Understanding Roots

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

Larry Costello, UCCE – SF & San Mateo (formerly)
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
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

![Diagram of root hairs with labeled parts: Seed, Primary root, Root hairs, Root apex, Nucleus, Root hair]
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
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
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”

Source: Roots Demystified
Vegetable Root Systems

- 1-ft. increments
- Plants grown individually in good soil

Source: Roots Demystified
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!!
More Typical Tree Root Growth
Actual Root Growth of Mature Trees
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
- Lateral root
- Fine roots
- Tap root
- Oblique root
- Main lateral root
- Tap roots
- Oblique root
Coast live oak (*Q. agrifolia*)

**Year 1**
- First root to emerge from the seed
- Rapid growth when young
- Other roots originate from it
- Many are <3 ft deep

**Year 2**
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
Lateral roots are dominant on some species but native oaks often have more oblique 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 Ginkgo Tree
Considered Deep Rooted

- Roots 12” below soil surface
- Soil line
- 4 ft.

[Image of Ginkgo tree roots]
From root excavations:

<table>
<thead>
<tr>
<th>Species</th>
<th>Roots extend this many times the branch crown diameter</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

Sycamore (London plane)

Liquidambar
the trend
“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
Tree-Based Strategies
Root Pruning

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.

and even 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
Linear barrier installed after root pruning

Barrier Too Low!

Roots under concrete

Barrier
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
Reducing Infrastructure Damage
Structural Soil for Strength and Root Growth
Girdled Roots
Kinked and Twisted Roots
Straighten roots (preferable) or cut them
Pots to Direct Roots Downward
Causes and Effects of Unhealthy Roots
Tree Watering Basin

Dead roots
Root-Knot Nematodes

- Problem in sandy soils
- Plants stunted
Root Diseases

Damping Off of Seedlings

Fusarium Wilt of Tomato

Root Rot of Gerbera
Rhizoctonia Root Rot
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?