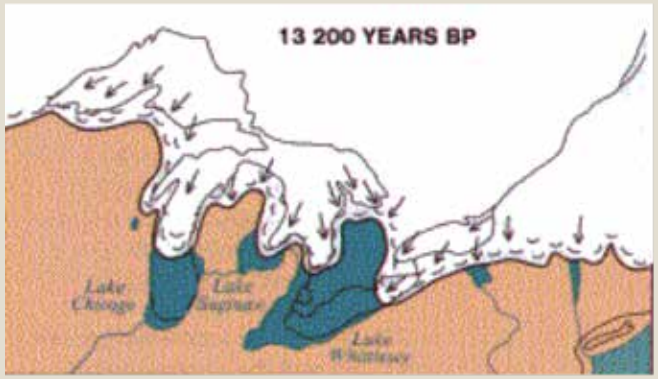
Basics of Lake Ecology

Courtesy of Lake Partnerships
Wisconsin Department of Natural Resources
Wisconsin Association of Lakes
University of Wisconsin Extension

Talk Outline

- Overview
- Physical, chemical, biological aspects of lakes
- Types of lakes
- Q & A

Wisconsin's Glacial Legacy

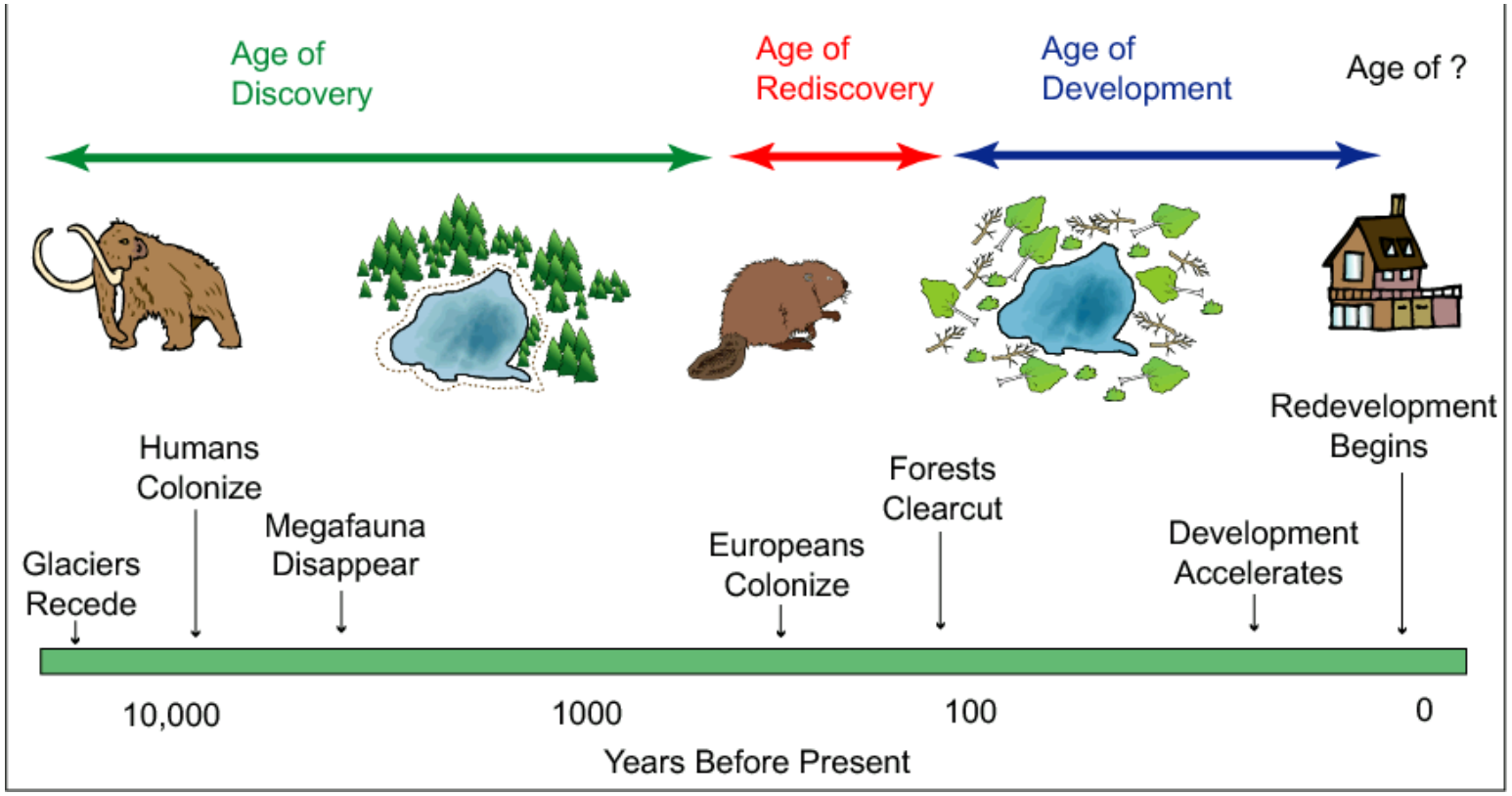


Wisconsin Lakes

Wisconsin has the 3rd largest concentration of fresh water glacial lakes on the planet.

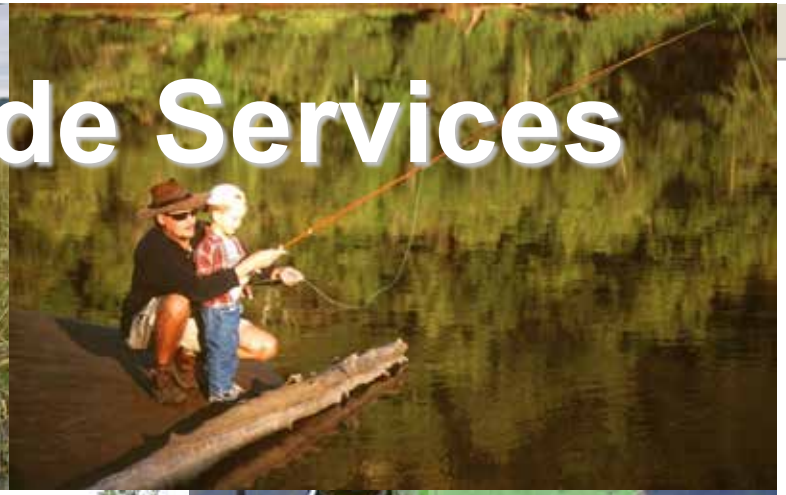
The Wisconsin Lakes Partnership

Recent History of Wisconsin's Lakes



Steve Carpenter

Lakes Provide Services



Ecosystem

Cultural

Societal

Wisconsin's Lakes are Changing Faster than Ever:

Algae blooms
(phosphorus pollution)

Destruction of
shoreline habitat

Invading plants and
animals

Climate Change
Temps and Hydrology

Steve Carpenter

Factors Important to Lake Composition

To understand how lakes will respond to stressors and in order to set realistic expectations about potential benefits, you should understand some basic characteristics:

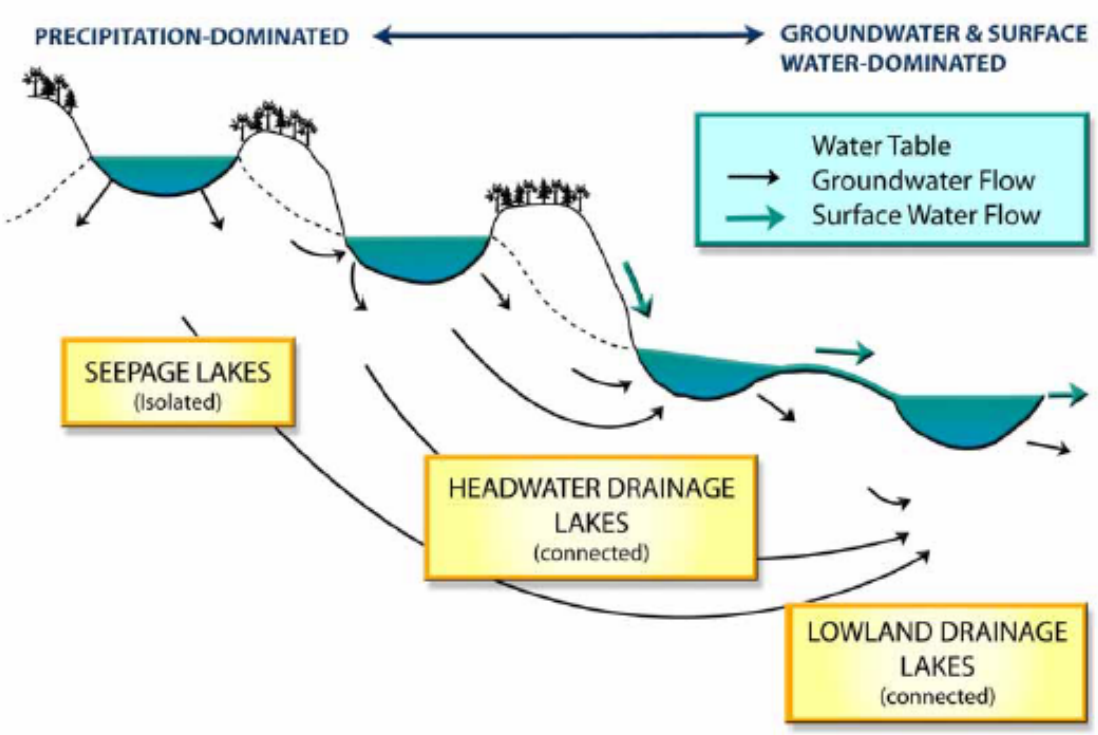
- Physical
- Chemical
- Biological

PHYSICAL CHARACTERISTICS

- Drivers of what is in the water

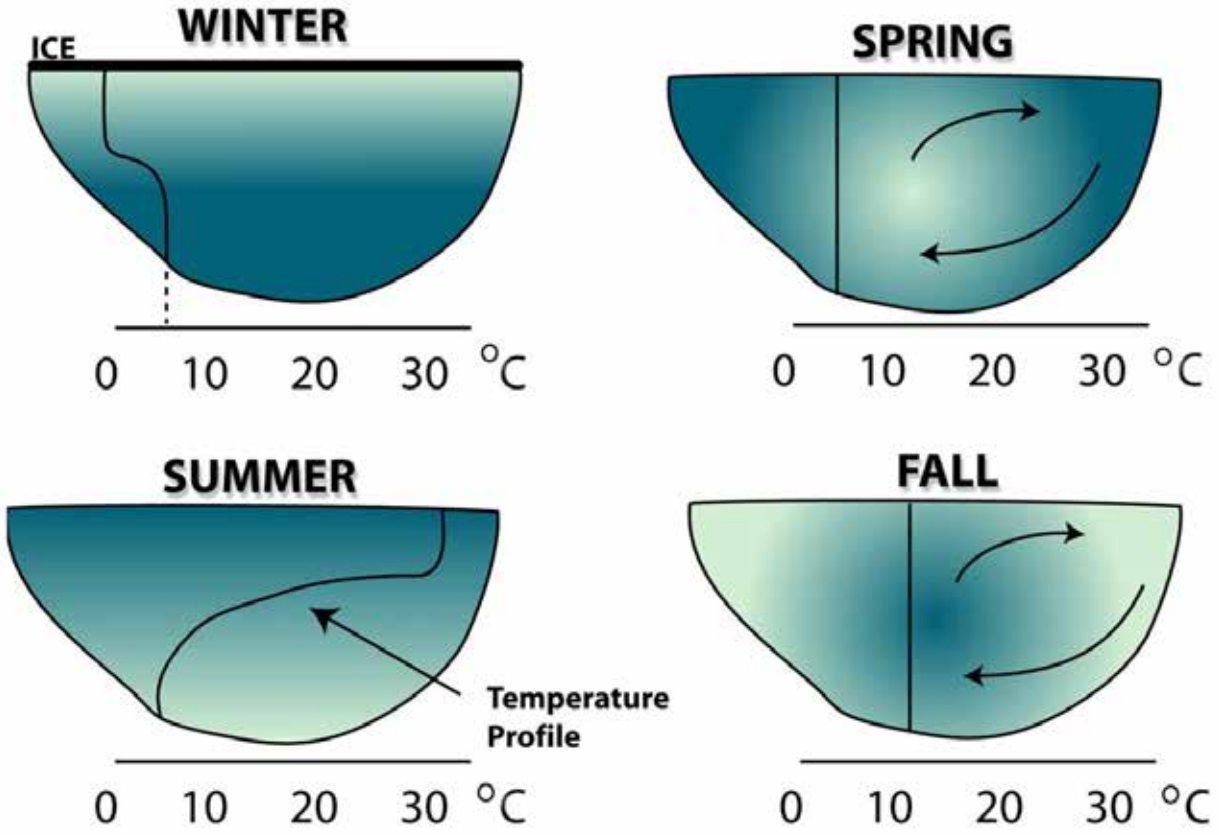
- Landscape Position
- Watershed Size
- Lake Depth

Landscape Position



Low nutrients	⟷	High nutrients
Fewer fish, snail, insect and plant species	⟷	More complex food web
Light Management	⟷	Increasing Management Scale

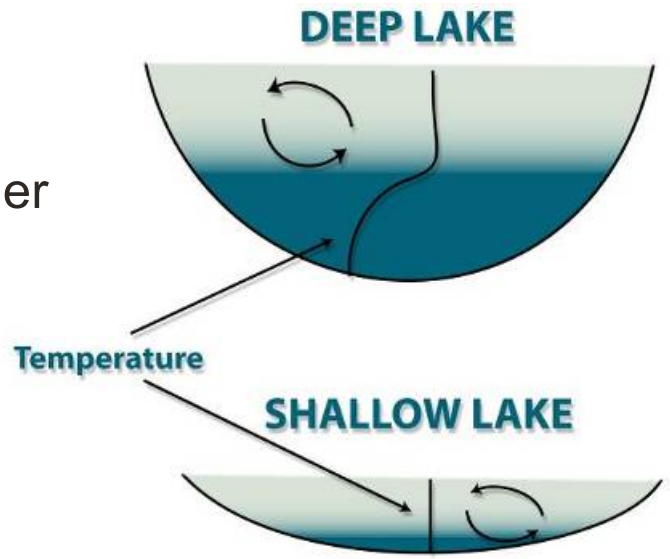
Lake Depth - Mixing/Stratification



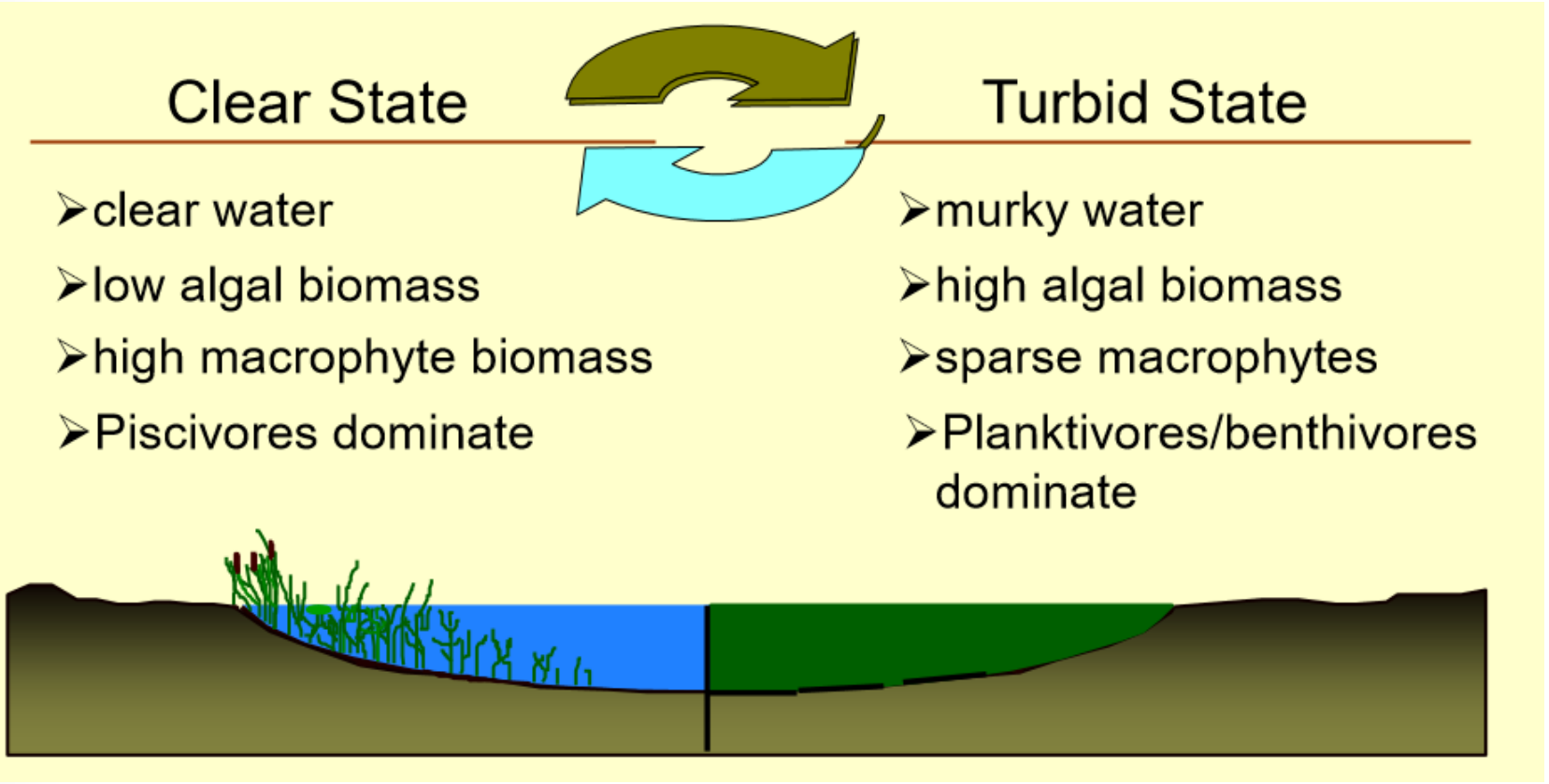
Lake Depth - Mixing/ Stratification

- **Deep Lakes**
  Stratified into layers
  Nutrients drop out of epilimnion during summer
  Nutrients mixed throughout during turnover

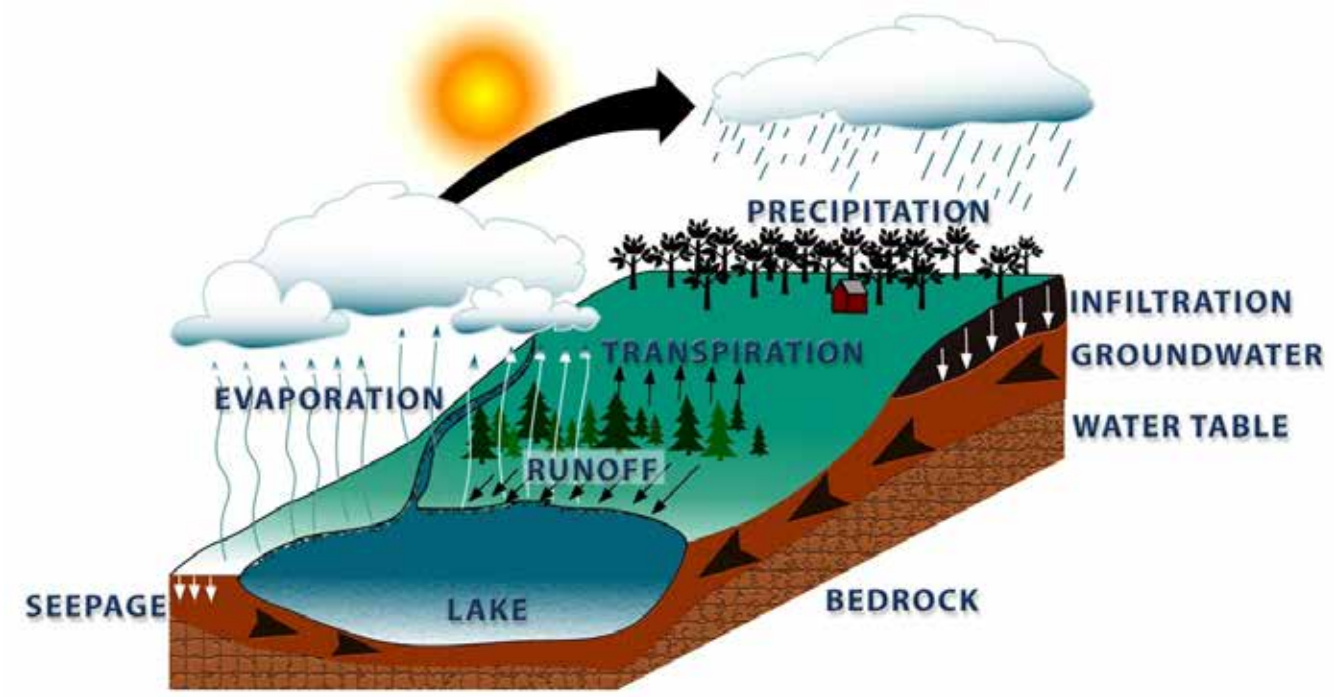
- **Shallow Lakes**
  Mix most of the time
  Continuous nutrient recycling



Problems More Noticeable in Shallow Lakes

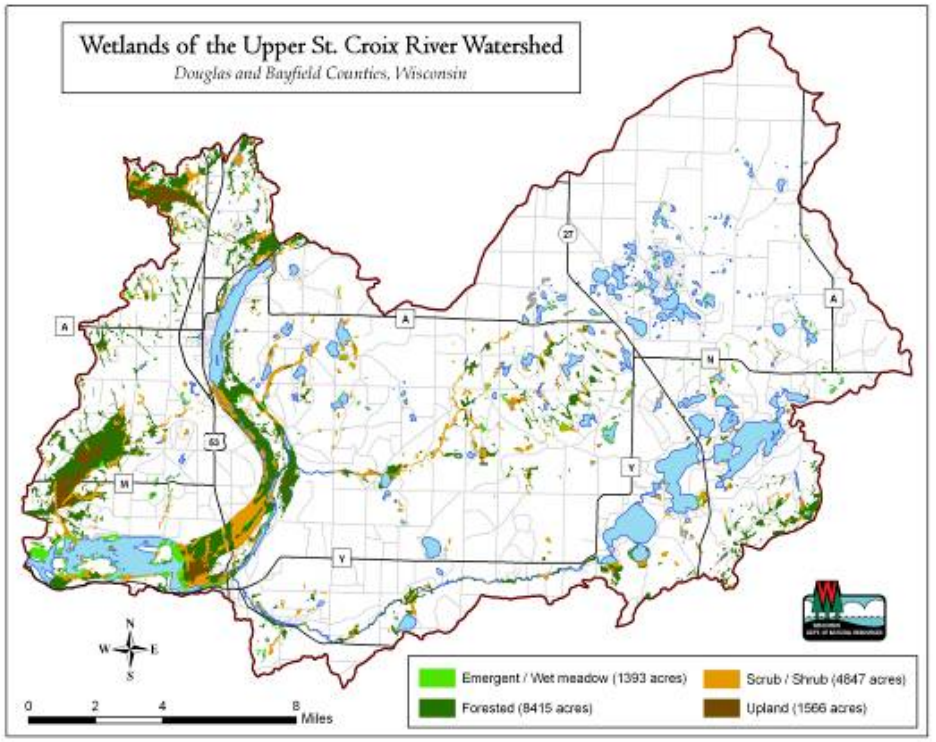


HYDROLOGIC CYCLE



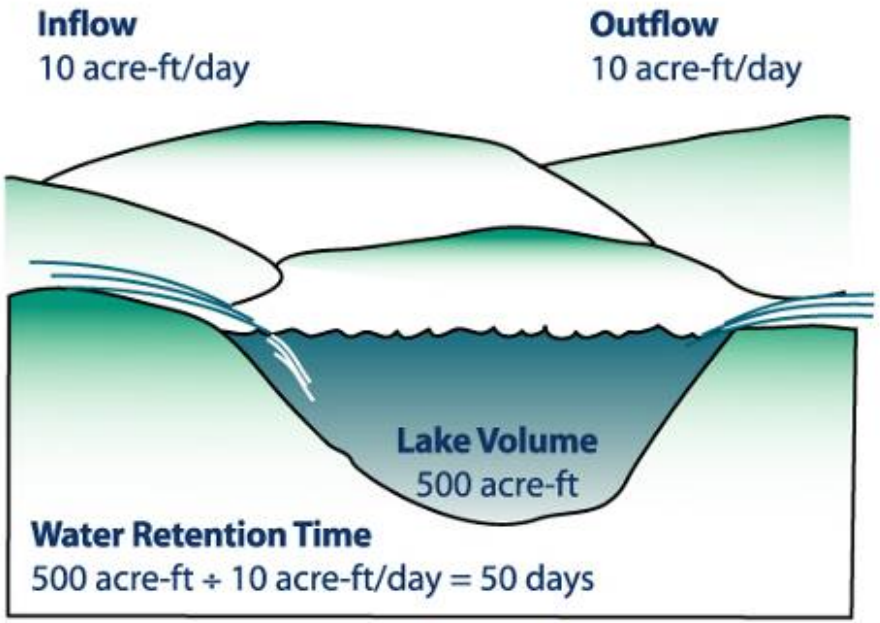
Watershed Size

- Larger watershed have more surface water runoff
- Seepage lake - small
  - Wheeler Lake – 1 square mile
- Drainage lake – medium to large
  - Headwater vs Lowland
  - Lake Menomin - 1788 square miles



Water Residence Time/Flushing Rate

- How long would it take to fill a drained lake?
- Riverine impoundment vs. deep drainage lake
  - Upper Red Lake, Shawano Co, 6 days
  - Peppermill Lake, Adams Co, 130 days
  - Upper Buckatabon, Vilas Co, 770 days
- Lakes with very short residence times are a reflection of the river running through them.
- Algae do not have time to reproduce if the residence time is very quick.



CHEMICAL CHARACTERISTICS

- Nutrients
  - P
  - N
- pH
- Hardness/ Alkalinity
- Dissolved Oxygen (optimum 5 ppm)

NUTRIENT FUNCTIONS

ELEMENT	AVAILABILITY	DEMAND	AVAILABILITY DEMAND	FUNCTION
Na	32	0.5	64	Cell membrane
Mg	22	1.4	16	Chlorophyll, energy transfer
Si	268	0.7	383	Cell wall (diatoms)
P	1	1	1	DNA, RNA, ATP, enzymes
K	20	6	3	Enzyme activator
Ca	40	8	5	Cell membrane
Mn	0.9	0.3	3	Photosynthesis, enzymes
Fe	54	0.06	900	Enzymes
Co	0.02	0.0002	100	Vitamin B12
Cu	0.05	0.006	8	Enzymes
Zn	0.07	0.04	2	Enzyme activator
Mo	0.001	0.0004	3	Enzymes

Phactoids: Importance of P to organisms

- **Phosphorus is a critical nutrient**
  - Genetic molecules: DNA, RNA
  - Structural molecules: phospholipids in cell walls
  - Energy metabolism: ATP
  - ***Every living organism needs phosphorus***
- **A little P goes a long way**
  - 1 lb of P can produce 500 lb of algae, and that P can be recycled many times
- **Phosphorus is less abundant than most other nutrients**
  - Both N and P tend to be high in demand by organisms, relative to their supply in the environment
  - N is often the limiting nutrient in terrestrial and marine ecosystems (with P close behind...)
  - ***But in lakes, P is nearly always the principal limiting nutrient***

LIMITING NUTRIENT PRINCIPLE

…That Nutrient in Least Supply
Relative to Plant Needs

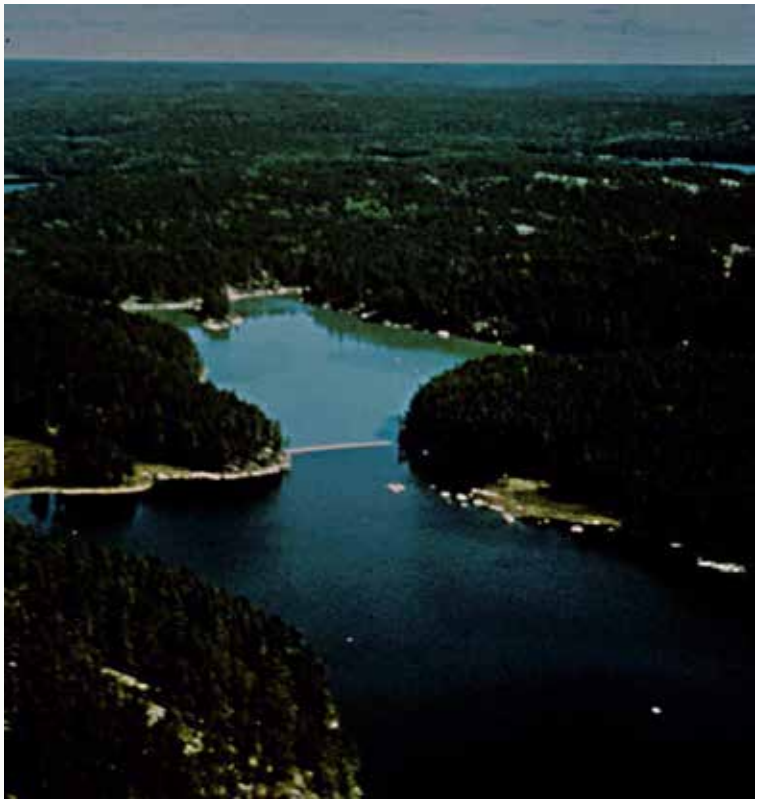
N:P Ratio in plant Tissue 10:1 - 15:1

If the Ratio of N:P in Water is

<10:1 Nitrogen Limited

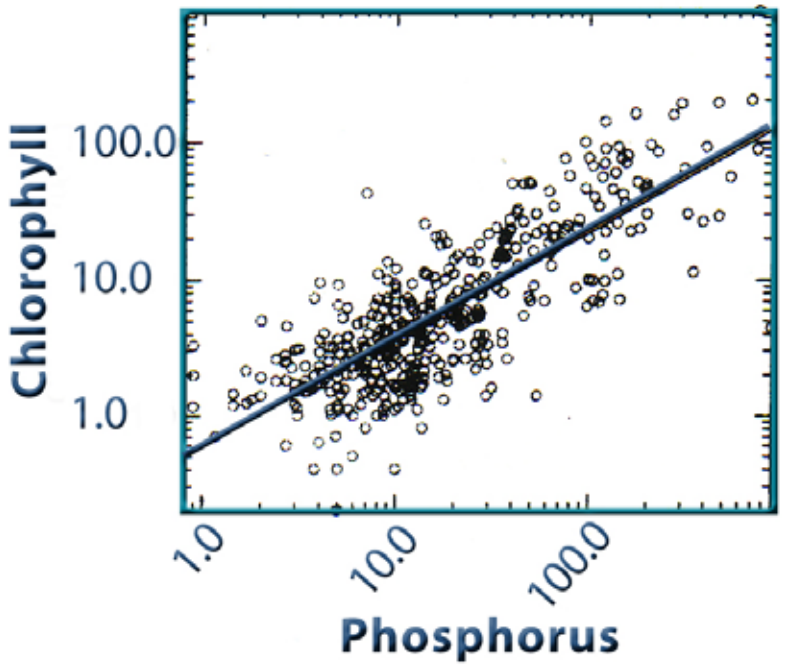
>15:1 Phosphorus Limited

PHOSPHORUS LIMITATION
LAKE 226



TOTAL PHOSPHORUS/ CHLOROPHYLL a RELATIONSHIP

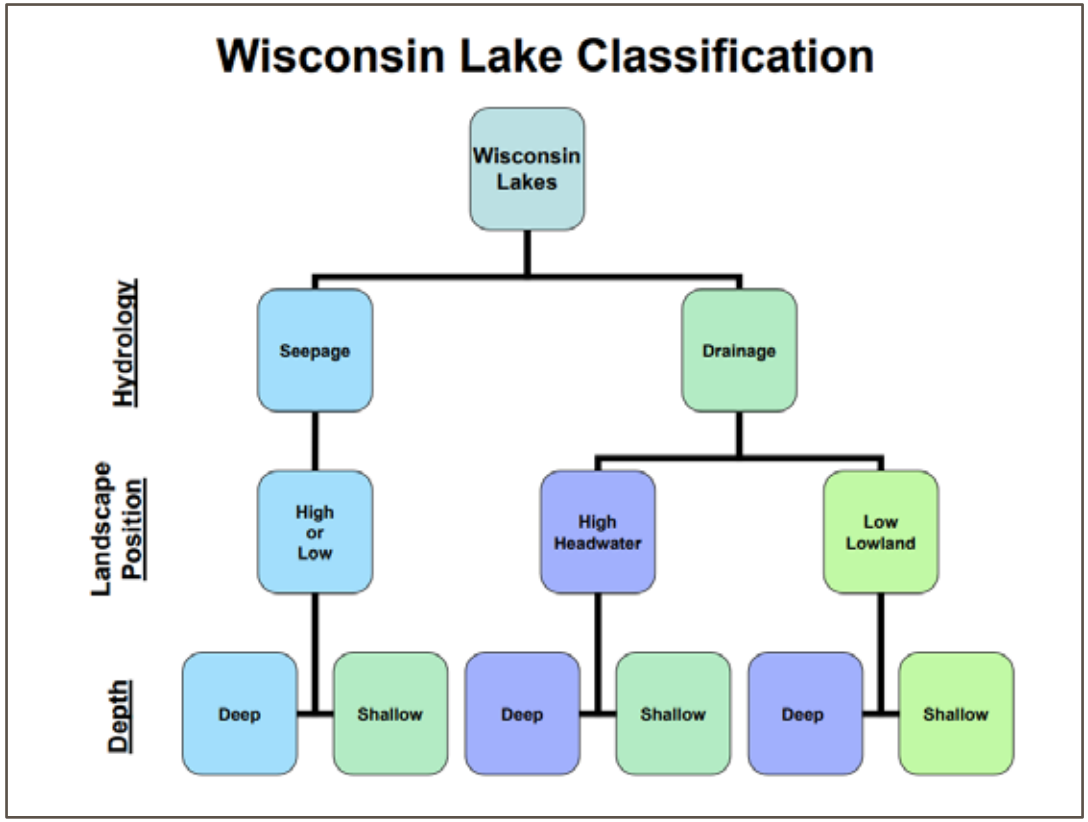
- Phosphorus causes algae to grow



WisCALM or Water Quality Classification

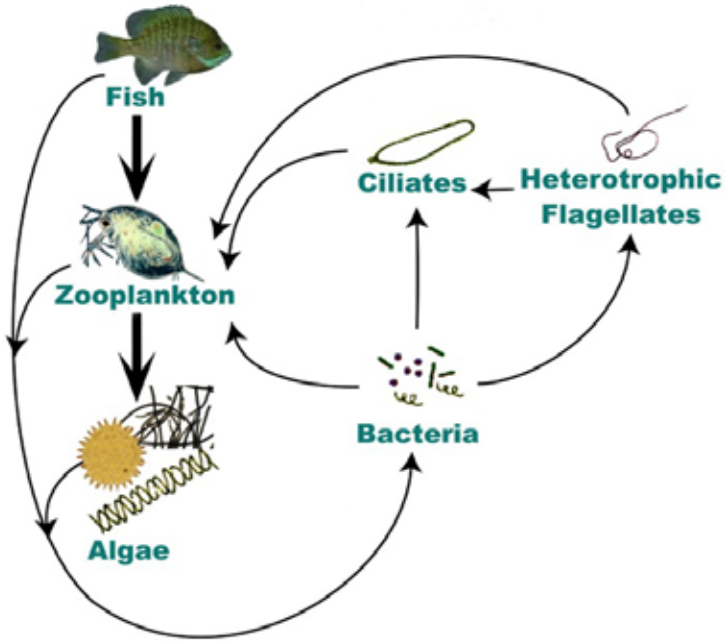
- Drainage – headwater vs lowland – based on size of upstream watershed
- Seepage – clear vs dark
- Depth – deep vs shallow (stratified vs polymictic)
- Reservoir – riverine vs impoundment (based on residence time)
- Unique types – spring ponds, meromictic, two-story fishery

- Shallow lakes/reservoirs – higher nutrients
- Deep drainage lakes/reservoirs – medium
- Seepage lakes – lower nutrients

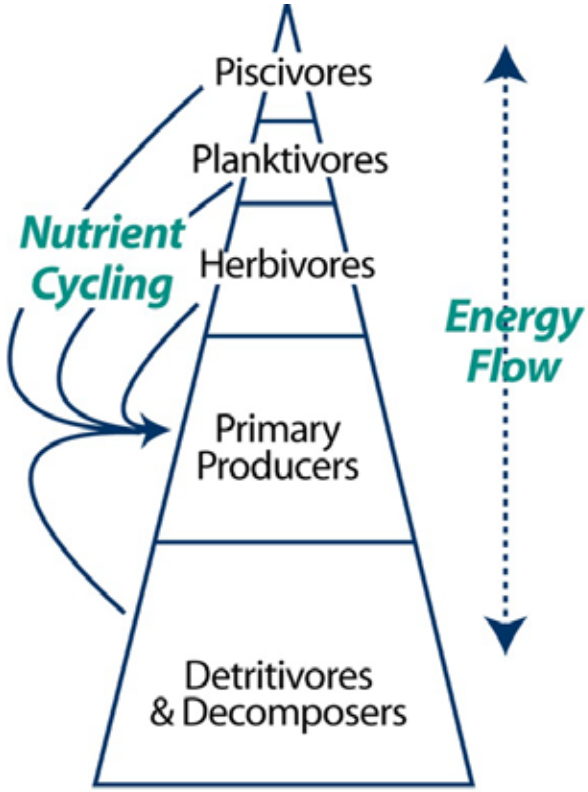


Biological Characteristics

- Trophic pyramid
- Primary producers
- Consumers
- Fish
- Trophic state



Trophic Pyramid

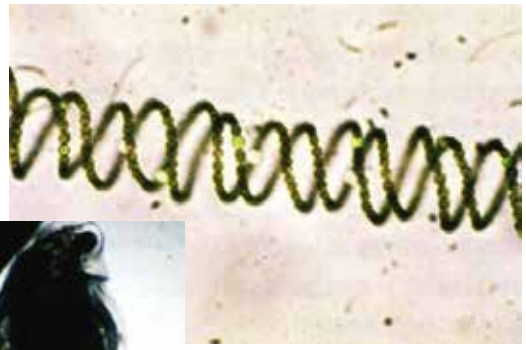


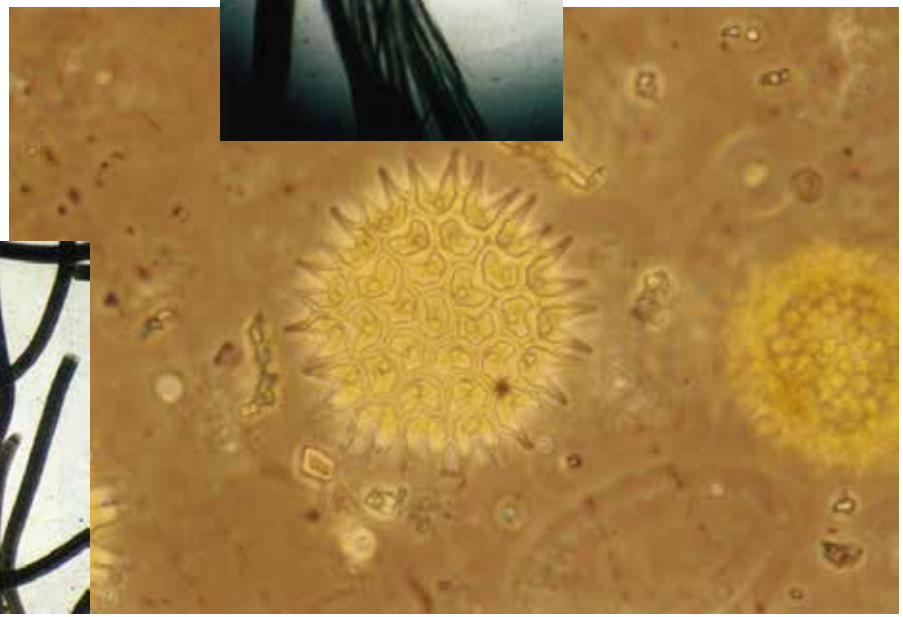
ENERGY PYRIMID

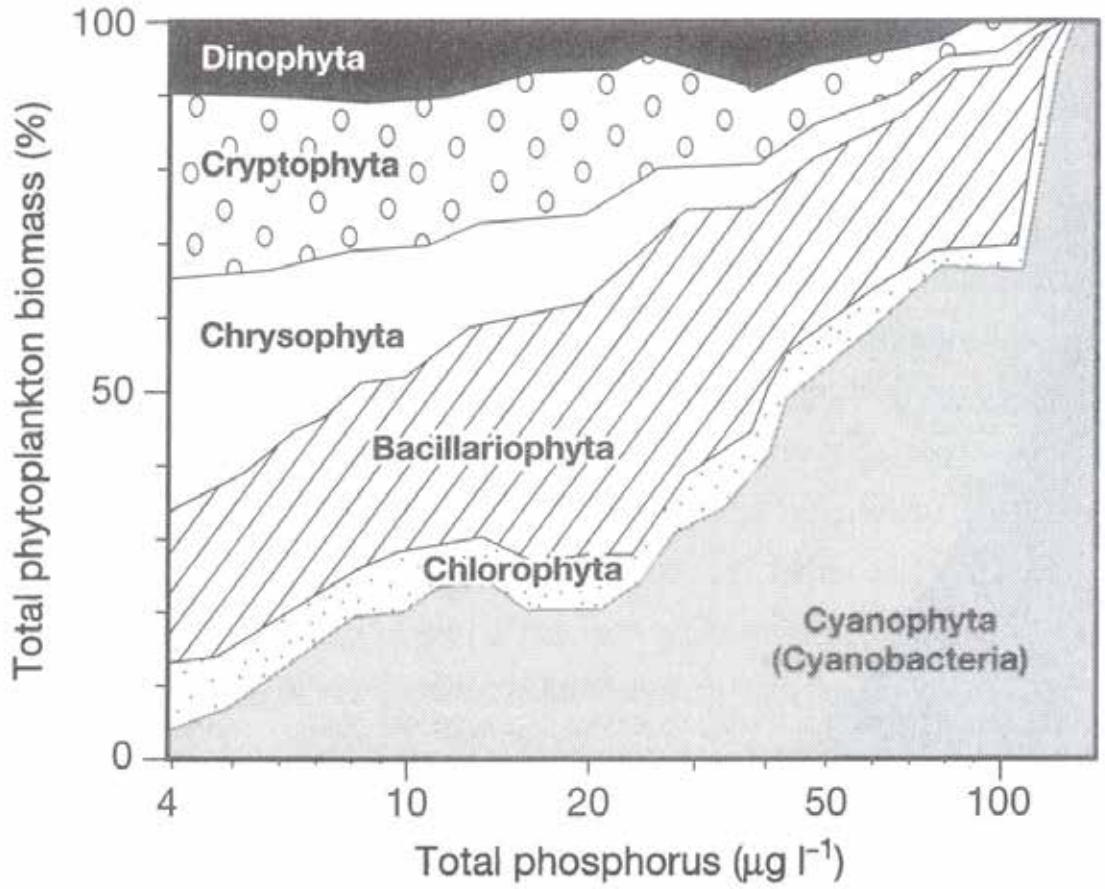
AQUATIC FOOD CHAIN

ALGAE

- Primary Energy Source for Invertebrates
- Can be Nuisance and Human Health Issue
- Produce O_2

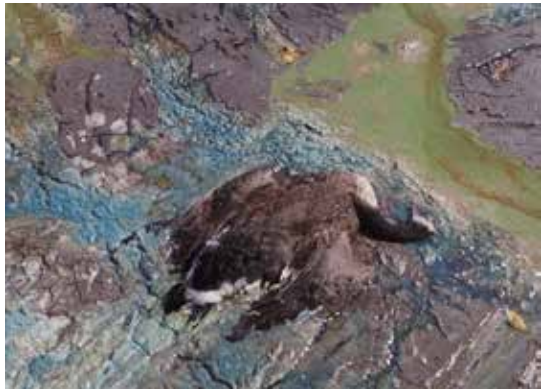






Watson SB, McCauley E, Downing JA. 1997. Patterns in phytoplankton taxonomic composition Across temperate lakes of differing nutrient status. Limnol Oceanog 42:487-495

Human Health Concerns



Common *human* symptoms associated with blue-green algae exposure include:		
Respiratory	**Dermatologic**	**Other**
Sore throat Congestion Cough Wheezing Difficulty breathing Eye irritation	Itchy skin Red skin Blistering Hives Other Rash	Earache Agitation Headache Abdominal pain Diarrhea Vomiting Vertigo

Common *animal* symptoms associated with blue-green algae exposure:
Lethargy Vomiting Diarrhea Convulsions Difficulty breathing General weakness

http://dhs.wisconsin.gov/eh/bluegreenalgae

ZOOPLANKTON & AQUATIC INVERTEBRATES

Zooplankton

Dragonfly

Crayfish

AQUATIC PLANTS

- Habitat
- Energy Dissipation/Shoreland Protection
- Nutrient Uptake
- O_2 Producers

FISH

Piscivore

Planktivore

Benthivore

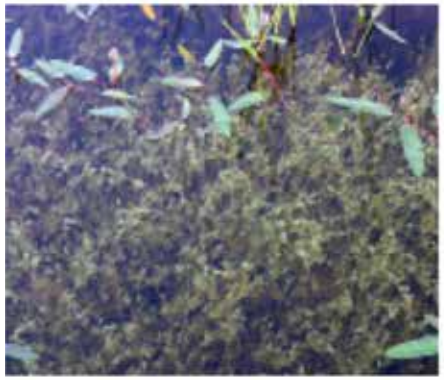
Fish Community Lake Types (Rypel et al, in press)

- Simple vs complex sport fish community – Walleye are indicators of complex sport fish community

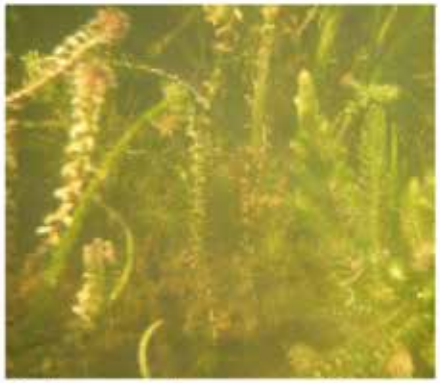
Factors Important to Fish

- Warm vs cool lakes
- Clear vs dark lakes
- Lake vs riverine
- Most common type were simple fishery in warm, dark lakes
- Most lake acreage was in complex fishery, warm, dark lakes

Aquatic Plant Community Assemblages



Chara-dominated



Submersed cosmopolitans

Characid/najas

Floating-leaf meadow

Mostly Moss

Isoetid glades

LAKE TYPES

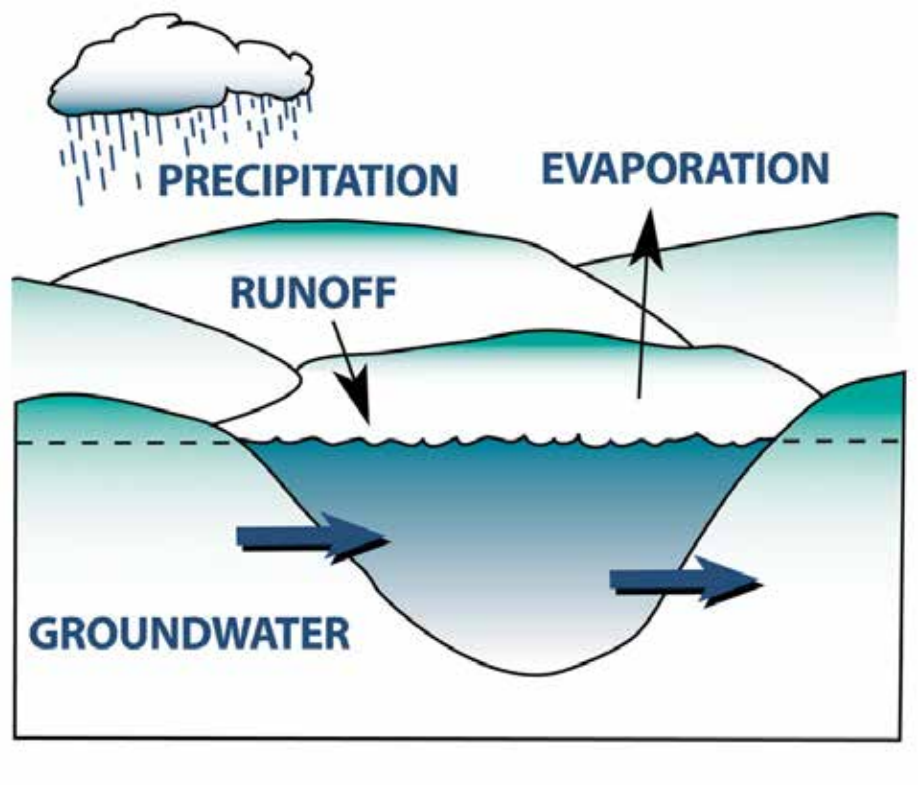
- Seepage
- Headwater/Groundwater Drainage
- Lowland Drainage
- Impoundments

SEEPAGE LAKE

- Natural Lake
- Water Source
  - Precipitation
  - Groundwater
- No Stream Inlet/ Outlet
- Small wtshd:lake area
- Can be stained or clear

Management focus:

- shoreland and in-lake habitat protection and restoration
- groundwater protection

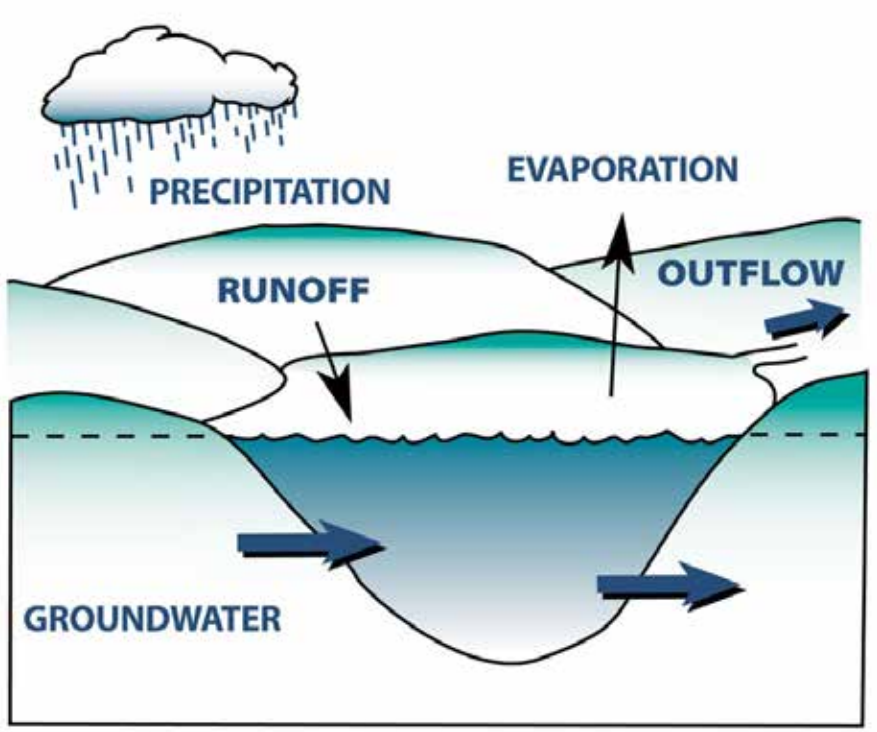


HEADWATER/GROUNDWATER DRAINAGE

- Natural Lake
- Water Source
  - Groundwater
  - Precipitation
  - Limited Runoff
- Has Stream Outlet

Management focus:

- groundwater protection
- shoreland and in-lake habitat protection and restoration

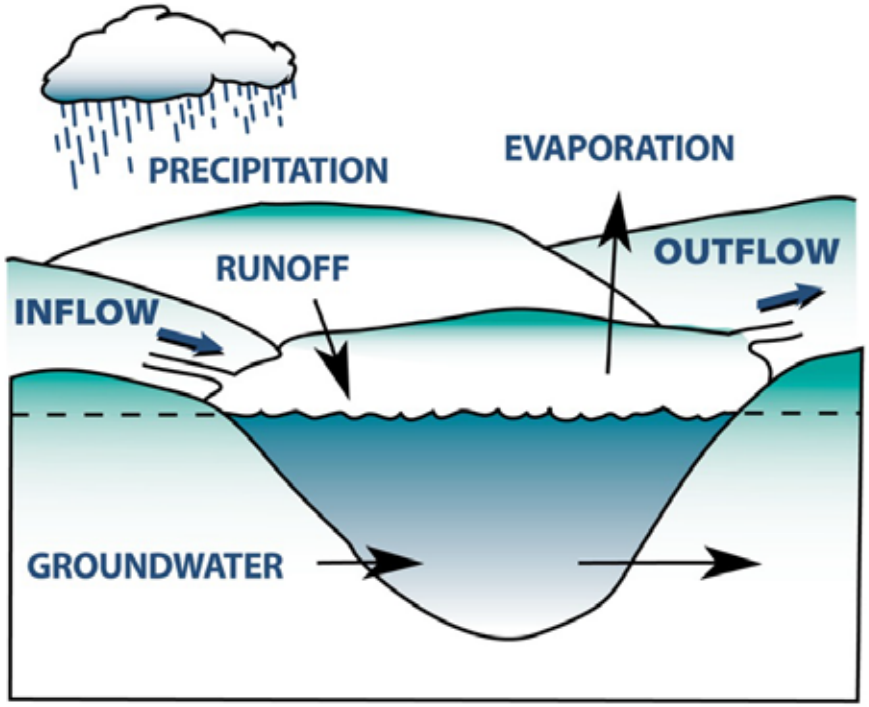


LOWLAND DRAINAGE LAKE

- Water Source
  - Streams
  - Groundwater
  - Runoff
  - Precipitation
- Streams in and out

Management focus:

- watershed management
- community capacity building

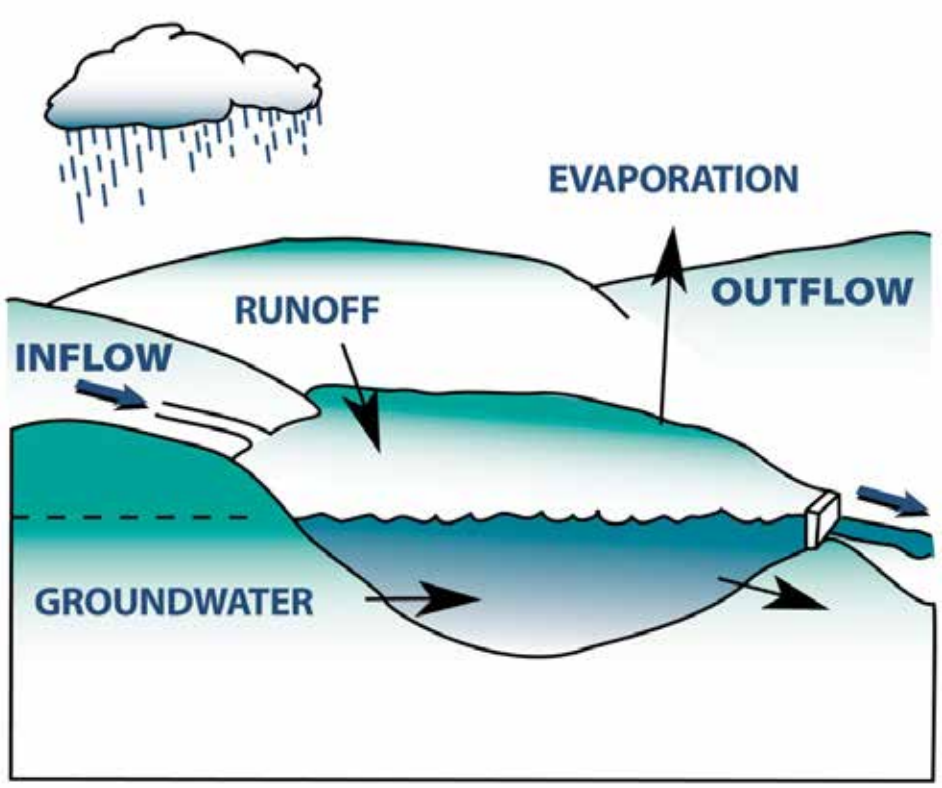


IMPOUNDMENT

- A manmade lake
- Dam more than doubles the depth of the water in the lake.
- Short water residence time

Management focus:

- watershed management
- community capacity building



Best Management Practices for Any Lake

- Healthy Lakes best practices
- Aquatic invasive species (AIS) prevention
- Conservation practices/bmp's through county land and water conservation departments statewide

Take Home Messages

- Important to understand reasonable expectations for lakes and set realistic management goals.
- Lake types can be used to understand what realistic expectations will look like.
- Find similar lakes nearby and talk with them about their management and outcomes.

LEAVING A LEGACY

Help Protect Wisconsin's…

WATER RESOURCES.