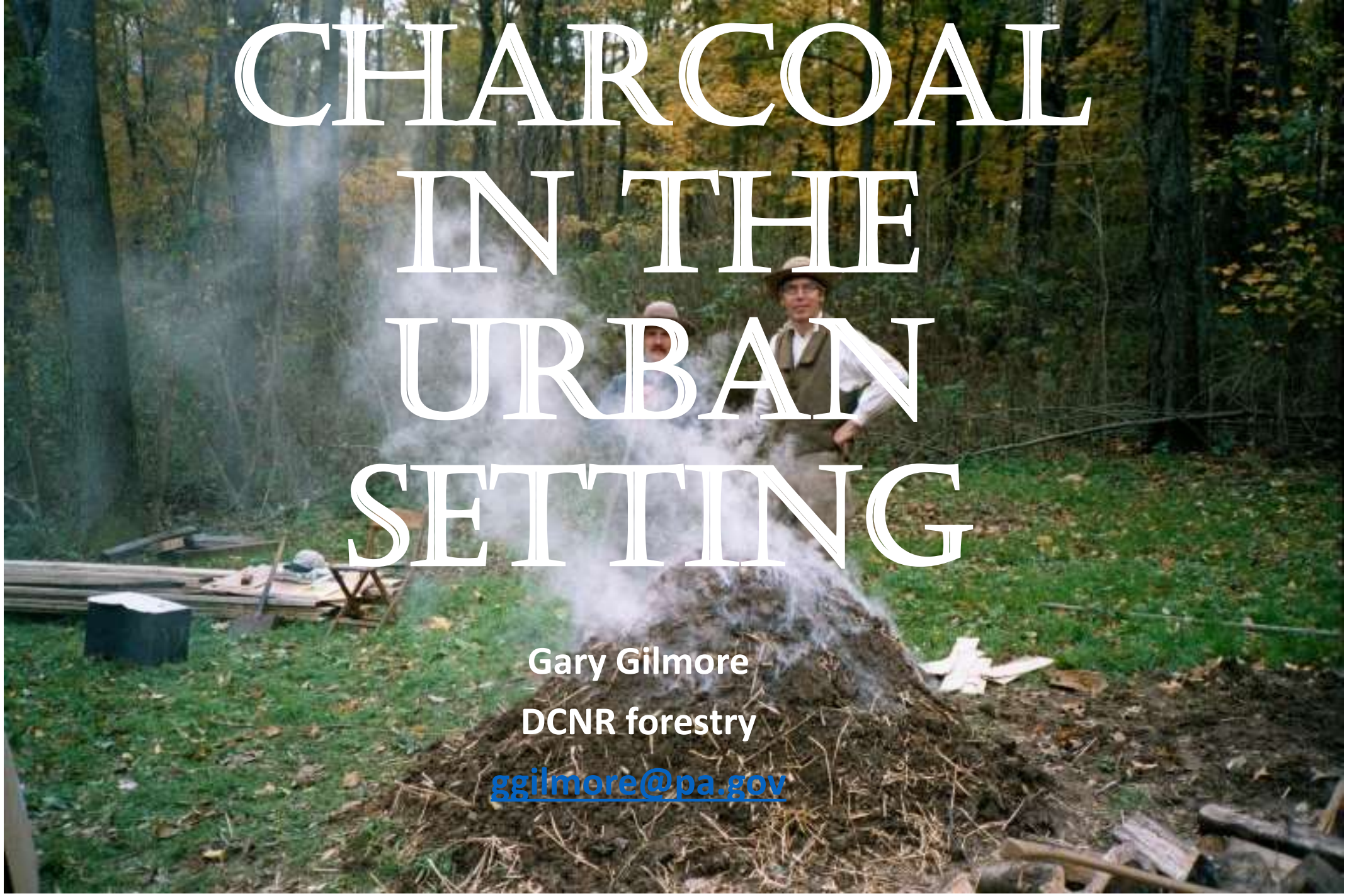
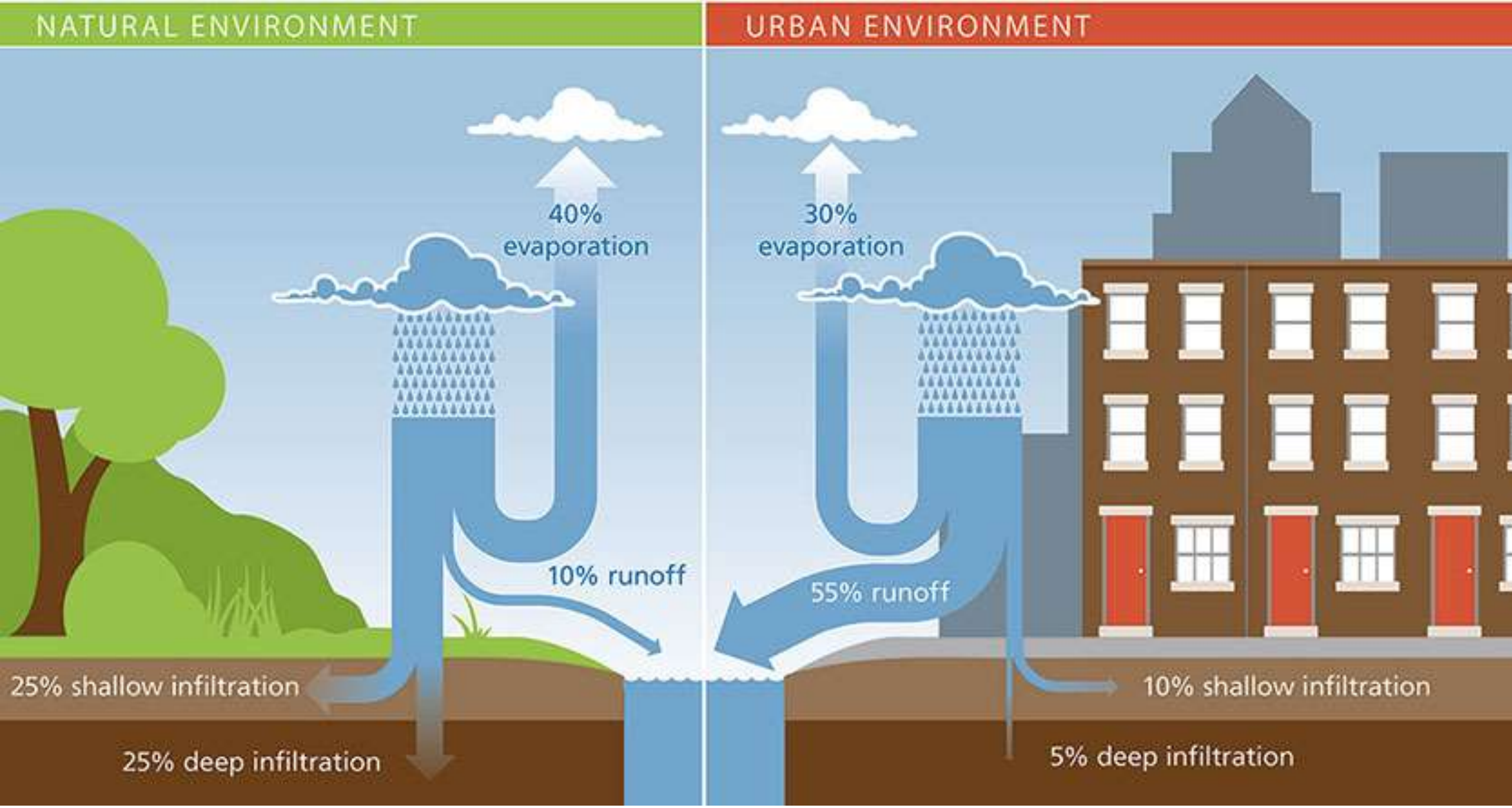


CHARCOAL IN THE URBAN SETTING

Gary Gilmore

DCNR forestry

ggilmore@pa.gov


NATURAL ENVIRONMENT
URBAN ENVIRONMENT
40% evaporation
30% evaporation
10% runoff
55% runoff
25% shallow infiltration
10% shallow infiltration
25% deep infiltration
5% deep infiltration

Making “DIRT” into “SOILS”

We have hundred’s of years of experience making “DIRT”. - It’s time to start using our knowledge and experience making “SOILS” on landscape level.

Soil Impacts

- Reduced Infiltration Rates
- Increased soil strength & bulk density
- Decreased soil physical fertility
- Decreased water storage & supply
- Reduced micro-organisms activities

SOIL COMPACTION – 70 TO 99% REDUCTION

Watershed Impacts

- Increased Stormwater Runoff
- Increased Flooding
- Decreased Water Quality
- Reduced Channel Base Flow
- Increased Stream Erosion

CHARCOAL = is a fuel

BIOCHAR = an investment in your soil

Biochar made from wood 70 -80% carbon

but can also be made from manure, sludge, bones, animal bedding

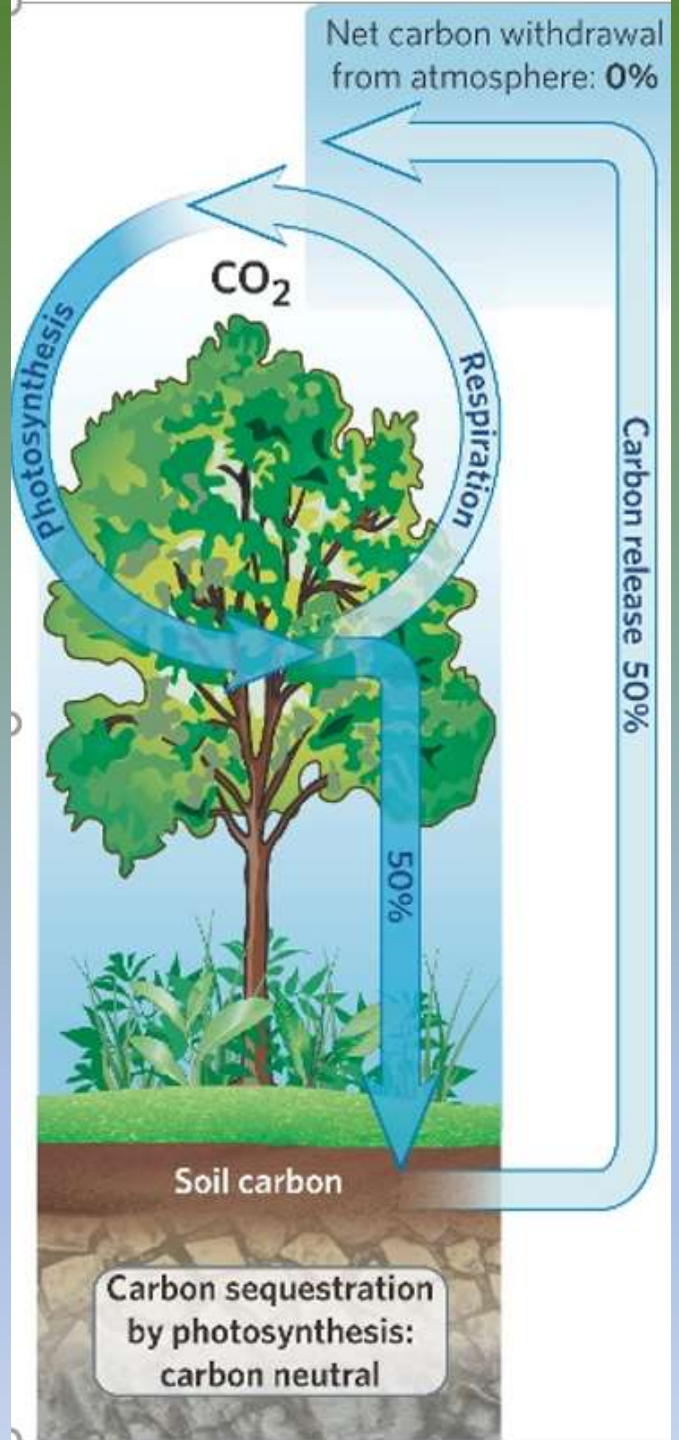
Points to make with wood sourced biochar

- It is renewable
- It is looooooong lasting
- It is inert
- It is a sponge

The Carbon cycle

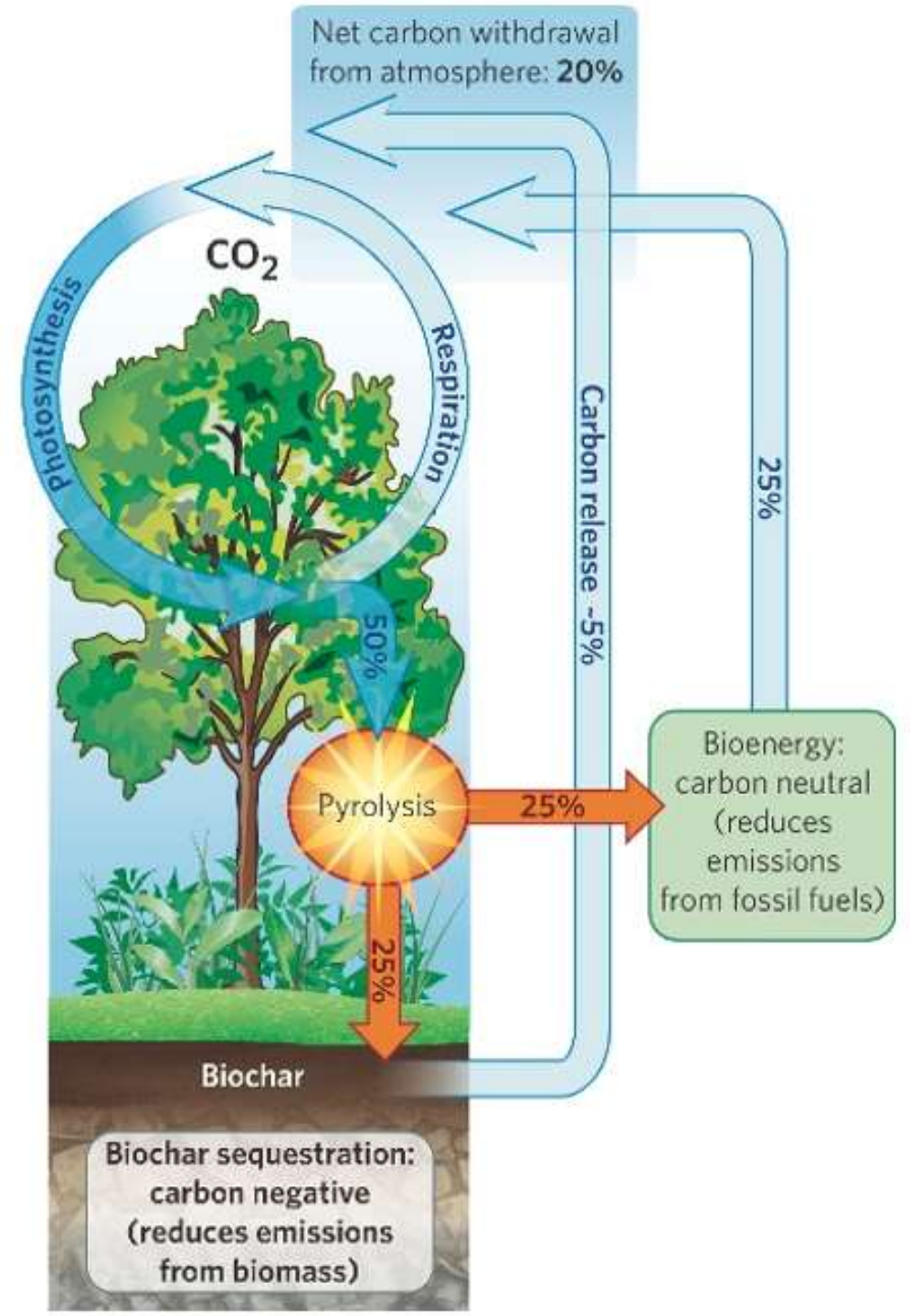
$CO_2 + H_2O + Photons =$
$C_6 H_{12} O_6 (wood) + O_2$

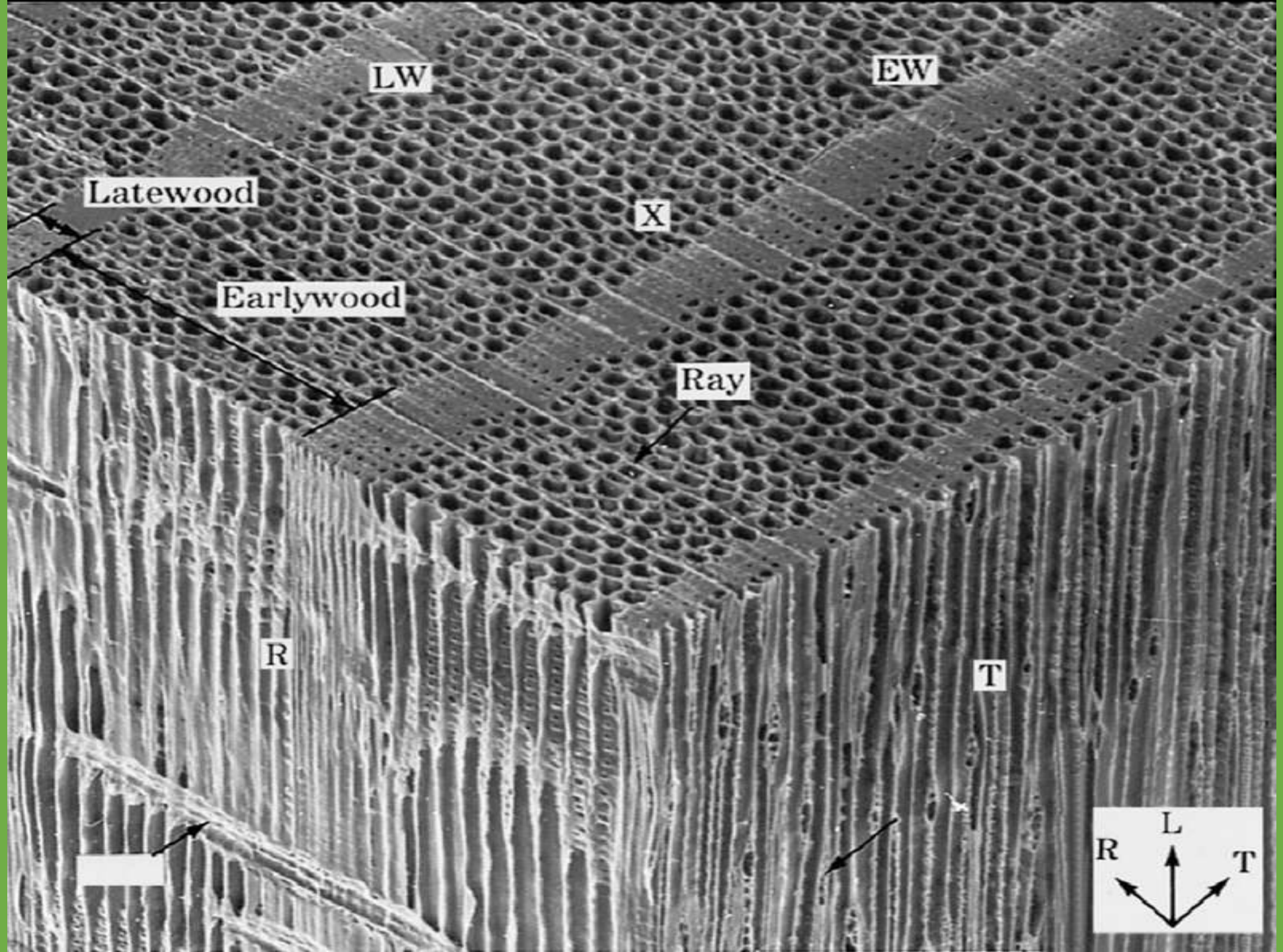
$C_6 H_{12} O_6$ decomposes into
$CO_2 + H_2O + heat$

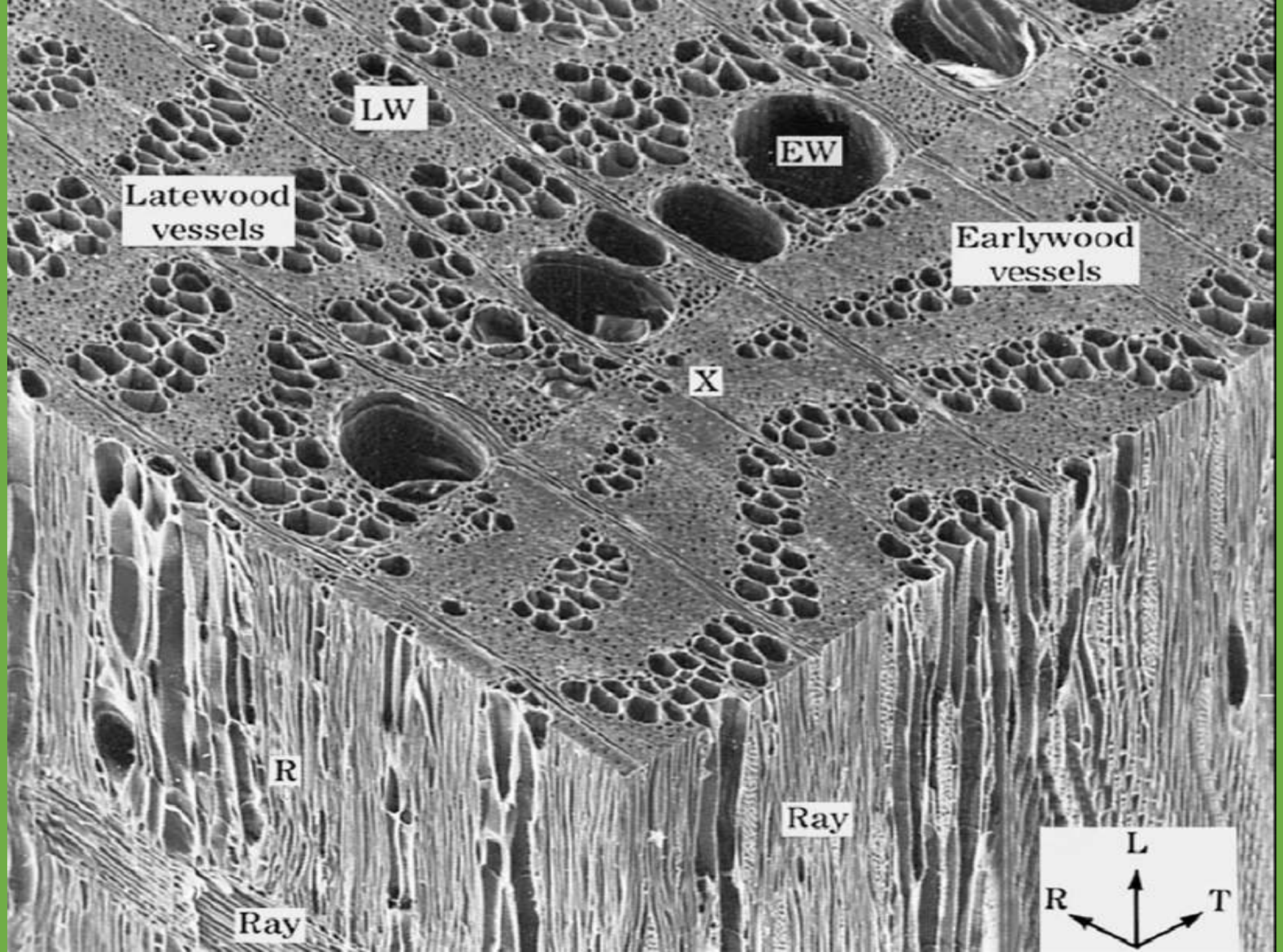


Carbon storage

$C_6 H_{12} O_6$ (wood) + heat =
H_2O + CO_2 + Carbon (Charcoal)




LW
EW
Latewood
X
Earlywood
Ray
R
T
L
R
T

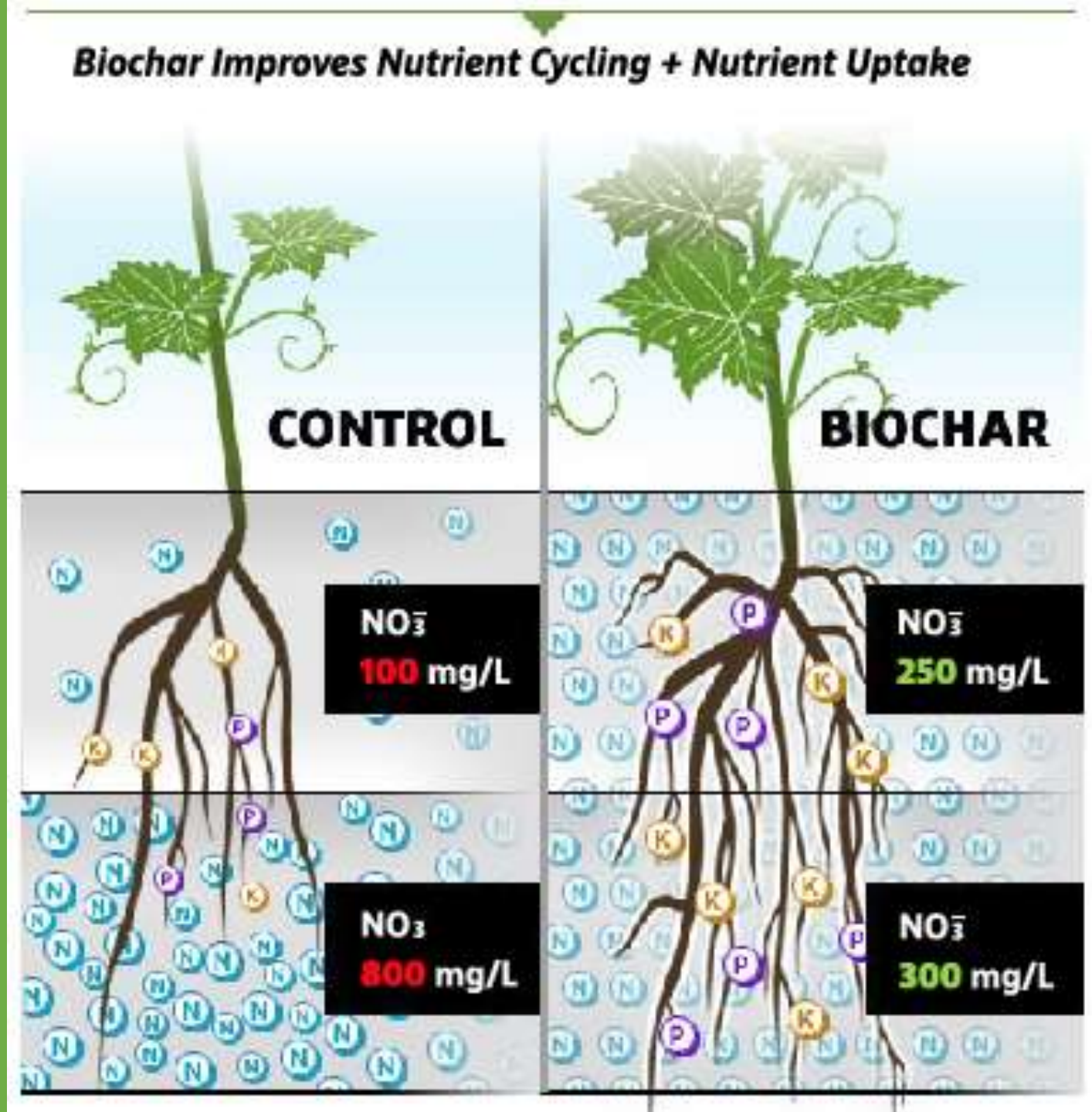

LW
EW
Latewood vessels
Earlywood vessels
X
R
Ray
Ray
L
R
T

Fungi
Bugs
Fire

Biochar in soil can alter soil chemical properties

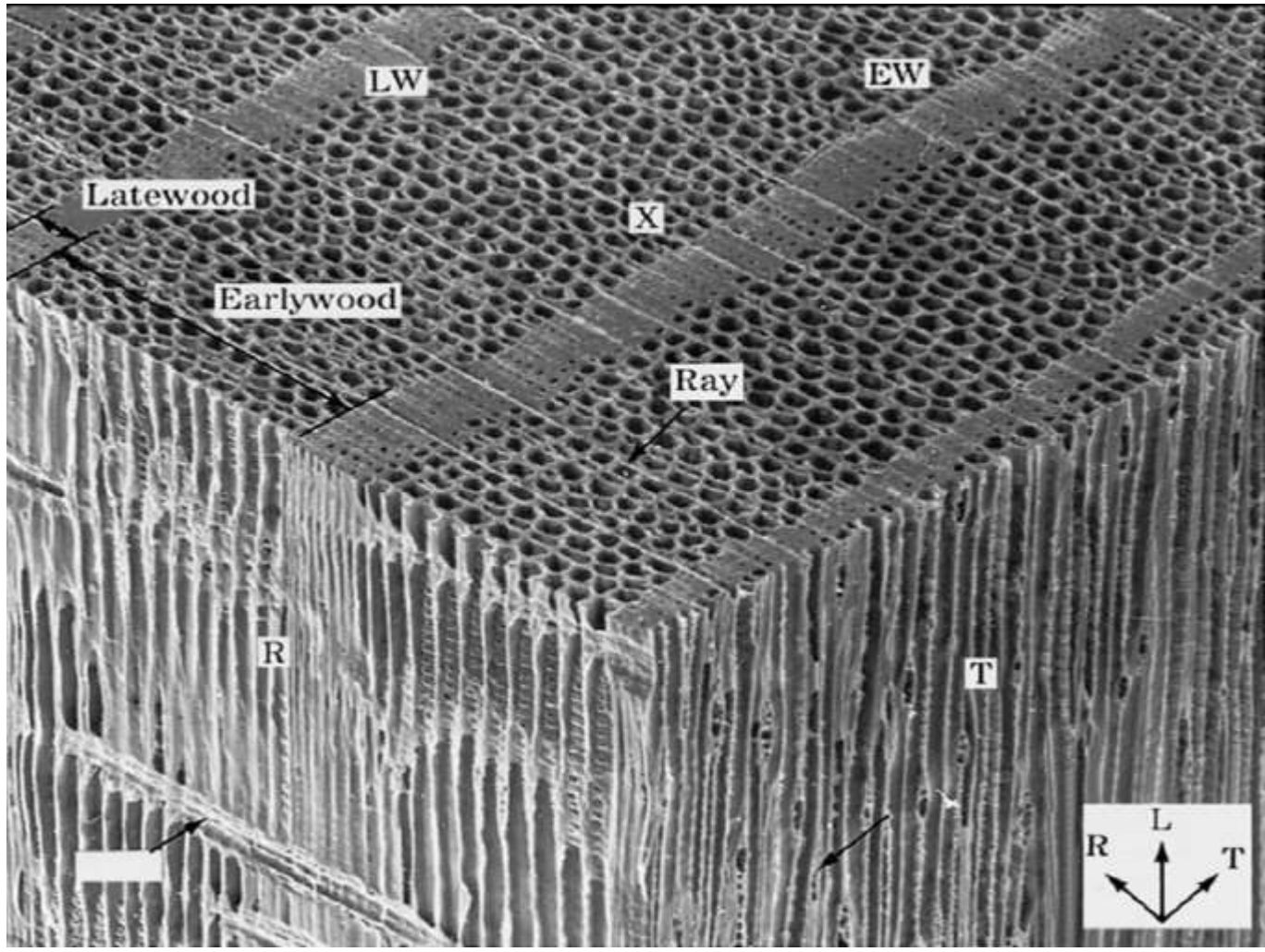
- Increase pH (temporary)
- Increase cation/ anion exchange capability

  Nutrient retention and capture (NH4, NO3, K, Ca, Mg, etc.)
- Ideal surface for the sorption of organic and ionic compounds
- Promotes movement of electrons


Biochar Improves Nutrient Cycling + Nutrient Uptake
CONTROL
BIOCHAR
NO_3^-
100 mg/L
NO_3^-
250 mg/L
NO_3
800 mg/L
NO_3^-
300 mg/L

Biochar into soil can alter soil physical properties

- reduced soil density
- Increase soil tilth
- increased porosity
- Increased aeration
- water infiltration
- water retention
- host site for micro flora/fauna



Biochar into soil can alter soil biological properties

- Some “food”

The following benefits occur with additions of biochar

- Improved soil water handling characteristics
- Increased soil tilth
- Reduced leaching of nutrients
- Reduced fertilizer requirement (estimate 10%)
- Increased cation exchange capacity
- Increased soil microbial respiration
- Increased soil microbial biomass
- Reduced nitrous oxide emission (estimate 50%)
- Stored carbon for a long time

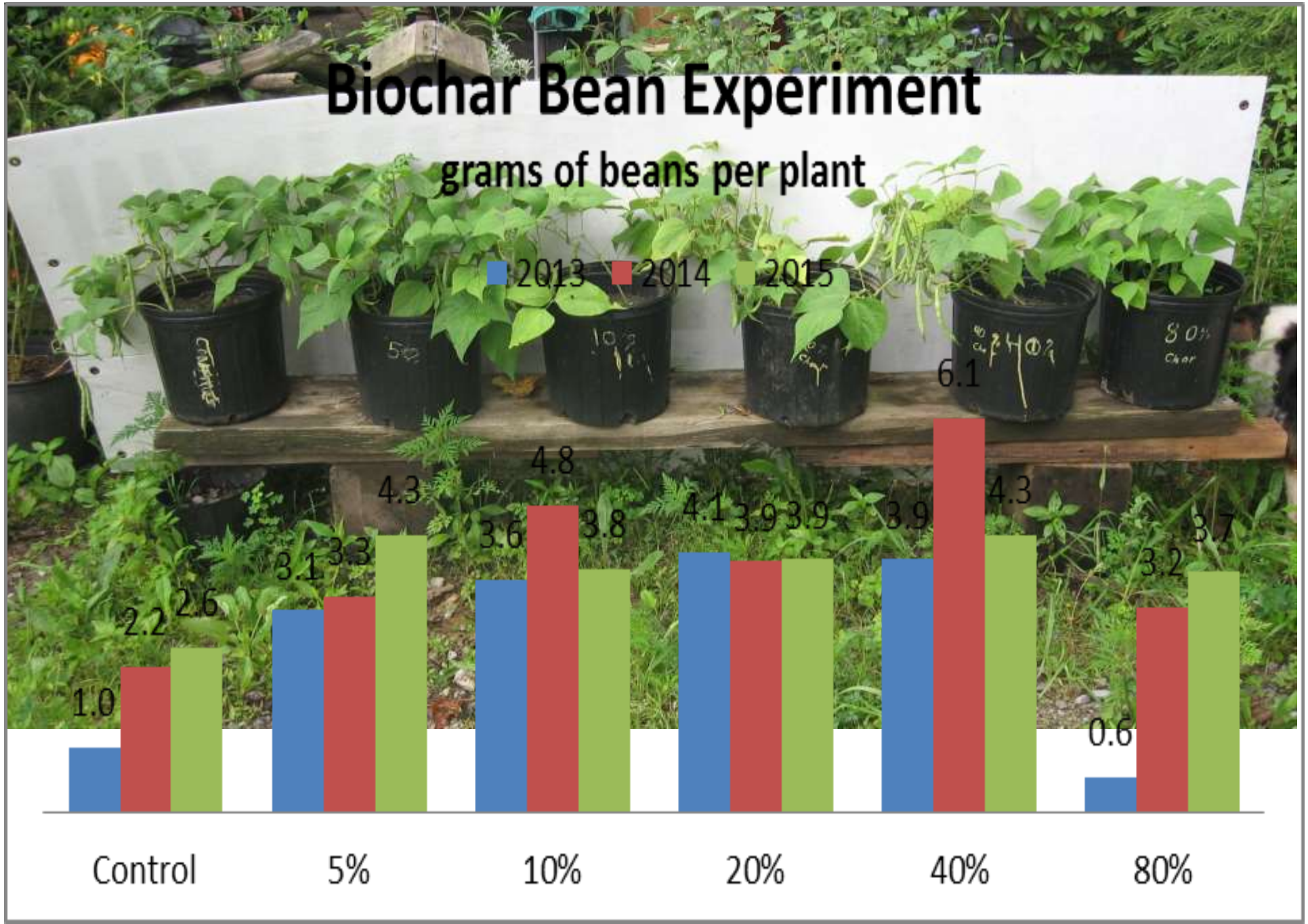
Adding bio-char to soil

Charcoal must be:

- Primed – soaked in a nutrient rich material
- Sized – corn kernel or smaller
- Damp – reduce dust and wind loss

The
bioc

Bean experiment 2013


Biochar Bean Experiment
grams of beans per plant
2013
2014
2015
1.0
2.2
2.6
3.1
3.3
4.3
3.6
4.8
3.8
4.1
3.9
3.9
3.9
6.1
4.3
0.6
3.2
3.7
Control
5%
10%
20%
40%
80%

2017


541.2
AUTO POWER OFF


10.1

MS4

- Municipal Separate Storm Sewer Systems (MS4s)
- EPA mandate to reduce pollution from storm runoff
- PA has two Large MS4s, no Medium MS4s, and 953 Small MS4s

Green Stormwater Infrastructure **Landscape Design Guidebook**

Version 4.0 April 2020

PHILADELPHIA WATER DEPARTMENT

Green Storm water Infrastructure Maintenance Manual

2.2.9 Soil Maintenance

2.2.9.5 MATERIALS 1. The following materials are required to execute this task: Organic soil amendments including, but are not limited to the following:

Grass clippings (cut prior to seed head formation) – to increase organic matter and moisture retention;

Compost (weed-free) – to increase organic matter and moisture retention;

Shredded leaves – to increase organic matter and moisture retention (avoid walnut, eucalyptus, and camphor laurel leaves, as well as any invasive species leaves);

Pine needles – to increase acidity and organic matter;

Sand – to increase permeability;

Mycorrhizal fungi – to encourage the surface absorbing area of plant roots, and in turn, aid in nutrient uptake and improved ability of the plant to access soil resources. Mycorrhizal fungi are very common in high quality, undisturbed soils, but are significantly less abundant in highly disturbed urban soils.

The Stockholm Biochar Project

- Turning the city's park and garden waste into renewable energy for heating while sequestering carbon.
- On line in March 2017

FHK 150311

Stockholms stad

Structural soil with biochar

A method for building with stability and to create good growing conditions for trees in paved areas with the use of stormwater and the added value of decreasing the risk of roots damaging paving or underground pipes

1. Paved surface with dished stormwater gutters
2. Geotextile
3. Leveling layer (crushed rock 8-16 mm) – also used for concrete bunker and water/air inlet
4. Aerated bearing layer (crushed rock 32-63 mm)
5. Structural soil (crushed rock 100-150 mm) with fertilized biochar hosed into the structural volume
6. Pure biochar on terrace
7. Concrete bunker
8. Surface grid
9. Crushed rock with fertilized biochar
10. Inlet for air and water supply

Compost 1/8

Biochar (0-10mm) 1/8

Stockholm Tree Cells & Bioretention using Structural Soils/Biochar

Emerging Best Management Practices in Stormwater:

Biochar as Filtration Media

pacific northwest
POLLUTION PREVENTION
resource center

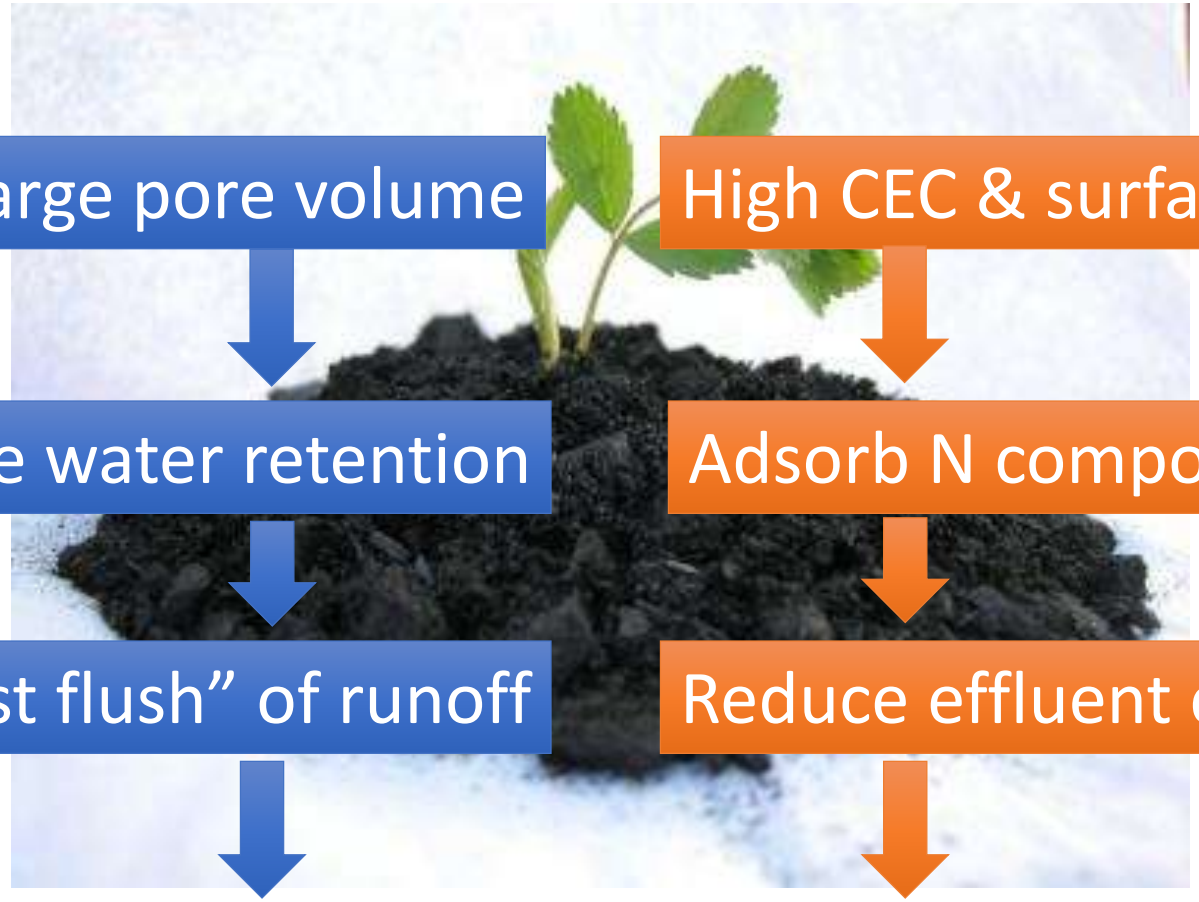
pprc

Figure 2: The Port of Port Townsend is using biochar to filter heavy metals in a below-grade swale. The galvanized fence in this photo is one of the boatyard's primary sources of zinc.(Image courtesy Francesco Tortorici)

Dare to be first.

UNIVERSITY OF DELAWARE

Biochar in Stormwater Management



Large pore volume

High CEC & surface area

Increase water retention

Adsorb N compounds

Capture “first flush” of runoff

Reduce effluent concentration

Enhance retention of N and water in the soil zone

Increase rates of infiltration and chemical transformations

Dare to be first.
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Biochar Enhanced Bioretention Media Conclusions

- Retained 11-27% more stormwater and more plant available water.
- Water retention time for higher redox
- Increased infiltration rates by 4 times
- After 1.5 yr, biochar increased infiltration rate by 50% (less clogging)
- Increased Nitrogen removal from 6% to 55% above control (all storms)
- Increased Nitrate removal 60-370% (Seasonality)
- Filter media properties/mixes

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Field Test of Roadway Biochar Amendment

- Biochar reduces runoff volume and peak flows
- Side-by-side comparison if biochar-amended and un-amended roadway soils

Control Strip - Tilled

4% Biochar Strip

Imhoff, P.T., et al. University of Delaware, Reducing Stormwater Runoff and Pollutant Loading with Biochar Addition to Highway Greenways, Final Report for NCHRP Idea Grant 182 October 2017

Research conducted by Joe Brown, PE, MS, ABD

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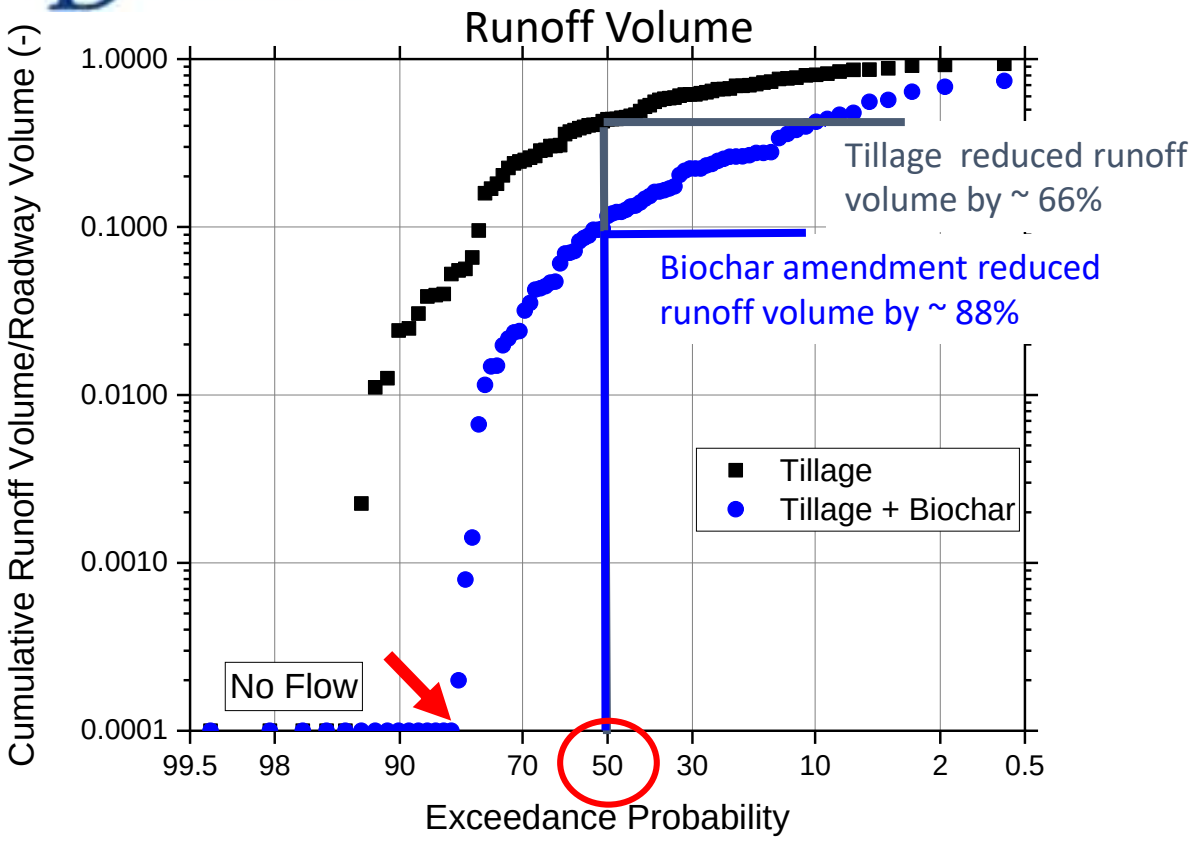
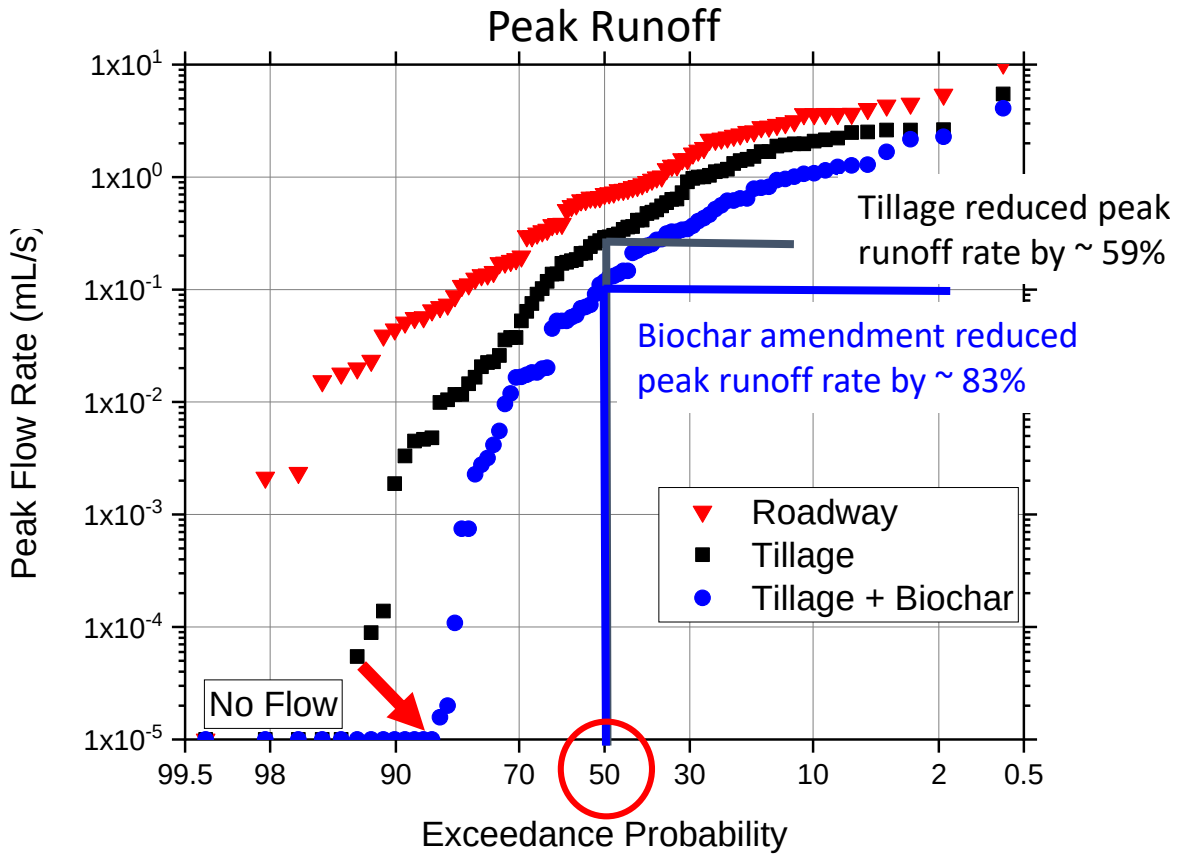
Roadway Biochar Amended Soils (Field Study)

84 Storms in 2016/2017





- Biochar increased geometric mean Ksat by ~ 50% over control (tilled)
- 41% reduction in runoff peak flow rate over control (tilled)

Imhoff, P.T., et al. University of Delaware, Reducing Stormwater Runoff and Pollutant Loading with Biochar Addition to Highway Greenways, Final Report for NCHRP Idea Grant 182 October 2017
Research conducted by Joe Brown, PE, MS, ABD

Urban Soils Restoration Using Decompaction Technology and Biochar Demonstration, Hanover PA

KEEP PA GROWING GREENER

State Grant Funder

Project Partner
School District

Project Partner
Borough

SKELLY AND LOY
ENGINEERING – ENVIRONMENTAL CONSULTANTS

Engineering Design Firm

TERRA AERATION

Soil Decompaction Technology

INFINITESOLUTIONS, L³C

Biochar Consultant/Supplier

First Lady Frances Wolf Unveils Governor's Residence Rain Garden During Annual Earth Day Celebration

April 23, 2018

Governor's Residence Rain Garden, Harrisburg PA

Photo Credit: Gary Gilmore, PA DCNR

Recreation and Wellness Center at UNL – Biochar Green Roof

- Project size 18.5’x12’ in size, depths X - X
- Green roof project was installed XX
- Biochar was added at 7% and mixed at 50:50 for 2 weeks with compost.
- Roof substrate achieved a weight of 21.1 lbs/cf

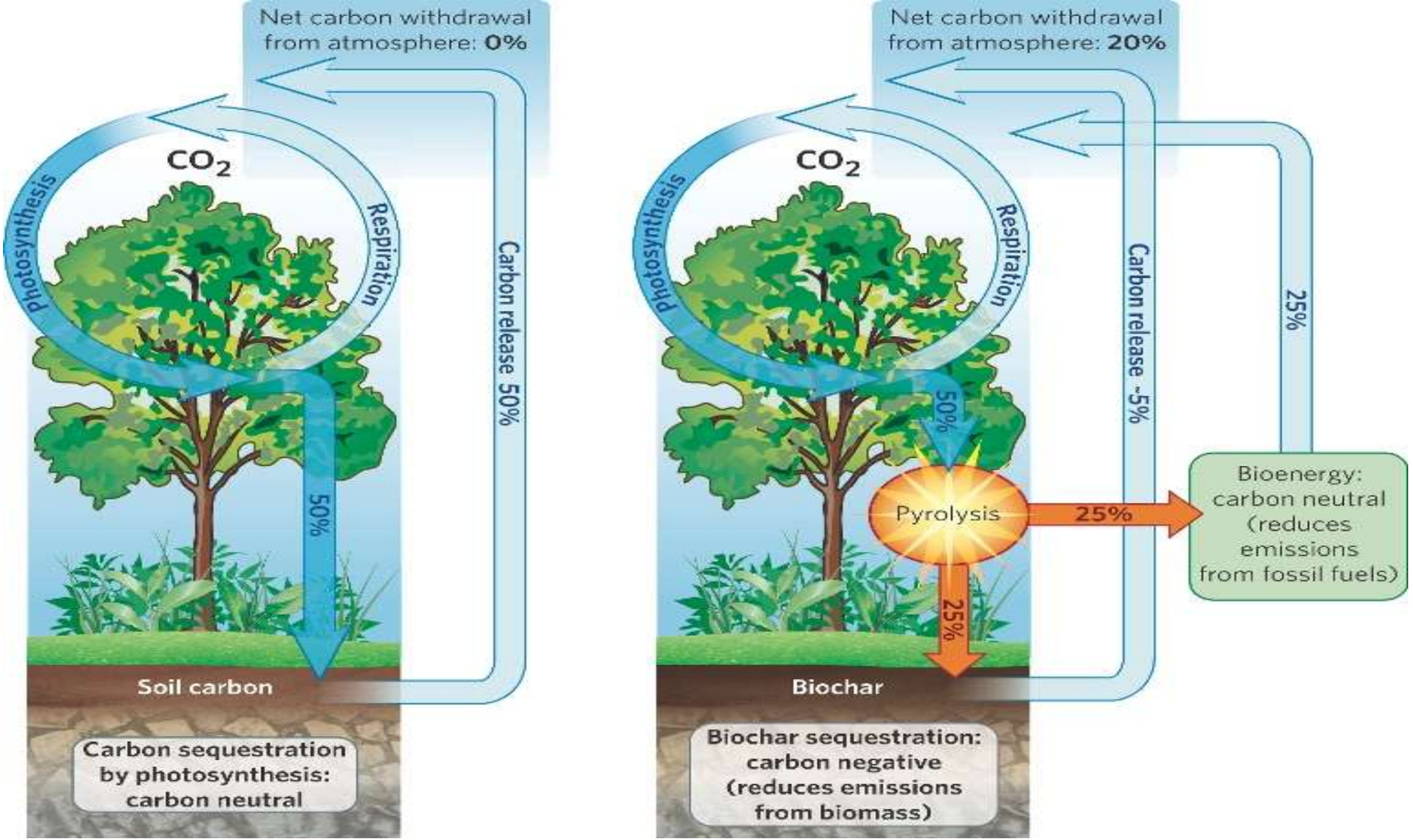
NEBRASKA FOREST SERVICE

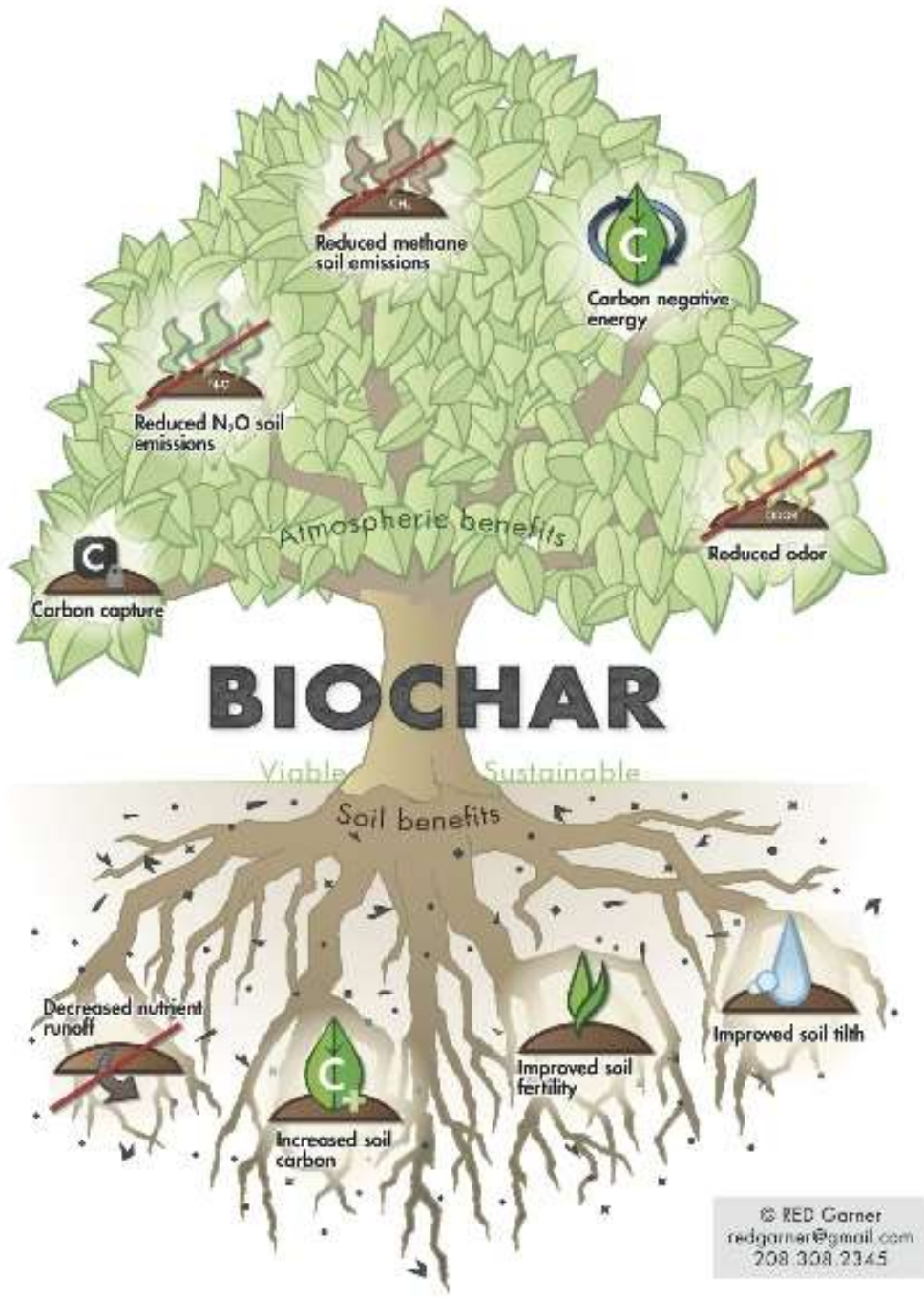
IANR

2014 -2020 green roof test


LEAF
COMPOST

WOOD CHIPS


Net carbon withdrawal from atmosphere: 0%
CO_2
Photosynthesis
Respiration
Carbon release 50%
50%
Soil carbon
Carbon sequestration by photosynthesis: carbon neutral
Net carbon withdrawal from atmosphere: 20%
CO_2
Photosynthesis
Respiration
Carbon release ~5%
25%
50%
Pyrolysis
25%
Bioenergy: carbon neutral (reduces emissions from fossil fuels)
25%
Biochar
Biochar sequestration: carbon negative (reduces emissions from biomass)


Reduced methane soil emissions
Carbon negative energy
Reduced N_2O soil emissions
Atmospheric benefits
Reduced odor
Carbon capture
BIOCHAR
Viable
Sustainable
Soil benefits
Decreased nutrient runoff
Increased soil carbon
Improved soil fertility
Improved soil tilth
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redgarner@gmail.com
208 308 2345