Soil Management ...
Soil Management …

Chapters 3, 4 and 5
Highlights …

• Soil texture  (Slide 12)
• Soil structure  (Slide 41)
• Effects on moisture availability  (Slide 47)
  – (Pore space)
• pH and nutrients  (Slide 85, 91)
Introduction – Why should I care?
Introduction – Why should I care?

• Different soil types have unique properties
Introduction – Why should I care?

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• Those properties, along with environment, affect tree survival and growth
Introduction – Why should I care?

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• Planting the wrong tree for the site is a waste of time and $
Introduction – Why should I care?

• Different soil types have unique properties
• Those properties, along with environment, affect tree survival and growth
• Planting the wrong tree for the site is a waste of time and $
• Soil physical properties – the first thing to know about a site
What do you see?

Barnes soil

Bowdle soil

Photos courtesy of Dave Hopkins, NDSU
Soil components
Soil components

• Solids and pores
Soil components

• Solids and pores
  – Solids – Minerals + Organic matter
Soil components

• Solids and pores
  – Solids – Minerals + Organic matter
  – Pores – Water + Air
Soil components

• Solids and pores
  – Solids – Minerals + Organic matter
  – Pores – Water + Air
  – Ideal soil – Even mix of solids and pores ...
Mineral 45%
Water 20-30%
Organic 5%
Air 20-30%

Brady, 1990
Soil components

- Solids and pores
  - Solids – Minerals + Organic matter
  - Pores – Water + Air
  - Ideal soil – Even mix of solids and pores ...

- Note:
  - Minerals – Sand (largest), silt, clay (smallest)
Soil components

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• Note:
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Soil components

• Solids and pores
  – Solids – Minerals + Organic matter
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  – Ideal soil – Even mix of solids and pores ...

• Note:
  – Minerals – Sand (largest), silt, clay (smallest)
  – Pores – Even mix of water and air
  – Organic matter is good stuff ...
Organic Matter – Quiz

What does organic matter do for, or provide to, the soil?

• A. Change soil texture.
• B. Increase water holding capacity.
• C. Disperse particles, decreasing aggregation.
• D. Decrease nutrient availability.
• E. None of the above.
Organic Matter – Quiz

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• E. None of the above.
Organic matter

- Holds onto water
- Great source of nutrients
- Binds soil particles together into larger aggregates
Texture
Texture

- Relative amount of sand, silt and clay only
Texture

- Relative amount of sand, silt and clay only
  - Lots of one part – soil named by that part
Texture

- Relative amount of sand, silt and clay only
  - Lots of one part – soil named by that part
    - e.g., 20% sand, 20% silt, 60% clay – clay
Texture

• **Relative amount** of sand, silt and clay only
  – Lots of one part – soil named by that part
    • e.g., 20% sand, 20% silt, 60% clay – **clay**
    • e.g., 12% sand, 82% silt, 6% clay – **silt**
Texture

• **Relative amount** of sand, silt and clay only
  – Lots of one part – soil named by that part
  – Mixtures are called loams
Texture

• **Relative amount** of sand, silt and clay **only**
  – Lots of one part – soil named by that part
  – Mixtures are called loams
    • e.g., 40% sand, 40% silt, 20% clay – **loam**
Texture

• **Relative amount of sand, silt and clay only**
  – Lots of one part – soil named by that part
  – Mixtures are called loams
    • e.g., 40% sand, 40% silt, 20% clay – **loam**
    • e.g., 33% sand, 33% silt, 34% clay – **clay loam**
Texture triangle
Fig. 3.5, p. 39
Example:
20% sand
60% clay
20% silt
Example:
20% sand
60% clay
20% silt
Example:
20% sand
60% clay
20% silt
Example:
20% sand
60% clay
20% silt
Example:
20% sand
60% clay
20% silt
Clay soil
Example:
62% sand
15% clay
23% silt
???? soil
Example:
62% sand
15% clay
23% silt
sandy loam soil
Texture

- **Relative amount** of sand, silt and clay only
Texture

- Relative amount of sand, silt and clay only
- What about ‘structure’?
Organic matter

- Holds onto water
- Great source of nutrients
- Binds soil particles together into larger aggregates

**aggregates**
Organic matter

- Holds onto water
- Great source of nutrients

Structure = arrangement of soil particles into aggregates
- Hard to define or describe in numbers
Organic matter

- Holds onto water
- Great source of nutrients

Structure = arrangement of soil particles into aggregates
- Hard to define or describe in numbers
- Building aggregates → building structure
  - *** Organic matter, and time ***
Organic matter

- Holds onto water
- Great source of nutrients

Structure = arrangement of soil particles into aggregates

- Hard to define or describe in numbers
- Building aggregates ➔ building structure
  - *** Organic matter, and time ***
- Destroying aggregates ➔ destroying structure
  - Excessive tilling or cultivation
  - Compacting a wet soil
Organic matter

- Holds onto water
- Great source of nutrients
- Binds soil particles together into larger aggregates
- And aggregates affect pore space
Organic matter

- Holds onto water
- Great source of nutrients
- Binds soil particles together into larger aggregates
- And aggregates affect pore space
- And pore space affects water availability
Pore Space
Pore Space

- Size matters
Pore Space

- Size matters – macropores and micropores
Pore Space

• Size
  – Macropores – large, water drains easily
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly
Pore Space

• Size
  – Macropores – large, water drains easily
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• Texture effects
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects
  – Sands – lots of macropores
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects
  – Sands – lots of macropores
  – Clays – lots of micropores
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects
  – Sands – lots of macropores
  – Loam – mixture of macro- and micropores
  – Clays – lots of micropores
Pore Space

• **Size**
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• **Structure** effects
  – Sands – lots of macropores
  – Loam – mixture of macro- and micropores
  – Clays – lots of micropores
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Structure effects
  – Sands – lots of macropores
  – Loam – mixture of macro- and micropores
  – Clays – lots of micropores

Soils with “good”, “well-developed” structure
Soils with “bad”, poorly-developed structure
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture-structure effects
  – Sands – lots of macropores
  – Loam – mixture of macro- and micropores
  – Clays – lots of micropores

Effect on infiltration and water availability?

Soils with “good”, “well-developed” structure
Soils with “bad”, poorly-developed structure
Water drains out of macropores

Field capacity

Available water

Soil moisture, $\theta$ (volume %)

Fineness of texture

Sand
Sandy loam
Loam
Silt loam
Clay loam
Clay

Brady, 1990
Water drains out of macropores

Field capacity

Available water

Wilting coefficient

Soil moisture, (\(\theta\)) (volume %)

Fineness of texture

Sand  Sandy loam  Loam  Silt loam  Clay loam  Clay
Water drains out of macropores

Field capacity

Available water

Water held tightly in micropores

Wilting coefficient

Soil moisture, $\theta$ (volume %)

Fineness of texture

Sand
Sandy loam
Loam
Silt loam
Clay loam
Clay

Brady, 1990
Water drains out of macropores

Field capacity

Available water

Water held tightly in micropores

Soil moisture, (θ) (volume %)

Fineness of texture

Sand Sandy loam Loam Silt loam Clay loam Clay

Brady, 1990
Effect of soil texture on available water?

Water drains out of macropores

Field capacity

Available water

Water held tightly in micropores

Wilting coefficient

Effect of soil texture on available water?
Water drains out of macropores

Field capacity

Available water

Water held tightly in micropores

Soil moisture, $\theta$ (volume %)

Fineness of texture

Sand, Sandy loam, Loam, Silt loam, Clay loam, Clay
Why is available water low in sandy soil?

Brady, 1990

Field capacity

Water drains out of macropores

Water held tightly in micropores

Wilting coefficient

Available water

Fineness of texture

Sand
Sandy loam
Loam
Silt loam
Clay loam
Clay

Volume %

0
10
20
30
40

Sandy

Loam

Clay loam

Clay

Why is available water low in sandy soil?
Why is available water low in clay soil?
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects

• Where do roots grow?
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects

• Where do roots grow?

• “Bulk density” – an indicator of pore space
Bulk density = \frac{(Weight of soil particles)}{(Volume of soil (solids + pores))}
Bulk density = \frac{(\text{Weight of soil particles})}{(\text{Volume of soil (solids + pores))}}
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Texture effects

• Where do roots grow?

• “Bulk density” – an indicator of pore space
  – Compaction –
    • Decreases pore space, esp. macropores
    • Increases bulk density
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Continuity – Water drains better if soil texture is consistent and continuous
The sponge example
The sponge example
The sponge example
The sponge example
The sponge example
The sponge example
The sponge example
The sponge example
Pore Space

• Size
  – Macropores – large, water drains easily
  – Micropores – small, water held tightly

• Continuity – Water drains better if soil texture is consistent and continuous

Or …
Water does not move well from one soil texture to another
Common practice — Add sand or gravel to bottom of planting hole to improve drainage.
Common practice – Add sand or gravel to bottom of planting hole to improve drainage.

Myth! Clay layer must be saturated before water begins to drain into sand.
What about the opposite: sandy soil over or into heavy clay soils?
What about the opposite: sandy soil over or into heavy clay soils?
What about the opposite: sandy soil over or into heavy clay soils?
What about the opposite: sandy soil over or into heavy clay soils?

It’s like planting the tree in a teacup …
pH
pH

- A measure of acidity/alkalinity
pH

• A measure of acidity/alkalinity

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<td>Neutral</td>
<td>Base</td>
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pH

• A measure of acidity/alkalinity

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• Average pH of ND soils?
Soil pH levels, upland positions, non-manured sites, 1998. (Franzen, 1999)
pH

- A measure of acidity/alkalinity
- Average pH of ND soils?
- pH affects nutrient availability
Ideal pH for most trees
What happens when pH > 7?
Fertilizer
Fertilizer

• Needed only to correct deficiencies
  – (e.g., iron)
Treatments don’t always work
Fertilizer

• “Analysis” – 15-12-5 = %N-P-K
Fertilizer

- Generic recommended amount – often based on N (2-4lbs/1000 sf)
Fertilizer

- Problems with fertilizer
Fertilizer

• Problems with fertilizer
  – Where/how to apply?
Where are the fine (absorbing) roots of the tree?
Where are the fine (absorbing) roots of the tree?
Where should fertilizer be applied?
Fertilizer

• Problems with fertilizer
  – Where/how to apply?
  – What is ‘fertilizer burn’?
  – Growth v. defense
  – Growth v. hardiness
Fertilizer

• Problems with fertilizer
  – Where/how to apply?
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Fertilizer

• Problems with fertilizer
  – Where/how to apply?
  – What is ‘fertilizer burn’?
  – Growth v. defense
  – Growth v. hardiness
Jan. 2012
Fertilized tree didn’t harden up for winter
Fertilizer

• Problems with fertilizer
  – Where/how to apply?
  – What is ‘fertilizer burn’?
  – Growth v. defense
  – Growth v. hardiness
  – ➔ When to fertilize?
Highlights …

- Soil texture
- Soil structure
- Effects on moisture availability
- pH and nutrients