HERMITAGE CAMPHOR TREES

5303 – 5305 Hermitage Avenue
CHC-2015-3149-HCM
ENV-2015-3150-CE

Agenda packet includes

Please click on each document to be directly taken to the corresponding page of the PDF.

Los Angeles Department of City Planning
RECOMMENDATION REPORT

CULTURAL HERITAGE COMMISSION

CASE NO.: CHC-2015-3149-HCM
ENV-2015-3150-CE

HEARING DATE:	September 17, 2015	Location: 5303 - 5305 Hermitage Avenue
TIME:	10:00 AM	Council District: 2
PLACE:	City Hall, Room 1010 200 N. Spring Street Los Angeles, CA 90012	Community Plan Area: North Hollywood Valley Village Area Planning Commission: South Valley Neighborhood Council: Valley Village Legal Description: Lot 9, TR 9237

PROJECT: Historic-Cultural Monument Application for the HERMITAGE CAMPHOR TREES

REQUEST: Declare the property a Historic-Cultural Monument

OWNER(S): Clinton J. Lathrop and Sydeny A. Edwards
11811 Loraleen Street
Garden Grove, CA 92841

APPLICANT: Aimee Frappied
263 W. Olive Avenue #159
Burbank, CA 91506

RECOMMENDATION **That the Cultural Heritage Commission:**

1. **Not take the property under consideration** as a Historic-Cultural Monument per Los Angeles Administrative Code Chapter 9, Division 22, Article 1, Section 22.171.10 because the application and accompanying photo documentation do not suggest the submittal warrants further investigation.

2. **Adopt** the report findings.

MICHAEL J. LOGRANDE
Director of Planning

[SIGNED ORIGINAL IN FILE]

Ken Bernstein, AICP, Manager
Office of Historic Resources

[SIGNED ORIGINAL IN FILE]

Lambert M. Giessinger, Preservation Architect
Office of Historic Resources

[SIGNED ORIGINAL IN FILE]

Shannon Ryan, City Planning Associate
Office of Historic Resources

Attachments: Historic-Cultural Monument Application

SUMMARY

The Hermitage Camphor Trees are located within the front yard of the multifamily property at 5303-5305 Hermitage Avenue at the corner of Weddington Street. The entire property was previously nominated under case CHC-2015-2179-HCM as the Hermitage Property. On May 12, 2015 the Cultural Heritage Commission denied the nomination. A new application has since been submitted nominating the two camphor trees in the front yard. The front yard is landscaped with a number of mature trees including two camphor trees, crape myrtle trees, Japanese hackberry, yew pine, and camellia trees as well as oleander, American sweetgun, and bottle brush. It is estimated that the two camphor trees are 80 years old and have withstood natural disasters such as the flood of 1938. The camphor trees are a fixture of the community and the large front yard is a gathering place for neighbors and tenants.

CRITERIA

The criterion is the Cultural Heritage Ordinance which defines a historical or cultural monument as any site (including significant trees or other plant life located thereon) building or structure of particular historic or cultural significance to the City of Los Angeles, such as historic structures or sites in which the broad cultural, economic, or social history of the nation, State or community is reflected or exemplified, or which are identified with historic personages or with important events in the main currents of national, State or local history or which embody the distinguishing characteristics of an architectural type specimen, inherently valuable for a study of a period style or method of construction, or a notable work of a master builder, designer or architect whose individual genius influenced his age.

DISCUSSION

The applicant argues that the trees reflect “the broad cultural, economic, or social history of the nation, State or community” because the trees are an established landscape of the local community on Hermitage Avenue, are important to the local wildlife, and have withstood the test of time. Staff does not agree that the Hermitage Camphor Trees meet this criterion of the Cultural Heritage Ordinance. The trees are large, beautiful, and have been in the community for 80 years, but do not rise to the level of significance for a Historic-Cultural Monument. While the trees are part of an important open space for the community, the trees are not reflective of the cultural, economic, or social history of Hermitage Avenue. The trees were not planted as part of the subdivision or through joint landscape efforts of the community. They also not a unique species, type, or specimen of camphor tree.

There are several landscapes or natural features that are designated Historic-Cultural Monuments. Some that have been designated Historic-Cultural Monuments are closely tied to the subdivision of the community and make up a planned landscape element such as the pepper trees lining Canoga Avenue, HCM #93, and the Sycamore Trees on Bienveneda Avenue, HCM #465. Other designated landscapes such as the palm trees on the Highland Avenue median, HCM #94, and the Coral Trees on San Vicente Blvd., HCM #148, were planted through neighborhood efforts to improve an abandoned equestrian path and railroad right of way and are demonstrative of community planning efforts. An example of an individual tree that met the criteria of the Cultural Heritage Ordinance is the Moreton Bay Fig Tree, HCM #19. Planted in 1875, the Moreton Bay Fig Tree has a span of 120 feet and is one of the largest and oldest moreton bay fig trees in the City. Another example, the Aoyama Tree, HCM #920, is a ninety year old rubber tree that was designated for its cultural association with the early Japanese community in Los Angeles and with the founding of the Koyasan Buddhist Temple in Little Tokyo, one of the oldest Buddhist Temples in Los Angeles. A final example, the Avalon Blvd. Mexican Fan Palm Trees, HCM #914, are significant as part of beautification efforts for the 1932 Olympic Games, but also as a way to distinguish the Wilmington harbor and community. The above mentioned designated landscapes or natural features have narratives that directly relate to one or more Historic-Cultural Monument designation criteria. The Hermitage Camphor Trees do not have significant cultural, economic, or social associations.

FINDINGS

Based on the facts set forth in the summary, discussion, and application, the Commission determines that the property is not significant enough to warrant further investigation as a potential Historic-Cultural Monument.

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

1. PROPERTY IDENTIFICATION

Proposed Monument Name: Hermitage TREES					
Other Associated Names:					
Street Address: 5303 Hermitage Ave.			Zip: 91607		Council District: 2
Range of Addresses on Property: 12301, 12301 1/2 Weddington St.			Community Name:		
Assessor Parcel Number: 2347025010	Tract: 9237			Block:	Lot: 9
Identification cont'd:					
Proposed Monument Property Type: Building	Structure	Object	● Site/Open Space	● Natural Feature	
Describe any additional resources located on the property to be included in the nomination, here: 2 Camphor Trees,					
Mulberry Tree, Crape Myrtle tree, Japanese Hackberry Trees, American Sweetgum Trees					

2. CONSTRUCTION HISTORY & CURRENT STATUS

Year built: 1934	● Factual	Estimated	Threatened? Private Development
Architect/Designer:			Contractor:
Original Use:			Present Use:
Is the Proposed Monument on its Original Site?	● Yes	No (explain in section 7)	Unknown (explain in section 7)

3. STYLE & MATERIALS

Architectural Style:	Stories:	Plan Shape:

FEATURE	*PRIMARY*	*SECONDARY*
CONSTRUCTION	Type:	Type:
CLADDING	Material:	Material:
ROOF	Type:	Type:
	Material:	Material:
WINDOWS	Type:	Type:
	Material:	Material:
ENTRY	Style:	Style:
DOOR	Type:	Type:

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

4. ALTERATION HISTORY

List date and write a brief description of any major alterations or additions. This section may also be completed on a separate document. Include copies of permits in the nomination packet. Make sure to list any major alterations for which there are no permits, as well.	
	N/A

5. EXISTING HISTORIC RESOURCE IDENTIFICATION (if known)

Listed in the National Register of Historic Places	
Listed in the California Register of Historical Resources	
Formally determined eligible for the National and/or California Registers	
Located in an Historic Preservation Overlay Zone (HPOZ)	Contributing feature Non-contributing feature
Determined eligible for national, state, or local landmark status by an historic resources survey(s)	Survey Name(s):
Other historical or cultural resource designations:	

6. APPLICABLE HISTORIC-CULTURAL MONUMENT CRITERIA

The proposed monument exemplifies the following Cultural Heritage Ordinance Criteria (Section 22.171.7):	
✓	Reflects the broad cultural, economic, or social history of the nation, state, or community
	Is identified with historic personages or with important events in the main currents of national, state, or local history
✓	Embodies the distinguising characteristics of an architectural-type specimen, inherently valuable for study of a period, style, or method of construction
	A notable work of a master builder, designer, or architect whose individual genius influenced his or her age

CITY OF LOS ANGELES
Office of Historic Resources/Cultural Heritage Commission

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

7. WRITTEN STATEMENTS **See enclosure #1**

This section allows you to discuss at length the significance of the proposed monument and why it should be designated an Historic-Cultural Monument. Type your response on separate documents and attech them to this form.

A. Proposed Monument Description - Describe the proposed monument's physical characteristics and relationship to its surrounding environment. Expand on sections 2 and 3 with a more detailed description of the site. Expand on section 4 and discuss the construction/alteration history in detail if that is necessary to explain the proposed monument's current form. Identify and describe any character-defining elements, structures, interior spaces, or landscape features.

B. Statement of Significance - Address the proposed monument's historic, cultural, and/or architectural significance by discussing how it satisfies the HCM criteria you selected in Section 6. You must support your argument with substantial evidence and analysis. The Statement of Significance is your main argument for designation so it is important to substantiate any claims you make with supporting documentation and research.

8. CONTACT INFORMATION

Applicant

Name: Aimee Frappied	Company:	
Street Address: 263 W Olive Ave. #159	City: Burbank	State: CA
Zip: 91506	Phone Number: (818) 800-8462	Email: aimeefrappied@gmail.com

Property Owner Is the owner in support of the nomination? Yes No • Unknown

Name: Marta Lathrop	Company:	
Street Address: 11811 Loraleen St.	City: Orange County	State: CA
Zip: 92841	Phone Number: (714)539-8365	Email:

Nomination Preparer/Applicant's Representative

Name:	Company:	
Street Address:	City:	State: CA
Zip:	Phone Number:	Email:

9. SUBMITTAL

When you have completed preparing your nomination, compile all materials in the order specified below. Although the entire packet must not exceed 100 pages, you may send additional material on a CD or flash drive.

APPLICATION CHECKLIST

1. Nomination Form
2. Written Statements A and B
3. Bibliography
4. Two Primary Photos of Exterior/Main Facade (8x10, the main photo of the proposed monument. Also email a digitial copy of the main photo to: planning.ohr@lacity.org)
5. Copies of Primary/Secondary Documentation
6. Copies of Building Permits for Major Alterations (include first construction permits)
7. Additional, Contemporary Photos
8. Historical Photos
9. Zimas Parcel Report for all Nominated Parcels (including map)

10. RELEASE

Please read each statement and check the corresponding boxes to indicate that you agree with the statement, then sign below in the provided space. Either the applicant or preparer may sign.

✓	I acknowledge that all documents submitted will become public records under the California Public Records Act, and understand that the documents will be made available upon request to members of the public for inspection and copying.
✓	I acknowledge that all photographs and images submitted as part of this application will become the property of the City of Los Angeles, and understand that permission is granted for use of the photographs and images by the City without any expectation of compensation.
✓	I acknowledge that I have the right to submit or have obtained the appropriate permission to submit all information contained in this application.

Name: AIMÉE FRAPPIED Date: 5/24/2015 Signature: [signature]

Mail your Historic-Cultural Monument Submittal to the Office of Historic Resources.

Office of Historic Resources
Department of City Planning
200 N. Spring Street, Room 620
Los Angeles, CA 90012

Phone: 213-978-1200
Website: preservation.lacity.org

enclosure #1

#7. WRITTEN STATEMENTS

A. PURPOSED MONUMENT DESCRIPTION

Existing on The Hermitage Property is a variety of flora and fauna that has been the most reliable and dependable source for local wildlife, beneficial insects our & community.
2 Camphor Trees over 80 years old & over 60 feet tall.
Amongst the open space landscape there are Crape Myrtle Trees, Japanese Hackberry, Podocarpus macrophyllus (yew pine), Camellia trees, Oleander, American Sweetgum & BottleBrush tree's that all thrive in their originally planted location, decades ago.

B. STATEMENT OF SIGNIFICANCE (also see attached)

The Hermitage Trees meet the criteria of the *broad cultural, economic or social history of the nation, State or community.* This is *reflected* ***&*** *exemplified* through the time periods in which it they survived & continue to provide beneficial elements to our residents, neighbors, passerby's & wildlife.
Existing Camphor Trees over 80 years old and over 60 feet tall continue to provide homes, food & habitats to dozens of species of birds, squirrels, & beneficial insects. There have been at least 4 (as of the date on this application) sightings of 2 birds listed State & Federal Endangered Species Lists.
These trees have the ability to reach more than 500 years old & are considered legends in other countries.
Amongst agricultural & biological significance, our older & mature trees continue to provide oxygen by their ability to absorb larger amounts of carbon dioxide than newly planted trees.
The existing vast root system is depended on by the Soil Food Web (see attached documentation). The nutrient cycling and disease suppression needed by trees & plants occurs immediately adjacent to roots.

The Camphor trees exist on the north west corner of what we believe to be a historically significant property known as, The Hermitage Property. Previously submitted documentation will indicate this property being 1 of the first 4 parcels to be erected in the early 1930's. Owner built by the same family who owned & built the first 3 on Hermitage Ave., between Magnolia and Chandler Blvd. The property has existed as a nucleus of the neighborhood since the 1930's. Bringing neighbors and families together. Used as the local voting location & local activities & events, the trees remain a large contributor in uniting our community.
Old vintage photos will indicate the camphor trees in their beginning stages of growth. Since the time of those photos, they have survived snow storms, the Los Angeles Flood of 1938 (deemed the fifth largest flood in history),[1] earthquakes & other natural disasters in the city, when others failed.

Over 90% of homes & buildings on Hermitage Ave. were constructed as early as the 1930's up until the 1970's. Some with originally existing landscape & some not. The Camphor trees are 2 of the oldest & largest trees on the block.

Designating these trees and its root system is designating important time periods that we depend on, to connect us & link us to our past.
It continues to provide home to the birds, shade to our neighbors and community, & views from our windows that aid in emotional challenges. Designation contributes to the solution in our city rather than the problem.
They are attractive to bees, butterflies, birds and beneficial insects. They are also known for their strong ability to withstand urban pollution.[2]

Please see attached documentation and enclosures for a more detailed description of the trees and how they are significant to the community and culture.

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[1] The History of the Los Angeles River". L.A. River Connection. Archived from the original on 2007-06-11.
[2] *Michelle Wishhart Portland, Ore UC Santa Cruz.*


Hermitage Ave.
MULBERRY TREE
PINE
CAMPHOR TREE
PALM
CAMPHOR TREE
Lagerstroemia
BOTTLEBRUSH
North
Garage

Camphor Tree

Family: Lauraceae
Genus: Cinnamomum
Species: C. camphora

FACTS

- Introduced to the contiguous United States around 1875, *C. camphora* escaped cultivation and became a naturalized species in southern California.
- An evergreen tropical tree growing into a shade tree upwards of **45 to 60 feet tall** can be nearly as **wide as 100 feet** in their natural range, according to Robert Lee Riffle in "The Tropical Look."
- Related to true cinnamon trees that provide the cinnamon spice from their bark, the camphor tree also produces scented foliage, twigs & seeds attractive to birds that pass intact through the digestive system. This makes it a much desired drupe.

The camphor tree makes an exceptional shade, windbreak or street tree in spacious landscapes. Camphor has been used for many centuries as a culinary spice, a component of incense, and as a medicine. The aromatic oils in the wood repel insects.
It has value for antiseptics and medications treating inflammation and itching.
[3] [4]

The largest camphor tree exists in Japan with a trunk circumference above 24.22 meters **(79 feet 5.5 inches)**. It is estimated to be **1500 years old** and has been a national monument since 1952. It is considered a legendary tree. In 2001 the town built elevated walkways to protect its root system. [5]

Every part of this tree contains camphor. For centuries these trees have been used for the extraction of this substance, which is used as a food additive, medicine, part of incense and other products.[6]
The extensive, broad root system of a camphor tree resents root disturbance.
The roots are also rather aggressive, growing wherever necessary to obtain moisture or richer soil. *Michael Dirr*

The fruit looks like 'berries', but they are actually drupes containing a hard centre. These fruit are globular (8-10 mm across), glossy in appearance, and turn from green to black as they mature. They are attached to the stem by an enlarged, greenish-coloured, cone-shaped or cup-like structure (a conicalor cupular receptacle) that is about 5 mm across.
http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Cinnamomum_camphora_%28Camphor_Laurel%29.htm

Camphor trees never loose their leaves making it a great contributor for the cooling of our streets & providing year round shade to our neighbors. This also makes them particularly attractive for birds & wildlife to create nesting spots where they are already utilizing the source of the drupes for a healthy diet.

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[3] Botanical.com
[4] http://www.gardenguides.com/113679-camphor-tree.html
[5] http://en.wikipedia.org/wiki/Cinnamomum_camphora
[6] http://www.wondermondo.com/Countries/As/Japan/Kyushu/KamounoOhkusu.htm

HEALTH BENEFITS OF CAMPHOR

Its properties as a stimulant, antispasmodic, antiseptic, decongestant, anesthetic, sedative and nervous pacifier, anti-neuralgic, anti-inflammatory, disinfectant, and insecticide substance.

Stimulant & Diaphoretic: Camphor oil is an effective stimulant, which boosts the activity of the circulatory system, metabolism, digestion, secretion and excretion. This property helps in treating problems and ailments associated with improper circulation, digestion, sluggish or overactive metabolic rates, obstructed secretions, and a wide variety of other less common conditions.

Antiseptic, Disinfectant, Insecticide, and Germicide: Camphor oil is an excellent disinfectant, insecticide and germicide. It can be added to drinking water to disinfect it, particularly during the summer and in rainy seasons when there is a higher chance of water becoming infected. An open bottle or container of camphor oil, or burning a piece of cloth soaked in camphor oil, drives away insects and kills germs. A drop or two of camphor oil, mixed with a large quantity of food grains, keep those food items safe from insects. Camphor is also used in many medical preparations such as ointments and lotion to cure skin diseases, as well as bacterial and fungal infections of the skin. When mixed into bathing water, camphor oil disinfects the whole body externally and kills lice or other small parasites of bugs that might be on your body.

Anesthetic & Nervous Pacifier: It acts as a good anesthetic and is very effective for local anesthesia. It causes numbness of the sensory nerves at the area of application. It also reduces the severity of nervous disorders and convulsions, epileptic attacks, nervousness, and chronic anxiety.

Antispasmodic: It is a very efficient antispasmodic and gives immediate relief from spasms and cramps. It is also effective at curing extreme spasmodic cholera.

Anti-inflammatory and Sedative: The cooling and penetrating effects of camphor oil make it an anti-inflammatory and sedative agent. It is very helpful in curing nearly all types of inflammation, both internal and external. It also relaxes the body and mind while giving a feeling of peace and freshness. It proves to be very cooling and refreshing, particularly in the summer. Camphor oil can also be mixed with bathing water to have that extra sensation of coolness in the summer heat.

Decongestant: The strong, penetrating aroma of camphor oil is a powerful decongestant. It immediately relieves congestion of the bronchi, larynx, pharynx, nasal tracts and lungs. It is therefore used in many decongestant balms and cold rubs.

Other Benefits

It is sometimes used in cases of cardiac failure, in combination with other medicines. It is also beneficial in the treatment of epilepsy, hysteria, viral diseases like whooping cough, measles, flu. food poisoning, infections of the reproductive organs, and insect bites.

Blending: Camphor oil blends particularly well with Basil, Cajuput, Camomile, Melissa and Lavender Oil, for uses in aromatherapy.[7]

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[7] https://www.organicfacts.net/health-benefits/essential-oils/camphor-essential-oil.html

Urban Deforestation has many negative effects on the environment. The most dramatic impact is a loss of habitat for millions of species. Seventy percent of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes.

Trees absorb carbon dioxide & turn it into oxygen. The removal of a mature tree causes less carbon dioxide to get absorbed which builds into the atmosphere with green house gas emissions contributing to global warming.
National Geographic Society

Keep the Trees You Have:
Local governments are finally responding to the problem. More than 2,000 big and small cities have launched long-term planting and preservation programs. For now, the most immediate answer is less the planting strategy than the preservation one, something that can best be achieved by curbing sprawl and downsizing our taste for too-big homes. *Source: Time magazine*

Impact on Environment:
Economic impact:
Ecology and aesthetics justify tree preservation and protection.
https://www.planning.org/pas/at60/report236.htm

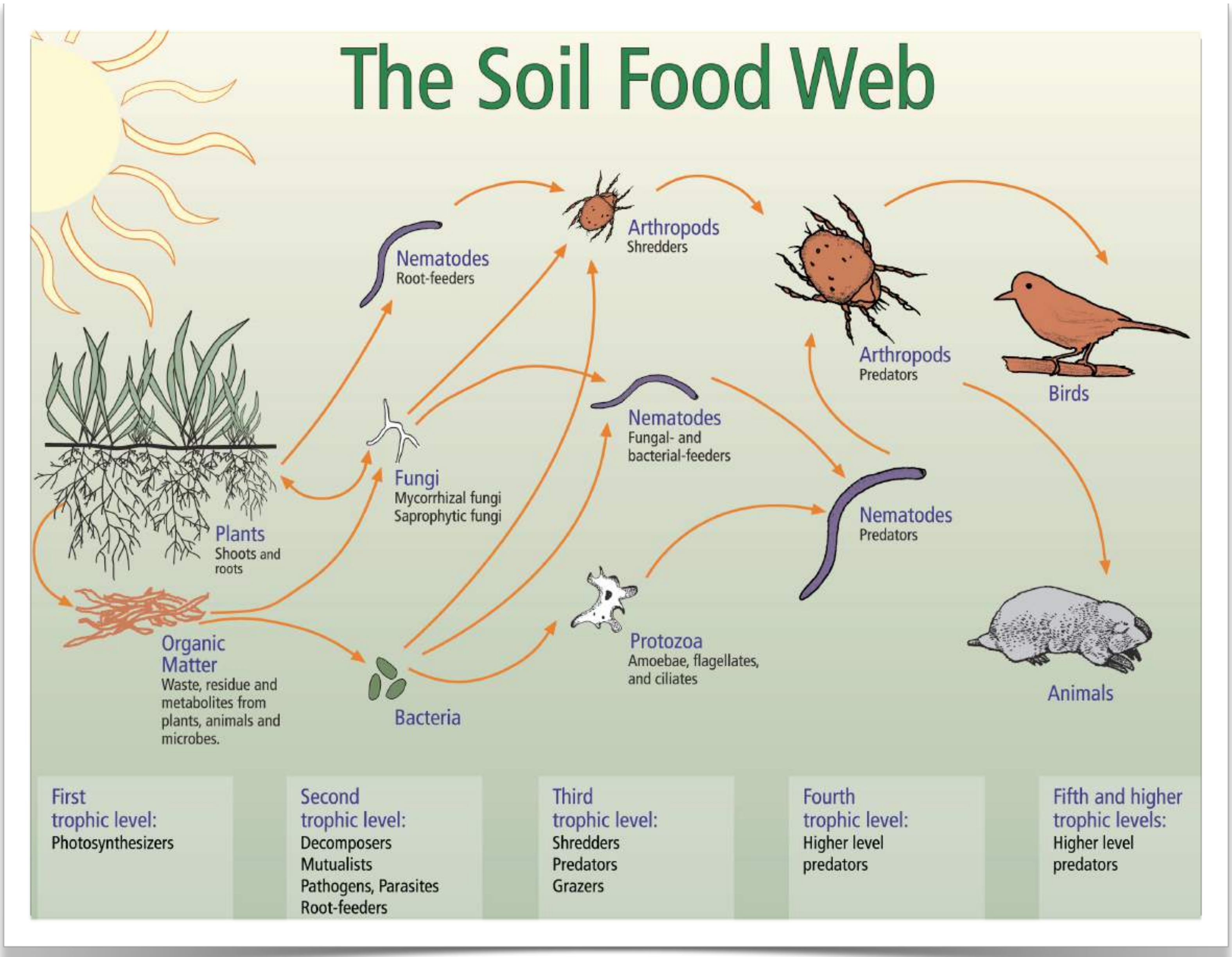
Existing designated Camphor Trees were found on HCM #509, processing ID HPOZC-07920
and listed as a district contributor.
(source: http://historicplacesla.org/reports/3adf14f7-2b37-4827-a05e-fc30e83bd5d9)

SOIL FOOD WEB

SOIL BIOLOGY AND THE LANDSCAPE [8]

An incredible diversity of organisms make up the soil food web. They range in size from the tiniest one-celled bacteria, algae, fungi, and protozoa, to the more complex nematodes and micro-arthropods, to the visible earthworms, insects, small vertebrates, and plants.

As these organisms eat, grow, and move through the soil, they make it possible to have clean water, clean air, healthy plants, and moderated water flow.



USDA - Natural Resources Conservation Service Soils
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868

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8 *http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868*

Functions of Soil Organisms

Type of Soil Organism		Major Functions
Photosynthesizers	• Plants • Algae • Bacteria	**Capture energy** • Use solar energy to fix CO_2. • Add organic matter to soil (biomass such as dead cells, plant litter, and secondary metabolites).
Decomposers	• Bacteria • Fungi	**Break down residue** • Immobilize (retain) nutrients in their biomass. • Create new organic compounds (cell constituents, waste products) that are sources of energy and nutrients for other organisms. • Produce compounds that help bind soil into aggregates. • Bind soil aggregates with fungal hyphae. • Nitrifying and denitrifying bacteria convert forms of nitrogen. • Compete with or inhibit disease-causing organisms.
Mutualists	• Bacteria • Fungi	**Enhance plant growth** • Protect plant roots from disease-causing organisms. • Some bacteria fix N_2. • Some fungi form mycorrhizal associations with roots and deliver nutrients (such as P) and water to the plant.
Pathogens **Parasites**	• Bacteria • Fungi • Nematodes • Microarthropods	**Promote disease** • Consume roots and other plant parts, causing disease. • Parasitize nematodes or insects, including disease-causing organisms.
Root-feeders	• Nematodes • Macroarthropods (e.g., cutworm, weevil larvae, & symphylans)	**Consume plant roots** • Potentially cause significant crop yield losses.
Bacterial-feeders	• Protozoa • Nematodes	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on bacteria. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of bacterial populations.
Fungal-feeders	• Nematodes • Microarthropods	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on fungi. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of fungal populations.
Shredders	• Earthworms • Macroarthropods	**Break down residue and enhance soil structure** • Shred plant litter as they feed on bacteria and fungi. • Provide habitat for bacteria in their guts and fecal pellets. • Enhance soil structure as they produce fecal pellets and burrow through soil.
Higher-level predators	• Nematode-feeding nematodes • Larger arthropods, mice, voles, shrews, birds, other above-ground animals	**Control populations** • Control the populations of lower trophic-level predators. • Larger organisms improve soil structure by burrowing and by passing soil through their guts. • Larger organisms carry smaller organisms long distances.

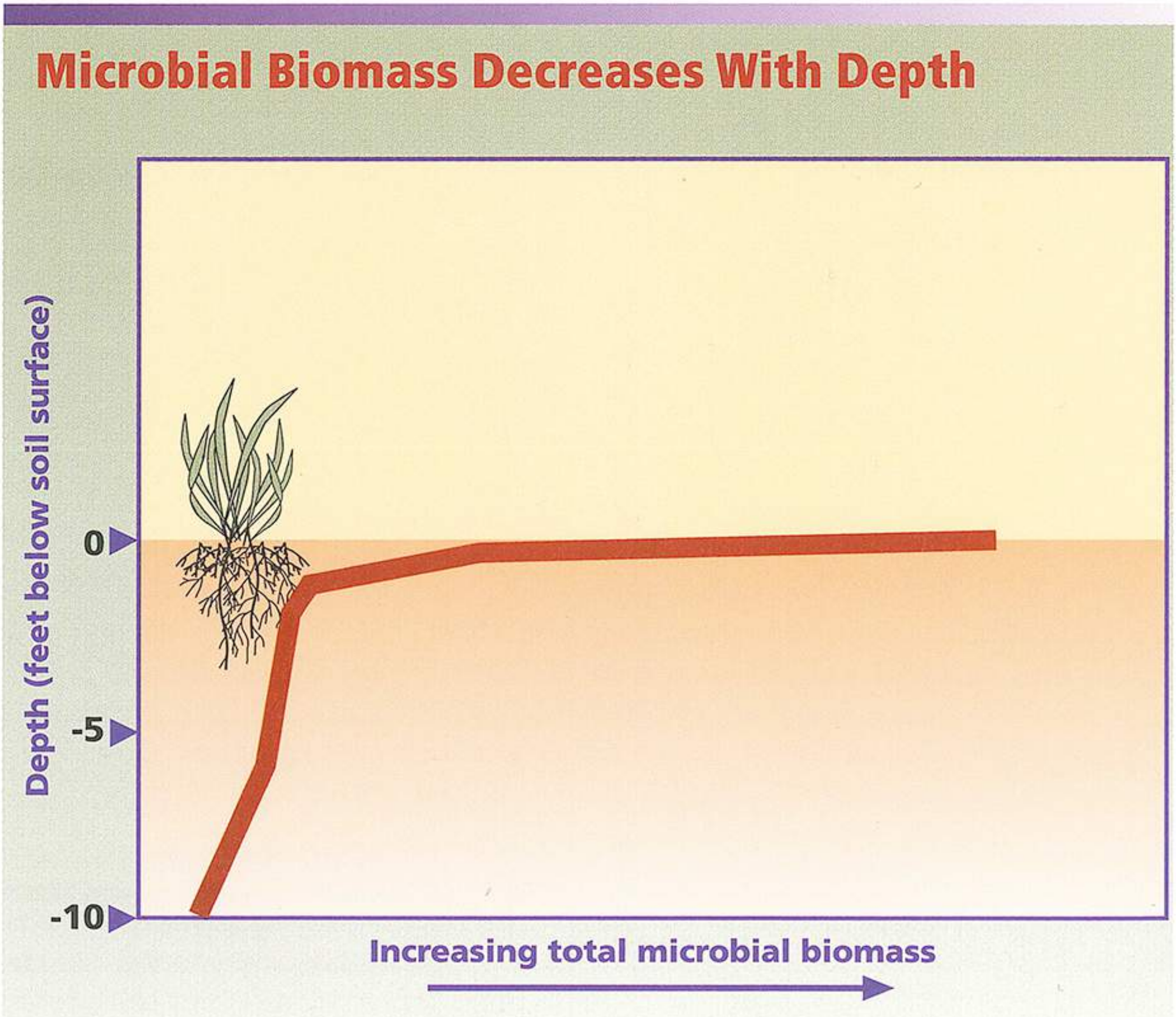
What Do Soil Organisms Do?

Growing and reproducing are the primary activities of all living organisms. As individual plants and soil organisms work to survive, they depend on interactions with each other. By-products from growing roots and plant residue feed soil organisms. In turn, soil organisms support plant health as they decompose organic matter, cycle nutrients, enhance soil structure, and control the populations of soil organisms including crop pests.

Soil organic matter is the storehouse for the energy and nutrients used by plants and other organisms. Bacteria, fungi, and other soil dwellers transform and release nutrients from organic matter. These microshredders, immature oribatid mites, skeletonize plant leaves. This starts the nutrient cycling of carbon, nitrogen, and other elements.

Where Do Soil Organisms Live?

Around roots.
The rhizosphere is the narrow region of soil directly around roots. It is teeming with bacteria that feed on sloughed-off plant cells and the proteins and sugars released by roots. The protozoa and nematodes that graze on bacteria are also concentrated near roots. Thus, much of the nutrient cycling and disease suppression needed by plants occurs immediately adjacent to roots.



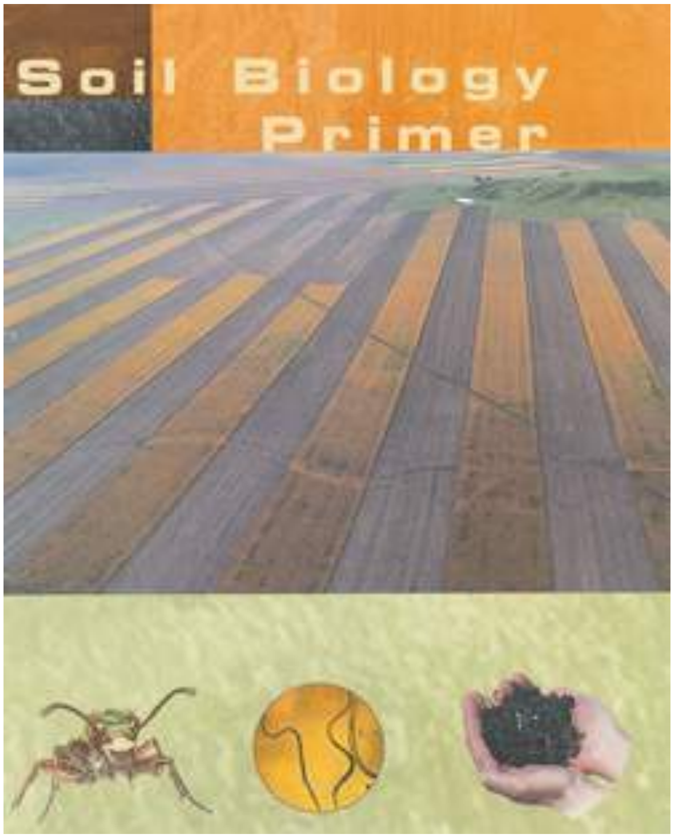
Bacteria are abundant around this root tip (the rhizosphere) where they decompose the plentiful simple organic substances.

The Importance of the Soil Food Web

The living component of soil, the food web, is complex and has different compositions in different ecosystems. Management of croplands, rangelands, forestlands, and gardens benefits from and affects the food web. The next unit of the Soil Biology Primer, The Food Web & Soil Health, introduces the relationship of soil biology to agricultural productivity, biodiversity, carbon sequestration and to air and water quality. The remaining six units of the Soil Biology Primer describe the major groups of soil organisms: bacteria, fungi, protozoa, nematodes, arthropods, and earthworms.

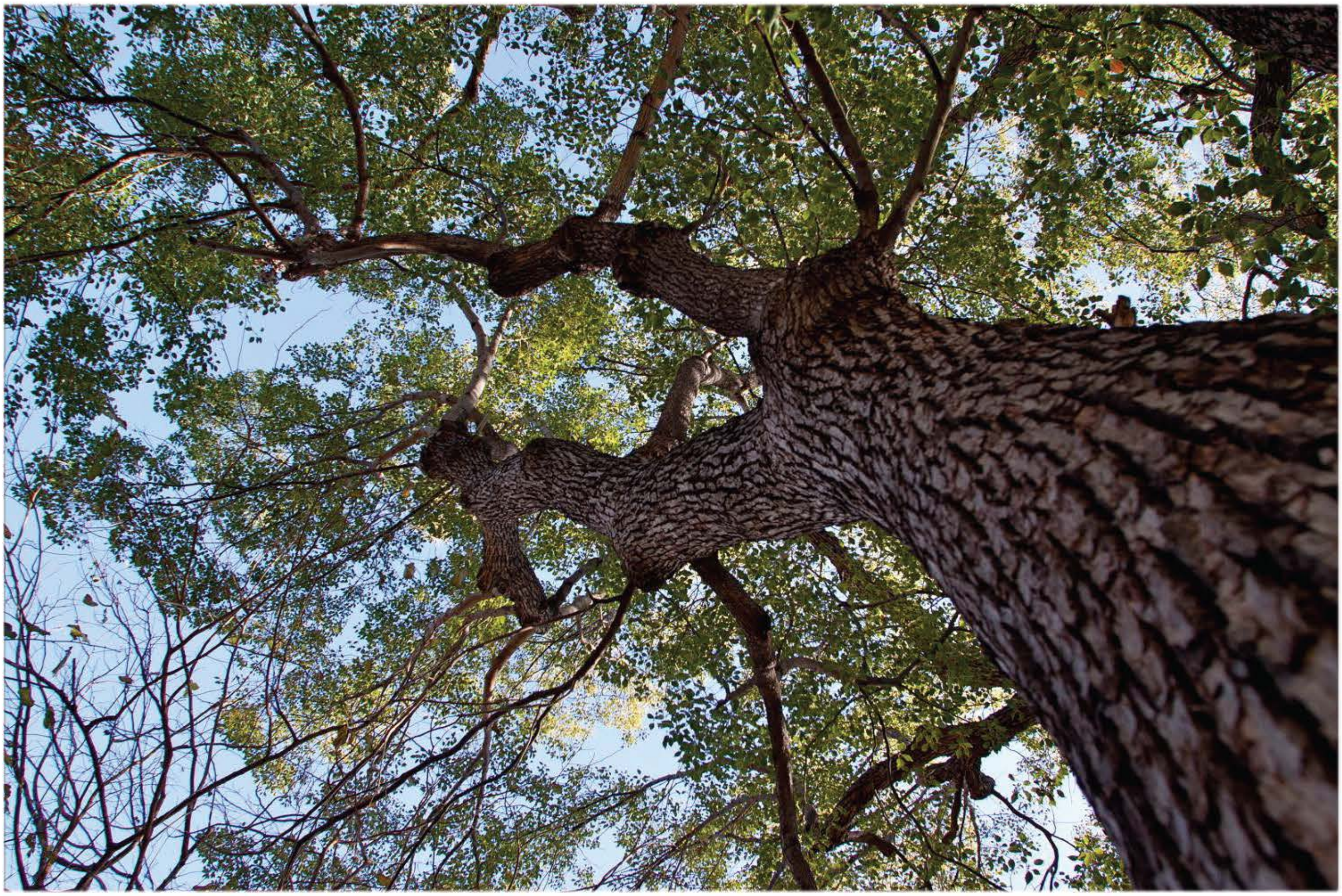
Soil Biology

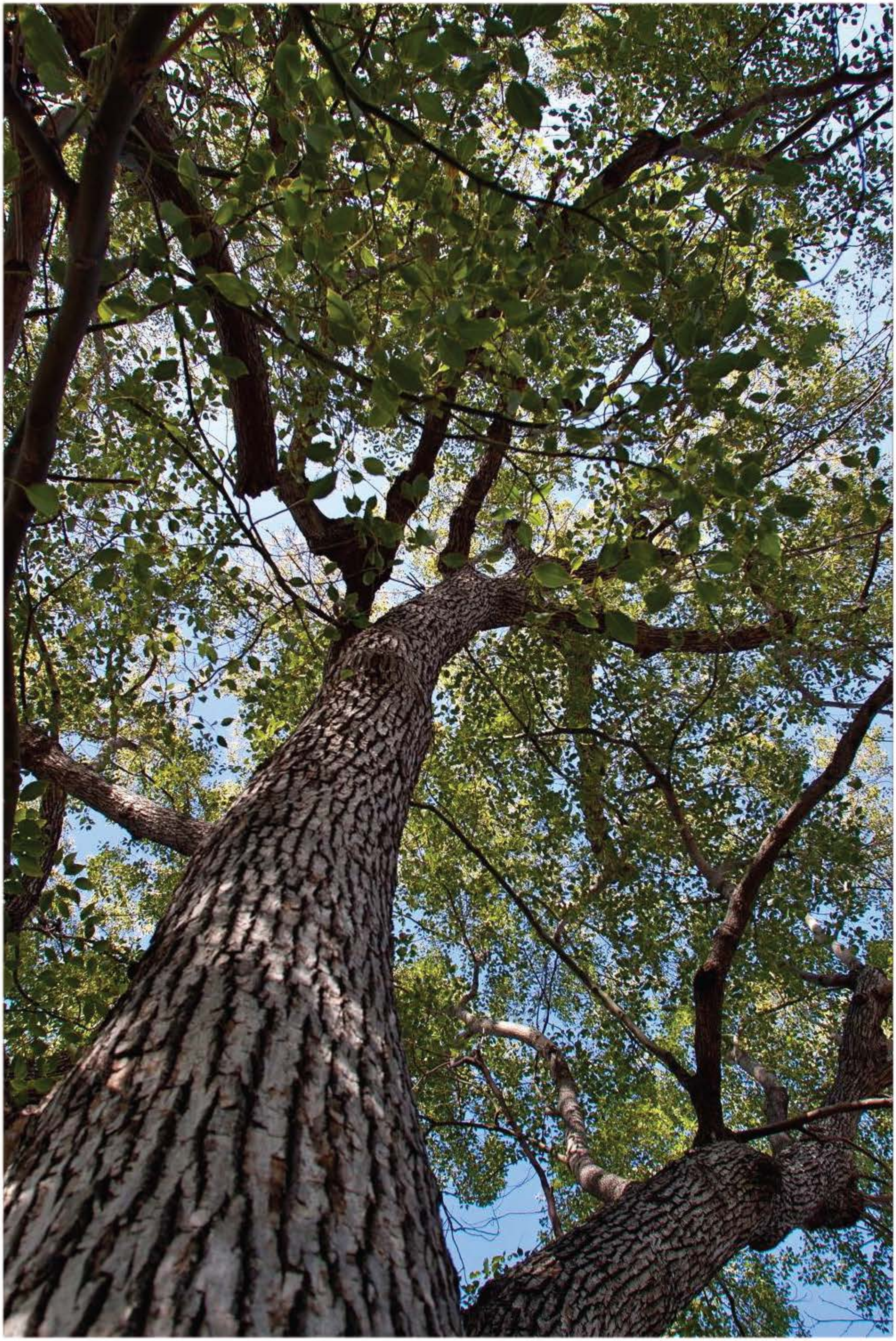
The creatures living in the soil are critical to soil health. They affect soil structure and therefore soil erosion and water availability.
They can protect crops from pests and diseases. They are central to decomposition and nutrient cycling and therefore affect plant growth and amounts of pollutants in the environment.
Finally, the soil is home to a large proportion of the world's genetic diversity.

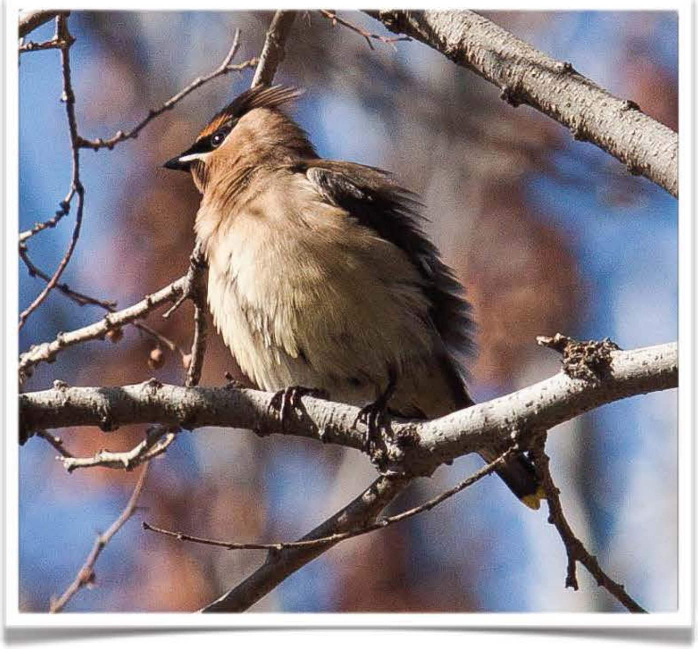


All plants – grass, trees, shrubs, agricultural crops – depend on the food web for their nutrition.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/#
http://soils.usda.gov/sqi/concepts/soil_biology/biology.html






PhytoLab
Camphor Oil
1 fl oz (30 ml)
ΚΑΜΦΟΡΗΟΕ ΜΑCΑΟ


CAMPHOR
CAMPHOR
OIL


CAMPHOR
(100mL)


NOW
essential oils
100% pure
camphor


NATURALLY PURE
J.R.WATKINS
Natural
APOTHECARY
MENTHOL CAMPHOR
VAPOR RUB
Natural
Menthol & Camphor
Soothing
Chest Ointment
and Cough
Suppressant
95.0% Natural
NET WT. 2.1 OZ.
NEW


HEM
CAMPHOR
INCENSE STICKS
HEM CAMPHOR
HEM CAMPHOR
HEM CAMPHOR


TRADE Vaseline MARK
CAMPHOR ICE
CAMPHOR IN A SPECIALLY PREPARED BASE
CHESEBROUGH MANUFACTURING CO. CONSD.
NEW YORK, N.Y., U.S.A.
NET 1 1/8 OZ.

TREES

Tree Root Survival & Growth Roots utilize space in the soil. The more space controlled the more potential resources controlled. The volume of soil space controlled by tree roots is directly related to tree health. The resources required are water, oxygen, physical space for growth processes, and open soil surface area for replenishment of essential resources. Tree roots occupy the spaces and gaps around, under, and between infrastructures. In heavily compacted sites, roots will be concentrated around the edges of infrastructures and filling any moist air space. The soil matrix is only a significant concern for essential elements, surfaces holding biological cooperators, and frictional and inertial forces for structural integrity. Figure 5. Tree roots and the soil surrounding them are an ecological composite of living, once-living, and abiotic features facilitating life. Compaction initiates many negative impacts in the soil including: decreases the volume of ecologically active space available; tree rootable space is decreased and made more shallow; the detritus food web, the ecological engine responsible for powering a healthy soil, is disrupted and modified; the diversity of living things decline, beneficial associates are eliminated, and a few ecological niche generalists succeed; and, pests favored by the new conditions (i.e. Pythium & Phytophera) consume organisms and roots not able to defend themselves. Tree roots become more prone to damage and attack at a time when sensor, defense, growth regulation, and carbon allocation processes are functioning at reduced levels.

Root Requirements:
Roots utilize soil spaces for access to water and essential element resources, and to provide structural support. Roots grow following pathways of interconnected soil pores. Pore space can be the result of the space between textural units (sand, silt, and clay particles), between structural units (blocks, plates, grains, prisms, etc.), along fracture lines (shrink / swell clays, frost heaving, pavement interfaces, etc.), and through paths of biological origins (decayed roots, animal diggings, etc.). Roots survive and grow where adequate water is available, temperatures are warm, and oxygen is present. Roots are generally shallow as limited by oxygen contents, anaerobic conditions, and water saturation in deeper soil. Near the base of the tree, deep growing roots can be found, but they are oxygenated through fissures and cracks generated as a result of mechanical forces moving the crown and stem under wind loads (sway)

Renovation of Sites Principles:
A summary of this discussion of soil compaction lies with those general principles and renovation techniques managers must use to reclaim a part of the **ecological integrity** of the site, as well as soil and tree health. General soil compaction renovation principles are listed below in a bullet format: – Soil compaction should be considered permanent. Studies demonstrate that after one-half century, compaction still afflicts soils under natural forest conditions.
Recovery times for significant compaction is at least two human generations.
Soils do not “come back” from compaction. – Every soil used by humankind has a representative compacted layer, zone, area, or crust. Changing management may not change the current compacted zone but may well add an additional compacted zone in a new position.

Conclusions:
Soil compaction is a hidden stressor which steals health and sustainability from soil and tree systems. Causes of compaction are legion and solutions limited. Without creative actions regarding the greening of inter-infrastructural spaces in our communities, we will spend most of our budgets and careers treating symptoms and replacing trees. Understanding the hideous scourge of soil compaction is essential to better, corrective management.
Please see attached document titled: **SoilCompactionAndTrees.pdf**

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The North Hollywood Community 4 Preservation

SEPTEMBER 9, 2015

CULTURAL-HERITAGE-COMMISSIONERS

NHC4P gives our full support to the applicants for their endeavors to protect these truly special trees.

Our communities continue to be in an emergency state when it comes to green scape. We are losing trees that are attached to the history of our neighborhoods. These are highly valued by the members of the community. They are the remnants of everything else that has already been destroyed and taken from us.

Environmentally speaking these trees are the oldest and most contributing sources of cooling, shade, source of food and habitat left on the block. Why in the world would anyone not be interested in protecting these trees.

These trees were planted by the original owners and builders of the property who were avid gardeners and food growers. They remain in their original location incredibly healthy.

There are groups working endlessly to enforce protection from outside threats who are determined to uproot everything and everyone in their way. History buildings, trees, landscape - None of them carry intentions that involve the citizens or the environment. We are living in a society where people are afraid to leave their homes not knowing if it will be demolished while their gone. Having to keep an eye on trees incase they are illegally poisoned in the middle of the night. This is what is going on right now Commissioners.

When constituents have to fight so incredibly hard to protect century old trees, something may be wrong.

The trees are a reflection of cultural, economic and social history.
Not protecting them imposes a tremendous negative impact on the community, on the environment, on our city.
NHC4P believes it would be a reflection of the cities priorities and true interests. Both; having nothing to do with the general welfare of society.

NHC4P urges the Commissioners to do the right thing in protecting a piece of historical nature - one used by community every single day.

Respectfully,

SAVE VALLEY VILLAGE
an unincorporated Association

September 1, 2015

To the attention of the Cultural-Heritage-Commission:

SAVEVALLEYVILLAGE encourages the Commissioners to support the applicants in their efforts to preserve these beautiful trees.

The history of Valley Village is depleting. Trees continue to go unnoticed as to their vital role in society. Getting over-looked as to being an essential benefiting contributor to our environment. They have become perceived as disposable - which is finally taking its toll.

The trees on the Hermitage Property emit a strength and energy one can feel when in their presence. They are the keys to our past, providing a window into our history. They have served this community well before it was established. We have a duty to protect them.

USDA Forest Service regards old trees as important simply because they have lived through eras with which we have few other connections.

There are severe and permanent consequences for tree removal. One of the most overlooked and affected the most is not visible to the eye. It is called soil compaction.
Studies demonstrate that after one-half century, compaction still afflicts soils under natural conditions.
Recovery times for soil compaction are a minimum of two human generations. Soils do not “come back” from compaction.
“Soil Compaction” is defined as a generic, negative impact on tree growth and soil health.
Soil compaction is primarily caused by construction and development activities. When the ecological integrity of a site is threatened, compaction must be prevented at all costs.
The closer to a tree compaction occurs, the geometrically greater the negative impact.
Using “biology-first’ rather than “aesthetics-first” and “personal-gain first” will assure an ecologically viable existence of the tree.
Please see the attached pages: **A Technical Guide to Urban and Community Forestry.**

Communities are counted on to ensure they are safe, healthy and sustainable. When they have stepped up to honor and respect the historic elements that make up their environment, it should be a significant indication of their pride of occupancy.

SaveValleyVillage lends our support to the efforts made to preservation the trees which have flourished and served their community for several decades.

It has become shameful - a bit embarrassing - that so many members of various communities have had to band together to work so rigorously - at preserving their own.

Respectfully,
sVV

Historic Values

Trees provide important symbolic links with the past. If a living tree is associated with important events, the tree takes on historical values unrelated to aesthetics or usefulness.
For example, a community would normally value a tree that shaded the deliberations of the community's founders. **Aside from specific events, old trees may be regarded as important simply because they have lived through eras with which we have few other connections.**

Psychological and Aesthetic Values

Although difficult to gauge, uplifted spirits is one important benefit of trees. Some of the difficulty in measuring these benefits may grow out of society's decision to exclude tree values from the marketplace.
Other emotion-based commodities, such as flowers, perfume, view property, prestige automobiles, and entertainment, are readily assigned monetary values. But with proper treatment, researchers can tie monetary values to the emotional benefits of trees.

The pleasure and good feelings we associate with trees may be far more practical than generally believed. Data on the connection between vegetation and human health are beginning to accumulate.
For example, surgery patients who could see a grove of deciduous trees recuperated faster and required less pain-killing medicine than matched patients who viewed only brick walls. And, prisoners with cells overlooking green landscapes used prison health facilities significantly less than prisoners whose cells provided views of other prison facilities. The vaguely expressed "enjoyment" people associate with trees may be partly a subconscious sign of substantial health benefits.

As for emotional and aesthetic values, historic values of trees depend primarily on community attitudes.
If historic trees are threatened by changes, such as new buildings and street widening, the issue will usually be settled by public pressure not by market forces.

Environmental Values

People value both the aesthetic and physical quality of our environment. Trees contribute to this quality by modifying local climates, reducing noise and air pollution, and by protecting soil and water.

Air pollution control is another way that trees improve the urban environment.
Urban trees could reduce heating and cooling demands enough to significantly cut fossil fuel consumption and could be about 10 times as effective as forest trees for lowering carbon dioxide in cities.

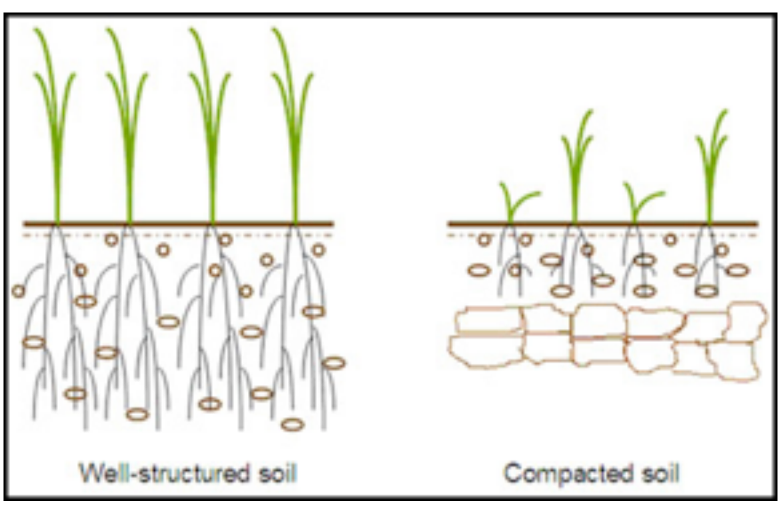
Soil and water quality are protected by trees. Trees and other vegetation protect the soil from erosion. Leaf litter that accumulates under trees creates an environment for earthworms and other organisms that help maintain soil porosity.

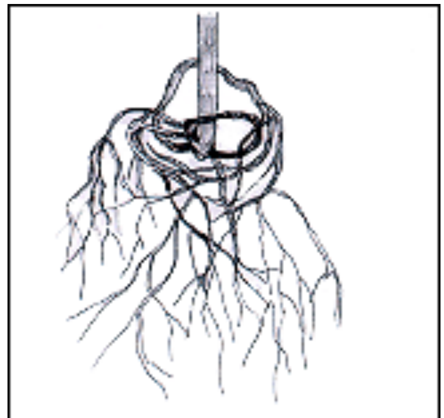
Relationship of Air and Water in the Soil
Soil provides a foundation for tree growth-structurally and biologically. Soil supports a tree's physical weight and resists the forces of wind. Soil al supplies water, air, and nutrients. The value of the soil as structural and biological support is related to soil structure.

Organic matter in the soil affects both the physical and chemical properties of the soil. A fertile soil rich in organic matter is literally alive. Although insects and earthworms are the most obvious inhabitants, microorganisms, such as bacteria and fungi, constitute the largest population by weight in the soil community. Organic matter in the soil comes from decomposed plant and animal tissue as well as the micro- organisms themselves. Organic matter enhances the aeration and water- holding capacity of the soil. It also affects the soil's chemical properties by supplying necessary plant nutrients.

The phrase "effective rooting depth" describes the portion of the soil where conditions are favorable for root growth-most often in the top three feet of the soil. Effective rooting depth may be limited by circumstances that restrict soil porosity or hinder plant growth. Four relatively common problems are surface crusting, high water tables, poor sub-surface drainage and claypans or hardpans.

Soil Compaction
Soil compaction is the major cause of death or decline of mature trees where efforts have been made to save them. Few soils can withstand traffic without becoming severely compacted.
Compaction is easier to prevent than to remedy. Avoid cultivating wet soils. Keep foot and vehicle traffic over the roots to a minimum.





(Fig. 2)

The Root System

A healthy root system serves multiple functions for the tree. Roots collect water and minerals from the soil, store nutrients, and anchor the tree. Fibrous roots are primarily responsible for the absorption of water and minerals from the soil. They most often grow in the top six inches of the soil. Woody roots provide a framework for anchoring the tree in the ground. They support the weight of the trunk and branches, including leaves, snow and ice. And, wind pressure adds to the load.

Woody roots radiate out horizontally and vertically, decreasing in size as they get farther from the trunk. Woody roots seldom penetrate the soil deeper than three feet. Because they are relatively shallow, roots are vulnerable to damage from activities on the surface. It's important to be aware of roots, because they are not easily seen, and structural deficiencies often remain unnoticed until the top of the tree dies back or the entire tree falls over.

Location of Tree Roots

Although root systems are often depicted as mirror images of the tops, they usually cover a much larger area. Roots can extend far beyond the dripline, as much as two to three times the diameter of the crown.
The major portion of the absorbing roots system of a mature tree is within the top three feet of soil, and most of the fine roots active in water and nutrient absorption are in the top twelve inches (Fig. 16). Many trees form vertical sinker roots that arise from larger horizontal roots near the trunk of the tree. Sinker roots aid in water and nutrient absorption from deeper layers of aerated soil during times of drought.

Root patterns also are affected by topography and characteristics of the soil or substrate.

Preliminary grading, stripping the site of debris and organic laden topsoil, can cause significant root damage. Most guidelines for tree preservation advise holding construction and grading outside of the dripline. However, based on a typical root structure, even that restriction could lead to removal of over half the tree's roots.

Structural Strength of Tree Crowns

A tree with branches spread out along the trunk generally has better structure than one with all its branches growing close together on the trunk. A clearly dominant leader or main trunk provides a strong framework-called a scaffold-that supports lateral branches. Several leaders of similar size offer a weaker scaffold. Even round, oval, and vase shaped trees that commonly have more than one leader should show a clear hierarchy of leader sizes. This distinction of leader size is a sign of a good scaffold. Trunk taper at the base of the trunk helps support for the entire crown. Finally, branches that have a wide angle of attachment or have connective tissue in the crotch are usually more structurally sound than those with sharp angles of attachment or imbedded bark in the crotch.

Plant Stress

Trees, regardless of species or location, have the same basic needs that must be met for the tree to remain healthy and grow. Basic requirements for plant growth include water, carbon dioxide, oxygen, nutrients, sunlight, appropriate temperature, and sufficient space.

A balance must be maintained between the amount of water lost through the leaves and that taken up through the roots. Soil conditions must allow enough root growth to supply the leaves and branches with nutrients, gaseous exchange, and water. Photosynthesis (the manufacture of sugar by the green parts in the presence of sunlight) must be able to supply the energy needs of the tree. And this energy must be conveyed from the leaves to the stem and roots.

Last but not least, the strength with which the tree grows , known as vigor, must remain high enough to prevent attack by disease-causing agents, such as bacteria, fungi, and insects.

The urban environment often places tremendous stress on trees that natural defenses may not adequately protect against. The urban environment changes rapidly, at least in comparison to the life span of most trees.

The amount of stress experienced by a tree is directly related to the rate of unfavorable change in its environment. Noninfectious diseases, which are not transmittable from a diseased plant to a healthy plant, will be especially threatening to trees whose defenses are weakened by urban pressures.

Most urban stresses can be divided into the broad categories of environmental stress, animal injury, and people pressure.

One of the most important factors contributing to moisture deficiency is the amount of space available for the roots. If roots are restricted, they cannot spread through enough soil to gather the moisture needed to support the crown.


Restricted root space is capable of causing roots to grow in a girdling pattern, creating a structural deficiency in the anchorage of the tree.

People apply a variety of pressures that adversely affect the health of trees. Trees are easily disturbed by construction of buildings and roads, soil compaction, chemicals, air pollution, and improper tree maintenance also fall into this category.

In addition to the stresses that come from the direct or indirect actions of people, urban trees also suffer from human inaction. Well meaning people sometimes impede appropriate urban forest management. Education is one way to increase the knowledge of urban forestry and to get people to work together to support it.

There appears to be a trend toward increasing density in many new residential and commercial developments. This threatens a corresponding reduction in the space available for trees.

Long-range Planning

Urban forestry concerns must be reflected in comprehensive planning. By adopting the plan, government officials signify their support for trees in the urban environment.

Comprehensive plans generally contain, among other things, elements that address the environment and transportation. Both of these elements should contain references to trees as they relate to the urban infrastructure.

The environmental element should identify the need for preservation of the natural environment within developed areas.

This element should also contain language calling for planting, maintenance, and preservation of native and introduced species along streets and in other open spaces. The transportation element should incorporate aesthetic considerations in the development of traffic circulation systems, and in providing for adequate right-of-way for tree planting.

Short-range Planning

Supporters of urban forestry can use the short-range plans to document areas in need of special attention. This may include preservation of critical habitat, development of tree-lined corridors or beautification of major entrances to the community. Including these concerns in the short-range planning process helps solidify support from planning staff and local decision makers.

Site Specific Planning

Enforced through land development regulations, this level of planning affects preservation.

Significant individual trees or entire stands may be planted, saved or removed based on a plan at this level. So regardless of the contents of higher level plans, site specific plans should be scrutinized before approval is given. Before development, sites should be inspected to verify that plans have been drawn correctly and that there are tree protection measures.

Because tree removal or replacement generates community concern, citizens and policy makers should both be involved in the process.

Criteria for tree removal form the basis for objectivity in the midst of the emotional furor that often develops over tree removal in urban areas. Objective criteria would include structural integrity, and public welfare. Secondary criteria would include: diminishing aesthetics, amenities, and engineering values, such as noise abatement and wind reduction, environmental impacts including species habitat.

Land Use

One goal of urban forest management is to create and maintain the maximum amount of visual and biological diversity. **Preserving the uniqueness of different areas that compliment the activities occurring there.**

The urban landscape can be divided into four broad land use categories: natural areas, parklands and campuses, residential property, and fragmented spaces. These categories are based primarily on activities that take place in them and the mood created by those activities.

Remember that maintaining and preserving the urban forest for future generations is a big job - Education campaigns can stress the value of trees to the community, their contribution to properties, environmentally and economically. Decisions on tree removal should not be influenced or based on private benefit.

Shannon Ryan <shannon.ryan@lacity.org>

FWD: letter_

info@savevalleyvillage.com <info@savevalleyvillage.com> Wed, Sep 9, 2015 at 12:35 PM
To: shannon.ryan@lacity.org
Cc: MacNaughtonEsq@gmail.com, contact@sfvts.com, aimeefrappied@gmail.com

------ Forwarded Message ------
From: The San Fernando Valley Tree Society <contact@sfvts.com>
Subject: Fwd: letter_

How are you.

I've attached a letter for submission. Per our discussion and after getting the boards feedback we strongly urge you to press for the other trees. That Mulberry is quite rare. . The fact that it produces so much fruit is notable. We can't even get those at the farmers market.

The Platycladus orientalis (Synonym Thuya) is on the Red List and Near Threatened - I strongly encourage you to do what you can to protect this tree. You may want to get in touch with the EPA and inform them as well. They may require it be protected.

In addition to, the P. macrophyllus trees are another rarity. The amount of fruit produced by the Yew is another fascinating discovery. These trees are incredibly important to that environment considering the surroundings. All of these findings demonstrate the care you have given all of these trees over the years Jennifer. It is quite remarkable.

I went ahead and included our additional findings on a second page. I hope you can use it.

To answer your question: We do our best to explain to the lay person the extensive damage caused by tree removal. As you know, sometimes we succeed and other times we do not. They may just not be capable of understanding the disruption, the affects. This is not good news for the trees, the web, our environment or us. Although taking time, I do believe people may be at the beginning stages of realizing how deep and how permanent the damage stretches. It makes perfect sense why your corner is such the oasis to everyone -- -- What is lacking throughout the entire city exists all on your property; so of course people are drawn to it. It is a truly special place and we enjoyed spending time there.

I asked Robert to do a little research as to the Office policies - he will get back to me no later than tonight. And yes - of course - we all know why he did what he did. He agrees it absolutely goes against the Code of Ethics. Let Rob do a little more digging, he is in his element.

Please keep us informed as to the actual determined date of the hearing. Let us wait and see in what other ways they furnish his needs.

Talk to you soon and looking forward to seeing you tomorrow.

------ End of Forwarded Message

SFVTS-letter_09_08_15.pdf
196K

September 8, 2015

SFVTS

To the Cultural-Heritage Commission of Los Angeles,

Please accept this letter from the San Fernando Valley Tree Society offering our absolute and full support in designating a pair of mature Cinnamomum camphora trees located in North Hollywood/Valley Village.

An ariel view (see attached page) of the area shows this to be the last remaining greenery of this scale in this location. . . . Urban deforestation continues to cause a significant number of species to become extinct for no other reason than the loss of trees. These in particular have been utilized and continue to be habitat to several species of birds, and a dependable food source for wildlife in the area; which is scarce.

There is never going to be factual evidence indicative of reasonable justification to remove healthy, mature, deep rooted, beneficial and much needed trees, with the notion that a replacement tree will somehow be sufficient in its place.

- It will not be in our lifetime anyone sees the benefits of trees planted today -

The removal of one tree:

✦ Loss of water and vapor released into the air.
✦ Loss of shade that keeps soil below moist causing soil erosion.
✦ Increase green house gases.
✦ Loss of habitat to wildlife and beneficial insects.
✦ Loss of food source.
✦ Loss of medicinal source.
✦ Loss of oxygen.

Well established near century old trees such as the two *C. Camphoras* have an entire world living below and above ground. Their root system is incredibly well established and has been known extend more than double the length of the tree. They are incredibly vulnerable to disturbance. The trees are in remarkable health. The loss of these trees would be a tremendous loss in history, and a tremendous mistake. A permanent one.

September 8, 2015

SFVTS

To the Cultural-Heritage Commission of Los Angeles,

After visiting the site and examining the trees, we learned this property to be filled with an abundance of trees, some more than 50 - 60 years of age.

✦ *P. macrophyllus* also known as Yew Pine, Buddhist Pine and sometimes the Fern Pine. Incredibly healthy and one of the most fruit bearing we have ever seen. Arils are used as the primary food source for birds. There are currently more than 3 nests occupying these wonderful trees.
✦ *Celtis sinensis* is a valuable tree known for its ability to withstand severe droughts. It is also one of the most popular pollen sources for bees. Some of the most valuable and wide range class of insects depend solely on the *Celtis saneness* in this environment.
✦ *Yucca gloriosa* was another unexpected discovery. A coalescent evergreen shrub which has grown incredibly tall, reflecting its health. This plant can live on almost zero water and provides a delicious fruit for both human and wildlife consumption.
✦ *Lagerstroemia speciosa* sometimes called Queen's Flower. Deciduous tree, has been known to grow more than 75 feet in height. A study done carried on their floral reproductive systems, diversity and constancy of visiting insects at different hours of day, revealed the behavior of the insects at the flowers and the influence of the environmental factors in relation to their visits. A great diversity of insects was verified visiting the flowers with the predominance of bees.

The above mentioned have established and signified their positions in our environment. Not protecting them is not in our best interest. There are significant effects both directly and indirectly which <u>can</u> and <u>should be</u> avoided.

The SFVTS sees this as an opportunity. One which has our full support.

In conclusion, there is simply no logical reason not to protect these amazing trees. At more than 80 years old - - - - - they have earned it.

SFVTS

To the Cultural-Heritage Commission of Los Angeles,

NOTE THE "ISLAND OF TREES" AMIDST MASSIVE BUILDINGS AND PAVING!

photo: Courtesy of Jan Scow

Jan C. Scow Consulting Arborists, LLC
Disease and Pest Diagnosis, Hazard Evaluation, Restorative Pruning Advice, Value Assessment

1739 Franklin Street Unit A
Santa Monica, CA 90404
(818) 789-9127

Date: 6/14/15
[redacted]
From: Jan Scow
Subject: Trees at 5303 Hermitage

You asked me to examine the property at the subject address and provide my opinion of the trees there to aid you in your efforts to have the property classified as a heritage site. My description follows.

This property is a throwback to a less urban feel in the Valley. It is a peaceful oasis in the midst of rapidly expanding apartments in the neighborhood. The most striking thing when you first approach it is the canopy of mature trees. Primary among these are the two large camphor trees (*Cinnamomum camphora*). These trees were probably planted when the property was first developed in the 1930's and are quite possibly the oldest trees in the neighborhood at over 80 years old. The larger of the two camphor trees has a trunk diameter of 37 inches at 4.5 feet above grade, while the smaller one is 28.5 inches in diameter. Both trees are relatively healthy and well cared for. These two large trees shade the entire front of the lot and provide food and habitat for many species of birds as well as tree squirrels. It is sometimes stated that tree roots may grow 1.5 times the distance of the canopy spread. If that is the case, potentially there are roots from these camphor trees under all the streets and properties surrounding this site.

Near the smaller of the two camphor trees is a small hackberry tree (*Celtis* sp.). While these are not considered rare in southern California, I do not see many of them in my travels around the southland. They are a durable, trouble-free tree that seldom needs pruning and has a reputation for being deep-rooted and not buckling sidewalks! These trees produce berries that squirrels and birds feed on. This particular tree is quite nice and although small, in very good condition. Its trunk diameter is 16 inches at 1 foot above grade.

In the front northeast corner, near and under the larger camphor tree, is a female white mulberry or "silkworm mulberry" (*Morus alba*). This is also something seldom seen in cultivation in SoCal. The tree is healthy and, although tucked under the huge camphor next to it, quite picturesque. We noted some fruit on this tree also, which is edible not only to squirrels and birds, but also to people. This tree may be more than 45 years old, based on old photos. Another interesting observation about this species is described in the following abstract:

High-speed pollen release in the white mulberry tree, *Morus alba* L
Philip E. Taylor, Gwyneth Card, James House, Michael H. Dickinson, Richard C. Flagan

> *Anemophilous plants described as catapulting pollen explosively into the air have rarely attracted detailed examination. We investigated floral anthesis in a male mulberry tree with high-speed video and a force probe. The stamen was inflexed within the floral bud. Exposure to dry air initially resulted in a gradual movement of the stamen. This caused fine threads to tear at the stomium, ensuring dehiscence of the anther, and subsequently enabled the anther to slip off a restraining pistillode. The sudden release of stored elastic energy in the spring-like filament drove the stamen to straighten in less than 25 μs, and reflex the petals to velocities in excess of half the speed of sound. This is the fastest motion yet observed in biology, and approaches the theoretical physical limits for movements in plants.*

Across this lot to the west and across Weddington Street to the southwest (not on the subject property) are two very large Tree-of-Heaven trees (*Ailanthus altissima*). While this species is often considered an undesirable tree, these two individuals are some of the largest I have ever seen and appear to be well cared for and quite healthy. The provide shade comparable to that cast by the two camphor trees. The larger of these two trees is over 36 inches trunk diameter at 18 inches above grade and at least 50 feet tall. Although this species is often criticized, I find them quite remarkable and noteworthy.

Finally, there is an American arborvitae (*Thuja occidentalis*) at the southwest corner of the front house. This tree is probably fairly old (it is estimated that this tree is over 65 years old based on photos), but it is still small, and picturesque in its setting, having grown more tall and narrow than typical, probably because of its location surrounded by buildings. Once again, while this tree is not terribly unusual or rare, it is native to the Pacific Northwest and I do not see many of these in LA.

This is an unusual property in the Valley Village area where so many large buildings have risen and so little open space remains. It provides an ambiance and peacefulness that is a welcome relief in the bustling San Fernando Valley. It is the home of several worthy and notable trees and provides habitat for many species of birds and mammals, at the very least. I have provided photographs of some of the trees discussed and hope that this is useful!

Please let us know if we can be of any further assistance or if you have any additional questions. Our goal is to satisfy our clients and help them to better care for their trees in the most effective way possible. We look forward to working with you toward that goal!

Sincerely,

Jan C. Scow
ASCA Registered Consulting Arborist #382
ISA Certified Arborist # WC1972

Attached:

1) Photos (5 pages)
2) Aerial photo

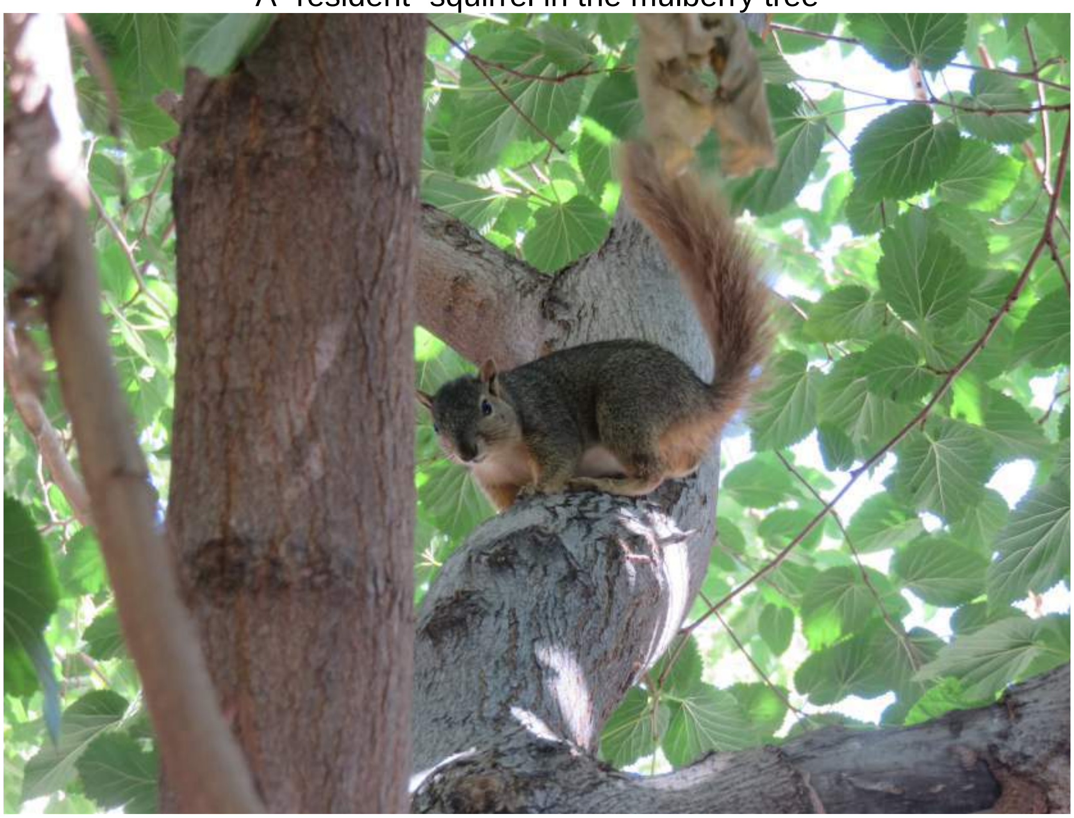
Looking east, at two large camphors, with hackberry in the right foreground.

Hackberry with fruit

White mulberry

Mulberry fruit

A “resident” squirrel in the mulberry tree



Looking up into the canopy of the “small” camphor tree.

Hackberry

Fruit (immature cone) of American arborvitae


THE ONLY "ISLAND OF TREES" AMIDST
MASSIVE BUILDINGS AND PAVING.
5303 Hermitage Ave
Weddington St
Hermitage Av

Soil Compaction & Trees: Causes, Symptoms & Effects

by Dr. Kim D. Coder, University of Georgia July 2000

Introduction

The health and structure of trees are reflections of soil health. The ecological processes which govern tree survival and growth are concentrated around the soil / root interface. As soils, and associated resources change, tree systems must change to effectively utilize and tolerate changing resources quantities and qualities, as well as the physical space available. Soil compaction is a major tree-limiting feature of community forest managers and arborists.

Soil compaction is the most prevalent of all soil constraints on shade and street tree growth. Every place where humans and machines exist, and the infrastructures that support them are built, soil compaction will be present. There are few soil areas without some form or extent of soil compaction. Soil compaction is a fact of life for trees and tree managers. Unfortunately, prevention and correction procedures are not readily used nor recognized for their value.

This paper is a summary of soil compaction processes and tree growth effects. In addition, some general renovation principles are proposed. Understanding how soil compaction occurs, developing more accurate and precise definitions of soil compaction effects, and recognizing tree growth effects stemming from compaction problems will be the primary emphasis here. This paper will concentrate entirely on the negative growth constraints of compaction. Figure 1.

Infrastructure Ecology

The small amounts of land where we concentrate many thousands of people do not represent the true carrying-capacity of the natural resources on the site. We are forced to concentrate natural resource inputs and outputs from a large surrounding area in order for our cities to exist. The means of concentrating resources is through building and maintaining engineered infrastructures such as streets, pipes, wires, curbs, buildings, parking lots, water collections and treatment systems, and environmental management devices for building interiors. The infrastructure waste-spaces (not needed for building or maintaining infrastructures) are delegated to "green" things.

Living systems which remain are containerized and walled into small spaces adjacent and intertwined with massive infrastructure systems. The ecology of infrastructures involve resource and process constraints to such a degree that living systems are quickly damaged and exhausted. A summary of the resource attributes around infrastructures are: many humans and machines functioning as sources for disturbance and stress problems (both chronic and acute); fragmented and diminished self-regulating ecological states and processes (declining living things, organic matter, biotic interactions); and, less open soil and ecologically active surfaces.

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As infrastructures requirements increase and generate more ecological impacts, the associated building, maintenance, demolition, and renovation processes cause natural resource quality and usability to decline. Key components of this decline are complex soil resource alterations including water, gas exchange, mechanical impedance, and pore space alterations. Soil compaction is a primary measurable feature of the ecological damage with which we are surrounded.

Defining Soil Compaction

Ideal Soil Features – Soil resources are always changing. Pore space, water and gas contents, and the electron exchange environment are dynamically changing in a soil every moment. Chemical, biological and physical soil features are always under change. Within this continuing changing environment, tree roots must develop growth and survival solutions.

An ideal soil has 50% pore space, divided among air-filled pores and water-filled pores. In addition, 45% of an ideal soil is composed of mineral materials with 5% composed of living and dead organic materials. Within ideal soils, structural units and specific horizons develop. Because an ideal soil does not exist around infrastructures, tree managers must work with soils which are fill-derived, trenched, cut, compacted, polluted, excavated, unstructured, crusted, and poorly developed.

Pore Spaces -- Pore space exists around: individual particles (texture units) such as sand, silt, and clay; individual structural units (soil aggregates); and, gaps, cracks, and the interfaces of infrastructure and soils. There are a series of trade-offs across pore spaces. Large sized soil pores are usually filled with air, and so provide good aeration but poor water holding capacity. Small soil pores are usually filled with water, and so have large water holding capacity but poor aeration. Soils dominated by small soil pores have more total pore space than soils dominated by large pores. For healthy soils, coarse textured soils dominated by large air-filled pores need more water availability. Fine textured soils dominated by small water-filled pores need more aeration for good root growth. Figure 2.

There are three primary forms of pore spaces in a soil: aeration pores filled with air at or below field capacity; and, capillary pores filled with water. Figure 3 provides semantic and size definitions. Capillary pores are further divided among two size subgroups: tree-available water-filled pores; and, tree-unavailable water-filled pores. The tree-unavailable water resides in the smallest soil pores where the tree can not exert enough force through transpiration to remove the pore water. Water is being held so tightly that the tree is unable to pull water into the roots. Figure 4.

Other Attributes -- Along with pore space volumes, there are three additional attributes of soils which must be appreciated. The first is resource changes with soil depth. With increasing soil depth there is a natural increase in CO_2 concentrations and a decrease in O_2 concentrations. The balance between these two gases change with water content and biological activity. The soil gas atmosphere directly impacts tree root growth.

A second attribute critical to soil and tree health is organic matter. Organic matter, as it decays, provides cation and anion exchange capacity, water hold capacity, mineralized essential elements, a substrate and fuel for the detritus food web, and pore space. Organic matter in natural soil systems is deposited on the surface as plant litter or near the soil surface as root breakdown / turnover. The decomposing materials then move downward through the soil and pass the absorbing roots.

A third soil attribute critical to tree root growth is a developed structure. Structural units, or soil aggregates, are the next order of particle yielding pore space. The basic soil particles (sand, silt, and clay) are held together in clumps, clods, or structural units. These structural aggregates are held together with metallic, organic, and/or colloidal coatings. Between structural aggregates are soil pore spaces utilized by tree roots. Because of pore size and availability, tree roots heavily utilize pore space derived from structural aggregate development.

Compaction Definition(s)

To properly discuss soil compaction as seen in the field which limits and damages tree health, a clearer definition is needed regarding soil compaction. A more precise and accurate definition is needed in order to discuss tree symptoms and managerial solutions. In this discussion the word "compaction" will be used as a composite, generic, negative impact on tree growth and soil health. My composite "compaction" concept will include soil compression, soil compaction, and soil consolidation.

Compression -- The process which damages soil around infrastructures called compaction starts with soil compressibility or loss of soil volume. Soil compression leads to a loss of total pore space and aeration pore space, and a increase in capillary pore space. In other words, large air-filled pore spaces are crushed leading to more small water-filled pores. Compression is most prevalent in soils under wet conditions.

Compaction -- The next process soil undergoes is true compaction. Compaction is the translocation and resorting of textural components in the soil (sand, silt, and clay particles), destruction of soil aggregates, and collapse of aeration pores. Compaction is facilitated by high moisture contents.

Consolidation -- The third primary component of soil compaction is consolidation. Consolidation is the deformation of the soil destroying any pore space and structure, and water is squeezed from the soil matrix. This process leads to increased internal bonding and soil strength as more particle to particle contacts are made and pore space is eliminated.

The three components of the generic term "soil compaction" listed above do not necessarily occur in order, or on any given soil. A general summary of compaction as applied to tree and soil health problems would be a soil which has: loss of soil aggregates; destroyed aeration pore spaces; crushed or collapsed pore spaces; and, undergone extensive resorting and packing of soil particles.

The depth to which a soil is compacted is determined by the compacting agent or process. Every type of management which requires soil contact has a characteristic compaction zone / layer either at the surface or at some given depth below the surface. Cultivation or management pans or layers form from soil cultivation, packing of soil fills or lifts, and various types of traffic patterns. New compaction requirements may be developed over the top of past compaction problems.

Additional Components – In addition to the "3Cs" of compaction listed above (compression, compaction, consolidation), generic compaction problems can often also include crusting, puddling, and rutting. These latter components represent the extent and depth of a damaged top surface layer of the soil or a top seal on a soil column. In addition to compaction, these components can generate soil conditions difficult for tree health maintenance and for effective remediation. Crusting, puddling and rutting generate soil and tree damage similar to applying a plastic sheet to the soil surface.

Crusting is the dislocation and packing of fine particles and organic matter on the soil surface. In addition, natural products and pollutants can be associated with the surface making a hydrophobic surface, and preventing water and oxygen infiltration. Primary causes of crusting is the impact of rain drops on open soil surfaces, irrigation impacts, and animal and pedestrian traffic. Small local impacts on the soil surface help facilitate crusting.

Puddling and rutting develop a dense, thick crust or cap on the soil surface. The primary mechanism of damage is from destruction of soil aggregates and aeration pores through particle movements caused by hydraulic pressure. In saturated soils under a top load, there is no place for non-compressible water to go except to the side, squashing structure and pores. Foot and vehicle traffic under saturated soil conditions, and equipment movement on the soil surface over shallow saturated soil layers facilitate puddling and rutting.

Measuring Compaction

Tree health management is limited in how easily and effectively we can measure absolute and relative soil compaction. The primary resources critical to tree growth in the soil are O2 availability, gas exchange with the atmosphere or circulation, and soil strength values. Because of the difficulty in simultaneously measuring these items quickly in the field, we have developed a number of approximate measures for soil compaction. The two measure most commonly used are bulk density and soil penetration force. Unfortunately both are soil moisture content and organic matter dependent. Additionally, bulk density and soil penetration force are not measures of the same features in the soil, and so, are not closely correlated.

Bulk density, when collected under the right soil conditions in the right soils can provide a great deal of information. Bulk density is the weight of the soil per unit volume (usually in g/cc). As bulk density increases, total pore space declines and aeration pore space is destroyed. In one soil for example, a 20% increase in bulk density initiated a 68% loss of aeration pores and an increase in 7% capillary pore space. Bulk density as a measure of soil compaction rapidly increases with the first few impacts on the soil surfaces then levels-off. Soils can be compacted to 90-95% of what they can be compacted to in as little as 3-4 trips over a single site. In other words, it is not years of traffic, but the first 4 trips that does the majority of compaction.

Table 1 provides bulk densities for selected construction materials and associated pore space. Some compacted soils have higher measured bulk densities than some common construction materials. It is possible to find soils around infrastructures which are more dense than the wall of the building they adjoin. Table 2 provides the formula calculation and table of values for the amount of pore space in a soil with a given bulk density.

Tree Root Survival & Growth

Roots utilize space in the soil. The more space controlled the more potential resources controlled. The volume of soil space controlled by tree roots is directly related to tree health. The resources required are water, oxygen, physical space for growth processes, and open soil surface area for replenishment of essential resources. Tree roots occupy the spaces and gaps around, under, and between infrastructures. In heavily compacted sites, roots will be concentrated around the edges of infrastructures and filling any moist air space. The soil matrix is only a significant concern for essential elements, surfaces holding biological cooperators, and frictional and inertial forces for structural integrity. Figure 5.

Tree roots and the soil surrounding them are an ecological composite of living, once-living, and abiotic features facilitating life. Compaction initiates many negative impacts in the soil including: decreases the volume of ecologically active space available; tree rootable space is decreased and made more shallow; the detritus food web, the ecological engine responsible for powering a healthy soil, is disrupted and modified; the diversity of living things decline, beneficial associates are eliminated, and a few ecological niche generalists succeed; and, pests favored by the new conditions (i.e. Pythium &

Phytophera) consume organisms and roots not able to defend themselves. Tree roots become more prone to damage and attack at a time when sensor, defense, growth regulation, and carbon allocation processes are functioning at reduced levels.

Root Requirements

Growth in trees may not be a positive increase in living mass, but does represent expansion of tissues into new spaces. For roots, the tips elongate and the tissues thicken in diameter. Lateral roots are developed adventitiously and allowed to elongate and radially thicken. Root density, mass, and activity vary with internal and external conditions. Resources required for root growth are summarized in Table 3.

Table 3: Brief list of root growth resource requirements.

root resource	requirements minimal	maximum
oxygen in soil atmosphere (for root survival)	3%	21%
air pore space in soil (for root growth)	12%	60%
soil bulk density restricting root growth (g/cc)	-	1.4 clay
	-	1.8 sand
penetration strength (water content dependent)	0.01kPa	3MPa
water content in soil	12%	40%
root initiation (O2% in soil atmosphere)	12%	21%
root growth (O2% in soil atmosphere)	5%	21%
progressive loss of element absorption in roots (O2% in soil atmosphere)	10%	21%
temperature limits to root growth	40°F/4°C	94°F/34°C
pH of soil (wet test)	pH3.5	pH8.2

Roots utilize soil spaces for access to water and essential element resources, and to provide structural support. Roots grow following pathways of interconnected soil pores. Pore space can be the result of the space between textural units (sand, silt, and clay particles), between structural units (blocks, plates, grains, prisms, etc.), along fracture lines (shrink / swell clays, frost heaving, pavement interfaces, etc.), and through paths of biological origins (decayed roots, animal diggings, etc.).

Roots survive and grow where adequate water is available, temperatures are warm, and oxygen is present. Roots are generally shallow as limited by oxygen contents, anaerobic conditions, and water saturation in deeper soil. Near the base of the tree, deep growing roots can be found, but they are oxygenated through fissures and cracks generated as a result of mechanical forces moving the crown and stem under wind loads (sway).

Growth Forces

The ability of primary root tips to enter soil pores, further open soil pores, and elongate through soil pores is dependent upon the force generated by the root and the soil penetration resistance. Root growth forces are generated by cell division and subsequent osmotic enlargement of each new cell . Oxygen for respiration, and adequate water supplies are required. Figure 6. Tree roots can consume large amounts of oxygen during elongation. At 77°F (25°C) tree roots will consume nine times their volume in oxygen each day, at 95°F (35°C) roots can use twice that volume per day. The osmotic costs to cells of resisting surrounding forces and elongating can be significant.

In response to increased compaction, roots thicken in diameter. Compaction also forces roots to generate increased turgor pressures concentrated farther toward the root tip, to lignify cell walls quicker behind the growing root tip, and to utilize a shorter zone of elongation. Thicker roots exert more force and penetrate farther into compacted soil areas. Figure 7. As soil penetration resistance increases in compacted soils, roots thicken to minimize their own structural failure (buckling), to exert increased force per unit area, and to stress soil just ahead of the root cap which allows for easier penetration.

For effective root growth, pore sizes in the soil must be larger than root tips. With compaction in a root colonization area, pore space diameters become smaller. Once soil pore diameters are less than the diameter of main root tips, many growth problems can occur. The first noticeable root change with compaction is morphological. The main axis of a root becomes thicker to exert more force to squeeze into diminished sized pores. As roots thicken, growth slows and more laterals are generated of various diameters. Lateral root tip diameters are dependent upon initiation by growth regulator and the extent of vascular tissue connections. If laterals are small enough to fit into the pore sizes of the compacted soil, then lateral growth will continue while the main axis of the root is constrained. If the soil pore sizes are too small for even the lateral roots, root growth will cease. Figure 8.

Tree Species Tolerance

Across the gene combinations which comprise tree forms, there is a great variability in reactions to soil compaction. As there are many different soils and associated responses to compaction, so too are there many gradations of tree responses to compaction. A tree's ability to tolerate compacted soil conditions is associated with four primary internal mechanisms: reaction to mechanical damage is effective and fast; continuation of respiration under chronic O2 shortages; ability to continue to turnover, reorient, and adjust absorbing root systems; and, ability to deal with chemically reduced materials (toxics).

A list of trees meeting the above criteria for soil compaction tolerance can be found in: *Coder, Kim D. 2000.* ***Compaction Tolerant Trees.*** *University of Georgia School of Forest Resources Extension Publication FOR00-2. 1pp. (Download at WEB site www.forestry.uga.edu/efr under "tree health care.")*

Causes of Compaction

In order to understand and visualize soil compaction more completely, the underlying causes must be appreciated. Soil compaction is primarily caused by construction and development activities, utility installation, infrastructure use and maintenance, and concentrated animal, pedestrian, and vehicle traffic. Below are listed individual components of how soil is compacted.

Conducive Moisture Contents – For every soil type and infrastructure situation there is a soil moisture content at which the soil can be severely compacted with minimal effort. These moisture content levels can be used to compact a soil for construction activities, but should be avoided when defending tree and soil health. Both direct impacts and vibrational energy will cause compaction when the soil is at or near its compaction moisture content maximum. Figure 9.

Pedestrian & Animals – The pounds per square inch of force exerted on the soil surface by walking, grazing, standing, and concentrated humans and other animals can be great. Problems are most prevalent on the edges of infrastructures such as fences, sidewalks, pavements, and buildings. Holding, marshaling, or concentration yards allow significant force to be delivered to soil surfaces. Paths and trails provide a guided journey of soil compaction.

Vehicles – Conveyances with tracks, wheels, and glides provide a great deal of force on the soil surface. Narrow rubber tires can transfer many pounds of compaction force to the soil. The classic example are in-line skates and high pressure bike tires. These wheels can impact soils beyond 60lbs per square inch. Broad, flat treads can dissipate compaction forces across more soil surface than tires, and reduce forces exerted per square inch.

Soil Handling – The movement, transport, handling, and stockpiling of soil destroys aeration pore spaces and disrupts soil aggregates. Soil cuts, fills, and leveling compacts the soil. Soil handling equipment can be large and heavy allowing compaction many inches deep.

Vibrations & Explosions – Any mechanical energy that impacts individual soil particles can cause compaction. Car and truck traffic can cause vibrations which compact soils effectively at higher moisture contents. One solution to compaction in the past was use of explosives to fracture soils. The end result was the explosive energy fractured the soil in areas but heavily compacted the soil in other areas. Explosives damaged the soil to a degree not offset by aeration pores formed.

Intentional Manipulations – In order for infrastructures to be built and maintained, the supporting soil must be properly compacted. Because of how forces in soil are distributed beneath infrastructures, a compacted pad with slanted base sides must be build. This process assures that infrastructure edges, bases, and lifts (compacted fill layers) are heavily compacted. The only space available for tree root colonization are fracture lines and coarse building materials where large air spaces occur. The greater the compaction, the closer to the surface the soil anaerobic layer develops, decreasing effective rooting volume.

A note needs to be made here regarding pavements. Soil is a complex material with a unique thermal and moisture expansion and contraction pattern. Soil expands and contracts over a day, season, and year at different rates than adjacent pavement or hard infrastructures. As a result, fissures and fracture lines filled with air occupy the interface between soil and infrastructures. These aeration pore spaces can be effectively colonized by tree roots. If infrastructures are not ecologically-literate in their construction, tree roots can generate enough mechanical force to accentuate any faults present.

In addition to the aeration pore space from structure / soil interfaces, the coarse sub-grade and paving bed materials can provide moist aeration pore space for tree root colonization. The interface between pavement and its bedding material can be a well aerated and moist growing environment. Compaction may have caused anaerobic condition to be found close to the surface under pavement while the pavement bed may provide a secure colonization space for tree roots. Physical or chemical root barriers may be needed to prevent root colonization of infrastructure aeration spaces.

Water Interactions – Water influences soil conditions conducive for compaction as well as providing energy directly to the soil surface for compaction. Direct irrigation impacts from sprinklers or rainfall hitting the soil surface can cause crusting and compaction. Piling of snow in winter when the soil is frozen compacts little, but large snow drifts remaining on-site as soils begin to thaw can lead to compaction from direct contact as well as from maintaining high moisture concentrations allowing for long periods of compaction susceptibility.

Soil saturation allows for hydraulic pressure to destroy soil aggregates and move fine particles into aeration pore spaces. Flooding events can lead to dissolved aggregate coatings and aggregate stability loss. Erosional processes across the surface of the soil and particle movement within the top portions of the soil (dislocated fine particles) can lead to aeration pore space loss and crusting.

Organic Matter Loss – Organic matter is the fuel, short-term building blocks of soil structure, and supply warehouse for living things in the soil. As organic matter decomposes and mineralizes without adequate replacement, soil becomes more compacted. Bulk density increases and aggregate stability declines as organic matter is "burned " out of the soil.

Functional Results of Compaction

Having reviewed the primary means by which soils become compacted, the results of compaction can be estimated for tree and soil health.

Destruction of soil aggregates and large pore spaces – The pore spaces from cracks, interface surfaces, biotic excavations, organic particle decomposition, and normal soil genesis processes help oxygenate the soil matrix. By definition, compaction results in the destruction of soil aggregates and aeration pore spaces. Pore spaces filled with O_2 and interconnected with other aeration spaces exchanging gases with the atmosphere are critical to a healthy soil and tree root system. The destruction of aeration spaces surrounding soil aggregates can be unrecoverable.

Resorting / redistribution of particles – (Change in particle distribution) Particles of soils are redistributed into new locations, many of which are open pore spaces in the soil matrix. Through processes of packing, erosion, and cultivation many fine particles can fill-in the spaces surrounding other particles, as well as the spaces between structural aggregates. Some soil types can be compacted more easily through this process than others. Mid-textured soils with a mix of particle sizes can be strongly compacted due to particle size availability to fill any size of pore space.

Total pore space changes – (Change in pore space distribution) Compaction initiates a redistribution of pore sizes within the soil matrix. Large pores are destroyed and small pore are generated. The total pore space of the compacting soil initially increases as more capillary pores are created as aeration pores are lost. With increasing compaction, soil strength increases and pore space declines. Figure 10.

Aeration pore space destruction – The crushing collapse of aeration pores facilitates the upward movement of the anaerobic layer. There are always anaerobic and aerobic micro-sites in and around soils aggregates within the surface layers of soil. The dynamic proportions of each type of micro-site changes with each rainfall event and each day of transpiration. Compaction shifts proportional dominance in the soil to anaerobic sites. With further compaction, aerobic sites are concentrated closer and closer to the surface until little available rooting volume remains. Table 4 lists root-limiting aeration pore space percentages in soils of various textures. Air pore space less than 15% is severely limiting.

Table 4. Root growth limiting air-pore space values by soil texture.

soil texture	root-limiting % pores normally filled with air
sand	24%
fine sand	21
sandy loam	19
fine sandy loam	15
loam	14
silt loam	17
clay loam	11
clay	13

<u>Increased mechanical impedance</u> – Compaction brings soil particles into closer contact with each other (less moisture and/or greater bulk density). Closer contact increases surface friction and soil strength. As soil strength increases and pore sizes decrease, the ability of roots to grow and colonize soil spaces declines rapidly. With compaction, soil strength reaches a level where roots can not exert enough force to push into pore spaces. Pore space average diameters significantly smaller than average root diameters are not utilized by tree roots. Figure 11. Table 5 lists root-limiting bulk densities by soil texture. The texture and bulk density must be known to estimate compaction impacts.

Table 5. Root growth limiting bulk density values by soil texture.

soil texture	root-limiting bulk density (g/cc)
sand	1.8 g/cc
fine sand	1.75
sandy loam	1.7
fine sandy loam	1.65
loam	1.55
silt loam	1.45
clay loam	1.5
clay	1.4

<u>Connectivity of aeration pores decreased</u> – The aeration pathway (lifeline) from the atmosphere to the root surface through all the interconnected aeration pores declines quickly with compaction. As the

tortuosity of the oxygen supply path increases, the closer to the surface the anaerobic layer moves. As pore sizes become smaller with compaction, more of the pore space is filled with water. Water-filled pores diffuse O2 at rates 7,000 to 10,000 times slower than air-filled pores. With all the other aerobes and roots in the soil competing for the same oxygen, oxygen limitations become severe. Figure 12.

<u>*Poor aeration*</u> – Compaction constrains O2 movement in the soil and shifts soil toward anaerobic conditions. Less O2 diffusion into the soil leads to a chemically reducing soil environment (both the soil solution and soil atmosphere). Under these conditions, toxins and unusable essential element forms are generated. In addition, organic matter is not mineralized or decomposed.

A soil anaerobic respiration sequence is initiated among bacteria starting with nitrogen and moving through manganese, iron, and sulfur, ending with carbon (fermentation of roots). Tree roots are aerobes as are root symbionts and co-dependent species of soil organisms. Less oxygen prevents growth, defense, and survival in aerobes. Roots use available food 20 times more inefficiently under near anaerobic conditions. Less oxygen also allows common pathogenic fungi which have oxygen demands must less than tree roots to thrive. As O2 concentration falls below 5% in the soil atmosphere, severe root growth problems occur. Figure 13. Figure 14. Figure 15.

<u>*Poor gas exchange with atmosphere*</u> – Compaction prevent gas exchange with the atmosphere. Compaction prevent O2 from moving to root surfaces, but also prevents CO2 and toxics (both evolved and resident) from being removed from around the roots and vented to the atmosphere. Poor gas exchange allows the anaerobic layer to move closer to the surface and reduce rooting volume. As CO2 comprises more than 5% of the soil atmosphere, problems of aeration become compounded. As CO2 climbs above 15% in soils, root growth dysfunctions accelerate. Figure 16.

<u>*Less tree available water / Less water holding capacity*</u> – One of the most ignored result of compaction is it effects on soil water availability. Soil compaction reduces the tree available water held in the large capillary pores and increases the volume of small capillary pores which hold water unavailable to trees. With the decreasing number of large capillary pores and increasing number of small capillary pores, the total water holding capacity of the soil declines. Irrigation scheduling and monitoring becomes critical around trees in compacted soils. Figure 17. Figure 18. Figure 19. Figure 20.

<u>*Decreased infiltration rates / Increased surface erosion*</u> – Compaction leads to smaller pore spaces and slower infiltration rates. With increasing residency time at the soil surface, water can horizontally move across the surface of the soil initiating erosion. Over the top of compacted soil, water can reach faster velocities (more erosion potential) than in areas where it infiltrates easily.

<u>*Poor internal drainage*</u> – Compaction prevents effective drainage of soils. Poor internal drainage limits tree available water, prevents O2 movement, and increases production and residence time of CO2 and toxics.

<u>*Increased heat conductance*</u> – Compaction changes the energy and water balance near the surface of the soil. With more particle to particle contact, heat transfer is greater into the soil. Results include burning-out of organic matter quicker, acceleration of evaporative and transpirational water loss, and increased respiration of roots and soil organisms. As temperature increases, respiration responds along a doubling sequence path – for every 18°F (10°C) increase in temperature, respiration doubles.

Tree Root Impacts of Compaction

Compaction impacts tree in many ways. Generally, compaction associated physiological dysfunctions cause systemic damage and decline, as well as failures in dealing with additional environmental changes. Physical / mechanical constraints negatively modify responses in the tree resulting in inefficient use of essential resources. The symptoms we see in trees under compacted soil conditions have causes stemming from disruptions of the internal sense, communication, and response process.

Biological Disruptions

Compaction disrupts respiration processes which power every function of the tree. Growth regulators are destroyed prematurely or allowed to buildup, causing wild changes in tissue reactions. Carbon allocation patterns, following highly modified growth regulation patterns, change food production, storage, use, and transport processes. Defensive capabilities with degraded sensor functions, associated growth regulator communications, and ineffective food use, is slow to react and incomplete in response. With compaction, short-term fluctuations in resource quality and quantity must be effectively dealt with and resulting chronic stress must be tolerated.

The presence of toxic materials can be highly disruptive to soil health. As oxygen concentrations decline, more reduced compounds (only partially oxidized) are generated by the tree roots and associated soil organisms. These reduced compound can buildup and damage organisms and move the soil toward anaerobic conditions. In normal soils, these materials (if produced at all) are quickly oxidized or removed from near tree roots. In compacted soil, normally produced materials, materials produced under low oxygen conditions, and anaerobically produced compounds are not oxidized nor removed from where they are produced. The longer the residence time of some of these materials, the more damage.

The structure of the tree can also be directly and indirectly impacted by compacted soils. Root decline and death can lead to catastrophic structural failures. Tissue death and subsequent compartmentalization processes can compound mechanical faults. Growth regulation and carbon allocation changes can modify stem and root collar taper and reaction wood development. Whole tree stress can result in tissue shedding internally to heartwood and externally. Top and root dieback as well as branch drop can be the result. Reduced rooting volume mechanically destabilizes the whole tree.

Compaction Effects

Major soil compaction effects on trees are defined below:

Reduced elongation growth – As compaction increases, roots are physically prevented from elongating into the soil by lack of O_2, by decreasing pore size, and by increased soil strength. As roots are put under greater than 1.2 MPa of pressure, elongation slows and stops. Figure 21.

Reduced radial growth – Trees begin to generate thick and short roots with many more lateral roots as surrounding soil pressure exceeds 0.5 Mpa. O_2 shortages and soil strength are major limitations.

Essential element collection and control problems – With less colonizable soil volume, there is less physical space to collect resources from and less resources within that space. With declining respiration processes, energy requiring steps in active element uptake (i.e. N, P, S) fail. Part of the difficulty in collecting essential resources is a buildup of toxics which pollute any existing essential resource supply.

Shallow rooting – As roots survive in a steadily diminishing aerobic layer, and as the anaerobic layer expands toward the surface, the physical space available for living roots declines. The consequences of having smaller volumes of colonizable space at the surface of the soil means roots and their resources are subject to much greater fluctuation in water, heat loading, and mechanical damage. Drought and heat stress can quickly damage roots in this small layer of oxygenated soil.

Constrained size, reach, and extent of root systems – Compaction limits the depth and reach of tree root systems leading to greater probability of windthrow and accentuating any structural problems near the stem base / root collar area. Limiting the reach of the root system also prevents effective reactions to changes in mechanical loads on the tree and concentrates stress and strain in smaller areas.

Stunted whole tree form – As resources are limited by soil compaction and more effort is required to seek and colonize resource volumes, trees are stunted. The disruption of growth regulation produces stunting as auxin / cytokinin ratios shift resource allocations and use. In addition, carbohydrate and protein synthesis rates enter decline cycles interfering with nitrogen and phosphorous uptake, which in-turn disrupts carbohydrate and protein synthesis. The result is a tree with a small living mass and with limited ability to take advantage of any short-term changes in resource availability.

Seedling establishment and survival problems – Micro-site variability in compaction levels and a limited resource base constrain young and newly planted trees. Less of a bulk density increase and crusting effect are needed for failure of new trees compared with older, established trees.

Root crushing and shearing-off – The mechanical forces generated in compacting a soil can crush roots, especially roots less than 2 mm in diameter. Larger root can be abraded and damaged. Rutting can shear-off roots as soil is pushed to new locations. The amount of crushing is dependent on root size and depth, weight of the compacting device, soil organic material, and depth to the saturated layer (for rutting). Figure 22.

Fewer symbionts / codependents – Soil compaction puts selective pressure against aerobes and favors low O2 requiring organisms, like Pythium and Phytophera root rots, or anaerobes. Because of the destruction of the detritus energy web coupled with successional changes, recovery of soils to pre-compaction conditions may not be possible. Management must move forward to new solutions for resource availability and deal with new patterns of pest management since returning to the soil microbiology and rhizosphere of pre-compaction is impossible.

Renovation of Sites

Principles -- A summary of this discussion of soil compaction lies with those general principles and renovation techniques managers must use to reclaim a part of the ecological integrity of the site, as well as soil and tree health. General soil compaction renovation principles are listed below in a bullet format:

– Soil compaction should be considered permanent. Studies demonstrate that after one-half century, compaction still afflicts soils under natural forest conditions. Recovery times for significant compaction is at least two human generations. Soils do not "come back" from compaction.
– Every soil used by humankind has a representative compacted layer, zone, area, or crust. Changing management may not change the current compacted zone but may well add an additional compacted zone in a new position.

– Management activities should concentrate on moving forward to increased aeration space and reduced soil strength as best you can, rather than trying to recover past ecological history.
– Measure bulk density, penetration force, O2 diffusion rates, and tree available water. These are the best proxy measures we have to understand soil compaction and its impacts on trees. More careful and direct measures of soil compaction constraints on tree growth are expensive and difficult to make.
– Alleviation of soil compaction is part of a good soil health management plan.
– Use extreme caution in management of water over and in compacted soils. Compaction provides little margin for error for drainage, aeration, infiltration, and water holding capacity of tree available water. (Wet soil / dry tree problems).
– Seek the assistance of a tree and soil specialist to avoid tree-illiteracy problems on compacted soils.

Techniques – Once the general principles of working with compacted soils are digested, the next requirement is to identify some techniques for renovating compacted soils. These recommendations are generic across many situations and soil types. General techniques are listed below in a bullet format:

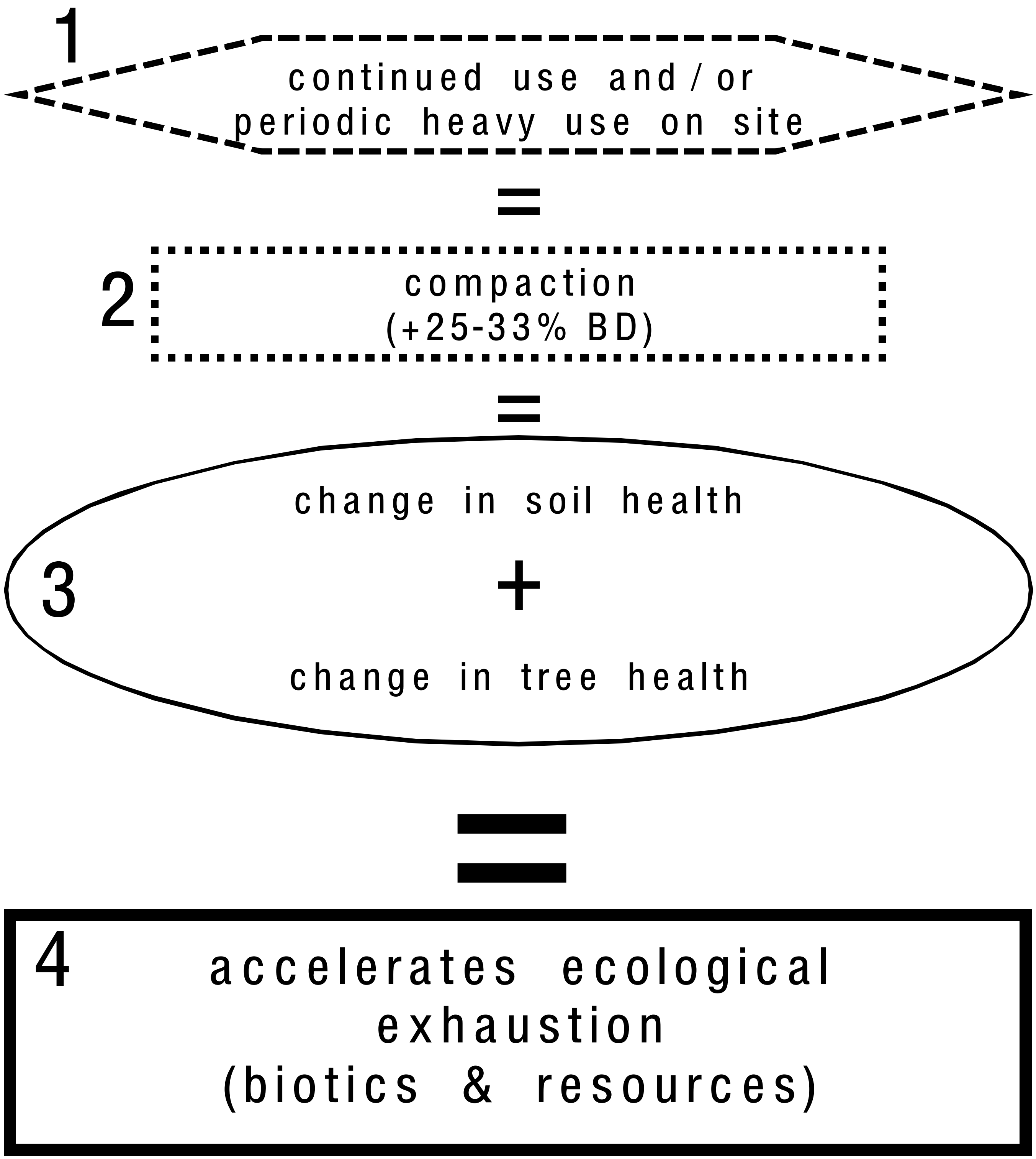
– Restrict site access to the soil surface as soon as possible with fences and fines (legal penalties). Try to be the first one on the site and setup anti-compaction protection.
– Defend the ecological "foot print" of the tree rooting area. Select working conditions (dry, dormant season, surface mulch, etc) that minimizes compaction.
– Restrict where possible vibrational compaction.
– Carefully design tree growth areas using "biology-first" design processes rather than the common (and damaging) "aesthetics-first" design processes.
– Try to soften and distribute compaction forces with temporary heavy mulch, plywood driving pads, and soil moisture content awareness planning.
-- Restart or improve the detritus energy web in the soil including addition of organic matter and living organisms, as well as trying to change soil physical properties by increasing aeration pore space.

Conclusions

Soil compaction is a hidden stressor which steals health and sustainability from soil and tree systems. Causes of compaction are legion and solutions limited. Without creative actions regarding the greening of inter-infrastructural spaces in our communities, we will spend most of our budgets and careers treating symptoms and replacing trees. Understanding the hideous scourge of soil compaction is essential to better, corrective management.

For more information on this subject review papers listed in the following reference: *Coder, Kim D. 2000. **Trees and Soil Compaction: A Selected Bibliography.** University of Georgia School of Forest Resources Extension Publication FOR00-1. 2pp. (Download at WEB site www.forestry.uga.edu/efr under "tree health care.")*

Figure 1: Cause and effect processes under soil compaction.



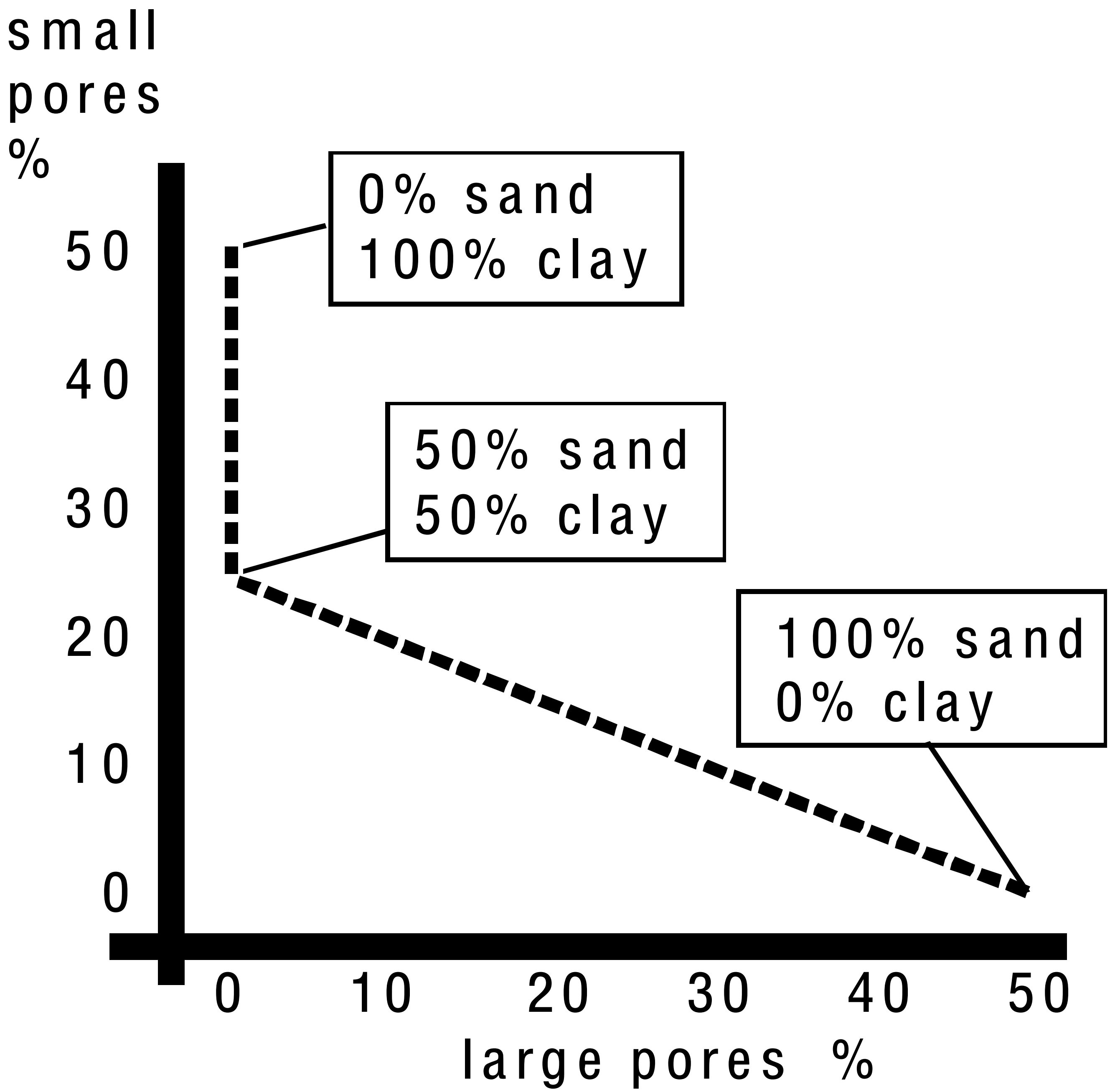


Figure 2: Large and small pore space percentages in various sand / clay mixtures.
(after Harris et.al. 1999)

Figure 3: Pore size definitions.

I. AERATION PORES

aeration pores
>60µm diameter
"macro-pores"

II. CAPILLARY PORES

1. available water pores
   0.2 -- 60µm diameter
   "meso-pores"

2. unavailable water pores
   <0.2µm diameter
   "micro-pores"

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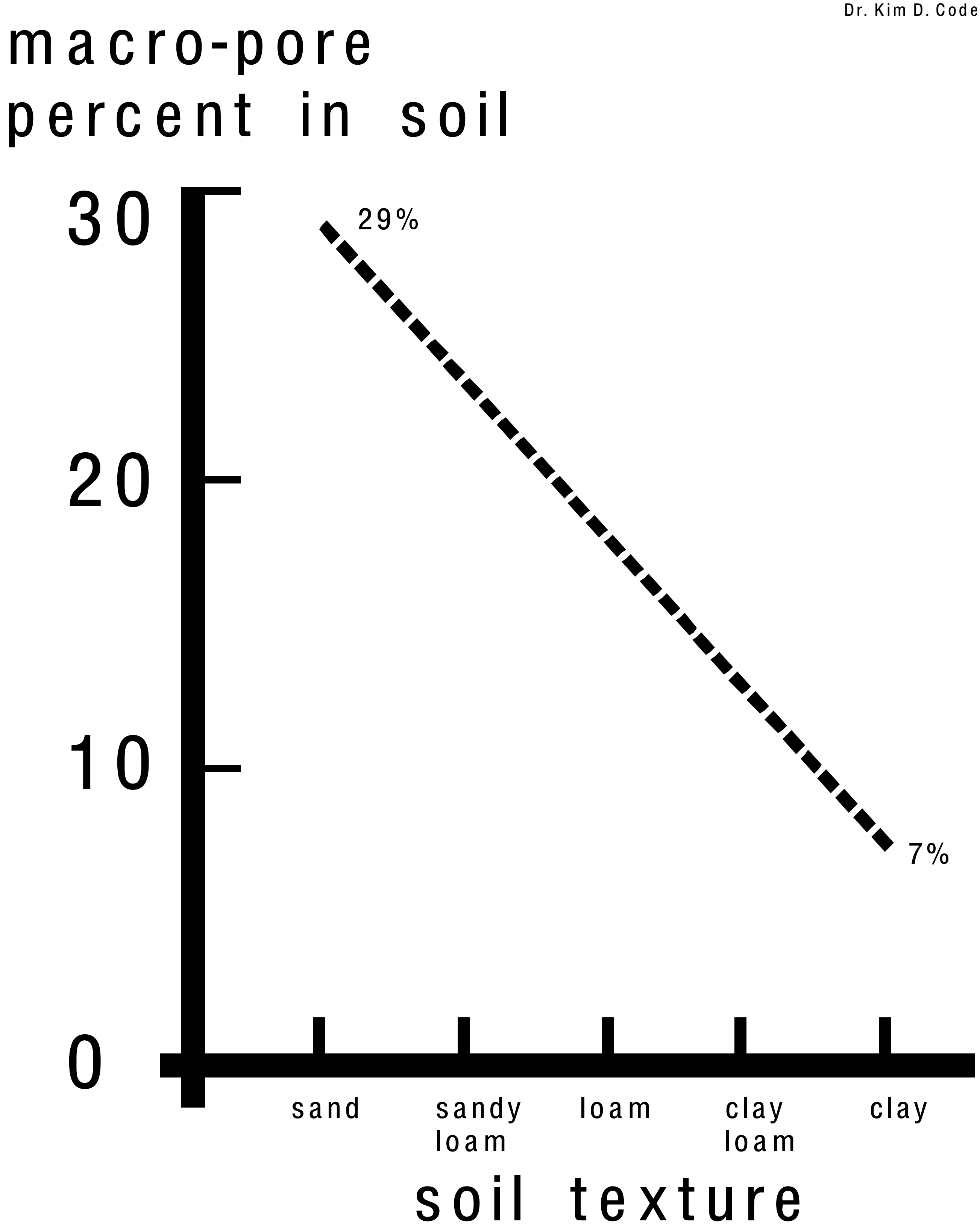

Figure 4: Macro-pore space by soil texture. (after Craul 1999)

Table 1: Physical attributes of selected construction materials.
(from Patterson)

material	BD	particle density	pore space
cinder block	1.70	2.64	36%
clay brick	1.75	2.72	36%
asphalt	2.19	2.35	7%
concrete	2.26	2.47	9%
units	g/cc	g/cc	% volume

Table 2: Calculation of pore space from bulk density and avaerage mineral density.

$$\% \text{ pore space} = (1 - BD / 2.65) \times 100$$

BD (g/cc)	% pore space
0.9	66
1.0	62
1.1	58
1.2	55
1.3	51
1.4	47
1.5	43
1.6	40
1.7	36
1.8	32
1.9	28
2.0	25
2.1	21
2.2	17

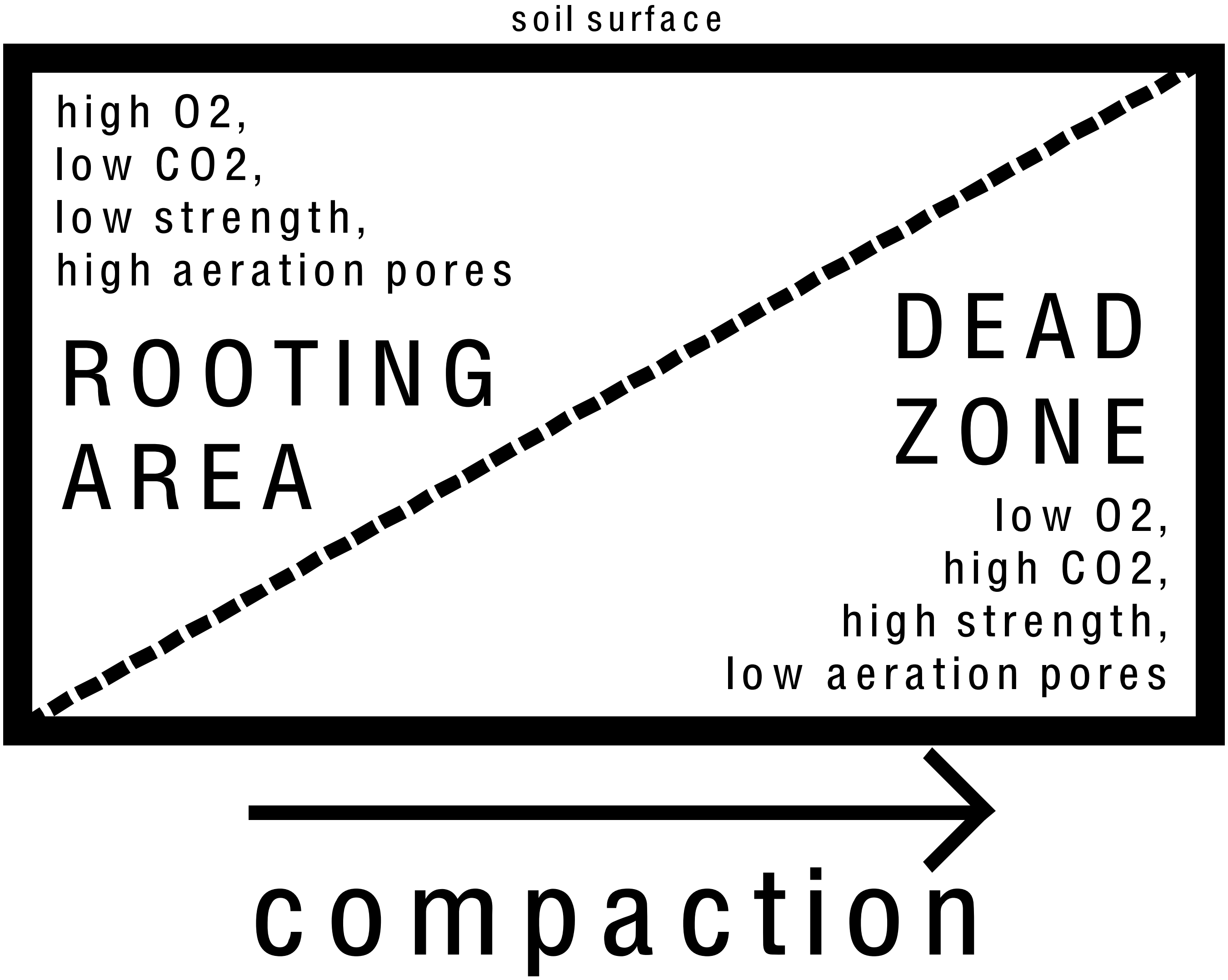

Figure 5: Graphical representaion of compaction effects on soil.

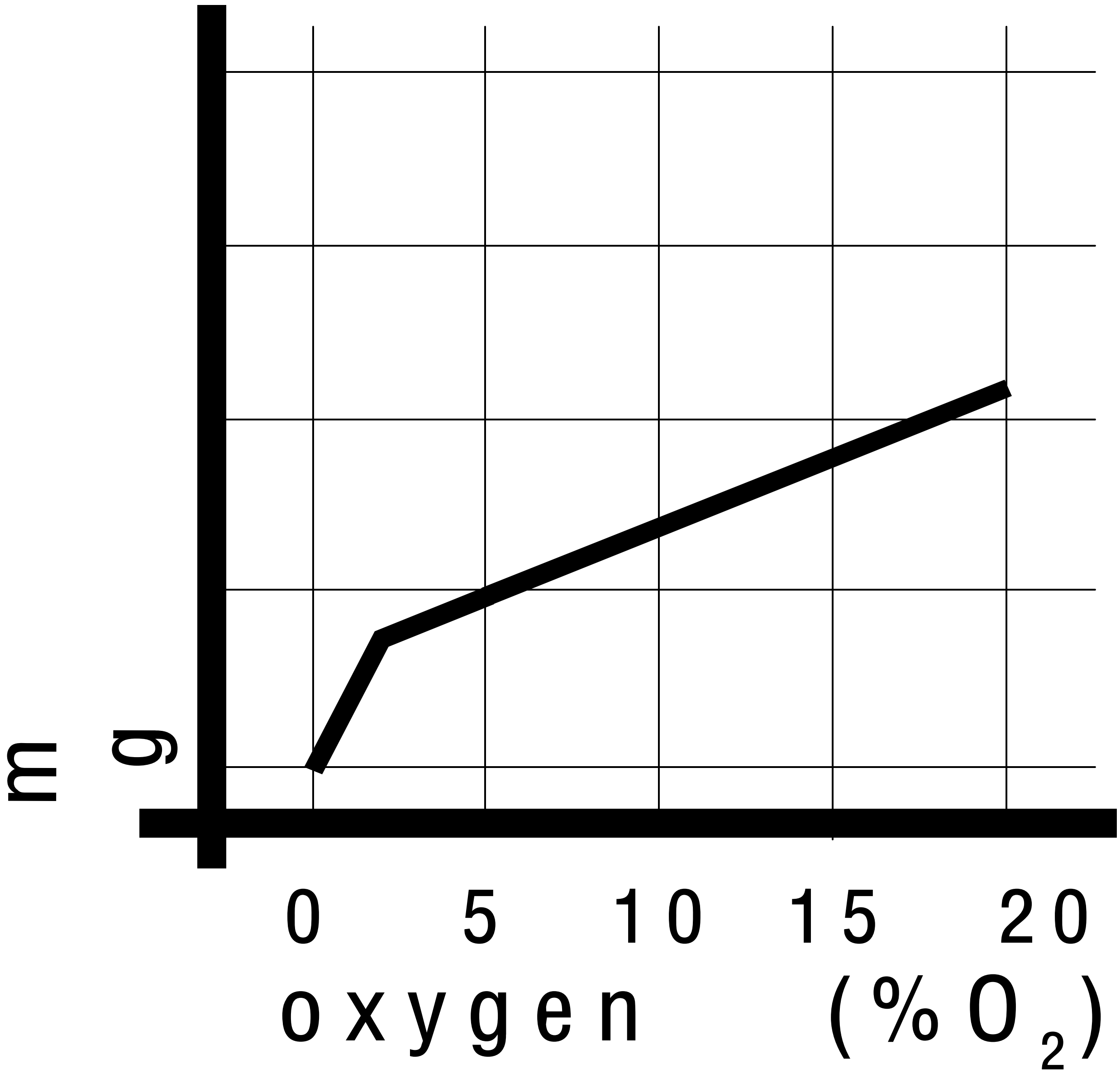

Figure 6: Maximum root growth force expressed by seedlings at various oxygen concentrations.
(after Souty & Stepniewski 1988)

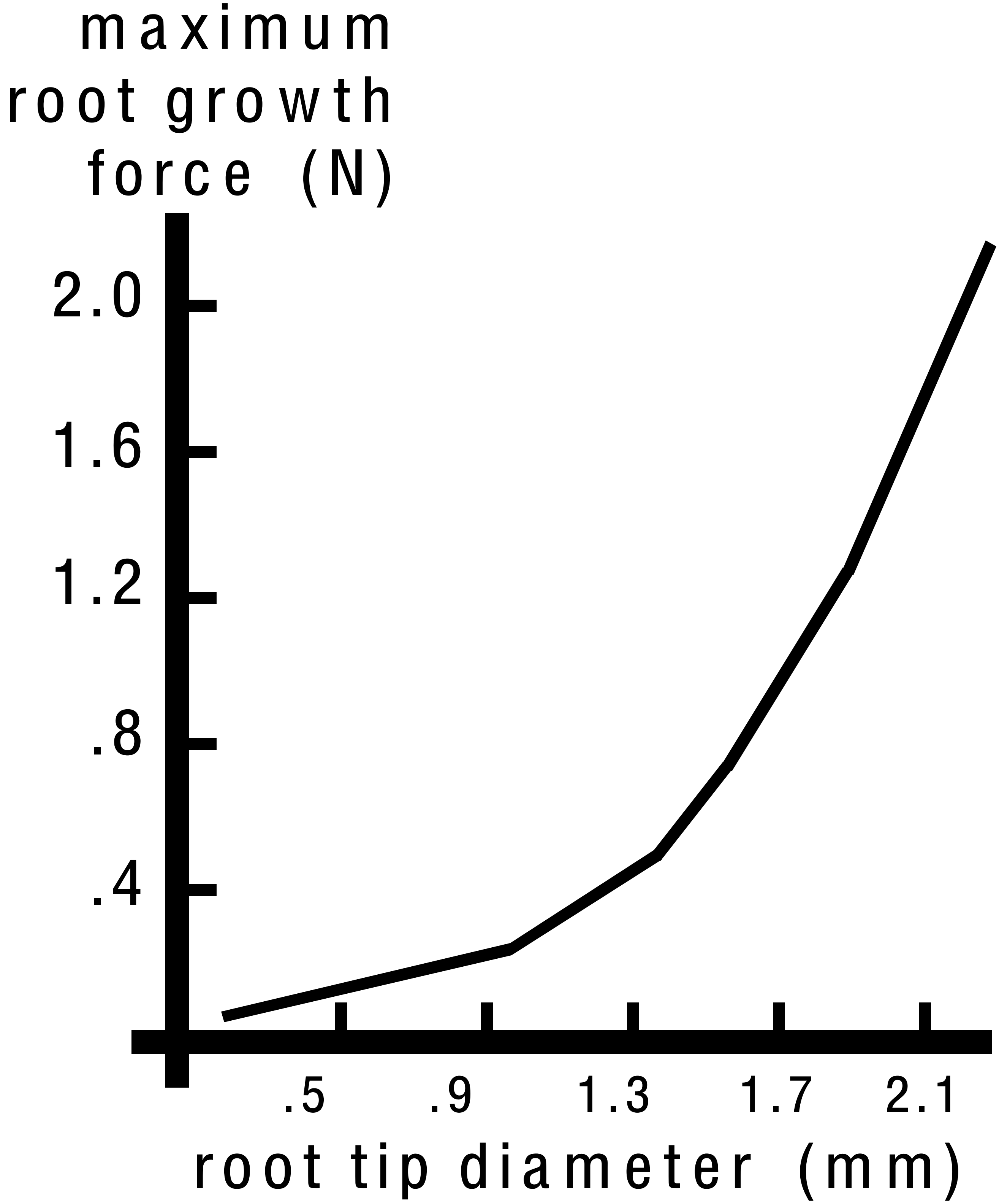

Figure 7: Maximum root growth force by root tip diameter.
(after Misra et.al. 1986)

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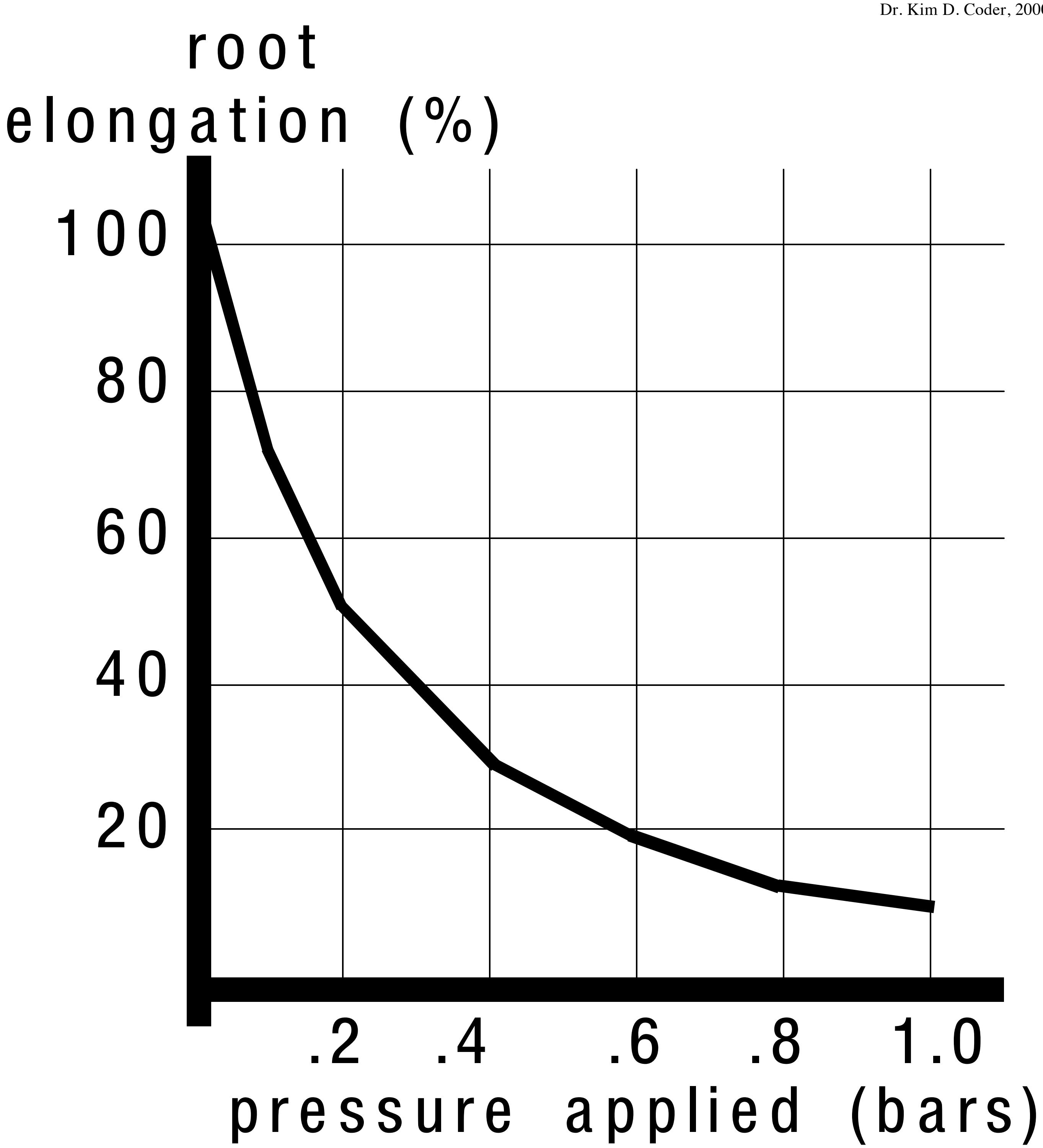

Figure 8: Pressure applied to roots that limit elongation.
(after Rendig & Taylor 1989; Russell, 1977) (1 MPa =100 kPa ▪ 1 bar)

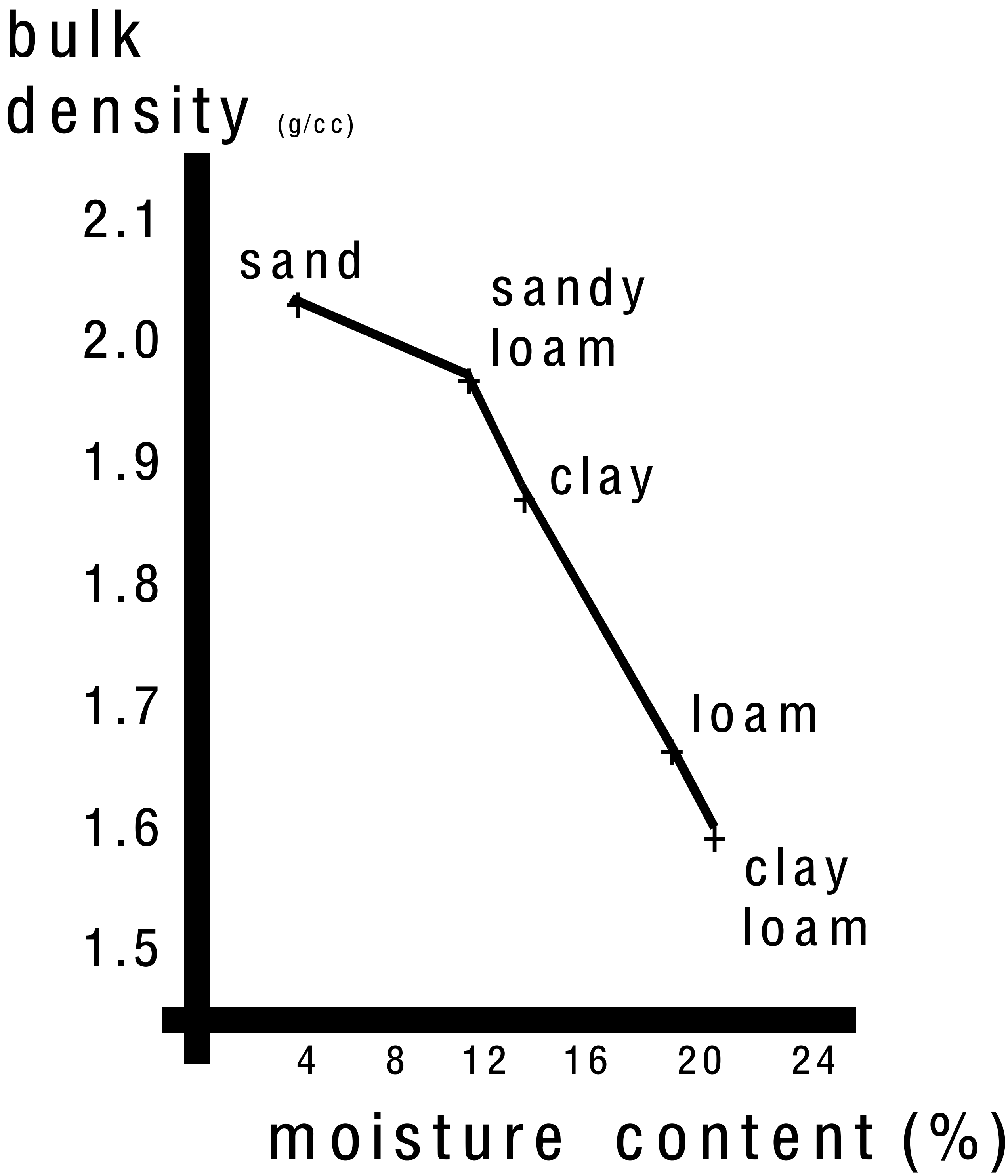

Figure 9: Maximum compaction capacity by moisture content.
(after Craul 1994)

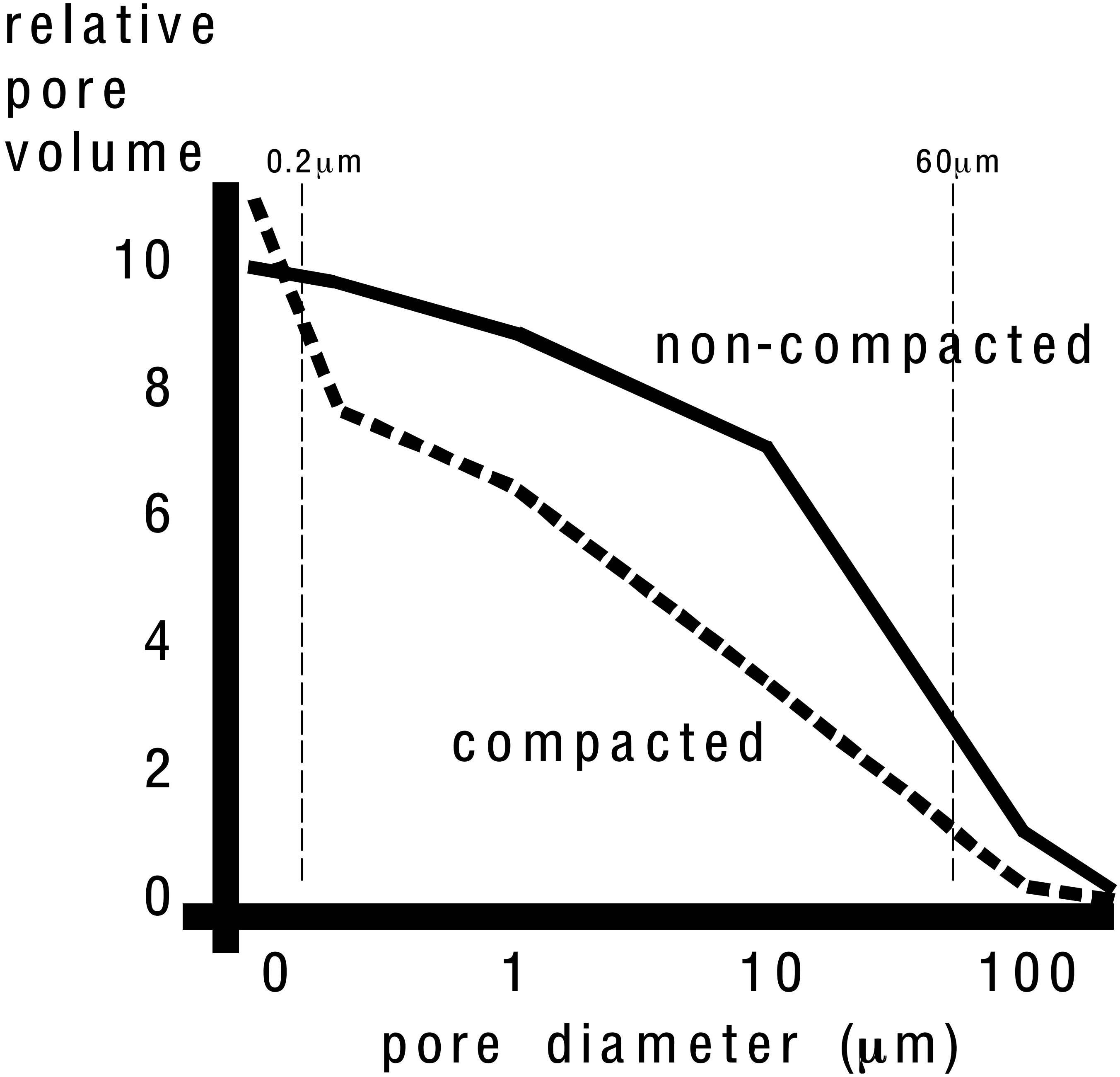

Figure 10: Soil pore diameters and relative volumes under non-compacted (1.4 g/cc) and compacted (1.8 g/cc) conditions.
(after Jim 1999)

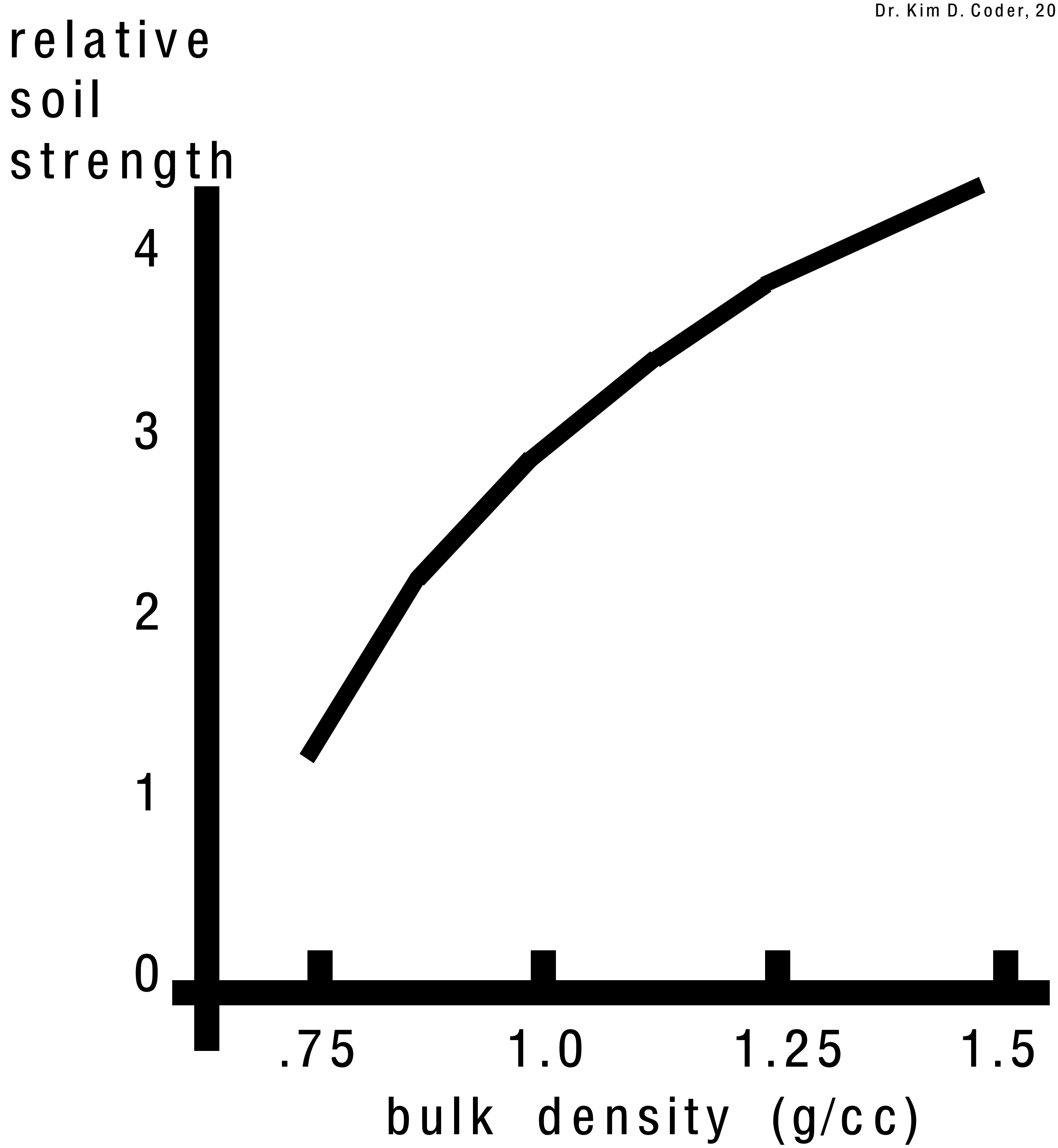

Figure 11: Relative soil strength with increasing bulk density values.
(after Craul 1994)

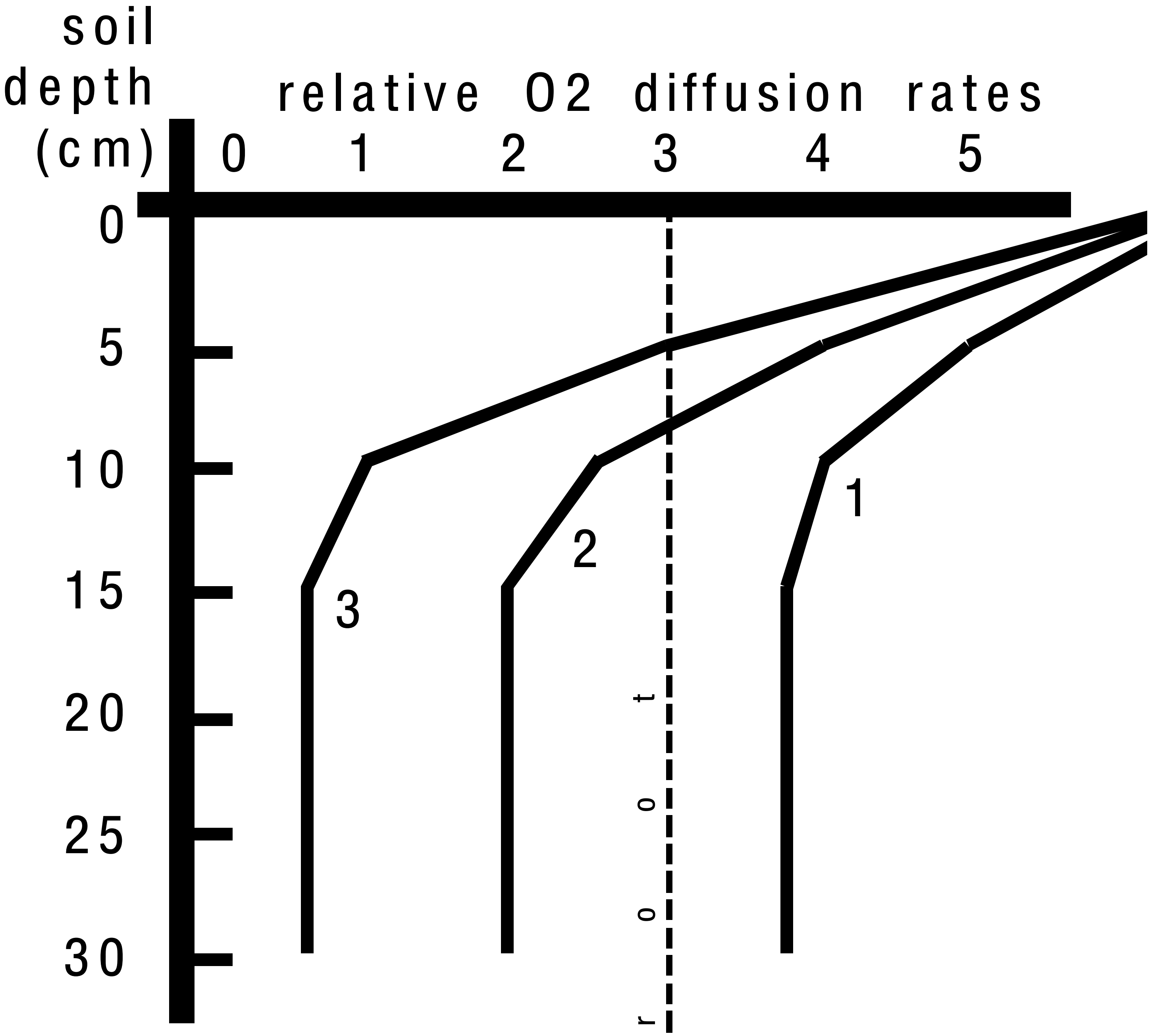

Figure 12: Relative oxygen (O2) diffusion rates with increasing soil compaction. (after Kelsey 1994)

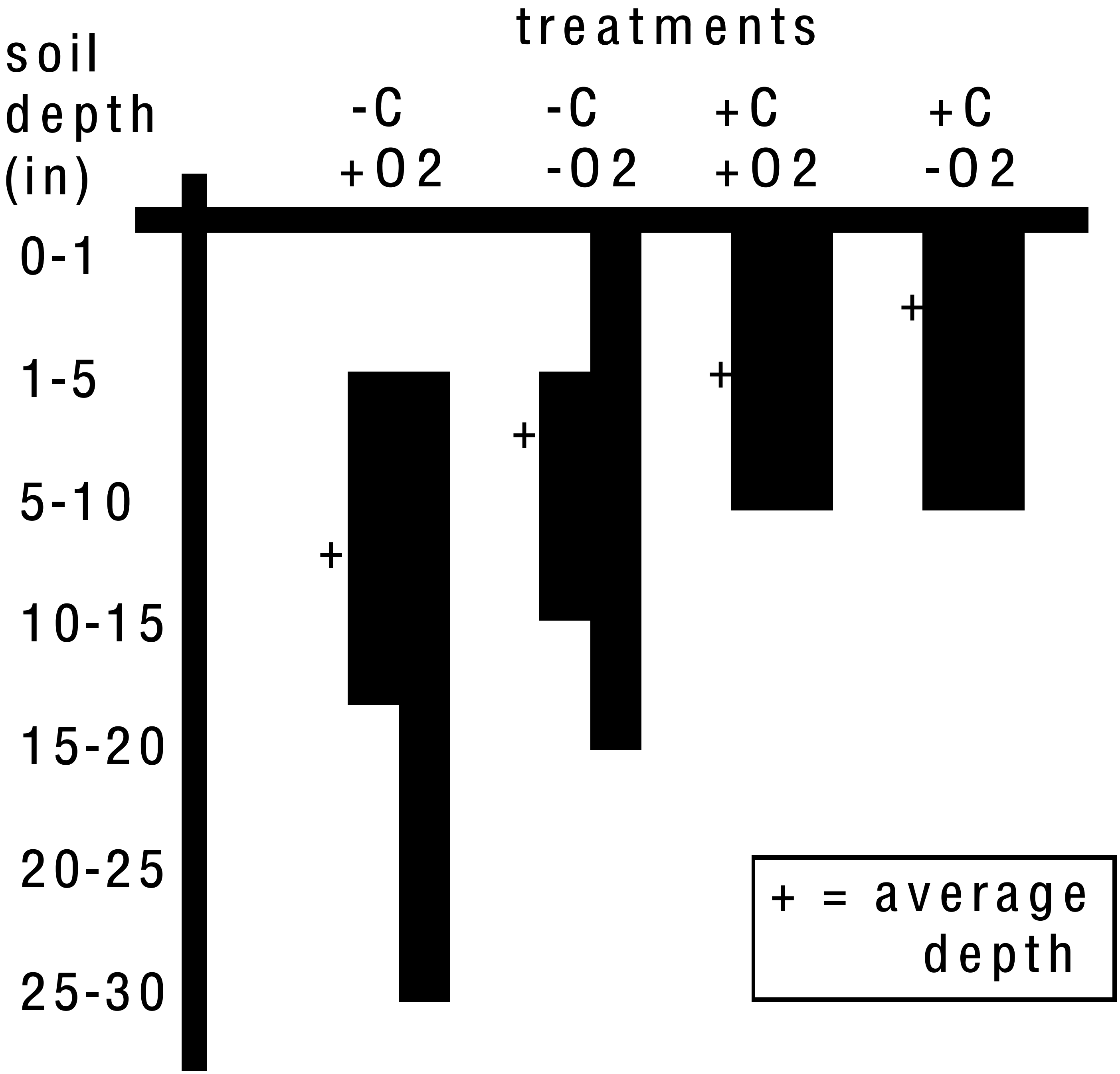

Figure 13: Compaction (+ 28%) and oxygen (- 5%) impacts on tree rooting depths. (after Gilman et.al. 1987)

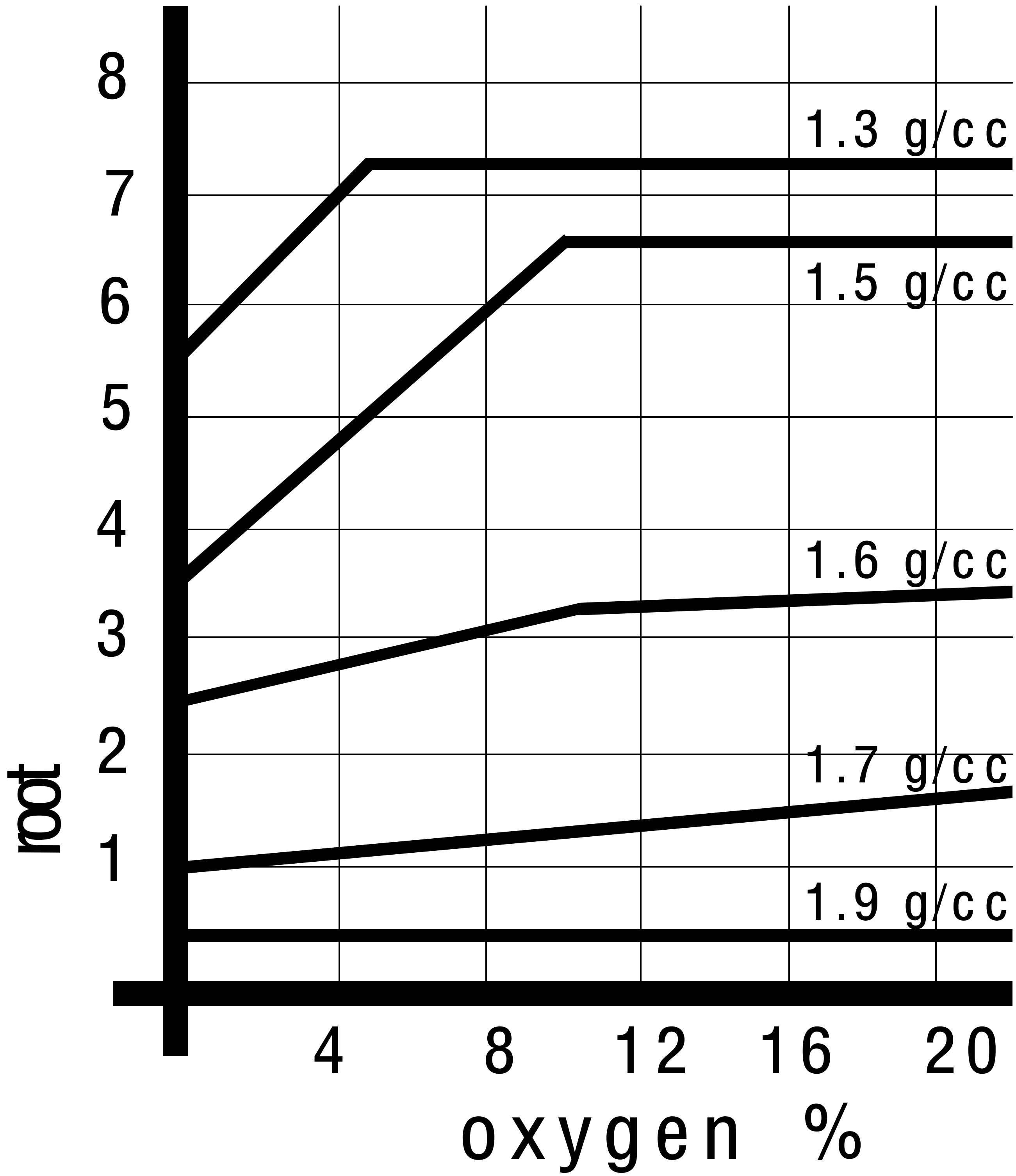

Figure 14: Percent oxygen and bulk density effects on root penetration. (after Rendig & Taylor 1989)

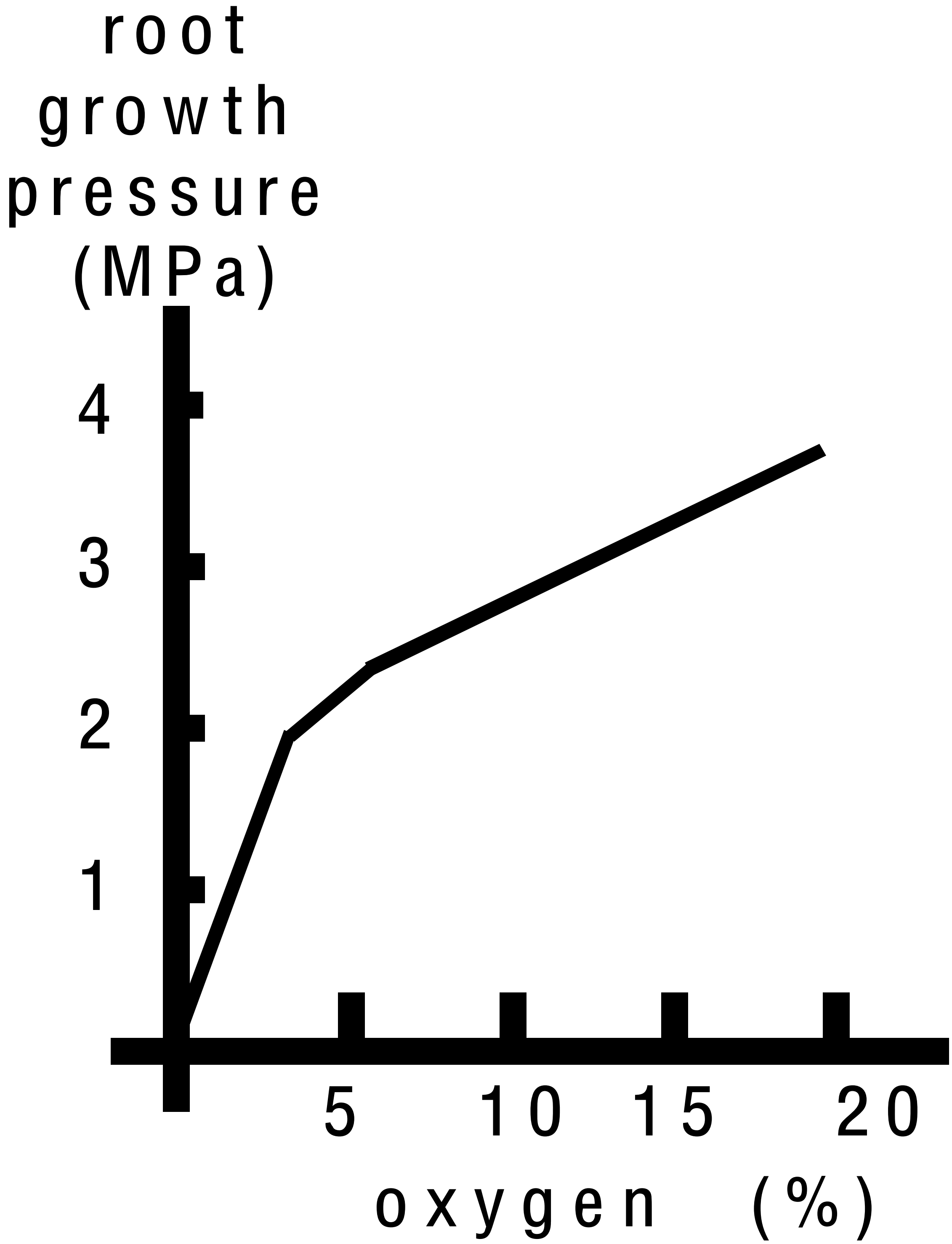

Figure 15: Root growth pressure by oxygen concentration.
(after Souty & Stepniewski 1988)

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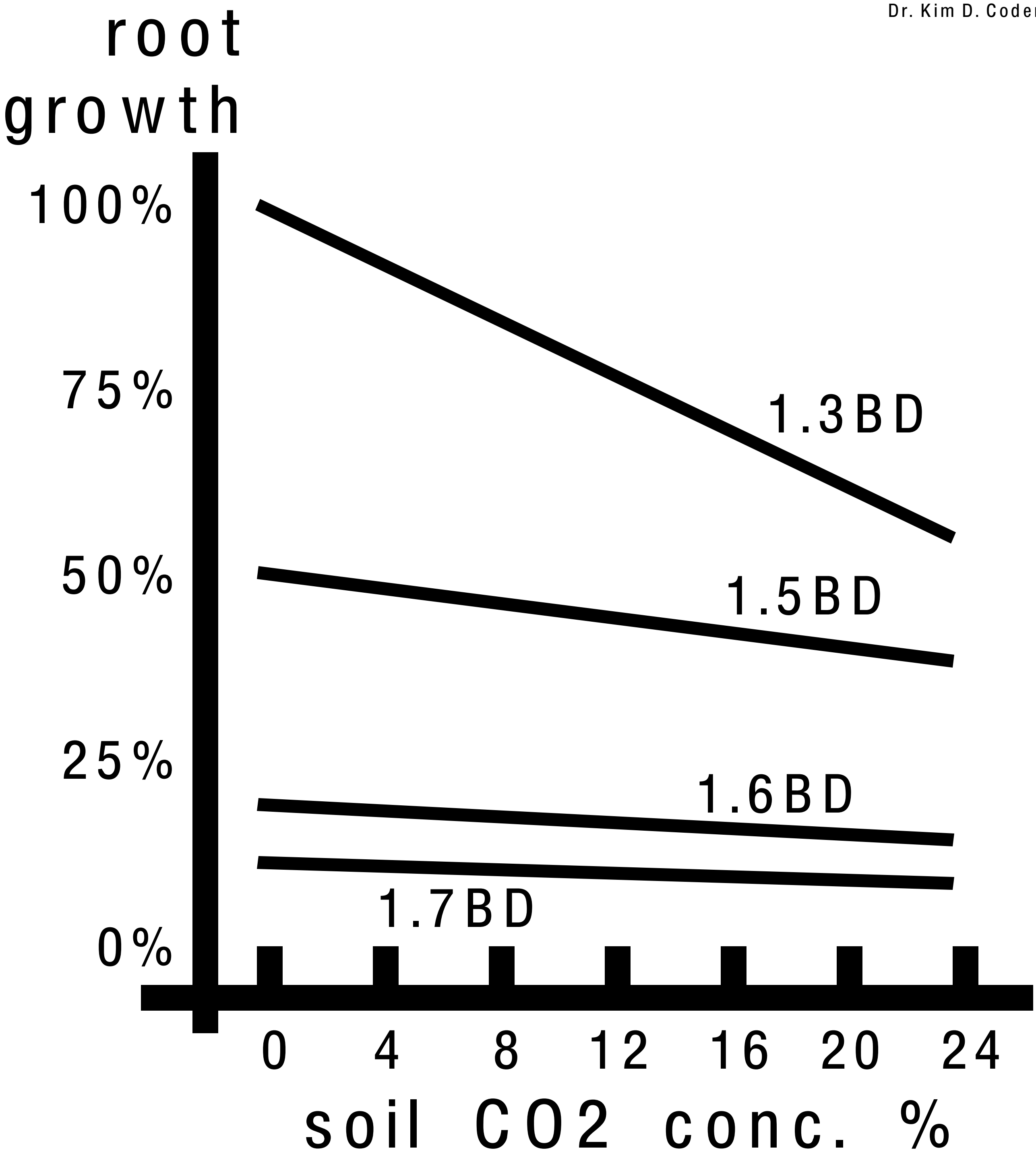


Figure 16: Carbon dioxide (CO_2) concentrations in the soil and bulk density impacts on root growth. (after Patterson)

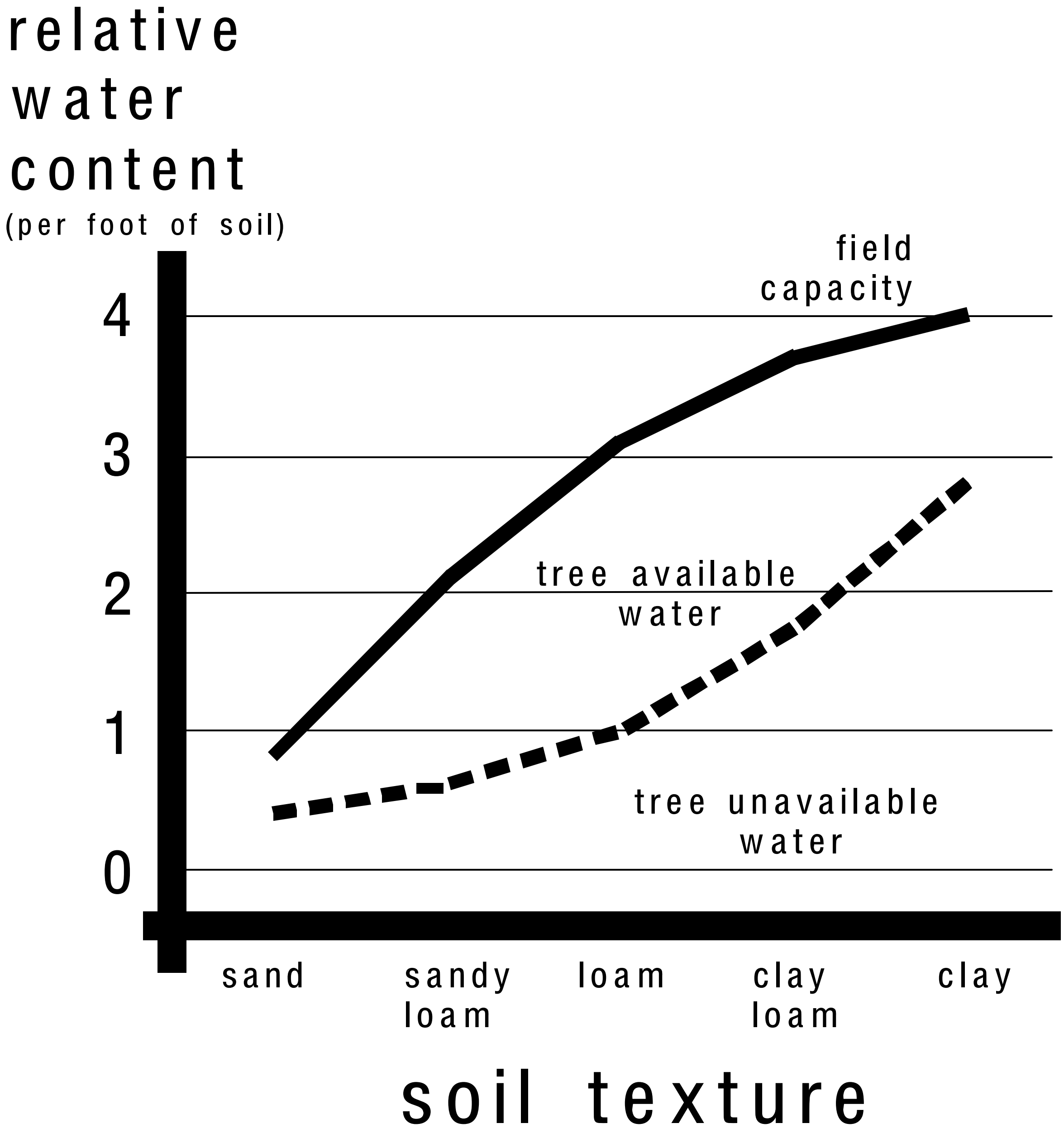


Figure 17: Tree-available water present at different soil textures.

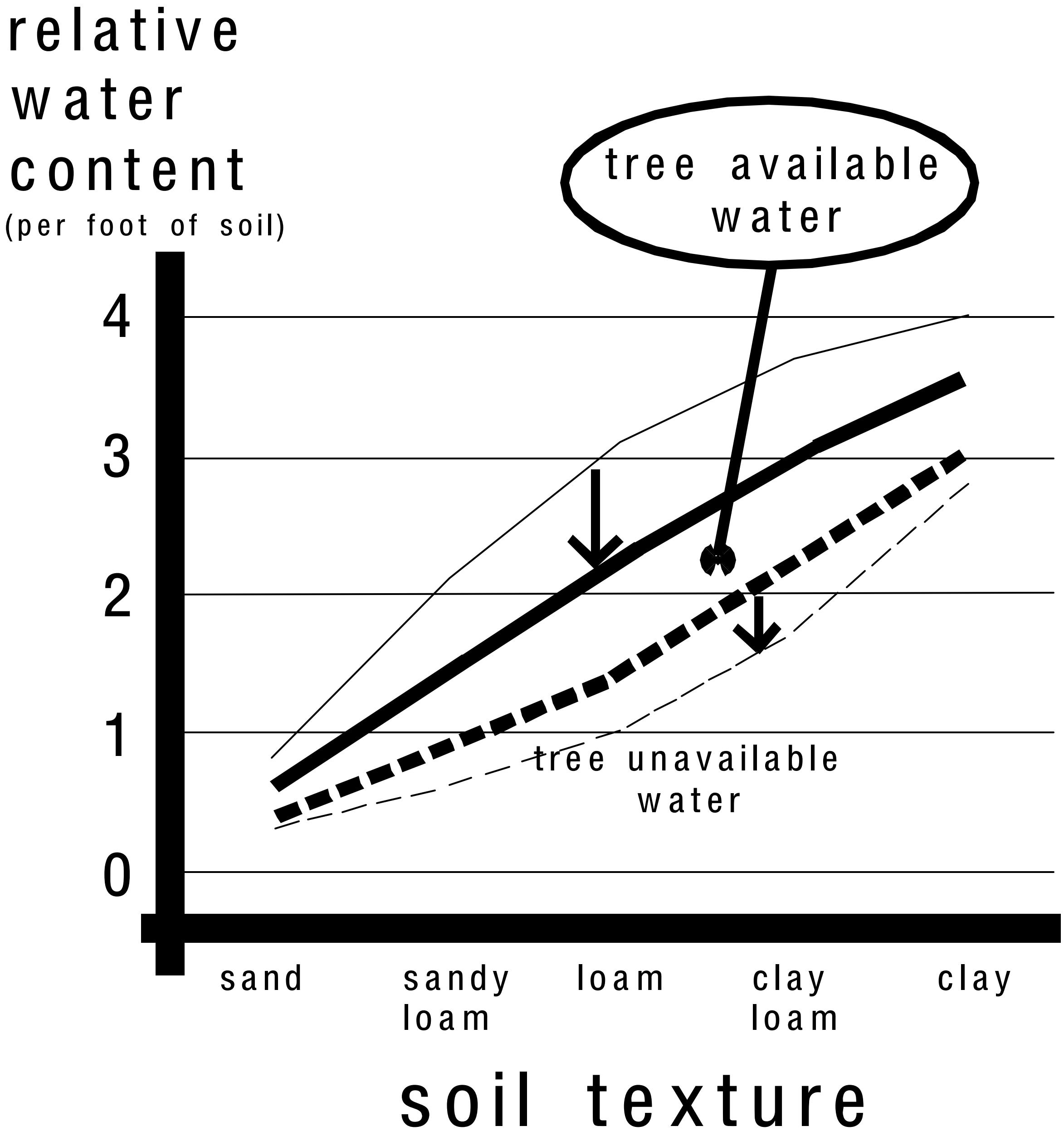


Figure 18: Tree-available water present at different soil textures under compaction.

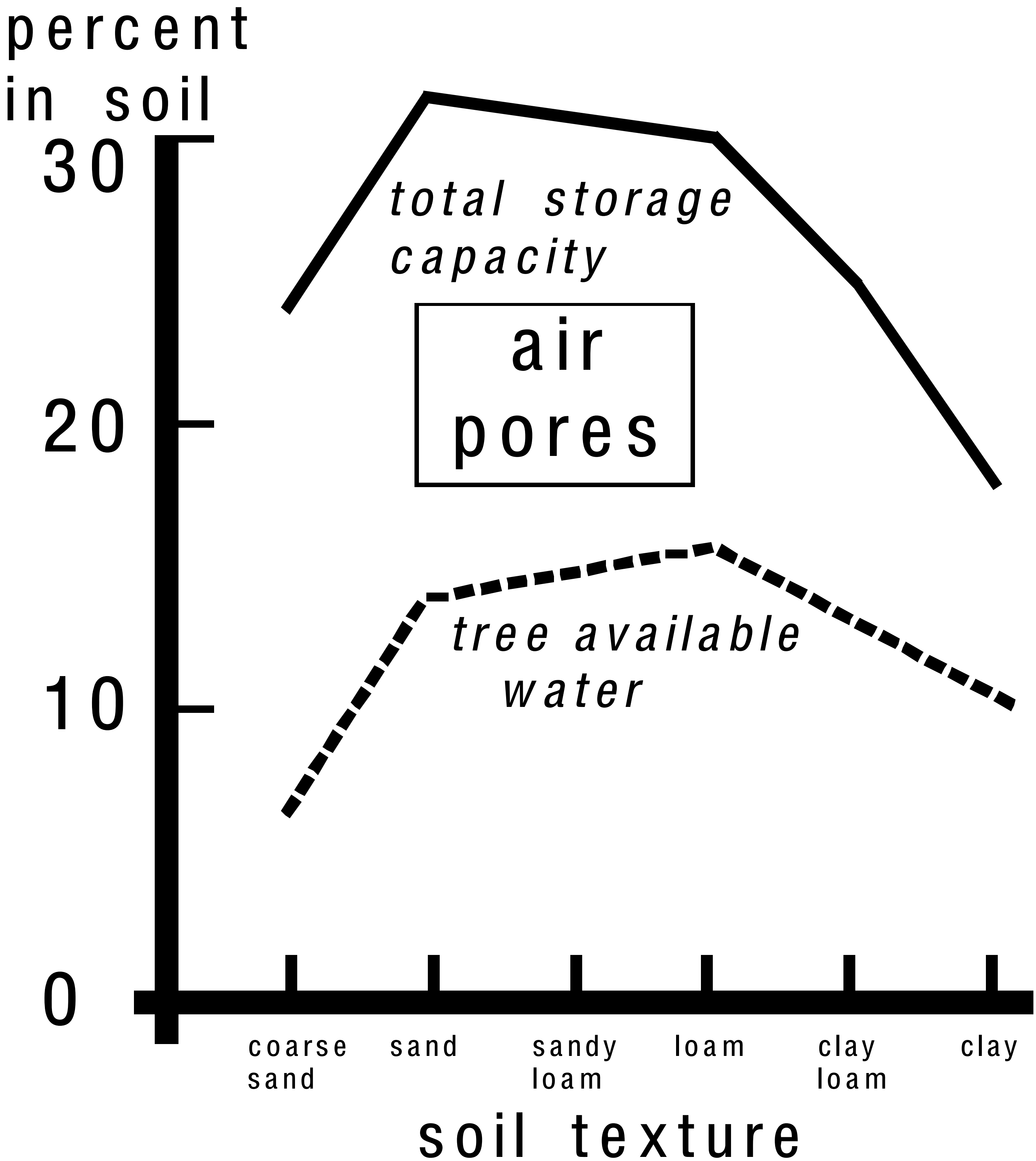


Figure 19: Water storage capacity in normal soil. (after Craul 1999)

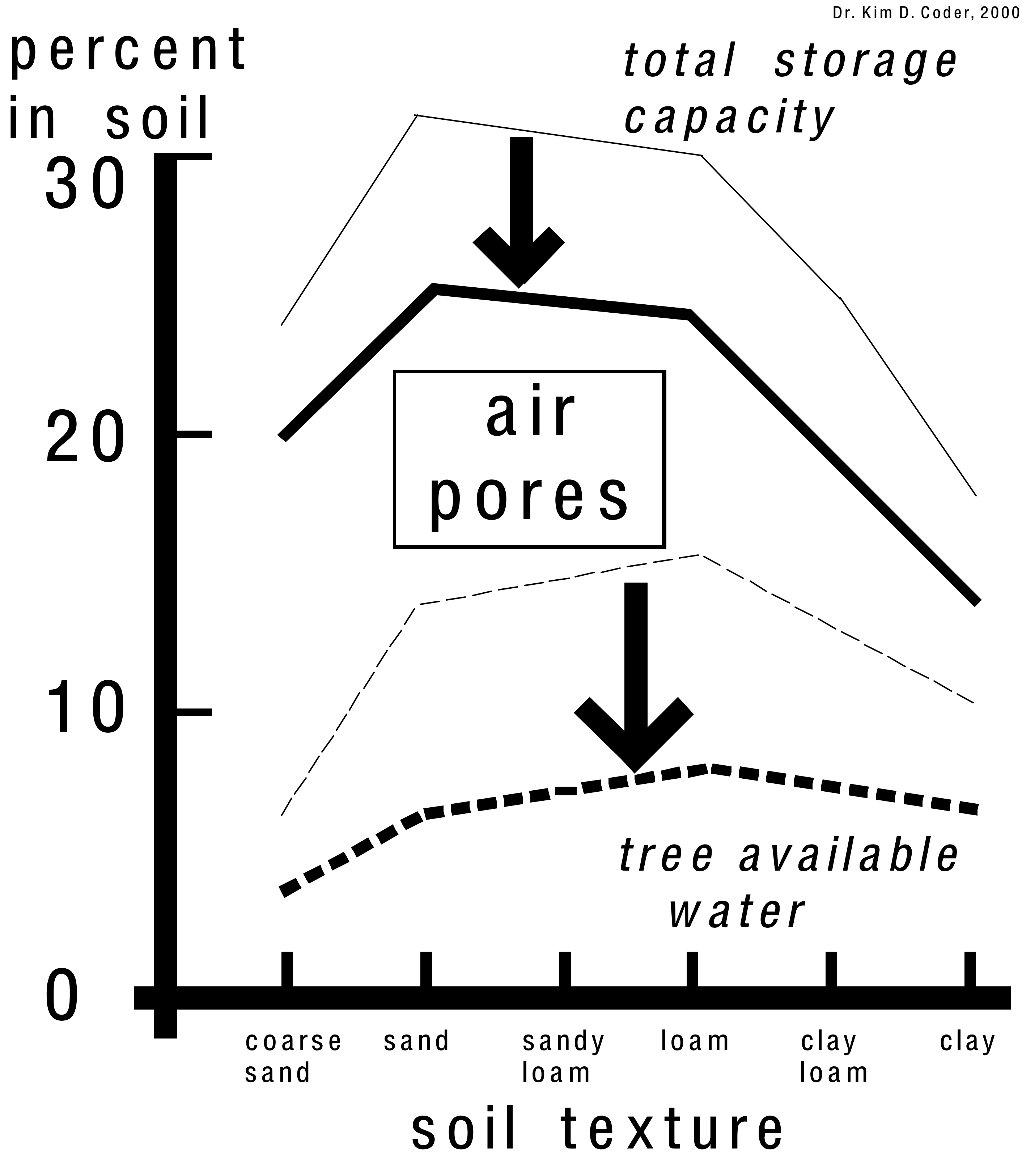


Figure 20: Water storage capacity under compaction. (after Craul 1999)

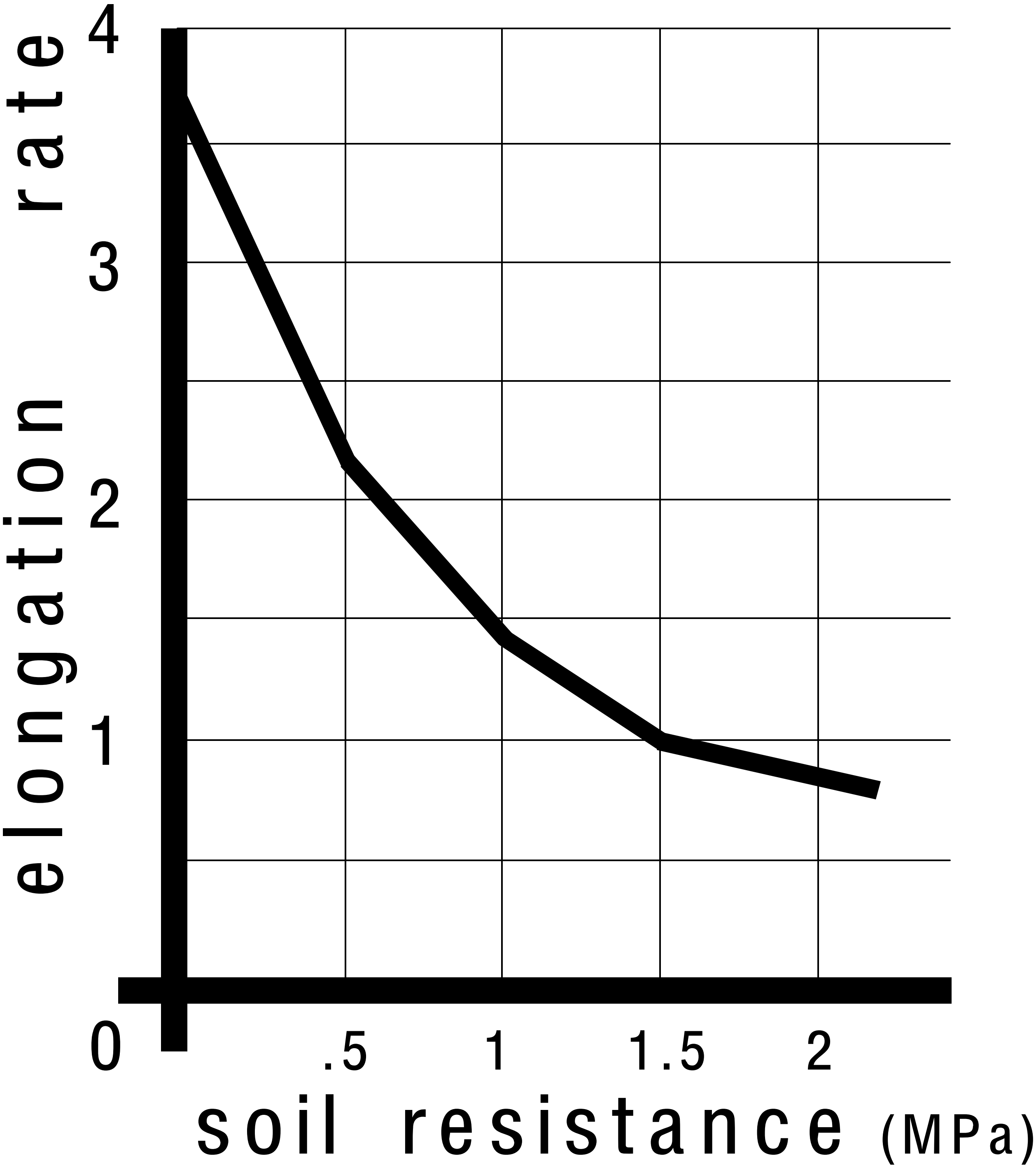


Figure 21: Soil penetration resistance and root elongation rate. (after Rendig & Taylor 1989)
(1 MPa =100 kPa ▪ 1 bar)

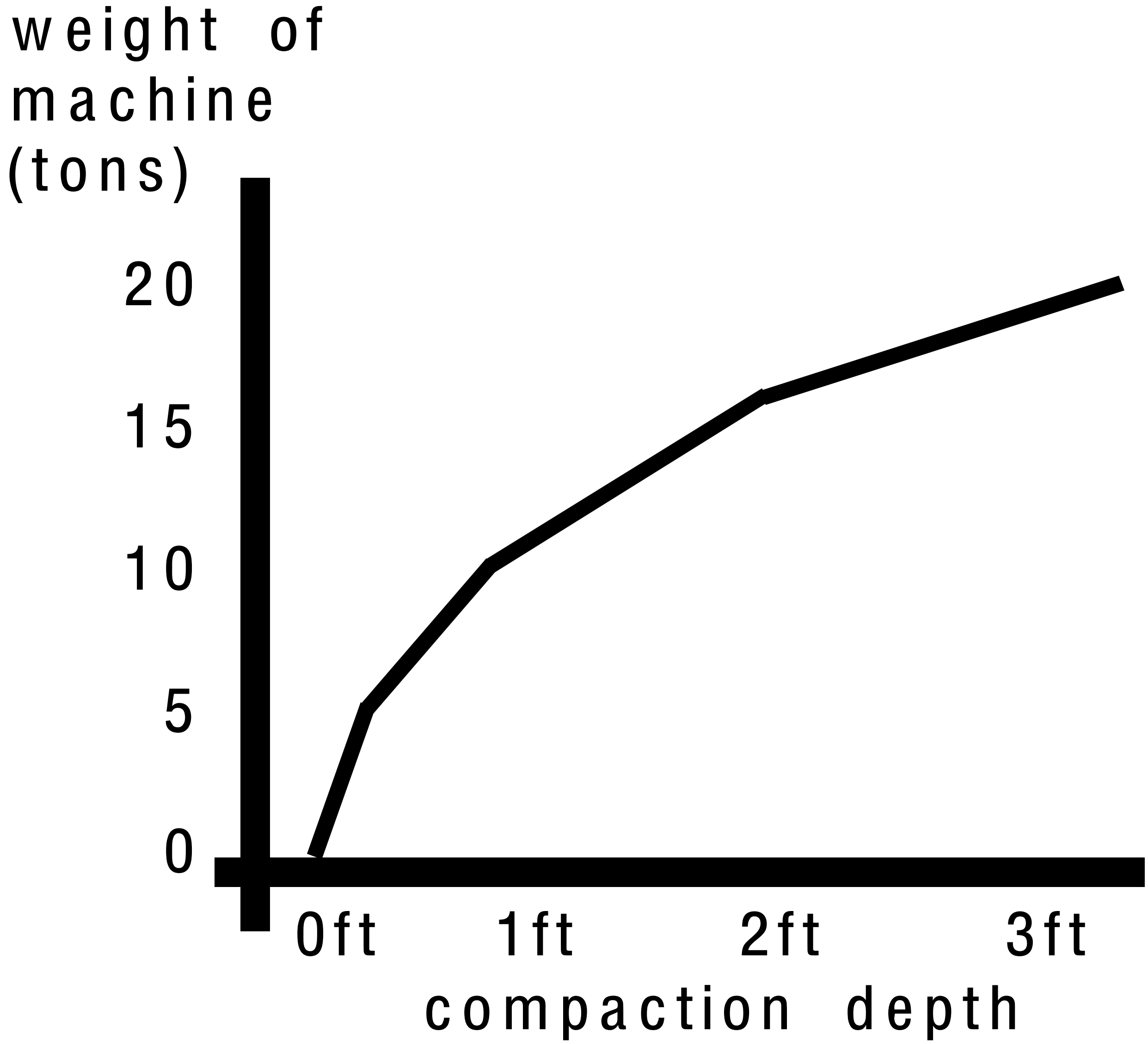


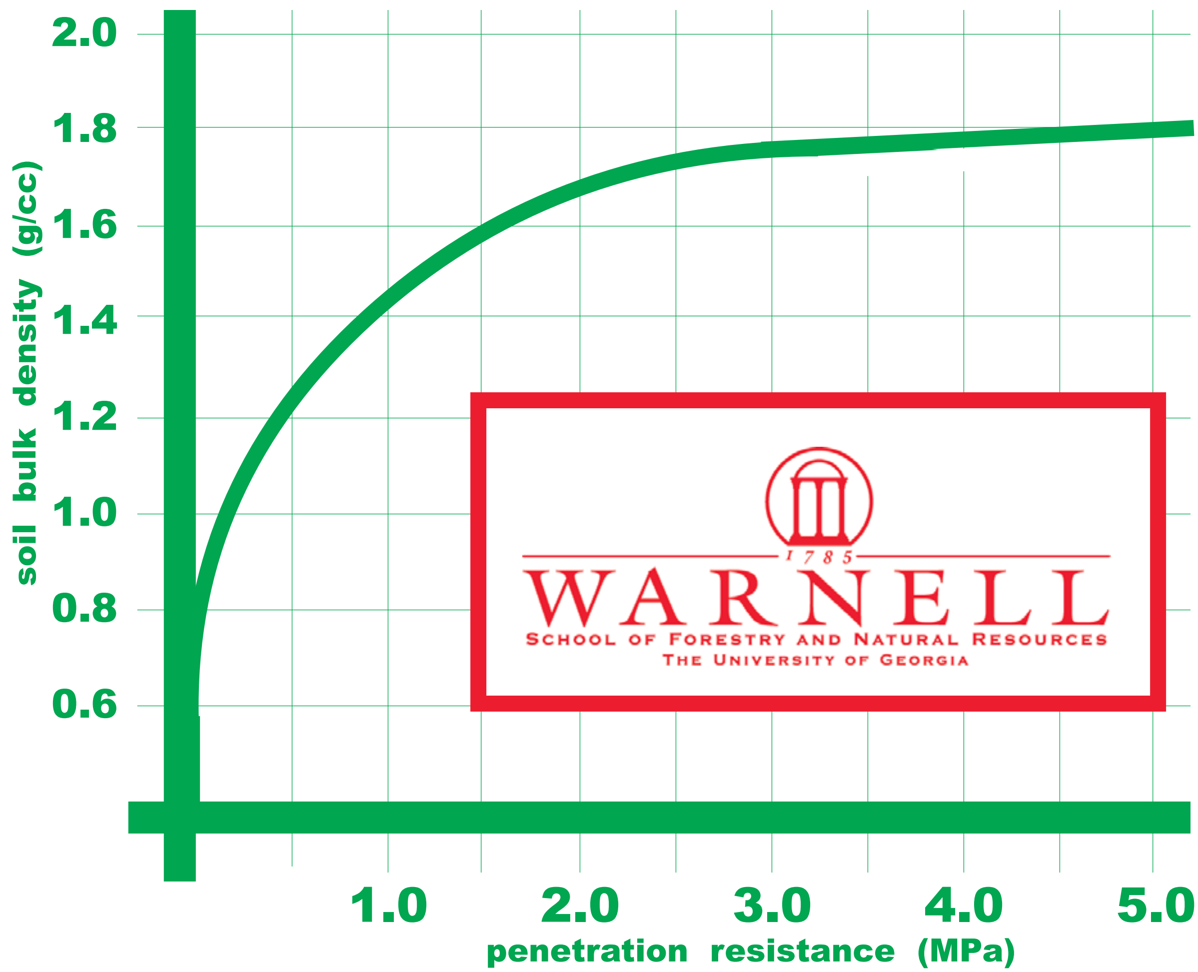
Figure 22: Depth of soil compaction under machines of various weights. (after Randrup 1999)

Soil Compaction Stress & Trees:

Symptoms, Measures, Treatments

by Dr. Kim D. Coder, Warnell School of Forestry & Natural Resources
University of Georgia Dec. 2007

Warnell School Outreach Monograph WSFNR07-9*



Soil Compaction Stress & Trees: Symptoms, Measures, Treatments

This is an educational treatment of soil compaction and tree health care. This is not bidding specifications, standards, a commercial marketing device, or an industrial consensus product. This is a professional educational monograph designed to assist professional tree health care providers appreciate and understand some of the complexities of soil compaction and its impact on tree health. The information presented here is from the research and field application literature, and from the personal experience of the author. The author has selected items to include and exclude based on their value to forward different educational concepts and learning objectives for the student. Because of the complexity of this work, this author and this institution can not be held responsible for errors and omissions which may be present, or effect professional interpretation and field applications. This publication is about learning basic information on compaction and tree interactions, not a "how to" on decompacting soils. Always seek the assistance of a professionally credentialed tree care provider to assure your tree receives the best possible care.

Contents

Soil Compaction Stress & Trees: Symptoms, Measures, Treatments

by Dr. Kim D. Coder, Warnell School of Forestry & Natural Resources, University of Georgia

The health and structure of trees are reflections of soil health. The ecological processes which govern tree survival and growth are concentrated around the soil / root interface. As soils, and associated resources change, tree systems must change to effectively utilize and tolerate changing resources quantities and qualities, as well as physical space available. Soil compaction is a major tree-limiting feature of many developed sites and a hidden stressor of community trees.

This monograph is a summary of soil compaction processes and tree growth effects. In addition, some general renovation principles are reviewed. Understanding how soil compaction occurs, developing more accurate and precise definitions of soil compaction effects, and recognizing tree growth impacts stemming from compaction problems will be emphasized here. This monograph will concentrate entirely on the negative growth constraints of soil compaction on trees.

Recognizing The Problem

Soil compaction is the most prevalent of all soil constraints on shade and street tree growth. Every place where humans and machines exist, and the infrastructures that support them are built, soil compaction is present. There are few soil areas we see without some degree of soil compaction. Soil compaction is a fact of life for trees and for tree health care providers. Unfortunately, prevention and correction procedures are not readily used nor recognized for their value.

There are many environmental constraints on tree survival and growth. All limitations for trees have impacts on daily and seasonal growth which can be measured and prioritized. Many people become obsessed by small constraints on trees while major life-altering impacts are ignored. Soil compaction is one of those major problems causing significant tree stress and strain, and whose impacts are usually blamed on other things. Figure 1 shows the individual items causing the greatest growth limitations for tree growth. The top three things (by far!) are soil water availability, soil aeration, and soil drainage -- all three greatly disrupted by site compaction. Drought and soil compaction head the list of major tree growth stress problems.

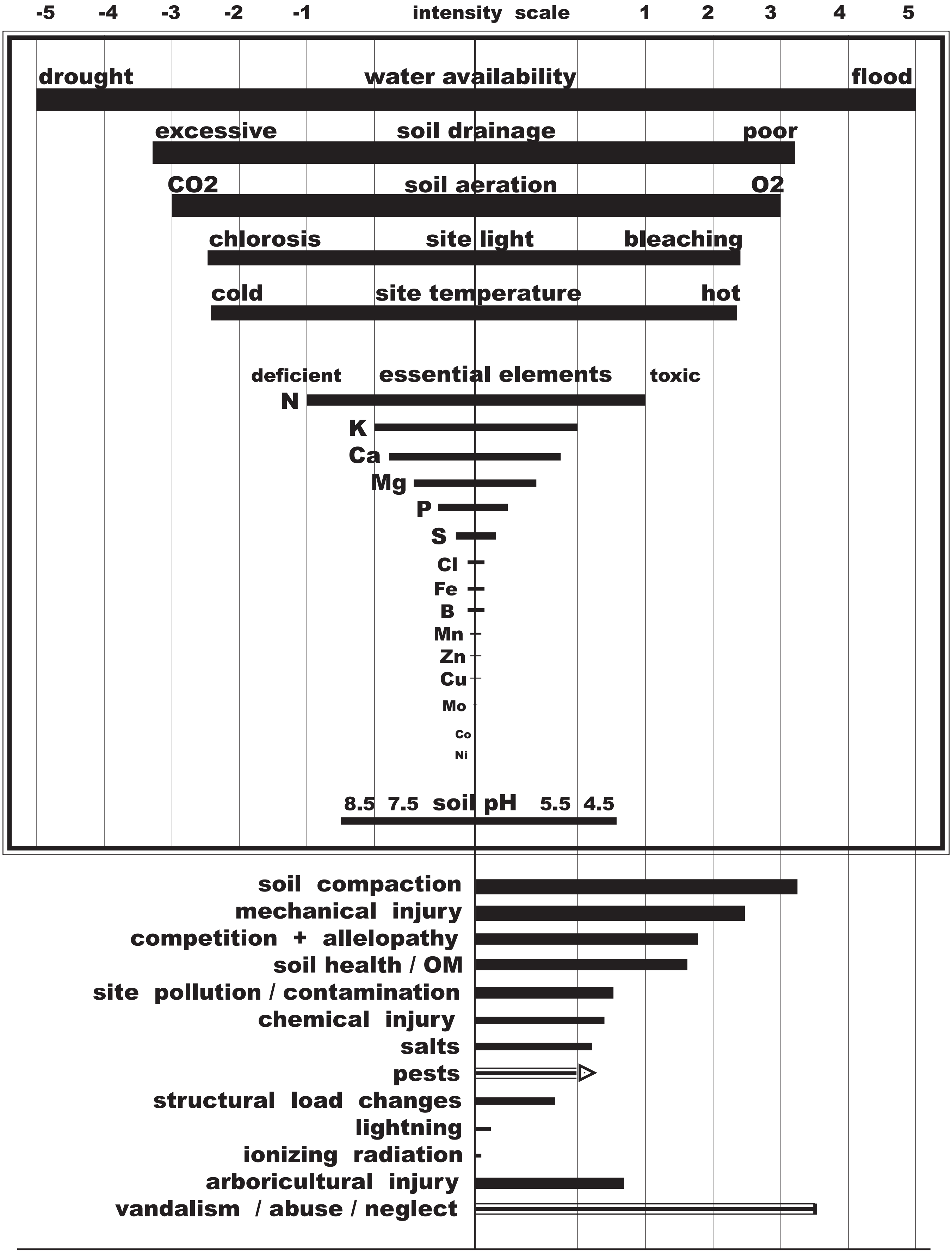
As long as people continue to obsess about trivial tree and site growth limitations, they will continue to ignore the biggest items causing tree stress and strain! Tree care providers must help people understand soil compaction influence on tree growth and the need for soil renovation.

Bearing All

As a site is used by animals, people, and machines, the bearing surface for all activities is the top of the soil. Soil is a composite material made of many different things each interconnected physically and biologically in many ways. Site use applies force to the soil surface and this force is resisted and distributed locally in the soil. The extent of soil impact depend upon many soil attributes, some inherent and some transient. For example, the size, shape, and geology of mineral components are long term features of a soil while moisture content greatly influences carriage of loads but is in constant flux.

Compaction occurs when people allow light to moderate site use on a relatively continuous basis, or periodically for heavy use. As compaction measures increase by 25-33%, soil health is seriously impacted. Tree health mirrors site health, and so negative compaction impacts in the soil negatively impact tree health and structure. As soil and tree health change, ecological health of the

Figure 1: The occurrence priority of stress in trees. The longer and thicker the bars, the greater the imapct.



site declines and approaches exhaustion as both biologics and essential resources are lost. Soil compaction, although usually unnoticed and unmeasured as a site quality issue, leads to severe tree problems and is difficult to correct once applied to a site.

Infrastructure Ecology

The small amount of land where we concentrate many thousands of people does not represent true carrying-capacity of the natural resources on a site. We are forced to concentrate natural resource inputs and outputs from across a large surrounding area in order for our communities to exist. The means of concentrating resources is through building and maintaining engineered infrastructures such as streets, pipes, wires, curbs, buildings, parking lots, water collection and treatment systems, and environmental management devices for building interiors. The infrastructure waste-spaces (not needed for building or maintaining infrastructures) are delegated to "green" things.

Living systems are containerized and walled into small spaces adjacent and intertwined with massive infrastructure systems. The ecology of infrastructures involve resource and process constraints to such a degree that living systems are quickly damaged and exhausted. A summary of the resource attributes around infrastructures include: many humans and machines functioning as sources for ecological disturbance and stress problems (both chronic and acute); fragmented and diminished self-regulating ecological states and processes (declining living things, organic matter, biotic interactions); and, less open soil surface and ecologically active volumes. Compaction is a leading stressor of trees under these resource conditions.

Summing Compaction

As infrastructure requirements increase and generate more ecological impacts, the associated building, maintenance, demolition, and renovation processes cause natural resource quality and usability to decline. Key components of this decline are complex soil resource alterations including water availability, gas exchange, mechanical impedance, and pore space alterations. Soil compaction is a primary feature of the ecological damage with which we are surrounded.

Defining Soil Compaction

Soil resources are always changing. Pore space, water, gas contents, and the electron exchange environment are dynamically changing in a soil every moment. Chemical, biological and physical soil features are always changing. Within this dynamically changing environment, tree roots use genetically crafted growth and survival strategies.

An ideal soil has 50% pore space, divided among air-filled pores and water-filled pores. In addition, 45% of an ideal soil is composed of mineral materials with 5% composed of living and dead organic materials. Figure 2. During genesis in an ideal soil, structural units and specific horizons develop. Unfortunately, soils surrounding infrastructures where we live are not ideal. Because ideal soils do not exist around infrastructures, tree health care providers must work with soils which could be fill-derived, trenched, cut, compacted, polluted, excavated, unstructured, crusted, desert-like, barren, and poorly developed. Figure 3.

Pore Spaces

Soil pore space exists around three primary components: individual particles (texture units) such as sand, silt, and clay; individual structural units (soil aggregates); and, as gaps and cracks at the interfaces of infrastructure and soil. Large sized soil pores are usually filled with air, and so provide good aeration but poor water holding capacity. Small soil pores are usually filled with water, but provide poor aeration. For a healthy soil, coarse textured soils dominated by large air-filled pores need more water availability -- fine textured soils dominated by small water-filled pores need more aeration for good root growth. Figure 4. Soils dominated by small soil pores (clay) have more total pore space than soils dominated by large pores (sand).

There are a series of physical and chemical differences among pore spaces based primarily on size. Aeration pores are filled with air at or below field capacity and capillary pores are filled with water. Figure 5 provides pore size definitions. Capillary pores are further divided into two sizes, tree-available water-filled pores and tree-unavailable water-filled pores. The tree-unavailable water resides in the smallest soil pores where a tree cannot exert enough force through transpiration to remove the pore water. Figure 6.

Dead Zone

Along with pore space volumes, there are three additional soil concepts or attributes which must be appreciated: the deep dead zone; organic matter contents; and, soil structure. Tree-available resources change with soil depth. With increasing soil depth there is a natural increase in carbon dioxide (CO2) concentrations and a decrease in oxygen (O2) concentrations. The balance between these two gases change with water content and biological activity. Somewhere below the surface there is a functionally anaerobic zone where tree roots can not survive called the “dead zone.”

Dead Stuff

Organic matter, as it decays, provides cation and anion exchange capacity, water holding capacity, mineralization of essential elements, substrate and fuel for the detritus food web, and additional pore space. Organic matter in natural soil systems is deposited on the surface as plant litter or near the soil surface as roots die and decay. The decomposing materials are then washed downward through the soil, moving pass living absorbing tree roots. Organic matter is important to soil health but is transient, providing value for a time as it is consumed.

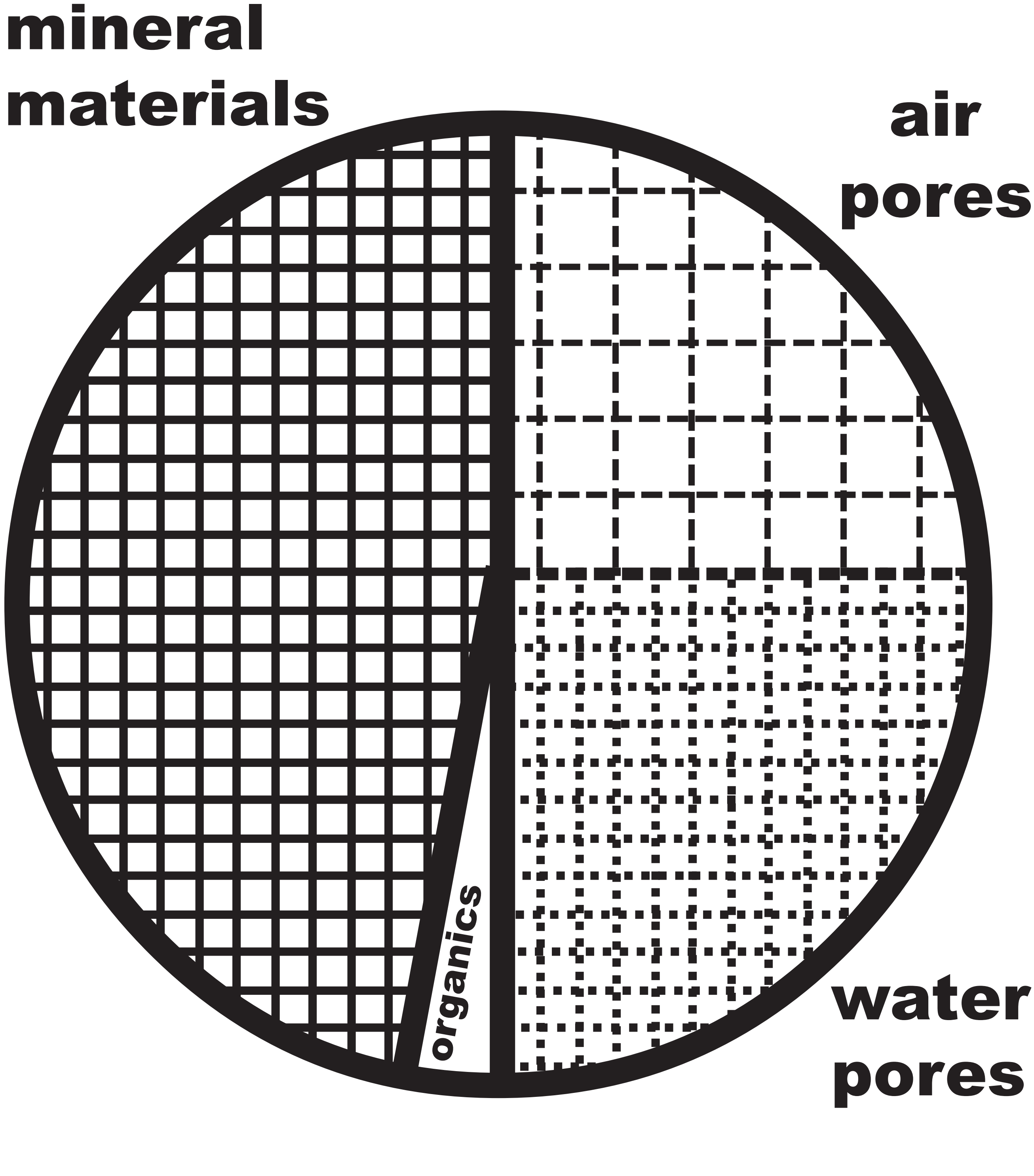


Figure 2: A classic diagram of the components of an idealized soil with a mineral matrix, organics (living & dead), and pore space (water-filled & air-filled).

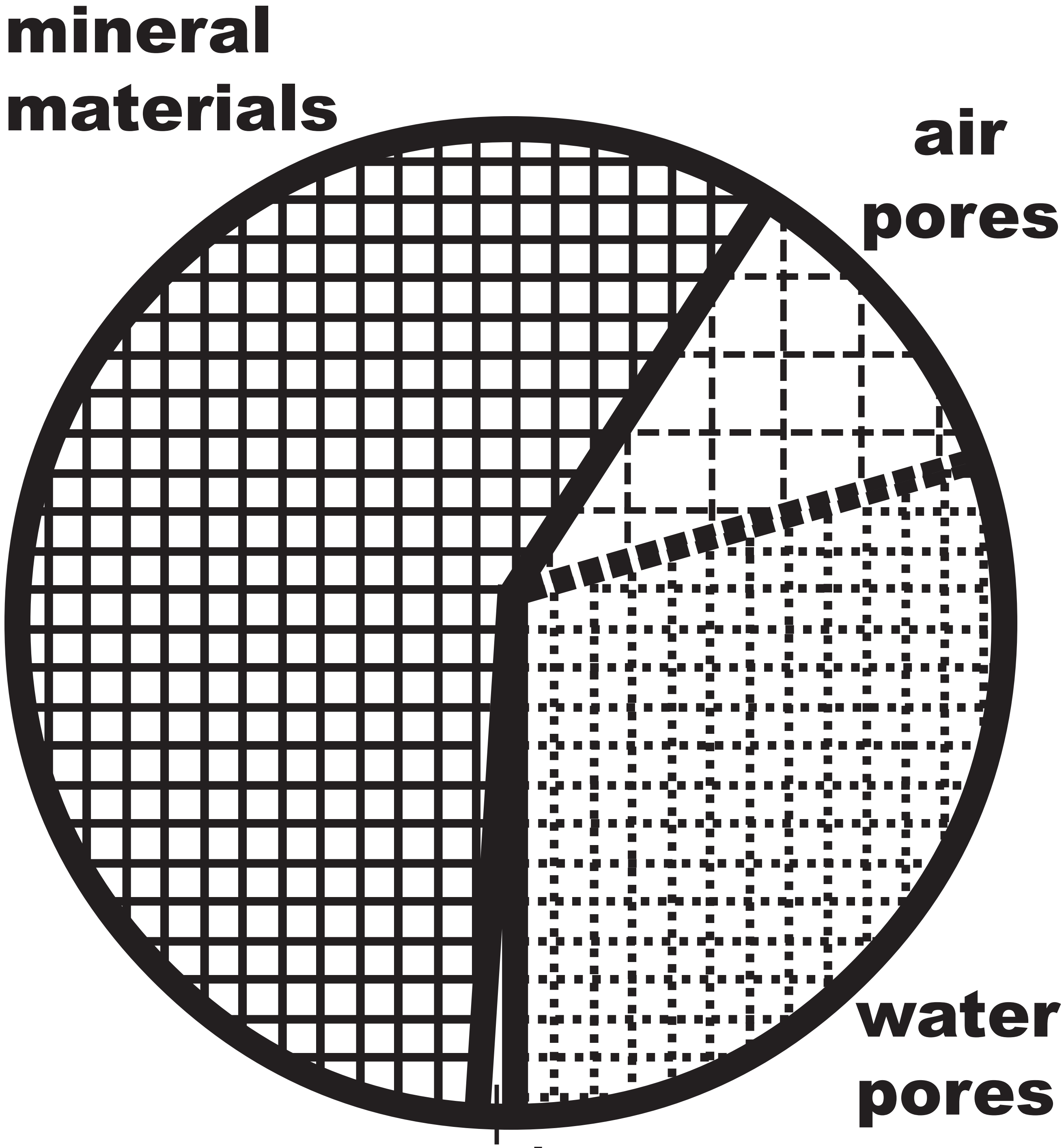


Figure 3: A diagram of the components of an urban compacted soil with a mineral matrix, organics (living & dead), and pore space (water-filled & air-filled).

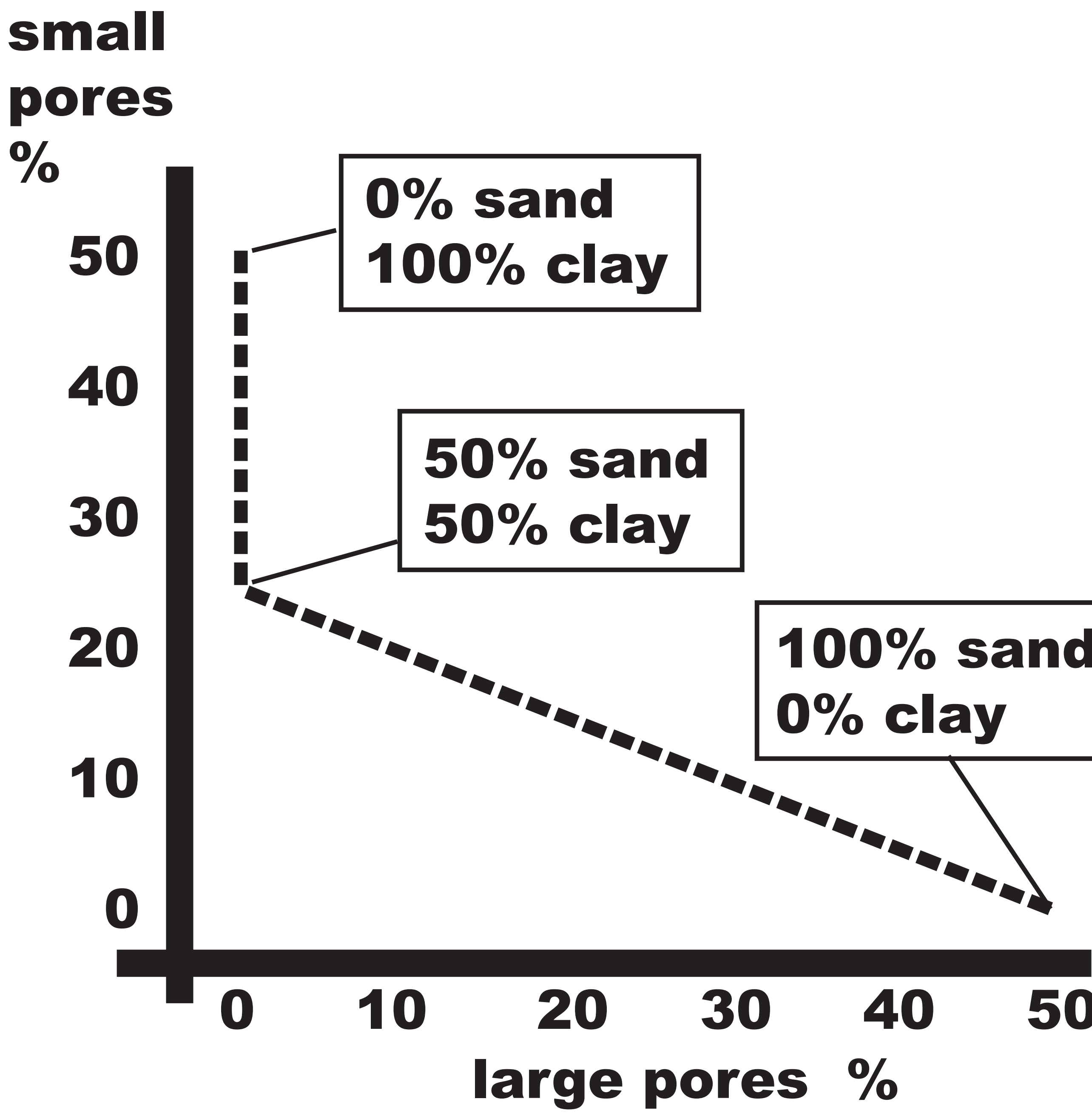
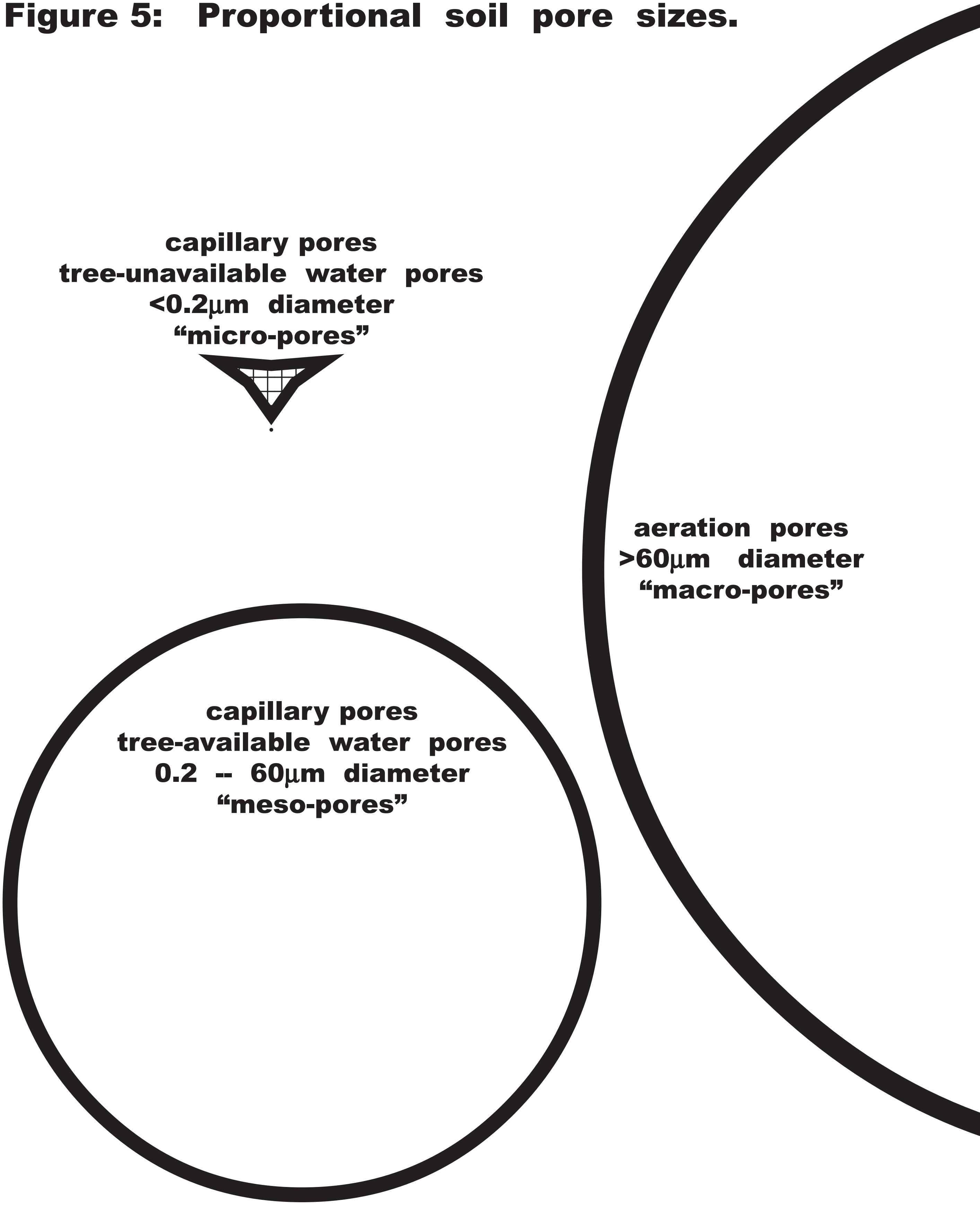


Figure 4: Large and small pore space percentages in various sand / clay mixtures at ~1.32 g/cc bulk density.
(after Harris et.al. 1999)

Figure 5: Proportional soil pore sizes.



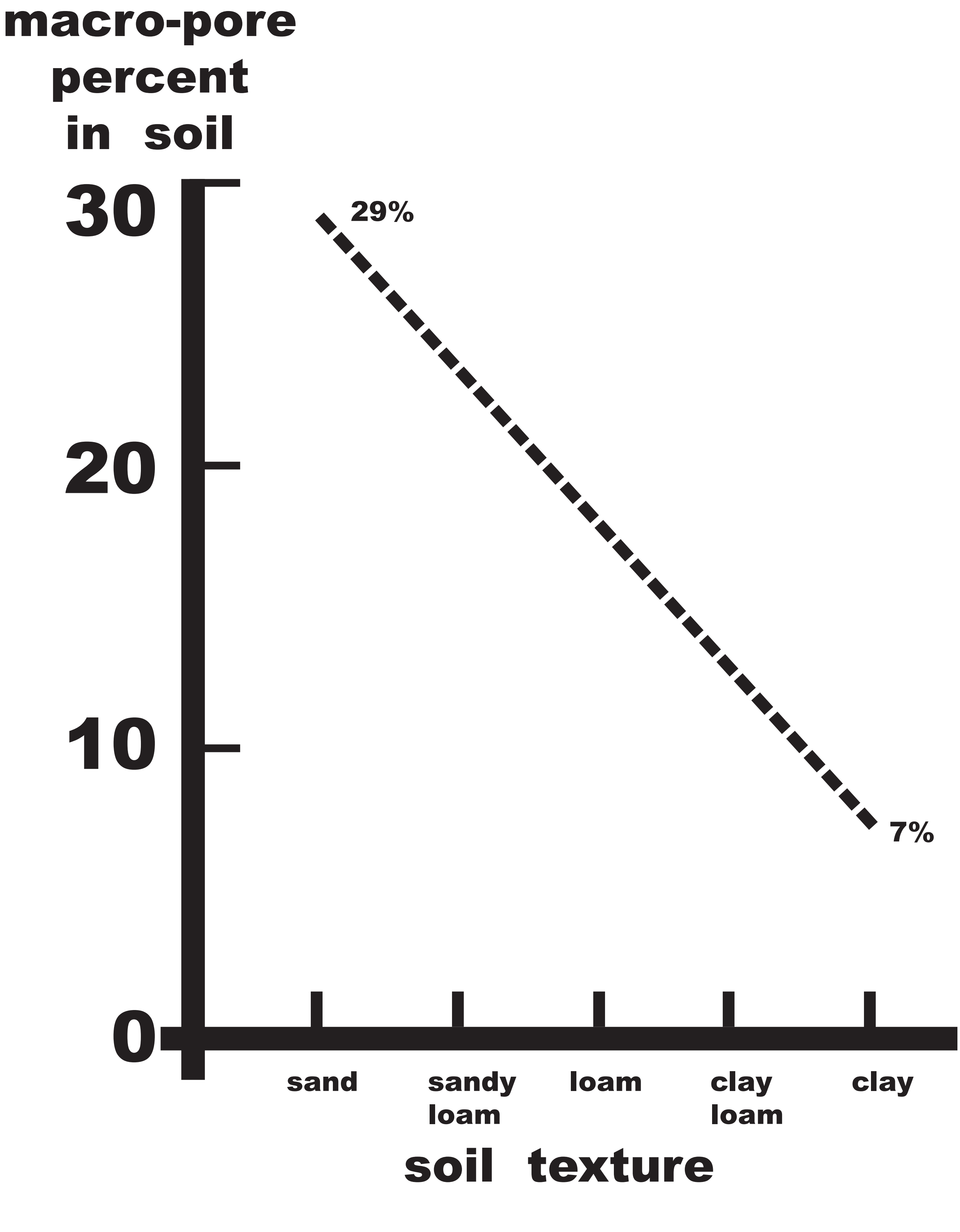


Figure 6: Macro-pore (air pore) space by soil texture. (after Craul 1999)

Bigger Clumps

Structural units, or soil aggregates, are the next order of soil unit above texture yielding pore space. The basic soil particles (sand, silt, and clay) are held together in clumps, clods, or structural units. These structural aggregates are held together with metallic, organic, or colloidal coatings. Between structural aggregates are soil pore spaces utilized by tree roots. Because of pore size and availability, tree roots heavily utilize pore spaces generated from structural aggregate development. Many compacted soils quickly loose the structural based pores, and the structural units themselves.

Defining

A more precise and accurate definition of soil compaction as seen in the field limiting and damaging tree health is needed in order to discuss tree symptoms and managerial solutions. In this discussion the word "compaction" will be used as a composite, generic, negative impact on tree growth and soil health. This composite "compaction" concept used here includes three negative soil changes which include soil compression, soil compaction, and soil consolidation.

"C" Threesome

The process which damages soil around infrastructures called "compaction" starts with soil compressibility or loss of soil volume. Compression leads to a loss of total pore space and aeration pore space, and an increase in capillary pore space. In other words, large air-filled pore spaces are crushed leading to more small water-filled pores. Compression is most prevalent in soils under wet conditions.

True compaction is the translocation and resorting of textural components in the soil (sand, silt, and clay particles), destruction of soil aggregates, and further loss of aeration pores. Compaction is facilitated by high moisture contents. Consolidation is the deformation of the soil, destroying any pore space and structure, by water squeezed from the soil matrix. This process leads to increased internal bonding and soil strength as more particle-to-particle contacts are made and pore space is eliminated.

Adding CPR

In addition to the "3Cs" of compaction listed above (compression, compaction, consolidation), compaction problems often include crusting, puddling, and rutting. These processes are surface centered and affect the extent and depth of damage to the top surface layer of the soil. These problems generate soil conditions difficult for effective tree health maintenance and remeadiation. Crusting, puddling and rutting generate soil and tree damage similar to applying a plastic sheet across the soil surface.

Crusting is the dislocation and packing of fine particles and organic matter on the soil surface. Natural oil and wax products, and pollutants, can be associated with the soil surface making a thin hydrophobic top layer which prevents water and oxygen infiltration. Primary causes of crusting is the impact of rain drops on open soil surfaces, sprinkler irrigation impacts, pollutant absorption, and animal and pedestrian traffic.

Puddling and rutting are both a cause and effect of a dense, thick crust or cap on the soil surface. The primary mechanism of this damage is from destruction of soil aggregates and aeration pores through particle movement. In saturated soils under a top load, there is no place for non-compressible water to go except to the side, squashing structure and pores. Foot and vehicle traffic under saturated soil conditions, and equipment movement on the soil surface over shallow saturated soil layers, facilitate puddling and rutting.

Generic "C"

All components of the generic term "compaction" listed above do not necessarily occur in any order, nor all occur on any given soil. A general summary of compaction as applied to tree and soil health problems would be: "A soil which has sustained a loss of soil aggregates, destruction of aeration pore spaces, crushing or collapse of pore spaces, and undergone extensive resorting and packing of soil particles."

The depth to which a soil is compacted is determined by the compacting agent or process. Every type of site management or maintenance which requires soil contact has a characteristic compaction zone or layer either at the surface or at some depth below the surface. Cultivation or management layers (pans) form from soil cultivation, packing of soil fills or lifts, and various types of traffic patterns. New compaction may develop over the top of past compaction problems. One site may present several layers of compaction at various depths representing a history of site use and tree growth limitations.

Compacted Fast

The extent of soil compaction rapidly increases with the first few impacts on the soil surface under the right conditions and then levels-off. Soils can be compacted to 90-95% of what they can be compacted to in as little as 3-4 trips over a single point. In other words, it is not years of traffic, but the first few trips over a site which does the majority of compaction damage. Figure 7.

Stressed Out

Compaction stresses and strains trees, damages soils, and interferes with effective tree health management. Compaction is an unseen cause for many tree problems. Tree health care providers must better appreciate, quantify, and mitigate compaction.

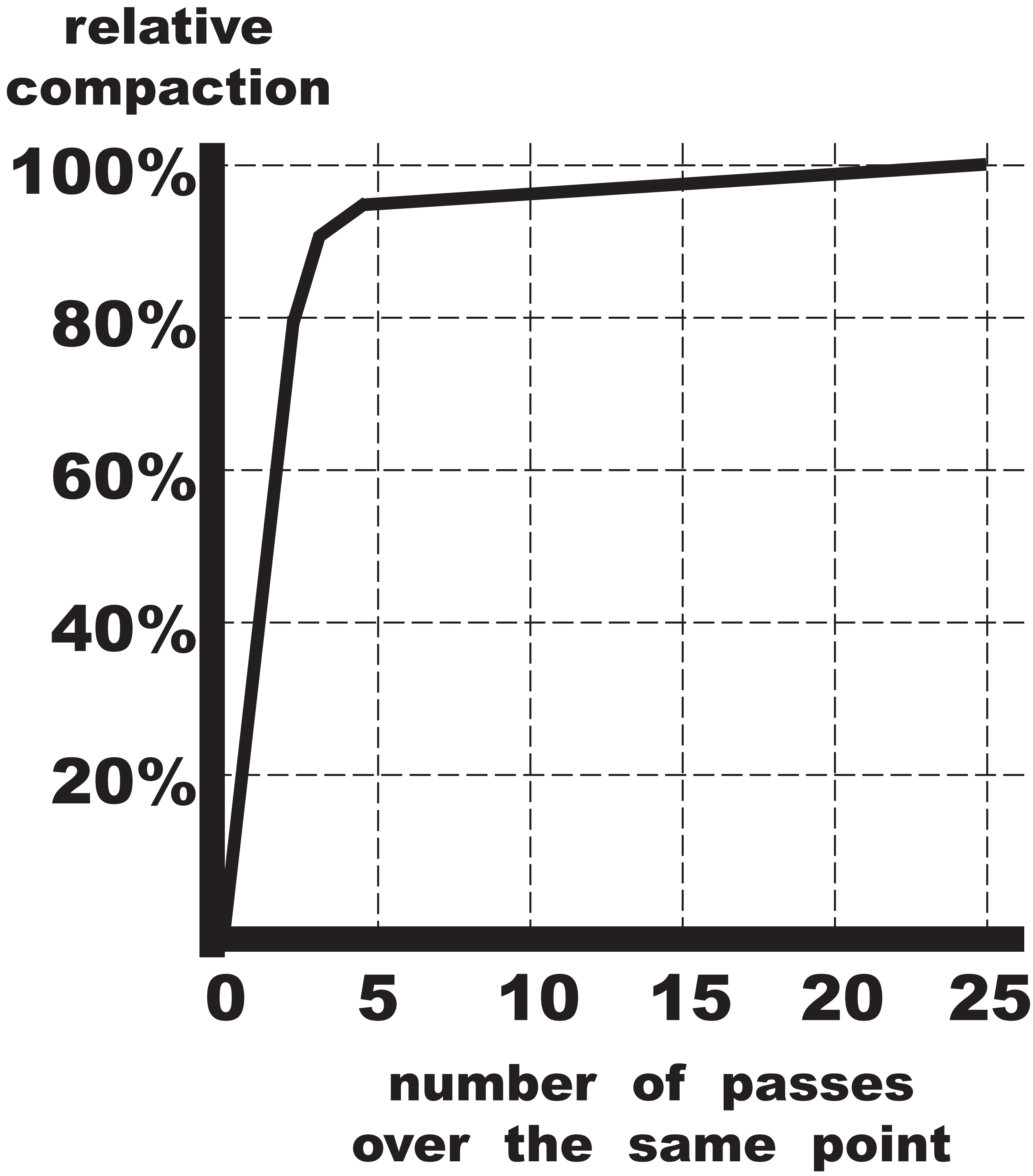


Figure 7: The number of passes over or impacts on the same soil area generating compaction.

Root Health

Roots utilize the space (pores) in soil. The volume of soil space controlled by tree roots is directly related to tree health. The more space controlled by roots, the more potential resources available. Healthy soil contains spaces giving roots access to required resources including water, oxygen, physical space for growth processes, and an open soil surface area for replenishment of essential resources.

The Matrix

After accounting for soil pore space, the rest of a soil is made of organic materials in the form of living organisms or dead materials, and a mineral matrix. The mineral matrix is only a significant concern for evolving essential elements, for surfaces holding biological cooperators, and for frictional and inertial forces for structural integrity. It is soil organic matter and pore space which are critical for tree health.

In developed landscapes, compaction robs soil of viable rooting space and robs trees of healthy roots. Figure 8. Tree roots under soil space constraints occupy gaps and cracks around, under, and between hardscapes and supporting infrastructures. Because hardscapes, like pavements and foundations, expand and contract at different rates than soils, the interface between soil and infrastructures is usually an air filled crack. On heavily compacted sites, roots will be concentrated around the edges of infrastructures, running along hardscape edges, and filling any accessible moist air space.

Bad Things

Soil surrounding tree roots are an ecological composite of living, once-living, and abiotic features facilitating life. Soil compaction disrupts the interconnections between ecological components in a soil. Compaction initiates many negative ecological impacts including: decrease volume of ecologically viable space available; decrease depth of tree rootable space; disrupt the detritus food web -- the ecological engine responsible for powering a healthy soil; eliminate the diversity of living things and beneficial associates, with only a few ecological niche-generalists succeeding; and, favor pests which consume beneficial organisms and roots not able to defend themselves (i.e. *Pythium* & *Phytophthera* root rots). Compaction causes tree roots to become more prone to damage and attack at a time when their sensor, defense, growth regulation, and carbon allocation processes are functioning at marginal levels.

Root Requirements

Growth in trees may not be an increase in total living mass, but does represent expansion of tissues into new spaces. Tree roots develop adventitiously, expand into the soil, and radially thicken. Root density, mass, and activity vary with internal and external conditions. Soil resources required for root growth are summarized in Table 1.

Roots utilize soil spaces for access to water and essential elements, and for providing structural support. Roots grow following pathways of interconnected soil pores. Pores can be the result of spaces between textural units (sand, silt, and clay particles), between structural units (blocks, plates, grains, prisms, etc.), along fracture lines (shrink / swell clays, frost heaving, pavement interfaces, etc.), and through paths of biological origins (decayed roots, animal diggings, etc.).

Roots survive and grow where adequate water is available, temperatures are warm, light is subdued or blocked, and plenty of oxygen is present. Roots are generally shallow and extensive on sites, as limited by oxygen contents, anaerobic conditions, and longterm water saturation. Near the

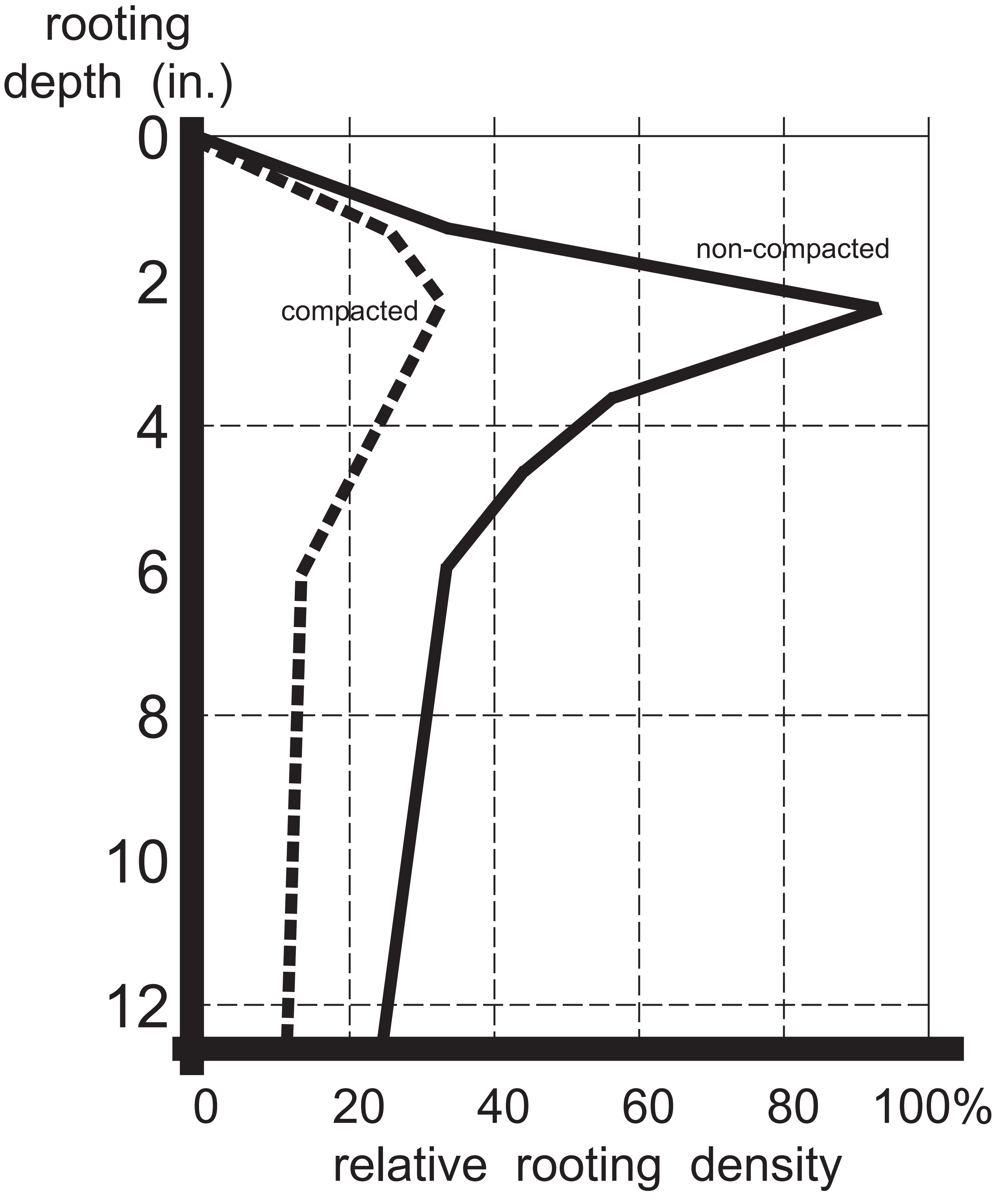


Figure 8: Relative rooting density of fine roots in pin oak (*Quercus palustris*) as depth in a soil increases, 4 years after compaction.

(based upon Watson & Kelsey, 2006)

Table 1: Brief list of soil based root growth resource requirements.

root resource	requirements minimal	requirements maximum
oxygen in soil atmosphere (for root survival)	4 %	21 %
air pore space in soil (for root growth)	15 %	60 %
soil bulk density restricting root growth (g/cc)	- -	1.4 clay 1.8 sand
penetration strength (water content dependent)	0.01 kPa	3 MPa
water content in soil	12 %	40%
root initiation (oxygen % in soil atmosphere)	12 %	21 %
root growth (oxygen % in soil atmosphere)	5 %	21 %
progressive loss of element absorption in roots (oxygen % in soil atmosphere)	10 %	21 %
temperature limits to root growth	40°F / 4°C	94°F / 34°C
pH of soil (wet test)	pH 3.5	pH 8.2

base of a tree, deep growing roots can be found, but are oxygenated through fissures and cracks generated as a result of mechanical forces moving the crown and stem under wind loads (sway) causing root plate wobbling.

Growth Forces

The ability of root tips to enter soil pores, further open soil pores, and elongate through soil pores is dependent upon forces generated in the root and resisted by the soil. Root growth forces are generated by cell division and subsequent osmotic enlargement of each new cell (hydraulic pressure). Oxygen and carbohydrate (food) for respiration, and adequate water supplies are required to produce root hydraulic pressure. Figure 9. Tree roots can consume large amounts of oxygen during elongation especaially at elevated temperatures as on some developed sites. At 77°F (25°C) tree roots can consume nine times (9X) their volume in oxygen each day, at 95°F (35°C) roots can use twice that volume (18X) per day. The osmotic costs to root cells of resisting surrounding soil forces and elongating are significant.

Compaction forces roots to generate increased turgor pressures concentrated farther toward the root tip, to lignify cell walls quicker behind the growing root tip, and to utilize a shorter zone of elongation. In response to increased soil compaction, roots also thicken in diameter. Thicker roots exert more force and penetrate farther into compacted soil areas. Figure 10. As soil penetration resistance increases in compacted soils, roots must thicken to minimize their own structural failure (buckling), to exert increased extension force per unit area, and to stress soil just ahead of the root cap which allows easier penetration.

Size Matters

For effective root growth, many pores in a soil must be larger than root tips. With compaction, pore space diameters become smaller. Once soil pore diameters are less than the diameter of main root tips, many growth problems occur. The first noticeable root change with compaction is morphological -- roots thicken, growth slows, and more laterals are generated of various diameters. Lateral root tip diameter is dependent upon initiation by growth regulators and extent of vascular tissue connections. If laterals are small enough to fit into the pore sizes of the compacted soil, then lateral growth will continue while the main axis of a root is constrained. If soil pore sizes are too small for even the lateral roots, root growth will cease. Figure 11.

Pavements

Soil is a complex material with unique thermal and moisture expansion and contraction patterns. Soil expands and contracts over a day, season, and year at different rates than adjacent pavement or hard infrastructures. As a result, fracture lines filled with air occupy the interface between soil and infrastructures. These aeration pore spaces can be effectively colonized by tree roots. If infrastructure construction is not completed in an ecologically-literate way, tree roots can expand in these spaces generating enough mechanical force, and facilitating soil volume changes, to accentuate any structural / material faults present.

In addition to the aeration pore space available at structure / soil interfaces, coarse sub-grade and paving bed materials can provide pore space for tree root colonization. The interface between pavement and its bedding material can be a well aerated and moist growing environment. Compaction may have caused anaerobic condition to be found close to the surface under pavement while the added pavement bed may provide a secure colonization space for tree roots. Physical or chemical root barriers may be needed to prevent root colonization of aeration spaces surrounding infrastructures.

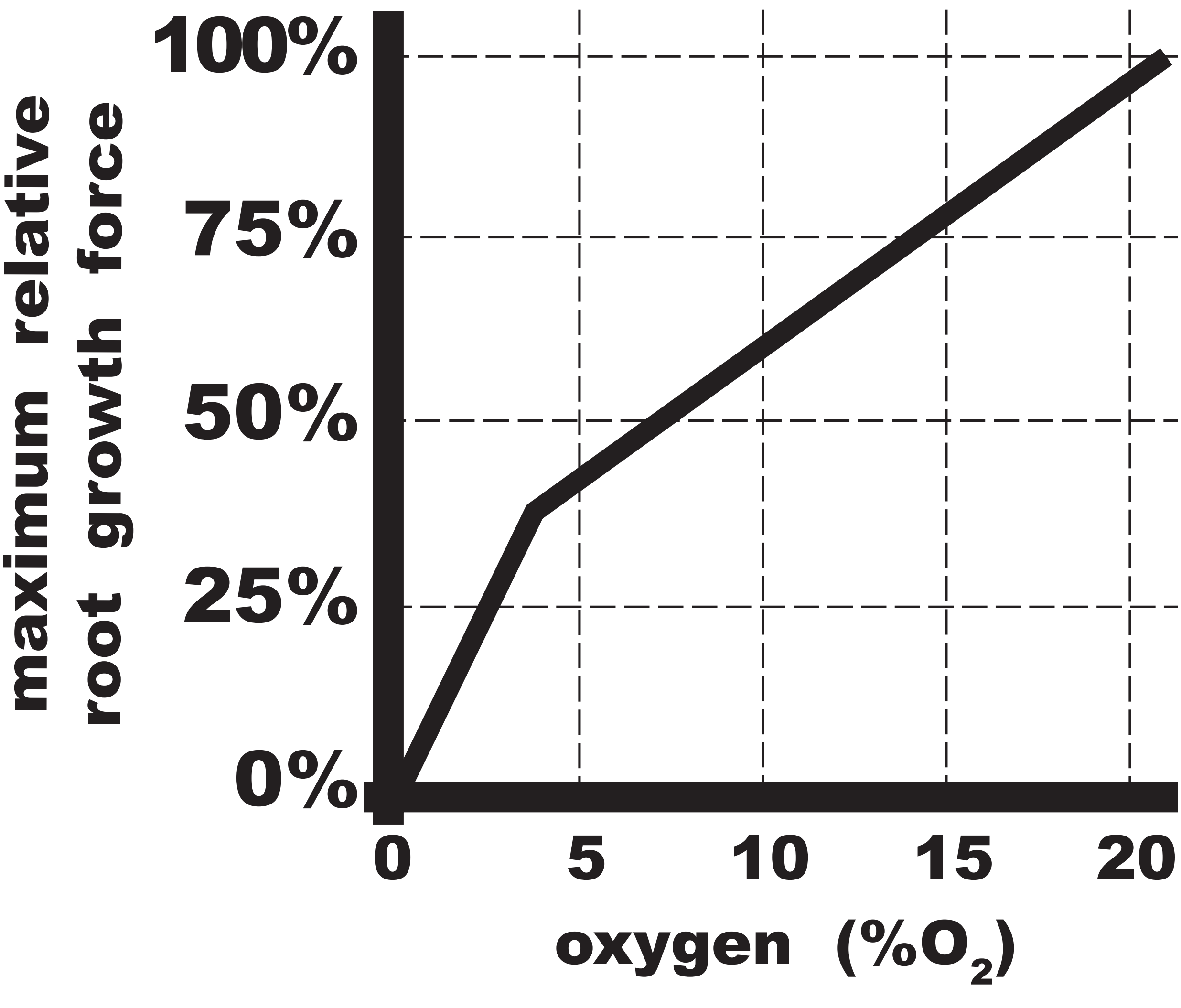


Figure 9: Maximum relative root growth force expressed by seedlings at various oxygen concentrations.

(after Souty & Stepniewski 1988)

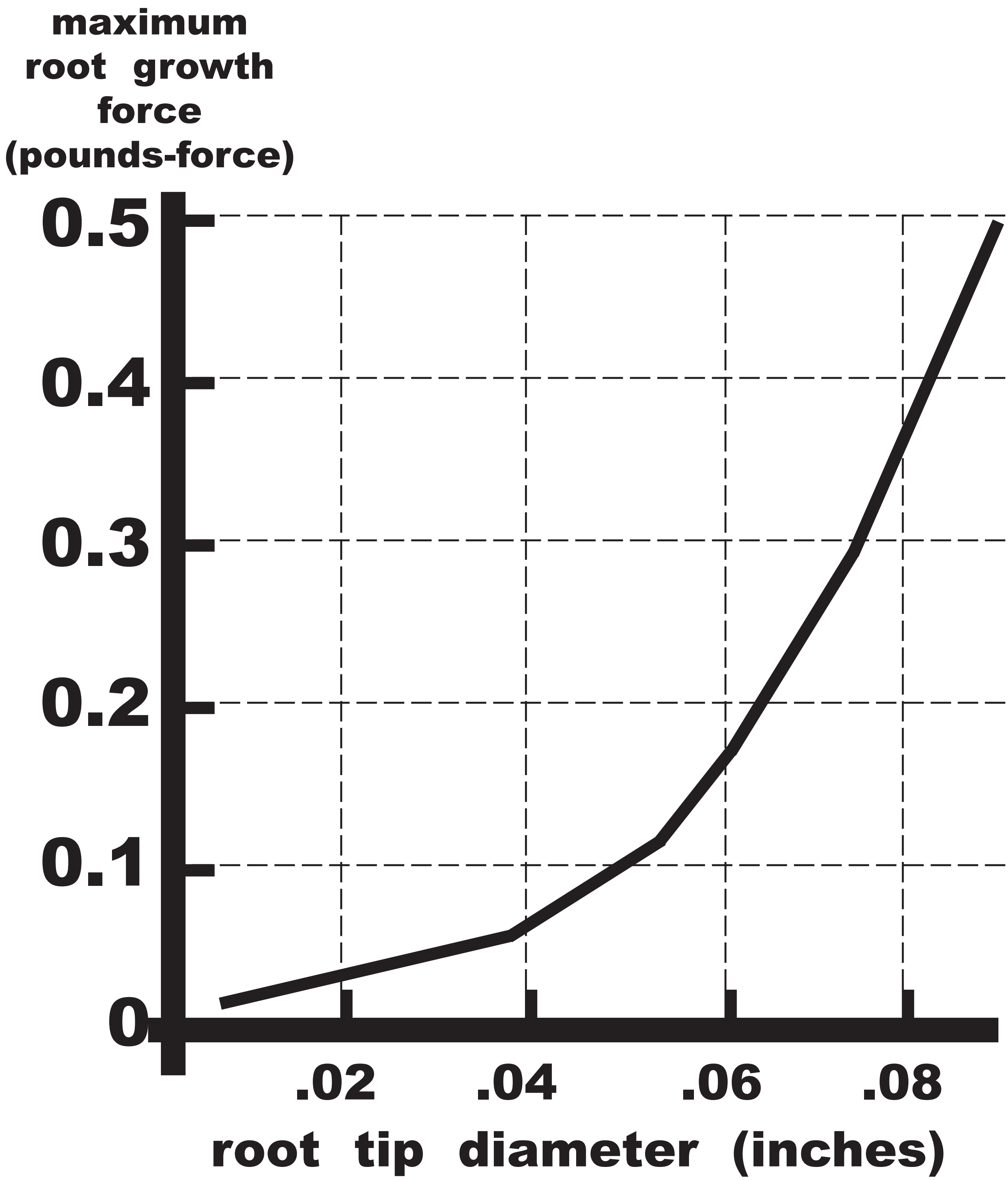


Figure 10: Maximum root growth force by root tip diameter. (after Misra et.al. 1986)

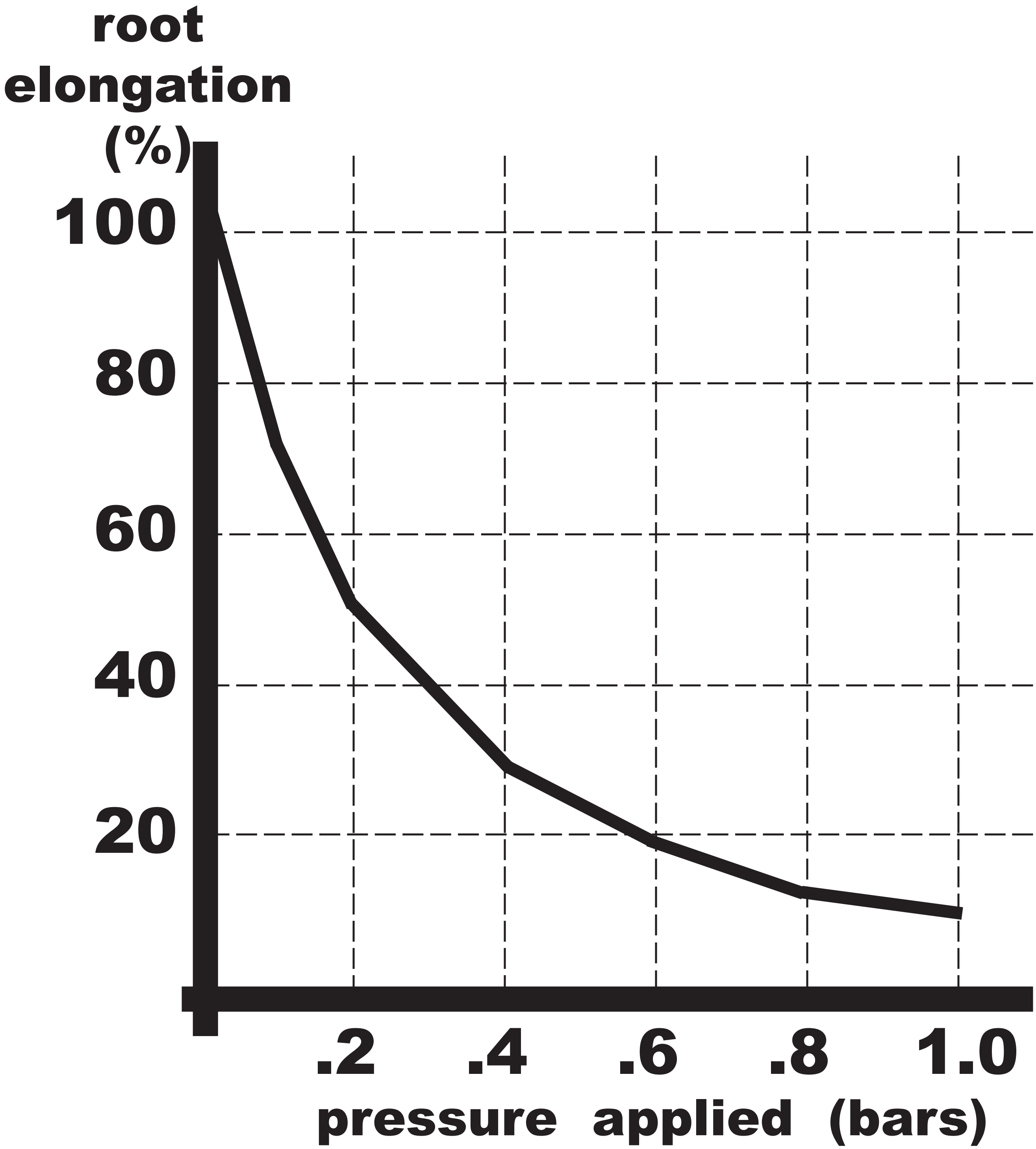


Figure 11: Pressure applied to root tips that limit elongation. (1 MPa = 100 kPa ≈ 1 bar)
(after Rendig & Taylor 1989; Russell 1977)

Tree Species Tolerance

Across the gene combinations which comprise tree forms, there is a great variability in reactions to soil compaction. As there are many different soil conditions impacted by compaction, so too are there many gradations of tree responses to compaction. A tree's ability to tolerate compacted soil conditions is associated with four primary internal root mechanisms: reaction to mechanical damage is effective and fast; continuation of respiration under chronic oxygen (O_2) shortages; ability to regenerate, reorient, and adjust absorbing root systems; and, ability to deal with chemically reduced materials (toxics).

A list of trees with many of these compaction tolerance mechanisms are in Appendix 1.

Compaction Causes & Soil Results

In order to understand and visualize soil compaction more completely, the underlying causes must be appreciated. Soil compaction is primarily caused by construction and development activities, utility installation, infrastructure use and maintenance, landscape maintenance activities, and concentrated animal, pedestrian, and vehicle traffic. Below are listed common individual causes of soil compaction.

Moisture Facilitation

For every soil type and infrastructure situation there is a soil moisture content at which soil can be severely compacted with minimal effort. Bringing soils to these optimum moisture content levels are used to compact soils for road construction. Compaction activities should be avoided on soils especially near these moisture contents. Both direct impacts and vibrational energy will cause compaction when soil is at or near its compaction moisture content optimum. Figure 12.

Water can provide energy directly to the soil surface causing compaction. Direct irrigation impacts from sprinklers, or rainfall hitting open soil surfaces, can cause crusting and compaction. Piling of snow in winter when soil is frozen compacts little, but large snow drifts remaining on-site as soils begin to thaw can lead to compaction both from physical weight and from maintaining high moisture levels allowing for long periods of compaction susceptibility. Saturated soil contact allows hydraulic pressure to destroy soil aggregates and move fine particles into aeration pore spaces. Flooding events can dissolve soil aggregate coatings and lead to soil structure loss. Erosion processes across a soil surface, and fine particle movement within the top portions of the soil, can lead to aeration pore space loss and crusting.

Trafficing

The pounds per square inch of force exerted on a soil surface by walking, grazing, standing, and concentrating humans and other animals can be great. Problems are most prevalent on the edges of infrastructures such as fences, sidewalks, pavements, and buildings. Holding, marshaling, or animal concentration yards allow significant force to be delivered to soil surfaces. Paths and trails provide a guided journey to soil compaction.

Vehicles with tracks, wheels, and glides provide a great deal of force on soil surfaces. Narrow rubber tires can transfer many pounds of compaction force to soil. The classic example are in-line skates and high pressure bike tires. These wheels can impact soils beyond 60lbs per square inch. Broad, flat treads can dissipate compaction forces across more soil surface than thin tires, and reduce forces exerted per square inch.

Manipulations

The movement, transport, handling, and stockpiling of soil destroys aeration pore spaces and disrupts soil aggregates. Soil cuts, fills, and leveling compacts soil. Soil handling equipment can be large and heavy allowing compaction many inches deep. Anytime soil is moved, air pore space is destroyed and soil is compacted. The most extreme form of compaction force applied to a soil is by explosions. One solution to compaction in the past was use of explosives to fracture soils. The end result was the explosive energy fractured soil to the sides and above the charge, but heavily compacted soil below. Explosives damage soil to a degree not offset by any fracturing or aeration pores formed.

Any mechanical energy that impacts individual soil particles can cause compaction. Nearby car and truck traffic can cause vibrations which compact soils effectively at higher moisture contents.

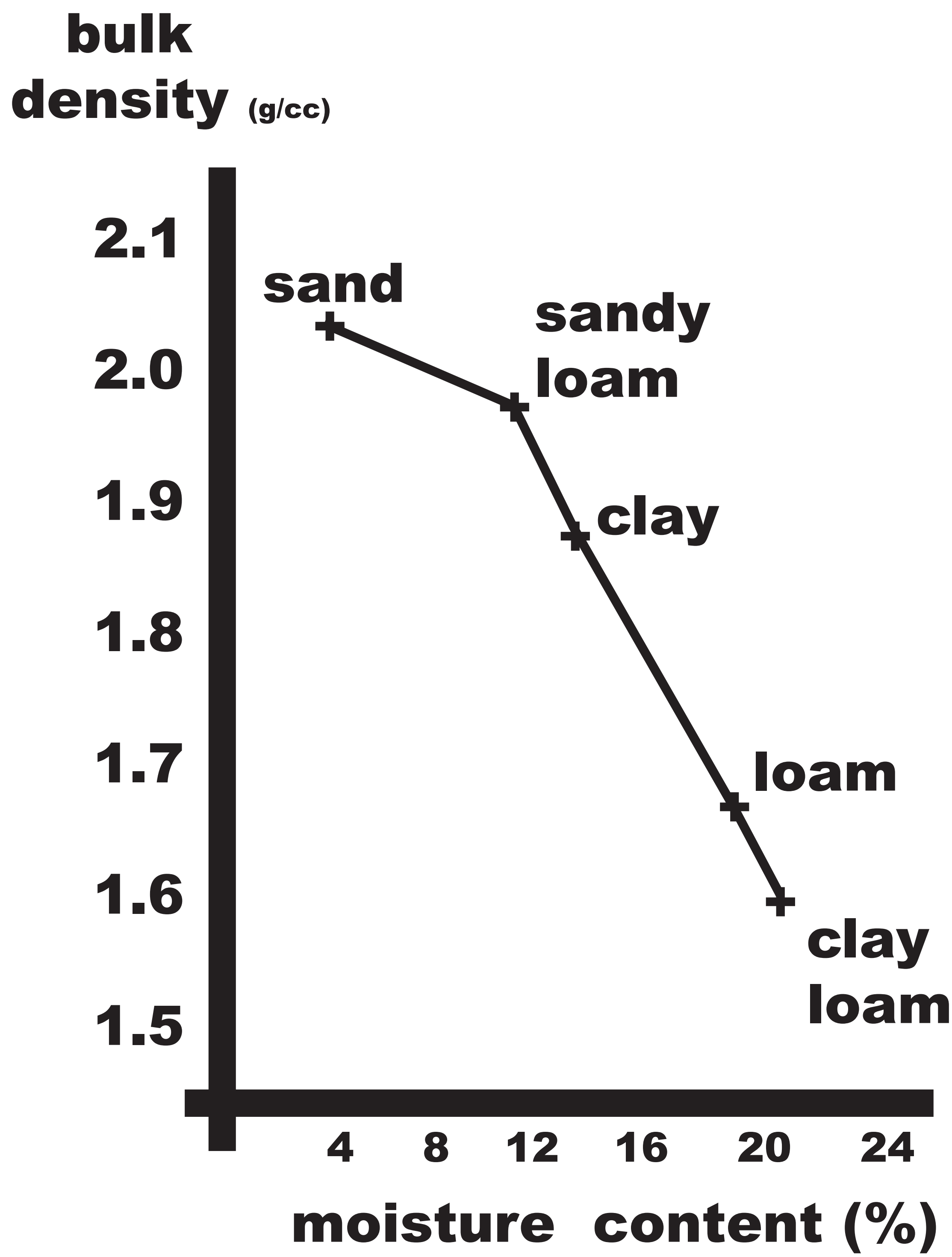


Figure 12: Maximum compaction capacity of a soil by moisture content.
(after Craul 1994)

Wet, boggy sites are especially prone to transferring vibrational energy through soil. Vibrational compaction can be significant in rooftop, bridge, and train station planter boxes, for example.

In order for infrastructures to be built and maintained, supporting soil must be properly compacted. Because of how forces in soil are distributed beneath infrastructures, a compacted pad with slanted base sides must be built. This process assures that infrastructure edges, bases, and lifts (compacted fill layers) are heavily compacted. Under these standard construction conditions, the only space available for tree root colonization in or adjacent to these areas are fracture lines, interface zones between building materials, and any pore space in or under coarse building materials. The greater soil compaction, the closer to the surface functional anaerobic layers develop, the less ecologically viable space available for roots, and the smaller soil pore sizes become associated with mechanically stronger soil, all minimizing tree root growth.

Organic Matter Loss

Organic matter is fuel, short-term building blocks of structure, and supply warehouse for living things in a soil. As organic matter decomposes and mineralizes without adequate replacement, soil becomes more compacted. Soil density increases and aggregate stability declines as organic matter is "burned" out of a soil through elevated temperatures and lack of replacement. The organic matter cycle spins down as a compacted soil system is exhausted and becomes less capable of sustaining life.

Resulting Problems

The actions of people compact soils in intentional and unintentional ways. Whatever the cause of compaction, the soil's ability to fully sustain tree growth is diminished. Ecological results of compaction lead to severe tree stress and strain, of which only the acute and severe impacts are usually ever recognized. The chronic problems of soil compaction remain on-site as a plague to current and future trees. The functional results of soil compaction on trees and their sites are many and complexly interconnected.

Aggregate Destruction

Air pore spaces from soil cracks, interface surfaces, biotic excavations, organic particle decomposition, and normal soil genesis processes help oxygenate the soil matrix. By definition, compaction results in the destruction of soil aggregates and aeration pore spaces. Pore spaces filled with oxygen, and interconnected with other aeration spaces exchanging gases with the atmosphere, are critical to a healthy soil and tree root system. The destruction of aeration spaces surrounding soil aggregates can be unrecoverable.

Under compaction, particles of soil are redistributed into new locations, many into open pore spaces within the soil matrix. Through packing, erosion, and cultivation processes, many fine particles can fill-in spaces surrounding other particles, as well as spaces between structural aggregates. Some soil types can be compacted more easily through this process than others. Mid-textured soils with a mix of particle sizes can be strongly compacted due to particle size availability to fill any size of pore space.

Pore Space Destruction

Compaction initiates a redistribution of pore sizes within a soil matrix. Large pores are destroyed and small pore are generated. The total pore space of soil being compacted initially increases as more capillary pores are created and as aeration pores are lost. With coniuing compaction, total porosity declines and oxygen diffusion rates plumate. Figure 13. The pore sizes which fill and empty with water and air are most impacted by compaction. Figure 14.

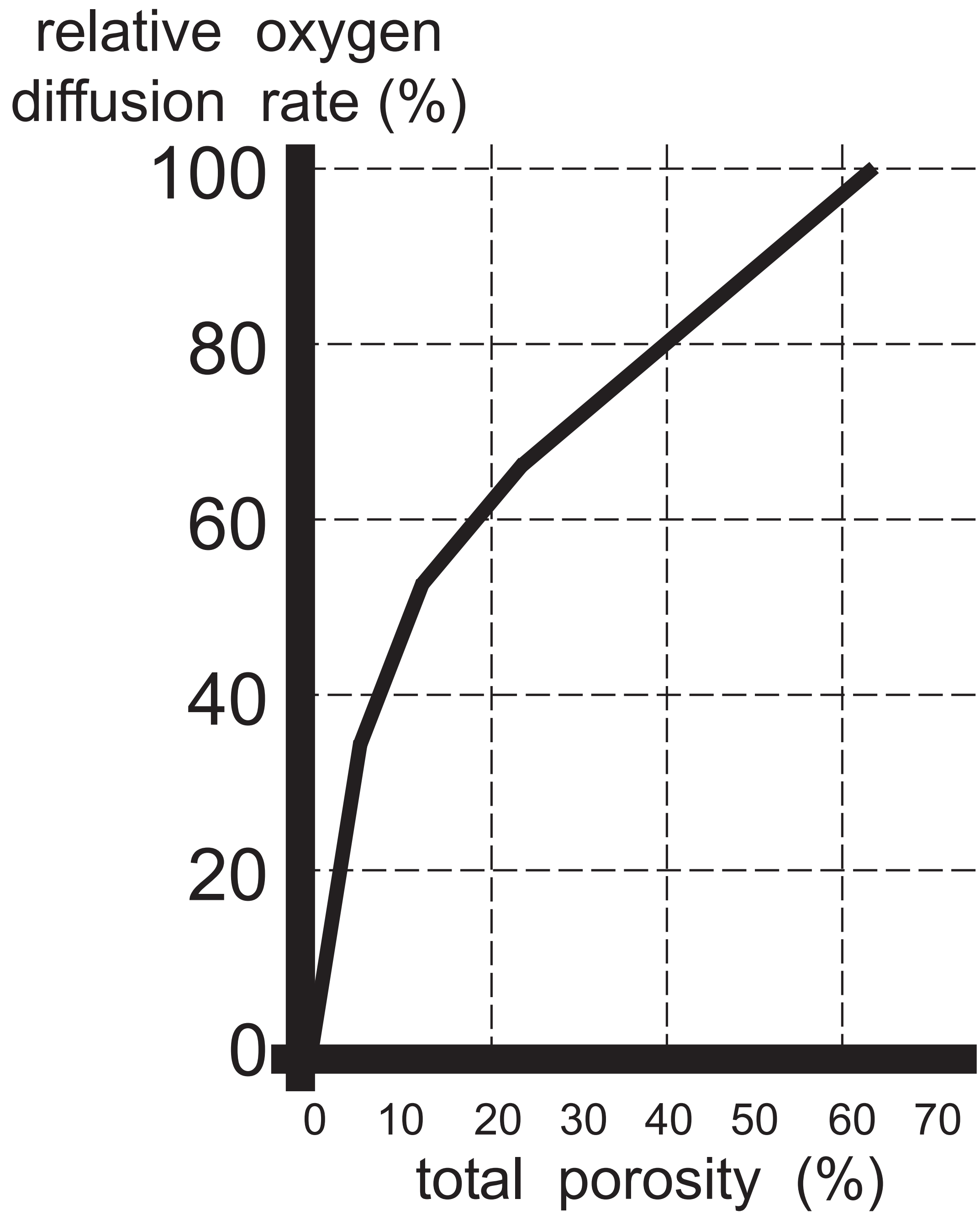


Figure 13: Relative oxygen diffusion rates
as total soil pore space changes.
(derived from Cook & Knight, 2003)

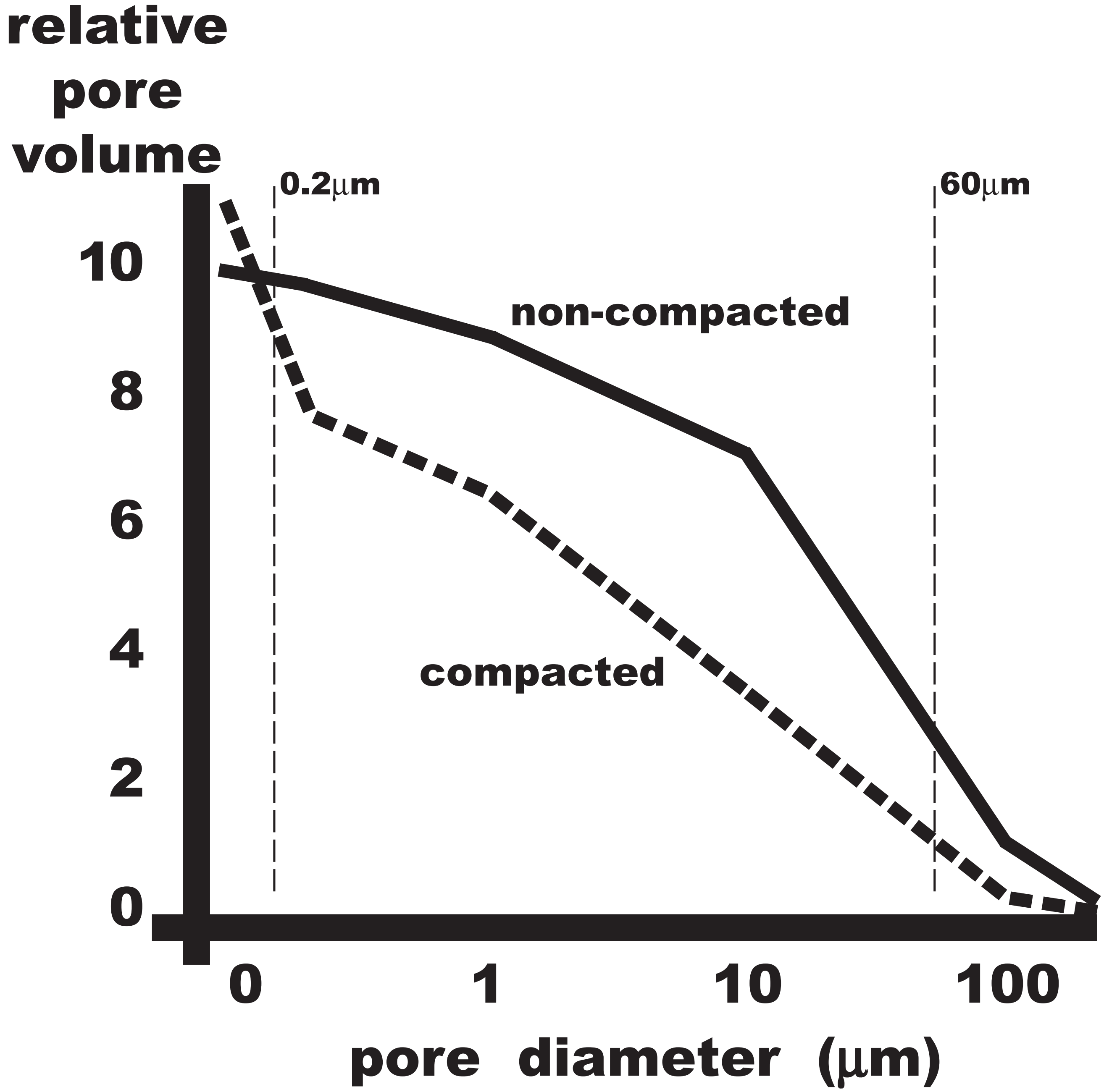


Figure 14: Soil pore diameters and relative volumes under non-compacted (1.4 g/cc) and compacted (1.8 g/cc) conditions. (after Jim 1999)

The crushing collapse of aeration pores facilitates the upward movement in a soil of a functionally anaerobic layer. Figure 15. There are always anaerobic and aerobic micro-sites in and around soils aggregates within surface layers of soil. The dynamic proportions of each type of micro-site changes with each rainfall event and each day of transpiration. Compaction shifts proportional dominance in a soil to anaerobic sites. With further compaction, aerobic sites are concentrated closer and closer to the surface until little available rooting volume remains. Figure 16. Table 2 lists root-limiting aeration pore space percentages in soils of various textures. Air pore space less than 15% is severely limiting.

Increased Strength

Compaction brings soil particles into closer contact with each other (less moisture and/or greater bulk density). Closer contact increases surface friction and soil strength. As soil strength increases and pore sizes and numbers decrease, the ability of roots to grow and colonize soil spaces decline rapidly. Average diameters of pores significantly smaller than average root diameters are not utilized by tree roots. With compaction, soil strength reaches a level where roots can not exert enough force to push into pore spaces. Figure 17. Figure 18. Table 3 lists root-limiting soil densities by texture. Soil texture and density must both be determined to estimate compaction impacts on tree health. Figure 19 shows a soil texture graph with root growth constraining soil density values. Regardless of soil texture, soil density values greater than 1.75g/cc severely limits growth.

Suffication

The aeration pathway (lifeline) from the atmosphere to a root surface through all the interconnected aeration pores declines quickly with compaction. Figure 20. Figure 21 demonstrates as air pore space falls below 15% (dotted line on graph), the pore interconnectiveness become highly convoluted and highly resistive to gas exchange. As tortuosity of the oxygen supply path increases, the closer to the surface the anaerobic layer moves. (Review Figure 15.) As pore sizes become smaller with compaction, more pore space is filled with water. Water-filled pores diffuse oxygen at rates 7,000 to 10,000 times slower than air-filled pores. With all the other aerobes and roots in a soil competing for the same oxygen, oxygen limitations can quickly become severe. Figure 22 shows oxygen diffusion rates declining in a soil under increasing (line 1 to 3 in figure) compaction.

Compaction constrains oxygen movement in soil and shifts soil aggregates toward more anaerobic conditions. Less oxygen diffusing into soil leads to a chemically reducing soil environment (both in the soil solution and soil atmosphere) closer to the surface. Figure 23. Under these conditions, toxins and unusable essential element forms are generated. In addition, organic matter is not mineralized or decomposed effectively. As oxygen is consumed, an anaerobic respiration sequence begins among bacteria starting with the use of nitrogen and moving through manganese, iron, and sulfur, ending with carbon (i.e. fermentation of organic matter including roots).

Limited Gas Exchange

Tree roots are aerobes, as are root symbionts and co-dependent species of soil organisms. Less oxygen minimizes root growth pressure, defense, and survival. Figure 24. Tree roots use available food twenty times (20X) more inefficiently under near anaerobic conditions. Less oxygen also allows common pathogenic fungi, which have oxygen demands must less than tree roots, to thrive. As oxygen concentrations fall below 5% in the soil atmosphere, severe root growth problems occur even at low soil densities. Figure 25. Figure 26

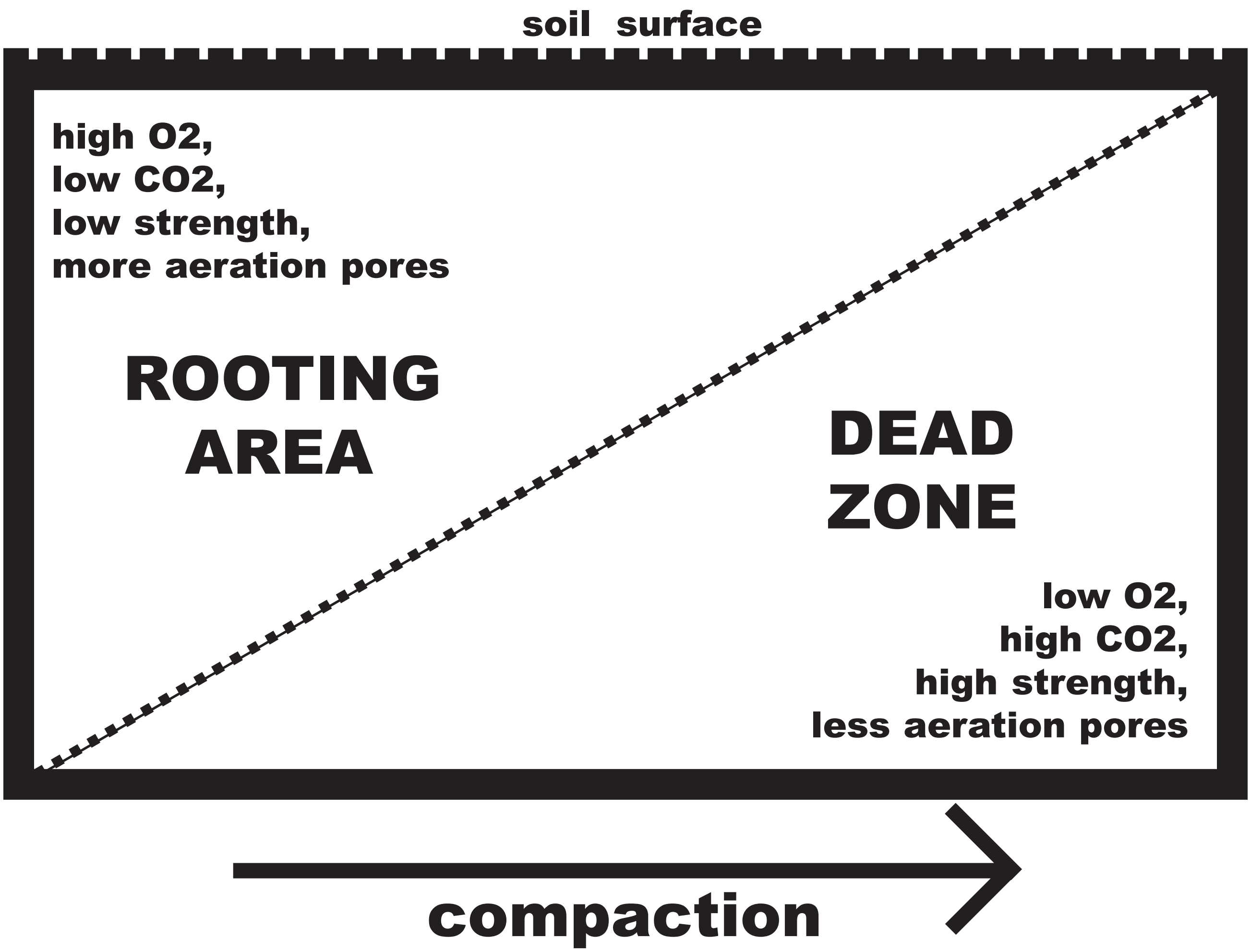


Figure 15: Graphical representation of compaction effects on soil.

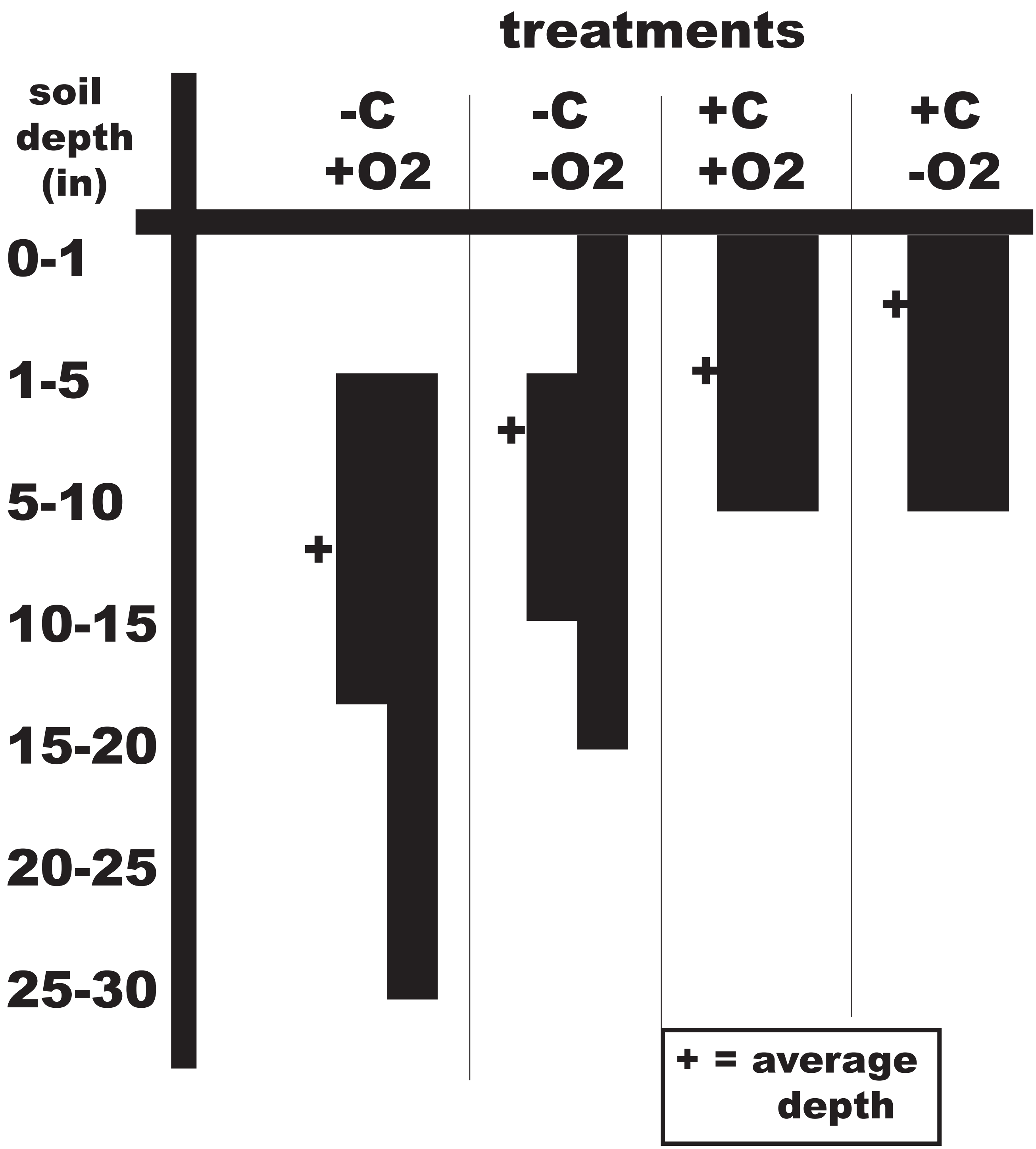


Figure 16: Compaction (C = + 28%) and oxygen (O2 = - 5%) impacts on tree rooting depths. (after Gilman et.al. 1987)

Table 2: Root growth limiting air-pore space values by soil texture. Pore space percentages at or less than the value given are limiting to tree root growth. (Daddow & Washington 1983)

soil texture	root-limiting air pore %
sand	24 %
fine sand	21
sandy loam	19
fine sandy loam	15
loam	14
silt loam	17
clay loam	11
clay	13

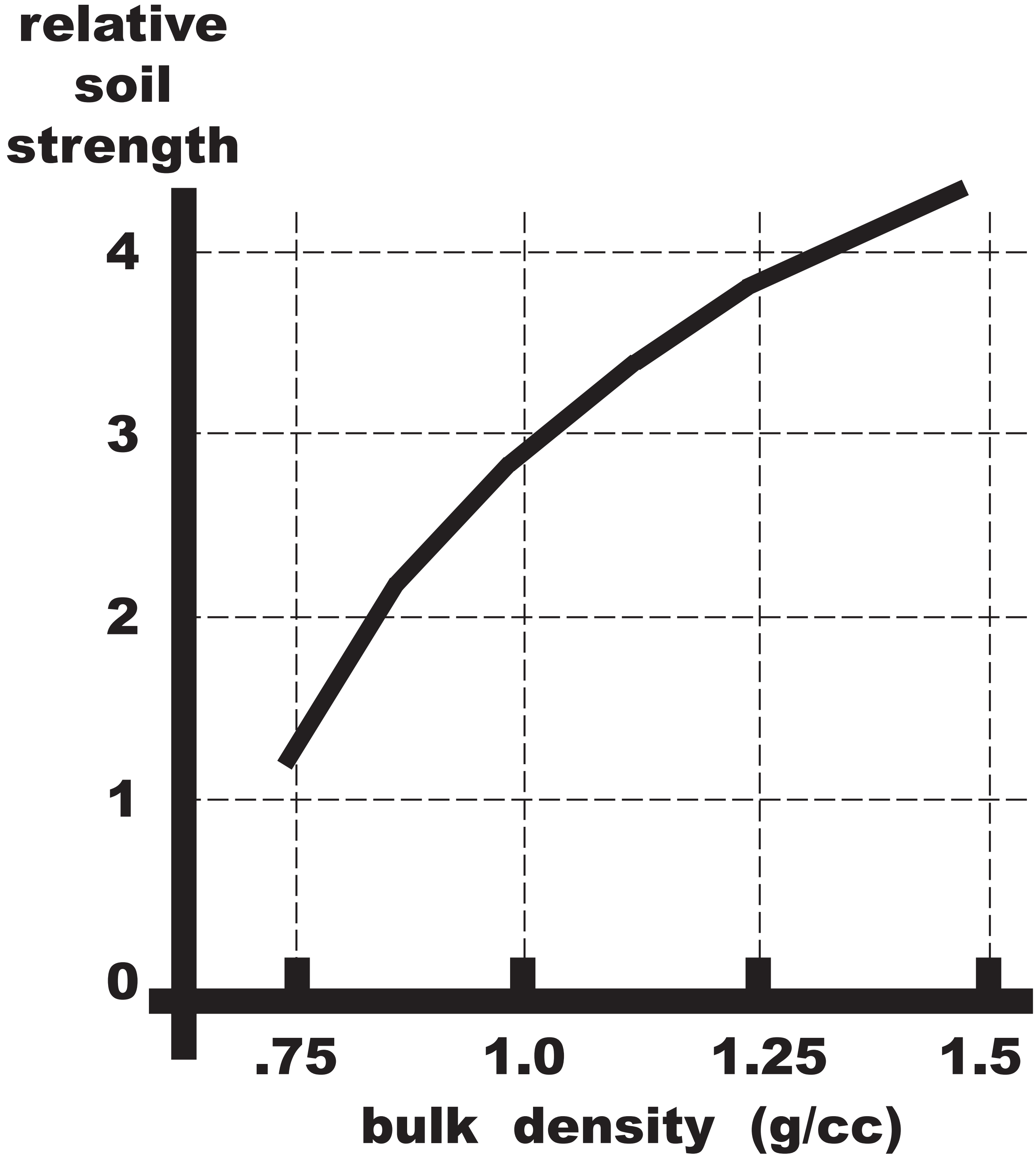


Figure 17: Relative soil strength with increasing density values.
(after Craul 1994)

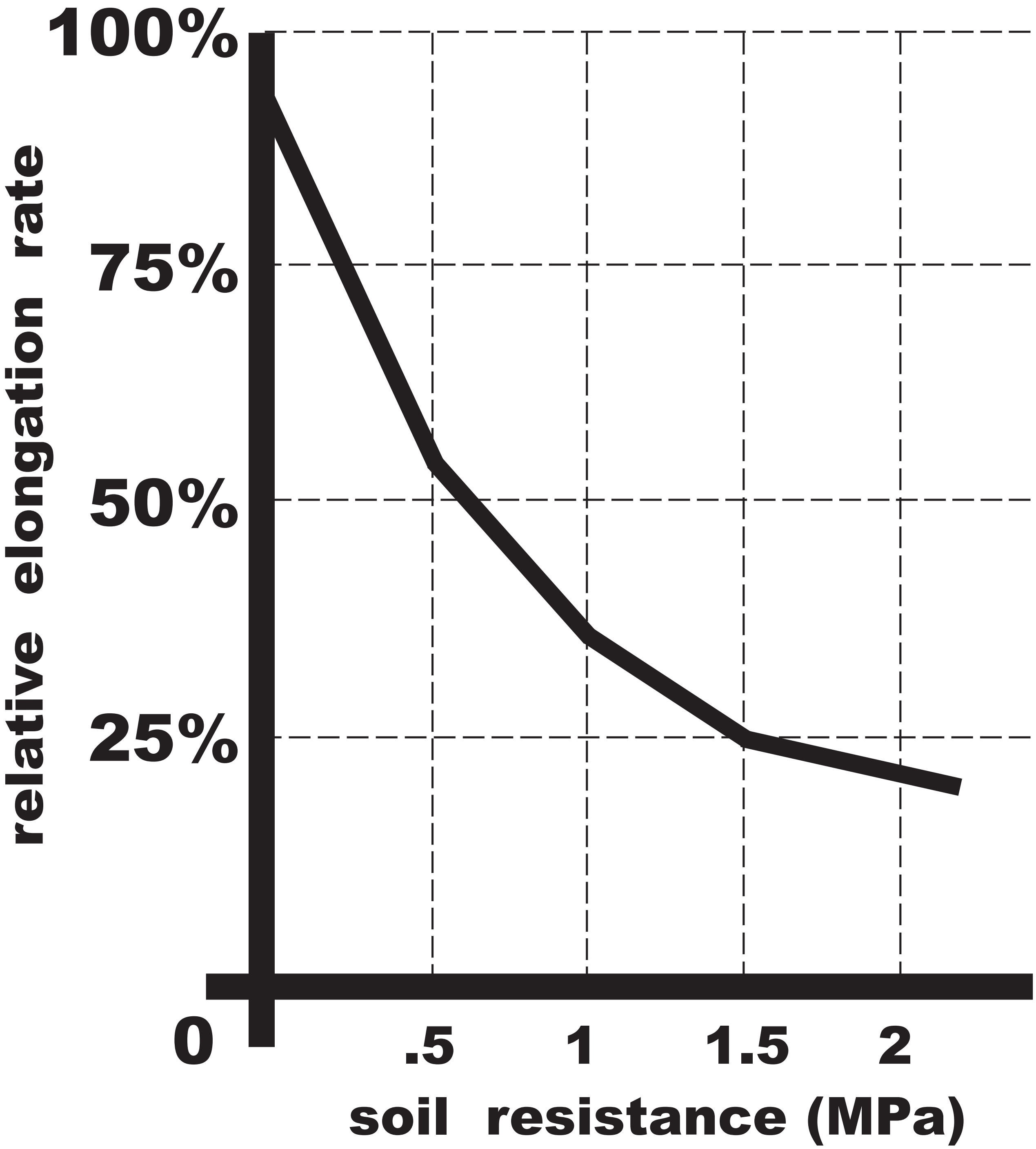


Figure 18: Soil penetration resistance and root elongation rate. (1 MPa = 100 kPa . 1 bar)
(after Rendig & Taylor 1989)

Table 3. Root growth limiting bulk density values by soil texture. Soil density values equal to or greater than listed values are limiting to tree root growth. (Daddow & Washington 1983)

soil texture	root-limiting bulk density (g/cc)
sand	1.8 g/cc
fine sand	1.75
sandy loam	1.7
fine sandy loam	1.65
loam	1.55
silt loam	1.45
clay loam	1.5
clay	1.4

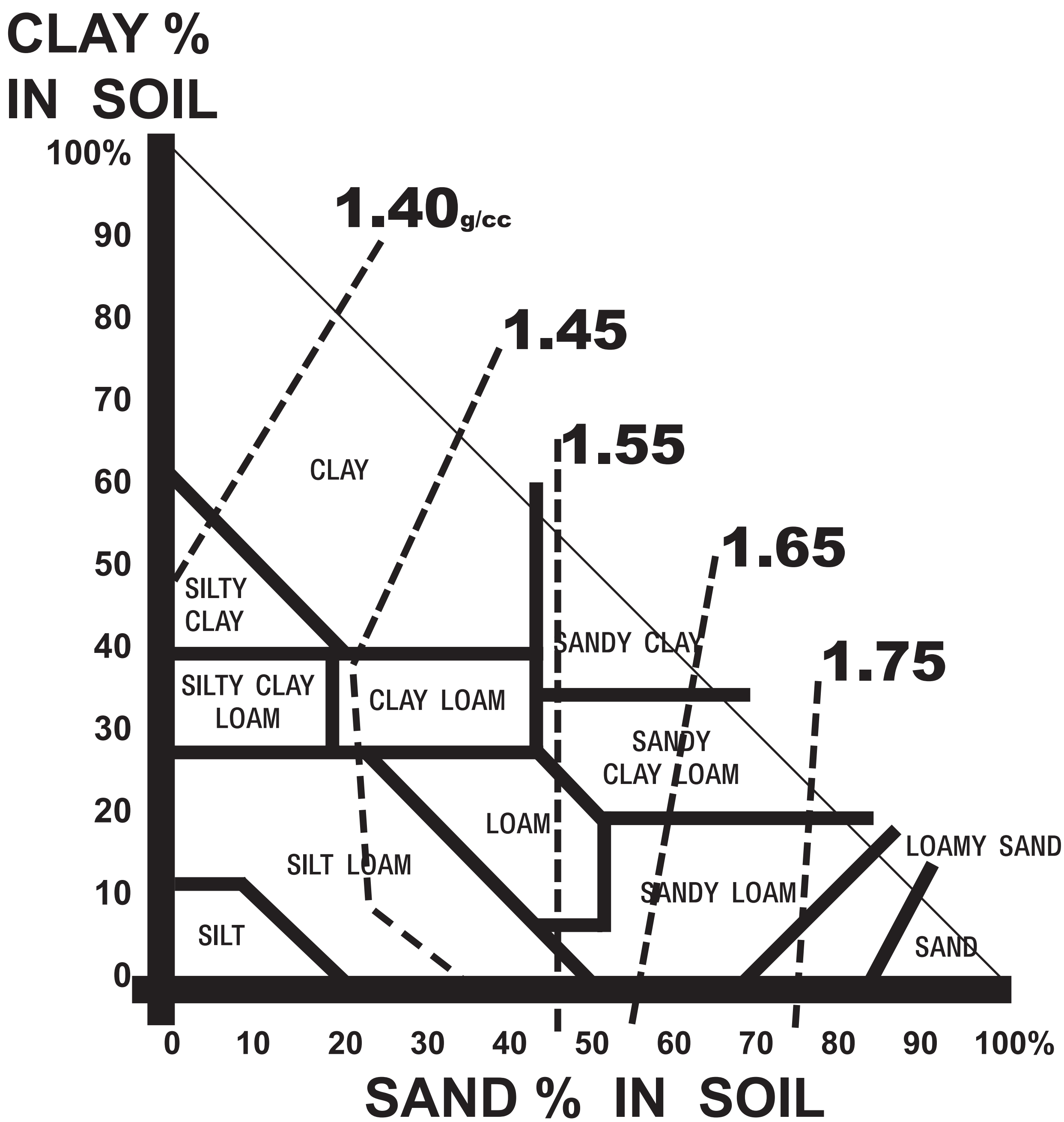


Figure 19: Soil texture graph showing texture classifications based upon sand and clay proportions, and dotted lines showing root-limiting bulk densities (g/cc). Values equal to or greater than the listed density value will significantly constrain tree root growth.

(Daddow & Washington 1983)

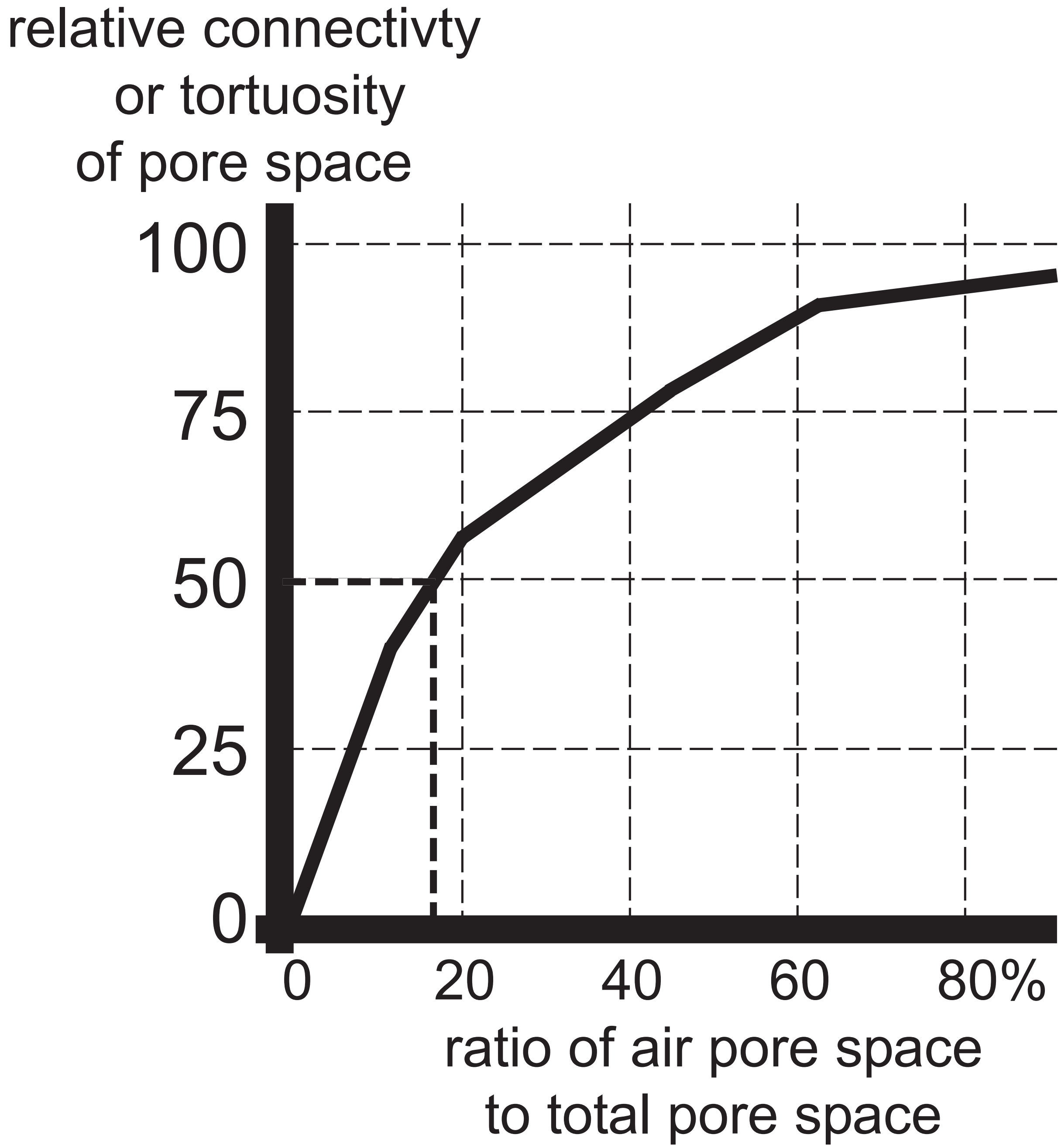


Figure 20: The relative interconnectedness or tortuosity of pore space for aeration in soils. The ratio of air pore space to total pore space (%) = (air porosity % in soil) / (total porosity % in soil). Heavy dotted lines represent one-half loss of pore space connectivity at an air pore to total pore space ratio of 18%
(derived from Moldrup et.al. 2004).

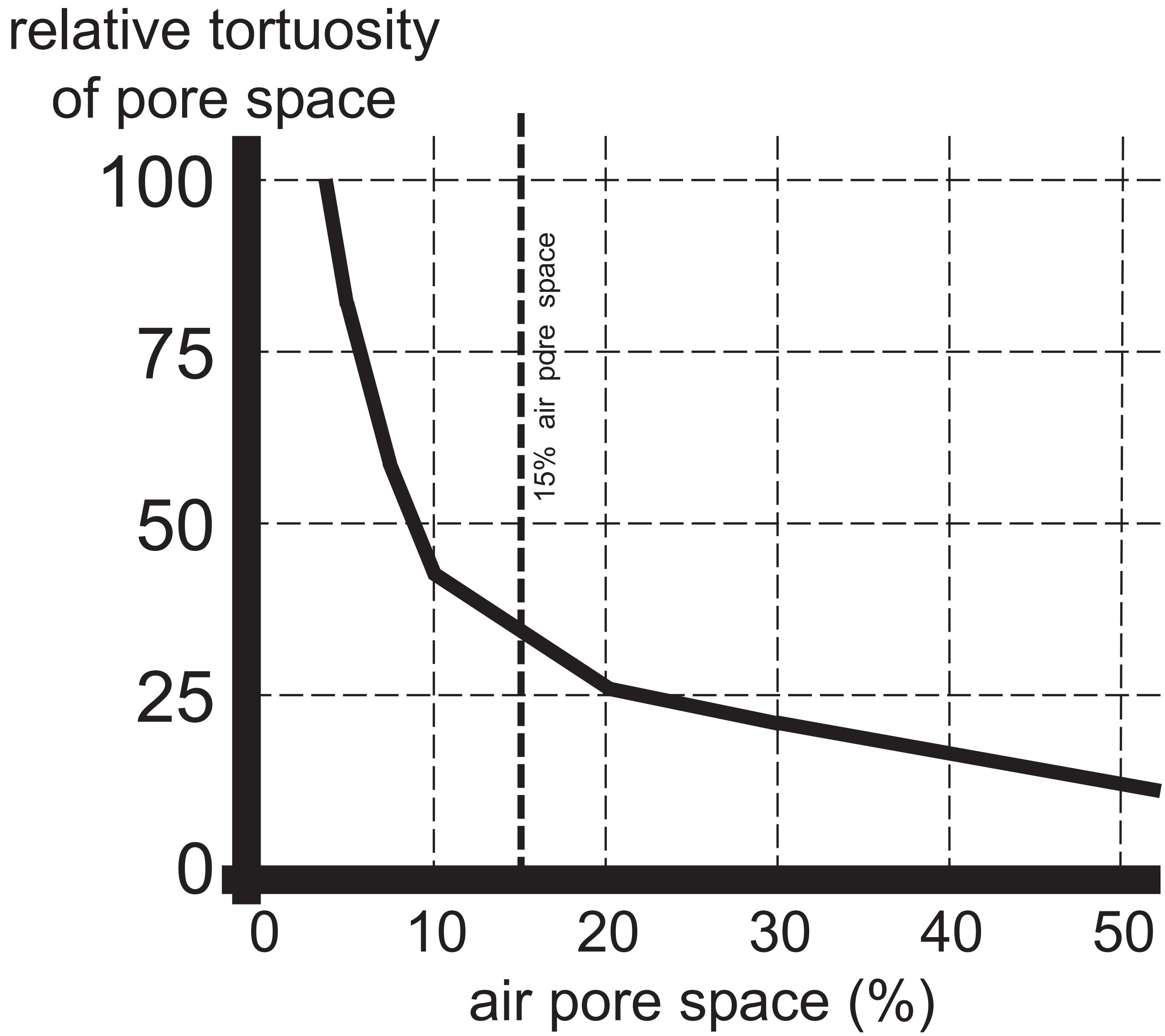


Figure 21: The relative interconnectedness or tortuosity of pore space for aeration in soils.
(derived from Moldrup et.al. 2001).

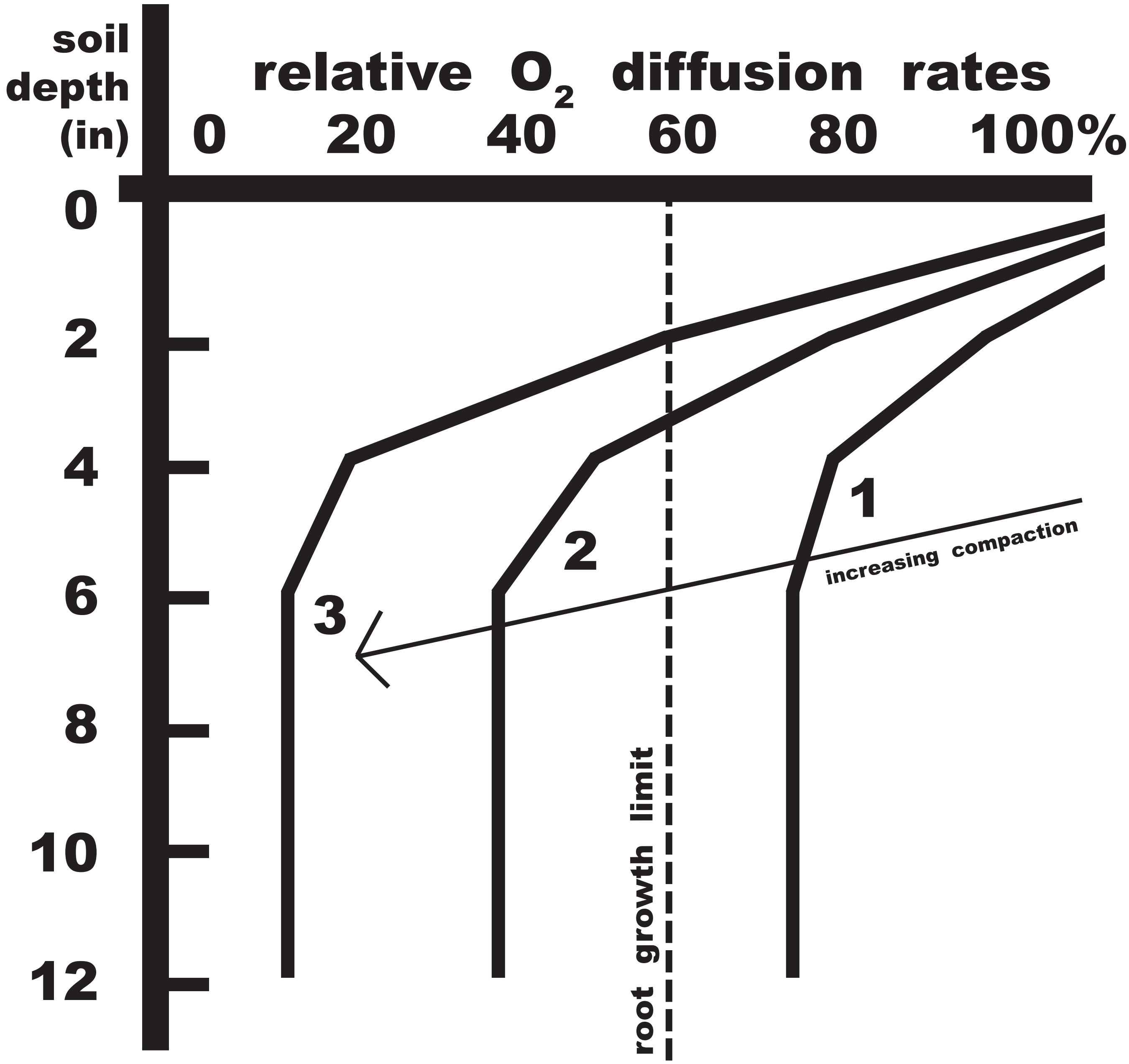


Figure 22: Relative oxygen (O_2) diffusion rates with increasing soil compaction.
(after Kelsey 1994)

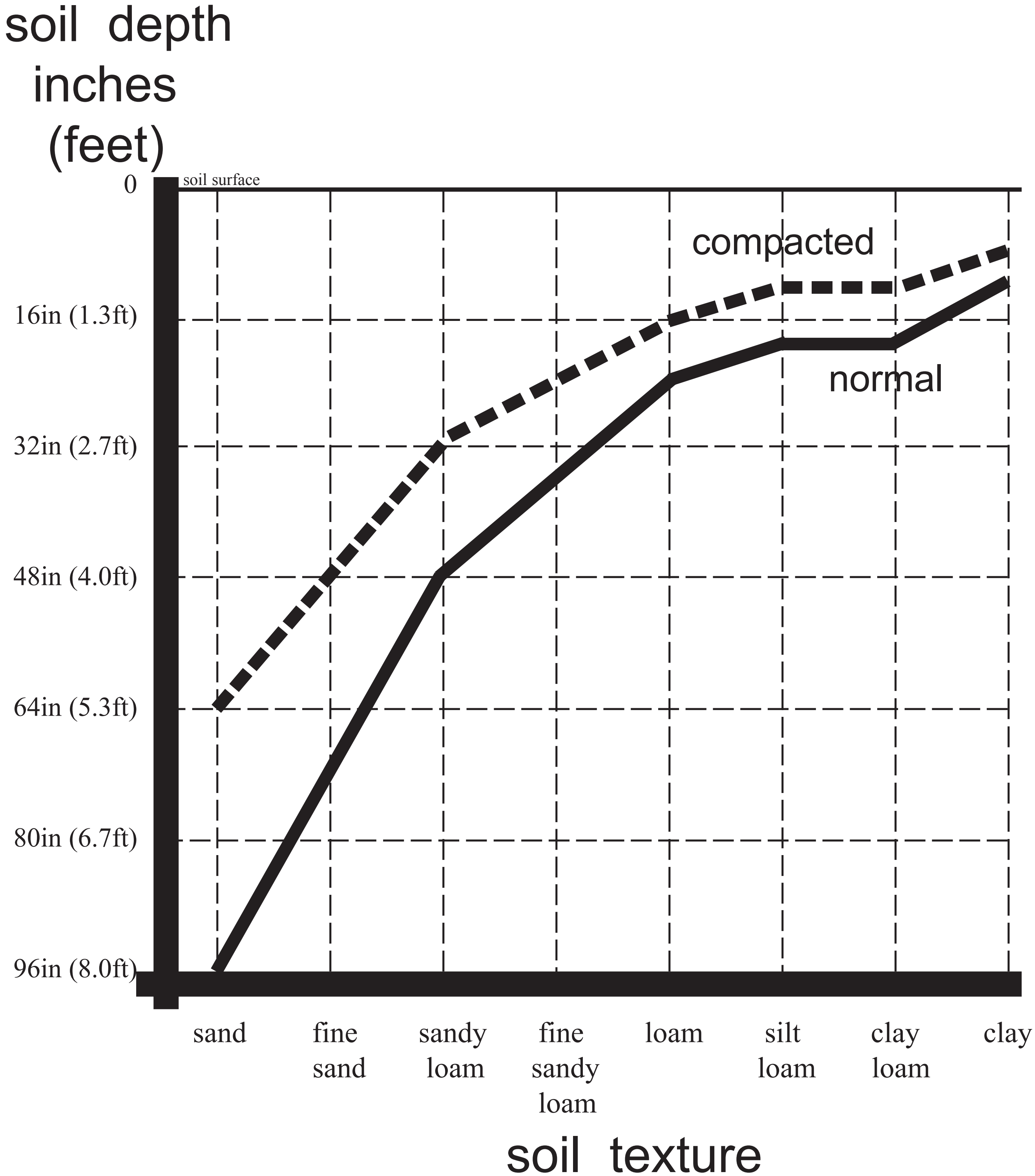


Figure 23: Constrained effective soil depth of biologically available resources in soils of various textures under compacted and non-compacted conditions.

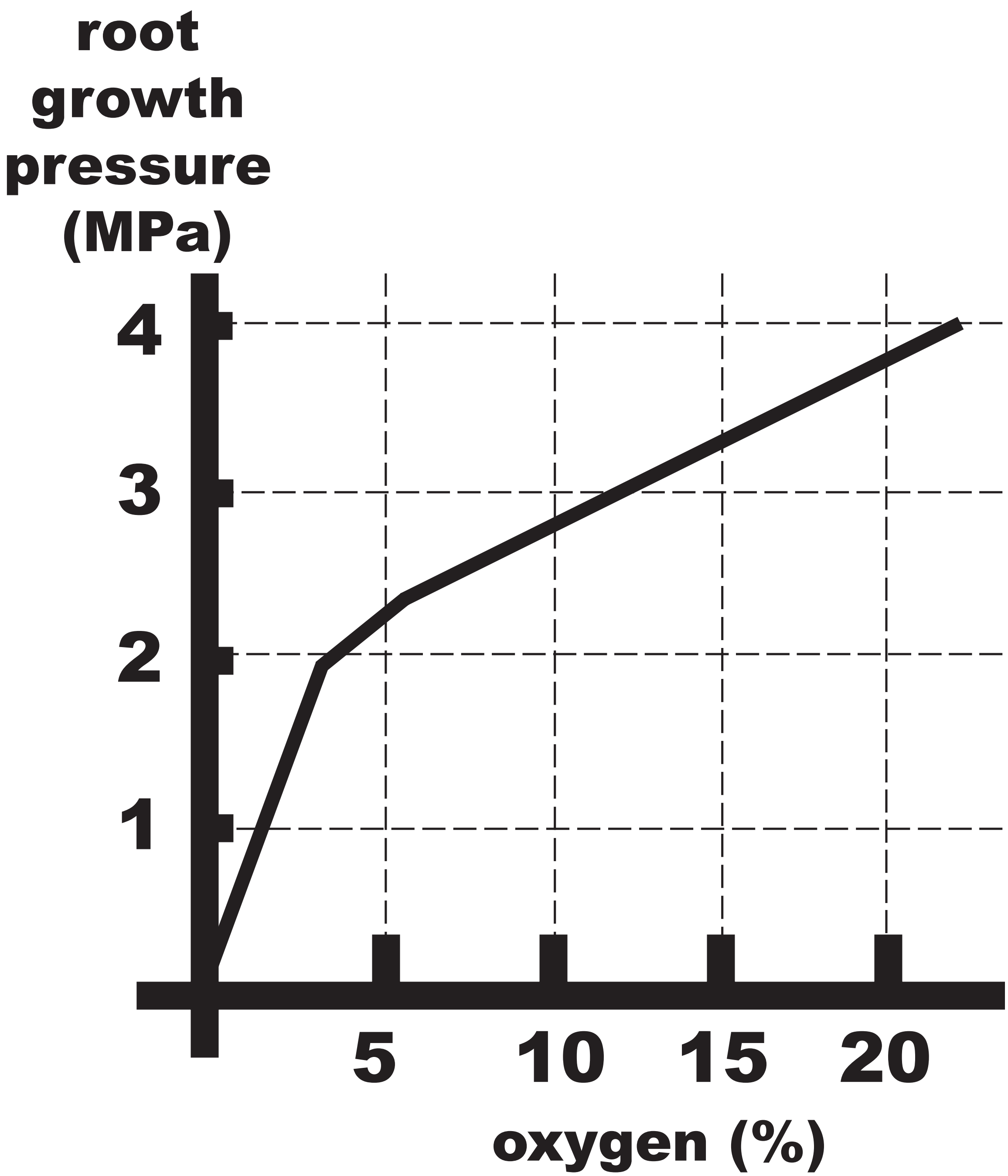


Figure 24: Root growth pressure by oxygen concentration. (after Souty & Stepniewski 1988)

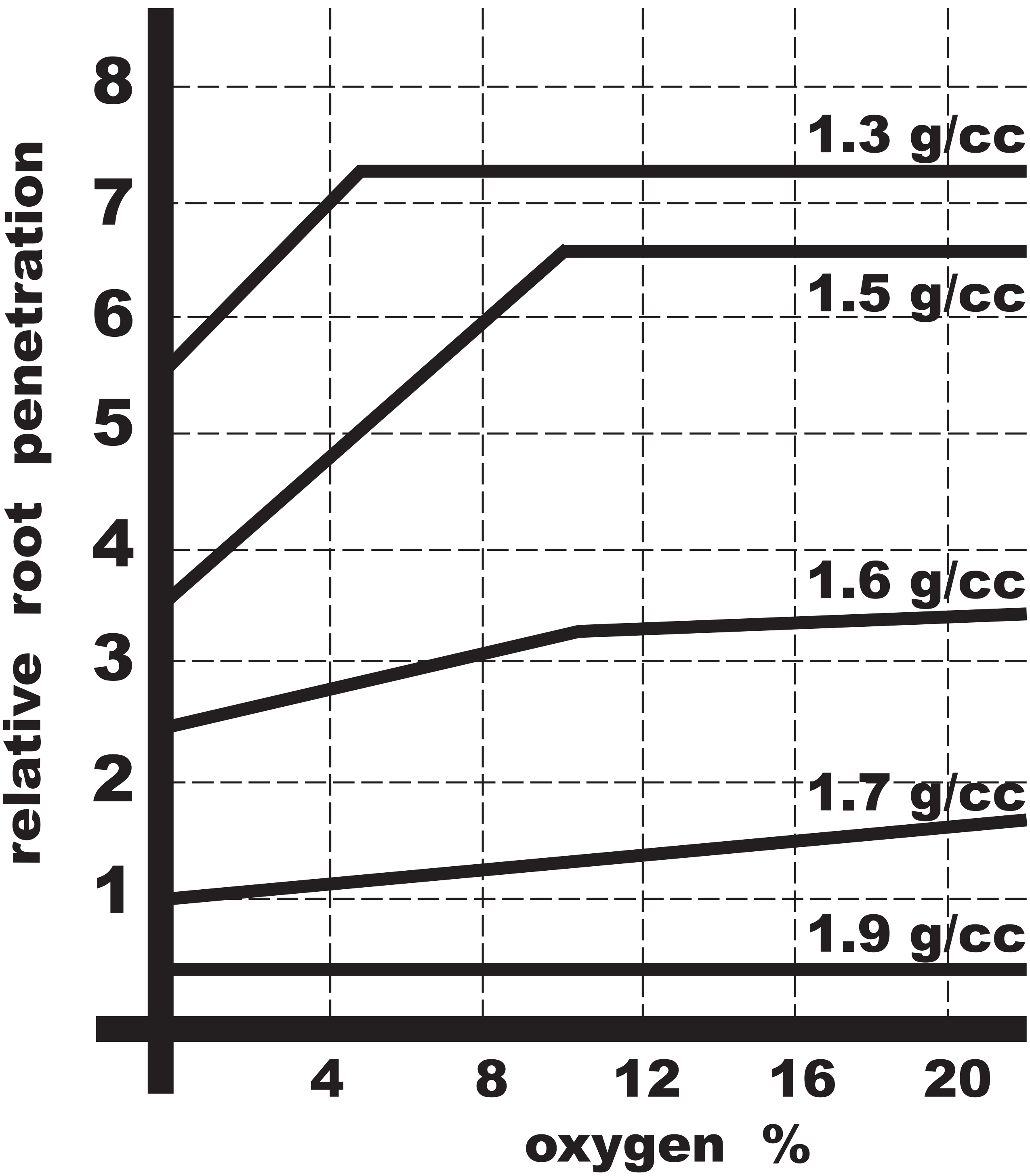


Figure 25: Percent oxygen and soil density (bulk density values) effects on root penetration.

(after Rendig & Taylor 1989)

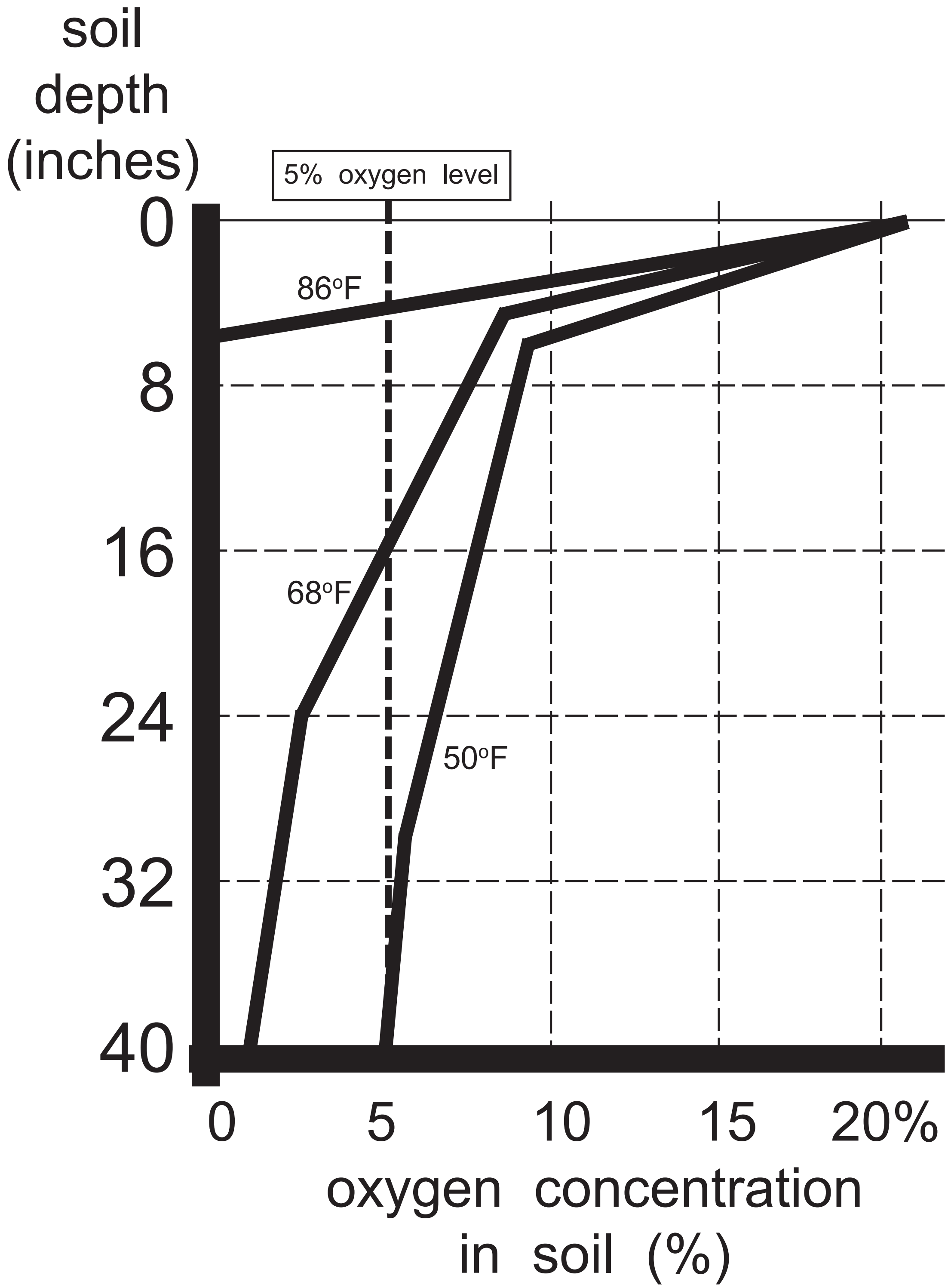


Figure 26: Oxygen concentration (percent) in soil with increasing depth (in inches) for three different temperatures (in degrees.)
(derived from Cook & Knight 2003)

Compaction prevents gas exchange with the atmosphere. Figure 27. Compaction prevents oxygen from moving to root surfaces, but also prevents carbon-dioxide and toxics (both evolved and resident) from being removed from around roots and vented to the atmosphere. Poor gas exchange allows the anaerobic layer to move closer to the surface and reduces rooting volume. As carbon-dioxide comprises more than 5% of the soil atmosphere, problems of aeration become compounded. As carbon-dioxide climbs above 15% in soils, growth problems accelerate. Figure 28.

Less Water

One of the most ignored result of compaction is it effects on soil water availability. Figure 29. Soil compaction reduces tree available water held in large capillary pores and increases the volume of small capillary pores which hold water unavailable to trees. Figure 30. With a decreasing number of large capillary pores and increasing number of small capillary pores, the total water holding capacity of the soil declines. Compare Figure 31 and Figure 32.

Irrigation scheduling and soil water monitoring becomes much more critical around trees in compacted soils. Compaction leads to smaller pore spaces and slower infiltration rates. With increasing residency time at the soil surface, water can move horizontally across the surface of the soil initiating erosion. Over the top of compacted soil, water can reach faster velocities (more erosion potential) than in areas where infiltration is eased. Inside a soil, compaction prevents effective drainage. Poor internal drainage limits tree available water, prevents oxygen movement, and increases production and residence time for carbon-dioxide and toxics. Figure 33.

More Heat

Compaction changes the energy and water balance near a soil surface. With more particle to particle contact, heat transfer is greater into the soil. Results include burning-out of organic matter quicker, acceleration of evaporative and transpirational water loss, and increased respiration of roots and soil organisms. As temperature increases, respiration responds along a doubling sequence – for every 18^{o}F (10^{o}C) increase in temperature, root and soil microbe respiration doubles.

Compaction Kills!

Soil compaction impacts tree and soil health in many ways. Generally, compaction associated physiological dysfunctions cause systemic tree damage and decline, as well as failures in dealing with additional environmental changes. Physical / mechanical constraints impact tree responses resulting in inefficient use of essential resources. The symptoms of compaction expressed by trees under compacted soil conditions are derived from disruptions of internal sense, communication, and response processes.

Compaction disrupts respiration processes which power every function of a tree. Growth regulators are destroyed prematurely or allowed to buildup, causing wild changes in tissue reactions. Carbon (food) allocation patterns, following highly modified growth regulation patterns, change food production, storage, use, and transport processes. Defensive capabilities with degraded sensor functions, associated growth regulator communications failures, and ineffective food use, are slow to react and incomplete in response. With compaction, short-term fluctuations in resource quality and quantity in a tree must be effectively dealt with and resulting chronic stress must be tolerated in order to survive.

Poisoning

The presence of toxic materials can be highly disruptive to soil health. As oxygen concentrations decline, more reduced compounds (partially oxidized) are generated by tree roots and associ-

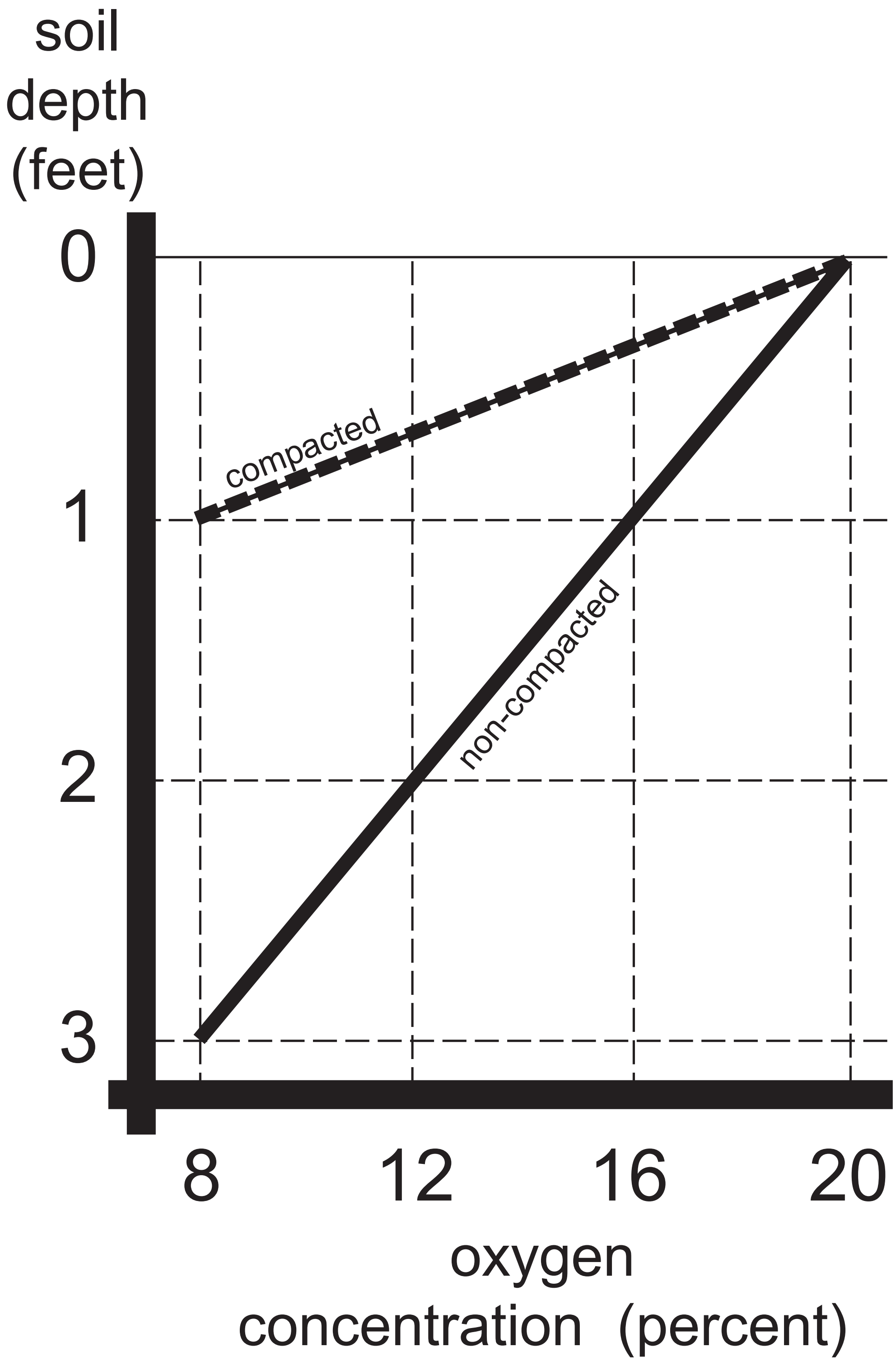


Figure 27: Oxygen concentrations (percent) with increasing soil depth (in feet) under compacted and non-compacted conditions.
(non-compacted data derived from Kalita, 1999)

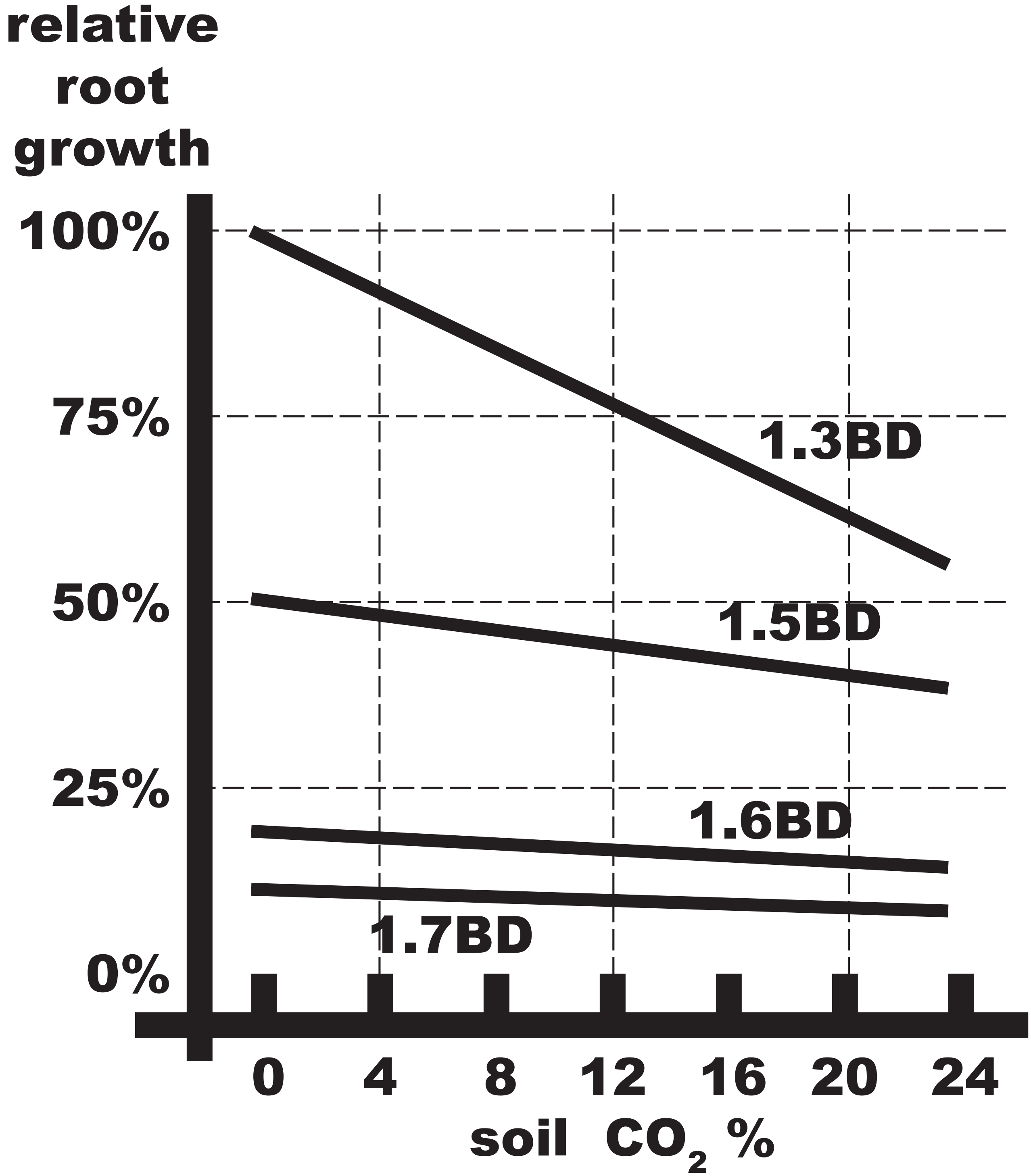


Figure 28: Carbon dioxide (CO_2) concentrations in the soil and soil density (bulk density values) impacts on root growth.
(after Patterson, 1976)

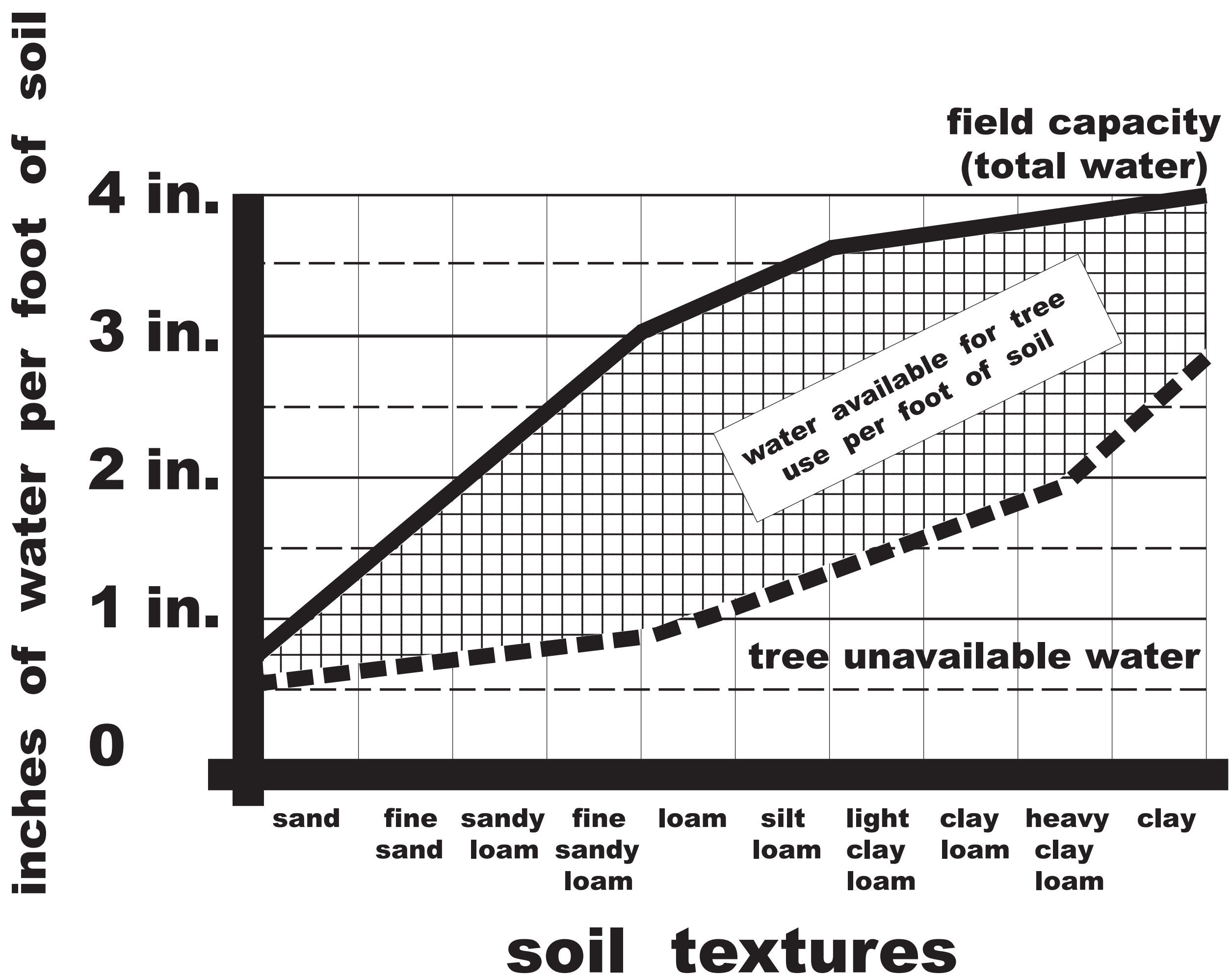


Figure 29: Tree available water is the difference between total water at field capacity and unavailable water held by a soil.

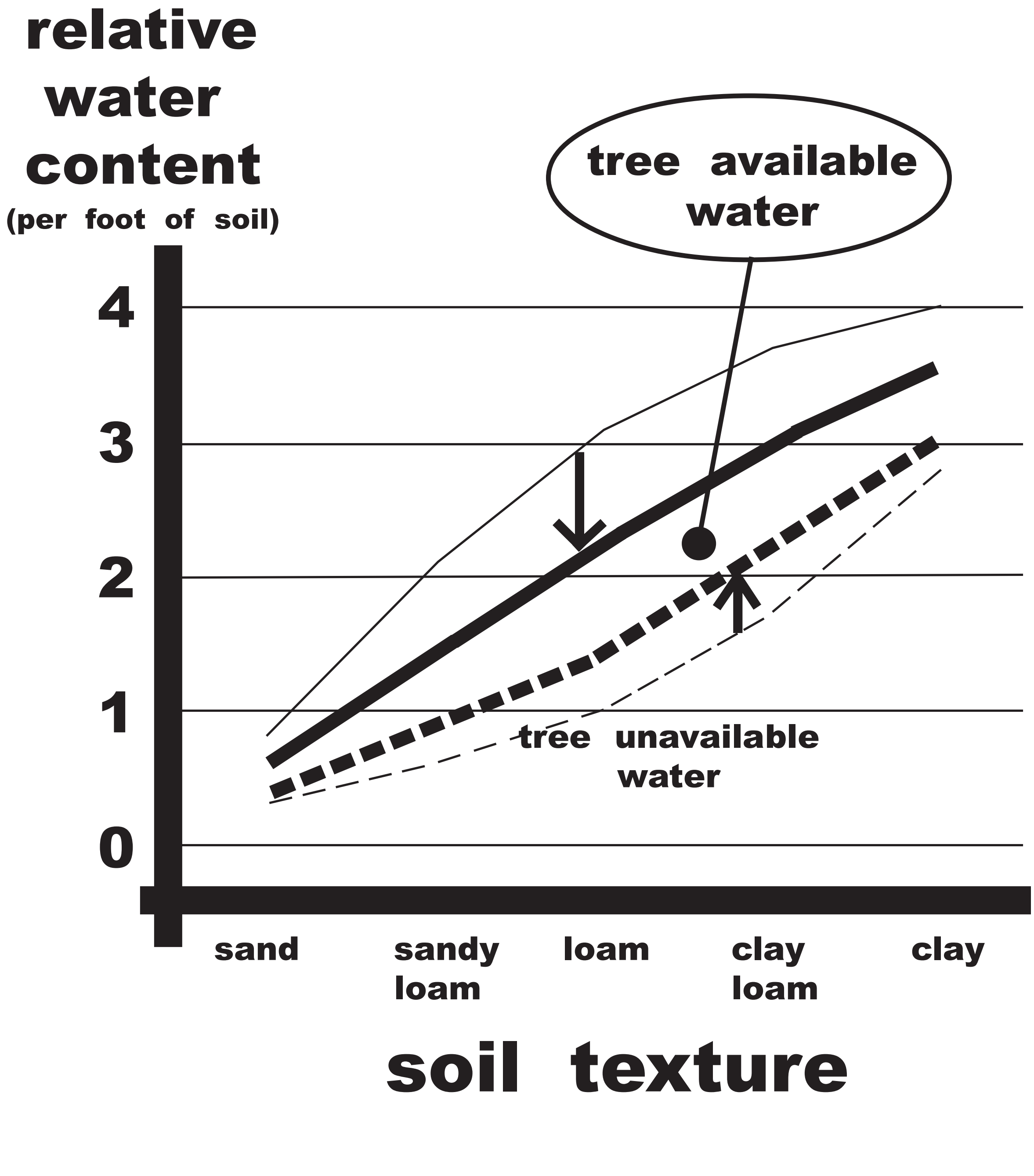


Figure 30: Declining tree-available water present in a soil as compaction is applied for different soil textures.

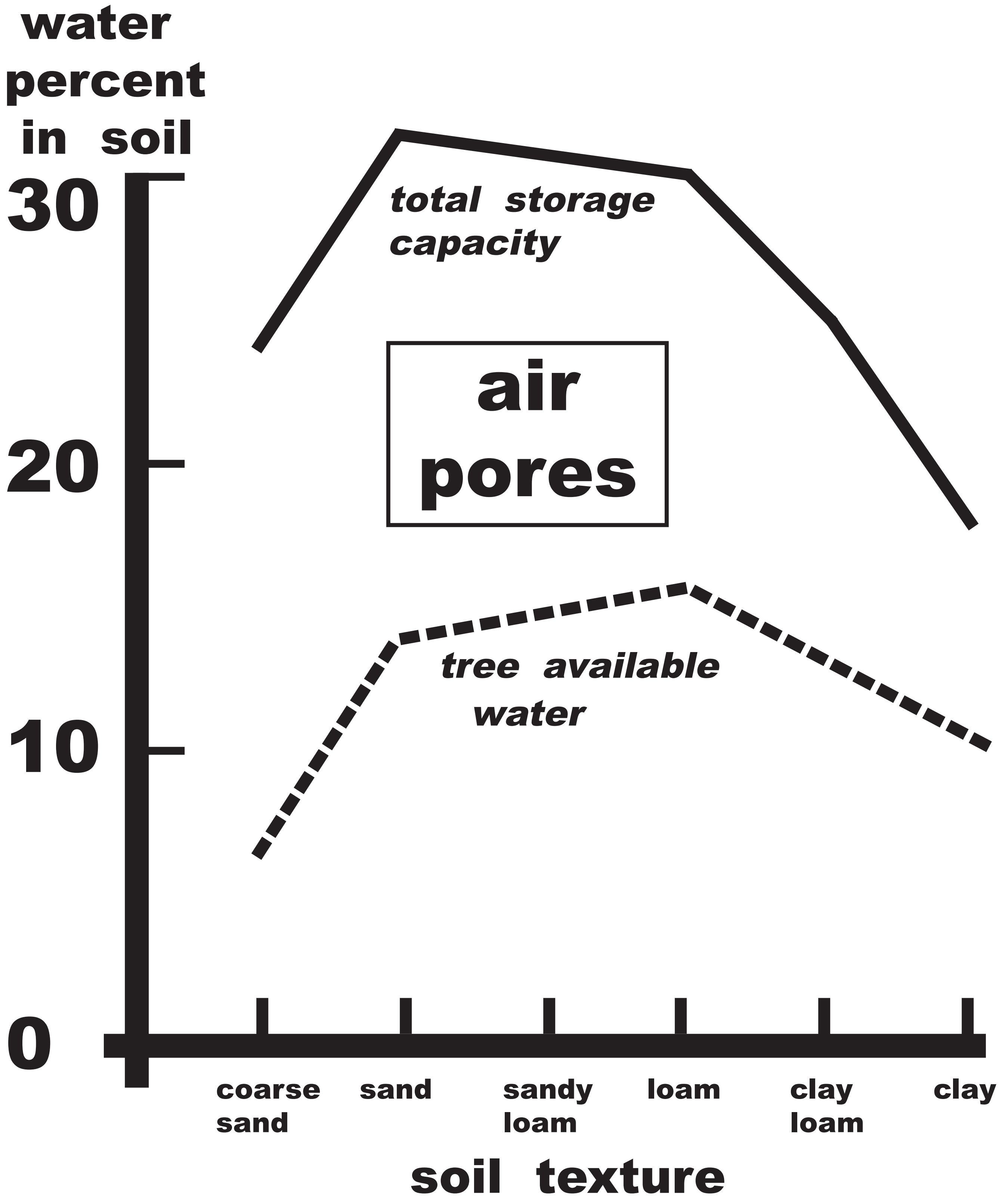


Figure 31: Water storage capacity in normal soil. (after Craul 1999)

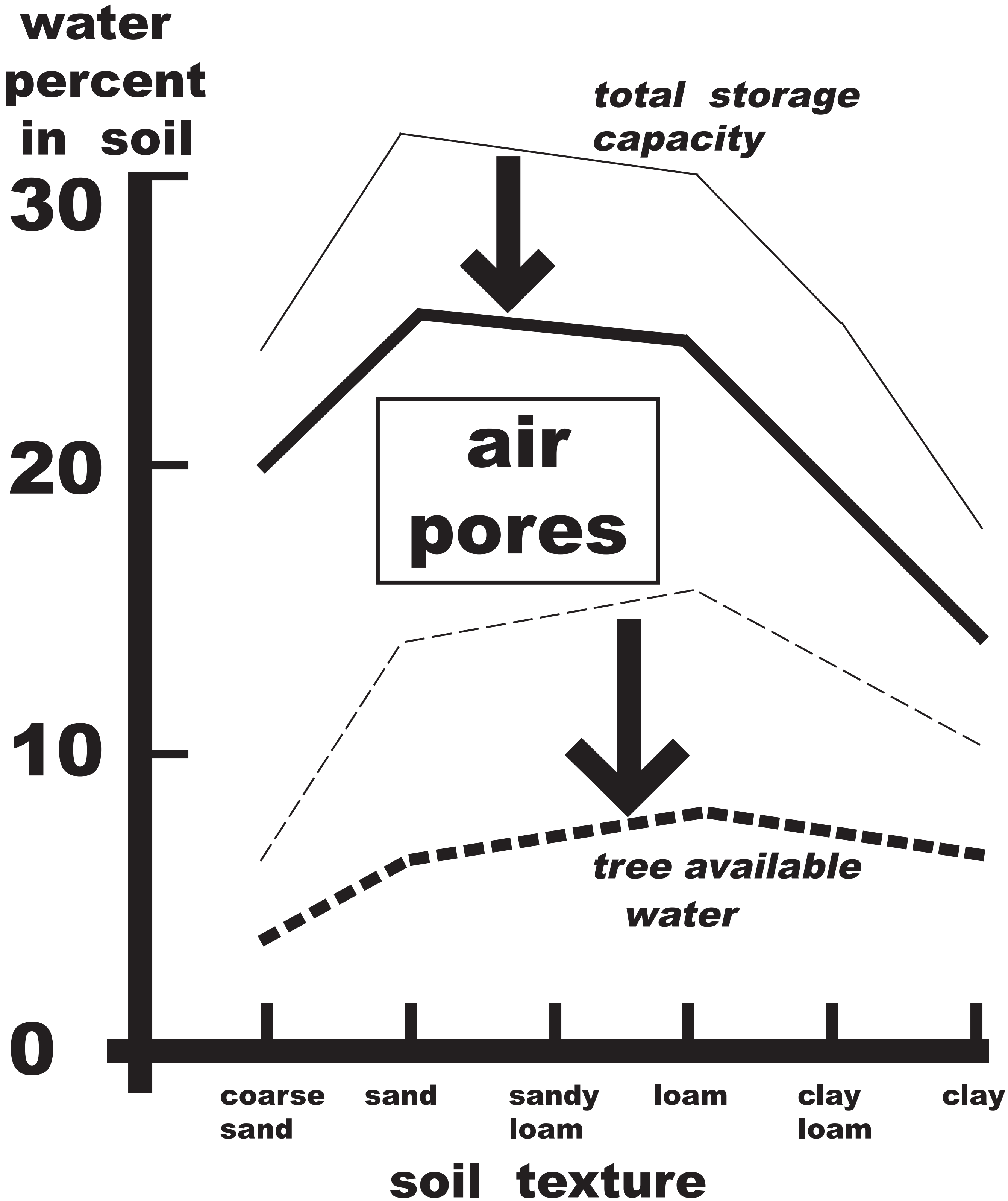


Figure 32: Water storage capacity under compaction. (after Craul 1999)

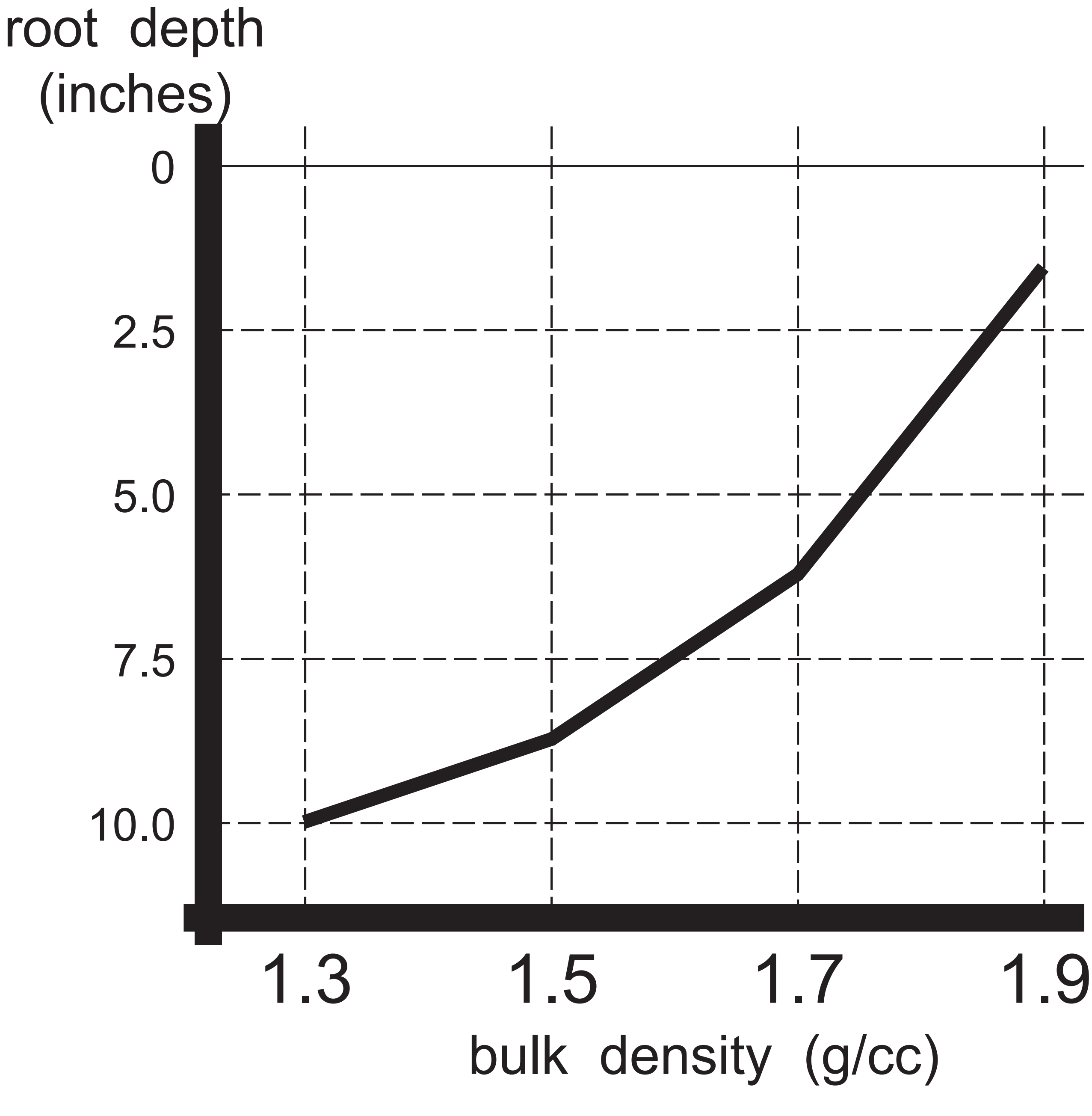


Figure 33: Rooting depth (in inches) limit on young pine (*Pinus taeda*) in controlled rooting experiments by soil bulk density (g/cc).
(derived from Torreano, 1992 -- PhD dissertation)

ated soil organisms. These reduced compound can build-up, damage organisms, and move soil toward anaerobic conditions. In normal soils, these materials (if produced at all) are quickly oxidized or removed from near tree roots. In compacted soil, normally produced materials, materials produced under low oxygen conditions, and anaerobically produced compounds, are not oxidized nor removed from where they are produced. The longer the residence time of some of these materials, the more damage to tree roots.

Structural Decline

The structure of a tree can also be directly and indirectly impacted by compacted soils. Root decline and death can lead to catastrophic structural failures. Tissue death and subsequent compartmentalization processes can compound mechanical faults. Growth regulation and carbon allocation changes can modify stem and root collar taper and reaction wood development. Whole tree stress can result in tissue shedding both internally to heartwood and externally shown as top and root dieback. Branch drop and root failures can result. Reduced rooting volume mechanically destabilizes the whole tree.

Measuring Compaction

Tree health management is limited in how easily and effectively we can measure absolute and relative soil compaction. Measures can be used that approach actual values and suggest impacts on essential tree resources. The primary resources impacted by compaction and critical to tree growth in soil are oxygen availability, gas exchange with the atmosphere, and soil strength values. These resources are severely limited by soil compaction. Mechanical impedance and gas movement in a soil for tree health is difficult to measure directly.

Because of the difficulty in simultaneously measuring soil resource limitations quickly in the field, a number of approximate measures for compaction have been developed. Two measures most commonly used are bulk density and soil penetration force. Unfortunately, both measures are soil moisture content and organic matter dependent. Additionally, bulk density and soil penetration force are not measuring the same features in a soil, and so, are not necessarily closely correlated. Bulk density is usually considered the best estimate of soil compaction on a site.

Bulk Density

Bulk density is a relative measure of soil density (weight of a given volume of soil). The most commonly used tool for measuring bulk density is a soil core slap-hammer that carefully drives a metal sleeve of a known volume down into the soil. The driving force used in sampling is shifted to soil surrounding the sample volume. Minimizing any disruption of a soil volume during collection is critical for an accurate measure. In addition, gravel, moisture content and percent of organic matter can all disrupt collection of an accurate sample. Bulk density cores consistently provide higher than actual (true) bulk density values for any sampled soil.

Dry & Wait

The collected soil volume must be dried in an oven until all measurable moisture (by weight) is removed. Oven-dry weight of the collected soil is recorded and divided by the known volume of the sample taken from the collection site. Clearly bulk density measures are not immediately available, but require drying and weighting time in the laboratory of usually a minimum of one day.

Bulk density characterizes both the mineral portion and pore space portion of a soil. Most mineral soils share similar densities of solid mineral components (~2.65g/cc). Organic soils and soils generated from parent materials with mineral densities significantly different from 2.65g/cc, will have different bulk densities simply due to different matrix component densities.

Open Spaces

If most soils share similar mineral densities, then any variability in their bulk density will be due to differences in pore space volume. Pore space volumes (composed of water-filled “micro” pores and air-filled “macro” pores) are measured in a bulk density sample. Table 4 provides a calculation of soil bulk density and percent of total pore space present for average mineral density soils. Note the larger bulk density value, the smaller pore space volume must be.

Bulk density, when collected under the right soil conditions in the right soils can provide critical management information. Because tree roots utilize soil spaces, any measure of these pore space volumes can help better manage tree growth. As soil bulk density increases (compaction increases), total pore space declines and aerated pore spaces collapse. For example in one soil, a 20% increase in bulk density initiated a 68% loss of aerated pore space and an increase in 7% capillary (water-filled) pore space. In another soil, compaction from a bulk density of 1.25g/cc (~50%

Table 4: Calculation of pore space within a soil. Value derived from bulk density (BD) and average mineral density (2.65 g/cc).

% pore space = [(1 - BD) / 2.65] X 100

BD (g/cc)	% pore space
0.9 g/cc	66
1.0	62
1.1	58
1.2	55
1.3	51
1.4	47
1.5	43
1.6	40
1.7	36
1.8	32
1.9	28
2.0	25
2.1	21
2.2	17

total pore space) to 1.5g/cc (~40% total pore space) left the soil with 45% fewer large pores, 98% fewer intermediate sized pores, 1% fewer small pores, and 14% more extremely small pores.

Dense As A Brick

Many materials can be measured using bulk density. Table 5 provides bulk densities for selected construction materials and associated pore space. Some compacted soils have greater measured bulk densities than some common construction materials. It is possible to find soils around infrastructures which are more dense than the walls and sidewalks of the building they adjoin.

Bulk density, as a measure of soil compaction, rapidly increases with the first few impacts on the soil surface and then only incrementally increases. (See Figure 7). Soils can be compacted to 90-95% of what they can be compacted to in as little as 3-4 trips over a single site under the right conditions. As tree rooting space is compacted, root growth declines and stops. Table 6 shows the bulk density and associated air pore volume, by each soil texture type, where tree root growth becomes limiting. Note bulk density limits root growth at different values for each soil texture type. Table 7 demonstrates it is not simply bulk density and total pore space which should be examined for tree health but air pore space in particular. There is not a single number but trends in several measures under varying conditions which should govern management decisions

Table 8 provides a list of bulk density measurement units and their interconversion.

Penetrometer Pressure

The second primary means used to measure soil compaction and estimate resulting tree available resources is by using a penetrometer. A penetrometer measures the energy (pressure) required to push a metal rod into soil. Penetrometers can be simple devices used to estimate packing density of mulch, surface compaction of roads beds, and bulk density of soils. Penetrometers provide immediate estimates without laboratory drying and weighting of samples, as needed with bulk density measures. But, penetrometers measure penetrative force not density of a soil. Penetrometer measures are much more sensitive to soil moisture contents and associated soil strength values than bulk density measures.

As a penetrometer is pushed into a soil, the soil resists. This resistance is measured on a dial or slide scale. As the penetrometer is inserted farther, different resistances are measured for different layers of soil, some may be significantly compacted and some not. Figure 34. Depending upon site history, different compacting events may have occurred and have left unique soil compaction signatures. The heavier the compacting items, the deeper into soil lasting compaction will occur. Fig. 35.

Pushing On

Penetrometers are a unique tool, easy to use for estimating a single-number composite of soil features and values. Penetrometers estimate the resistance of a soil to root penetration (resistance = compression of soil in front of probe plus soil/metal friction around the probe). In soils with uniform physical characteristics across all dimensions, the penetrometer measure is well correlated to tree root elongation. Soils which contain large pores, fracture lines, cracks, gravel or stones are not good candidates for accurate and precise penetrometer use.

Penetrometers do not displace soil in a manner like a tree root. Tree roots are soft, flexible, and mucilaginous with a rounded cap. The penetrometer probe is rigid, large in cross-sectional area, and usually has a conical point on its end. Penetrometers with a tapered tip having approximately a 30^{o} angle point have 40% less friction moving through soil than a blunt tip, and more closely mimic root penetrations than a blunt tip.

Table 5: Physical attributes of selected construction materials. (Patterson, 1976)

material	bulk density	particle density	pore space
cinder block	1.70	2.64	36%
clay brick	1.75	2.72	36%
asphalt	2.19	2.35	7%
concrete	2.26	2.47	9%
units =	g/cc	g/cc	percent volume

Table 6: Root growth limiting bulk density and percent air pore space values by soil texture.

(Daddow & Washington 1983)

soil texture	root-limiting bulk density (g/cc)	root-limiting % pores normally filled with air (%)
sand	1.8 g/cc	24%
fine sand	1.75	21
sandy loam	1.7	19
fine sandy loam	1.65	15
loam	1.55	14
silt loam	1.45	17
clay loam	1.5	11
clay	1.4	13

General tree root growth limits:

A) physical limit is bulk density greater than 1.75 g/cc.

B) aeration limit is air pore less than 15%.

Table 7: Relative proportion of air, water and mineral materials in the top foot of soils with different textures and bulk densities (g/cc).

texture = bulk density =	sand 1.52 g/cc	silt 1.20	clay 1.05
mineral matrix	55%	50%	45%
total pore space	45%	50%	55%
air pore	30%	25%	10%
water pore	15%	25%	45%

Table 8: Estimated interconversion factors for bulk density values. Columns represent given measurement units. Lines represent interconversions between measurement units. NOTE: Use table horizontally (along one line) only, not vertically (along a column). Conversion factor estimates are rounded for ease of use.

For example, all units of measure in the first column (Mg/m^3, g/ml, g/cc, and g/cm^3) are equivilent to each other. Reading across the first line in the table, 1 g/ml is approximately equal to 1,000 kg/m^3, or 1 million g/m^3, or 62.43 lbs/ft^3, or 0.036 lbs/in^3. Always read across one line.

Mg/m^3 g/ml g/cc g/cm^3	kg/m^3	g/m^3	lbs/ft^3	lbs/in^3
1	1,000	1,000,000	62.43	.036
.001	**1**	1,000	.0624	3.61×10^{-5}
1.0×10^{-6}	.001	**1**	6.2×10^{-5}	3.6×10^{-8}
.016	16.02	16,018	**1**	5.77×10^{-4}
27.8	27,778	27,777,778	1,734.2	**1**

[1.0×10^{-3} = .001; 1.0×10^{3} = 1,000]

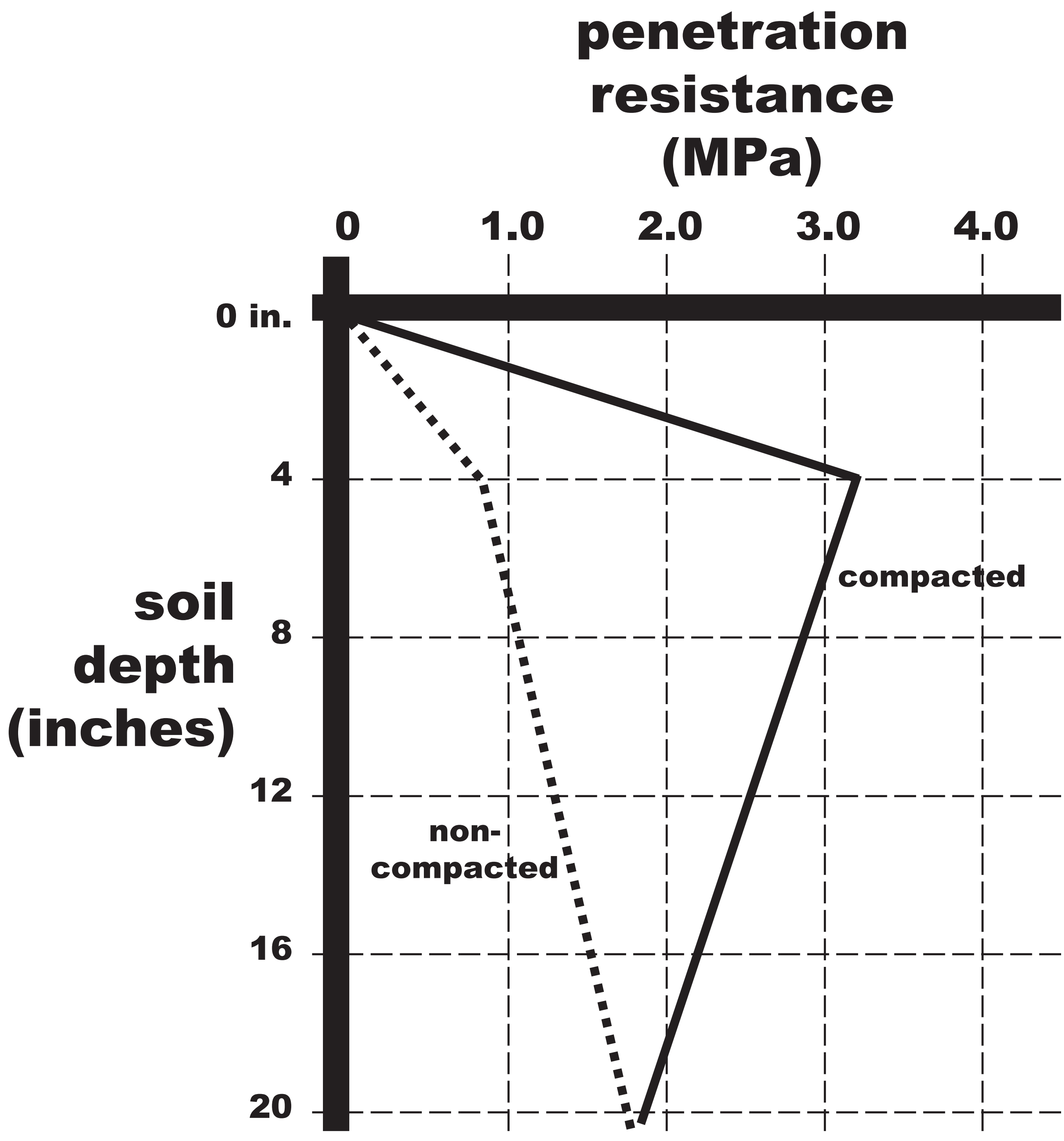


Figure 34: Example penetration resistances (MPa) by soil depth for a compacted soil and a non-compacted soil.

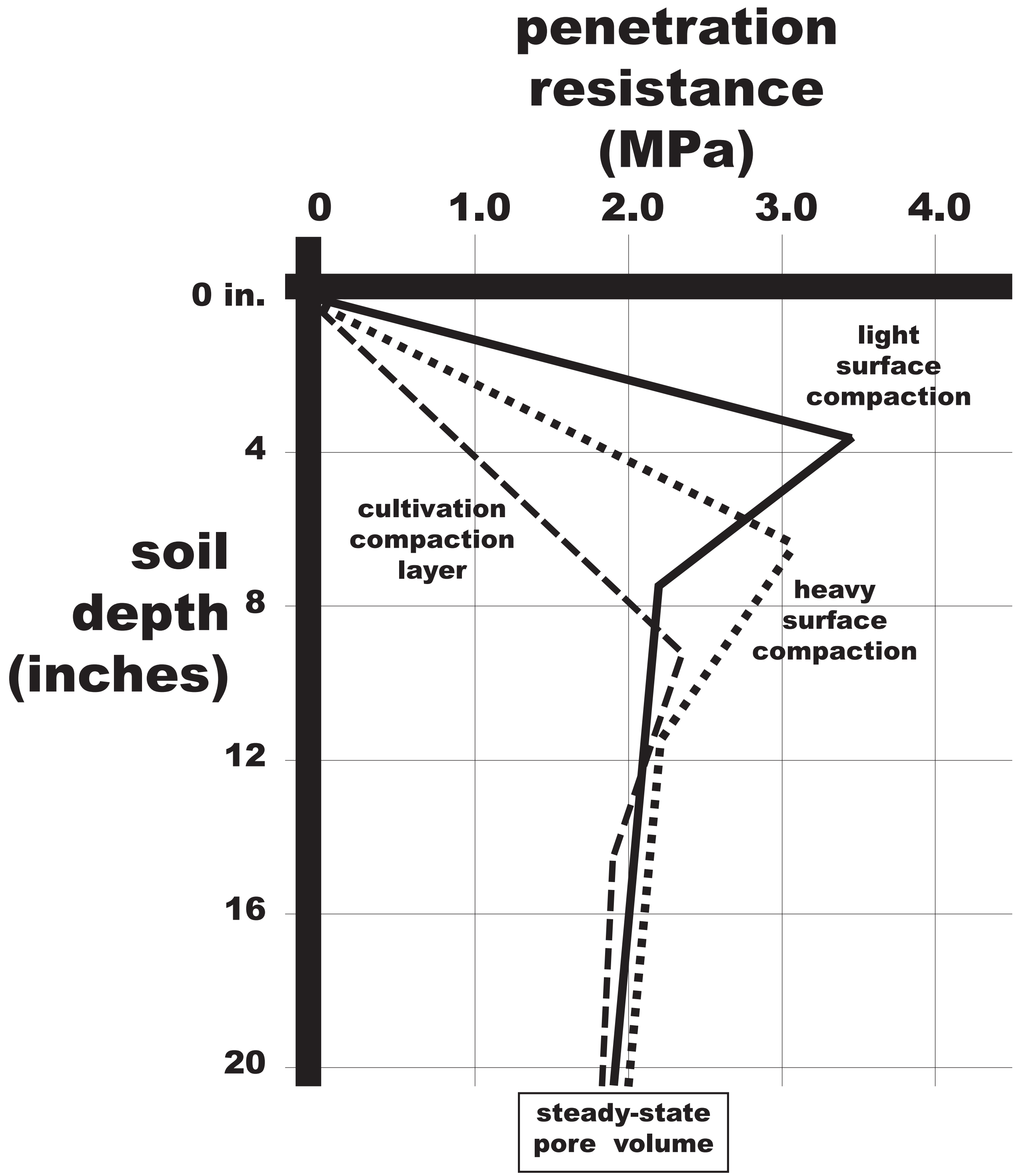


Figure 35: Example penetration resistances with increasing soil depth for three different types of soil compaction. Note all three eventually reach some steady-state resistance at some soil depth.

Steady & Vertical

Because of displacement and frictional forces on a penetrometer as it is pushed into soil, penetrometers tend to overestimate impacts of penetration resistance on tree root growth. The deeper a penetrometer is pushed into the soil, the greater soil / metal friction. When pushing a penetrometer into a soil always keep the probe vertical, do not wobble, and apply a constant pressure. A steady, moderate pressure is preferable over a suddenly-exerted high pressure.

Pushing Roots

Traditionally a penetration resistance of 0.5 MPa begins to constrain root growth, 2.0 MPa cuts root growth by 60%, and 3.5 MPa of penetration resistance prevents elongation or expansion of tree roots. Two recent studies show root growth limitations at much smaller pressures and have been combined into Figures 36 & 37. These figures provide two views of relative tree root penetration of a soil (in percent) compared with measured penetrometer resistance values (in MPa).

Figure 36 shows a comparison among values of penetration resistance which have been transformed into natural logarithms (base e) for preparing a linear regression model. This figure suggests penetration resistances above 2.3 MPa are extremely limiting and penetration resistances below 0.6 represent few root growth impediments. Figure 37 is a field-usable comparison between penetration resistance and relative root penetration percent. Remember extremely large penetration resistances in soil allow for root growth only along fractures (cracks), along the soil surface, and along infrastructures boundaries.

Water Problems

When using penetrometers, it is critical to account for moisture contents. All sites measured should have roughly the same soil moisture content in order to be comparable. The lower water content of a soil, the greater soil strength values become, and the greater penetration resistance values become. As an approximation in average soils -- for every one percent reduction in moisture below 35% soil moisture content, soil strength is increased by 0.11 MPa (a reduction of 10% moisture content in a soil would increase soil penetration resistance by 1.1 MPa. Site irrigation the day before sampling with adequate drainage provided would be ideal.

When water contents are at saturation, penetration resistances are reduced by a lubrication effect and ease of hydraulic deformation of the soil. Heavily compacted, uniform soils saturated with water will read a much lower penetration resistance value than expected, given the known level of soil compaction. For soil at or near saturation for long periods (or short periods with relatively hot soil temperatures) penetration resistances have little value in determining biological ability for roots to colonize new soil volumes. As total pore volumes fill with water (>85% water-filled), and oxygen in the soil drops below ~5%, the soil provides major constraints to root growth which has little correlation to penetration resistance.

Table 9 provides a list of penetrometer measurement units and their interconversion.

Using Penetrometers To Estimate Bulk Density

Both penetration resistance and bulk density values provide good relative, composite (multi-factor) estimates of soil compaction for use by tree health care providers and landscape managers. There are a number of growth estimating tables, figures, or rules for each estimated measure. Some tree health care providers would like to rely on one easily determined value to estimate both. Because of laboratory drying and weighting time involved with bulk density measures, and the ease of which many penetrometer measures can be made in a given amount of time, the use of penetrometer resistance values as an approximation of bulk density would be ideal for field estimates.

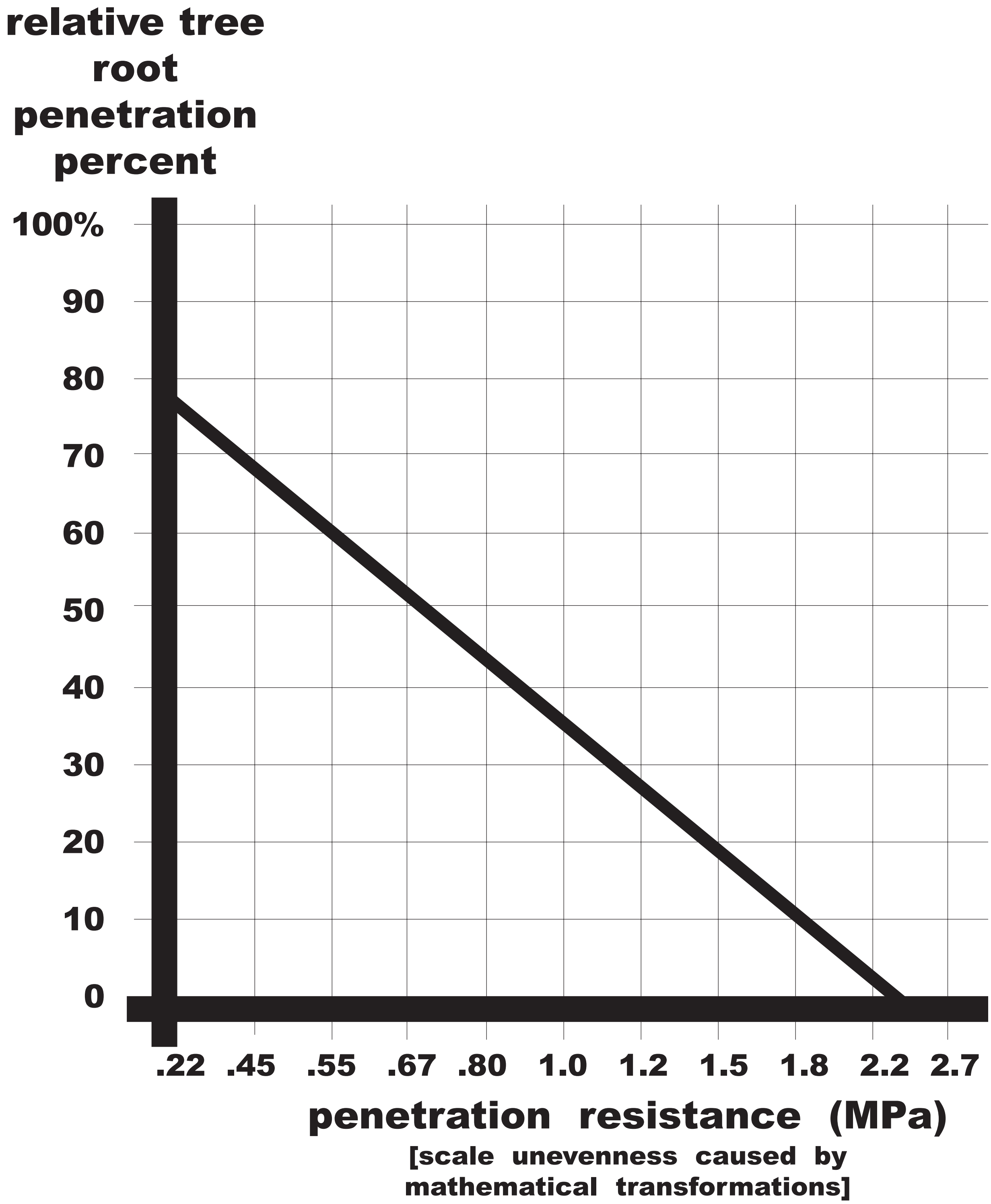


Figure 36: Linear model comparision of relative tree root penetration percentages with penetrometer resistance (MPa).

Regression is: $y = 35.5 - 43(\ln x)$ R-square is 0.967.

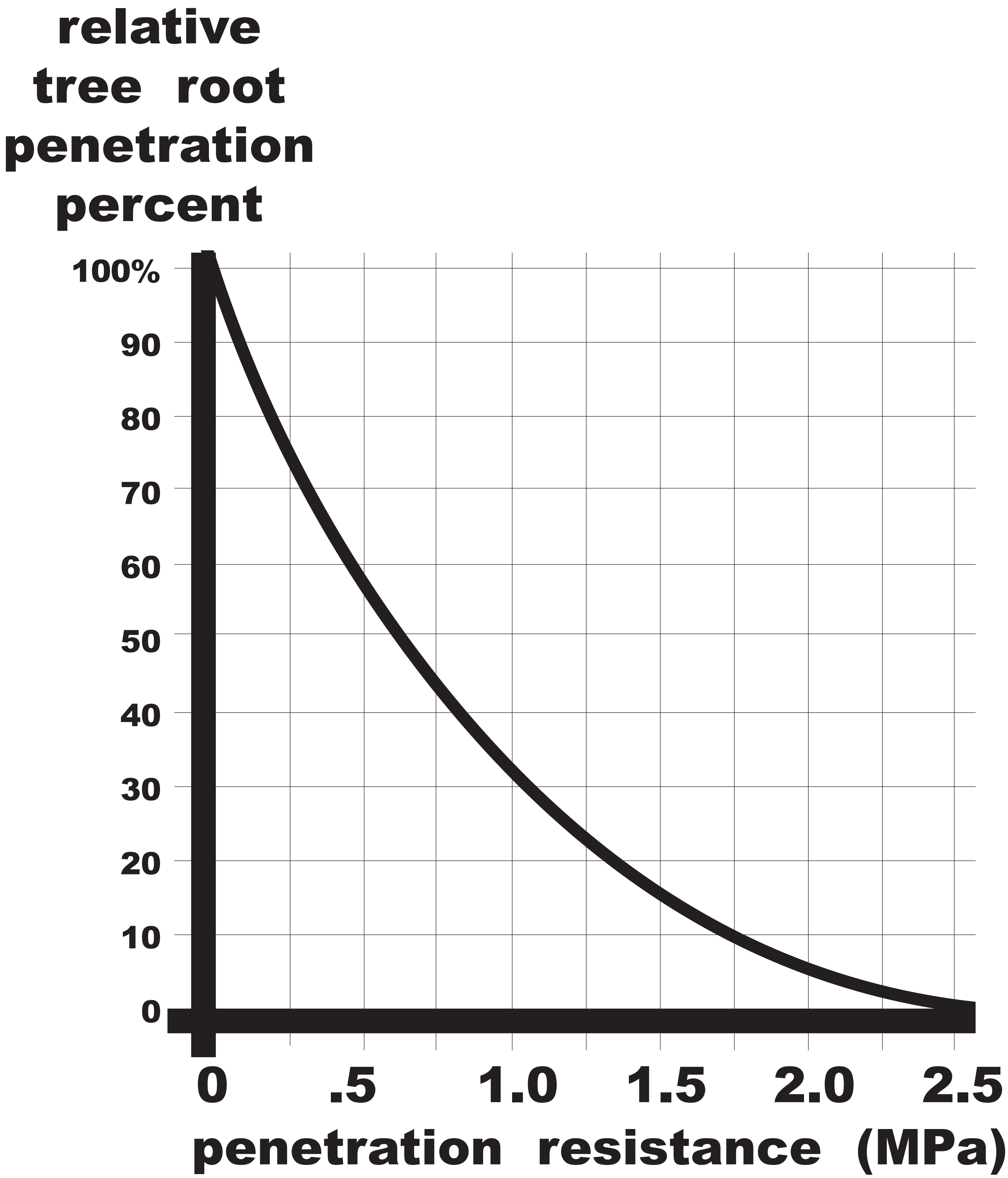


Figure 37: Comparision of relative tree root penetration percentages with penetrometer resistance (MPa).

Table 9: Estimated interconversion factors for different soil penetration pressure units.

NOTE: Use table horizontally (along one line) only, not vertically (along columns). Conversion factor estimates are rounded for ease of use. [1.0 x 10^{-3} = 0.001; 1.0 x 10^{3} = 1,000]

Atmospheres	Bars	Lang Units (blue)	pds/in^2 PSI	pds/ft^2	tons/ft^2 (short)	pascals (Pa)	kilopascals (KPa)	megapascals (MPa)	kg/cm^2
1	1.01	.288	14.7	2,130	1.06	101,325	101.3	.101	1.03
.987	**1**	.284	14.5	2.089	1.04	100,000	100	.10	1.02
3.47	3.52	**1**	51.0	7,347	3.67	353,701	353.7	.354	3.61
.068	.069	.020	**1**	144	.072	6,895	6.9	.007	.07
4.74 x 10^{-4}	4.8 x 10^{-4}	1.35 x 10^{-4}	.007	**1**	4.97 x 10^{-4}	47.9	.048	4.8 x 10^{-5}	4.9 x 10^{-4}
.945	.958	.272	13.9	2013	**1**	95,761	95.8	.096	.98
9.87 x 10^{-6}	1.0 x 10^{-5}	2.84 x 10^{-6}	1.45 x 10^{-4}	.021	1.04 x 10^{-5}	**1**	.001	1.0 x 10^{-6}	1.02 x 10^{-5}
.01	.01	.0028	.145	20.9	.010	1000	**1**	.001	.01
9.9	10	2.84	145	20,890	10.4	1,000,000	1000	**1**	10.2
.968	.981	.279	14.2	2,061	1.02	98,067	98.1	.098	**1**

Bulk density is a weight to volume measure while penetrometer resistance is a pressure measure. Geometrically, bulk density is a three-dimension based value while penetration resistance is a two dimension value. The correlation between these two types of measures is roughly 50-60% across all soils under various conditions. The correlation between measures is much more closely related in mineral soils with more uniform textures without gaps, cracks, or gravel.

Appreciating Correlations

Remembering that correlations between bulk density values and penetration resistances are not strong for every sampled condition, a set of interconversion figures have been prepared. Figure 38 provides the graphical definition of a linear regression model comparing penetration resistance with soil bulk density, where the penetration resistance values have been mathematically transformed using natural logarithm (base e). Figure 39 presents the field data for comparing penetration pressure values with soil bulk density values under good soil moisture content values. See Appendix 2 for a field worksheet.

Soil resources are constraining on tree growth. Soil compaction is a major stressor of trees. Tree health care providers must realize the qualitative and quantitative values associated with compaction. Using a bulk density sampler or a penetrometer provide one means of more fully appreciating tree growth limitations.

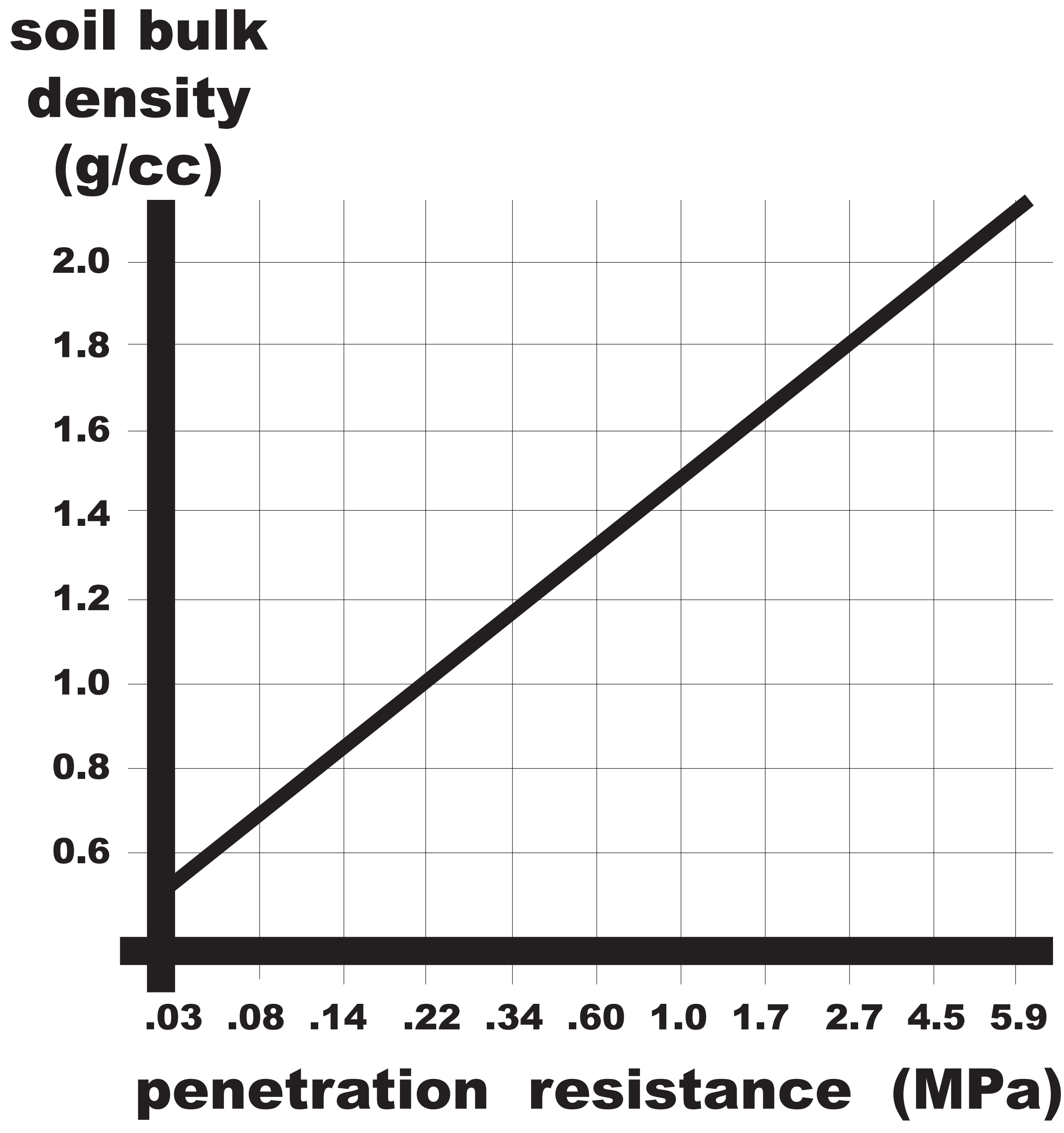


Figure 38: Linear model comparision of soil bulk density (g/cc) with penetrometer resistance (MPa).

Regression is y = 1.5 + 0.3 (ln x). R-square is 0.97.
[scale unevenness caused by mathematical transformations]

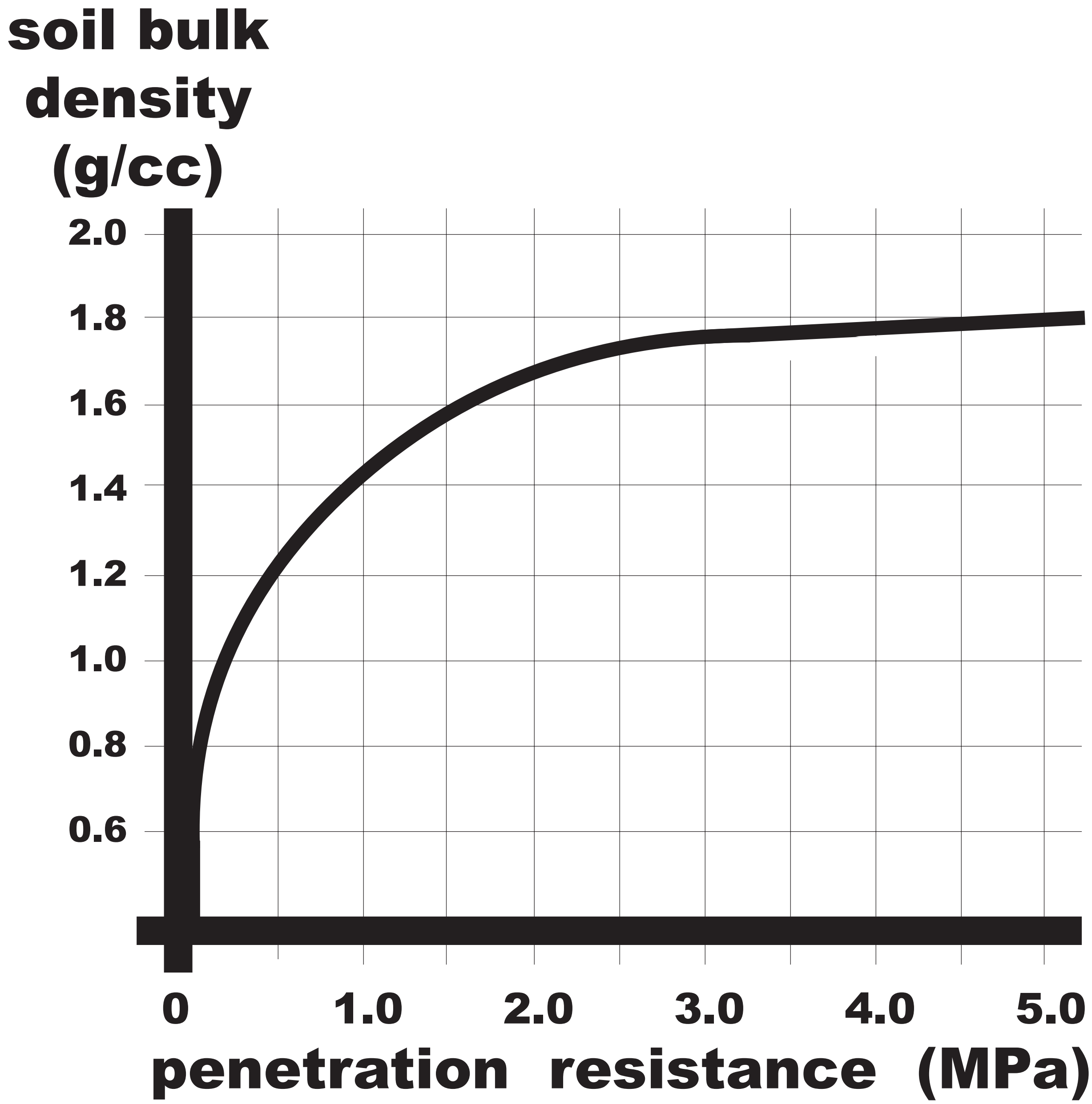


Figure 39: Comparision of soil bulk density (g/cc) with penetrometer resistance (MPa).

Tree Impacts & Site Renovation

Soil compaction lingers as an abiding stress on developed sites from which there is no escape by trees unless tree health care providers actively renovate the soil. Soil compaction can quickly limit tree reactions under other stress events making them worse. Compaction is not usually visible nor measured, but controls the most significant tree resources on a site. Tree health care providers must begin measuring compaction and making clients aware of the severe problems arising from increased soil density. Tree symptoms of compaction come in many forms and severities. A selected number of major tree damaging impacts from soil compaction are reviewed here.

Reduced Growth

As compaction increases, roots are physically prevented from elongating into soil by lack of oxygen, by decreasing pore size, and by increased soil strength. As roots are put under greater than 1.5 MPa of pressure, elongation slows. Trees begin to generate thick, short roots with many more lateral roots as surrounding soil pressure exceeds 1.0 MPa. Oxygen shortages and soil strength increases are major limitations to both elongation and radial growth.

Less Resource Space

With less colonizable soil volume, there is less physical space to collect resources from and less resources within that space. With declining respiration processes, energy requiring steps within active element uptake processes (i.e. N, P, S) fail. Part of the difficulty in collecting essential resources is a buildup of toxics which pollute any existing essential resource supply.

As roots survive in a steadily diminishing aerobic layer, and as the anaerobic layer expands toward the surface, physical space available for living roots declines. The consequences of having smaller volumes of colonizable space at the surface of a soil means tree roots and their resources are subject to much greater fluctuation in water content, heat loading, and mechanical damage. Drought and heat stress can quickly damage roots in this small shallow layer of oxygenated soil.

Constrained & Stunted

Compaction limits the depth and reach of tree root systems leading to greater probability of windthrow and accentuating any structural problems near the stem base / root collar area. Limiting reach of a root system also prevents effective reactions to changes in mechanical loads and concentrates stress and strain in smaller areas. Micro-site variability in compaction levels and a limited resource base constrain young and newly planted trees. It requires less soil density (compaction) and crusting impacts for failure to occur in new trees compared with older, established trees.

As resources are limited by soil compaction, and more effort is required to seek and colonize resource volumes, trees are stunted. The disruption of growth regulation produces stunting as auxin / cytokinin ratios shift resource allocations and use. In addition, carbohydrate and protein synthesis rates enter decline cycles interfering with nitrogen and phosphorous uptake, which in-turn disrupts carbohydrate and protein synthesis. The result is a tree with a small living mass, with limited ability to take advantage of any short-term changes in resource availability, and with reduced resistance to other environmental stresses.

Root Injury

The mechanical forces generated in compacting a soil can crush roots, especially roots less than 1/10 inch diameter. Larger root can be abraded and damaged. Rutting can shear-off roots as

soil is pushed to new locations. The amount of crushing is dependent on root size and depth, weight of the compacting device, organic material, and depth to the saturated layer (for rutting). Figure 40
.

Life Decline

Soil compaction puts selective pressure against aerobes and favors low oxygen requiring organisms, like *Pythium* and *Phytophthera* root rots, or anaerobes. Destruction of the detritus energy web, coupled with successional changes, assures renovation of soils to pre-compaction conditions is not possible. Management must move forward to new solutions for resource availability and deal with new patterns of pest management, since returning to the soil microbiology and rhizosphere of pre-compaction is impossible.

Renovation Principles

Tree health care providers and site managers must correct compaction and its limitations on tree growth. Compaction is "forever," being reduced by natural processes at such a slow rate (~1% reduced bulk density per six (6) years) as to be unseen in tree health changes. Compaction must be actively prevented and actively corrected. There are a number of renovation principles to consider when reclaiming a part of the ecological integrity of a site, as well as soil and tree health.

Principle 1 -- Past soil compaction should be considered a permanent management constraint. Studies demonstrate that after one-half century, compaction still afflicts soils under natural forest conditions. Recovery times for significant compaction is at least two human generations, if no further site impacts occur. Soils do not "come back" from compaction. Soil must be actively renovated.

Principle 2 -- Every soil used by humankind has a representative compacted layer, zone, area, or crust. Changing management may not change the current compacted zone but may well add an additional compacted zone in a new position. A site is a composite of many compaction events over many years, all needing remeadiation.

Principle 3 -- Management activities should concentrate on moving forward to increase aeration space and reduced soil strength, rather than trying to recover past ecological history.

Principle 4 -- Estimate soil compaction now as a bench-mark for gauging effectiveness of any treatment. Do not suggest compaction problems exist until confirmed by measurements.

Principle 5 -- Measure compaction using any or all resource availability approximations, like bulk density, penetration force, oxygen diffusion rates, and tree available water. These are the best proxy measures we have to understand soil compaction and its impacts on trees. More careful and direct measures of soil compaction constraints on tree growth are possible but are expensive, time consuming, and difficult to make.

Principle 6 -- Alleviation of soil compaction is part of a good tree and soil health management plan. Any soil renovation is a positive investment in the future.

Principle 7 -- Use extreme caution in water management over and in compacted soils. Compaction provides little margin of error for drainage, aeration, infiltration, and water holding capacity of tree available water. For example, a moist soil may contain a dry tree, or a wet soil may contain a root-suffocated tree under compaction.

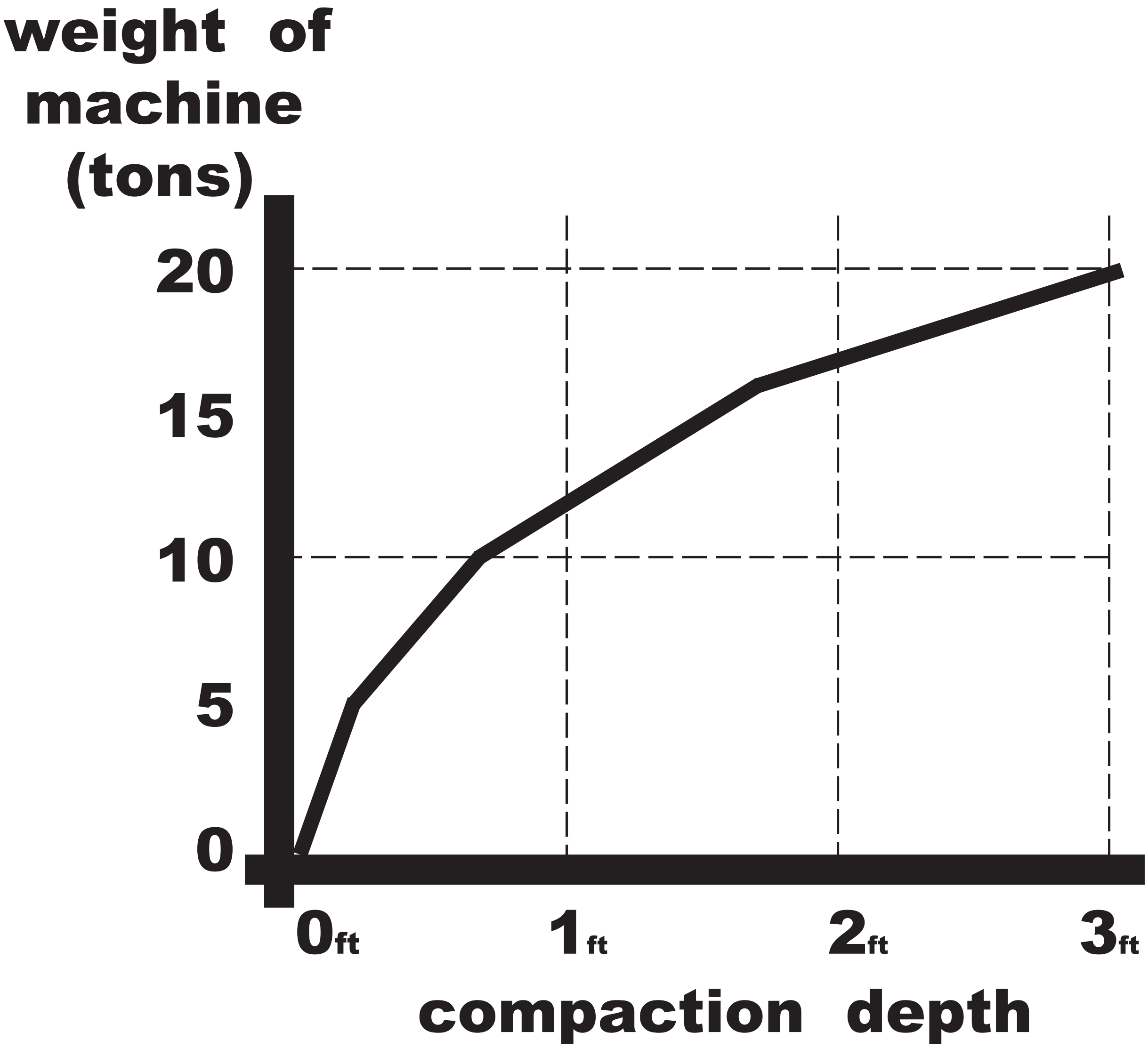


Figure 40: Concentration depth of soil compaction under machines of various weights. (after Randrup 1999)

Principle 8 -- Optimize tools and site renovation processes which have minimal negative tree biology impacts for the greatest soil compaction reduction.
Principle 9 -- Seek assistance of a tree and soil health specialist to avoid tree-illiteracy problems on compacted soils. Always seek to educate clients about compaction. Awareness of the problem is critical to initiation and maintenance of a renovation program.

Renovation Techniques

Once the general principles of working with compacted soils are digested, the next requirement in tree health care is to identify general techniques for renovating compacted soils. These recommendations are generic across many situations and soil types. Specific actions must be crafted for specific sites and tree situations.

One of the most important decision points in decompacting soil and facilitating tree root health is setting the treatment objective. The two objectives are: 1) remove enough soil volume from compacted soil to make a significant difference is soil bulk density, fracturing, and soil lightening; or 2) pierce the soil enough to significantly impact gas exchange with the atmosphere and oxygen diffusion. Selecting either a soil volume or oxygen diffusion treatment will depend upon soil texture, water saturation conditions over time, extent of compaction currently, and potential compaction in the future.

Technique 1 -- Restrict site access to the soil surface as soon as possible with fences and fines (legal penalties). Try to be the first one on-site and setup anti-compaction protection. Prevention is the best way of minimizing compaction impacts on trees.

Technique 2 -- Defend the ecological "foot print" of a tree rooting area. Select working conditions (dry, dormant season, surface mulch, etc) that minimizes compaction in a tree rooting area. Figure 41. The closer to a tree compaction occurs, the geometrically greater impact any damage.

Technique 3 -- Carefully design tree growth areas or compartments using "biology-first" design processes rather than the common (and damaging) "aesthetics-first" design processes. Assure well aerated and drained, ecologically viable space is provided, as well as adequate water supply, under the conditions present.

Technique 4 -- Try to soften and distribute any new compaction forces applied by using: 1) temporary coarse, thick organic mulch, plywood or rubber driving pads; 2) designated non-tree rooting areas as material and vehicle storage / parking; and, 3) develope soil moisture content awareness planning. Restrict and minimize, where possible, any vibrational compaction.

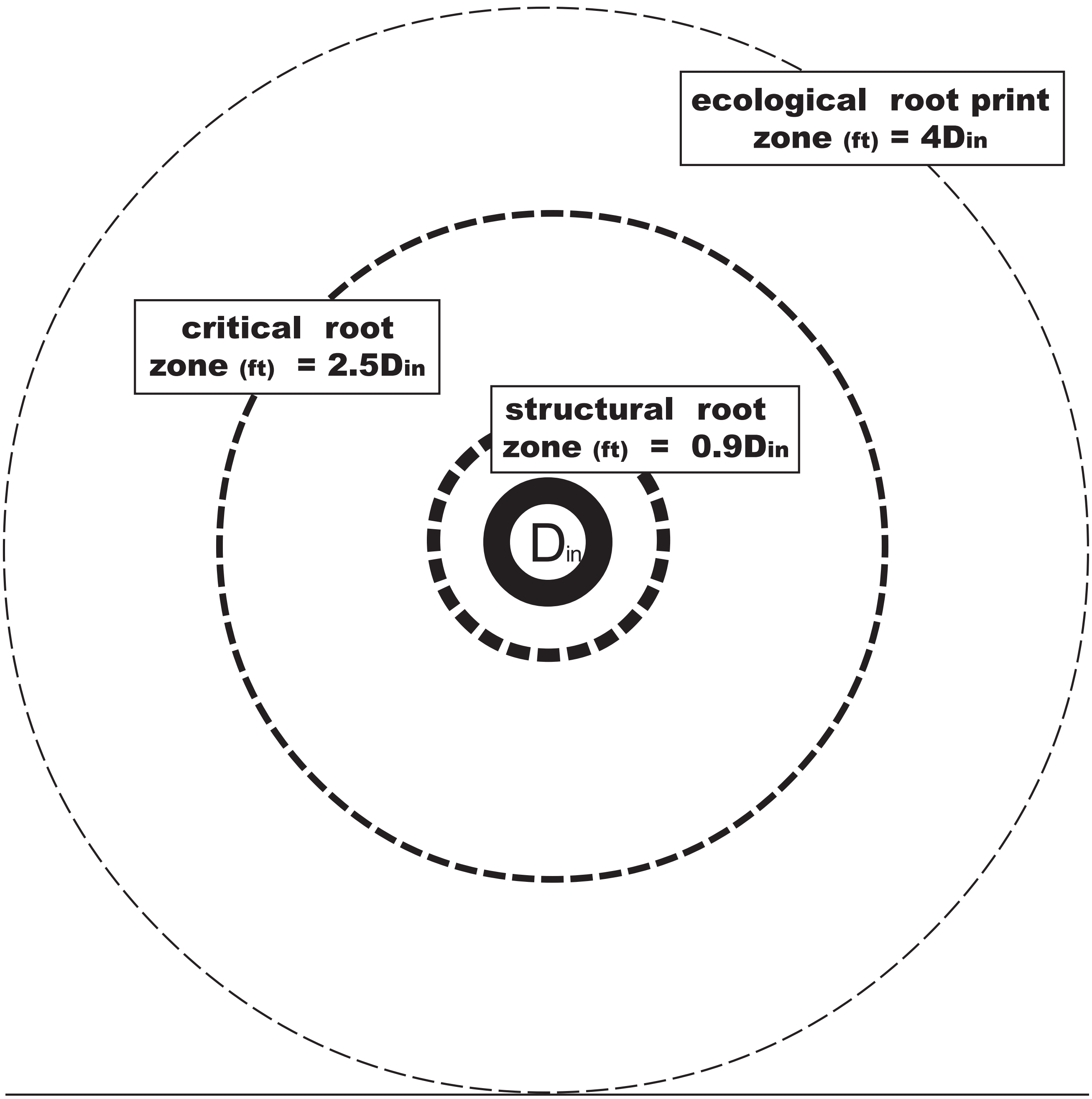
Technique 5 -- Restart or improve the detritus energy web in soil, including the addition of composted organic matter, living organisms, essential elements in short supply, and water (supply & drainage). Pursue soil health by changing physical, chemical and biological soil conditions.

Technique 6 -- If tree roots are not present on-site, use deep tilling and/or sub-soiling to fracture and aerate soil before other activities are begun for planting trees.

Technique 7 -- In some locations, especially where soils are containerized or are required to carry light to intermediate loads, consider either amending the soil with large sized, porous, low density, solids, or replacing the soil with structural / constructed soils. Utilize porus paving materials, soil binding materials, or root aggregation structures, where possible, to avoid further compaction. (See

Figure 41: View from above a tree rooting area showing the ecological foot print area (ecological root print zone), critical root zone, and structural root zone (root plate) surrounding a tree. All distance measures are diameters centered on the tree in feet and based upon tree diameter (D_{in}) at 4.5 feet above the ground measured in inches.

(Example: For a 20 inch diameter tree (D=20”), ecological root print = 80 feet in diameter; critical root zone = 50 feet in diameter; structural root zone = 18 feet in diameter.)



excellent text by Ferguson, 2005.) Structurally bridge-over soils with tree roots. Constructed soils and porous pavements are both distinct subject areas not further reviewed here.

Technique 8 -- Use core (not punch) aerators designed for compacted areas which reach 8-14 inches in depth. These are large hydraulic powered core aerators, not shallow surface aerators as used in turf culture. Figure 42 shows two holes excavated into a soil. These holes could have been generated by a punch aerator, core aerator, drill, water gun, or air gun. A punch aerator, and to a lessor extent a water gun, would have generated more compaction and disrupted addition pore space and are not recommended. Note in Figure 42 there is an aerated soil volume near the soil surface which has always existed to some depth, and two new aerated volumes around the excavated holes.

Figure 43 is a diagram of an excavated hole. There is both a volume of soil removed and an additional surface area of soil exposed inherent in any hole excavation. Table 10 presents the estimated aeration diameters and radii for different soil textures. Under compaction, aeration is greatly limited by air pore space in clay textured soils while aeration distances in sandy textured soil can be relatively deep, depending upon water saturation levels. The aeration diameter distance is the maximum distance apart holes can be in the soil in order to aerate the soil volumes in-between. Deep core aeration, to be effective, must have great enough hole density and depth to impact aeration and break through surface compaction.

Technique 9 -- In highly limited areas vertical mulching can be used to increase ecologically viable space. Vertical mulching is, in essence, deeper and more impactful core aeration as listed in Technigue 8 above. Drill or blow out small diameter vertical holes 12-24 inches deep into a soil. Figure 44 shows a vertical mulching hole field from above. Note this treatment is applied away from the tree stem base at some distance to prevent large root damage. Keep the treatment zone away from the tree base at least 3.5 times tree diameter measured in inches, if not farther, especially in large trees or trees on very shallow soils. Table 10 lists aeration distances for soils with different textures. Use these values to determine how far apart vertical holes should be placed.

Table 11 provides the center-to-center distance apart holes should be for different soil textures and for different hole diameters. In the field, there is little real difference in distances within a single soil texture class. The dotted lines around the two inch hole diameter size in Table 11 represents a good average value for hole distance apart in application. Table 12 provides the estimated amount of additional soil surface area exposed by excavating holes of various sizes and to various depths. Note each value in Table 12 is how many times greater the new surface area generated from a single hole is larger than the previous surface area of the soil. For example from Table 12, a 2 inch diameter hole excavated to 20 inches in depth would add 41 times more surface area of soil to a site than the surface area before excavation.

Table 13 lists the amount of soil volume removed and the amount of soil surface area added by excavating a single hole with a given diameter and depth. For example from Table 13, a 2 inch diameter hole excavated to a depth of 20 inches would remove 63 cubic inches of soil and expose an additional 129 square inches of soil surface area than before excavation. Table 14 provides an estimate of how many holes of a given size and depth would be needed to remove one cubic yard of soil. This value can be used to compare this treatment with other treatments in how each impacts soil volume changes. Note it takes tens-of-thousands of small shallow holes to have any significant impact on soil volume aerated. For example from Table 14, it would take 743 separate holes, two inches in diameter and 20 inches deep, to remove one cubic yard of soil from a site. As usually applied, vertical mulching does not influence much soil volume per treatment.

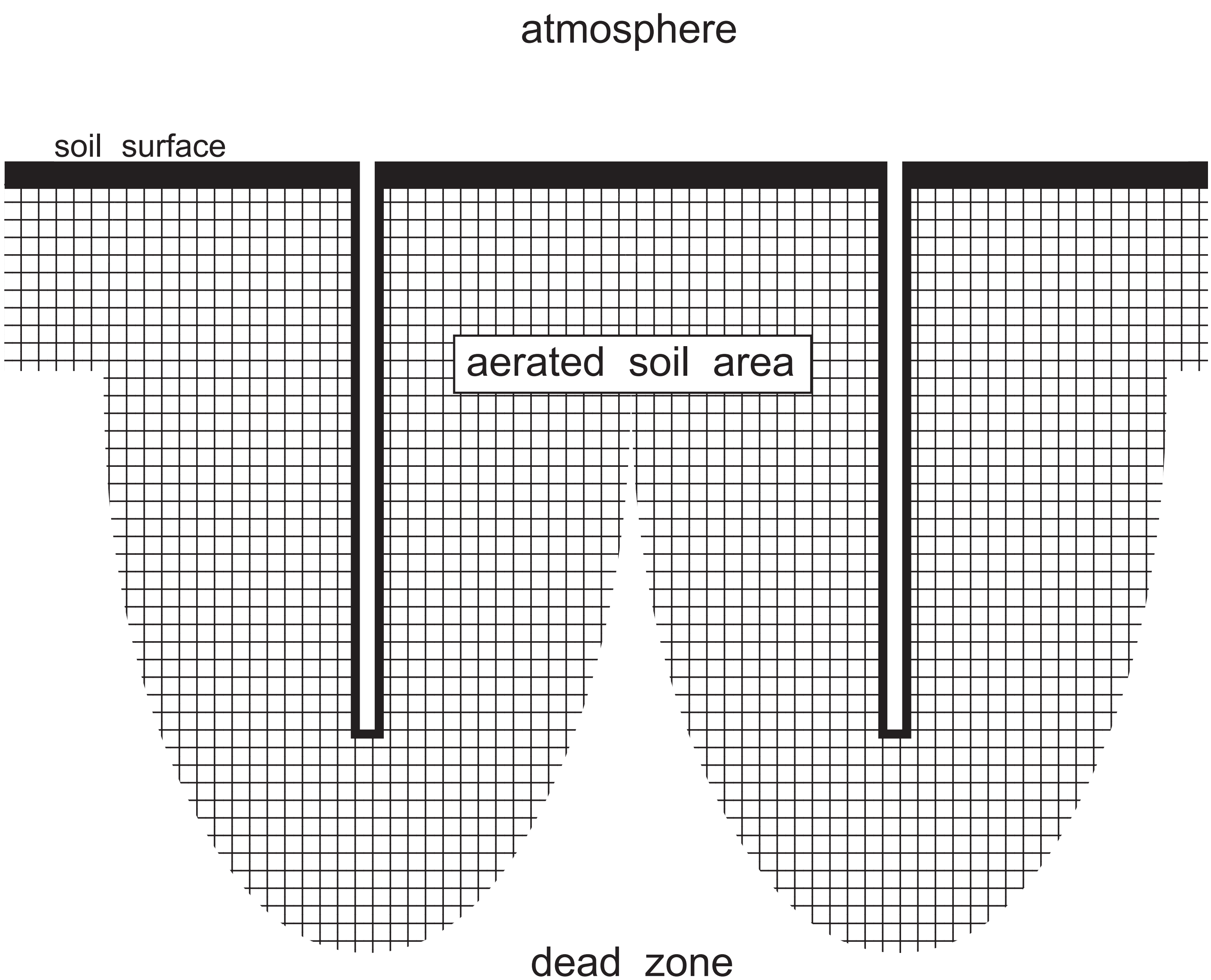


Figure 42: Diagrammatic side view of aerated soil area (shaded) below a compacted soil surface. Newly aerated space is a result of excavating two holes.

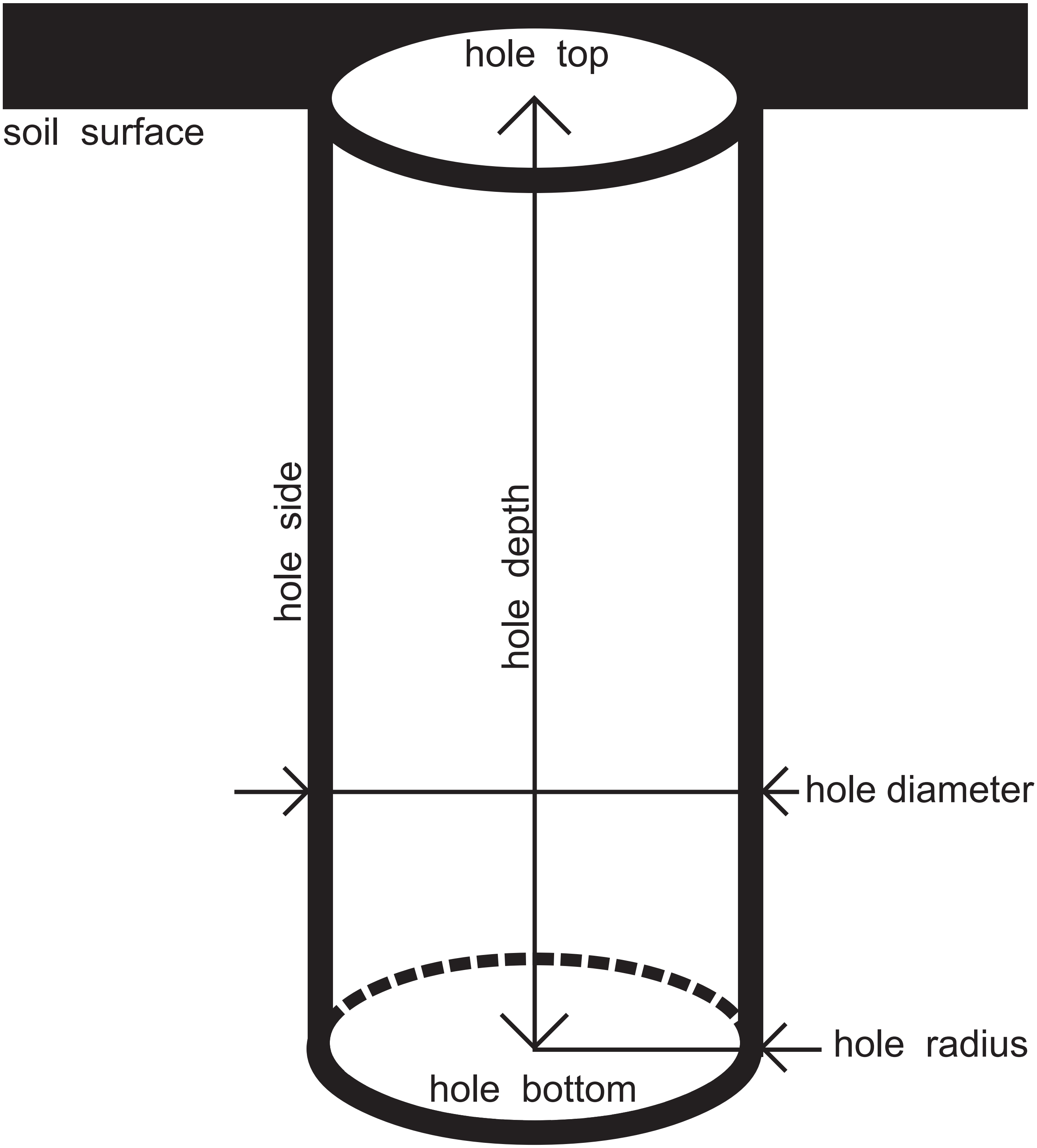


Figure 43: Diagrammatic definition of a round vertical excavated hole in soil. Volume of the hole is a right cylinder volume. Surface area of the hole is a right cylinder surface area minus the area of the hole top.

Table 10: Estmated aeration (oxygen diffusion and flow) diameter and radius (in inches) around an excavated hole within different soil textures not under continuous saturation or continuous air dry conditions. Aeration rates were estimated based on minimum oxygen diffusion rates needed for tree root health and at a soil temperature of 68°F. Aeration radius is also the depth in the soil of aeration from the surface.

soil texture	aeration distance (in) diameter	radius
clay	12”	6”
clay loam	16	8
silt loam	16	8
loam	24	12
fine sandy loam	30	15
sandy loam	36	18
fine sand	48	24
sand	48	24

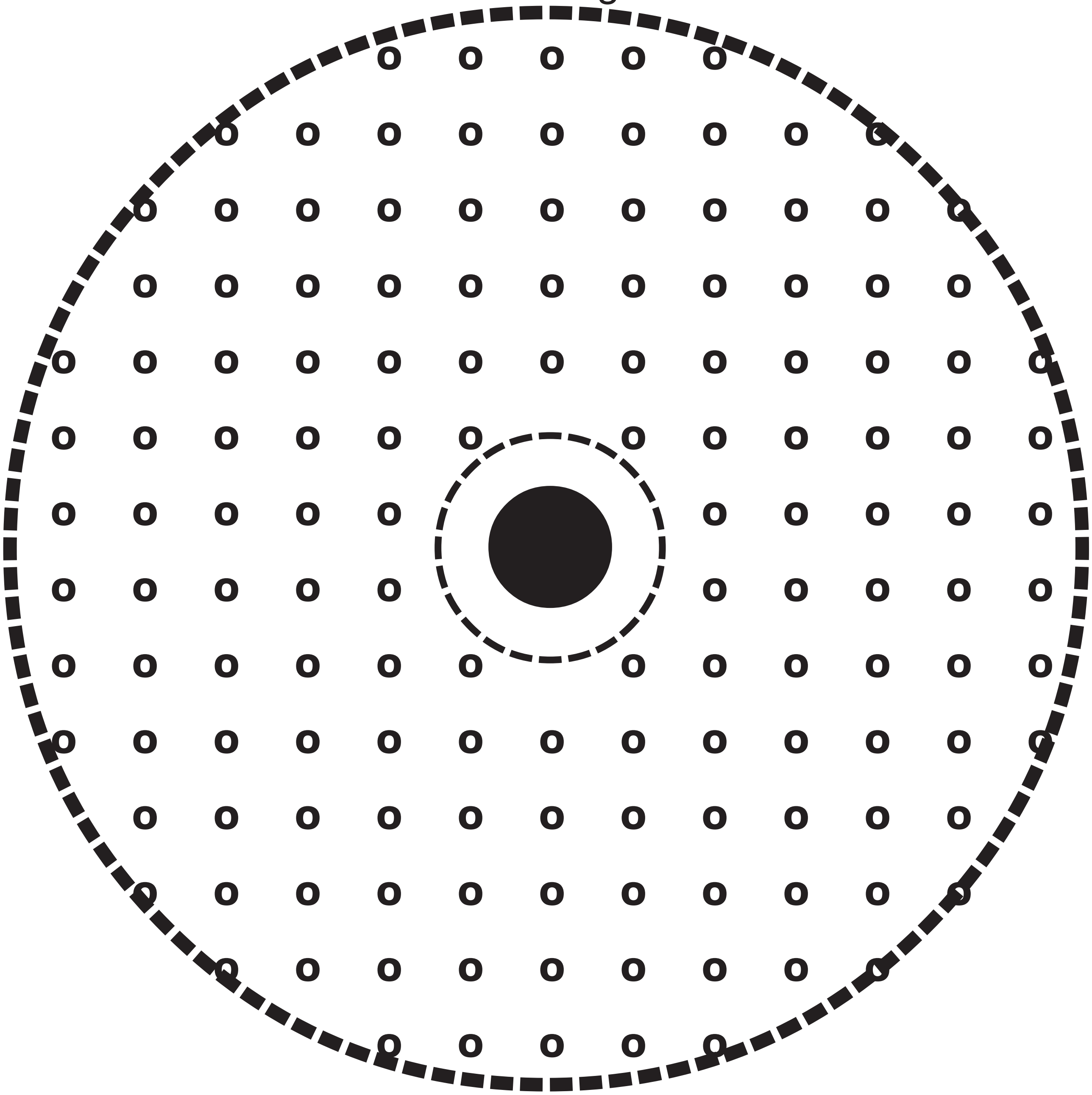


Figure 44: Diagrammatic view from above a vertical mulching field of holes systematically distributed within the critical rooting area of a tree. The distance between hole centers are specified when the treatment is installed. The center black circle represents the tree trunk.

Table 11: Distance apart (in inches), center-to-center, excavated holes should be for adequate aeration (oxygen diffusion and flow) supporting tree root health in various soil textures and for various sized holes (inches in diameter). Values rounded to next highest whole number.

soil texture	hole size in inches 0.5”	1”	1.5”	2”	2.5”	3”	4”
clay	13”	13	14	14	15	15	16
clay loam	17	17	18	18	19	19	20
silt loam	17	17	18	18	19	19	20
loam	25	25	26	26	27	27	28
fine sandy loam	31	31	32	32	33	33	34
sandy loam	37	37	38	38	39	39	40
fine sand	49	49	50	50	51	51	52
sand	49	49	50	50	51	51	52

Table 12: Approximate amount of additional soil surface area exposed by excavating a round vertical hole of a given diameter (in inches) and depth (in inches) into soil. Value shown is the number of times greater the surface area would be increased by excavating a hole versus the existing soil surface area.

hole depth (inches)	hole diameter in inches 0.5"	1"	1.5"	2"	2.5"	3"	4"
8"	65X	33	22	17	14	12	9
12"	97	49	33	25	20	17	13
16"	127	65	44	33	27	22	17
20"	161	81	54	41	33	28	21
24"	193	97	65	49	39	33	25
28"	225	113	76	57	46	38	29X
soil surface area removed	0.2 in^2	0.8 in^2	1.8 in^2	3.1 in^2	4.9 in^2	7.1 in^2	12.6 in^2

table value = {[6.283 X radius X depth] + [3.142 X $(radius)^2$]} / [3.142 X $(radius)^2$]

Table 13: Approximate open volume (upper value in cubic inches) and increased surface area of soil (bottom value in square inches) exposed by excavating a round vertical hole of a given diameter (in inches) and depth (in inches) into soil.

hole depth (inches)	diameter of hole in inches 0.5”	1”	1.5”	2”	2.5”	3”	4”
8”	1.6 in³	6.3	14	25	39	57	101
	13 in²	26	40	53	68	83	113
12”	2.4	9.4	21	38	59	85	151
	19	39	58	79	99	120	163
16”	3.1	13	28	50	79	113	201
	25	51	77	104	131	158	214
20”	3.9	16	35	63	98	141	251
	32	64	96	129	162	196	264
24”	4.7	19	42	75	118	170	302
	38	76	115	154	193	233	314
28”	5.5	22	50	88	137	198	352
	44	89	134	179	225	271	364

upper table value = [3.142 X $(\text{radius})^2$ X depth] = volume in cubic inches
bottom table value = [6.283 X radius X depth] + [3.142 X $(\text{radius})^2$] = surface area in square feet

Table 14: Number of round vertical holes of a given depth (in inches) and diameter (in inches) needed to remove one (1) cubic yard of soil volume. 1 $yard^3$ volume = 46,656 $inch^3$ volume

hole depth (inches)	hole diameter in inches						
	0.5”	1”	1.5”	2”	2.5”	3”	4”
8”	29,717	7,406	3,309	1,859	1,187	826	464
12”	19,769	4,963	2,201	1,238	792	550	309
16”	14,859	3,703	1,649	928	594	413	232
20”	11,872	2,972	1,322	743	475	330	186
24”	9,906	2,482	1,100	620	396	275	155
28”	8,483	2,121	943	530	340	236	133

Table 15 lists additional soil volume aerated below the soil surface aeration zone by a single vertical hole 24 inches deep. Note in more coarsely textured soils the surface aeration zone descends far enough into the soil to make vertical mulching useless for aeration objectives, but can

begin to impact soil density. Review Table 10. Vertical mulching holes should be backfilled with a non-compressible material, small amounts of composted organic material, and some native soil materials. Assure holes are immediately filled and periodically checked for settling.

A derivation of vertical mulching is the use of compresed air probes. Air probes are inserted at specified intervals into the soil generating a hole field across the site. High pressure air is then used to fracture soil. Some devices require pre-excavation for the probe while others can be driven into and through compacted soil. With some probes, additional materials can be added into the hole and along any fracture lines created in a soil. Materials added could be either liquid or granular, and include fertilizers, organic matter, biologics, and porous solids for holding soil fractures apart. As in vertical mulching it is the volume of soil impacted which comprise the value of the technique.

Technique 10 -- With large established trees on-site which can not have the soil surface greatly disturbed through sub-soiling to alleviate compaction, radial trenching can be utilized. A trencher, soil saw, or air gun device can be used to excavate radially aligned trenches around a tree. Trenches can be inserted starting at a distance away from a tree of 3.5 times tree diameter in inches (3.5D). Primary radial trenches (1^o) can be placed close together for aeration diffusion objectives, based upon aeration radii in soil of different textures, or can be placed farther apart and made wider in size to disturb and remove more soil volume.

Table 16 gives the number of primary trenches required for trees of various sizes and for distances between the initiation points of primary trenches. For example from Table 16, if soil compaction and tree root health warrants increasing aeration (oxygen diffusion and flow), the number of primary trenches can be determined by multiplying tree diameter in inches by 0.94. These primary trenches would be placed with starting points every two feet around the tree at a distance of 3.5 times the diameter of the tree in inches away from the tree. Alternatively, if general soil volume disturbance and removal is sought, using a factor of 0.31 times tree diameter would determine the number of primary trenches to install every 6 feet along a circumference of a circle whose radius is 3.5 times tree diameter. Note the minimum number of primary trenches is three for any small tree.

Additional trenches (secondary = 2^o; tertiary = 3^o) will need to be placed between primary radial trenches at set distances from the tree. Figure 45. Replace soil removed from trenches with non-compressible materials, small amounts of composted organic material, and some native soil. French drain materials could also be installed. Assure trenches are immediately filled and checked periodically for settling. Table 17 shows the estimated volume in cubic inches and the surface area in square inches generated along each linear foot of trench for a given width and depth. For example from Table 17, a trench excavated 4 inches wide and 3 feet deep would generate 1,728 cubic inches of soil volume removed and replaced, and 1,200 square inches of soil surface area exposed, per linear foot of trench. The amount of soil influenced by radial trenching is much greater than in vertical mulchng.

Technique 11 -- Use soft excavation techniques like air guns to cultivate (stir-up) soil in selected areas under a tree over several months or growing seasons (Bartlett renovation technique). The soil area for treatment can be divided into subdivisions and each segment eventually treated down to 6-12 inches of depth. Soil moisture content and level of compaction is critical for effective cultivation. Figure 46 shows the critical rooting area of a tree divided into eight equal areas with every other area treated this year and the remaining areas treated the following year for a 50% area per year treatment

Table 15: Additional soil volume (in cubic inches) aerated below the surface aeration zone by a vertical hole of a given diameter by soil texture class. Depth of hole is set to 24 inches.

soil texture	hole diameter in inches 0.5"	1"	1.5"	2"	2.5"	3"	4"
clay	3.5 in^3	14	32	57	88	127	226
clay loam	3.1	13	28	50	79	113	201
silt loam	3.1	13	28	50	79	113	201
loam	2.4	9.4	21	38	59	85	151
fine sandy loam	1.8	7.1	16	28	44	64	113
sandy loam	1.2	4.7	11	19	29	42	75
fine sand	0	0	0	0	0	0	0
sand	0	0	0	0	0	0	0

aerated soil volume in^3 = $(\text{hole radius})^2$ X [(hole depth - diffusion radius) X 3.142].

Table 16: Number of primary trenches required radiating from around the base of a tree either for increasing effective oxygen diffusion and flow in different soil textures or for removal of specific target soil volumes. Table values are multipliers of tree diameter (in inches) yielding the number of primary trenches needed.

Example: Tree diameter of 10 inches with a multiplier from table 0.47 for an initial distance apart of 4 feet -- (0.47 X 10) = 5 primary radial trenches installed (value rounded to nearest whole number).

multiplier value for number of primary radial trenches needed	initial (closest) distance between primary trenches	reason for and type of trench
0.94 X tree diameter inches	2 ft	diffusion / texture thin trenches
0.63 X tree diameter inches	3 ft	diffusion / texture thin trenches
0.47 X tree diameter inches	4 ft	diffusion / texture thin trenches; soil volume wide trenches
0.31 X tree diameter inches	6 ft	soil volume wide trenches
0.24 X tree diameter inches	8 ft	soil volume wide trenches
0.19 X tree diameter inches	10 ft	soil volume wide trenches
0.16 X tree diameter inches	12 ft	soil volume wide trenches

Decide whether to concentrate on volume of soil removed or diffusion facilitation; minimum approachable distance is 3.5 x D; minimum number of trenches is 3; carry trenches out as far as 26 x D if possible.

Figure 45: View from above a tree rooting area showing the distances away from a tree where primary (1°), secondary (2°), and tertiary (3°) radial trenches begin. All distance measures are multipliers of tree diameter (D in inches at 4.5 feet above the ground) yielding the distance in inches away from the tree.

(Example: For a 9 inch diameter tree (D=9"), four 1° trenches begin at 31.5" or 2.6 feet [3.5D] away from the tree; four 2° trenches begin at 63" or 5.3 feet [7D] away from the tree; and, eight 3° trenches begin at 126" or 10.5 feet [14D] away from the tree running out to 234" or 19.5 feet [26D] or beyond.)

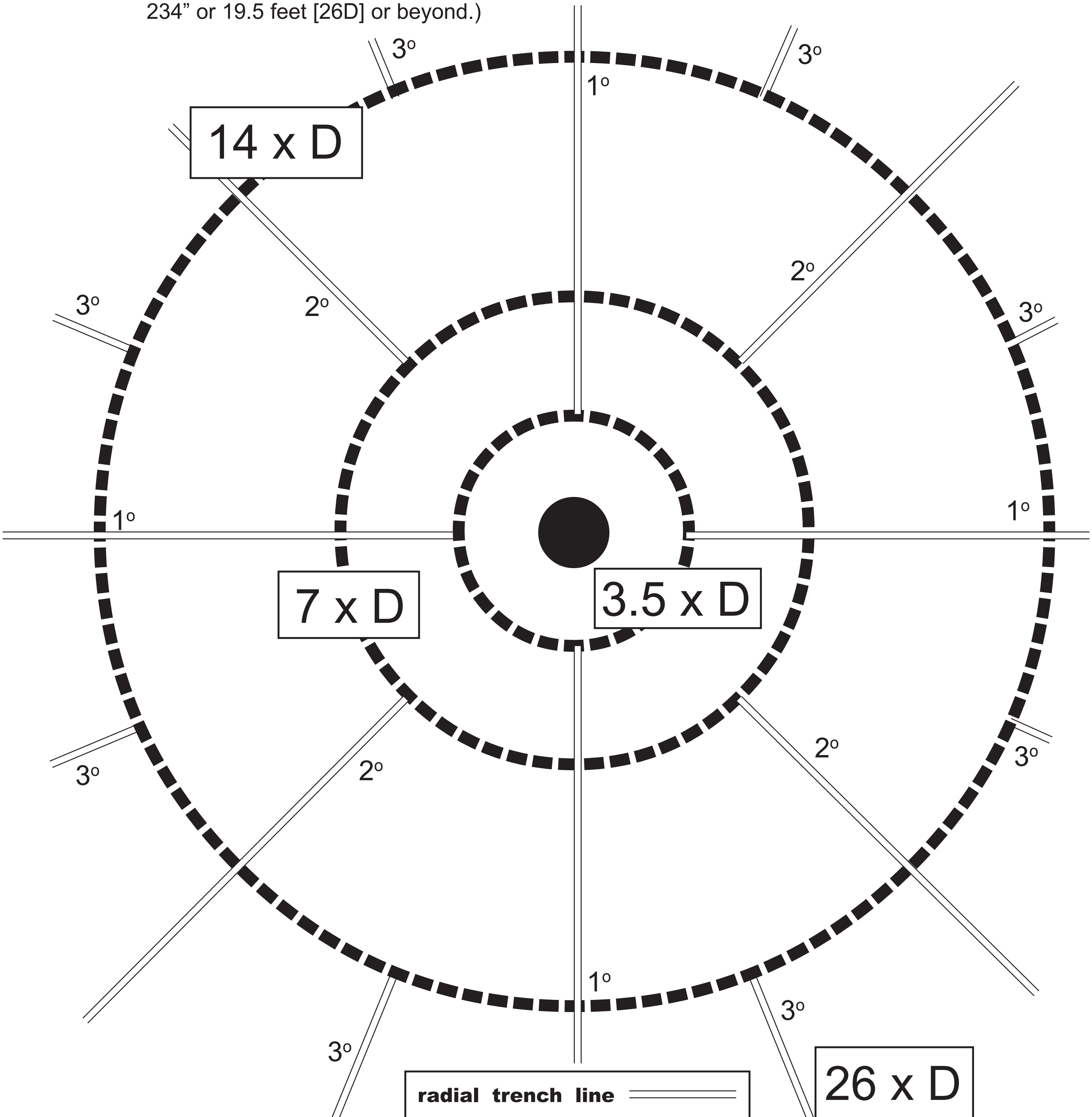


Table 17: Approximate volume (upper value in cubic inches) and increased surface area of soil (bottom value in square inches) exposed for each linear foot by trenching at a given trench depth (in inches) and trench width (in inches).

trench depth inches (ft)	width of trench in inches					
	1”	2”	4”	6”	8”	10”
12”(1’)	144 in^3 324 in^2	288 360	576 432	864 504	1,152 576	1,440 648
24”(2’)	288 636	576 696	1,152 816	1,728 936	2,304 1,056	2,880 1,176
36”(3’)	432 948	864 1,032	1,728 1,200	2,592 1,368	3,456 1,536	4,320 1,704
48”(4’)	576 1,260	1,152 1,368	2,304 1,584	3,456 1,800	4,608 2,016	5,760 2,232

NOTE: These values are per foot of trench.

upper volume value = [width X depth X 12]
bottom surface area value = [(2 X depth X width) + (12 X width) + (24 X depth)]

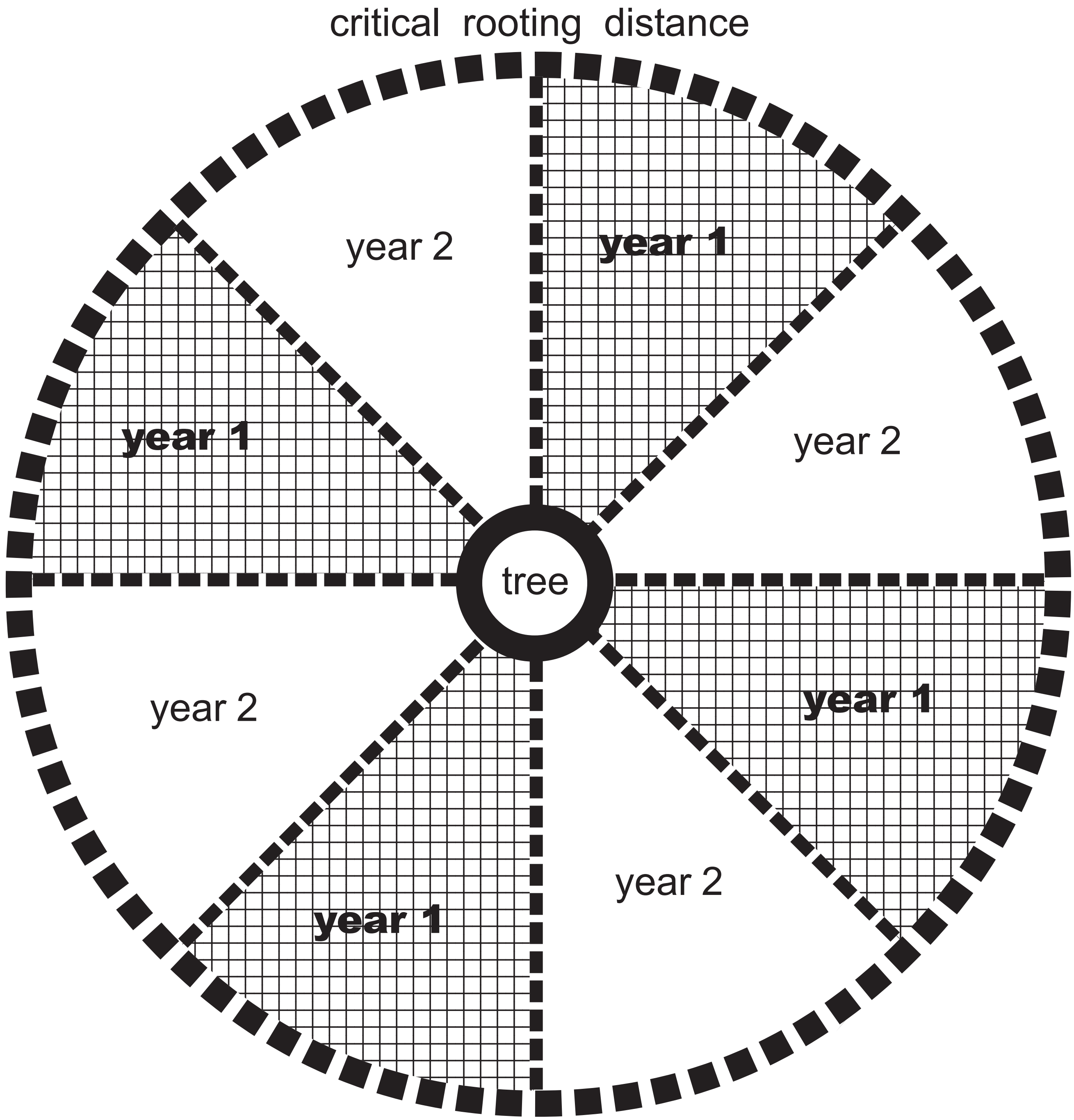


Figure 46: Radial wedges of equal area representing soil around the base of a tree for decompaction treatment over two years (one-half of critical rooting area decompacted per year).

process. Figure 47 shows the critical rooting area of a tree from above divided into 12 equal areas with every third area treated this year and each neighboring area to the left (counter-clockwise in this example) treated in year two, and the remaining areas treated in year three, for a 33% area per year treatment process. Immediately after cultivation, watering is essential.

Table 18 provides an estimate of how many square feet of the pretreatment soil surface area would be impacted in any one year for various sized trees. Table 18 lists 100%, 50%, 33%, and 25% treatment intensity. For example from Table 18, a 40 inch diameter tree would have 3,927 square feet of soil surface beneath its canopy treated each year for two years (50% of the area treated per year.)

Table 19 shows the volume of soil decompacted beneath every square foot of a treatment area for a variety of soil depths. For example from Table 19, if the decompaction treatment depth was 8 inches, then 1,152 cubic inches (0.67 cubic feet) of soil is influenced for every square foot treated. Deep decompaction treatments using soft excavation techniques become progressively more difficult and variable in application below 8 inches. Composted organic matter and other soil and growth materials can be incorporated during this operation. Note this technique greatly exceeds the soil impact volume of radial trenching.

Technique 12 -- As seen is the previuos techniques, increasing depth of aeration and volume of soil impacted are key elements in successful compaction renovation. Micro-slits or mini-trenches can be excavated deeply (16-24 inches) in a thin radial line away from the trunk base with a soil saw or compressed air nozzle in large treatment fields around a tree (Coder renovation technique). Figure 48. Figure 48 shows micro-slits installed in four wedge shaped areas around the tree. These treatment segements or wedges do not begin until the distance from the tree is 3.5 times the tree diameter in inches (3.5D). This technique is designed for extreme compaction and does have the potential to significantly increase root damage and tree structural failures. The trade-off between biology and biomechanics must be evaluated. Micro-slits begin at 3.5D distance and slit number are increased at 6D and 10D distances away from a tree. The micro-slits should be installed out to at least a distance of 15D from the tree.

Micro-slits must be inserted deep into the soil for best effect and placed close together. Table 20. For example from Table 20, if a tree diameter is 35 inches and is growing in heavily compacted clay soil, the micro-slit number per treatment segement is “5+4+6.” The first number (5) denotes five micro-slits are started at the 3.5D distance and run radially out to at least the 15D distance. At the 6D distance, four (4) new micro-slits are started and ran out to at least the 15D distance. At the 10D distance, another six (6) micro-slits are started and ran out to at least the 15D distance.

For each soil texture (based upon oxygen diffusion and flow level), and for each tree diameter, three numeric values are provided in Table 20 giving the number of micro-slits to install and where each should be started. It is not critical the micro-slits are perfectly aligned, spaced, or even straight. It is the soil volume impact which is critical. Note the value of this technique is concentrated in the finer textured soils which are heavily compacted.

Only one-third of a tree’s critical rooting area should be treated in any one year. No soil distrubance should occur closer than 3.5 times the tree diameter in inches (3.5D) from the tree tunk. Table 21 provides the surface area of soil impacted by this technique. Table 19 provides the volume of soil impacted for various treatment depths for each square foot of surface area. Micro-slits can be filled by raking in non-compressable materials, some composted organic material, and some native soil. Additional tree growth and soil health materials can be added to the soil surface and raked in. Watering should be completed immediately after treatment. In heavily compacted soils which are

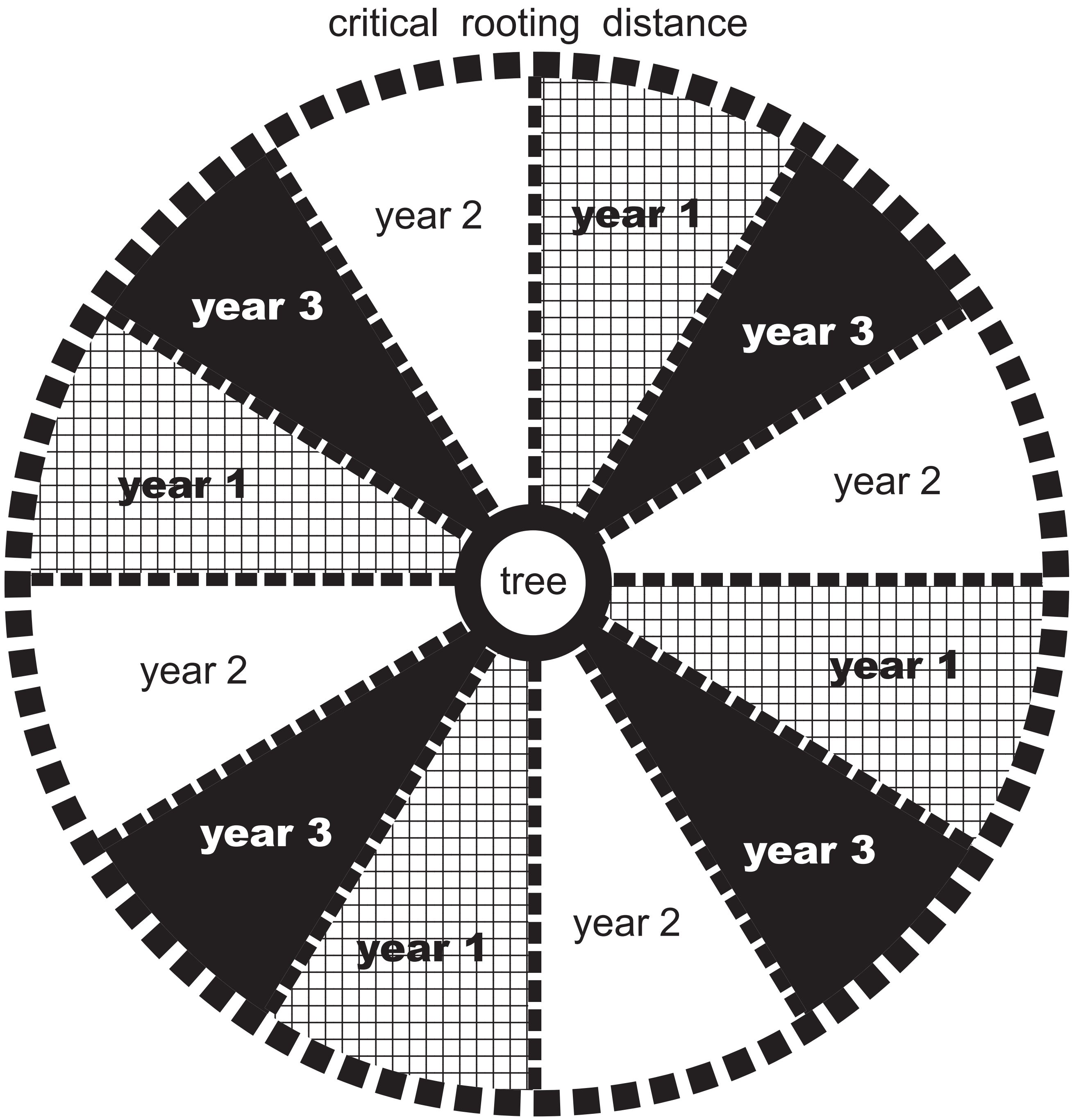


Figure 47: Radial wedges of equal area representing soil around the base of a tree for decompaction treatment over three years (one-third of critical rooting area decompacted per year in a counter-clockwise progression).

Table 18: Surface area of soil (in square feet) within the critical rooting area of a tree decompacted in any one year or treatment.

tree diameter (inches)	critical rooting area decompacted per treatement (ft^2) 100%	50%	33%	25%
10”	491 ft^2	246	162	123
15	1,105	553	365	276
20	1,964	982	648	491
25	3,068	1,534	1,012	767
30	4,418	2,209	1,458	1,105
35	6,013	3,007	1,984	1,503
40	7,854	3,927	2,592	1,964
45	9,940	4,970	3,280	2,485
50	12,272	6,136	4,050	3,068
55	14,849	7,425	4,900	3,712
60	17,671	8,836	5,831	4,418
65	20,739	10,370	6,844	5,185
70	24,053	12,027	7,938	6,013
75	27,611	13,806	9,112	6,903
80	31,416	15,708	10,367	7,854

$[(\text{diameter} \times 2.5)^2 \times 0.785] \times \text{treatment percent} = \text{table value}$

Table 19: The volume (in cubic inches and cubic feet) of soil decompacted below each square foot of soil surface for different soil treatment depths (in inches).

depth of decompaction treatment (in)	volume below one (1) square foot of soil surface	
	cubic inches (in^3)	cubic feet (ft^3)
2”	288 in^3	0.17 ft^3
4	576	0.33
6	864	0.50
8	1,152	0.67
10	1,440	0.83
12	1,728	1.00
14	2,016	1.17
16	2,304	1.33
18	2,592	1.50
20	2,880	1.67
22	3,168	1.83
24	3,456	2.00
26	3,744	2.17
28	4,032	2.33
30	4,320	2.50

table value in cubic inches = depth X 144
table value in cubic feet = cubic inch value / 1,728

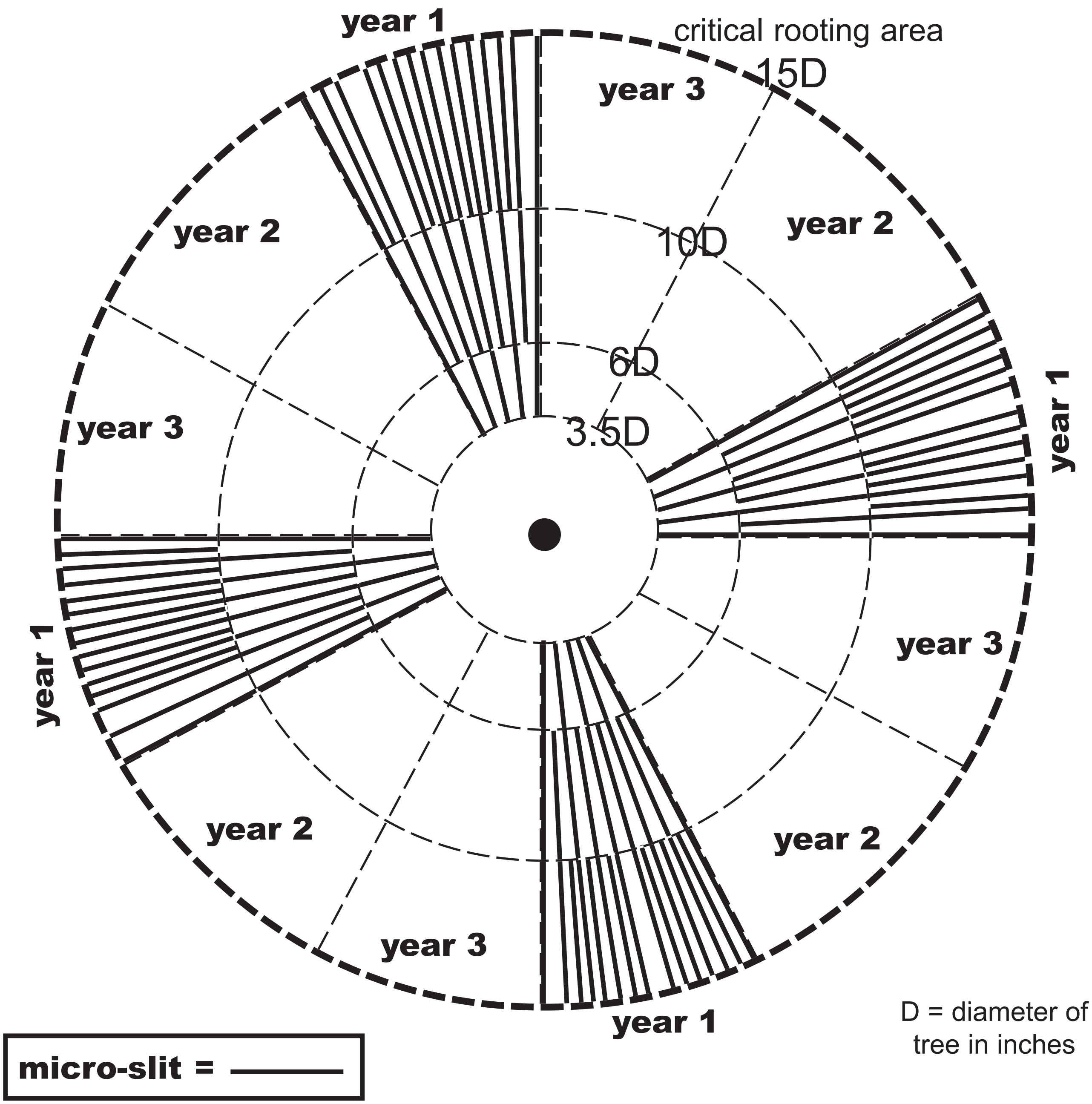


Figure 48: View from above of micro-slit fields arranged in radial patterns around a tree. Only one-third of the critical rooting area is treated each year. (This example shows a 35-inch diameter tree in the center growing in compacted clay soil surrounded by micro-slit fields in the pattern 5+4+6)

Table 20: The number of radial micro-slits to place in each segment wedge (one of four wedges installed per year) within the critical rooting area of a tree of a given diameter (in inches). The first number is the micro-slits per segment installed between 3.5 times the tree diameter distance inches (3.5D) and 15 times the tree diameter distance inches (15D) away from a tree. The second number is the additional micro-slits added after the 6D radial distance per segment. The third number is the additional micro-slits added after the 10D radial distance per segment. Micro-slits should run out to at least the 15D radial distance, if not beyond.

tree diameter	soil texture: clay	clay loam	silt loam	loam	sandy loam	fine sandy loam	fine sand	sand
5 in	0+1+1	0+1+0	0+1+0	0+0+1	0+0+0	0+0+0	0+0+0	0+0+0
10	1+1+2	1+1+1	1+1+1	0+1+1	0+1+1	0+0+1	0+0+1	0+0+1
15	2+2+2	1+2+2	1+2+2	1+1+1	1+1+1	0+1+1	0+1+1	0+1+1
20	3+2+3	2+2+2	2+2+2	1+1+2	1+1+1	1+1+1	0+1+1	0+1+1
25	3+3+5	3+2+3	3+2+3	2+1+2	1+1+2	1+1+1	1+1+1	1+1+1
30	4+4+5	3+3+3	3+3+3	2+2+2	1+2+2	1+1+2	1+1+1	1+1+1
35	5+4+6	4+3+4	4+3+4	2+2+3	2+2+2	1+2+2	1+1+1	1+1+1
40	6+4+7	4+4+5	4+4+5	3+2+3	2+2+3	2+2+2	1+1+2	1+1+2
45	7+4+8	5+4+5	5+4+5	3+3+3	2+2+3	2+2+2	1+2+2	1+2+2
50	7+6+8	5+4+7	5+4+7	3+3+5	3+2+3	2+2+3	2+2+2	2+2+2
55	8+6+10	6+4+8	6+4+8	4+3+5	3+2+4	2+2+4	2+2+2	2+2+2
60	9+6+11	7+4+8	7+4+8	4+4+5	3+3+4	3+2+4	2+2+2	2+2+2
65	10+7+11	7+5+9	7+5+9	5+4+5	4+3+4	3+2+4	2+2+3	2+2+3
70	10+8+12	8+5+10	8+5+10	5+4+6	4+3+5	3+3+4	2+2+3	2+2+3
75	11+8+13	8+6+10	8+6+10	5+4+7	4+4+5	3+3+5	3+2+3	3+2+3

3.5D # = (0.153D) / diffusion value. 6D # = (0.262D) / diffusion value. 10D # = (0.436D) / diffusion value.

Table 21: Treatment surface areas (in square feet) per year for micro-slit technique. One column is for a single segment or wedge between a distance of 3.5 times tree diameter and 15 times tree diameter, and the other column is for the combined area treated under one tree in a single year.

tree diameter (inches)	individual segment / wedge surface area (ft^2)	combined (all 4) segments / wedges surface area (ft^2)
5”	9.7 ft^2	38.7 ft^2
10	38.7	155
15	87	348
20	155	619
25	242	967
30	348	1,392
35	474	1,895
40	619	2,475
45	783	3,133
50	967	3,867
55	1,170	4,680
60	1,392	5,569
65	1,634	6,536
70	1,895	7,580
75	2,175	8,702

table value individual segment =
{[3.142 X (tree diameter” X 1.25)^2] - [3.142 X (tree diameter” X 0.292)^2]} / 12.
table value combined = individual segment value X 4.

dry, thin-kerf micro-trenchers and soil saws will usually provide quicker and more effective treament than soft excavation methods.

Other Techniques -- Other methods for decompacting sites are being developed and tested. Complete soil and tree replacement may be realities for some extremely damaged and growth constraining sites.

Conclusions

Soil compaction is a hidden stressor which steals health and sustainability from soil and tree systems. Causes of compaction are legion and solutions limited. Without creative actions regarding the sustainable greening of inter-infrastructural spaces in our communities, we will spend most of our budgets and careers treating compaction symptoms and replacing trees. Understanding the hideous scourge of soil compaction is essential to better, enlightened, and corrective tree health management.

Trees & Soil Compaction: A Selected Bibliography

Abercrombie, R.A. 1990. Root distribution of avocado trees on a sandy loam soil as affected by soil compaction. Acta Horticulturae. 275:505-512.

Alberty, C.A., Pellett, H.M., & Taylor, D.H. 1984. Characterization of soil compaction at construction sites and woody plant response. Journal of Environmental Horticulture 2(2):48-53.

Barber, R.G. & Romero, D. 1994. Effects of bulldozer and chain clearing on soil properties and crop yields. Soil Science Society of America Journal. 58 (6):1768-1775.

Coder, K.D. 1998. Soil constraints on root growth. University of Georgia Cooperative Extension Service Forest Resources Publications FOR98-10. 8pp.

Cook, F.J. & J.H. Knight. 2003. Oxygen transport to plant roots: Modeling for physical understanding of soil aeration. Soil Science Society of America Journal 67:20-31.

Corns, I.G.W. & Maynard, D.G. 1998. Effects of soil compaction and chipped aspen residue on aspen regeneration and soil nutrients. Canadian Journal of Soil Science. 78(1):85-92.

Craul, P.J. 1992. **Urban Soil in Landscape Design**. John Wiley & Sons, New York. Pp. 396.

Craul, P.J. 1994. Soil compaction on heavily used sites. Journal of Arboriculture 20(2):69-74.

Craul, P.J. 1999. **Urban Soils: Applications and Practices**. John Wiley & Sons, New York. Pp. 366.

Daddow, R.L. & G.E. Washington. 1983. Growth-limiting soil bulk densities as influenced by soil texture. USDA-Forest Service Report WSD6-TN-00005. Pp.17.

Day, S.D. & Bassuk, N.L. 1994. A review of the effects of soil compaction and amelioration treatments on landscape trees. Journal of Arboriculture 20(1):9-17.

Day, S.D. Bassuk, N.L. & VanEs, H. 1995. Effects of four compaction remediation methods for landscape trees on soil aeration, mechanical impedance and tree establishment. Journal of Environmental Horticulture. 13(4):64-71.

Donnelly, J.R. & Shane, J.B. 1986. Forest ecosystem responses to artificially induced soil compaction. I. Soil physical properties and tree diameter growth. Canadian Journal of Forest Research 16 (4):750-754.

Ferguson, B.K. 2005. **Porous Pavements.** CRC Press, Boca Raton, FL. Pp.577.

Gilman, E.F., Leone, I.A., & Flower, F.B. 1987. Effect of soil compaction and oxygen content on vertical and horizontal root distribution. Journal of Environmental Horticulture 5(1):33-36.

Greene, T.A. & Nichols, T.J. 1996. Effects of long-term military training traffic on forest vegetation in central Minnesota. Northern Journal of Applied Forestry. 13 (4):157-163.

Gregory, J.H., M.D. Dukes, P.H. Jones, & G.L. Miller. 2006. Effects of urban soil compaction on infiltration rate. Journal of Soil & Water Conservation 61(3):117-124.

Helms, J.A. & Hipkin, C. 1986. Effects of soil compaction on tree volume in a California ponderosa pine plantation. Western Journal of Applied Forestry. 1(4):121-124.

Hitchmough, J.D. 1994. **Urban Landscape Management.** Inkata Press, Sydney, AUS. Pp.115, 129, 273.

Jim, C.Y. 1998. Soil compaction at tree-planting sites in urban Hong Kong. Pp. 166-178 in **The Landscape Below Ground II: Proceedings of a Second International Workshop on Tree Root Development in Urban Soils** (San Francisco, CA). (Neely, D. & Watson, GW. editors). International Society of Arboriculture, Champaign, IL.

Jordan, D., F. Ponder, & V.C. Hubbard. 2003. Effects of soil compaction, forest leaf litter and nitorgen fertilizer on two oak species and microbial activity. Applied Soil Ecology 23(1):33-41.

Kalita, P. 1999. Transient finite element method solution of oxygen diffusion in soil. Ecological Modelling 118:227-236.

Licher, J.M. & Lindsey, P.A. 1994. Soil compaction and site construction: Assessment and case studies. Pp. 126-130 in **The Landscape Below Ground: Proceedings of an International Workshop on Tree Root Development in Urban Soils** (Chicago, IL). (Watson, GW. & Neely, D. editors). International Society of Arboriculture, Champaign, IL.

Matheny, N. & J.R. Clark. 1998. **Trees & Development: A technical guide to preservation of trees during land development.** International Society of Arboriculture, Champaign, IL. Pp. 84-85, 126-127.

Moldrup, P., T. Olesen, S. Yoshikawa, T. Komatsu, & D.E. Rolston. 2004. Three-porosity model for predicting the gas diffusion coefficient in undisturbed soil. Soil Science Society of America Journal 68:750-759.

Moldrup, P., T. Olesen, T. Komatsu, P. Schjonning, & D.E. Rolston. 2001. Tortuosity, diffusivity, and permeability in the soil liquid and gaseous phases. Soil Science Society of America Journal 65:613-623.

Page-Dumroese, D.S. Harvey, A.E. Jurgensen, M.F. & Amaranthus, M.P. 1998. Impacts of soil compaction and tree stump removal on soil properties and out-planted seedlings in northern Idaho, USA. Canadian Journal of Soil Science. 78(1):29-34.

Patterson, J.C. 1976. Soil compaction and its effects upon urban vegetation. Pages 91-102 in proceedings of symposium "Better trees for metropolitan landscapes." USDA-Forest Service General Technical Report NE-22.

Pittenger, D.R. & Stamen, T. 1990. Effectiveness of methods used to reduce harmful effects of compacted soil around landscape trees. Journal of Arboriculture 16(3):55-57.

Randrup, T.B. 1998. Soil compaction on construction sites. Pp. 146-153 in **The Landscape Below Ground II: Proceedings of a Second International Workshop on Tree Root Development in Urban Soils** (San Francisco, CA). (Neely, D. & Watson, GW,. editors). International Society of Arboriculture, Champaign, IL.

Randrup, T.B. & Dralle, K. 1997. Influence of planning and design on soil compaction in construction sites. Landscape & Urban Planning 38:87-92.

Rolf, K. 1994. Soil compaction and loosening effects on soil physics and tree growth. Pp.131-148 in **The Landscape Below Ground: Proceedings of an International Workshop on Tree Root Development in Urban Soils** (Chicago, IL). (Watson, GW. & Neely, D. editors). International Society of Arboriculture, Champaign, IL.

Smiley, E.T. 1994. The effects of soil aeration equipment on tree growth. Pp. 207-210 in **The Landscape Below Ground: Proceedings of an International Workshop on Tree Root Development in Urban Soils** (Chicago, IL). (Watson, GW. & Neely, D. editors). International Society of Arboriculture, Champaign, IL.

Stone, D.M. & Elioff, J.D. 1998. Soil properties and aspen development five years after compaction and forest floor removal. Canadian Journal of Soil Science. 78(1):51-58.

Torbert, J.L. & Burger, J.A. 1990. Tree survival and growth on graded and ungraded minesoil. USDA-Forest Service. Tree Planters' Notes 41(2):3-5.

Torreano, S.J. 1992. Effects of soil water availability, aeration,and soil mechnical impedance on loblolly pine (*Pinus taeda*) root development. PhD dissertation, University of Georgia Warnell School. Pp.125.

Watson, G.W. & P.K. Kelsey. 2006. The impact of soil compaction on soil aeration and fine root density of *Quercus palustris*. Urban Forestry & Urban Greening 4:69-74.

Worrell, R. & Hampson, A. 1997. The influence of some forest operations on the sustainable management of forest soils -- a review. Forestry 70 (1):61-85.

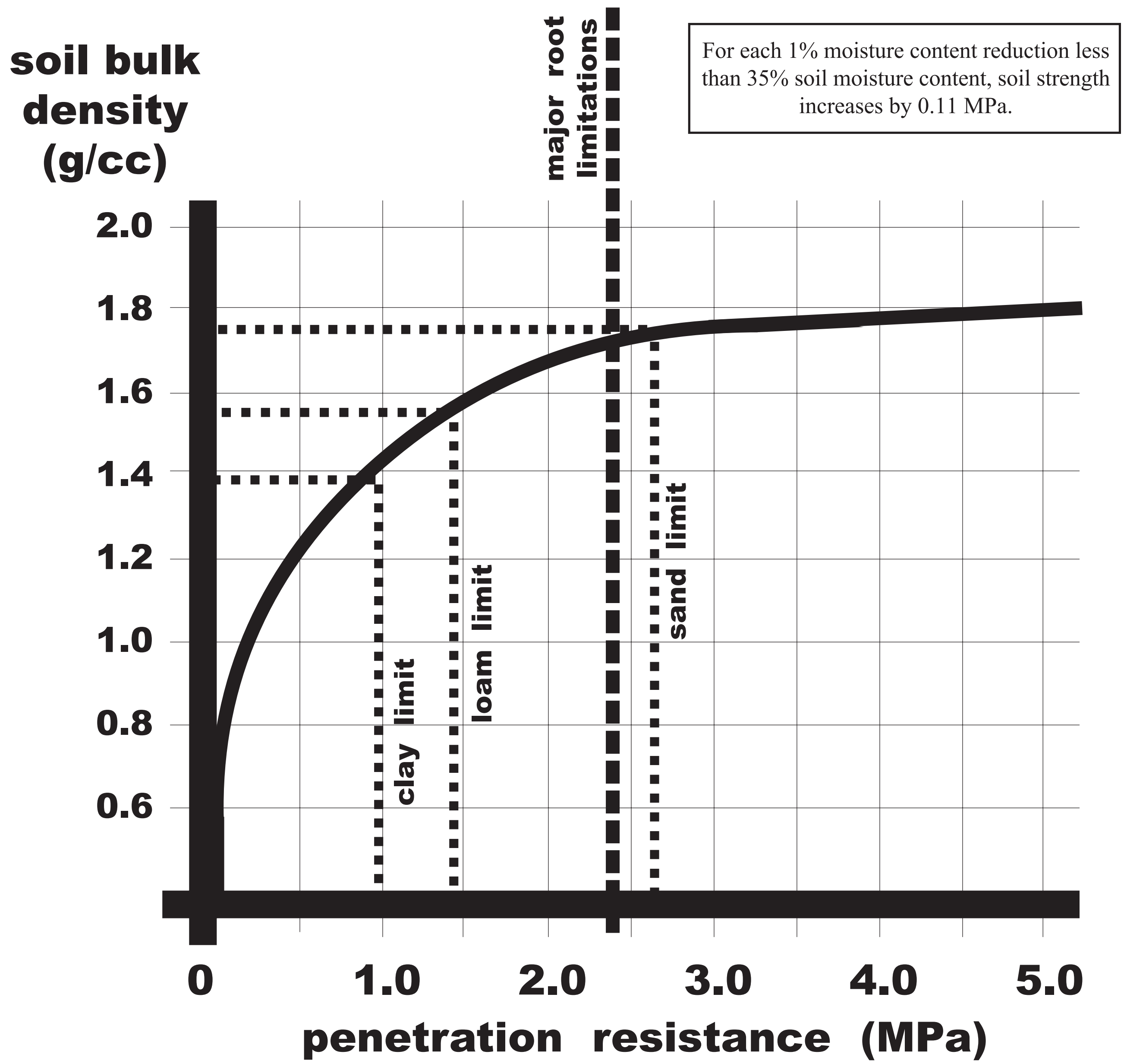
Appendix 1: Compaction Tolerant Trees

Soil compaction is a complex set of physical, chemical, and biological constraints on tree growth. Principle components leading to limited growth are the loss of aeration pore space, poor gas exchange with the atmosphere, lack of tree available water, and mechanical impedance of root growth. There are significant genetic differences between tree species for tolerating various levels of soil compaction.

This is a select list of compaction tolerant trees. Tolerant species were selected for their effectiveness in reacting to mechanical damage quickly, in surviving anaerobic soil conditions, and in adjusting their root systems to new conditions. This is not a comprehensive list and is only provided to show average species examples. Chronic and severe compaction will kill any tree. Some species, varieties, and individuals may tolerate various compacted soil conditions better than others.

scientific name	common name	scientific name	common name
Acer negundo	boxelder	Persea borbonia	redbay
Acer rubrum	red maple	Pinus elliottii	slash pine
Acer saccharinum	silver maple	Pinus glabra	spruce pine
Alnus spp.	alders	Pinus serotina	pond pine
Betula nigra	river birch	Pinus taeda	loblolly pine
Carya aquatica	water hickory	Planera aquatica	planer-tree
Carya illinoensis	pecan	Platanus spp.	sycamore / planetree
Carya laciniosa	shellbark hickory	Populus spp.	cottonwood / aspen
Catalpa spp.	catalpa	Pyrus calleryana	callery pear
Celtis laevigata	sugarberry	Quercus bicolor	swamp white oak
Celtis occidentalis	hackberry	Quercus falcata	Southern red oak
Cephalanthus occidentalis	button-bush	Quercus imbricaria	shingle oak
Cercis canadensis	redbud	Quercus laurifolia	laurel oak
Chamaecyparis thyides	Atlantic whitecedar	Quercus lyrata	overcup oak
Cliftonia monophylla	buckwheat tree	Quercus macrocarpa	bur oak
Crataegus spp.	hawthorns	Quercus michauxii	swamp chestnut oak
Diospyros virginiana	persimmon	Quercus nigra	water oak
Fraxinus spp.	ash	Quercus nuttallii	Nuttall oak
Gleditsia spp.	water / honeylocust	Quercus palustris	pin oak
Ilex spp.	holly	Quercus phellos	willow oak
Juglans nigra	black walnut	Quercus rubra	red oak
Juniperus spp.	junipers / redcedar	Quercus shumardii	Shumard oak
Leitneria floridana	corkwood	Robinia pseudoacacia	black locust
Lindera benzoin	spicebush	Salix spp.	willows
Liquidambar styraciflua	sweetgum	Taxodium spp.	bald / pondcypress
Magnolia virginiana	sweetbay	Thuja occidentalis	arborvitae
Maclura pomifera	Osag-orange	Ulmus spp.	elms
Nyssa spp.	tupelo / blackgum	Viburnum spp.	viburnum

Appendix 2: Field Data Sheet



COMPACTION FIELD SHEET

soil samples

# 1 ____________	# 6 ____________
# 2 ____________	# 7 ____________
# 3 ____________	# 8 ____________
# 4 ____________	# 9 ____________
# 5 ____________	#10 ____________

average penetration resistance

____________ MPa

estimated bulk density value = ____________ g/cc

est. tree root growth reduction = ____________ %

CITY OF LOS ANGELES
Office of Historic Resources/Cultural Heritage Commission

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

1. PROPERTY IDENTIFICATION

Proposed Monument Name: **Hermitage TREES**					
Other Associated Names:					
Street Address: **5303 Hermitage Ave.**		Zip: **91607**		Council District: **2**	
Range of Addresses on Property: **12301, 12301 1/2 Weddington St.**		Community Name:			
Assessor Parcel Number: **2347025010**	Tract: **9237**		Block:	Lot: **9**	
Identification cont'd:					
Proposed Monument Property Type:	Building	Structure	Object	● Site/Open Space	● Natural Feature
Describe any additional resources located on the property to be included in the nomination, here: **2 Camphor Trees, Mulberry Tree, Crape Myrtle tree, Japanese Hackberry Trees, American Sweetgum Trees, P. orientalis, P. macrophyllus**					

2. CONSTRUCTION HISTORY & CURRENT STATUS

Year built: **1934**	● Factual	Estimated	Threatened? **Private Development**
Architect/Designer:			Contractor:
Original Use:			Present Use:
Is the Proposed Monument on its Original Site?	● Yes	No (explain in section 7)	Unknown (explain in section 7)

3. STYLE & MATERIALS

Architectural Style:	Stories:	Plan Shape:

FEATURE	*PRIMARY*	*SECONDARY*
CONSTRUCTION	Type:	Type:
CLADDING	Material:	Material:
ROOF	Type:	Type:
	Material:	Material:
WINDOWS	Type:	Type:
	Material:	Material:
ENTRY	Style:	Style:
DOOR	Type:	Type:

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

4. ALTERATION HISTORY

List date and write a brief description of any major alterations or additions. This section may also be completed on a separate document. Include copies of permits in the nomination packet. Make sure to list any major alterations for which there are no permits, as well.

	N/A

5. EXISTING HISTORIC RESOURCE IDENTIFICATION (if known)

	Listed in the National Register of Historic Places	
	Listed in the California Register of Historical Resources	
	Formally determined eligible for the National and/or California Registers	
	Located in an Historic Preservation Overlay Zone (HPOZ)	Contributing feature Non-contributing feature
	Determined eligible for national, state, or local landmark status by an historic resources survey(s)	Survey Name(s):
Other historical or cultural resource designations:		

6. APPLICABLE HISTORIC-CULTURAL MONUMENT CRITERIA

The proposed monument exemplifies the following Cultural Heritage Ordinance Criteria (Section 22.171.7):

✓	Reflects the broad cultural, economic, or social history of the nation, state, or community
	Is identified with historic personages or with important events in the main currents of national, state, or local history
✓	Embodies the distinguising characteristics of an architectural-type specimen, inherently valuable for study of a period, style, or method of construction
	A notable work of a master builder, designer, or architect whose individual genius influenced his or her age

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

7. WRITTEN STATEMENTS <u>**See enclosure #1**</u>

This section allows you to discuss at length the significance of the proposed monument and why it should be designated an Historic-Cultural Monument. Type your response on separate documents and attech them to this form.

A. Proposed Monument Description - Describe the proposed monument's physical characteristics and relationship to its surrounding environment. Expand on sections 2 and 3 with a more detailed description of the site. Expand on section 4 and discuss the construction/alteration history in detail if that is necessary to explain the proposed monument's current form. Identify and describe any character-defining elements, structures, interior spaces, or landscape features.

B. Statement of Significance - Address the proposed monument's historic, cultural, and/or architectural significance by discussing how it satisfies the HCM criteria you selected in Section 6. You must support your argument with substantial evidence and analysis. The Statement of Significance is your main argument for designation so it is important to substantiate any claims you make with supporting documentation and research.

8. CONTACT INFORMATION

Applicant

Name: Aimee Frappied		Company:	
Street Address: 263 W Olive Ave. #159		City: Burbank	State: CA
Zip: 91506	Phone Number: (818) 800-8462	Email: aimeefrappied@gmail.com	

Property Owner Is the owner in support of the nomination? Yes No Unknown

Name:		Company:	
Street Address:		City:	State:
Zip:	Phone Number:	Email:	

Nomination Preparer/Applicant's Representative

Name:		Company:	
Street Address:		City:	State: CA
Zip:	Phone Number:	Email:	

HISTORIC-CULTURAL MONUMENT
NOMINATION FORM

9. SUBMITTAL

When you have completed preparing your nomination, compile all materials in the order specified below. Although the entire packet must not exceed 100 pages, you may send additional material on a CD or flash drive.

APPLICATION CHECKLIST

1. Nomination Form
2. Written Statements A and B
3. Bibliography
4. Two Primary Photos of Exterior/Main Facade (8x10, the main photo of the proposed monument. Also email a digitial copy of the main photo to: planning.ohr@lacity.org)
5. Copies of Primary/Secondary Documentation
6. Copies of Building Permits for Major Alterations (include first construction permits)
7. Additional, Contemporary Photos
8. Historical Photos
9. Zimas Parcel Report for all Nominated Parcels (including map)

10. RELEASE

Please read each statement and check the corresponding boxes to indicate that you agree with the statement, then sign below in the provided space. Either the applicant or preparer may sign.	
✓	I acknowledge that all documents submitted will become public records under the California Public Records Act, and understand that the documents will be made available upon request to members of the public for inspection and copying.
✓	I acknowledge that all photographs and images submitted as part of this application will become the property of the City of Los Angeles, and understand that permission is granted for use of the photographs and images by the City without any expectation of compensation.
✓	I acknowledge that I have the right to submit or have obtained the appropriate permission to submit all information contained in this application.

Name: Date: Signature:

Mail your Historic-Cultural Monument Submittal to the Office of Historic Resources.

Office of Historic Resources
Department of City Planning
200 N. Spring Street, Room 620
Los Angeles, CA 90012

Phone: 213-978-1200
Website: preservation.lacity.org

#7. WRITTEN STATEMENTS

A. PURPOSED MONUMENT DESCRIPTION

Existing on The Hermitage Property is a variety of flora and fauna that has been the most reliable and dependable source for local wildlife, beneficial insects our & community.
2 Camphor Trees over 80 years old & over 60 feet tall.
Amongst the open space landscape there are Crape Myrtle Trees, Japanese Hackberry, Podocarpus macrophyllus (yew pine), Camellia trees, Oleander, American Sweetgum & BottleBrush tree's that all thrive in their originally planted location, decades ago.

B. STATEMENT OF SIGNIFICANCE (also see attached)

The Hermitage Trees meet the criteria of the *broad cultural, economic or social history of the nation, State or community.* This is *reflected* ***&*** *exemplified* through the time periods in which it they survived & continue to provide beneficial elements to our residents, neighbors, passerby's & wildlife.
Existing Camphor Trees over 80 years old and over 60 feet tall continue to provide homes, food & habitats to dozens of species of birds, squirrels, & beneficial insects. There have been at least 4 (as of the date on this application) sightings of 2 birds listed State & Federal Endangered Species Lists.
These trees have the ability to reach more than 500 years old & are considered legends in other countries.
Amongst agricultural & biological significance, our older & mature trees continue to provide oxygen by their ability to absorb larger amounts of carbon dioxide than newly planted trees.
The existing vast root system is depended on by the Soil Food Web (see attached documentation). The nutrient cycling and disease suppression needed by trees & plants occurs immediately adjacent to roots.

The Camphor trees exist on the north west corner of what we believe to be a historically significant property known as, The Hermitage Property. Previously submitted documentation will indicate this property being 1 of the first 4 parcels to be erected in the early 1930's. Owner built by the same family who owned & built the first 3 on Hermitage Ave., between Magnolia and Chandler Blvd. The property has existed as a nucleus of the neighborhood since the 1930's. Bringing neighbors and families together. Used as the local voting location & local activities & events, the trees remain a large contributor in uniting our community.
Old vintage photos will indicate the camphor trees in their beginning stages of growth. Since the time of those photos, they have survived snow storms, the Los Angeles Flood of 1938 (deemed the fifth largest flood in history),[1] earthquakes & other natural disasters in the city, when others failed.

Over 90% of homes & buildings on Hermitage Ave. were constructed as early as the 1930's up until the 1970's. Some with originally existing landscape & some not. The Camphor trees are 2 of the oldest & largest trees on the block.

Designating these trees and its root system is designating important time periods that we depend on, to connect us & link us to our past.
It continues to provide home to the birds, shade to our neighbors and community, & views from our windows that aid in emotional challenges. Designation contributes to the solution in our city rather than the problem.
They are attractive to bees, butterflies, birds and beneficial insects. They are also known for their strong ability to withstand urban pollution.[2]

Please see attached documentation and enclosures for a more detailed description of the trees and how they are significant to the community and culture.

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[1] The History of the Los Angeles River". L.A. River Connection. Archived from the original on 2007-06-11.
[2] *Michelle Wishhart Portland, Ore UC Santa Cruz.*

Camphor Tree

Family: Lauraceae
Genus: Cinnamomum
Species: C. camphora

<u>FACTS</u>

- Introduced to the <u>contiguous United States</u> around 1875, *C. camphora* escaped cultivation and became a naturalized species in southern California.
- An evergreen tropical tree growing into a shade tree upwards of **<u>45 to 60 feet tall</u>** can be nearly as **<u>wide as 100 feet</u>** in their natural range, according to Robert Lee Riffle in "The Tropical Look."
- Related to true cinnamon trees that provide the cinnamon spice from their bark, the camphor tree also produces scented foliage, twigs & seeds attractive to birds that pass intact through the digestive system. This makes it a much desired drupe.

The camphor tree makes an exceptional shade, windbreak or street tree in spacious landscapes. Camphor has been used for many centuries as a culinary spice, a component of incense, and as a medicine. The aromatic oils in the wood repel insects.
It has value for antiseptics and medications treating inflammation and itching.
[3] [4]

The largest camphor tree exists in Japan with a trunk circumference above <u>24.22 meters</u> **<u>(79 feet 5.5 inches)</u>**. It is estimated to be **<u>1500 years old</u>** and has been a <u>national monument</u> since 1952. It is considered a legendary tree. In 2001 the town built elevated walkways to protect its root system. [5]

Every part of this tree contains camphor. For centuries these trees have been used for the extraction of this substance, which is used as a food additive, medicine, part of incense and other products.[6]
The extensive, broad root system of a camphor tree resents root disturbance.
The roots are also rather aggressive, growing wherever necessary to obtain moisture or richer soil. *Michael Dirr*

The fruit looks like 'berries', but they are actually drupes containing a hard centre. These fruit are globular (8-10 mm across), glossy in appearance, and turn from green to black as they mature. They are attached to the stem by an enlarged, greenish-coloured, cone-shaped or cup-like structure (a conicalor cupular receptacle) that is about 5 mm across.
http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Cinnamomum_camphora_%28Camphor_Laurel%29.htm

Camphor trees never loose their leaves making it a great contributor for the cooling of our streets & providing year round shade to our neighbors. This also makes them particularly attractive for birds & wildlife to create nesting spots where they are already utilizing the source of the drupes for a healthy diet.

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[3] Botanical.com
[4] http://www.gardenguides.com/113679-camphor-tree.html
[5] http://en.wikipedia.org/wiki/Cinnamomum_camphora
[6] http://www.wondermondo.com/Countries/As/Japan/Kyushu/KamounoOhkusu.htm

HEALTH BENEFITS OF CAMPHOR

Its properties as a stimulant, antispasmodic, antiseptic, decongestant, anesthetic, sedative and nervous pacifier, anti-neuralgic, anti-inflammatory, disinfectant, and insecticide substance.

Stimulant & Diaphoretic: Camphor oil is an effective stimulant, which boosts the activity of the circulatory system, metabolism, digestion, secretion and excretion. This property helps in treating problems and ailments associated with improper circulation, digestion, sluggish or overactive metabolic rates, obstructed secretions, and a wide variety of other less common conditions.

Antiseptic, Disinfectant, Insecticide, and Germicide: Camphor oil is an excellent disinfectant, insecticide and germicide. It can be added to drinking water to disinfect it, particularly during the summer and in rainy seasons when there is a higher chance of water becoming infected. An open bottle or container of camphor oil, or burning a piece of cloth soaked in camphor oil, drives away insects and kills germs. A drop or two of camphor oil, mixed with a large quantity of food grains, keep those food items safe from insects. Camphor is also used in many medical preparations such as ointments and lotion to cure skin diseases, as well as bacterial and fungal infections of the skin. When mixed into bathing water, camphor oil disinfects the whole body externally and kills lice or other small parasites of bugs that might be on your body.

Anesthetic & Nervous Pacifier: It acts as a good anesthetic and is very effective for local anesthesia. It causes numbness of the sensory nerves at the area of application. It also reduces the severity of nervous disorders and convulsions, epileptic attacks, nervousness, and chronic anxiety.

Antispasmodic: It is a very efficient antispasmodic and gives immediate relief from spasms and cramps. It is also effective at curing extreme spasmodic cholera.

Anti-inflammatory and Sedative: The cooling and penetrating effects of camphor oil make it an anti-inflammatory and sedative agent. It is very helpful in curing nearly all types of inflammation, both internal and external. It also relaxes the body and mind while giving a feeling of peace and freshness. It proves to be very cooling and refreshing, particularly in the summer. Camphor oil can also be mixed with bathing water to have that extra sensation of coolness in the summer heat.

Decongestant: The strong, penetrating aroma of camphor oil is a powerful decongestant. It immediately relieves congestion of the bronchi, larynx, pharynx, nasal tracts and lungs. It is therefore used in many decongestant balms and cold rubs.

Other Benefits

It is sometimes used in cases of cardiac failure, in combination with other medicines. It is also beneficial in the treatment of epilepsy, hysteria, viral diseases like whooping cough, measles, flu. food poisoning, infections of the reproductive organs, and insect bites.

Blending: Camphor oil blends particularly well with Basil, Cajuput, Camomile, Melissa and Lavender Oil, for uses in aromatherapy.[7]

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[7] https://www.organicfacts.net/health-benefits/essential-oils/camphor-essential-oil.html

TREES AS HISTORICAL MONUMENTS

When the Los Angeles Cultural Heritage Board was formed in 1962, its first-designated sites were HCM #1 (Leonis Adobe) and HCM #2 (Bolton Hall), both located in the San Fernando/Crescenta Valleys.

The role of trees in the development of the Valley is celebrated with monument listings for a 1,000-year-old oak tree in Encino (removed in 1996), 114 Himalayan Deodar trees along White Oak in Granada Hills, 76 mature olive trees along Lassen Street in Chatsworth, and 300 pepper trees lining in Canoga Avenue in Woodland Hills.

HCM # 24: Oak Tree Designated 1963
1,000 year old oak tree in Encino.

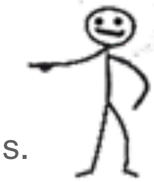
HCM # 41: 114 Deodar Trees Designated 1966
Cedrus deodara trees native to the Himalayas, planted in 1932; between San Fernando Mission and San Jose St. along White Oak in Granada Hills.

HCM # 49: Olive Trees Designated 1967
76 Mature Olive Trees planted in late 19th Century lining both sides of Lassen St. between Topanga Canyon Blvd. and Farralone Ave.in Chatsworth.

HCM # 93: Pepper Trees Designated 1972
Approximately 300 California Pepper Trees (Schinus molle) planted for Girard development in the 1920s forming an arch over Canoga Ave. between Ventura Blvd. and Saltillo St.

Protecting mature trees in the San Fernando Valley is essential and plays an important role in society.

HISTORY



The San Fernando Valley's history includes sheep ranching, wheat farming & fruit orchards.

In October 1887, J. B. Lankershim and eight other developers organized the Lankershim Ranch Land and Water Company, purchasing 12,000 acres from the Lankershim Farming and Milling Company.
They then established a townsite which the residents named Toluca (later Lankershim, and now North Hollywood) along the old Tulare Road from Cahuenga Pass to San Fernando.
On April 1, 1888, they offered ready-made small farms for sale, already planted with deep-rooted deciduous fruit and nut trees—mostly peaches, pears, and walnuts.

Sheep grazing on a ranch owned by the Weddington family at 4141 Whitsett Ave. circa late 1800s. Later, it was a wheat farm, a casaba melon farm, and eventually a golf course.

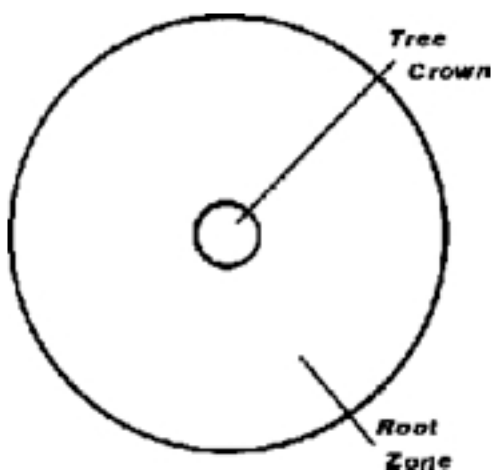
Healthy Roots and Healthy Trees

Tree Root Survival & Growth Roots utilize space in the soil. The more space controlled the more potential resources controlled. The volume of soil space controlled by tree roots is directly related to tree health.
The resources required are **water**, **oxygen**, **physical space for growth processes**, **and open soil surface area for replenishment of essential resources**.

Tree roots occupy the spaces and gaps around, under, and between infrastructures. In heavily compacted sites, roots will be concentrated around the edges of infrastructures and filling any moist air space.
The soil matrix is only a significant concern for essential elements, surfaces holding biological cooperators, and frictional and inertial forces for structural integrity.
Tree roots and the soil surrounding them are an ecological composite of living, once-living, and abiotic features facilitating life.
Compaction initiates many negative impacts in the soil including: decreases the volume of ecologically active space available; tree rootable space is decreased and made more shallow; the detritus food web, the ecological engine responsible for powering a healthy soil, is disrupted and modified; the diversity of living things decline, beneficial associates are eliminated, and a few ecological niche generalists succeed; and, pests favored by the new conditions (i.e. Pythium & Phytophera) consume organisms and roots not able to defend themselves.
Tree roots become more prone to damage and attack at a time when sensor, defense, growth regulation, and carbon allocation processes are functioning at reduced levels.

Quick Facts:

- Most tree roots are located in the top 6 to 24 inches of the soil and occupy an area two to four times the diameter of the tree crown.
- Roots obtain water, oxygen and minerals from soil. They do not grow toward anything or in any particular direction.
- To avoid root disease, maintain a healthy, vigorous environment around a tree. Once a root system is severely affected, the tree usually must be removed.



Fact Sheet No. 2.926 Colorado State University, U.S. Department of Agriculture
Soil Compaction & Trees: Causes, Symptoms & Effects by Dr. Kim D. Coder, University of Georgia July 2000

Healthy Roots and Healthy Trees

Root Requirements:
Roots utilize soil spaces for access to water and essential element resources, and to provide structural support. Roots grow following pathways of interconnected soil pores. Pore space can be the result of the space between textural units (sand, silt, and clay particles), between structural units (blocks, plates, grains, prisms, etc.), along fracture lines (shrink / swell clays, frost heaving, pavement interfaces, etc.), and through paths of biological origins (decayed roots, animal diggings, etc.).
Roots survive and grow where adequate water is available, temperatures are warm, and oxygen is present.
Roots are generally shallow as limited by oxygen contents, anaerobic conditions, and water saturation in deeper soil. Near the base of the tree, deep growing roots can be found, but they are oxygenated through fissures and cracks generated as a result of mechanical forces moving the crown and stem under wind loads (sway).

Camphor tree's fibrous roots span long distances and smell strongly of camphor so it is easy to id them.[8]
Camphor tree roots carry an extensive broad root system are very sensitive to disturbance.[9]

Renovation of Sites Principles:
A summary of this discussion of soil compaction lies with those general principles and renovation techniques managers must use to reclaim a part of the **ecological integrity** of the site, as well as soil and tree health.
General soil compaction renovation principles are listed below in a bullet format: –
Soil compaction should be considered permanent. Studies demonstrate that after one-half century, compaction still afflicts soils under natural forest conditions.
Recovery times for significant compaction is at least two human generations.
Soils do not "come back" from compaction. – Every soil used by humankind has a representative compacted layer, zone, area, or crust. Changing management may not change the current compacted zone but may well add an additional compacted zone in a new position.

Conclusions:
Soil compaction is a hidden stressor which steals health and sustainability from soil and tree systems. Causes of compaction are legion and solutions limited. Without creative actions regarding the greening of inter-infrastructural spaces in our communities, we will spend most of our budgets and careers treating symptoms and replacing trees. Understanding the hideous scourge of soil compaction is essential to better, corrective management.

Please see attached document titled: **SoilCompactionAndTrees.pdf**

Fact Sheet No. 2.926 Colorado State University, U.S. Department of Agriculture

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Soil Compaction & Trees: Causes, Symptoms & Effects by Dr. Kim D. Coder, University of Georgia July 2000
8 http://davesgarden.com/guides/pf/go/54395/#b
9 Michael A. Dirr, Ph.D

Urban Deforestation has many negative effects on the environment. The most dramatic impact is a loss of habitat for millions of species. Seventy percent of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes.
The quickest solution to Urban Deforestation would be to simply stop cutting down trees..

Trees absorb carbon dioxide & turn it into oxygen. The removal of a mature tree causes less carbon dioxide to get absorbed which builds into the atmosphere with green house gas emissions contributing to global warming.
National Geographic Society

Keep the Trees You Have:

Local governments are finally responding to the problem.
More than 2,000 big and small cities have launched long-term planting and preservation programs.
In San Francisco, new laws treat mature trees like historic buildings.

For now, the most immediate answer is less the planting strategy than the preservation one, something that can best be achieved by curbing sprawl and downsizing our taste for too-big homes.

In 2007 Time Magazine said: *“Los Angeles, whose plans are perhaps the most ambitious, is looking to plant 1 million trees over the next 30 years, though of course the effects would not be felt for a long time”.*
Every tree that's subtracted from a city's ecosystem means some particulate pollution that should have been filtered out remains.
Simply replanting does not suffice because small, young trees require decades to grow to full size.
A big tree does 60 to 70 times the pollution removal of a small tree
Source: Time magazine
http://content.time.com/time/magazine/article/0,9171,1635842,00.html

Time magazine concluded that preservation of our trees is much more immediately needed than simply the planting of new ones. This benefits our city on a grand scale including all of its inhabitants.

It is important to preserve our cities trees. They are our local source that represent time periods that link us to present day.

- In 1856 Massachusetts enforced Shade Tree protection where ‘the spirit of the law’ was defined in 1915.[10]
- New Jersey, Pennsylvania, Maryland, Michigan, New York all enacted legislative laws to protect & preserve their trees.

Impact on Environment:
Economic impact:
Ecology and aesthetics justify tree preservation and protection.
https://www.planning.org/pas/at60/report236.htm

Existing designated Camphor Trees were found on HCM #509, processing ID HPOZC-07920
and listed as a district contributor.
(source: http://historicplacesla.org/reports/3adf14f7-2b37-4827-a05e-fc30e83bd5d9)

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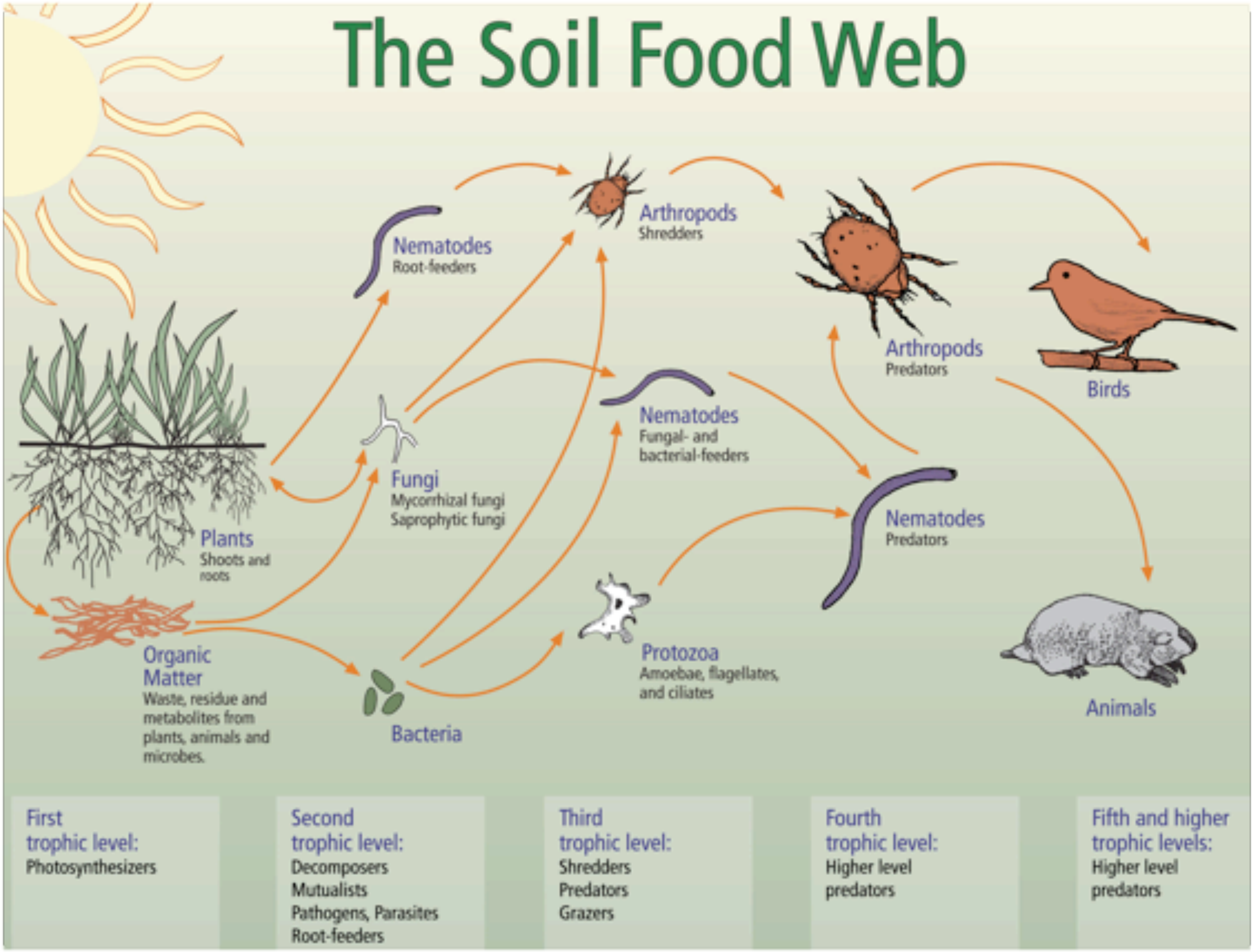
[10] *https://www.planning.org/pas/at60/report236.htm*

SOIL BIOLOGY AND THE LANDSCAPE [11]

An incredible diversity of organisms make up the soil food web. They range in size from the tiniest one-celled bacteria, algae, fungi, and protozoa, to the more complex nematodes and micro-arthropods, to the visible earthworms, insects, small vertebrates, and plants.

As these organisms eat, grow, and move through the soil, they make it possible to have clean water, clean air, healthy plants, and moderated water flow.



USDA - Natural Resources Conservation Service Soils
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868

[11] *http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868*

Functions of Soil Organisms

Type of Soil Organism		Major Functions
Photosynthesizers	• Plants • Algae • Bacteria	**Capture energy** • Use solar energy to fix CO_2. • Add organic matter to soil (biomass such as dead cells, plant litter, and secondary metabolites).
Decomposers	• Bacteria • Fungi	**Break down residue** • Immobilize (retain) nutrients in their biomass. • Create new organic compounds (cell constituents, waste products) that are sources of energy and nutrients for other organisms. • Produce compounds that help bind soil into aggregates. • Bind soil aggregates with fungal hyphae. • Nitrifying and denitrifying bacteria convert forms of nitrogen. • Compete with or inhibit disease-causing organisms.
Mutualists	• Bacteria • Fungi	**Enhance plant growth** • Protect plant roots from disease-causing organisms. • Some bacteria fix N_2. • Some fungi form mycorrhizal associations with roots and deliver nutrients (such as P) and water to the plant.
Pathogens **Parasites**	• Bacteria • Fungi • Nematodes • Microarthropods	**Promote disease** • Consume roots and other plant parts, causing disease. • Parasitize nematodes or insects, including disease-causing organisms.
Root-feeders	• Nematodes • Macroarthropods (e.g., cutworm, weevil larvae, & symphylans)	**Consume plant roots** • Potentially cause significant crop yield losses.
Bacterial-feeders	• Protozoa • Nematodes	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on bacteria. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of bacterial populations.
Fungal-feeders	• Nematodes • Microarthropods	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on fungi. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of fungal populations.
Shredders	• Earthworms • Macroarthropods	**Break down residue and enhance soil structure** • Shred plant litter as they feed on bacteria and fungi. • Provide habitat for bacteria in their guts and fecal pellets. • Enhance soil structure as they produce fecal pellets and burrow through soil.
Higher-level predators	• Nematode-feeding nematodes • Larger arthropods, mice, voles, shrews, birds, other above-ground animals	**Control populations** • Control the populations of lower trophic-level predators. • Larger organisms improve soil structure by burrowing and by passing soil through their guts. • Larger organisms carry smaller organisms long distances.

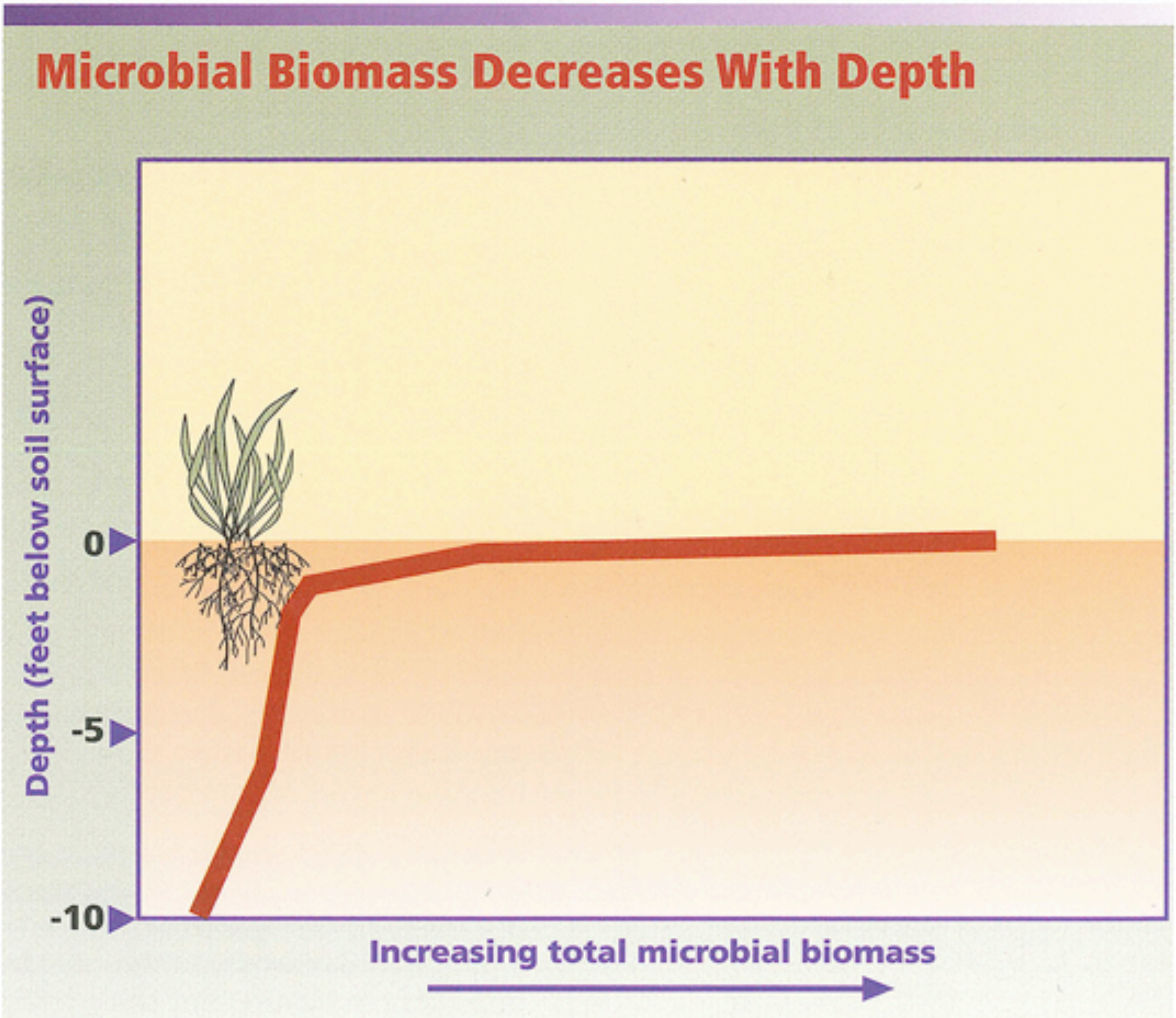
What Do Soil Organisms Do?

Growing and reproducing are the primary activities of all living organisms. As individual plants and soil organisms work to survive, they depend on interactions with each other. By-products from growing roots and plant residue feed soil organisms. In turn, soil organisms support plant health as they decompose organic matter, cycle nutrients, enhance soil structure, and control the populations of soil organisms including crop pests.

Soil organic matter is the storehouse for the energy and nutrients used by plants and other organisms. Bacteria, fungi, and other soil dwellers transform and release nutrients from organic matter. These microshredders, immature oribatid mites, skeletonize plant leaves. This starts the nutrient cycling of carbon, nitrogen, and other elements.

Where Do Soil Organisms Live?

Around roots.
The rhizosphere is the narrow region of soil directly around roots. It is teeming with bacteria that feed on sloughed-off plant cells and the proteins and sugars released by roots. The protozoa and nematodes that graze on bacteria are also concentrated near roots. Thus, much of the nutrient cycling and disease suppression needed by plants occurs immediately adjacent to roots.



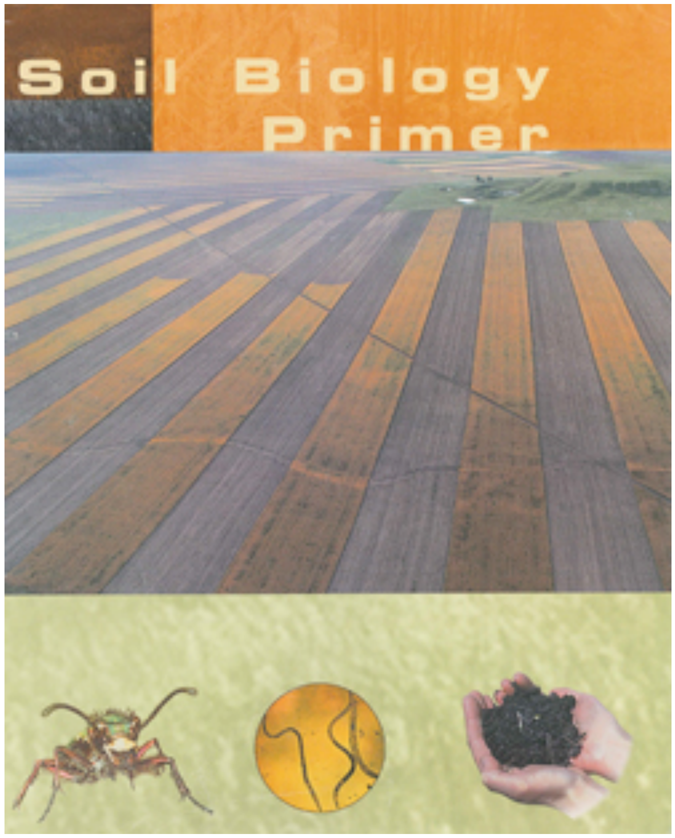
Bacteria are abundant around this root tip (the rhizosphere) where they decompose the plentiful simple organic substances.

The Importance of the Soil Food Web

The living component of soil, the food web, is complex and has different compositions in different ecosystems. Management of croplands, rangelands, forestlands, and gardens benefits from and affects the food web. The next unit of the Soil Biology Primer, The Food Web & Soil Health, introduces the relationship of soil biology to agricultural productivity, biodiversity, carbon sequestration and to air and water quality. The remaining six units of the Soil Biology Primer describe the major groups of soil organisms: bacteria, fungi, protozoa, nematodes, arthropods, and earthworms.

Soil Biology

The creatures living in the soil are critical to soil health. They affect soil structure and therefore soil erosion and water availability.
They can protect crops from pests and diseases. They are central to decomposition and nutrient cycling and therefore affect plant growth and amounts of pollutants in the environment.
Finally, the soil is home to a large proportion of the world's genetic diversity.



All plants – grass, trees, shrubs, agricultural crops – depend on the food web for their nutrition.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/#
http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

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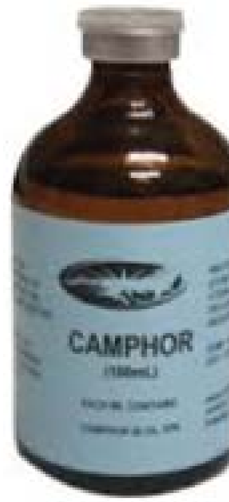
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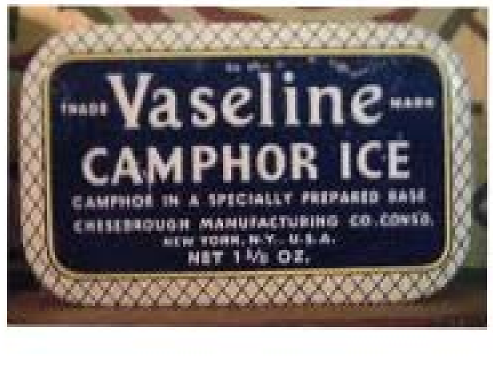
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ADDITIONAL EXISTING MATURE TREES ON PROPERTY

P. *macrophyllus*

yew pine

Family: Podocarpaceae
Genus: Podocarpus
Species: *P. macrophyllus*

FACTS

- Evergreen conifer tree

- Can reach **20 meters (65 feet) tall**

- When mature, the scales swell up and become reddish purple, fleshy and berry-like, 10–20 mm long; they are then eaten by birds.

Existing pair estimated 45+ years old.

- Because of its resistance to termites and water, it is used for quality wooden houses.

- The Yew Pine (also referred to as Buddhist Pine) is highly regarded as a feng shui tree in Hong Kong and has become illegal to remove.[12]

- Currently listed as population decreasing on iucnredlist.org with Deforestation impacting the area of occupancy of this species, especially in the southern parts of its range.[13]

- Highly desired by birds & wildlife for habitat as well as reliable food source.

- Longevity is listed as greater than **150 years.**

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[12] http://en.wikipedia.org/wiki/Podocarpus_macrophyllus

[13] http://www.iucnredlist.org/details/42517/0

Celtis *sinensis*

Hackberry

Family: Cannabaceae
Genus: Celtis
Species: *C. sinensis*

FACTS

- Deciduous tree in the hemp family.
- Can reach between **10–25 meters (33–82 feet)** up to **40 meters (130 feet)** tall.
- The fruit is a globose drupe 6–10 mm (0.24–0.39 in) in diameter, edible in many species, with a dryish but sweet, sugary consistency.
- The genus is present in the fossil record at least since the Miocene of Europe[14]
  It is possible to compare Celtis growth with that of other drupaceous fruits but no other data have been published for drupes with high concentrations of silica and calcium. It seems probable that this highly mineralized condition maybe a major contributing factor to the excellent preservation of Celtis in the fossil record.[15] The Miocene epoch lasted from 23.3 million to 5.2 million years ago. During this time, the Alps and Himalayas were being formed and there was diversification of the primates, including the first apes.
  That is how far back this tree goes.

Celtis trees are known & valued for their drought tolerance. Celtis is a valuable pollen source for bees. They are also utilized by the Lepidoptera order, which includes but is not limited to caterpillars, brush-footed butterflies & most importantly the distinct genus Libythea (beak butterflies) and some Apaturinae (emperor butterflies).

Leaves and bark are used in medicine to treat menstruation & lung abscess. It is a naturalized non-invasive species an an important part of our ecosystem.

Existing tree estimated 65+ years old.

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[14] Harlow and Harrars Textbook of Dendrology
[15] Growth and Biomineralization of Celtis

Yucca gloriosa

Spanish dagger

Family: Asparagaceae
Genus: Yucca
Species: *Y. gloriosa*

FACTS

- Species of flowering plant in the family Asparagaceae, native to the southeastern USA.
- Coalescent evergreen, perennial shrubs or trees with tough, sword-shaped leaves and large clusters of white, rounded to bell-shaped flowers.
- The plant is widely cultivated in warm temperate and subtropical climates, and valued as an architectural focal point.
- Y. *gloriosa* and the cultivar 'Variegata' have both gained the Royal Horticultural Society's Award of Garden Merit.[16]
- NatureServe lists the Y. *gloriosa* as having G4 Conservation Status.

ASSOCIATED ORGANISMS
Beneficials: native bees (nesting material)
hummingbirds (nectar)

[16] https://www.rhs.org.uk/plants/details?plantid=4318

Lagerstroemia speciosa

Crape Myrtle

Family: Lythraceae
Genus: Lagerstroemia
Species: *Lagerstroemia*

FACTS

- Deciduous evergreen tree growing up to 66 ft tall, with smooth, flaky bark.
- The leaves are deciduous, oval to elliptic, 3.1–5.9 in long and 1.2–2.8 in broad, with an acute apex.
- The flowers are produced in erect panicles 7.9–15.7 in long, each flower with six white to purple petals 0.79–1.38 in long.
- Fruit is a capsule that splits along six or seven lines, producing teeth much like those of the calyx, & releases numerous, small, winged seeds.
- Named after Magnus von Lagerstroem, a Swedish naturalist who provided specimens from the East for Linnaeus.
- In Theravada Buddhism, this plant is said to have been used as the tree for achieved enlightenment, or Bodhi by the eleventh Lord Buddha.
- One of the most popular pollen sources for bees.

MEDICINAL USES

- In Ayurvedic medicine, it is used successfully in the treatment of diabetes.[17]
- Useful for astringent purposes.
- Roots provide a diuretic effect, also detoxifying.
- Using the stem bark, it serves as a fever reducer by means of infusion or decoction.
- Using the stem bark, stimulates the body and stop bleeding of minor cuts.
- Petals are used externally on wounds for healing, having some of those astringent and styptic qualities themselves.
- The seeds contain powerful anti-oxidents and are used as antibacterial preparation.
- The leaves, as an infusion, contain a great amount of zinc and magnesium, both important daily dietary needs.
- The leaves, cooked, provide plenty of fiber.[18]

Existing tree Crap estimate over 45 years old.

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[17] *https://www.diabeteshealth.com/uncategorized/banaba-lagerstroemia-speciosa-l/*
[18] *http://www.examiner.com/article/crepe-myrtle-has-healing-properties-a-pretty-package*

P. orientalis

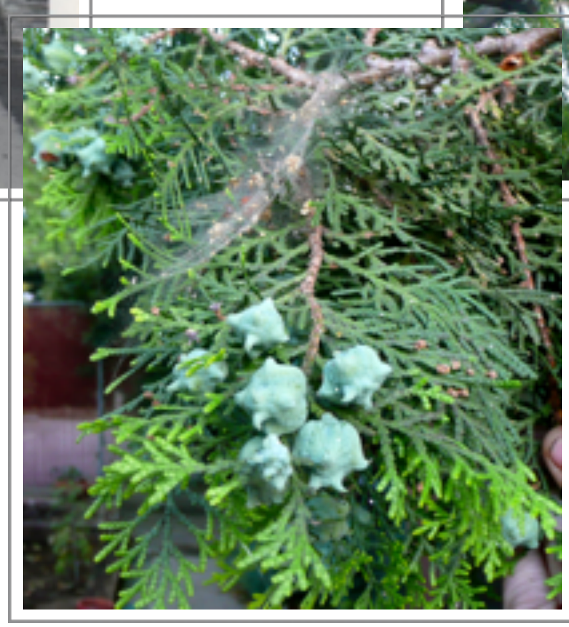
Thuya arborvitae

Family: Lythraceae / Cupressaceae
Genus: Platycladus / Thuya
Species: P. orientalis

FACTS

- Cypress family containing only one species.
- Distinct genus of evergreen coniferous slow-growing tree with distinct cones.
- Common name 'arborvitae' is from Latin, 'tree of life'; based on its association with long life and vitality in Buddhism.
- 15–20 m tall and 0.5 m trunk diameter (exceptionally to 30 m tall and 2 m diameter in very old trees).
- The Foliage forms in flat sprays with scale-like leaves 2–4 mm long.
- The cones are 15–25 mm long, green ripening brown in about eight months from pollination.
- The seeds are 4–6 mm long, with no wing.
- Associated with long life and vitality.
- The wood is used in Buddhist temples, both for construction work, and chipped, for incense burning.
- Fruit is used by wildlife as a food resource.
- Fairly close relatives are Juniperus and Cuprous.
- Its cultivars have gained Royal Horticultural Society's Award of Garden Merit.

Photo taken of Thuya early 1950‘s in same location. Estimated 65+ years old.



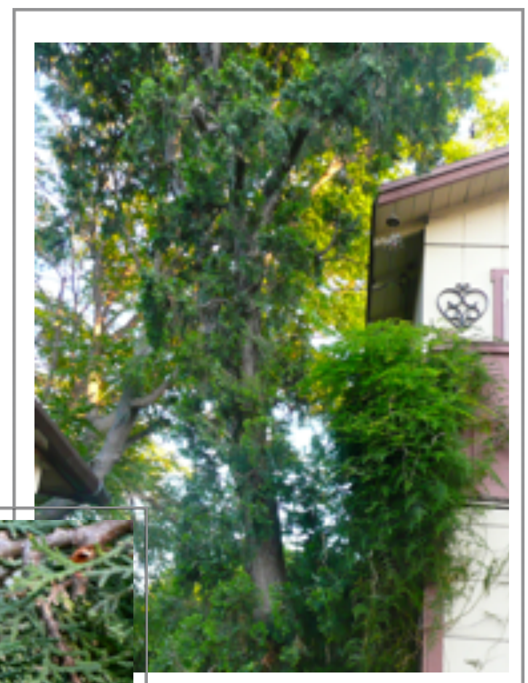


Photo taken of Thuya 2015 in same location.

September 9, 2015

PLEASE INCLUDE IN ADMINISTRATIVE RECORD

Cultural Heritage Commission
Richard Barron, President
Gail Kennard, Vice President
Jeremy Irvine, Commissioner
Barry Milofsky, Commissioner
Elissa Scrafano, Commissioner

Re: 5303 and 5303 ½ Hermitage Ave, 12301 and 12301 ½ Weddington St, Valley Village, CA
Case No. CHC-2015-3149-HCM

Dear Historical Board,

My name is Marta Lathrop and I am executor of the Estate of Clinton J. Lathrop, a current co-owner of this property.

I do not support the Historic-Cultural Monument nomination of the trees on my property.

I am unaware of anything historical or culturally significant that happened at the property that would cause these trees to be historic.

I do not support the Historic-Cultural Nomination and respectfully request that you do NOT take this nomination under consideration.

Sincerely,

Marta Lathrop

Marta Lathrop

PLEASE INCLUDE IN THE ADMINISTRATIVE RECORD
Case # CHC-2015-3149-HCM

HARMONY GARDENS, INC.
Landscape Design Feng Shui
Certified Arborist WE-10883A
www.harmonygardens.net

Shelley Sparks, RLA #2896
12224 Addison Street
Valley Village, CA 91607
Phone (818) 505 - 9783
Shelley@harmonygardens.net

September 4, 2015

Dear Cultural Heritage Commissioners,

I have reviewed the site at 5303-5305 Hermitage Avenue and 12301-12301 ½ Weddington Street, Valley Village, CA 91607 in light of the application for Historical Cultural Monument that has been filed.

As a response to this application, I would like to discuss the *Cinnamomum camphora*, Camphor Trees primarily and secondarily review the other trees listed as part of the nomination. The two Camphor trees are aesthetically beautiful and seem healthy; however, the application is somewhat puzzling.

Camphor trees are not a rare or unusual species, either culturally or horticulturally. In fact, in casual drives in the San Fernando Valley, I have seen two Camphor trees that are equivalent in size, caliper, form and health within 5 miles of this site. Both other specimens are street trees. Throughout Los Angeles, there are many more Camphor Trees that match and exceed the specifications of these two Camphor trees.

The sizes of the Camphor trees do not approach the standards for a big tree in California or nationally according to The National Register of Big Trees, maintained by American Forests or the Official Registry California of Big Trees.

In terms of the tree species, *Cinnamomum camphora* is not a native species and not noted for any particularly unique or special qualities or status. The general longevity of these species is 50 – 150 years old though the oldest is registered at ± 211 years old in Italy.

Any tree of this size and good health will have ecological value. This neighborhood, developed in the 30's and 40's has many trees of the same age that are as large or larger than these Camphor trees. Species such as *Fraxinus uhdei, Cedrus deodara, Magnolia soulangeana, Pinus pinea, Pinus canariensis, Quercus agrifolia, Platanus racemosa, Washingtonia robusta, Eucalyptus citriodora, Schinus molle* all exist within a one mile radius that provide all of the size, age and ecological benefits as the *Cinnamomum camphora*. This particular species is not distinguished in terms of the type of habitat it provides for various species of birds. It does, of course, provide soil stabilization and partially provides for the soil food web. The fact that it is planted on a flat site, soil stabilization is of questionable value and because it is in the lawn, its leaf litter is removed, also removing most of its value from the soil food web.

The location or style of the tree is not associated with any particular architectural period or style.

The other trees on site can be similarly analyzed. None of the following trees listed in the nomination application have a particular species or ecological value:

- Mulberry
- Crape Myrtle
- Japanese Hackberry
- Sweetgum
- Camellia *(this is a shrub, not considered a tree)*
- Bottlebrush
- Oleander *(this tree is diseased/dead)*
- Yew Pine

It is my professional opinion as a registered Arborist and Landscape Architect, with 30+ years of professional experience, that the trees nominated in the application for Historic-Cultural Monument should not be designated as Historic-Cultural Monuments.

Should you have any questions, please contact me.

Regards,

Shelley Sparks

Shelley Sparks, Harmony Gardens

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PLEASE INCLUDE IN ADMINISTRATIVE RECORD
CASE NUMBER CHC-2015-3149-HCM

September 9, 2015

Los Angeles Cultural Heritage Commission
Los Angeles Department of City Planning
Office of Historic Resources
200 North Spring Street, Room 620
Los Angeles, California 90012-4801

Reference: Architectural History Peer Review of a Historic-Cultural Monument Nomination Form for the "Hermitage Trees" located at 5303 Hermitage Avenue; 12301-12301 ½ Weddington Street, Los Angeles, California.

Dear Commissioners:

SWCA Environmental Consultants (SWCA) conducted a peer review of a Historic-Cultural Monument (HCM) Nomination Form for the "Hermitage Trees" located at 5303 Hermitage Avenue; 12301-12301 ½ Weddington Street, Los Angeles, California.[1] As described in the nomination, the proposed HCM includes two Camphor trees, a Mulberry tree, a Crape Myrtle tree, Japanese Hackberry trees, and American Sweetgum Trees. The subject trees are located on the "Hermitage Property," which comprises two perpendicular lots with multiple structures and situated in the North Hollywood-Valley Village Community Plan Area (CPA).[2]

The North Hollywood-Valley Village CPA was previously surveyed in 2013 as part of SurveyLA, a citywide historic resources survey that is currently being completed by the Los Angeles Department of City Planning, Office of Historic Resources (OHR) to identify significant properties, including buildings, structures, sites, and trees.[3] At that time, neither the Hermitage Property nor the Hermitage Trees were identified as significant historic resources. In May 2015, a separate HCM nomination for the Hermitage Property was submitted to OHR, which reviewed the nomination and recommended the

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[1] Historic-Cultural Monument Nomination Form: Hermitage Trees, 5303 Hermitage Avenue; 12301-12301 ½ Weddington Street, prepared by Aimee Frappied, May 2015.

[2] Note both the names "Hermitage Trees" and "Hermitage Property" were listed by the HCM nomination applicants; research did not confirm that these were the historical names of either. This memorandum uses both to avoid confusion and not to suggest any potential significance.

[3] Architectural Resources Group, Historic Resources Survey Report: North Hollywood-Valley Village Community Plan Area, prepared by Architectural Resources Group for the Los Angeles Department of City Planning, Office of Historic Resources, February 2015.

property not be declared an HCM. The Los Angeles Cultural Heritage Commission (CHC) concurred with these findings in its meeting on May 12, 2015 and declined the request for HCM designation.[4]

SWCA conducted this peer review to assess if whether the 2015 HCM nomination for the Hermitage Trees has adequately addressed the potential significance of the subject trees in consideration of the eligibility criteria for individual listing as an HCM. It included a field visit, independent background research, and a review of relevant historic preservation guidance materials, specifically OHR's HCM Nomination Information Guide.[5] SWCA Architectural Historian Steven Treffers, M.H.P. conducted the peer review and authored this memorandum detailing the results. Mr. Treffers meets and exceeds the Secretary of Interior's Professional Qualifications Standards (PQS) for History and Architectural History. With 6 years of experience in historic preservation planning within Los Angeles, Mr. Treffers has extensive experience applying HCM criteria. He is also currently a commissioner on the South Pasadena Cultural Heritage Commission where he oversees local landmark nominations.

After reviewing the current nomination, completing a field survey, and conducting independent background research, **SWCA finds that the Hermitage Trees do not meet the criteria for HCM designation**. The nomination presents information that is vague and not substantiated by primary and secondary resources as is required by OHR.[6] In describing the proposed HCM, it is unclear which trees are included as part of the proposed monument, with the sketch map included in the nomination failing to identify where each of the various trees are located. Additionally, the nomination lists a factual "construction" date of 1934 but provides no documentation supporting this claim. The nomination fails to identify which trees (Camphor, Oleander, Crape Myrtle, etc.) were purportedly planted in 1934; given the size of these various trees (some of which are smaller), it is unlikely that all date to this time.

Most notably however, the nomination fails to identify how the Hermitage Trees meets the criteria required for HCM designation. As stated in the Cultural Heritage Ordinance Section 22.171.7, a property must meet at least one of four criteria for HCM designation: 1) be a reflection of the broad cultural, economic, or social history of the nation, state or community; 2) be identified with historic personages or important events in the main currents of national, state, or local history; 3) embody the characteristics of an architectural-type specimen inherently valuable for a study of a period, style, or method of construction; or 4) be the notable work of a master builder, designer, or architect whose individual genius influenced his or her age.

The nomination states that trees meet two criteria: Criterion 1) that they are reflective of the broad cultural, economic, or social history of the nation, state, or community; and Criterion 3) that they embody the characteristics of an architectural-type specimen inherently valuable for a study of a period, style, or method of construction. The significance statement however fails to address how the Hermitage Trees meet these criteria. In discussing Criterion 1, the nomination suggests that the trees

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[4] Los Angeles Department of City Planning, Case Number: CHC-2015-775-HCM, The Hermitage Property, 5303 Hermitage Avenue, May 22, 2015.

[5] Los Angeles Department of City Planning, Office of Historic Resources|Cultural Heritage Commission, Historic-Cultural Monument Nomination Information Guide, updated August 2014.

[6] Ibid, 11.

reflect and exemplify the broad history of the nation, state, or community through the time periods in which they survived. However, simply surviving through an extended a period of time does not inherently make a property significant or exemplary of the period's history; it should have a direct and important association with events that have made a significant contribution to the broad patterns of our history.[7] The nomination further suggests that the two Camphor trees are the oldest on the block and that they are located on a property (the Hermitage Property) that is believed to be historically significant, and which acted as a nucleus of the neighborhood. The nomination provides no documentation to support either of these claims. Additionally, both OHR and the CHC have already determined that the Hermitage Property does not possess the important associations or integrity required to satisfy HCM criteria. No new information is presented to suggest that the trees embody any additional significance that was not previously considered by OHR of the CHC. Finally, the significance statement fails to address how the subject trees embody the characteristics of an architectural-type specimen inherently valuable for a study of a period, style, or method of construction.

SWCA's independent research failed to identify any information that suggests the Hermitage Trees are eligible for HCM designation. In considering the individual significance of the subject trees, they include multiple tree varieties that appear to have been planted over time as landscaping for a residential property that was first developed in 1934 by Clinton Lathrop.[8]

Criterion 1) The Hermitage Trees were not planted as part of a larger neighborhood street improvement project and historic research does not indicate that they were the first such trees to be planted in the North Hollywood-Valley Village CPA, an area which first began to be suburbanized twenty years earlier with the arrival of the Los Angeles Aqueduct in 1913.[9] The subject trees therefore do not significantly reflect of the broad cultural, economic, or social history of the nation, state or community.

Criterion 2) Although the Hermitage Property may have been a polling place and location of local activities and events (as is suggested in the HCM nomination for the Hermitage Trees), these events must be considered significant and the trees would have to be directly associated with these events to be considered eligible as an HCM. Historically, this was one of many polling places within the CPA and research does not indicate that any of these associated events were in themselves important within the main currents of national, state, or local history. Further, neither Clinton Lathrop nor any other owners of the Hermitage Property appear to be historic personages and as a result the subject trees do not appear to be eligible for associations with historic events or persons.

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[7] As recommended by the National Park Service, see National Park Service, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* U.S. Department of the Interior, National Park Service, Washington D.C., 1995.

[8] Los Angeles Department of Building and Safety, Building Permits for 5303 Hermitage Avenue, Document No. 1934LA16992, available at http://ladbsdoc.lacity.org/idispublic/ (accessed August 20, 2015).

[9] Architectural Resources Group, 10.

Criteria 3/4) As identified during SWCA's reconnaissance-level survey of the surrounding area (and as noted by certified arborist Shelly Sparks[10]) there are other similar trees to those identified in the HCM nomination located within 5 miles of the site. They are not part of a larger, architect-designed landscape and do not embody the characteristics of an architectural-type specimen inherently valuable for a study of a period, style, or method of construction; nor are they the notable work of a master builder, designer, or architect whose individual genius influenced his or her age.

In conclusion, SWCA disagrees with the findings of the HCM nomination and recommends the Hermitage Trees not eligible for HCM designation. Should you have any questions or comments regarding this review, please do not hesitate to contact me at (626) 240-0587, extension 6610, or at streffers@swca.com.

Sincerely,

Steven Treffers, M.H.P.
Architectural Historian

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[10] Shelly Sparks, Memorandum to the Cultural Heritage Commission, Harmony Gardens, Landscape Design, September 4, 2015.