How to Understand and Manage Your Lake, Part 1 Limnology

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Objectives

- Promote technical understanding to advance Ohio's nutrient reduction efforts
  - Focus on reducing the occurrence and impact of HABs (harmful algal blooms) in inland lakes
  - Priority for lakes that are sources of drinking water
- This webinar is designed to provide a basic understanding of limnology and lake management
- Goal is to show audience how to evaluate existing data and identify data needed to define the most effective alternatives to reduce nutrient loads and protect water quality

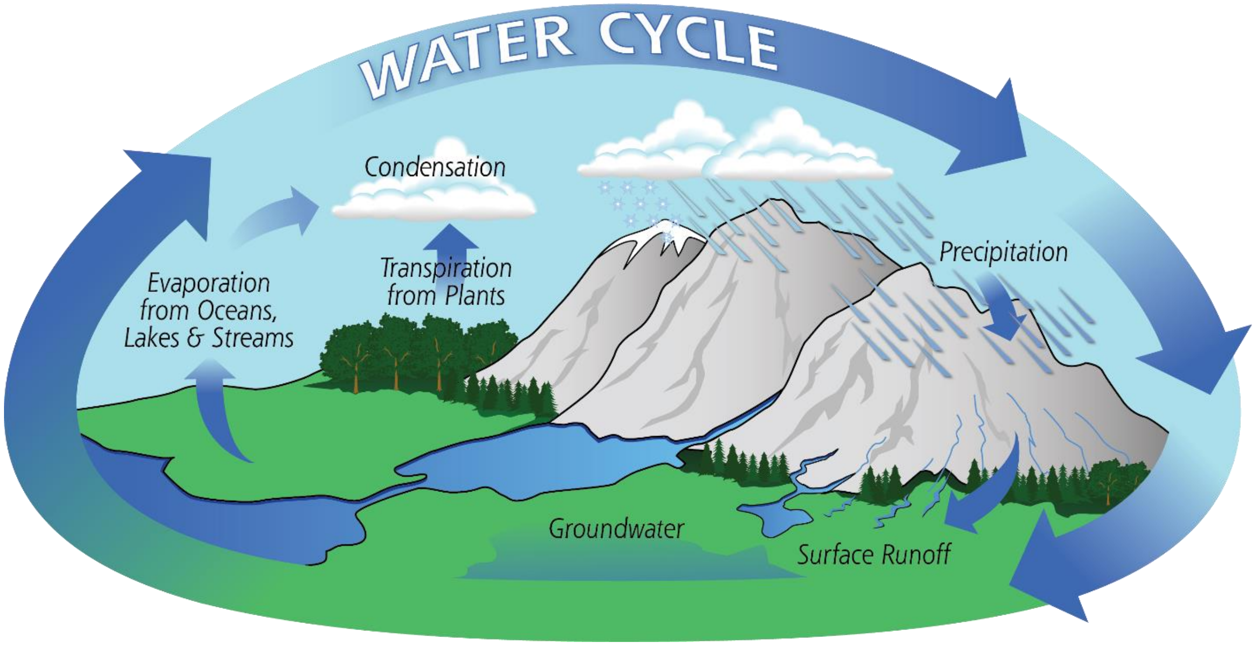
Lakes and Reservoirs

- Lakes and reservoirs are water containers
  - But what happens within these containers is not simple
- Ecological conditions are dependent upon many factors
  - Physical
  - Chemical
  - Biological
  - Energy dynamics and
  - Interaction between all of the above

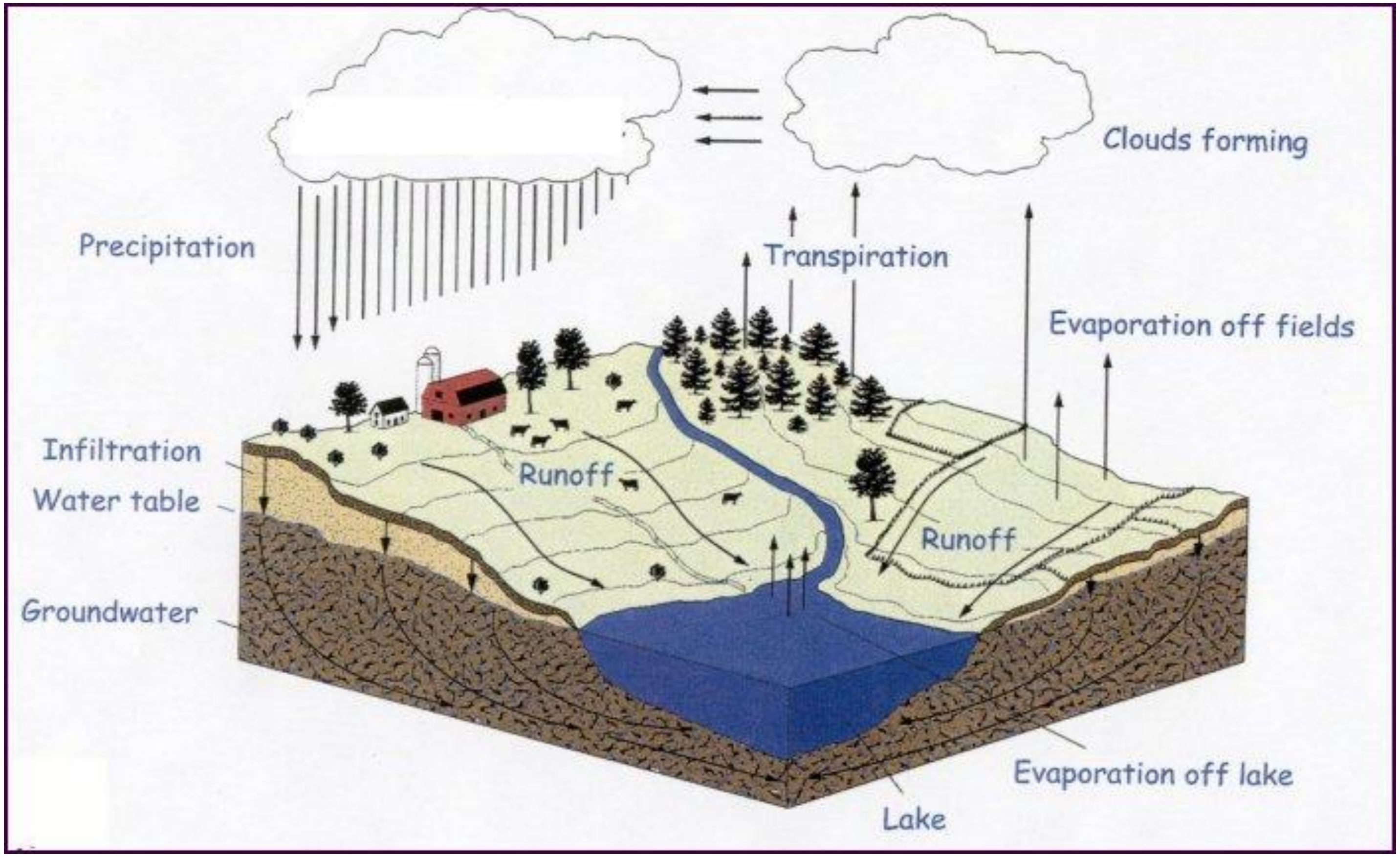
Basic Limnology

- Lakes and reservoirs are influenced by physical, geochemical, climatic and biological interactions. This includes human activities and land-use!

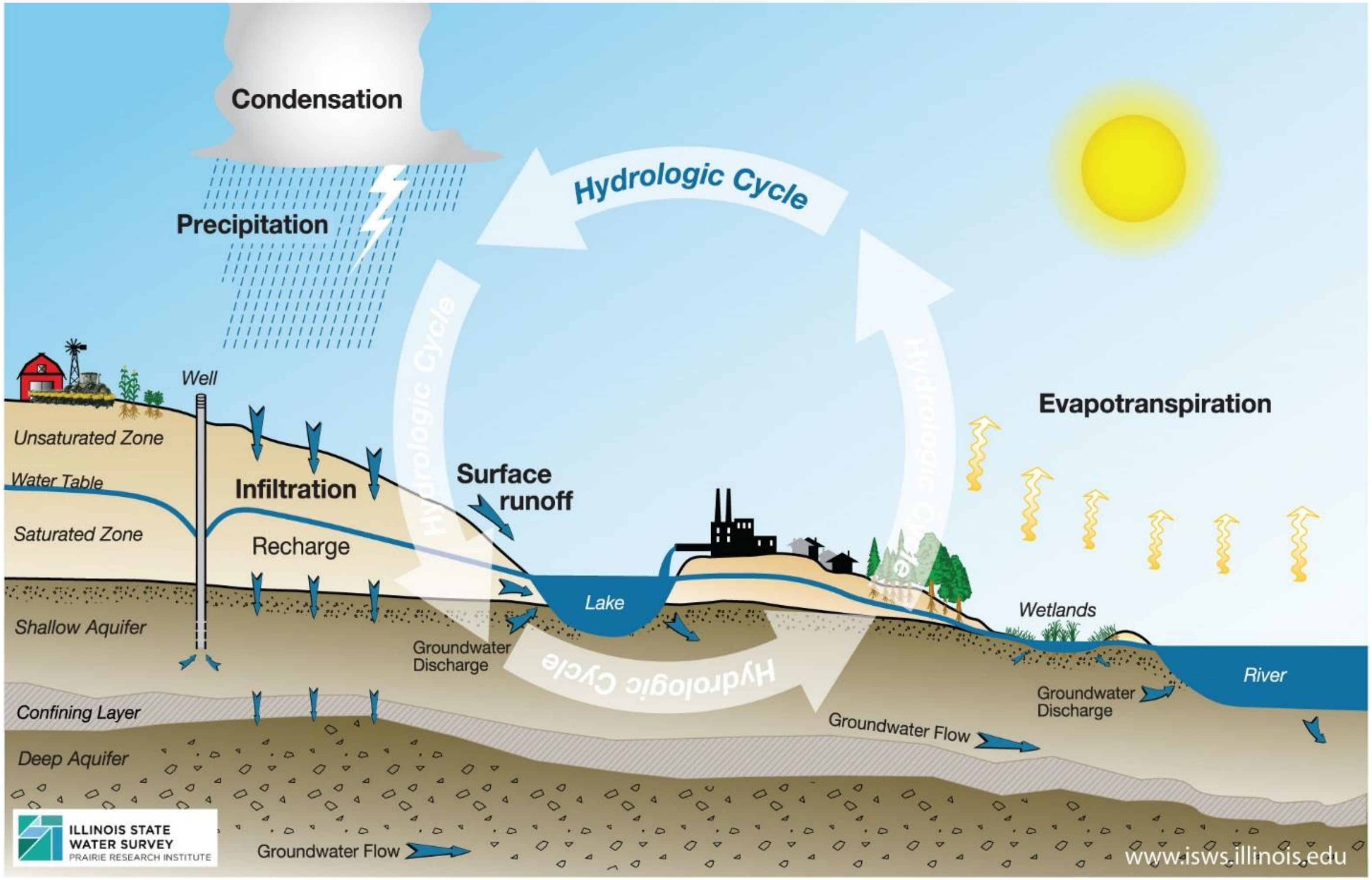
Water Cycle


WATER CYCLE
Condensation
Precipitation
Evaporation
from Oceans,
Lakes & Streams
Transpiration
from Plants
Groundwater
Surface Runoff

Water Cycle from a Watershed Perspective



Water Cycle with a Groundwater Perspective

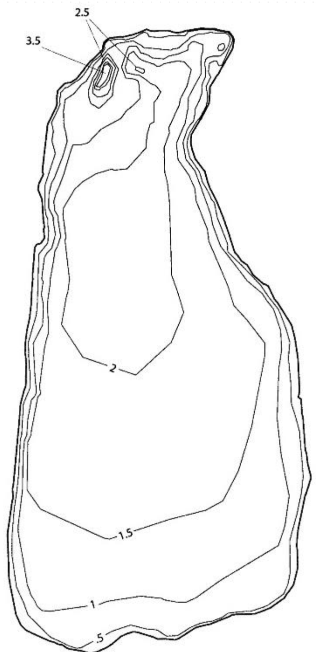


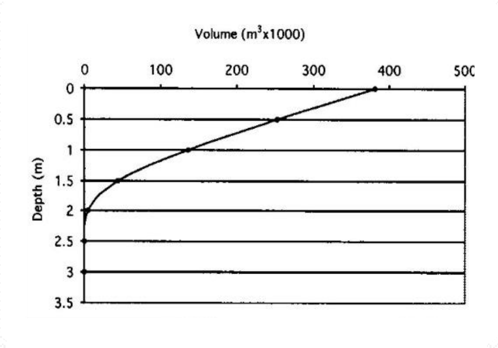
Water Cycle Impacts

- Water retention, inflow and outflow define lake and reservoir:
  - Existence
  - Physical morphology and sedimentation rate
  - Rate of chemical interaction
  - Availability of chemicals to drive biological
  - Biological residence time
  - Biochemical feed back rates
- Key factors – Residence Time and Flushing Rate

Morphometry

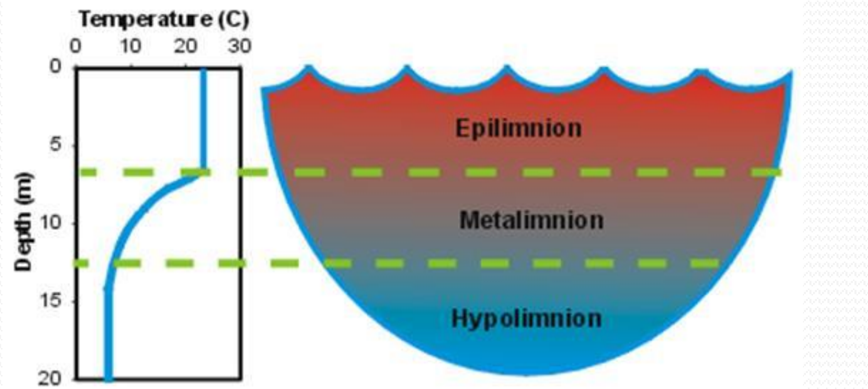
- Bathymetric mapping
- Hypsographic curves of volume vs depth should be available (or determined) to volume-weight constituents in the epilimnion and hypolimnion and whole lake, or whole-lake only if unstratified
- DO-temperature profiles 1-2 m intervals to determine depth of mixing, hypolimnion depth, and depletion rate of DO

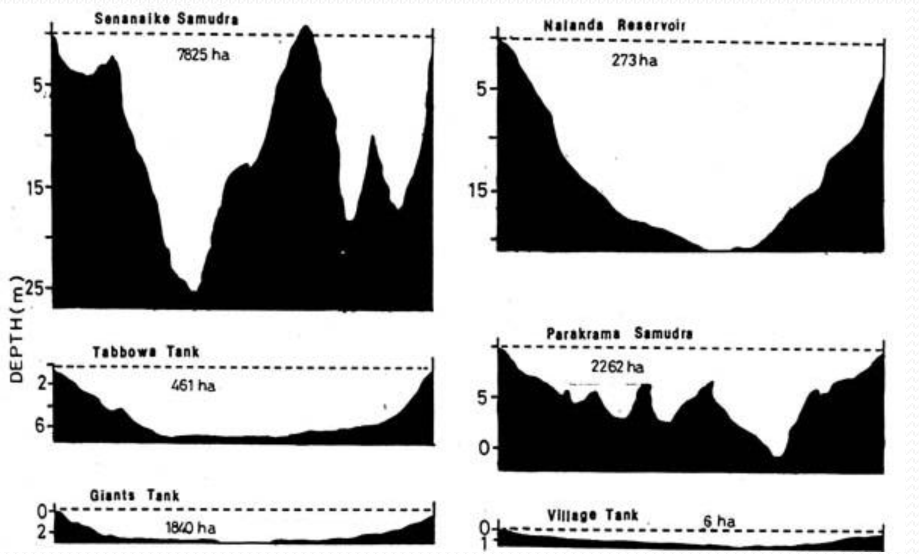


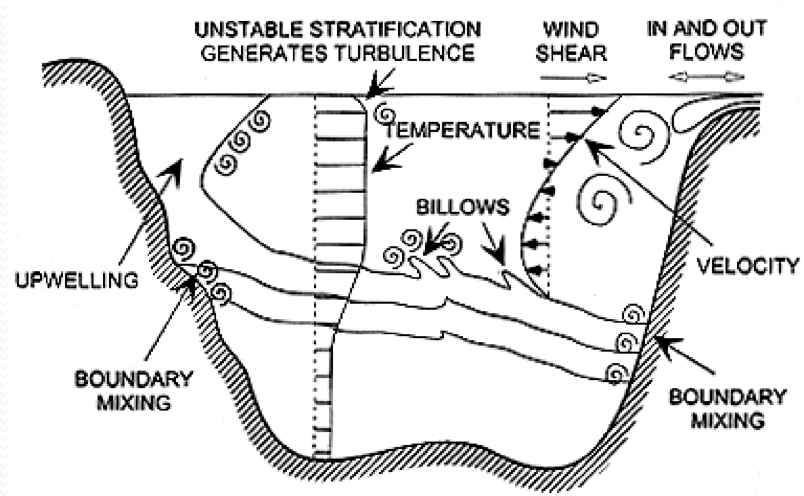


Morphology and Mixing

- Lake morphology influences physical dynamics
  - Occurrence and stability of stratification
  - Frequency of mixing







What Drives Aquatic Life

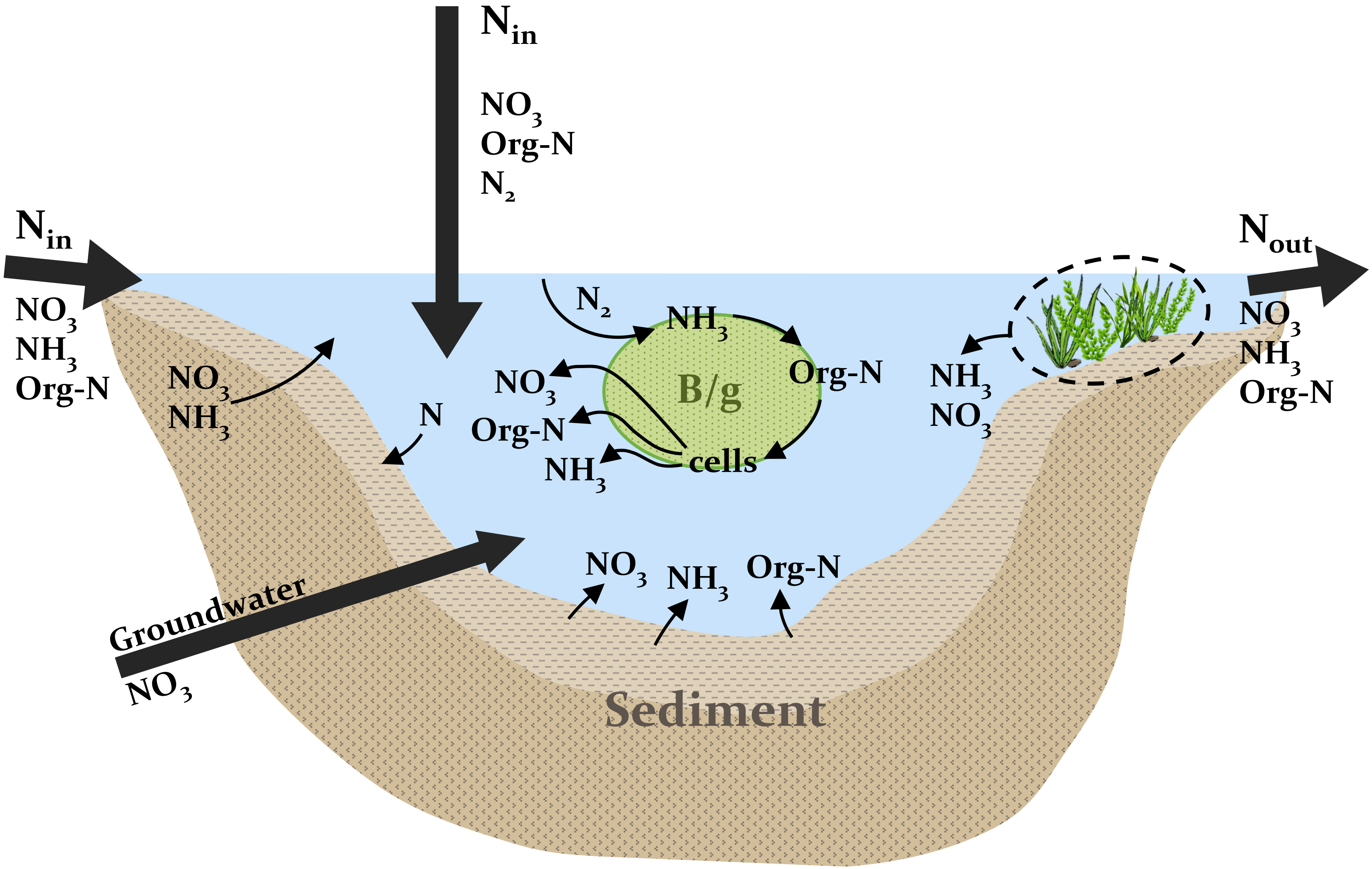
- WATER
- Light is the energy source
- Nutrients are the building blocks for cells
- Temperature
- It all starts with plants driven by light and nutrients
  - Once in motion, carbon fixation controls the rate of nutrient cycling that is driven by biological metabolism
- Within the constraints of seasonality plant and algal growth is driven by nutrient availability, which is in turn dominated at times by the biological community

Nutrient Cycling

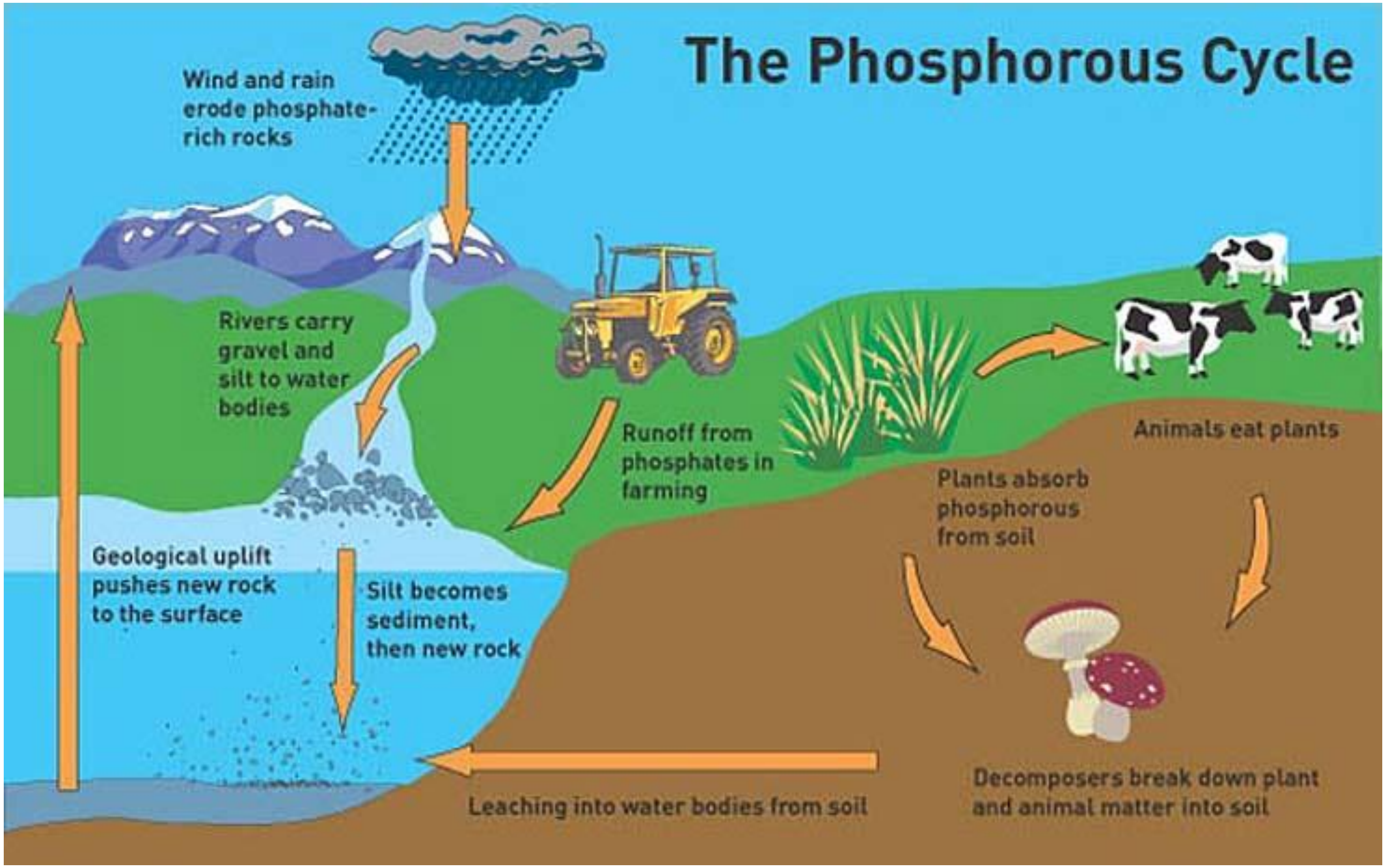
Key macronutrients relative to primary productivity (algal and rooted plant growth)

- Carbon
  - Inorganic carbon supply from the atmosphere has more than doubled compared to the quantities available less than 80 years ago (from 180 ppm to 400 ppm for just CO_2)
  - No longer limiting
- Silica
  - Not a limiting factor for Cyanobacteria nor truly limiting for most shallow lakes and reservoirs
- Nitrogen
- Phosphorus

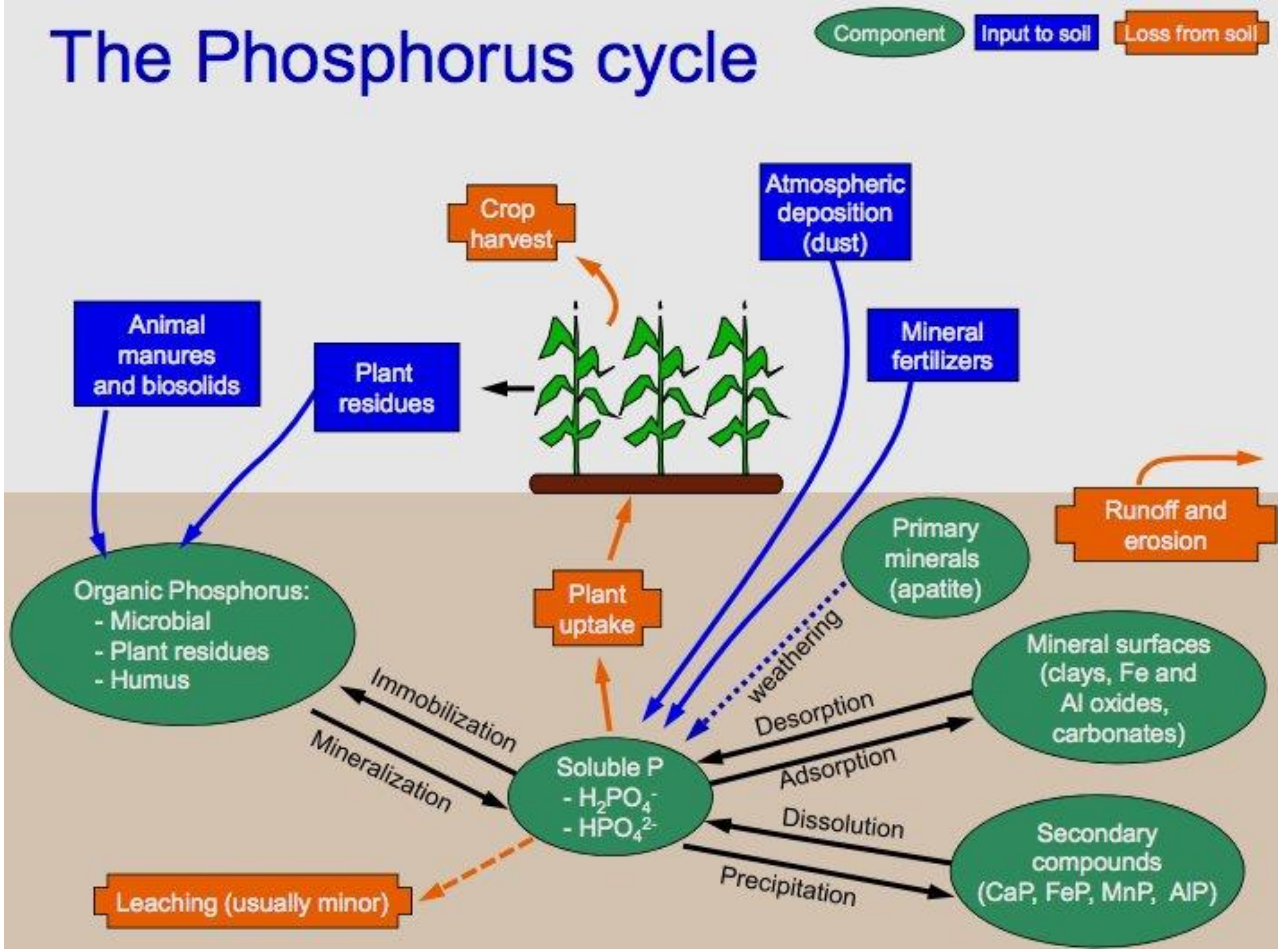
Nitrogen Cycle



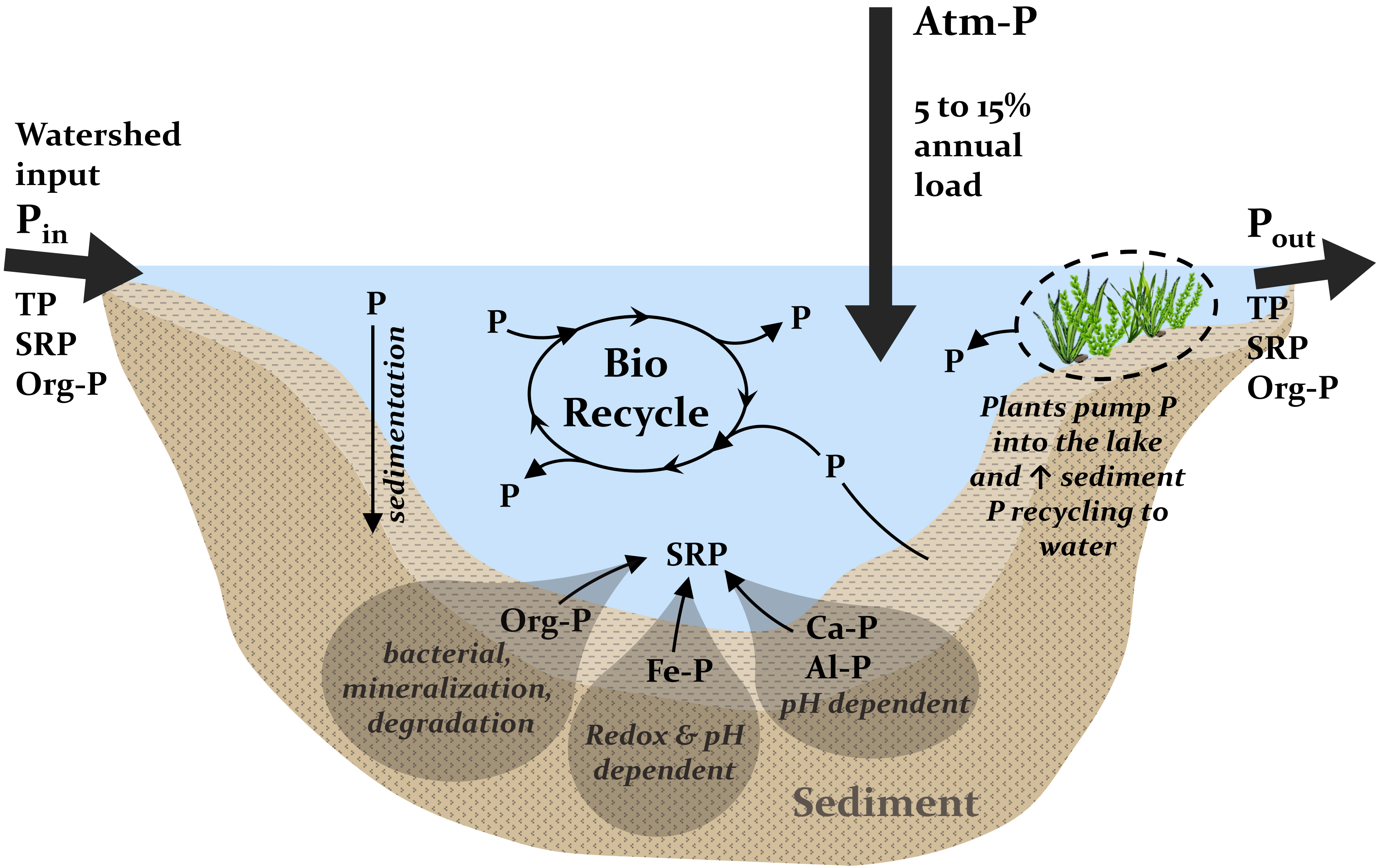
Phosphorus Cycle Overview



Phosphorus Cycle Ag Perspective

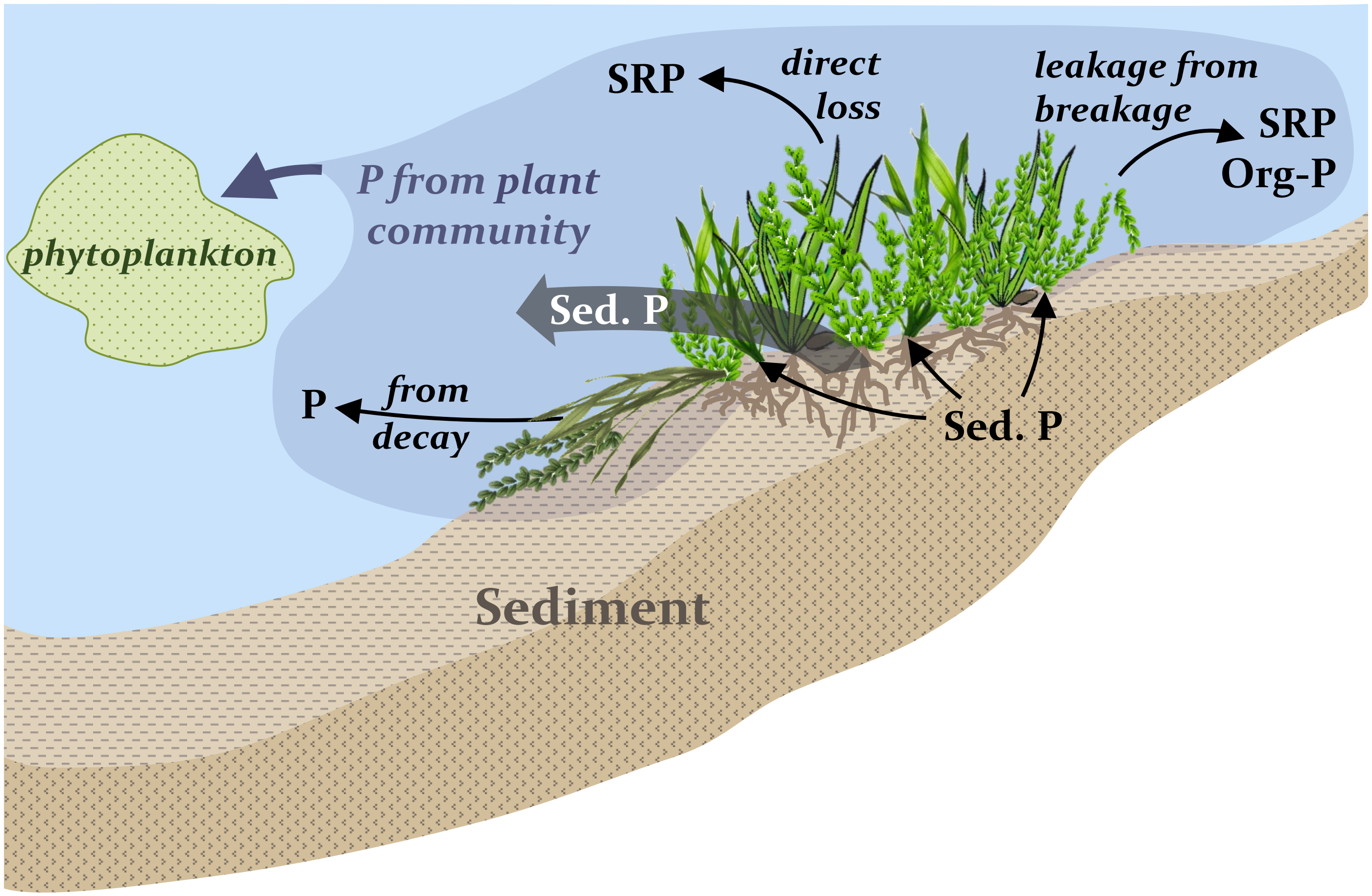


Phosphorus Cycle



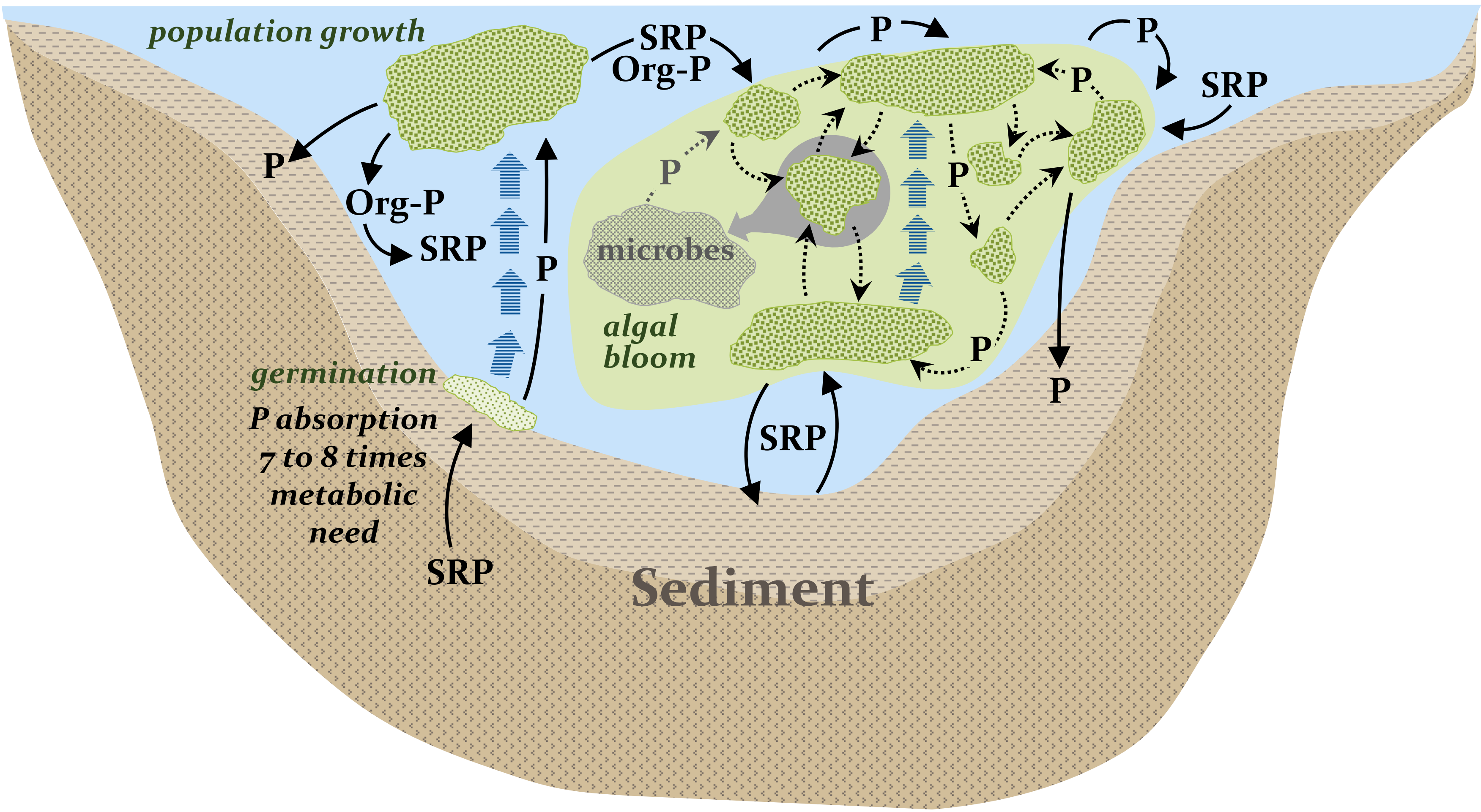
Phosphorus Cycle Cont…

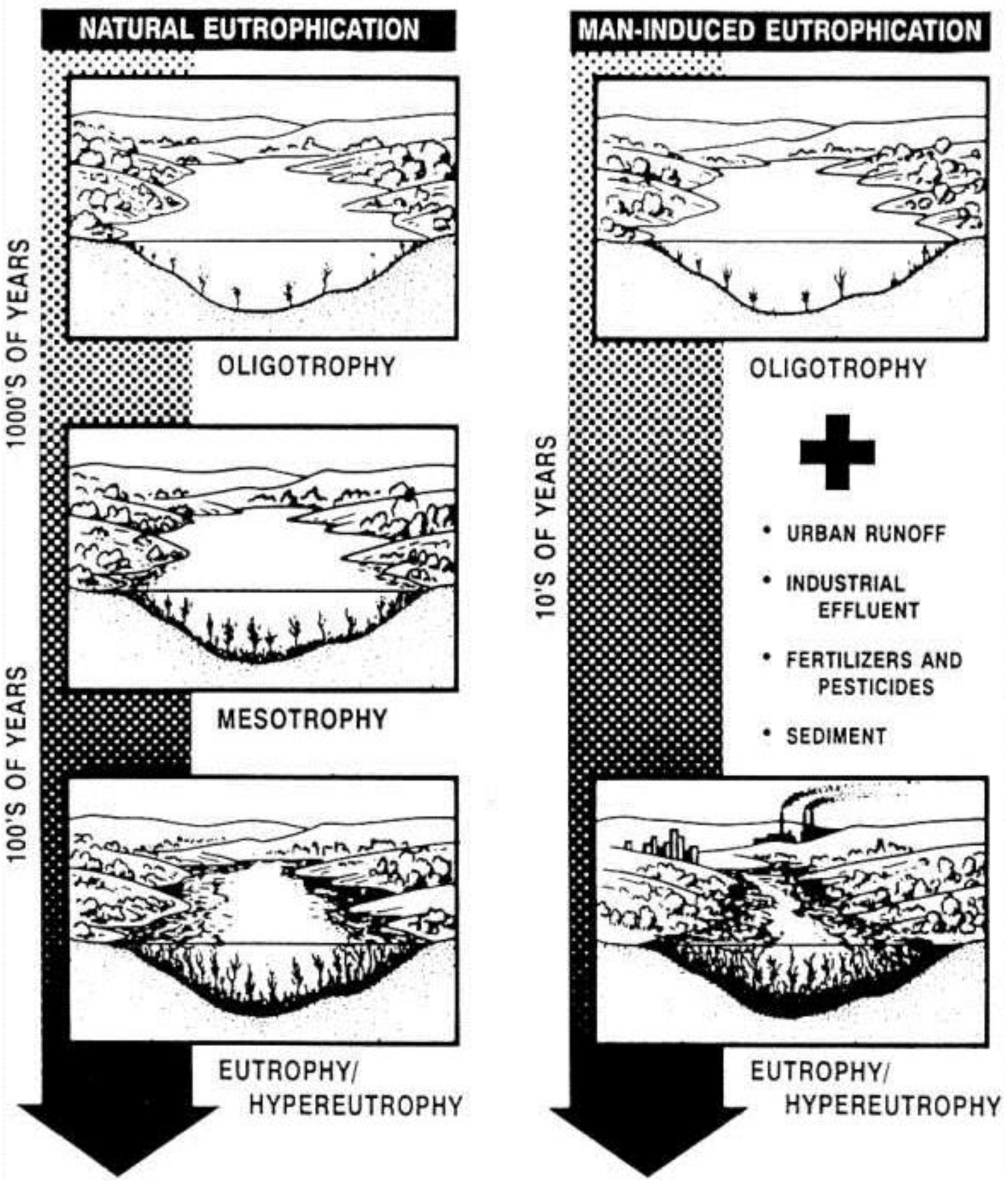
Biocycle - Macrophytes



Phosphorus Cycle Cont.

Biocycle – Phytoplankton, Cyanobacteria




NATURAL EUTROPHICATION
1000'S OF YEARS
OLIGOTROPHY
100'S OF YEARS
MESOTROPHY
EUTROPHY/
HYPEREUTROPHY
MAN-INDUCED EUTROPHICATION
10'S OF YEARS
OLIGOTROPHY
• URBAN RUNOFF
• INDUSTRIAL EFFLUENT
• FERTILIZERS AND PESTICIDES
• SEDIMENT
EUTROPHY/
HYPEREUTROPHY

Nutrient Loading

- Rate of nutrient loading and the total amount of nutrients delivered to an aquatic system drives its primary production
  - Input (loading) versus concentration
    - An input of 1 kg of P put into a lake can grow 10,000 kg of algal, but that 1 kg of P can recycle within the lake up to 40 times; leading to the production potential of 400,000 kg of algal biomass.
    - So a loading of 2 kg of P at the same concentration would produce a potential algal biomass of 800,000 kg.
      - For example, the human liver can process 1 oz of whiskey per hour, but if a person consumes 4 ozs in an hour 75% of the alcohol is released to the blood stream ☹

Nutrient Loading cont…

- Loading of nitrogen and phosphorus can be 20 to 40 times background conditions with certain land-uses
- Relative to eutrophication;
  - 20 to 40 times the rate of loading and total nutrient delivered to the system will stimulate 20 to 40 times the algal biomass!
  - Even with BMPs in place at 50% nutrient retention that is 10 to 20 times background, at 90% retention it is still 2 to 4 times the background rate!

Nutrient Loading cont…

- Things to keep in mind,
  - Impervious vs pervious area
  - Vegetated surfaces relative to storage and pollution retention vs non-vegetation surfaces
  - Industrial surfaces generate up to 20 times that of forested areas in terms of nitrogen and phosphorus
  - Ag lands can generate up to 40 times that of forested areas in terms of nitrogen and phosphorus
  - Suburban and urban land-use will generate 10 to 20 times the nutrients over background levels.

Nutrient Loading cont…

- Animal loading equivalents relative to humans:

	grams P/D	grams N/D	P Human Equivalents	N Human Equivalents
Beef	90	234	39	16
Dairy	64	409	27	26
Hogs	22	57	9	3.6
Layers	0.56	1.5	0.24	0.09
Broilers	0.51	1.7	0.22	0.1
Turkeys	1.91	5	0.88	0.32
Humans	1.37-3.29	12.6-19.18		

Questions