Soil Compaction on Campus: How to prevent it… How to correct it

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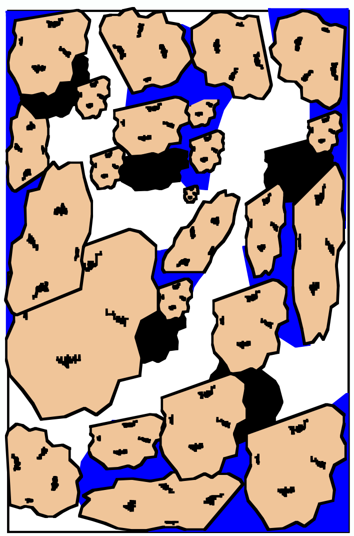
The University of Georgia WARNELL SCHOOL OF FORESTRY & NATURAL RESOURCES

Georgia Tree COUNCIL Sustaining Georgia's Green Legacy

What is Soil Compaction?

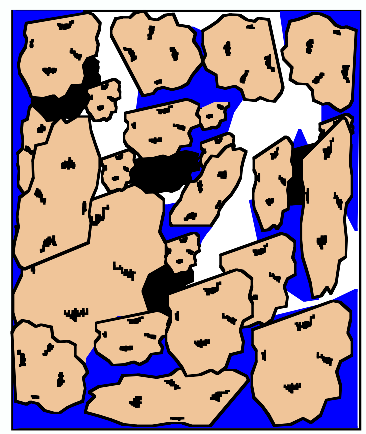
Compression of unsaturated soil that reduces pore space and increased dry mass/volume

Undisturbed



1.32 g/cm3
50% Solid
50% Pores

Compacted



1.60 g/cm3
60% Solid
40% Pores

<u>Key Factors Affected:</u>

Bulk Density ↑

Root Resistance ↑

Pore Space (Air-filled) ↓

Water Infiltration ↓

Slide courtesy of L. Morris

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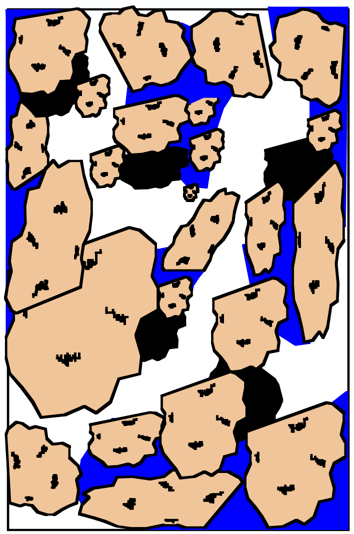

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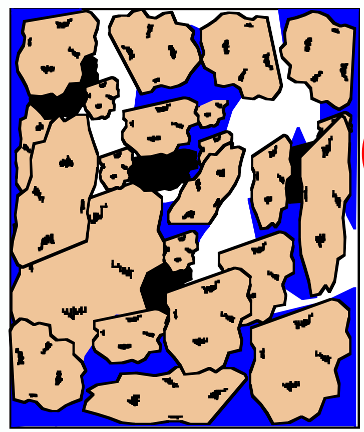

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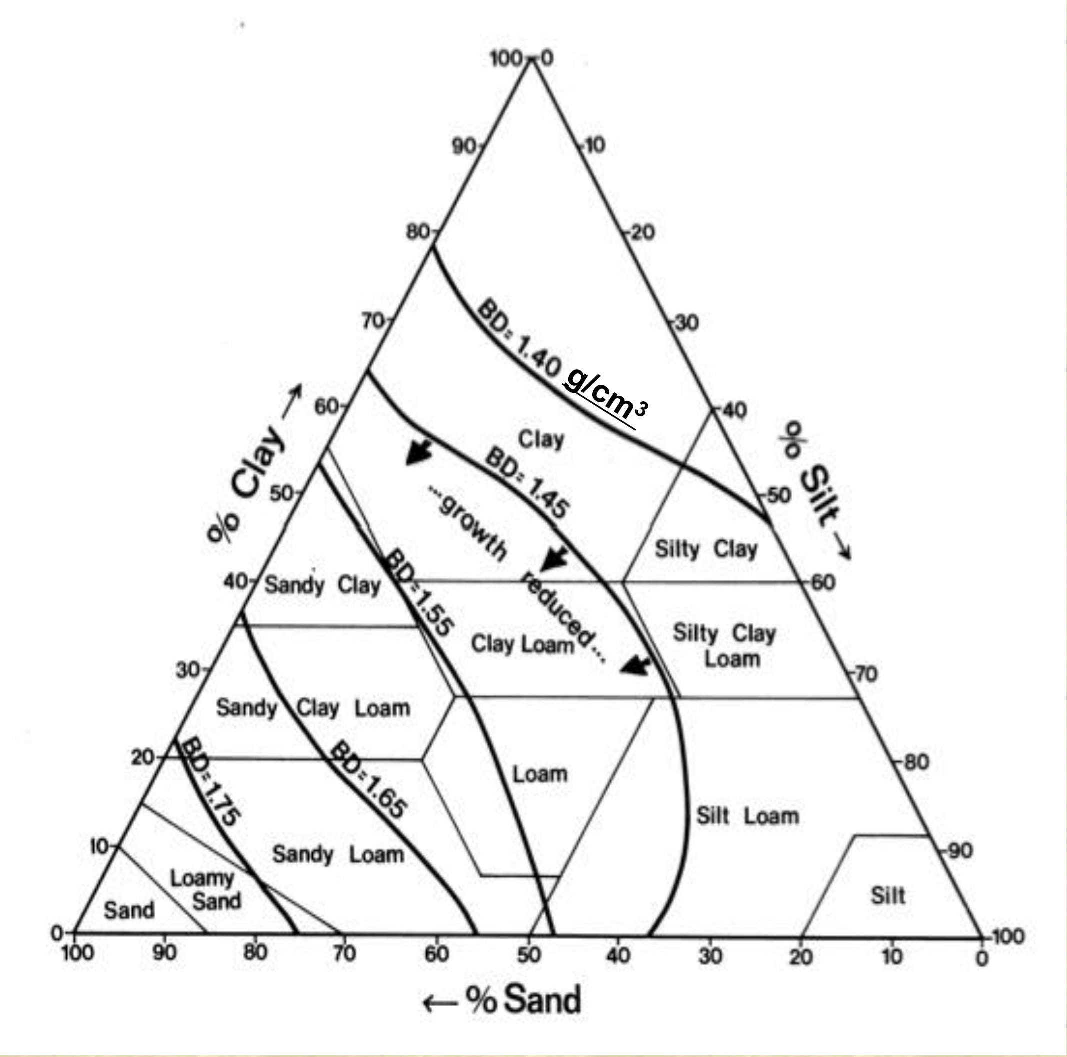
Measuring Compaction

Bulk Density (dry wgt/volume)

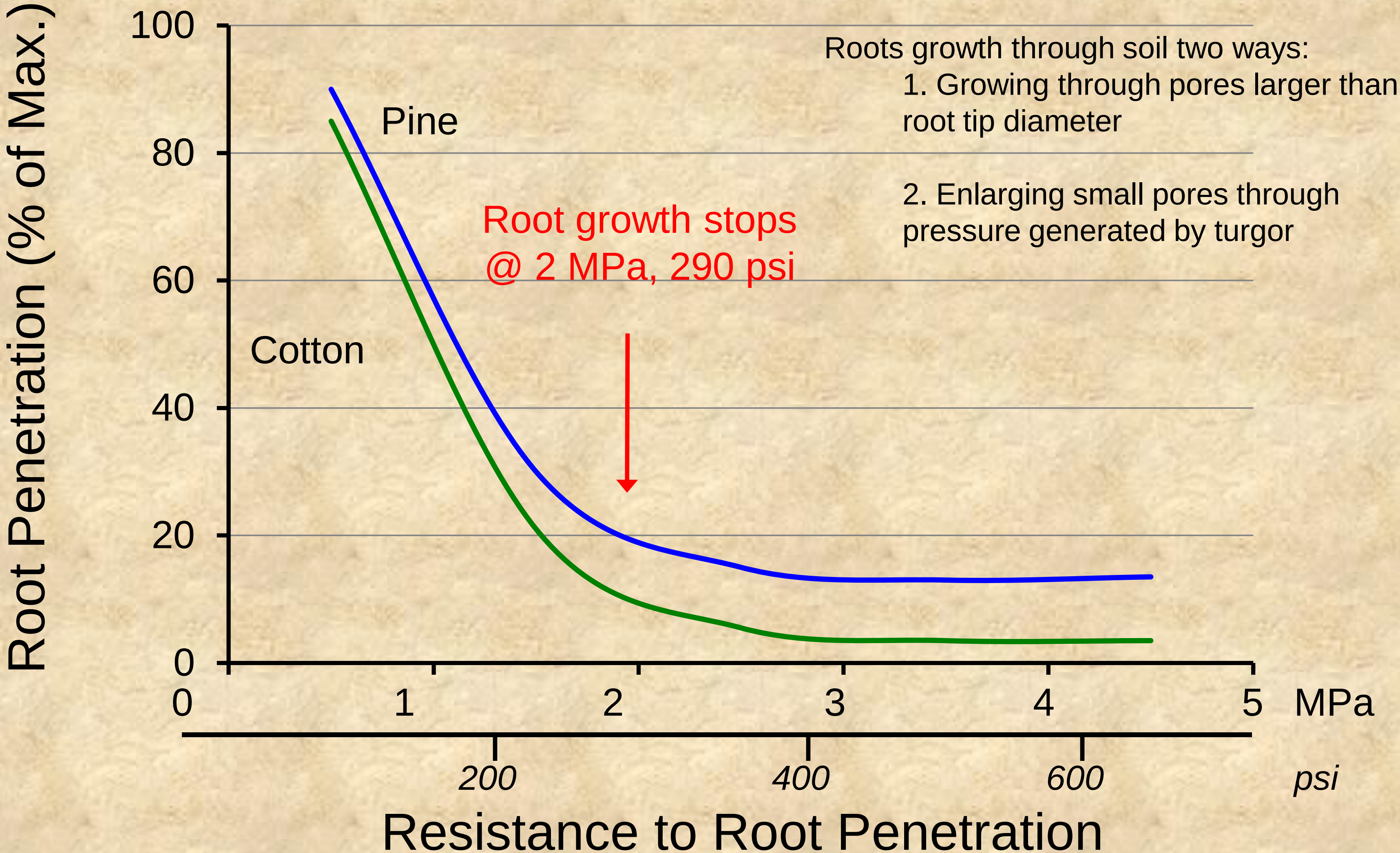


Measuring Compaction

Resistance to Penetration

Roots Can’t Growth in “Hard” Soil

Growth Relationship to Resistance



Adapted from Taylor and Barr 1991, Greacen and Sands 1980

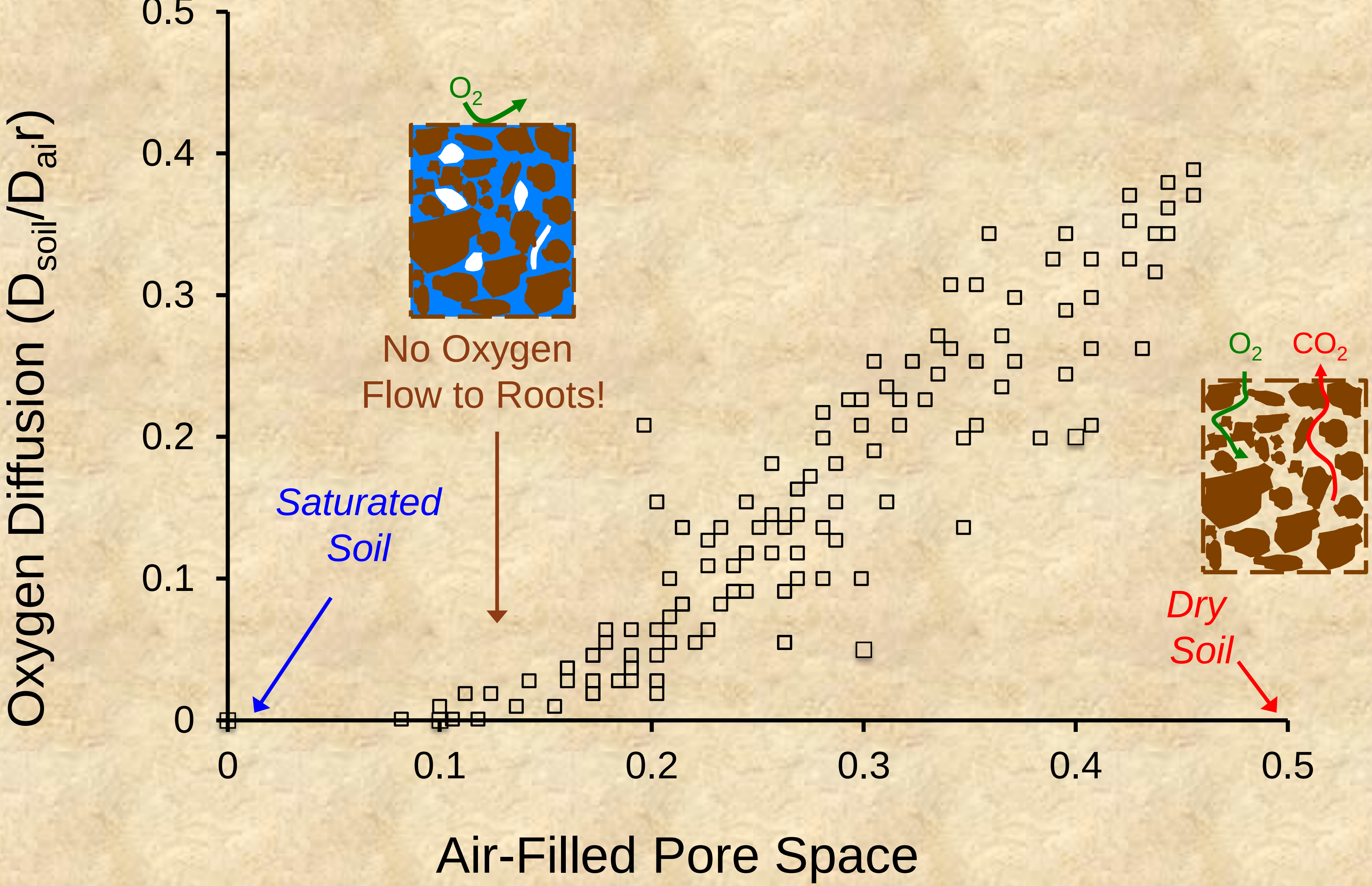
Slide courtesy of L. Morris

Resistance to Root Growth

Slide courtesy of K Fite

Roots Need Oxygen

Growth Relationship to Air-Filled Pores



adapted from Vomocil and Flocker 1961

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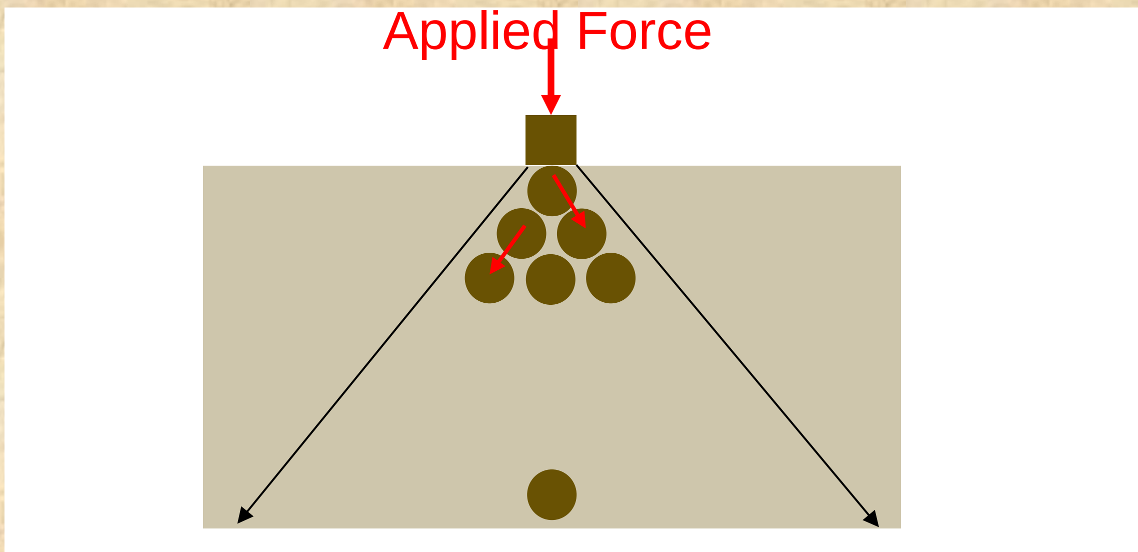
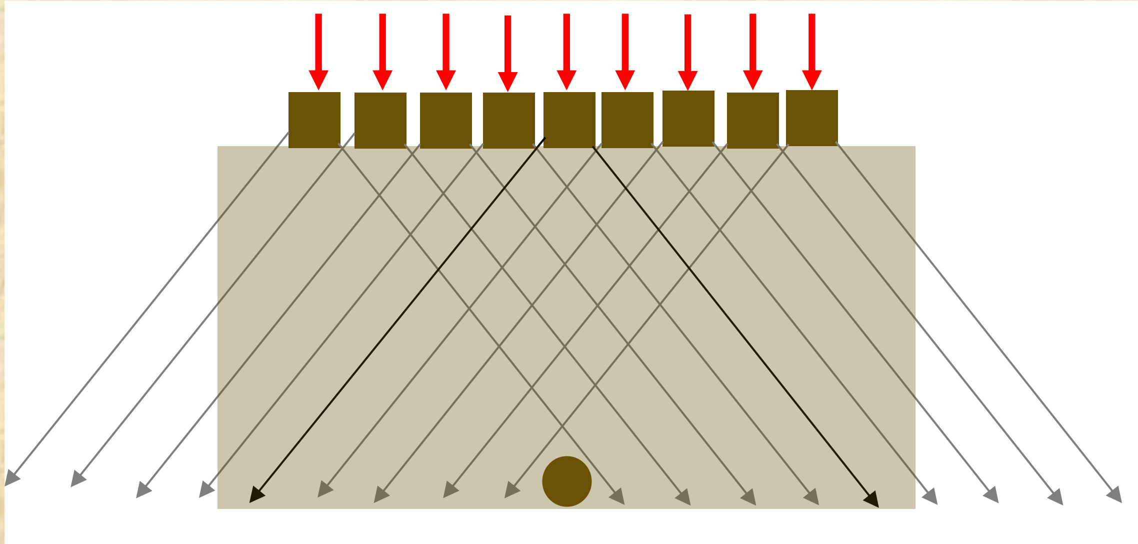
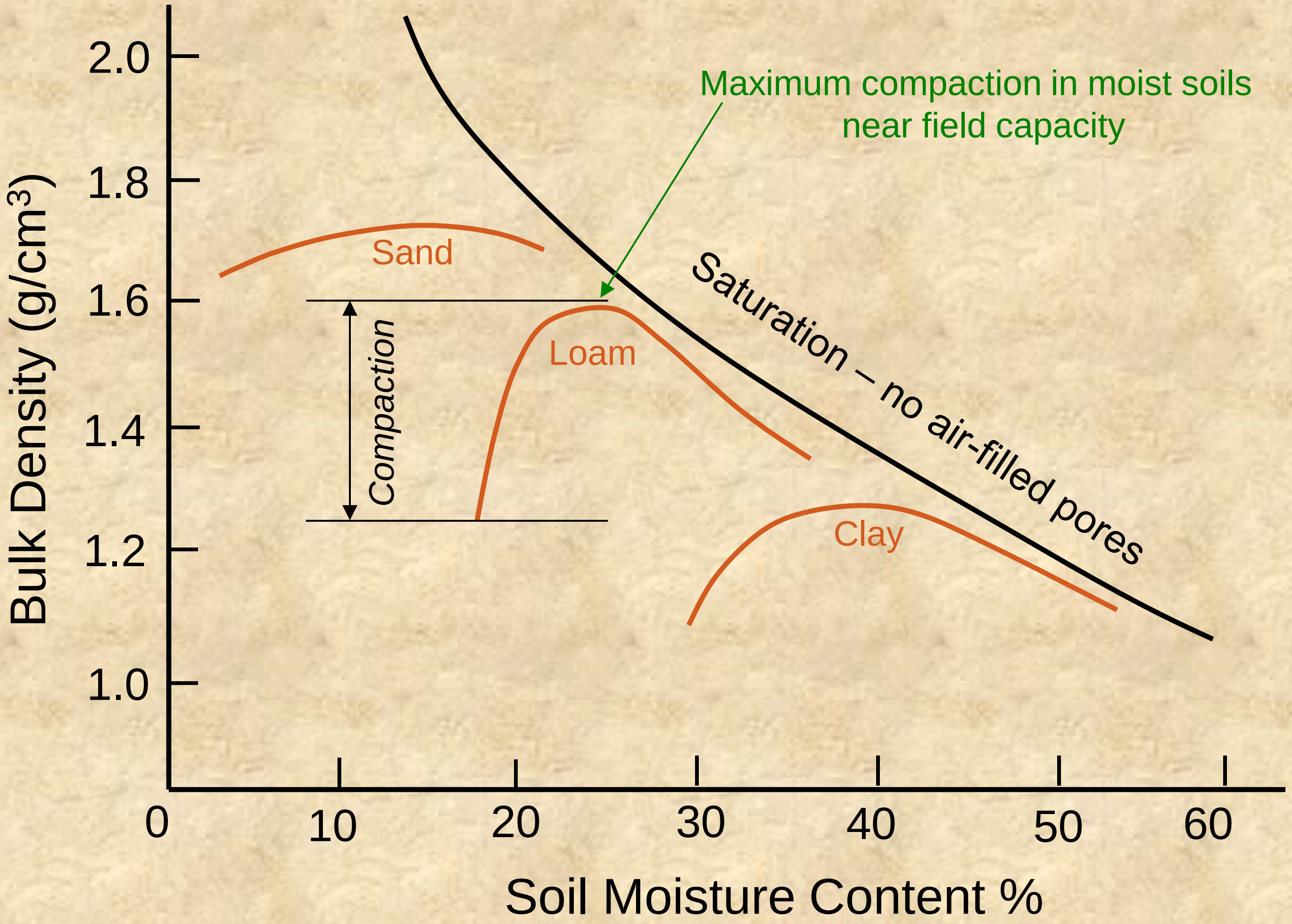
Compaction Process





Soil Moisture – Compaction Relationship

at a defined pressure (load)



Soil Compaction on Campus

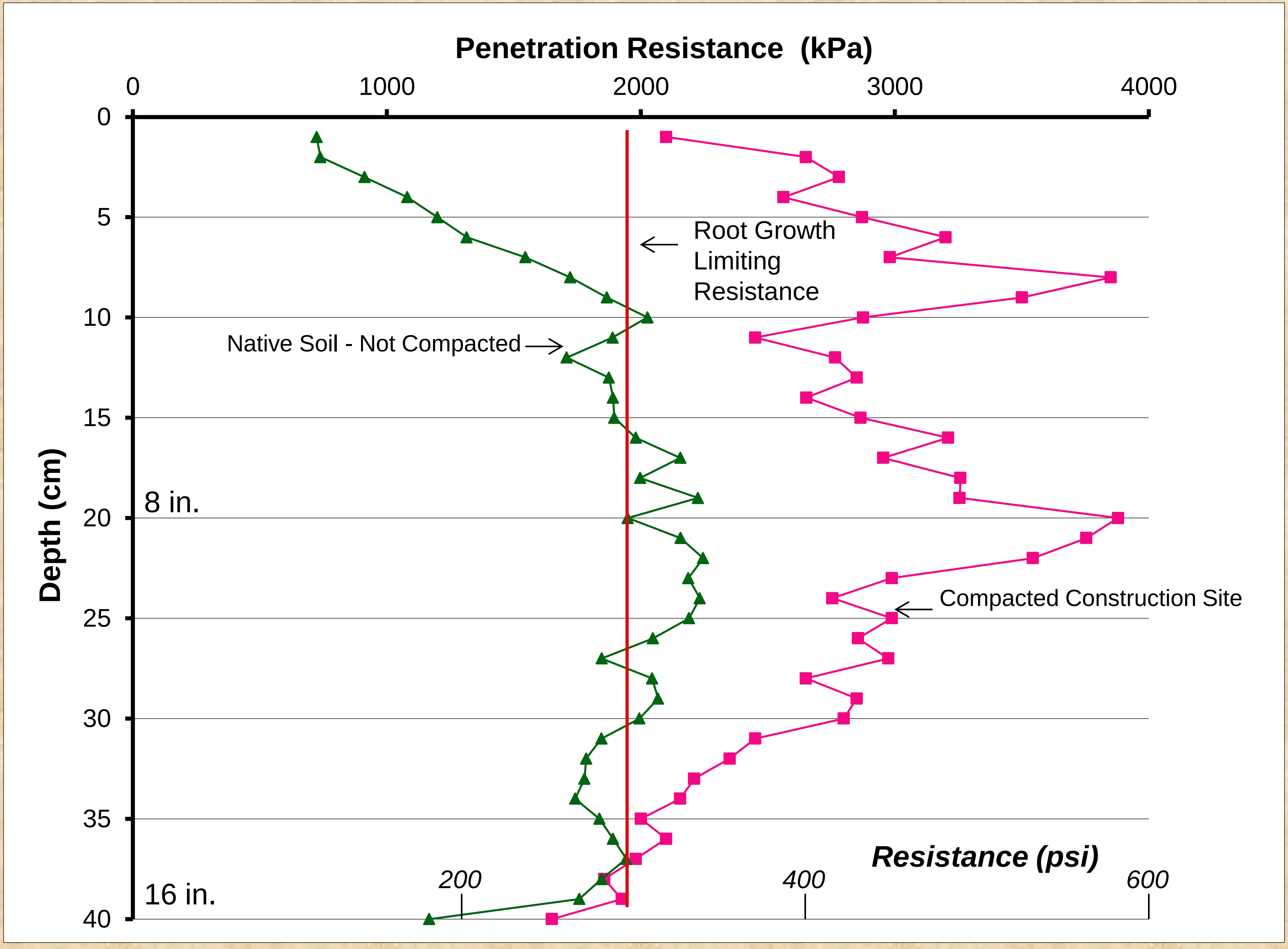
- Construction Legacy (Donors!)
- Pedestrian Traffic (Student Life)
- Game Day Compaction

Slide courtesy of L. Morris

Construction Compaction

Donors and Building = Heavy Vehicles and Equipment

Large Equipment = Deep Compaction



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Pedestrian Traffic
Student Life

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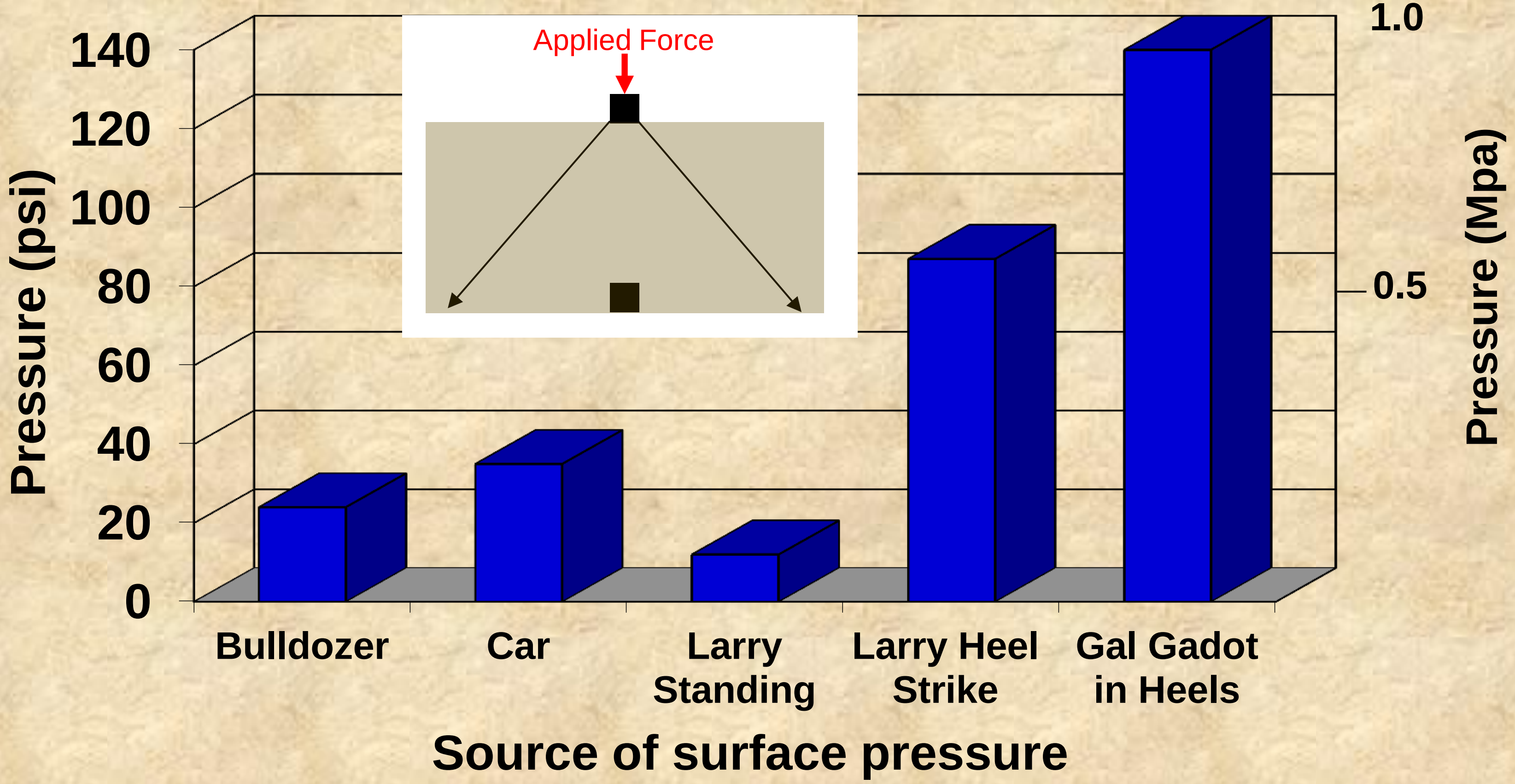
Pedestrian traffic = Surface Compaction



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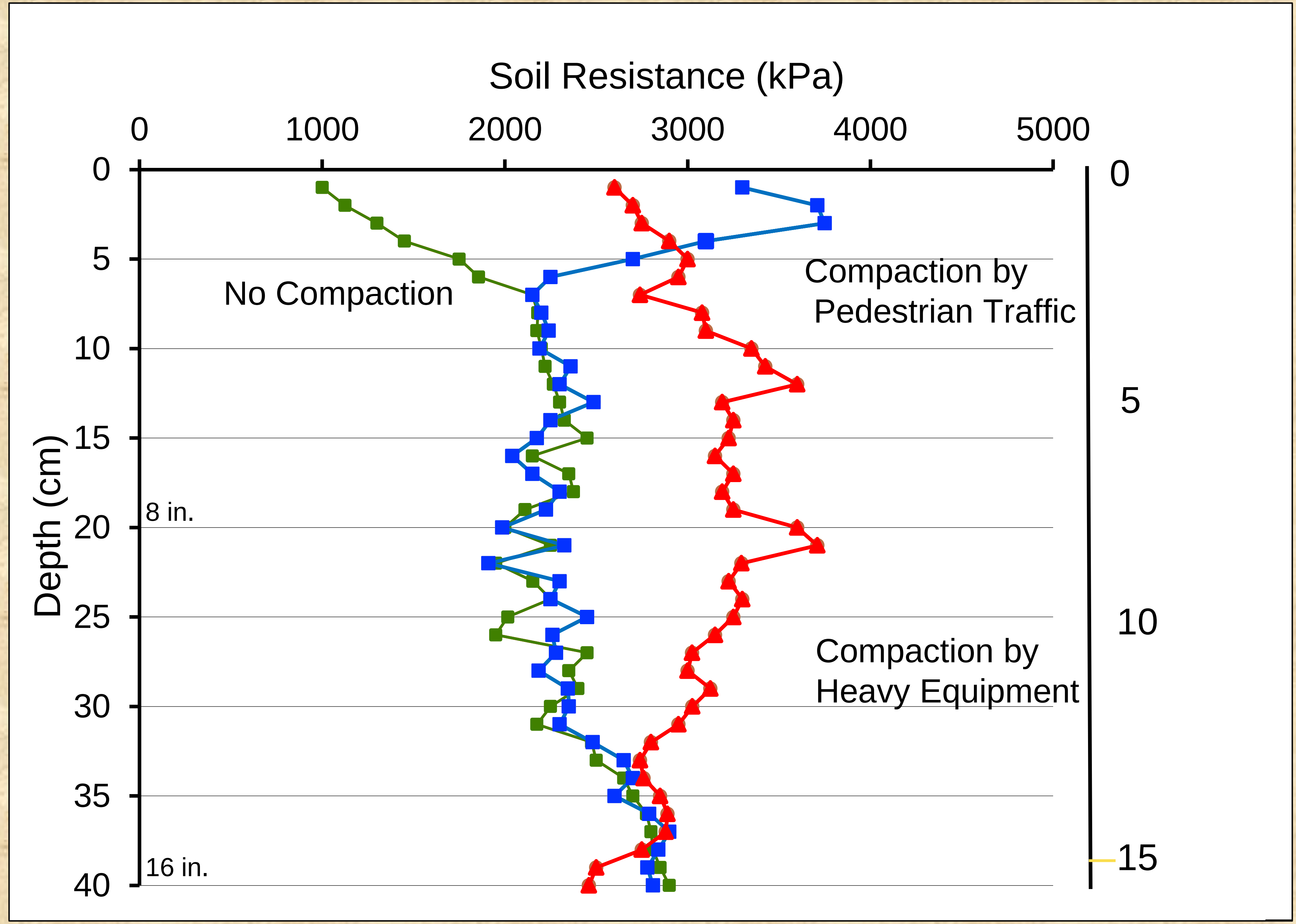


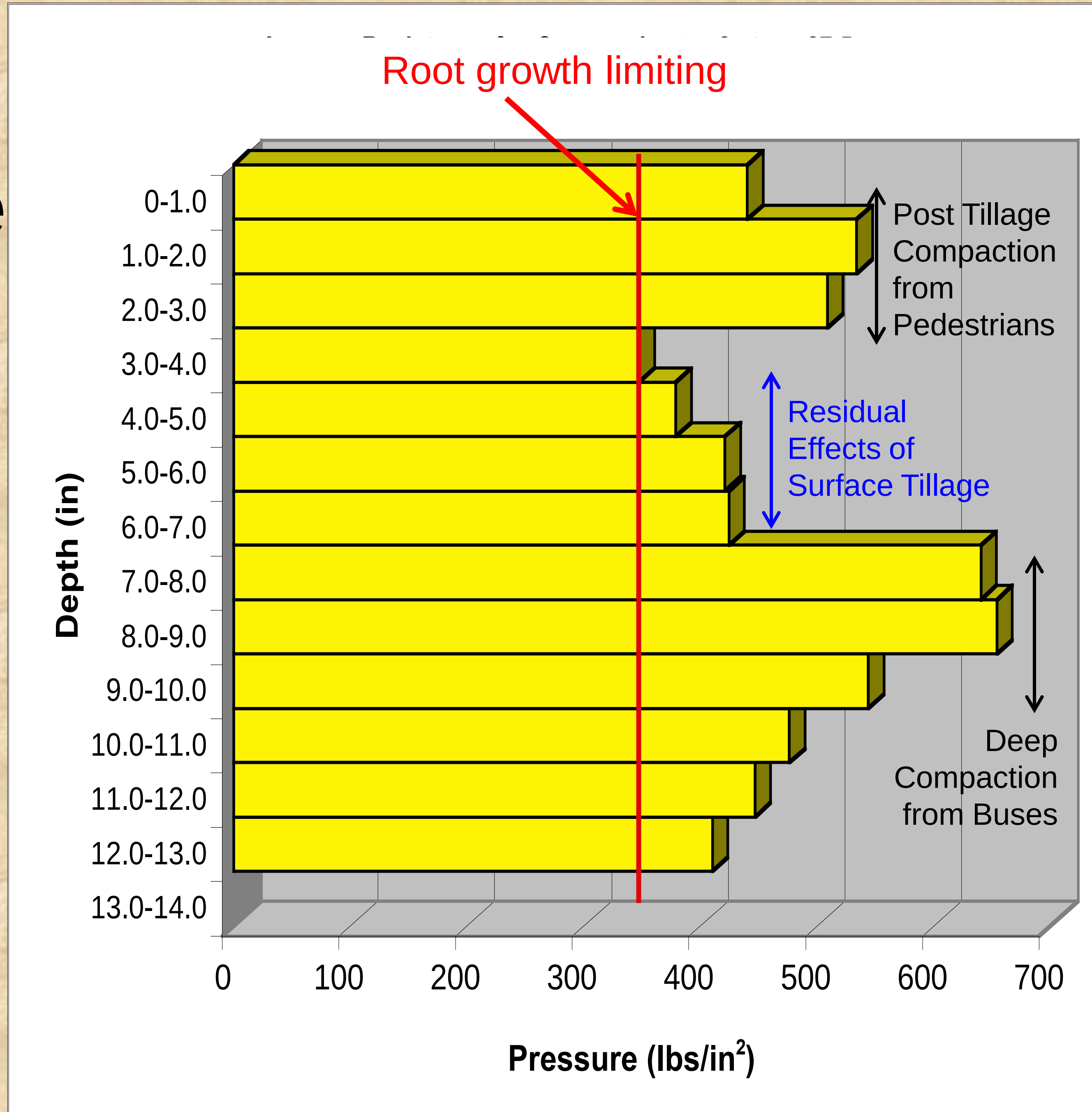
Slide courtesy of L. Morris

Game Day Compaction
Vehicles and Pedestrians

Slide courtesy of L. Morris

Soil Resistance

UGA Bus Stop



Slide courtesy of L. Morris

Avoiding Compaction

1. Protect soil (not just trees) during construction

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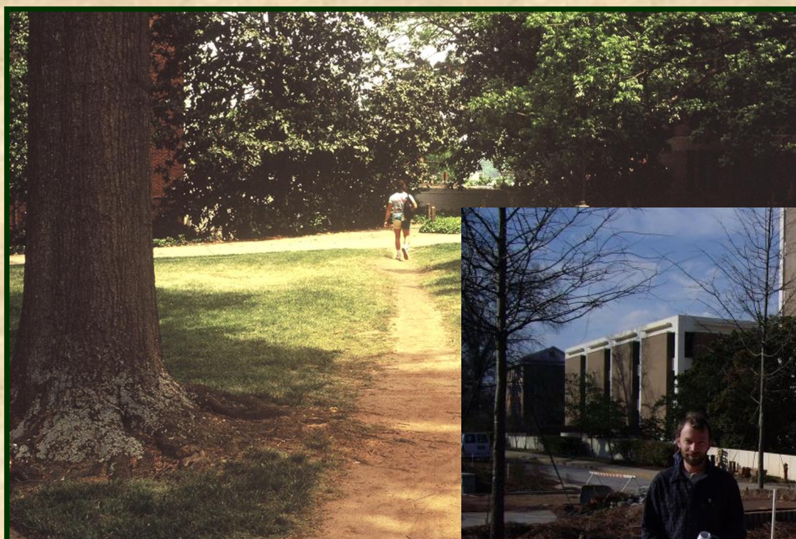
Avoiding Compaction

1. Protect soil (not just trees) during construction
2. Fit hardscape to use patterns – don't expect use pattern to fit hardscape &
3. Landscape to encourage traffic concentration to hardscape



Ameliorating Deep Compaction Prior to Planting

- Disk harrowing/rototilling
  - Conventional disking or rototilling
  - 6-8 in. depth is typical
- Subsoiling/ chisel plowing
  - Shank pulled through soil, lifts and fracture
  - 12-16 inches
- Lift and drop
  - Backhoe used to excavate lift and drop soil back into place
  - Often used to prepare planting beds

Slide courtesy of L. Morris

Disking or Rototilling

Lift and Drop Bed Preparation

Subsoiling

Slide courtesy of L. Morris

Ameliorating Deep Compaction

Pre-planting

Tillage Method	Depth (in.)	Volume (ft^3/100 ft^2)	Reduced Bulk Density/ Resistance
Disking or Rototilling	8	66	Yes
Subsoiling (4 ft. center)	16	21	Yes
Lift and Drop	16	130	Yes

All of these are effective but note:

- *Greater Volumes = greater benefits*
- *Disking/rototilling does not ameliorate deep compaction*
- *Subsoiling needs dry soil, no infrastructure in vicinity*

Slide courtesy of L. Morris

Deep Compaction

This does not replace this

Lift and Drop with Excavator

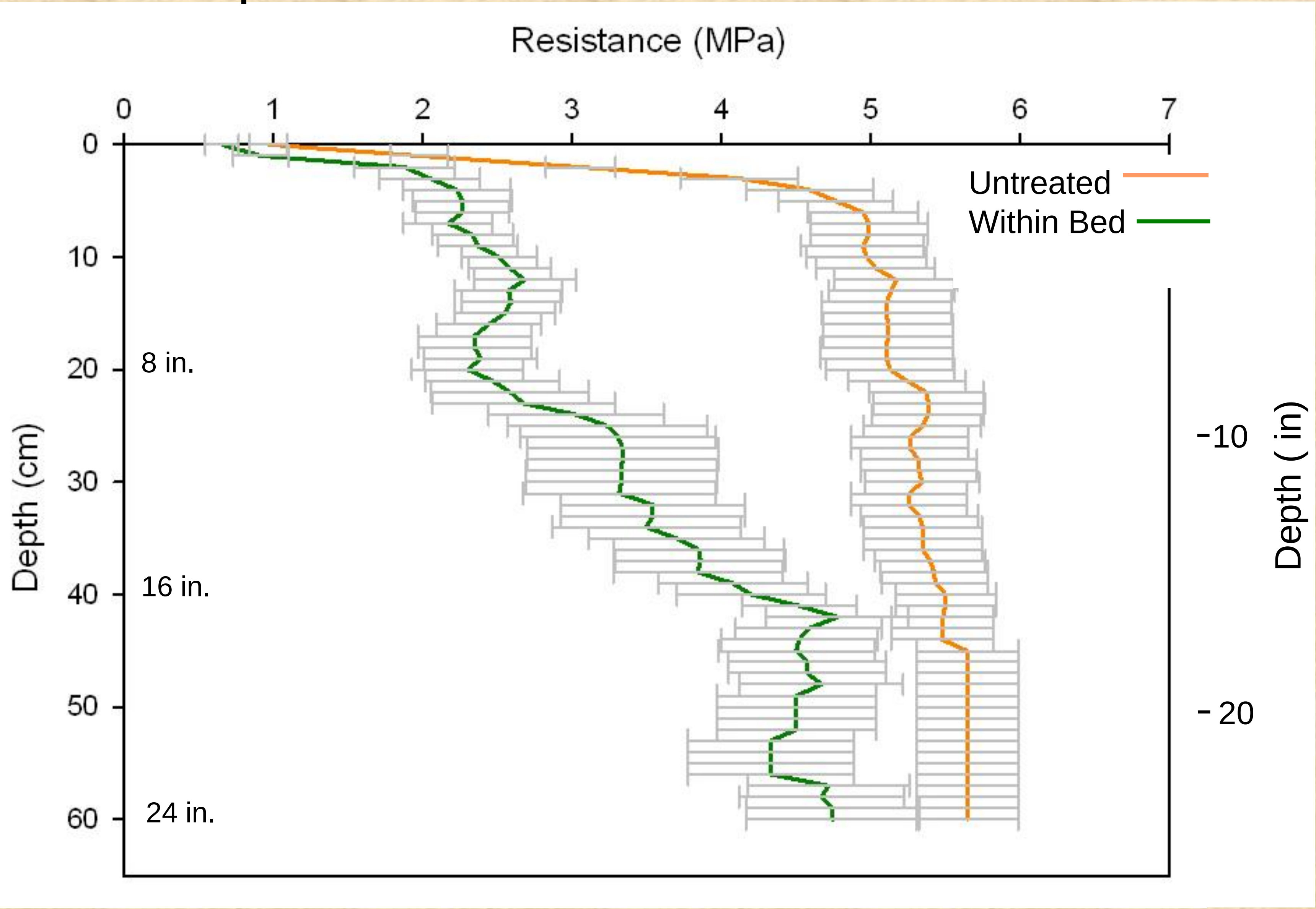
Slide courtesy of L. Morris

Ameliorating Deep Compaction

Pre-planting

Slide courtesy of L. Morris

Lift and Drop Benefits
Compacted Construction Site after 3 Years



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Ameliorating Deep Compaction Established Trees

- Radial Trenching
- Vertical Mulching
    - 4 in. auger holes at regular intervals, usually 6-8 inches
    - Compost/vermiculite/soil spread over the top and into the holes
- Air fracturing
    - Air forced into soil to lift soil, may inject solution
- Air Tillage (Air Spade)
    - Compressed air-tillage over the entire plot area to a depth of about 6-8 in
    - Compost incorporated, mulched on surface

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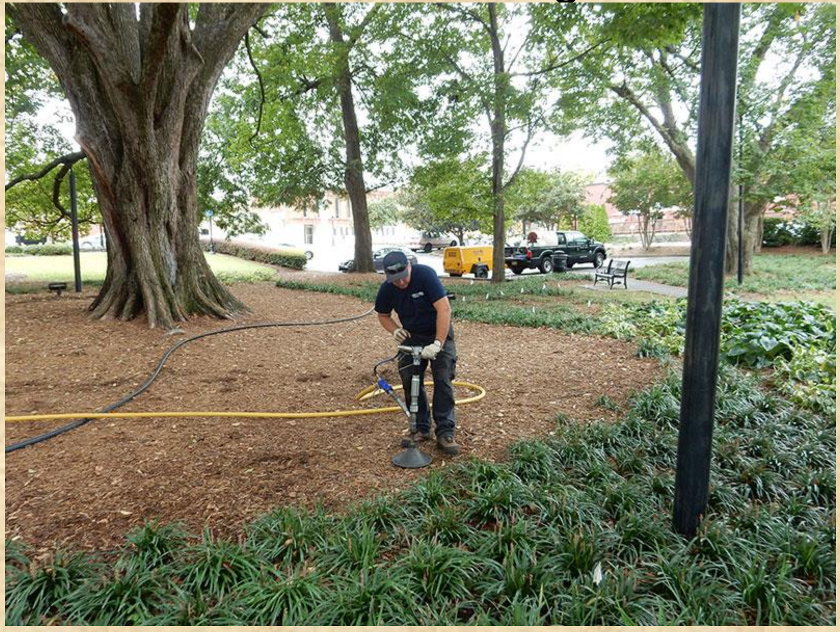
Vertical Mulching

Air Fracturing



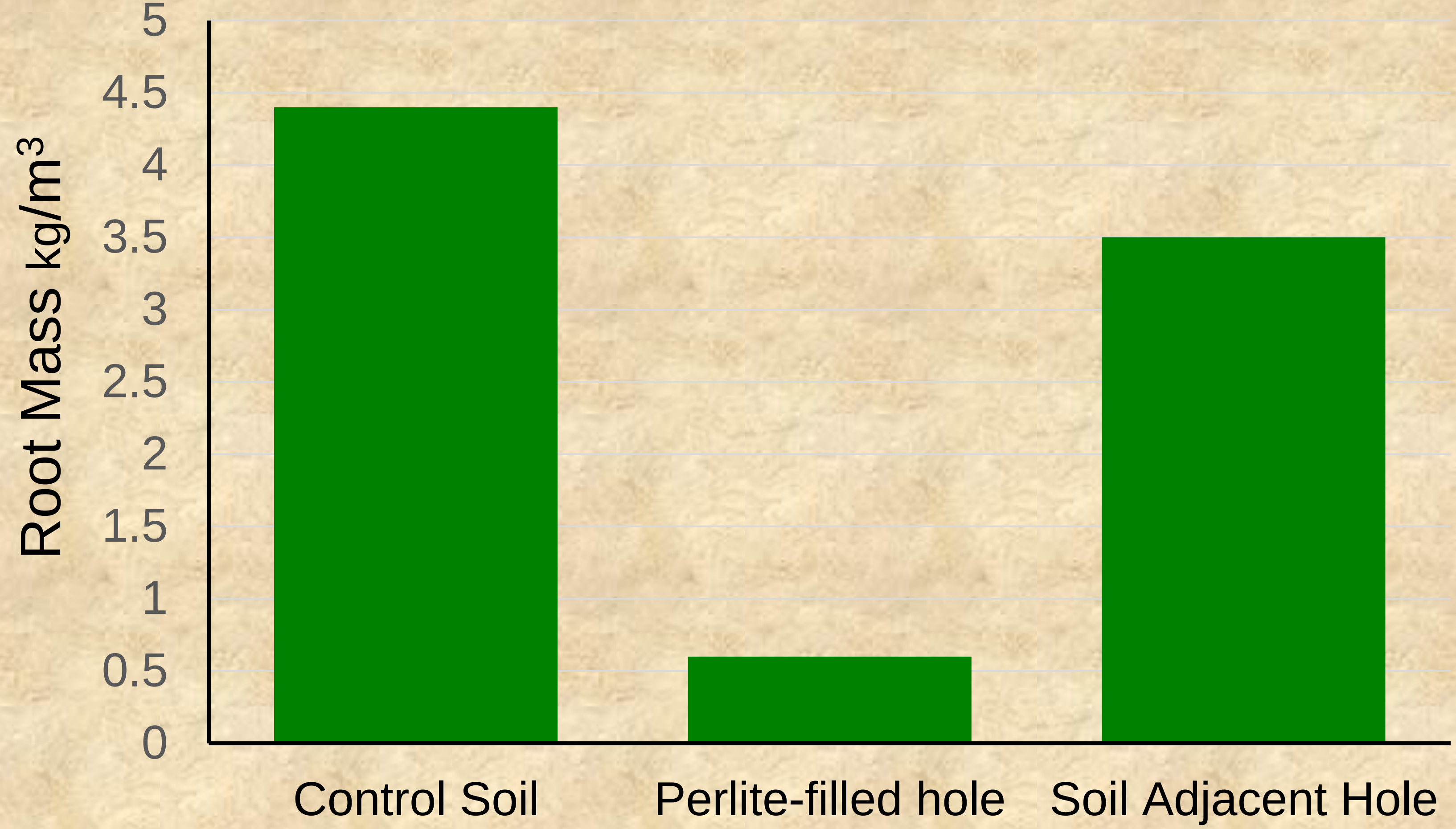
Radial Trenching

https://s3-media2.fl.yelpcdn.com/bphoto/NoG3rUFKXeFq1cIGv_RZyQ/o.jpg

Air tillage(Air Spade™)

Root Growth and Vertical Mulching

3 years after treatment



Slide courtesy of L. Morris; Data source: Kalitz et al. 1994

Ameliorating Shallow Compaction Established Trees

- Compost or compost in combination with Air Tillage

  Encourage natural biota

- Radial Trenching
- Vertical Mulching
  - 4 in. auger holes at regular intervals, usually 6-8 inches
  - Compost/vermiculite/soil spread over the top and into the holes
- Air fracturing
  - Air forced into soil to lift soil, may inject solution
- Air Tillage (Air Spade)
  - Compressed air-tillage over the entire plot area to a depth of about 6-8 in
  - Compost incorporated, mulched on surface

Slide courtesy of L. Morris

Composting Alone

Air tillage(Air Spade™)

Ameliorating Compaction

Established Trees

Tillage Method	Depth (in)	Volume ($ft^3/100\ ft^2$)	Bulk Density/ Resistance Reduced?
Composting	1-2	0 ➔16	Yes (years?)
Radial Trenching (15% area)	12	15	Yes
Vertical Mulching (4” dia., 16” on center)	12	7	Yes/No
Air fracturing (5 ft. on center)	12	8	No
Air tillage (33% area)	8	22	Yes

Slide courtesy of L. Morris

Ameliorating Compaction Established Trees

UGA Case Study

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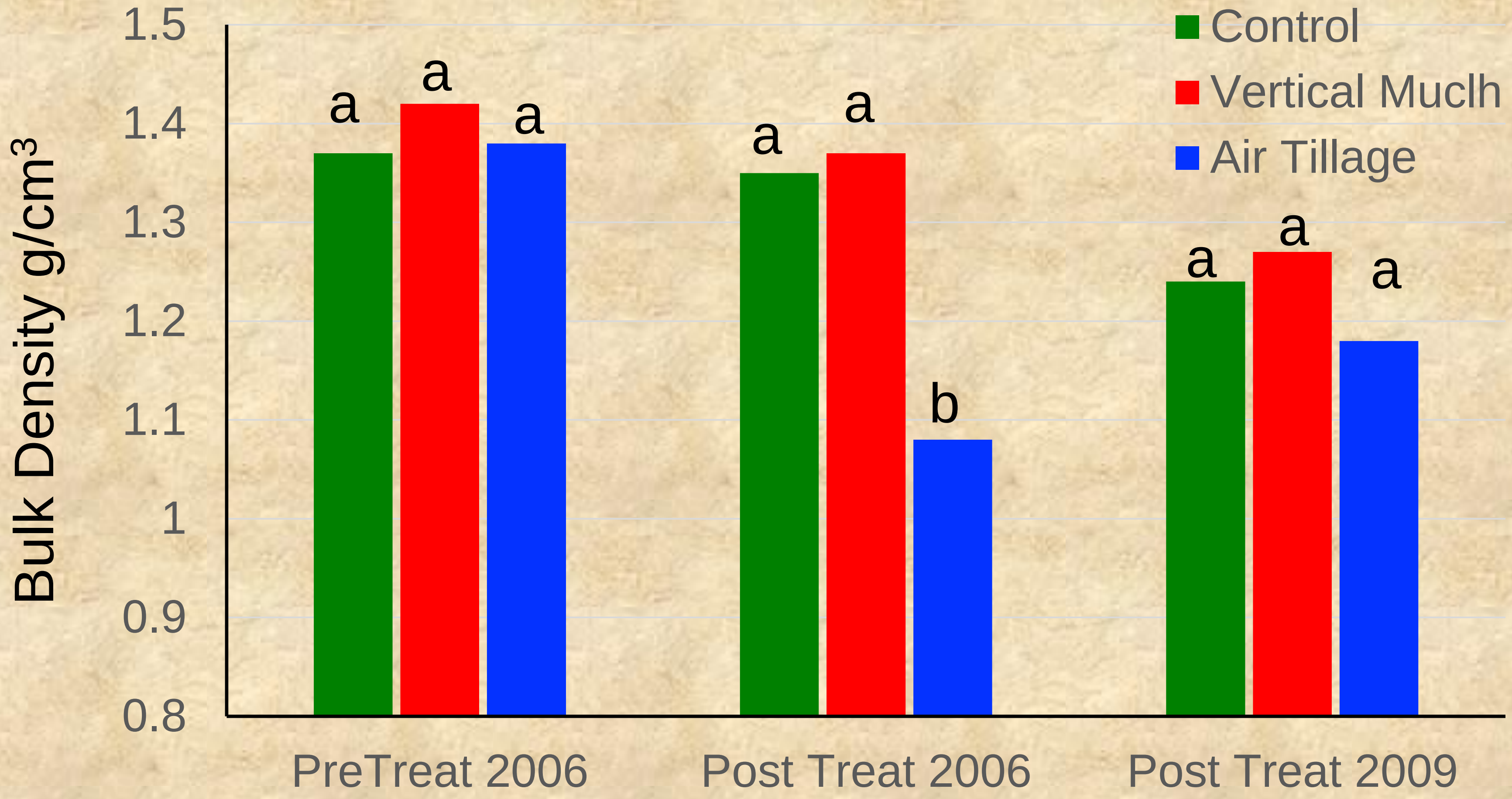
Results: Bulk Density



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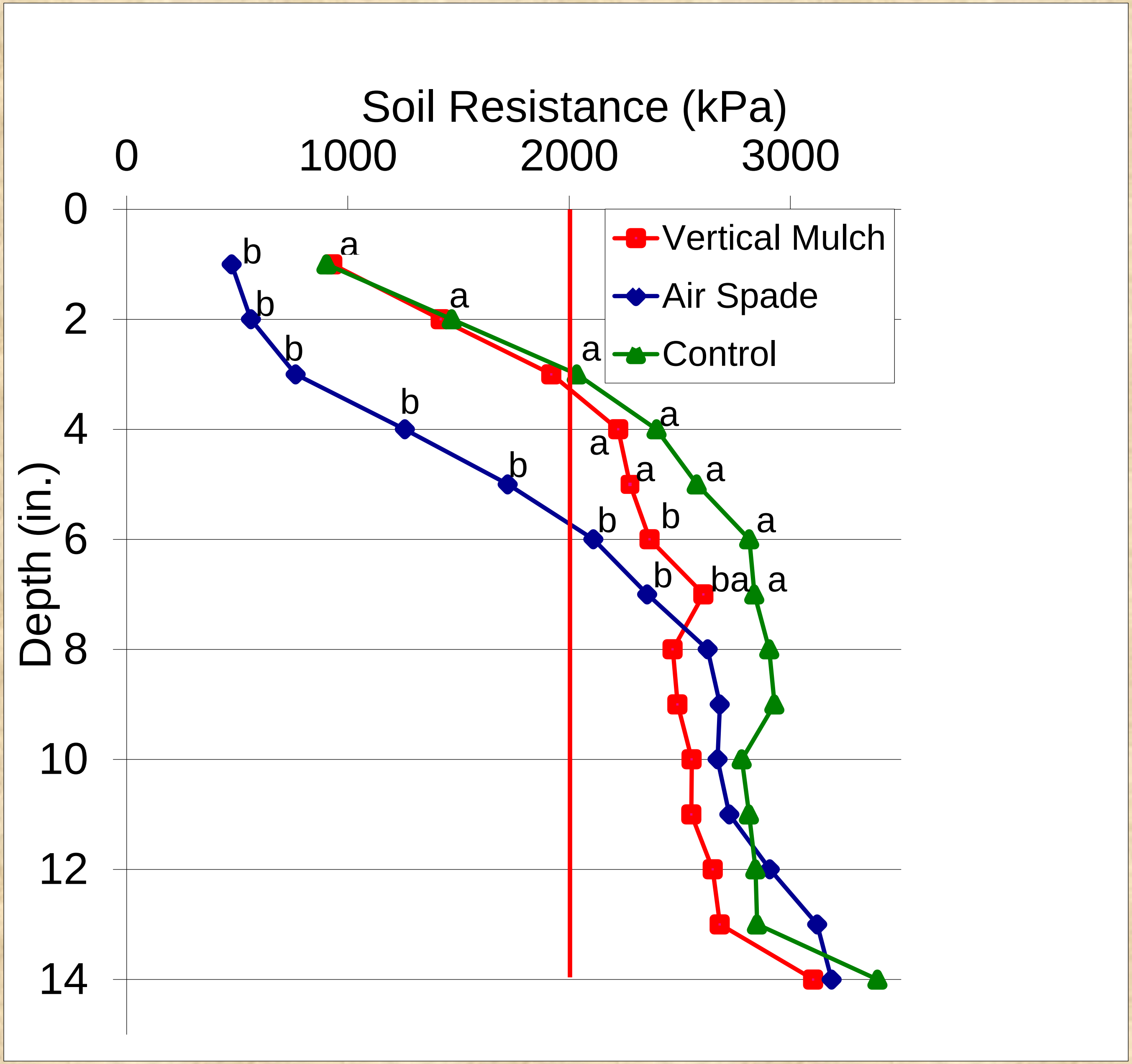
Results: Resistance Just After Treatment (2006)



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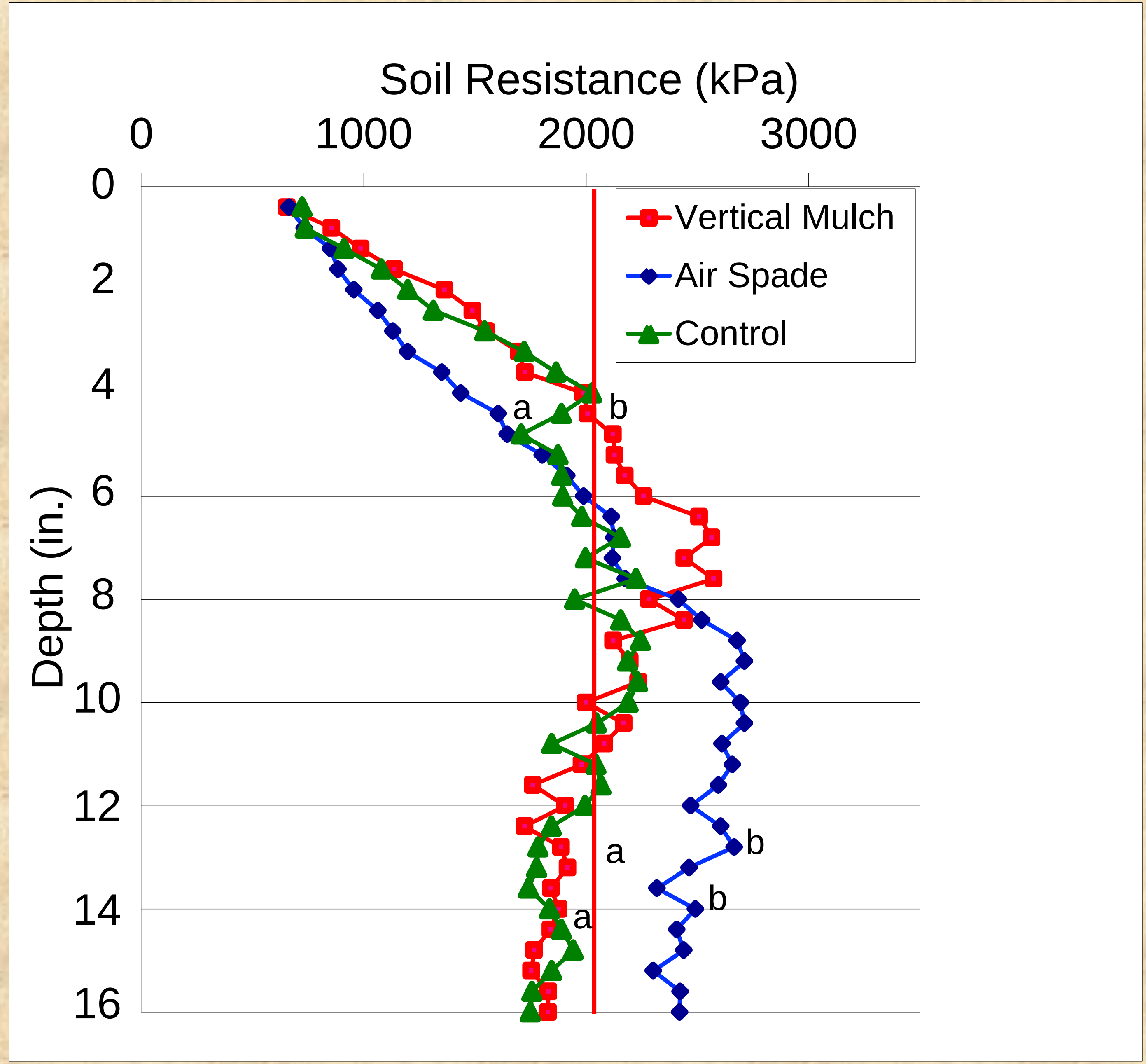
Results: Resistance After 3 Yrs. (2009)



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Recommendations

- Avoid compaction in the first place - Soil protection (not just tree protection) always best
- Prior to planting
  - Deep compaction (subsoil large areas; lift and drop to create planting beds
  - Shallow compaction (disk or rototill)
- Established trees
  - Air tillage (1/3) of area beneath root crown in 3 annual treatments
  - Vertical mulch best when compacted layer (plow pan) penetrated (refill with compost-amended native soil)

Slide courtesy of L. Morris

Recommendations

- For all treatments, discourage continued trafficking (mulch – but this may not be enough, barriers)
- Periodic amelioration may be required on some sites

Slide courtesy of L. Morris

Questions?