CARBON

- most carbon exists as equilibrium products of carbonic acid
- small amts as dissolved / detrital organic C
- small amt as living biota

- CO_2 in air = about 3.2% (increasing)
- Highly soluble in water (200 x > than O_2)
- 1.1 mg/L at 0°C $\rightarrow$ 0.4 mg/L at 30°C:

CO_2 (air) $\leftrightarrow$ CO_2 (dissolved) + H_2O

Then, CO_2 hydrates to form carbonic acid: $CO_2 + H_2O \leftrightarrow H_2CO_3$

Then, bicarbonate (H_2CO_3) disassociates: $H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{2-}$$

Also:

$HCO_3^- + H_2O \leftrightarrow H_2CO_3 + OH^-$

$CO_3^{2-} + H_2O \leftrightarrow HCO_3^- + OH^-$

$H_2CO_3 \leftrightarrow H_2O + CO_2$

These reactions act as a buffer to resist changes in pH (Fig 11-1)

→ absorb H^+ as long as CO_3^{2-} reserves remain

→ absorb OH^- as long as HCO^- reserves remain

ALKALINITY = quantity and kinds of compounds present that shift pH up

- e.g. HCO_3^-, CO_3^{2-}, OH^-

Alkalinity aka *acid neutralizing capacity* (ANC)

- total alkalinity = amount of acid needed / L to neutralize all these ions
- usually expressed as mg/L $CaCO_3$ (which assumes that alkalinity results only from $CaCO_3$ and HCO_3^-

HARDNESS = Ca and Mn salts of CO_3 and HCO_3 and also SO_4, Cl, etc

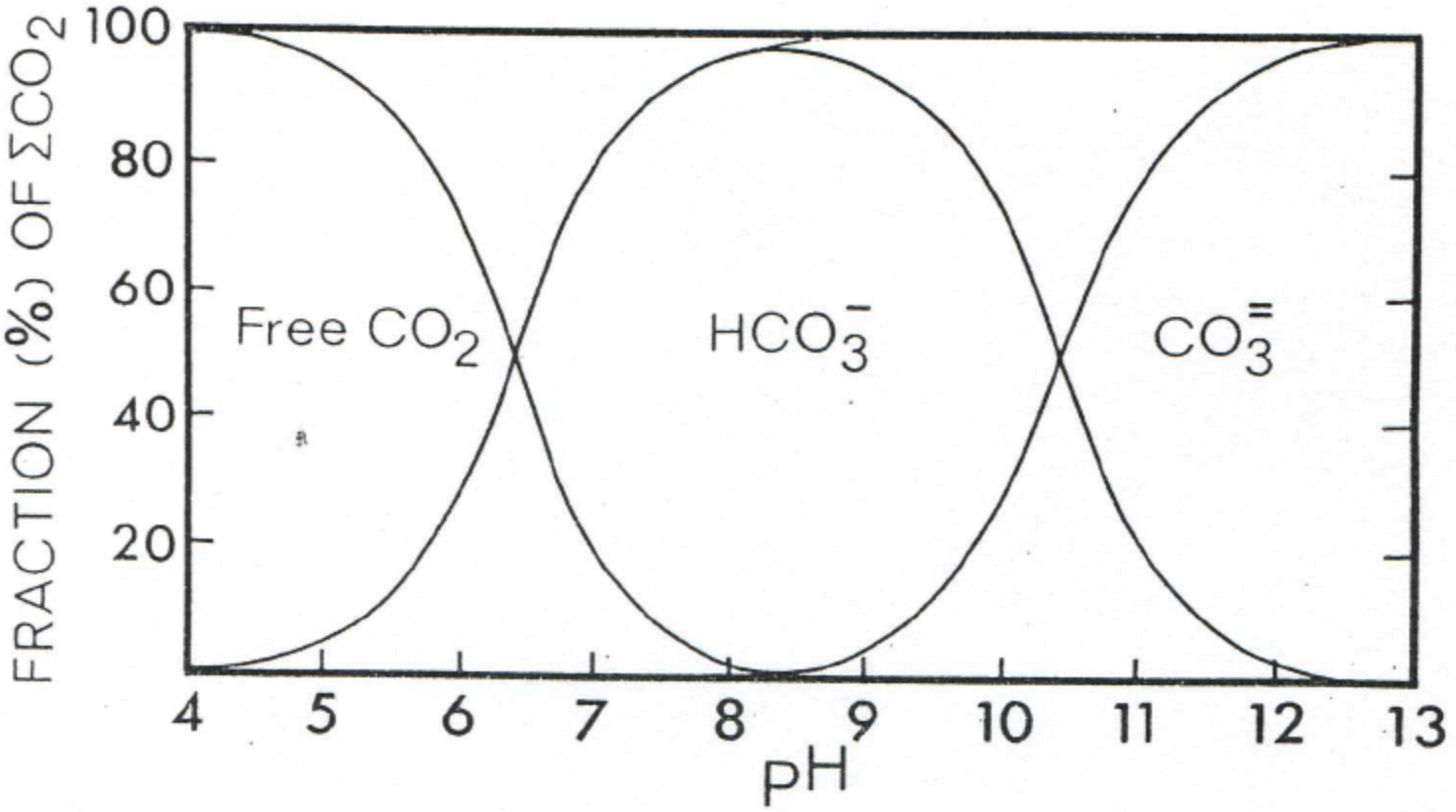
- often expressed as mg/L $CaCO_3$ in USA
- elsewhere other systems are used (Table)

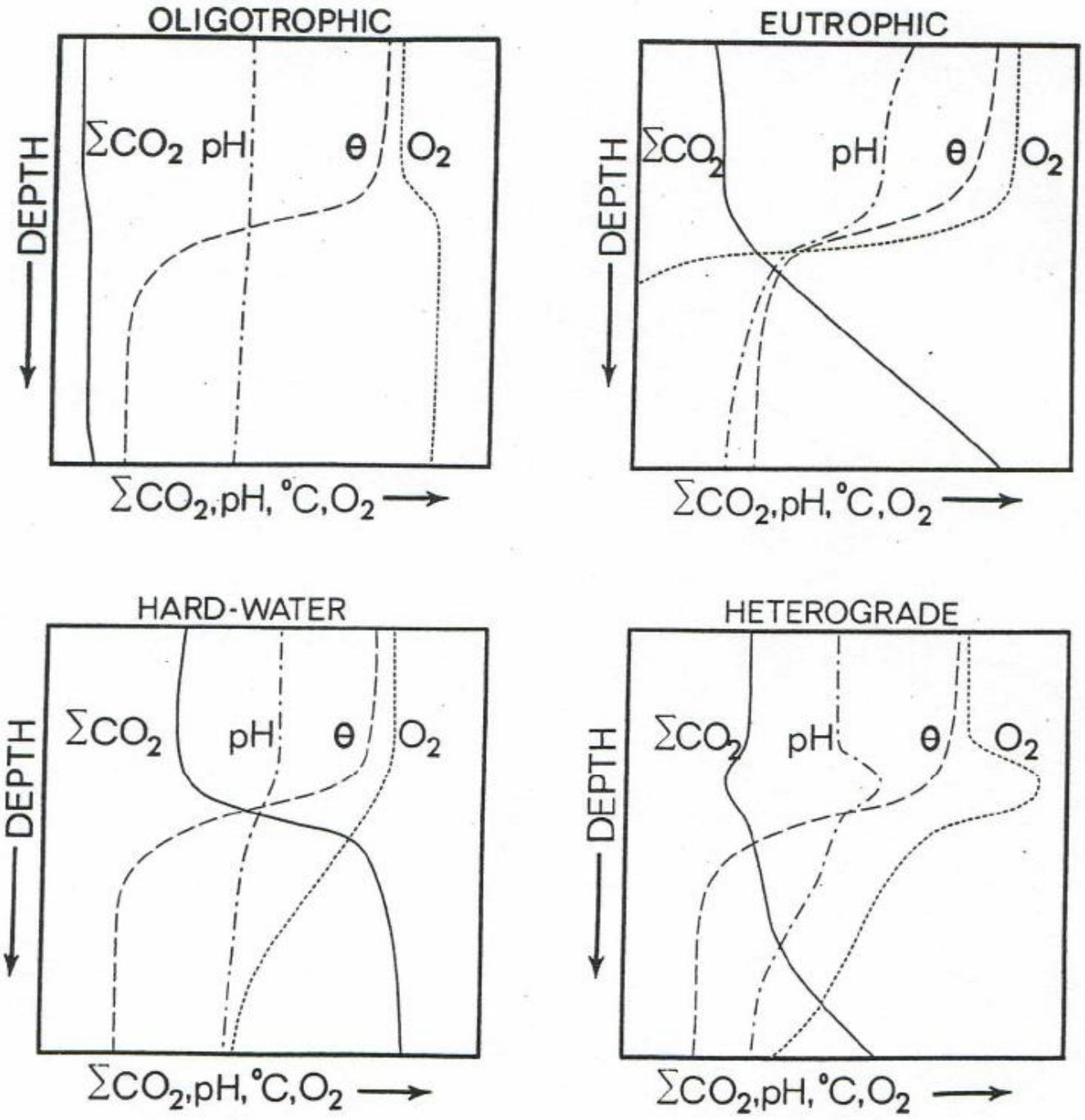
pH

- ranges from 2 to 12 in lakes
- *Sphagnum* bogs ~ pH 3.3-4.5
- endorheic regions can have very high pH
- most lakes in the 6 to 9 range (HCO_3^-)

Interaction of C with pH

- the dominant C species depends on pH
- pH < 5 $\rightarrow$ free CO_2 dominates; pH 6 to 9.5 $\rightarrow$ HCO_3^- dominates
- pH > 9.5 $\rightarrow$ CO_3^{2-} dominates




OLIGOTROPHIC
DEPTH
ΣCO2 pHi θ O2
ΣCO2,pH,°C,O2
EUTROPHIC
DEPTH
ΣCO2 pHi θ O2
ΣCO2,pH,°C,O2
HARD-WATER
DEPTH
ΣCO2 pH θ O2
ΣCO2,pH,°C,O2
HETEROGRADE
DEPTH
ΣCO2 pH θ O2
ΣCO2,pH,°C,O2

Interaction of C with Ca

$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3$

- water from runoff, percolating through soil:
  $H^+ + CaCO_3 \rightarrow Ca(HCO_3)_2$

- an important source of C in watersheds over limestone ($CaCO_3$)
  $Ca(HCO_3)_2 \rightarrow CaCO_3 \downarrow + H_2O + CO_2$

- as CO_2 is consumed by photosynthesis, [$CaCO_3$] exceeds solubility $\rightarrow CaCO_3 \downarrow$