Athletic Field Soils and
How to Manage Them

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What's Different about Altheticfield Soils?

- Turf Soils are different from Agricultural soils in that there is no opportunity to till them and open them up.
- Athletic Field Soils differ from most turf soils in the amount of traffic they are exposed to.
- We also have very high expectations, despite receiving excessive traffic, a high quality field is still expected.

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A place to start Soil Web App

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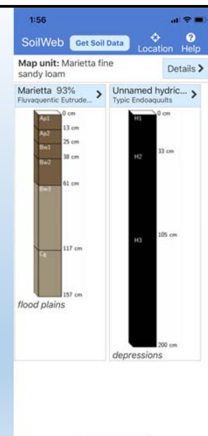

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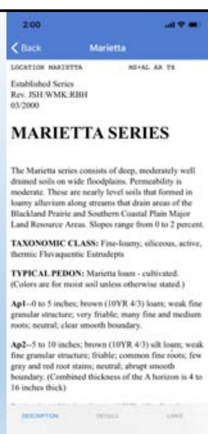

2:00
Back
Marietta

LOCATION MARIETTA MS+AL AR TX

Established Series
Rev. JSH/WMK:RBH
03/2000

MARIETTA SERIES

The Marietta series consists of deep, moderately well drained soils on wide floodplains. Permeability is moderate. These are nearly level soils that formed in loamy alluvium along streams that drain areas of the Blackland Prairie and Southern Coastal Plain Major Land Resource Areas. Slopes range from 0 to 2 percent.

TAXONOMIC CLASS: Fine-loamy, siliceous, active, thermic Fluvaquentic Eutrudepts

TYPICAL PEDON: Marietta loam - cultivated. (Colors are for moist soil unless otherwise stated.)

Ap1--0 to 5 inches; brown (10YR 4/3) loam; weak fine granular structure; very friable; many fine and medium roots; neutral; clear smooth boundary.

Ap2--5 to 10 inches; brown (10YR 4/3) silt loam; weak fine granular structure; friable; common fine roots; few gray and red root stains; neutral; abrupt smooth boundary. (Combined thickness of the A horizon is 4 to 16 inches thick)

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Role of soil in plant growth

- A quality soil is the foundation that a quality athletic field is built upon
- Water reservoir
- Supply of nutrients
  - N P K Ca Mg S Fe Mn B Cu Zn Mo Cl
- Support, anchor
- Oxygen, O_2

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What makes a Healthy Soil?

- Soil quality and soil healthy are used interchangeably
- To me they are different. The state of health of a soil depends on other things: an arid soils could be perfectly healthy for an arid soil but would not be considered healthy if productivity were taken into account.

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Vital Soil Functions

- Sustaining biological activity, diversity, and productivity
- Regulating and partitioning water and solute flow
- Altering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials including agricultural, industrial and municipal by-products and atmospheric deposition
- Storing and cycling nutrients and other elements with the Earth's biosphere
- Providing support of socioeconomic structures and protection of archeologic treasures associated with human habitation. *Karlen et al. 1997*

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Soil Quality

- A simple definition would be "the capacity of soil to function."
- It includes physical, chemical and biological characteristics.
- USDA has defined a simple kit for measuring soil quality

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Soil Quality

- Biological properties measured are soil respiration rate and a simple count of earthworms.
- Physical properties measured are bulk density, water content, infiltration rate, aggregate stability, slaking, and morphological characteristics.
- Chemical properties measured are pH, electrical conductivity (EC), and soil nitrate levels.

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General soil respiration class ratings (Woods End Research, 1997)

Soil respiration rate (lbs CO2 – C/ac/day	Class	Soil condition
0	No soil activity	Virtually sterile
<9.5	Very low soil activity	Soil is depleted of organic matter and has little activity
9.5-16	Moderately low soil activity	Soil somewhat depleted of organic matter and activity is low
16-32	Medium soil activity	Soil is approaching or declining from ideal state
32-64	Ideal soil activity	Soil in ideal state of biological activity
>64	Unusually high activity	Very high activity usually do to application of large quantities of fresh OM

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Components of soil

- Mineral (inorganic)
- Organic (living and dead, plants and animals)
- Water (and dissolved salts)
- Air (N_2, O_2, CO_2, H_2O, CH_4, H_2S)

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Thing 1 and Thing 2
Particle Size Distribution and Gradation

- Will give us a lot of information on how our soil will behave and give insights into Cultural Practices.
- Soil hydrometer test and sand sieving test.
- Many ways to interpret the results

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Soil mineral matter

- Sand (0.05 - 2 mm)
  - sand separates
    - very coarse: 1 - 2 mm
    - coarse: 0.50 - 1 mm
    - medium: 0.25 - 0.50 mm
    - fine: 0.10 - 0.25 mm
    - very fine 0.05 - 0.10 mm
  - distribution of size range - packing
  - rounded vs angular (firmness)
  - mineralogy - mostly quartz (very stable)

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Soil mineral matter

- Size separates and characteristics
- Clay (< 2 micron)
  - plate like structure
  - surface area - related to small size
  - mineralogy (secondary minerals)
  - negative charge
  - cation exchange capacity (CEC) - the sum of the exchangeable cations that a soil can adsorb
  - adhesion of water

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Soil mineral matter

- Size separates and characteristics
  - Silt (0.002 - 0.05 mm)
    - mineralogy

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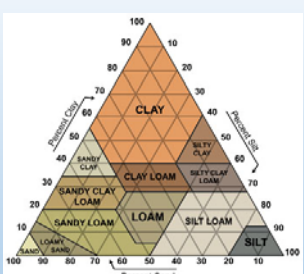

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Grain Size Groups

Size Group	Sieve Size	
	Passing	Retained On
Cobbles	No Maximum Size	3 inches
Gravels	3 inches	No. 4 (≈0.25 inches)
Sands	No. 4 (≈0.25 inches)	No. 200 (0.072 mm)
Fines (silt or clay)	No. 200 (0.072 mm)	No minimum Size
In military engineering, the maximum size of cobbles is accepted as 40 inches, based on the maximum jaw opening of a rock-crushing unit.		

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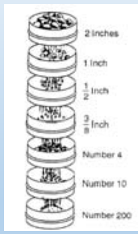
Dry Sieve Analysis



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Gradation

- Distribution of particles within a soil.
- Soils are either:
  - Well graded – good distribution of particle sizes
  - Poorly graded – bad distribution of particles sizes
    - Uniformly graded – only one soil size
    - Gap graded – missing soil sizes

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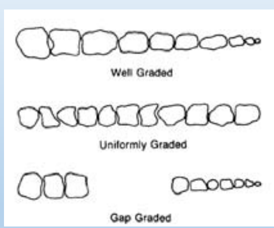
Soil Gradations



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Grain Shape

- Influences a soils strength and stability
- Two general shapes:
  - Bulky – three dimensional
    - Angular – recently been broken
    - Sub angular – sharper points and edges are worn
    - Sub rounded – further weathered than sub angular
    - Rounded – no projections and smooth in texture
  - Platy – two dimensional

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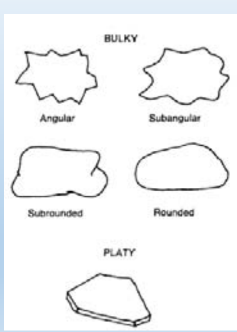
Soil Particle Shapes



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Soil mineral matter

- Soil texture - percentage of sand, silt and clay in soil
  - influenced by parent material, weathering (clay formation), transport of clay, erosion/sedimentation
  - textural classes
    - textural triangle
  - profile textural differentiation

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importance of texture

- pore space
- aeration
- water retention, available water
- water infiltration and percolation
- runoff, erosion
- cohesion, plasticity
- shrink-swell character

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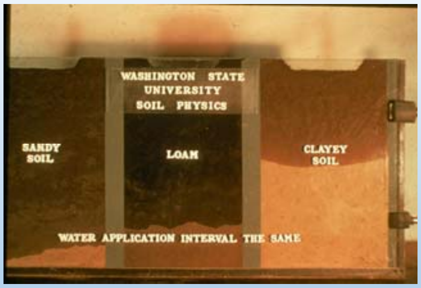

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importance of texture

- soil structure
- management - tillage
- microbial activity, o.m. content
- soil pH (acidity)
- soil temperature
- fertility, productivity

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Management

- Soil Texture can be improved over time with a topdressing and hollow tined aerification approach.
- Often we have to manage what we are given, but knowing what we are dealing with is helpful.
- Perhaps we can manage this up front by choosing sites with good soils or building our turf rootzone from quality materials.

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Thing 3 Bulk Density/Compaction

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Measuring Bulk Density

- Most common method is to use a core sampler. Takes core of a known volume.
- Sample is usually then weighed wet, then oven dried to a constant weight at 105 C. (usually 24 hrs).
- You now have a mass and a volume of soil
- BD = mass of OD soil (g)/ vol. soil (cm^3)

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Bulk density

- dry weight of a given volume of soil
- Used to characterize structure
- More porespace = less weight = lower BD
- Texture influences structure and density
- Range for mineral soils: 1.1 - 1.5 g/cm^3 (68.7 - 93.6 lbs/cf)
- organic soils: 0.1 - 0.6 g/cm^3 (6.2 - 37.4 lb/cf)

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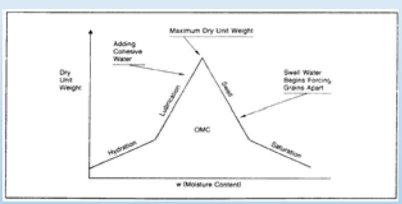
Effect Of H2O on Density



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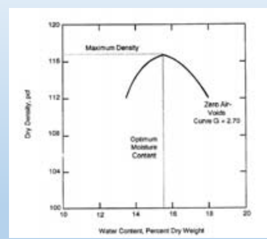
Typical H2O-Density Relationship



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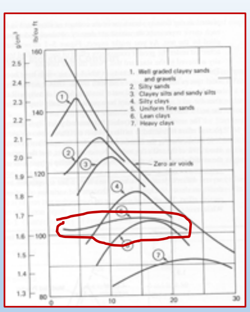
Compaction Characteristics of Various Soils



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General relationship of BD to root growth based on soil texture

Soil Texture	Ideal BD g/cm^3	BD affecting root growth	BD restricting root growth
Sands, Loamy Sands	< 1.60	1.69	> 1.80
Sandy loams, loams	< 1.40	1.63	> 1.80
Sandy clay loams, clay loams	< 1.40	1.60	> 1.75
Silts, silt loams	< 1.30	1.60	> 1.75
Silt loams, silty clay loams	< 1.40	1.55	> 1.65
Sandy clay, silty clay, some clay loams	< 1.10	1.49	> 1.58
Clays < 45% clay	< 1.10	1.39	> 1.47

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What good does it do?

- Punches a hole YES
- Decreases compaction YES
- Returns loosened material to surface YES
- Potential to break down thatch YES
- Creates a large pore YES
- Breaks through layers YES
- Adds Material to Profile YES

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Thing 4 pH

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Soil Reaction (pH)

- measure of the acidity or alkalinity of the soil solution
- pH = - log[H$^+$]

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Soil pH

pH	[H+]	[OH-]	
7	10^{-7} or 0.0000007	10^{-7}	neutral
3.5	$10^{-3.5}$ or 0.00032	$10^{-10.5}$	acidic
9	10^{-9} or 0.000000001	10^{-5}	alkaline

•note that the exponents of [H+] and [OH-] add to -14.
•When both are -7 the ions are in equal concentration,
•therefore the system is neutral

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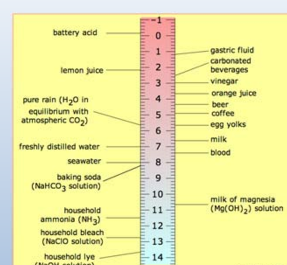

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The importance of soil pH

- indication of weathering (parent material, leaching)
- availability of nutrients
- toxicity of metals, esp, Al^{3+}
- oxidation of reduced S

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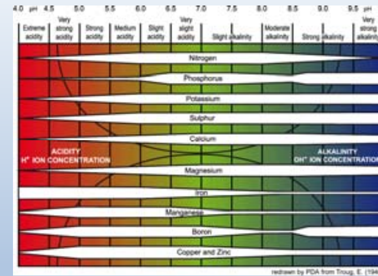

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Active acidity in soil solution

- H^+ [measured as pH]
- Exchangeable acidity (Reserve)
- Residual acidity (Bound)

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$$Al^{3+} + H_2O \rightarrow Al(OH)^{2+} + H^+$$

$$Al(OH)^{2+} + H_2O \rightarrow Al(OH)_2^+ + H^+$$

$$Al(OH)_2^+ + H_2O \rightarrow Al(OH)_3 + H^+$$

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Processes increasing soil acidity

- CO_2 (from respiration) + H_2O + HCO^{3-} + H^+
- Organic acids
- H^+ releases upon cation uptake by the root
- leaching of anions (Cl^-, SO_4^-) requires leaching of equal + charge
- Oxidation of reduced substances (e.g. sulfide minerals, organic matter, ammonia fertilizers)
- Acid rain

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Buffering capacity of soils

- Resistance to change in pH of soil solution
- Exchange site equilibrium with soil solution
- Higher the CEC, the greater the buffering capacity

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Processes increasing alkalinity

- Reduction of Fe^{3+}, Mn^{4+} consumes H^+ or releases OH^-
- $Fe(OH)_3 + e^-$ $Fe(OH)_2 + OH^-$ (anaerobic situations)
- Recycling of basic cations by deep-rooted plants - maintains B.S.
- Liming

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Modifying Soil pH

- Raise pH – add lime (carbonates, oxides or hydroxides of Ca, Mg
  - Limestones (carbonates) – calcitic, dolomitic, dolomite
    - $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2O + CO_2$
    - $MgCO_3 + 2H^+ \rightarrow Mg^{2+} + CO_2 + H_2O$
  - Burned or Quicklime (oxides) – produced by heating limestone
  - Hydrated lime (hydroxides) – water added to burned lime

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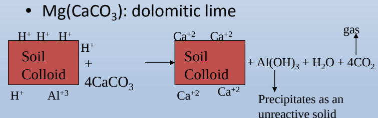
Liming

- Lime is an amendment used to raise soil pH
- Calcium carbonate ($CaCO_3$): Lime
- $Mg(CaCO_3)$: dolomitic lime



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Approx. Lime Amounts to Raise pH to 6.5

Pounds of limestone/1000 ft^2			
pH	Sandy	Loamy	Clayey
6.0	20	35	50
5.5	45	75	100
5.0	65	110	150
4.5	80	150	200
4.0	100	175	230

Finer the lime, the quicker it reacts, but harder to apply

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Lime Requirement – Factors determining amount to add

- pH change desired
- soil's buffer capacity
- chemical composition and purity – guarantee
  - Compare H^+ neutralizing power per weight
- Calcium Carbonate Equivalent (CCE)
  - fineness of lime

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Lower pH

- Add organic matter
- Elemental sulfur
  - $2S + 3O_2 + 2H_2O \rightarrow 4H^+ + 2SO_4^{2-}$
  - $FeSO_4 \rightarrow Fe^{2+} + SO_4^{2-}$

  $Fe^{2+} + 2H_2O \rightarrow Fe(OH)_2 + 2H^+$

  Ferrous sulfate

  $4Fe^{2+} + 6H_2O + O_2 \rightarrow 4Fe(OH)_2^+ + 4H^+$

  Aluminum sulfate

  $Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$

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Thing 5 Surface Hardness

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Surface Hardness

- Different from compaction. Especially with sands a soil may be firm without necessarily being compacted.
- Surface Hardness – Safety Issue
- Compaction - Plant growth

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Clegg Impact Soil Tester

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Surface Hardness Management

- Water if dry
- Aerification with small solid tines
- Grow more grass
- Topdressing

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Thing 6 Organic Matter

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Soil organic matter

- organically derived fraction of soil, including plant, animal, & microbial residues in various stages of decomposition
- Organic residue degradation and formation of humus
  - residue addition to soil – plant, animal, microorganisms
  - microbial activity (decomposition)

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Soil organic matter

- How to measure – Most soil testing labs have a CN or CNS analyzer. For a minimal fee you can know your soil organic matter content and its C:N ratio.

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C:N Ratios

Fungi	9:1
Actinomycetes	5:1
Bacteria	4:1
Young Legumes	12-20:1
Young Grasses	20-40:1
Oat/Wheat Straw	80-90:1
Tree Leaves	60-100:1

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- With additions of residue, N becomes the limiting nutrient
- If residue C:N < 20:1, excess N is released as residue decomposes
- If residue C:N > 30:1, microorganisms require soil N, (competing with plants)
- Residue C is respired ($CO_2\uparrow$) during decomposition, but N is recycled as microorganisms die; so C:N decreases

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- residue is transformed
- humus results – relatively stable modified organic molecules resistant to further breakdown
  - C 50-60%
  - N 5%
  - P 0.6-1.2%
  - S 0.5%

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Characteristics of Soil Organic Matter

- low bulk density
- negative charge; high CEC compared to mineral fraction
- buffering capacity
- water holding capacity
- source of N, P, S, micronutrients

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Organic matter in soils

- Amount
  - range in A horizon 0.5-7.0%
  - subsoils have less: 0.25-1.75%

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Significance of Soil OM

- Soil bulk density, porosity
- Soil structure stability, resilience
- Water holding capacity
- Fertility (N, P, S contents, CEC, chelates)
- pH buffer
- supports microbial biomass
- adsorbs some pesticides
- heat absorption (color)

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Thing 6 Water Infiltration Rate

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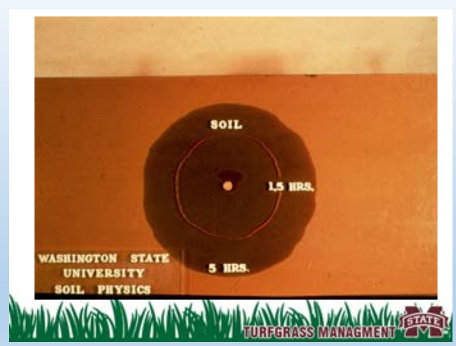

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Infiltration Rate

- Soil texture and compaction will give us an idea.
- Gold Standard is the double ring infiltrometer but even those can be squirrelly.
- Pounding a coffee can with ends removed into soil works ok except in sand based soils.
- Best is to watch your field drain and look for trouble spots. Then look for source of bad drainage/standing water.

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Thing 7 Nutrient Levels

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Soil Testing Nutrient Levels

- Stick with the same lab using the same procedure
- Use a lab without skin in the game
- Keep track of numbers. Should be able to build fertility into fine textured soils. In sandy soils you may end up chasing numbers you cannot attain. Best is to watch your field drain and look for trouble spots. Then look for source of bad drainage/standing water.

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MLSN Guidelines

	MLSN Guidelines		SLAN Carrow et al 2004	
	Lbs/A	Lbs/1000 ft^2	Lbs/A	Lbs/1000 ft^2
Potassium (K ppm)	74	1.7	>234	>5.4
Phosphorus (P ppm)	42	1.0	>110	>2.5
Calcium (Ca ppm)	696	16.0	>1500	>35
Magnesium (Mg ppm)	94	2.1	>242	>5.5
Sulfur (S ppm)	14	0.3	>82	>2

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Soil Testing Nutrient Levels

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Thing 8 Grade

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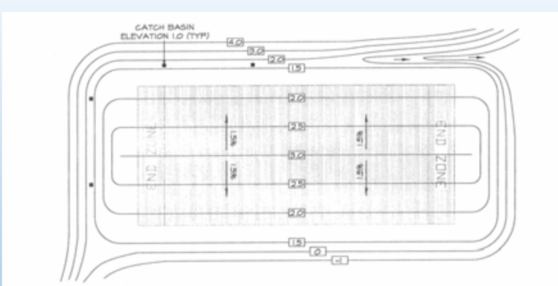

Figure 12.1. Crowned field with level sidelines—elevations noted in feet.

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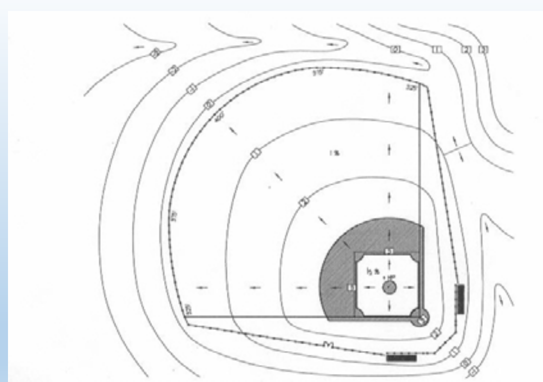

Figure 11.1. The simplest and most common (good) field design—elevations noted in feet.

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Thing 9 What does my

soil profile look like?

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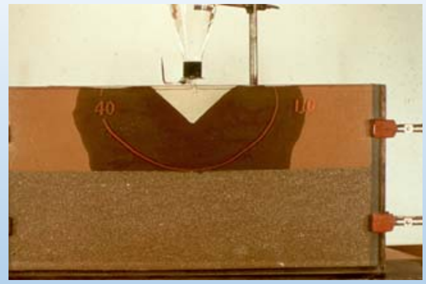

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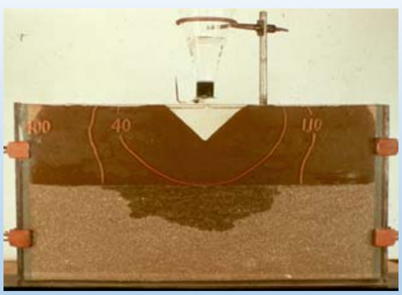

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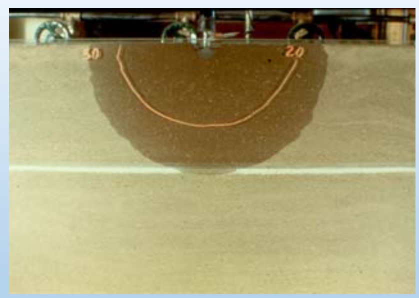

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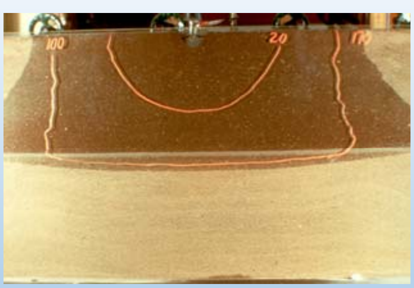

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Layering

- Deep tine aerification.
- Other aerification that goes deep.
- If you are doing things correctly your drainage should improve.

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Thing 10 Thatch Thickness

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Thing 11 CEC Cation Exchange Capacity

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CEC Cation Exchange Capacity

- Usually calculated by sum of cations from soil test.
- Dedicated CEC test using a double wash method would be more accurate – especially for sandy soils.
- Best way to manage would be to add organic matter such as compost or peat. These will increase CEC. I've never heard of someone trying to decrease CEC.

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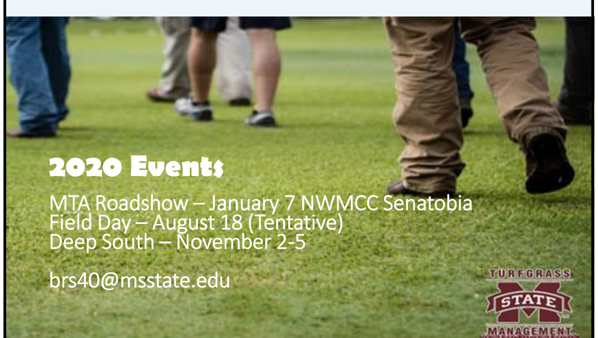

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