

**Cornell University**

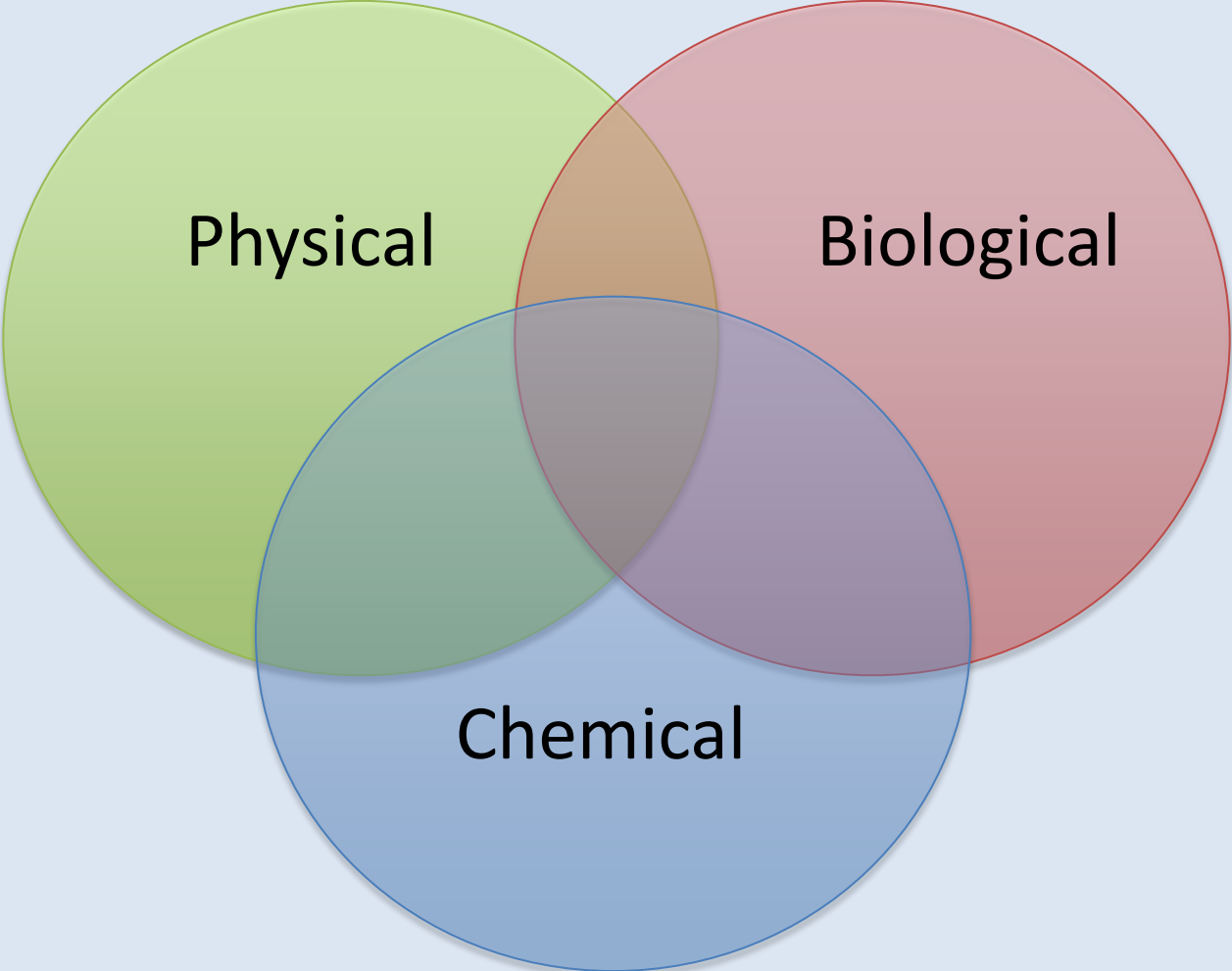
**SOIL HEALTH  
AND  
THE SCOOP & DUMP  
METHOD OF REMEDIATION**

By

Miles S. Sax & Nina Bassuk

**URBAN HORTICULTURE INSTITUTE  
DEPT. OF HORTICULTURE**

# Soil Health



# Soil Health Indicators

- **Physical**
  - Aggregate Stability (%)
  - Water Holding Capacity (m/m)
  - Bulk Density ( $\text{g}/\text{cm}^3$ )
  - Texture
  - Resistance (PSI)
- **Biological**
  - Organic Matter (%)
  - Active Carbon (ppm)
  - Soil Respiration
  - Soil Protein
- **Chemical**
  - pH
  - Nutrients (P,N,K,Ca,Mg,Fe,Mn, Zn)

# What Are Urban Soils?



“Non agricultural man made surface layer more than 50 cm thick that has been produced by mixing, filling, or by contamination of land surface in urban and suburban areas”  
(Bockheim 1974; Craul 1992)



# Urban Soil Characteristics

## Urban soils have distinct characteristics

- High Soil bulk density
- Decrease in Organic Matter
- Poor structure
- High pH
- Low Water Holding Capacity
- Decreased Aggregate Stability
- Inadequate soil depth for root growth
- Decrease in microbial biomass & activity





# Effects of the Scoop & Dump Soil Remediation Technique on Urban Soil Quality





# Scoop & Dump Technique

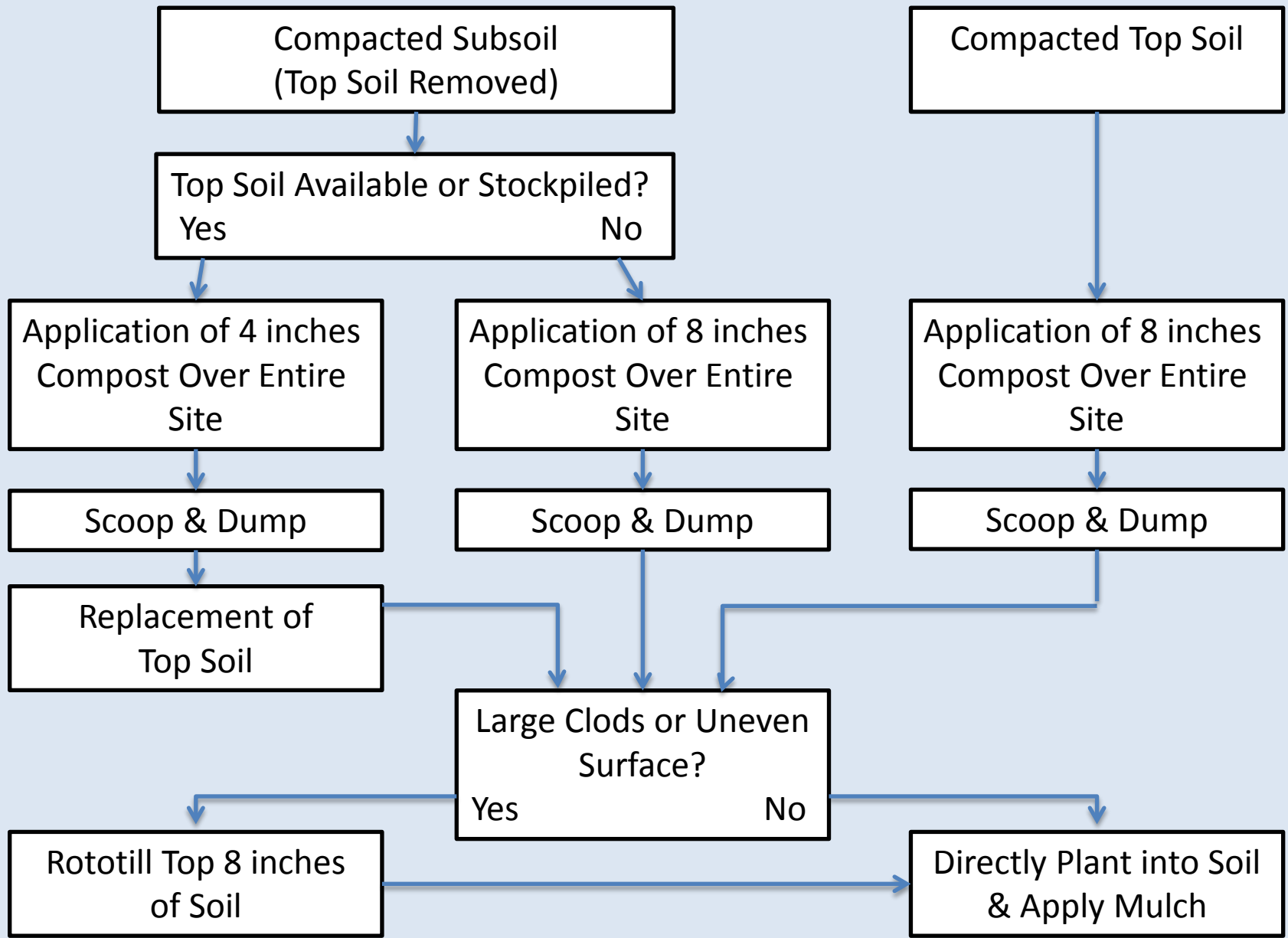


- **Apply 6-8” of compost to compacted soil**
- **Use backhoe bucket to dig down to 18”**
- **Mulched added every year to replenish organic matter**





# Scoop & Dump Work Flow



(Adapted from "The Sustainable Sites Handbook: Chapter 5 Site Design Soils")

# Similar Research & Recommendations

- “Profile Rehabilitation” – Virginia Tech
- Site Design Soils - Sustainable Sites Initiative
- “Soil Modification Fracturing” – Urban Tree Foundation





# Scoop & Dump at Cornell



Creating The Urban Eden

Woody Plant ID & Landscape Establishment Class









2005 5 3









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08.22.2012



# Study Sites

**Roberts  
2009**

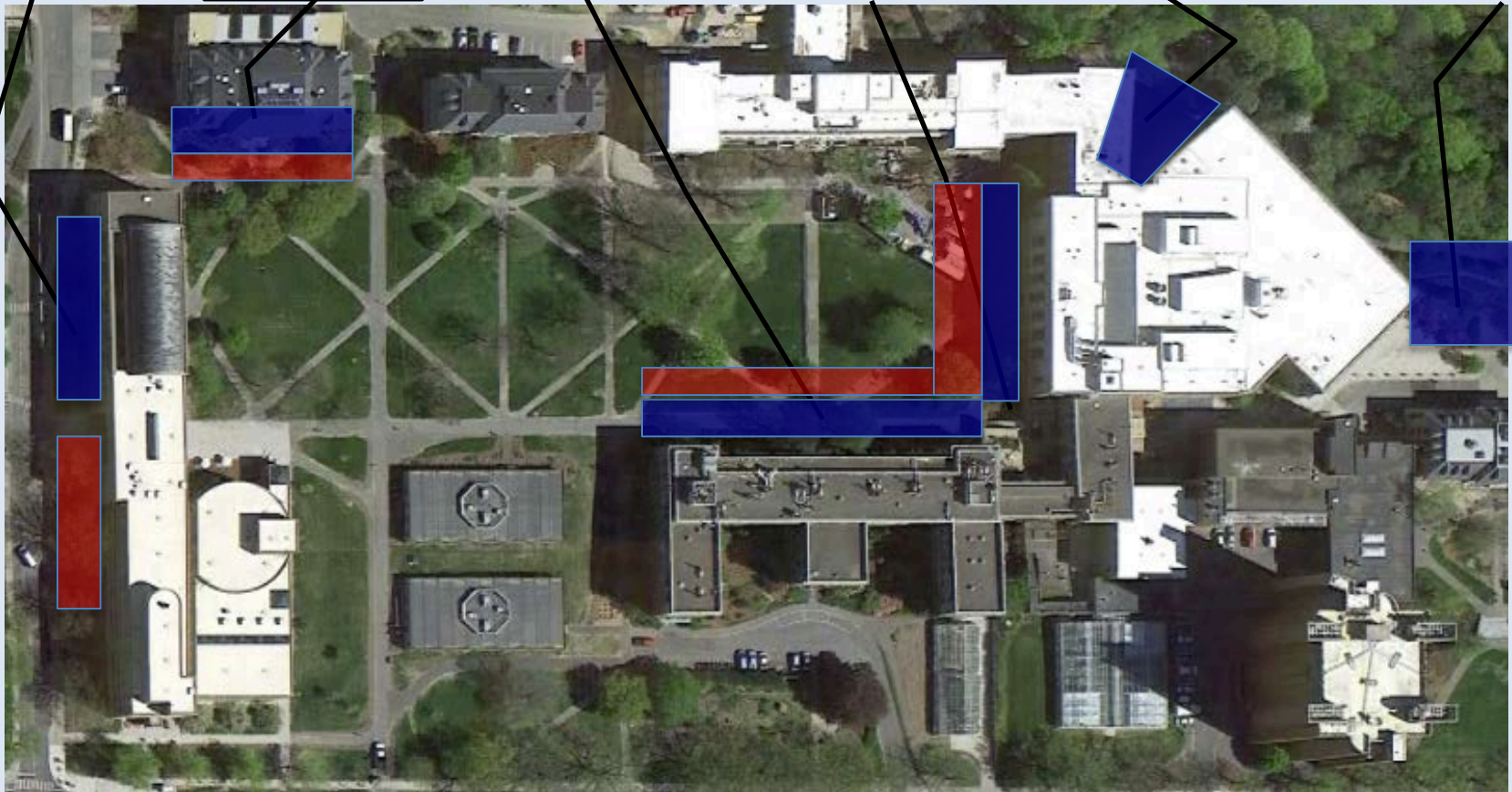
**CCC  
2012**

**Plant  
Science  
2007**

**Mann  
2010**

**Centennial  
2004**

**Fernow  
2001**



**[Blue Rectangle] = Study Site (n=6)**

**[Red Rectangle] = Control (n=4)**

# Scoop & Dump vs. Unamended



Study Site: In garden bed



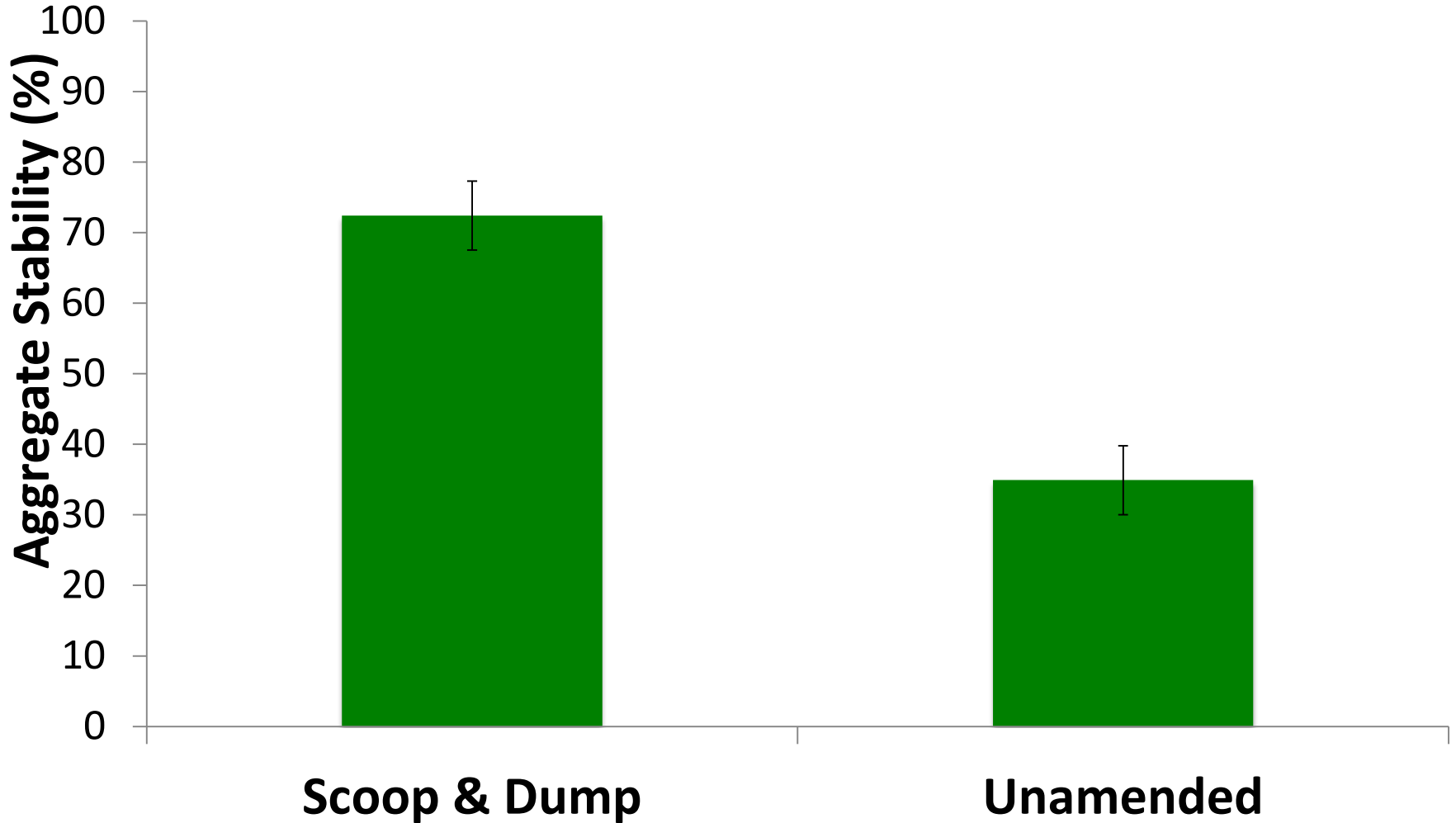
=

Control Site: In turf



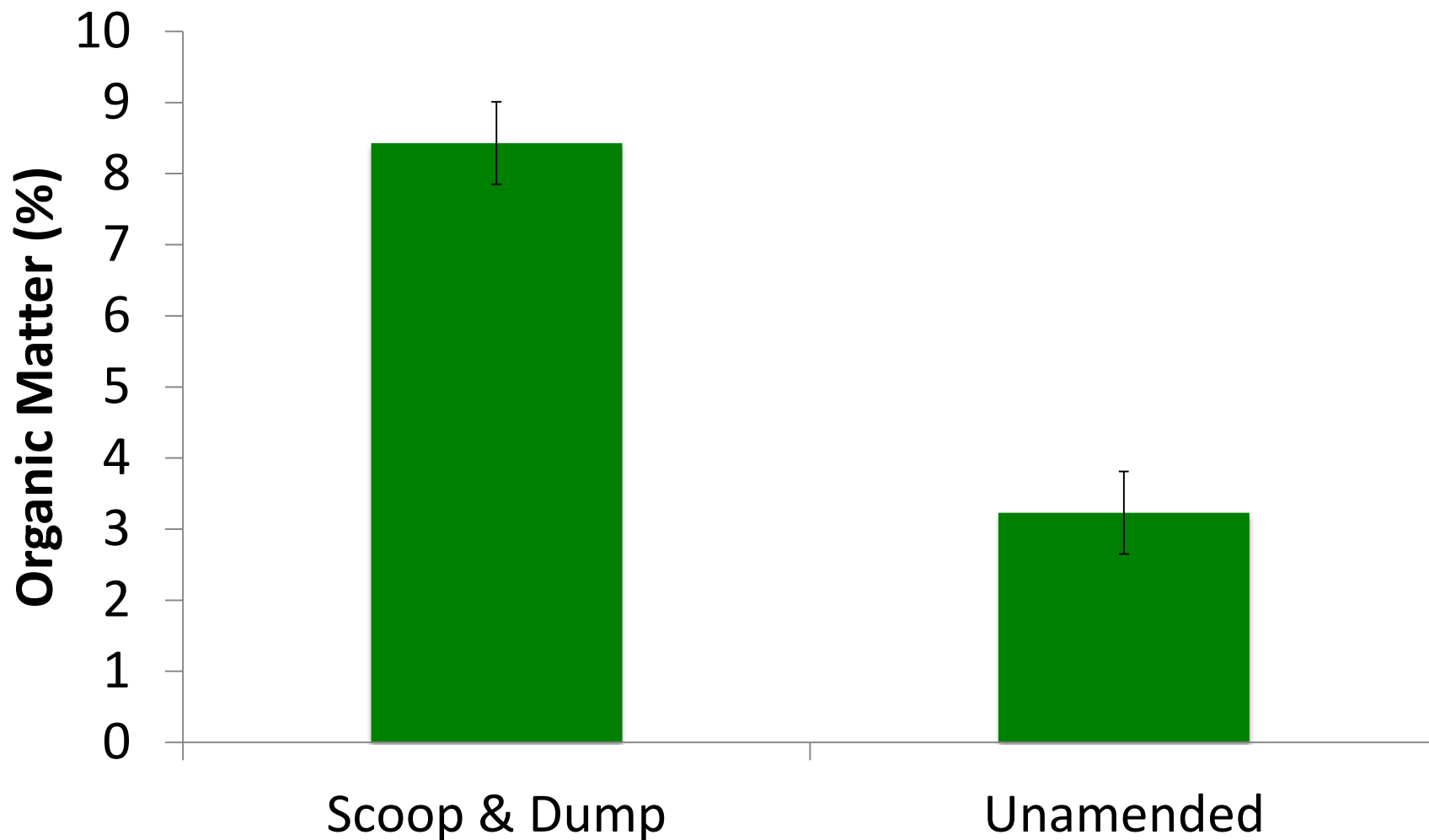


# Aggregate Stability (%) (n=30)



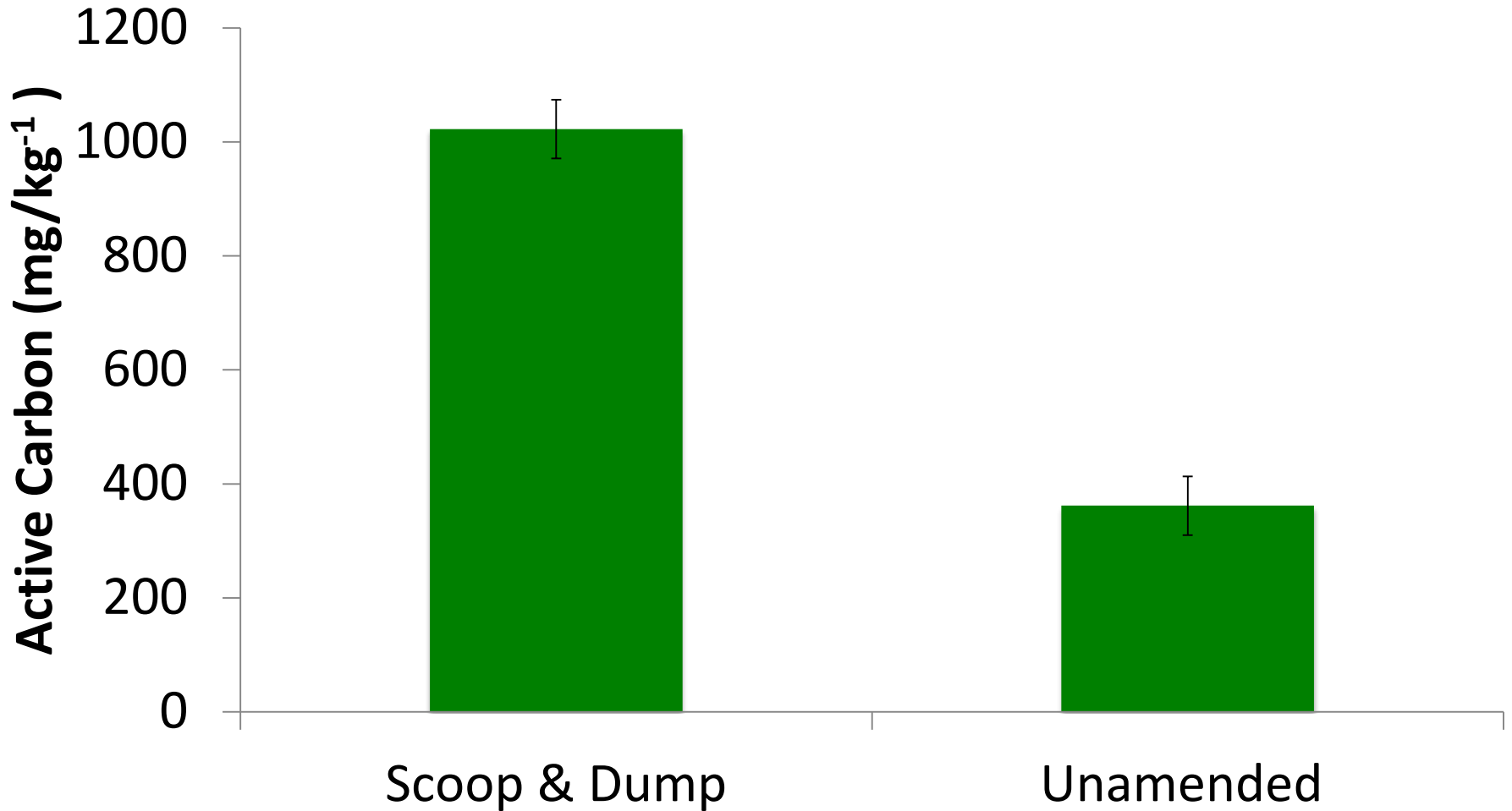
Scoop & Dump	Unamended	Std. Err.	P Value
<b>72.41</b>	<b>34.90</b>	<b>4.88</b>	<b>&lt;.0001</b>

## Organic Matter (%) (n=30)



Scoop & Dump	Unamended	Std. Err.	P Value
<b>8.43</b>	<b>3.23</b>	<b>0.58</b>	<b>&lt;.0001</b>

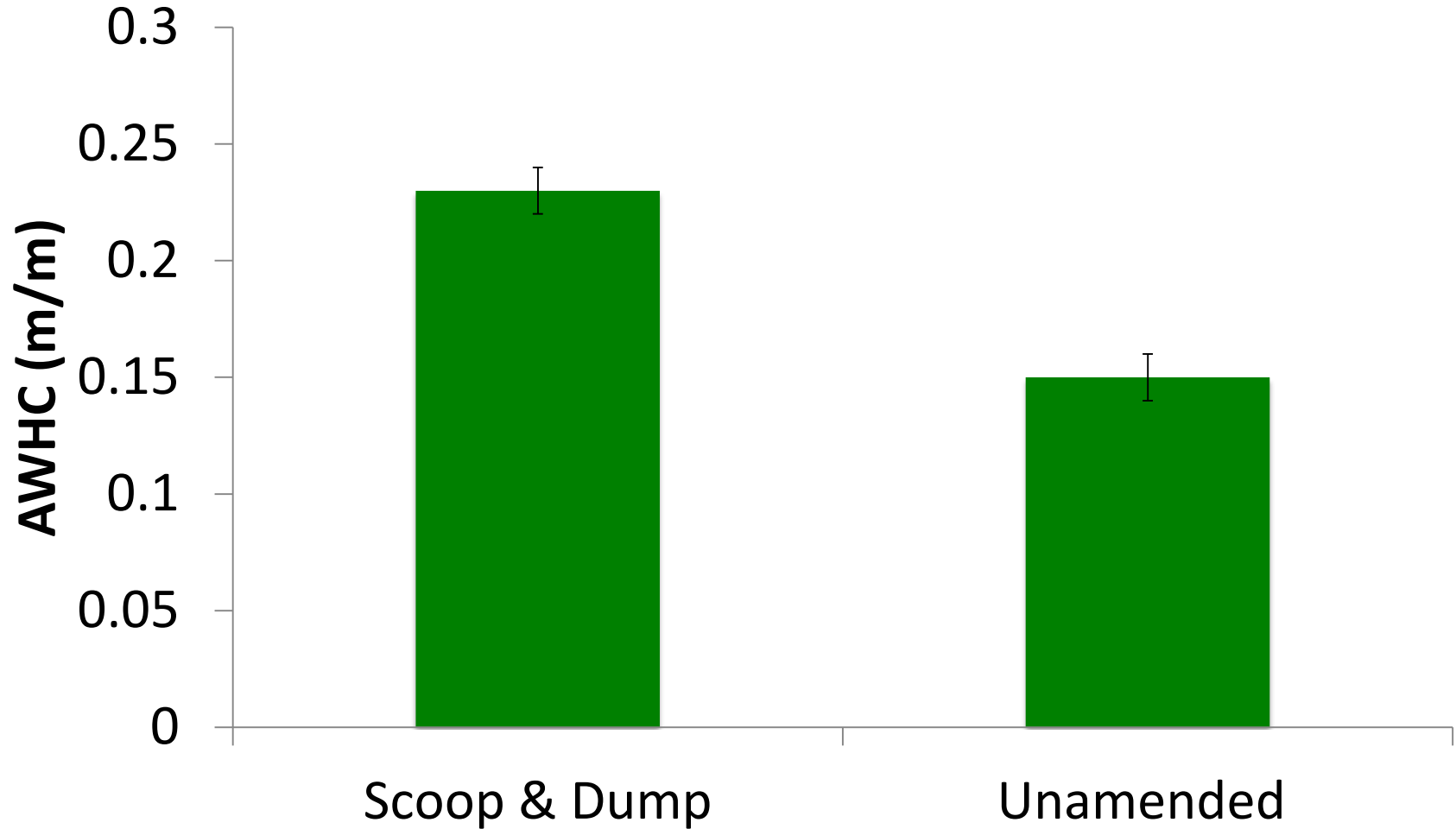
# Active Carbon (mg/kg<sup>-1</sup>) (n=30)



Scoop & Dump	Unamended	Std. Err.	P Value
<b>1022.47</b>	<b>361.60</b>	<b>51.51</b>	<b>&lt;.0001</b>

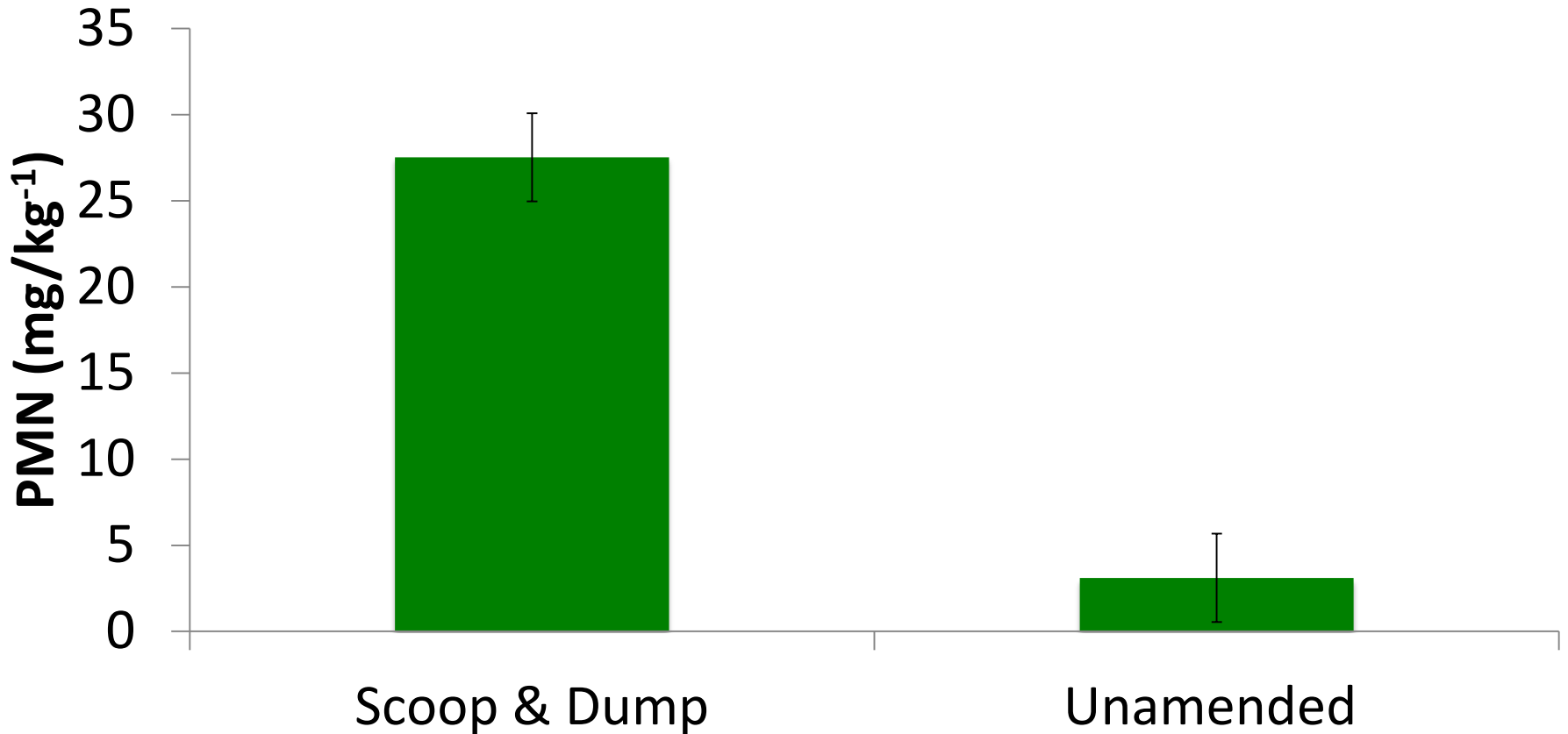


## Available Water Holding Capacity (n=30)



Scoop & Dump	Unamended	Std. Err.	P Value
<b>0.23</b>	<b>0.15</b>	<b>0.01</b>	<b>&lt;.0001</b>

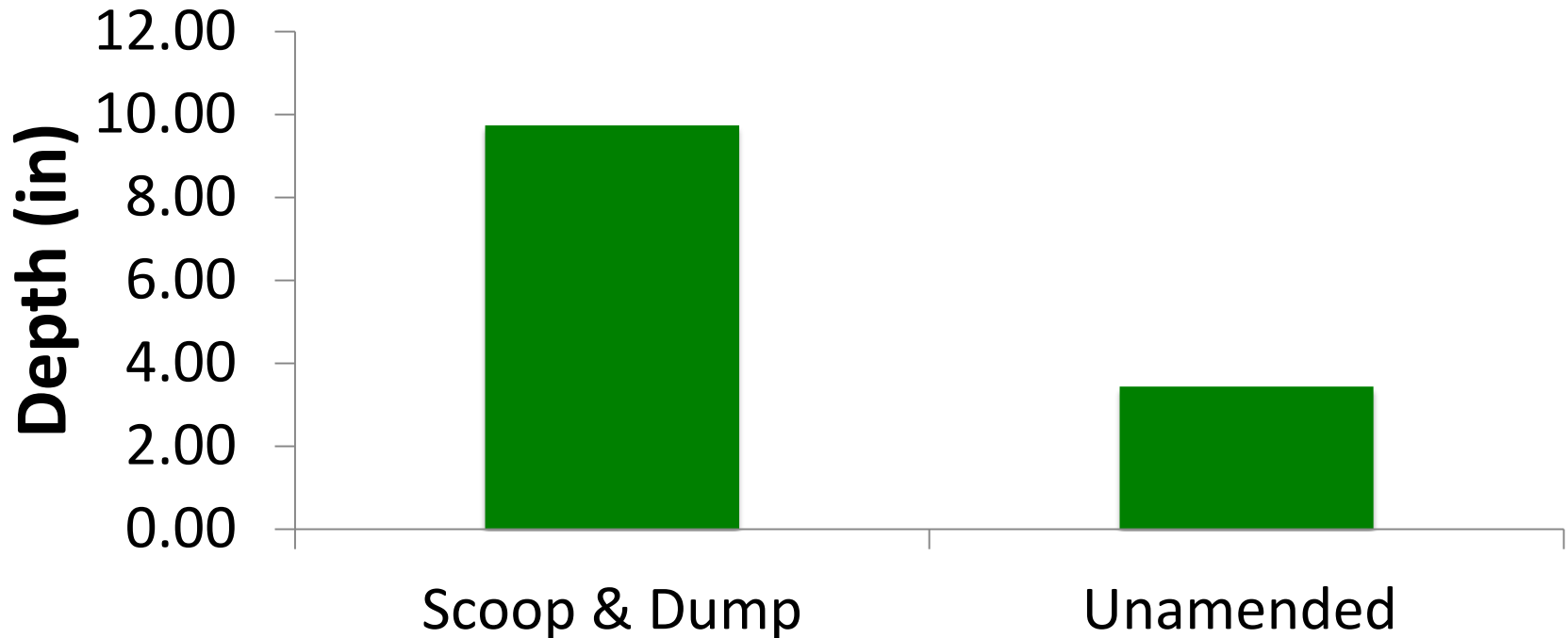
# Potentially Mineralizable Nitrogen (mg/kg<sup>-1</sup>) (n=30)



Scoop & Dump	Unamended	Std. Err.	P Value
<b>27.53</b>	<b>3.11</b>	<b>4.41</b>	<b>.0005</b>

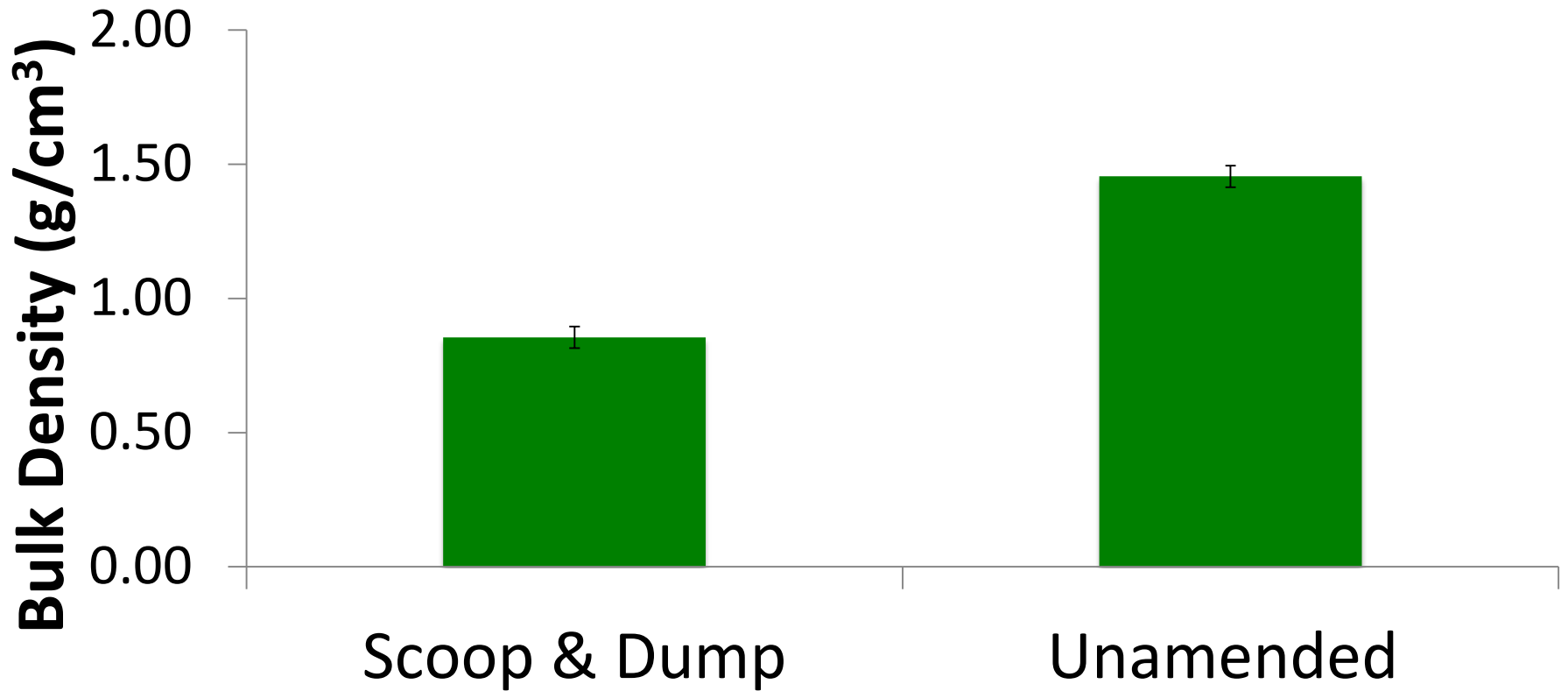
# Resistance (Penetrometer)

## Average Depth of Root Limiting Resistance ( 300 PSI)



Treatment	Mean	St. Dev.
Scoop & Dump	9.74	2.24
Unamended	3.44	1.65

## Bulk Density (g/cm<sup>3</sup>) (n=30)



Avg. Bulk Density

Root Limiting Bulk Density

S&D	Unam.	Std. Err.
0.89	1.47	0.06

Texture	Bulk Density
Sand	1.75 (g/cm <sup>3</sup> )
Silt & Clay	1.40 (g/cm <sup>3</sup> )

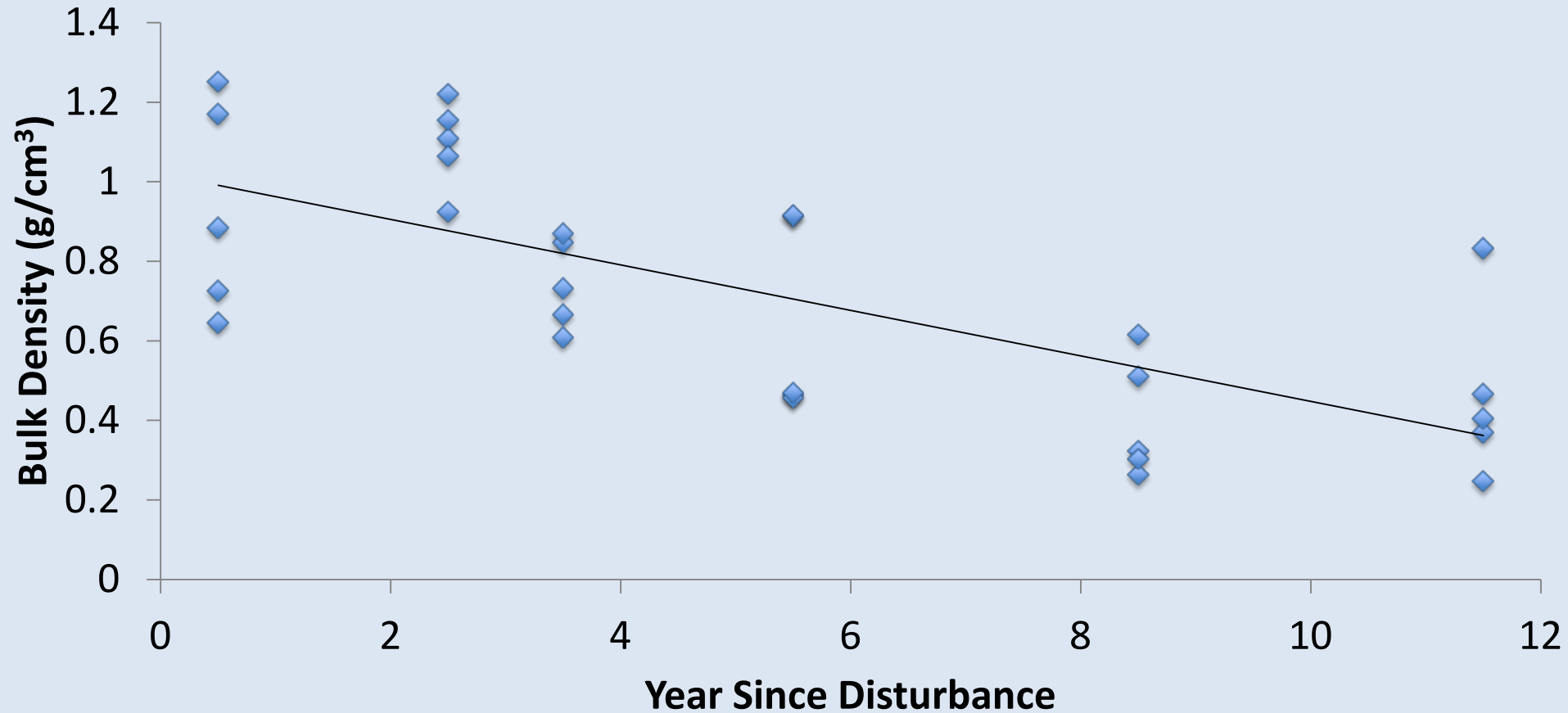


# Scoop & Dump Over Time



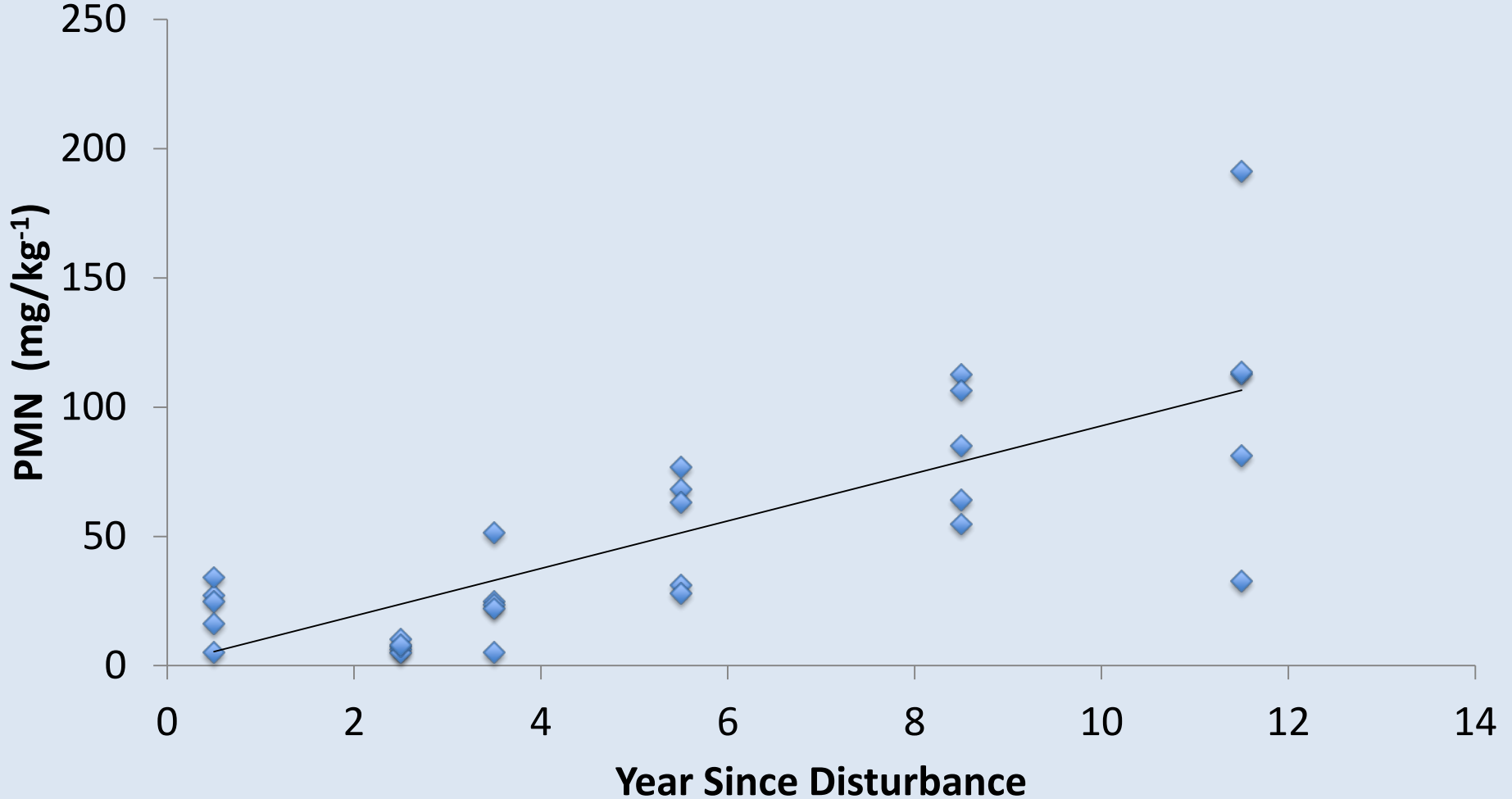
# Bulk Density

**Bulk Density (g/cm<sup>3</sup>) Over time (R<sup>2</sup>= 0.50, P<.0001, n=30)**



# Potentially Mineralizable Nitrogen

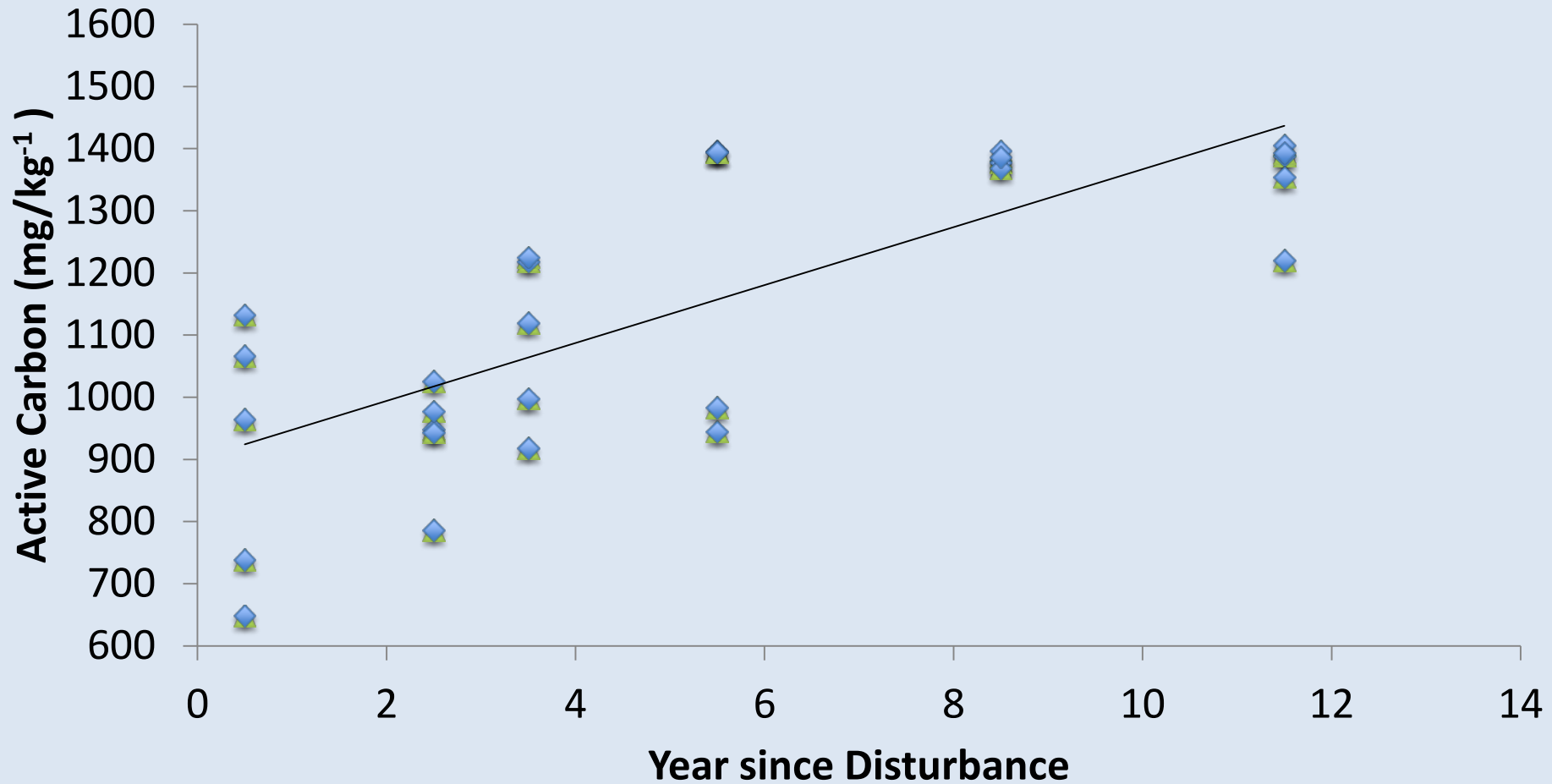
PMN ( $\text{mg}/\text{kg}^{-1}$ ) Over Time ( $R^2=0.61$ ,  $P<.0001$ ,  $n=30$ )





# Active Carbon

Active Carbon ( $\text{mg}/\text{kg}^{-1}$ ) Over Time ( $R^2= 0.57$ ,  
 $P<.0001$ ,  $n=30$ )



# Soil Container Study

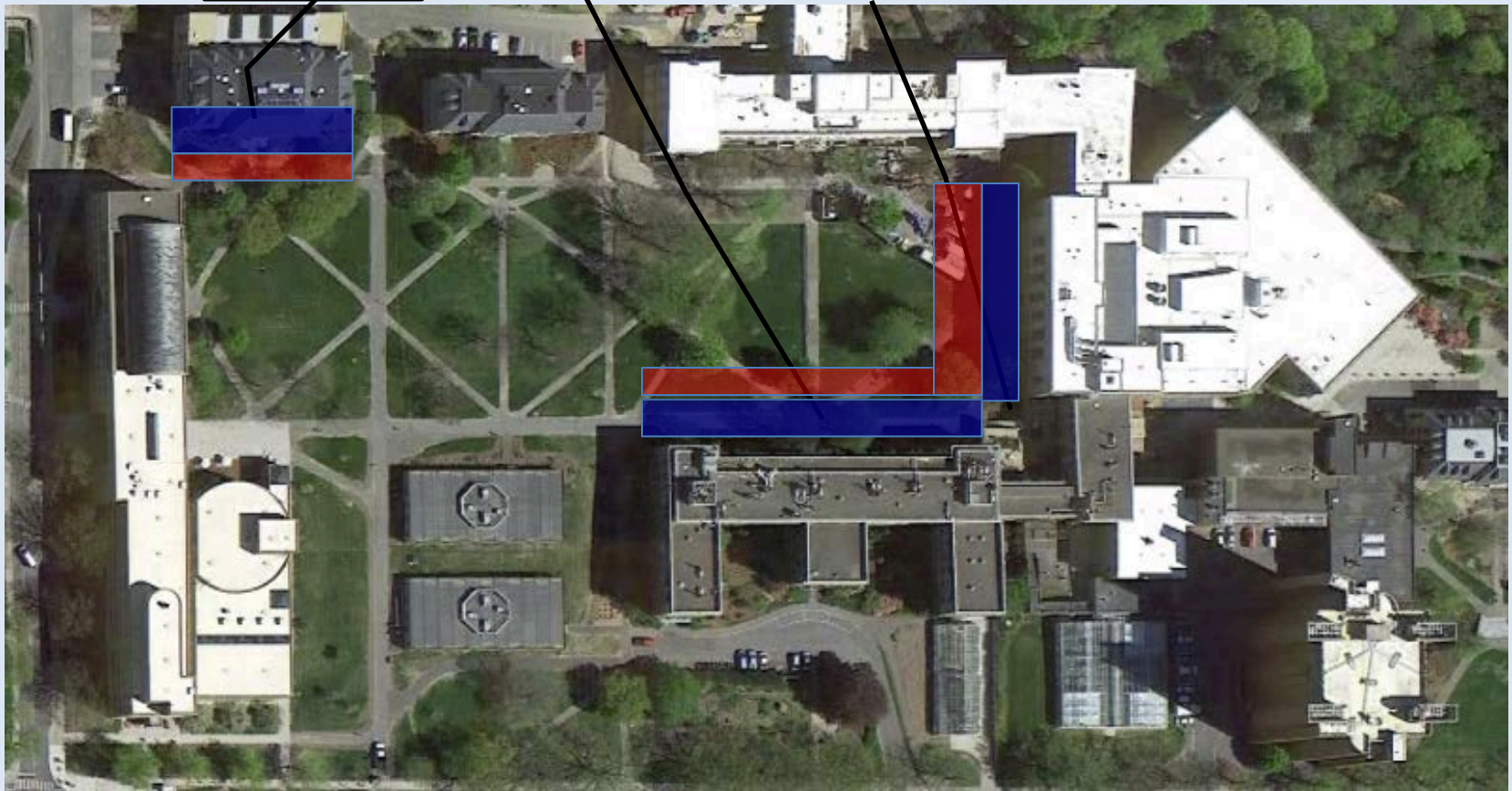


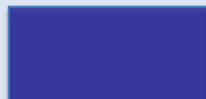
# Study Sites

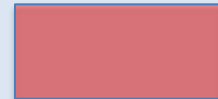
**CCC  
2012**

**Plant  
Science  
2007**

**Mann  
2010**



 = Study Site (n=3)

 = Control (n=3)



# Soils Collected



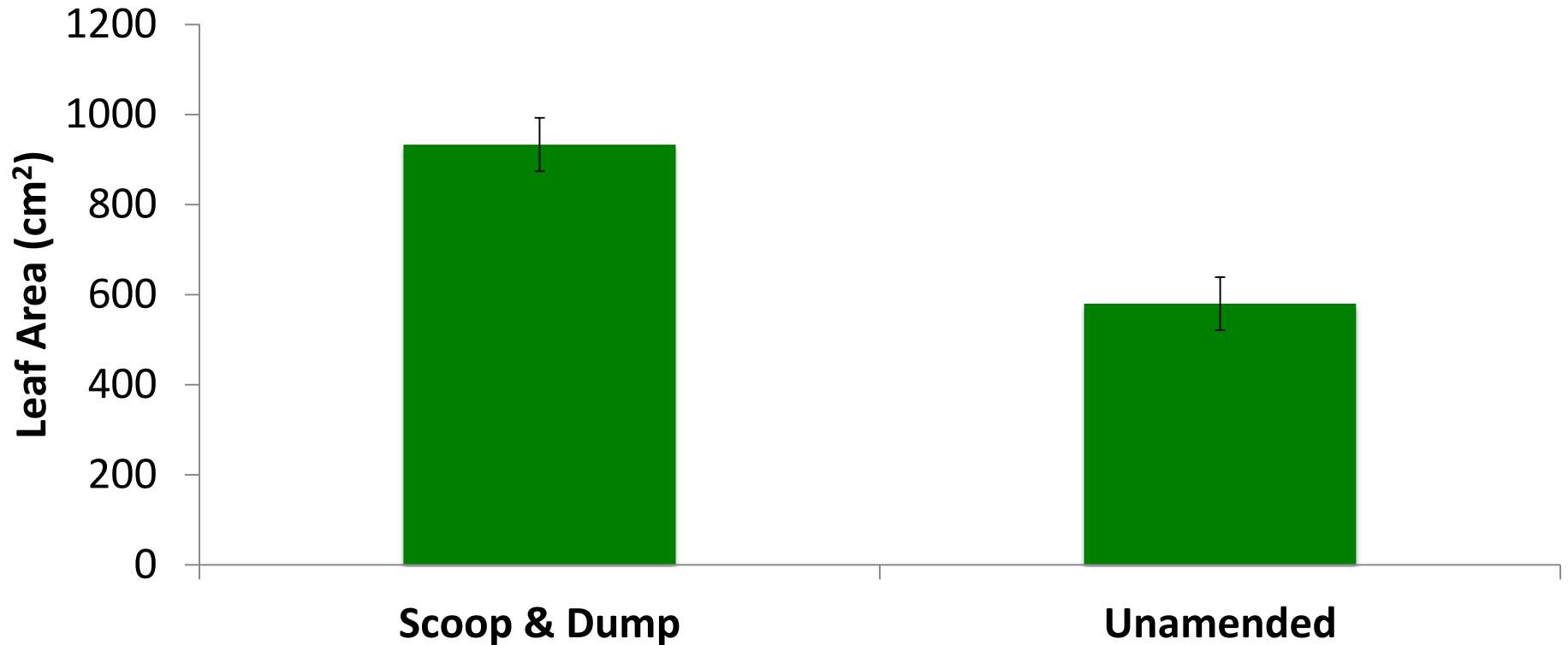


# *Ficus benjamina* as a Street Tree



Photo courtesy Jonathan Wright- Mexico

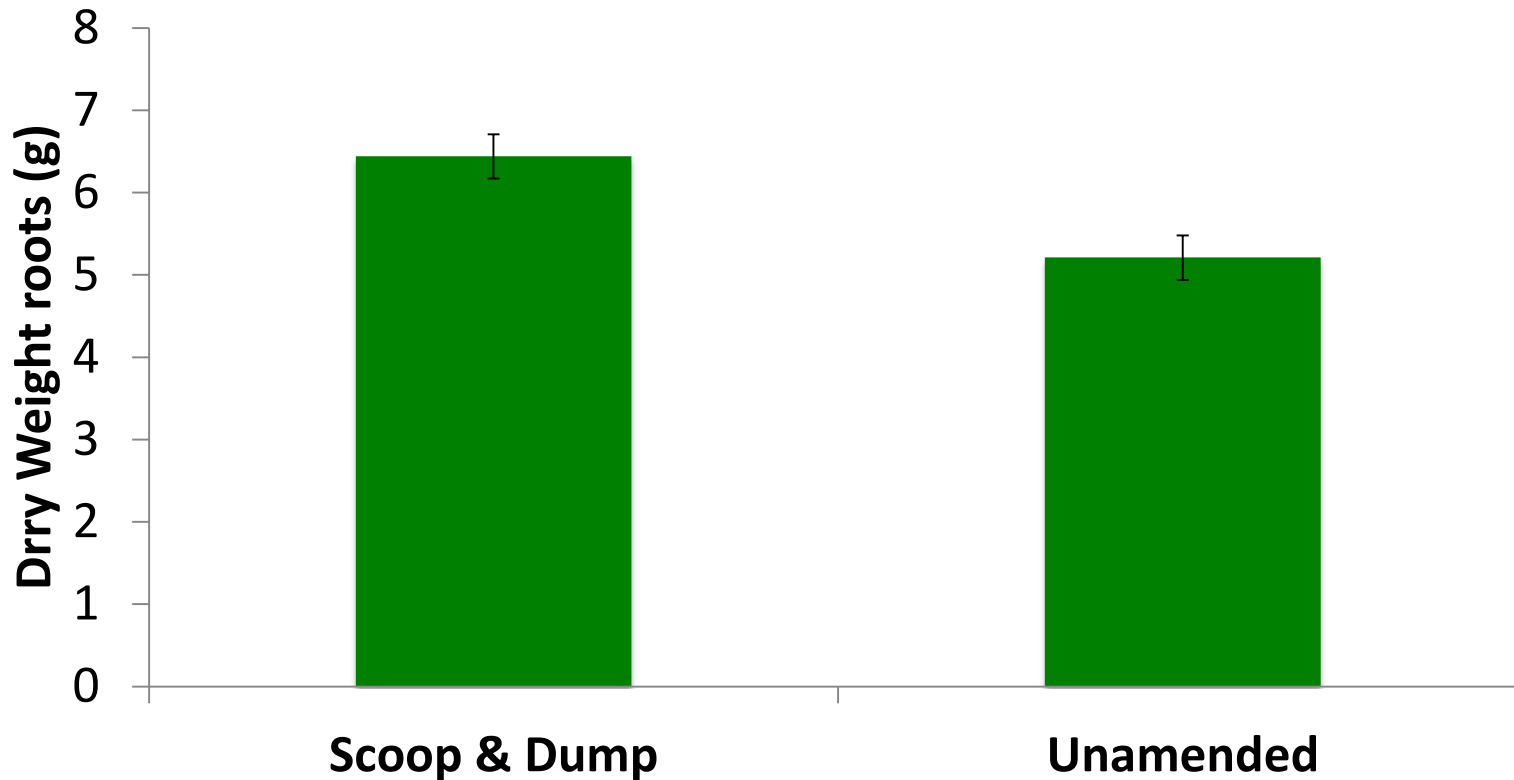
# Leaf Area (cm<sup>2</sup>) by Treatment (n=30) (P<0.0002)



S&D	Unam	Std. Err.	P-value
933.18	579.89	59.14	0.0002



# Dry Weight Roots (g) by Treatment (n=30) (p= 0.012)

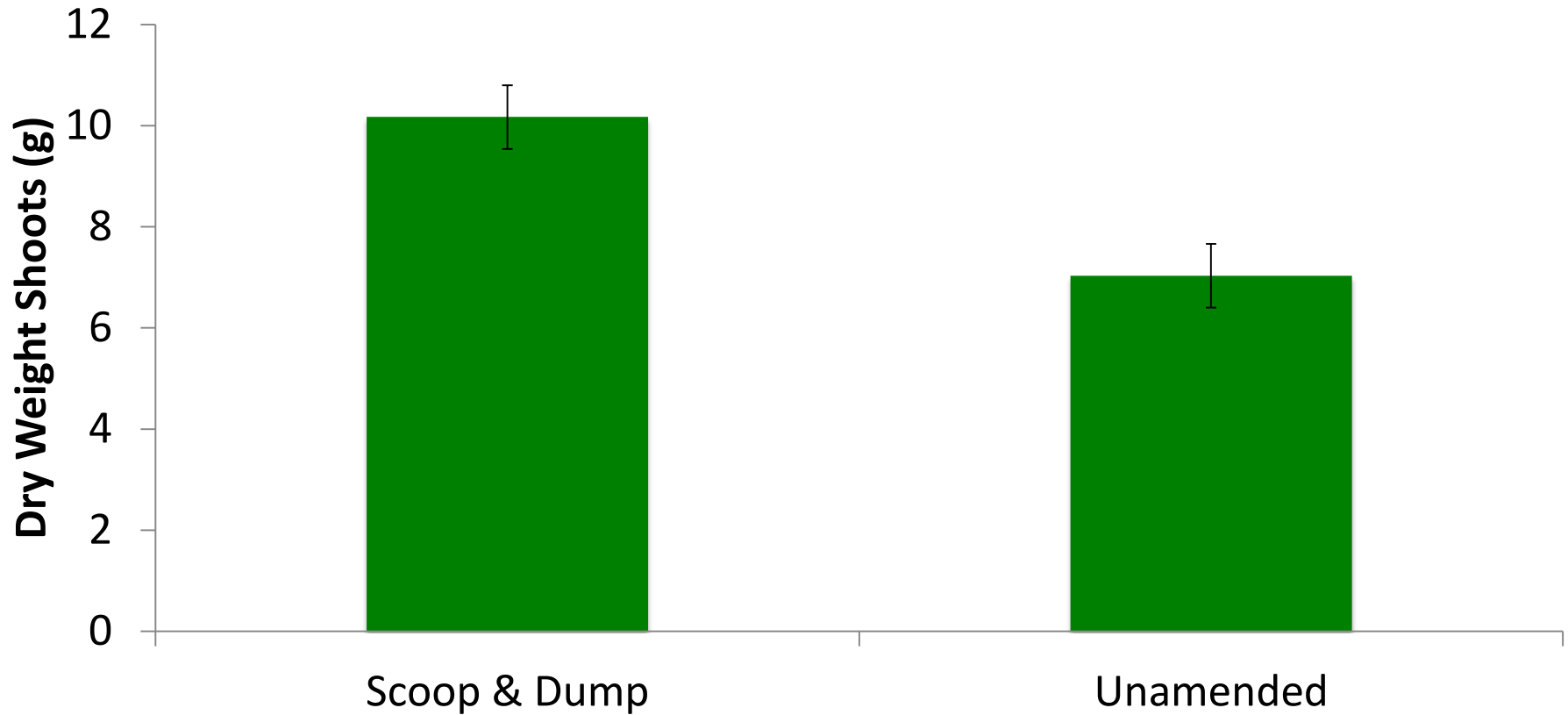


S&D	Unam	Std. Err.	P-value
6.44	5.21	0.32	0.012





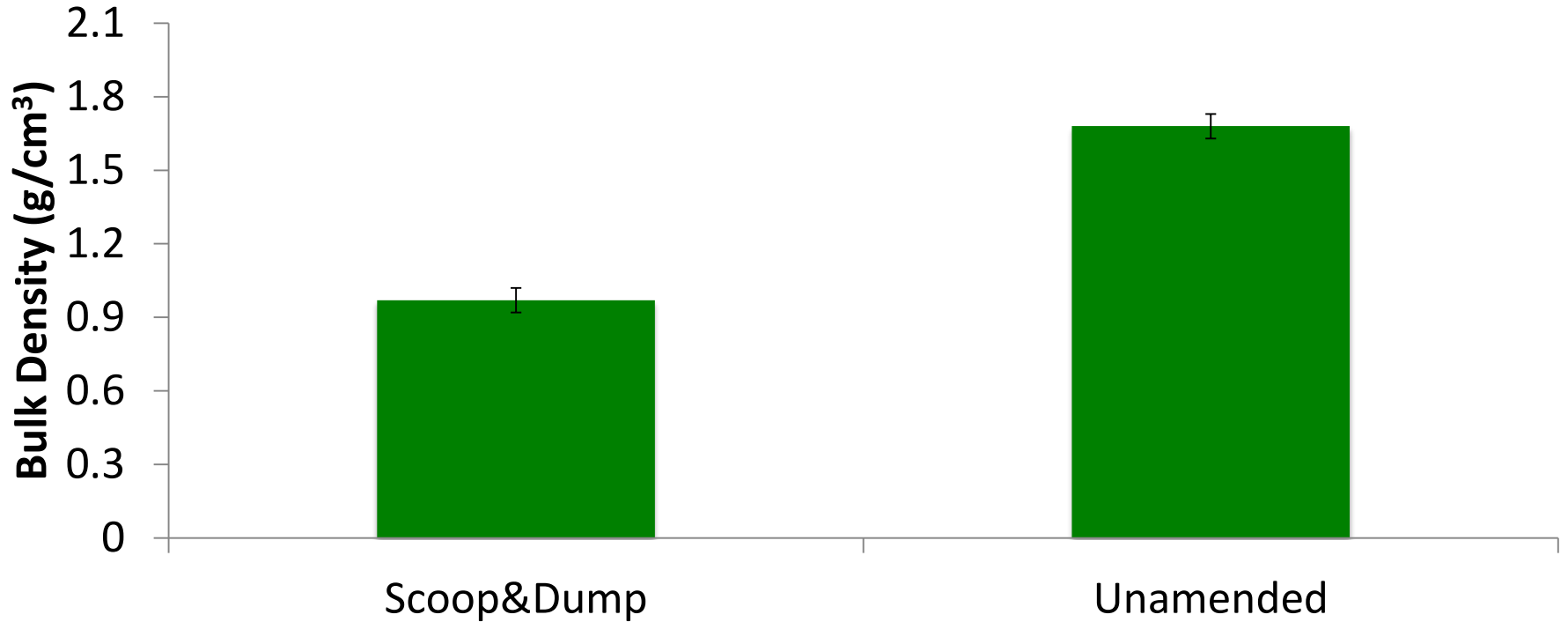
# Dry Weight Shoots (g) by treatment (n=30) (p=0.0015)



S&D	Unam	Std. Err.	P-value
10.17	7.03	0.63	0.0015



# Bulk Density (g/cm<sup>3</sup>) by Treatment (n=30) (p<.0001)



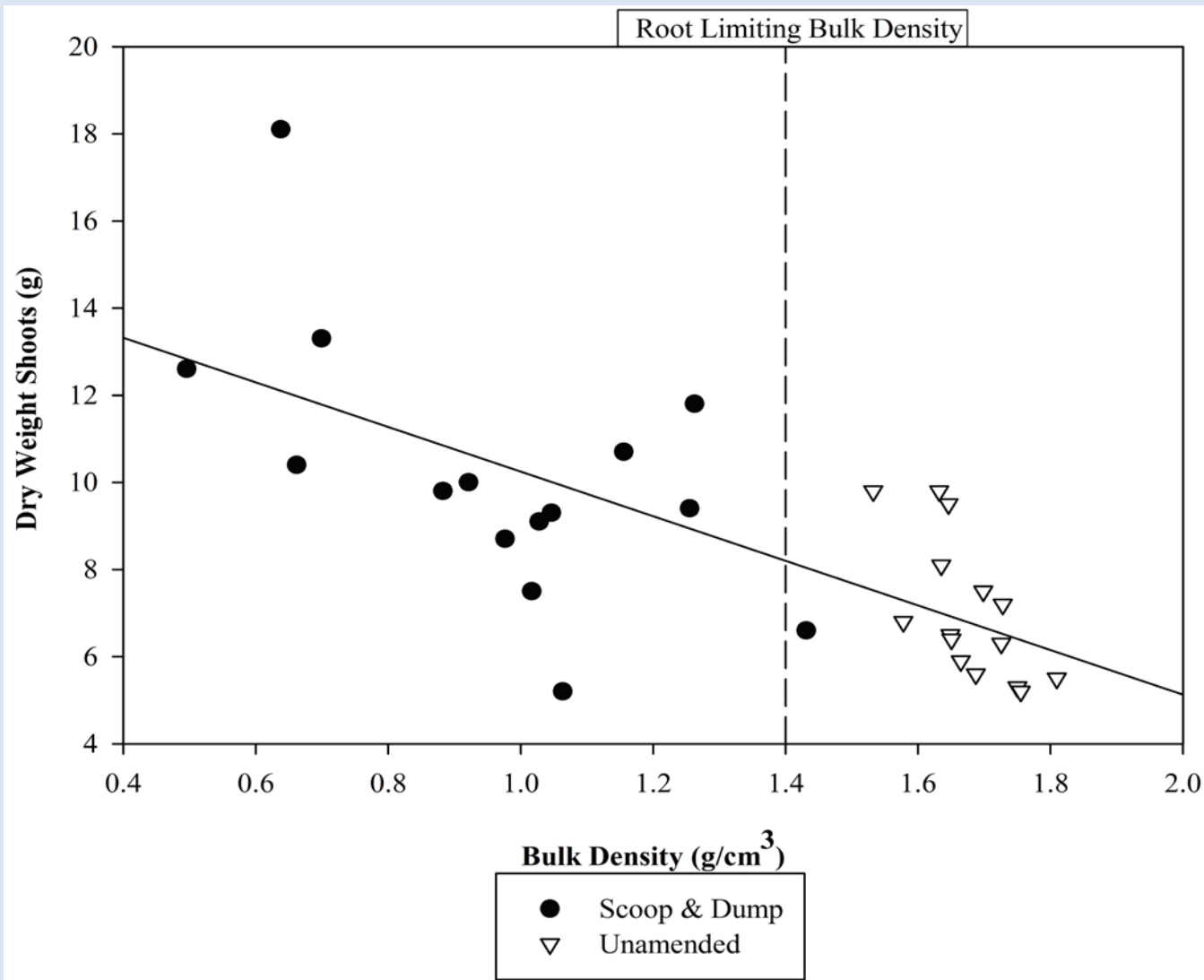
Avg. Bulk Density

Root Limiting Bulk Density

S&D	Unam	Std. Err.	P-value
0.97	1.68	0.05	<.0001

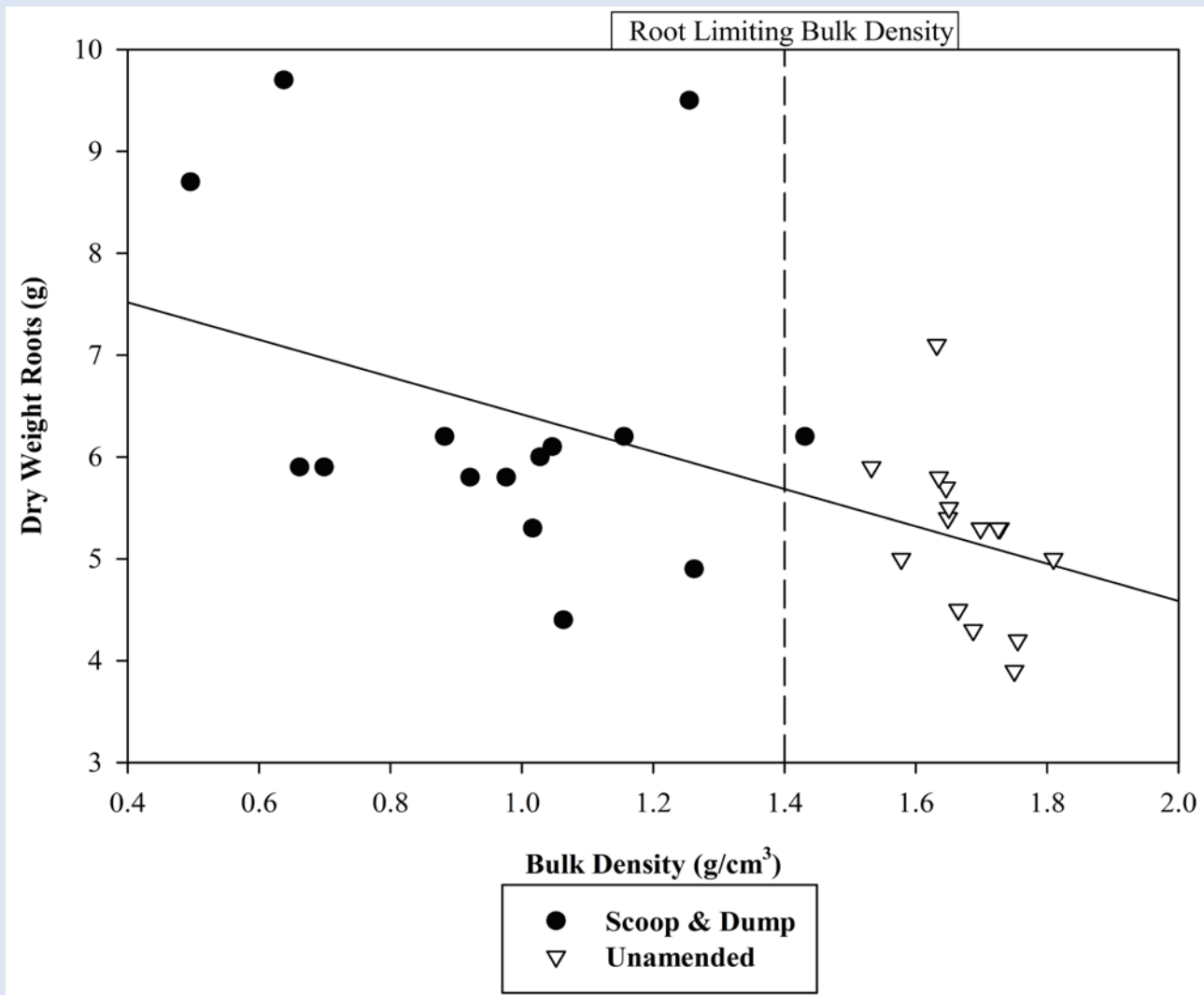
Texture	Bulk Density
Sand	1.75 (g/cm <sup>3</sup> )
Silt & Clay	1.40 (g/cm <sup>3</sup> )

Linear regression show effect of bulk density on dry weight of shoots ( $R^2=0.47$ )( $p<.0001$ )( $n=30$ )

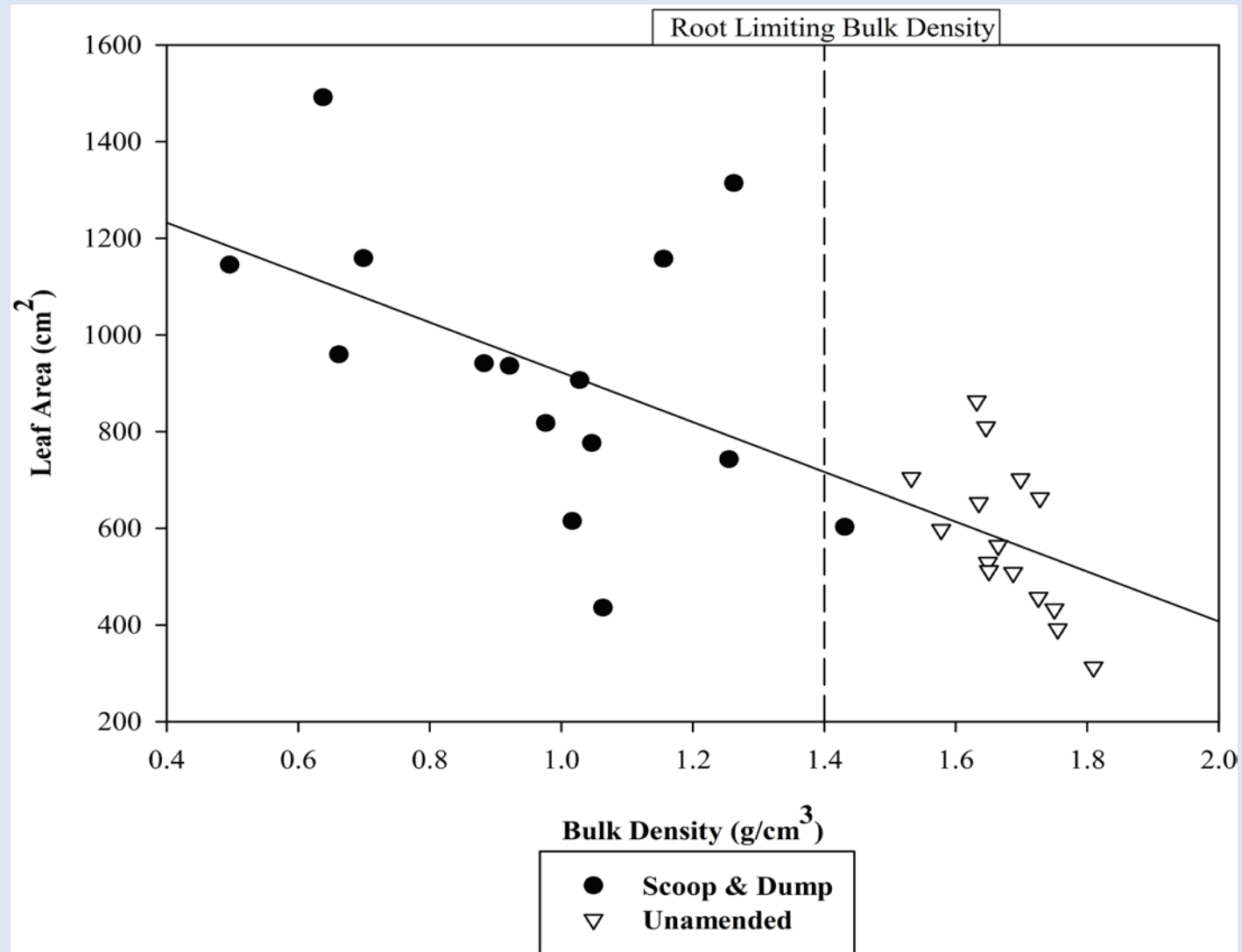




Linear regression showed effect of bulk density on dry weight of roots ( $R^2= 0.25$ )( $p=0.005$ )( $n=30$ )



Linear regression show effect of bulk density on leaf area ( $R^2= 0.47$ )( $p<.0001$ )( $n=30$ )



# Destructive Harvest Observations



Root avoidance of compact soils

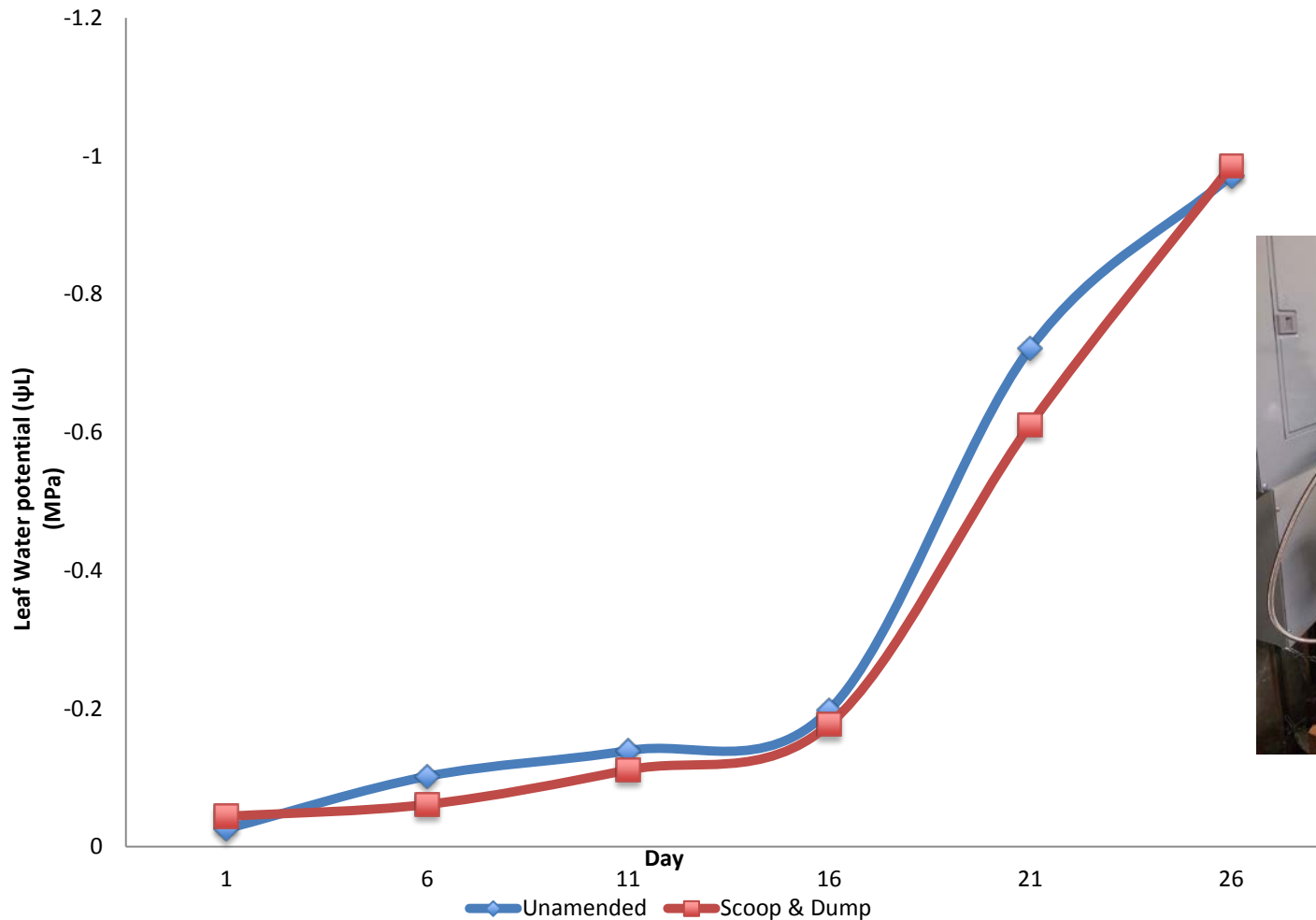


# Destructive Harvest Observations

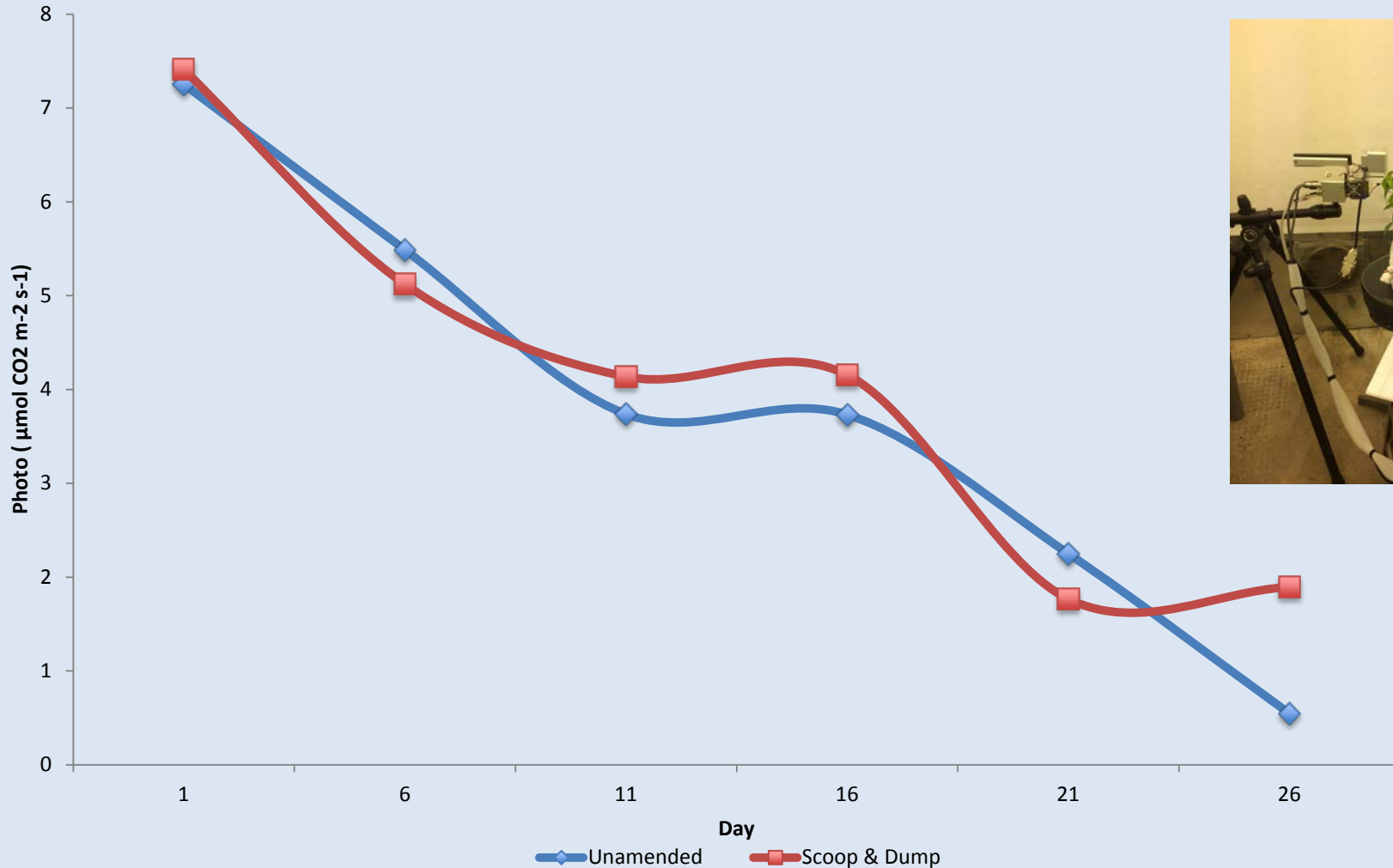


Root Exploration

# Leaf Water Potential $\psi_L$ (MPa) by Day



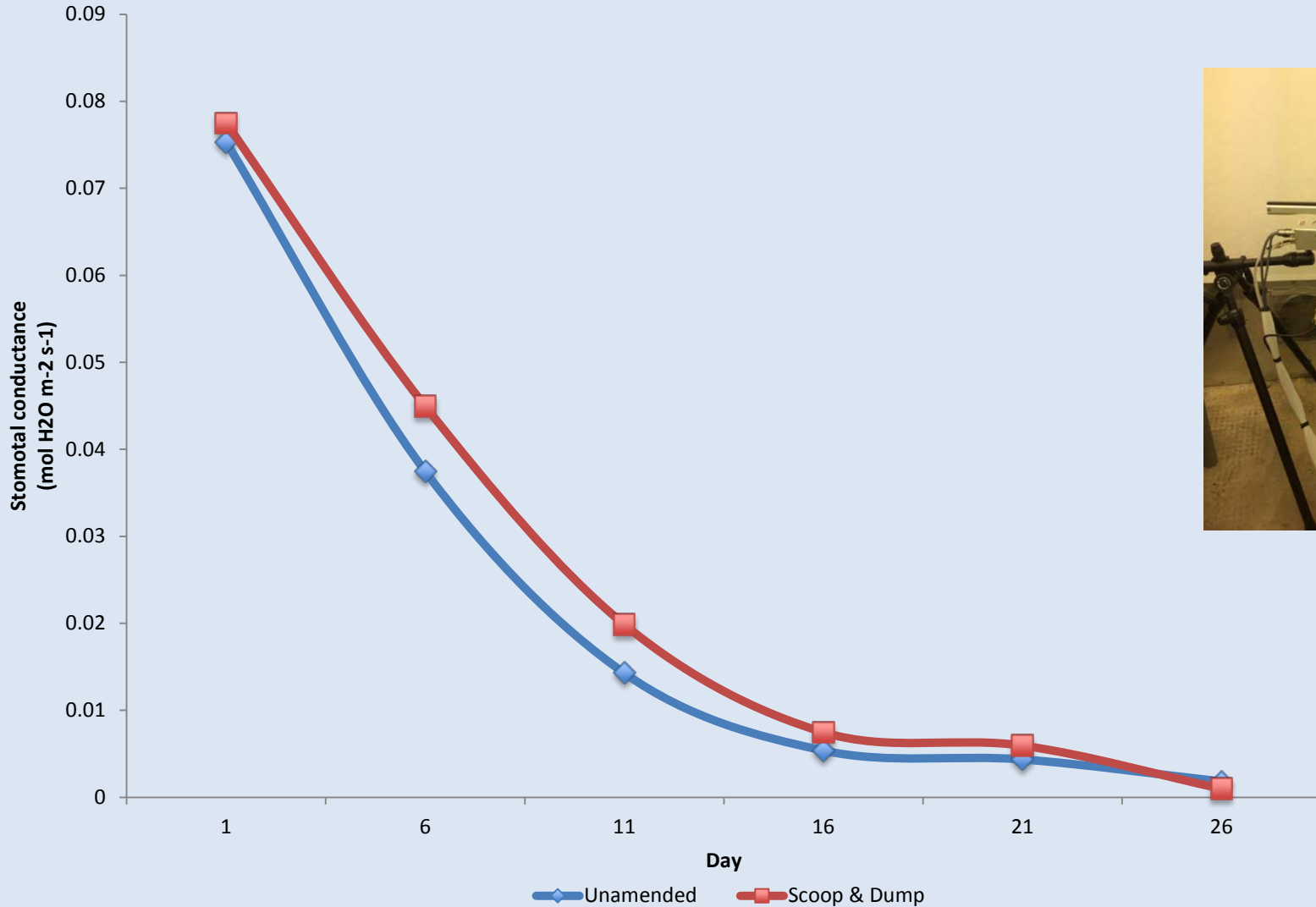
# Photosynthetic Carbon Assimilation Rate ( $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ )



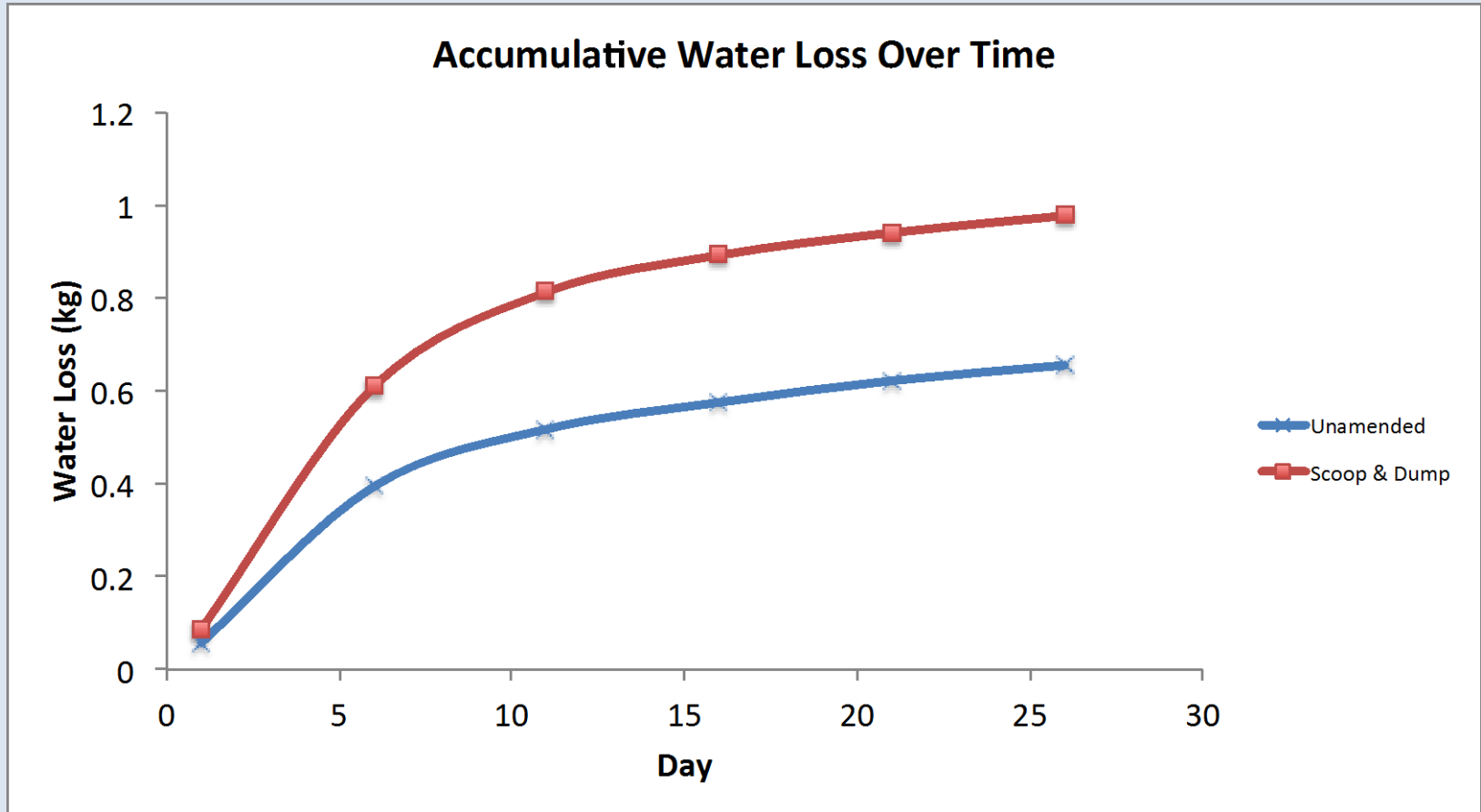


# Average Stomatal Conductance

(mol H<sub>2</sub>O m<sup>-2</sup> s<sup>-1</sup>)



# Accumulative Water loss

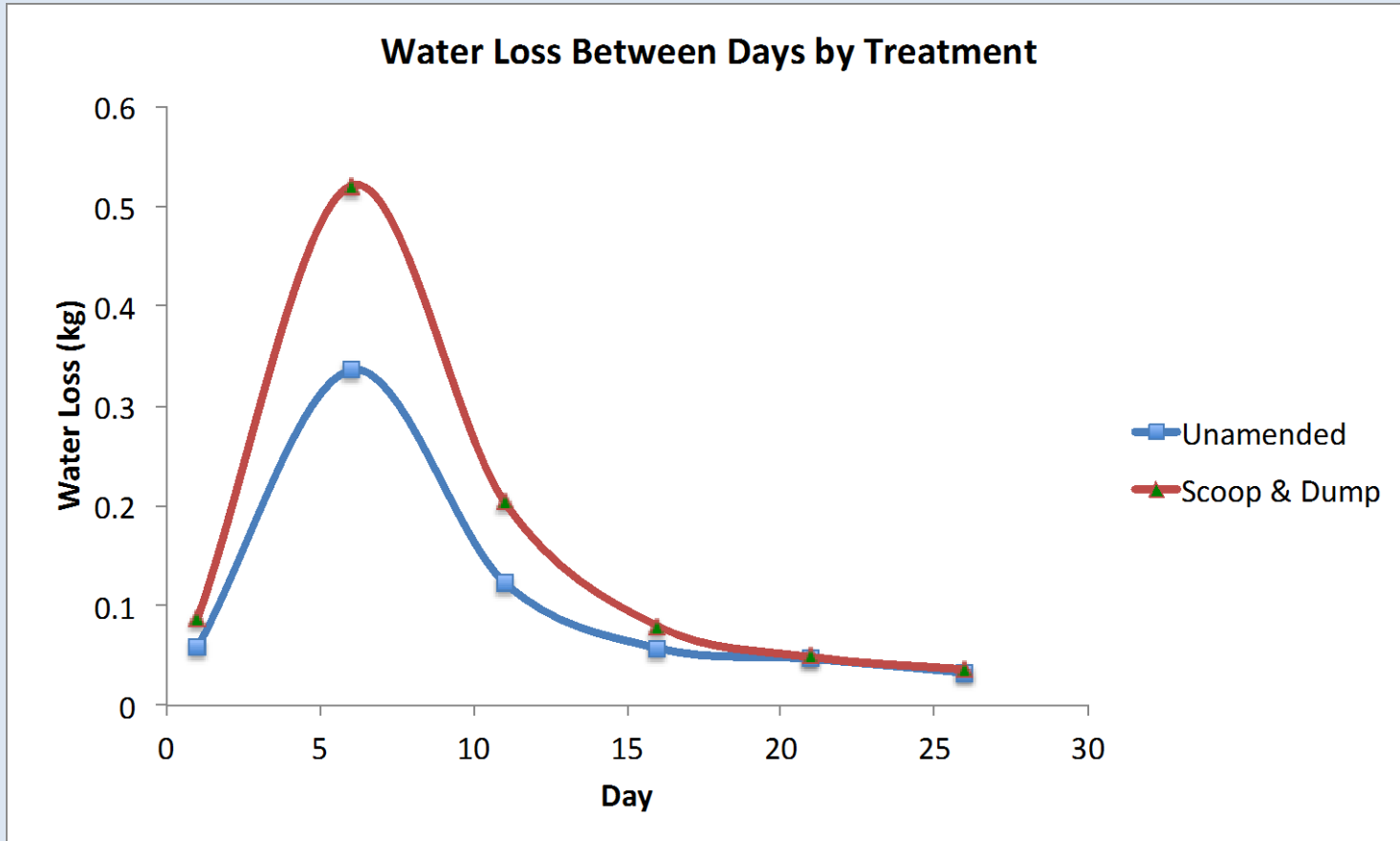


**Accumulative Water Loss (kg)**

Day	1	6	11	16	21	26	
Unamended		*0.058	*0.39	*0.052	*0.58	*0.62	*0.65
S&D		*0.017	*0.61	*0.97	*0.89	*0.94	*0.98

\*= statistically different mean values

# Water Loss Between Days



**Water Loss Between Days (kg)**

Day	1	6	11	16	21	26
Unamended	*0.058	*0.34	*0.12	*0.06	0.05	0.03
S&D	*0.088	*0.52	*0.2	*0.08	0.05	0.04

\*= statistically different mean values



# Scoop & Dump Remediation Improves Urban Soil Characteristics

## Urban soils distinct characteristics:

- **High Soil bulk density\***
- **Decrease in Organic Matter\***
- **Poor structure\***
- High pH
- **Low Water Holding Capacity\***
- **Decreased Aggregate Stability\***
- **Inadequate soil depth for root growth\***
- **Decrease in microbial biomass & activity\***





















# Soil Health Test

## Cornell Soil Health Assessment Training Manual



B.K. Gugino, O.J. Idowu, R.R. Schindelbeck, H.M. van Es,  
D.W. Wolfe, B.N. Moebius-Clune, J.E. Thies, and G.S. Abawi

Second Edition



Cornell University  
College of Agriculture and Life Sciences



**Rapid Soil Texture**

**Penetration Resistance**

**Soil Protein assay**

**Soil Respiration**

**Wet Aggregate Stability**

**Available Water Capacity**

**Active Carbon**

**Root Pathogen Pressure**

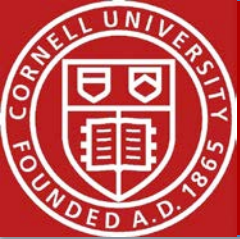
**Cornell Soil Health Assessment indicators are:**

- Sensitive to Management
- Agronomically Meaningful
- Quantitative
- Standardized
- Updated with Current Research
- Inexpensive



# Thank You

- Nina Bassuk
- Harold VanEs
- Don Rakow
- Tom Whitlow
- Bryant Scharenbroch
- Sunshine Horticulture
- Cornell Soil Health Lab
- Cornell Urban Horticulture Institute
- Morton Arboretum
- Cornell Plantations
- International Society of Arboriculture



# Cornell University

## Questions



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