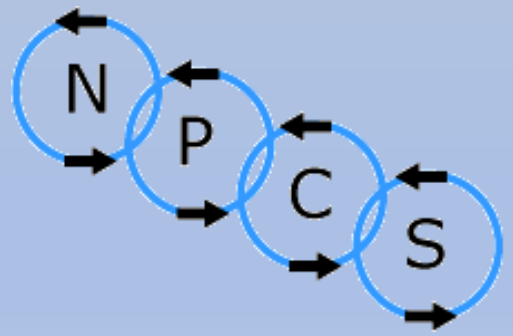
URBAN SOIL HEALTH

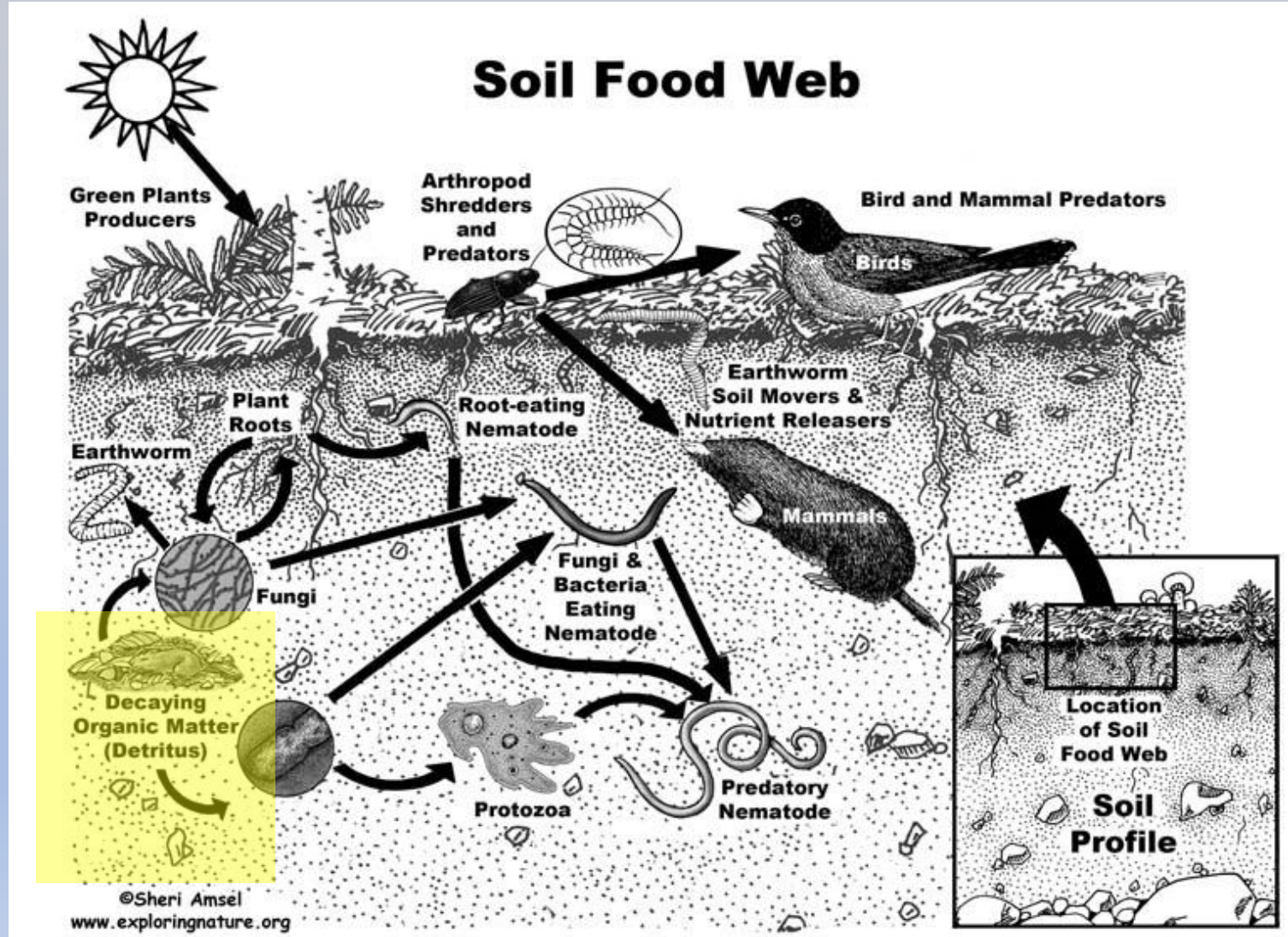
April 13, 2023

11th – Biennial Bay-Wide Stormwater Partners' Retreat

What is Soil Health?

Vitality of soil to sustain the ecological functions of our lands & living systems





Native Planting

Nutrient Cycling

Organic Waste Recycling

Soil Erosion

Agriculture & Economics

Climate

Carbon Sequestration

Human Nutrition

Fertilizers

Water Quality

Flooding

Irrigation

Hydrology

Drought

Heat Islands

Groundwater Recharge

Air Quality

PERFECTING PERCOLATION IN DISTRICT PARKLANDS

Testing Soil Amendment Techniques and Subsoiling on Compacted Urban Land in DC

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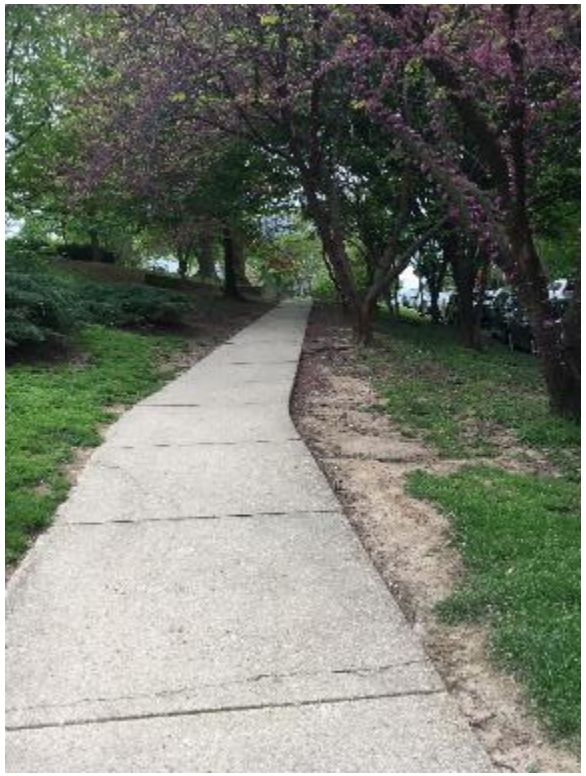
DEPARTMENT OF ENERGY & ENVIRONMENT
WE ARE WASHINGTON DC
GOVERNMENT OF THE DISTRICT OF COLUMBIA
MURIEL BOWSER, MAYOR

The Problem

- Compacted, sandy soils with poor infiltration capacity and little organic content
- Stormwater runOFF volumes increase
- Soil loss from "open space" ends up in storm sewers and waterways
- Carries pollutants attached to sediment
- Loss of soil impacts site directly:
  - Tree health: lack of water, loss of soils
  - User experience

The Problem



(Kalorama pictured)

Impacts to Trees

(Takoma pictured)

Impacts to Site Users

Impacts to Water Quality

Impacts to Water Quality

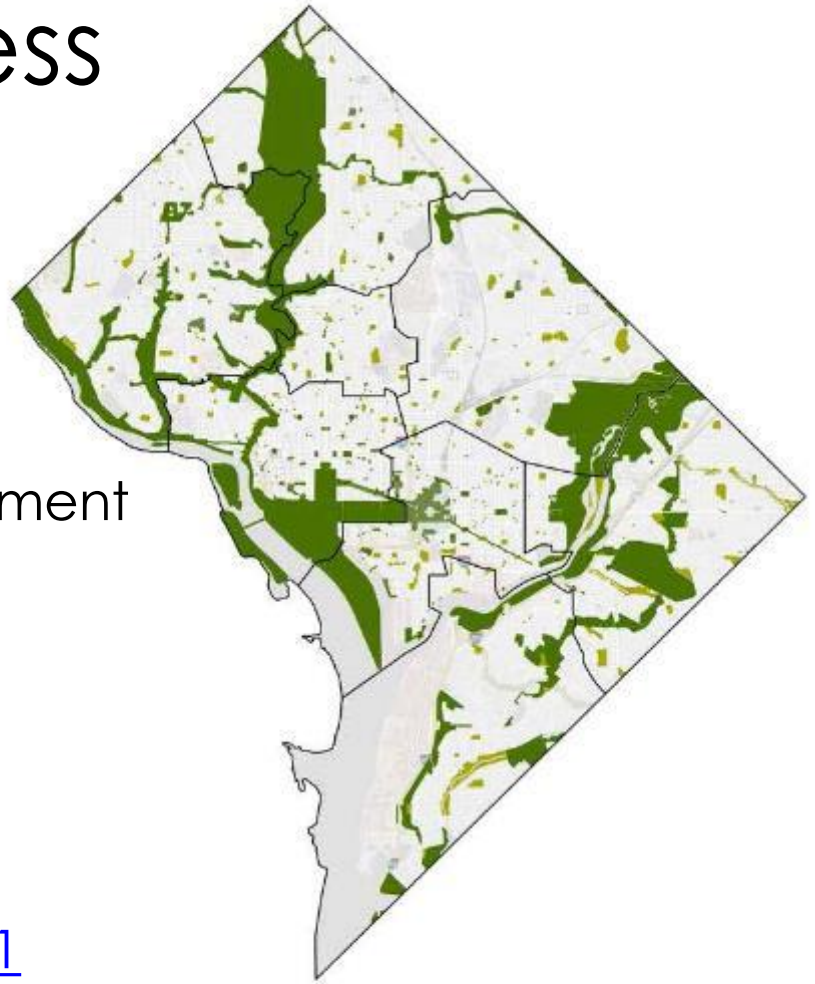
Hickey Run ($100k/yr)

VOLUME!

Results & Management Implications

- Addressing existing problems
- Responsive to community concerns
- Better design guidance
- Soil "restoration" specs improved
- Recs for sustainable land mgmt

Process



- Literature review
- Desktop assessment
- Site selection
- Field assessment
- Monitoring and work plan development
- Implementation and monitoring
- Results and recommendations
- Two-year effort 2023-2025

- Website: https://doee.dc.gov/node/1635051
- POC: Cecilia Lane, cecilia.lane@dc.gov

Questions ?

Soil Profile Rebuilding in Arlington VA

BAY STORMWATER RETREAT

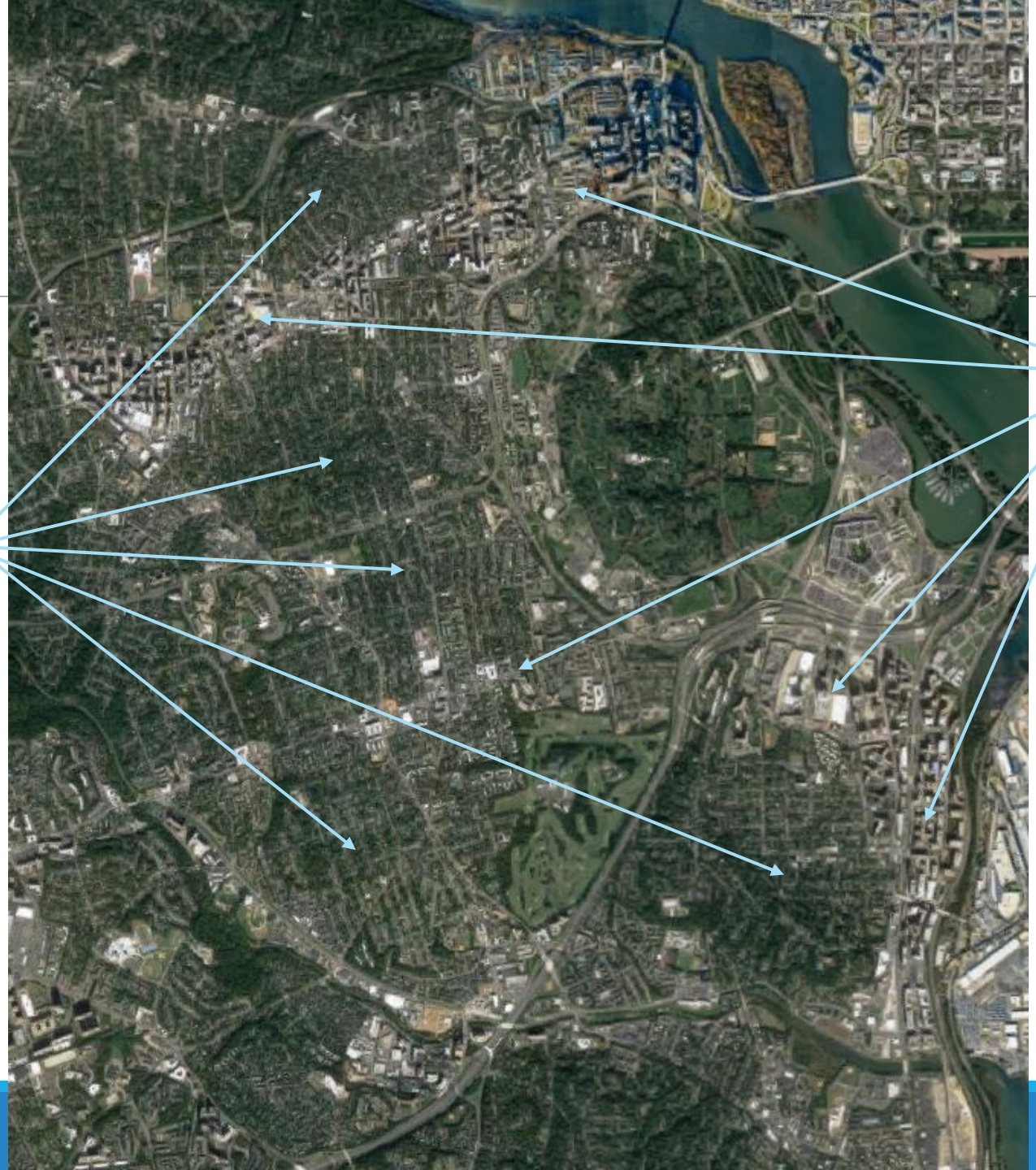
APRIL 13, 2023

A Tale of Two Cities

SINGLE FAMILY NEIGHBORHOODS
IMPERVIOUS SURFACE INCREASES, TREE CANOPY IMPACTS, AND SOIL COMPACTION

73% of Arlington's land use

>50% of impervious surface increase from regulated activities



URBAN CORRIDORS
ALREADY HIGH IMPERVIOUS SURFACES, LOWER TREE CANOPY AND GREEN SPACE

OPPORTUNITIES FOR IMPROVEMENT

LDA 2.0 – Single Family Homes
(effective 09/2021)

- Manage more water - Emphasis on heavy rainfall and protecting downhill properties
- New gravity detention tank tool
- Requirement to restore soil permeability after construction
- Right-sized detention credits for trees

LDA = Land Disturbing Activities permitting program

INFILTRATION CHARACTERISTICS OF OLD AND NEW ARLINGTON COUNTY RESIDENTIAL SITES

October 2021

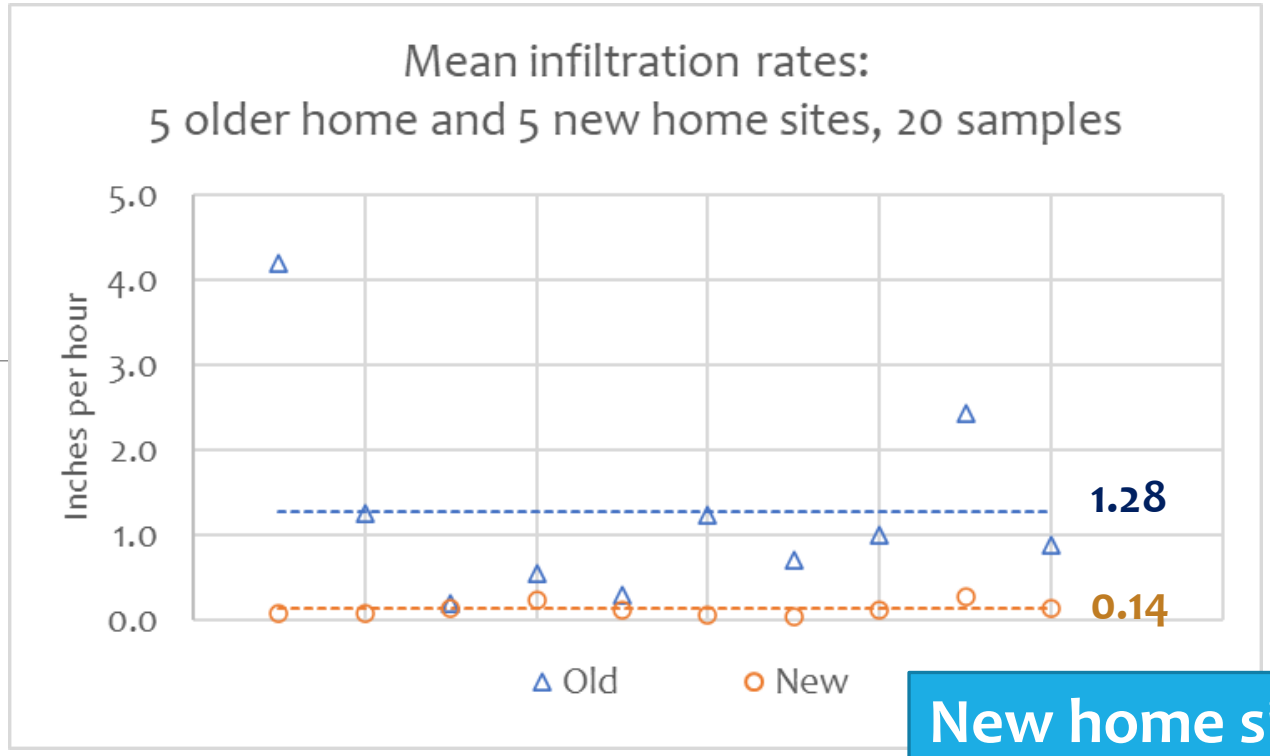
Prepared for Arlington County Department of Environmental Services, Office of Sustainability and Environmental Management

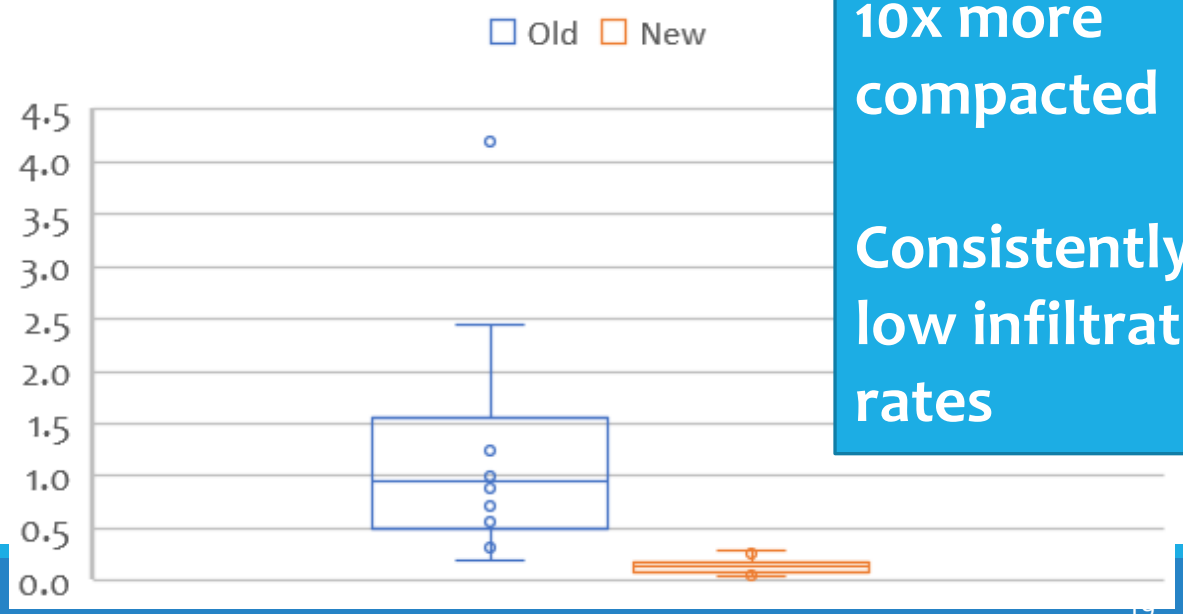
Prepared by Dan Schwartz and Maria Harwood

Northern Virginia Soil and Water Conservation District

Statistical analysis by Chris Ruck

Fairfax County Department of Public Works and Environmental Services, Stormwater Planning Division

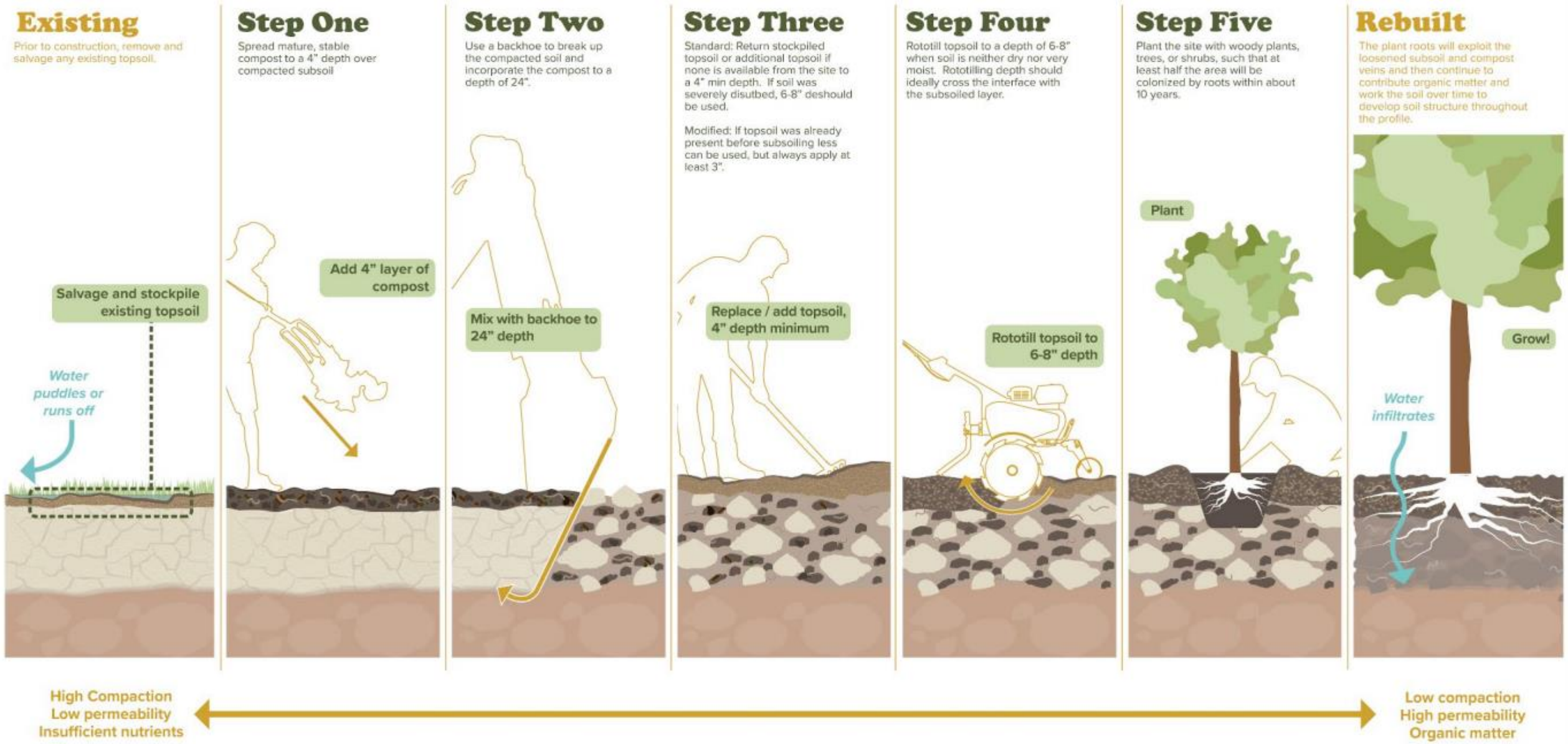




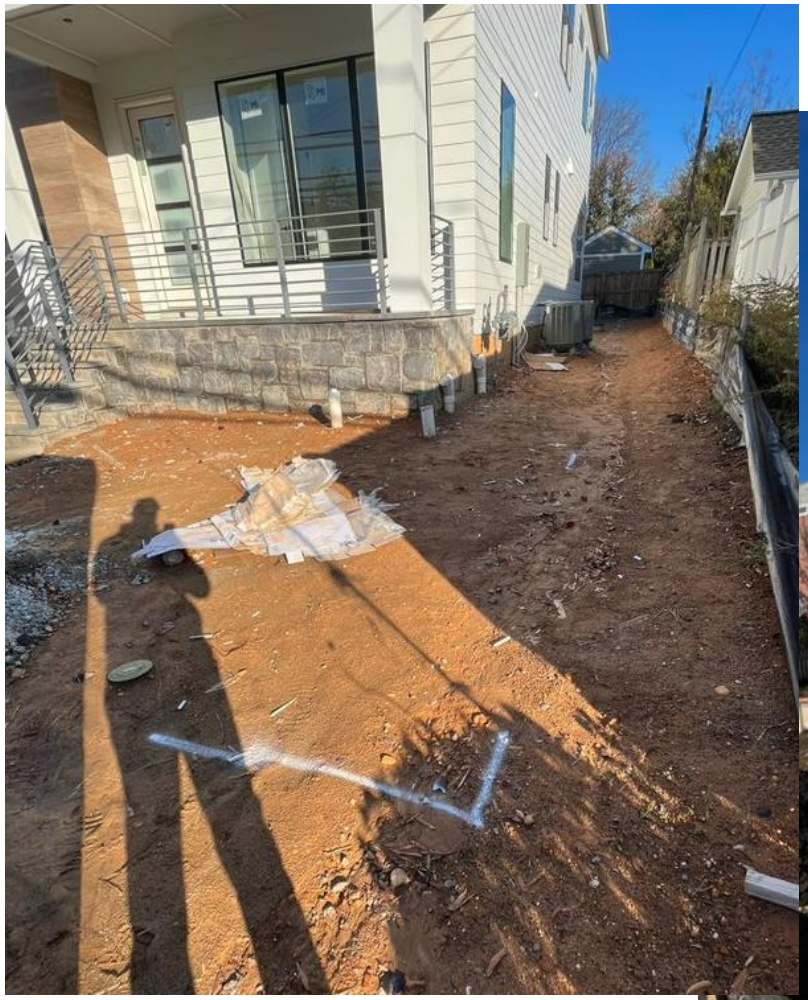
New home sites 10x more compacted

Consistently low infiltration rates


https://sres.frec.vt.edu
Soil Profile Rebuilding
A technique for rehabilitating compacted urban soils in place.
DOWNLOAD THE SPECIFICATION



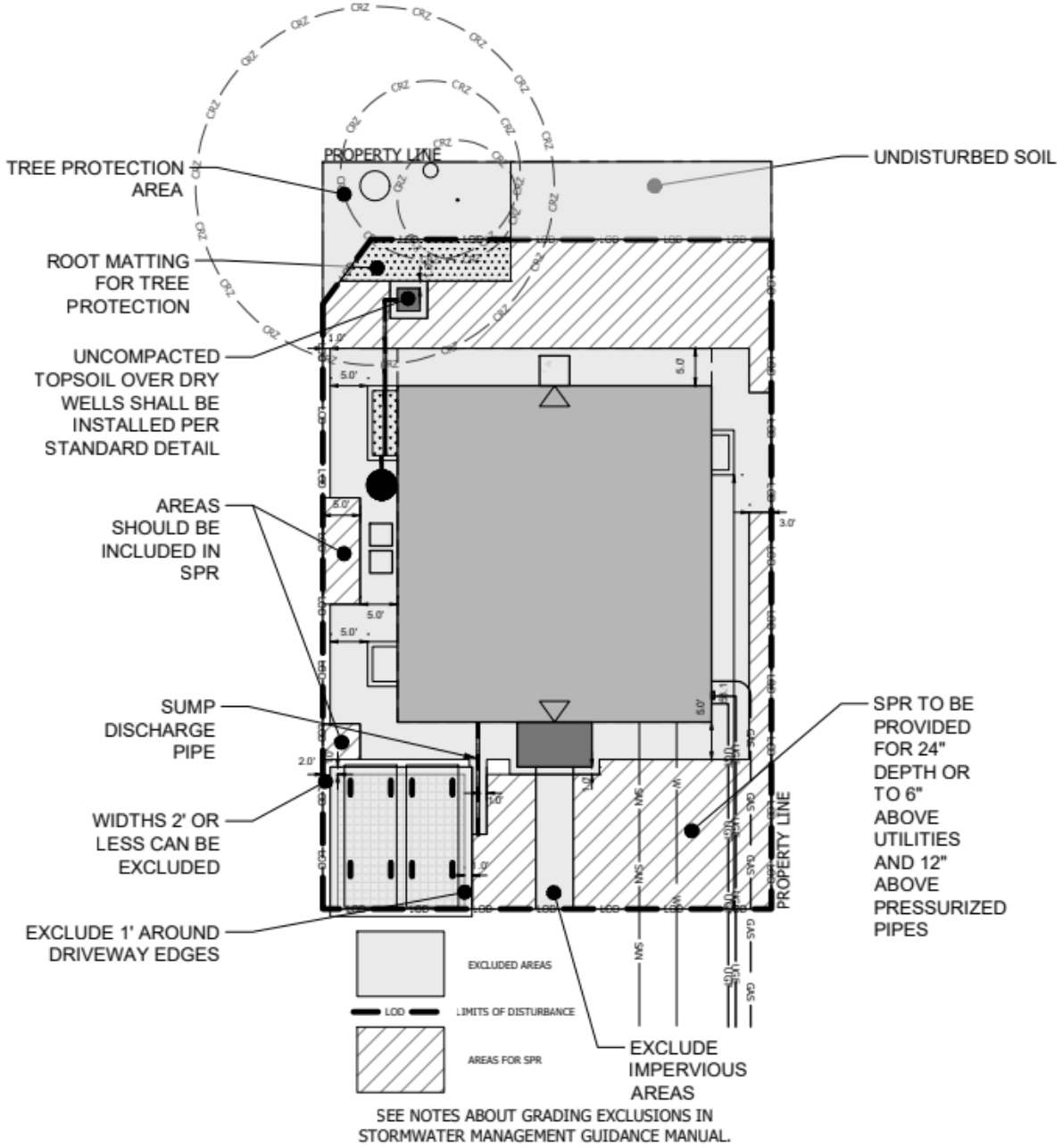
Source: Tree People Los Angeles



From this ….

to this →

PLAN REVIEW



SOIL PROFILE REBUILDING (SPR)
SCHEMATIC EXAMPLE

PHOTO DOCUMENTATION

RECEIPTS and INSPECTION

Quantity	Item Code	Description	Price Each	Amount
40	Misc Plant Material	Grow Good Compost	45.00	1,800.00
40	Misc Plant Material	Topsoil	45.00	1,800.00
		Sales Tax	5.30%	0.00

VIRGINIA NURSERY STOCK CERTIFICATE - This is to certify that Owl Run Nursery, 10318 Bristersburg Rd; Catlett; Fauquier County, VA has paid the license fee in accordance with the requirements of the Commonwealth of Virginia's Plants and Plant Products Inspection Law. The stock of this nursery has been inspected and found apparently free from destructive plant pests. Expires: Dec 31, 2019

	Total This Inv	$3,600.00
Customer Total Balance	Pmnt/Crdt Applied to This Invoice	$0.00
	Balance Due - This Invoice	$3,600.00

COMPOST TECHNICAL DATA SHEET

A & L Great Lakes Laboratories, Inc. 3505 Conestoga Drive Fort Wayne IN 46808

Compost Parameters	*Method*	*Reported as (units of measure)*	*Test Results*	
Plant Nutrients:		%, weight basis	Not Reported	
Moisture Content	TMECC 03.09-A	%, wet weight basis	33.42	
Organic Matter Content	TMECC 05.07-A	%, dry weight basis	67.16	
pH	TMECC 04.11-A	pH units	6.1	
Soluble Salts *(electrical conductivity EC_5)*	TMECC 04.10-A	dS/m (mmhos/cm)	1.60	
Particle Size	TMECC 02.02-B	% < 9.5 mm (3/8 in.), dw basis	100.00	
Stability Indicator *(respirometry)*				*Stability Rating:*
CO_2 Evolution	TMECC 05.08-B	mg CO_2-C/g OM/day	2.1	Stable
		mg CO_2-C/g TS/day	1.7	
Maturity Indicator (bioassay)				
Percent Emergence	TMECC 05.05-A	average % of control	93	
Relative Seedling Vigor	TMECC 05.05-A	average % of control	100	
Select Pathogens	TMECC 07.02	PASS/FAIL: per US EPA Class A standard, 40 CFR § 503.32(a)	PASS	*Salmonella*
Trace Metals	TMECC 04.06	PASS/FAIL: per US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3.	PASS	*As, Cd, Pb, Hg, Mo, Ni, Se, Zn*

A quick aside about the Virginia Runoff Reduction Method

Runoff Coefficients (Rv)

	A Soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Assumption of excellent soil conditions ☺

VS

Reality ☹

What our folks say so far…

Under our Urban Forestry program – Vincent Verweij, Melissa Gildea, Jose Portuhondo Sanchez, Aftab (Shaw) Hussain

Their insights:

- Important to have trained staff who understand why and can explain; forestry/plant people know about soils.
- And they are also on-site to inspect trees anyway.
- If you require materials receipts and other documentation, they'll do it.
- SPR works well because you don't have to remove/replace the soils.
- First time through, more attention to verification.
- Needed a lot of elbow grease to find materials and sources; still a bit of a sticking point; open for suggestions.
- Settlement? We have done on our own SPR and have monitored. No evidence so far.

For your convenience for Soil Profile Rebuilding, Arlington County staff checked with several suppliers in the region and so far, have confirmed that the following suppliers offer compost, soil, or both. As additional suppliers are identified, contacts may be updated here. Email urbanforestry@arlingtonva.us if you would like to send in tests to be included in this list.

Discussion

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SPR at George Mason and Lee Hwy - YouTube

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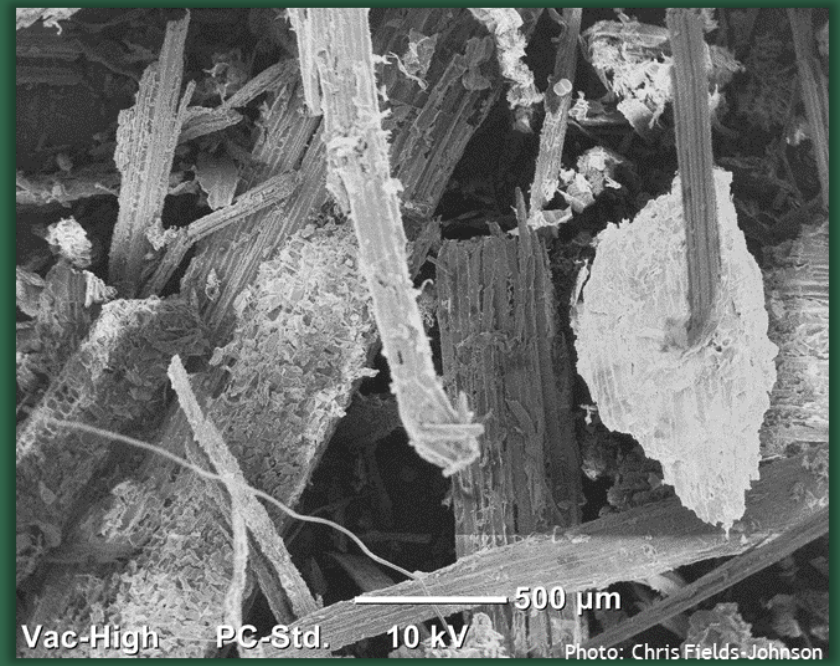

Urban Soil Conservation and Management Methods

Chris Fields-Johnson, PhD

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Loss of the Forest Floor

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Soil Structure

Surface Structure

- Avoid it being crusty, compacted
- Want it to be porous, granular

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Long-term Effects of Mulch: 7 Years

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Soil Structure

Sub-angular Blocky

- Common Natural Sub-Soil Structure

Platy Compacted

- Common Urban Soil Structure with Low Organic Matter

Spongy

- Tillage with High Organic Matter

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Soil Improvement

Topdressing
- Low Disturbance
- Common on Turf
- Fertilizer, Lime, Organics


Photo: Chris Fields-Johnson

Vertical Mulching
- Med Disturbance
- Improve Deep Drainage
- Organics


Photo: Gil Mitchell

Hydraulic Fracturing
- Low Disturbance
- Decompaction
- Deep Liquid Fertilizer, Organic Suspensions

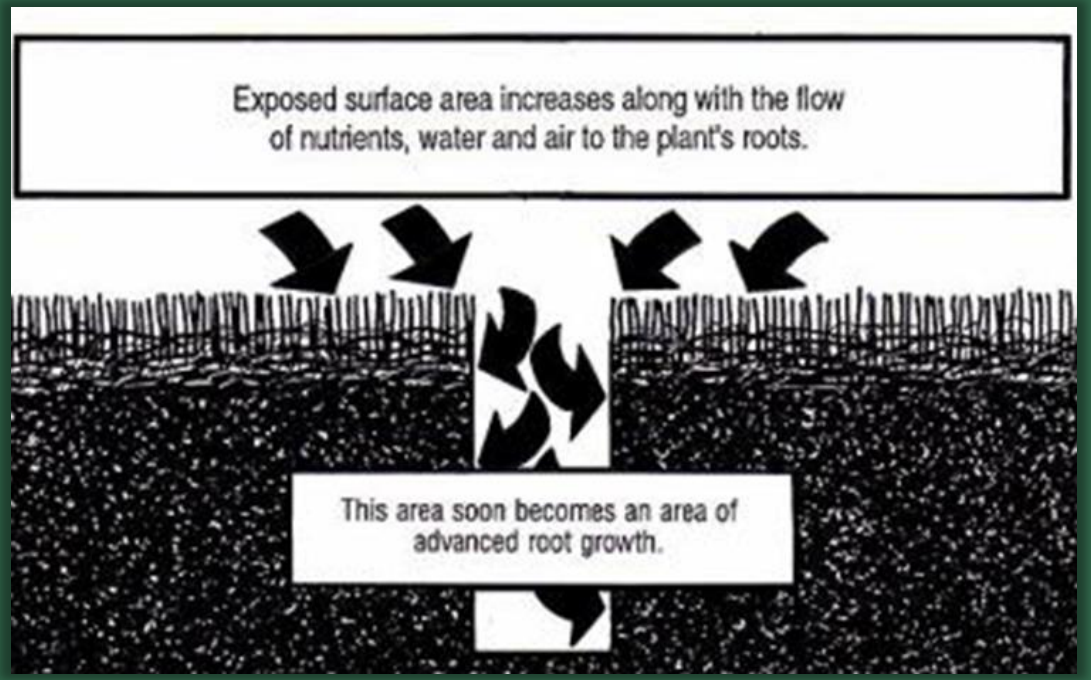

Photo: Chris Fields-Johnson

Air Tillage
- High Disturbance
- Decompaction
- High Input of Organics


Photo: Chris Fields-Johnson

Turf Renovation

- Turf Care Annual Cultural Practice
- Reduce Compaction and Grow Roots
- Begin with 3”+ Depth Core Aerification
- Overseed with Desirable Turf Varieties
- Topdress with Compost + Biochar
  - 5-10% Biochar in Blend
  - Fresh and Pelletized Options



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Soil Profile Rebuilding

- Spread 4” Compost
- Scoop-and-Dump 2’+ Depth
- Spread 1” Compost and ½” Biochar
- Till 6”+ Depth
- Plant Trees


Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson

Soil Compaction

Penetrometer:
Relative resistance of soil to penetration

- Need moderate soil moisture

- < 100 PSI Optimal
- > 200 PSI Action Threshold
- > 300 PSI Severe Root Limitations

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SPR after 1 YR of Traffic

Penetrometer Transect

Soil compaction ratings by depth in pounds per square inch.

Treatment Area

Soil Depth Difference Significance
p = 0.0001

Depth	0 m	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m	11 m	12 m	13 m	14 m
10 cm	225	250	350	75	75	125	100	100	100	125	100	100	350	350	350
20 cm	350	350		100	350	175	175	100	100	150	150	175			
30 cm				125		175	175	100	100	150	150	125			
40 cm				125		150	150	200	125	125	250	250			
50 cm				125		150	150	350	125	125	350	350			
60 cm				350		100	100		175	200	350				
70 cm						200	200		350	350					

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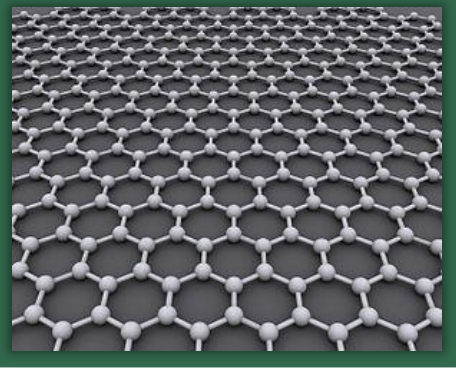
Biochar Material Properties

- Good charcoal is resonant, refractory and burns without flame

- sp^2 C-C bonding: delocalized electrons
  - conduct electricity
  - strongly resist compaction
  - facilitate electron transfer (catalytic)
  - resist decomposition

- Functional groups provide ion exchange
  - 100 $cmolc^{+}\ kg^{-1}$ CEC
  - 30 $cmolc^{-}\ kg^{-1}$ AEC

- High Surface Area: 400 $m^2\ g^{-1}$



Penetration Resistance Comparison (α = 0.01)

Structural Soil

-

Clay Loam (CL) Only

350 PSI

a

Clay Loam + 50% Biochar

100 PSI

b

CL + 25% Biochar, 25% Biosolids

60 PSI

c

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Aboveground Biomass Comparison (α = 0.05)

Structural Soil

18 g
a

Clay Loam (CL) Only

28 g
a

Clay Loam + 50% Biochar

73 g
b

CL + 25% Biochar, 25% Biosolids

99 g
b

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Baldcypress bare root seedling in pure biochar backfill.

May 2017: 1’6”

July 2018: 6’

August 2021: 12’

Missouri Gravel Bed Biochar Variant

Other Similar Applications

- Containerized Seedlings
- Green Roofs
- Freestanding Planters

CU Soil Filtration

	% NO_x Retained α = 0.01	% P Retained α = 0.01
Granite Stone	-83.27 c	90.20 b
Diabase Stone	-83.29 c	90.16 b
Limestone Stone	-99.50 c	97.77 a
Granite CU Soil	99.93 a	99.96 a
Diabase CU Soil	99.49 a	99.96 a
Limestone CU Soil	96.79 b	99.67 a

Photo: Chris Fields-Johnson

Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson

CU Soil Evaporation

	Evaporation mm year^{-1} α = 0.05
Granite Stone	46 b
Diabase Stone	60 b
Limestone Stone	63 b
Granite CU Soil	181 a
Diabase CU Soil	179 a
Limestone CU Soil	151 a

Photo: Chris Fields-Johnson

Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson

CU Soil Demonstration

- Drainpipe outfall sealed since 2018 installation
- All surface water is going into groundwater, even over poorly-drained Triassic siltstone residuum
- Trees are well established, healthy, and growing

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Biochar Filtration

- Pure Biochar vs. Biochar + Limestone Structural Soil

- Nitrate + Nitrite (α = 0.01)
  - 41.5 ppm influent
  - Biochar: 100.00 % Retention A
  - B&L SS: 64.12% Retention B

- Total Phosphorus (α = 0.01)
  - 143.6 ppm influent
  - Biochar: 91.69% Retention B
  - B&L SS: 99.91% Retention A

- Water Evaporation (α = 0.05)
  - Biochar: 276 mm A
  - B&L SS: 126 mm B

Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson


Photo: Chris Fields-Johnson

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Biochar Lifecycle in the Green Industry

Chris Fields-Johnson, PhD

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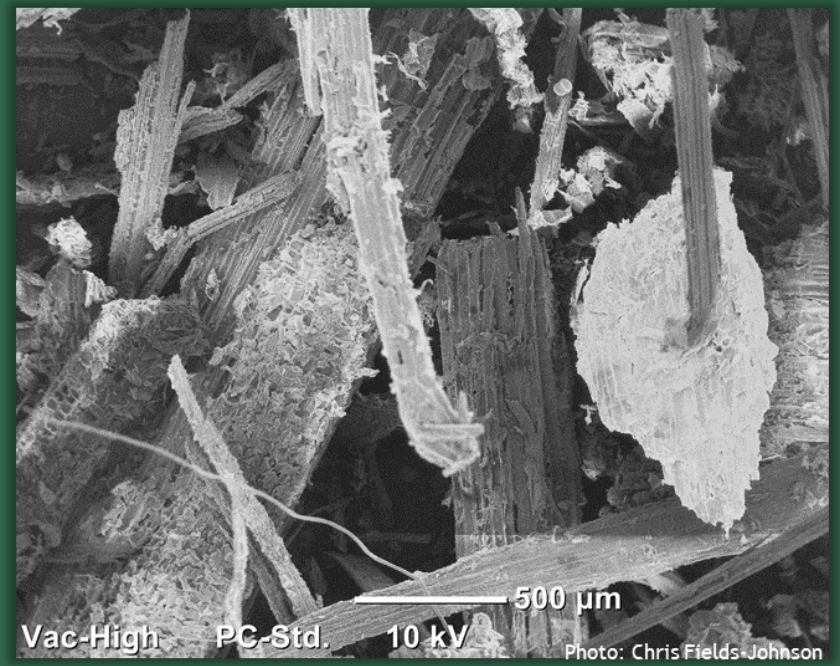

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