Warm-Season Turfgrass Physiology

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Gators TURFGRASS SCIENCE

What Makes a Grass a “Turfgrass”?

Taxonomy of grasses

- All grasses are members of the Gramineae, or Poaceae
  - 25 Tribes; 600 Genera; 7500 species
  - Only a few dozen are turfgrasses.

Definitions:

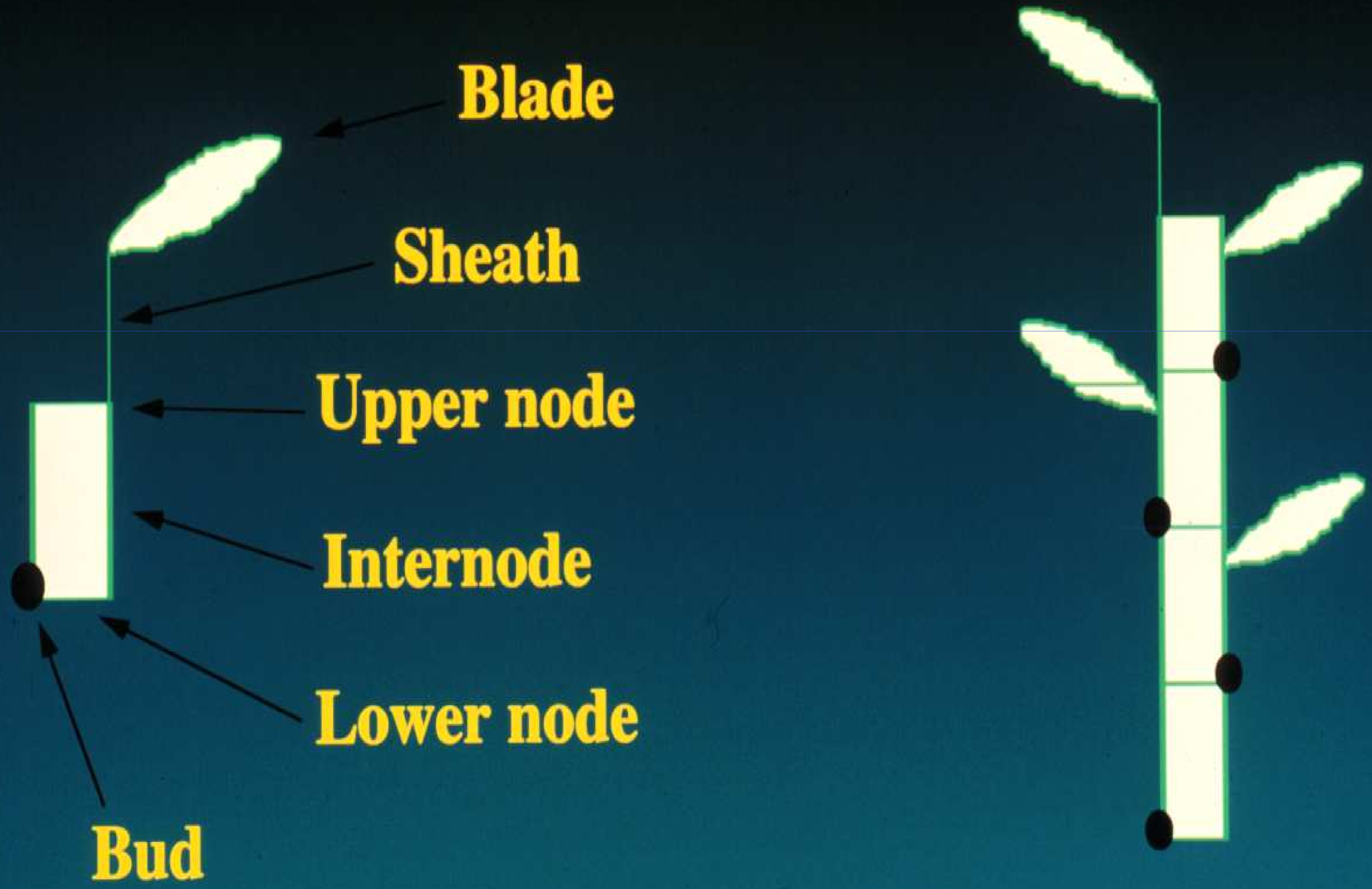
- Turfgrass - are plants that form a more or less contiguous ground cover that persists under regular mowing and traffic.

- Turf - the interconnecting community of turfgrasses and the soil adhering to their roots and other below ground organs.

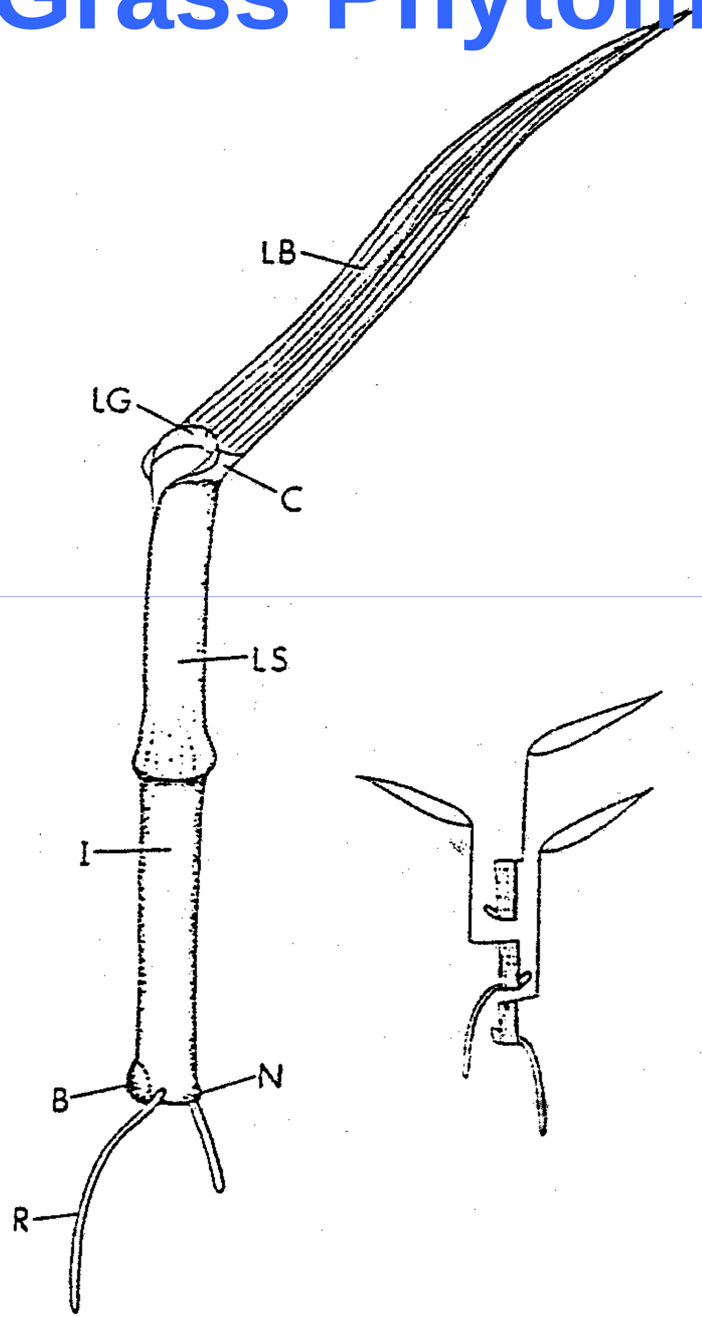
Taxonomy of Grasses

- Warm-season
  - Generalities
    - Optimum growth range = 80° to 95 °F.
    - Warm-season grass adaptation is limited by the intensity and duration of cold temperatures.
  - Two Subfamilies
    - Panicoideae
      - Mostly tropical and sub-tropical origin grasses.
      - 29 Genera; 356 species. Amounts to about 33% of the grasses in North America.
    - Erogrostoideae
      - Mostly warm & semi-arid grasses.
      - 42 Genera; 309 species. Amounts to about 28% of the grasses in North America.

Phytomere



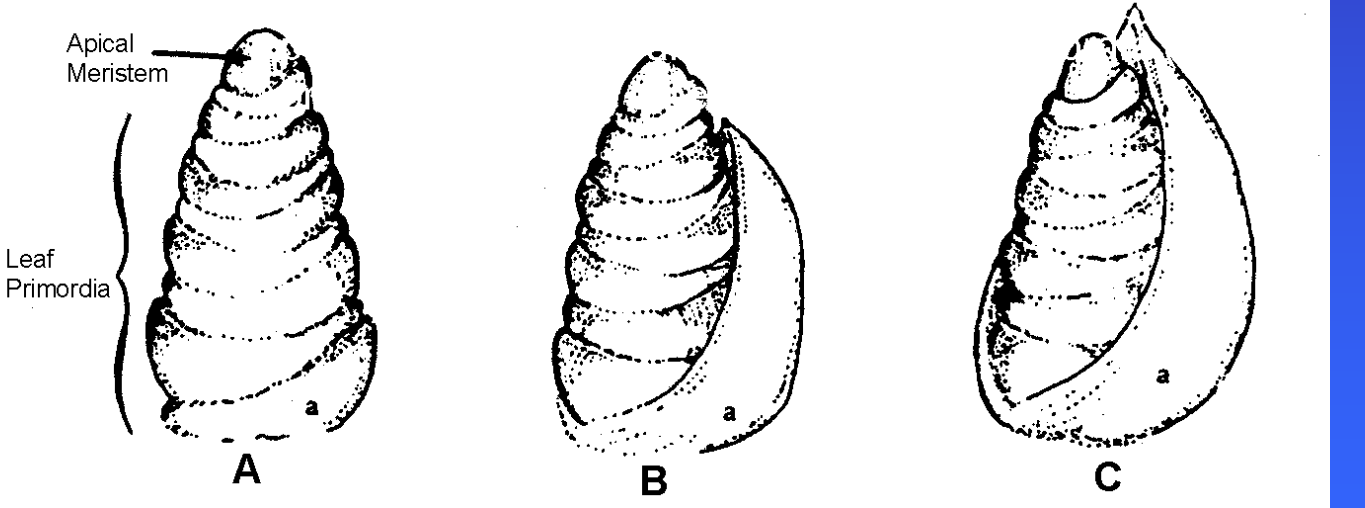
The Grass Phytomer



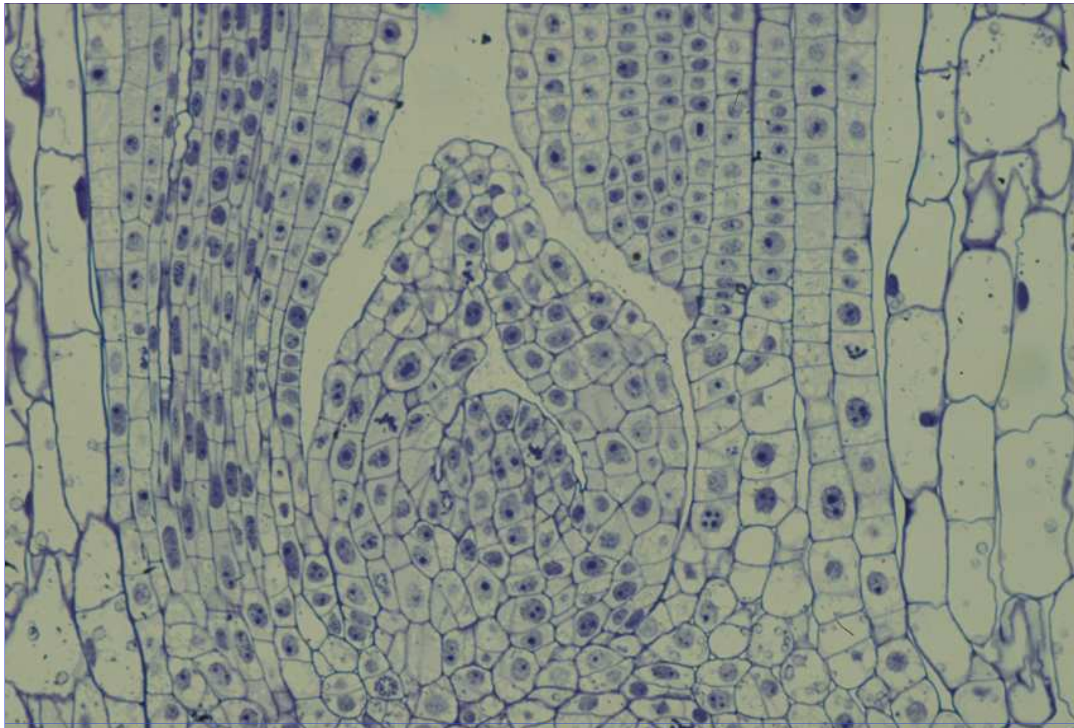
A grass phytomer. LB, leaf blade; LG, ligule; C, collar; LS, leaf sheath; I, internodal piece; N, nodal plate; B, bud at the nodal plate on the opposite side of the axis from the leaf blade; R, adventitious roots arising at the node. Although the ligule and collar are not essential parts of the phytomer, they occur in other monocot families as well as the Gramineae. The diagram to the right illustrates how phytomers are stacked to make a plant.

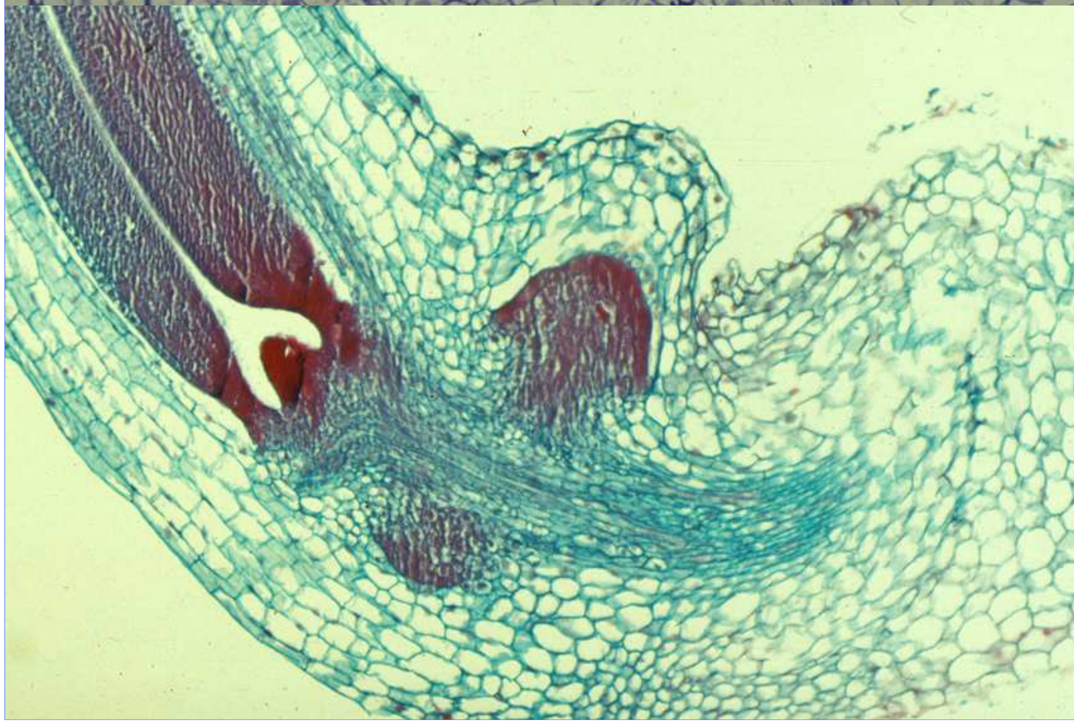
The Grass Plant

- The Phytomer Concept of Structural Units
  - Apical Meristems - Origin for all growth of phytomers.
    - Continually form leaf primordia below the apical meristem.



Leaf emergence from the growing point. The basal leaf primordia (a) grows around upper leaf primordia (A-C) in the process of forming a newly emerging leaf.






A
B
C

The Grass Plant

- Stems
  - Types
    - Crown
      - The crown is the key organ giving rise to leaves, roots, tillers, and elongated stems of the turfgrass plant.
      - Crowns serve as storage organs for carbohydrate reserves to support the growth of new plant organs.

The Grass Plant

- Lateral Stems
  - Rhizomes - An underground, elongated stem (or shoot) with scale leaves and adventitious roots arising from the nodes.

The Grass Plant

- Lateral Stems
  – Stolons – An elongated stem (or shoot) that grows along the surface of the ground and from which leaves and adventitious roots develop at the nodes.

The Grass Plant

- Stems
  - Tiller – Newly developing lateral stem which grows upward and within the sheaths of the enclosing leaves.

The Grass Plant

- Roots
  - Seminal (seedling)
    - Develops from the seedling radicle.
    - Life span is less than a year.
  - Adventitious
    - Develop from nodes of the crown and lateral stems.
    - Begin forming soon after the first leaf emerges.
    - Life span may be as long as that of the shoot they support; however, stresses and unfavorable soil conditions may cause death.

Atmospheric Environment - Light

- Turfgrasses process Incoming Solar Radiation (**Insolation**) in three ways.
  - Absorption
    - Turfgrasses absorb about 50 to nearly 80% of insolation depending on leaf orientation; the more horizontally oriented leaves are more efficient. They convert to chemical energy, through photosynthesis, only about 1 to 2 percent of incident radiation.
    - Most of the absorbed energy is reradiated at longer wavelengths.

Atmospheric Environment - Light

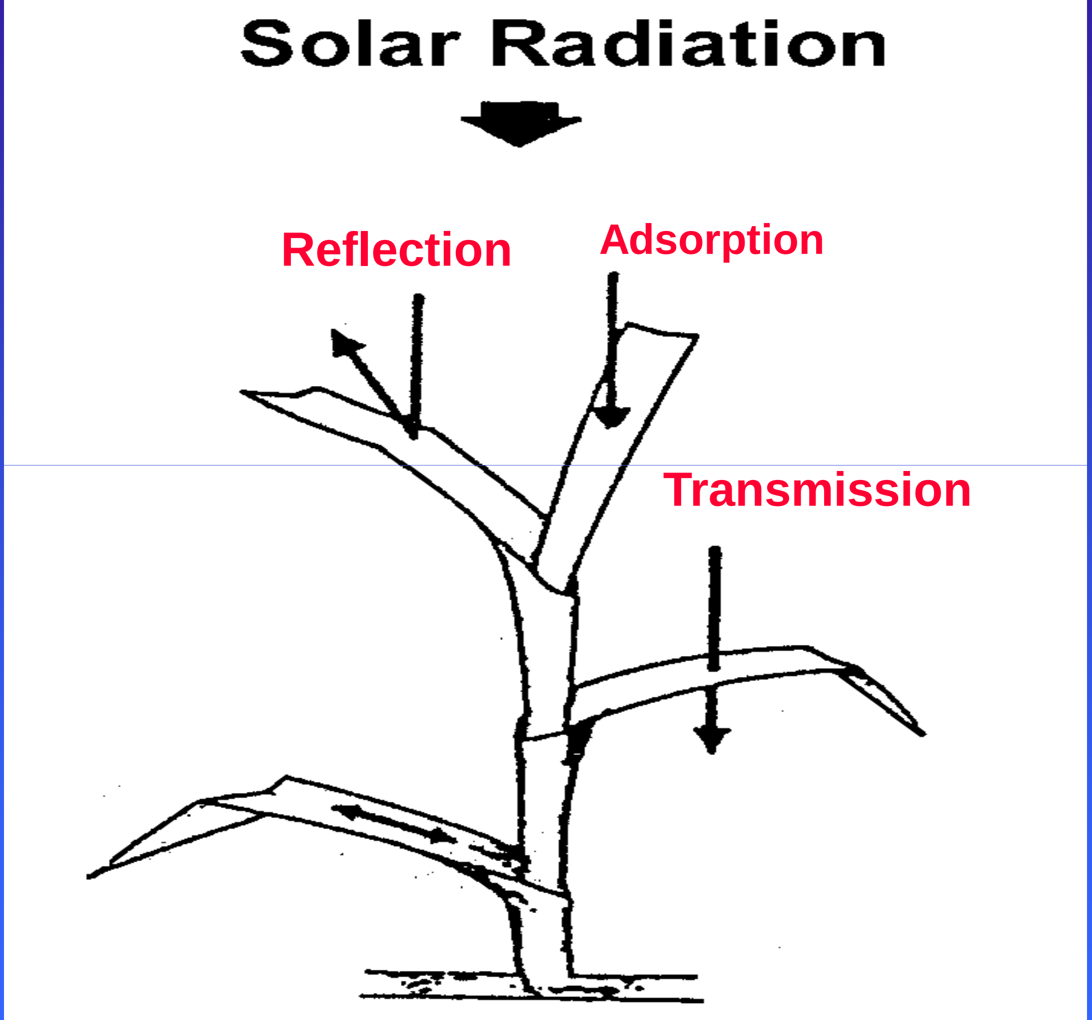
– Reflection

  - Reflected radiation varies among plants and is affected significantly by moisture conditions.
  - Glossy or wet leaf surfaces are more reflective than dry, dull leaves.

– Transmission

  - Light transmission through leaves varies from 15 to 30%.

Atmospheric Environment - Light

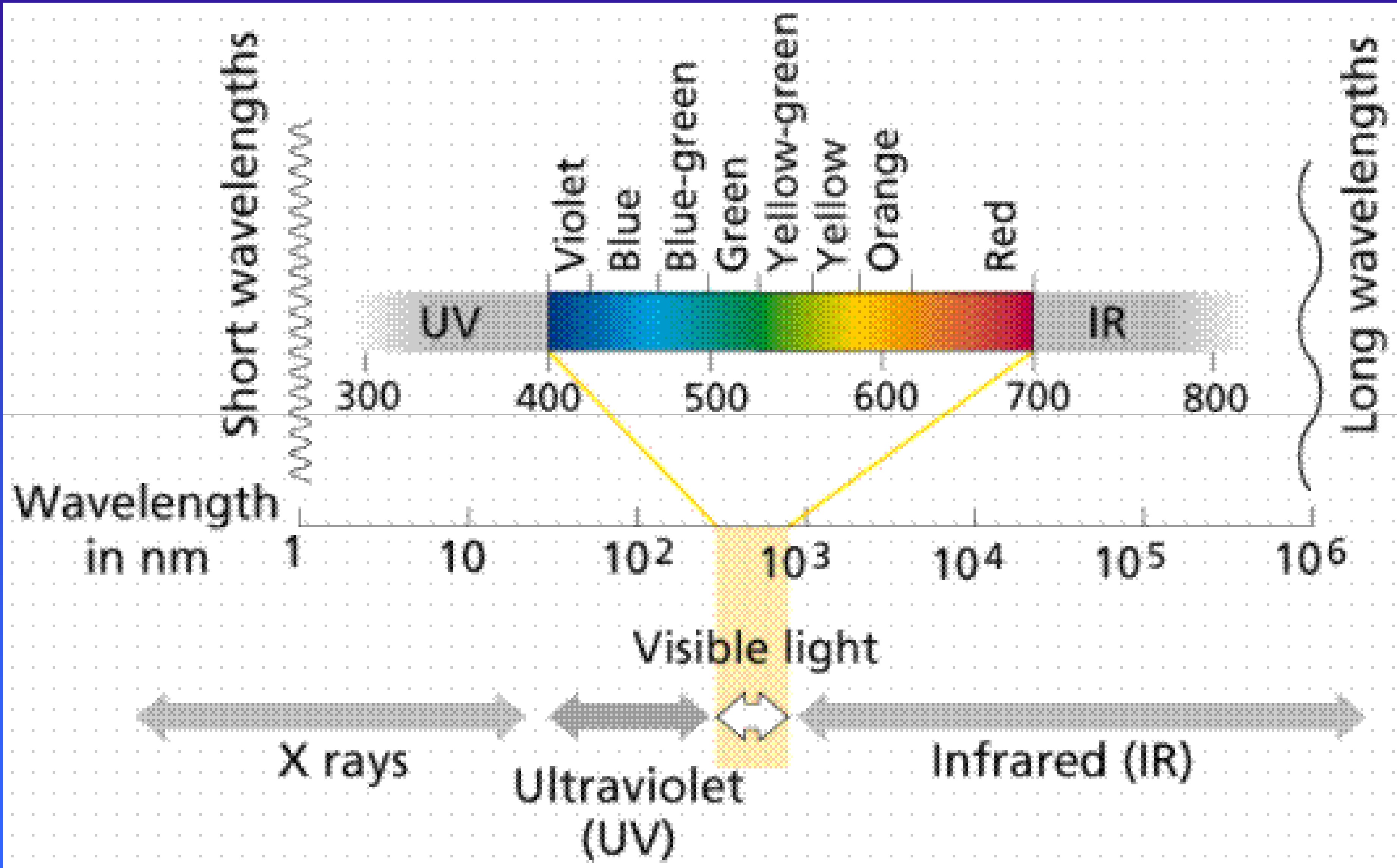


Solar radiation on leaf blades.

Atmospheric Environment - Light

- Effects of Light on Plant Growth
  - Light Quality - Involves phytochromes in the plant.
    - Violet, blue, and ultraviolet (UV) regions produce a short, sturdy growth habit.
    - Yellow and red enhance shoot elongation and spindly growth.
    - Far red region is important in promoting or inhibiting flowering, leaf enlargement, seed germination, leaf enlargement, rhizome development, and numerous other photomorphogenic responses.

Light Spectrum



Atmospheric Environment - Light

- Effects of Light on Plant Growth
  - Light Duration - Influences plant growth and development.
    - Flowering Responses
      - Flower Induction - short day
      - Floral development - long day
    - Developmental Responses
      - Short day length responses
        - Increased shoot density
        - Increased tillering
        - Increased leaf appearance rate
        - Reduced leaf and shoot length
        - Reduced internode length

Atmospheric Environment - Light

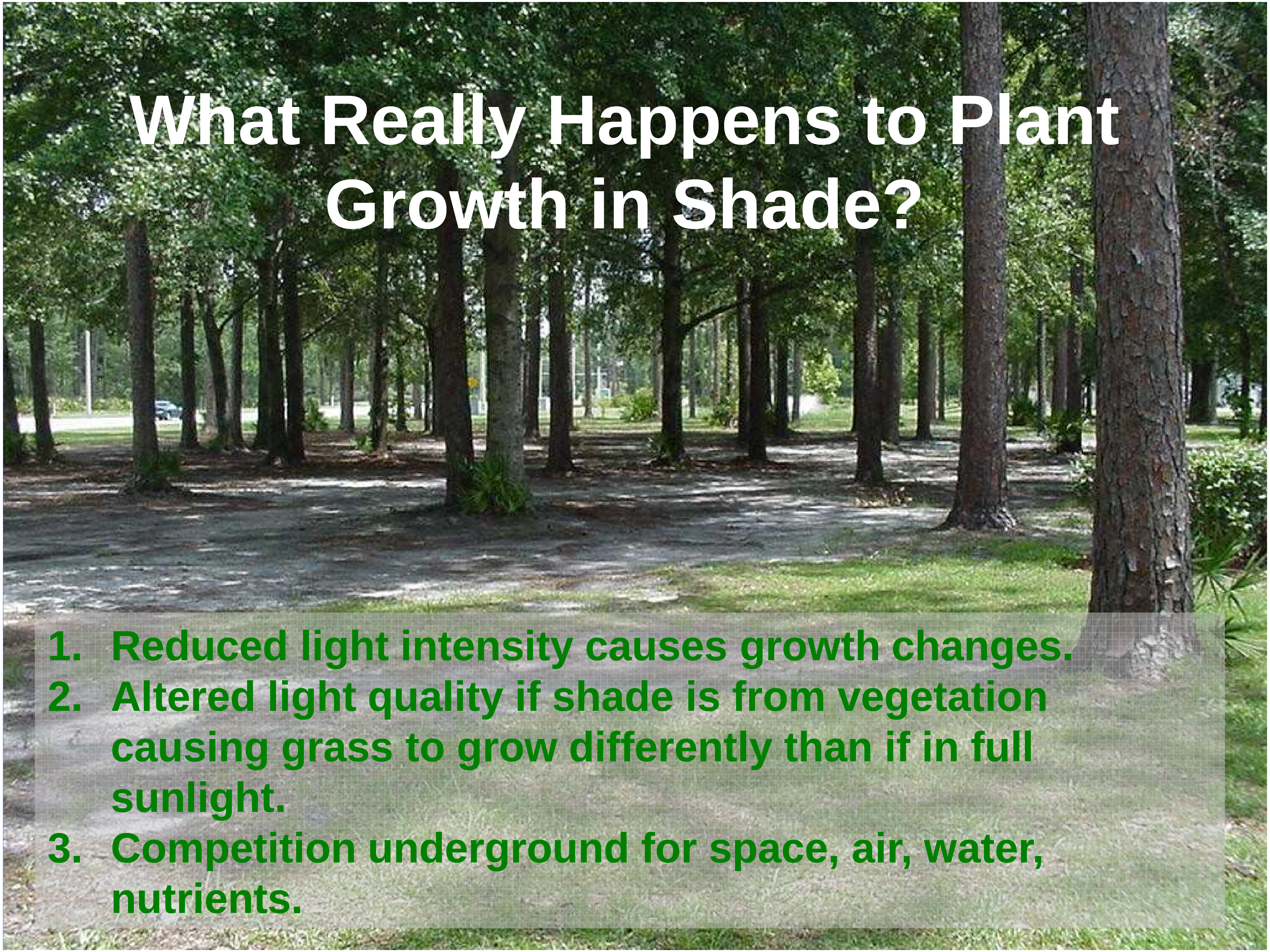
- Effects of Light on Plant Growth
  - Light Intensity - varies greatly depending on:
    - Season of year -
      - Highest during the summer season.
    - Latitude -
      - Decreases with increasing latitude.

Atmospheric Environment - Light

- Effects of Light on Plant Growth
  - Light Intensity
    - Time of day
      - Low at sunrise and sunset, high at midday.
    - Atmospheric Screening -
      - High on clear days. Cloud cover can screen up to 96%.
      - Smoke can screen out as much as 90% of the incoming radiation.
    - Topography -
      - Causes localized variations in light intensity because it affects the angle at which radiation strikes the earth.


80-10


Delmar



What Really Happens to Plant Growth in Shade?

1. **Reduced light intensity causes growth changes.**
2. **Altered light quality if shade is from vegetation causing grass to grow differently than if in full sunlight.**
3. **Competition underground for space, air, water, nutrients.**

What Are the Growth Changes?

- Grass leaf blades actually reach up to capture light, becoming long and skinny

So, How Do I Manage Turf in the Shade?

- Remove shade sources (trimming trees).
- Reduce traffic in shaded areas.
- Increase mowing height if possible – more shoot tissue for photosynthesis will help turf perform better.
- Reduce irrigation in shaded areas.
- Reduce fertilization quantity but increase frequency
  - Trying to promote shoot growth with high fertility will further stress the grass.

Atmospheric Environment - Moisture

- Water is the most important requirement for turfgrass growth and survival.
  - The water content of actively growing turfgrasses approaches 90% of total mass.
- Water has many functions in turfgrass plants:
  - maintains cell turgidity for structure and growth;
  - transport medium for nutrients and organic compounds;
  - constitutes a raw material for various chemical processes; and
  - evapotranspiration.

Irrigation

- How much water does turf need?
  - Key Factors:
    - Evapotranspiration
    - Rooting
    - Soil Type

Evapotranspiration

- **Evaporation** = water loss from the soil surface.
- **Transpiration** = water loss from the plant.
  - In turf, the soil surface is usually covered by the turf canopy and most of the water loss is due to transpiration.

Factors Affecting Evapotranspiration

- Grass Species
  - Warm-season grasses have lower ET rates than cool-season grasses.
    - Cool-season grasses require about 3X more water to produce a gram of dry matter through photosynthesis.
      - This difference is particularly important during stress periods when stomata close.
        - Closed stomata decrease water loss but also restrict the entry of CO_2 which limits photosynthesis.

Factors Affecting Evapotranspiration

- Humidity
  - Transpirational water loss occurs because of the gradient that exists between the moist cells of the plant and the moisture level in the surrounding environment.
    - The drier the air, the greater the gradient and the more water lost from the plant.

Factors Affecting Evapotranspiration

- Temperature
  - The higher the temperature, the greater the evaporation.
  - The effect of temperature on transpiration is a little more complex.
    - High temperatures can trigger a closing of the stomata, which helps conserve water.

Factors Affecting Evapotranspiration

- Wind
  - The leaf surface is surrounded by an **air boundary layer** of air molecules that form a barrier of still air that reduces water loss.
    - Wind disrupts this boundary layer and increases water loss.
- Canopy Resistance
  - A collective term that refers to the many resistances that water confronts as it passes through and exits the turf canopy.
    - Affected by shoot density, leaf orientation, leaf area, and growth rate.

Estimating Evapotranspiration

- Key information required:
  - Weather-pan evaporation
    - This is a measure of the evaporation from an open, circular pan of water.
  - Crop coefficient (K_C)
    - In turf, open pan evaporation cannot be used alone.
      - The K_C is a decimal number that is usually less than 1.0.
        - ‘Tifway’ bermudagrass = 0.67
        - Common bermudagrass = 0.68
        - ‘Meyer’ zoysiagrass = 0.81
        - Common centipedegrass = 0.85
        - ‘Raleigh’ St. Augustinegrass = 0.72

Estimating Evapotranspiration

$ET_{TURF} = (K_C)$ (Pan Evaporation)

- In the following example, a pan evaporation rate of 60 mm / week has been measured.
- The K_C value for 'Tifway' Bermudagrass is listed as 0.67.
- The weekly water requirement of this turf area is:

ET_{TURF} = (0.67) (60 mm) = 40.2 mm / week


'Palmetto'
'Empire'
Zoysia grass
'Sea Isle 1'
'Floratam'
St. Augustinegrass
'Argentine'
40% ET
Rep 2

Rooting

- The depth and extent of the root system plays an important role.
  - The greater the soil volume from which the plant can draw water, the more efficient the plant will be at using the water it receives.
    - Varies by species.
      - Warm-season grasses usually have more extensive root systems than cool-season grasses.

Short, frequent irrigations

Longer, less frequent irrigations

Soil Factors

- Type
  - Coarse-textured, sandy soils have poor water holding capacity and water that is not used by the root system shortly after application can quickly drain to a depth where it cannot be reached.
  - Clays have poor infiltration rates, which causes irrigation water to puddle on the surface and evaporate before it can be used by the plant.
- Condition
  - Compaction can restrict rooting of grasses that would normally develop a deep, extensive root system.

How Often Should Water Be Applied?

- Complex question!
  - Generally turf is overwatered!
- Deeply and Infrequent *vs* Shallow and frequent
  - D&I - promotes a thickening of the cuticle and the development of a more extensive root system.
  - D&I - promotes certain patch diseases.
  - D&I - wastes water on sandy soils and clay soils with poor infiltration.

Atmospheric Environment - Wind

- Wind is air in motion
  - Wind can carry debris, atmospheric gases, water, and other materials to turfgrasses.
- Wind Effects on Turf
  - Wind can be very beneficial to turfgrasses or highly detrimental, depending on its intensity.
    - Air flowing at a few miles per hour can accelerate heat transfer to substantially cool a turf during hot weather.
    - Wind can dry foliage and, thus, reduce disease incidence.

Atmospheric Environment - Wind

- Wind Effects on Turf (cont.)
  - Severe winds promote rapid drying of the turf – may require more irrigation.
  - In winter, severe winds across turfgrass sites can cause substantial desiccation and loss of turf.
  - Wind is also important in disseminating weed seeds and vegetative propagules, fungal spores, salt sprays, as well as atmospheric pollutants.

Edaphic Environment

- The soil-thatch atmosphere, including roots and other below ground plant organs.
  - Soil Physics
  - Soil Chemistry

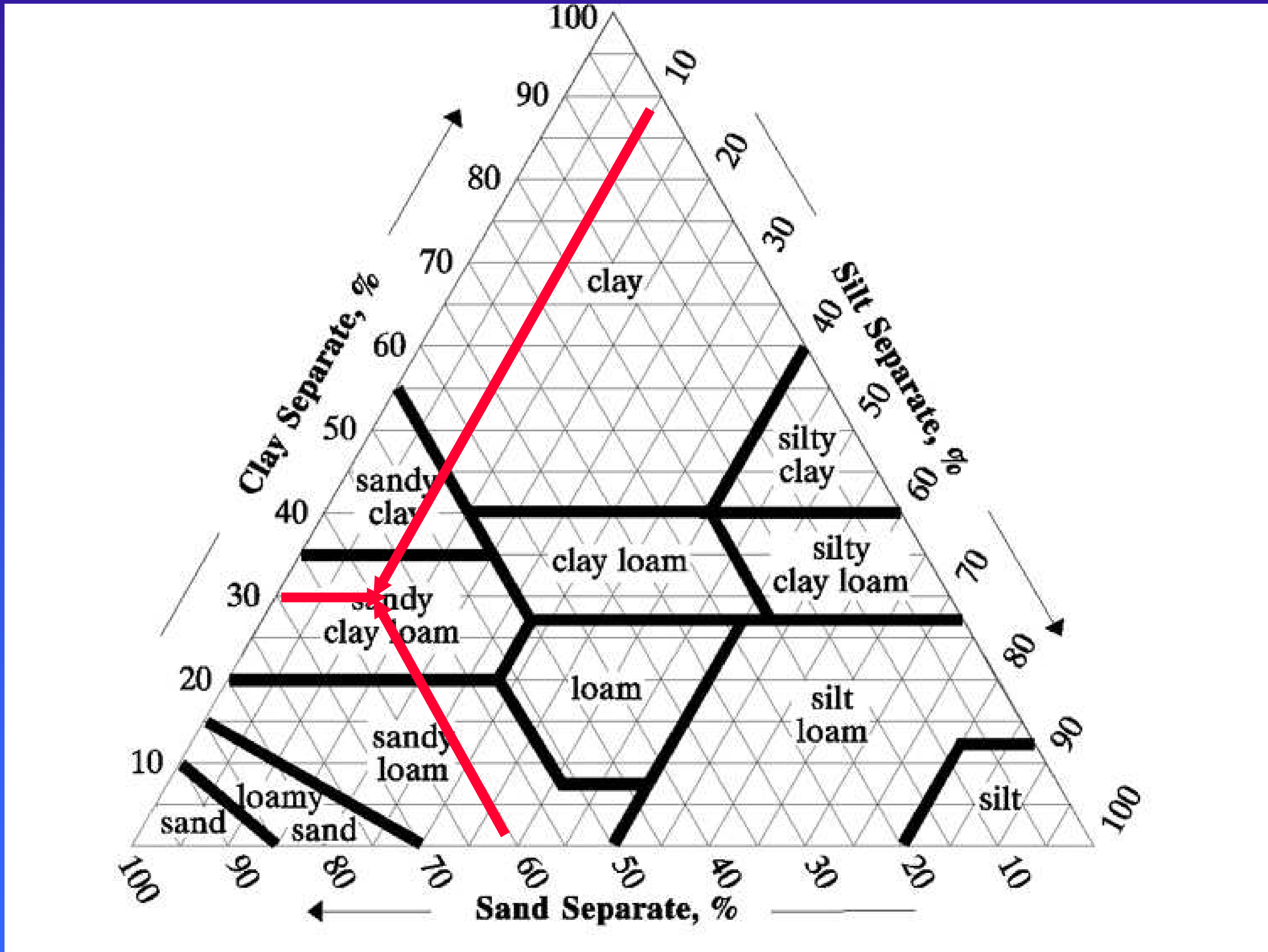
Edaphic Environment

- Soil Physics - The physical properties of a soil, including texture and structure, directly affect its aeration, moisture, and temperature and indirectly affect fertility and the activity of soil organisms.

Edaphic Environment

- Texture - determined by the size of soil particles and their relative proportion.
  - Textural classification of Soil Particles is based on the diameter of the soil particle.
    - Clay is important in chemical reactions involving the adsorption and exchange of plant nutrients. Pore sizes are so small that much of the water they contain is generally unavailable.
    - Silt pores are larger and retain higher amounts of plant-available moisture.
    - Sand pores are so large that they contribute little to water retention. Sand is important, however, in promoting soil aeration and drainage.

Soil Textural Triangle



Edaphic Environment

Separate	Diameter Size (cm)	Surface Area (cm^2)
Very Coarse Sand	2.00 – 1.00	11
Coarse Sand	1.00 – 0.50	
Medium Sand	0.50 – 0.25	
Fine Sand	0.25 – 0.10	
Very Fine Sand	0.10 – 0.05	
Silt	0.05 – 0.002	
Clay	< 0.002	8,000,000

Edaphic Environment

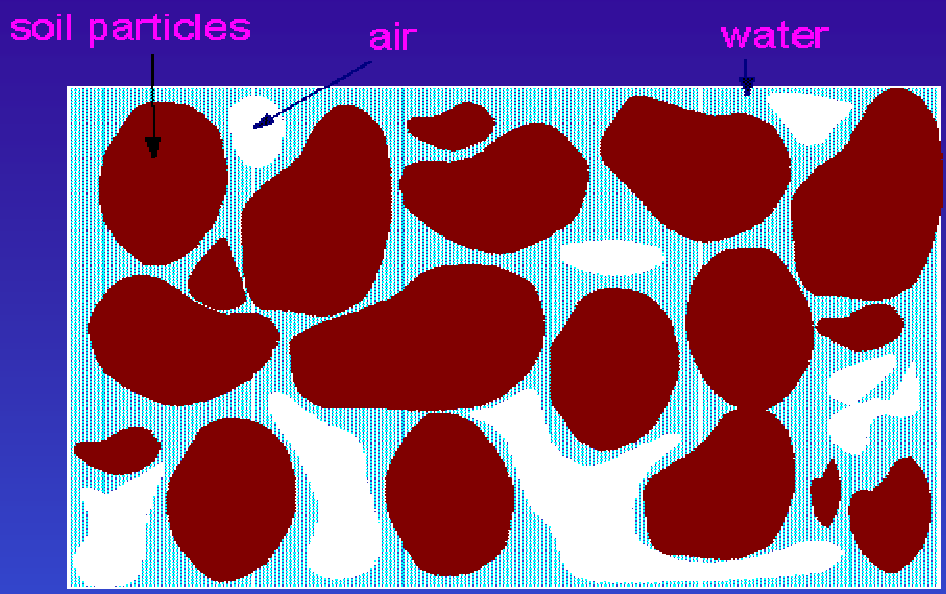
- Structure - refers to the arrangement of soil particles.
  - Clays form aggregates in which individual particles are held together in various configurations.
    - An individual aggregate may be as large as, or larger than, a sand particle.

Edaphic Environment - Moisture

- The importance of soil structure and density lies in their influence on the number and size of pores and the consequent movement of water and air within the soil.
  - Soil Water
    - Gravitational Water - water that drains rapidly from large (aeration) pores due to gravitational force.
    - Available Water - the portion of retained water that plant roots can absorb.
    - Unavailable Water - the tightly held water that is essentially unavailable to plants.

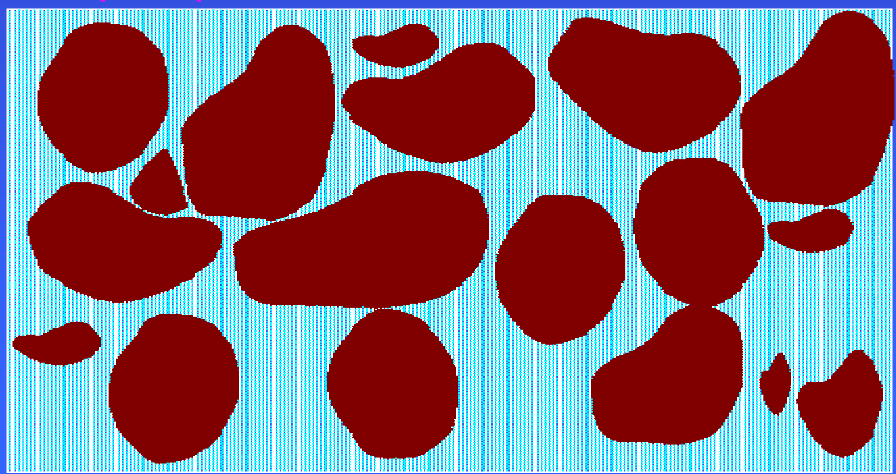
Edaphic Environment - Moisture

- Water Content
  - Saturation - the wettest possible condition of a soil in which all the soil pores are filled with water.
  - Field Capacity - the water content of the soil following drainage of the aeration pores.
  - Permanent Wilting Point - the point at which water is held so tightly that plants cannot obtain it leading to a permanent wilting point.



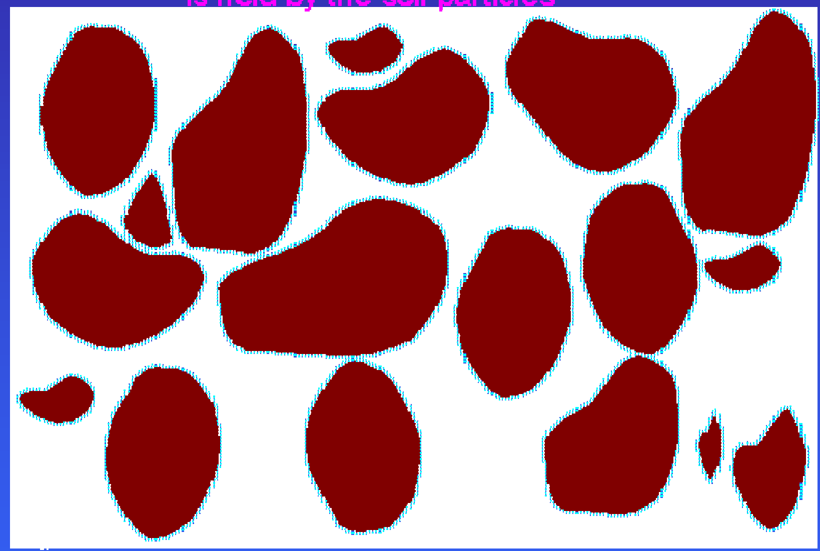
Field Capacity

All pore spaces are water filled in a saturated soil



Saturation

At the wilting point the remaining water is held by the soil particles



Permanent Wilting Point

Edaphic Environment - Moisture

– Saturated Flow
  - Occurs when all or most of the pores are filled with water.
  - It takes place through large pores and, thus, is most rapid in coarse-textured soils.
  - The principle force acting on the water is gravity, and the direction of flow is primarily downward.
  - If the number of large pores decreases suddenly, downward movement is restricted, and water may accumulate. (i.e., occurs in sand or thatch overlying loam soil or with a compact subsoil.)

Edaphic Environment - Moisture

– Unsaturated Flow

- Occurs in soils in which the large pores are not filled with water.
- The rate of flow depends on the thickness of water films surrounding soil particles; thicker films allow faster flow rates than thinner films.
- Unsaturated flow proceeds in any direction, irrespective of gravitational forces.
- Where the continuity of water films is disrupted, as at the interface between a fine-textured soil and an underlying coarse-textured soil, unsaturated flow is slowed or stopped altogether. This is a perched water table (i.e., USGA spec. putting green).

Edaphic Environment - Aeration

- The process by which soil air is replaced by atmospheric air.
  - Soil air has higher concentrations of CO_2 and water vapor, but less oxygen than atmospheric air.
    - This is due to the consumption of oxygen and production of CO_2 by soil organisms.
  - Diffusion is low in compacted soils because of reduced pore size and number and the discontinuity of soil pores.
  - Diffusion is low in wet soils because of the absence or reduction of air-filled pores.
  - Poorly aerated soils are often deficient in oxygen leading to:
    - poor root growth,
    - reduced absorption of nutrients and water, and
    - limited microbial activity.


Poor Infiltration


GREENSAIRE II
SAFETY WARNING

Edaphic Environment - Temperature

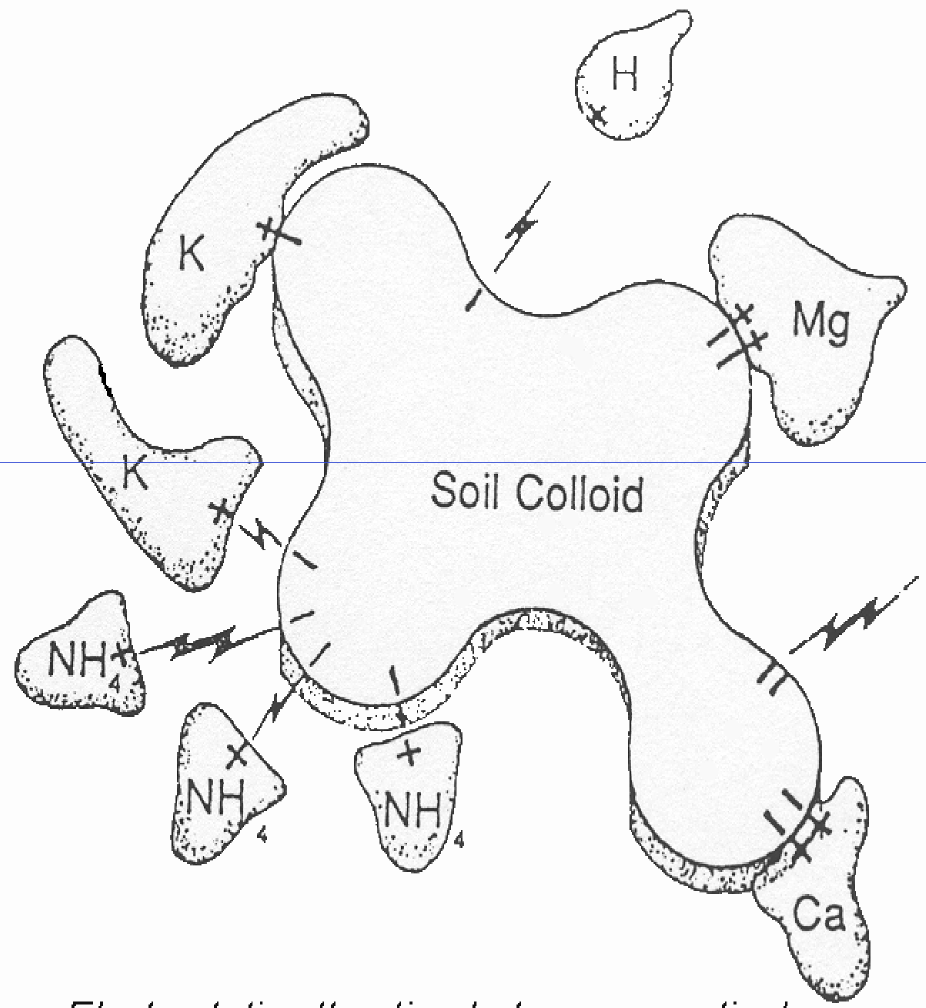
- Many physical, chemical, and biological events that take place in soil are strongly temperature dependent.
  - Soil temperature affected by:
    - atmospheric conditions (air temperature, moisture, wind, and solar radiation),
    - thermal absorption and conductivity of the soil, and
      - Is a function of the color, moisture level, and organic matter content of the soil.
        - Generally, darker soils, high in organic matter, are more efficient in absorbing heat from the atmosphere.
        - Heat absorption occurs faster in drier soils, since is takes additional heat to warm the soil water.
    - plant cover.

Edaphic Environment - Soil Chemistry

- Soil Colloids
  - The clay and humus fractions of the soil are made up of extremely small, colloidal particles.
  - The particles have a large surface area per unit weight and because of their structure have a net negative electrical charge.

Edaphic Environment - Soil Chemistry

- Cation Exchange
  - Cations (ions with a positive charge (Fe^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+})) are attracted to the negatively charged surfaces of the clay and humus particles.



Electrostatic attraction between negatively charged soil colloid and positively charged ions.

Edaphic Environment - Soil Chemistry

- The capacity of the particles to attract or adsorb cations is called the *cation exchange capacity* (CEC) of the soil.
  - Measured in milliequivalents (mEq) per 100 grams (g) of soil.
  - CEC of a soil depends on its:
    - Texture - fine textured soils typically contain more clay, and therefore, more exchange sites.
    - Type of clay
      - montmorillonite ranges from 80 to 150 mEq/100 g,
      - kaolinite has CECs between 3 and 15 mEq/100 g.
    - Percent organic matter - different types of OM contribute differently.
    - pH - increasing pH usually leads to higher CECs.

Edaphic Environment - Soil Chemistry

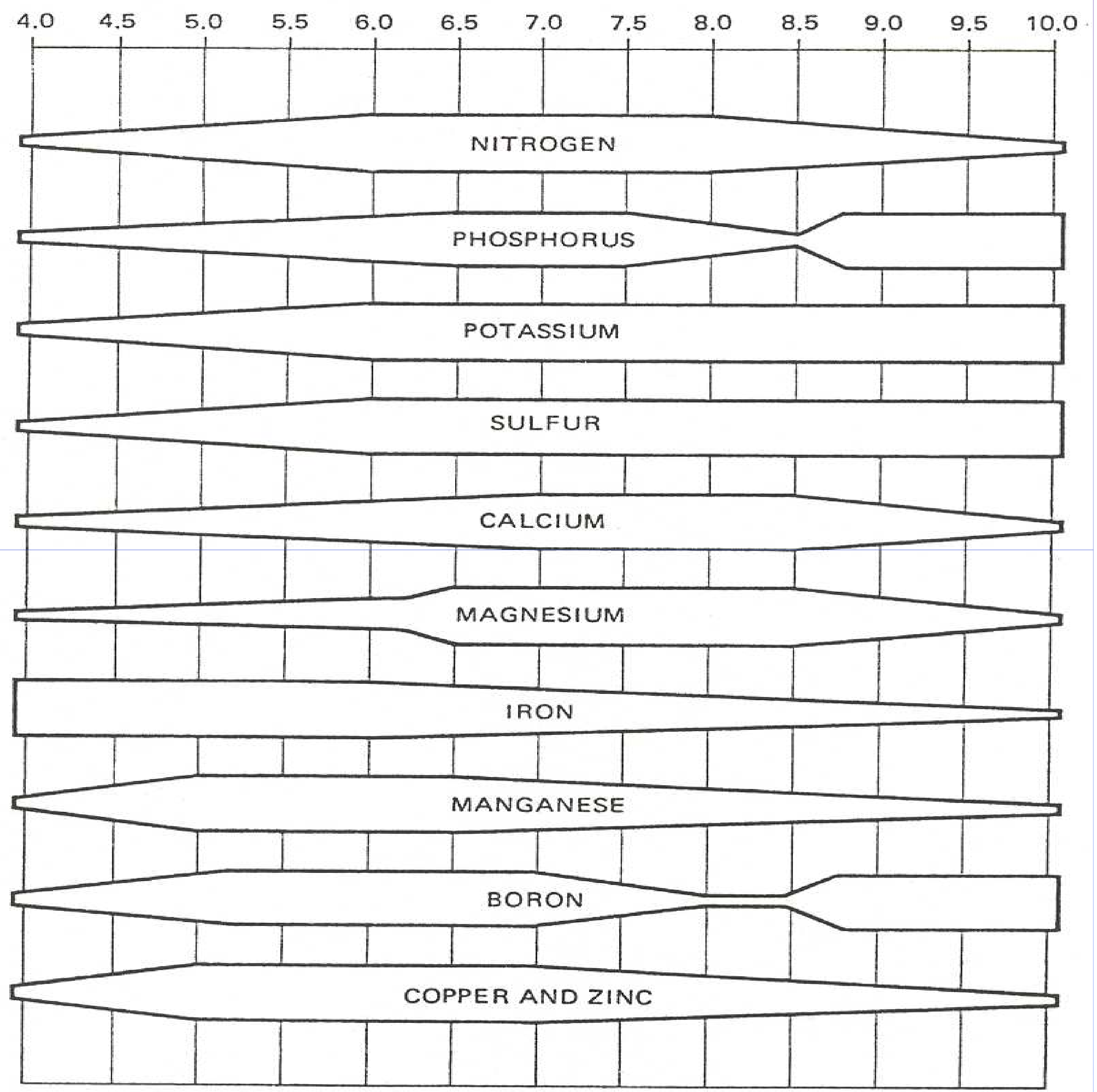
- Cations adsorbed on the colloidal particles are called exchangeable cations because they can be replaced or exchanged by other cations from the soil solution surrounding the particles.
  - The distribution of different cations on exchange sites can dramatically affect soil physical properties.
    - Saturation of the exchange sites with Na^+ causes dispersal of clay particles and a consequent loss of desirable soil structure leading to severe compaction and water impermeability.

Edaphic Environment - Soil Chemistry

- Soil Reaction - is an indication of the acidity or alkalinity of a soil and is measured in units of pH.
  - Soil pH is the negative logarithm of the hydrogen (H^+) ion concentration.
  - The pH scale extends from 0 to 14; each whole-number unit reflects one magnitude of change in the hydrogen ion concentration.
    - At a pH of 7, the H^+ and OH^- concentrations are said to be at neutrality.

Edaphic Environment - Soil Chemistry

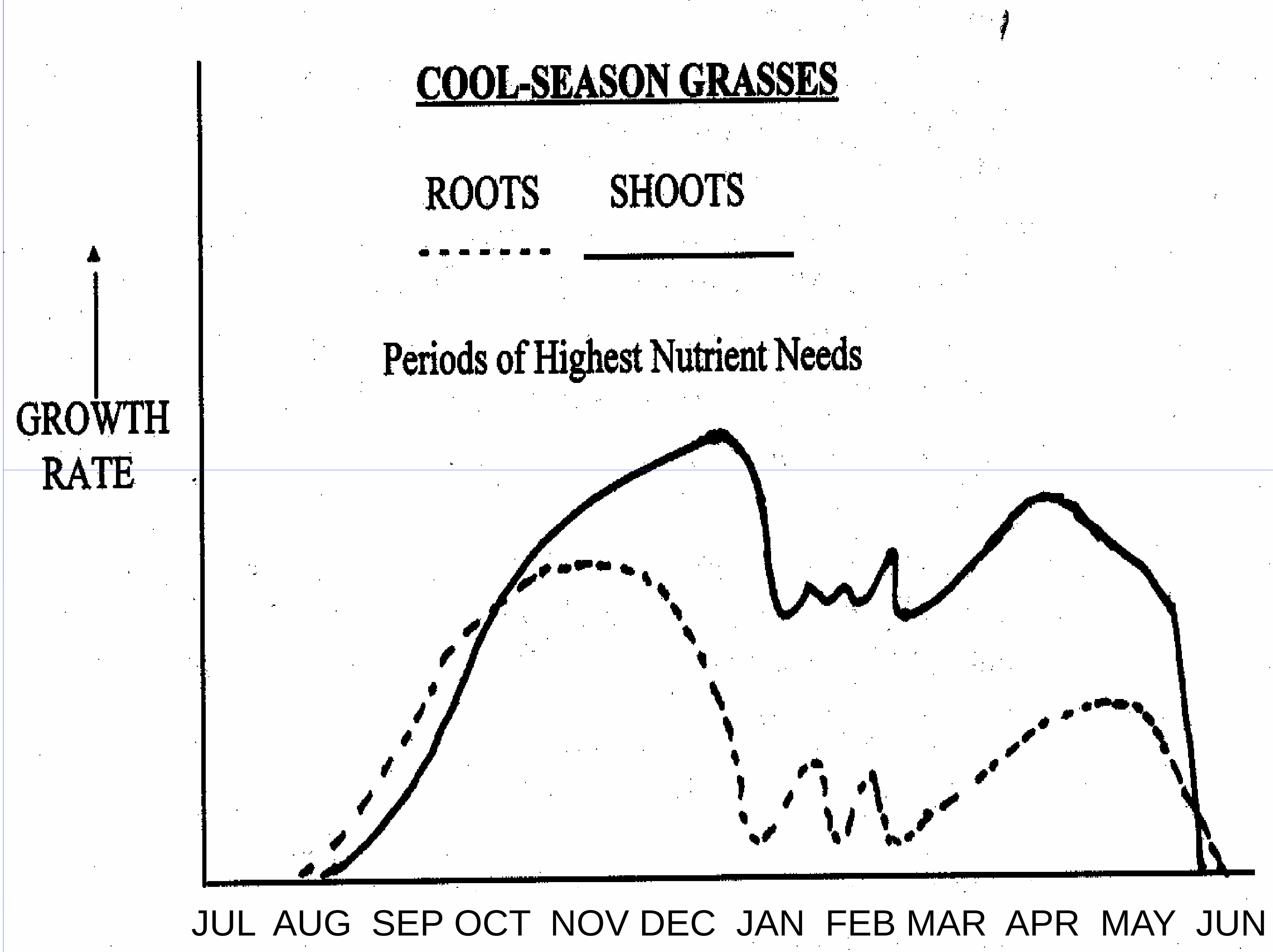
- The normal pH range in soil is 4.0 to 8.0.
  - In areas where sufficient precipitation occurs to leach soluble salts, the soil pH tends to decrease.
    - Irrigation can have the same effect.
  - In dry regions where evapotranspiration exceeds precipitation, soil pH tends to be alkaline due to the accumulation of basic salts in the surface soil.



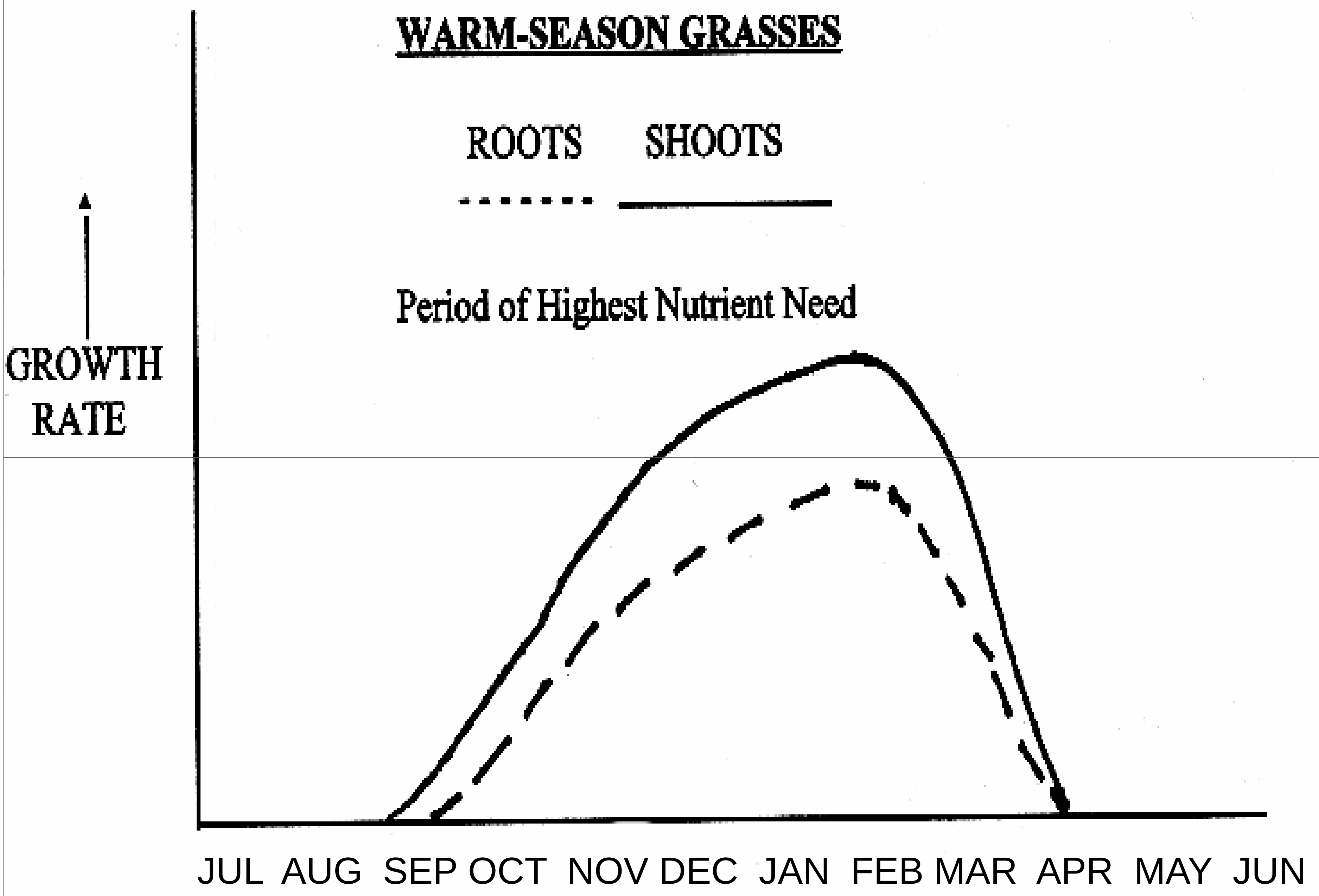
Maximum availability is indicated by the widest part of the bar.

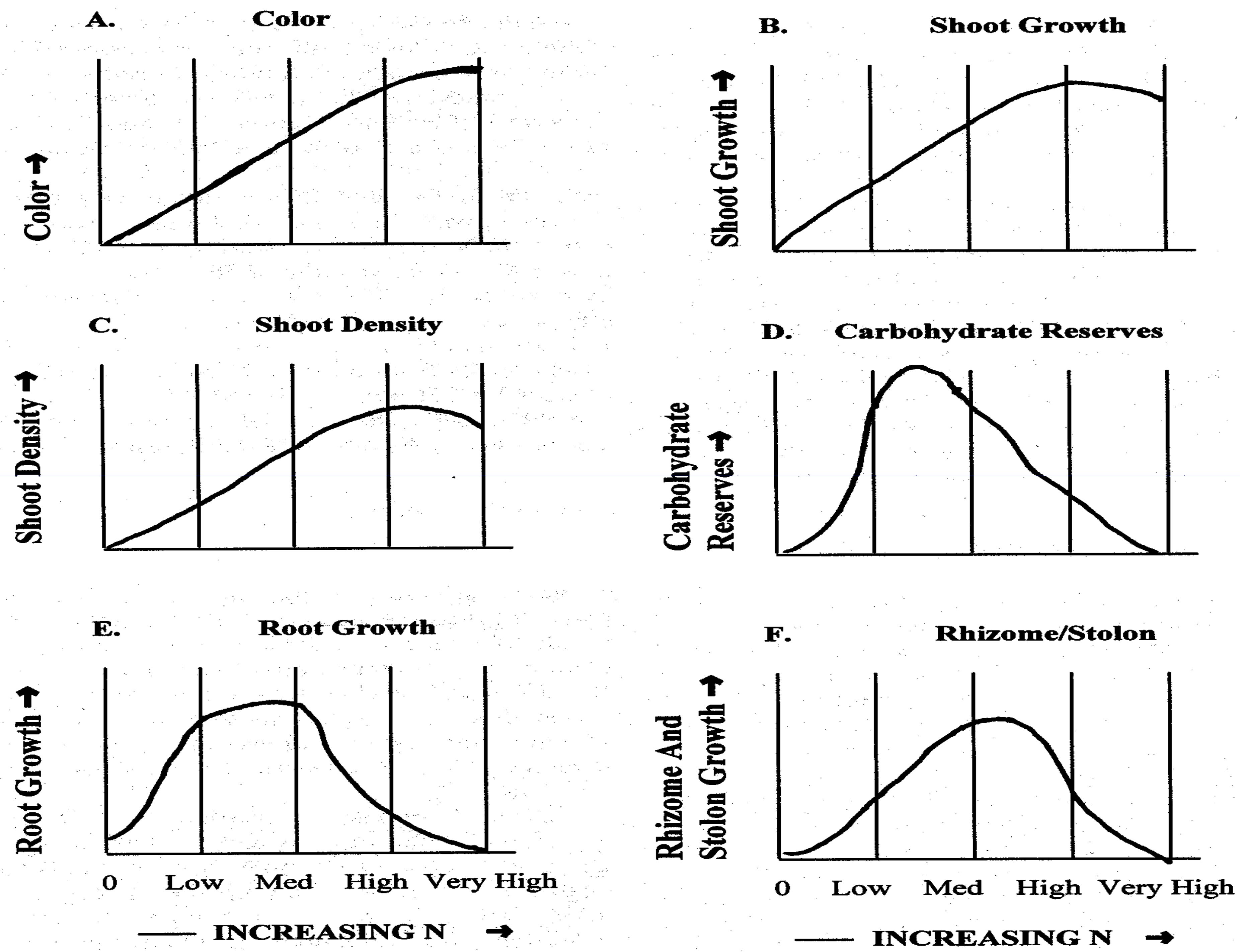
Edaphic Environment - Soil Chemistry

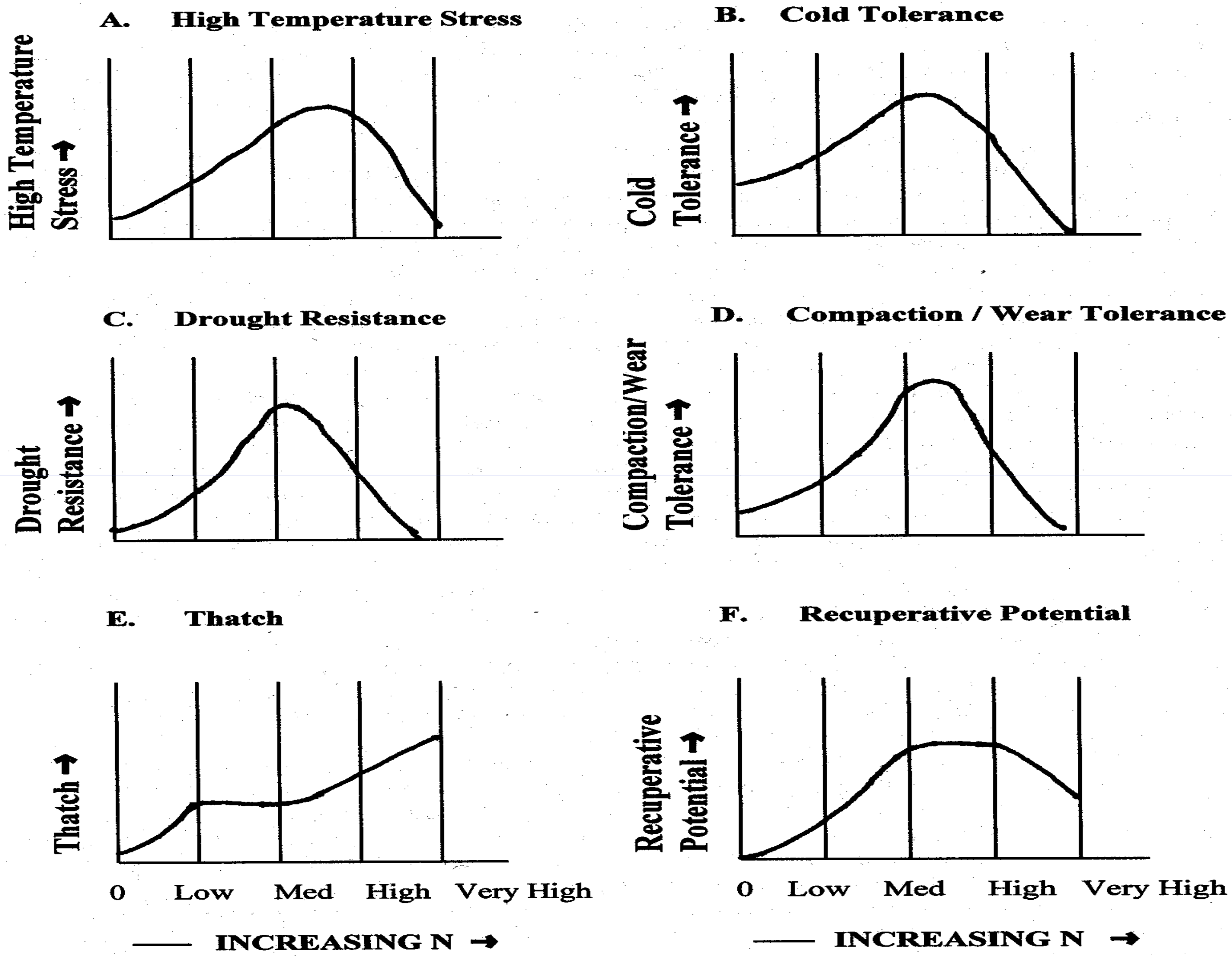
- Turfgrass species are adapted to a wide range of soil pHs; however, optimum growing conditions usually exist where the pH is neutral to slightly acid (7.0 - 6.0).
  - Increase pH through periodic applications of lime results in
    - better rooting,
    - increased turfgrass vigor,
    - improved availability of some plant nutrients,
    - reduced availability of toxic elements, and
    - more favorable microbial activity.
  - Decrease pH through periodic applications of acidifying fertilizers, such as elemental sulfur and sulfates of ammonium, iron, and aluminum.



COOL-SEASON GRASSES
ROOTS
SHOOTS
Periods of Highest Nutrient Needs
GROWTH RATE
JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN

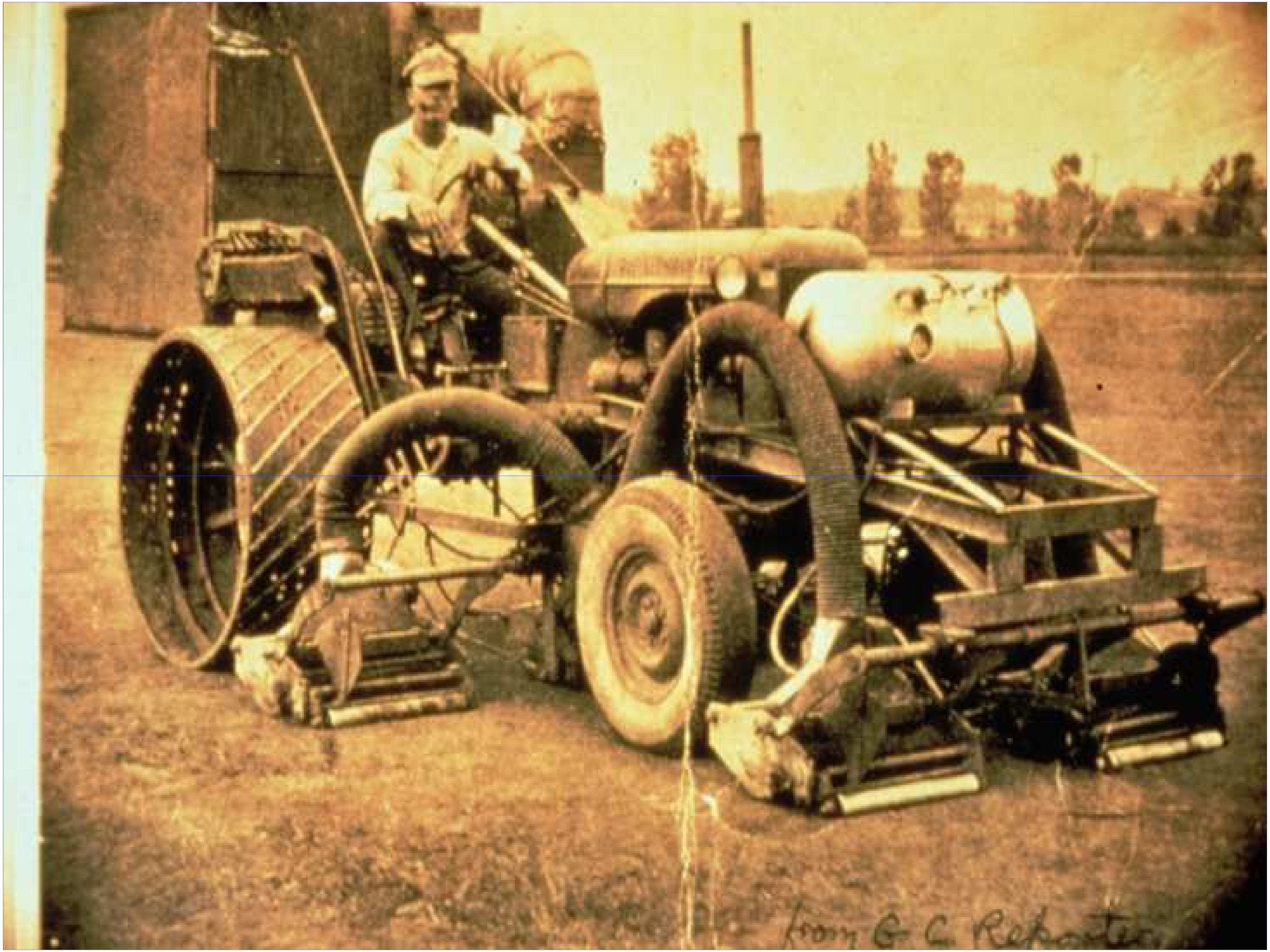

WARM-SEASON GRASSES
ROOTS
SHOOTS
Period of Highest Nutrient Need
GROWTH RATE
JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN


A.
Color
Color ➜
B.
Shoot Growth
Shoot Growth ➜
C.
Shoot Density
Shoot Density ➜
D.
Carbohydrate Reserves
Carbohydrate Reserves ➜
E.
Root Growth
Root Growth ➜
F.
Rhizome/Stolon
Rhizome And Stolon Growth ➜
0 Low Med High Very High
INCREASING N ➜
0 Low Med High Very High
INCREASING N ➜


A. High Temperature Stress
High Temperature Stress ➜
B. Cold Tolerance
Cold Tolerance ➜
C. Drought Resistance
Drought Resistance ➜
D. Compaction / Wear Tolerance
Compaction/Wear Tolerance ➜
E. Thatch
Thatch ➜
F. Recuperative Potential
Recuperative Potential ➜
0 Low Med High Very High
INCREASING N ➜
0 Low Med High Very High
INCREASING N ➜


Showing Her Steam

RECENTLY, Lady Montague trimmed the ancestral lawns of Palace House, Beaulieu, England, aboard a steam-powered mower that was made in the 1930's from a design drawn in 1897. The vehicle was on loan as part of anti-pollution exhibition presented at Beaulieu. Lady Montague's verdict? "It's most efficient, certainly more interesting than any modern mowers."


from G C Reporter

Mowing is a STRESS

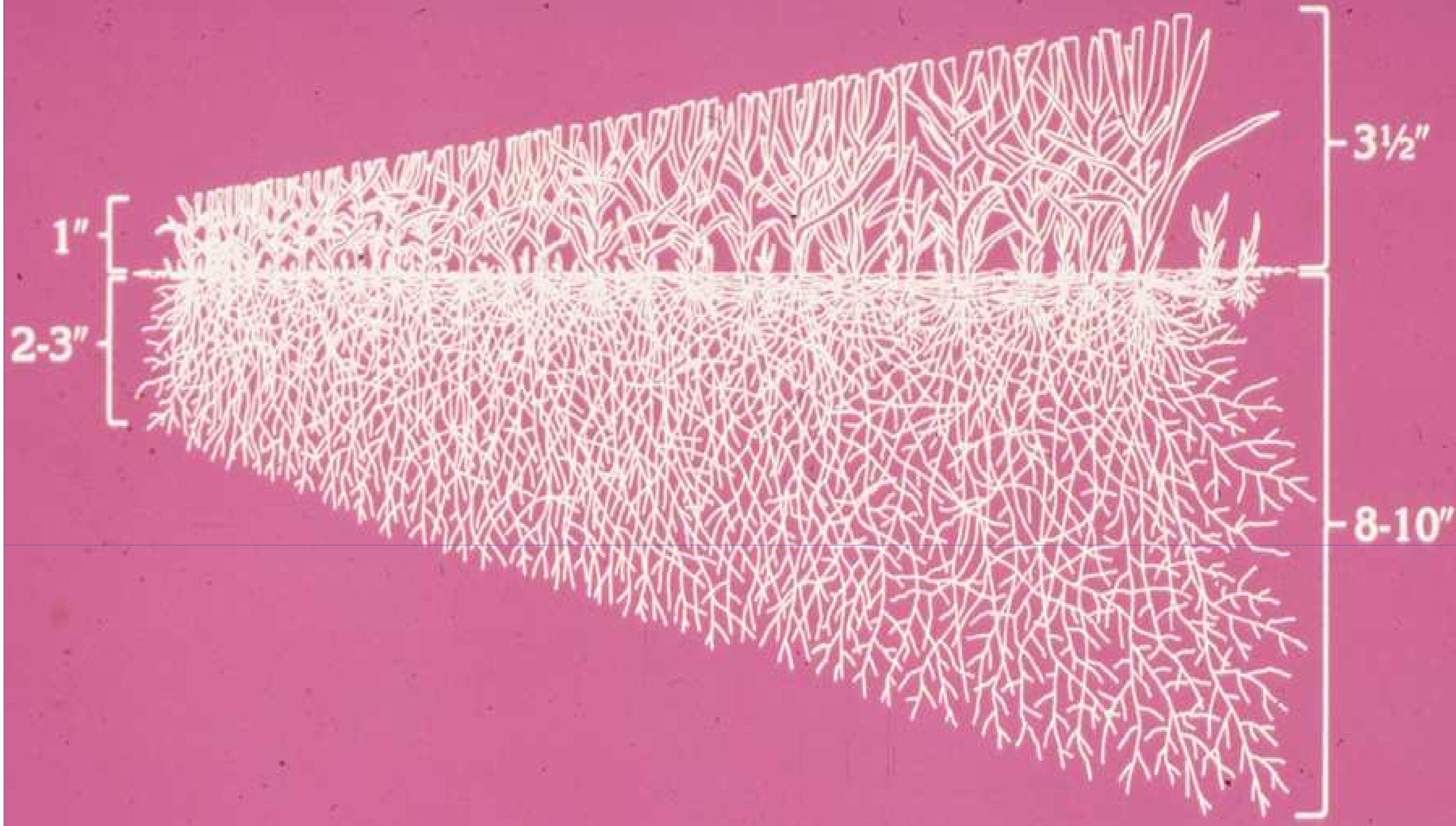
- Effects of Mowing
  - Water loss
  - Disease Development
  - Decreased Carbohydrate Storage
  - Increased Shoot Density
  - Small Shoots
  - Decreased Root and Rhizome Growth

Mowing Height

- Species/Cultivar
  - Each turfgrass species has an adapted range in which it tolerates mowing.
    - This range will be lower than the recommended mowing height.
      - Mowing below the recommended mowing height, but within the range of tolerance, requires a higher level of maintenance to maintain a healthy turfgrass stand.
      - Mowing below the tolerance range will result in rapid deterioration of turfgrass quality.
        - Excessively close mowing heights will decrease the total leaf area, carbohydrate reserves, and root growth thereby creating a situation where the plants are unable to produce enough food to meet their own demands.
        - Thus, turfgrass plants will be more susceptible to drought, high temperature, and wear injury.

Mowing Height

- Species/Cultivar (cont.)
  - Mowing above the tolerance range will reduce tillering and cause mating of the grass.
    - Reduced tillering results in fewer and coarser plants, while matted grass creates a good microenvironment for disease development.
    - Also increases thatch accumulation, which creates a need for higher maintenance.



Higher mowing heights favor root and rhizome growth.

Mowing Height

- Use
  - The use of the site will dictate how short or tall to mow.
    - Putting green = 5/32" or lower.
- Time of Year
  - Increase mowing height during the stressful time of the year.
    - Higher mowing heights:
      - provide insulation to the crown of the plant against high temperatures;
      - provide more leaf area thereby increasing photosynthesis;
      - will result in deeper root systems.

Mowing Frequency

- Determine the mowing frequency by the grass growth rate, not by any set schedule.
- Remove no more than one-third of the total leaf area at any one mowing.
  - For example, if you mow a St. Augustinegrass lawn at a 3-inch height, the grass should be 4 inches tall.
  - Removing more than one-third shocks turfgrass plants, which may result in temporary thinning of the turf.
    - Reserve carbohydrates within the plant are utilized for shoot regrowth, which will deplete the stored carbohydrates and reduce the capability of the plants to withstand environmental stresses.

Clipping Removal

- It has been taught that clippings should be removed because they contribute to thatch.
  - Clippings contribute very little to thatch development because clippings are primarily water and cellulose that decompose easily.
  - Only remove long clippings that remain on top of the grass.
    - Excess clippings shade the turfgrass and create a microenvironment that favors disease development.