

The hydrogeological cycle

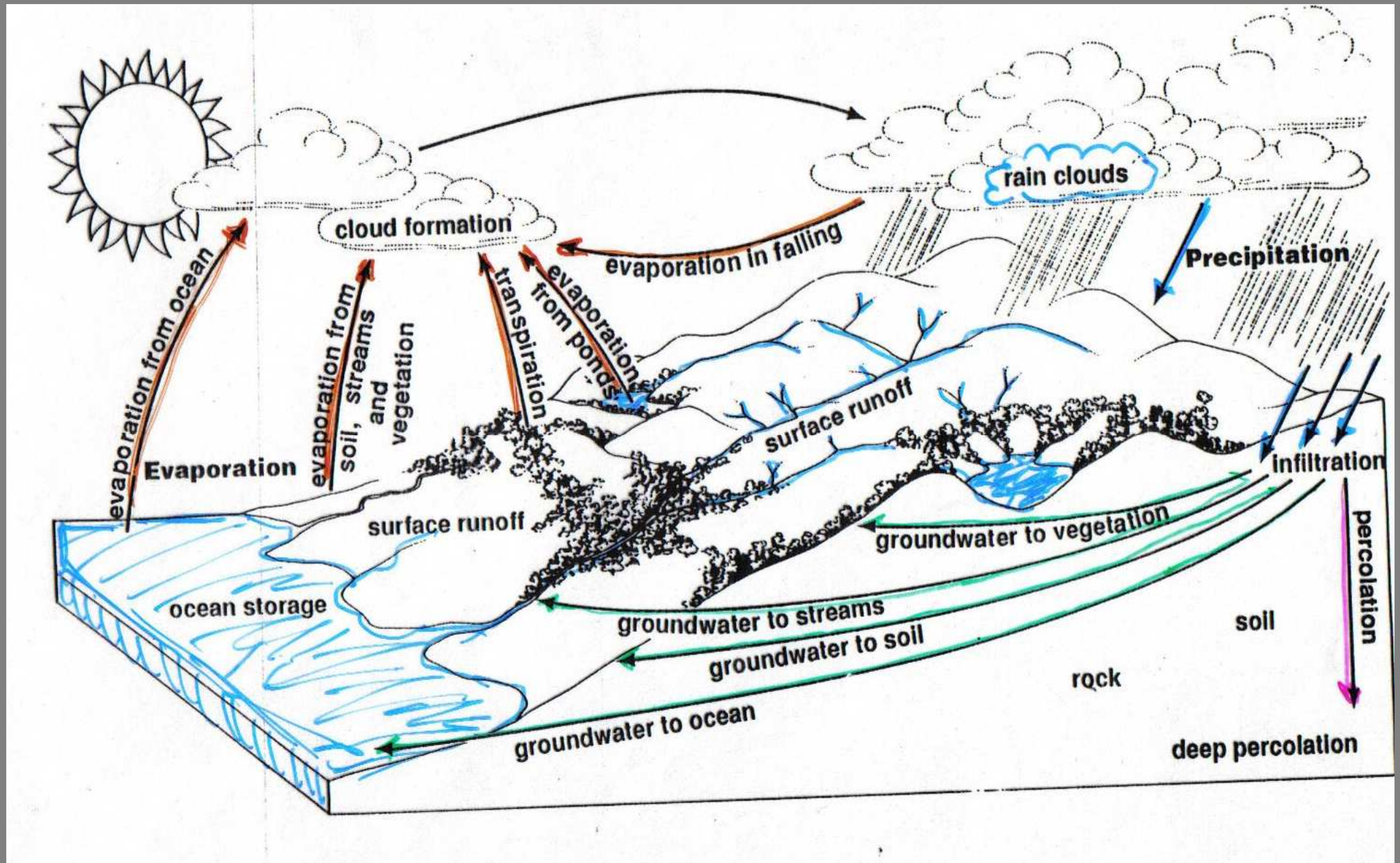


TABLE 1.1 Locations and Amounts of Water on the Earth^a

<i>Location</i>	<i>Amount (thousands of km³)</i>	<i>Total %</i>	<i>% inland liquid water</i>
Freshwater lakes	125	0.009	1.45
Saline lakes and inland seas	104	0.008	1.20
Rivers (average volume)	1	0.0001	0.01
Shallow and deep soil water	67	0.005	0.77
Groundwater to 4000 m depth	8,350	0.61	96.56
Ice caps and glaciers	29,200	2.14	
Atmosphere	13	0.001	
Oceans	1,320,000	97.3	

^aData from Todd (1970).

Distribution of Water

Natural lakes and ponds - 4.2 million km²

Large Impoundments - 0.26 million km²

Farm ponds cover about - 0.08 million km²

Downing et al. 2006

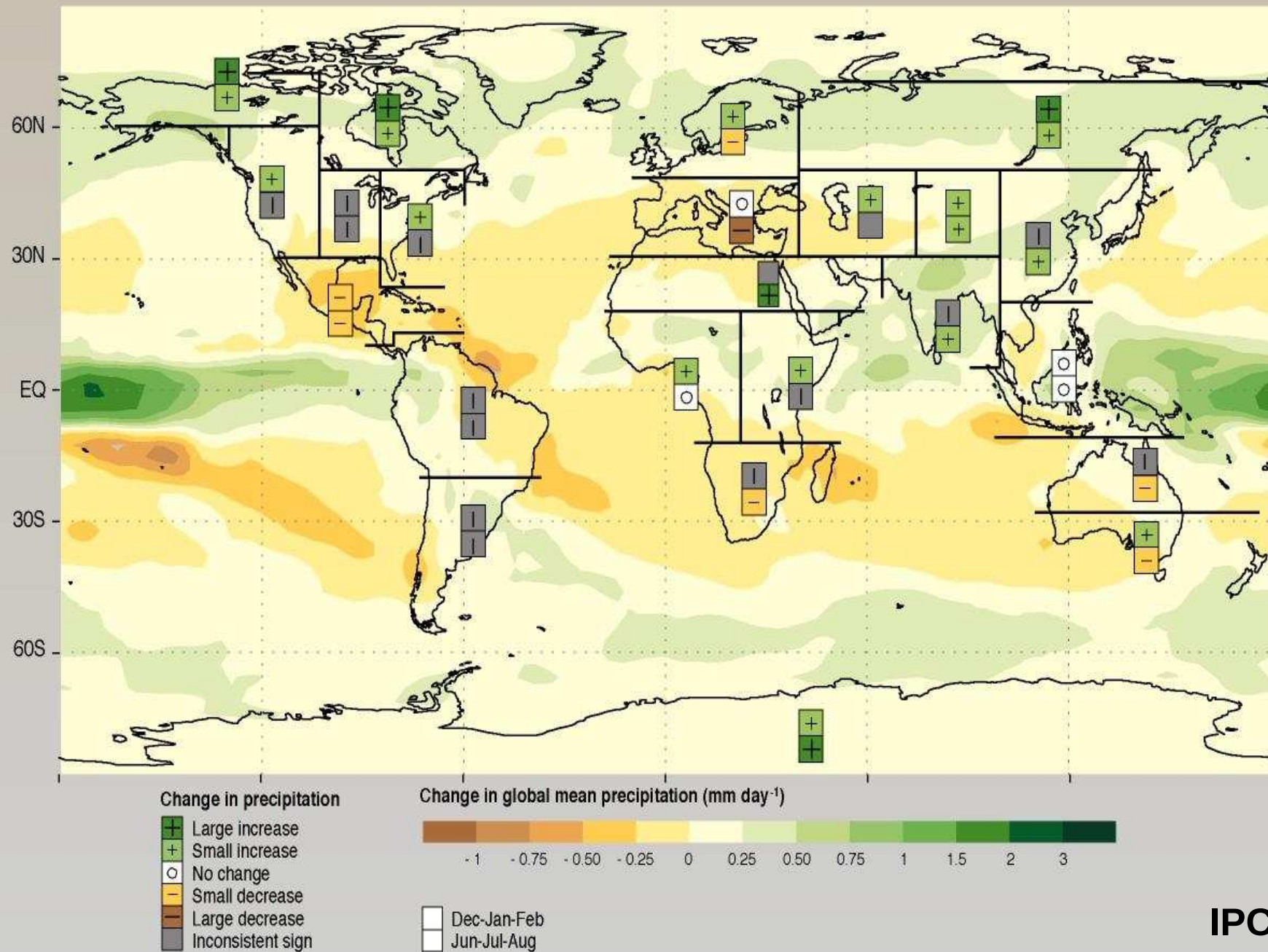
**Lakes, ponds and
impoundments cover
>3% of the earth's
surface.**

TABLE 1.2 General Ranges of Water Use with Varied Socioeconomic Conditions on a Per Capita Basis^a

<i>Society</i>	<i>Range or mean (m³ year⁻¹ capita⁻¹)</i>
Irrigated semiarid industrial countries	3000–7000
Irrigated semiarid developing countries	800–4000
Temperate industrial countries	170–1200
United States	2200
Switzerland	480
Jordan	200
Ghana	75

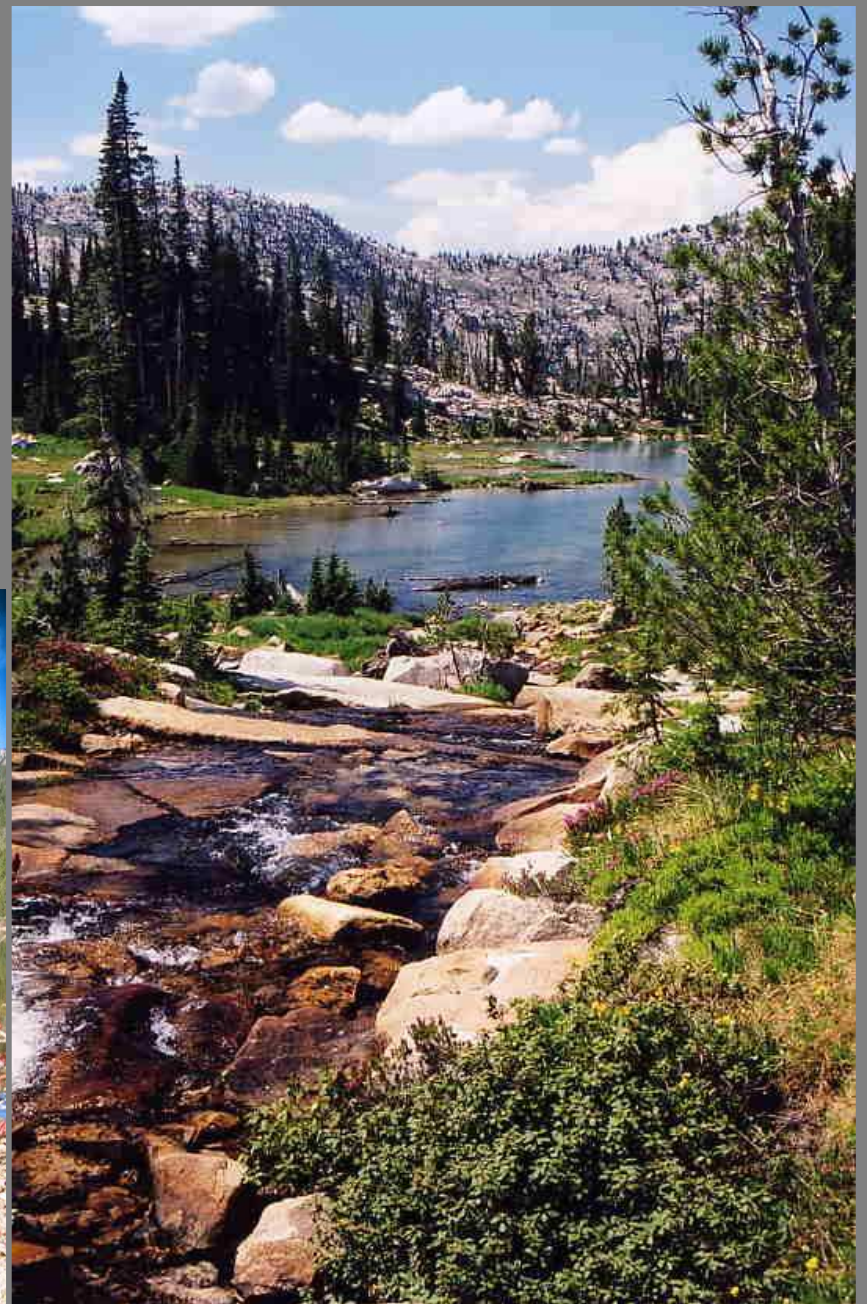
^aModified from Falkenmark (1992) and la Rivière (1989).

Change in precipitation for scenario A2



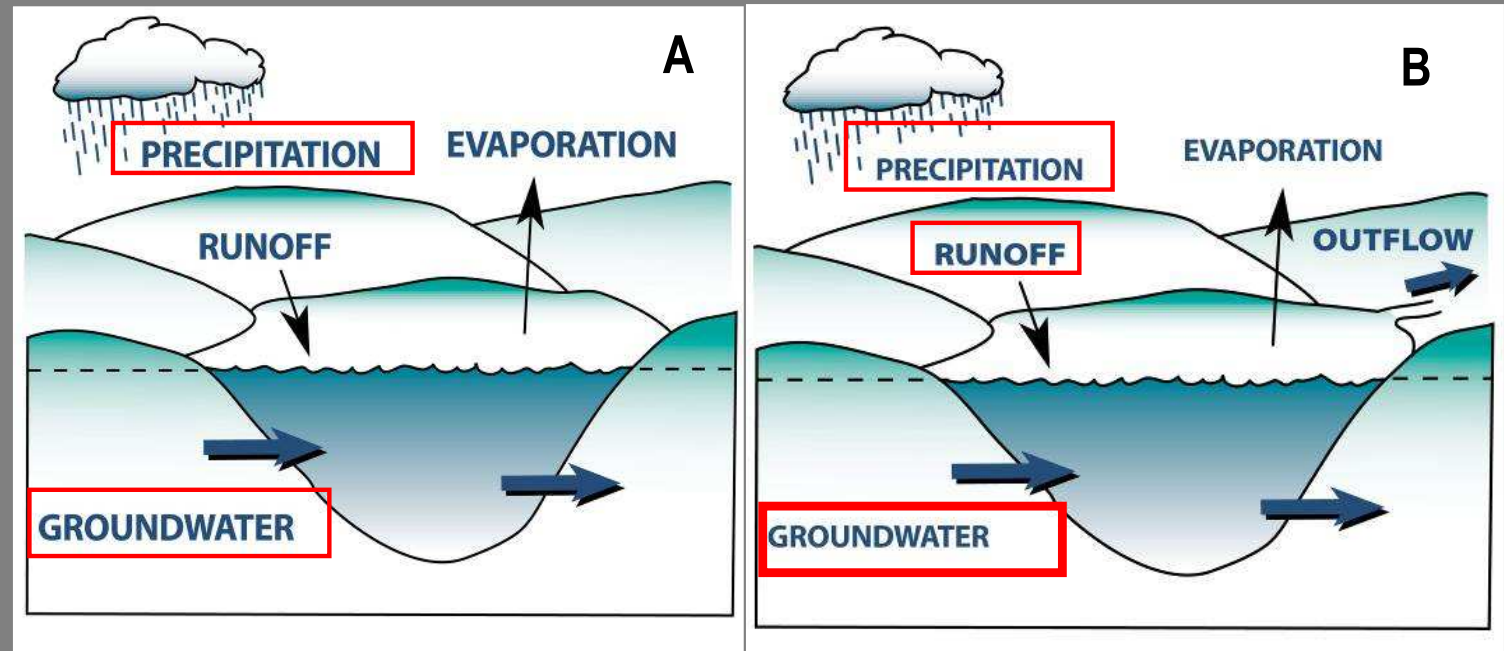
Limnology: the study of Inland Waters

- Lentic (lakes, ponds, reservoirs, pools)
- Lotic (creeks, streams, rivers, springs)



LAKE TYPES

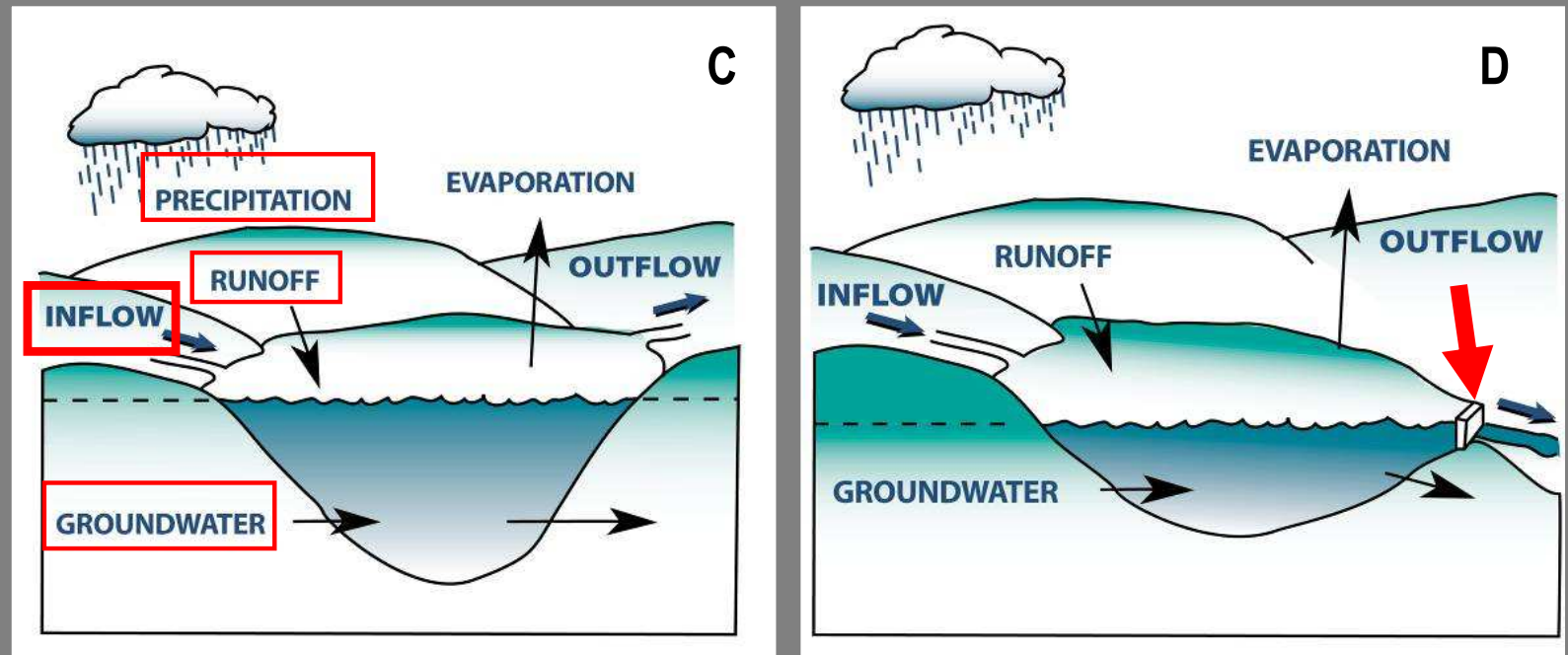
- A Seepage
- B Groundwater
- C Drainage
- D Impoundments



Water level variation:

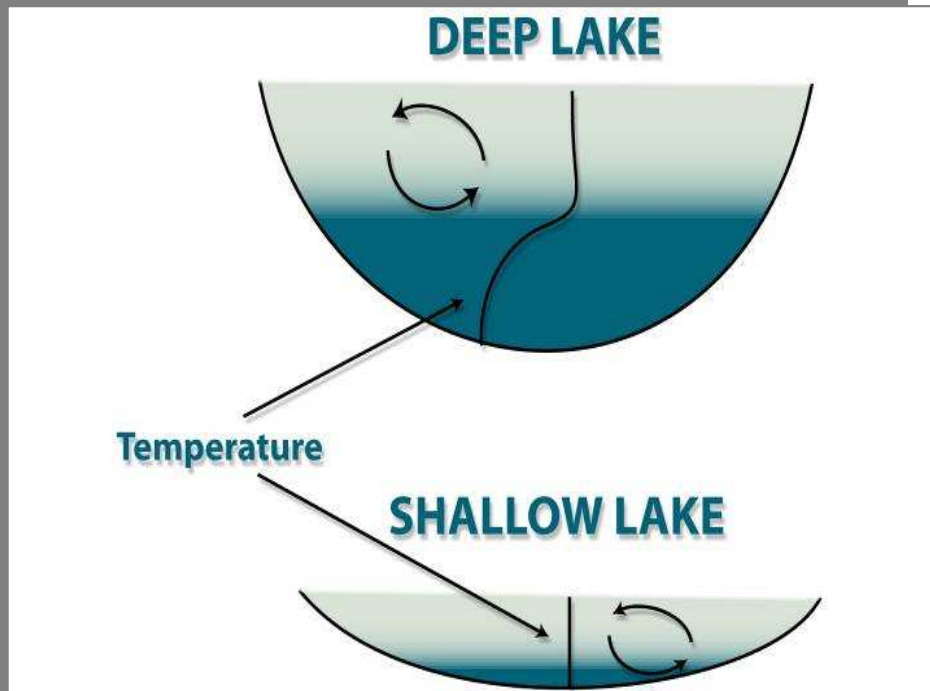
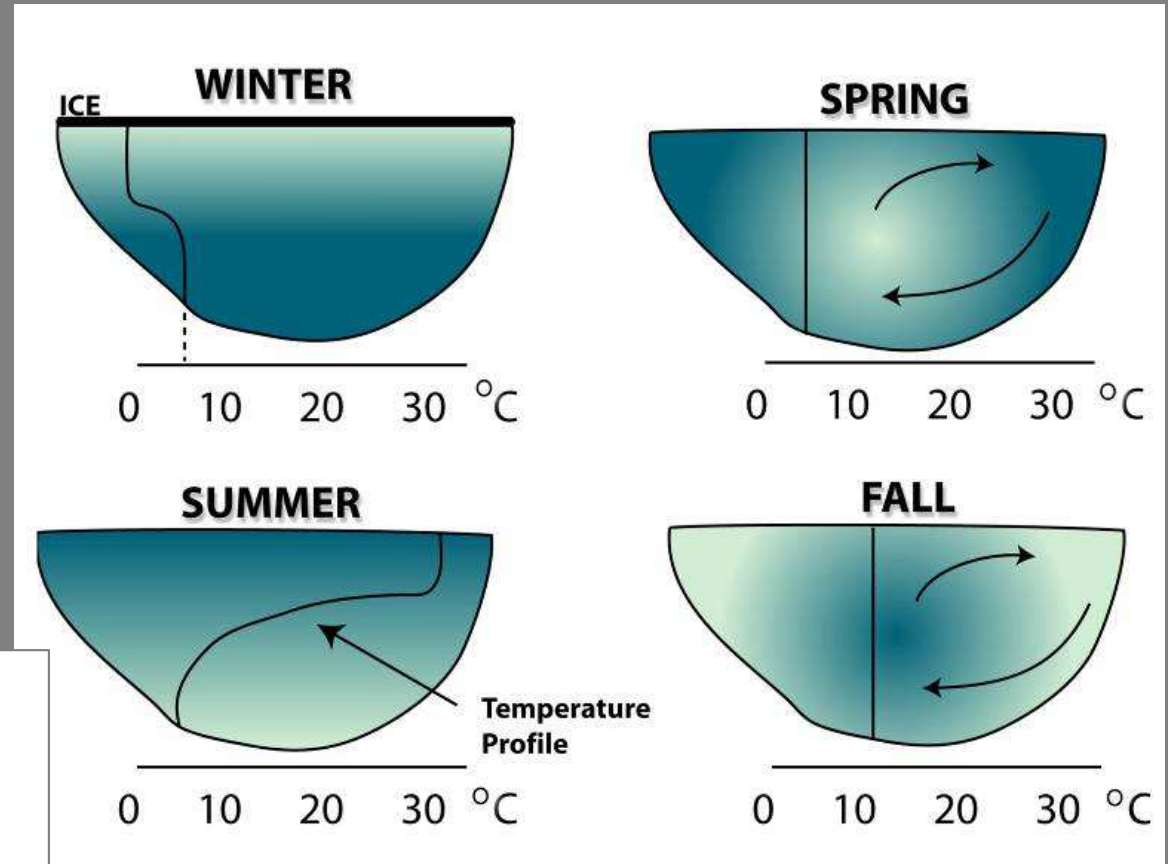
Groundwater
Precipitation
Runoff
Inflow/outflow
Evaporation

Residence time

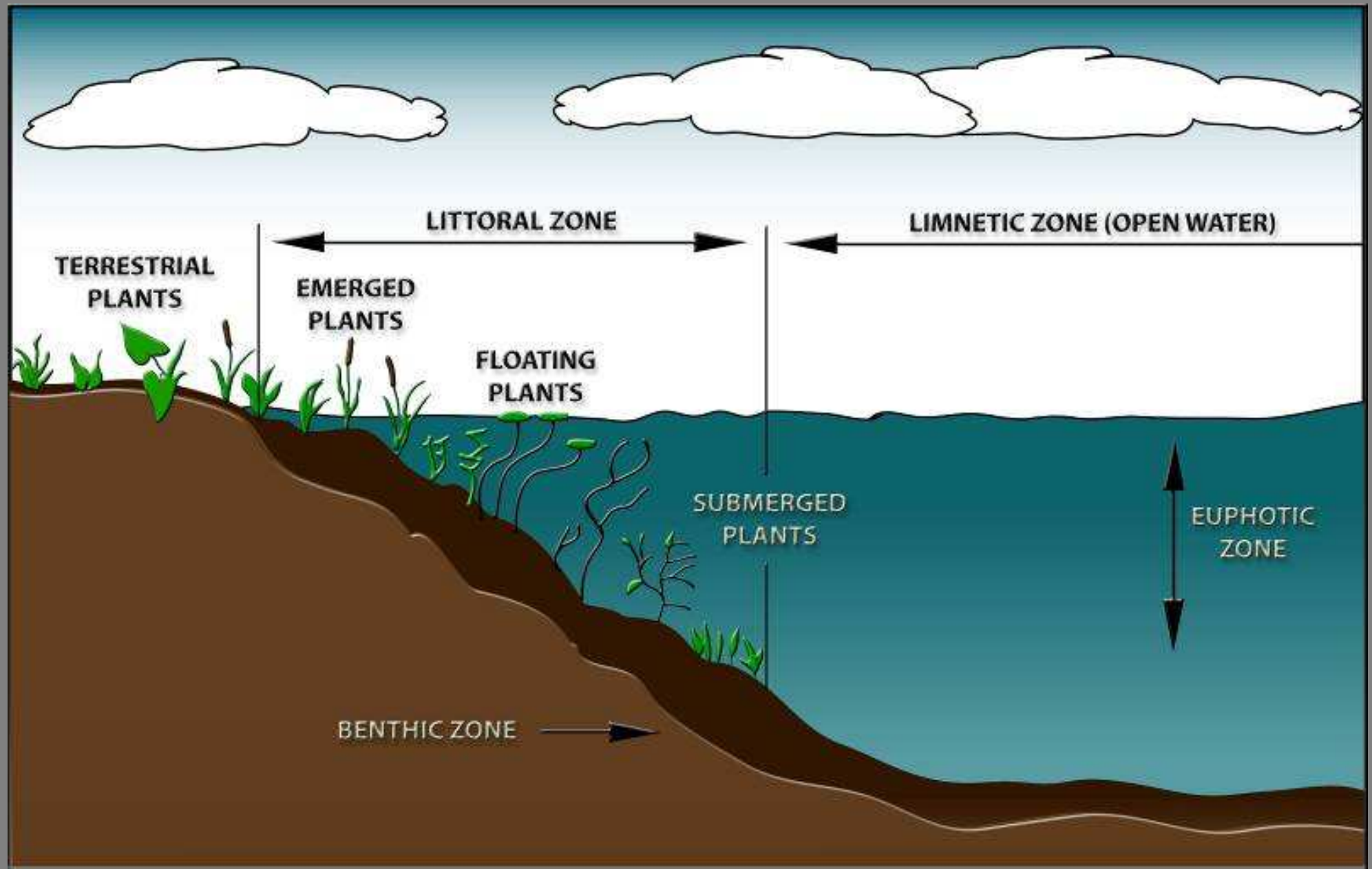


PHYSICAL CHARACTERISTICS

- Mixing / Stratification
- Lake Depth

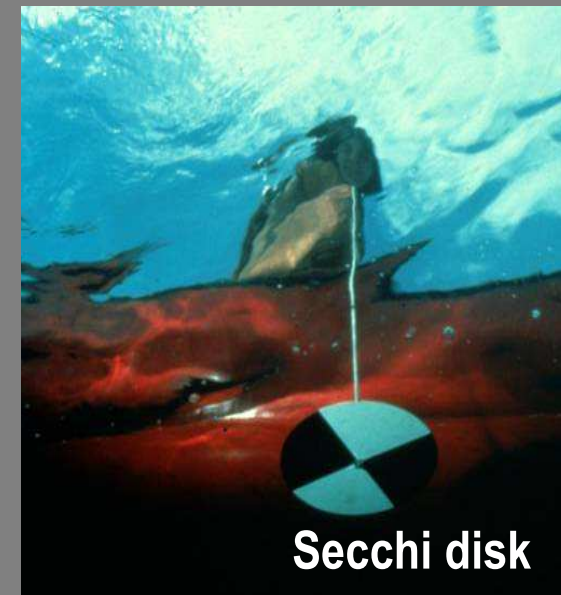
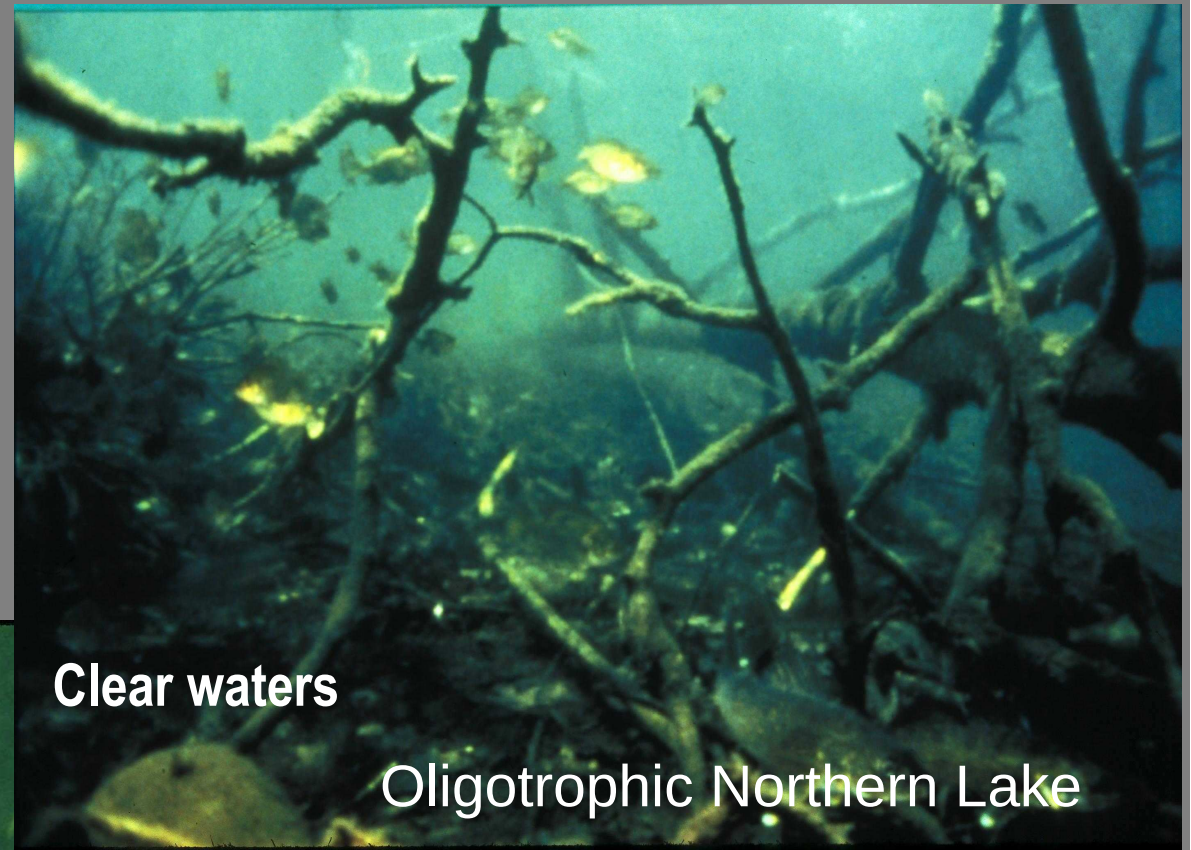


LAKE HABITAT ZONES



LAKE LITTORAL ZONE

- Functions:
 - Intercepts Nutrients
 - Refuge from Predators
 - Nursery for Fish

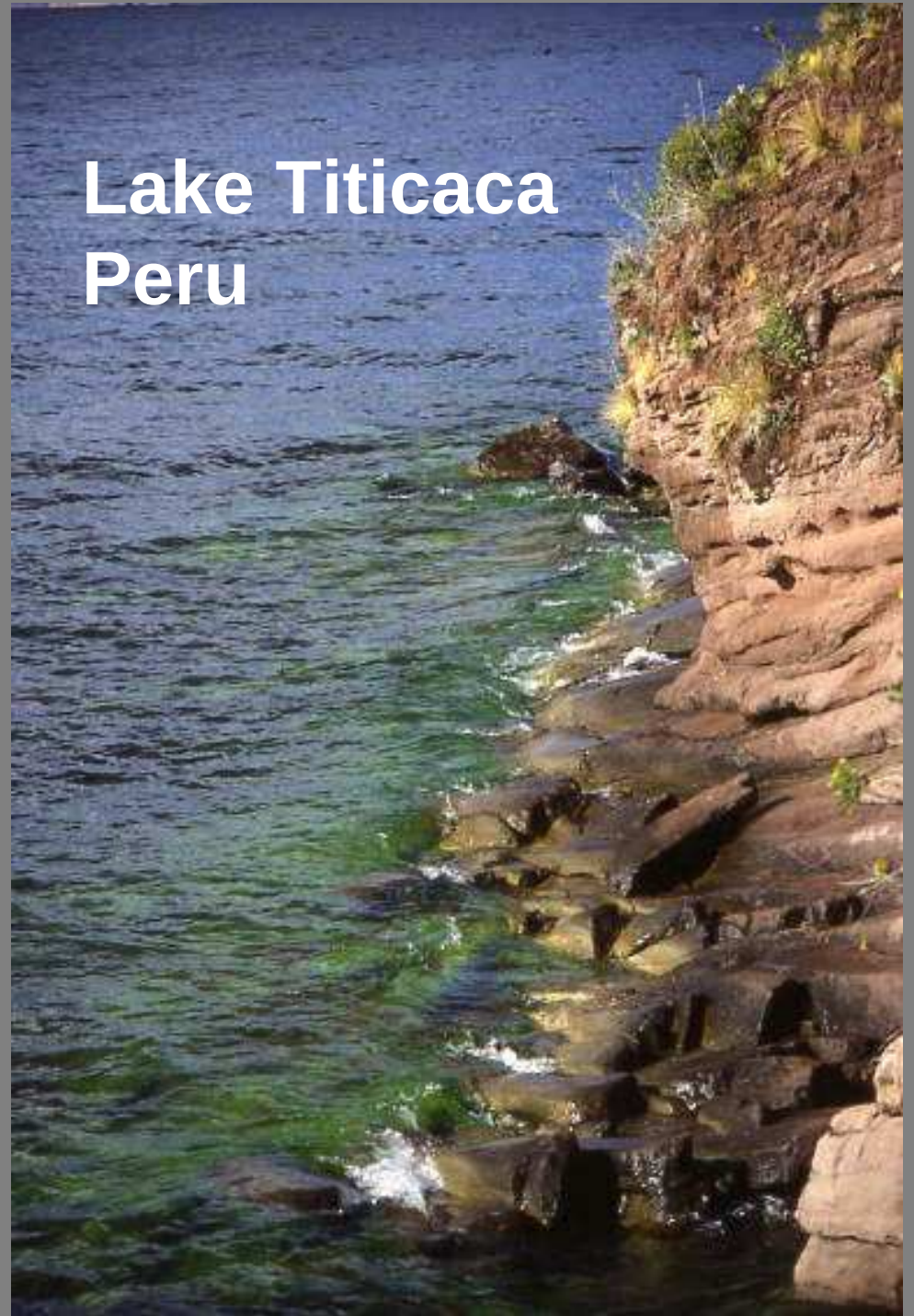


Periphyton

**Stream diatom
community**



**Lake Titicaca
Peru**

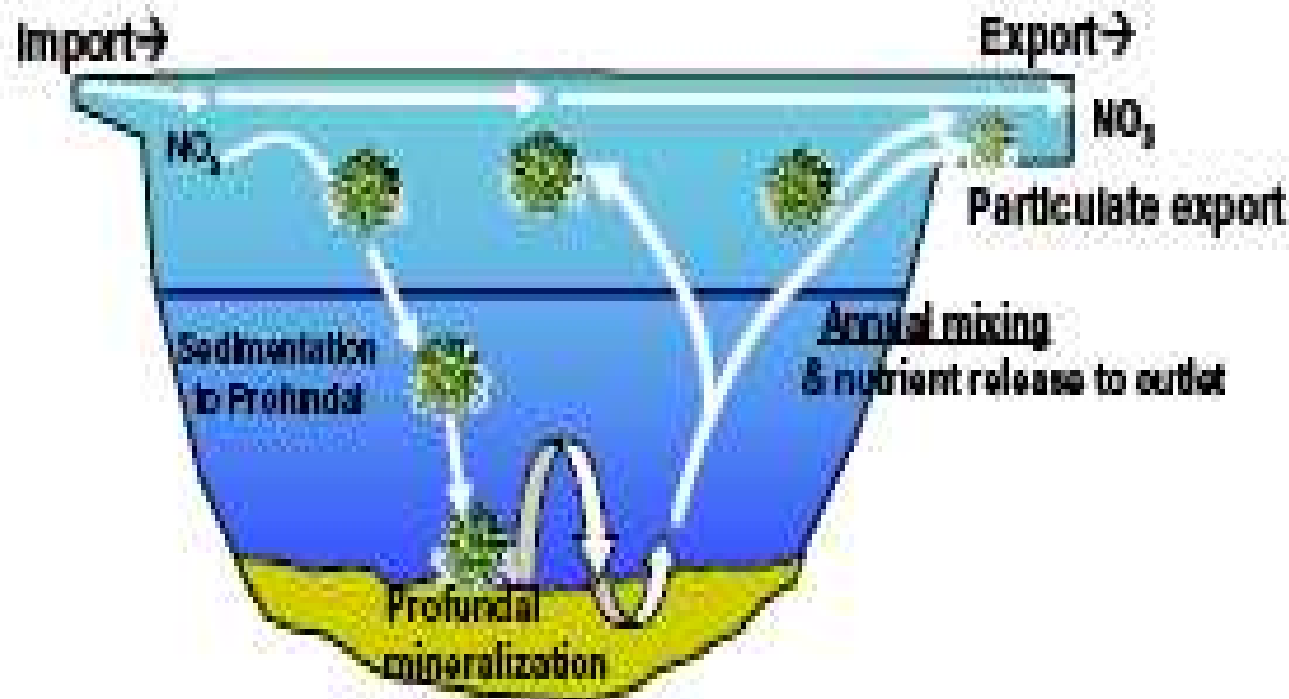


Macrophytes

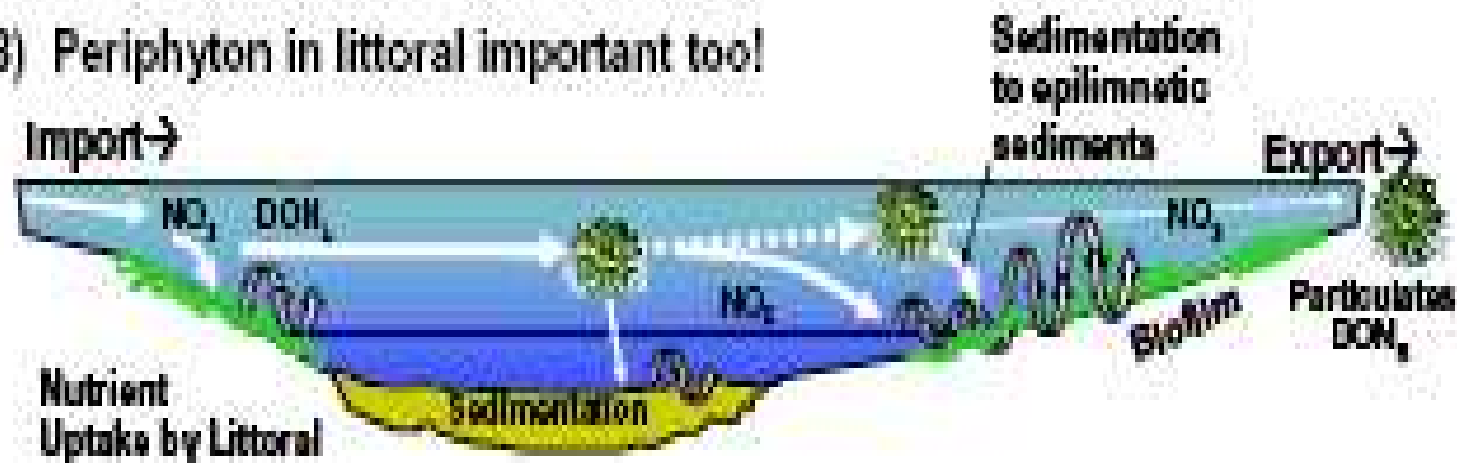


Where does the algae grow?

A) CURRENT CONCEPTUALIZATION

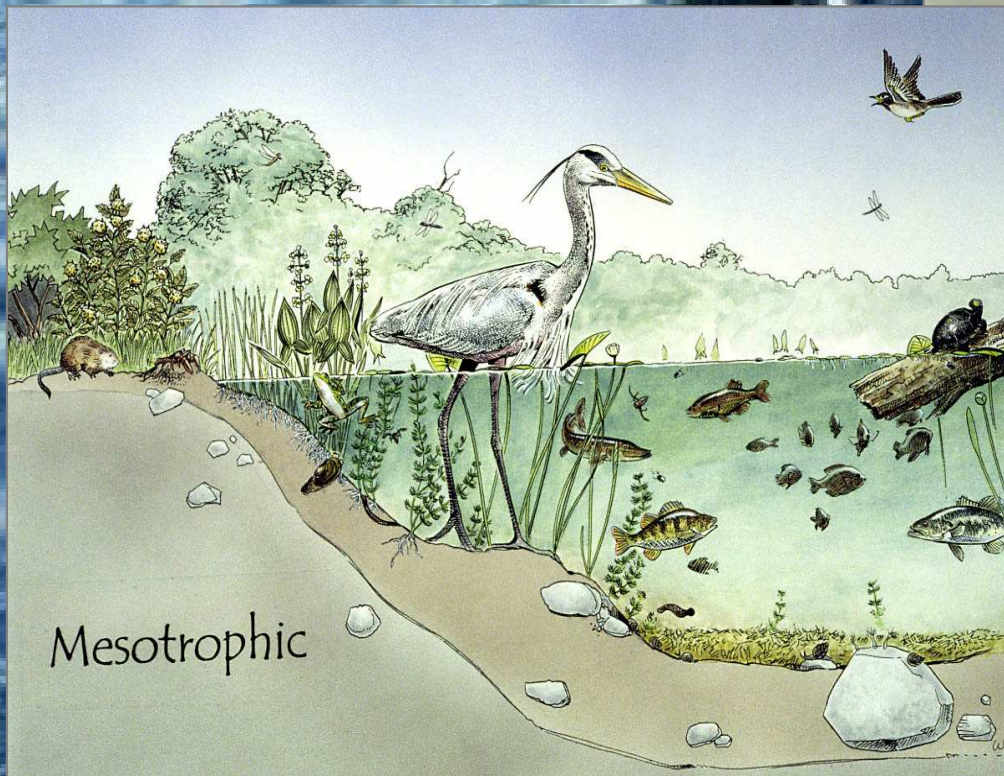


B) Periphyton in littoral important too!

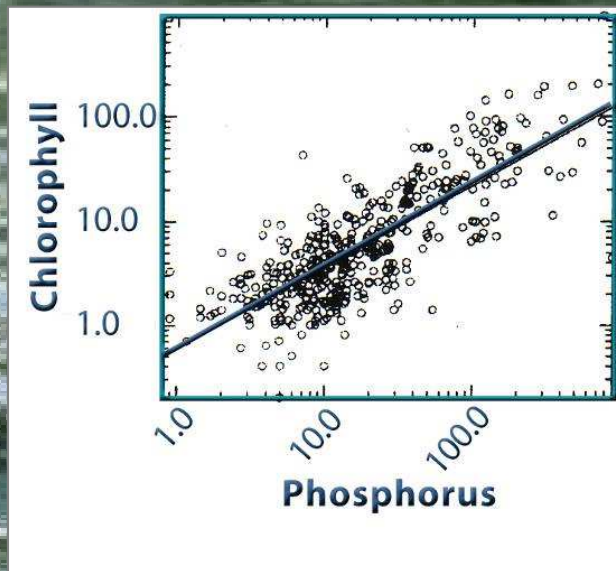


TROPHIC STATE

- Nutrients & Productivity
- Sediment & Accumulation
- Species Shifts
- Species Richness



Eutrophic waters: Phosphorus causes algae to grow



- P uptake in epilimnion
- P bound with iron in epilimnion
- P released in hypolimnion *via* decomposition
- P released from iron oxides *via* redox
- P diffuses from sediments

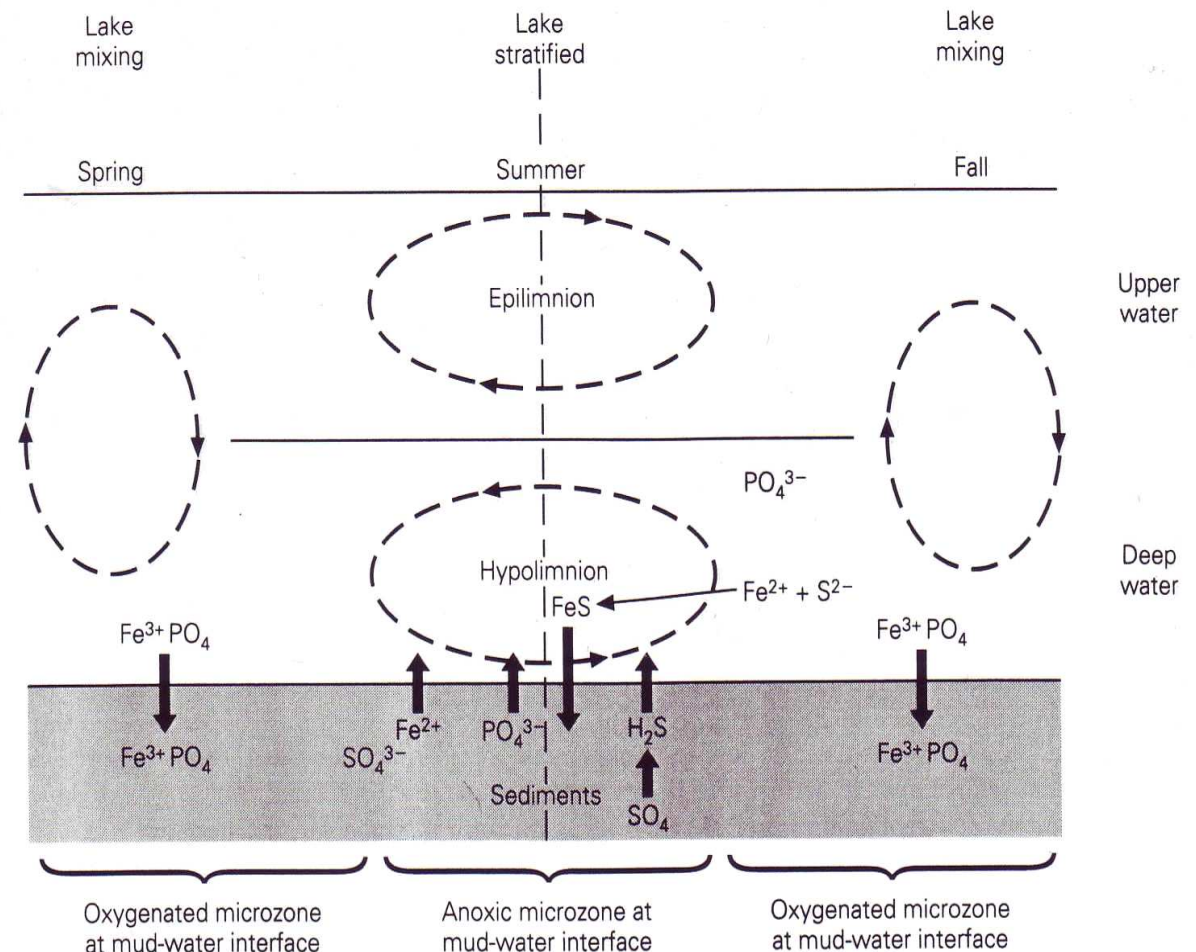


FIGURE 10-5 The iron, sulfur, and phosphorus interaction in eutrophic lakes. During overturn and whole-lake mixing, oxygenated water precipitates ferric (Fe^{3+}) phosphate. During the summer anoxic period, eutrophic lake sediments release ferrous (Fe^{2+}) ions, phosphate ions (PO_4^{3-}), and hydrogen sulfide (H_2S). The dissociated sulfide ion (S^{2-}) from H_2S can precipitate ferrous sulfide, a very insoluble substance, and remove iron and sulfur from the system.

Defining Eutrophication

transparency

Arbitrary scales

Phosphorus, Nitrogen, Chlorophyll a & Secchi depth
as indicators of trophic state. Note overlap of some values.

	Summer mean epilimnetic			
	Total P ($\mu\text{g/L}$)	Tot N ($\mu\text{g/L}$)	Chl a ($\mu\text{g/L}$)	Secchi depth (m)
Oligotrophic	<5	600	1.5	>10
Mesotrophic	5-30	750	5	2-10
Eutrophic	30-100	1900	15	1-4
Hypereutrophic	>100	-	>75	<1

Modified from Wetzel 1983

Sardinian Lakes and reservoirs

- Chl a
- [TP]
- cyanobacteria
and algae

TABLE 2

Mean annual values of total phosphorus and chlorophyll a on the basis of four seasonal samplings and the most important taxa in terms of density in hierarchical order.

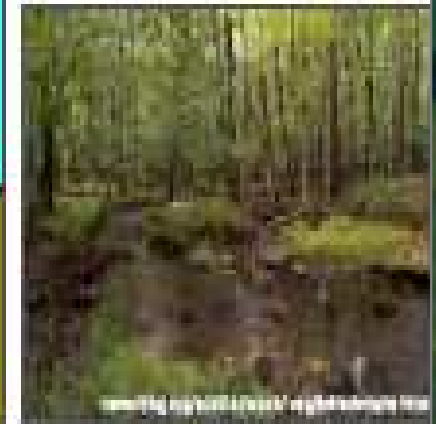
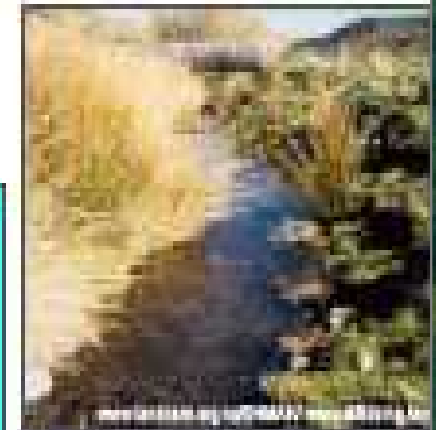
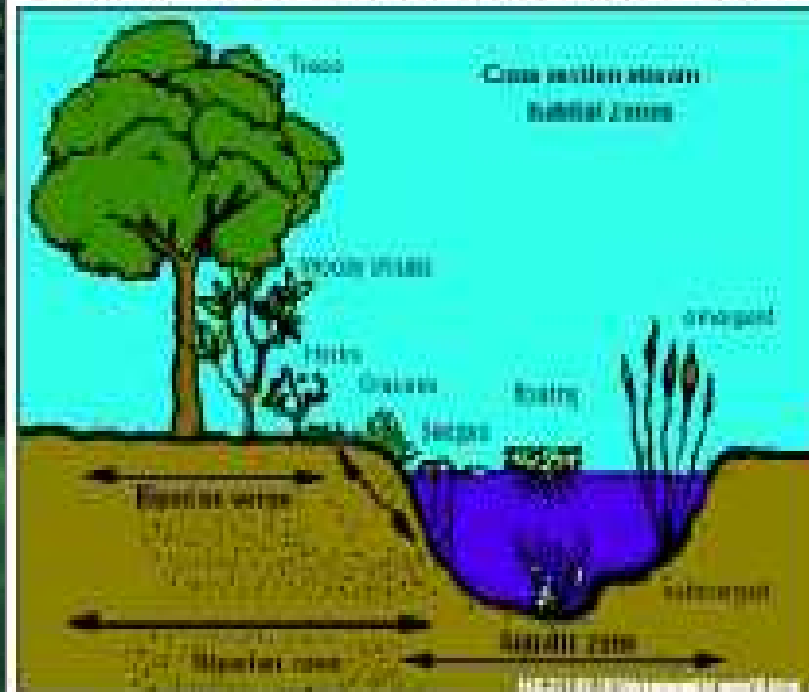
NAME	[P] mg m ⁻³	[CHL]	Most important taxa					
			1°	2°	3°	4°	5°	6°
Nuraghe Pranu Antoni	203	9	Mic aer	Chl sp.	Dic sp.	Ana spi	Rho sp	Cyc spp
Cuga	169	15	Mic aer	Aph fqu	Pse muc	Ana pla	Ana fqu	Cyc spp
Bidighinzu	166	28	Ooc spp	Apc sp.	Mic fqu	Ste spp	Coe spp	Ana fqu
Omodeo	160	13	Mic aer	Mic fqu	Mer pun	Apt spp	Ana spi	Mel amb
Monteleone Roccadoria	148	9	Mic aer	Ana spi.	Pse muc	Apc sp.	Gom apo	Cyc spp
Bunnari alto	98	9	Mer pun	Apc sp.	Ooc spp.	Sce spp	Coe spp	Sph pla
Cedrino	91	22	Ana pla	Mic aer	Ste han	Cyc spp	Aph fqu	Chl sp.
Casteldoria	90	15	Mic aer	Ana fqu	Mic fqu	Ana spp.	Pse muc	Mel dis
Santa Lucia	89	70	Mic aer	Apt spp	Fra cro	Osc spp	Gom apo	Ank spp
Monte Pranu	79	37	Osc spp	Clo gra	Ana pla	Chl sp.	Mic aer	Rho sp
Liscia	78	20	Mic aer	Gom apo	Apc sp.	Mel dis	Mel amb	Rho min
Coghinas	76	11	Mic fqu	Ana fqu	Mic aer	Aph fqu	Apc sp.	Mel dis
Cixerri	75	45	Osc spp	Mic aer	Ped sim	Cer hir	Ana pla	Pse muc
Is Barroccus	71	8	Aph fqu	Apt spp.	Ooc spp.	Chl sp.	Coe pse	Apc sp.
Posada	65	17	Gom apo	Mel dis	Mic aer	Apc sp.	Aph fqu	Osc spp
Surigheddu	61	7	Aph fqu	Mic aer	Gom spp	Cyc oce	Pse muc	Chr acu
Simbirizzi	56	20	Aph fqu	Cos sp.	Osc spp	Ped sim	Tet min	Chl sp.
Monteponi	49	21	Apc sp.	Tet min	Chl sp.	Cyc oce	Sce qua	Did sp.
Medau Zirimilis	43	3	Cyc oce	Cyc spp	Chl sp.	Ooc spp	Osc spp	Sph pla
Pattada	35	15	Mic aer	Apc sp.	Gom spp	Mel dis	Ooc spp	Vov aur
Flumineddu	33	7	Syn tab	Mon spp	Sce spp	Per sp	Tet min	Chl sp.
Sos Canales	33	19	Ana spp	Ank fal	Apc ela	Gym lim	Eut pla	Rho min
Alto Flumendosa	33	13	Osc spp	Gom apo	Apt spp	Cyc spp	Rho min	Ooc spp
Bau Pressiu	32	6	Apc sp.	Chl sp.	Cyc spp	Ank spp	Cru qua	Cru tet
Barzolu	30	5	Fot sp.	Ana spp.	Mal akr	Mon min	Ank fal	Cos ten
Gusana	29	8	Mel spp	Chl sp.	Mel gra	Vov sp.	Sta gra	Mic aer
Medio Flumendosa	28	4	Osc spp	Sta spp	Ped sim	Mel gra	Cyc oce	Fra cro
Punta Gennarta	27	8	Sph pla	Cyc oce	Chl sp.	Rad sp.	Mic aer	Ela sp.
Torrei	27	3	Ank fal	Cen sp	Cyc oce	Dyn div	Ooc lac	Rho min
Benzone	25	10	Mel amb	Ela sp.	Fra cro	Ank spp	Osc spp	Dyn div
Mulargia	25	4	Osc spp	Ped dup	Chl sp.	Aph fqu	Cyc spp	Mic aer
Govossai	24	4	Ank spp	Apt spp	Chl sp.	Apc sp.	Rhi sp.	Dic sp.
Cucchinadorza	22	10	Sce spp	Mel amb	Chl sp.	Ank spp	Fra cro	Ana sp.
Corongiu II	21	2	Gom apo	Ank spp	Chl sp.	Sph sp.	Vov aur	Cyc spp
Corongiu III	21	2	Cyc spp	Chl sp.	Ank spp	Vov aur	Apc sp.	Rho min
Leni	15	3	Apc sp.	Cyc oce	Ank fal	Chl sp.	Sph pla	Ooc spp

Sources of organic matter

- Autochthonous – instream
- Allochthonous – out of stream

Autochthonous organic matter:
produced within lakes and streams (cyanobacteria, diatoms and other algae; submerged, floating, and emergent macrophytes)

Allochthonous organic matter:
produced outside of the stream and imported into the channel. (includes, but is not limited to leaves, woody debris, dissolved organic compounds, dead organisms)



Rivers

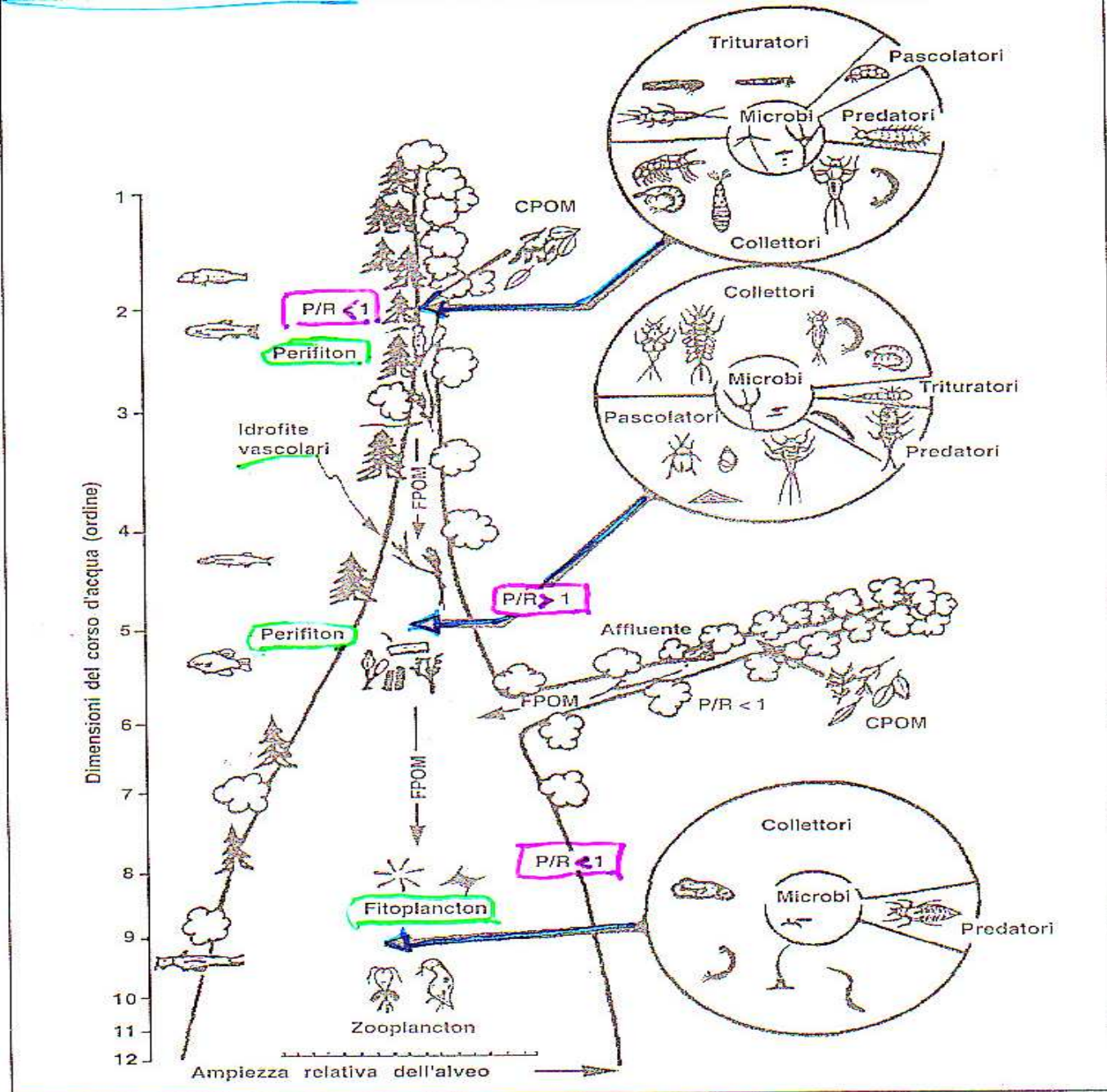


Figura 1: Relazioni proposte dal River Continuum Concept tra le dimensioni del corso d'acqua ed i graduali aggiustamenti nella struttura e nella funzione delle comunità lotiche (Vannote et al. 1980).

CPOM = Coarse Particulate Organic Matter (materia organica particolata grossolana);

FPOM = Fine Particulate Organic Matter (materia organica particolata fine);

P/R = Rapporto Fotosintesi/Respirazione.

Indici qualità acque fiumi: qualità e abbondanza del macrofitobentos (alghe *Charophyceae*, briofite, pteridofite, angiosperme)

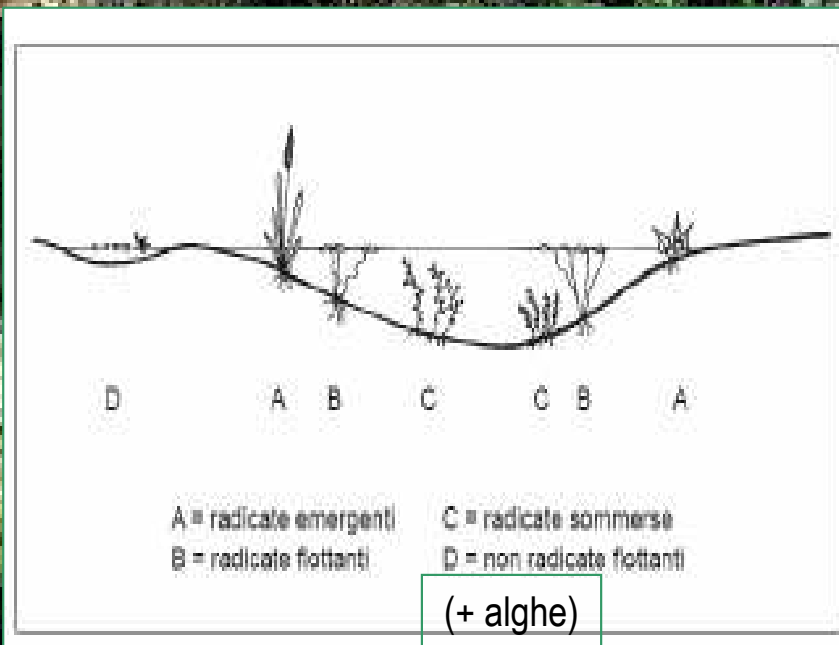


Fig 2.1: Esempificazione schematica di tipologia di macrofite (da Siligardi et al., 2001)

TIM, Trophie index macrophyten (Schneider et al., 2000).

TAXA	TW	G
<i>Chara aspera</i>	1.1	8
<i>Chara contraria</i>	1.7	4
<i>Chara delicatula</i>	1.58	4
<i>Chara globularis</i>	2.03	4
<i>Chara hispida</i>	1.05	16
<i>Chara intermedia</i>	1.15	8
<i>Chara vulgaris</i>	2.23	2
<i>Acorus calamus</i>	3.20	2
<i>Berula erecta</i>	2.65	4
<i>Butomus umbellatus</i>	2.98	4
<i>Callitriche cophocarpa</i>	2.50	4
<i>Callitriche hamulata</i>	1.80	2
<i>Callitriche obtusangula</i>	2.50	4

[] P µg/l	Livello trofico	Indice di valenza
$x < 15$	Oligotrofo	1.0
$15 < x < 50$	Oligo/mesotrofo	1.5
$50 < x < 100$	Mesotrofo	2.0
$100 < x < 200$	Meso/Eutrofo	2.5
$200 < x < 500$	Eutrofo	3.0
$500 < x < 1500$	Eu/Ipereutrofo	3.5
$x > 1500$	Ipereutrofo	4.0

TIM	Stato trofico
$1.00 < TIM < 1.45$	Oligotrofo
$1.45 < TIM < 1.87$	Oligo/mesotrofo
$1.87 < TIM < 2.25$	Mesotrofo
$2.25 < TIM < 2.63$	Meso/Eutrofo
$2.63 < TIM < 3.05$	Eutrofo
$3.05 < TIM < 3.50$	Eu/Ipereutrofo
$3.50 < TIM < 4.00$	Ipereutrofo

Bioindicatore è una specie:

- dei *range di tollerabilità ristretti*, così che la sua presenza possa essere ritenuta indice di particolari condizioni ambientali;
- una *relativa facilità di identificazione*, affinché tale studio possa essere svolto anche da personale non specializzato;
- una *distribuzione cosmopolita*, che permetta eventuali comparazioni a livello regionale, nazionale ed internazionale;
- una *presenza in elevate densità e delle dimensioni piuttosto grandi*, che facilitino la raccolta sul campo e lo smistamento in laboratorio;
- una *variabilità ecologica piuttosto bassa*, che non permetta adattamenti a situazioni degradate; una *mobilità limitata*, utile ad identificare la situazione propria dello specifico sito di campionamento;
- una *durata del ciclo vitale relativamente lunga*, che permetta di esprimere un effetto cumulativo rispetto all'azione, nel tempo, dei vari fattori di stress;
- una *valenza ecologica ben conosciuta in letteratura*: infatti le particolari richieste autoecologiche di una specie, ritrovata in un dato habitat, ci indicano che, in quel luogo, lo specifico parametro considerato si trova entro i limiti di tolleranza.



Fresh water environment

< 5‰ salinity

phytobenthos

periphyton

epilithon - rocks

episammon
endosammon

sediments

epipelton - surface

rizobenthos - sediments

cyano
diatoms
greens
filam.
dennids

diatoms
cyano
coccal group

diatoms
cyano
green flagell

→ charales

epiphyton

→ diatoms

metaphyton

diatoms
cyano

endophyton

(symbiosis)

phytoplankton

Lakes

polar

temperate

tropical

eutrophic

mesotrophic

oligotrophic

distrophic

cyano
diatoms
greens

dinoflagellates

diatoms
dennids

chrysophyceae
diatoms

• saledonic

• baltic