Mitigation: Soil Remediation

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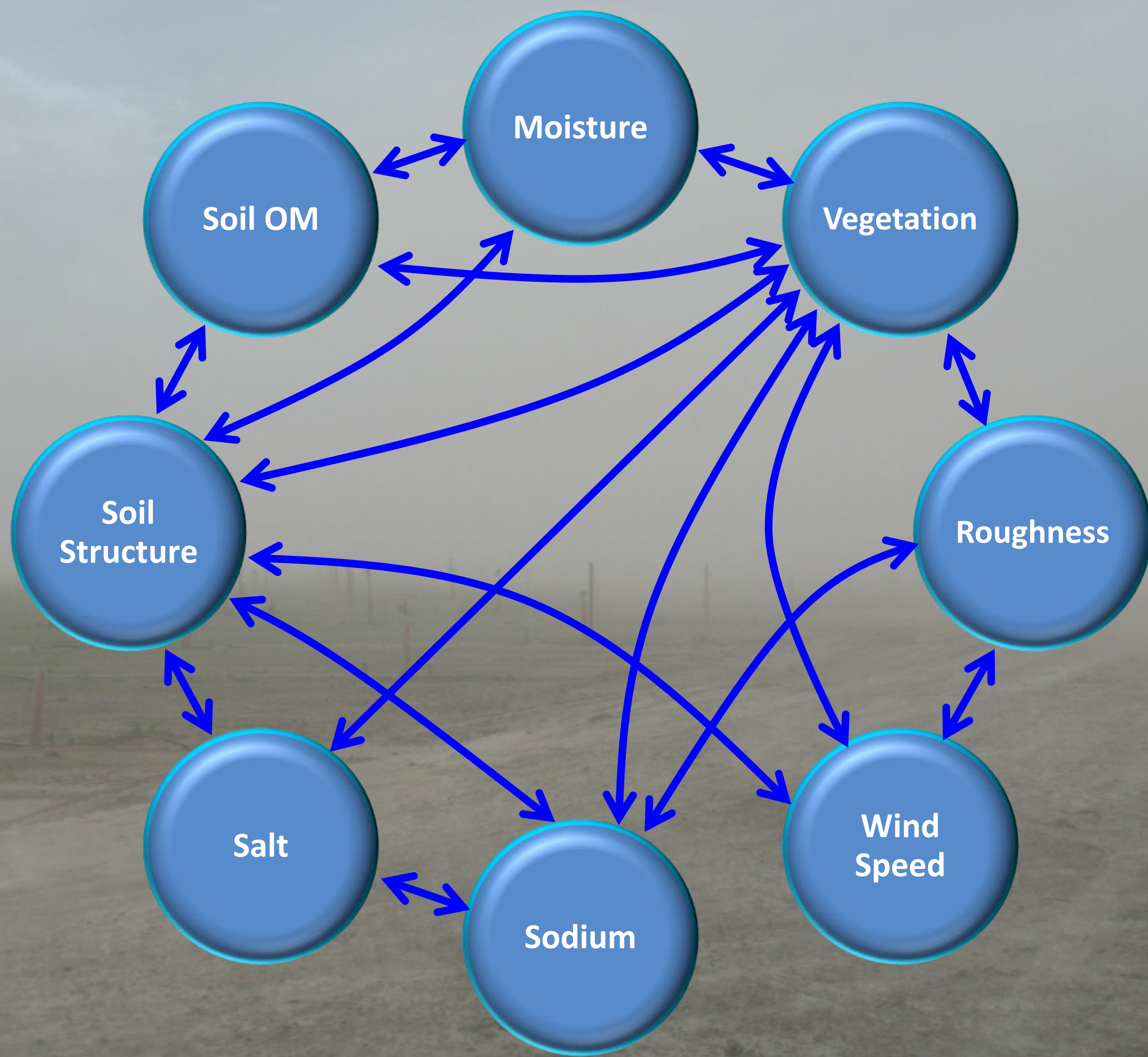
http://arizonahighways.wordpress.com/2011/07/07/lets-talk-haboob-people/

‘Controllable’ soil conditions

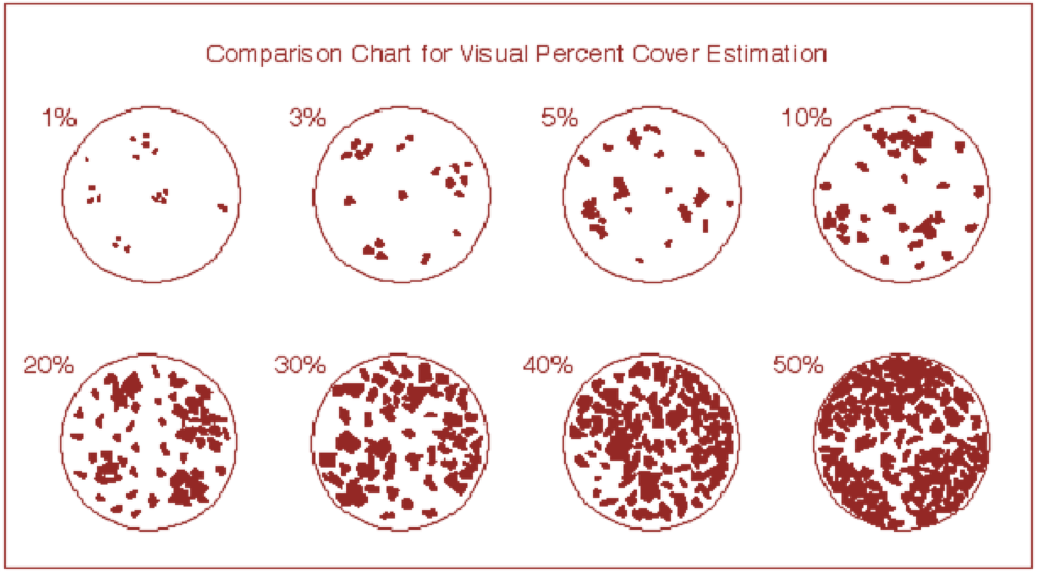


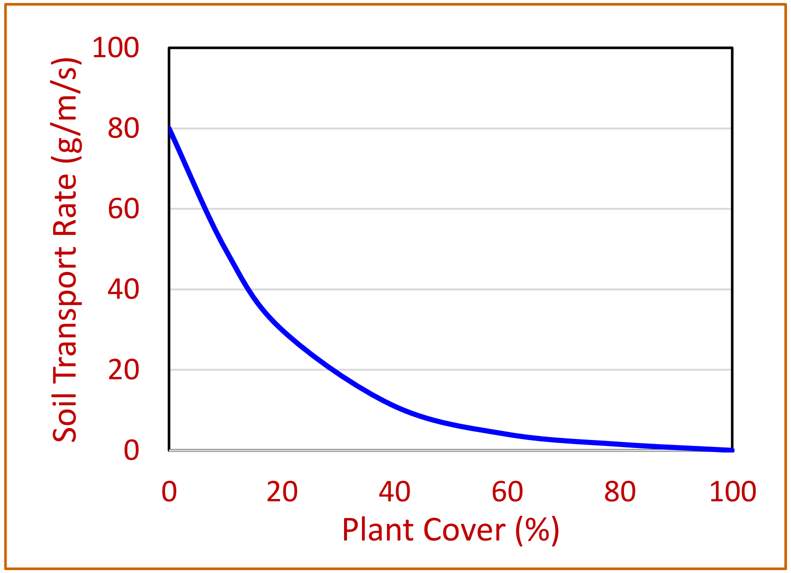
If soil is dispersed, then when it rains…

1. Water can’t soak into soil
2. Water accumulates, along with dissolved salts
3. Water evaporates, leaving salts behind
4. Soil becomes saltier
5. Vegetation dies

Vegetation protects the soil surface

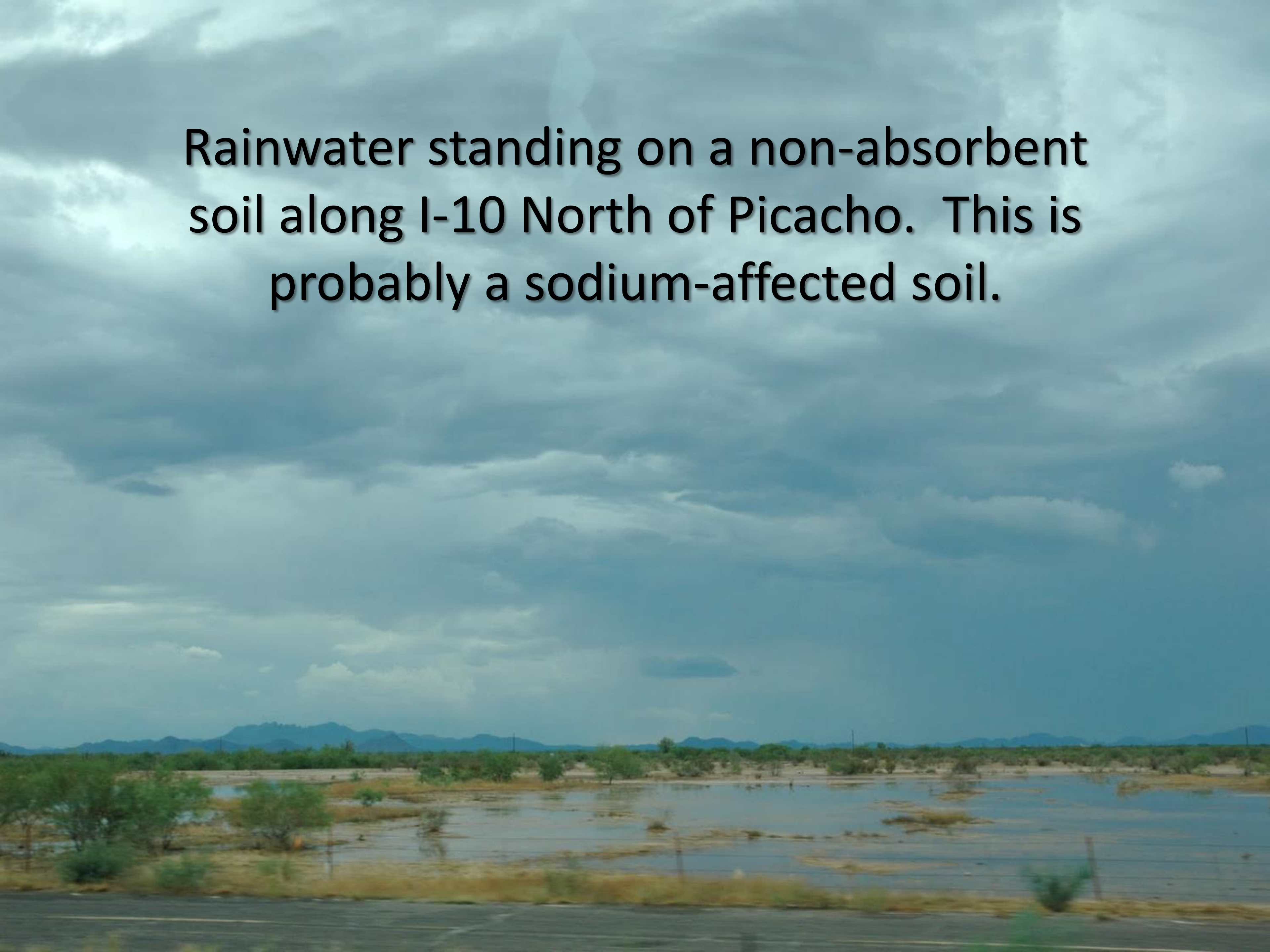
- Slows wind
- Intercepts raindrops
- Adds organic matter
- Cools soil surface, reducing eddies
- Intercepts airborne particles





http://www.nature.nps.gov/protectingrestoring/damageassessmentandrestoration/DO14Handbook/appendices/appendixb.htm

http://www.environment.nsw.gov.au/soildegradation/winder.htm


Rainwater standing on a non-absorbent soil along I-10 North of Picacho. This is probably a sodium-affected soil.

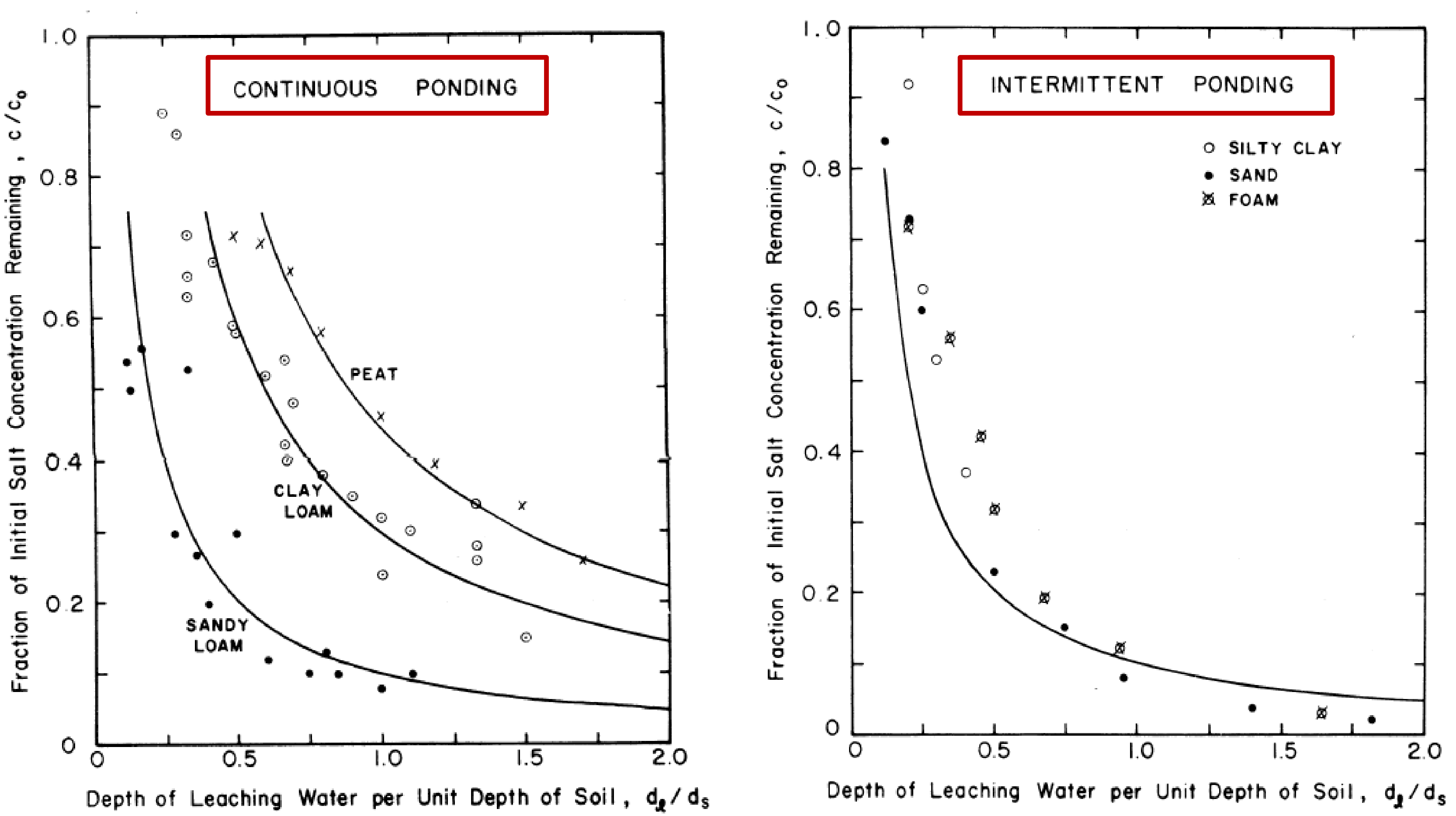
- Vegetation is sparse
  - Soil salinity
  - Lack of water from poor infiltration
  - Hard crusts inhibit seedling establishment

Getting Rid of Soil Salts

WATER

H_2O and Salts

K^+ $SO_4^=$ Cl^- Na^+ K^+ $SO_4^=$ H_2O Cl^- Na^+



Leaching Salts: Depth of leaching water per unit depth of soil required to reclaim saline soils with continuous or intermittent ponding

Hoffman - Guidelines for Reclamation of Salt-affected Soils

Maintaining Salts in Irrigated Soils: Salt leached out of the soil must equal salt additions, so excess irrigation water must be used to leach salts from soil

$$Leaching\ requirement = \frac{EC_w}{(5 \times EC_e) - EC_w}$$

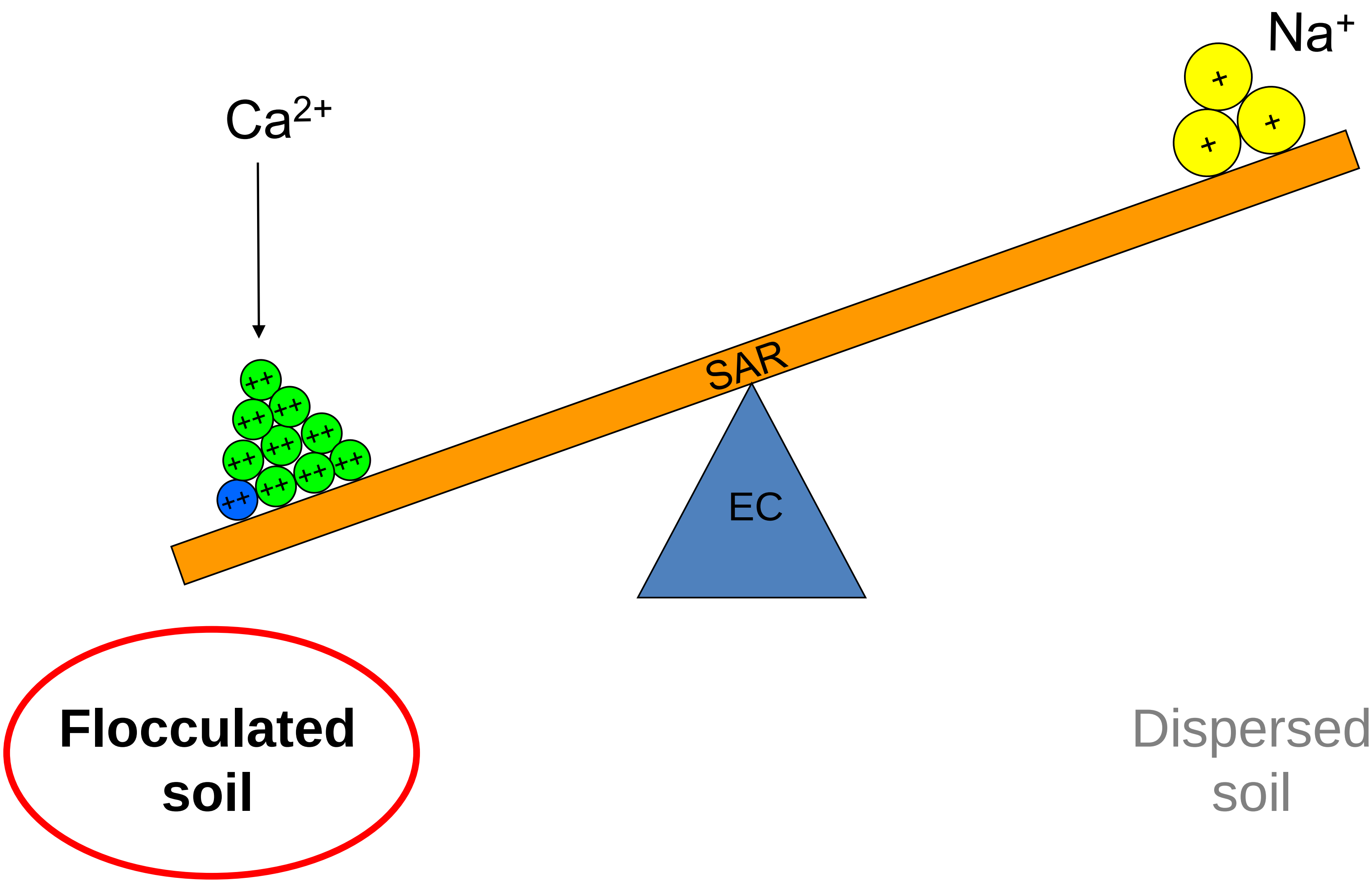
where

EC_w = EC of irrigation water (measured)
EC_e = max EC crop will tolerate (from research)

If we add the right cations to a dispersed soil

the soil will flocculate and form aggregates

Increasing *soluble* calcium improves aggregate stability in soils with poor structure.



Gypsum is the most widely used calcium soil supplement

Blue Diamond mine, Nevada

Calcium sulfate

$CaSO_4 \cdot 2H_2O$

22 - 23% Ca

TIME = 0

Two tubes were filled with high sodium soil

One was watered with pure water

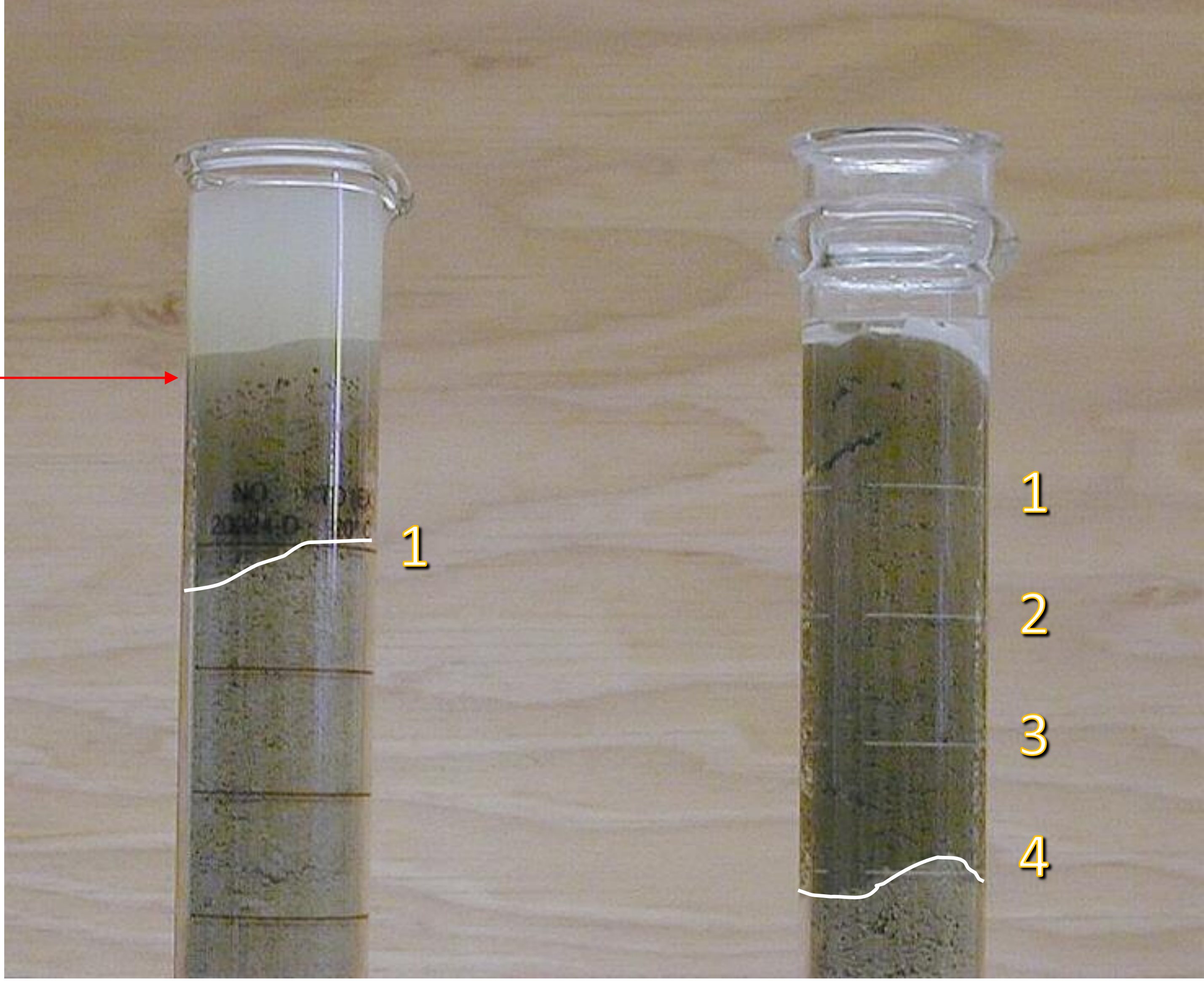
One was watered with water & gypsum (calcium sulfate)

Water

Water & Gypsum

TIME = 10 min

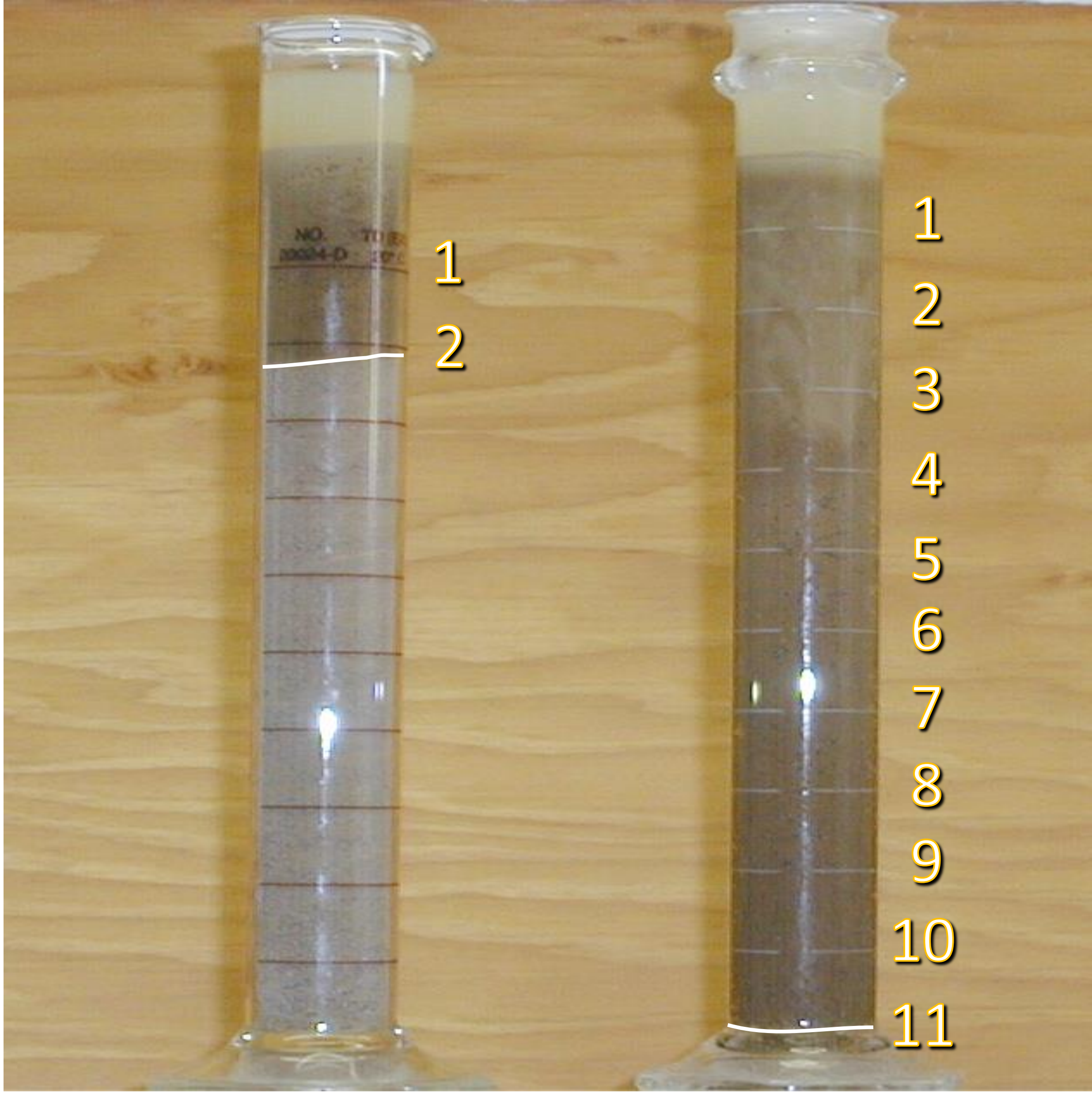
Dispersed soil



Water

Water & Gypsum

TIME = 24 hours

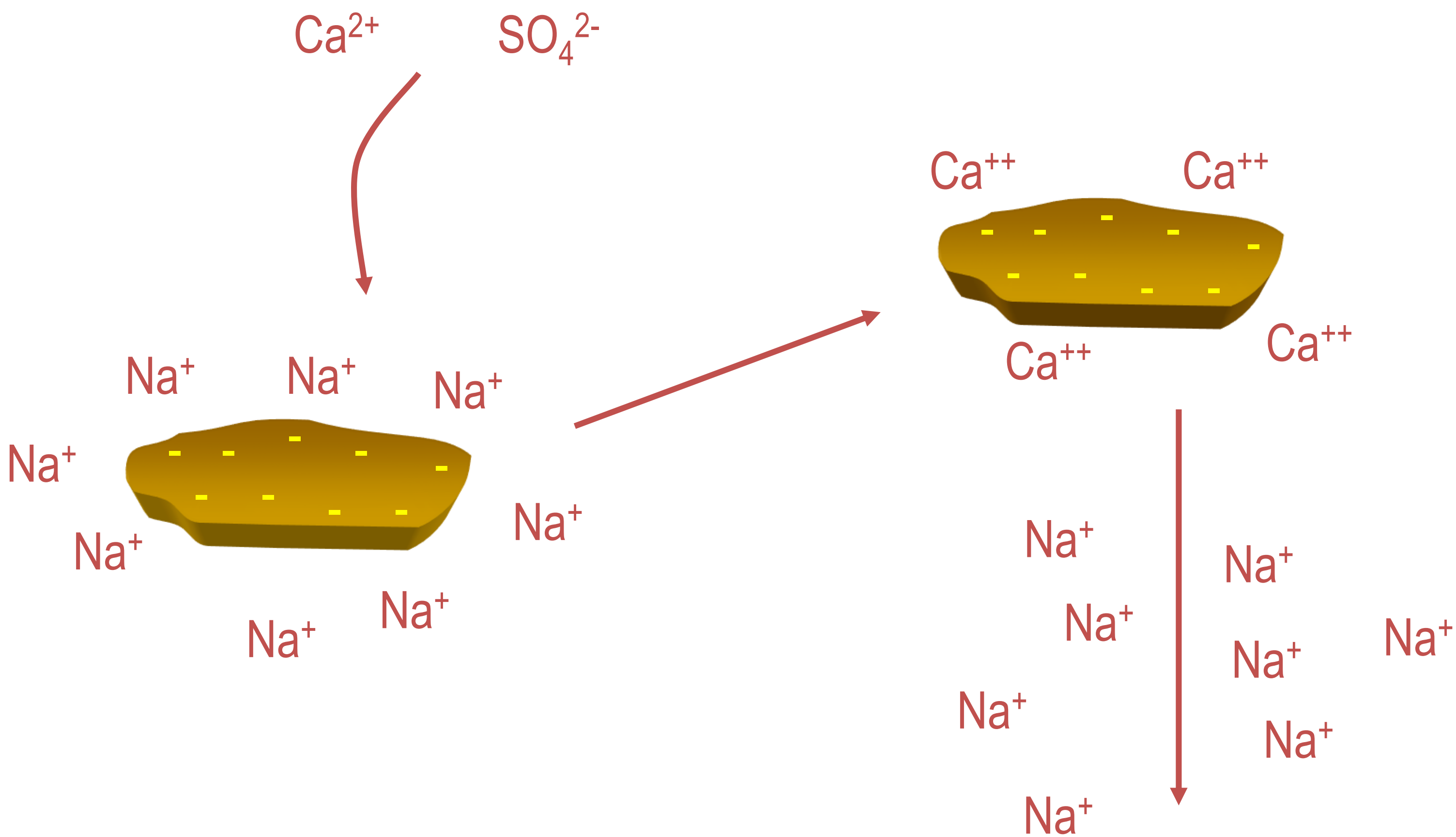


Water

Water & Gypsum

Getting Rid of Salt in Sodic Soils

Apply gypsum *before* leaching salts out of soils susceptible to dispersion (the amount of gypsum needed can be determined by a soil test). Replacing sodium with calcium before leaching will stabilize soil structure.



Calcareous soil

$$CaCO_3 + 2HCl \rightarrow Ca^{+2} + 2Cl^{-} + H_2O + CO_2$$

gas bubbles

Sulfuric acid can be used instead of gypsum on calcareous ($CaCO_3$ containing) soil only

- Sulfuric acid dissolves calcium carbonate in the soil

$$H_2SO_4 + CaCO_3 \rightarrow CO_2 + H_2O + CaSO_4$$

and makes gypsum!

Elemental sulfur can also be used as an alternative to gypsum on calcareous soils

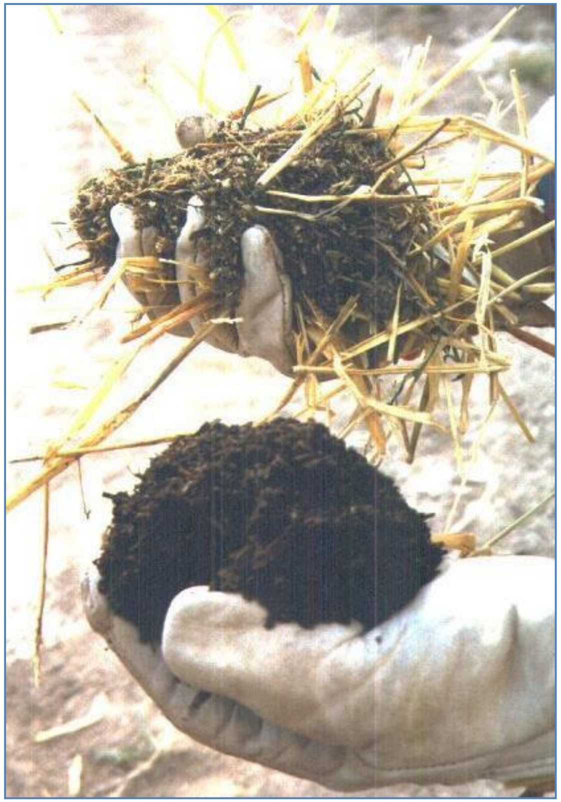
- Soil microbes convert sulfur into sulfuric acid

$$S + \frac{1}{2}O_2 + CO_2 + 2H_2O \rightarrow H_2SO_4 + CH_2O$$

  - H_2SO_4 dissolves calcium carbonate and makes gypsum
    - Conversion to sulfuric acid takes time
      - several weeks
      - faster in warm soils

Other soil factors: Soil organic matter (OM)

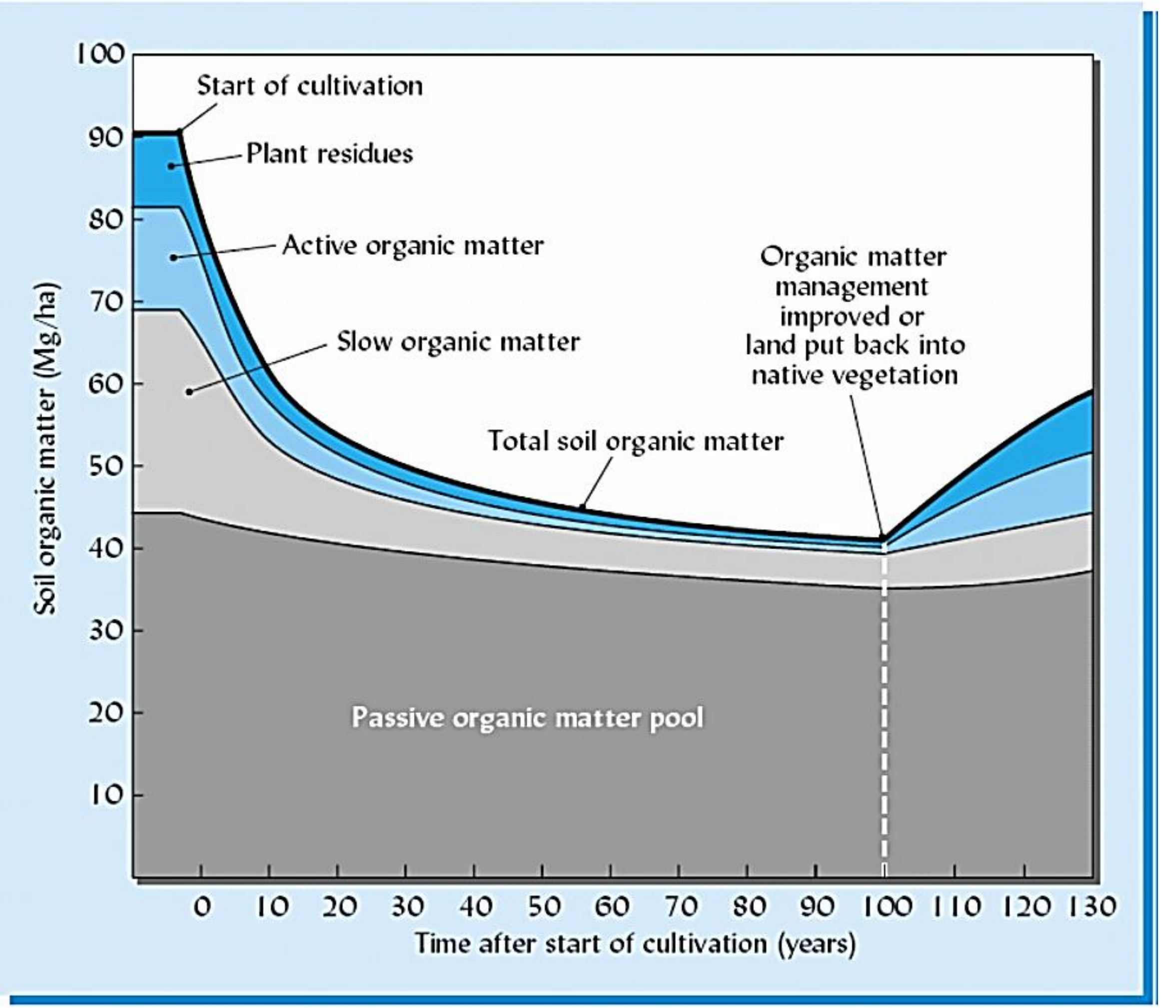
- OM consists of living organisms, plant and animal residues in various stages of decomposition, and humus (decomposition by-product)
  - Living soil organisms ~ 0.2% of soil mass
  - Soil OM ~ 0.5 to 2% of soil mass in desert soils
- Soil OM
  - Supplies plant nutrients
  - Improves soil water holding capacity
  - Cements soil particles into aggregates
  - Decomposes rapidly in desert soils



Effect of cultivation (tillage) on soil organic matter

Plowed soils generally have less OM than native soils

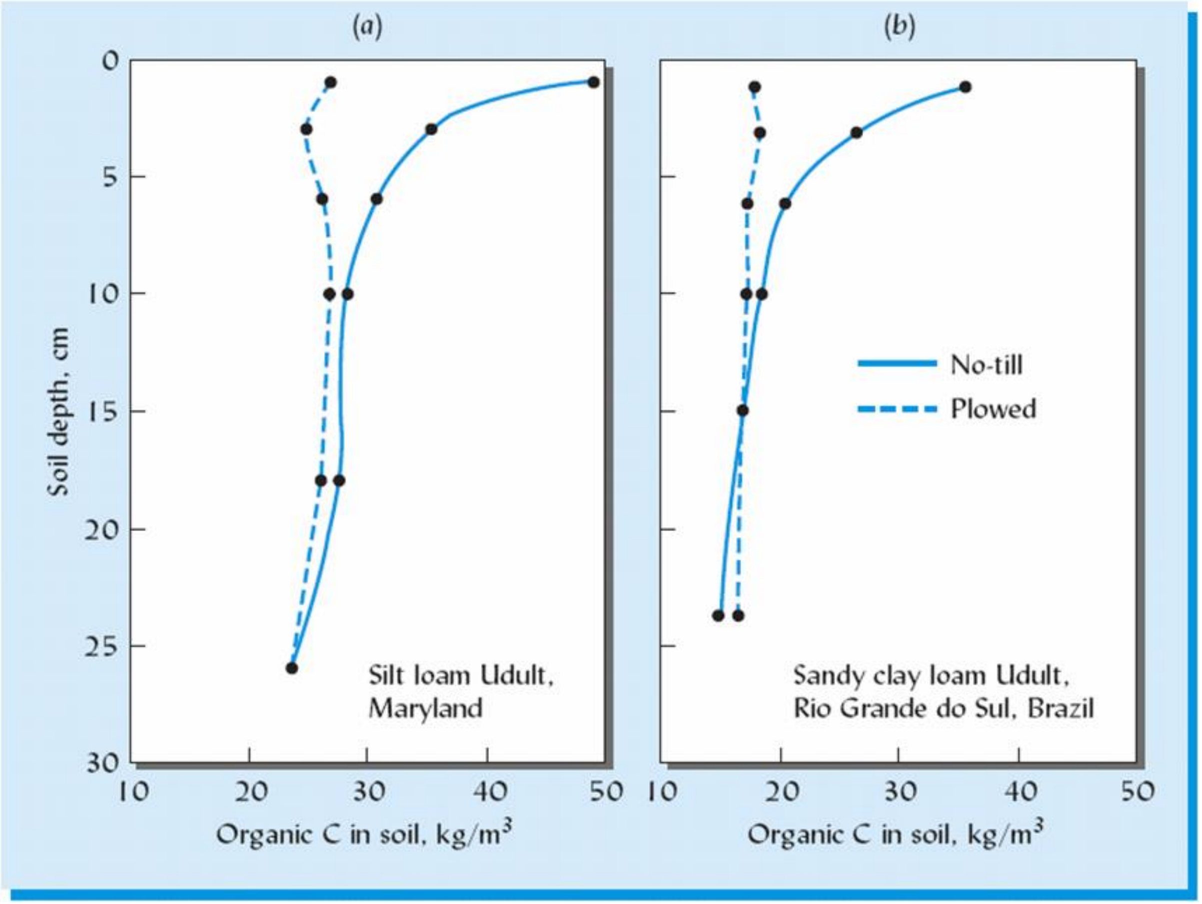
1. Plowing/tillage break down aggregates, and bury plant residues, encouraging decomposition
2. Plowed soils are more prone to erosion
3. Removal of plant material from soils during harvest reduces OM addition



‘Minimum Tillage’
‘Zero Tillage’
‘Conservation Tillage’
‘Reduced Tillage’

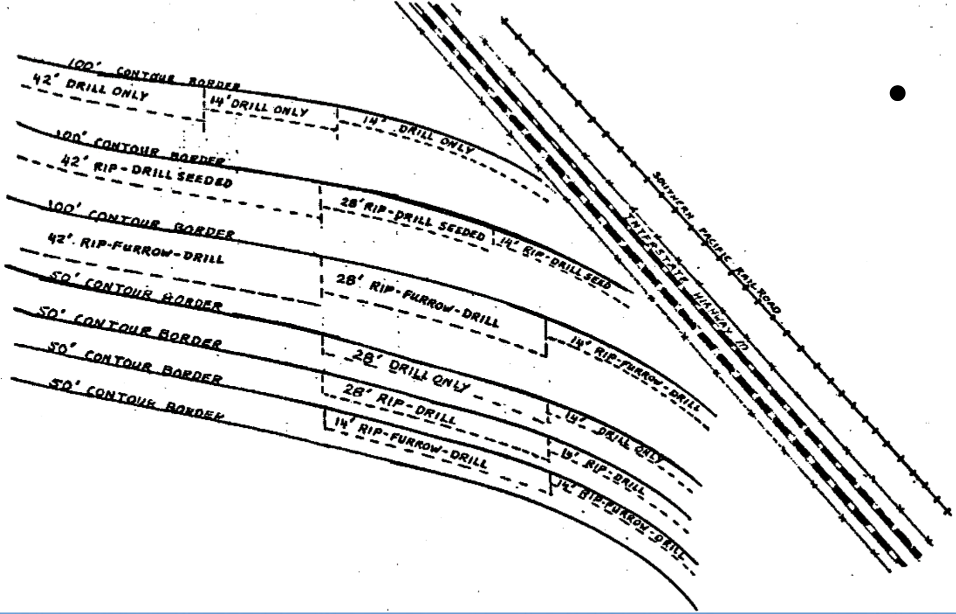
Management systems that keep plant residues at the soil surface, reduce OM degradation, and protect the soil surface from erosion

Effect of tillage on soil OM



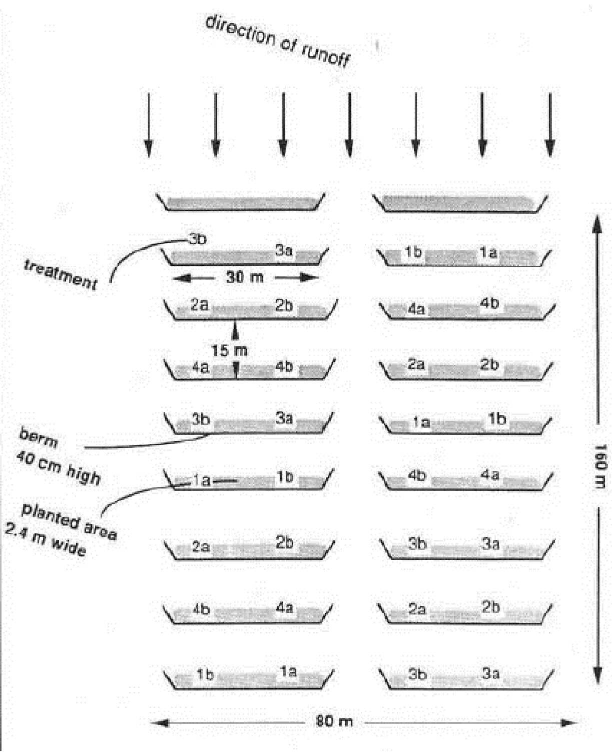
Effects of two conservation tillage systems on soil organic carbon content. Both no-till systems leave crop residue on or near the soil surface and also leave the soil almost completely unmixed, slowing decomposition.

Passive Soil Moisture Conservation: water collection & retention



- I-10 Corridor S of Picacho (NRCS)
  - Abandoned farmland
  - Contour borders 50 or 100 ft wide
  - Seeded w/ native grasses and shrubs
  - Initiated in 1979

- I-10 Corridor N of Picacho (Desert Botanical Garden, UA)
  - Abandoned farmland
  - Berms 30m long, 40cm high, 15m apart
  - Uphill seed bed 2.4m wide planted w/grasses
  - Initiated in 1991



- Waterman Mountains (AZ Native Plant Society)
  - Former gravel pit, landing strip
  - Hand-built water retention structures
  - Seeded w/Palo Verde, Ironwood
  - Initiated in 2006

http://imgc.artprintimages.com/images/art-print/joel-sartore-swirling-wind-kicks-up-a-dust-devil-near-the-pan-american-highway_i-G-27-2705-4OGND00Z.jpg