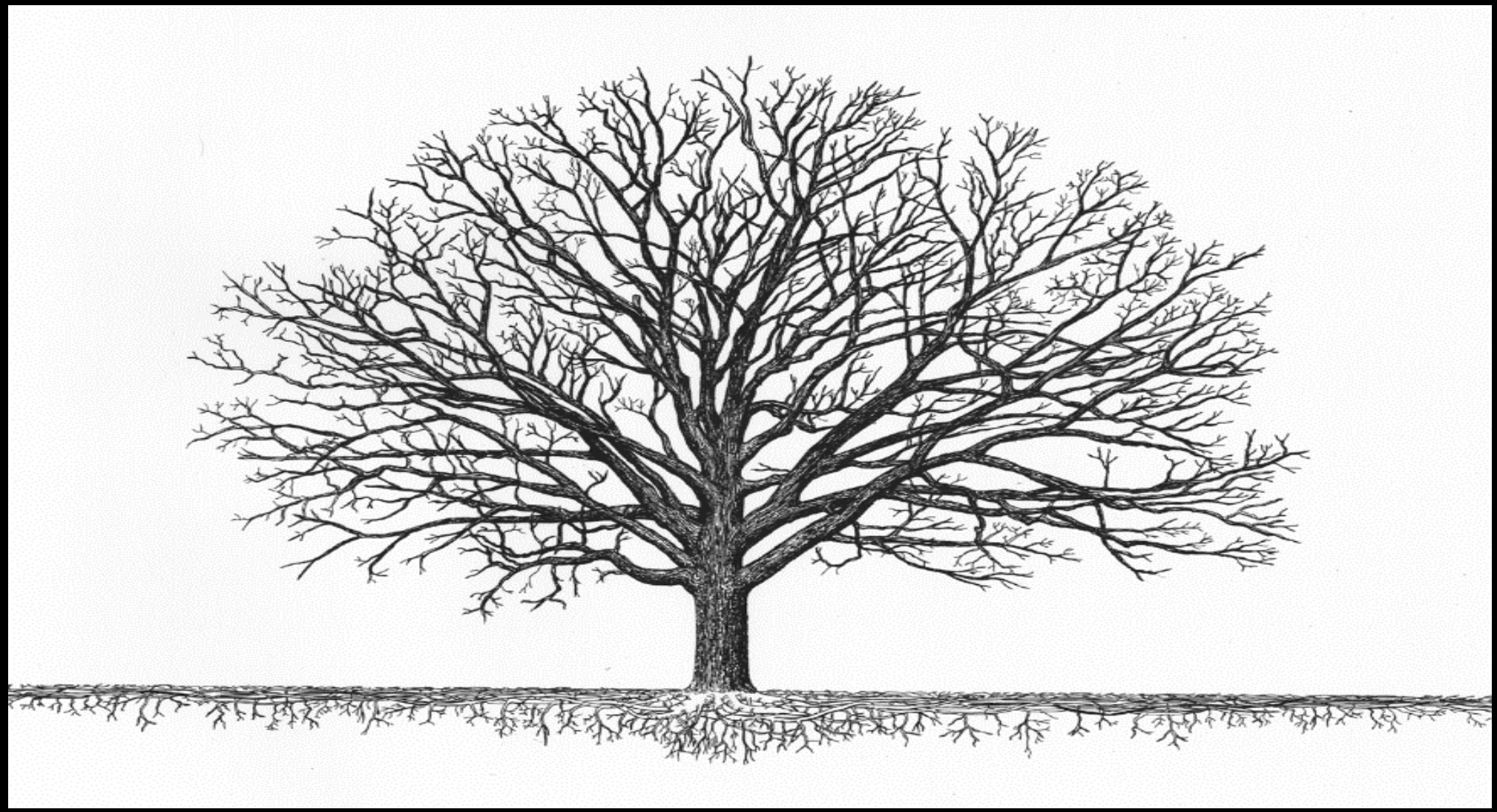
The Underground World of Tree Roots

Tom Smiley, Ph.D.
Bartlett Tree Research Laboratories

Open Grown Tree Root System



After Dr. Gary Watson Morton Arboretum

Challenges of Tree Root Growth in the Urban Environment

Root Loss can Result in Tree Loss

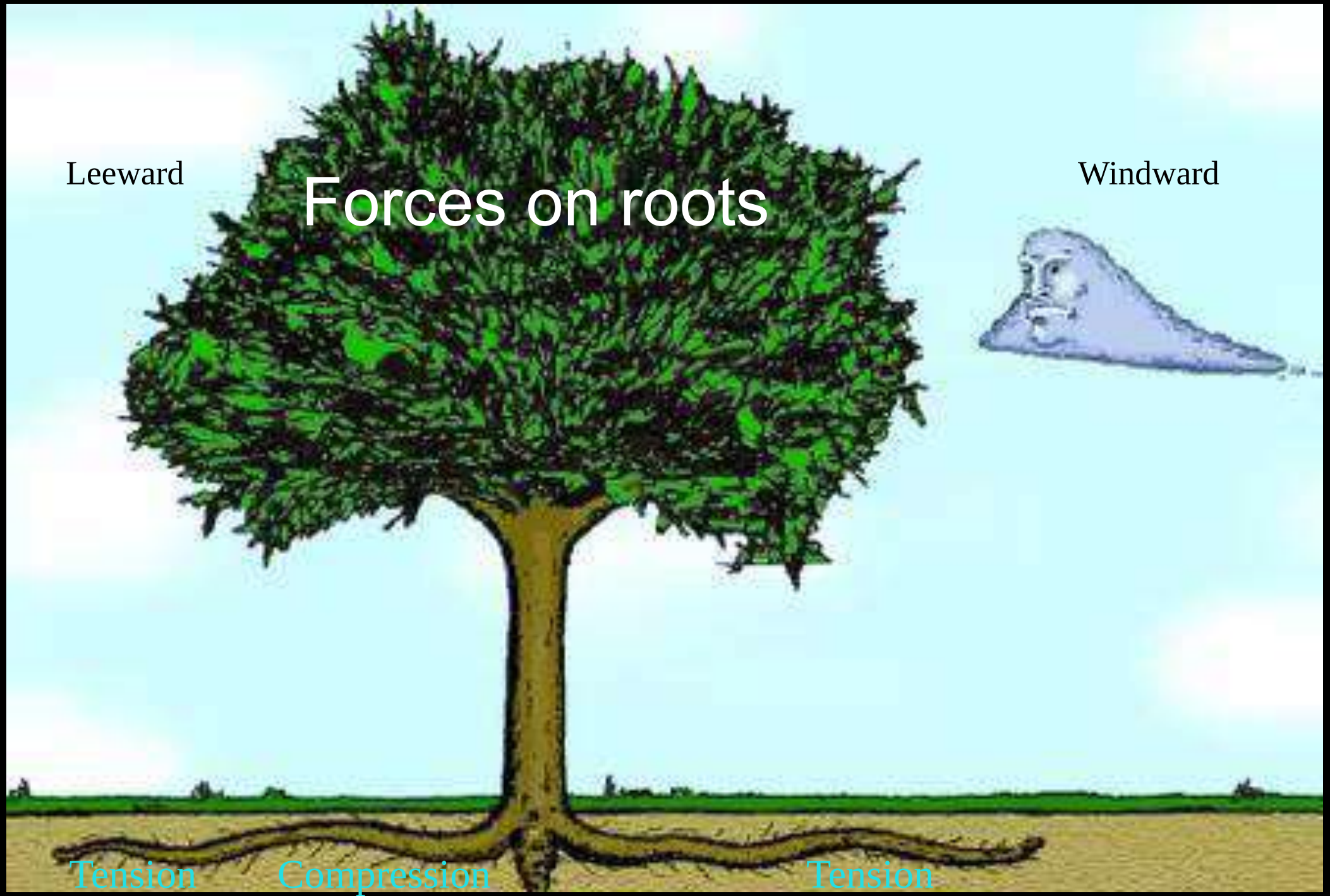
Functions of Tree Roots

Anchorage and Support

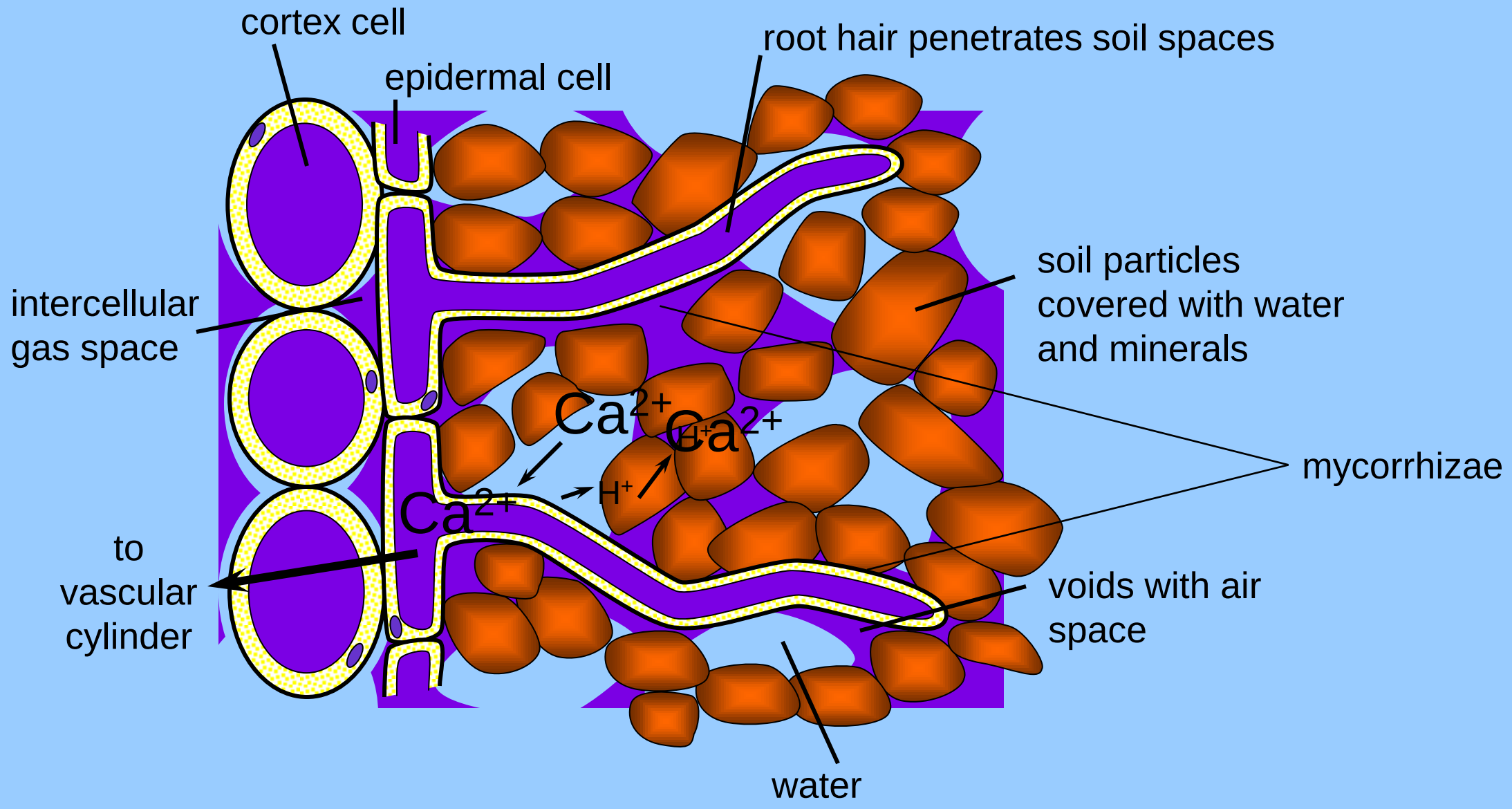
Water and Nutrient Uptake

Storage and Sharing of Food

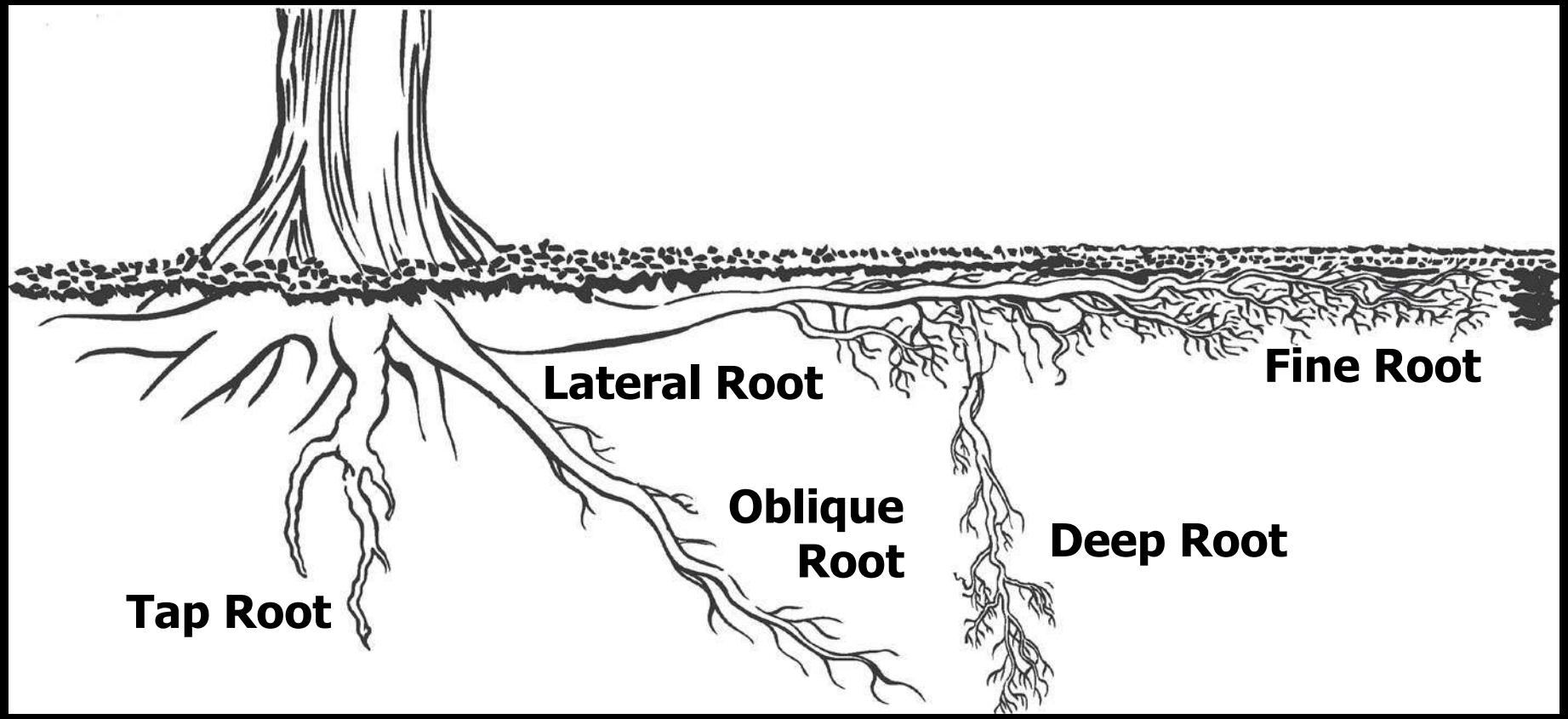
How do roots work?

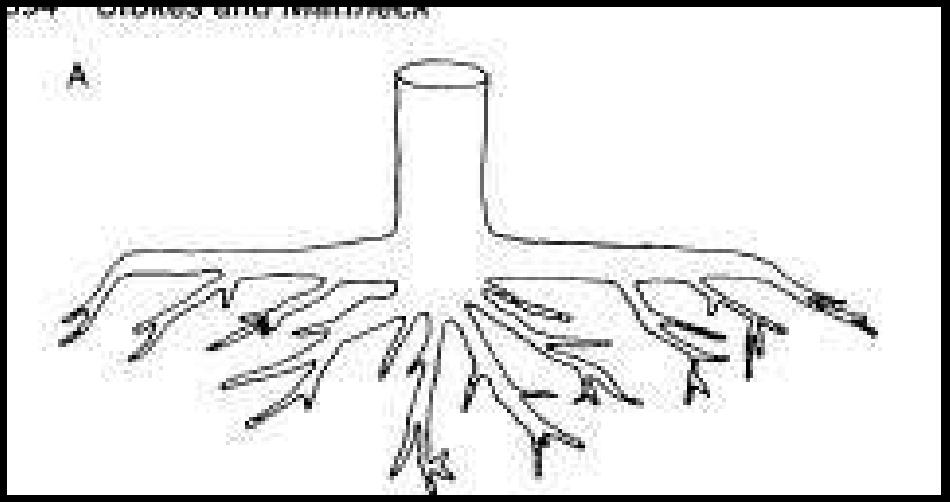


Water and Nutrient Uptake



5 basic types of tree roots





Root System Classifications

Root System Configurations after Kostler et al. 1968.

A. Deep root or Heart root system

B. Horizontal, lateral or plate root system

C. Tap root system

Tip of a Fine Root

Zone of Cell Elongation - cell expansion

Zone of Cell Division - new cells by mitosis

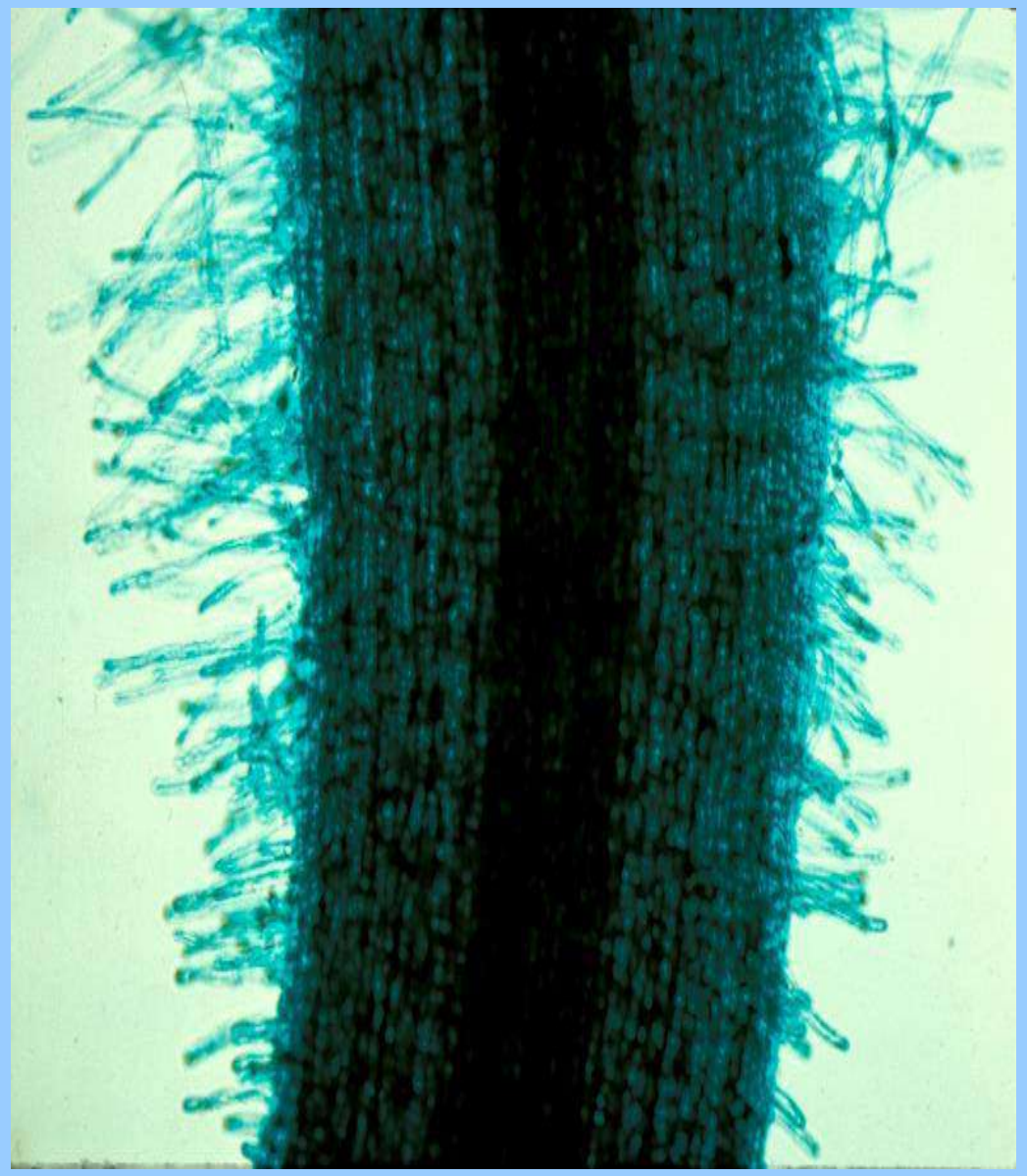
Root Cap – penetration and protecting the meristem

Root Hairs

Increase Surface Area

Secrete Acid (H^+) and carbohydrates

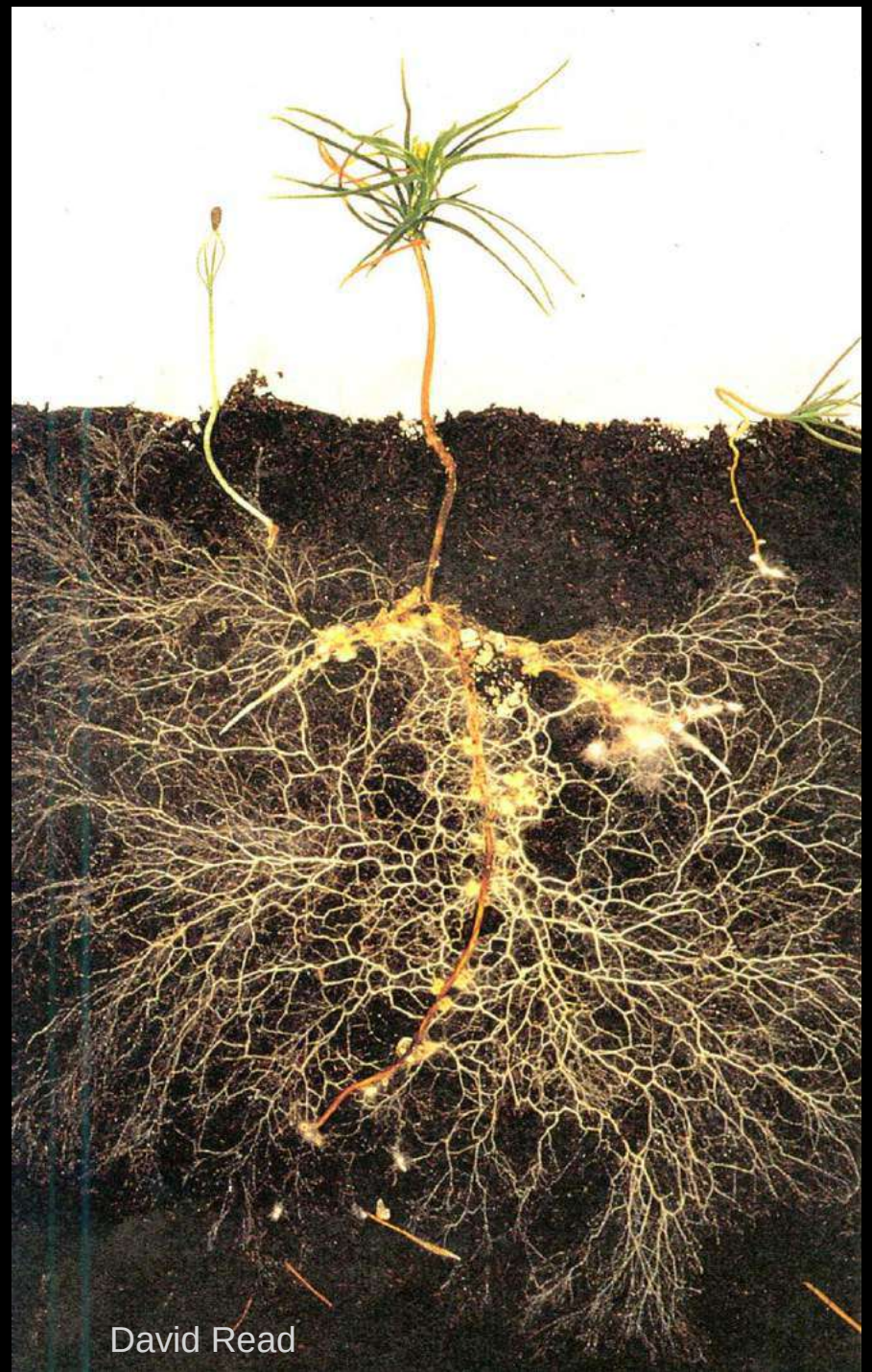
Water and Mineral Uptake



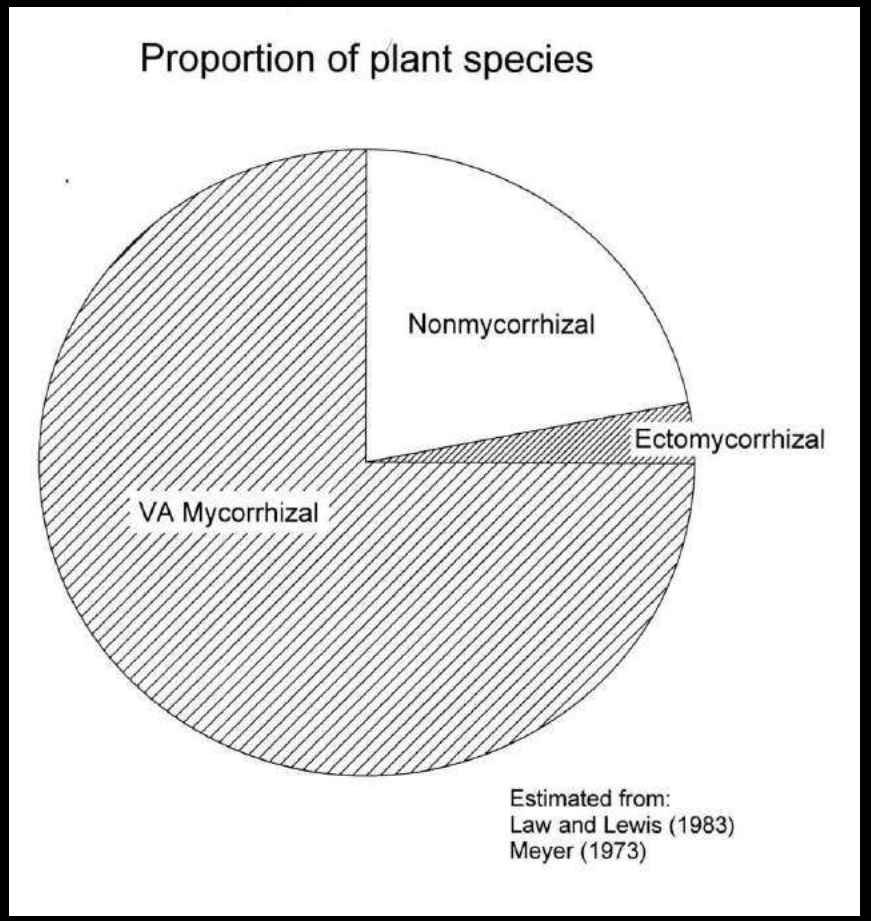
Long root hairs increase the surface area for water and mineral uptake

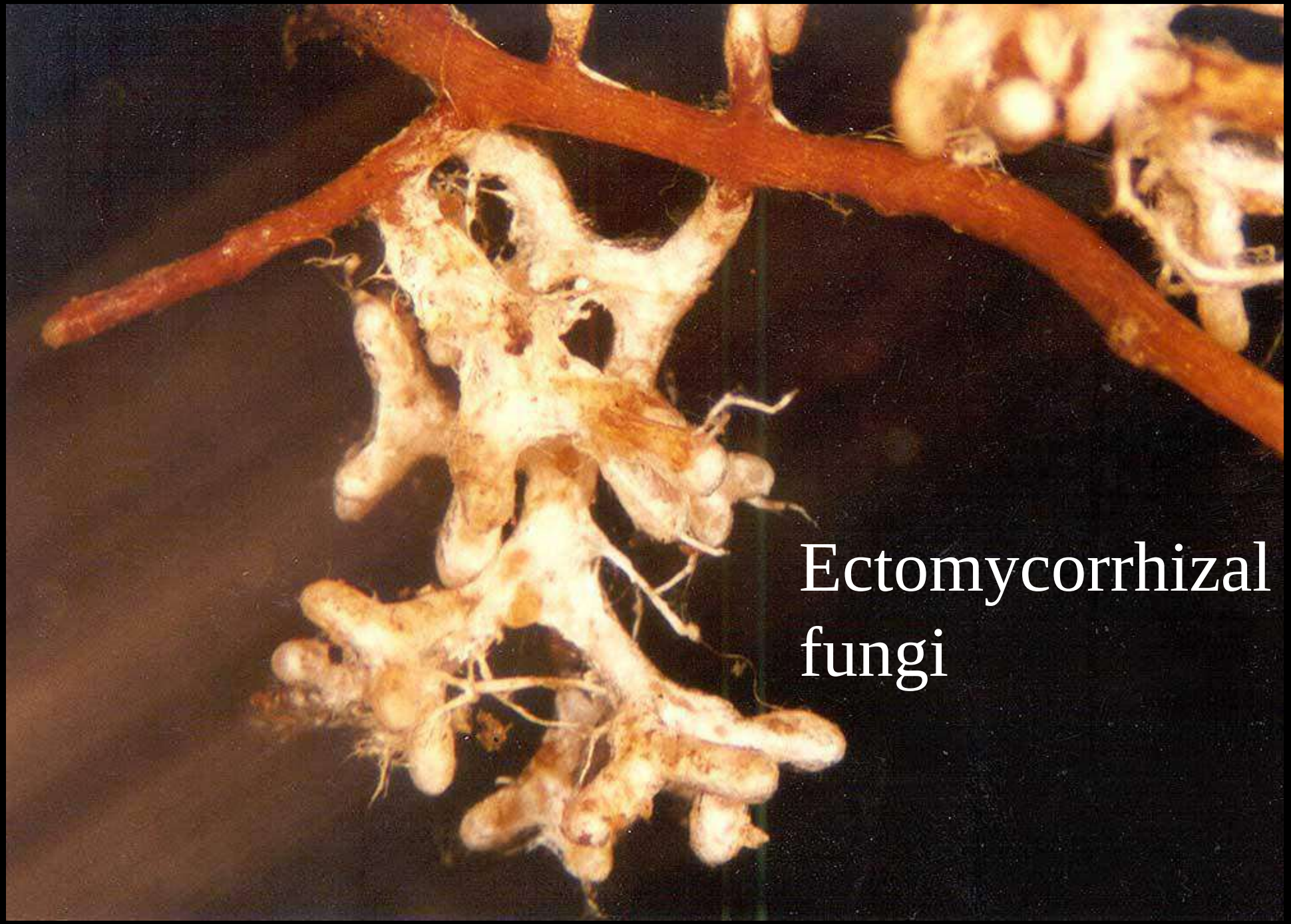
Plants can loose 10% of their carbohydrates through their roots

What will used this carbon?



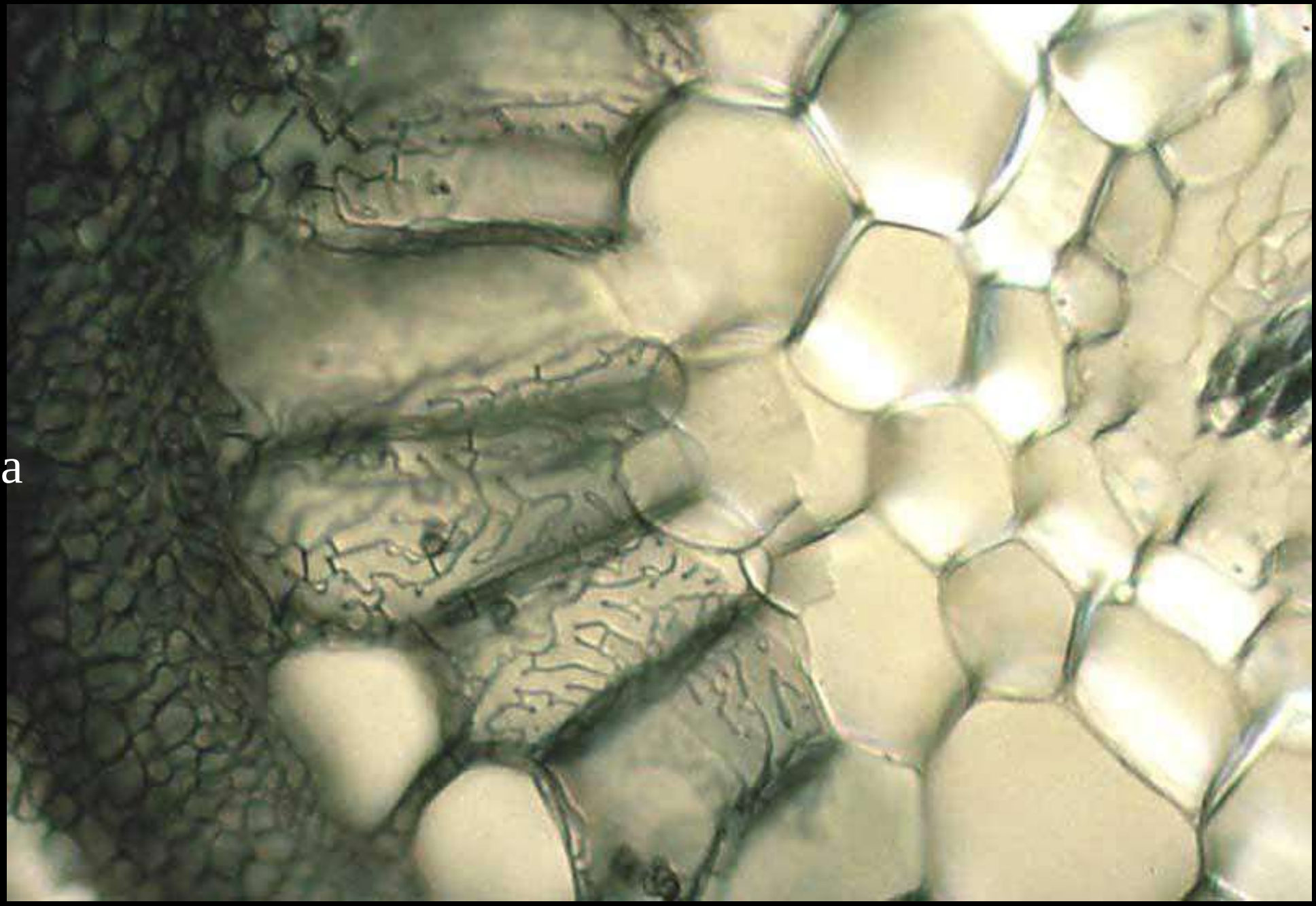
Mycorrhizae -
The mutually beneficial relationship between a fungus and plant roots.





Ectomycorrhizal fungi

There is no root cell penetration by the fungus. Thus it is called ECTOmycorrhiza



Mark Brundrett

Mark Brundrett

Wood Wide Web

Mycorrhizae can allow the exchange of:

Carbohydrates (sugar),

Hormones and

Defense Compounds

Between different tree species

Suzanne Simard Univ of British Columbia

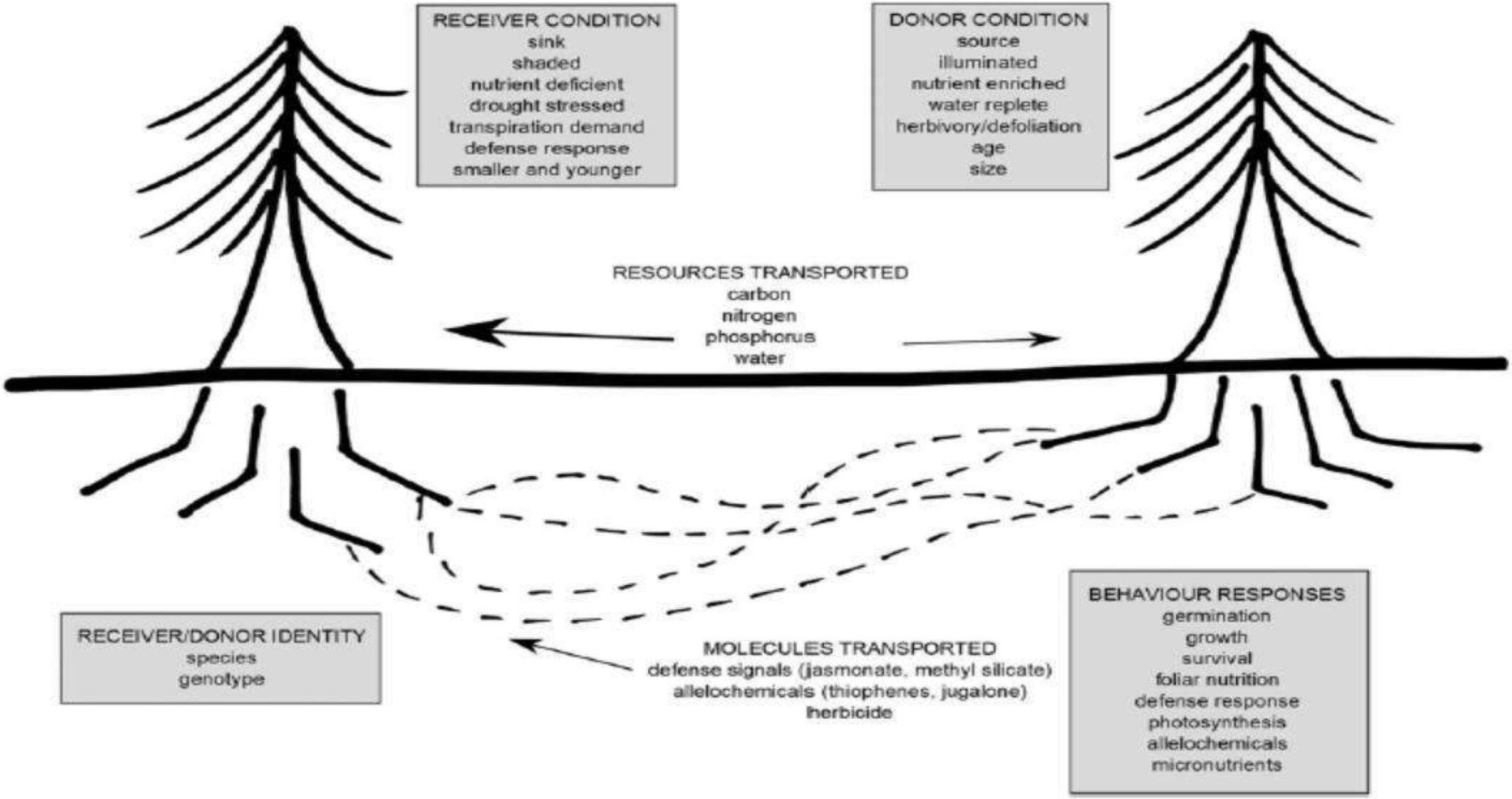


Figure 1. Schematic of resources and signals documented to travel through an MN, as well as some of the stimuli that elicit transfer of these molecules in donor and receiver plants.

More complex landscape should do better than simple plantings

How Can We Improve Root Growth in the Urban Environment?

Providing more soil volume for root development

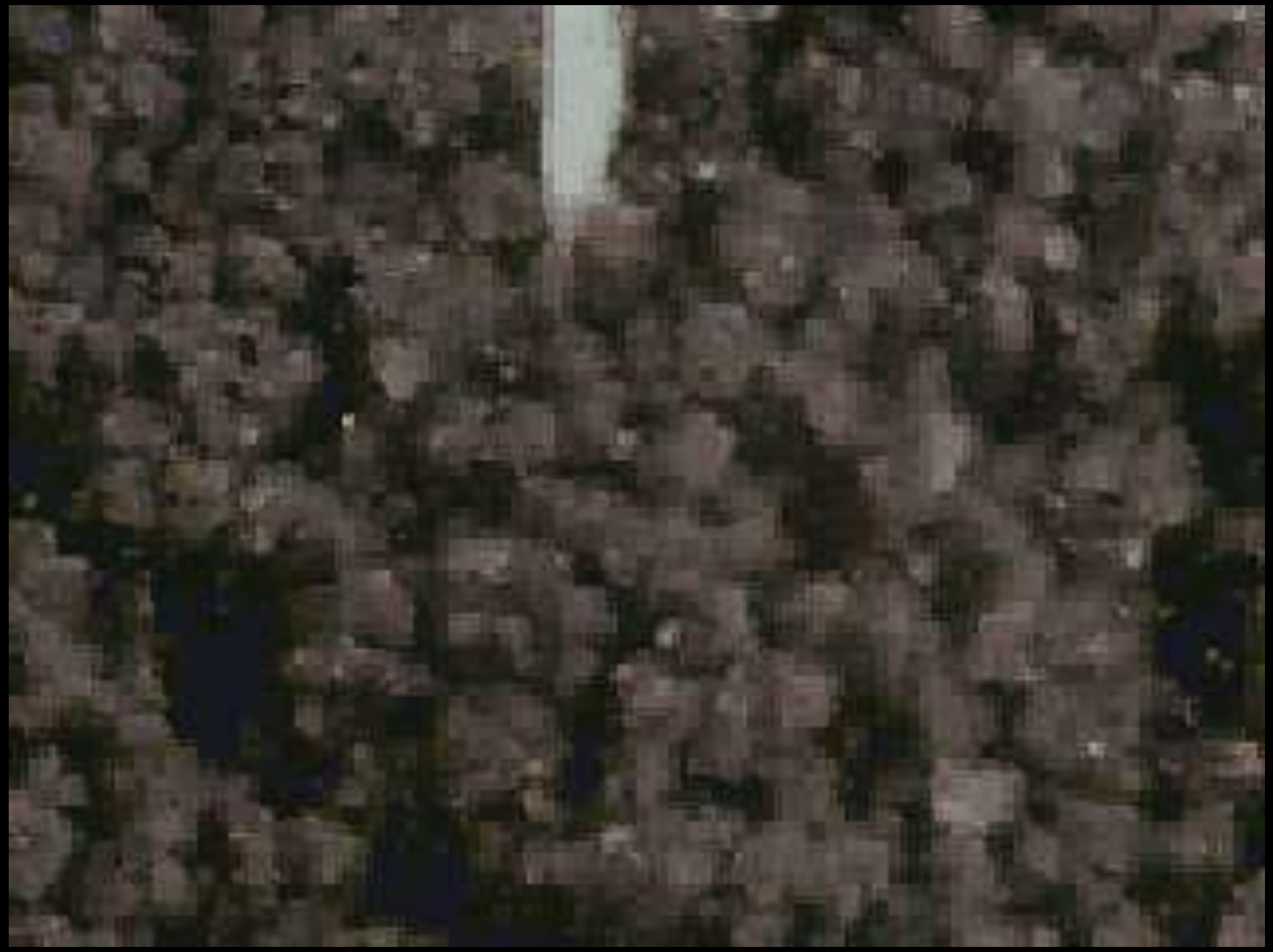
Reducing Soil Density

Supplementing essential mineral nutrients

Manage Soil Moisture

Increasing Soil Organic Matter levels

High density soils will reduce root growth



How can we reduce soil density?

Mulch

Tilling

Mulch

A material applied to the soil surface.

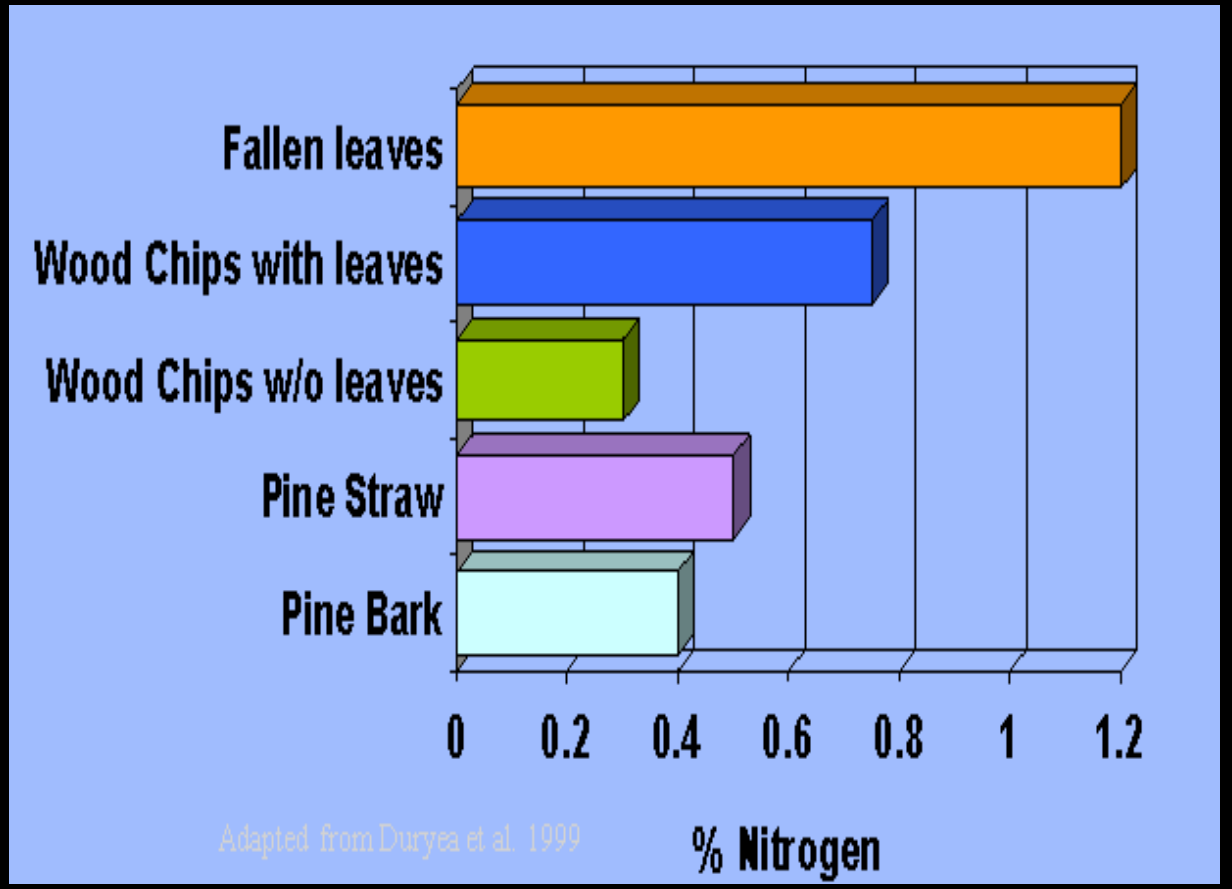
Examples:

Leaves, twigs other forest debris

Arborist wood chips

Bark chips

Gravel



Benefits of Organic Mulch

Reduces compaction
Reduces soil moisture loss
Minimizes weed competition
Moderates soil temperatures
Improves plant vigor
Improves soil aeration and soil structure
Minimizes frost heaving of small transplants
May increase fertility
Can reduce some diseases
Reduce mowing area

Benefits Mulch

Promotes tree root growth three to five times the density compared to turf.

Over a period of

Photo courtesy Gary Watson, Morton Arboretum, Chicago

Excess Mulch

Too much mulch can:

- Reduce water movement into the soil
- Promote root disease
- Create root collar problems/disease
- Hide other root collar problems
- Kill trees!

Tilling

- Rototilling
- Excavator/backhoe lift and drop
- Plowing
- Air tilling

Root Invigoration

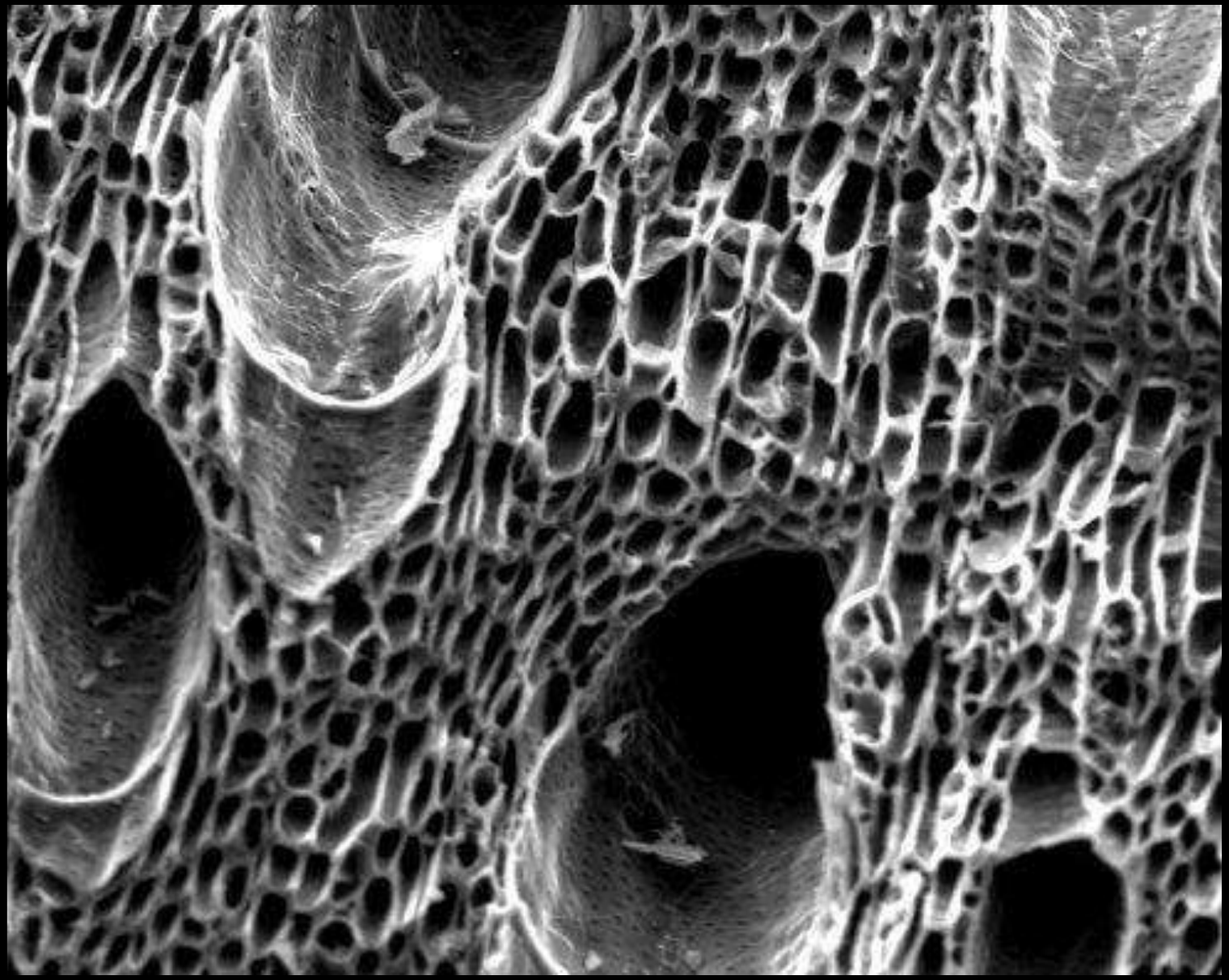
- Done to reduce soil compaction
- Increase root growth
- Increase soil organic matter
  - Biochar for long term organic matter

Biochar as a Soil Amendment with Root Invigoration

Unlike compost, Biochar provides a ‘permanent’ form of organic matter.

by Fite, Ph.D. Bartlett Tree Research Laboratories

High surface area and porosity are keys to Biochar effects



Biochar works best as specific rates and mixed with fertilizer


Trees are Most Valuable to
People when they grow large
where we live and work

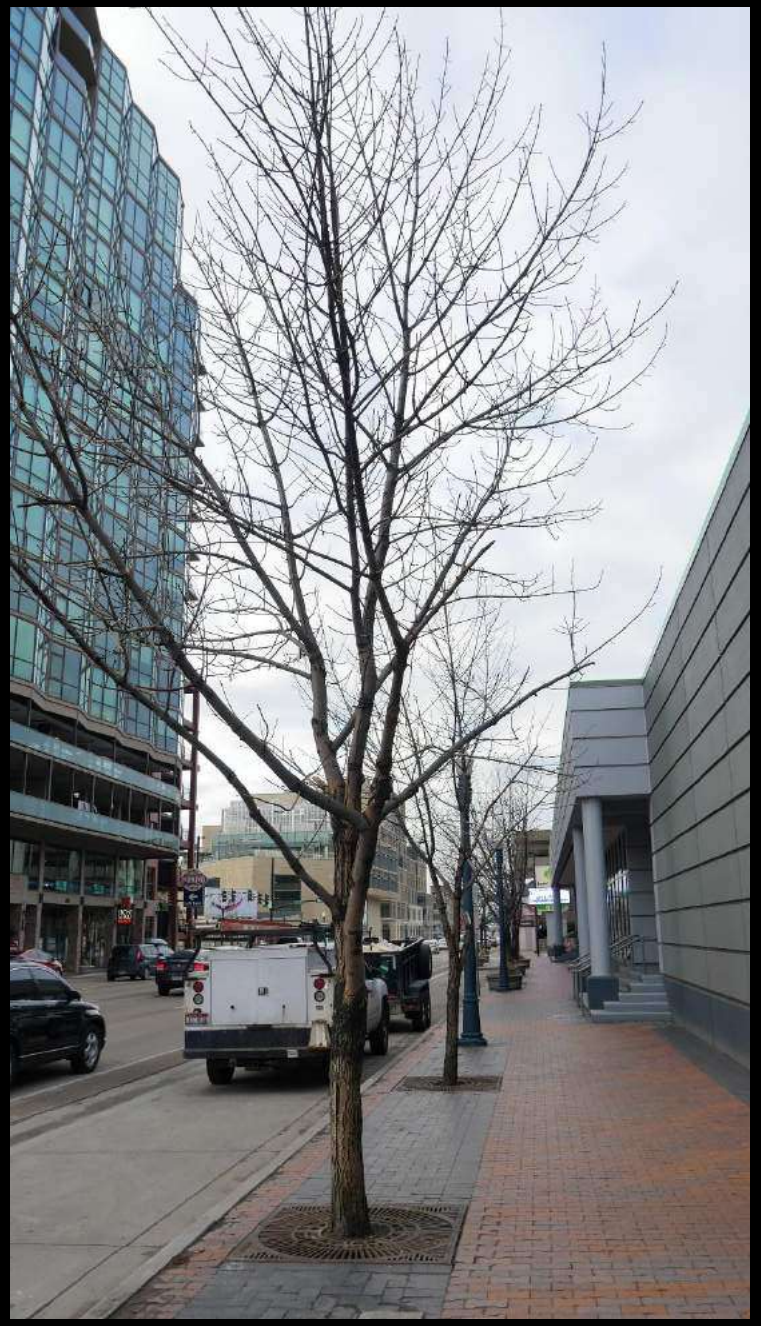
How can we find more space for roots in a downtown environment?

Leave more open space

Promote root growth under pavement by

1) Creating a soil mix that allows root growth while it is compacted

2) Supporting pavement from below



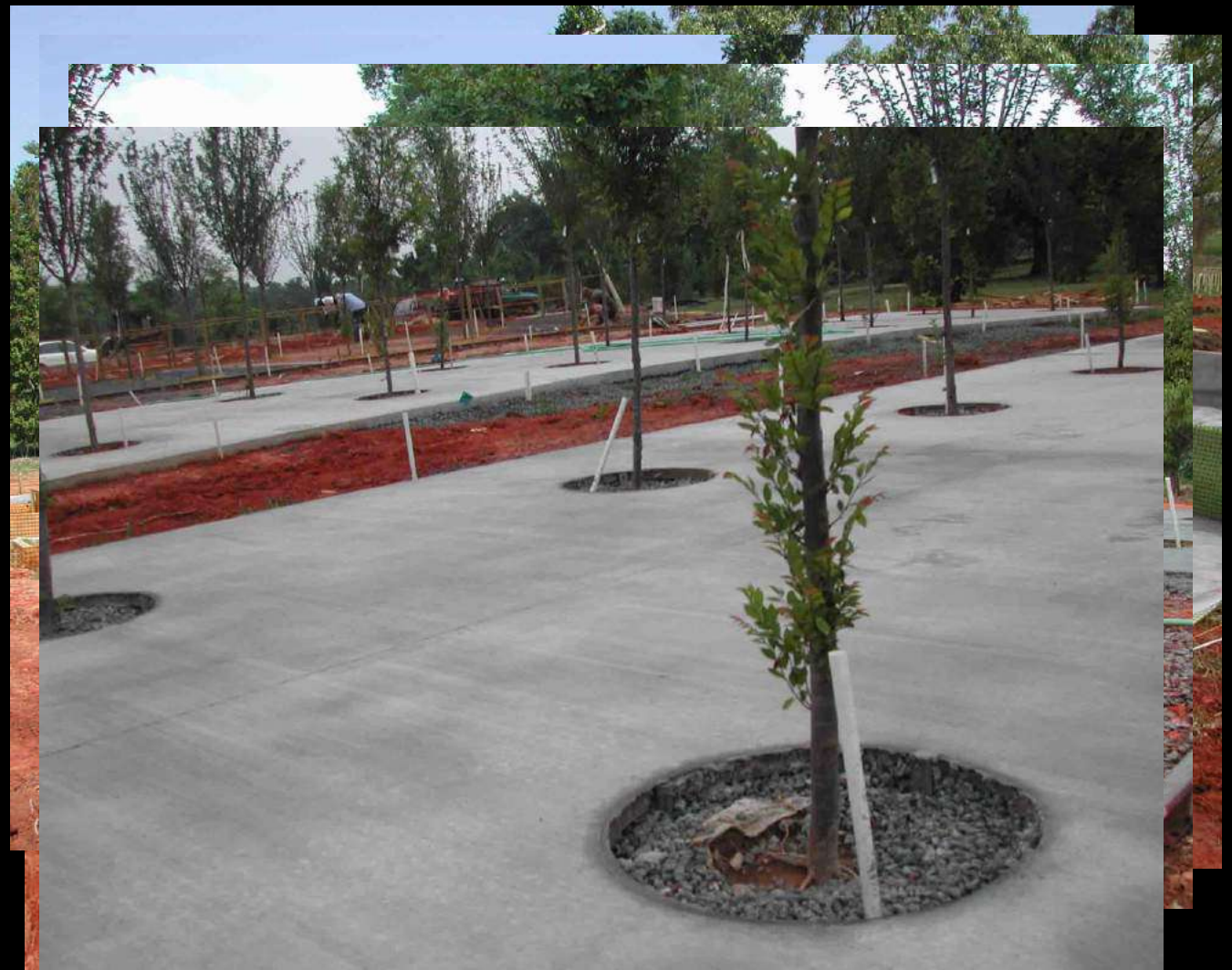
Urban Plaza Trial

Built spring 2004

Purpose: 1) To compare tree growth rates associated with different structural soils

2) To determine potential maintenance needs of trees growing in different structural soils

3) To determine the impact of the trees on hardscape



Urban Plaza Research at the Bartlett Tree Research Lab

Planted 2004 Treatments:

Concrete supported/suspended pavement (sandy clay loam)

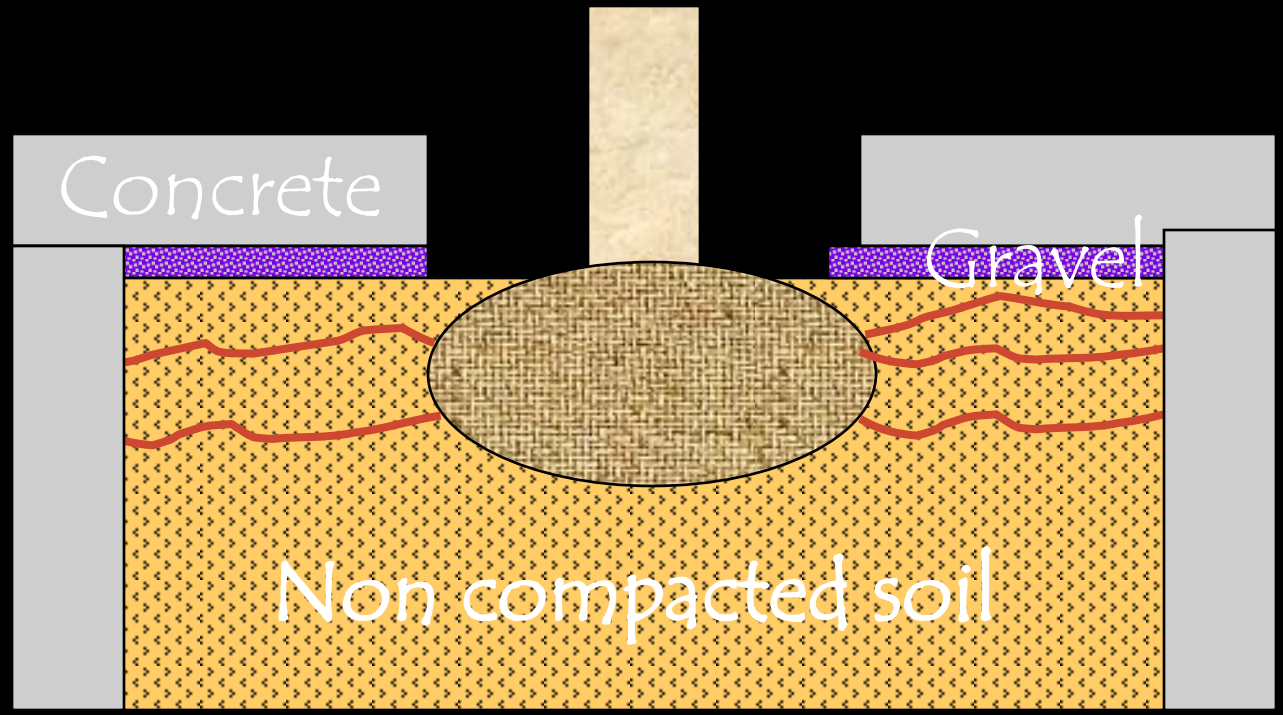
Compacted soil (95% Proctor)

Gravel based structural soil (80/20%, 25- 38 mm dia)

Expanded slate structural soil (80/20, 19-25mm dia)

Expanded slate - (100%)

Supported/Suspended Pavement



Urban Plaza at One Year 2005


Urban Plaza at the Bartlett Tree Reseach Laboratory
July 21, 2006
Gravel/Soil
Stalite
Stalite / Soil
Compacted
Stalite/Soil
Compacted
Stalite
Gravel/Soil
Suspended Pavement
(c) E. Thomas Smiley 2006

Urban Plaza at 2.5 years
2006

a


Urban Plaza at the Bartlett Tree Research Lab
September 2007
Stalite/soil
Stalite
Compacted
Gravel/
Soil
Suspended Pavement
3.5 years after planting


Urban Plaza
Bartlett Research
Laboratory
July 3, 2008
4 + years
Gravel/soil
New Plot
Stalite soil
Compacted
Stalite/soil
Compacted
New plot
Gravel/soil
Suspended Pavement


Urban Plaza
Bartlett Tree
Research Lab
9/9/09
Gravel/soil
New
Stalite/soil
Compacted
Stalite/Soil
Compacted
New
Gravel/Soil
Suspended Pavement
5.5 years


Urban Plaza Research Plot
at the Bartlett Tree
Research Lab
July 14, 2010
New Control
Compacted
Stalite/Soil
Gravel/Soil
New
Gravel/Soil
New
Stalite/Soil
Compacted
Stalite/Soil
Compacted
New
Gravel/Soil
Suspended Pavement
6 years
after planting
(c) E. Thomas Smiley 2010

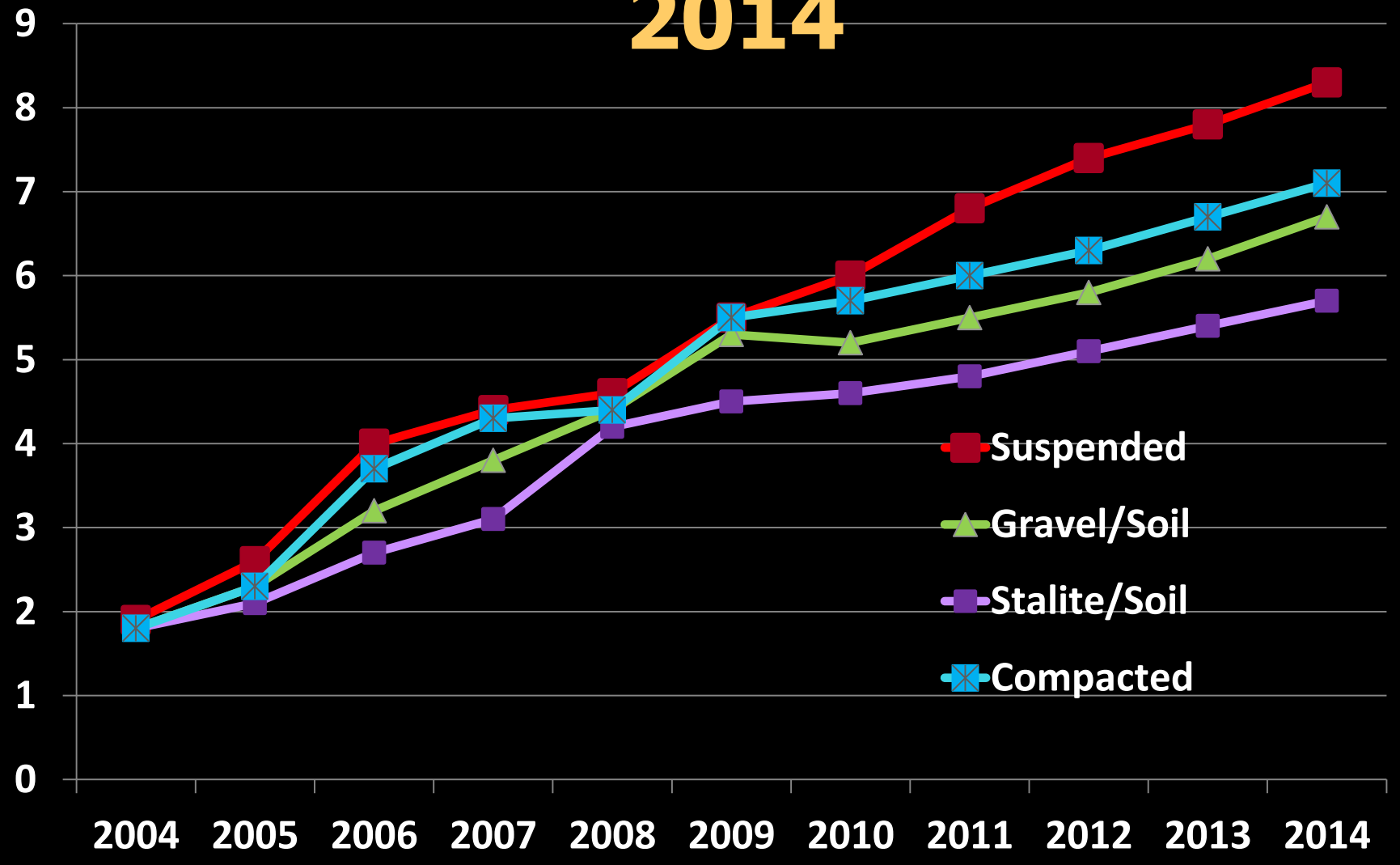
7 years after planting


Urban Plaza
Bartlett Tree
Research Lab
6/27/12
Gravel/Soil
New
Stalite/Soil
Compacted
Stalite/Soil
Compacted
New
Gravel/Soil
Suspended Pavement


Urban Plaza
Bartlett Tree
Research Lab
7/19/2013
Gravel/Soil
New
Stalite/Soil
Compacted
Stalite/Soil
Compacted
New
Gravel/Soil
Suspended Pavement


Urban Plaza
Bartlett Tree
Research Lab
7/29/2014
Gravel/Soil
New
Stalite/Soil
Compacted
Stalite/Soil
Compacted
New
Gravel/Soil
Suspended Pavement
(c) E. Thomas Smiley 2014

Urban Plaza Bosque Elm Trunk Diameter (Inches) 2014



Since 2004 there have been new products and soil mixes developed.

Some of these were installed in a new plot at the Bartlett Laboratory in 2014.