F-994

TREE ROOTS and Their Growth

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"Tree roots growing under North Dakota soil and moisture conditions do not penetrate to unusual depths."

A.F. Yeager, 1937

There are many myths and ideas about how, why and where tree roots grow. The problems of drought, root compaction and construction injuries are best understood with the knowledge of tree growth habits. If such injuries continue, the tree is weakened and the soundness of tree structure is in question. The tree can then become a hazard to man, animal and property.

Some of the early research on tree roots was done by Dr. A.F. Yeager at the North Dakota Agricultural College in 1937. He secured special relief funds to hire a massive crew to uncover root systems of 30 different tree species at two locations in the state. The conclusions of his research are still used today. The following information is based on Yeager's work and that of other tree root experts across the United States.

Roots have three main functions: 1.) absorption, 2.) support or anchorage and 3.) food or nutrient storage. Tree roots absorb needed minerals, water and oxygen from the soil. They grow where these essential elements are present and die back where they are low in quantity of lacking in the soil. Warm soil temperatures contribute to good root growth. Tree root growth and stem and branch growth are proportional for balance and anchorage. The root system must be large enough to support the stem and crown of the tree. Most tree roots are in the top 2-4 feet of soil and spread beyond the width of the tree's canopy. Tree root growth is essential to photosynthesis in the leaves and thus the total growth of the tree. Minerals, water and oxygen are absorbed through the roots and are transported to the leaves where they are used

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APRIL 1990

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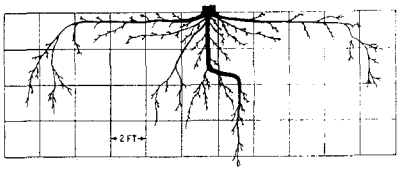
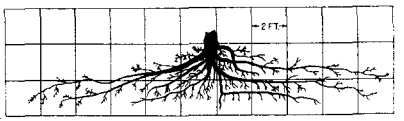
during photosynthesis. Food or nutrient products are then transported back to stem and roots. The roots store these reserves of nutrients and food products for next year's growth and the future life of the tree. A healthier root system in good soil conditions will have a longer life. Roots are classified in five groups:

1. **Transport roots** are large roots that stretch out horizontally from the root collar. These roots transport minerals from the absorptive roots to the trunk and provide a base for anchor roots. These roots may show annual rings similar to the trunk and branches.
2. **Absorptive roots** or feeder roots are smaller and are attached to the transport roots. They extend upward toward the soil surface. Minerals and oxygen are taken in through absorptive roots. In many tree species, fungi are associated with these roots and assist in mineral uptake. These fungi are called mycorrhizae.
3. **Root hairs** are microscopic threads of roots connected to absorptive roots. They perform the greatest amount of mineral uptake. The absorptive roots and associated root hairs occur in the surface soil layer (top 6-12 inches) and drip line area of the tree. These roots are ephemeral (short-lived) and may die and new ones grow daily.
4. **Anchor roots** (sinker roots) are similar in size to the absorptive roots but grow in downward from transport roots. Some of these roots also absorb water and minerals.
5. **The tap root** is a main root that grows downward and is primarily for anchorage. There is usually one tap root per tree, which makes up less than 1 percent of the total root system. There are some species that only occasionally set a tap root. American elm has a fibrous root system along rivers and streams, but sets a tap root in dry upland sites. (Figure 1c and 1d).

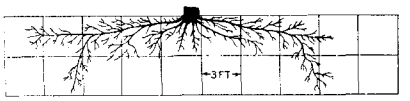
Tree root growth is also determined by the tree species (Table 1). For example, the root spread of American elm is greater than the tree's height, whereas the root spread of Colorado blue spruce is less than the tree's height. Spread is measured from the trunk of the tree out to the root ends. Root depth will vary by species also. In Table 1, trees



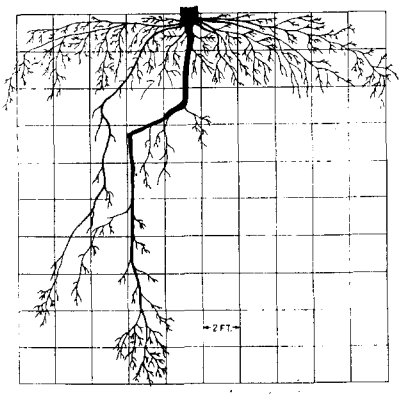
(1a) Tap root system of 50 year old bur oak in LaMoure clay loam, McHenry County.



(1b) Fibrous root system of 38 year old green ash in Fargo silty clay.



(1c) Fibrous root system of 50 year old American elm in LaMoure clay loam, McHenry County.



(1d) Tap root system of 30 year old American elm in dune sand, McHenry County.

Figure 1. Root systems of bur oak, green ash, and American elm. Some tree species are characterized by tap roots (1a) while others by a fibrous root system (1b and 1c). Some species with fibrous roots will set a tap root in certain soils (1c and 1d).

with depths of more than 4 feet have a strong tap root.

Tree root growth can vary from rural sites (windbreaks and native woodlands) to more urban/city sites (streets, boulevards, yards and parks). The difference in growth is due to the amount of available oxygen in the soil.

Forests or rural tree plantings tend to have a denser root system with a protective humus or leaf litter layer on the soil surface. This layer adds organic matter and minerals to the soil. A dense canopy and the leaf litter layer protect roots from drying out. These soils are more porous due to lack of human activity and compaction. Porous soils have more available oxygen.

Urban trees tend to have shallow and sparse roots systems. Grass covers the soil surface and severely competes with the tree for moisture and minerals. The canopy is less dense than rural plantings so there is less protection from the sun. In many cases, intense heat is created by nearby pavement and concrete surfaces. The soils in urban or community settings are more compacted through man's activities. Compaction occurs from walking paths, parking vehicles, or regular activities under the canopy of a favorite shade tree. Compacted soils have less pore space and oxygen. If trees in a rural setting are competing with weeds, grasses, and compacted soils, their root growth may be similar to the urban site.

Table 1. Root depth and spread of some common woody plants.

Tree Species	Root Depth (in feet)	Root Spread (compared to height)
DECIDUOUS TREES		
American Elm	1-4	More/Ht
Hackberry	1-5	More/Ht
Bur Oak	1-9	Twice/Ht
Green Ash	1-4	Equal/Ht
Basswood	1-6	Less/Ht
Boxelder	1-5	More/Ht
Cottonwood	1-10	More/Ht
Silver Maple	1-5	Equal/Ht
White Willow	1-7	More/Ht
Russian-olive	1-6	More/Ht
Siberian Elm	1-5	Equal/Ht
Apple	1-10	More/Ht
Siberian Crabapple	1-7	More/Ht
Black Walnut	1-6	Twice/Ht
Butternut	1-5	Equal/Ht
Northern Catalpa	1-5	Equal/Ht
Honeylocust	10-20	More/Ht
Black Locust	5-10	More/Ht
EVERGREEN TREES		
Ponderosa Pine	1-4	Less/Ht
Colorado Spruce	1-4	Less/Ht
Black Hills Spruce	1-4	Less/Ht
Norway Spruce	1-5	Less/Ht
Scotch Pine	1-5	More/Ht
Jack Pine	1-4	More/Ht
Eastern Red-cedar	1-4	Equal/Ht
Rocky Mountain Juniper	1-4	Equal/Ht
Tamarisk	1-7	Less/Ht
SHRUBS		
Siberian Peashrub	1-6	Equal/Ht
Tatarian Honeysuckle	1-4	Equal/Ht
Buckthorn	1-5	Equal/Ht
Common Lilac	1-5	More/Ht
Silver Buffalo berry	1-6	More/Ht
Chokecherry	1-7	Twice/Ht
American Plum	1-3	Equal/Ht
Amur Maple	1-4	Less/Ht

Less/Ht=Less than height
More/Ht=More than height
Twice/Ht=Twice the height
Equal/Ht=Equal to the height

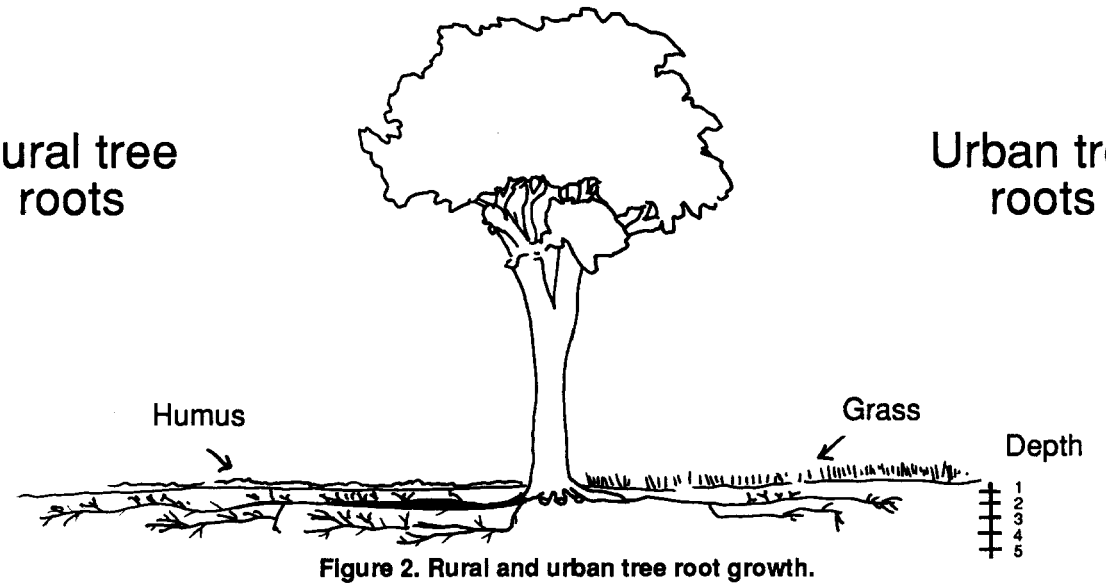


Figure 2. Rural and urban tree root growth.

Conclusions

- Most roots grow horizontally and upward through the soil.
- Most roots are in the top 3 feet of soil; a few are deeper.
- Many roots extend outward radially, far beyond the tips of tree branches, and usually exceed the height of the tree.
- Roots grow best in the upper layers of soil because the available oxygen, water and minerals are concentrated in these areas.
- When additional water is supplied, tree roots spread less and penetrate deeper. This is particularly true of some of the less drought resistant species, such as willows.
- Roots will not grow where moisture and oxygen are unavailable.

Table 2. Tree root growth under rural and urban sites.

Soil Depth (inches)	% Rural Soil Oxygen	% Urban Soil Oxygen	Rural Root Density (Gr/CC)	Urban Root Density (Gr/CC)
0	20	16	1.1	1.4
12	20	10	1.4	1.6
24	19	--	1.6	1.8
36	18	--	--	--
48	--	--	1.8	--

Gr/CC=Growing Roots/Cubic Centimeter
Source: American Forestry Association

- The general distribution of tree roots is much the same on clay soils as in sandy soils. Roots grow deeper in sandy soils due to higher oxygen content.
- The surface area of the root system is larger than that of the leaves and branches.
- The small root hairs that make up the majority of the root surface die and regenerate on a daily basis.
- If soils are too wet, eg. flooding in summer, tree roots die from lack of oxygen.

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