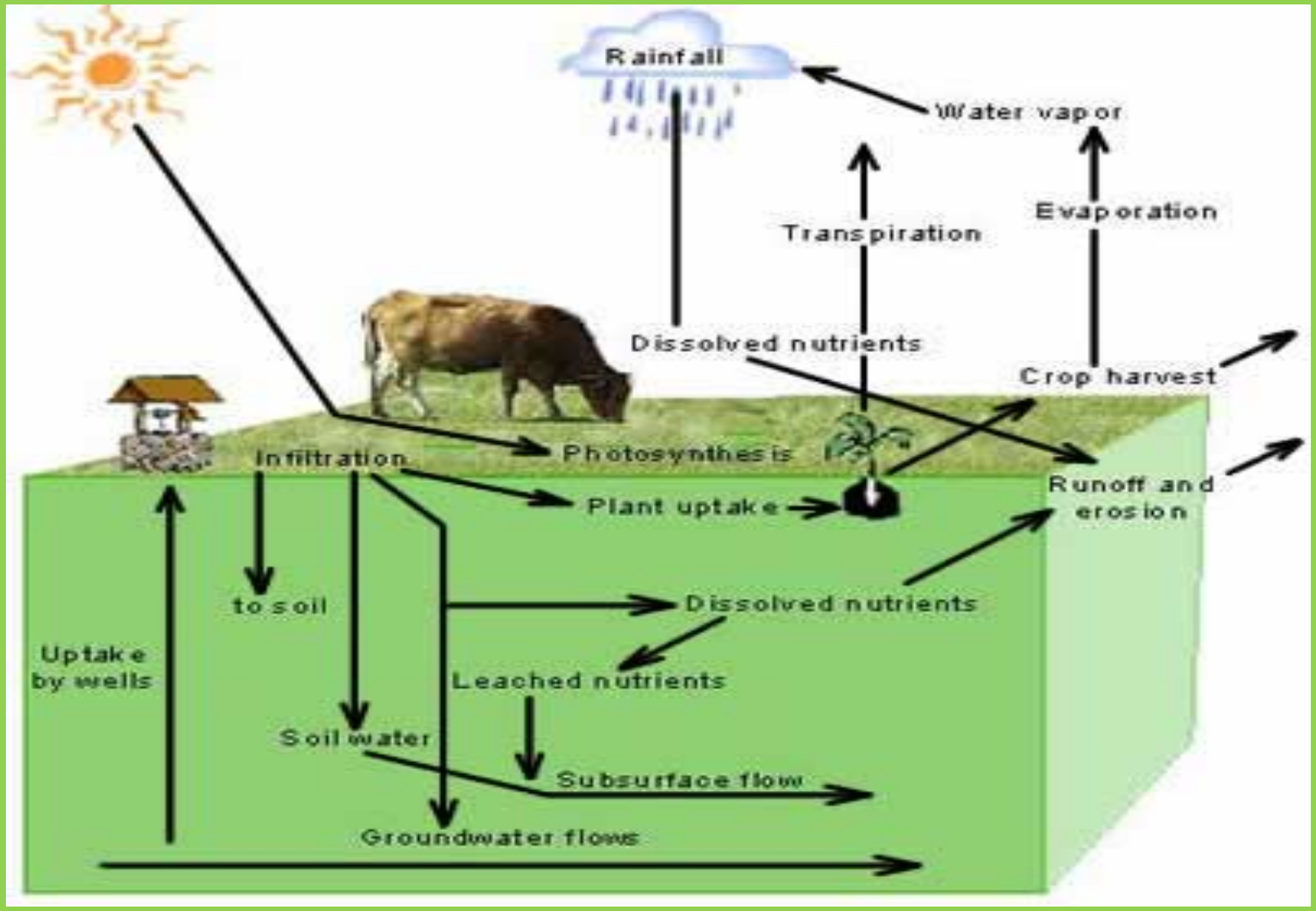
Nutrient Cycling



http://attra.ncat.org/images/nutrientcycling/fig3.jpg

17 Essential Plant Nutrients

Taken from air and water:

- C
- H
- O

Primary and most commonly deficient:

- N
- P
- K

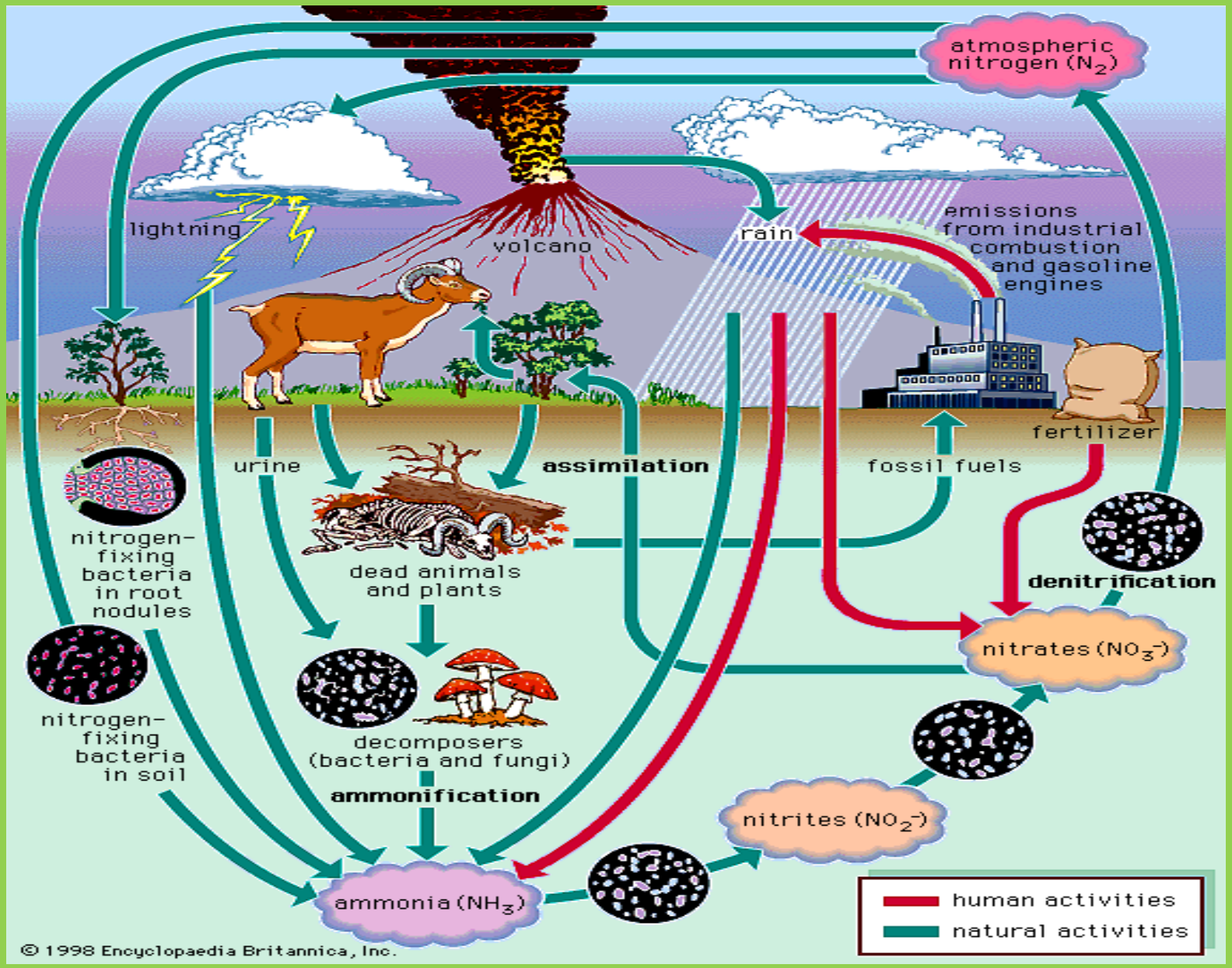
Secondary:

- Ca
- Mg
- S

Micro:

- Zn
- Fe
- Mn
- Cu
- Bo
- Mo
- Cl
- Ni

Nitrogen


atmospheric nitrogen (N_2)
lightning
volcano
rain
emissions from industrial combustion and gasoline engines
fertilizer
urine
assimilation
fossil fuels
nitrogen-fixing bacteria in root nodules
dead animals and plants
denitrification
nitrates (NO_3^-)
nitrogen-fixing bacteria in soil
decomposers (bacteria and fungi)
ammonification
nitrites (NO_2^-)
ammonia (NH_3)
human activities
natural activities
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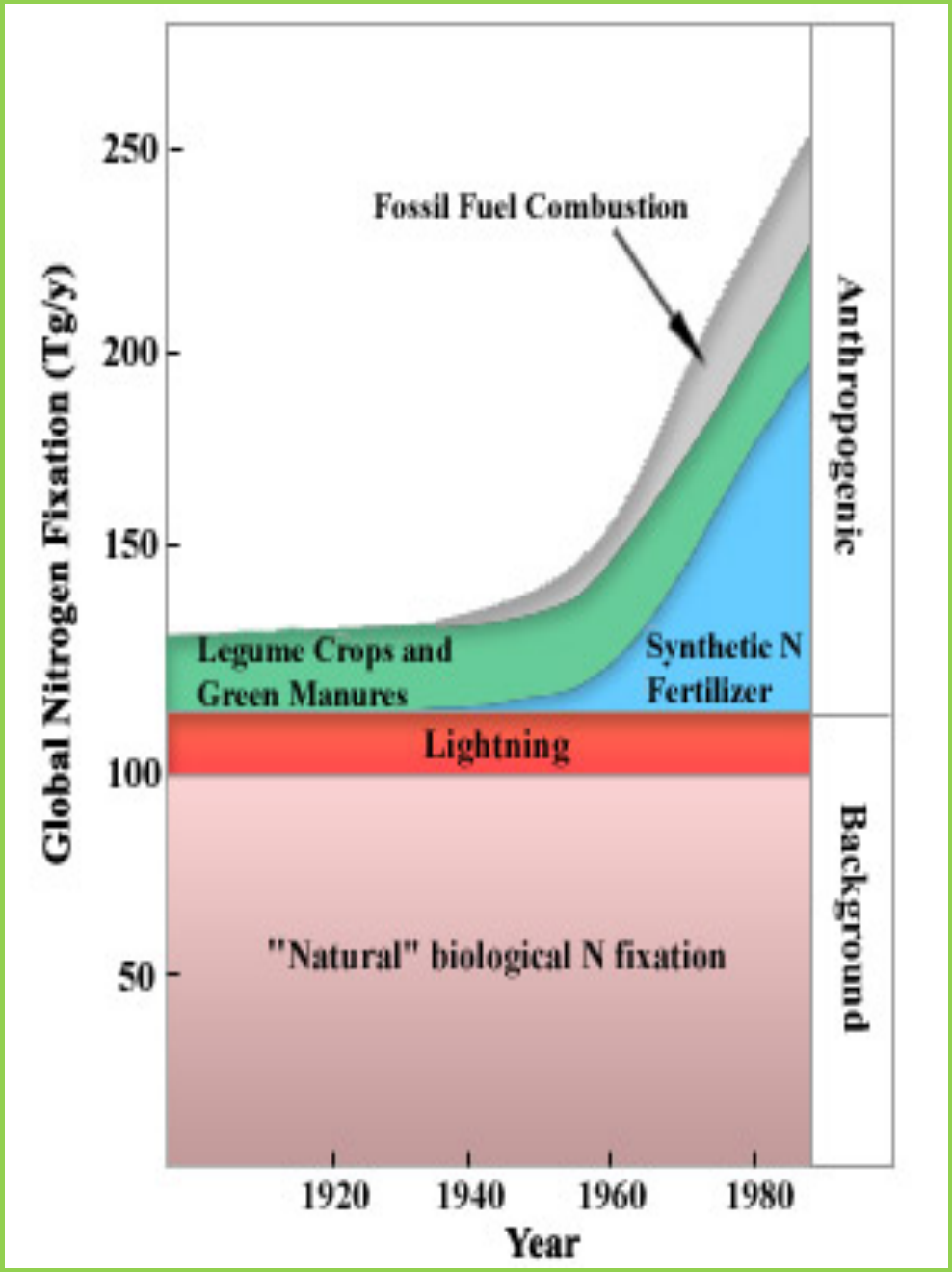
The productivity of crops is most often limited by Nitrogen deficiencies

Nitrogen is required in RNA and DNA synthesis

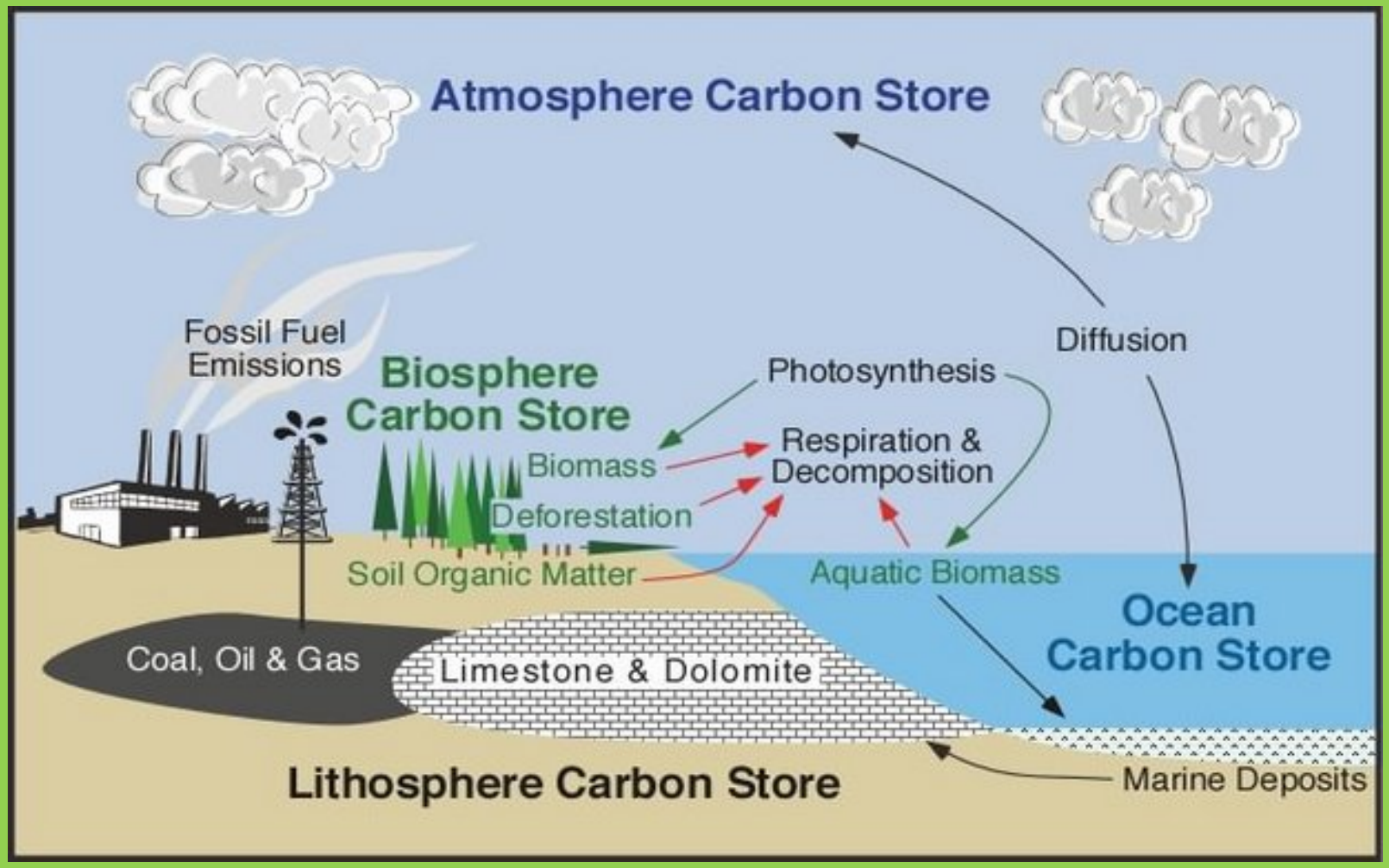
Although the atmosphere N content is 78%, making this the largest N pool, it is unavailable for plant uptake

N_2 must be fixed into other N forms for plant uptake



http://www.visionlearning.com/library/module_viewer.php?mid=98

The Carbon Cycle



Aerobic Respiration

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Photosynthesis

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Carbonates

$CO_2 + H_2O \rightleftharpoons H_2CO_3$

$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

Carbon Cycle

Table 1: Estimated major stores of carbon on the Earth.

Sink	Amount in Billions of Metric Tons
Atmosphere	578 (as of 1700) - 766 (as of 1999)
Soil Organic Matter	1500 to 1600
Ocean	38,000 to 40,000
Marine Sediments and Sedimentary Rocks	66,000,000 to 100,000,000
Terrestrial Plants	540 to 610
Fossil Fuel Deposits	4000

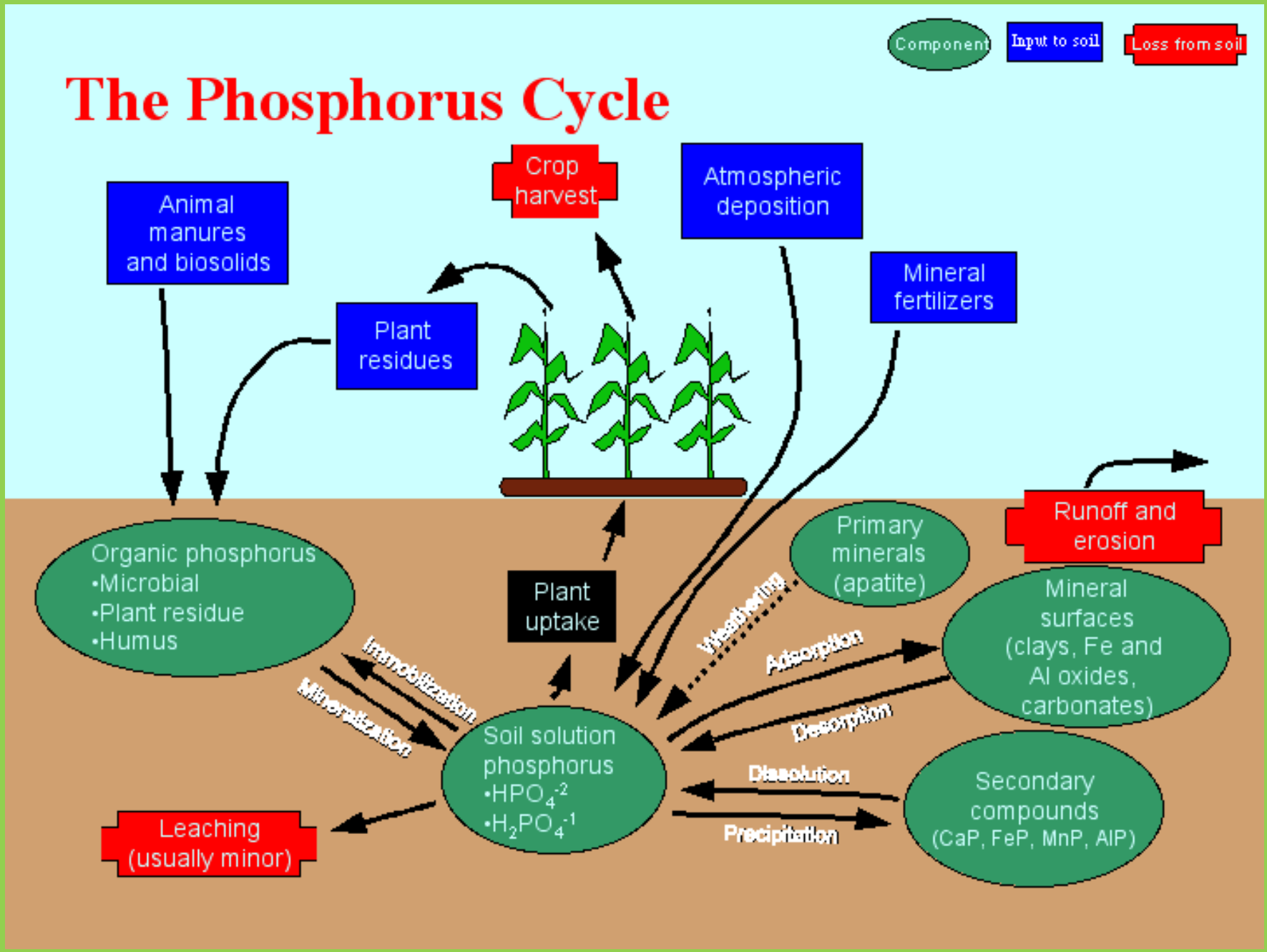
1 petagram = 10^{15} grams
= 10^{12} kilograms
= 1 billion metric tons

so 110 petagrams
= 110 billion metric tons
= 121 billion tons

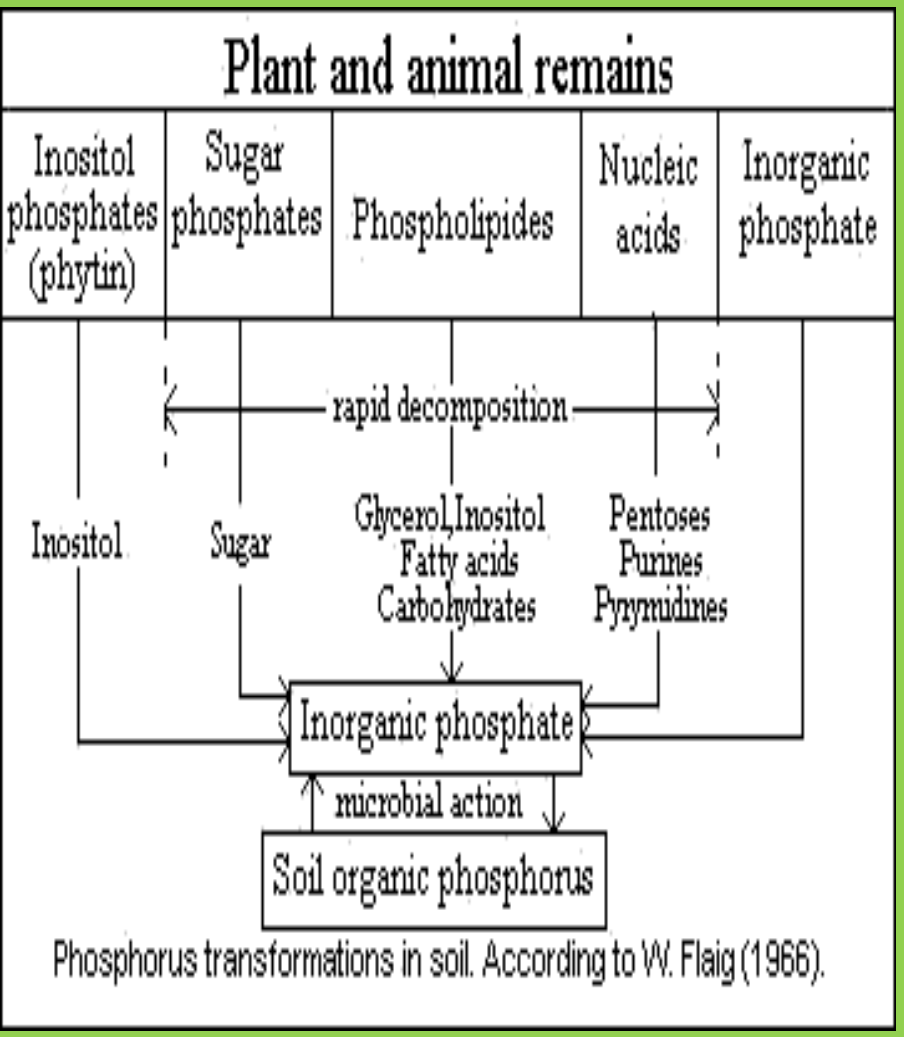
ANNUALLY…

- Photosynthesis by land plants moves about 110 metric tons (121 billion tons) of carbon from the atmosphere to living organisms.
- Respiration returns almost half or 50 billion metric tons (55 billion tons) of the carbon dioxide to the atmosphere that was absorbed for photosynthesis
- Decay via detritivores (organic material decomposes; becomes the soil C storage pool) where C is broken into H_20 and CO_2 is returned to the atmosphere; accounts for about 60 billion metric tons (66 billion tons)

http://www.eoearth.org/article/Carbon_cycle?topic=49505

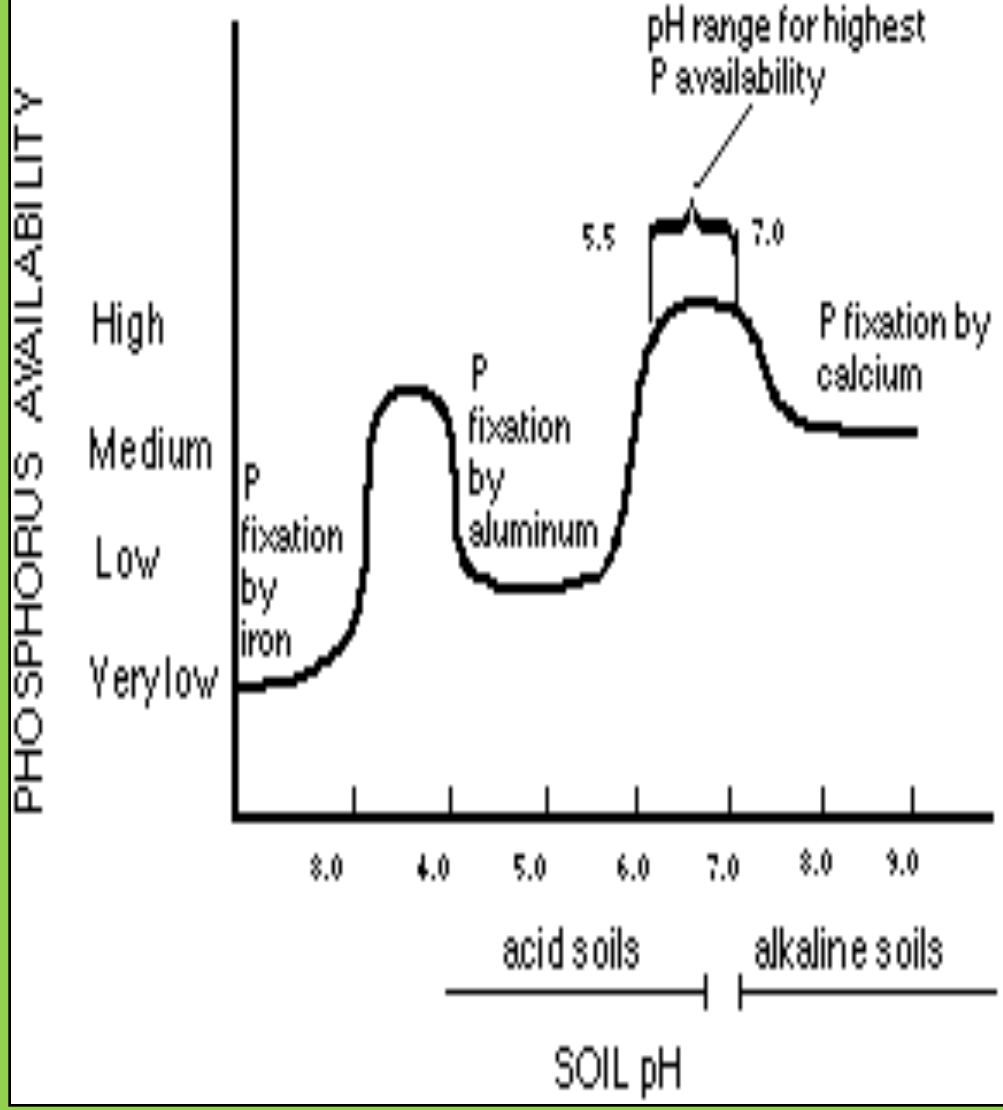


http://msucares.com/crops/soils/images/phosphorus.gif



Phosphorus transformations in soil. According to W. Flaig (1966).

http://www.humintech.com/001/articles/img/article_definition_of_soil_organic_matter31.gif



http://www.extension.umn.edu/distribution/cropsystems/DC6795.html

•Almost entirely inorganic

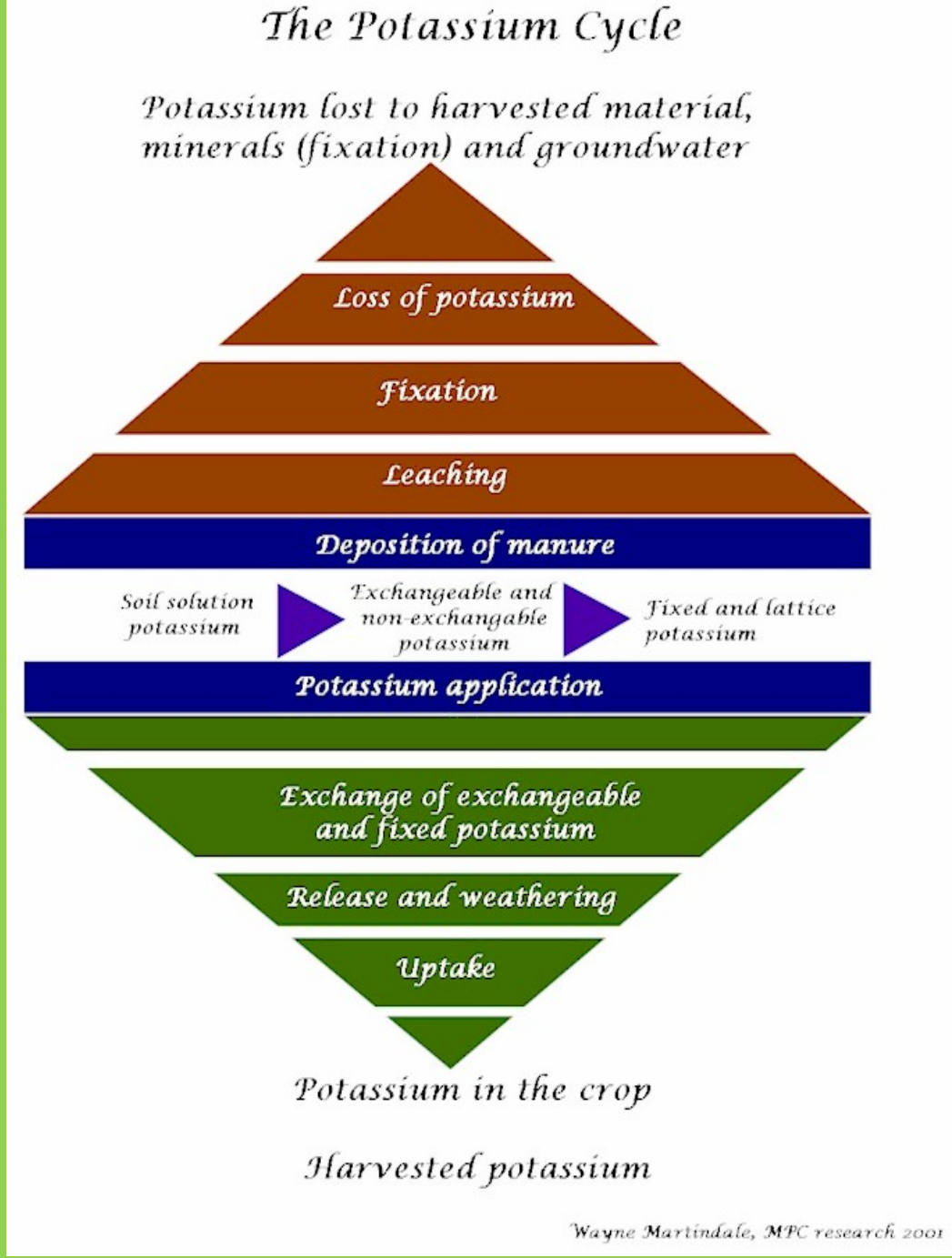
•Major roles of K: water use, growth, protein production, disease resistance

•K in soil solution ≈ exchangeable K

•Soils contain K in more slowly exchangeable forms = crop sources; K becomes available as minerals weather

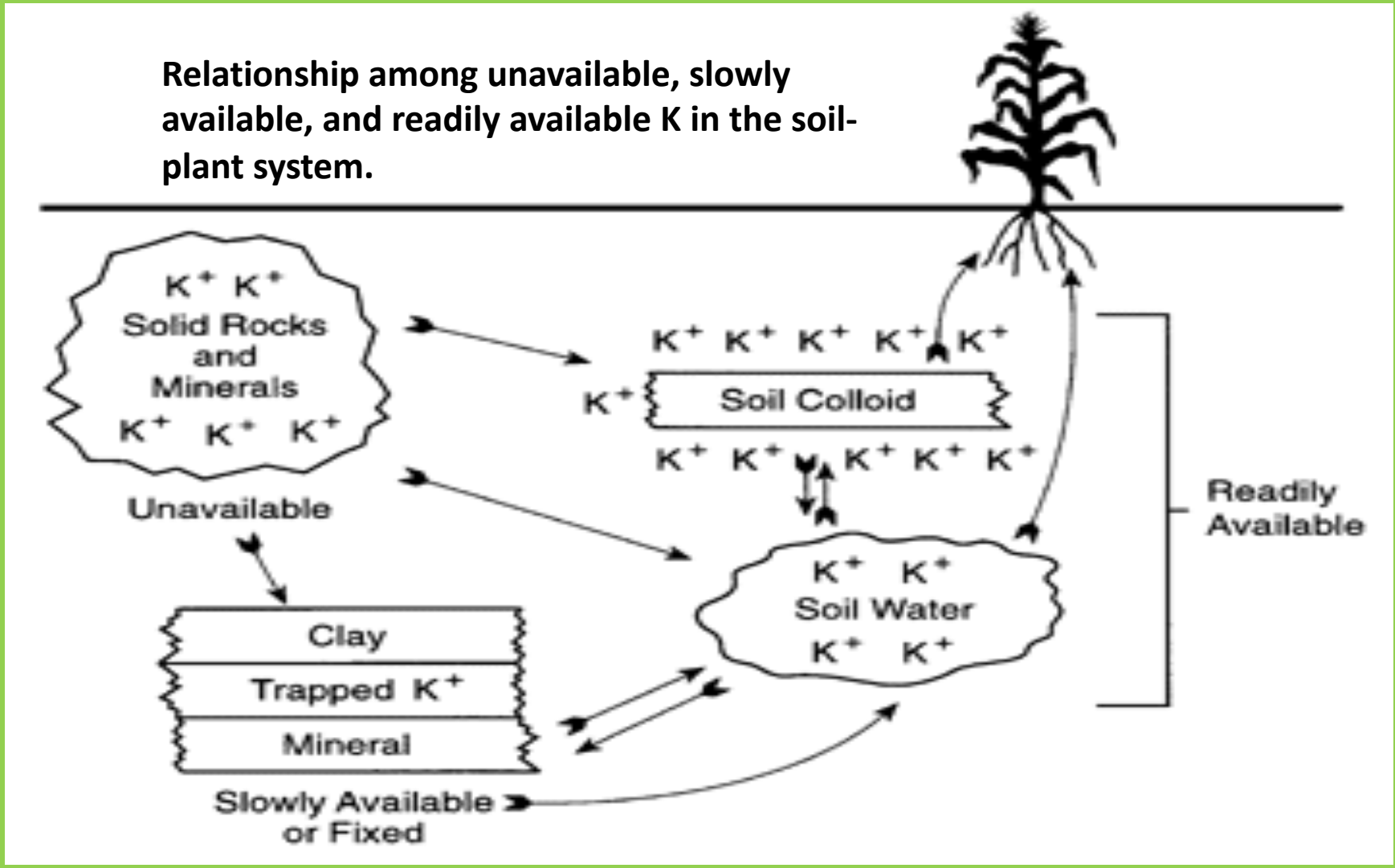
• In some soils (e.g. boulder clays) this source of K meets the requirements of cereals for decades without supplemental fertilizers

forum.fwag.org/data/public/727_4.doc



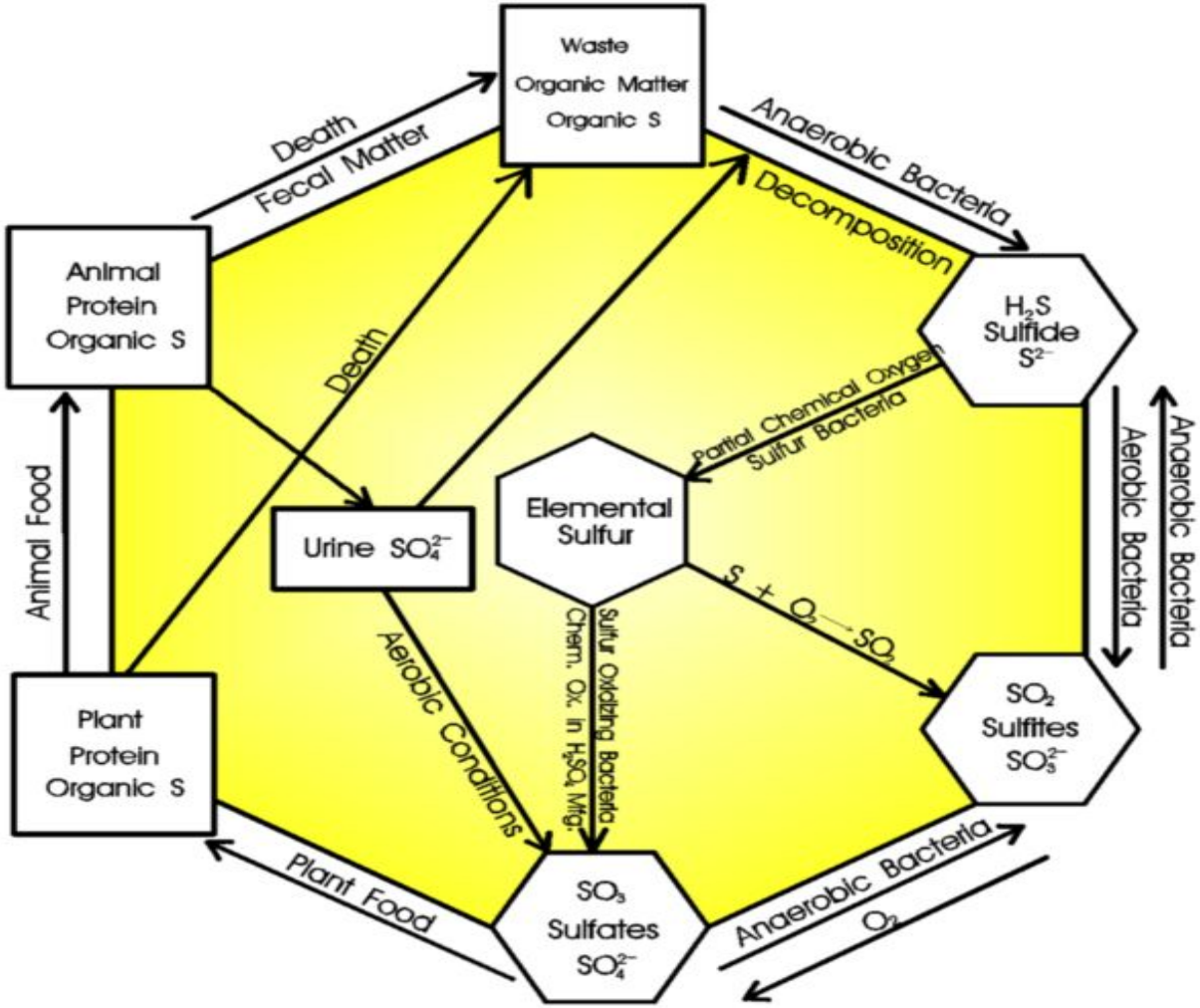
http://www.mpcresearch.com/mpcresearchcom060603/ipns/Kcycle.jpg

Potassium Cycle



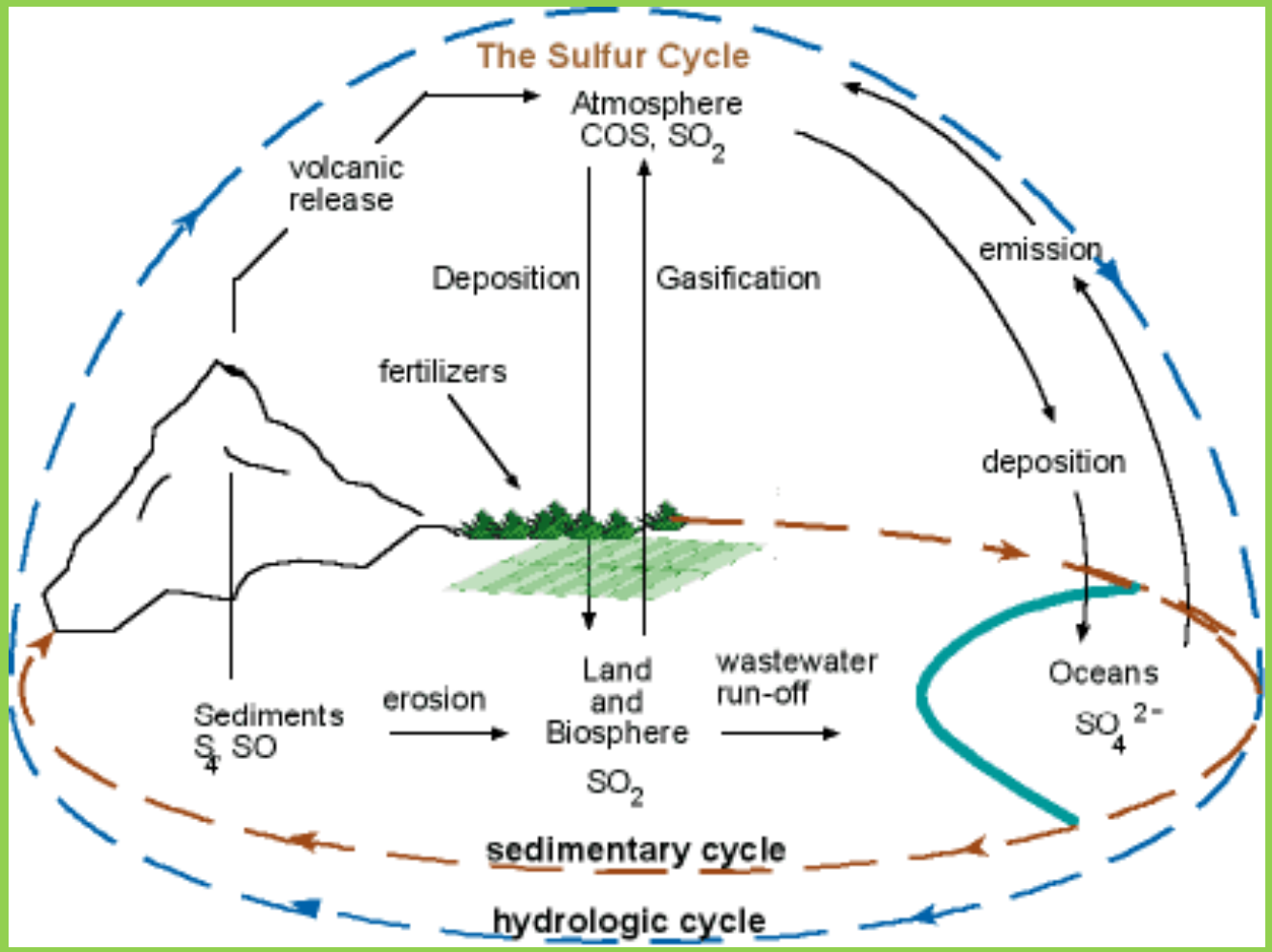
http://www.extension.umn.edu/distribution/cropsystems/dc6794.html

The Sulfur Cycle



http://www2.visalia.k12.ca.us/teachers/lmiller/classpage/APES/APES%20Review/Sulfurcycle.jpg

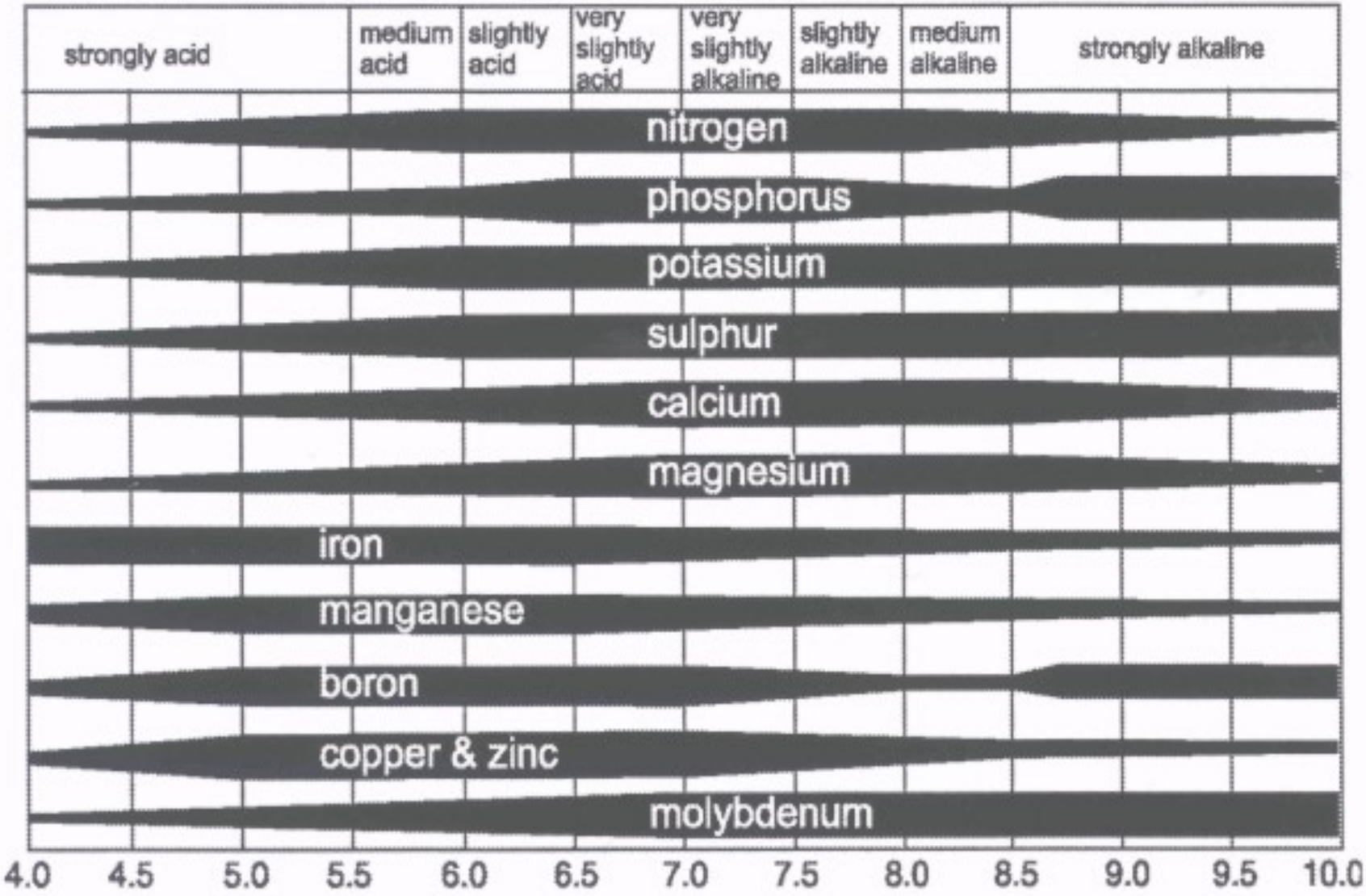
Sulfur Cycle



Factors Affecting Nutrient Availability

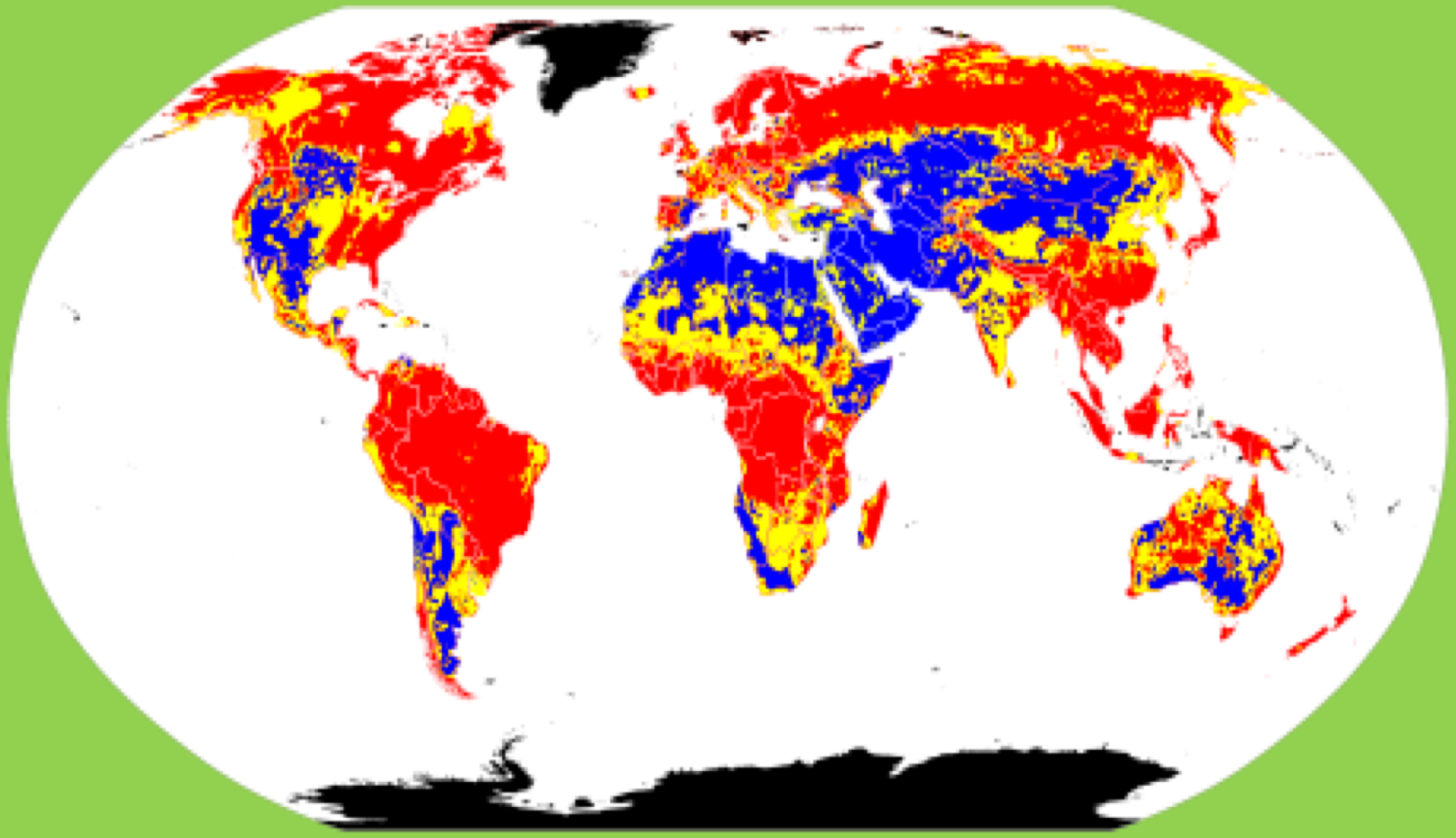
- Soil texture
- Weathering
- Climate
- Parent Material
- Microbial Community
- Organic Matter
- pH
- Others?

pH and nutrient availability



http://www.avocadosource.com/tools/FertCalc_files/pH.htm

Global Variation in Soil pH



Red = acidic soil. **Yellow** = neutral soil.
Blue = alkaline soil. **Black** = no data.

http://en.wikipedia.org/wiki/Soil_pH