
Grant County
July 23, 2014 Lake Survey
Vegetation and Depth
Access
3.25
3.5
3.75
3.75
3.75
3.5
4
4
4
3.75
4
4
3.75
3.25
3.75
4
3.75
3.75
3.25
3.5
3.25
3.5
4
3.75
3.75
Wildlife Lake Survey Results
N
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged / Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2013 FSA Orthophoto
700
350
0
700
Feet


2004


2015

Ash Lake, Grant Co.

216 ACRES


ASH
DOW# 26029400
Grant County
June 9, 2010 Lake Survey
Vegetation and Depth
1.75
1.00 1.50
2.00
2.50 2.25
1.75 3.00 3.25 3.00
1.50 3.75 3.50 3.00
4.00 4.00 4.00
3.50 4.00 4.00 4.00
4.00 4.00 4.00 4.00 3.75
3.75 4.00 4.00 4.50 4.25 4.25
3.75 4.00 4.25 4.50 4.50 4.25 3.75
4.00 4.00 4.00 4.00 4.00 4.25 4.00
3.75 3.75 4.00 4.25 4.50 4.00 3.75
3.00 3.50 4.00 4.50 4.50 4.00 4.00 3.00
2.75 4.00 4.25 4.00 4.00 3.50 2.25
4.00 4.00 4.00 3.75 3.50 2.75
3.50 4.00 4.00 3.75
2.75 3.00 3.50 3.50 3.00
2.50 3.00 3.00 2.75
Wildlife Lake Survey Results
N
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged / Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2009 FSA Orthophoto
800 400 0 800
Feet


Spring 2012


Summer 2012


September 2012


September 2013


Ash
DOW# 26029400
Grant County
July 22, 2014 Lake Survey
Vegetation and Depth
Access
Benchmark
900 450 0 900
Feet
Wildlife Lake Survey Results
N
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged / Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2013 FSA Orthophoto

Smith Lake

- 316 acres
- Wright County
- Water control structure installed in the winter of 2010-2011 to allow for almost complete drawdown
- Drawdown 2011-2012
- Gradual refilling 2012-2013


Smith
DOW# 86025000
Wright County
August 23, 2010 Lake Survey
Vegetation and Depth
1.75
3.50 4.25 4.25 4.25 4.00
4.50 5.00 5.00 4.75 4.75 4.00
2.50 3.00 3.50 4.00 5.00 5.25 5.25 5.00 5.00 5.00
3.25 3.75 4.00 4.25 5.00 5.25 5.00 5.00 5.00 5.00 5.00 3.50 2.75
3.50 3.50 3.50 4.00 4.50 4.25 4.50 4.75 5.00 5.00 5.00 4.00
3.25 3.50 3.00 3.00 3.25 4.25 4.25 3.50
3.00 3.25 2.75 3.00 2.75 3.00
3.00 3.25 3.00
2.75 3.25 2.25
Access
Benchmark
Wildlife Lake Survey Results
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged/Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2010 FSA Orthophoto
N

Survey Map


KOMATSU


KOMATSU

High velocity tubes


August
2011

May and June
2012-
Daphnia soup


July 2012

At least 12 Species of Greatest Conservation Need documented during and after drawdown


Smith
DOW# 86025000
Wright County
June 09, 2014 Lake Survey
Vegetation and Depth
3.25
3.00
3.00
3.00
4.00
4.00
4.00
3.50
3.00
3.00
4.00
4.00
4.00
4.00
4.00
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Access
3.00
4.00
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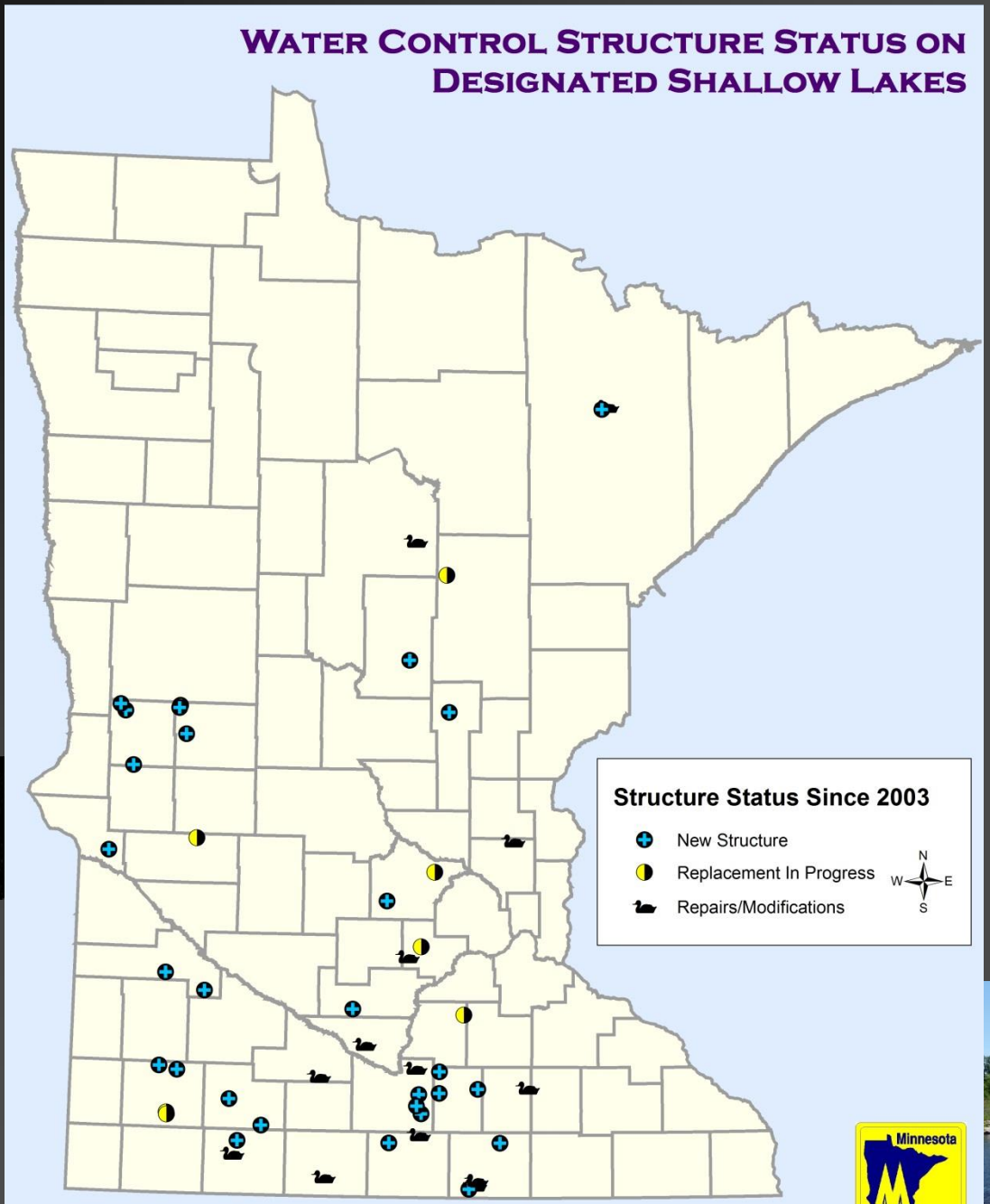
4.00
4.00
4.00
2.75
3.50
3.50
3.50
4.00
4.50
4.00
3.75
3.00
Benchmark
2.00
3.50
3.00
1,000
500
0
1,000
Feet
Wildlife Lake Survey Results
N
Emergent Vegetation Observed
Submerged Vegetation Observed
Submerged / Emergent Vegetation Observed
No Vegetation Observed
Not Surveyed
2013 FSA Orthophoto


Smith Lake
2015

Water Control Structure Status on Designated Shallow Lakes



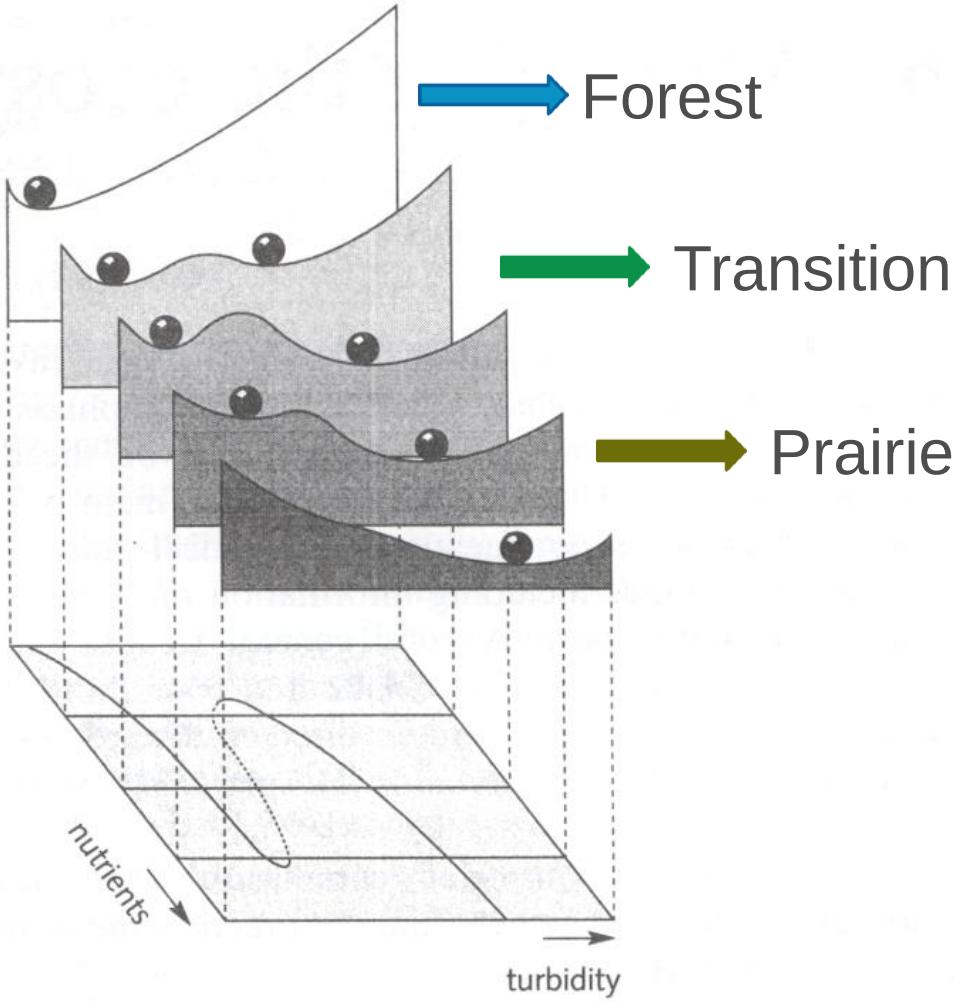


Fig. 6.1 'Marble-in-a-cup' representation of stability at five different levels of nutrient loading. The minima correspond to stable equilibria, tops to unstable breakpoints (see text). Modified from Scheffer (1990).

Questions?