# The Role of Structural Soil in Urban Green Infrastructure

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***What is soil, anyway?***

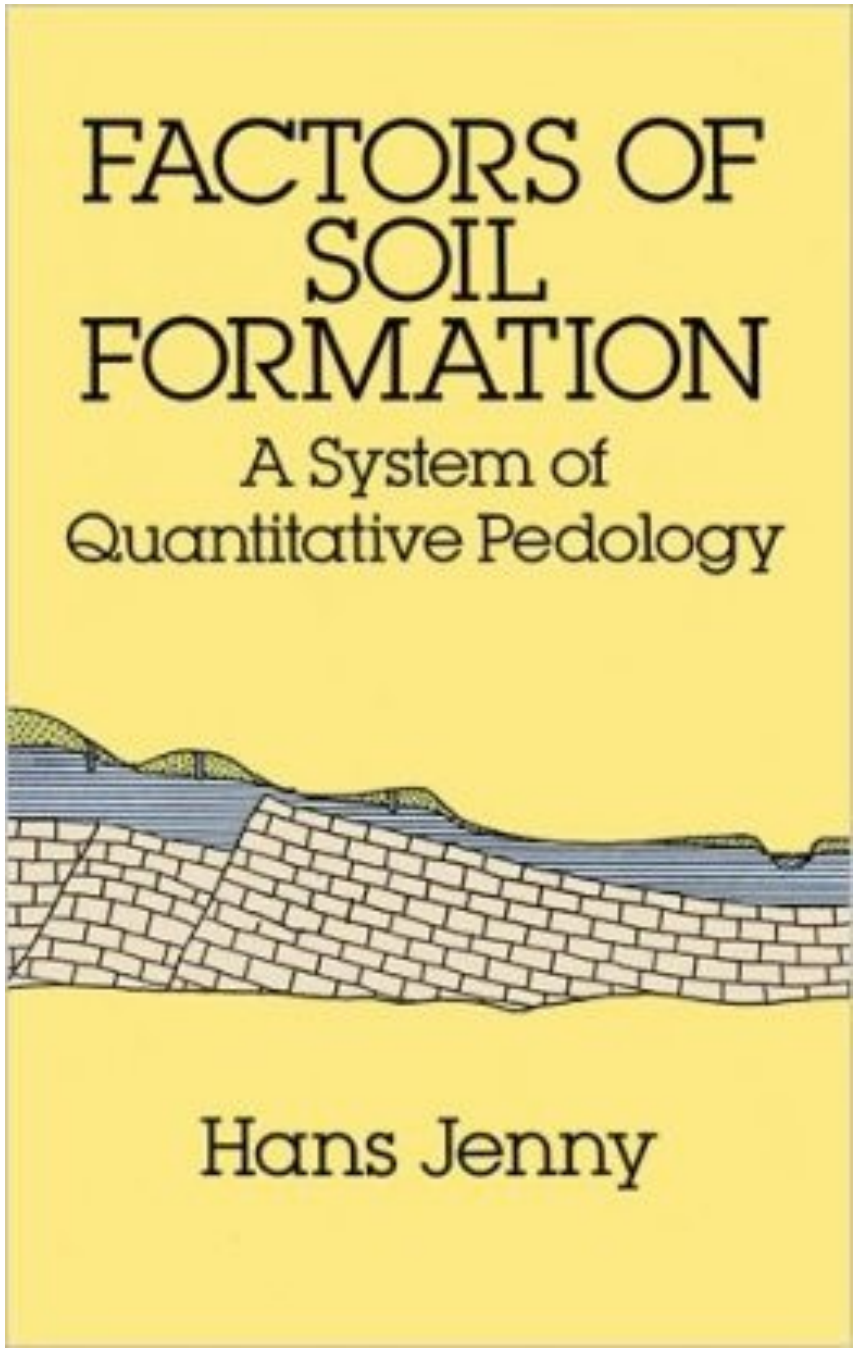
***How does Nature make a soil??***


Lal • Stewart
URBAN SOILS
TOMPKINS
Soil Survey—TOMPKINS COUNTY, N.Y. Series 1961, No. 25
Series 1961, No. 25
Soil Genesis and Classification
BUOL, HOLE, AND MCCRACKEN
BUCKMAN
BRADY
THE NATURE AND PROPERTIES OF SOILS
Seventh Edition
FACTORS OF SOIL FORMATION
JENNY

# 10 Soil: The Least Renewable Physical Component of the Ecosystem

# Hans Jenny

1941 publication



# *The CLROPT Equation*

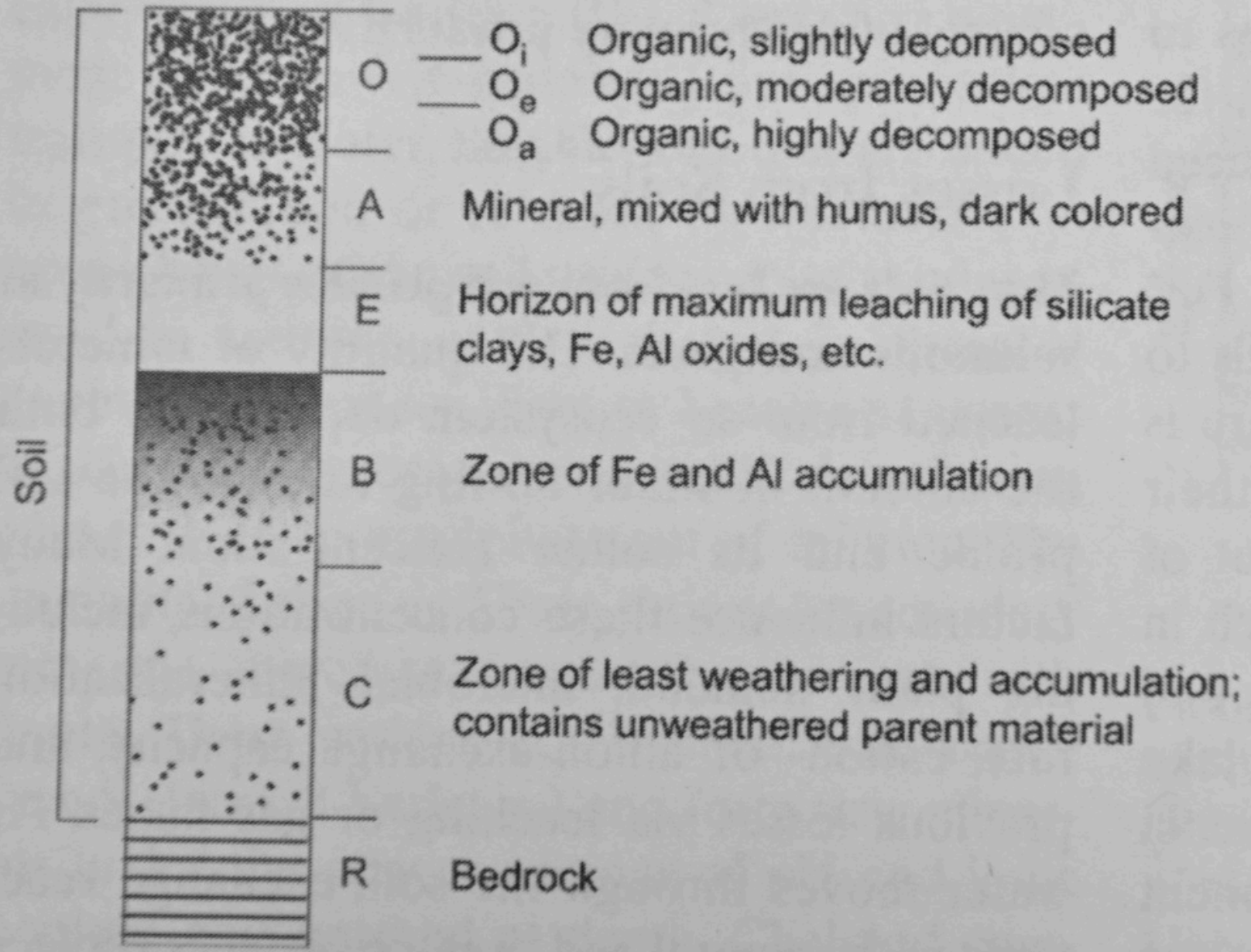
Soil = f (**Cl**imate, **O**rganisms, **R**elief, **P**arent material, **T**ime)

***A Functional Factorial Model for Soil Formation, Modification and Management***

# *The CLROPT Equation*

Soil = f (Climate, Organisms, Relief, Parent material, Time)

***Which of these variables can we control in designing urban green infrastructure?***


Soil
O
A
E
B
C
R
$O_i$ Organic, slightly decomposed
$O_e$ Organic, moderately decomposed
$O_a$ Organic, highly decomposed
Mineral, mixed with humus, dark colored
Horizon of maximum leaching of silicate clays, Fe, Al oxides, etc.
Zone of Fe and Al accumulation
Zone of least weathering and accumulation; contains unweathered parent material
Bedrock

**GREENBELT**

Course-loamy, mixed, active, mesic Typic Dystrudepts

Very deep, well drained, moderate permeability

**CONESUS**

Fine-loamy, mixed, active, mesic Glossaquic Hapludalfs

Very deep, moderately well drained, formed in till

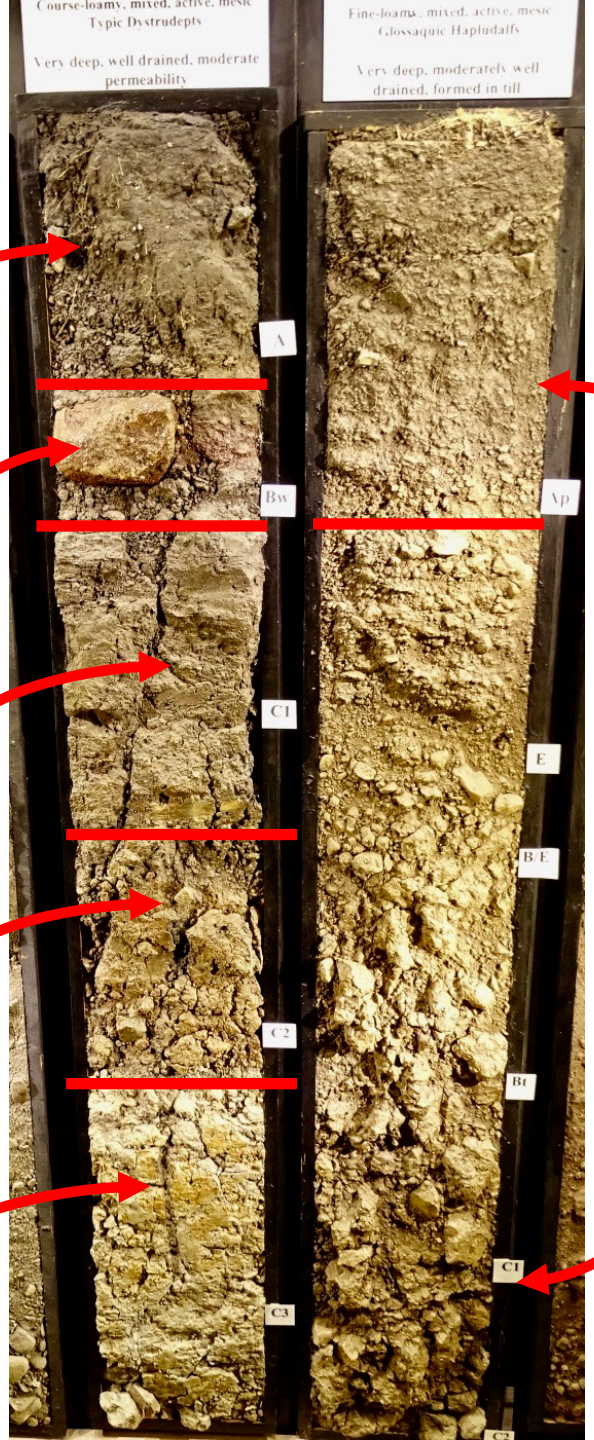
**Topsoil dump**

**Drainage layer dump**

***Parent material dump 3…….***

***Parent material dump 2……***

***Parent material dump 1 !!***

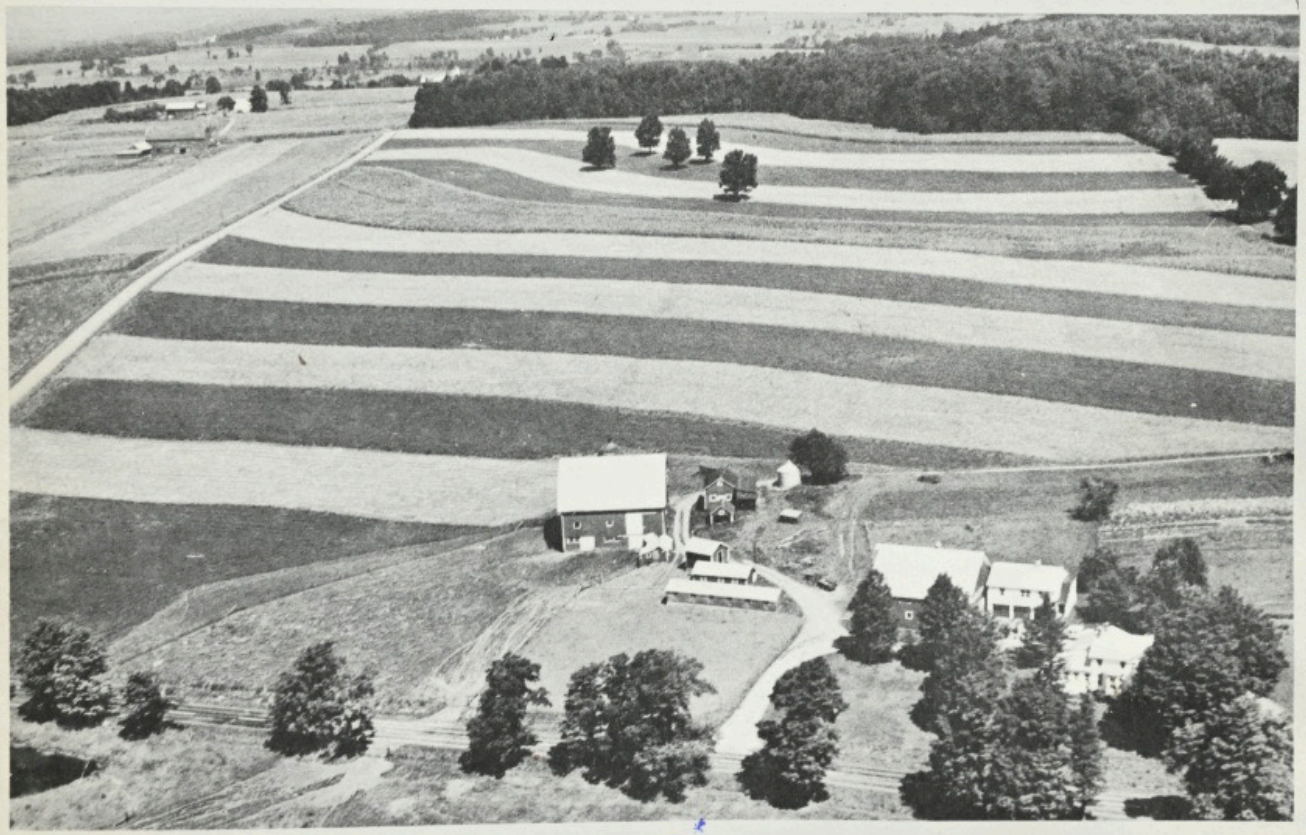



**Plow Layer**

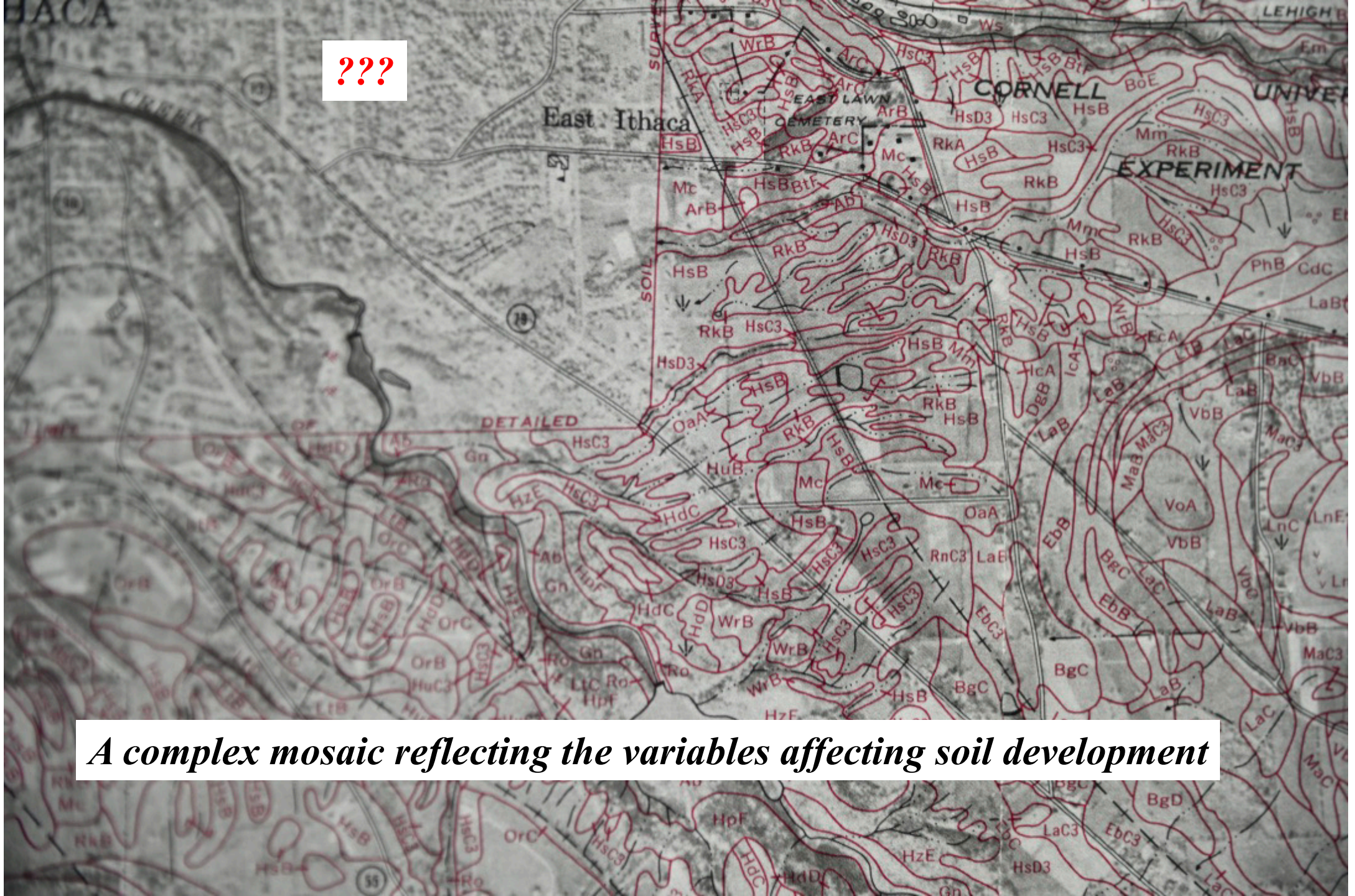
**C Horizon**
**= Parent Material**

# SOIL SURVEY

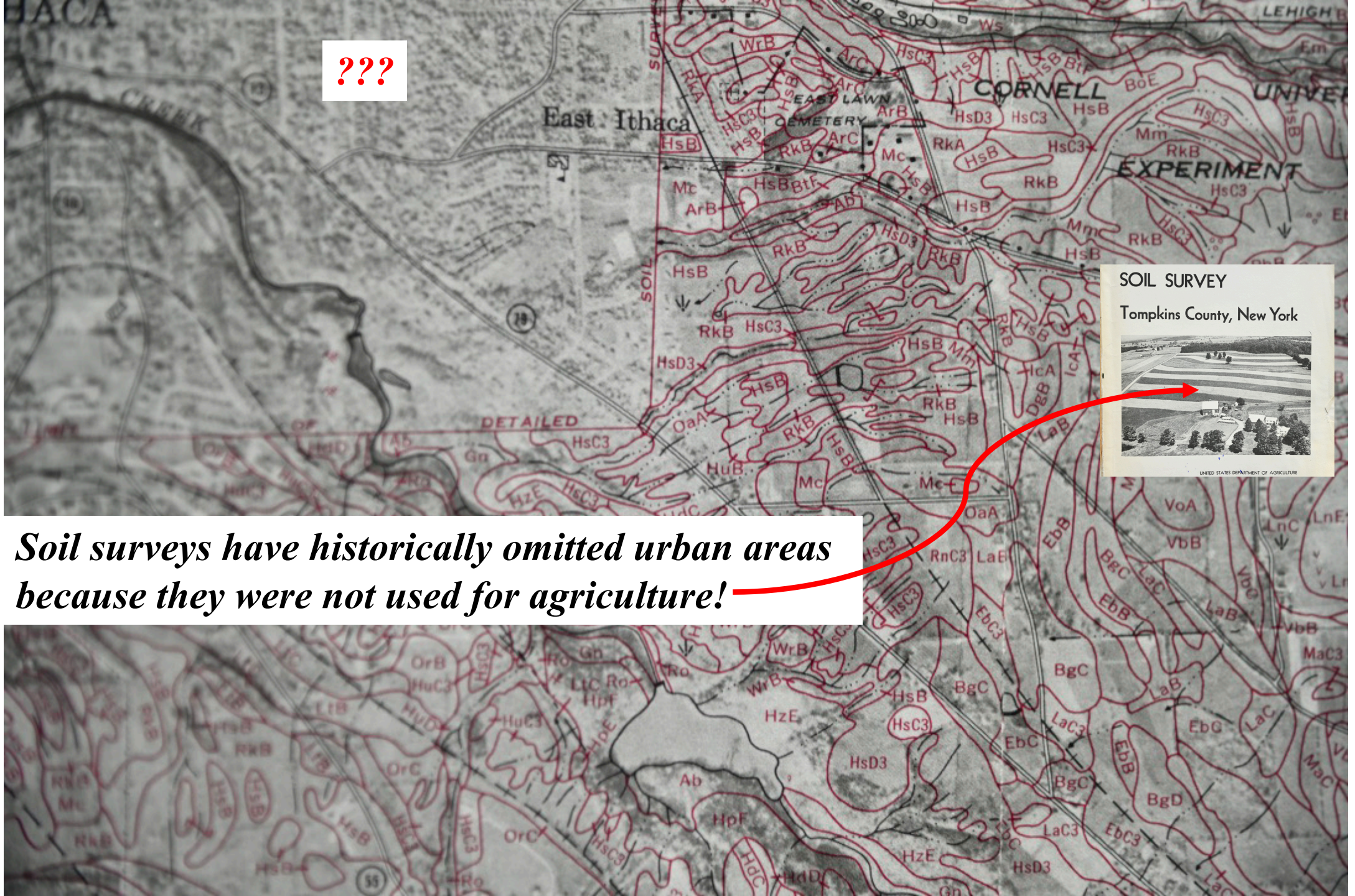
# Tompkins County, New York



UNITED STATES DEPARTMENT OF AGRICULTURE




***A complex mosaic reflecting the variables affecting soil development***

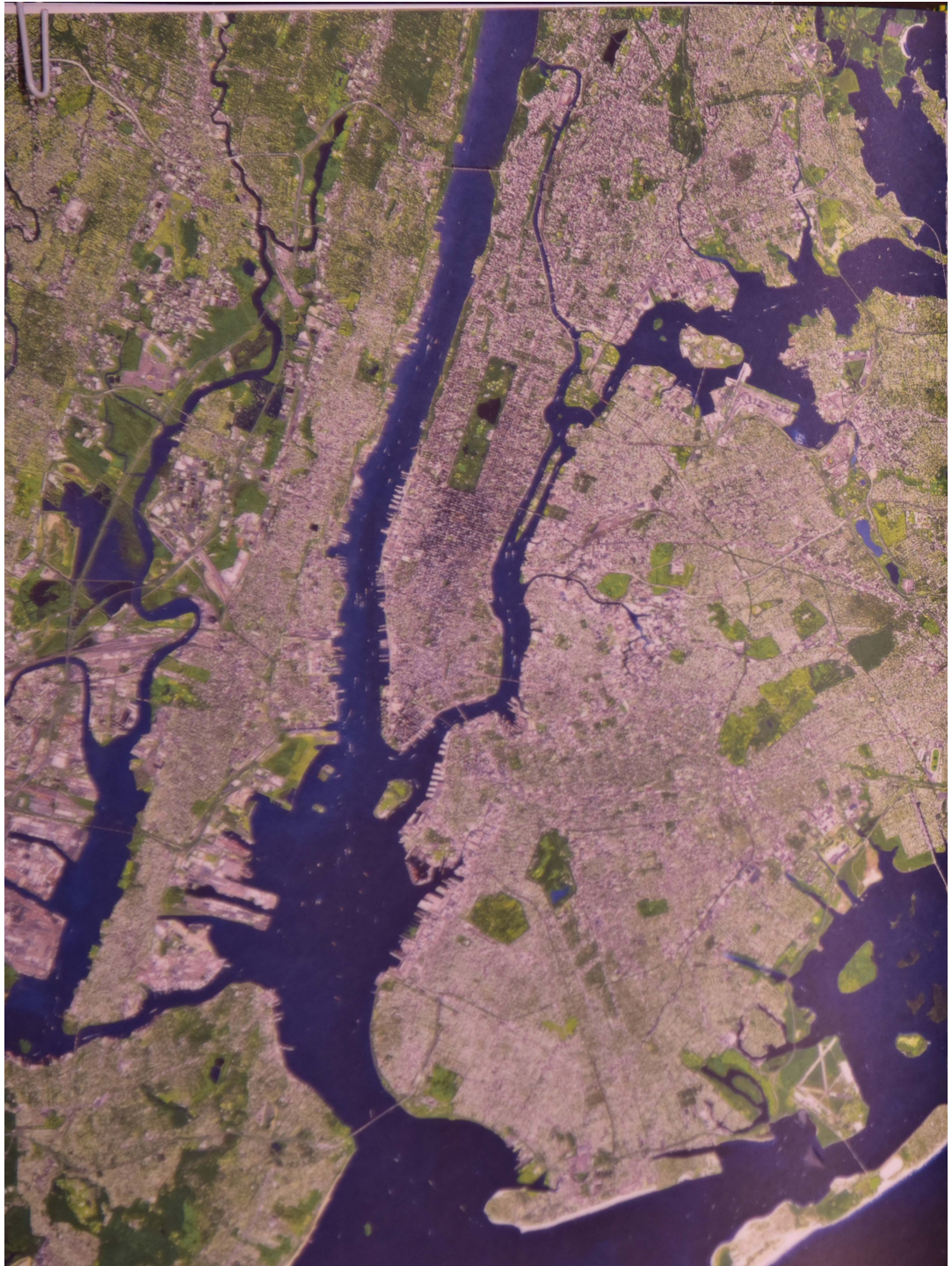

???
East Ithaca
CORNELL
EAST LAWN CEMETERY
EXPERIMENT
SOIL SURVEY
Tompkins County, New York
UNITED STATES DEPARTMENT OF AGRICULTURE
Soil surveys have historically omitted urban areas because they were not used for agriculture!

**New York City**

**Where is the green?**

**Welcome to the**
***Anthropocene!***

***Does soil exist***
***in this landscape of***
***impervious surfaces?***

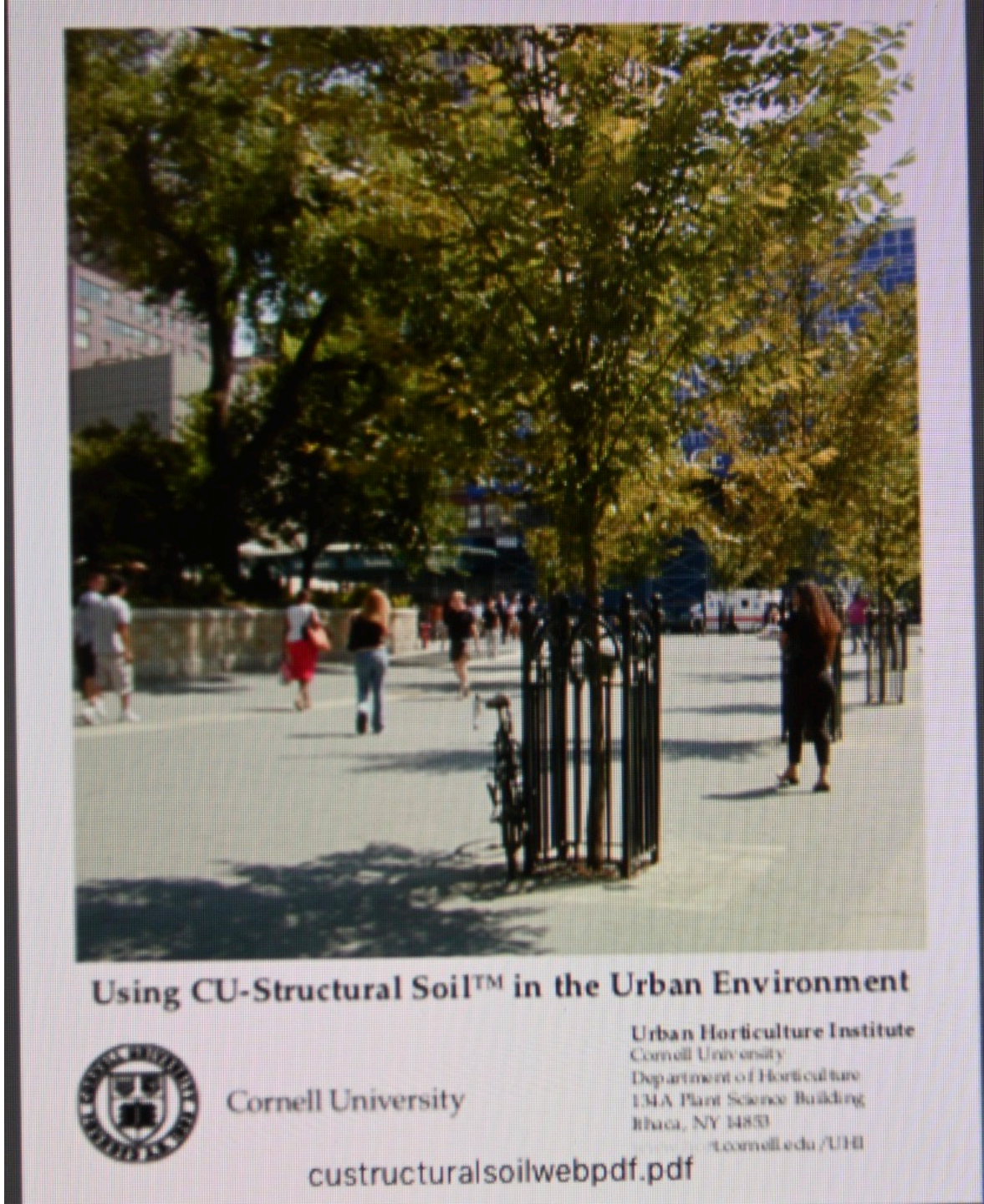


*And how can you grow anything in this compacted stuff?*

# Answer

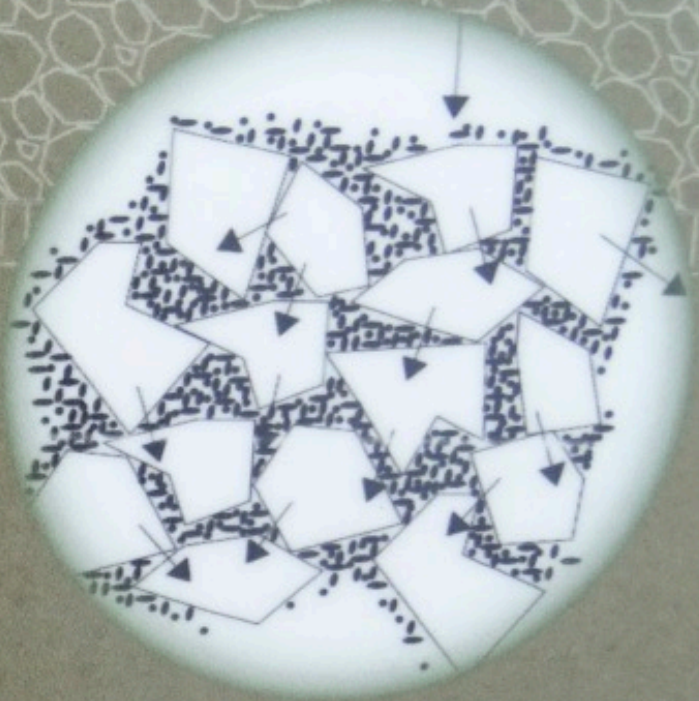
## Use *Structural Soil*

Patented: CU-Soil[R]
Amereq Inc. bkalter@amereq.com



# CU-Structural Soil®

A mixture of stone and soil, structural soil allows the roots of nearby plants to reach further for nutrients and water. CU-Soil® increases the volume of soil available to trees and plants near paved areas while also supporting pavement.



coarse stone
provide structure

All photo credit to Urban Horticulture Institute, Cornell University

Patented: CU-Soil®
Amereq Inc. bkalter@amereq.com

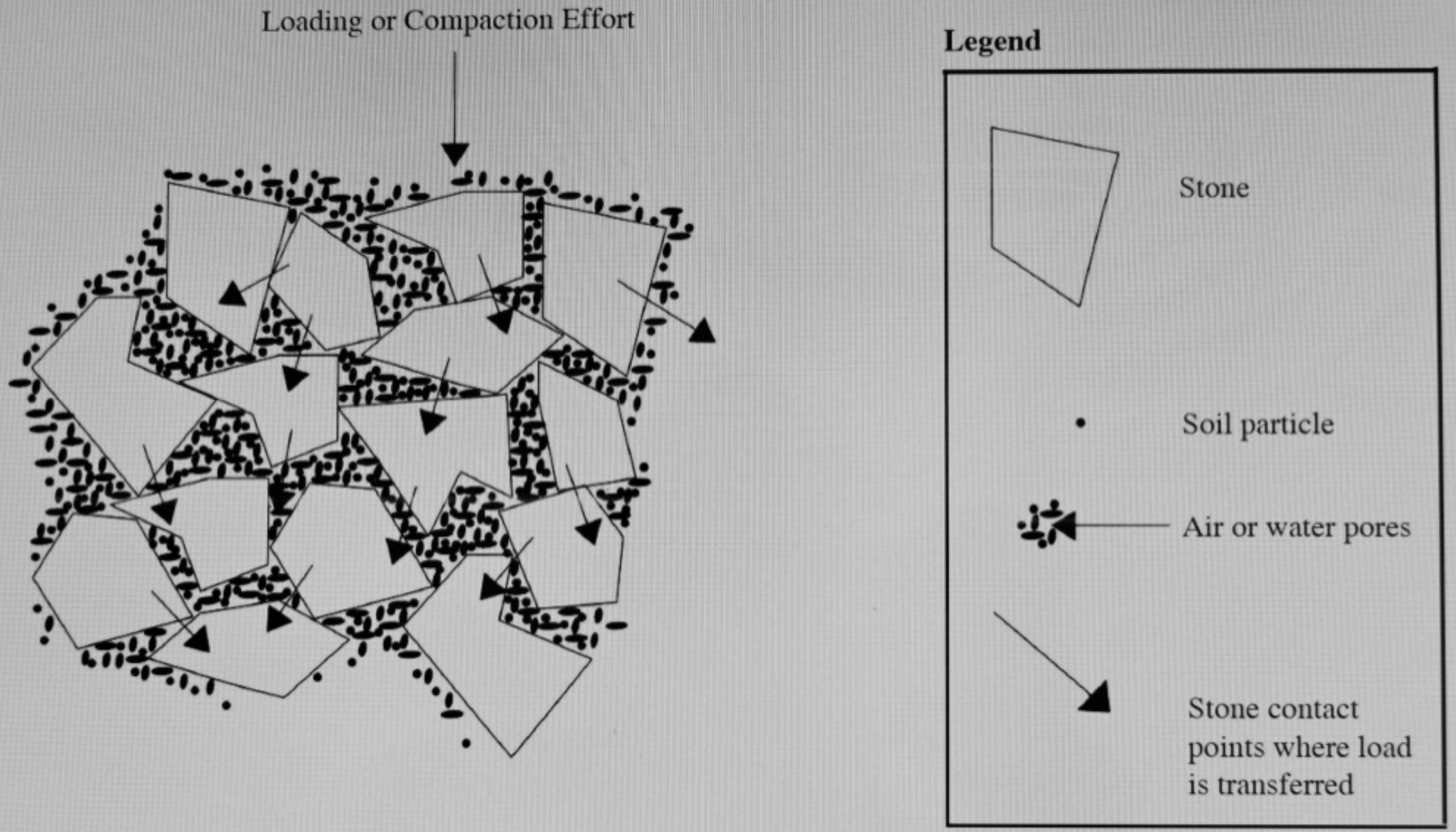



Fig.1.7 Conceptual diagram of CU-Structural Soil™ including stone-on-stone compaction and soil in interstitial spaces used as a base course for pavements.

Patented: CU-Soil$^{R}$
Amereq Inc. bkalter@amereq.com

# Components

**Washed angular crushed stone lattice**

**20% Clay loam**

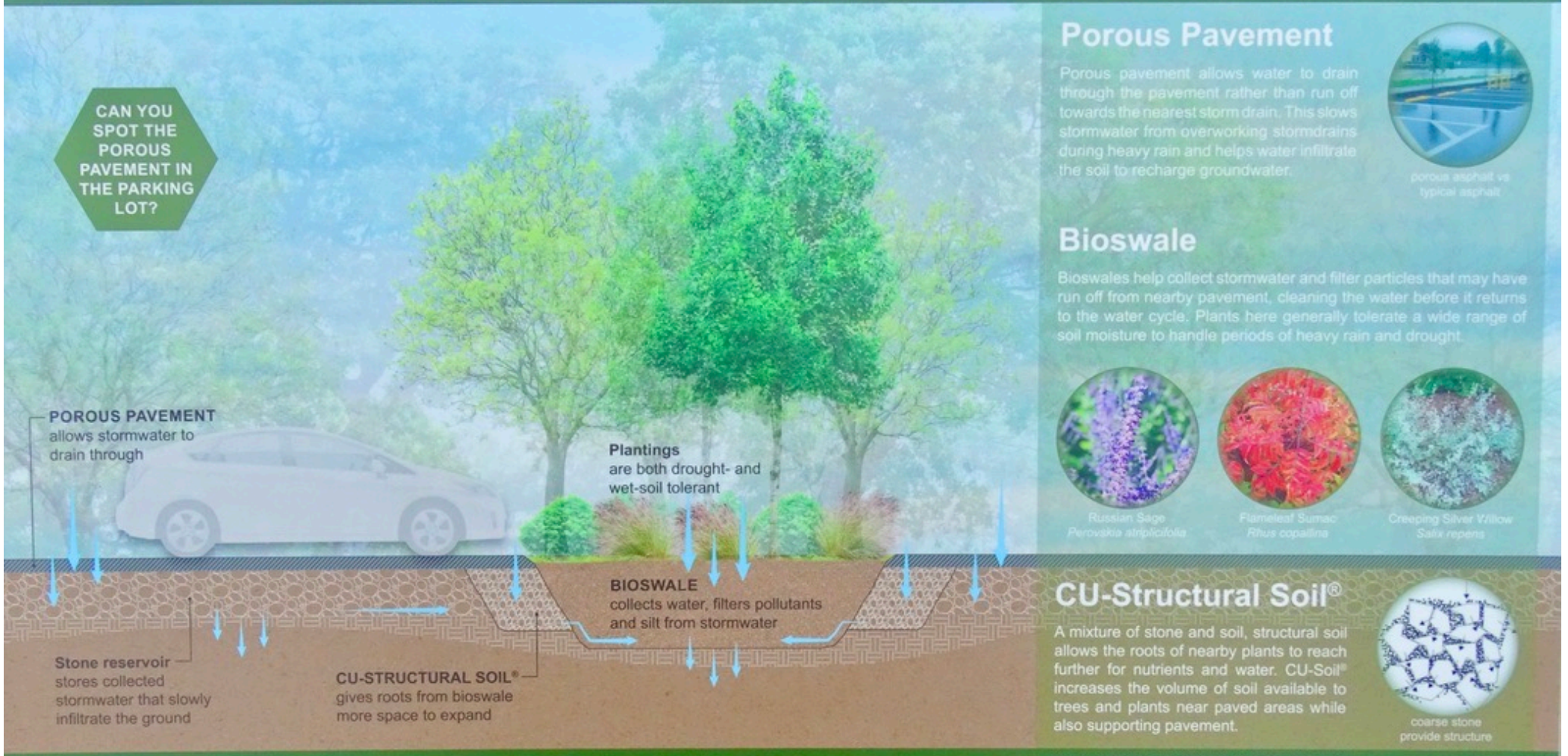
**2-5% Organic Matter**

**Gelscape tackifier to aid uniform mixing**

# Peterson Green Parking Lot

AT FIRST GLANCE, this parking l…neath the surface. Porous asphalt and the bioswale in the center of th… pavement. The Peterson Parking Lot was designed to slow and store …and recharging groundwater.

*It's part on a more complex system*




## Porous Pavement

Porous pavement allows water to drain through the pavement rather than run off towards the nearest storm drain. This slows stormwater from overworking stormdrains during heavy rain and helps water infiltrate the soil to recharge groundwater.



porous asphalt vs typical asphalt

## Bioswale

Bioswales help collect stormwater and filter particles that may have run off from nearby pavement, cleaning the water before it returns to the water cycle. Plants here generally tolerate a wide range of soil moisture to handle periods of heavy rain and drought.



Russian Sage
*Perovskia atriplicifolia*



Flameleaf Sumac
*Rhus copallina*



Creeping Silver Willow
*Salix repens*

## CU-Structural Soil®

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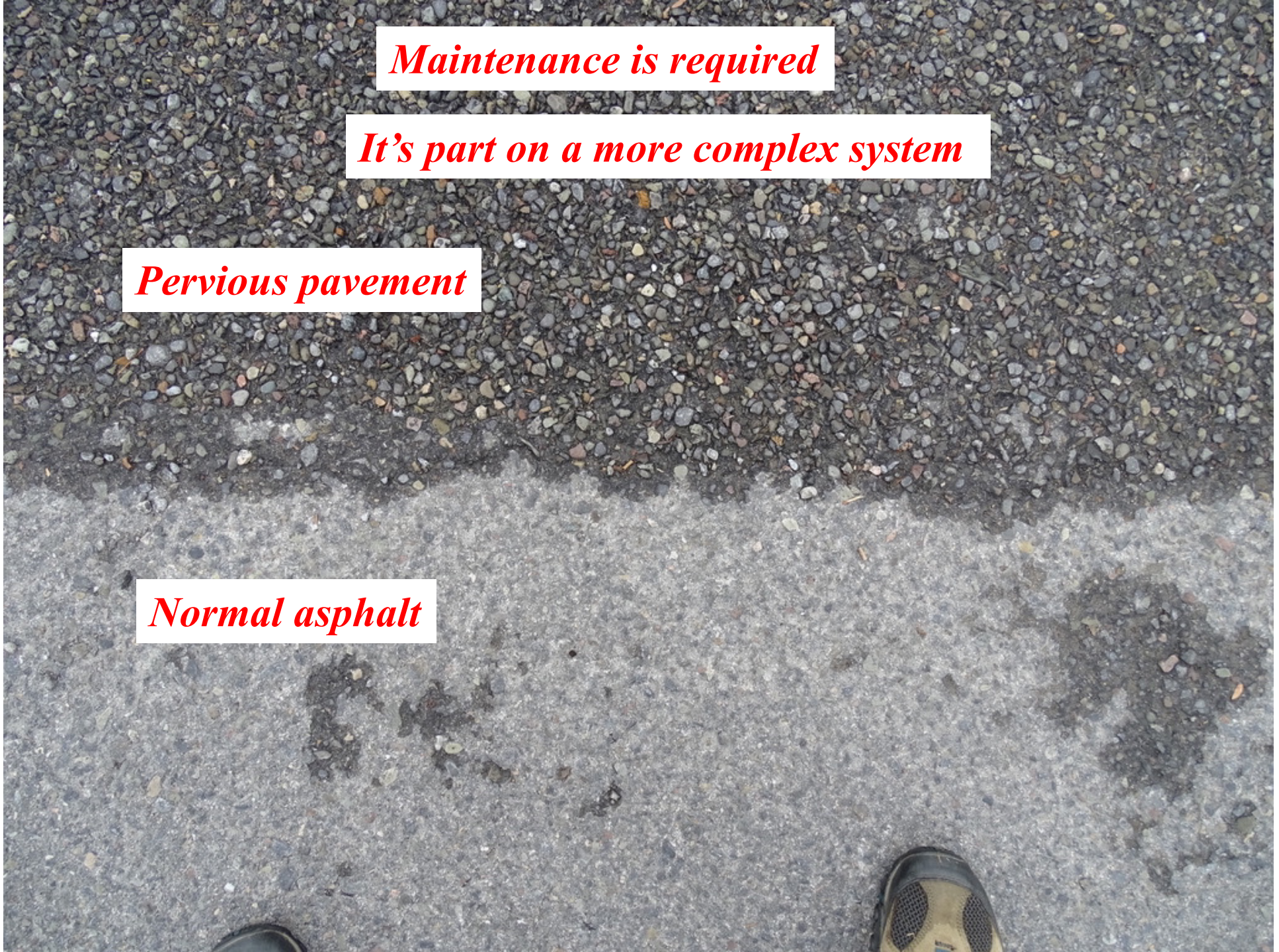
coarse stone provide structure

All photo credit to Urban Horticulture Institute, Cornell University

Cornell University

SUSTAINABLE CAMPUS

NEW YORK STATE OF OPPORTUNITY. Environmental Facilities Corporation


Maintenance is required
It's part on a more complex system
Pervious pavement
Normal asphalt

***How can we develop out understanding of green infrastructure?***

# Native Forest

*Many inputs, processes and outputs*

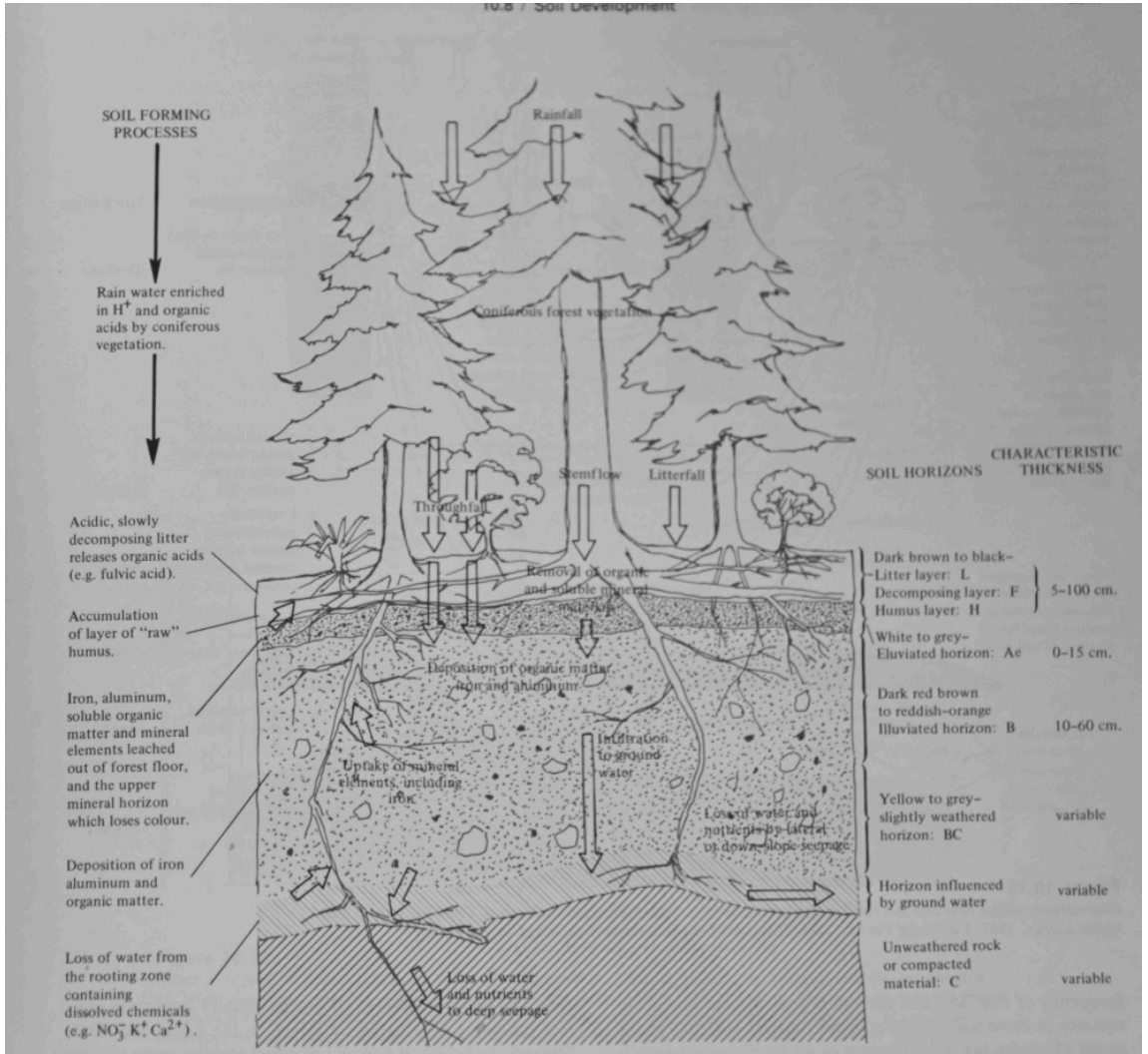



**Figure 10.15**
Characteristic major horizons and soil-forming processes of a typical coniferous forest podzol, a pedalfer type of soil. (After Clarke, 1967. Copyright 1967 by John Wiley & Sons, Inc., New York. Used by permission.)

# Urban Planting

*What/where are the analogous features in this system?*

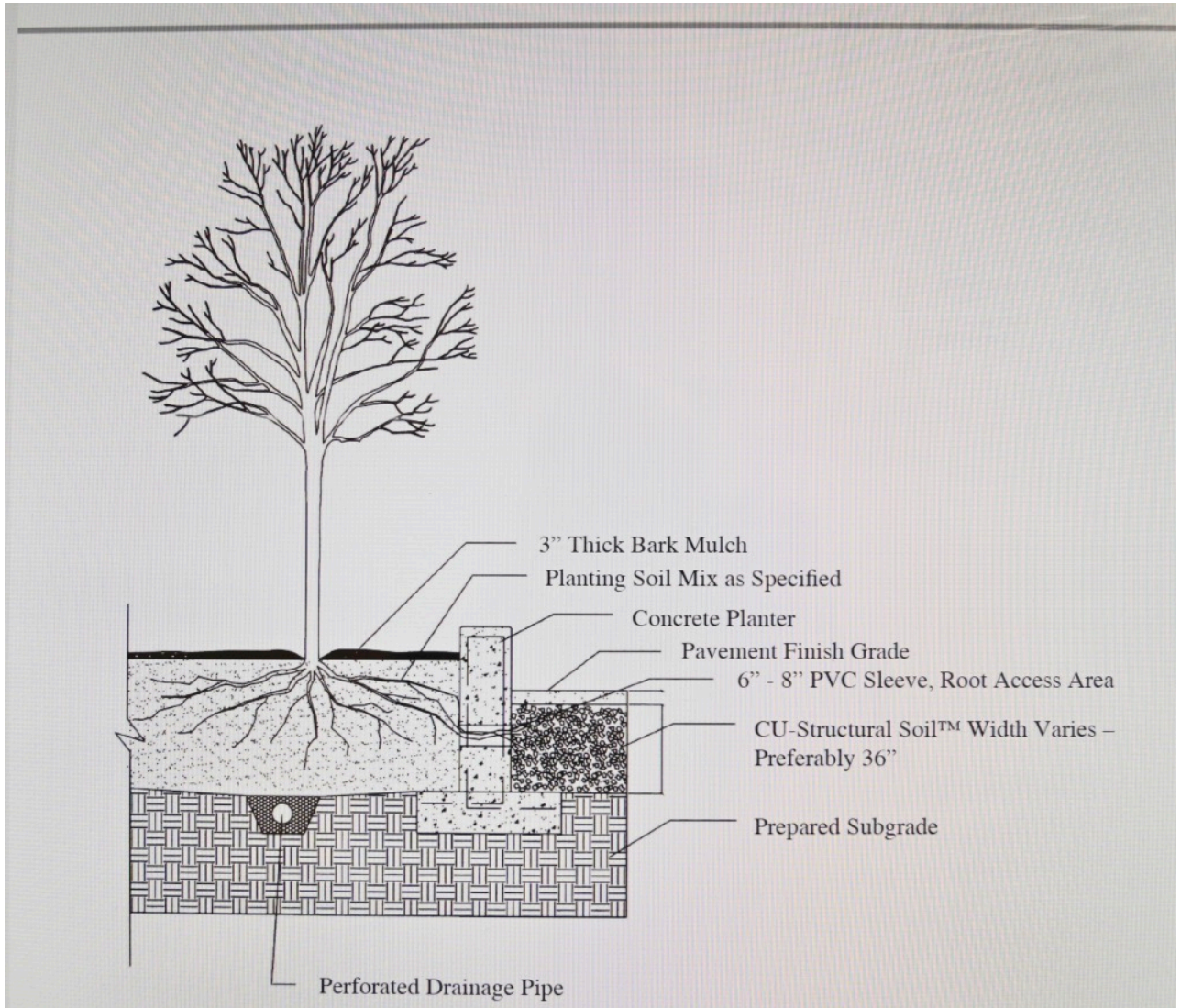



Fig. 1.18 Limited soil volume planter with root access into CU-Structural Soil™ under plaza pavement

***Thoughts on emerging needs***

***Long term monitoring***

*Thoughts on emerging needs*

*Long term monitoring*

*Tree performance*


***Thoughts on emerging needs***

***Long term monitoring***

***Tree performance***

***Changes in soil***


***Thoughts on emerging needs***

***Long term monitoring***

- ***Tree performance***
- ***Changes in soil***
- ***Ecosystem function, services***


*Thoughts on emerging needs*

*Long term monitoring*

*Tree performance*

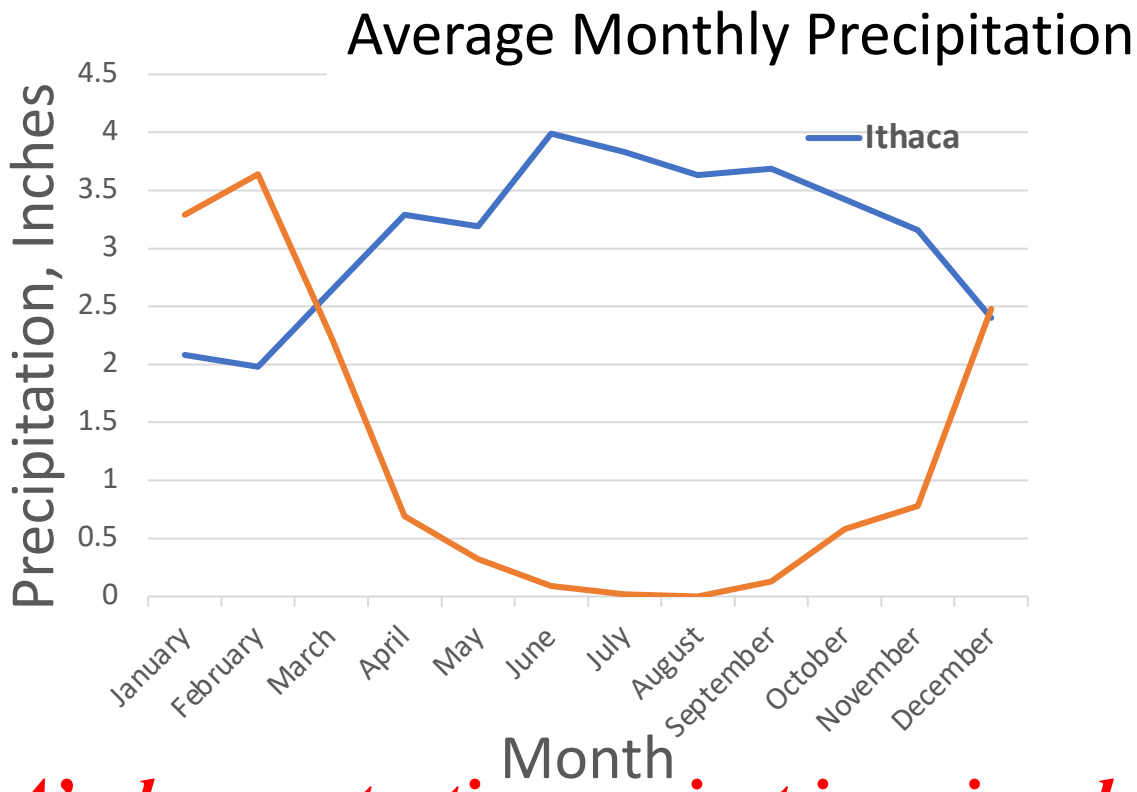
*Changes in soil*

*Ecosystem function, services*

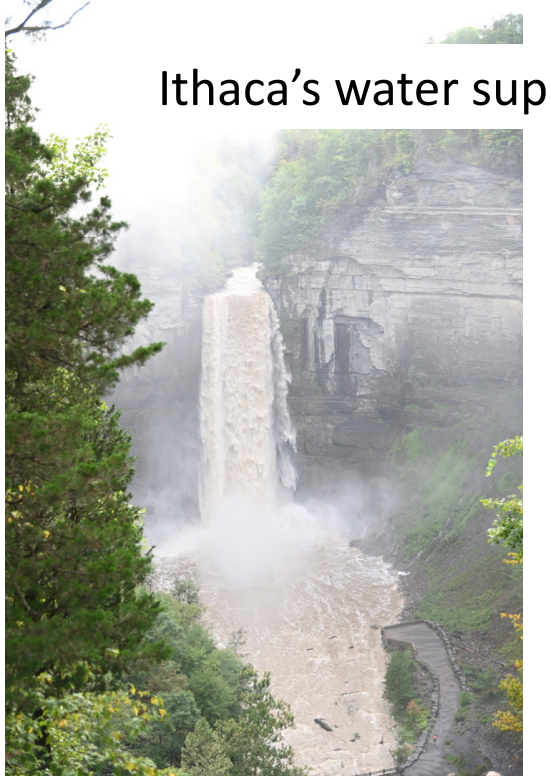
***Don't forget GLOBAL CHANGE!***

***We need to manage for***

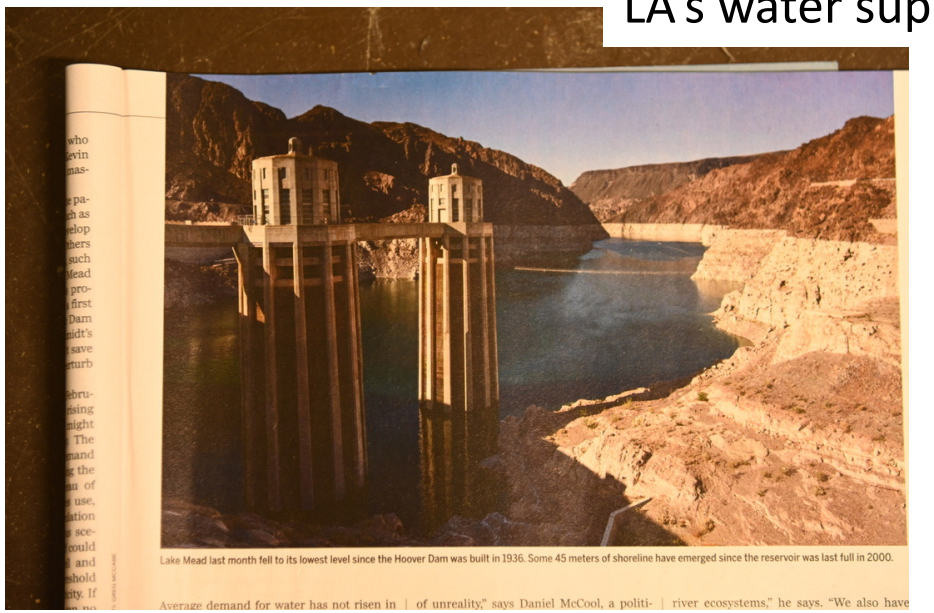
***Radical Ecosystem Change***




Ithaca's water supply



LA's water supply




***LA's demonstration project is uniquely positioned to initiate cooperative research. Unlike much of the eastern US, Los Angeles plantings will need irrigation. Competition with other demands for water?***

***Much research is needed***

***HOW to fund this??***

***Partner with cities across the US***

***Get funding for a Research Coordination Network***

***NSF***

***USDA***

***USGS***

EARTH SCIENCE

## New observatory to bring soil up from the deep

Ecotron will move 3-meter cores into the laboratory for global change experiments

By Erik Stokstad

Just a meter or two down, below the topsoil that nurtures crops, is a little known part of the ecosystem that may be critical to the planet's climate future. But this deep soil is surprisingly hard to study. It helps to know the right backhoe operator, and even then extracting samples without disturbing their structure or inhabitants is tricky. "The deeper you go, the harder it is," says Daniel Richter, a soil scientist at Duke University.

Last month, the U.S. National Science Foundation announced funding for a new $19 million research facility, called the Deep Soil Ecotron, that aims to make studying this frontier easier. The initial design for the lab, to be built over the next 5 years at the University of Idaho, calls for 24 richly instrumented soil columns topped with airtight chambers for vegetation. These ecosystems-in-a-lab, or ecounits, will allow researchers to manipulate environmental conditions down to 3 meters. Surprises are assured. "It's kind of like when people launched the first deep-sea submarine," says Zachary Kayler, a co-principal investigator (co-PI) and biogeochemist at the University of Idaho. "The possibilities are endless."

Ultimately, researchers hope to use the ecotron facility to study a wide range of questions, including how the deep soil might release carbon and accelerate climate change, how soil microbes and plants interact, and how torrential summer rains and hard winter freezes influence the birth and growth of soil. The center could also become a testbed for new sensors that reveal what's happening in deep soil in the real world. Planners hope to attract researchers from across the United States and host multiple experiments at once. "This facility has potential that's incredibly exciting," says Sharon Billings, an ecosystem scientist at the University of Kansas, Lawrence.

About a dozen ecotron facilities exist, nearly all in Europe. But they allow researchers to tinker with just one or two soil conditions, usually precipitation. In contrast, the new U.S. lab will allow researchers to manipulate a host of factors throughout the entire columns, including temperature, moisture, and carbon dioxide concentrations (which influence rock weathering and soil formation). They will be able to simulate the upwelling of groundwater and perhaps even the freeze-thaw cycles that can speed soil development.

The ecotron also opens the door to studying deep life, including invertebrates, says Nico Eisenhauer, an ecologist at the German Centre for Integrative Biodiversity Research who advises the U.S. ecotron. Little is known about the activity of these organisms, he says, but their hidden behavior could be monitored in the new ecounits. Acoustic sensors, for instance, can track earthworm activity, whereas buried tubes with small entrances collect and count tiny invertebrates that stumble in.

Researchers who study soil carbon note that 30 centi… because it … tists have … microbe-ri… But a few … soils sugge… much carb… roots. "It's … carbon," s… Schmidt of…

Studying how that carbon might respond to future climate change is a key goal for the ecotron, which can simulate changing conditions "with a degree of control I've never seen before," says Emma Aronson, a soil scientist at the University of California, Riverside. Deep soils … expected to warm as Earth heats up, … field experiments suggest that could ca… soil to release carbon into the atmosph… 30% to 50% faster than today, accelerating global warming. Precipitation shifts … caused by climate change will also have an impact. For example, wetting of desert soils, especially those that have been pol… luted with reactive nitrogen, can lead to much greater emissions of nitrous oxide, a potent greenhouse gas.

Idaho is "really a cool place" to locate the ecotron lab because it boasts a diverse range of soil types, says the project's PI, microbial ecologist Michael Strickland of the University of Idaho. He and colleagues are still mulling how many and which types of soils to place into the columns. "Capturing dynamics in different types of soils will be key," says soil biogeochemist Asmeret Asefaw Berhe, who is awaiting Senate confirmation to lead the Department of Energy's Office of Science.

One challenge will be ex… tracting and moving the se… lected soils. Field crews must disturb them as little as possible, Richter says, because their structure influences the movement of gases, water, and particles. Stricklan… hopes new equipment from the compan… building the facility will be able to extrac… long cores intact. But no matter how tende… the touch, researchers expect the sampl…

Ecotron scientists and visitors examine columns of soil in this artist's concept.

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Native soils project

Agriculture project

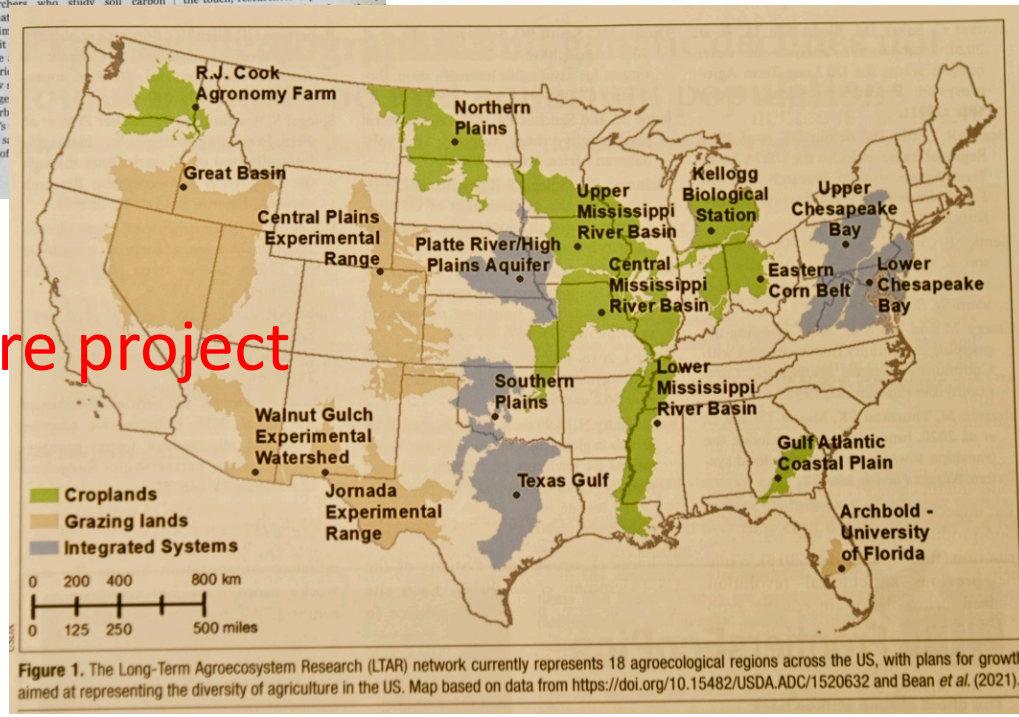


**Figure 1.** The Long-Term Agroecosystem Research (LTAR) network currently represents 18 agroecological regions across the US, with plans for growth aimed at representing the diversity of agriculture in the US. Map based on data from https://doi.org/10.15482/USDA.ADC/1520632 and Bean *et al.* (2021).

Expand Jenny's legacy:

# A Functional, Factorial Model for Soils in Green Infrastructure Projects

There's green at the end of the tunnel