Soil is Life Webinar Series:

Soil's Role in Processing Pollutants: Case Studies of Green Infrastructure and Carbon Sequestration

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THE UNIVERSITY OF ARIZONA

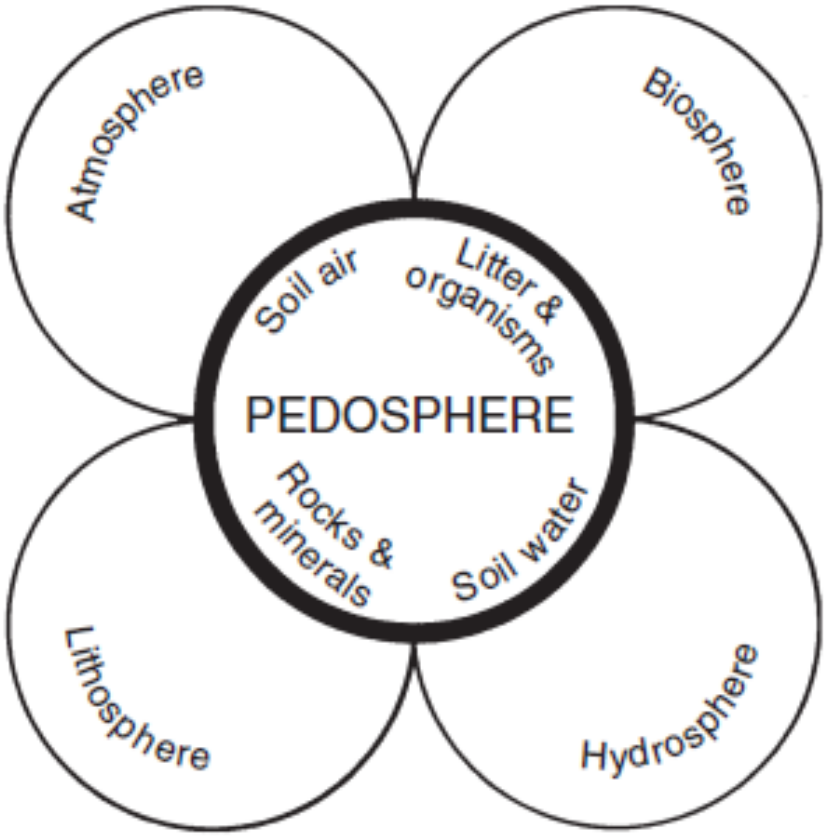
"In place of a ***type-true people***, born of and grown on the ***soil***, there is a new type of nomad, cohering unstably in fluid masses, the ***parasitical city-dweller***…“

Spengler, O. (1917-22) *The decline of the west (trans.)*

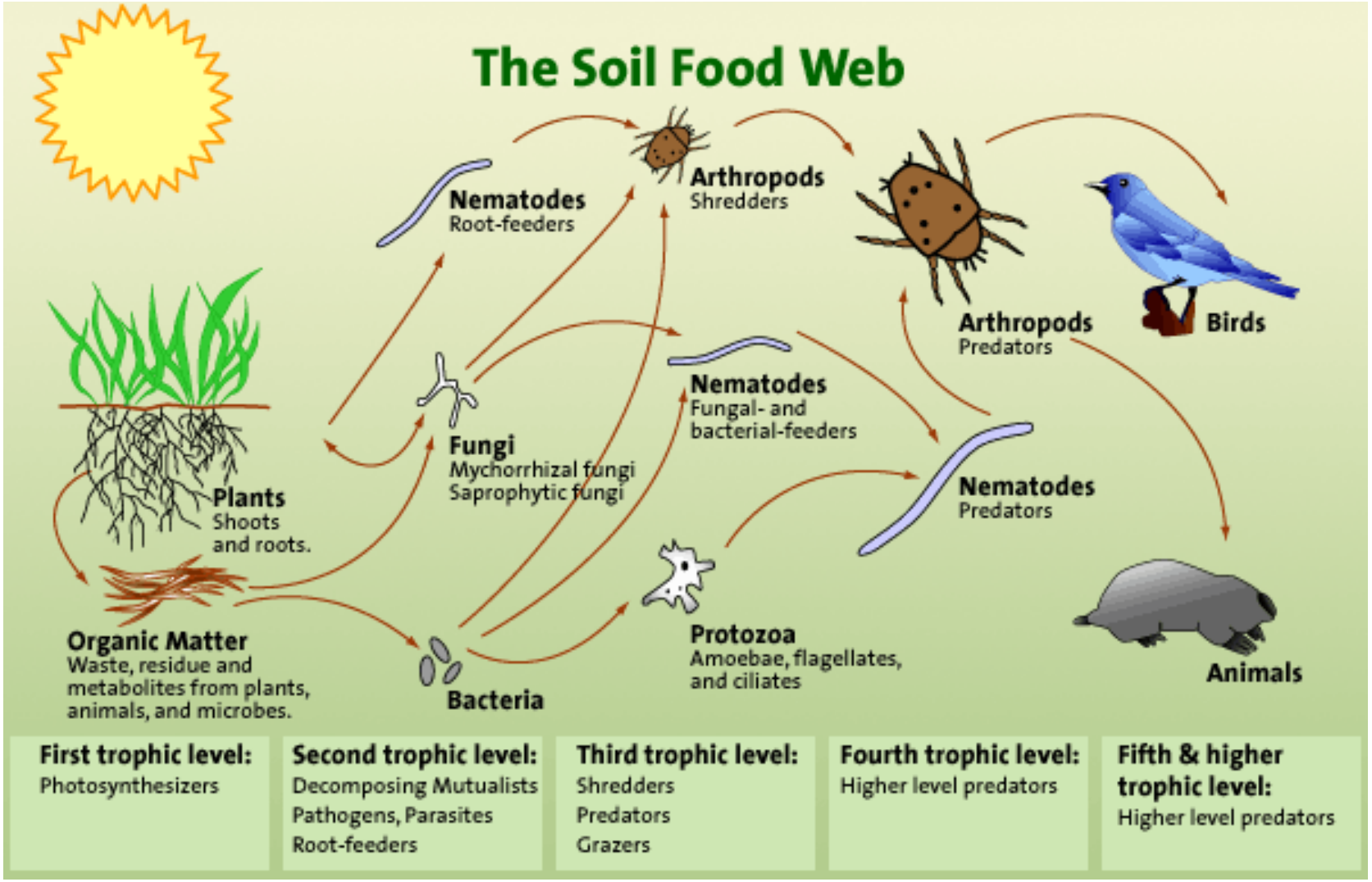
Overview

1. Intro to soils & soil food webs
2. Urban environment
3. Soils, Green Infrastructure (GI), Management
4. Soils and pollution
5. Soils and C-sequestration

What is soil?



- A sand-silt-clay matrix
- Living and dead organic matter
- Gases and liquids in the matrix

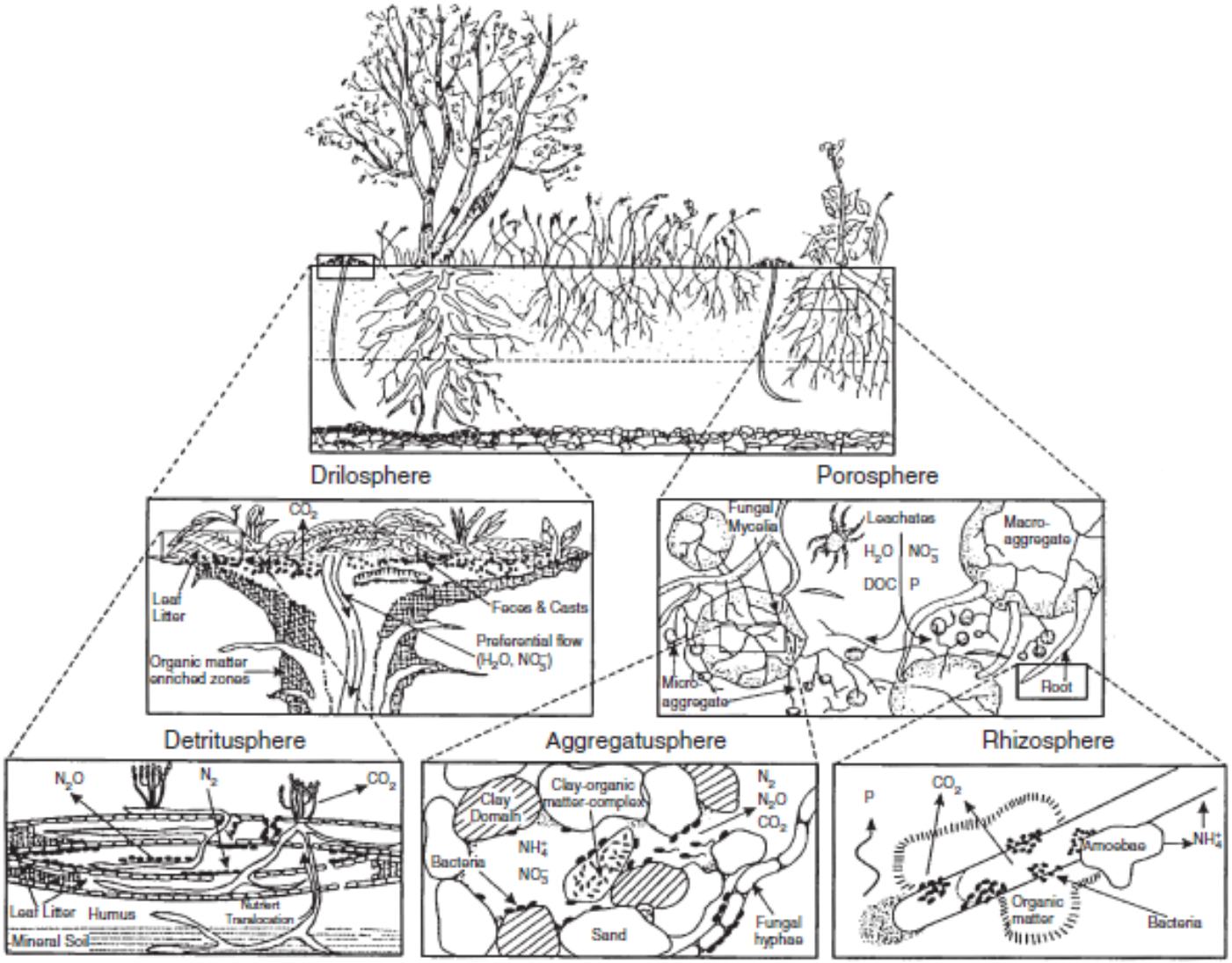


Decomposition

Predation

Litter fragmentation

Hot spots – make up 10 % of soil volume but account for 90% of activity



Variation in Space

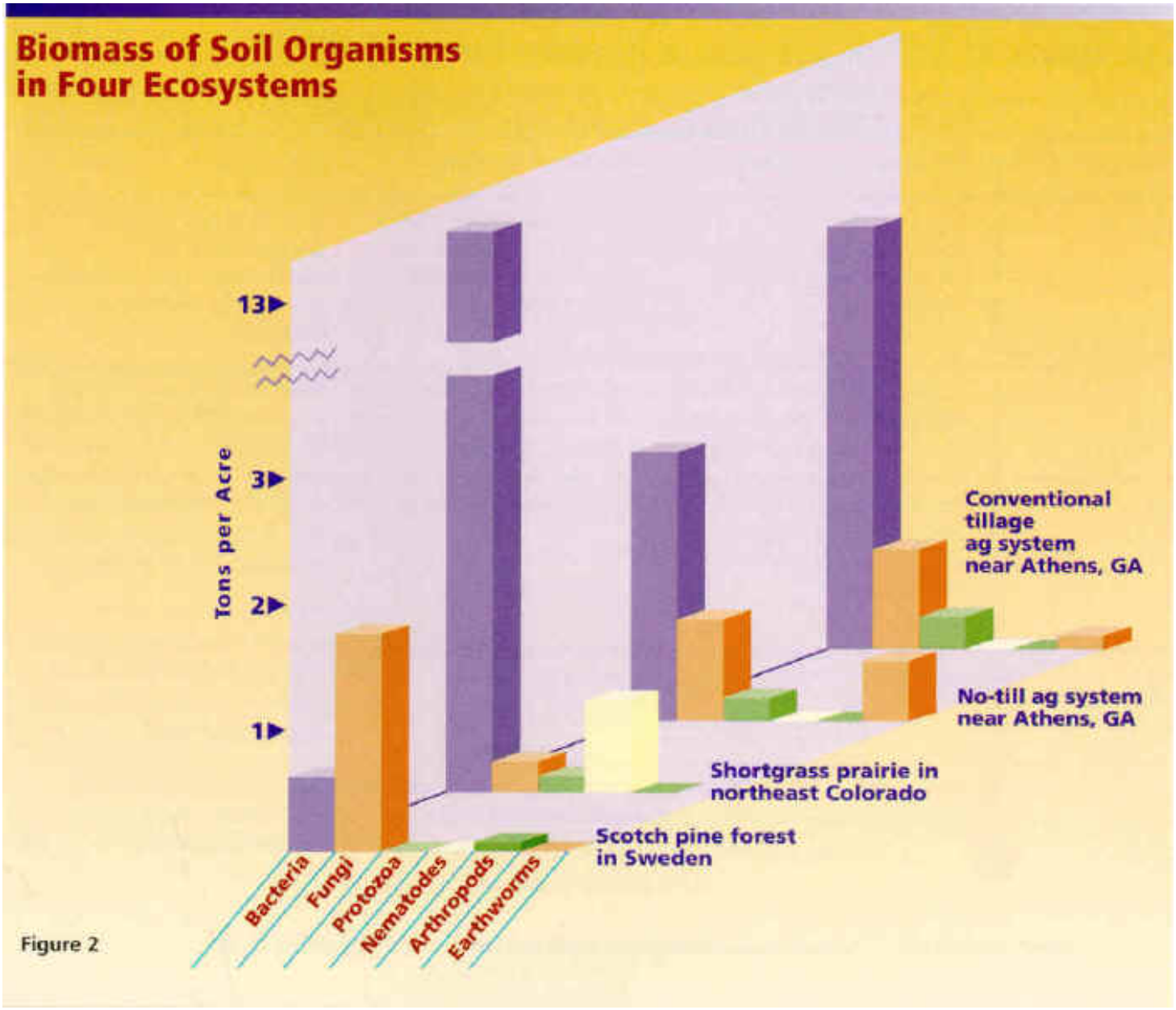


Figure 2

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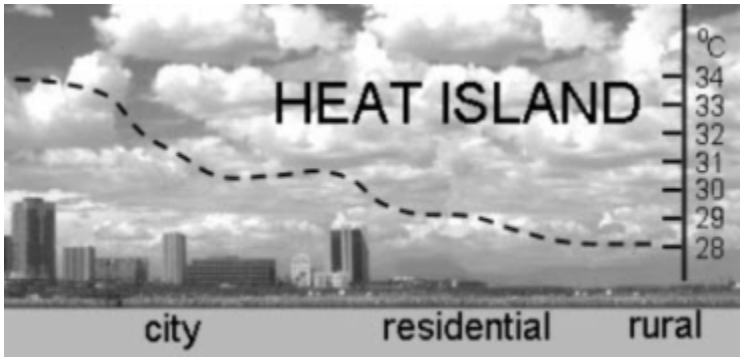
urban soil issues

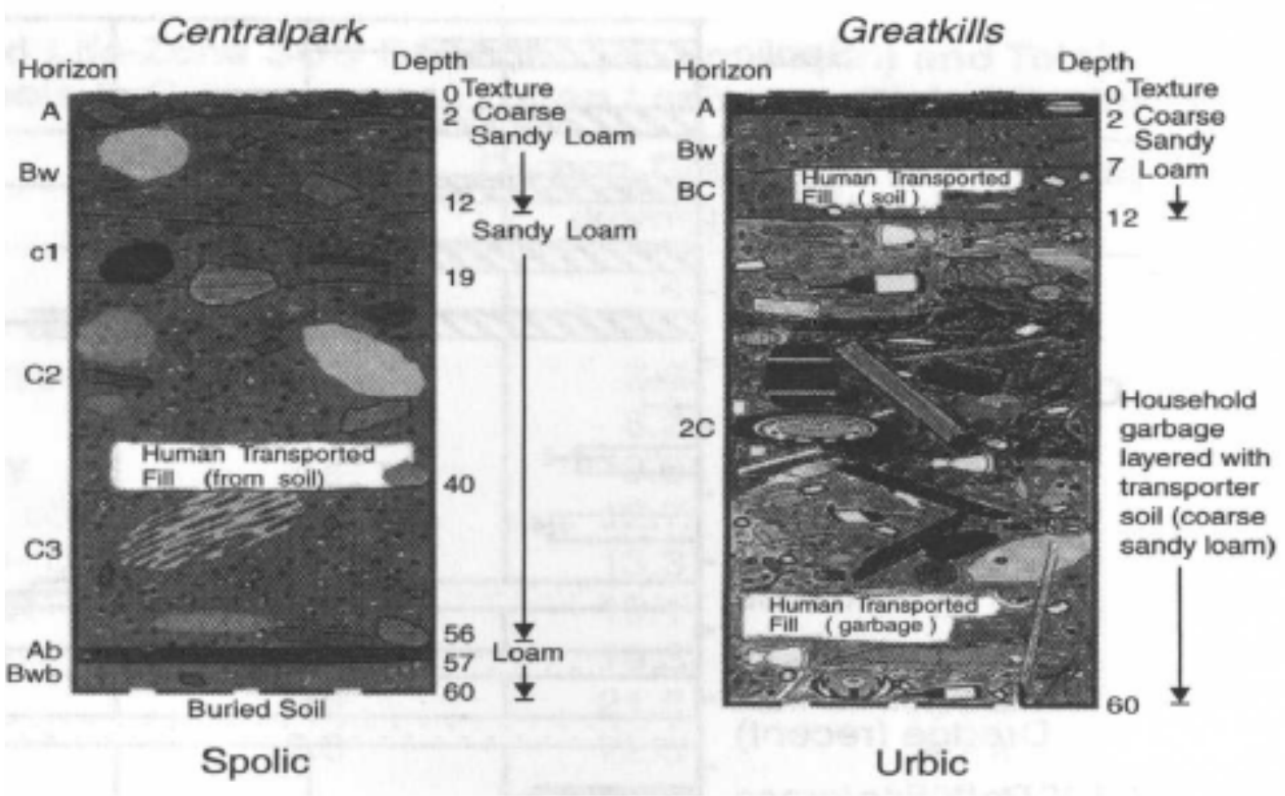


sealing

soil quality

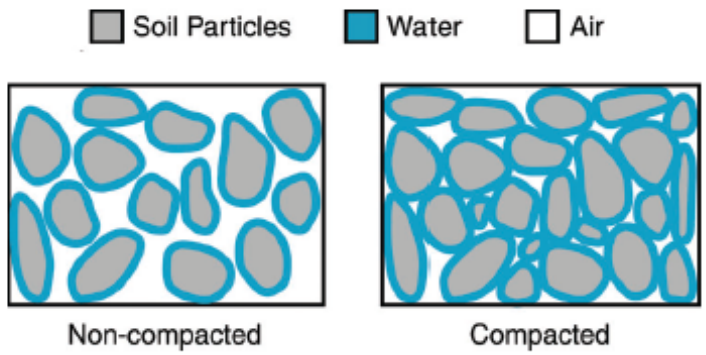
composition

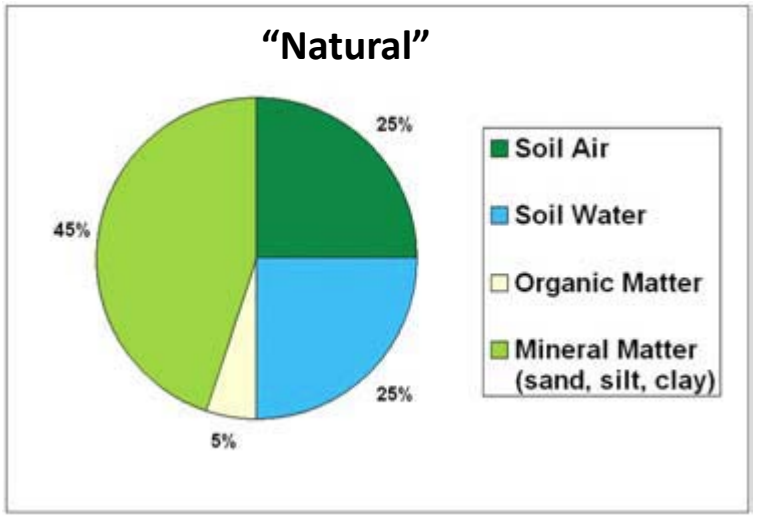
Urban soils are highly disturbed or even made soils

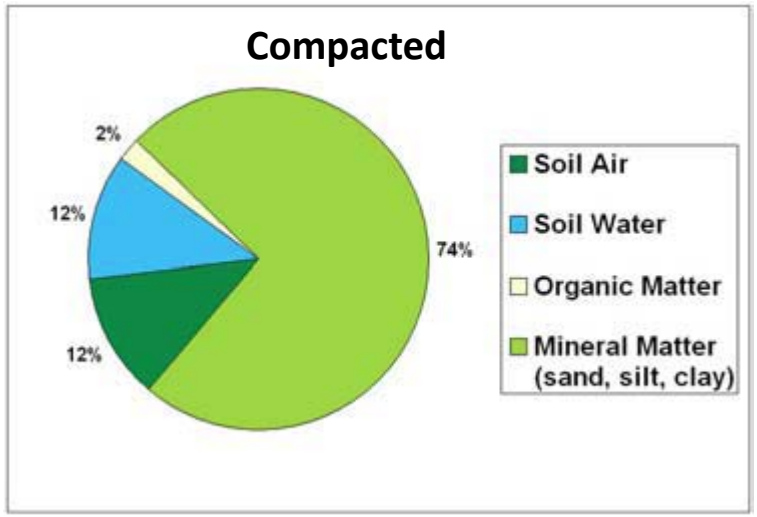


Pouyat et al. 2001

Urban Soils – Physical Impacts

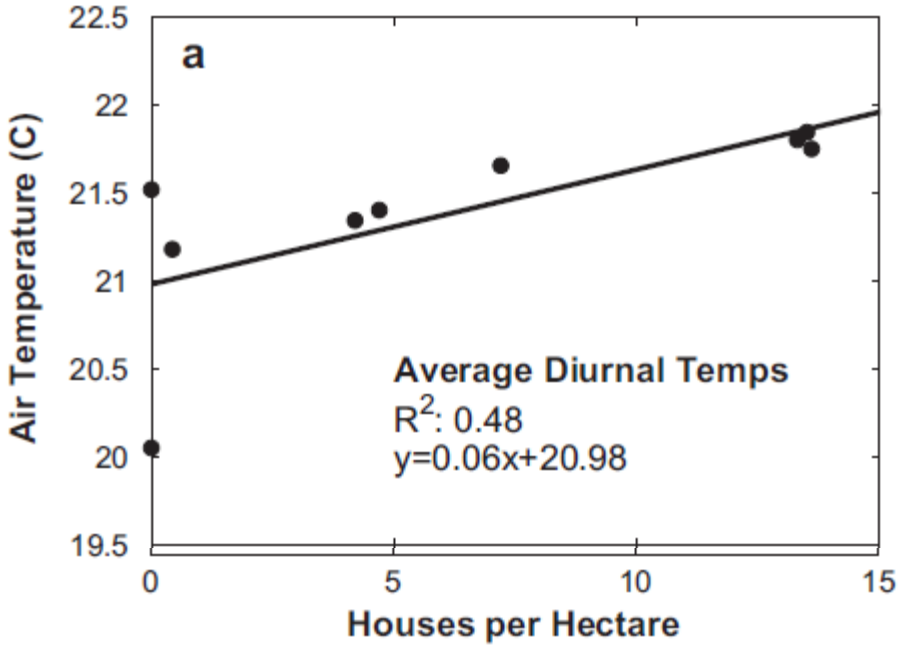






Scheyer et al. 2005

Urban Soils – Climate Impacts



Martin et al. 2012

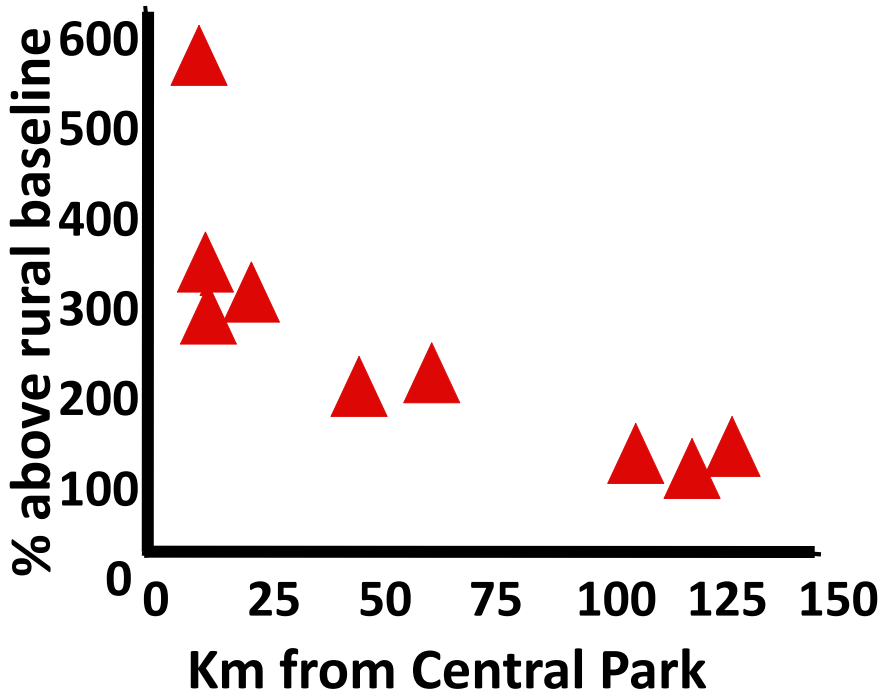
- Small city – 32,000
- Elevation of 1.5 °C

Urban Soils – Chemical Impacts

Metal Pollution

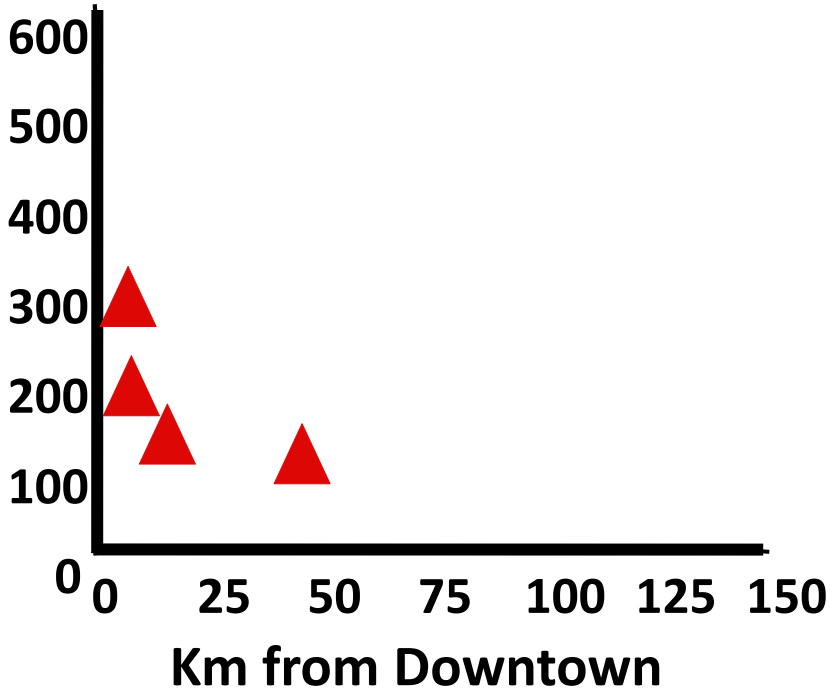
New York City

Pb, Cu, Ni



Louisville, KY

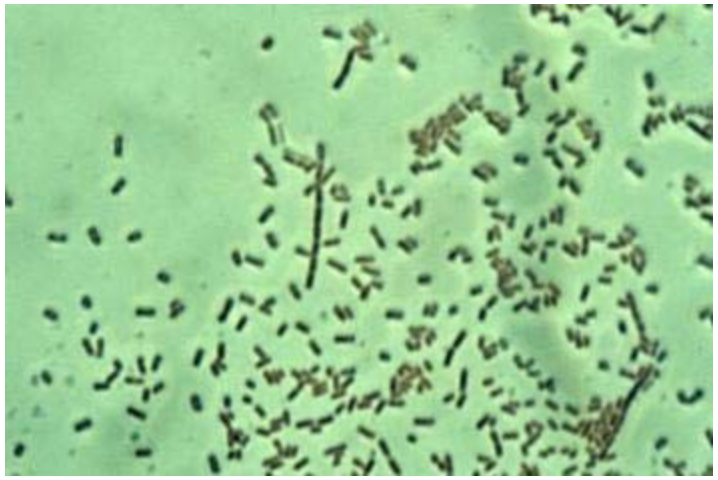
Pb, Cu, Ni



Pouyat and McDonnell, 1991

Carreiro et al., unpublished

Urban Soils – Biota Impacts



Cities affect their local ecosystems differently.

	New York City		Baltimore		Asheville	
Population	*7,420,166*		*645,593*		*61,607*	
Soil Variable	Rural	Urban	Rural	Urban	Rural	Urban
Ph	4.7	4.5	4.6	5.2	4.9	4.9
SOM ($g\ kg^{-1}$)	75	108	110	90	97	79
Annual temperature (°C)	8.5	12.5	12.8	14.5	11.9	13.0
N-mineralization ($mg\ kg\ d^{-1}$)	4.02	10.3	2.2	8.0	0.11	0.26
Leaf decay ($mg\ d^{-1}$)	0.0068	0.0113	n.a.	n.a.	0.0012	0.0009

Pavao-Zuckerman & Coleman 2003, Pouyat et al. 2008

Overview

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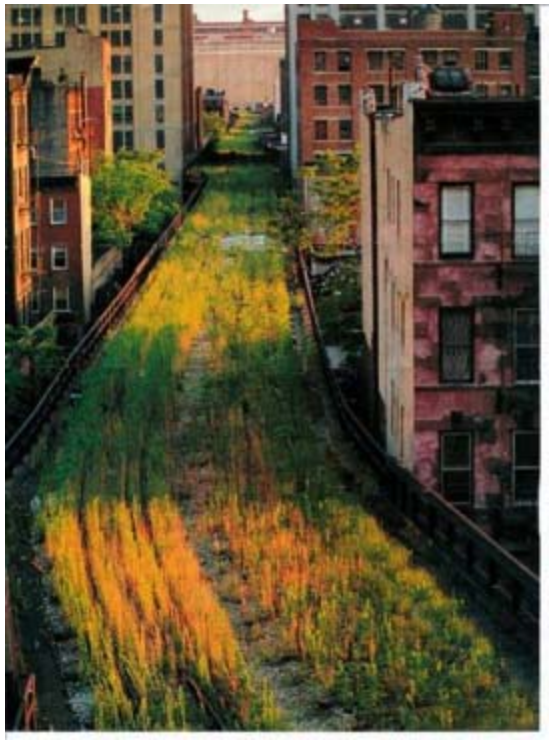
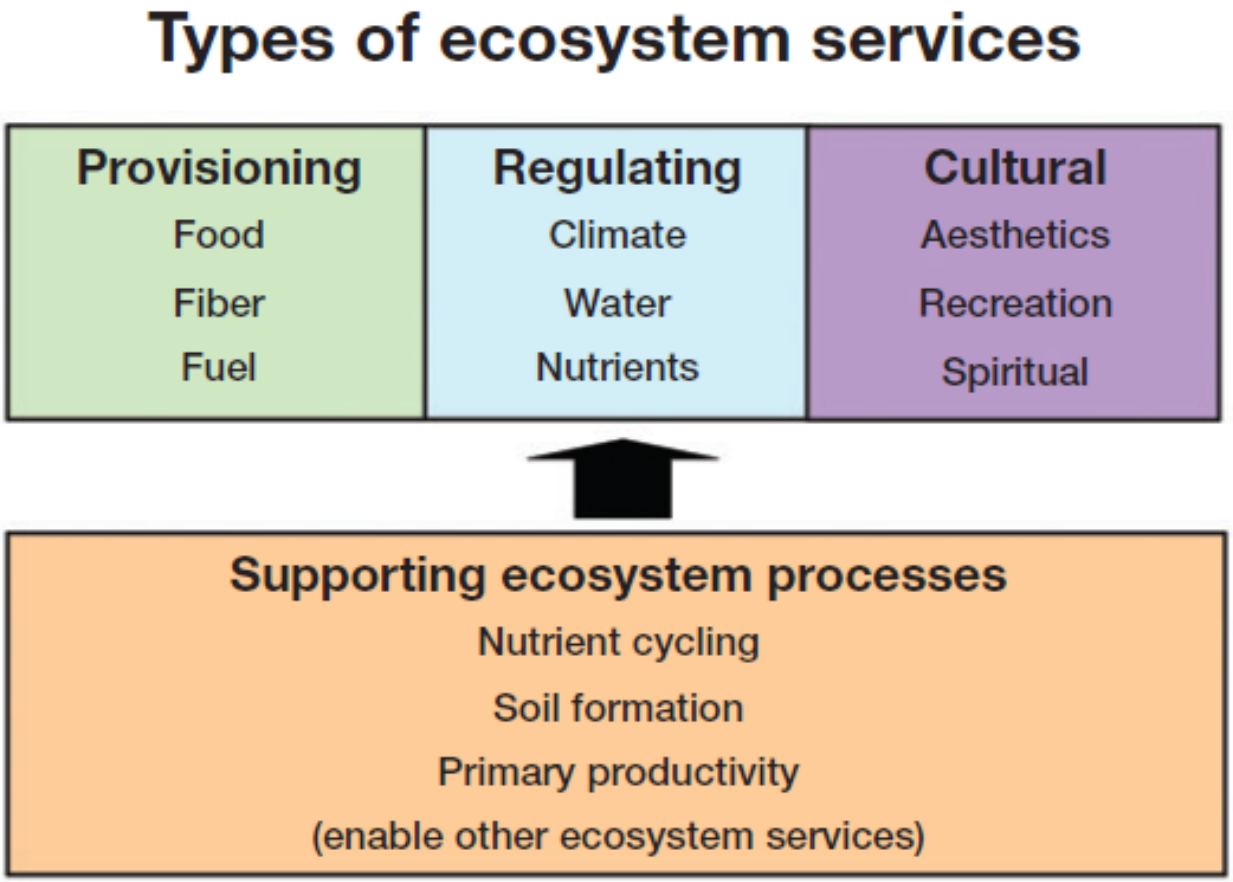
urban soil opportunities

restoration
reclamation
urban design
novel ecosystems



GI – Ecosystem Services



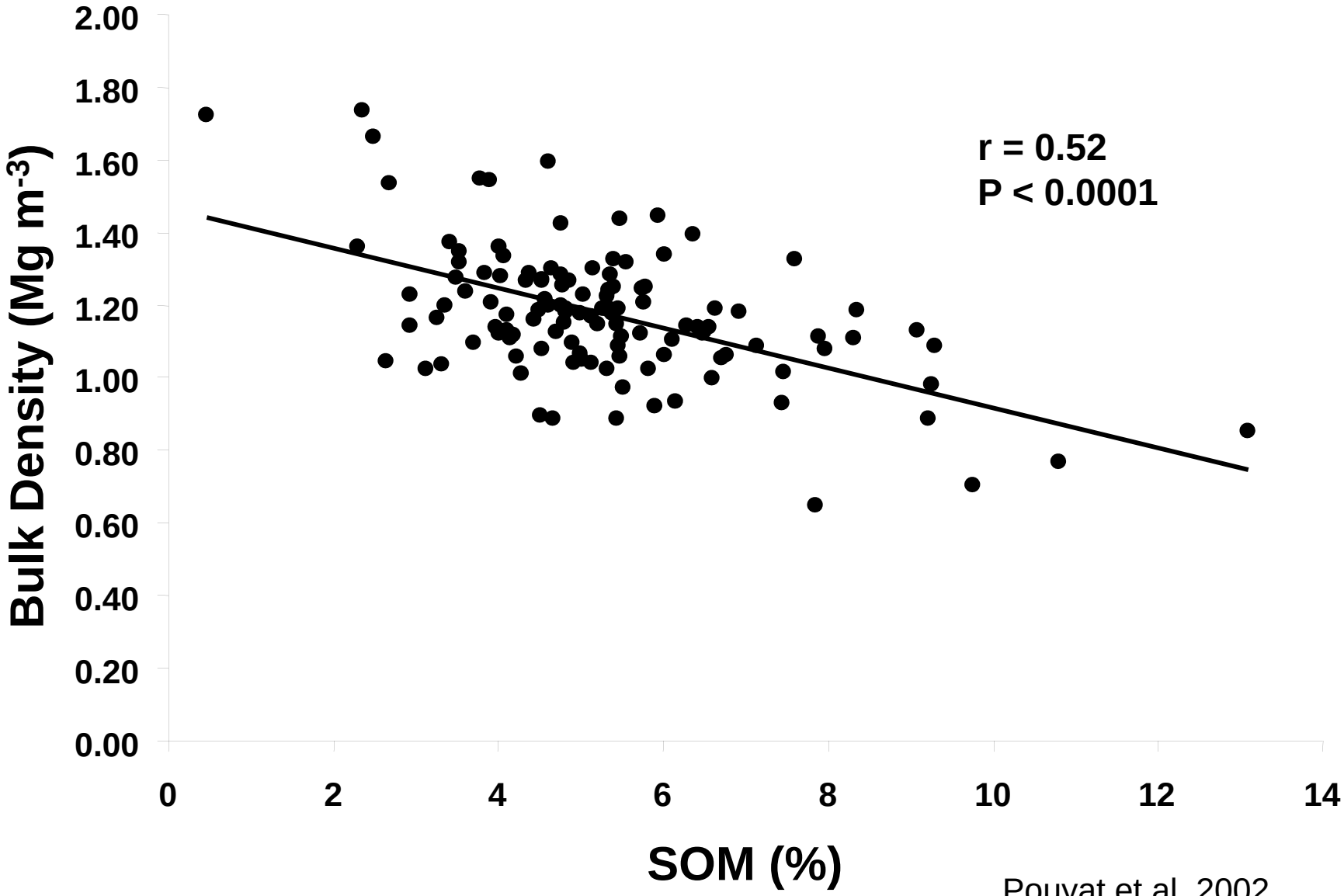
Pataki et al. 2011

Ecosystem service	*Potential magnitude*	*Current level of uncertainty*
C sequestration	Low	Low
Net GHG emissions	Moderate	High
Local cooling	High	Moderate
Stormwater mitigation	High	Moderate
Water-quality mitigation	High	High
Air-quality mitigation	Low	High
General human health	Moderate	Moderate

Ecosystem disservice	*Potential magnitude*	*Current level of uncertainty*
Water use	High	Moderate
Net GHG emissions	Moderate	High
Source of allergens	High	Low
VOC emissions	Moderate	Moderate

Pataki et al. 2011

Compaction and Soil Organic Matter



Pouyat et al. 2002

Important Functions - Soil Food Web

- **Chemical:** nutrient cycling and retention, carbon sequestration, pollutant degradation
- **Physical:** infiltration, structure, aggregates, etc.
- **Biotic:** disease suppression, biodiversity

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Rain Gardens and Bioretention

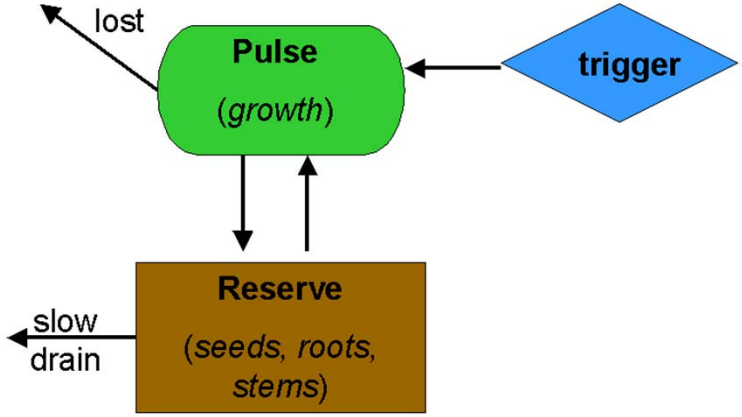
TABLE 1 LABORATORY AND ESTIMATED BIORETENTION

Pollutant	Removal Rate
Total Phosphorus	70%-83% [1]
Metals (Cu, Zn, Pb)	93%-98% [1]
TKN	68%-80% [1]
Total Suspended Solids	90% [2]
Organics	90% [2]
Bacteria	90% [2]

Source: [1]Davis et al. (1998)
[2]PGDER (1993)

http://water.epa.gov/infrastructure/greeninfrastructure/

Desert Ecosystems Function with Precipitation Pulses



Noy-Meir 1973, Reynolds et al. 2004

Green Infrastructure -Reconnecting Urban Ecohydrology

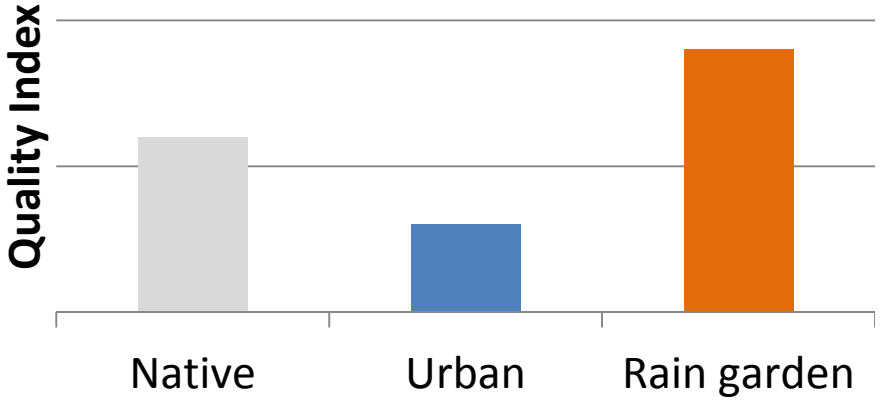
Soil quality?

Ecosystem Function?

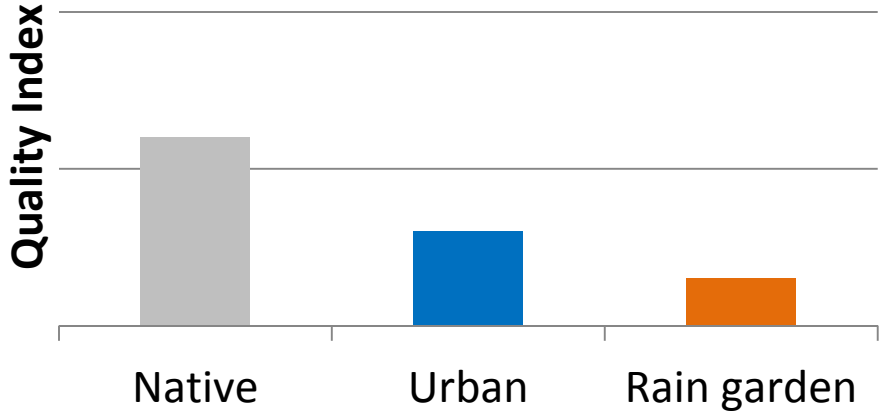
Ecosystem services?

Hypotheses

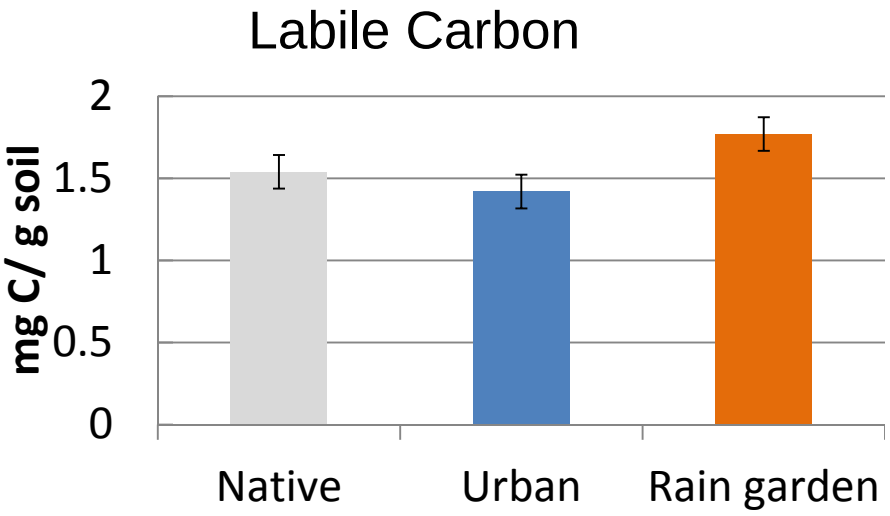
H1: Rain gardens improve urban soil quality

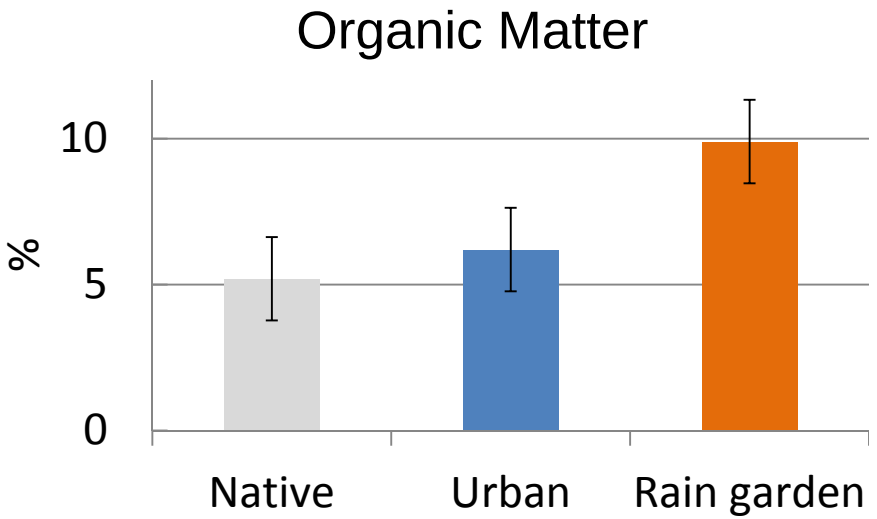


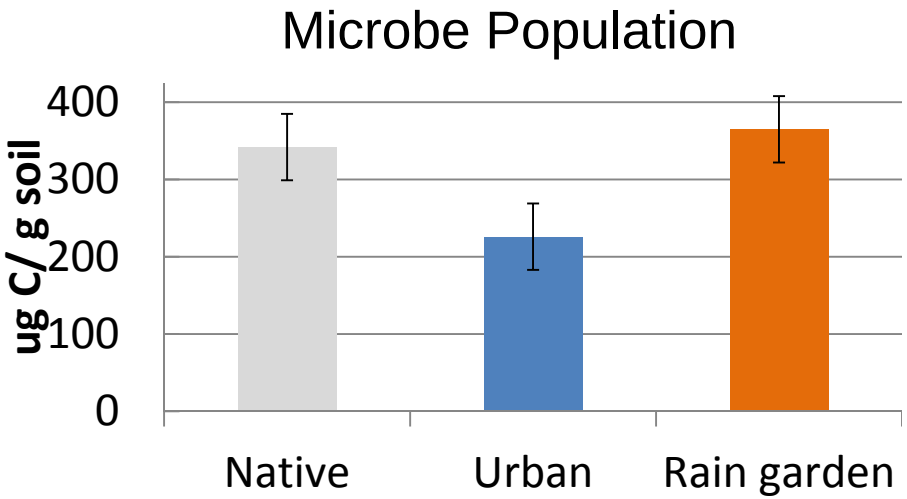
H2: Rain gardens further degrade urban soil quality



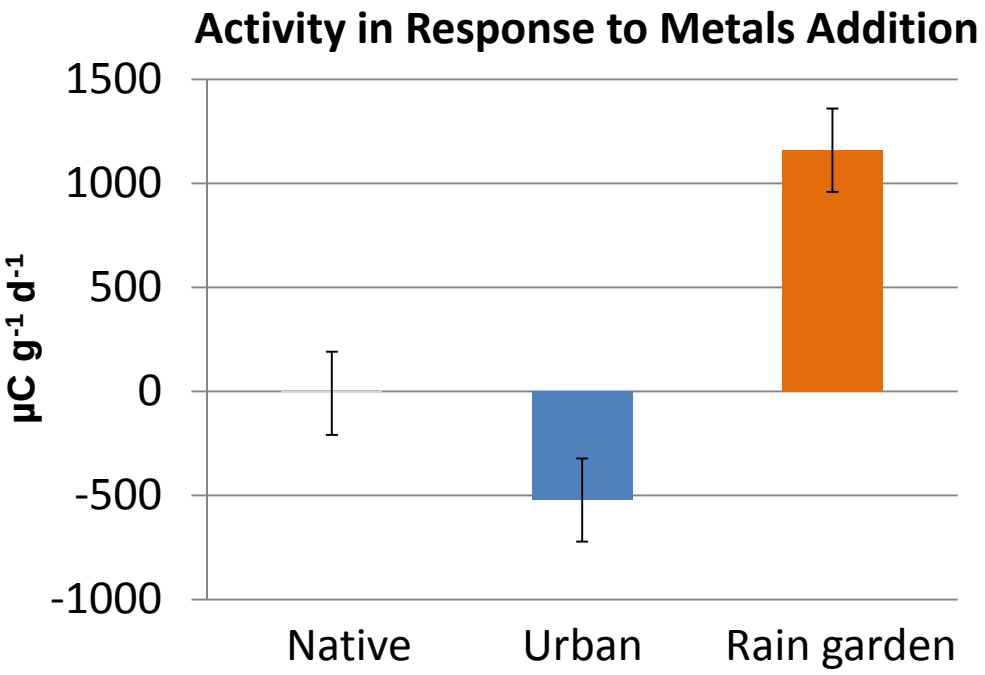
Soil carbon pools are slightly elevated in rain garden basins







Rain garden microbes are active when we soak them in metals



Microbial adaptation or acclimation to metal stress?

Urban soils and ecosystems may recover quickly from disturbance

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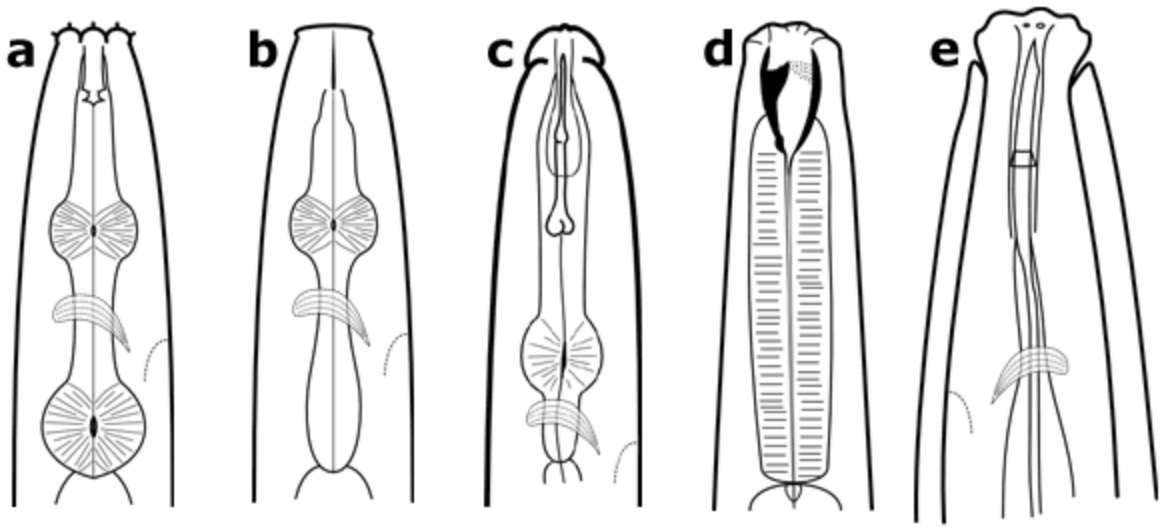
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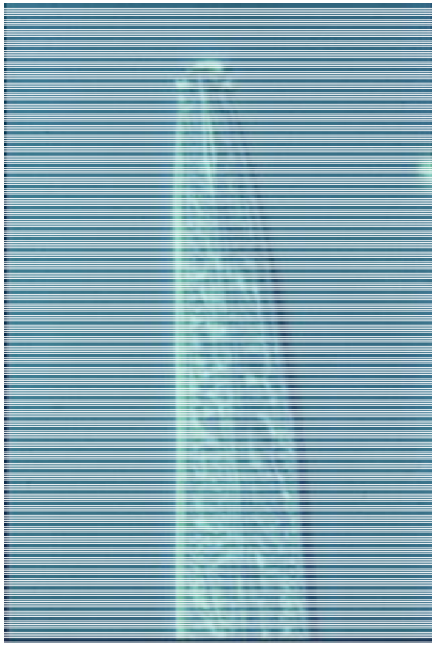
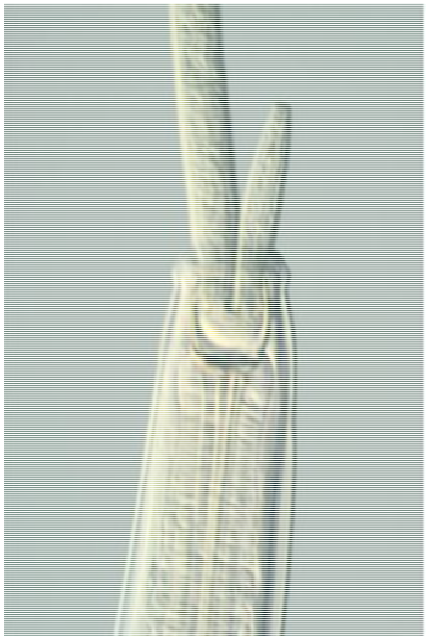
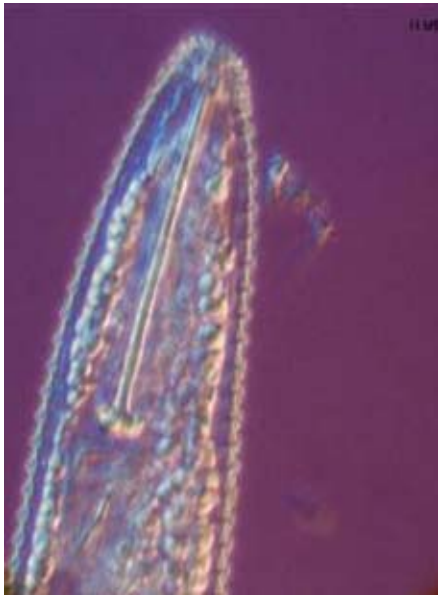


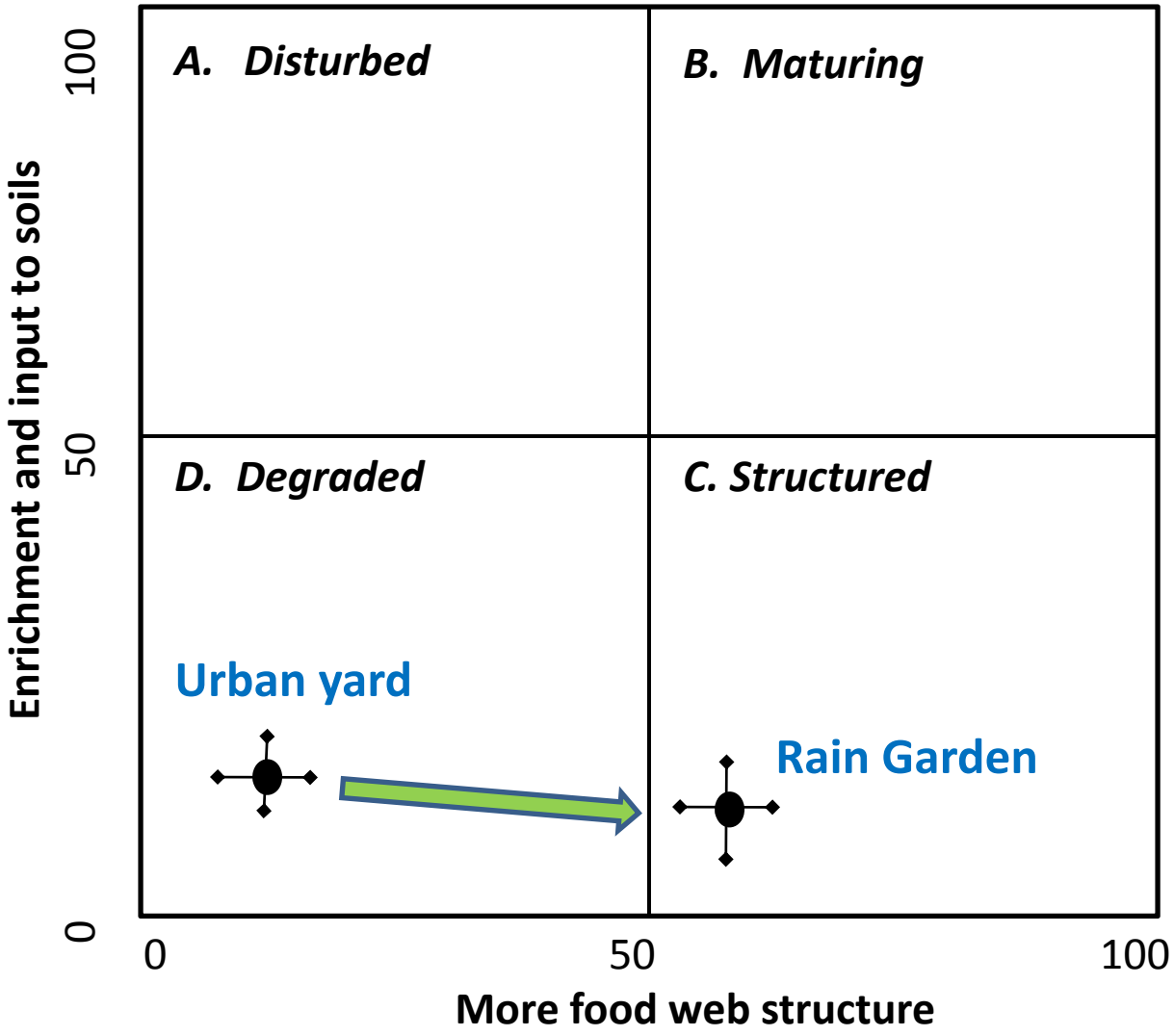




Nematode community analysis - food web development in rain garden basins

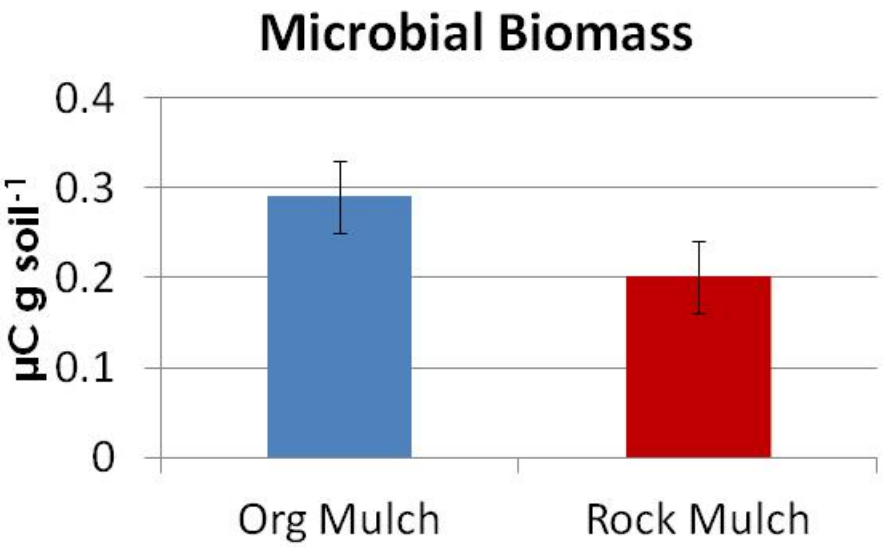
	Urban Yard	**Rain Garden Basin**
Abundance	6.9 g soil^{-1} [0.7]	8.5 g soil^{-1} [0.9]
Bacteria Feeders	7.8 [1.7]	6.2 [1.6]
Fungal Feeders	0.5 [0.6]	1.3 [0.5]
Omnivores	0.0	0.25
Carnivores	0.25 [0.5]	1.5 [.8]
FF: BF Ratio	0.06	0.21

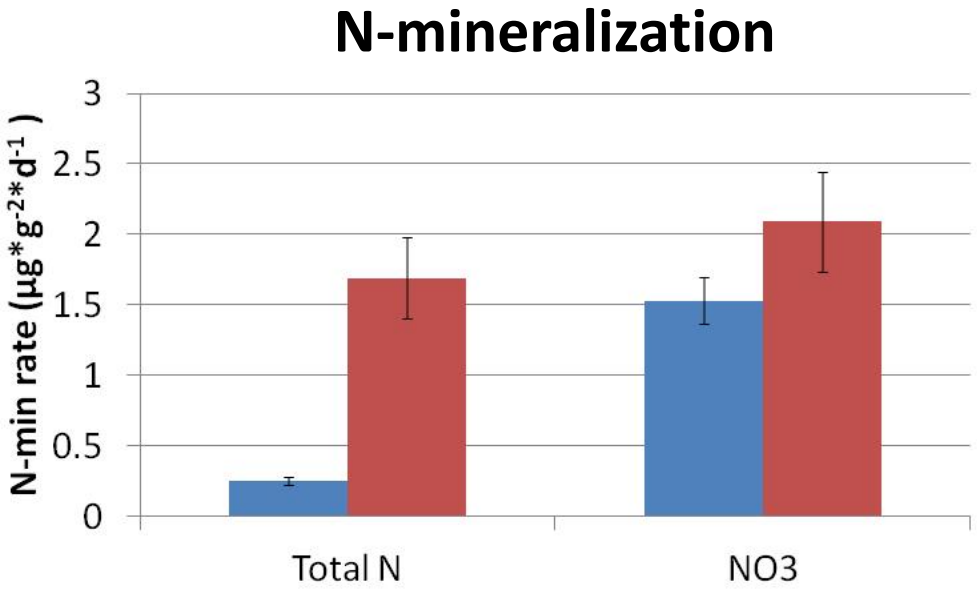
Rain Gardens have more structured soil food webs



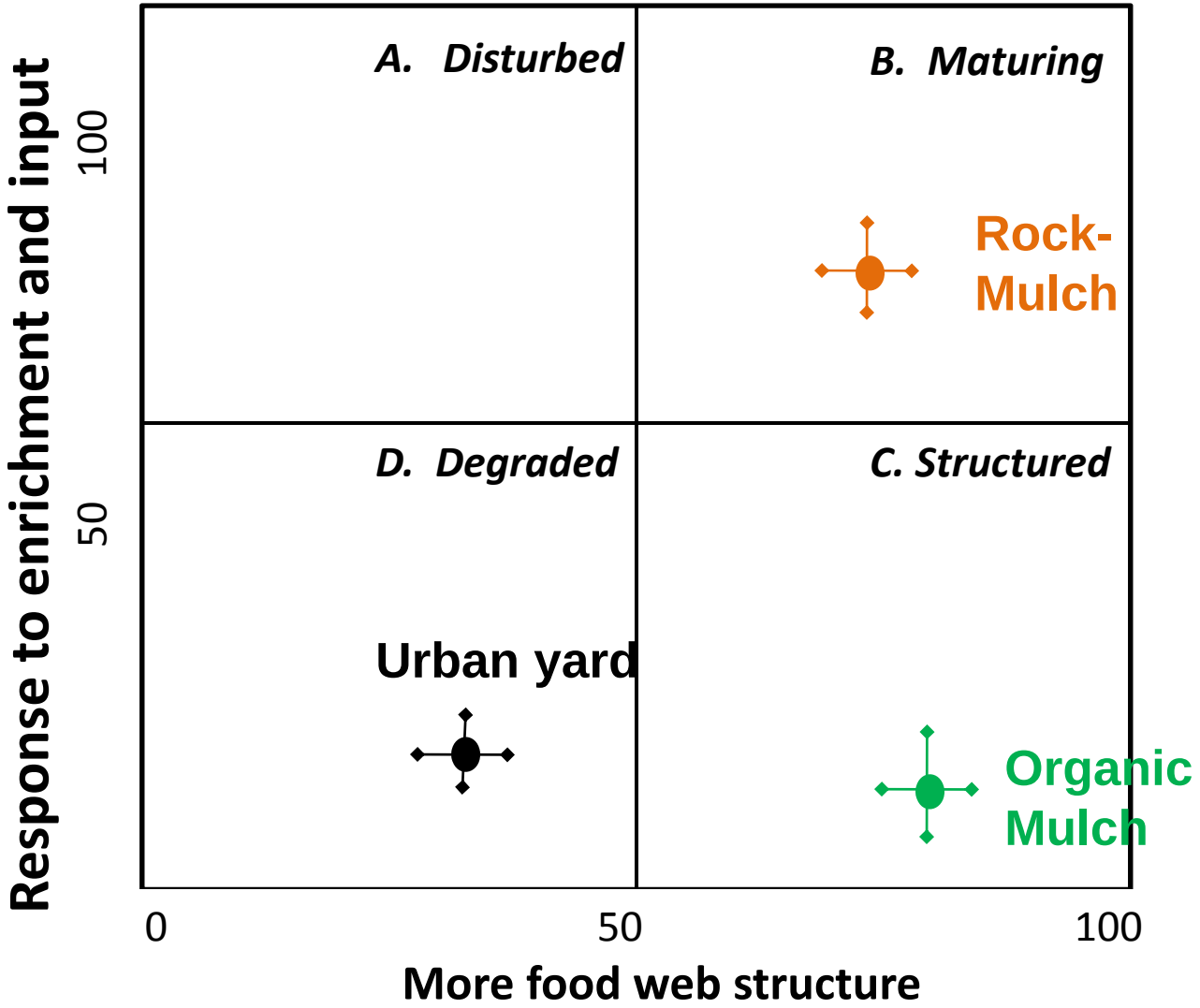
- 5x increase in F:B ratio
- 6x increase in predators

Organic mulch reduces N-mineralization rates



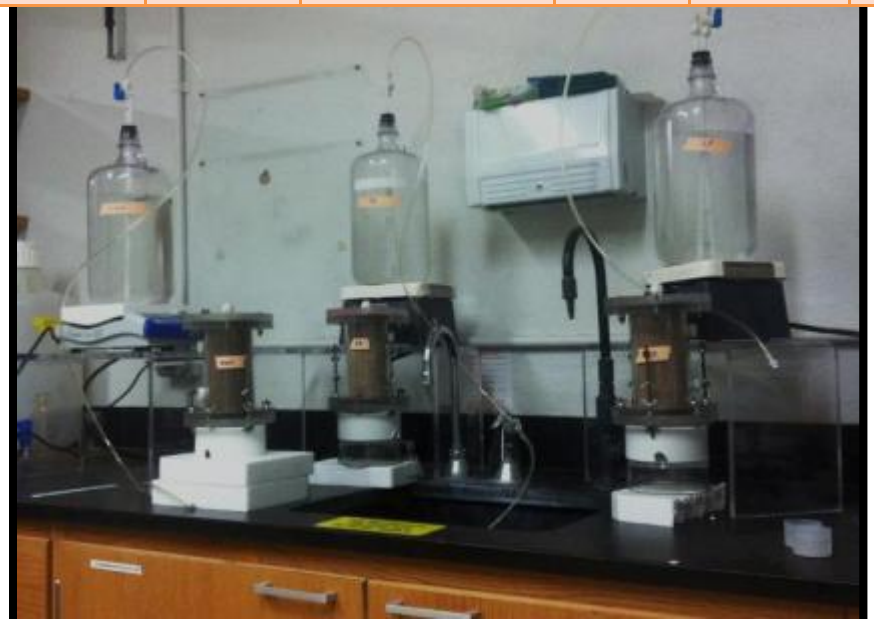


Nematode Community Indices: more food web structure with organic mulch



Bioretention Potentials

Soil Mixture	SOM	Infiltration Rate	Removal Efficiency (%)		
	(%)	(cm/min)	Cd	Pb	NO_3-N
Sand	1.28	1.96	97	94	35
Sand + mulch	1.28	2.56	98	92	53
Loam	3.26	1.25	98	98	44
Loam + mulch	3.26	0.51	82	69	25



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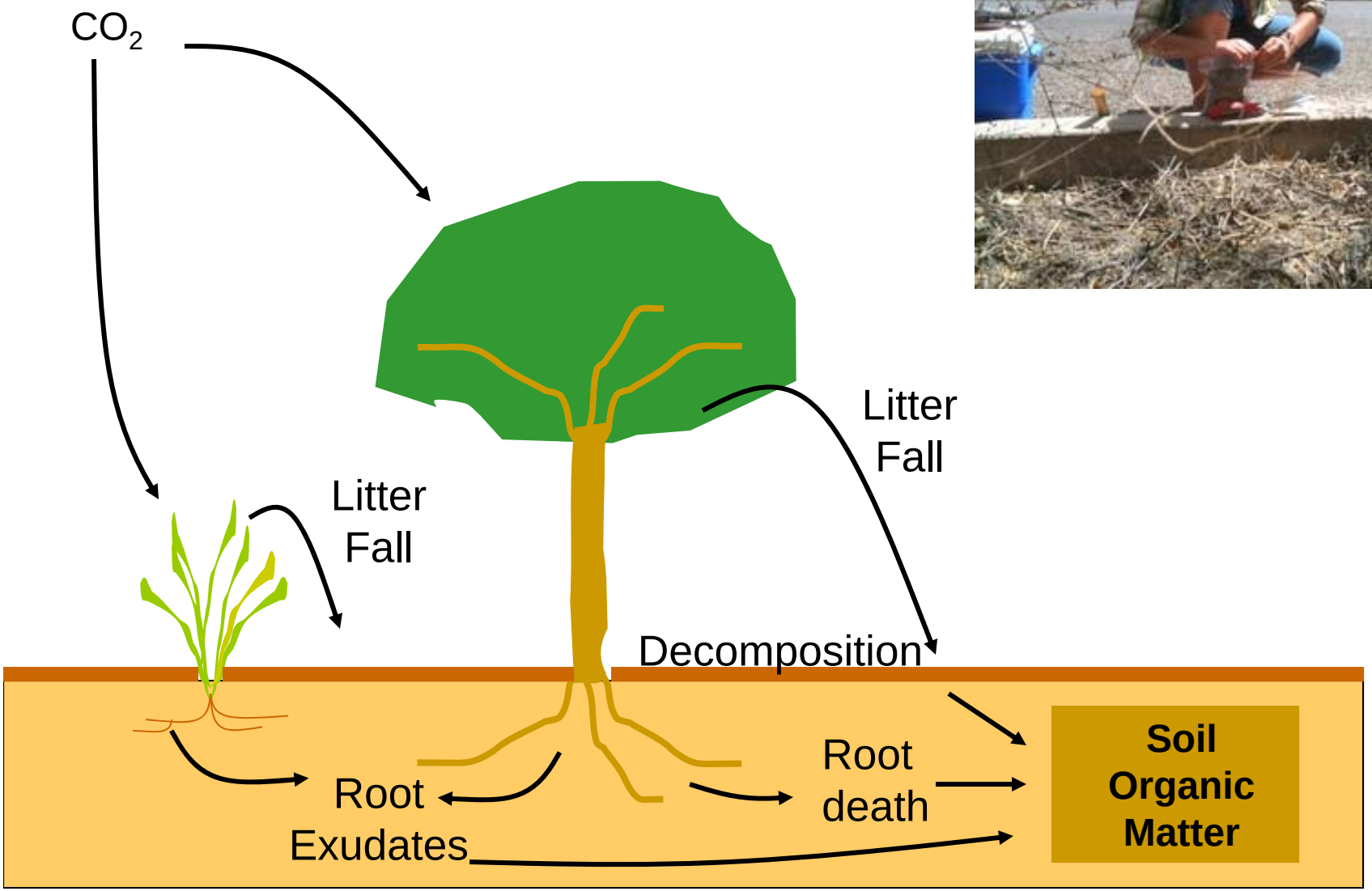
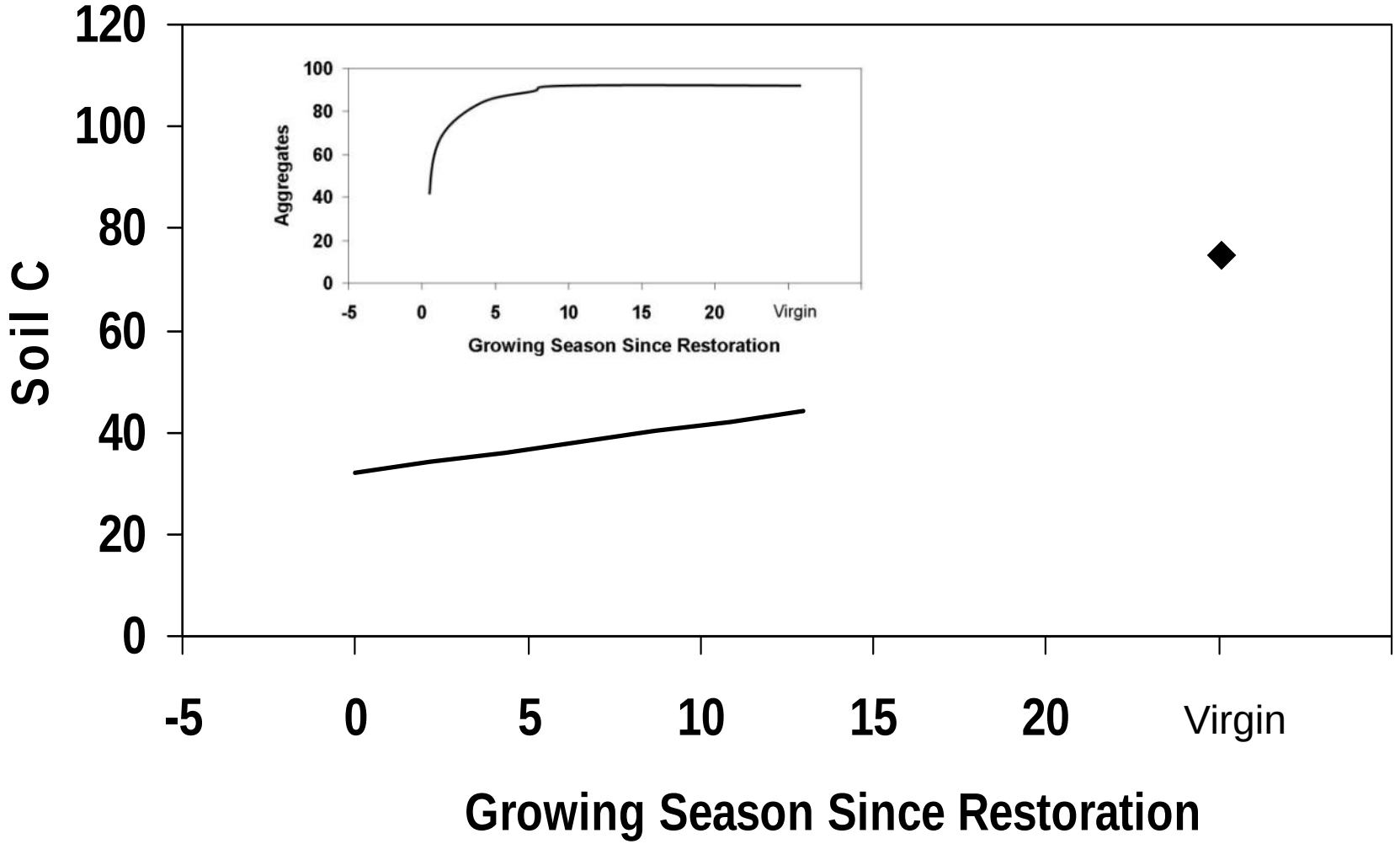
To be sequestered in the soil CO_2 in the atmosphere must first be taken up a plant

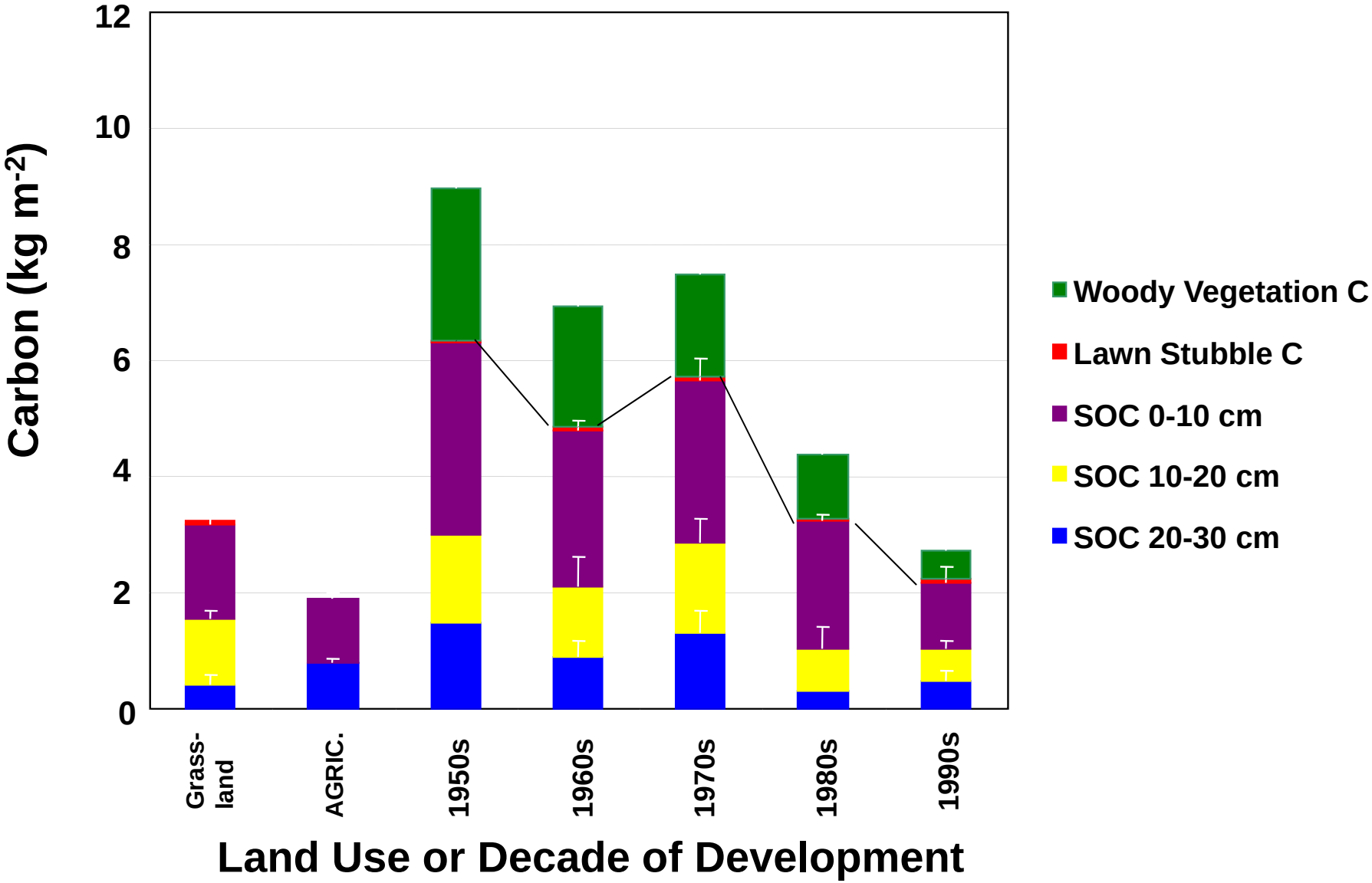


Soil C increases with prairie restoration



Jastrow 1996

Soil C increases w/ age since development



Golubiewski (2006)

How to Promote Soil C-sequestration (Lal et al. 2003)

Residue management

Use of soil amendments

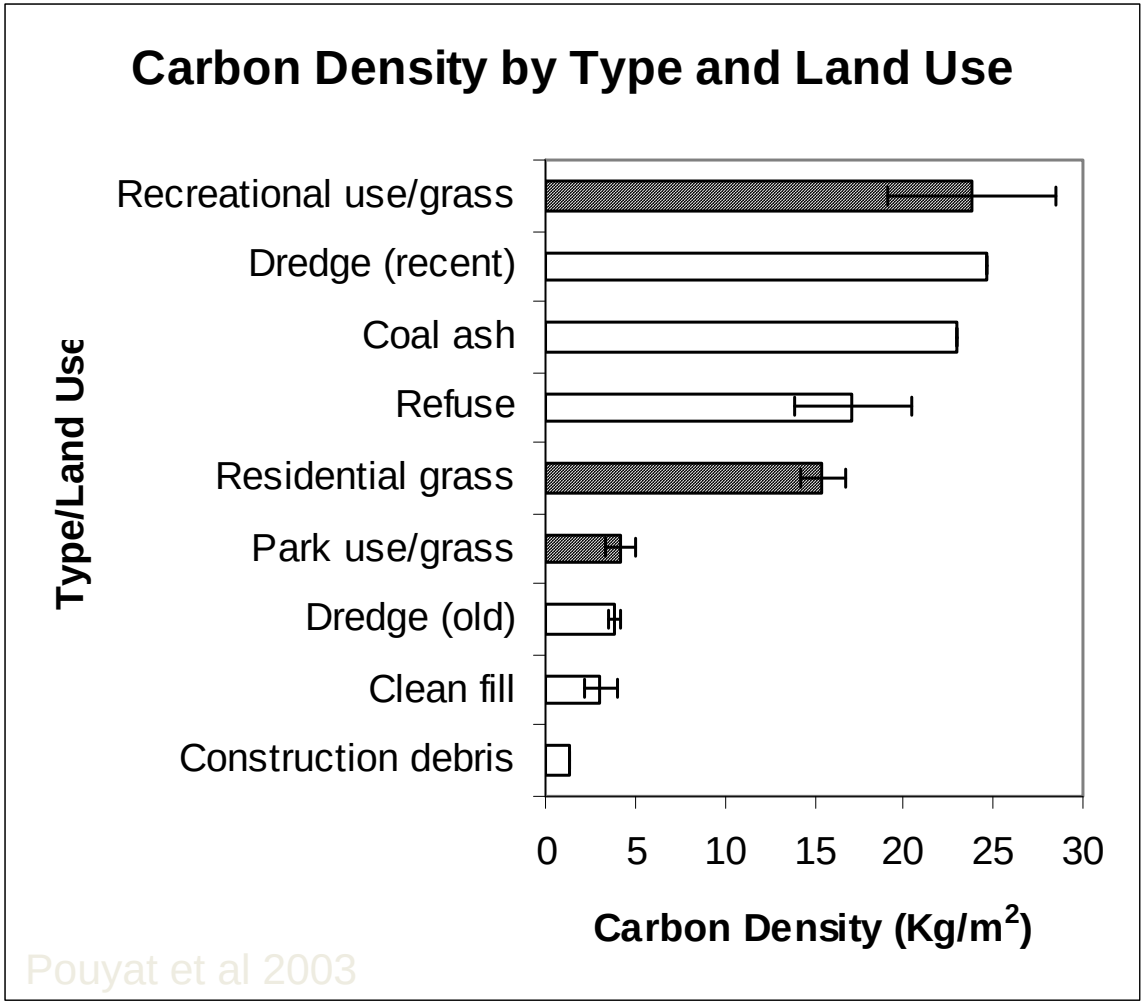
Less disturbance

Maintain root biomass in soil

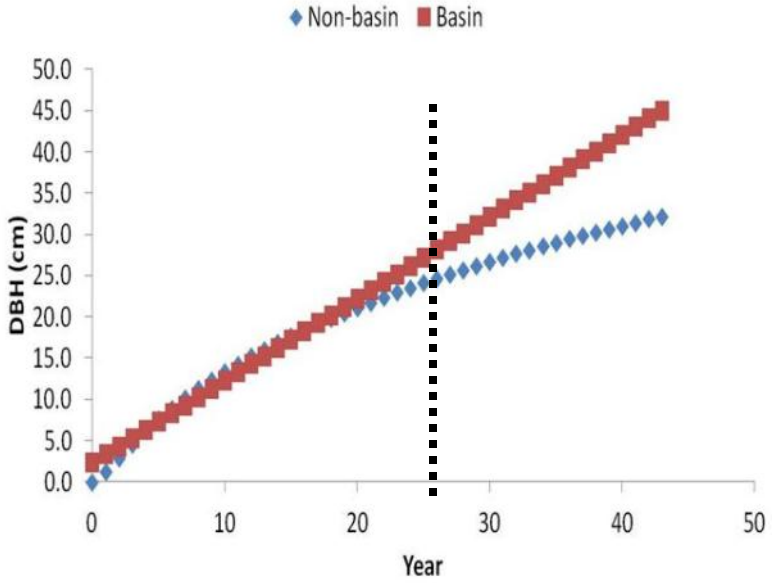
Prescribed fire

Mimic the natural ecosystem

Soil C Varies in the Urban Landscape

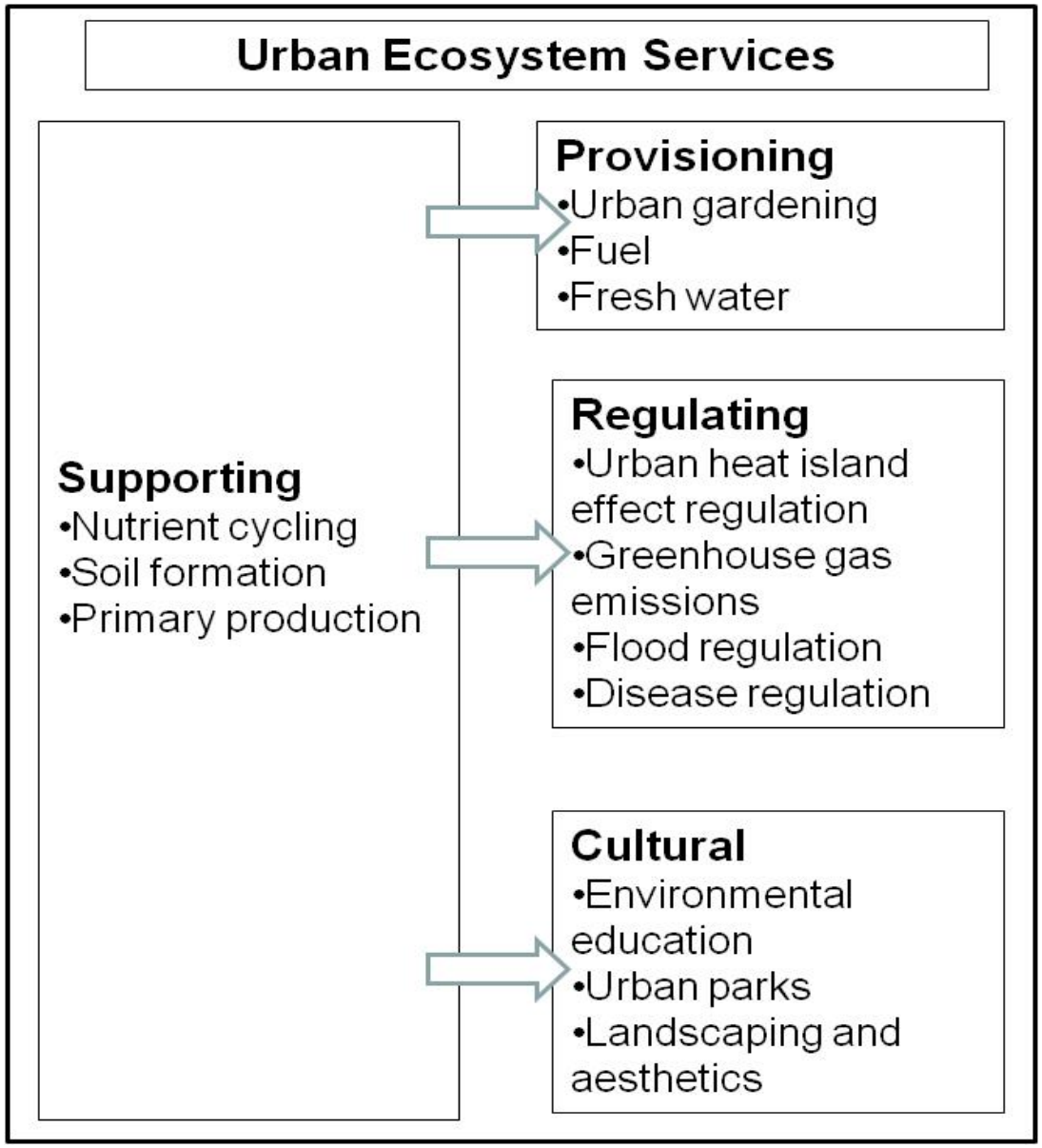


Rain harvesting basins - 33% larger trees



	CO_2 Sequestered (kg/tree)	Aboveground Biomass (kg/tree)
Basin tree	1754.2	745.7
Non-basin tree	678.0	288.2

Relevance of soil knowledge for…..



Pavao-Zuckerman *2012*

Global Urbanization and the Separation of Humans from Nature

WILL R. TURNER, TOSHIHIKO NAKAMURA, AND MARCO DINETTI

BioScience *June 2004 / Vol. 54 No. 6*

Digging Deeper…

- D.C. Coleman et al. “Fundamentals of Soil Ecology”
- D. Wall et al. “Soil ecology and ecosystem services”
- USDA, Urban Soil Primer: http://1.usa.gov/V83iwA
- EPA, Evaluation of Urban Soils for Green Infrastructure http://1.usa.gov/Weamfn