

Building Soil
Foundation for Success

Healthy Trees ... Healthy Cities

Tree Preservation Strategies for a Sustainable City

City of Seattle
Department of Transportation
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Healthy Trees were here first...
... think of this time as B.C.
Before Cities...
...Before Construction

Before Cities:

Healthy soil, the foundation of vibrant native forests, was commonly thought of as "Dirt". This material was considered by pioneers in the early development of cities until very recent times, a plentiful & expendable waste product.

Understanding soil: ... a living resource

Soil components:

- "The Dirt" (mineral part)
 - sand
 - silt
 - clay
- Air and Water
- Organic Matter and Soil Life
creates structure: aggregates, pores, resistance to compaction

*Good soil is about
- half mineral
- half space (air & water)
- plus a smaller but essential amount of organic matter & soil life*

Puget Sound "Dirt": Left by glaciers & volcanoes

glacial till: unsorted mix of clay, silt, sand, gravel, and boulders
hardpan: till compacted under glacier
outwash soils: layers sorted by water - s
lake/marine bed soils: clay & silt settled in lakes & estuaries
volcanic ash: light, fe (mostly blown east or Cascades)
mudflows: mixed size, compact - like till

Learn about Puget Sound soils at:
www.puyallup.wsu.edu/soilmgmt/Soils.htm

From Dirt to Soil -it's alive!

Soil horizons & their evolution

- Bedrock (R) weathers physically & chemically to subsoil (B)
- Biological processes create topsoil (A) and organic (O) horizon
- Healthy soil...healthy trees
 - nutrient cycling
 - cat ion exchange
 - disease protection
 - water supply
 - gas exchange
 - root space

USDA-NRCS
"Soil Biology Primer"
<http://soils.usda.gov/en/>

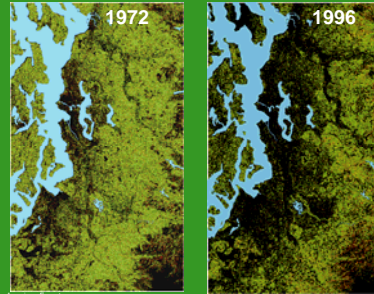
After Cities (i.e. After Construction)

What Changed? The world around us.

With the soil went the trees...both older trees that could not tolerate grading and compaction along with the future of new trees planted in "dead" 4' x 4' bits of ground surrounded by paved surfaces and filled with potting mixes. With the trees went the wildlife and the human liveability of urban centers in exchange for suburban sprawl we now recognize as a form of cancer for which a cure must be found.

The Soil / Forest Connection as forests have become cities...

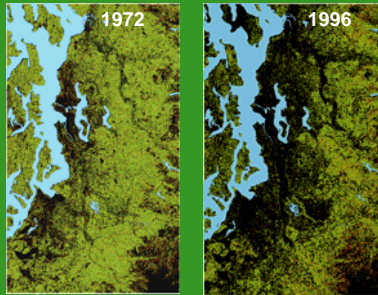
1972-1996: Amount of land with 50% tree cover decreased by 37% in Puget Sound region (from 42% of land down to 27%).



Impervious surface (roads, buildings) increased proportionately.

The Soil / Forest / People Connection as forests have become cities

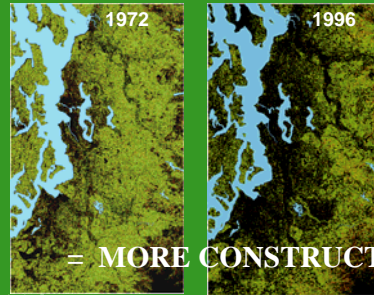
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+ 2.7M by 2020 !

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Impervious surface (roads, buildings) increased proportionately
WA population doubled 1962-98.
+ 2.7M by 2020 !

= MORE CONSTRUCTION !!!!!

What if we don't change?

- Pollution
- Erosion
- Salmon decline
- Flooding & property damage
- Drop in property value
- INCREASED PUBLIC SAFETY RISK



Trees fight for their lives in the urban environment



Tree abuse...



After the "wake up call"

What Now? The CURE...or at least a prescription to reverse Tree Loss.

With recognition of a problem comes hope for a solution.

Rehabilitation requires :

1. early intervention (before design begins)
2. coordination (city staff with development applicants and with each other)
3. coordination (city staff with contractors)

PRESCRIPTION:

Rehabilitation requires :

1. coordination -- with applicants before design begins.
2. coordination -- city staff with development applicants and with each other)
3. coordination -- city staff with contractors during construction

...Most effective if codified

i.e. signed by elected or appointed authority

Design review process

Tree Protection Best Management Practices (BMPs)

RULE OF THUMB:

Retain and protect the SOIL under the tree to save the TREE

- Establish balanced tree protection standards
restrictive requirements often result in tree loss
- Require tree inventory with project submittal
accurate grade at dripline as important as location
- Require tree protection to be represented on plans
if it's on the plans, it's in the contract
- Integrate tree protection with TESC requirements
ensures ongoing monitoring and maintenance

ARTICLE IN PRESS

Working proactively with developers to preserve urban trees

Bill Amers'Shaner Dewald

To address the challenge of preserving street trees as an element of urban project design and construction, the City of Seattle Department has developed a pilot program to provide early consultation and guidance, before building plans become more or generally more costly.

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Article on Seattle's tree preservation methods

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www.elsevier.com/locate/cities

1530 3rd Ave

Working proactively with developers to preserve urban trees. Bill Aron and Shane Dowdell

Running conduit through roots (carefully!)
A successful project: healthy trees!

Working proactively with developers to preserve urban trees. Bill Aron and Shane Dowdell

successful project completed. A new 11-story building and mature street trees. Photo by Bill Aron

www.seattle.gov/transportation/forestry.htm

Figure 4 - Chasing a root for new conduit. Roots exposed by an A-1 Spade® and soil covered using a Vactor truck. Photo by Bill Aron

Tree... & Soil preservation

Wrong!

Right – fence to protect roots

- not ideal (grading cuts into roots along ROW...
... but a lot better!

Cranes, Lanes, and Automobiles ...all have to work together...safely.

Street tree protection measures in action

3401 Fremont Ave

401 Ferry

2208 2nd Ave

Boxes, Boxes...

And more BOXES!!

TREES have the ROW...in the ROW!!!

Trees inspire creative solutions!!!



ROUTINE INSPECTION...
...The most important BMP!!!!



Open Trenching & Root Protection



The AIR SPADE
at work.

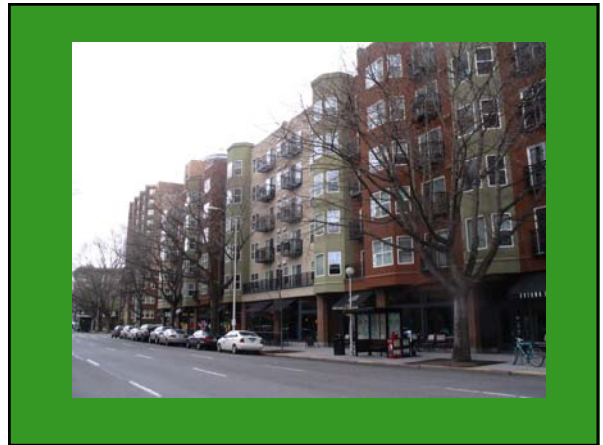
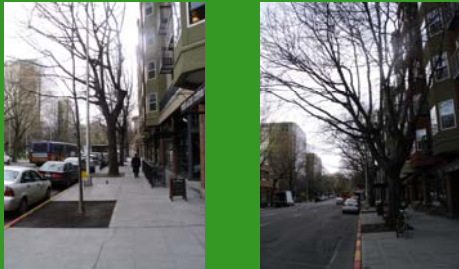
Occasionally, the best protection is to move the tree.

- 80,000 pounds of cherry tree.





TREES BEFORE ...and **AFTER** Seattle's
forester dedicated to development oversight



Trees & Sidewalk
Construction



Again....The **tree** has the ROW.



INTERLOCKING PAVERS--



Rubber---yes **RUBBER** Sidewalks...

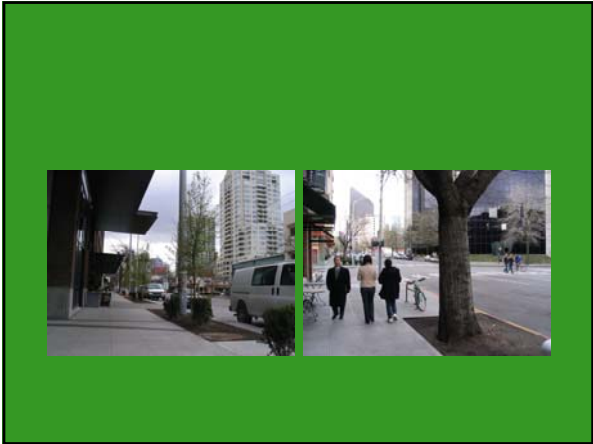


MAKE ROOM FOR **TREES**...
A Creative Application



TREES and Seattle's GREEN FACTOR





Trees, an important tool to manage **STORMWATER**

Broadview Green Grid, Seattle (right after Oct. 2004 "100 year" storm)

- Compost-amended soil in bio-retention swales
- Erosion control with compost blankets, berms, and socks

High Point, urban redevelopment

- Swale drainage system
- Compost-amended soils on entire site
- Tree preservation

www.seattle.gov/util/NaturalSystems/

Tree protection at High Point – fence to protect root zone

Structural Soil Benefits

- Maintains spaces (macro-pores) for air and water, and root growth
- Provides foundation for paving
- Prevents/reduces root heaving of pavement

The Case for CU-Structural Soil™:
Why do we need it, what is it, and how is it used?

Urban trees experience a litany of environmental insults: soil and air pollution, heat loads, driving salts, and impacts from vehicles, vehicles, and buildings. The most significant problem that urban trees face, however, is lack of available soil volume for root growth, since trees are often an afterthought in city planning and construction design (Fig. 1.1).




Soil Compaction
During construction, including sidewalks and road repair, disturbs and compacts soil (Fig. 1.2), resulting in macropores (Fig. 1.3). Loss of macropores has three negative consequences, restricted aeration, diminished water drainage, and creating a dense soil that is difficult for roots to penetrate. These effects limit available rooting space.

Macropores
• are relatively large open spaces between and adjacent to
• water drains quickly through macropores
• trap diffuse through macropores

Macropores are the spaces between soil aggregates (see Fig. 1.3). Macropores are spaces between soil aggregates that allow water, air and other gaseous root growth.




What happens when roots encounter dense, compacted soil?
When roots encounter dense soil, they change direction, slow growing (Fig. 1.5) or adapt by remaining almost fully close to the surface (Fig. 1.4). This superficial rooting makes urban trees more vulnerable to drought and soil temperature fluctuations. However, if a dense soil is waterlogged, tree roots can rot from lack of oxygen.

How Structural Soils improve tree health, stability

- Increase soil volume/area accessible to tree roots

The role of soil volume on tree growth

The soil in urban tree lawns or parks can be improved by amendment or soil replacement. Where soil volume is limited by pavement, tree roots suffer (Fig. 1.6). The highly compacted soils required for constructing pavements do not allow root penetration, resulting in the declining trees, all too common in cities. Yet it is precisely these paved areas such as parking lots and streets that most need the mitigating effects of shade trees.

Healthy trees need a large volume of non-compacted soil with adequate drainage and aeration and reasonable fertility. CU-Structural Soil™ meets these needs while also fulfilling engineers' load-bearing requirements for base courses for pavements.

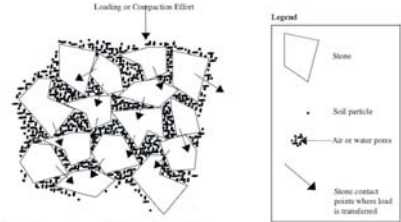


image from CU-Structural Soil™

Structural Soil components

- Angular crushed rock (maximum spaces under load)
- Clay or clay loam (nutrient holding)
- Organic (compost)
- Stabilizers, etc. (proprietary mixes)

CU-Structural Soil™ Basics

CU-Structural Soil™ (CS, Patent # 5,847,000) is a two-part system comprised of a rigid stone "lattice" to meet engineering requirements for a load bearing soil, and a quantity of soil, to meet tree requirements for root growth. The lattice of load bearing stone provides stability as well as interconnected voids for root penetration, air and water movement (Fig. 1.7). The uniformly graded 3/4" to 1 1/2" angular crushed stone specified for CU-Structural Soil™ is designed to ensure the greatest porosity. Crushed or angular stone provides more contact and structural interface of stone to stone than round stone. Because stone is the load bearing component of structural soil, the aggregate used should meet regional or state Department of Transportation standards for pavement base courses.

Since structural soil systems, they have the most water and nutrient holding capacity, a heavy clay loam or loam, with a minimum of 20% clay, is selected for the CU-Structural Soil™ system. CU-Structural Soil™ should also have organic matter content ranging from 2% to 5% to ensure nutrient and water holding, while encouraging beneficial microbial activity. A minimum of 20% clay is also essential for an adequate cation exchange capacity.

With carefully chosen uniformly graded stone and the proper stone to soil ratio, a medium for healthy root growth is created that also can be compacted to meet engineer's load bearing specifications (Fig. 1.8). The intention is to "suspend" the clay soil between the stones without over filling the voids, which would compromise aeration and drainage capacity. CU-Structural Soil™ utilizes Gilsomper Hydrogel as a non-toxic non-photosynthetic stabilizer, in addition to stone and soil components.



image from CU-Structural Soil™

Typical street tree detail

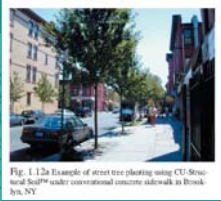
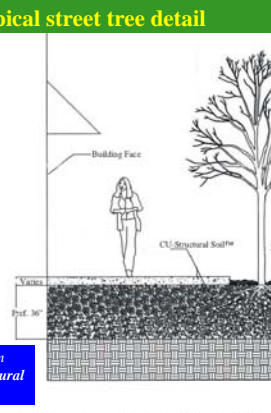



image from CU-Structural Soil™

Root access under pavement

Trees in Parking Lots and Plazas:
CU-Structural Soil™ may also be used to enlarge a "tree island" within a parking lot. With a large tree planting area, good, well draining top soil can be used in the island and CU-Structural Soil™ added as an access rooting media under the asphalt (Figs. 1.13 - 1.15).

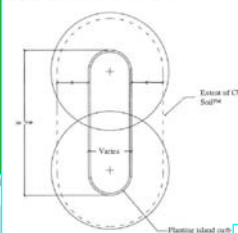






image from CU-Structural Soil™

Other, non-patented structural soil specifications:

- City of Abbotsford, BC
- City of Seattle (based on standards developed by the City of Olympia)

City of Abbotsford Structural Soil Short Specification

STRUCTURAL SOIL: A growing medium for trees installed in hard surface situations

1.1 GENERAL:
Structural Soil is to be utilized where trees are installed in hard surface paved areas where additional growing medium is required to provide adequate space for tree root development. Do not place Structural Soil in planting beds or planting pits.

1.2 STRUCTURAL SOIL MATERIAL MIX:

1.2.1 Structural Soil is a consistent even distribution of its components. The ratio of components may vary and may require adjustment to ensure soil volume is adequate to fill all voids in the stone.

1.2.2 The following is a recommended base ratio of materials for structural soil:

(60 parts of aggregate stone)	(20 parts of Growing Medium)
(10 parts of Stabilizer)	(10 parts of Water as required)
(The amount of water required will vary according to moisture level of Growing Medium.)	

1.2.3 The stone, growing medium and stabilizer product are to be combined into a homogeneous medium.

1.3 GROWING MEDIUM:

1.3.1 TABLE ONE: The growing medium within the structural soil mix to meet the requirements of the above Schedule.

TABLE ONE - PROPERTIES OF GROWING MEDIUM FOR STRUCTURAL SOIL	
TEXTURE: Particle size Classes by the Canadian System of Soil Classification	
Gravel: greater than 2 mm - less than 75 mm	0
Sand: greater than 0.075 mm - less than 2 mm	maximum 60%
Silt: greater than 0.002 mm - less than 0.075 mm	maximum 20%
Clay: less than 0.002 mm	maximum 15%
Clay & Silt Combined	maximum 45%
ACIDITY (pH):	6.0 - 7.0
SALINITY: Saturated extract conductivity shall not exceed:	3.0 millimhos/cm at 25°C
ORGANIC CONTENT: Percent of Dry Weight (%)	6-12%

Links to useful soil BMP specifications:

“Building Soil” Guidelines Manual
for Implementing WDOE Soil
Quality & Depth BMP
(includes APWA & CSI specs)
www.soilsforsalmon.org



Puget Sound Action Team, LID Technical Manual
www.psat.wa.gov/Programs/LID.htm

WsDOT “Soil Bioengineering” specs
<http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm>



Seattle “Natural Drainage Systems” specs
www.seattle.gov/util/NaturalSystems