Healthy Soils – Part 2:
Soil Preservation, Restoration, and Maintenance Practices for Sustainable Landscapes

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With slides from
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Urban Tree + Soils

Based on Healthy Soils Part 1 and Healthy Soils Part 2 by James Urban and David McDonald from ASLA conference Phoenix 9/6/2012, and Soil Improvement for Stormwater, Erosion, & Landscape Success by David McDonald for WSU Low Impact Development. Updated 2/27/2019

www.SoilsforSalmon.org
www.BuildingSoil.org
Regulatory requirements for new construction, in WA Dept. of Ecology’s Stormwater Mgmt. Manual for Western WA

BMP T5.13 “Post-Construction Soil Quality and Depth”

- Retain native soil and duff wherever possible
- All areas cleared and graded require 8 inch soil depth:
  - Organic matter content $\geq 10\%$ dry weight (5% for turf)
  - Use native topsoil, amend existing soil with compost, or import topsoil blend
  - Subsoil scarified 4 inches below 8-inch topsoil layer
  - Protect amended soil from compaction
  - Mulch after planting
  - Maintenance practices to replenish organic content
Guidelines Manual for Implementing BMP T5.13

- Manual developed regionally with experts
- 10% O.M. for landscape beds; 5% for turf
- Develop a “Soil Management Plan” for each site
- Four options for soil management (can use 1 or more / site):
  1) Retain undisturbed native soil & vegetation, protect from compaction
  2) Amend existing soil in place with compost
  3) Stockpile topsoil prior to grading, and reuse on site (amend if needed)
  4) Import topsoil meeting organic matter content requirements

- Choose pre-approved or custom calculated amendment rates
- Simple field inspection and verification procedures
- Includes model specs written in CSI and APWA formats
- Available [www.soilsforsalmon.org](http://www.soilsforsalmon.org) or [www.buildingsoil.org](http://www.buildingsoil.org)
Designing to Modify Past and Future Soil Disturbance

- Compaction
  - Density: weight / volume pore space
- Reduced Soil Biology
  - Organic matter
  - Carbon
  - Lower organic matter
- Grading
  - Structure: clumps / clods
  - Peds
- Soil mixing
  - Texture: sand / silt
  - Clay
- Nutrients
  - N, P, K+
- Salts
  - Acidity
- Fertilizer
  - pH
- Higher pH
- Limited air and water movement
- Water / Drainage
  - Too much / too little

Too much / too little

Soil mixing

Grading

Compaction

Reduced Soil Biology
Grading and compaction impacts

- Planting into heavily compacted subsoil
- Thin layer of topsoil
- Deep cut slope
Soil Interfaces

Topsoil over smooth compacted layers causes drainage and root growth problems.

Better:
Scarified subsoils

Subsoiling (ripping)
Loss of organic matter

- Plan to preserve existing soil & vegetation where possible
- Minimize grading, cut and fill
- Minimize traffic off road bases
- Even a low-organic subsoil can be substantially restored by amending 10-25% (by volume) with mature, stable compost.
Chemical changes

- pH (sometimes due to compacted, anaerobic conditions)
- Nutrient deficiencies (loss of topsoil)
- Toxins: oil, metals, chemicals

Compost amendment tends to correct all of these

Visually examine and smell, then test for suspected deficiencies, toxins, & pH

Chose well-adapted plants, tolerant of your soil conditions (pH etc.)
Preserve Existing Soil
Protect soil & vegetation during construction

- Fence *vegetation & soil protection zones*
- Inform all contractors & subs: no stockpiles etc.
- If temporary vehicle access required, place steel plates over 6” coarse wood chip.
Reducing soil disturbance

Reduce, simplify paved foot print
Consolidate the planted spaces
Decide early which trees to preserve/protect, or remove
Balance/reduce cut and fill
Control the grading plan

Shallow subsoils (B horizon soils) better than deeper C horizon soils
Contractor laydown/staging in areas that will be disturbed or paved
Fence off areas of good topsoil that don’t have to be to be graded
Restoring Top Soil and Sub Soil in Place
Restoring soil in place

- Place sub-drainage if req’d
- Range of equipment for different-sized sites
- If compacted, rip (scarify) to 12-18” depth before or while amending
- 2-4” compost mixed into upper 8-12” of soil
Subsoiling large site

Subsoiling small site

SUBSOILING (RIPPING)

Trenches filled with compost
Modify Existing and Imported Soil
Soil harvesting, storage, & re-installation

• Harvest at start of grading
• Store covered with breathable fabric, coarse wood chips, or sterile annual grass to prevent erosion and weeds
• Amend with compost just before re-spreading
• Rip in first lift to avoid sharp soil interfaces (which can limit air and water movement)
• Don’t work soil when saturated
Soil removal / replacement

Soil removal and ped retention

Use big loaders and excavators

Remove soil in big scoops to preserve clumps. Do not screen. Preserve peds!
Soil Installation
Working with soils with retained peds

Constantly loosen soil while installing to avoid buildup of deep compaction. Back drag over loader tracks each time.

Require all equipment to have teeth on bucket to scarify soil

Require low ground pressure equipment (4 psi preferred - 5 psi max)
Soil Installation

A/O horizon with added compost tilled into upper soil layer

Added soil to accommodate settlement

Specified soil depth

Surface preparation prior to planting

Anticipated settlement
Sand Lawn soils
Soil/sand/compost soil mix
Loam soil w/ peds and small amounts of compost

5% of soil depth
10% of soil depth
10-15% of soil depth
Over 15% compost in soil mix increases soil settling.

- Base hard features on subsoil, not amended soil.
- Allow for settling by slightly mounding amended soil, or spreading 1-2 topsoil to meet finish grades.
Amending soil (existing, stockpiled, or imported soil)
Amending soils on site

- Place sub-drainage if req’d
- Range of equipment for different-sized sites
- If compacted, rip (scarify) to 12-18” depth before or while amending
- 2-3” compost mixed into upper 8-12” of soil
Clearing up the confusion about “% Organic Matter”

**Soil Organic Matter** = long term accumulation of living soil organisms and dead organic material in the soil. In natural soils organic matter is completely integrated into smallest soil particles.

“% Soil Organic Matter Content” reported in a lab soil tests is by loss-on-ignition method. Just measures **Carbon % by dry weight**

**Compost and other organic amendments** = material in process from raw dead matter into a more stable form.

Most composts and plant materials are 40-70% organic content by the loss-on-ignition test method.

Organic amendments float in-between clumps of soil. As compost decomposes it feeds soil life, and some is turned by those organisms into long term soil organic matter.
Compost is added (amended) into the soil by moist volume. The resulting soil is tested by dry weight loss-on-ignition.

Adding 10% compost to a soil does not increase the Soil Organic Matter by 10%. It will raise the tested SOM by only 1-3% (depending on the organic content of the compost, and its dry density relative to heavier soil’s density).

% (volume) compost added to mineral soil or soil mix % (dry weight loss-on-ignition) rise in tested Soil Organic Matter

for trees 10-15% → 2-4%

for lawns 15-25% → 3-8%

% (volume) compost added to sand for bioretention soil mix (for stormwater swales)

30-40% → 10%

Use less compost in clay/fine-textured soils
Add Compost:
Most of it in the top layer of the soil profile – *mimic natural profile!*

Plants and decaying organic matter in soil must respire (bring in oxygen expire carbon)

Aerobic Soil
Good respiration

Saturated Soil
Slow respiration

Anaerobic Soil
No respiration

• Too much compost too deep in the soil profile promotes anaerobic conditions
• Plants will die more quickly with too much water than too little !!!!!
• Add most compost to upper 8-12” of soil
• Rip a little compost into deeper soil when subsoiling – just enough to restart soil biology
How to Select Compost

Know your supplier!

Field tests:
- earthy smell - not sour, stinky, or ammonia
- brown to black color
- uniform particle range
- stable temperature (does not get very hot if re-wetted)
- not powdery or soaking wet

Soil/compost lab test info:
- Nutrients
- Salinity
- pH
- % organic content (OM)

Mfr.-supplied info:
- State permitted composting facility
- Meets US Compost Council (STA) “Seal of Testing Assurance”

TMECC lab test methods, specs:
- C:N ratio
- Weed-seed trials
- Nutrients, salinity, contaminants
- Size: “screen”, % fines

Stability /Maturity:
- use Solvita test on-site (> 6)
  or
- rely on mfr’s TMECC tests: CO$_2$ evolution and seedling growth
Carbon to Nitrogen ratio of composts

- For turf & most landscapes
  C:N ratio of 20:1 to 25:1 - good nutrient availability for first year of growth (no other fertilizer needed)

- For native plants and trees
  C:N ratio of 30:1 to 35:1, and coarser (1” minus screen)
  - less Nitrogen better for woody natives, discourages weeds
  - for streamside, unlikely to leach nitrogen

Compost feedstocks for tree soil amendment

- Generally, yard waste &/or bark compost
  - Higher carbon, lower nitrogen
  - Maturity / stability very important

- Possibly biosolids, manure fully composted with wood
  - Watch the nutrients, C:N, stability/maturity – caution!
Compost Based Erosion Control BMPs

- EPA-approved BMPs: blankets, berms, and socks
  see www.buildingsoil.org

- “2 for 1” value – use compost for erosion control, then till in at end to restore soil:
  - No disposal costs
  - Faster planting, better growth

- Costs: blankets similar to rolled products, but savings on disposal, plus 2 for 1 benefits

More info at www.BuildingSoil.org
Adding sand to improve drainage???

Sand does not mix into *surface soil* well and is *not advised* unless the soil is a soil mix component and large equipment is used.

Use coarse sand (concrete sand) at quantities where the *medium to coarse sand* in the *final mix* will exceed 55%. Below that amount you can do more harm than good. Self compacting, and drainage not improved or made worse
Soil texture modification

In heavy clay soils:

Gypsum can improve structure which improves drainage

Adding expanded shale (or lava rock) at about 25-30% by volume may increase soil drainage.

Organic matter (compost) opens up micro-structure and improves macro-structure, which improves drainage, aeration, root access, water and nutrient cycling.
Soil biological additive products

Compost teas – useful in remediation, but just use good compost for soil preparation

Mycorrhizal inoculants – species specific, also in soil from healthy trees

Kelp & other organic additives – match plant nutrient needs – good for micronutrients

Fertilizers – stick with organic sources, match plant needs – compost often supplies most needs for establishment.

*Base fertilization on soil test results!*
Soil chemistry & pH modifications

- **Match plant selection to site soils**, rather than trying to modify chemistry
- Compost buffers pH, acid or alkaline towards optimal 6.3-6.8
- Compost increases cation exchange capacity (CEC) = nutrient storage & availability

- Lime as needed for Ca & Mg plant needs
- Sulfur applications only lower pH temporarily

**Plant problems?**
Get a soil test.
**pH**

**Best option, pick plants that are pH adaptable.**

pH can be raised easily with lime.

pH can be lowered with sulfur products but.....

Is only temporary and requires continuous re treatment

Long term treatments can create other soil toxicities.
Rationale for less fertilizer for urban trees and landscapes

Not crops – Fruit production or crop yields not required

Sufficient required nutrients available to support plant goals

No yearly harvest/removal of biomass

Slower growth may be a desirable trait

Too much N increases sucking insects and foliar diseases, and annual weeds

Feed the soil, not the plant by mulching and leaving fallen leaves.

Plant problems? Get a soil test.
Soil Toxicity

Explore possible contaminants early in site design
• Involve a local soil expert, and dependable lab
• Know the site’s history
  • Lead, arsenic, chemical, oil tanks, etc.

When to get rid of, cap, or remediate the soil
• Toxic plant nutrients, salts
• Other chemicals toxic to plants
• Chemicals toxic to soil organisms or people

Remediating soil
• Compost amendment reduces heavy metal mobility, toxicity, and breaks down hydrocarbons & most pesticide residues
• Specific microbial remediation for complex chemicals
SECTION 02910
PLANTING SOIL PREPARATION

PART 1 – GENERAL

1.1 SUMMARY
A. The work in this section includes, but is not limited to, the following:
   1. Mixing and testing of top soil, sand and organic material to create planting mixes.
   2. Installation of planting mix.
   3. Compacting and grading of planting mix.

1.2 RELATED DOCUMENTS AND REFERENCES
A. Related Sections:
   1. Section 02300 EARTHWORK
   2. Section 02625 – PLANTER DRAINAGE
   3. Section 02810 – IRRIGATION SYSTEM
   4. Section 02930 – EXTERIOR PLANTS
   5. Section 02935 – LAWN

B. References:
   1. The following references and standards are use herein and shall mean:
      b. USDA: United States Department of Agriculture.
      c. U.S. Department of Agriculture, Natural Resources Conservation Service
Create A Soil Management Plan (SMP)

- A scale-drawing identifying areas where each treatment (soil protection or restoration) option will be applied.
- A completed SMP form identifying treatment options, amendment products and calculated application rates for each area.
- Identify a Reference Soil as a guide for planned soil restoration.
Developing a Soil Management Plan

step 1: Identify & map
- Healthy soil areas as “vegetation and soil protection zones”
- Disturbed areas needing different soil restoration treatments
Soil Management Plan

step 2: Compute compost amendment or amended topsoil and mulch needed for each area

This form is in the Building Soil Manual at www.BuildingSoil.org (see pages 8-13)
step 3:
Communicate SMP vegetation and soil protection zones and restoration plans to all contractors and crews.

Soil and tree preservation are similar, but trees sometimes need extra effort.
Soil Management Plans – real world challenges, schedules, and conflicts

On site storage limitations:
• Space / Time and need or other contractor operations.
• Cost vs environmental benefit

Wet periods and overly moist soil:
• Options for overly tight schedule must be in specification
• Require covered storage (breathable fabric not plastic film)

Contractor / owner resistance to new ideas:
• Education
• Pre bid and preconstruction meetings
• Need to do it a few times with better contractors to convince the hold-out contractors

See http://www.buildingsoil.org/tools/When_to_Amend.pdf
Soil Maintenance

Using mulches after planting and for annual maintenance

BENEFITS:

Mulches limit weed growth, and make weeds that sprout easier to pull or cultivate.

Mulches conserve water, moderate soil temperature, and reduce erosion.

Mulches replenish soil organic matter, enhancing soil biodiversity, structure, and nutrient cycling = increased plant vigor.
Mulching

**WHEN**  After planting, and once every year or two:
- Spring or fall on trees and shrubs to prevent weeds.
- Early summer on gardens. (Let soil warm up.)
- Fall on beds to prevent erosion and compaction.

**WHERE**  Whole beds, paths, 3 ft. or larger ring around trees & shrubs in lawns.

**HOW**  Remove weeds & grass before spreading mulch. Keep mulch away from plant stems. Use cardboard weed barrier (not fabric) to control aggressive weeds.
Mulching

WHAT

Woody mulches (arborist wood chips, bark) for woody plants (trees & shrubs).

Non woody mulches (compost, leaves, grass clippings, composted manure or biosolids) for non-woody plants (annuals, perennials, berries, roses).

HOW MUCH

Compost, leaves, sawdust, fine bark, grass clippings: 1-2” deep.

Wood chips or coarse bark: 2-4” deep.
Other Soil Maintenance Practices

• Leave plant litter, recycle fall leaves and chipped prunings into mulch on site.

• Base all fertilizer applications on soil tests (every 1-3 years on most sites). Learn about soil testing at [www.puyallup.wsu.edu/soilmgmt/Soils.html](http://www.puyallup.wsu.edu/soilmgmt/Soils.html)

See videos and factsheets on “Collecting a soil sample”, “Determining soil texture by hand”, and “Understanding soil test results”.

• More urban soil remediation & maintenance strategies in *Up by Roots* by James Urban.
Soil and the Design Process – SITES Guidelines

best practices for every project

SITES™ is a new national rating system for site and landscape development, similar to the LEED ™ green building system.

Like LEED, SITES has “Prerequisites” (required practices) and “Credits” (recommended practices).
<table>
<thead>
<tr>
<th>Project Phase</th>
<th>SITES guidelines</th>
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<tbody>
<tr>
<td>Site Selection</td>
<td>➢ Preserve farmland soils, select already impacted sites</td>
</tr>
<tr>
<td>Pre-Design Planning</td>
<td>➢ Survey soils, protect soil &amp; veg. (esp. trees) where possible</td>
</tr>
<tr>
<td>Design – Soil &amp; Veg.</td>
<td>➢ Develop Soil Management Plan to protect or restore soils</td>
</tr>
<tr>
<td>Design – Water</td>
<td>➢ Use soil BMPs to conserve water &amp; manage stormwater</td>
</tr>
<tr>
<td>Construction</td>
<td>➢ Implement Soil Mgmt. Plan with all contractors on site</td>
</tr>
<tr>
<td>Operations &amp; Mtce.</td>
<td>➢ Recycle organics, monitor soil health, plan for sustainable mtce.</td>
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Protect and Conserve Soil – key ecoPRO BMPs

**DESIGN**
1. Identify and map soil characteristics of landscape site
   - Designate soil protection, disturbance, and other construction management areas on a Soil Management Plan
2. Review site grading specifications for accuracy

**CONSTRUCTION**
1. Use the least invasive construction methods and site sensitive methods
2. Protect tree root zones
3. Reduce import and export of earth materials
4. Amend soil with compost to improve water & nutrient capacity

**MAINTENANCE**
1. Build healthy soils, with compost, mulch, mulch-mowing etc.
2. Address problem drainage areas with appropriate drainage solutions
3. Create a sustainable plant nutrient management program
Resources to learn more:

WSU Soil Management – testing & more
www.puyallup.wsu.edu/soilmgmt/Soils.html

www.sustainablesites.org

**Up By Roots:** Healthy Soils and Trees in the Built Environment
By James Urban, available at Amazon

Building Soil Manual
Natural Landscaping: Design, Build, Maintain
and other resources at www.buildingsoil.org
Soil Goals and Requirements – *Right plant, right place, right soil!*
Discussion Question:

Name 2-3 techniques or actions that reduce or eliminate soil compaction on construction sites.