Dynamic Soil Properties Southeastern U.S. Ultisols

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Acknowledge: U.S. Forest Service

Transition

- Regional NCSS Conferences
  - Refinements of Soil Taxonomy
  - New Technologies
  - **Interpretations** and **Databases**

Interpretations and Databases

- Several functions and interpretations depend on near-surface properties (largely within the epipedon)
- Databases largely developed in a use-invariant manner

Guy Smith

- *"It has been suggested that **properties of surface soil horizons** be used as **soil family criteria** to enhance interpretive values. But no, **I see no way that can be done economically**. The physical, chemical, properties of the plow layer, admittedly are critical to the growth of plants, and yet they can vary **enormously** from one system of management to another on what is essentially the same kind of soil."*

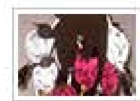
NATIONAL GEOGRAPHIC NEWS
REPORTING YOUR WORLD DAILY

Thursday, May 7, 2009

Human Activities Triggering "Global Soil Change"

Scott Norris
for National Geographic News
February 5, 2008

Earth's climate and biodiversity aren't the only things being dramatically affected by humans—the world's soils are also shifting beneath our feet, a new report says.



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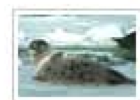

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Concept of *Soil Change*

- Temporal variability
- Dynamic soil properties
  - Decadal or Centurial scales

    (Tugel et al., 2006; Richter and Markewitz, 2001)
  - Use-dependent properties are components of *Soil Change*.
- Related to Dynamic Soil Quality

NCSS Soil Change Working Group

- Vision: “Enhancing NCSS products with information about soil change and its consequences.”
- The NCSS plans to:
  - 1) inventory some changes in soil properties over the human time scale;
  - 2) evaluate mechanisms leading to the property changes, and
  - 3) interpret the consequences of those changes.

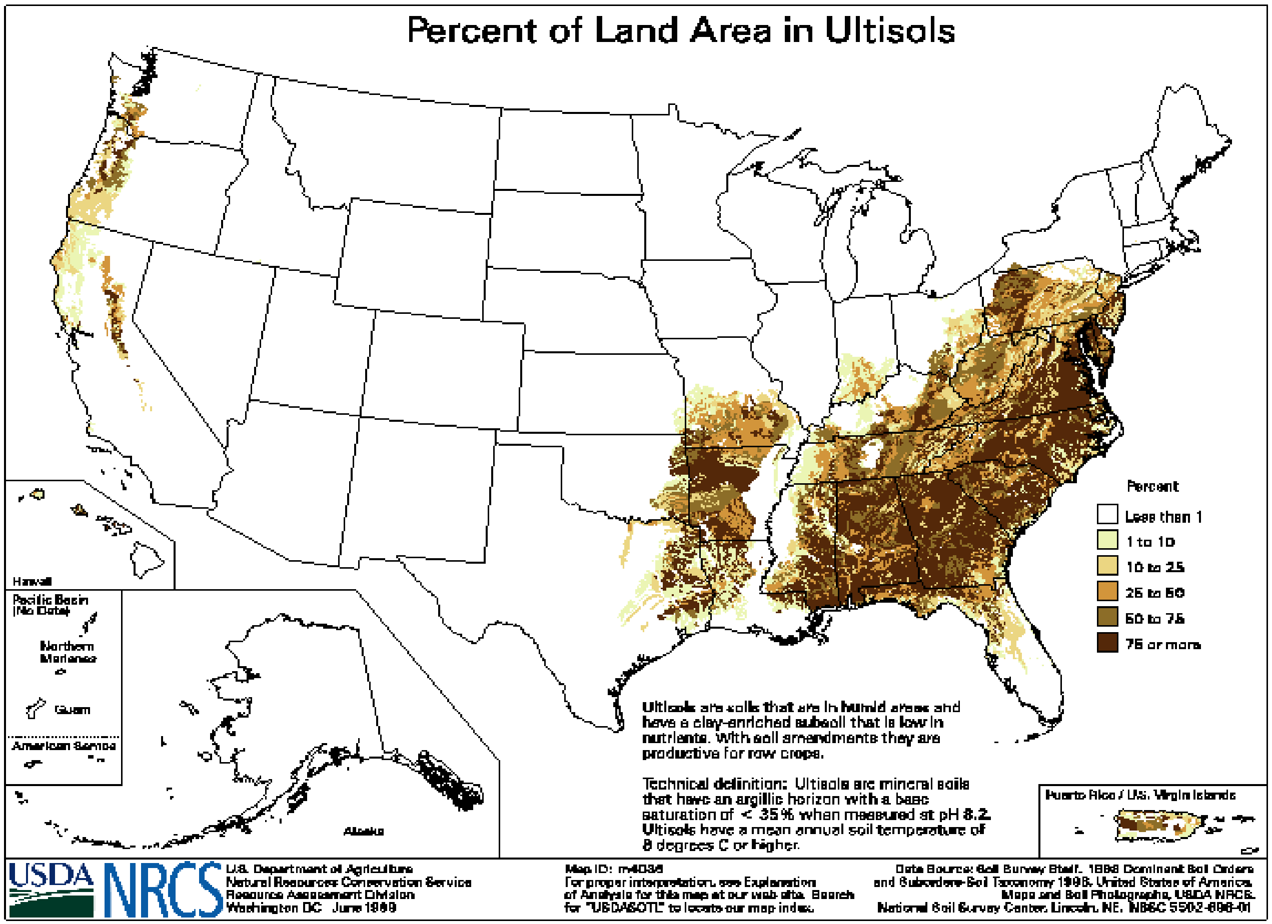
Andrews, Tugel, West 2008

A “New soil survey paradigm”

- Soil properties that:
  - Change over decade scale
  - Important to function
  - Reflect management
  - Can be documented with one time measurement

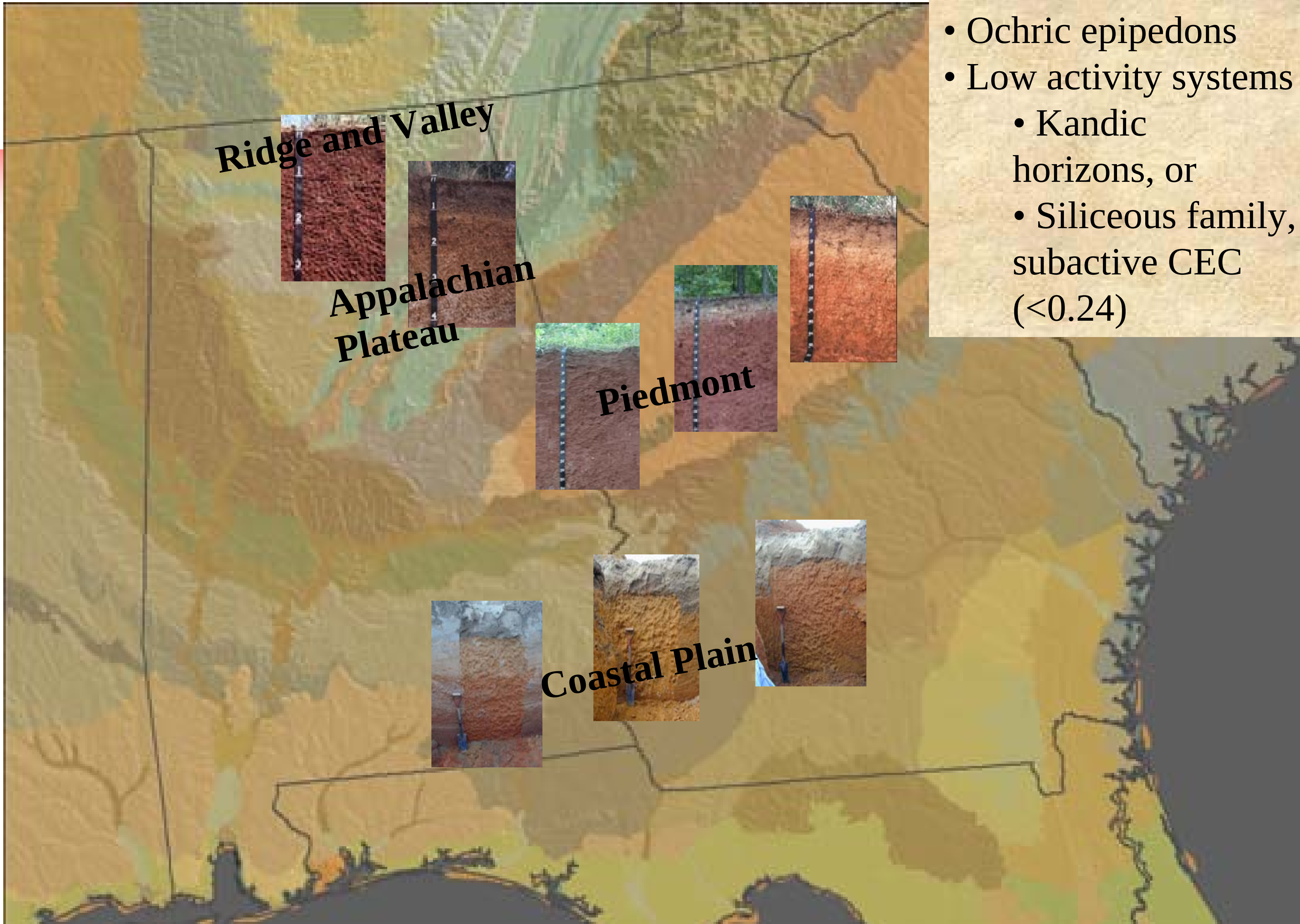
Tugel et al, Soil Change Guide ver. 1.1, 2008

Highly weathered soil systems (U.S.)



USDA-NRCS

Alabama and Georgia



- Ochric epipedons
- Low activity systems
  - Kandic horizons, or
  - Siliceous family, subactive CEC (<0.24)

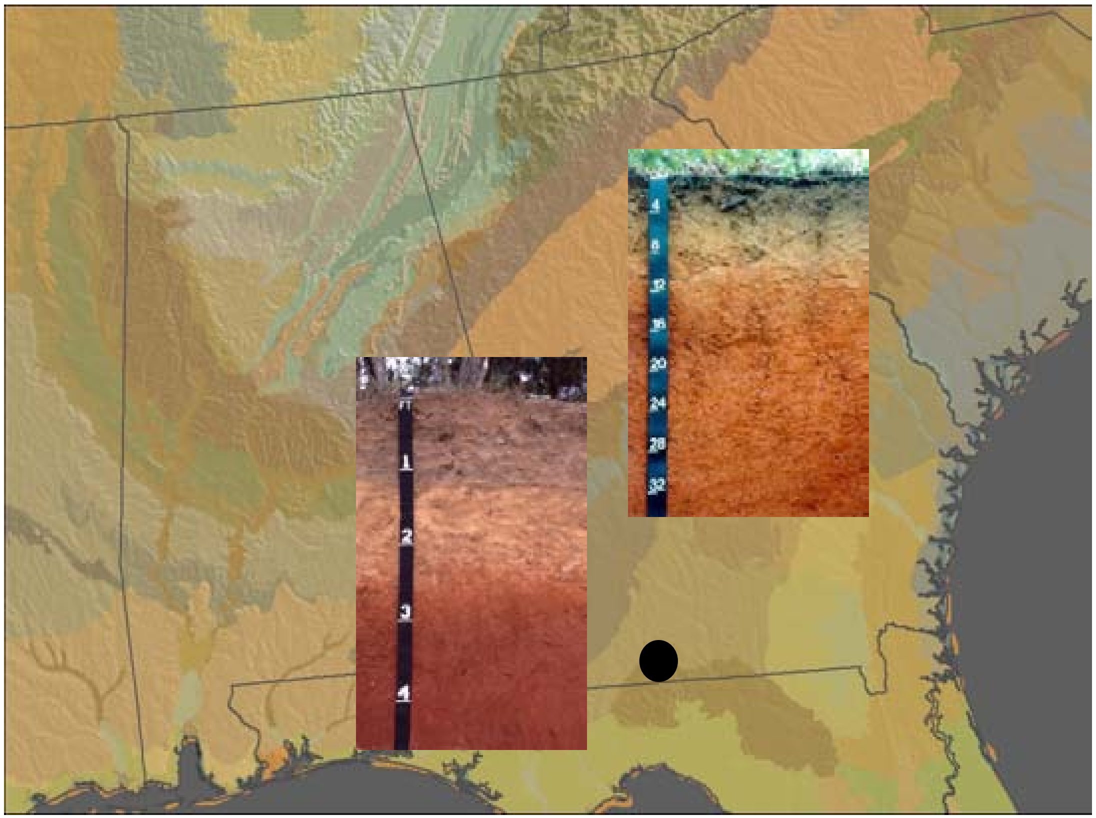
Intensive use

- Degraded soil resource
- Potential to sequester soil C relatively high:
  - Low C stocks
  - Long growing seasons allow high cropping intensity, biomass production, and photosynthetic C fixation
  - Conservation systems increases SOC ~ 0.5 Mg C ha^{-1} yr^{-1} in SE cotton production systems (Causarano et al., 2006).

Objectives

- Evaluate land use and management effects on near-surface, use-dependent soil properties of several Southeastern U.S. agroecosystems-
  - Are there systematic differences among these systems?
  - Which properties are most responsive?

Case study - “Space for Time”
Georgia Coastal Plain, Tallahassee Hills

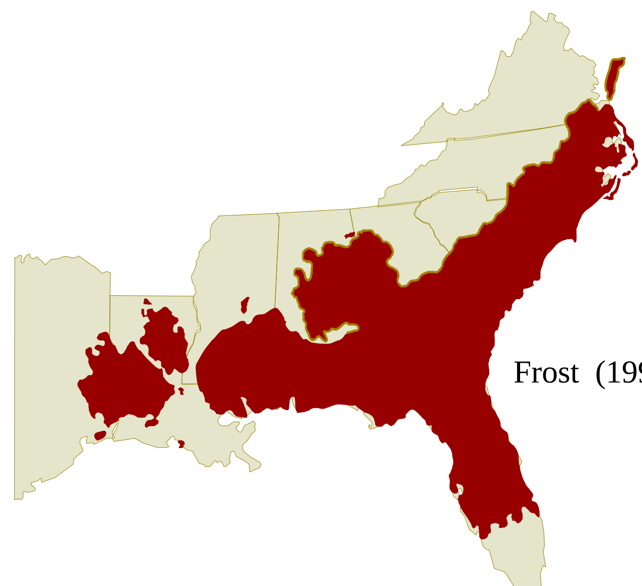


Soils:
1) fine, kaolinitic, thermic Typic Kandiudults (Faceville loamy sand, FaB),
2) fine-loamy, kaolinitic, thermic Typic Kandiudults (Orangeburg loamy sand, OrB),
3) loamy, kaolinitic, thermic Arenic Kandiudults (Lucy loamy sand, LuB)

Rationale

- Reference sites (*Reference State*) are not extensive in southeastern, U.S
- Longleaf pine-wiregrass ecosystems are rare
  - 37 million hectares stretched from Virginia to Texas prior to European establishment
  - <3 % of original acreage remains



Frost (1993)

Systems

- Longleaf pine (*Pinus palutris* Miller) - wiregrass (*Aristida stricta* Michx)
  - seedlings to ~200 yrs
  - native groundcover
  - periodic fire
- Planted Slash pine (*Pinus elliottii* Engelm.)
  - > 20 yrs
  - poles and/or saw timber
  - site preparation upon establishment
- Conventional row crop
  - > 30 yrs
  - corn (*Zea mays*) – peanut (*Arachis hypogaea* L.) – soybean (*Glycine max* (L.) Merr.) (some years fallow)
  - conventional tillage

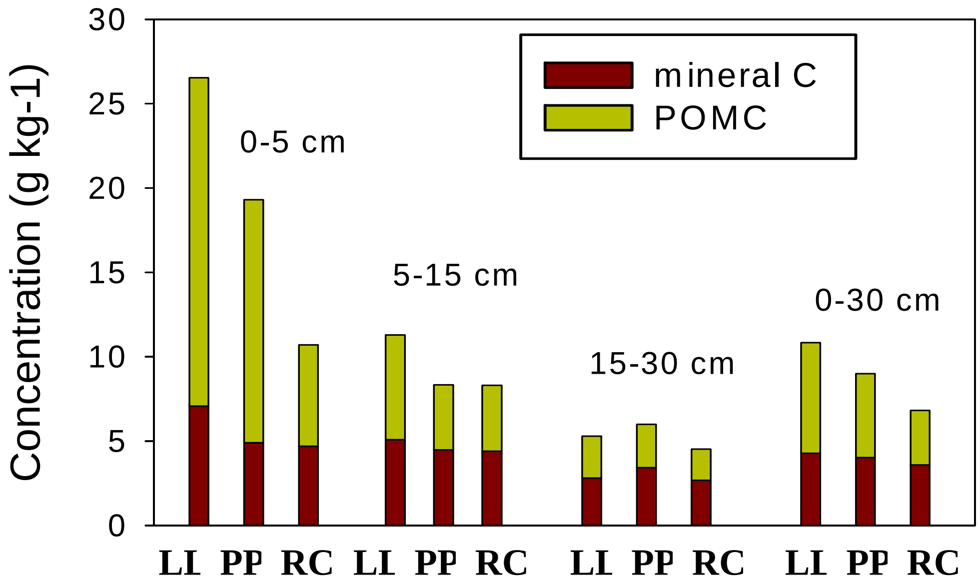
Near-surface Soil Property Measurements (30 cm)

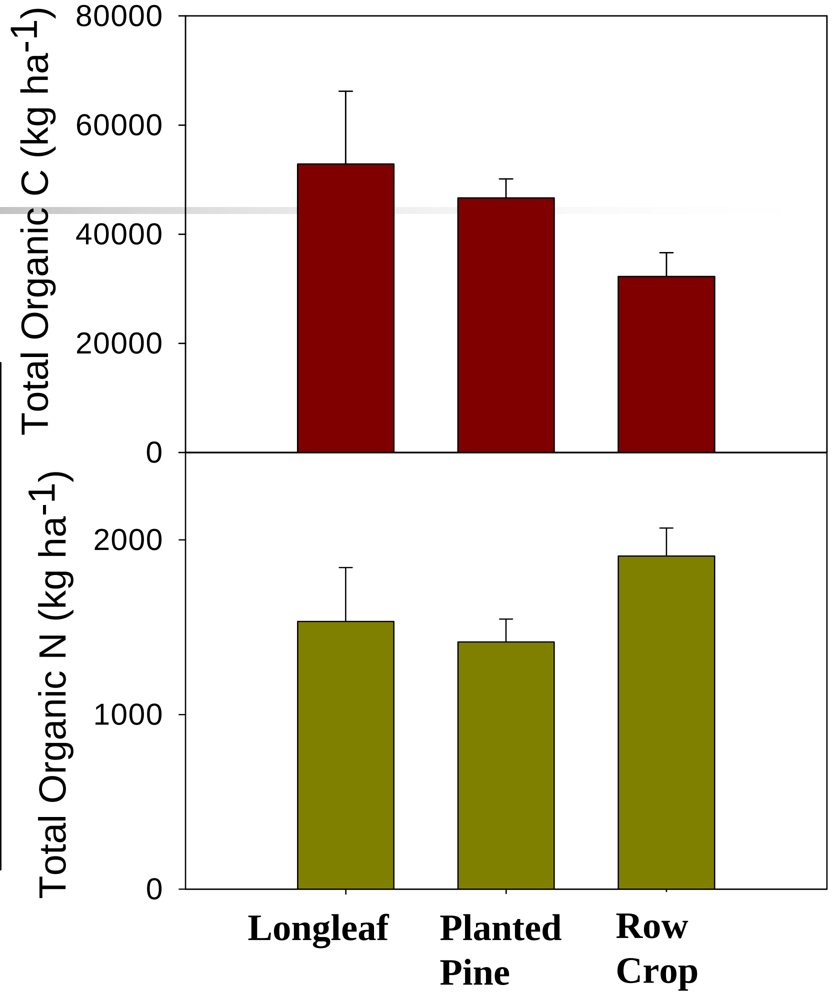
- Chemical/Biological
  - Carbon Pools
    - TOC, TON
    - Microbial biomass (active)
    - Particulate organic C
    - Mineralizeable C & N
  - pH
  - CEC, ECEC
  - Exchangeable bases
  - Extractable Al
  - Double Acid extractable nutrients

- Hydraulic
  - Infiltration
  - Saturated Hydraulic Conductivity
  - Soil Water Retention

- Physical
  - Bulk Density
  - Soil Strength
  - Aggregate Stability
  - Water Dispersible Clay

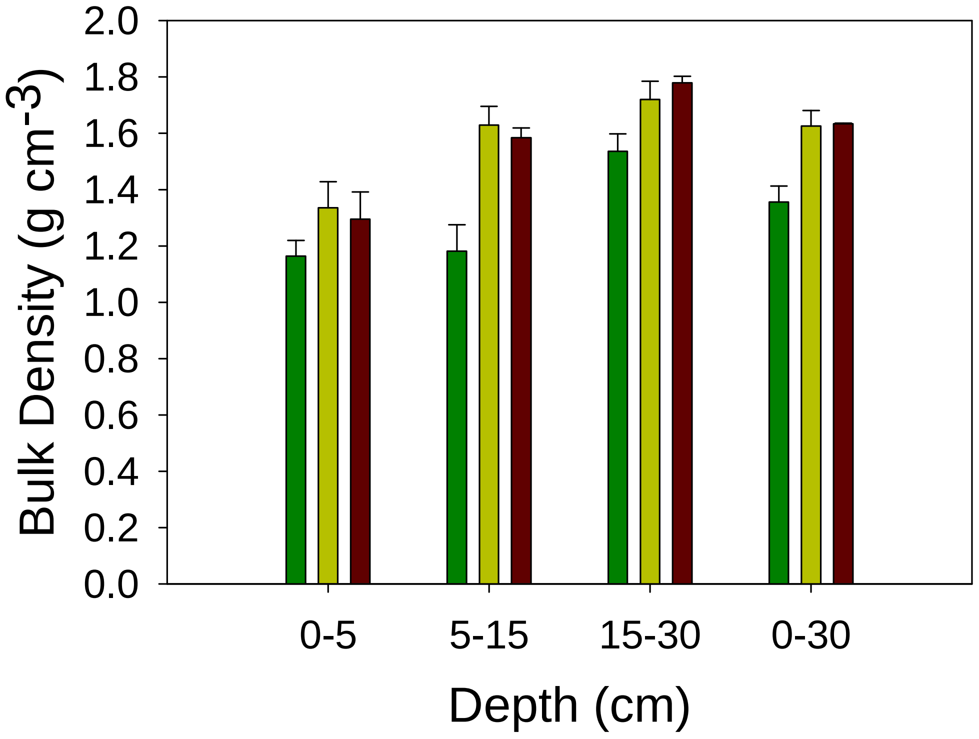
C and N

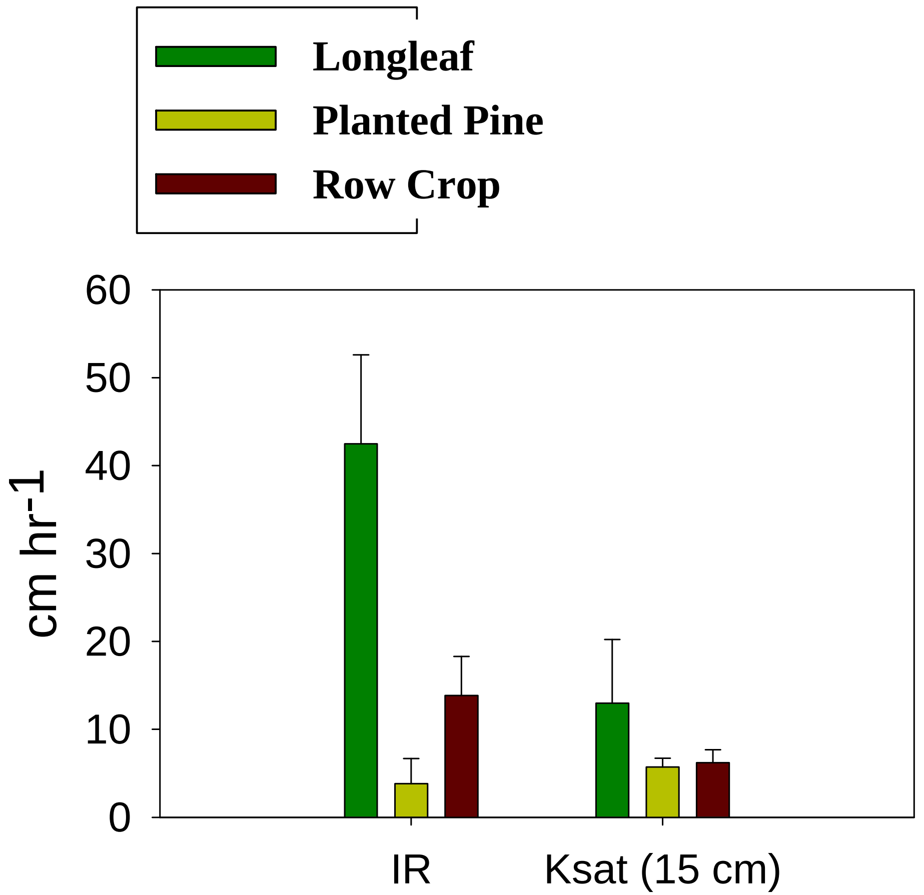




Levi et al, in review

Physical Properties





Levi et al, in review

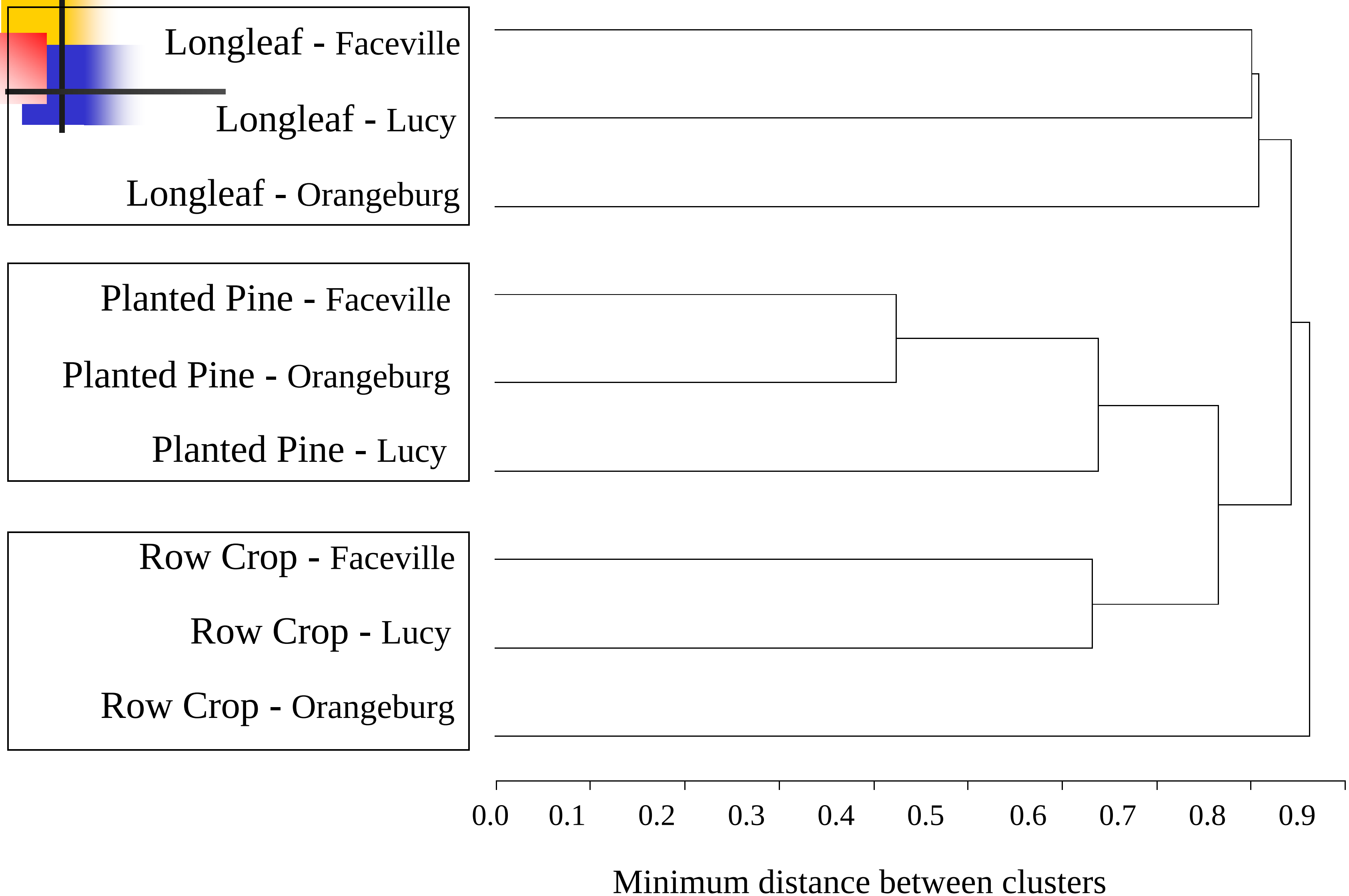
CV's (%) within map units

Map unit	Field Cap. 0-30	PWP 0-30	Ksat 15 cm	IR	SOC 0-5 cm	SOC 0-30cm	BD 0-30cm	Sand 0-30cm	Clay 0-30cm	Depth Arg.
	------------------------------	-management-	------------------------------					-----------static	-----------	
FaB	16	27	53	98	31	11	5	4	21	27
OrB	27	40	53	134	58	46	12	5	29	28
LuB	5	13	78	75	22	11	11	2	41	10
avg	16	26	61	102	37	23	9	4	30	22

Multivariate: Principal Component Analysis

	Prin1	Prin2	Prin3	Prin4
BD0_30	0.26	0.14	-0.17	-0.13
CEC0_30	0.08	0.30	0.30	-0.02
ECEC0_30	0.19	0.27	-0.04	-0.02
BS0_30	0.27	-0.14	-0.13	0.19
Ca0_30	0.29	0.03	0.03	0.01
Mg0_30	0.26	0.17	0.01	-0.04
K0_30	0.31	-0.01	0.08	0.02
Al0_30	-0.13	0.25	-0.18	-0.07
P0_30	0.26	-0.11	0.06	-0.03
SMB0_30	-0.06	0.30	-0.12	-0.16
Nmin0_30	0.24	-0.20	0.13	0.03
Cmin0_30	0.22	0.19	-0.05	0.27
TON0_30	0.22	-0.02	0.24	0.28
TOC0_30	-0.15	0.29	0.20	0.01
POMN0_30	0.13	-0.29	0.02	0.31
POMC0_30	-0.23	0.19	0.10	-0.12
mineralN0_30	0.14	0.23	0.26	0.05
mineralC0_30	0.02	0.30	0.25	0.18
IR	-0.21	-0.11	0.37	0.21
Ksat	-0.13	-0.24	-0.01	0.04
Awater0_30	-0.21	-0.04	0.39	-0.03
SS0_50	0.18	0.14	-0.27	-0.16
WDC0_30	-0.01	0.25	-0.03	0.50
WSA5	-0.20	0.11	-0.32	0.33
WSA15	-0.20	0.06	-0.30	0.43
Proportion Explained Variance	**40 %**	**28 %**	**11 %**	**6 %**
Cumulative	**40 %**	**68 %**	**79 %**	**85 %**

Multivariate Clustering Dendrogram of near surface properties (0-30 cm) GA Coastal Plain Sites



Levi et al, in review

Issues

- **Quantity of data**
  - **Pedotransfer functions?**

Potential PTFs for near-surface soil hydraulic properties for GA Coastal Plain site:

hydraulic	property	map unit	basic property	R^2
Infiltration rate	management	FaB	wdc(0-30)	0.47
		OrB	log(ss)(0-30),log(bd)(0-30)	0.99
		LuB	log(ss)(0-30)	0.83
	static	FaB	none significant	na
		OrB	sand(2nd hor.),clay(0-30)	0.99
		LuB	none significant	na
Field capacity 0-30 cm	management	FaB	ss(0-30)	0.34
		OrB	wdc(0-5)	0.93
		LuB	soc(0-5)	0.33
	static	FaB	none significant	na
		OrB	sand(surface hor.), clay(surface hor.)	0.94
		LuB	none significant	na
PWP 0-30 cm	management	FaB	none significant	na
		OrB	log(wsa)(0-5)	0.87
		LuB	log(wdc)(0-30),bd(0-5)	0.99
	static	FaB	none significant	na
		OrB	sand(surface hor.),clay(surface hor.)	0.96
		LuB	none significant	na

Note: Ksat not related to either set of properties

Summary

- Pedology and *Soil Change*
- What can reasonably be done?
  - Benchmark soils
  - Resistance and Resilience
  - Identify measured vs “estimated” data