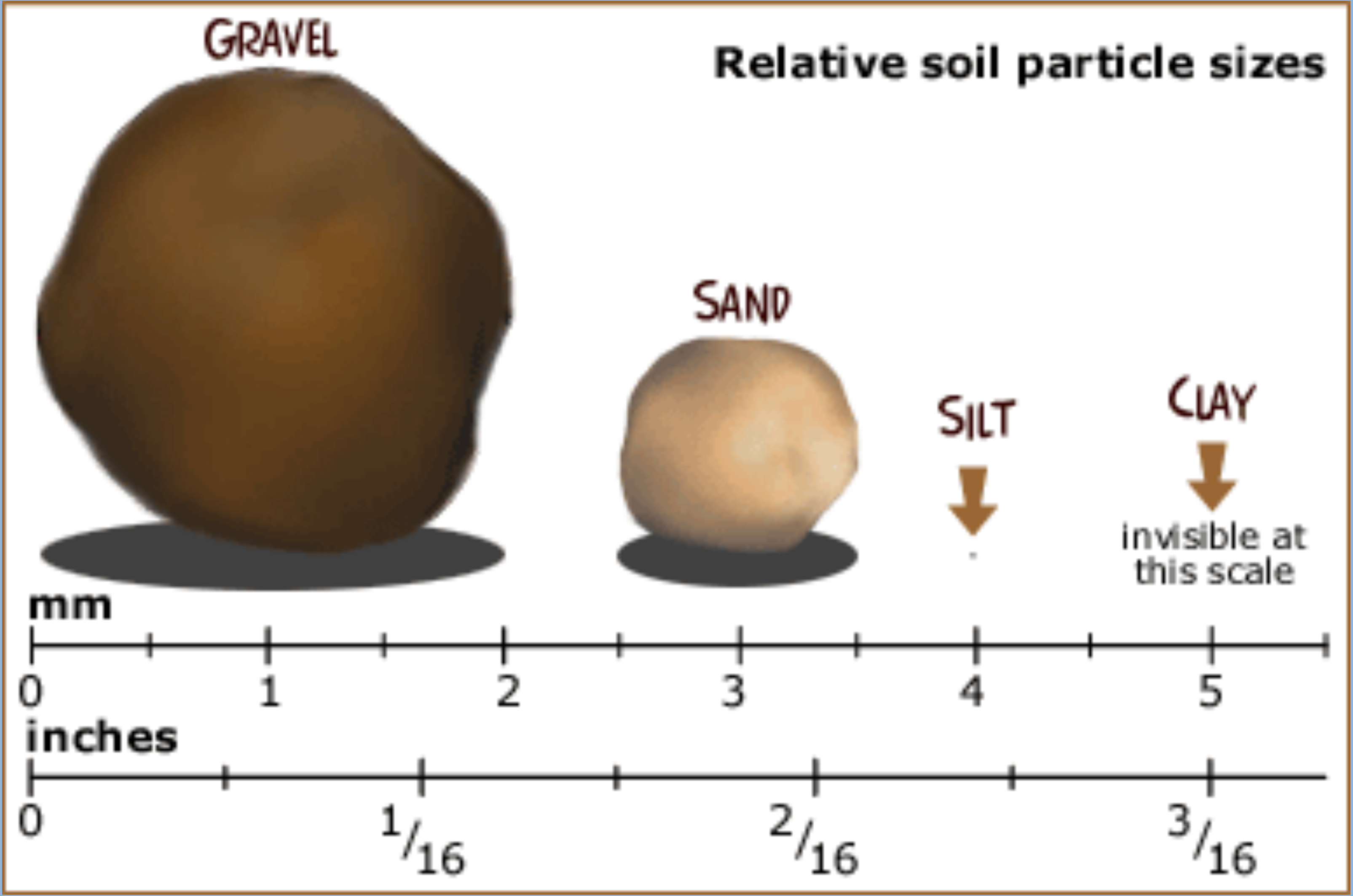
Saline, Sodic, & Saline-Sodic Soils

http://www.nrcs.usda.gov/news/archive/2004newsroom.html

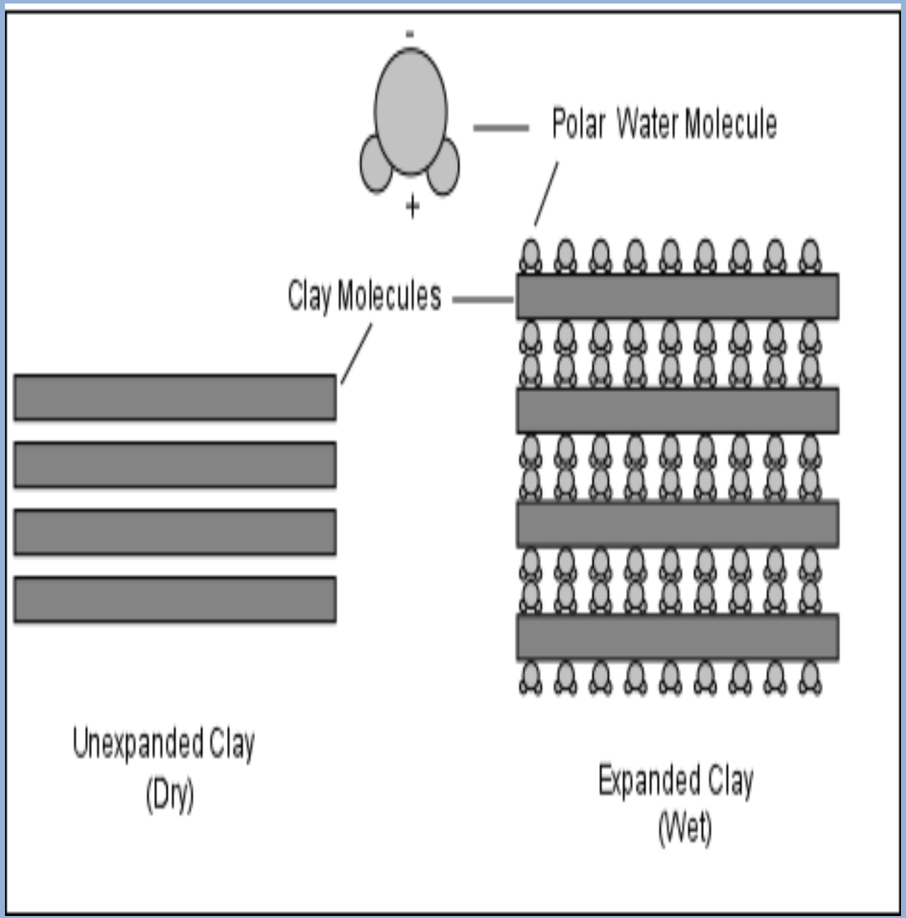
Soil Properties: A Review

Sand & Silt: larger coarse particle sizes .002- 2.0 mm; larger pores; lower surface area which does not create negative charge, and therefore low nutrient retention and shrink swell characteristics; high infiltration



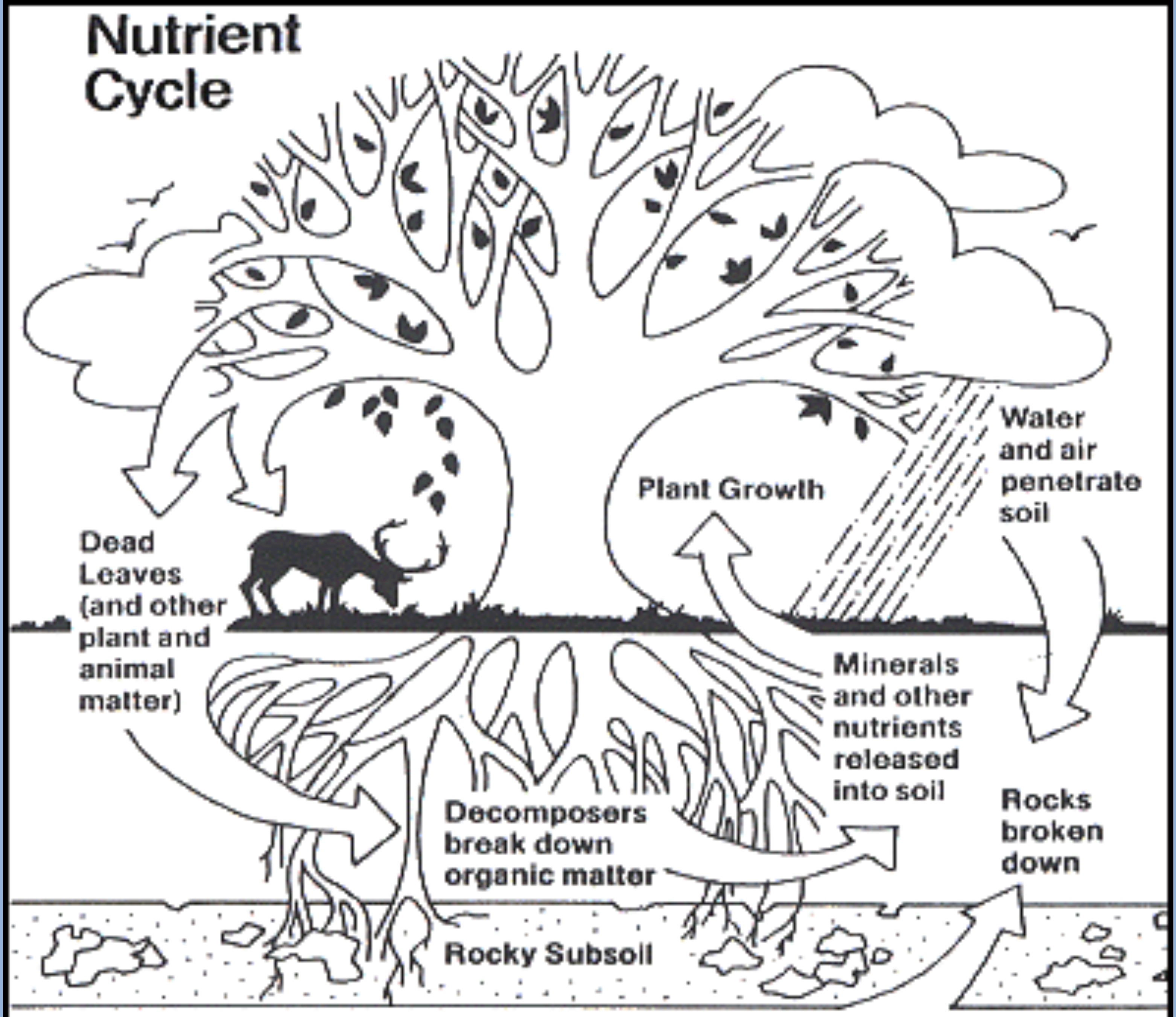
http://school.discoveryeducation.com/schooladventures/soil/name_soil.html

Clay & Organic Matter: for clays, small particle size less than .002 mm; isomorphic substitution and hydration between sheets which can create shrink/swell properties, for clays and OM negative surface charge which allows for cation exchange capacity and nutrient and contaminant retention

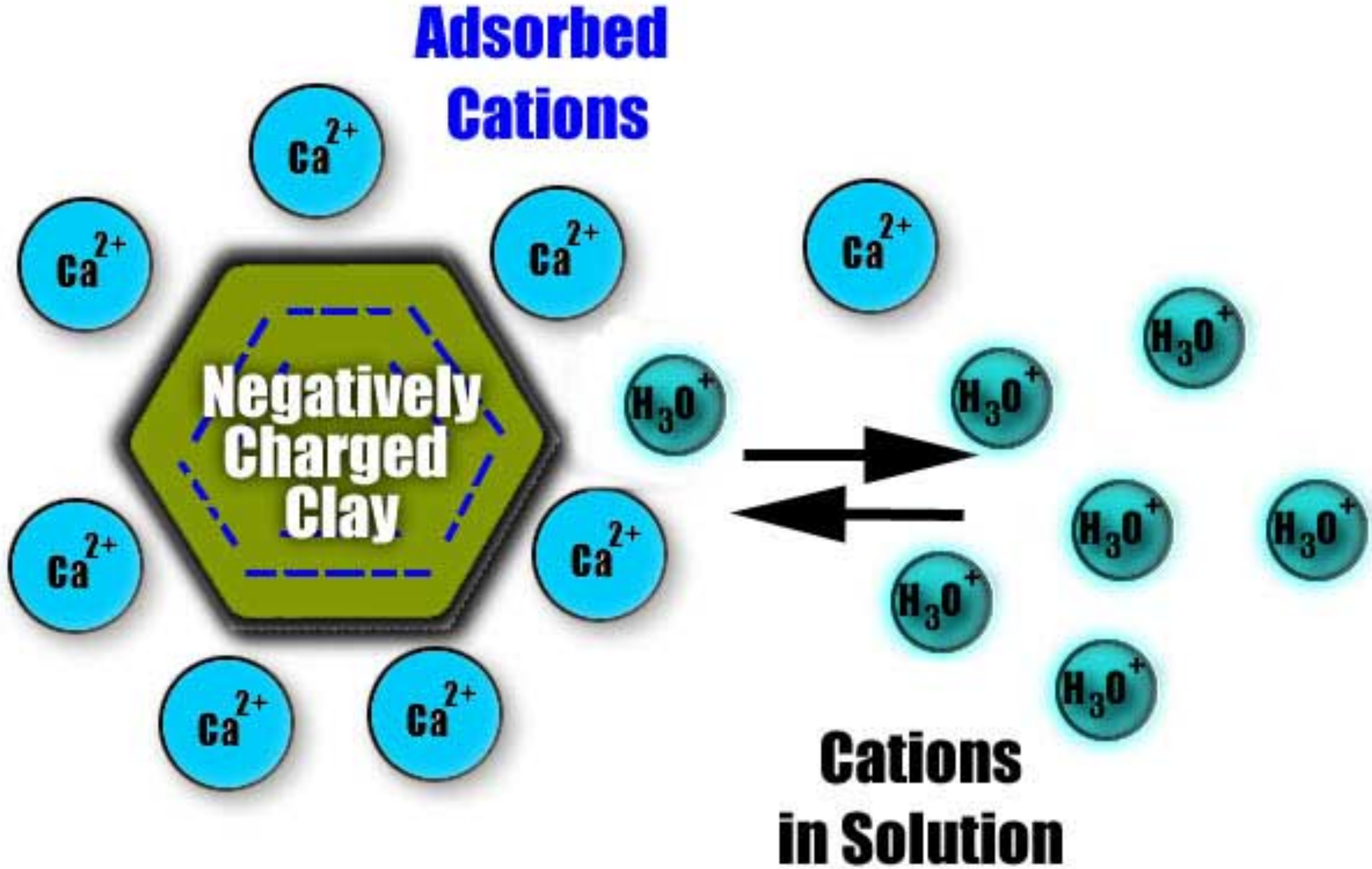


http://www.featurepics.com/online/Cracked-Earth-Death-Valley-Picture263373.aspx

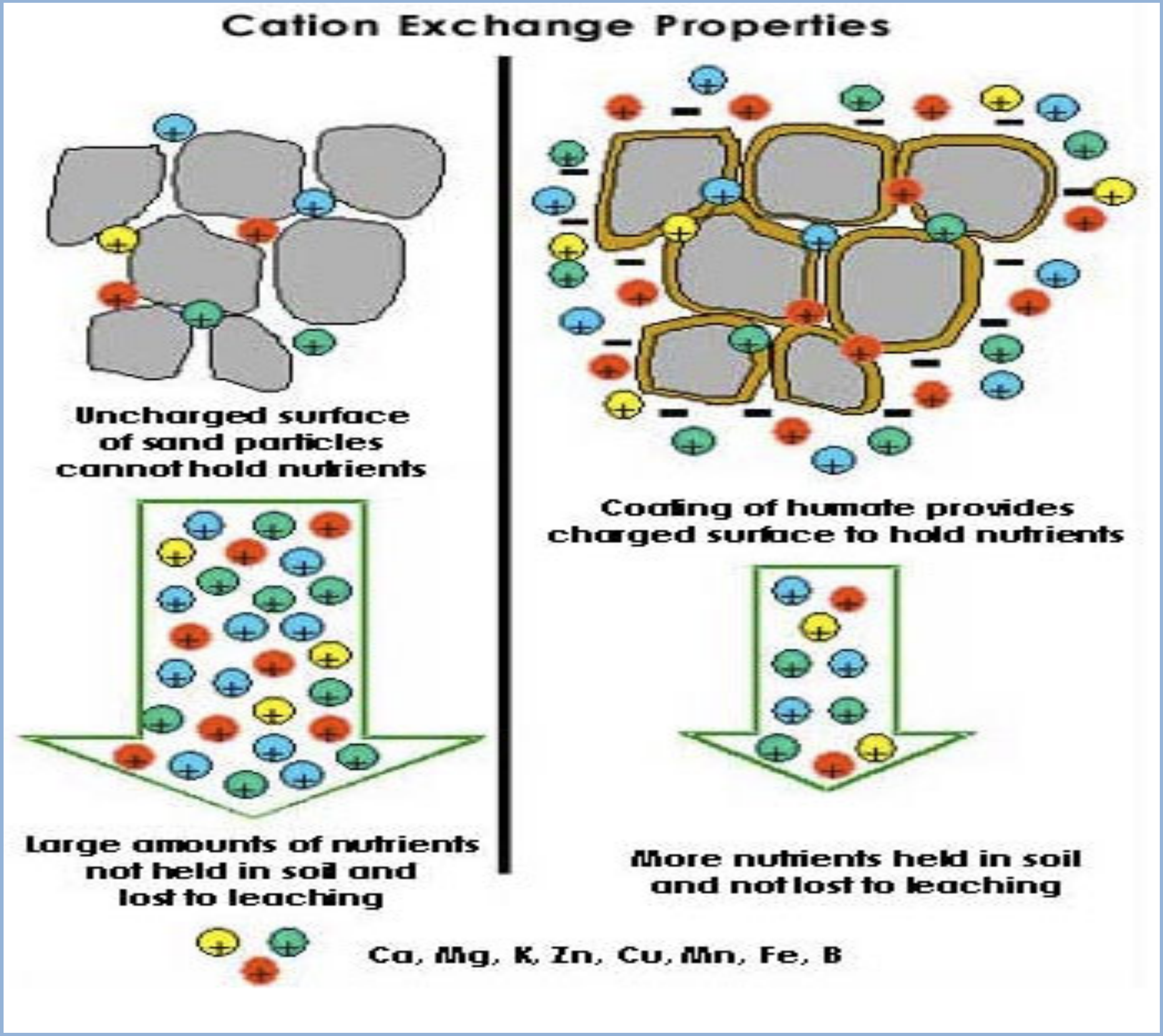
http://hotdogjam.files.wordpress.com/2008/11/compost_heap.jpg



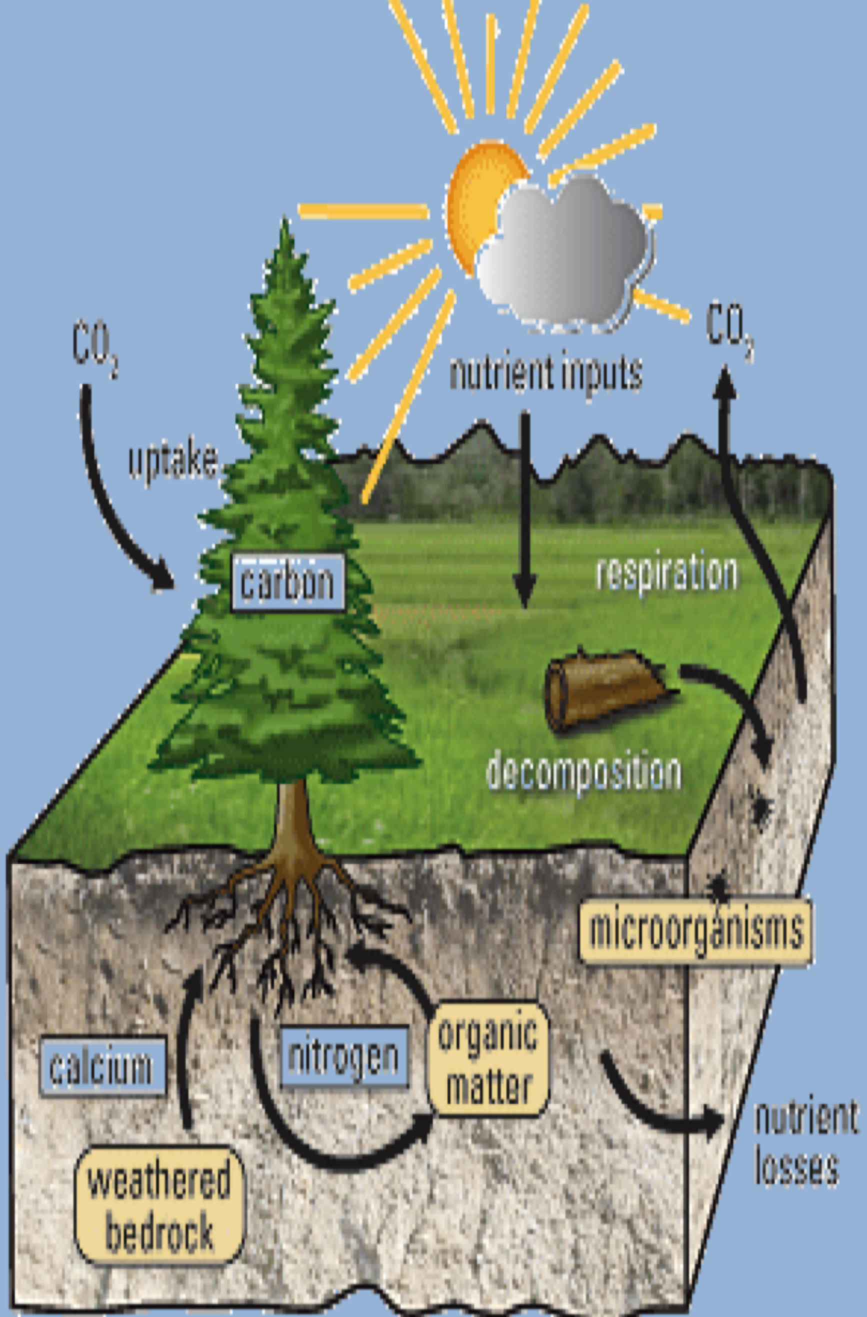
http://www.computernutsinc.com/pccd/images/NutrientCycle.gif



http://www2.mcdaniel.edu/Biology/botf99/nutrition/catex.jpg



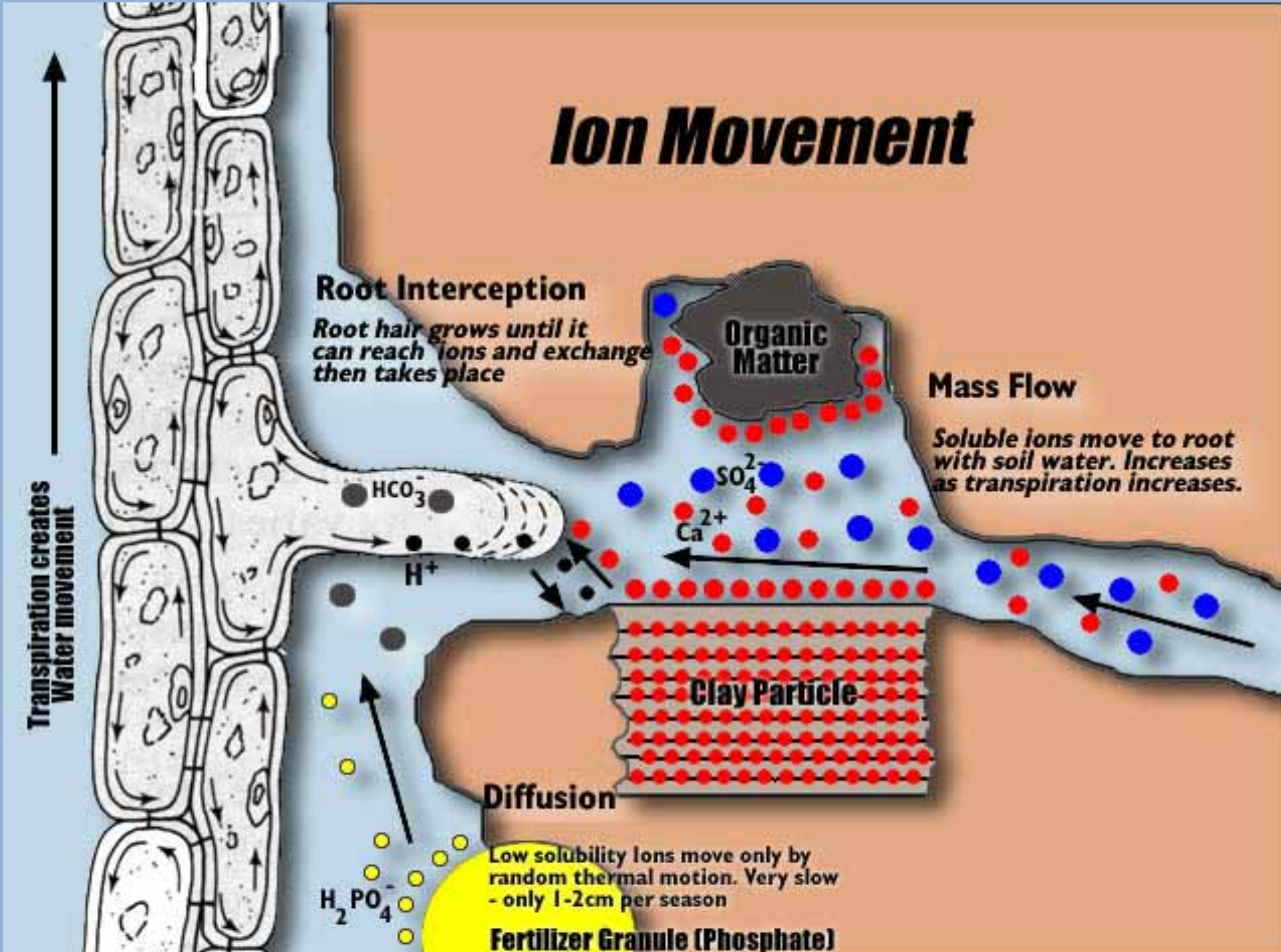
http://superchargeit.org/images/graphs/cation-exchange-properties.jpg



http://pubs.usgs.gov/fs/2009/3078/images/fig2.png

Base cations are defined as the most prevalent, exchangeable and weak acid cations in the soil.

Base cations include ions such as calcium (Ca2+), magnesium (Mg2+) potassium (K+) and sodium(Na+). These ions, except for Na+, are nutrients for ecosystems and vegetation and are thus of importance for the sustainability of ecosystem. The base cations occur in air in the *particulate phase*. In precipitation, base cations are to a large part *dissolved and occur as ions*. A part of the base cations available to the environment come from rock weathering.



http://www2.mcdaniel.edu/Biology/botf99/nutrition/ionmove.jpg

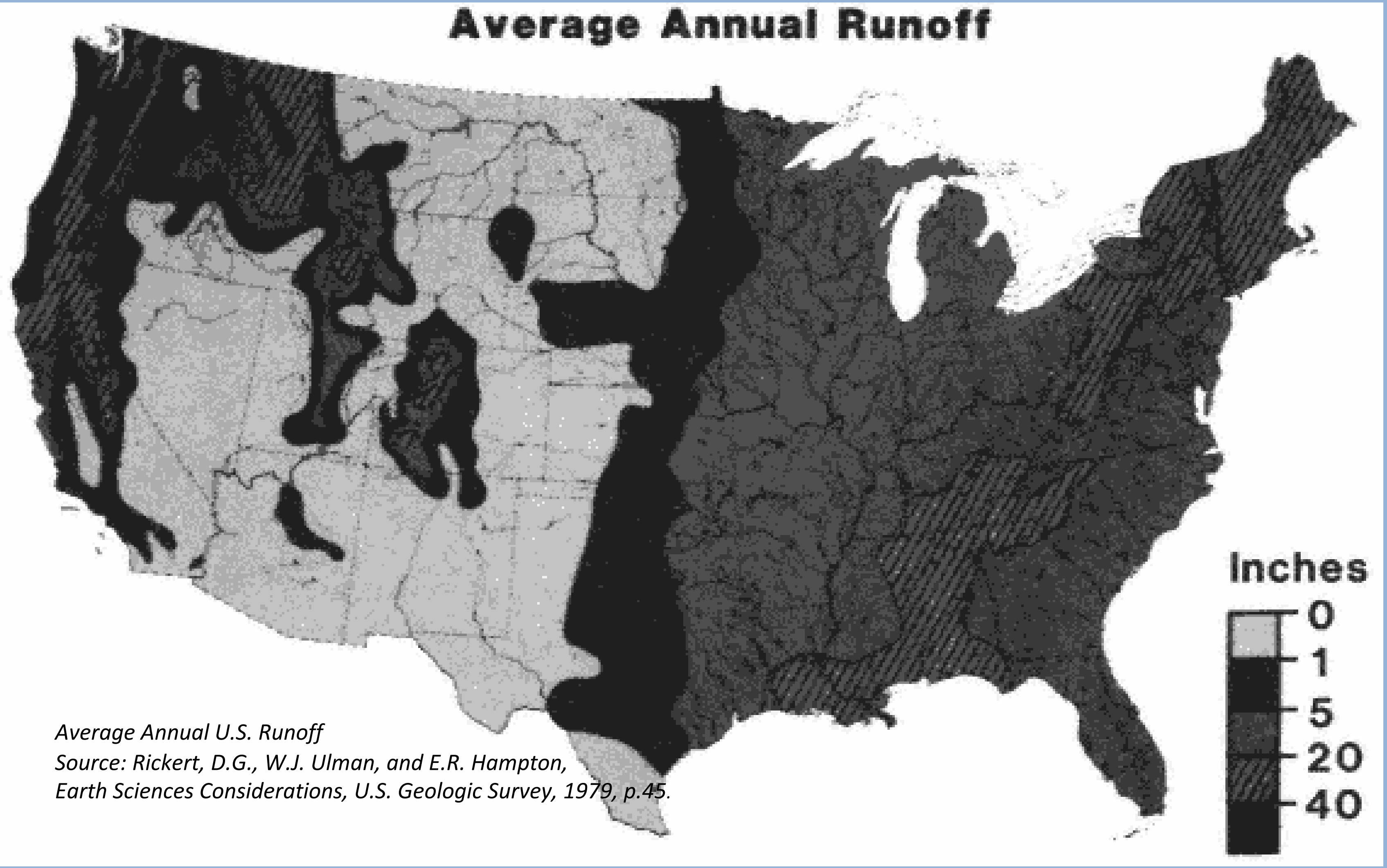
How do Salts and Sodium Affect this Ion Retention and Flow??

What are salts and how do they accumulate in the soil?

A salt is a water-soluble compound that, in soil, may include Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-}, SO_4^{--}

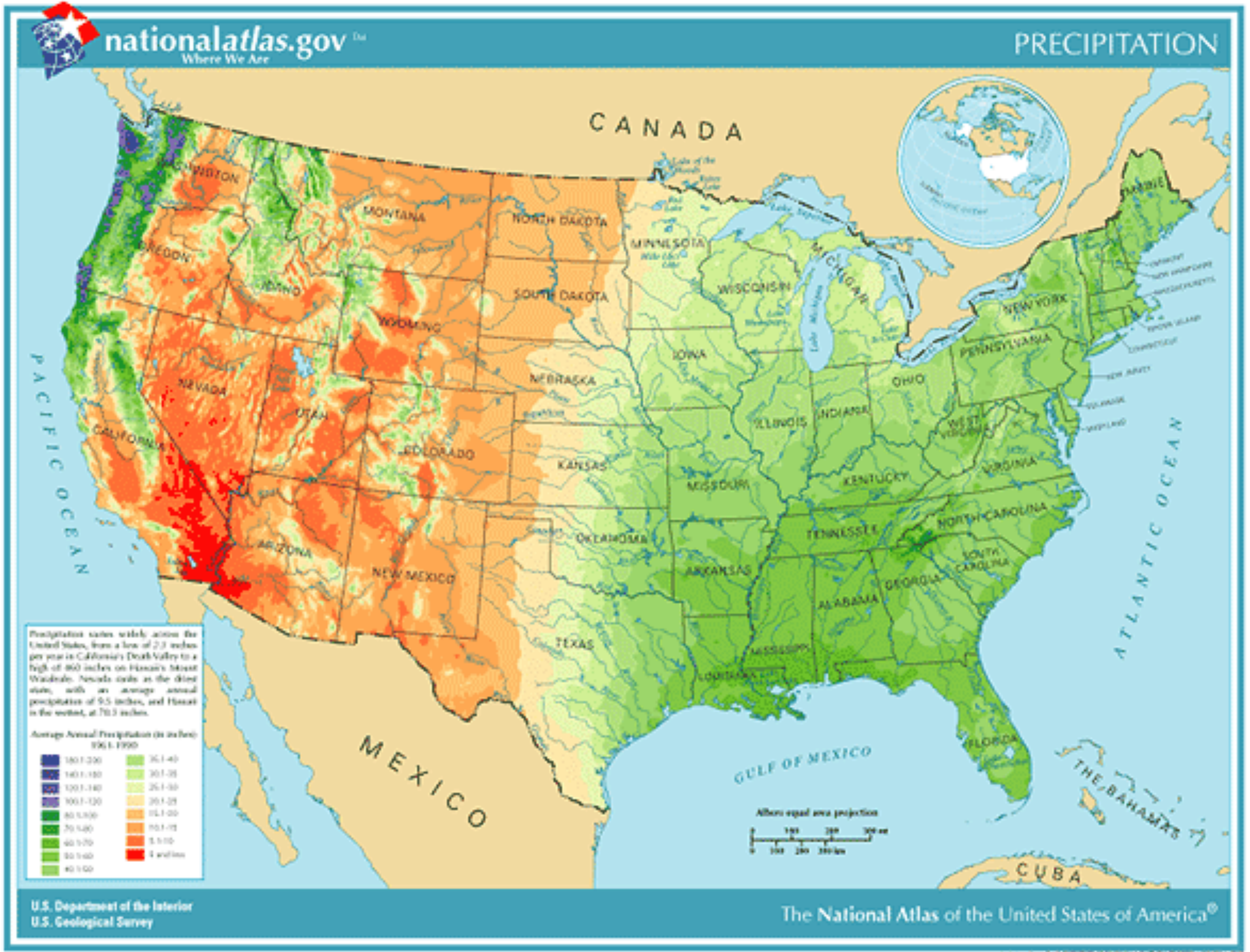
Salts can develop from the weathering of primary minerals, or be deposited by wind or water

Salt-affected areas generally occur in semi-arid and arid climates where precipitation is not adequate to leach salts from the profile



Average Annual U.S. Runoff
Source: Rickert, D.G., W.J. Ulman, and E.R. Hampton,
Earth Sciences Considerations, U.S. Geologic Survey, 1979, p.45.

In general: **acidity** arises from **biological activity** and **vigorous leaching of salts** while **alkalinity** and salinity arise from the accumulation of salts and bases lacking adequate leaching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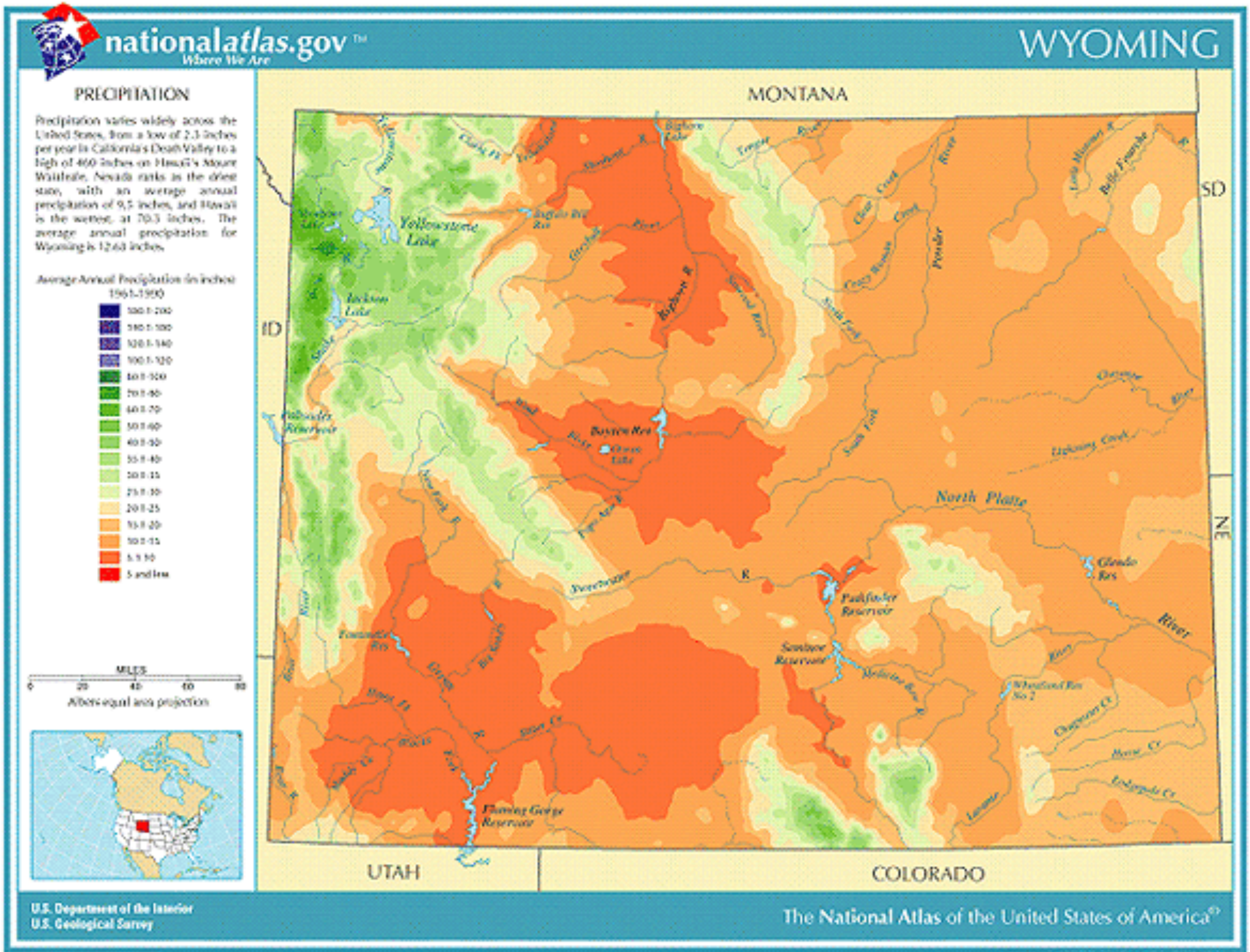
Where We Are
PRECIPITATION
CANADA
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WISCONSIN
MICHIGAN
WYOMING
NEW YORK
IOWA
PENNSYLVANIA
NEBRASKA
NEVADA
UTAH
OHIO
ILLINOIS
INDIANA
CALIFORNIA
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
NORTH CAROLINA
TENNESSEE
OKLAHOMA
ARIZONA
NEW MEXICO
ARKANSAS
GEORGIA
ALABAMA
TEXAS
FLORIDA
MAINE
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
GULF OF MEXICO
THE BAHAMAS
CUBA
Albers equal area projection
U.S. Department of the Interior
U.S. Geological Survey
The National Atlas of the United States of America®



nationalatlas.gov
Where We Are
WYOMING
PRECIPITATION
Precipitation varies widely across the United States, from a low of 2.3 inches per year in California's Death Valley to a high of 460 inches on Hawaii's Mount Waialeale. Nevada ranks as the driest state, with an average annual precipitation of 9.5 inches, and Hawaii is the wettest, at 70.3 inches. The average annual precipitation for Wyoming is 12.63 inches.
Average Annual Precipitation (in inches) 1961-1990
5 and less
MILES
0
20
40
60
80
Albers equal area projection
MONTANA
SD
NE
ID
UTAH
COLORADO
Yellowstone Lake
Jackson Lake
Palisades Reservoir
Boysen Res
Pathfinder Reservoir
Seminoe Reservoir
Glendo Res
Flaming Gorge Reservoir
North Platte
Powder
Bighorn Lake
U.S. Department of the Interior
U.S. Geological Survey
The National Atlas of the United States of America

Saline Soils

Saline soils are soils that contain large amounts of soluble salts. Most commonly these are Na, Ca, and Mg with **chloride**, **sulfate** and bi**carbonate**

Electrical Conductivity (EC) is an acceptable and easy way to measure these salts, because as ions, they are good conductors of electricity in water

Saline soils have a pH less than 8.5 b/c the Mg and Ca kick enough H ions off exchange sites to maintain some acidity

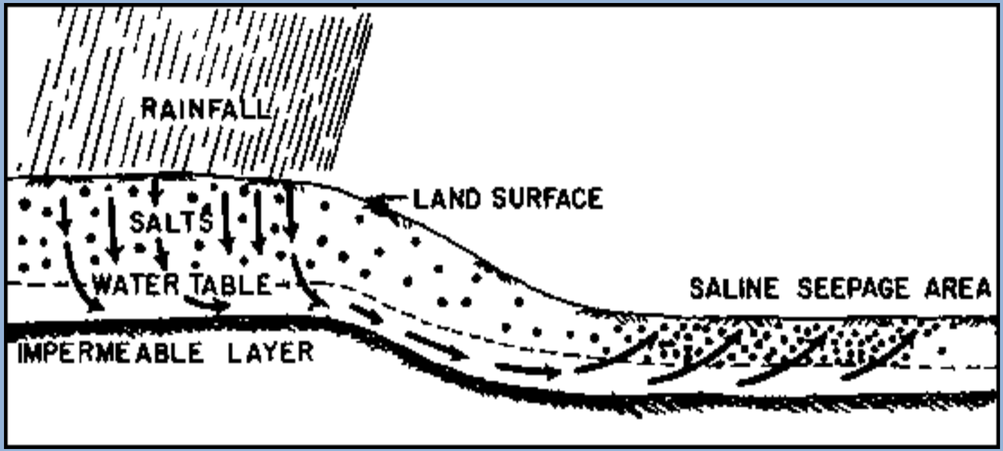
Soils are considered saline if they have an EC greater than 4.0 dS/m; this can be hazardous to plant growth b/c salts in the root zone can reduce the amount of water available to plants, making them expend more energy trying to transpire, and at excessive salt levels can cause water to flow to the higher concentration gradient toward the saltier water.

Vegetation loss in saturated zone, LDS Range Conservationist

Saline Soil Reclamation

- Saline: excess water in fall or spring prior to planting at unsaturated conditions; finer soils require more leaching

- Saline seeps: more water may worsen problem; may need to dry up recharge area first or install tile drainage



The diagram above illustrates how saline seep typically occurs. Water soaks into the ground at the "recharge area". Excess water that is not absorbed by plants moves (percolates) downward through the soil. On its way it dissolves (leaches) mineral salts. In the diagram, the salt-laden groundwater reaches an impermeable layer and then migrates to a lower area where the water table is at the surface. At this "discharge area", the water evaporates, leaving the salts behind as a white crust on the surface.

http://formontana.net/seep.html

Sodic Soil

Sodic soils have relatively low EC, but high Na occupying exchange sites, which often results in soils with a pH of 8.5 or greater. Also have SAR >12 and an ESP >15

SAR = [Na]/(([Ca] + [Mg])^.5)
ESP = 100 [exch. Na]/[exch. Na + exch. Ca + exch. Mg]

Na causes soil dispersion if sufficient flocculating cations (Ca and Mg) are not present to override the effects of Na

Dispersed colloids clog soil pores, preventing effective transport of water and air, this Causes low water permeability, crusting, and drying, as well as shrink/swell phases during periods of wetting and drying, further damaging soil structure

http://wps.prenhall.com/wps/media/objects/57/58641/fig10_16.gif

Fine textured soils are more at risk due to higher water and cation retention characteristics

http://www.google.com/search?hl=en&source=hp&q=picture+of+sodic+soil&aq=f&aqi=&aql=&oq=

Saline-Sodic Soils

These soils have characteristics of both saline (EC greater than 4 dS/cm and a pH of less than 8.5) and sodic (ESP greater than 15 and SAR greater than 12) soils.

Physical characteristics are intermediate between sodic and saline soils. Flocculating salts may help moderate dispersing effects of Na so structure may not be as poor as sodic soils.

Sodic and Saline-Sodic Reclamation

- Sodic and Saline-Sodic: more expensive and difficult; prior to leaching Na needs to be replaced from exchange sites by another cation such as Ca or Mg. Gypsum: $CaSO_{4,}$ lime: $CaCO_3$, calcium chloride, or magnesium chloride are examples of these sources. Leaching with water to carry away excess Na is followed by these amendments if it is available

- $CaSO_4$ is the preferred amendment because it is soluble

- If EC levels are low saline water may be appropriate to help with flocculation, tillage may also be advised to break up crusts and help with infiltration

- Introduce halophytes: barley, sugar beet, russian wild rye, slender wheat grass

Classifying Saline, Sodic, and Saline-Sodic Soils

Soil Classification	EC (dS/cm)	SAR	ESP	pH
saline	>4.0	<12	<15	<8.5
sodic	<4.0	>12	>15	>8.5
saline-sodic	>4.0	>12	>15	<8.5

http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_dispersion-animation