Restoration of Degraded Soils

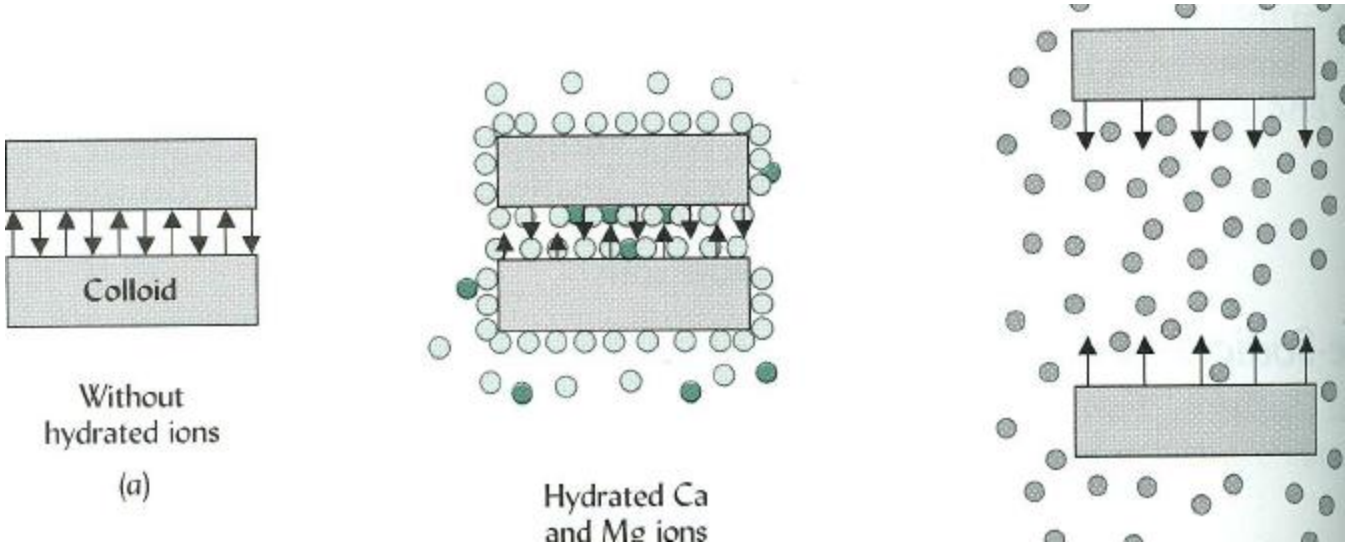
- Saline Soils
  - Electrical Conductivity (EC)≥4dS m^{-1}
- Sodic Soils
  - EC<4dS m^{-1}, with Sodium Adsorption Ratio (SAR)≥13
- Saline/Sodic Soils
  - EC ≥4dS $m^{-1}$and SAR≥13
- Both can be naturally occurring or caused by management

Sodium Adsorption Ratio (SAR)

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}\left([Ca^{2+}] + [Mg^{2+}]\right)}}$$

- SAR is the ratio of Na/Ca+Mg in a saturated soil extract
- High levels of sodium cause soil particles to disperse
- Soil becomes structureless because of loss of aggregate stability and structure

Na and soil structure



- Sodium has a large hydrated radius
- Prevents adhesion of clay particles
- Causes disintegration of aggregates

Problems associated with Sodic Soils

- Problems are associated with decreased porosity of the soil
- Poor root growth, aeration, and infiltration.
- Difficulties planting due to compaction.

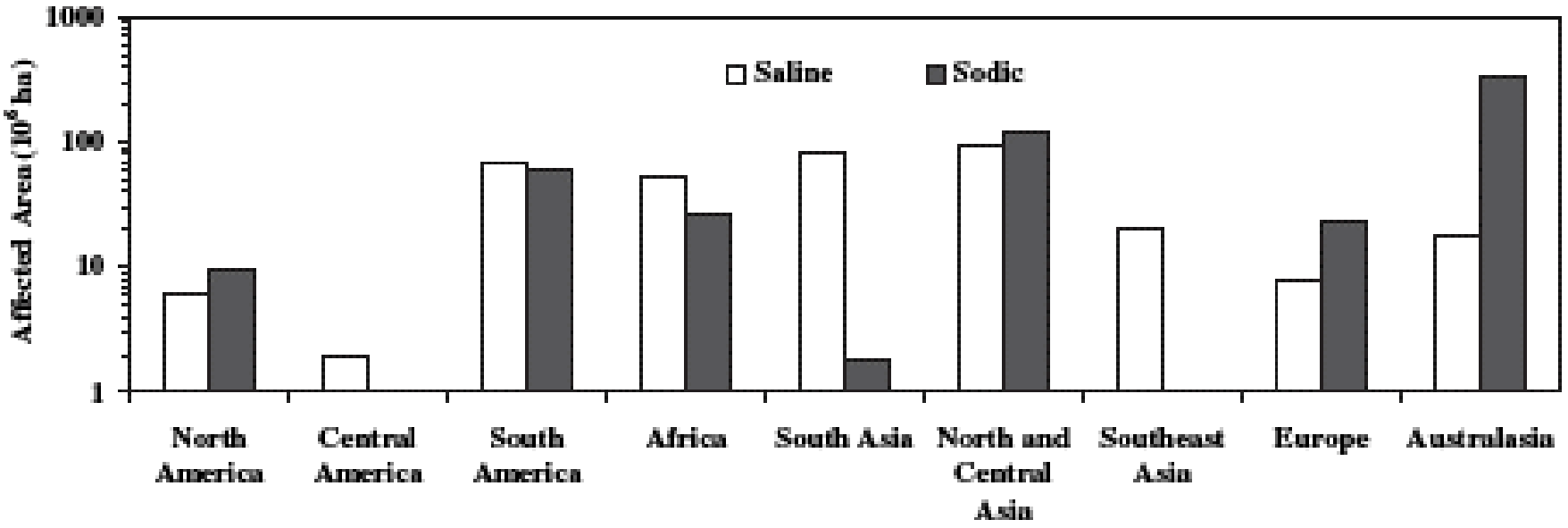
Saline Soils

- Elevated concentrations of salts
  - Ca, Mg, K, Na, Cl, SO_4, H_4BO_4, etc.
- Affects on plant growth:
  - Osmotic effect:
    - Salts decrease the osmotic water potential of the soil making it more difficult for plants to extract water
  - Specific ion effect:
    - Some salts such as Cl, or H4BO4 can be toxic to plants at high concentrations.

Saline/Sodic soils

- Most problematic because they not only decrease osmotic potential and present potential salt toxicity but are also dispersed and have poor structural character.

Extent of Salt Affected Soils



Causes of Salt Affected Soils

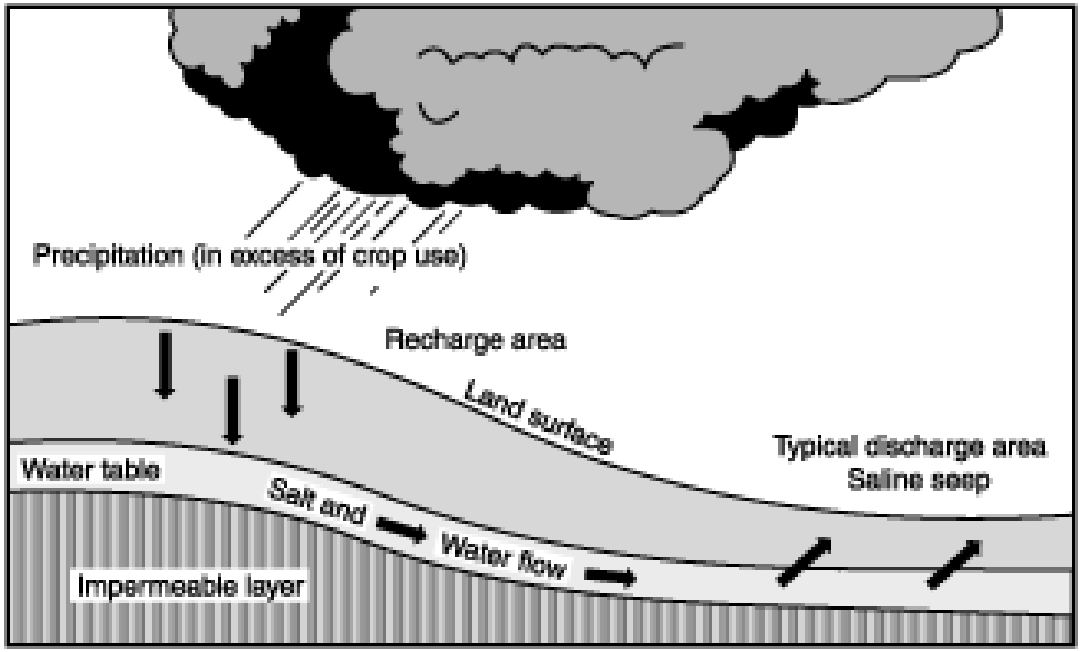
- Low precipitation
- High evaporation rates
- Poor drainage
- Irrigation with saline water
- Poor irrigation drainage systems
  - Creates shallow water table
- Low permeability
- Saline parent material
- Shallow water table

Salt affected areas in Arid Environments

- Salts accumulate/persist naturally in some soils because of insufficient rainfall to leach salts from surface
- The source of salts may be now-extinct lakes or oceans that served as parent material Example
- In coastal areas sea spray can be an important source of salts

Saline and/or Sodic seeps

- Occur naturally but can be created or expanded by changes in the landscape water balance
- Seeps occur where water tables come near the surface
- Video
- Soil survey



Seeps

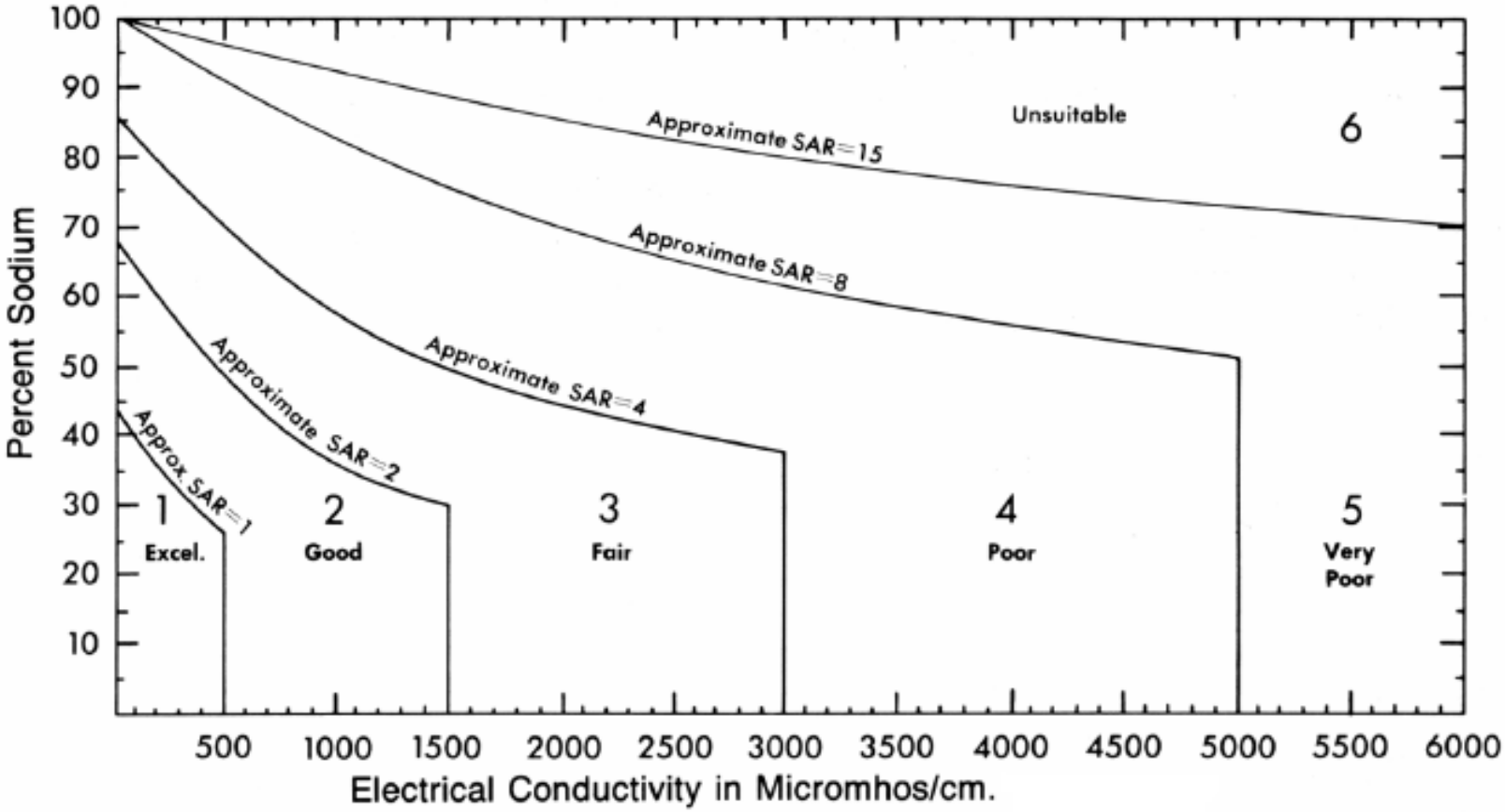
- Clayey textures soils can conduct water form greater depths compared to sands.
  - Shallower water tables are required in sandy soils
  - Tile drainage is an option in sandy soils but not in Clayey soils
  - Water is not always saline
  - It can simply be the SLOW accumulation of salt from low EC water.
  - Before drainage is considered groundwater should be tested.

Irrigation induced salinity

- Irrigation brings in more water AND salt
- The total Salinity (EC) and SAR of water are used measure the hazard of irrigation water:
  - EC:
    - 0-250 μmhos/cm = low salinity hazard
    - 250-750 μmhos/cm = medium salinity hazard
    - 750-2250 μmhos/cm = high salinity hazard
    - >2250 μmhos/cm = very high salinity hazard

Irrigation Induced Salinity

- Interaction between Salinity and Sodium content



Water Quality interpretation

- Class 1(excellent)=No problems should result in its use
- Class 2 (Good)=suitable for use on most crops under most conditions. Extensive use on poorly drained soils may eventually cause salinization
- Class 3 (Fair)=can be used for most crops but care must be taken to prevent salt accumulation
- Class 4 (Poor)=restricted to use on permeable, well drained soils for production of salt tolerant crops
- Class 5 (Very Poor)= restricted to use on sandy, well drained soils in areas receiving more than 30 inches of rain
- Class 6 (unsuitable)=not recommended for irrigation

Other Water Quality Consideration

- Carbonates:
  - When total carbonates exceed total Calcium and Magnesium they may precipitate.
    - This will cause the ratio of Na to (Ca+Mg) to increase
    - Increasing SAR
- Boron:
  - May be toxic to plants

Irrigation induced salinity

- In very arid environments salinization must always be considered because even the best quality water contains
- Optimizing water use efficiency and minimizing water applications are key components of efforts to prevent salinization
  - Drainage of excess water is also critical
  - In clayey soils, surface drainage may be needed.
  - Tile drainage may also be used in more permeable soils

Salt tolerate Crops

-

Tolerant	*Moderately Tolerant*	*Sensitive*
	Field Crops	
10,400 ppm	*7,800 ppm*	*2,600 ppm*
Barley (grain)	Rye (grain)	Field Beans
Sugar Beet	Wheat (grain)	
Cotton	Oats (grain)	
	Grain sorghum	
	Soybeans	
	Corn	
	Sunflower	
7,800 ppm	3,900 ppm	

	Forages	
11, 700 ppm	*7, 800 ppm*	*2, 000 ppm*
Alkali sacaton	White sweetclover	Peanuts
Saltgrass	Yellow sweetclover	White Dutch clover
Bermudagrass	Perennial ryegrass	Red clover
Rhodesgrass	Dallisgrass	Ladino clover
Rescue grass	Sudangrass	
Barley (hay)	Alfalfa	
Birdsfoot trefoil	Rye (hay)	
Wheatgrass	Wheat (hay)	
	Oats (hay)	
	Blue grama	
	Fescue	
	Smooth bromegrass	
7,800 ppm	*2,600 ppm*	*1,300 ppm*

Reclamation of Saline Soils

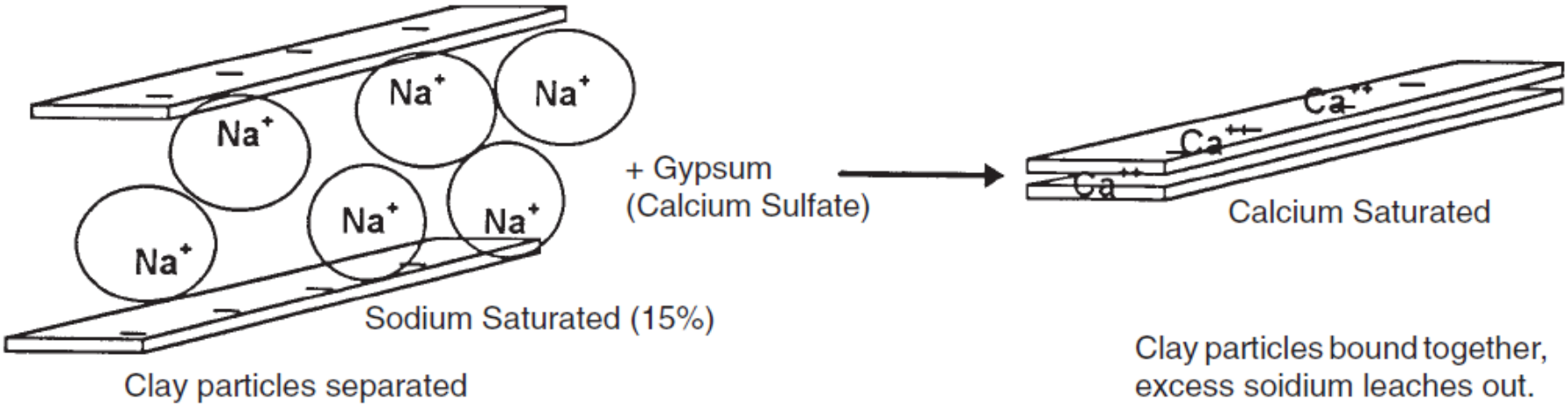
- Identify problem.
  - Is it saline, sodic or both
  - Are there toxic salts
  - Collect samples from the top 3 inches of soils for salinity analysis.
- What caused the problem:
  - Naturally poor drainga
  - Poor irrigation water and/drainage
  - Brine Spills
  - Exposure of saline or sodic subsoil

Reclamation of Saline Soils

- Improve internal drainage
  - Tile drainage or surface ditches
  - If compaction is a problem sub-soiling may be needed
- Incorporate 10-15 tons of organic matter per acre to improve surface infiltration
  - Temporarily creates large pores
  - Also decreases capillary movement of water during dry periods
- Maintaining surface cover will prevent crusting and improve infiltration

Reclamation of Saline Soils

- Apply gypsum to Sodic soils:
- Gypsum (CaSO4) applications can flush the system with Ca which replaces Na on the exchange capacity and allows it to be leached.



Reclamation of Saline Soils

- Leaching a saline/sodic soil without applications of gypsum can cause the soil to become sodic
  - Sodic soils are much more difficult to reclaim because leaching is limited by dispersion

Reclamation of Saline Soils

- How much gypsum to apply?

Texture	Exchangeable Sodium Percentage				
	15	20	30	40	50
	Tons per acre				
Coarse	2	3	5	7	9
Medium	3	5	8	11	14
Fine	4	6	10	14	18

Reclamation of Saline Soils

- Final steps in reclamation:
- Avoid deep tillage after leaching has been initiated
  - Deep tillage may move previously leach salts back to the surface
- Minimize activities that may compact or otherwise reduce internal drainage of the area.
- Wait for practice to work

Reclamation of Saline Soils

- Alternatives to drainage:
- Learn to live with it.
- This may be required for some saline seeps because downward movement of water is limited by shallow water table:
- Avoid input applications to the area
- Establish a salt tolerant cover crop and farm around it!