Root Structures, Functions, and Growth

Master Gardener Training
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http://cesacramento.ucanr.edu
Acknowledgments/Selected Information Sources

Larry Costello, UCCE SF & San Mateo (formerly)

Robert Kourik (and Roots Demystified)
Root Functions

- Absorption and transport of water and nutrients
- Storage of starch and nutrients
- Synthesis of hormones
- Anchorage
Anatomy of Young Roots

- Emerging lateral root
- Root hairs
- Cell elongation
- Cell division
- Root cap
- Root cap

Diagram showing various root structures including root hairs, cell elongation, cell division, and root cap.
• Covers apical meristem
• Grouping of cells held within slimy “mucigel”
• Protects & lubricates root tip as it grows
• Cells slough off
Root Hairs

- Cells, not roots!
- Greatly increase root surface area
- Very short lived
The Rhizosphere

• Region of soil that is directly influenced by root secretions (exudates) and soil microbes
• Exudates include amino acids, sugars, & acids
• Functions of exudates:
  ➢ Protect against pathogens
  ➢ Obtain nutrients
  ➢ Stabilize soil aggregates
SOIL BIOTA POPULATIONS AS A FUNCTION OF SOIL DEPTH

- Bacteria: 9750, 2175, 570, 11, 1
- Actinomycetes: 2080, 245, 49, 5
- Fungi: 119, 50, 14, 6, 3
- Algae: 25, 5, 0.5, 0.1

1-3 inches: 9750
8-10 inches: 2175
14-16 inches: 570
26-30 inches: 119
53-57 inches: 25

Source: Roots Demystified
Mycorrhizae
(“Fungus-Roots”)  

• Fungal infection of roots – symbiotic relationship  
• Fungi – receive sugars; plants – nutrients & water  
  ➢ Mainly P, but also NH$_4^+$, NO$_3^-$, and K$^+$  
• Poor growth without myc. where nutrients limited  
• Lacking only in sedges & brassicas (cabbage fam.)  
• Soil inoculation helpful only in poor/disturbed soils  
• Two main types: Ecto- and endo-mycorrhizae
Mycorrhizal Fungi
Ecto-Mycorrhizae

• Grow on trees in pine, oak, beech, birch, and willow families
• Grow outside and between cells of young roots
Mycorrhizal Fungi
Endo-Mycorrhizae

- Most important is vesicular-arbuscular myc. (VAM)
- 80% of plant species
- Most crops (monocots & dicots), hardwoods, non-pine conifers

- Infection directly into root cells
Mycorrhizae

Poor growth of forest trees without mycorrhizae where nutrients limited

But not necessary to add to garden soils!
Depth of Rooting
(Majority of Roots)

Turf – 8 to 12 in.

Shrubs - Small – 1 ft.
- Large – 2 ft.

Trees - Small – 2 ft.
- Large – 3 ft.
Turf Root Depths

Most water & nutrients taken from 8-12”
Field Bindweed (morning glory)
Roots capable of budding at great depths
Fibrous Roots vs. Taproot

Barley

Fava bean

Clover
Suckering from Raspberry Roots

Bamboo root barrier, FOHC 2013
Tree Root Growth

Mimics Top Growth
Tree Root Growth

Mimics Top Growth

NO!!
Typical Tree Root Growth

Apple

Sandy soil
Loam soil

Source: Understanding Roots
Typical Tree Root Growth
Apricot

Source: Understanding Roots
Actual Root Growth of Mature Trees
Cherry (27 yrs.) and Hazelnut (20 yrs.)

Heavier (clay) soil
Lighter (sandy) soil

Source: Understanding Roots

1 m
Root System and Drip Irrigation
Stone Pine

Source: Understanding Roots
Types of Roots in Trees

1. Tap
2. Oblique (Heart)
3. Lateral
4. Sinker
5. Fine
Types of Roots in Trees

- Tap root
- Sinker root
- Oblique root
- Tap root
- Lateral root
- Fine roots

Types of Roots in Trees:

- Tap root
- Sinker root
- Oblique root
- Tap root
- Lateral root
- Fine roots
Coast live oak (Q. agrifolia)

1. Tap Root

- First root to emerge from the seed
- Rapid growth when young
- Other roots originate from it
- Many are <3 ft deep
Generally, tap roots do not persist. One study: Tap roots found in only 2% of 697 trees inspected.
2. Oblique (Heart) Roots

- Develop from the tap root or shallow lateral roots
- Grow downward & outward
- Few fine roots
- Important role in anchorage
3. Lateral Roots

- Develop from tap root, form network of long, untapered roots similar to ropes
- Branching, many fine roots at ends
- Water absorption and anchorage
- With trunk tissues, form “trunk flare” or root buttress
- Majority of root system of most species

Ash
Lateral Roots

Sinker roots

4. Sinker Roots

- Arise along lateral roots, typically within the drip line, near the trunk
- Grow vertically, vary in length
- Active in water and mineral absorption
- Provide anchorage
5. Fine Roots

- Small diameter (up to 2 mm)
- Often near soil surface
- Branch many times to form masses of thousands of roots
- Relatively short lived; some develop into lateral roots
- Most water and mineral absorption; large surface area with root hairs
Roots Find the Best Soil

Bed by redwood tree

Compost holding area
Lateral Root Development from Fine Roots
Lateral roots develop from cut roots as well; variability among species
Adventitious Roots

Arise from trunks and branches

Grape trunk hit by lawn sprinkler

Air layering – Rubber tree
Most roots are in surface 3 ft of soil. Uncommon for trees to root to depths greater than 6 ft.
Deeper Rooting in Dry Areas

Roots have been found up to 75 ft. deep

Engelmann oak (Q. engelmannii)
San Diego Co.

Blue oak (Q. douglasii)
Sacramento Co.
Avoiding Roots and Pipes

Pneumatic excavation would have prevented damage
Root System of Mature Gingko Tree
Considered Deep Rooted

Roots 12” below soil surface

4 ft.

Soil line
From root excavations:

<table>
<thead>
<tr>
<th>Species</th>
<th>Root Spread Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnolia</td>
<td>3.7</td>
</tr>
<tr>
<td>Red Maple</td>
<td>3.0</td>
</tr>
<tr>
<td>Locust</td>
<td>2.9</td>
</tr>
<tr>
<td>Poplar</td>
<td>3.0</td>
</tr>
<tr>
<td>Ash</td>
<td>1.7</td>
</tr>
</tbody>
</table>

From E. Gilman
Tree Protection Zone to Drip Line
Is That Wide Enough?
Infrastructure Damage by Tree Roots
Tree-Based Strategies
Matching Species with Planting Space

the good...
...the bad...
.....the really bad

Fremont poplar
Surface Roots in Lawns

Liquidambar

Sycamore (London plane)
“Plant (large trees) at least 8 feet from sidewalks and driveways, 15 feet (now 17 feet) from home foundations and swimming pools, and 6 feet from fences.”
Root Damage
To Foundation Too?

Chinese hackberry

Root cut

Drip line
Factors affecting impact: Size & number of roots, species, age, condition, proximity to trunk
Structural Failure from Pruning Roots
Reducing Infrastructure Damage
Provide Adequate Space for Trees

Magnolia in a 28” wide planting strip

Callery pear in 5’ x 5’ cutout
and even better

9 x 12 ft.

better

20 ft.
Curving sidewalks

Pop-Outs

Tree Islands
Reducing Infrastructure Damage
Grind Down the Concrete

- Liability issues with raised sections
- Grinding temporary – will continue to lift
Reducing Infrastructure Damage
Root Barriers
Reducing Infrastructure Damage
Root Barrier Problems

Roots also grow under barrier, then up
Barrier Too Low!

Linear barrier installed after root pruning

Roots under concrete
Root-Control Devices

• Tend to be most effective in soils where they are least needed:
  ➢ In well-drained, non-compacted soils

• Tend to be least effective where most needed:
  ➢ Where poor soil aeration or compaction encourages shallow rooting
Girdled Roots
Kinked and Twisted Roots
Straighten roots (preferable) or cut them
Pots to Direct Roots Downward
Pots to Direct Roots Downward
Still can get rootbound

Kiwi vine

Soak to bare-root
Kiwi vine

Pots to Direct Roots Downward
Bare-root (winter), spread roots
Causes and Effects of Unhealthy Roots
Tree Watering Basin

Dead roots
Root-Knot Nematodes

- Problem in sandy soils
- Plants stunted

Lettuce

Tomato
Root Diseases

Damping Off of Seedlings

Fusarium Wilt of Tomato

Root Rot of Gerbera
Crown Gall
-FOHC

- Bacteria enter at wounds
- Can come from nursery
- Stunts/kills tree
Oak Root Fungus
Armellaria mellea

Rhizomorphs ("Shoestring fungus")

ORF Mushrooms
Phytophthora Crown & Root Rot

Peach

Avocado
Phytophthora Crown Rot

Drip emitters (pink flags) were never moved away from trunk.
Questions?