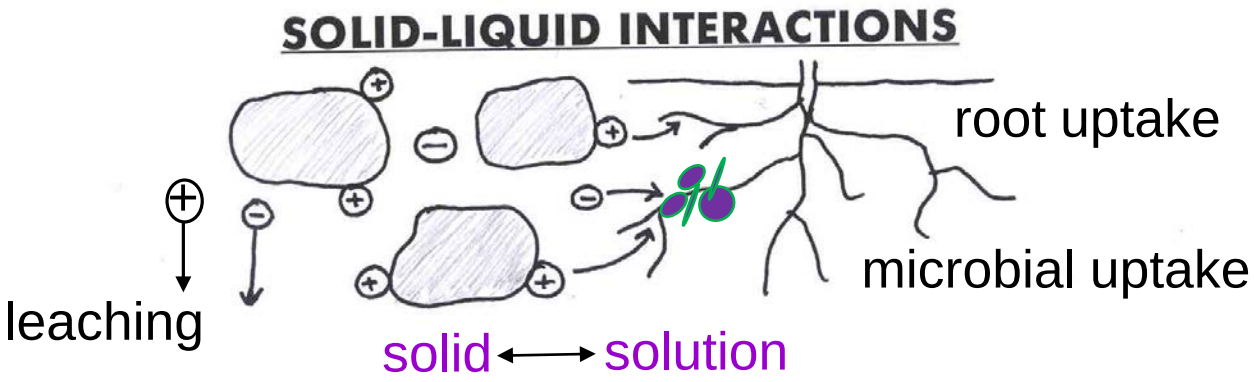
Nutrients: Nitrogen (N), Sulfur (S), Phosphorus (P), Potassium (K)

Essential for all life, their availability (or lack thereof) controls the distribution of flora and fauna

Look into their:

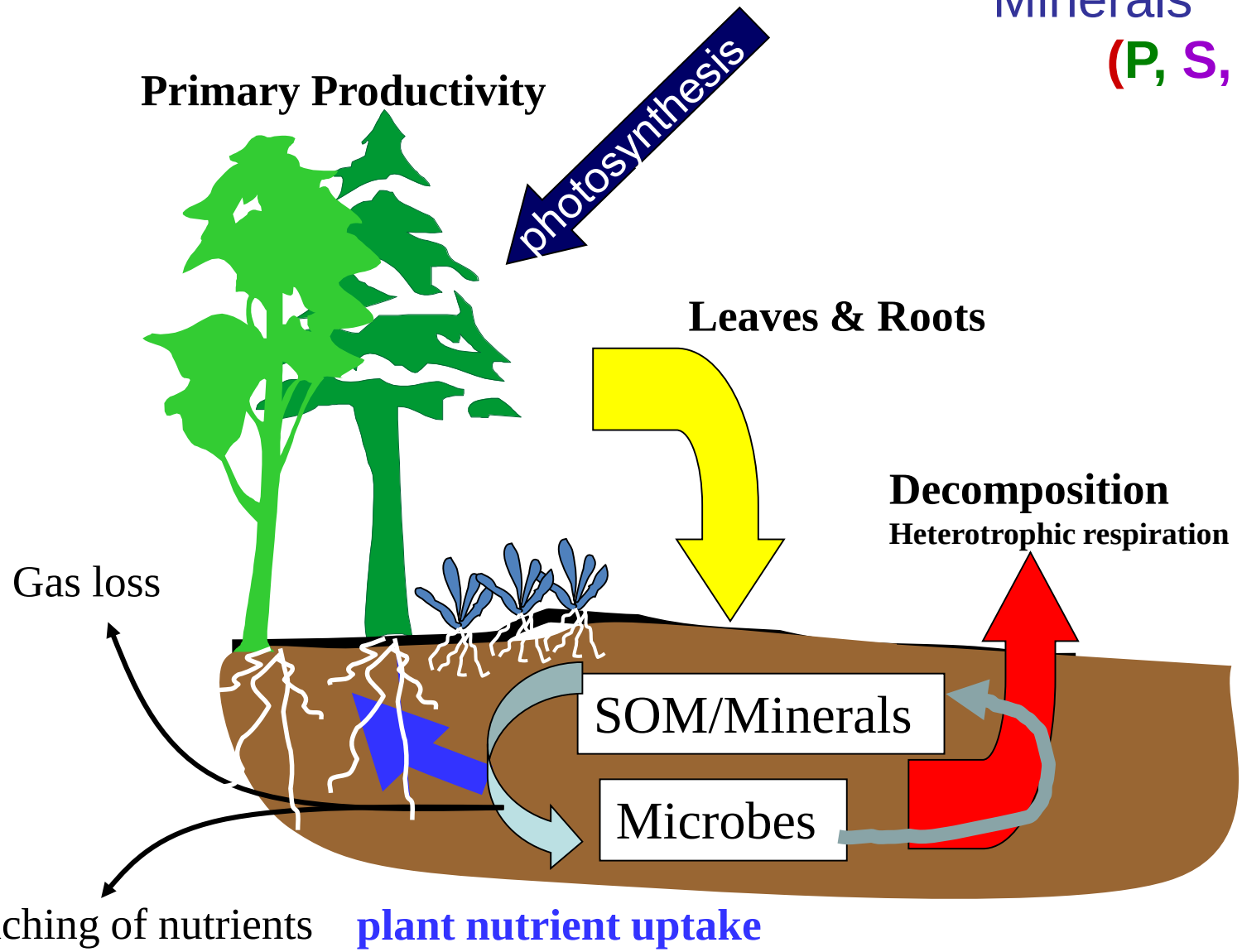
Sources **Pools (sinks)** **Fluxes**



Nutrients must be in a specific form – **specie** - for use by organisms

Nutrient Cycling: N, S, P, K

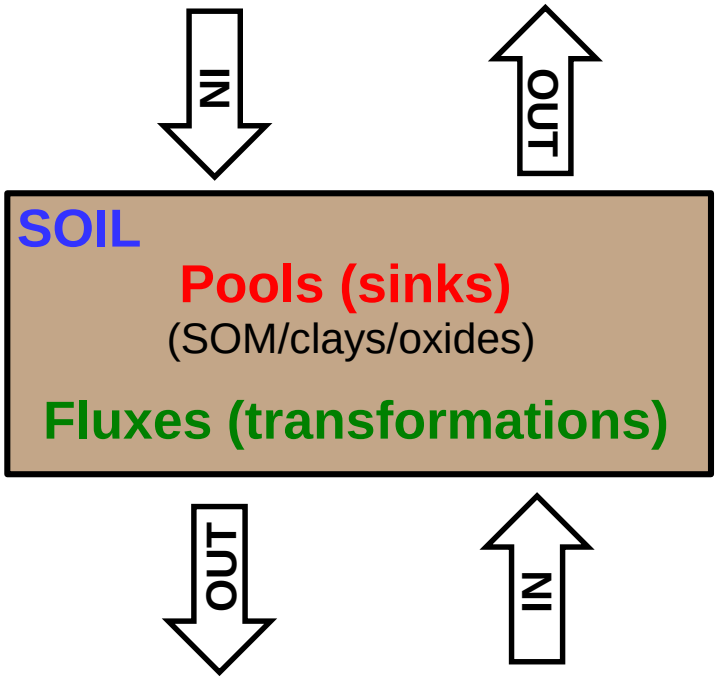
Soil Organic Matter
(CHONPS)
Minerals
(P, S, K)



Nutrients: natural & anthropogenic sources (IN) and outputs (OUT)

N_2
fertilizers (chemical, manure, sludge)
pesticides
wet and dry deposition (acid rain, aerosols)
plant tissue/residues

gases and particulates to atmosphere
(fossil fuel combustion (coal/oil); cycles; trees)
harvesting
root uptake



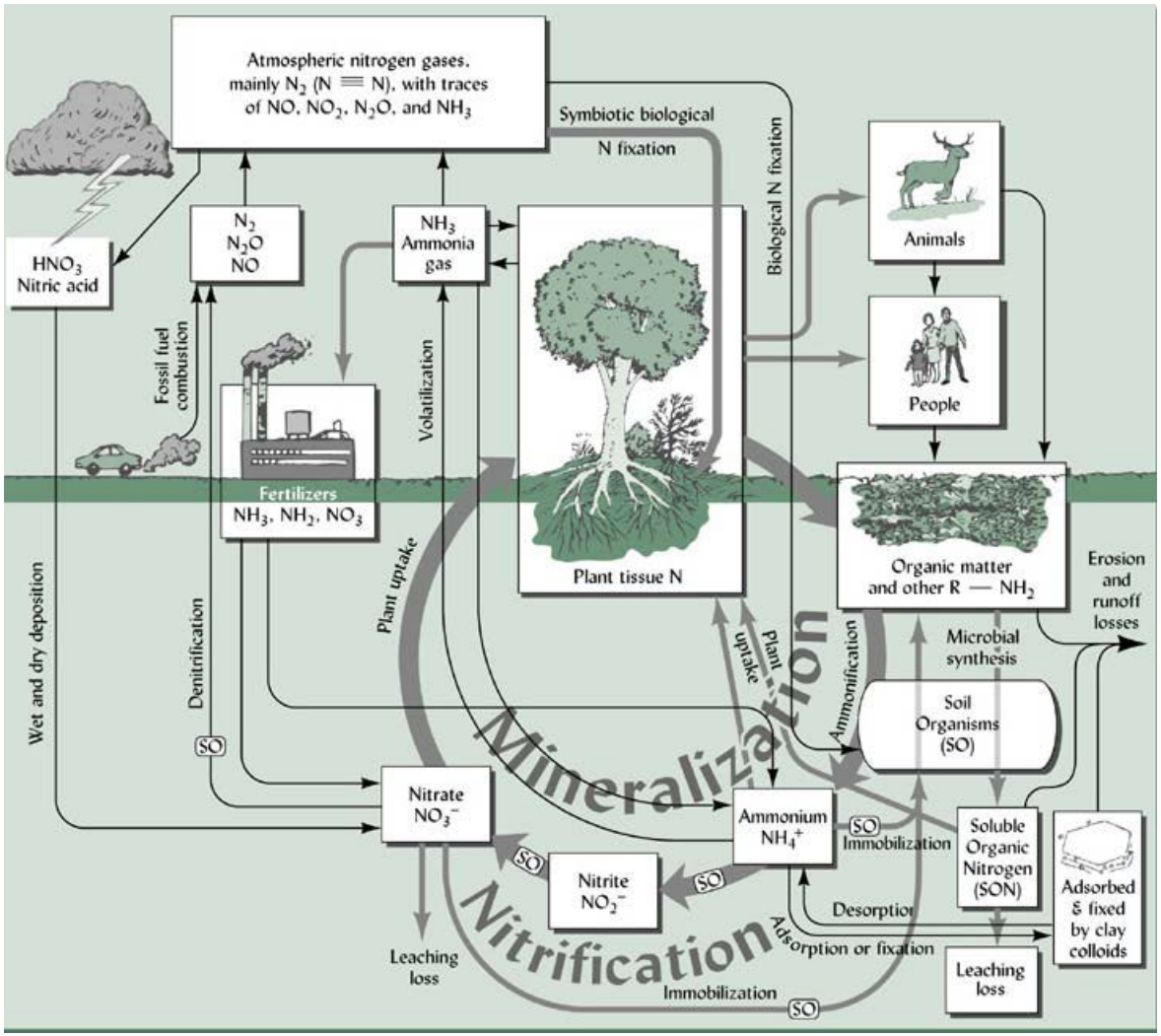
ions and molecules in solution (leaching)
colloidal transport
erosion
runoff

roots (exudates, biomass)

bedrock (1^{ry}/2^{ry} minerals in parent material)

The Nitrogen Cycle

	N Content, $\times 10^{16}$ kg
Terrestrial soils	
Organic matter	0.022
Clay-fixed NH_4^+	0.002

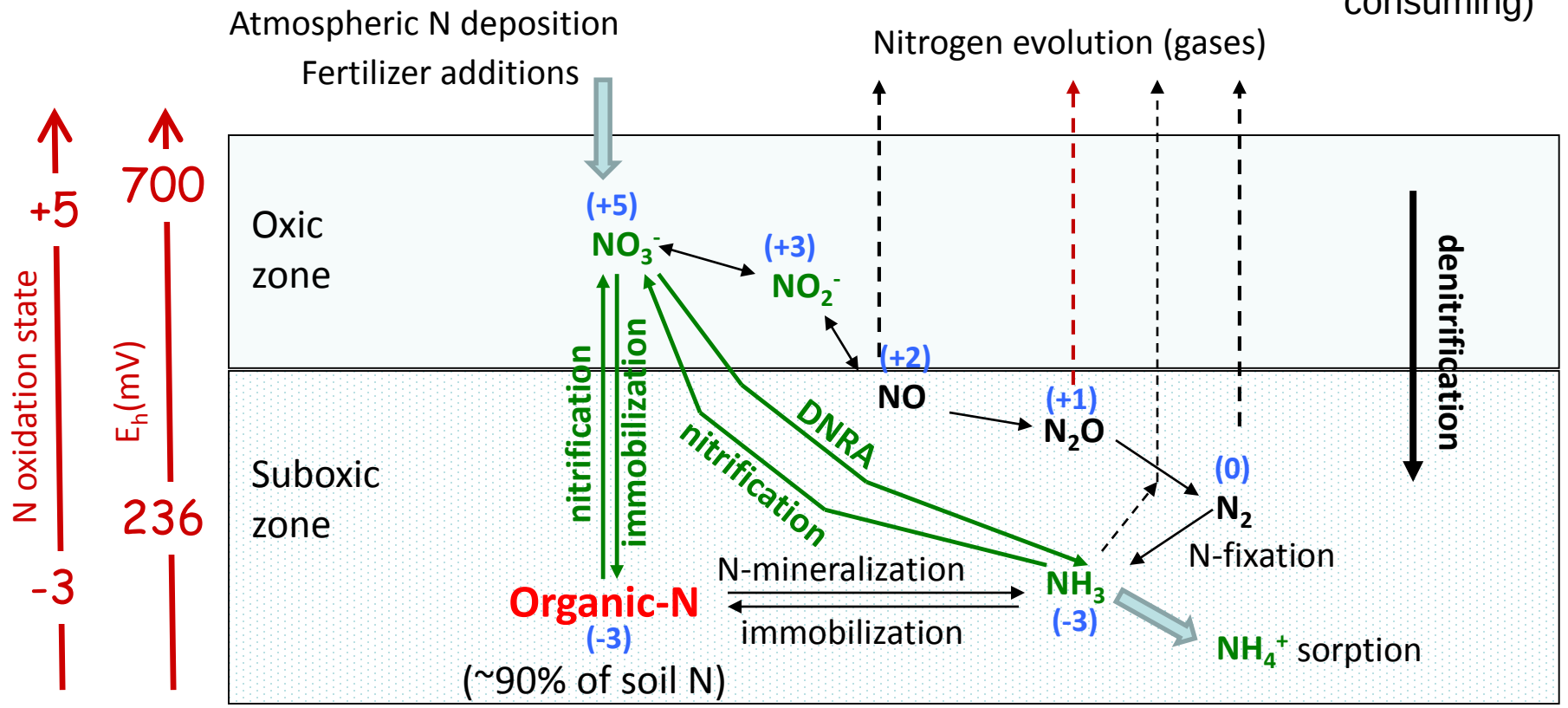


The Nitrogen Cycle

NO_3^- is the most stable chemical form of N in aerated soil solutions

N_2 (g) is prevalent in the air of soil pores

Denitrification: reduction of NO_3^- to reduced forms of N (N_2) (energy-consuming)



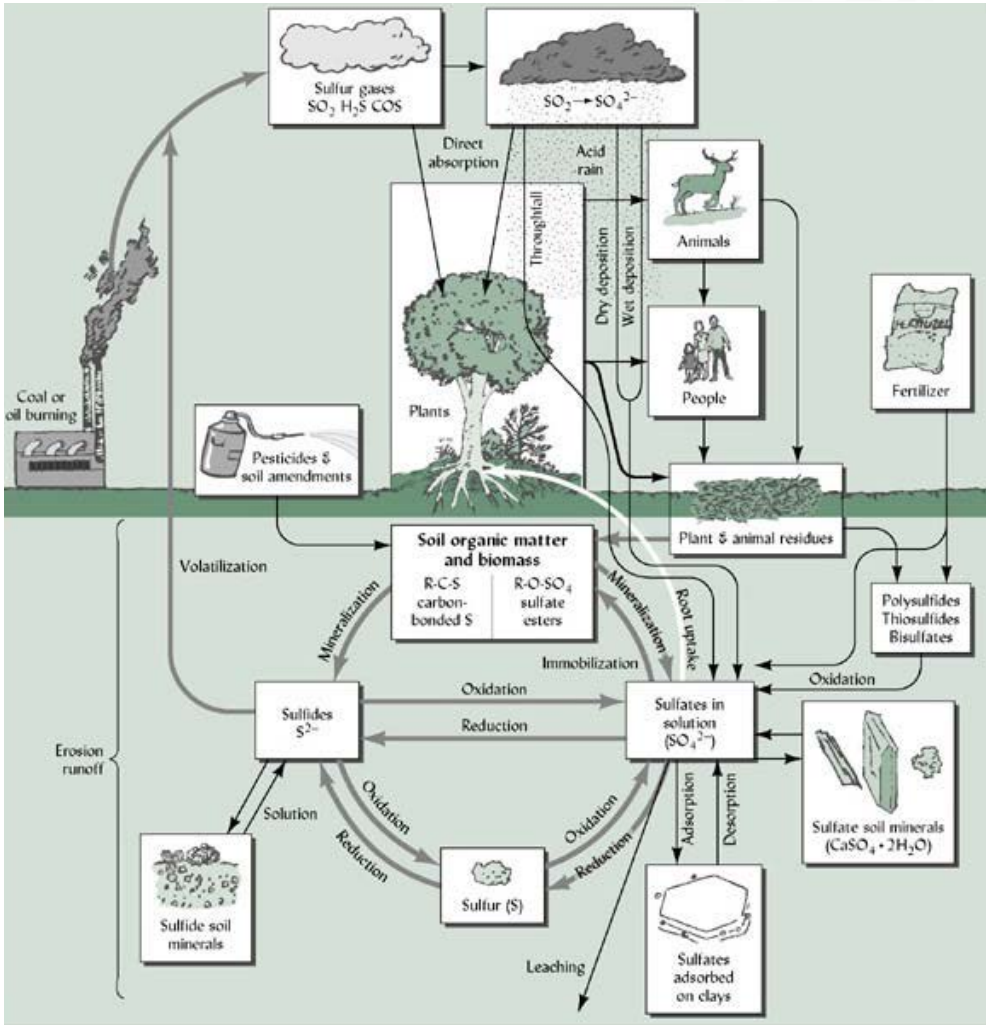
Nitrification: NH_3 to oxidized forms of N (NO_2^-, NO_3^-) (energy-releasing)

Oxidation of N_2 does not occur except in a few organisms (N-N triple bond)

N-fixation: enzyme-catalyzed reaction (occurs only in living organisms)

The Sulfur Cycle

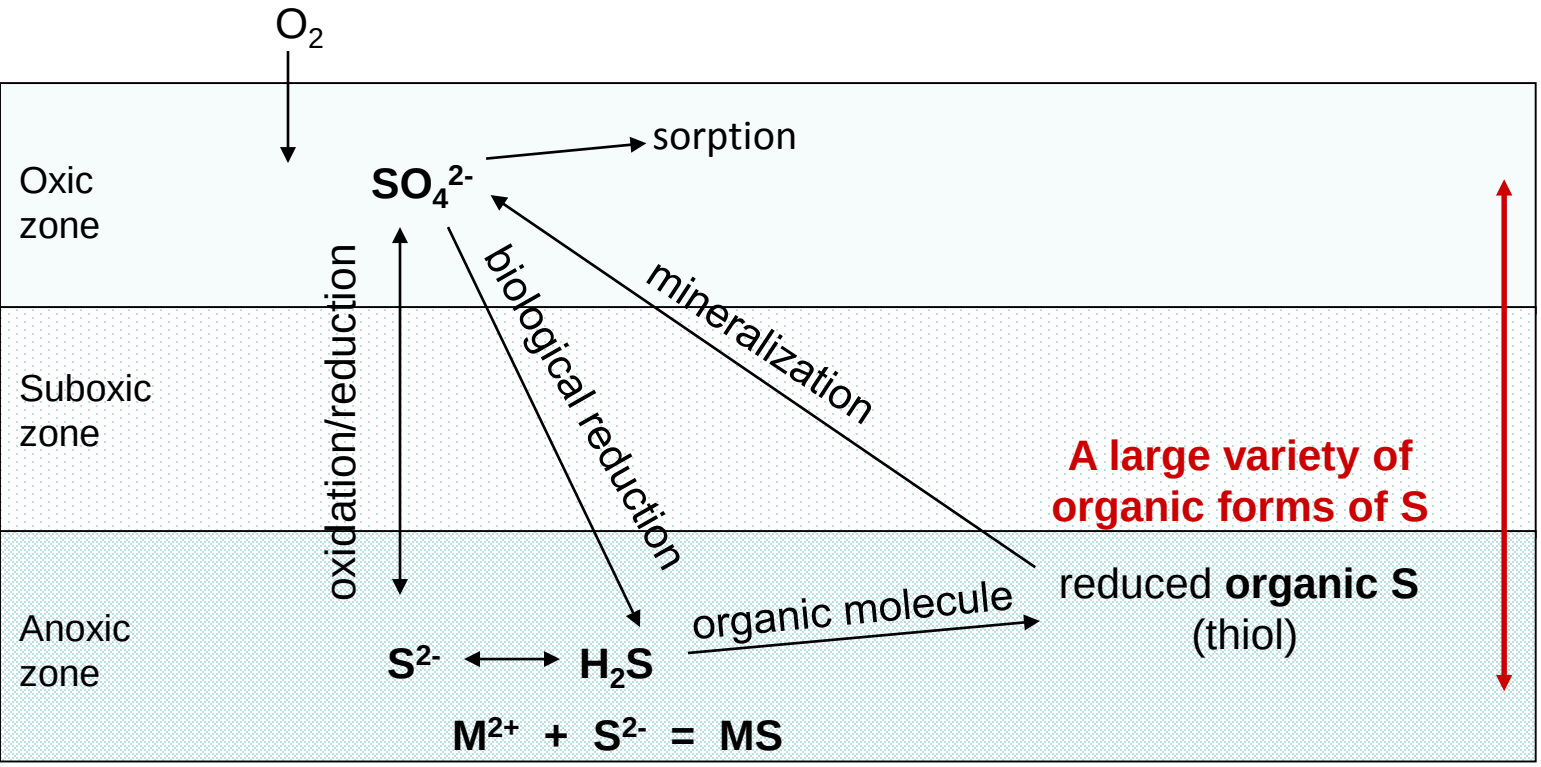
Pedosphere	Amount of S, kg
Soil	2.6×10^{14}
Soil organic matter	0.1×10^{14}
Land plants	7.6×10^{11}



The Sulfur Cycle

Sulfur undergoes dramatic changes in redox cycling

Oxidation states range from +6 to -2

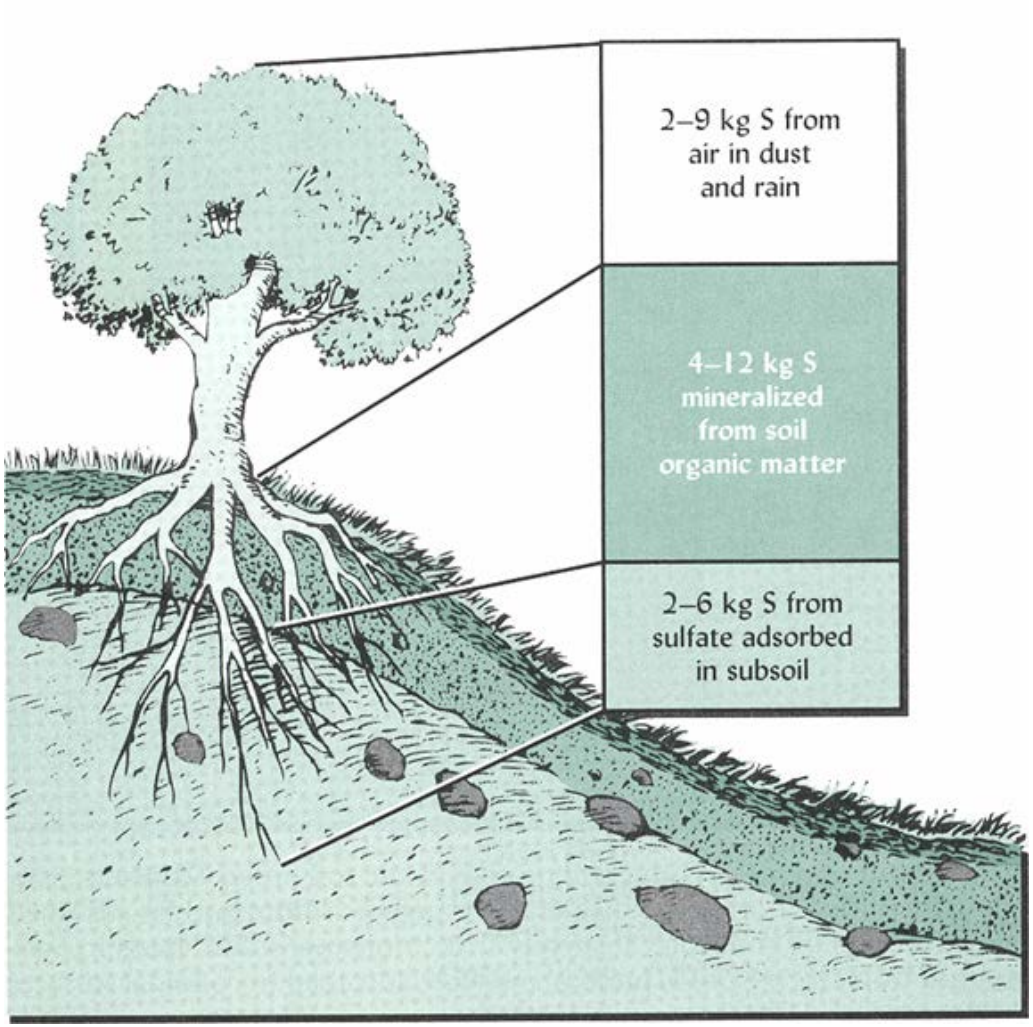


Sulfate found in oxidized environments

degradation of organic materials (plant/animal)

metal sulfides tend to be “insoluble”
(Hg, Ag, Cd, Cu, Pb, Zn, Fe(II))

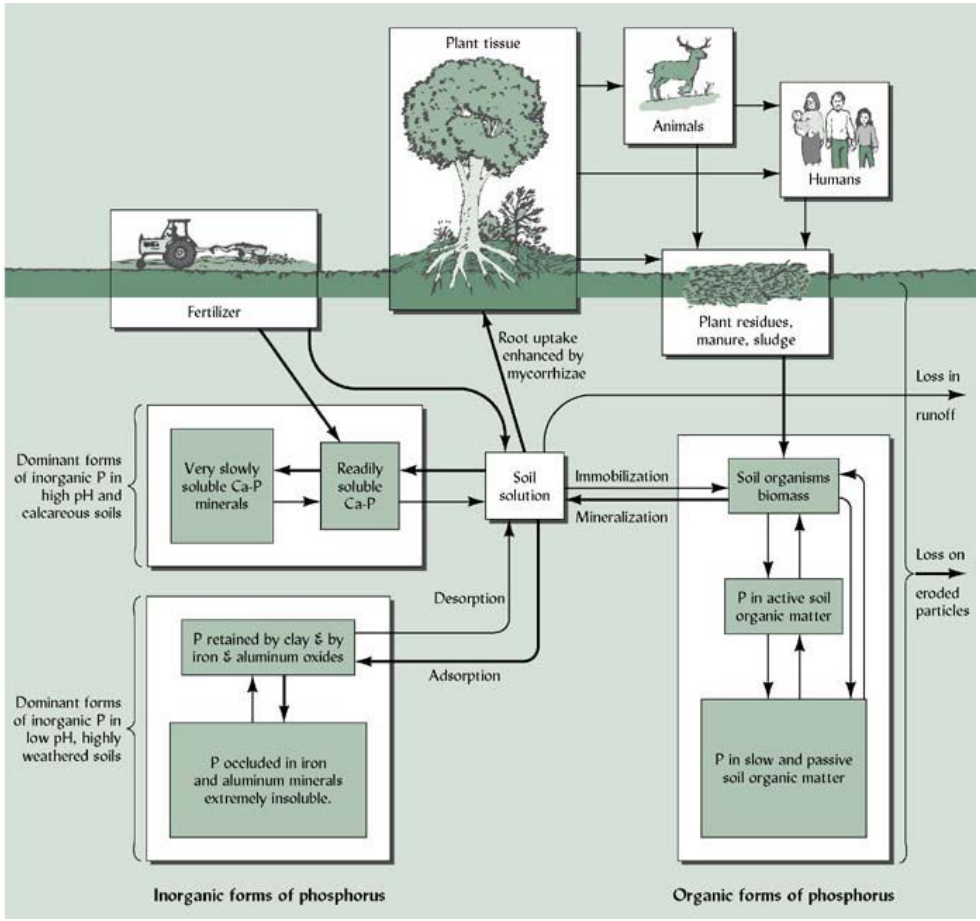
In soil, SO_4^{2-} originates from



- Organic matter mineralization
- Weathering of soil minerals
- Sulfur inputs from atmosphere

The Phosphorus Cycle

	Total P × 10^{12} kg
Land	
Soil	96–160
Mineable rock	19
Biota	2.6
Fresh water (dissolved)	0.090

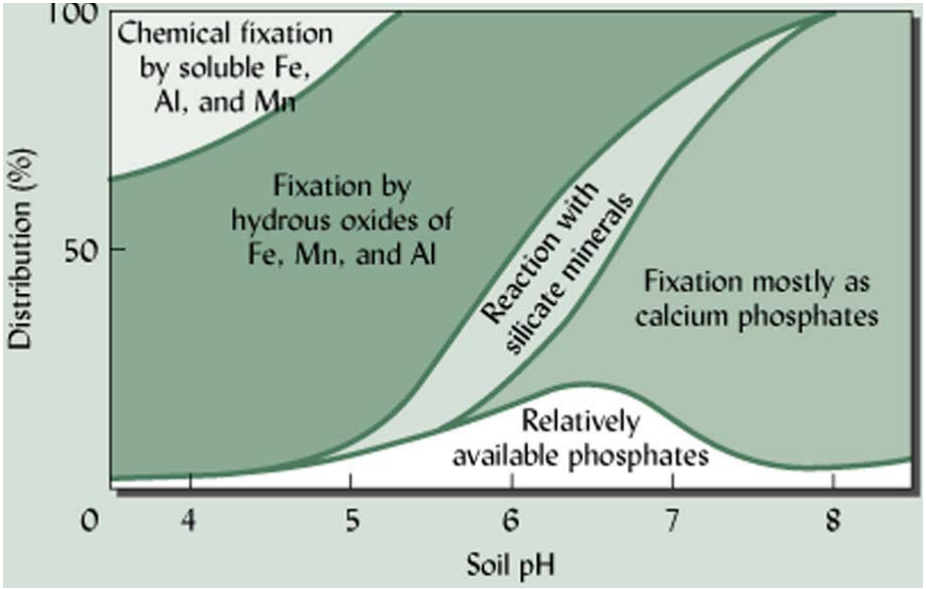


P primarily as phosphate (PO_4^{3-}), with an oxidation state of 5+

Mostly in organic P and inorganic P forms

PO_4^{3-} is strongly retained by soils but can be transported in colloidal forms

PO_4^{3-} sorption onto Al and Fe oxides is strong



Phosphate minerals (low solubility):

Al and Fe phosphates (acid mineral soils)

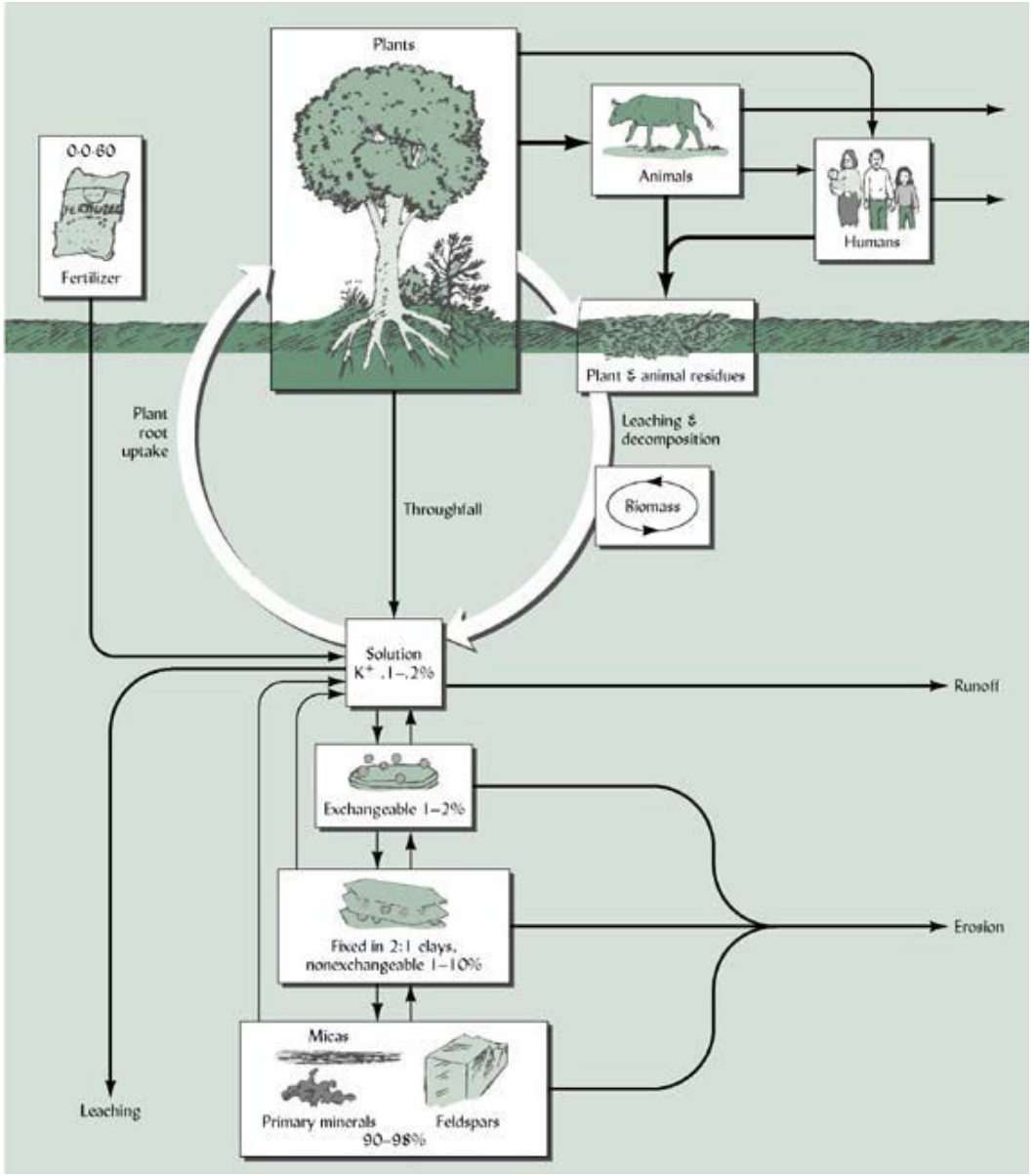
(variscite, $AlPO_4.2H_2O$)

(strengite, $FePO_4.2H_2O$)

Ca phosphates (non acid soils)

(hydroxyapatite, $Ca_5(PO_4)_3OH$)

The Potassium Cycle



Potassium as K^+ with no changes in oxidation state

K^+ flux controlled by CEC & chemical weathering ~ no organisms

Sources: Primary and Secondary Minerals