



# *Soils and Fertilizer*

TEXAS A&M  
AGRILIFE  
EXTENSION

by Fred Wiebel  
with Modifications

# Why study soils?

- **Important in land use and planning**

- Foundational use of soils
- Landscape Use
- Rare soil and ecosystem preservation
- Development of steep lands
- Agricultural land use

Waste repository

Building

Transportation

Bridge between  
mineral and life

Foundation of

Civilizations

- **Homeowners perspective:**

- A thorough knowledge of soil properties and characteristics and its relation to water and fertilizer is necessary to make proper decisions with regard to gardening, fruit production and landscaping

# Summary of Course

- Learn about basic soil science
- Establish and understanding of plant nutrition, soil fertility and nutrient management
- Increase our understanding of the chemical, physical and biological relationships of soils.

# Function of Soils

- Soil is the primary source of
  - Water
  - Nutrients
  - Physical support

# What is soil?

- Produced when parent material (rock) is weathered (acted upon by climate and vegetation over time)

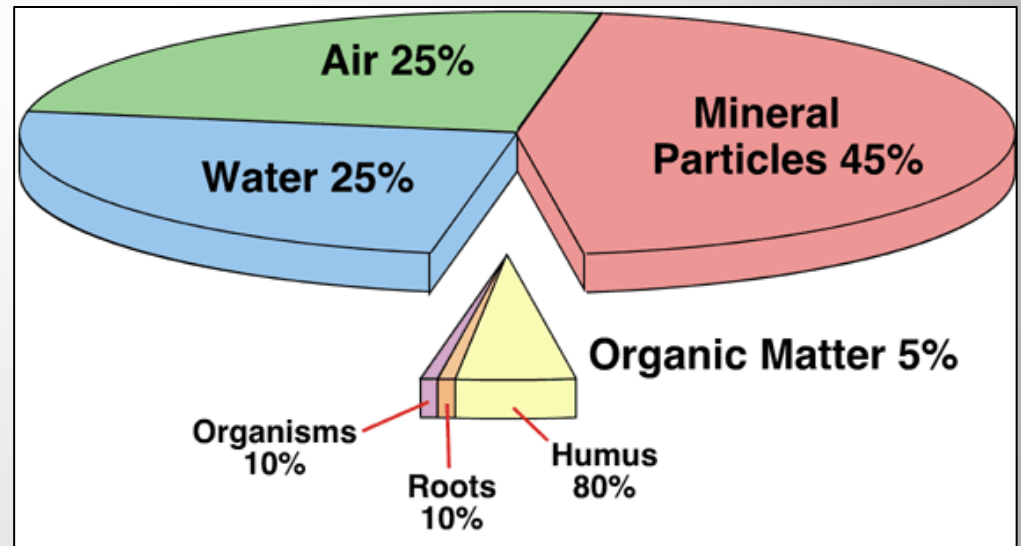
# What is soil made up of?

- Made up of
  - Different size mineral particles
    - Sand
    - Silt
    - Clay
  - Organic matter
  - Numerous species of living organisms



# Parts of the Soil

- Mineral portion (45%)
- Water (25%)
- Air (25%)
- Organic Matter (5%)



# Physical Properties

- Soil depth
  - Effective depth of a soil for plant growth
  - Vertical distance from the surface down to where downward growth of roots stops
- Caliche
  - Found in soils that receive low rainfalls

# What is Caliche

- A more or less cemented deposit of calcium carbonate found in many soils of warm-temperature areas. The material may consist of soft, thin layers; or hard, thick beds just beneath the soil. Sometimes it may be exposed at the surface by erosion.

# Problems Caliche Cause

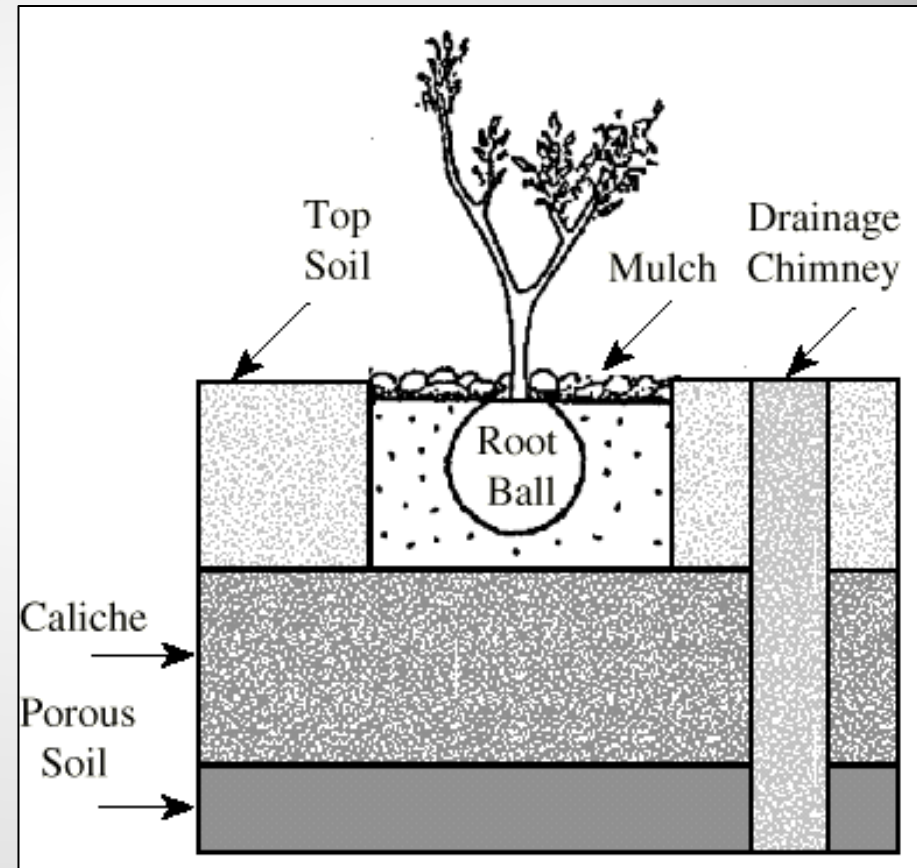
- An impermeable caliche layer prevents water from draining properly, which can keep the roots from getting enough oxygen
- The impermeable nature of caliche beds also prevents plant roots from going through the bed
- Caliche beds will also cause the surrounding soil to be basic

# Fixing These Problems

- The best solution to these problems is to remove the layer of caliche and replace it with a mixture of organic material and soil.
- If the caliche is too thick.
  - Dig a hole large enough for the mature root system.
  - Then, a smaller hole or holes can be dug through the remaining caliche to provide drainage.

# Fixing These Problems

- To test drainage, the hole should be filled with water. If the level drops by 1 inch per hour, the drainage is sufficient.



## Fixing these problems

- If a lawn is to be grown over caliche, provide at least eight inches of good topsoil above the caliche.
- If you are going to add topsoil, make sure a good amount of compost is also added.

- Why is soil important to gardening?
- What are the 4 parts of a soil?
- What is caliche? Why are we talking about it?
- What are the components of organic matter in the soil?

**Questions**

# Physical Properties of Soils

- Color
- Texture
- Structure
- Drainage
- Water holding capacity (WHC)
- Soil organic matter (OM)

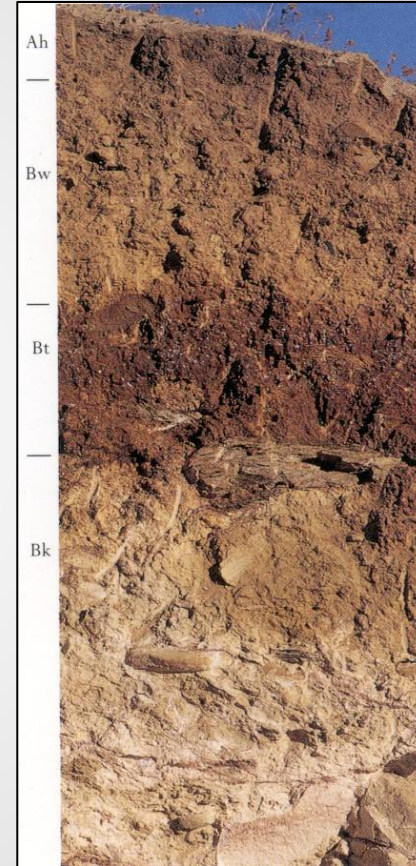
# Soil Color

- Is of minor importance by itself
- But it does indicate other soil conditions that are extremely important

# Soil Color

## Light Colors

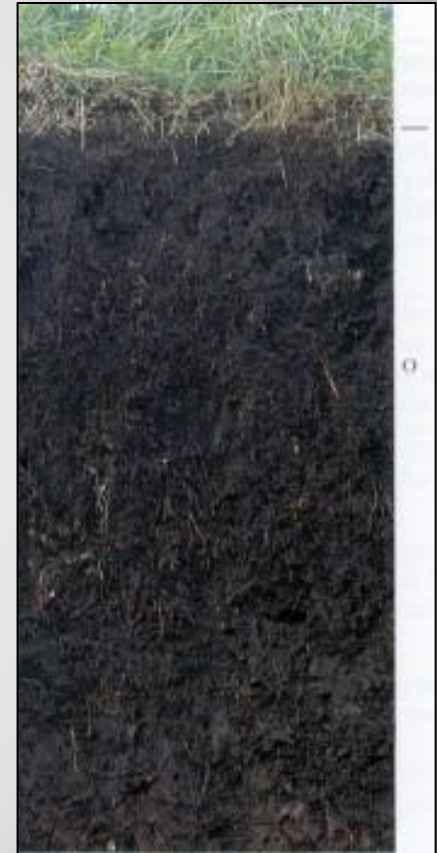
- Low organic matter
- Coarse texture
- Well drained
- High annual temperature



# Soil Color

## Dark colors

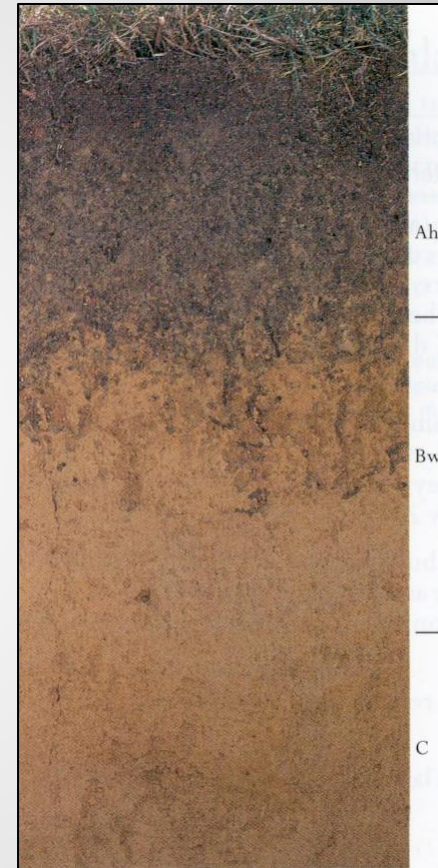
- Slow oxidation of organic matter
- Poor drainage
- Color of the parent material
- Lower temperatures



# Soil Color

## Red and Brown

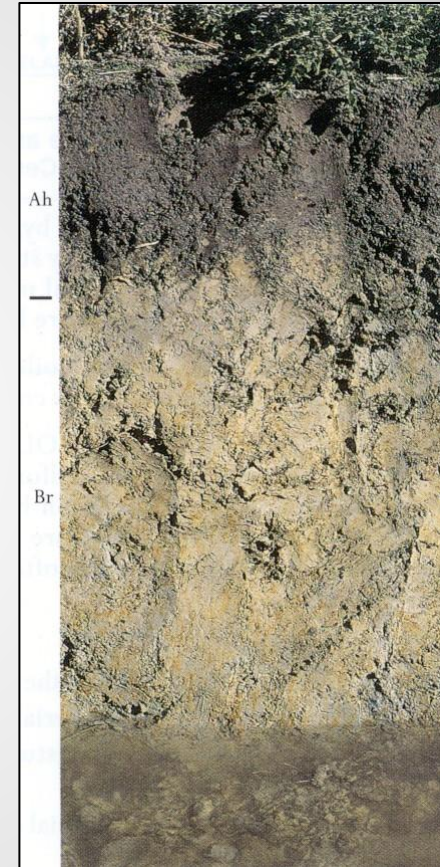
- Iron (Fe) in well-drained soils
- Well aerated soils



# Soil Color

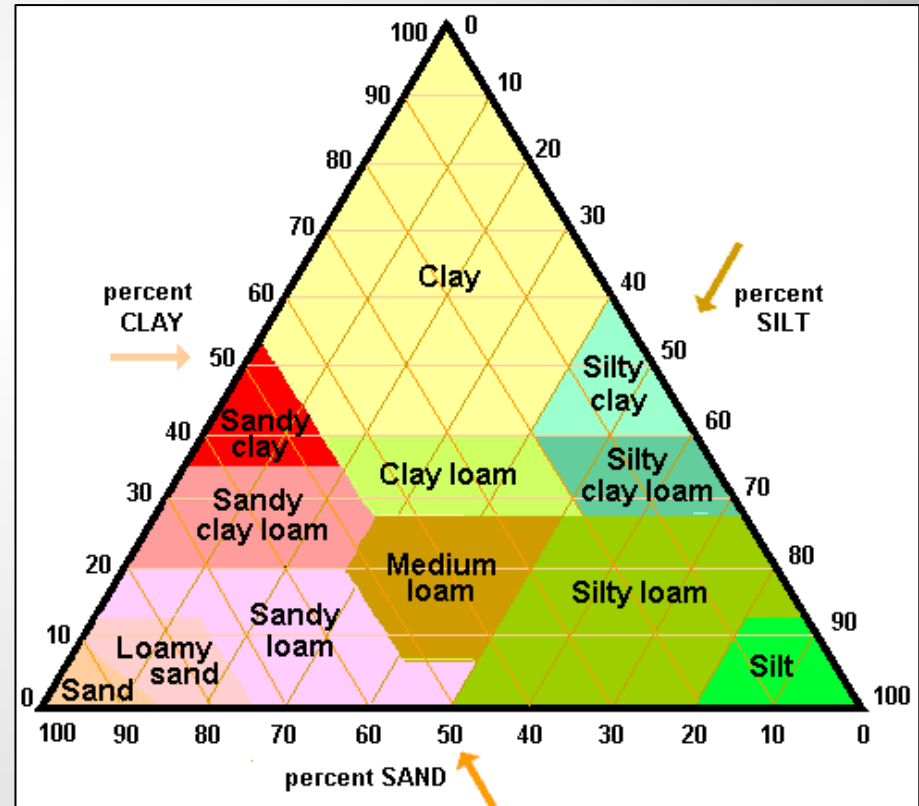
## Gray

- Wet soils-anaerobic condition (low oxygen) that chemically and biologically removes the iron (Fe) leaving a gray color



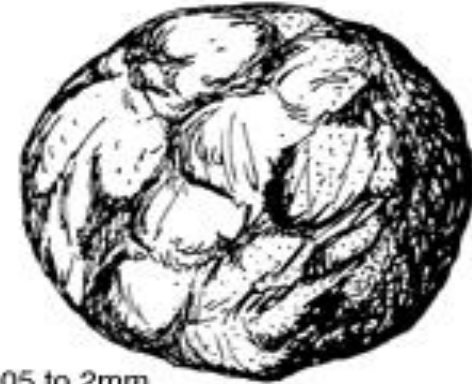
# Physical Properties - Texture

- Relative amounts of differently sized soil particles
- Fineness or coarseness of the mineral particles.
- Relative amounts of
  - Sand
  - Silt
  - Clay



# Physical Properties of Soils - Texture

- The ratio (%) of Sand, Silt and Clay in the soil



Sand .05 to 2mm  
feels gritty



Silt .002 to .05 mm  
feels smooth



Clay <.002 mm  
feels smooth

# Soil Texture

## How estimated? – the “feel method”

- Sand – feels rough and gritty when wet or dry
- Silt – feels smooth when wet or dry but NOT sticky
- Clay – feels smooth when dry and sticky when wet (can make a “ribbon” of soil)

# Soil Texture

## Jar test

- 1 clean quart jar and tight-fitting lid, clean water and your soil sample
- Fill the jar about 2/3 full of clean water
- Take a sample of soil and fill the jar until the jar is nearly full.
- Leave about 1/2" of air space at the top.
- Screw on the lid and shake it vigorously for a minute or two.

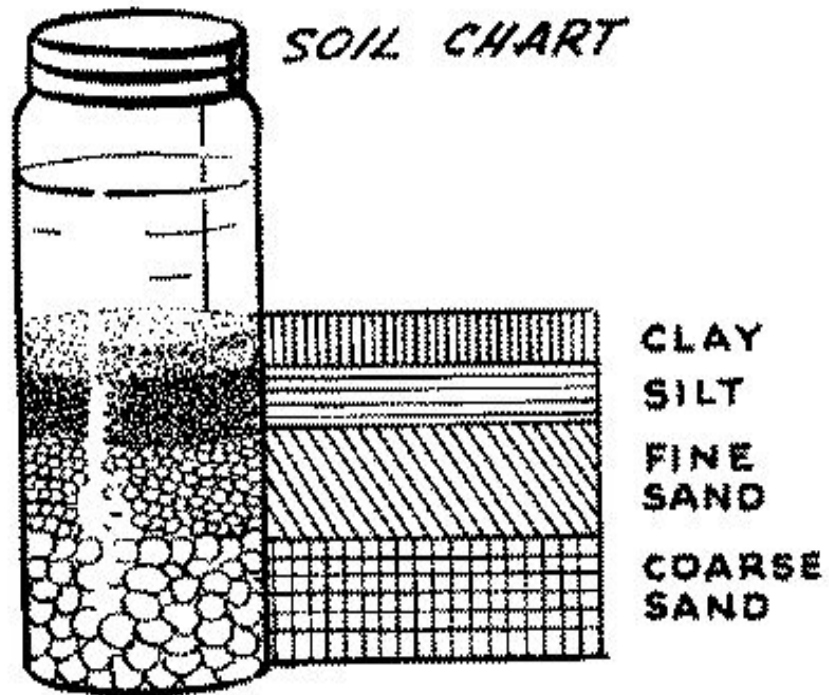
# Soil Texture

- Allow the suspended soil to settle for about a minute, and **place a mark** on the side of the jar at the top of the layer that has settled out.
- Set the jar aside, being **careful not to mix** the sand layer that has already settled and wait approximately an hour.
- **Place a second mark** on the side of the jar at the top of the next layer . This is the **silt layer**

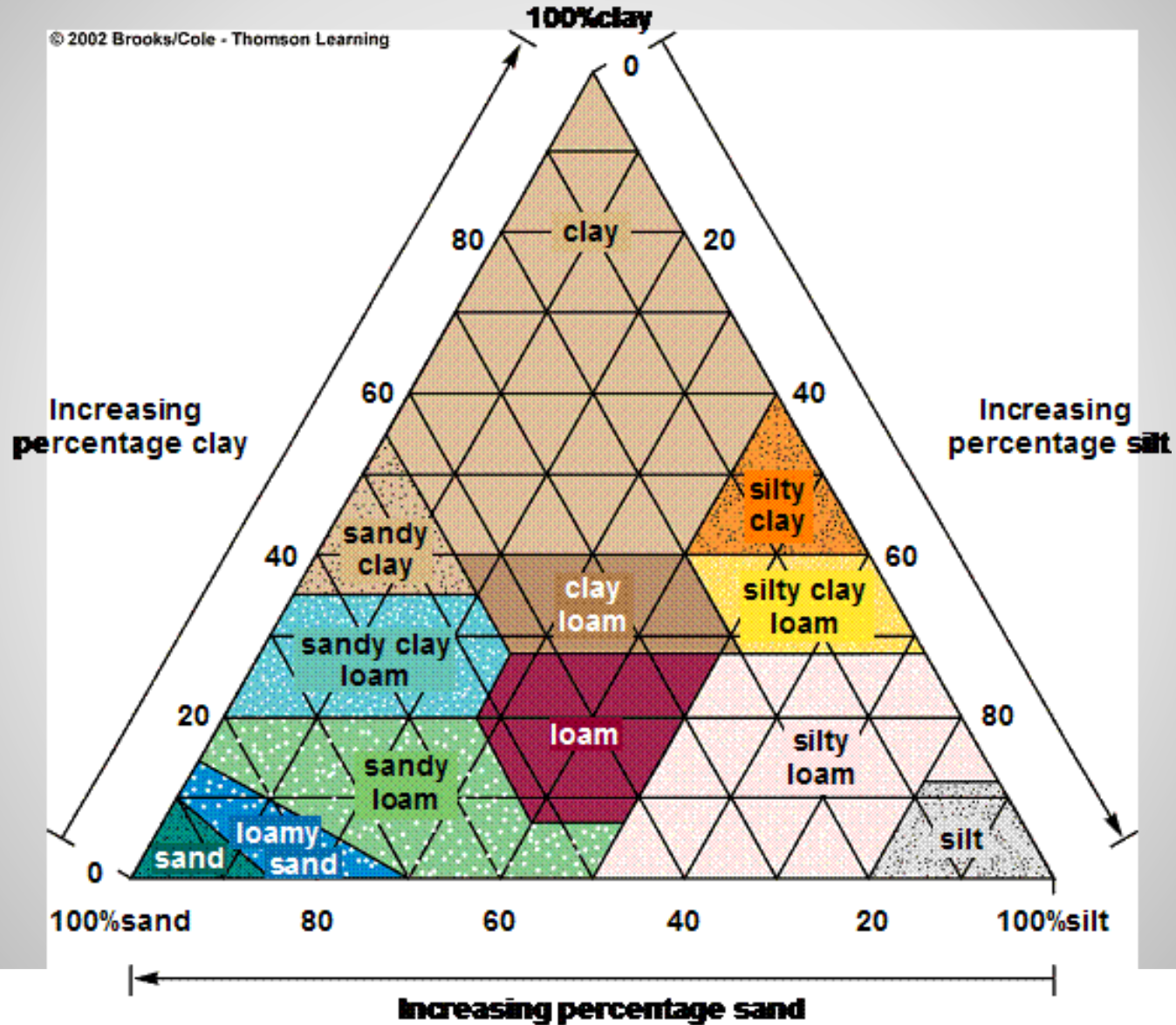
# Soil Texture

- After 24 hours, or when the water is once again clear, place a **third mark** on the side of the jar at the top of the final layer.
- This is the **clay layer**.
- The percentage of each layer tells you what kind of soil you have.

*SOIL CHART*



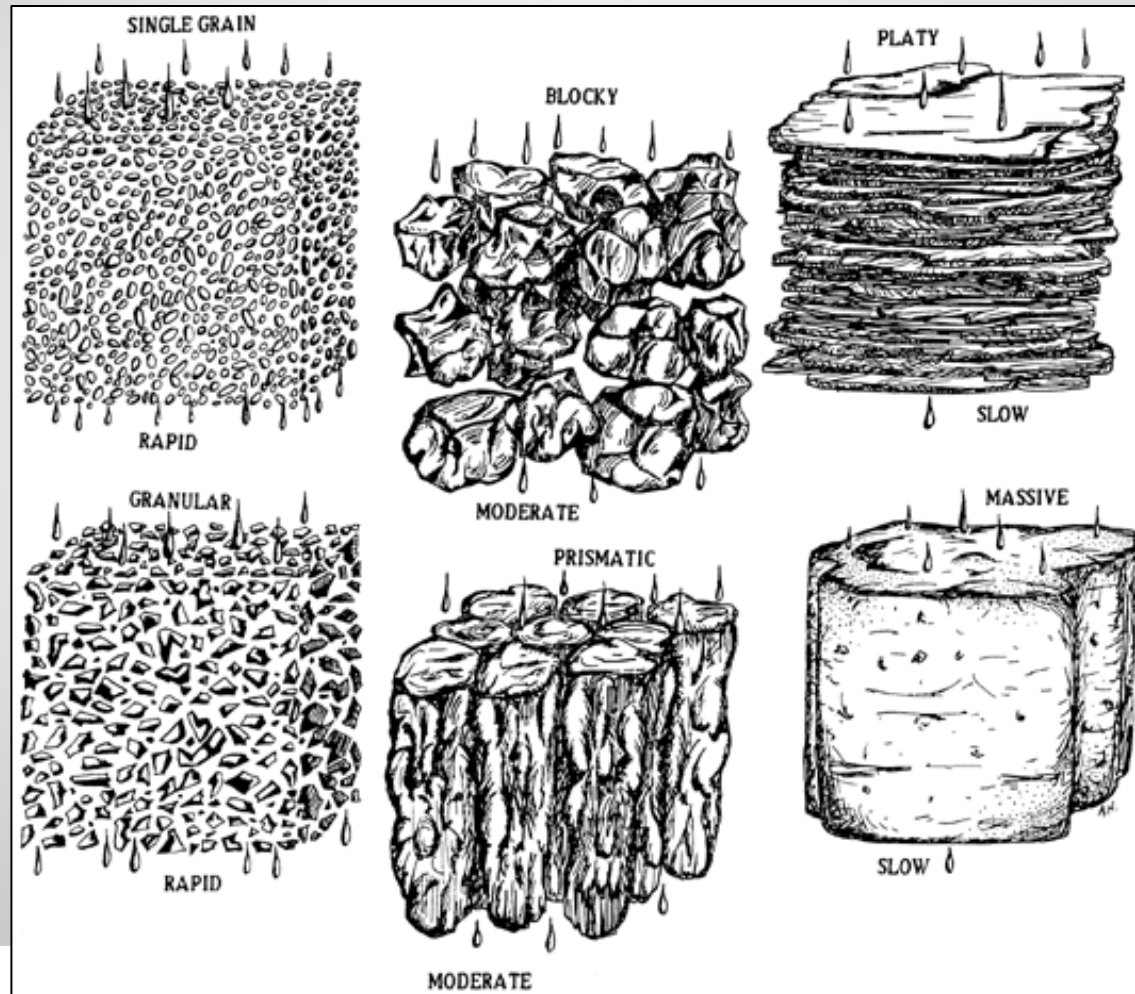
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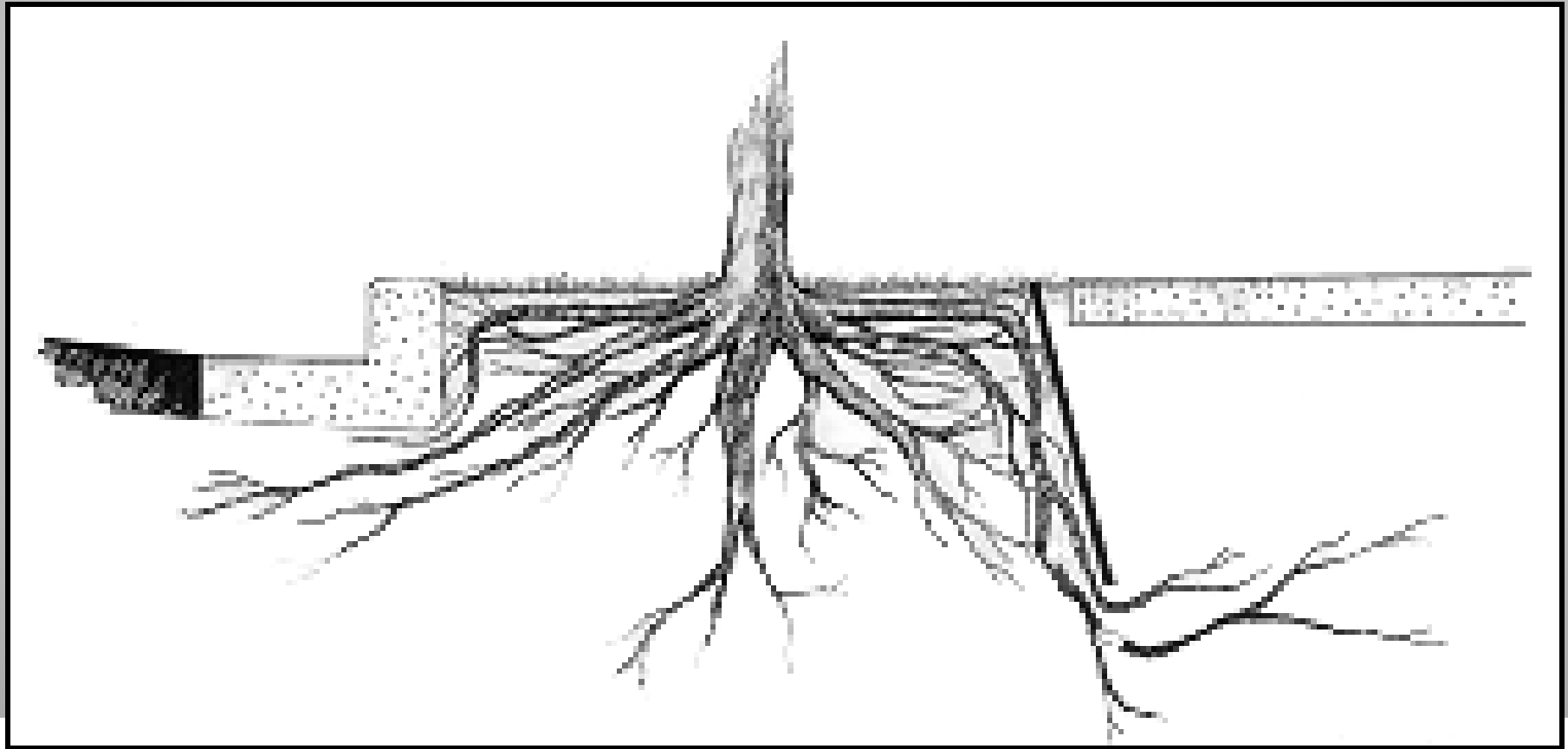
Note: Texture cannot be altered. What you have is what you got.



# Water Movement



# Root Growth



- Describe soil texture.
- Name the 3 textural groups.
- Describe structure.
- Why is texture and structure important in gardening?
- Can you modify soil texture?
- What test can you use to determine soil texture?

**Questions**

# Soil Water

- **Available soil Water**
  - Ease in extraction by plants for use
- **Soil moisture storage**
  - Dependent on structure, texture and organic matter content
  - Relative degree of pore spaces

# Soil Texture and Structure



# Physical Properties of Soils

## Good structure affects

- Air movement
- Water movement
- Root growth

# Air Movement

- Clay soils are problems for the plant in several ways.
- It's difficult for roots to penetrate soil whose particles are tightly pressed together (compacted).
- Oxygen is also limiting in these types of soils not only because of the lack of space for it, but also in many cases, applied water displaced the oxygen.

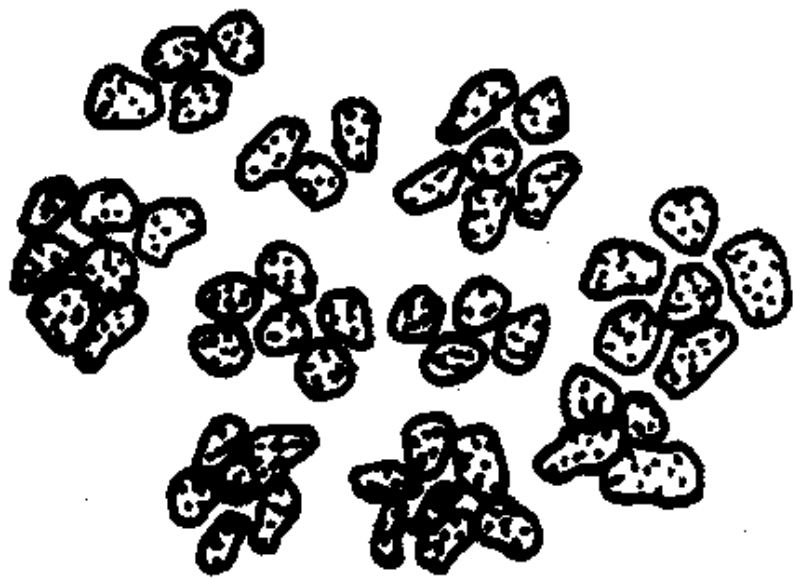
# What promotes good soil structure?

- Promoted by organic matter (OM) additions
  - Mulch
  - Compost
  - “Don’t bag It “practice in lawns
- Promoted by root growth
  - Soil aeration
- Tillage – especially when wet can destroy structure

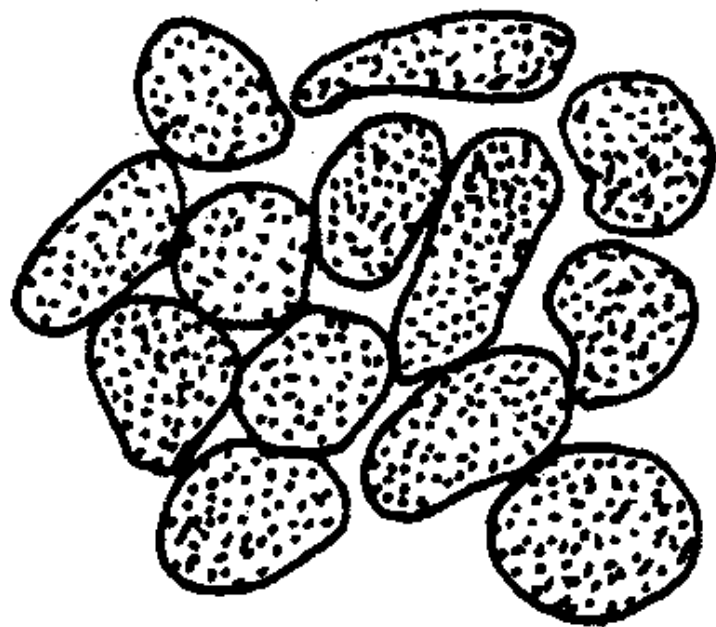
# Drainage

**Drainage- the rate and extent of soil water movement**

- Is affected by:
  - Topography or slope
  - Soil texture and structure
    - Hydraulic conductivity is based on pore size
  - Soil stratification (layering) in the subsoil inhibits drainage
  - Initial soil moisture content



Clay

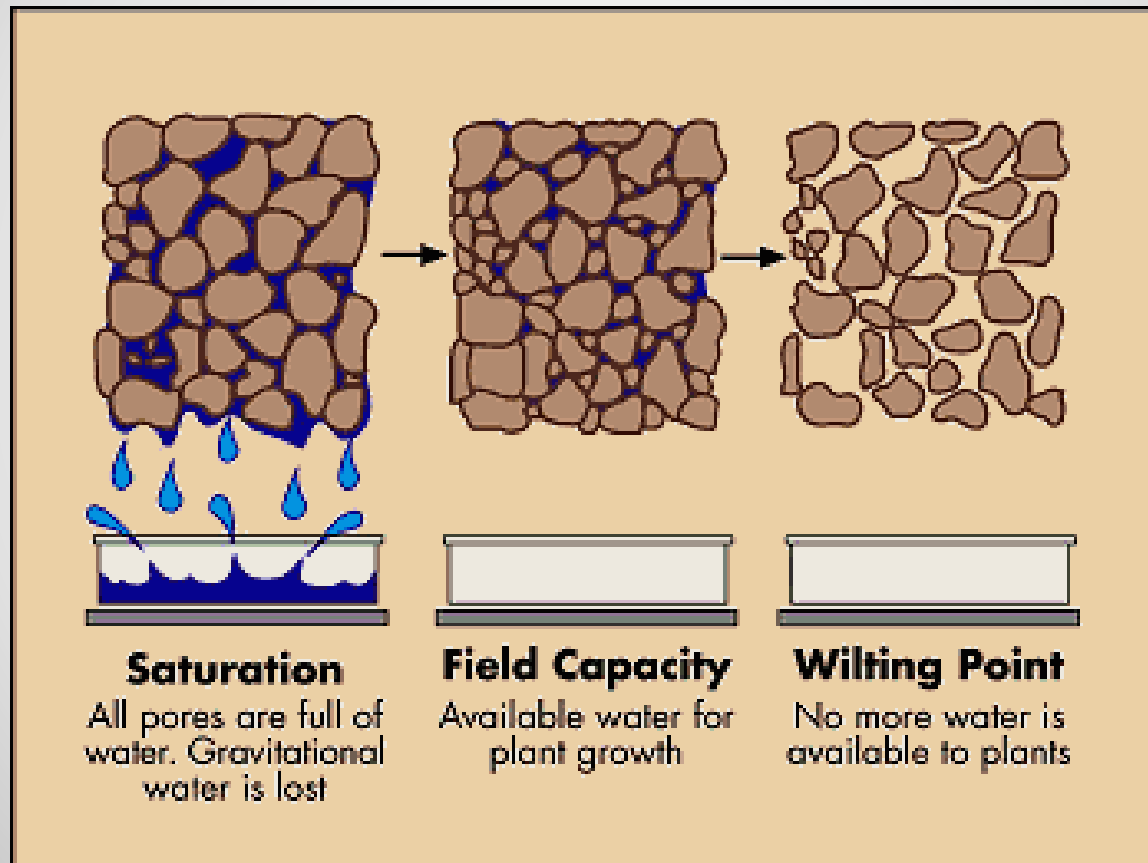


Sand

# Pore Space

- There is more pore space in clay soils than there is in sandy soils.
- The problem is that there is a certain amount of water bound to the soil particles which is not available for use by the plant,

# Water Holding Capacity



# Depth Of Water Required (Inches)

1

2

3

4

Depth Of  
Soil Wet  
(Inches)

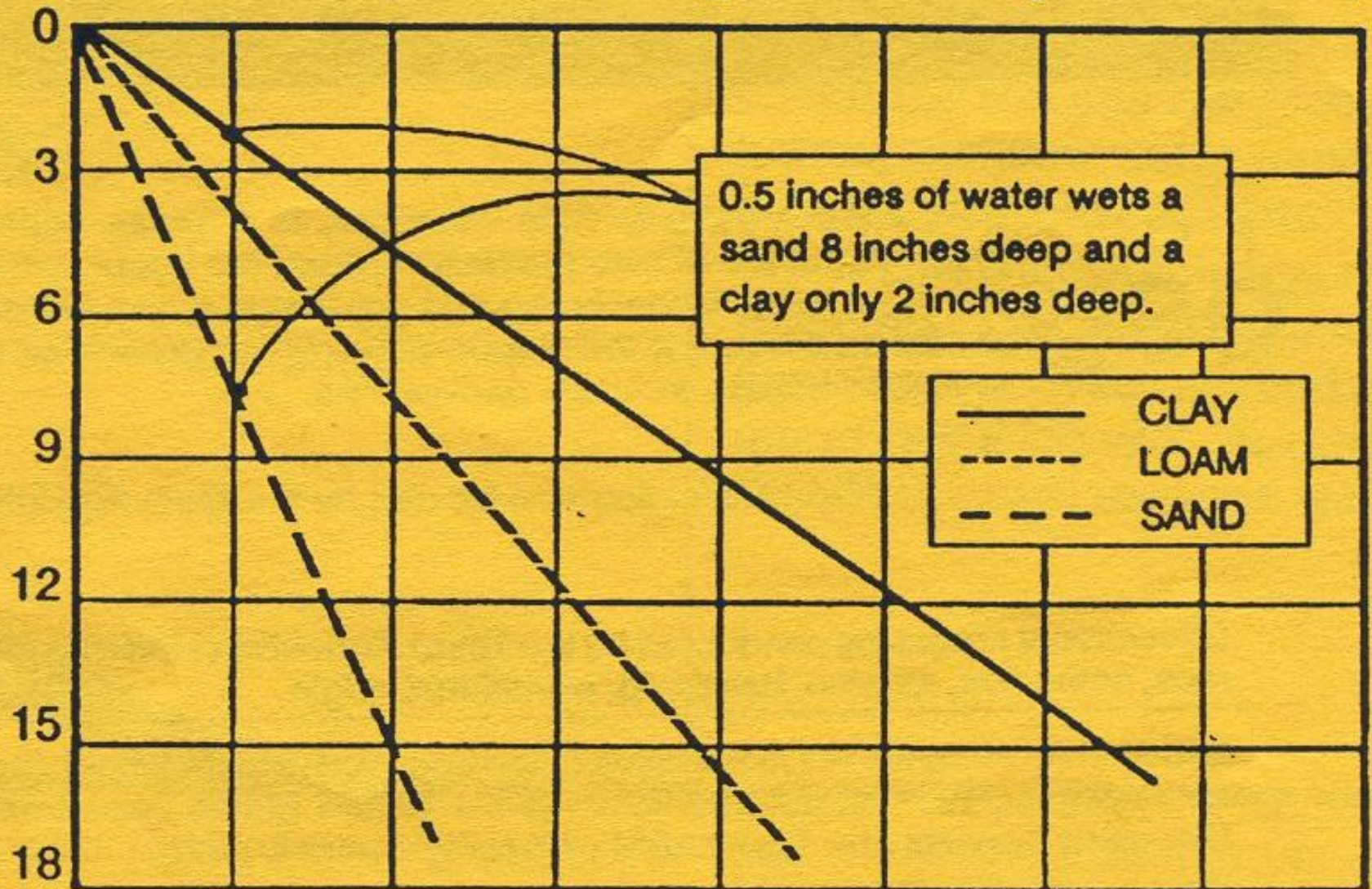


Figure 3. Water penetration in various soil types.

# Water Movement in Soil

- If you put  $\frac{1}{4}$  inch of water on a sandy soil it will only go down 4 inches. The soil below that point will stay dry.
- Does not make any difference if the soil is deeper than that.

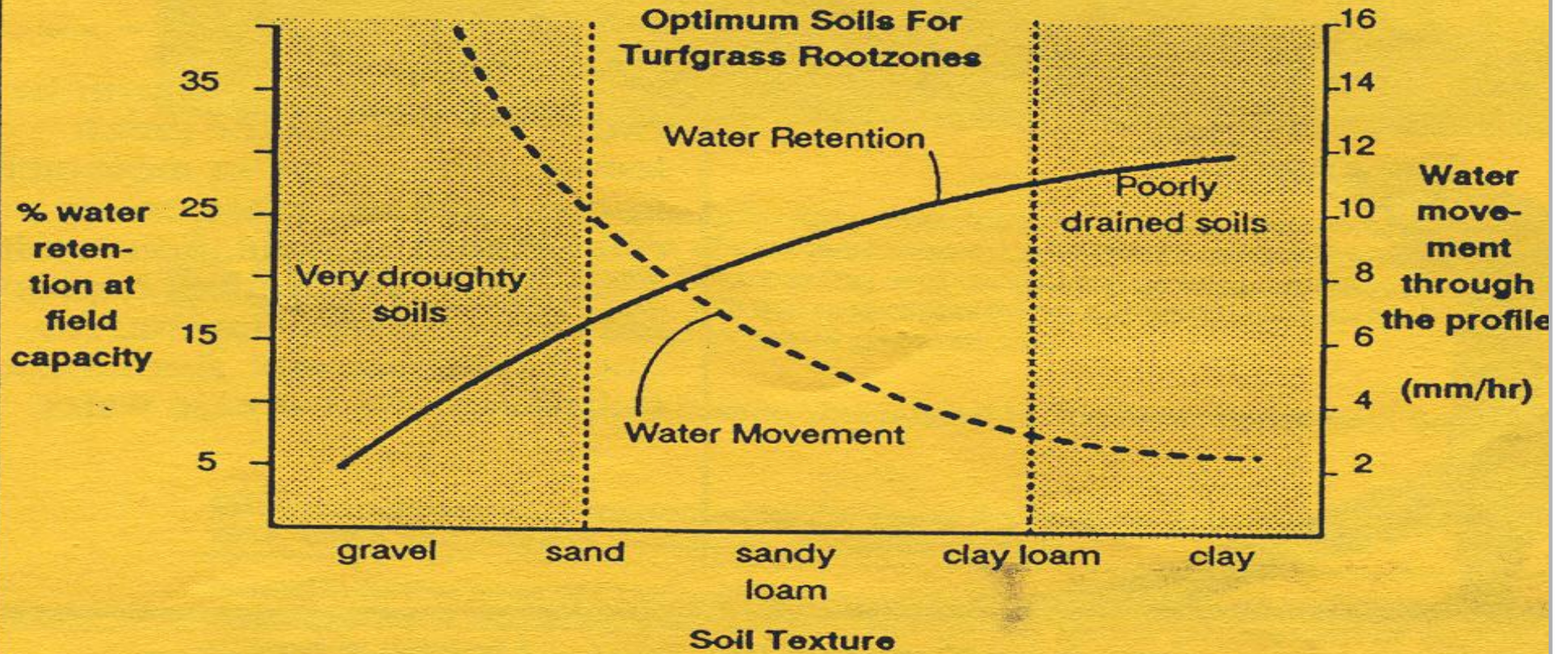


Figure 1. Influence of soil texture on water infiltration and retention.

# 1 Inch/Hour Precipitation Rate

RUNOFF %

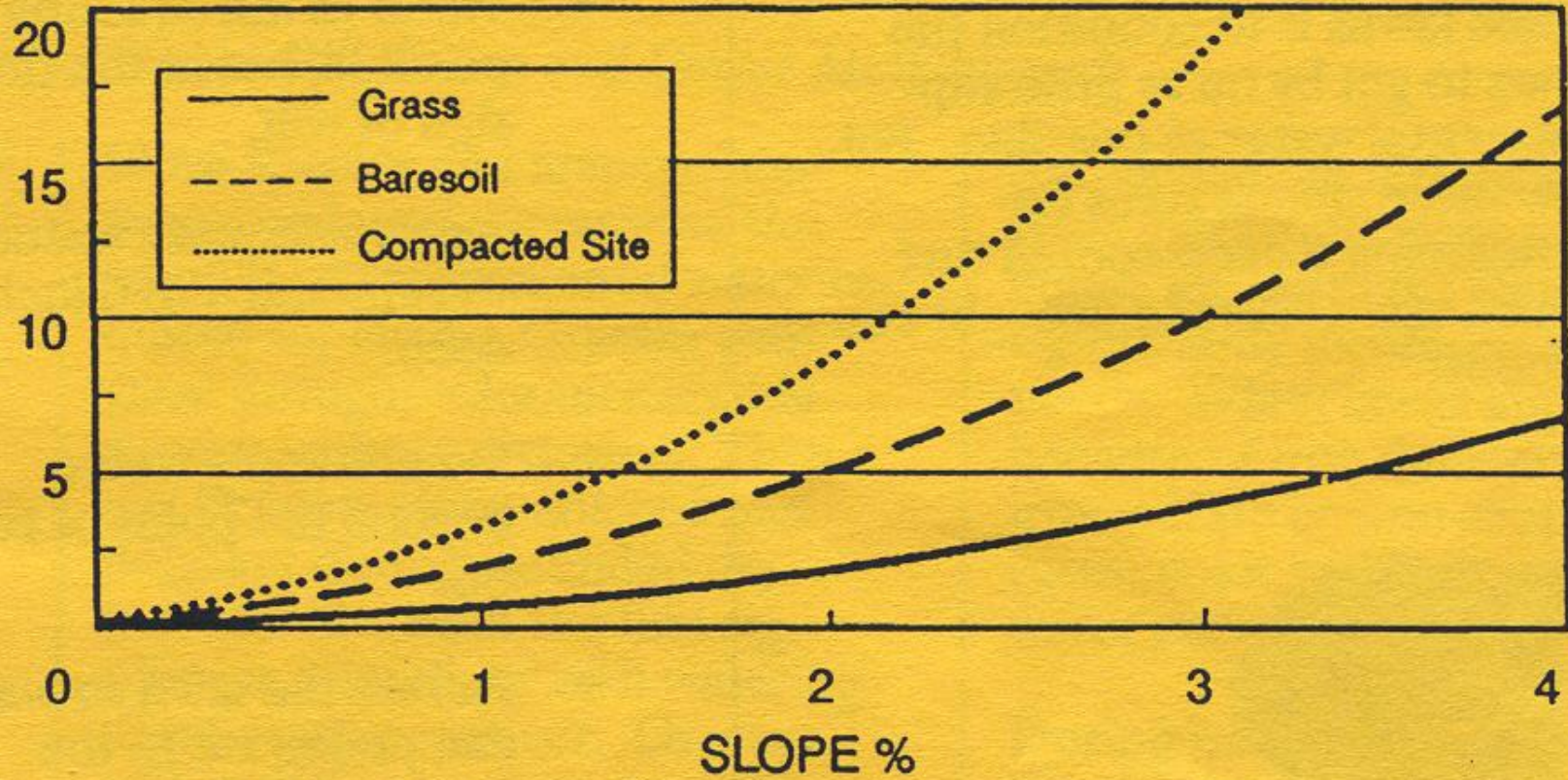
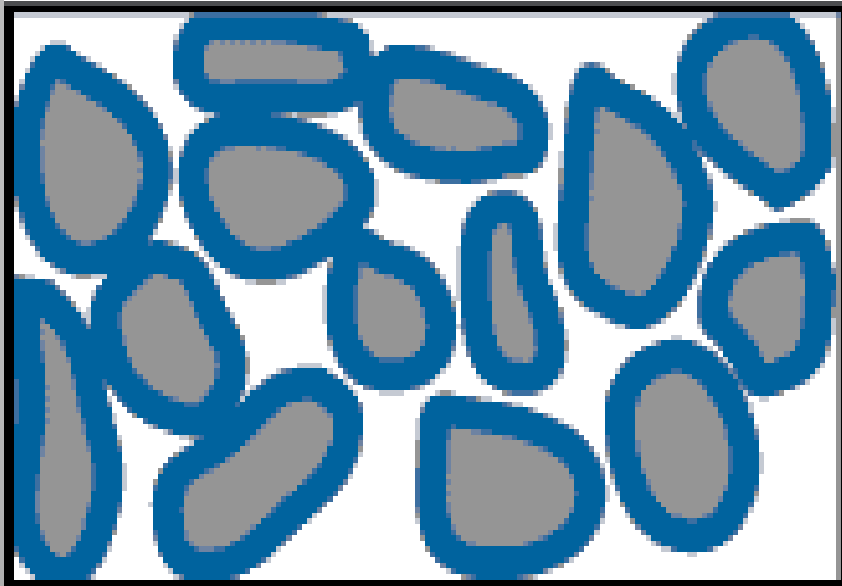
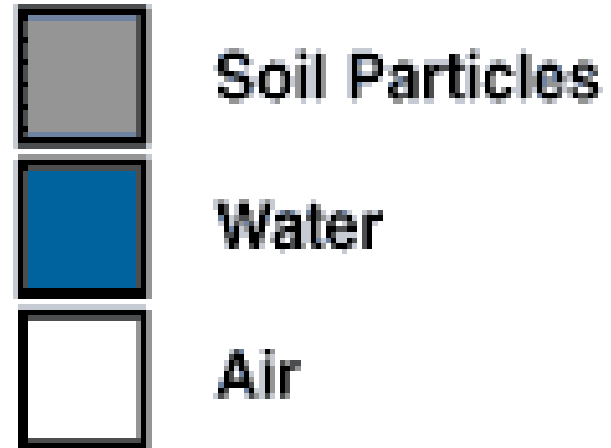
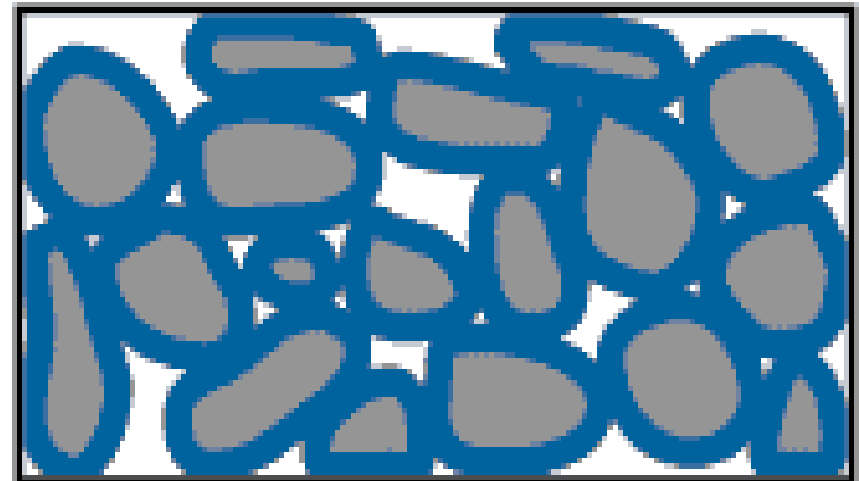


Figure 2. Run-off potential on various sites.



**Non-compacted**



**Compacted**

- Is soil water and soil air different from our atmosphere and surface waters?
- Which soils have more pore space?
- Which soils have greater water retention?
- Which soils have greater water movement?
- What is field capacity?
- What happens to pore space in a compacted soil?

## Questions

# Soil Organic Matter (OM)

- OM- greatly affects both the physical and chemical properties of the soil
- Soils in Texas generally have <1% OM in them

# Benefits of Adding OM or Mulch

- Soil color is darkened – black to brown
- Improves soil structure – granulation encouraged in coarse textures and plasticity and cohesion reduced in fine textured soils
- Increases the water holding capacity (WHC)
- Increases soil microorganisms
- Increases the cation exchange capacity (CEC) of the soil
- Adds some nutrients

# Chemical Properties of Soils

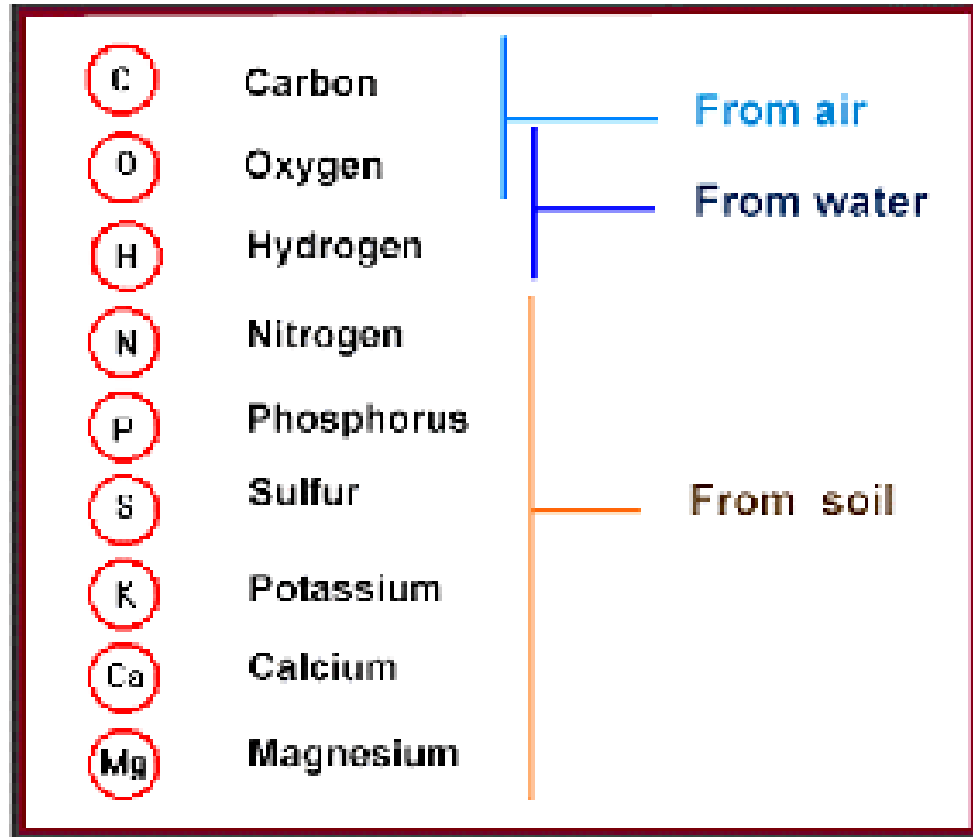
- Plant nutrients
- Soil pH
- Soil salinity
- Soil fertility
- Soil OM

- Plant Nutrients
  - 16 essential elements
  - N, P, K, Mg, Ca mostly limiting
  - Others usually enough in the soil
  - Know relationship with soil pH
    - Hydrogen ion activity of a soil
    - Degree of acidity or alkalinity
- El Paso soils:
  - Average pH of 7.8
  - O.M. Less than 1 %

## Chemical Properties

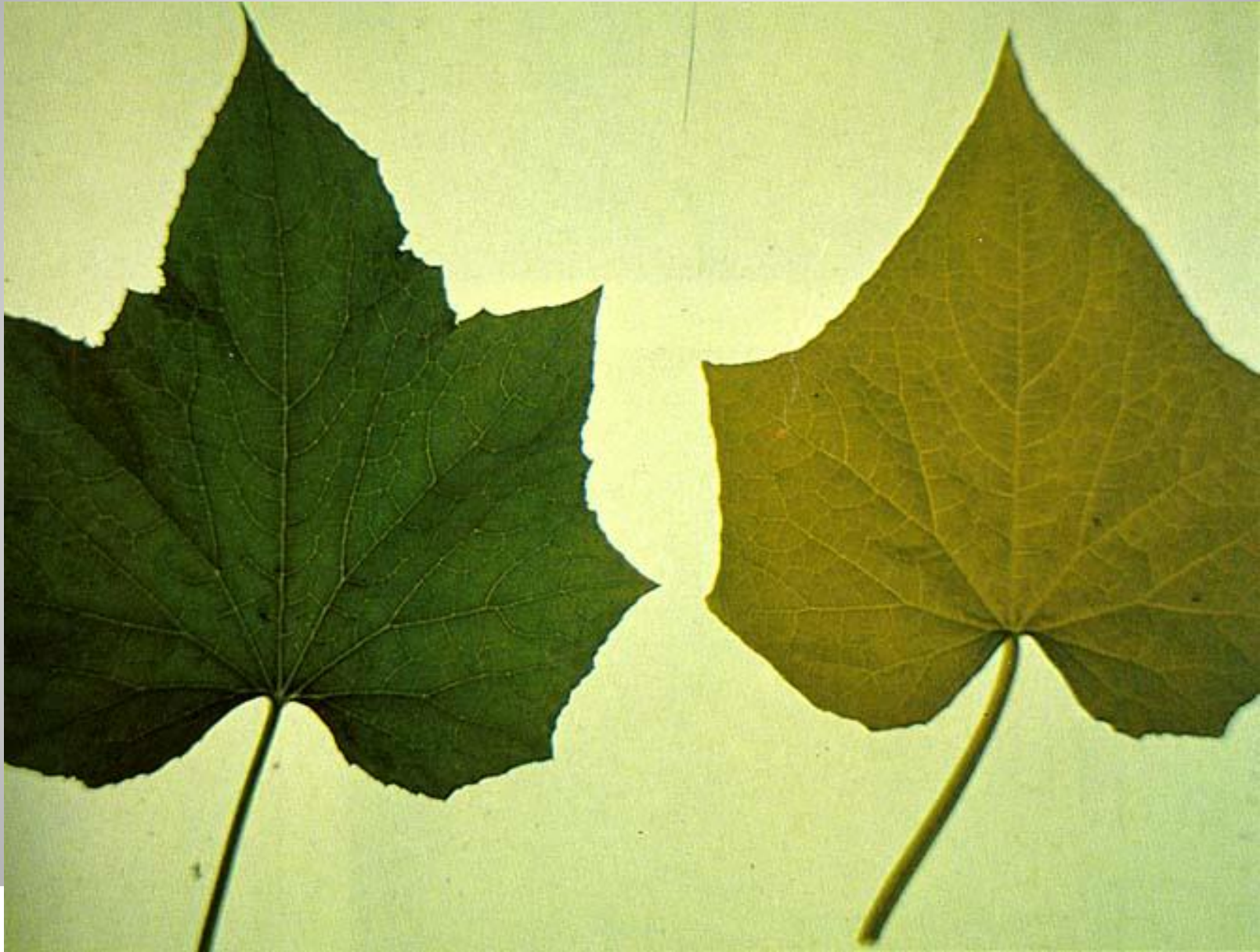
# 16 Essential Elements

- C – Carbon
- H – Hydrogen
- N – Nitrogen
- P – Phosphorus
- K – Potassium
- S – Sulfur
- Mg – Magnesium
- Ca – Calcium
- Fe – Iron
- Cu – Copper
- B – Boron
- Cl – Chlorine
- Mo – Molybdenum
- Mn – Manganese



## *Common nutrient deficiency symptoms*

- **Nitrogen:** This is a mobile nutrient, which means that when nitrogen is deficient, plants move it from the older foliage to the younger, actively growing leaves. The older leaves (the ones lower on the stem of the tree) become yellow first, while the new leaves remain green.



## *Common nutrient deficiency symptoms*

- **Phosphorus:** The entire seedling is stunted, especially during early growth. Depending on the species, the leaves may become dull green, yellow or purple tinged. The purplish leaves is a classic symptom, but sometimes there are no color differences in leaves, so visual diagnosis is not always reliable.



## *Common nutrient deficiency symptoms*

- **Potassium:** Symptoms appear in older leaves first. These start to yellow at the edges, and have some green at the base. Later, leaf edges turn brown and may crinkle or curl and small necrotic (dead) spots may appear. Plants may wilt, even though sufficient water is available in the substrate. When deficiencies are severe, leaves will die.



## *Common nutrient deficiency symptoms*

- **Calcium:** This is difficult to detect because signs include slow growth, and dieback of bud or root tips. Seedlings will have stubby little roots with brownish discoloration. The problem is most common in very acidic soils. A well-developed root system with many fine root hairs is important for calcium uptake.



## *Common nutrient deficiency symptoms*

- **Magnesium:** This nutrient is commonly deficient in coarse-structured soils and in acidic soils. Uptake may be blocked if there is too much potassium in the soil. Like nitrogen, magnesium is a mobile nutrient, so deficiency symptoms show up in the older leaves first. These leaves show a very characteristic yellowing between the veins or ribs, and they appear streaked.



MAGNESIUM  
DEFICIENT  
GRAPE

Image courtesy of  
Potash & Phosphate  
Institute

## *Common nutrient deficiency symptoms*

- **Sulphur:** Plants will be slightly stunted. This is not a mobile nutrient, so the symptoms show up on younger leaves which are initially light green, but eventually develop scorched and curled margins. Dry areas can form along the margins and then spread inward to the leaf midrib.

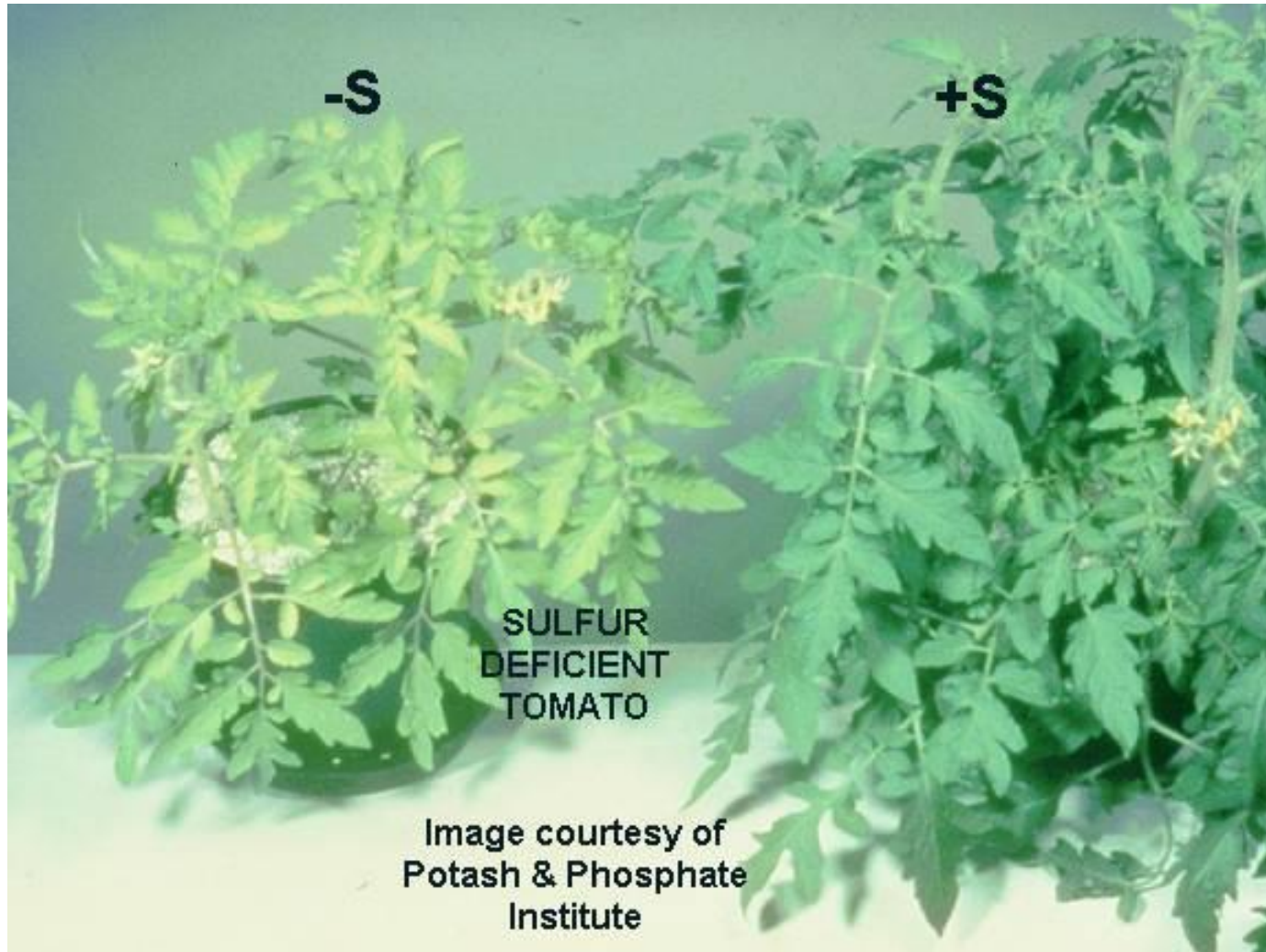
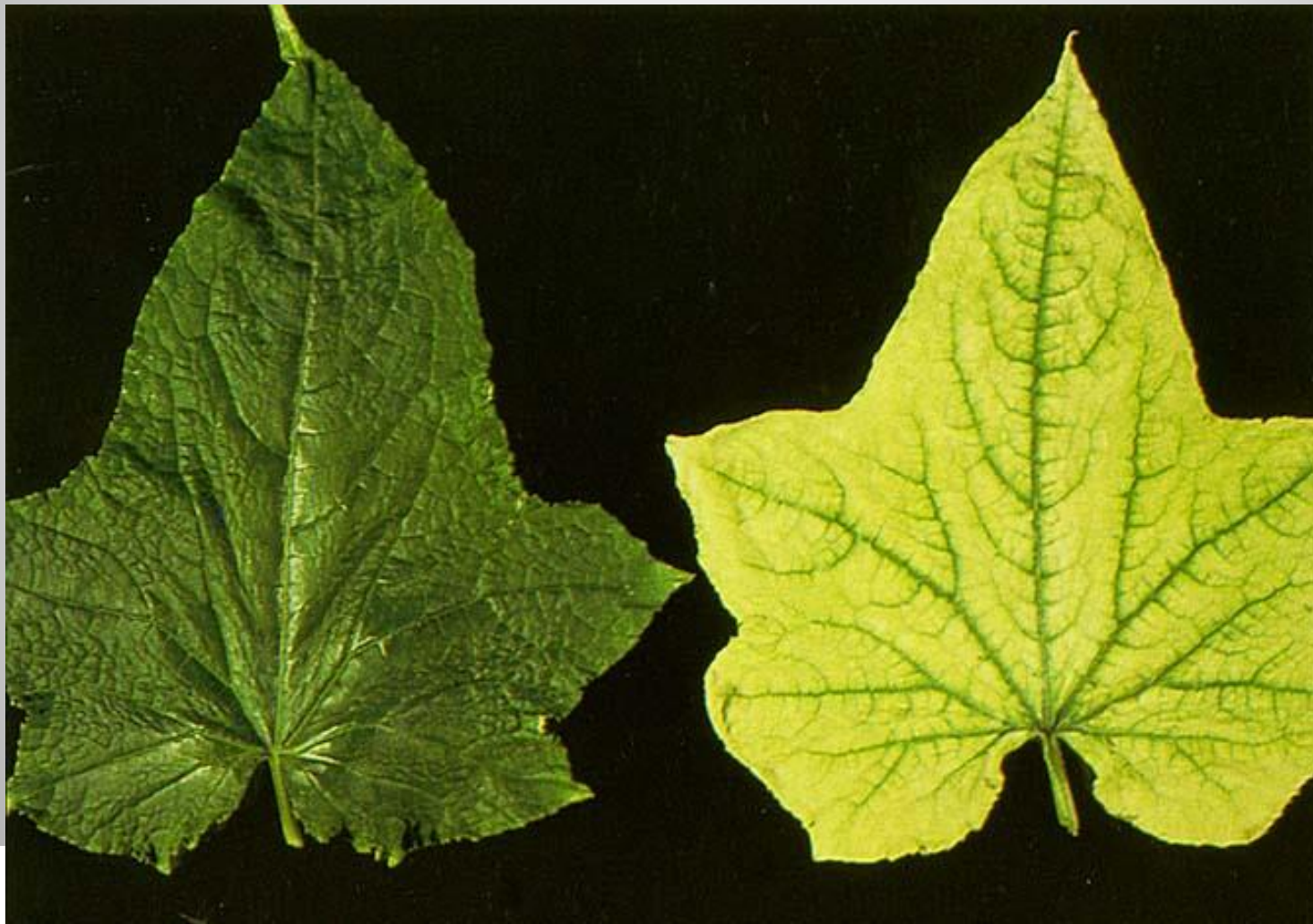


Image courtesy of  
Potash & Phosphate  
Institute

## *Common nutrient deficiency symptoms*

- **Iron:** Deficiency is common on alkaline or calcareous soil (pH above 7). Younger leaves become yellow to white and dry up.
- **Manganese:** The tissue between the veins mottles, while the veins remain green and are surrounded by a band of green tissue.
- **Copper:** New leaves are yellow at the tips and often become twisted.
- **Boron:** The deficiency affects the terminal bud which yellows, dries out and dies. Plants grow slowly.

# • Iron Deficiency



# Manganese Deficiency

- 



# Copper Deficiency

- 



# Boron Deficiency

- 



# Chemical Properties of Soils

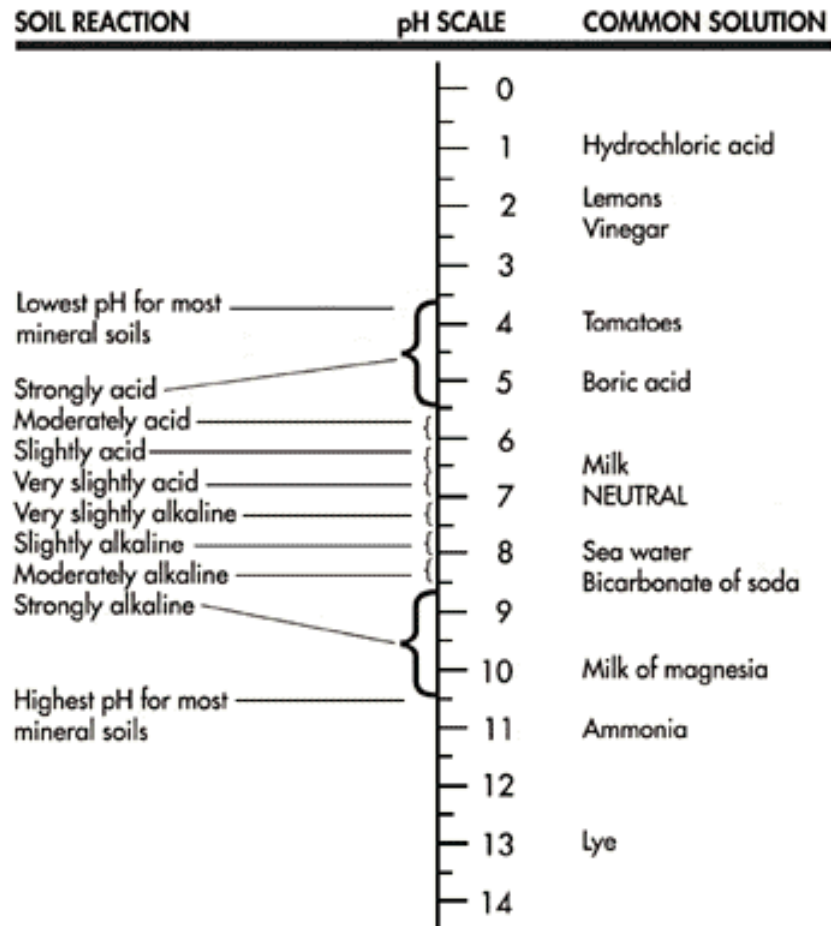
- Soil pH – A measurement of the hydrogen ( $H^+$ ), or acid forming, ion activity of soil or growth media.
- The scale of measuring acidity or alkalinity has units from 0 to 14
- The middle of the scale (pH 7) is neutral. Above pH 7, the condition is alkaline (basic), having more hydroxyl ( $OH^-$ ) ions and below it is acidic.

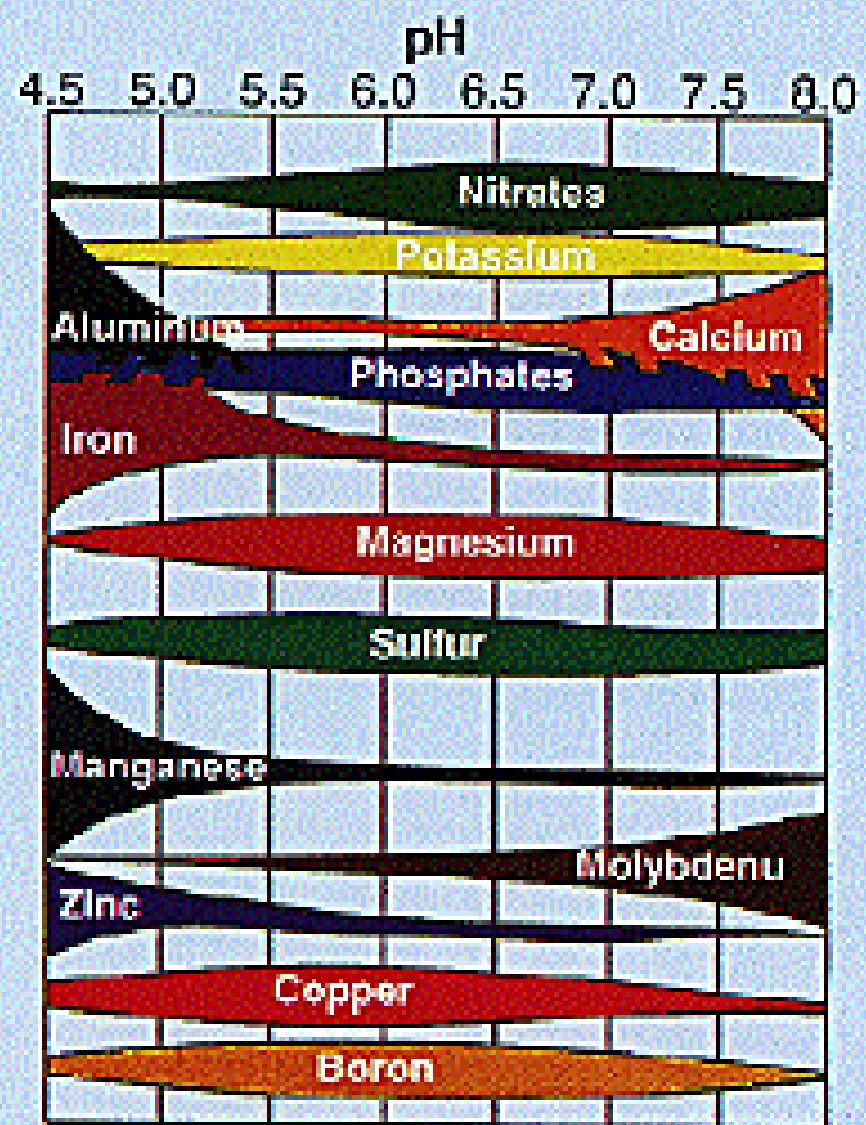
# Soil pH

- The measurement is on a logarithmic scale. This means that to change the pH of your soil 1 unit, you will need to change the  $H^+$  ion activity by 10-fold.
- Soil pH has a major impact on the availability of certain nutrients;
- The ideal pH range is 6.5 to 7.5

## Soil pH

- Our soils in West Texas are generally alkaline with a pH around 8
- If pH is high then elemental sulfur and organic matter will reduce the pH over time.





# Cation Exchange Capacity (CEC)

- A net negative charge that is associated with the mineral and organic fractions of the soil.
  - Is dependent on the type and amount of clay in the soil
  - Is dependent on the amount of OM in the soil and the soil pH.
  - OM has carboxyl groups that are negatively charged at a high pH
  - This has implications for the fertility and movement of chemicals in the soil

- Is organic matter important in gardening?
- What are the benefits of OM?
- Name macronutrient.
- Name micronutrients.
- Can plant symptoms help formulate fertility management?
- What is pH? Why are we discussing it?
- Define CEC.

## Questions

# Soil Salinity

- The accumulation of salts in the soil caused by the evaporation of water from the soil surface and poor quality irrigation water

# Soil Salinity

- Saline soils (resulting from salinity hazard) normally have a pH value below 8.5, are relatively low in sodium and contain principally sodium, calcium and magnesium chlorides and sulfates.
- These compounds cause the white crust which forms on the surface and the salt streaks along the furrows.
- The compounds which cause saline soils are very soluble in water, therefore leaching is usually very effective in reclaiming these soils.

# Soil Salinity

- Sodic soils (resulting from sodium hazard) generally have a pH value between 8.5 and 10.
- These soils are called "black alkali soils" due to their darkened appearance and smooth, slick looking areas caused by the dispersed condition.
- In sodic soils, sodium has destroyed the permanent structure which tends to make the soil impervious to water.
- Thus, leaching alone will not be effective unless the high salt dilution method is used.

# Correcting Saline Soil Problems

- Leaching with good quality irrigation water is sufficient for saline soils because of low  $\text{Na}^+$  levels.
- Leaching a Saline-Sodic soil may produce a Sodic soil if  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  are leached leaving  $\text{Na}^+$  in the soil
- For sodic soils, additions of gypsum ( $\text{CaSO}_4$ ) or elemental sulfur are required along with leaching

# Correcting Saline Soil Problems

- Organic matter additions will also help in the remediation process since organic acids will dissolve  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  and improve soil structure and pore size.

- Describe saline and sodic soils.
- How might this effect gardening?
- How can you manage salinity?

**Questions**

# Soil Tests

- The purpose of a soil test is to provide basic information on the nutrient supplying capacity of a soil
- Soil test can be a valuable tool in developing an efficient soil fertility program.
- Test will be unreliable if soil sample is not taken correctly.

# Soil Tests

- Techniques vary among laboratories, therefore the number values vary from lab to lab.
- College Station – 750 miles from El Paso
- Lubbock – 425 miles from El Paso
- Other considerations regarding soil tests

# Fertilizers

- All fertilizer are labeled as % by weight of nitrogen (N) phosphate ( $P_2O_5$ ) and potassium ( $K_2O$ )
- A complete fertilizer contains some amount of all three components ( N, P and K)
- If a fourth number is included in the analysis it is sulfur (S)
- Special Purpose Fertilizers – Watch out!

COVERAGE UP TO 5,000 SQ. FT.

Slow Release Formulation



**ferti·lome**<sup>®</sup>

## Lawn Fertilizer **15-0-15**

- Super Greening Power.
- Contains Iron And Other Micro-Nutrients.
- Long Lasting Feeding Formula.
- Use on Centipede, Bluegrass, Perennial Ryegrass, Fescue, St. Augustine, Bahia, Bermuda, Zoilya, and Bentgrass Lawns.

NET WEIGHT 20 LBS. (9.07 KG)

# How good is Ammonium Sulfate

- 21-0-0 is a fast release source of nitrogen
- Nitrogen is a volatile nutrient
  - Apply it to your lawn and large portions of it volatilize into the air or leach into the soil.
- It is easy to burn the lawn and is a threat to the groundwater.



## Slow Release Fertilizers – Generally a N source:

- Need not apply as frequently
- Less damage of leaf burn
- Be cautious of excessive rates in late summer (trees and shrubs won't harden off for winter)
- Common types are sulfur coated urea (SCU) and resin-coated fertilizers. SCU is the cheapest and adds sulfur ( this is a good choice )

# Organic Fertilizers

- Naturally occurring organic fertilizers include manure, slurry, worm castings, peat, seaweed, sewage, and guano.
- Green manure crops are also grown to add nutrients to the soil.
- Naturally occurring minerals such as mine rock phosphate, sulfate of potash and limestone are also considered Organic Fertilizers.
- Manufactured organic fertilizers include compost, blood meal, bone meal and seaweed extracts. Other examples are natural enzyme digested proteins, fish meal, and feather meal.



# Organic Fertilizers

## Manure

- Complete but low analysis fertilizer
- Best use a mulch rather than a nutrient source
- Fresh manure may contain high levels of salts depending on the source
- Mulching first will remove salts and weed seeds that may be present

# Fertilizer is a salt that contains plant nutrients

- When applied to soil, water moves toward the fertilizer and salts (nutrients) diffuse or move away from the source.
- Water can be drawn away from roots or seeds and cause damage ( burn)
- Two rules
  - Don't over apply N fertilizer
  - Make sure there is adequate soil moisture after application but avoid leaching

# Fertilizer Application Methods

- Broadcasting
  - Good for mobile nutrients such as N fertilizers
  - Poor for immobile nutrients, Phosphorus sources are also subject to further reductions in availability when mixed with the soil
  - Best use – fertilizing turf, where you want an even application over entire area.

# Fertilizer Application Methods

- Banding – narrow bands of fertilizer placed in furrows 2 to 3 inches deeper than the seeds or plants
  - Good for P sources because of fixation in calcareous soils
  - Placement too close to seeds or plants can cause damage ( burn)

# Fertilizer Application Methods

- Foliar – fertilizer is applied as a liquid to the foliage
  - Nutrients are rapidly absorbed and quickly used (short-lived effect)
  - Generally used for micronutrients – iron or zinc
  - Need to be careful where you spray – iron stains concrete

# Fertilizer Application

Total Fertilizer needed

$$= \frac{\text{Application rate/unit area}}{\% \text{ content of fertilizer (decimal)}} \times \frac{\text{Total area}}{1,000}$$

## Examples and Problems:

- Determine the amount of ammonium sulfate (21-0-0) a 5,000 square foot lawn needs if the lawn requires 1 lb N/1000 square feet
- Determine how much ( 20-10-5) needs to be applied to get 2 lb of P per 1000 sq feet in a garden that measures 20 x 10 feet

- Are soil fertility tests useful? Even if the testing lab is far away?
- What is a complete fertilizer?
- What is an organic fertilizer?
- What are the three numbers on the bag?
- Which macronutrient is mobile in soil?
- Which macronutrient is immobile in soil?
- What are some potential disadvantages to fertilizers?

## Questions

# Characteristics of desert soil



**Spatially heterogeneous or ‘patchy’**

- **Sandy, clayey, stoney, etc.**

- **Alkaline, high pH, sometimes saline, sometimes sodic**

- **‘Built’ to support relatively little vegetation**

- **Low nitrogen and organic matter content**

## Tips on management of desert soils in urban landscapes

- Organic matter, organic matter, organic matter
- The lack of proper soil microorganisms, (mycorrhizal fungi, etc.) on plant root systems is a leading cause of poor plant establishment and growth in a variety of restoration, suburban and urban landscapes.
- Managing to improve plant fitness is in the long run more cost beneficial and effective than relying on corrective maintenance practices.

- Include soil conservation practices (mulching, row planting, cover cropping, etc) to minimize soil erosion.
- Know the soils you have and land use constraints imposed by certain soil properties.
- Land use planners consider constraints imposed by certain soil properties when plants or turf grass is to be a major component such as in parks.

**Tips**



# Soil Crusts

Table 4.23. In VEST Parametrization: Average Carbon Pools in Aboveground Biomass, Belowground Biomass, Soil Carbon, and Dead Organic Matter Used for the European-Scale Carbon Stocks Modeling and Sensitivity Analysis (Mg C/ha)

Land Use and Land Cover Class	Aboveground Biomass	Belowground Biomass	Soil Carbon	Dead Organic Matter	Source
Built-up area	0	0	0	0	(1)
Nonirrigated arable land	6	2	60	0	(2)
Pasture	2	4	90	1	(2)
Transitional woodland/shrub	20	8	90	7	(3)
Inland wetlands	10	5	87	0	(4)
Glaciers and snow	0	0	0	0	(1)
Irrigated arable land	6	2	60	0	(2)
Recently abandoned arable land	10	4	60	3	(2)
Permanent crops	20	10	70	0	(2)
Forest	50	13	90	15	(3)
Sparsely vegetated areas	1	1	2	0	(1)
Beaches, dunes, and sands	0	0	0	0	(1)
Salines	0	0	0	0	(1)
Water and coastal flats	0	0	0	0	(1)
Heather and moorlands	8	15	50	1	(4)

(1) Sharp et al. (2015).

(2) EEA (2014), Smith, Powlson, Glendining, and Smith (1997).

(3) FOREST EUROPE, UNECE, and FAO (2011).

(4) IPCC (2003, 2006).