TREE PLANTING

European Tree Planting Standard

European
Arboricultural
Standards

European Arboricultural Standards

EUROPEAN ARBORICULTURAL COUNCIL EAC

EUROPEAN ARBORICULTURAL STANDARDS

Tree Planting Standard	2022

BG: Засаждане на дървета
CS: Výsadba stromů
DA: Træplantning
DE: Baumpflanzung
EL: Φύτευση δένδρων
EN: Tree Planting
ES: Plantación de árboles
ET: Puude istutamine
FI: Puiden istuttaminen
FR: Plantation d` arbres
GA: Plandáil crann
HR: Sadnja stabala
HU: Faültetés
IT: Piantagione degli alberi
LT: Medžių ir krūmų sodinimas
LV: Koku stādīšana
MT: Tħawwil tas-siġar
NL: Planten van bomen
PL: Sadzenie drzew
PT: Plantação de árvores
RO: Plantare de arbori
SK: Výsadba stromov
SL: Sajenje dreves
SV: Trädplantering

We are very grateful for all comments and support of national arboricultural representatives and individual arborists across Europe, who responded to the call for cooperation on the text of this standard.

This standard is intended to define the technical procedures used for planting amenity trees.

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Editorial:

Standard text:
Working group "Technical Standards in Treework – TeST"

Team of authors:
Jaroslav Kolařík (team coordinator, Czech Republic)
Junko Oikawa-Radscheit (Germany, European Arboricultural Council)
Dirk Dujesiefken (Germany)
Thomas Amtage (Germany)
Tom Joye (Belgium)
Kamil Witkoś-Gnach (Poland)
Beata Pachnowska (Poland)
Paolo Pietrobon (Italy)
Henk van Scherpenzeel (Netherlands)
Gerard Passola (Spain)
Daiga Strēle (Republic of Latvia)
Algis Davenis (Lithuania)
Tomáš Fraňo (Slovak Republic)
Goran Huljenić (Croatia)

Text revision:
Simon Richmond (United Kingdom)
Keith Sacre (United Kingdom)
Sarah Bryce (United Kingdom)

Pictures:
Olga Klubova (Republic of Latvia)

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EAS 03:2022 (EN) – European Tree Planting Standard.

If you want to translate text of the standard to other languages, please contact the project leader on info@arboristika.cz

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1. Purpose and content of the standard

1.0 Purpose

1.0.1 This standard was published by the working group of the TeST project (Technical Standards in Tree Work) in cooperation with the EAC (European Arboricultural Council) and was released in August 2022.

1.0.2 In the text of the standard the following formulations are used:
- where the standard says „can“, this refers to possible options,
- where the standard says „should“, this refers to a recommendation,
- where the standard says „must“, this refers to mandatory activities.

1.0.3 The purpose of the standard is to present the common techniques, procedures and requirements related to planting trees in non-forest environments.

1.0.4 The standard sets out safety criteria for arborists and other workers engaged in arboricultural operations. It serves as a reference for safety requirements for those engaged in tree-planting procedures.

1.0.5 Each person must be responsible for their own safety on the job site and must comply with the appropriate federal or state professional safety and health standards and all rules and regulations that are applicable to their own actions. Each person must also read and follow the manufacturer's instructions for the tools, equipment and machinery that he/she uses.

1.1 Main objectives

1.1.1 Planting amenity trees is one of the most important arboricultural activities and it should be carried out in a way that ensures the establishment and successful development of young trees.

1.1.2 The standard is intended for application in the planting of trees whose main purpose is not the production of fruits, wood and other commodities.

1.1.3 The standard presents common fundamental practices used in European countries.

1.1.4 Other different practices and preferences, based on national and regional experiences, are listed in the national appendices.

1.2 Biosecurity

1.2.1 People who are professionally involved in working on trees are inherently at high risk of transmitting pests and diseases between trees and worksites and thus should apply appropriate biosecurity procedures to limit this risk.

1.2.2 To reduce the risk of transmitting pests and diseases, the cleaning of tools and other equipment should be part of daily maintenance. All equipment should be cleaned and disinfected after use on each site.

1.2.3 Where there is a high probability of trees being infected with contagious pests and diseases, increased biosecurity standards must be implemented. National legislation applies.

1.2.4 Nursery trees should be provided with a tree passport stating:
- the tree species,
- a code tracing the producer,
- the country of origin of the tree.[1]

1.2.5 Every tree should come from the nursery with a label stating its full scientific name and size class.

1.2.6 Phytosanitary passports for nursery trees must contain certain prescribed elements when the trees are moved within the EU. One of these elements is called the „traceability code".[2]

1.2.7 All trees for planting, including auxiliary material, must be free of diseases and pests, especially species monitored within the EU.[3]

1.2.8 Natural/organic products should be used in preference to plastics.

1.2.9 Avoid transporting soil and plant material (woodchip) over large distances; preferably, use local material.

1.2.10 Planting of host tree species in areas where significant pests and diseases are present should be considered carefully.[3] The State Phytosanitary Administration provides an up-to-date list of quarantine pathogenic organisms and their host plants.

1.2.11 New plantings should preferably improve species diversity on the site to improve resistance to the spread of potential pests and diseases.

[1] European, national/regional legislation applies.
[2] EU Commission Implementing Regulation (EU) 2020/1770.
[3] Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC.

2. Normative references

2.0 This standard is complementary to other EU standards and national/regional regulations.

2.1 Qualification

2.1.1 Planting of trees and related arboricultural operations are professional activities that can only be performed by a suitably trained and experienced worker or by a trainee under supervision.

2.1.2 Planting of trees is covered by variety of formal educational programmes in the disciplines of forestry, horticulture, arboriculture and gardening.

2.1.3 Generally accepted proof of an arborist's qualifications is established by international or national certifications. Within the EU, the following certification schemes are recognised for practising arborists:
- European Tree Worker (EAC),
- ISA Certified Arborist.

2.1.4 The following certification schemes are recognised for consulting arborists:
- European Tree Technician (EAC),
- ISA Board Certified Master Arborist.

2.1.5 Meeting the standards of professional qualification includes continuous professional development/lifelong learning. National qualification may be recognised locally. These are listed in the national appendices to this standard.

2.2 General safety requirements

2.2.1 Tools and equipment must conform to the requirements of CE and EN standards and certification.

2.2.2 A site-specific risk assessment (SSRA) must be carried out and all relevant control measures, plus a briefing for the work, must be communicated to all workers by the qualified arborist/supervisor on site.

2.2.3 Traffic and pedestrian control around the worksite must be established prior to the start of any arboricultural operations.

2.2.4 Arborists and other personnel working near traffic and operating temporary traffic control zones must be trained in temporary traffic control techniques, device usage and placement, and safe procedures for working near traffic.

2.2.5 Arborists and other workers exposed to risk of highway traffic must wear high-visibility safety clothing which meets the requirements of national regulations.

2.2.6 Arborists and other workers who use any equipment, tools or machinery must be familiar with safe work practices and the use of appropriate personal protective equipment (PPE) in line with the manufacturers' instructions for the tools, machinery and equipment in use.

3. Location of tree planting

3.1 Regions

3.1.1 In each country, there are different regional systems for defining growing areas, based on experience of tree planting (mainly in forestry) and crop production. As a rule, in addition to climatic factors, these systems also consider pedological and geological contexts.

3.1.2 See the national appendices for the region(s) definition.

3.2 Site inspection

3.2.1 Initial desktop research should be part of a planting plan, including details of future urban development plans, the location of underground and above-ground infrastructure and its protective zones, and other legislative restrictions (e.g. heritage, nature protection).

3.2.2 A field survey should identify parameters:
- a) using visual characteristics,
- b) using approximate indication techniques,
- c) using field instruments.

3.2.3 A field assessment of growing conditions must be performed prior to planting. This can include:
- above-ground space,
- visual inspection of general soil properties,
- level of soil compaction (soil probe or penetrometer),
- water infiltration test.

Laboratory analysis may be appropriate for analysis of soils.

3.2.4 When appropriate, also assess the hydrology of the planting location and its potential impact on the tree, e.g. in places with high groundwater levels. This can be done either by assessing soil horizons (e.g. gley) or by visually assessing the surroundings (e.g. proximity of watercourses, signs of waterlogging, etc.).

3.2.5 The speed of water infiltration into the soil and movement of water through the soil are assessed using infiltration tests within the planting pit.[4]

3.2.6 Compaction of urban soils for construction purposes requires levels of compaction up to 95% Proctor density.[5] These levels of compaction inhibit root colonisation. The maximum compaction which will still allow root growth is around 85%. Planting trees in higher compaction levels is not advisable.

3.2.7 Soils which are compacted above 85% Proctor density, or 3 MPa measured with the penetrometer, will need decompaction to allow for root growth.

3.2.8 Soils that need to be compacted above 85% Proctor density for infrastructure building purposes and which are also required to accommodate root growth will need auxiliary technical solutions to facilitate this (e.g. replacement by structural soil).

[4] This type of hydrodynamic test is based on the rapid infusion of a certain volume of water into the planting pit. The rate of decrease of the water level in the well is then proportional to the permeability of the investigated horizon. Proper evaluation of this hydrodynamic test requires measuring the water level in the probe at regular intervals.

[5] The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. Tests generally consist of compacting soil at known moisture content into a cylindrical mould with a collar of standard dimensions of height and diameter using a compactive force of controlled magnitude. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content. For a 100% Proctor test, density varies depending of soil typology. In clay soils Proctor 100% give densities of 1.7 g/cm^3; for loam soils 1.8 g/cm^3; and for sandy soil about 2.2 g/cm^3.

3.3 Tree species selection

3.3.1 The basic procedure for tree species selection for a specific site is to carry out a site survey and an assessment of growing conditions. This must consider the site's altitude as well as other conditions – e.g. solar and wind exposure, soil, landscape topography, etc.

3.3.2 To maintain natural genetic variability, it is advisable to use local (regional) sources of planting material, particularly for rare species.

3.3.3 Resistance to frost/drought/heat is an important limiting factor for tree selection. The resistance of tree species and adaptation of trees to a specific site should be considered.

3.3.4 In a natural landscape it is advisable to use species that correspond to the natural plant composition in the region (including rare species), as well as tree species traditionally used in the area.

3.3.5 When planting in urbanised areas, the principal issue to consider is the taxon's ability to survive on the site while optimally performing the required functions. As a result, introduced species and cultivars are frequently used. Use of taxa with the potential to be invasive is restricted.[6] (See Appendix 4.)

3.3.6 When trees are planted along roads, the impact of winter road maintenance should be taken into account. It might be appropriate to select salt-tolerant species. Tree species sensitive to salinity are listed in Appendix 3.

3.4 Preconditions of the planting site

3.4.1 Before a planting site is selected, a survey must be carried out to locate **utility networks** (underground cables, overhead power lines, pipelines, etc.) in the area. Protective zones for utility networks are specified in national/regional regulations.

3.4.2 **Trees along roads** ("linear forest") are essential to achieve aesthetic, biological and microclimatic benefits as well as an adequate environment for drivers (low sun protection, speed limitation, etc.).

3.4.3 **Space for above-ground tree parts**. The planting site must allow the crown to develop to the dimensions of a mature individual of the given species. Exceptions may include where trees are planted that will be shaped in the future, or for temporary plantings. Surrounding buildings, street infrastructure, above-ground utility networks, surrounding trees, etc. must be taken into consideration.

3.4.4 As a principle, it is not advisable to plant new trees under the crowns of existing ones.

3.4.5 The distance between planted trees (pitch) should correspond to the target dimensions of the crown of the mature tree of the given species (in general 50–100% of the crown spread of a mature tree). Where trees are deliberately planted at a denser pitch (e.g. when establishing tree stands), the technical report must set out the necessary follow-up procedures (pruning or thinning) and include a time-frame for these interventions.

3.4.6 Special requirements resulting from the condition of the planting site and the services required of the tree will influence the choice of species (cultivar) and must be respected (specific clearance, maximum tree height, etc.).

6 Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species

3.5 Potential underground space

3.5.1 Any planting site must have enough underground growing space (rootable volume) for new roots to develop so that the tree can grow sustainably.

3.5.2 Rootable volume comprises all soil and substrates that can accommodate root growth (that is, enough oxygen, moisture and mineral supply with a healthy soil food web).

3.5.3 The size of the rootable volume will differ according to the spatial requirements of different tree species (see Appendix 5).

3.5.4 The rootable volume is quoted in m^3. The usable depth of the rootable volume of trees is at least 0.5 m and usually no more than 1.5 m.

3.5.5 For new urban designs, it is advisable to avoid conflicts between tree roots and infrastructure by respecting a minimum obstacle-free distance between the tree and the infrastructure. This distance depends on the specific situation, tree size and the type of infrastructure but is typically between 0.5 m and 3 m.

3.5.6 On existing tree sites these distances can often not be respected when (re)planting trees, so mitigating or repetitive remedial measures (see chapter 6 - Additional technical solutions) might be necessary to minimise future conflicts.

3.5.7 Planting trees within the protective zones of utility infrastructure may require the agreement of the utility manager and the use of auxiliary technical solutions to reduce conflicts.

3.5.8 Installation of new utility infrastructure within the root protection zones of trees is not advisable. Where necessary, all means must be taken to protect rootable volume and the root systems of existing trees (e.g. trenchless technologies).

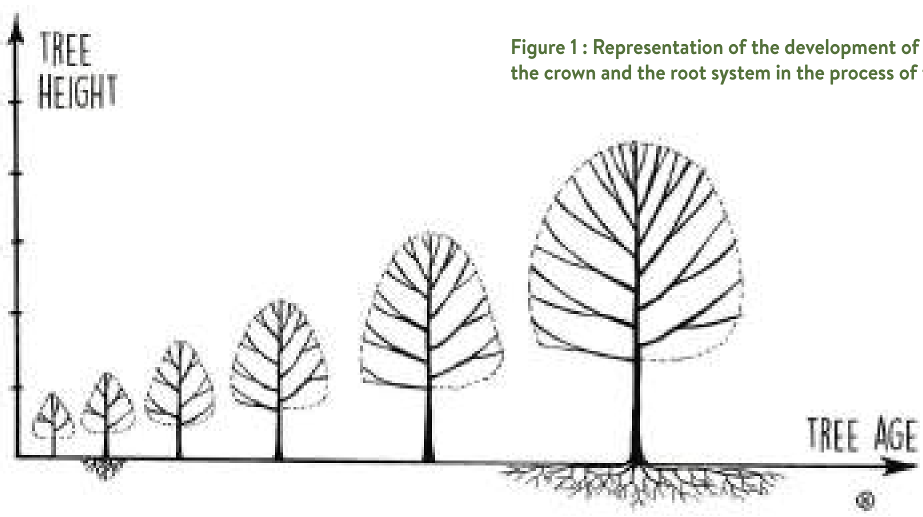

Figure 1 : Representation of the development of the volume of the crown and the root system in the process of tree growth.

3.6 Types of soil

3.6.1 In general, we distinguish 4 specific types of soil:
- clay,
- loam (silt),
- sand,
- peat.

3.6.2 **Clay soils** have low drainage and low aeration, but good mineral and water retention capacity. These soils can easily be overcompacted. The planting pit should drain sufficiently so that waterlogging is prevented.

3.6.3 **Sandy soils** have good drainage and aeration, but low mineral and water retention capacity. These soils dry out quickly and, in general, even if compacted retain sufficient porosity.

3.6.4 The capacity for water storage and water delivery in sandy soils depends on the percentage of organic matter (stable humus) and/or percentage of clay/loam particles.

3.6.5 Planting trees in **peat soils** is not common in urban situations. Trees planted in peat are growing on unstable soils and have a shorter life expectancy. Smaller-sized trees should be preferred.

3.6.6 The depth of the peat layer and the pH level must be measured before planting to select the most suitable tree species for the site.

3.7 Open growing locations

3.7.1 Trees planted in normal soil that is not degraded usually do not need special measures.

3.7.2 Minimal soil amendments can be provided to optimise tree resilience, e.g. improving root space, oxygen supply, moisture retention, mineral supply and the soil food web.

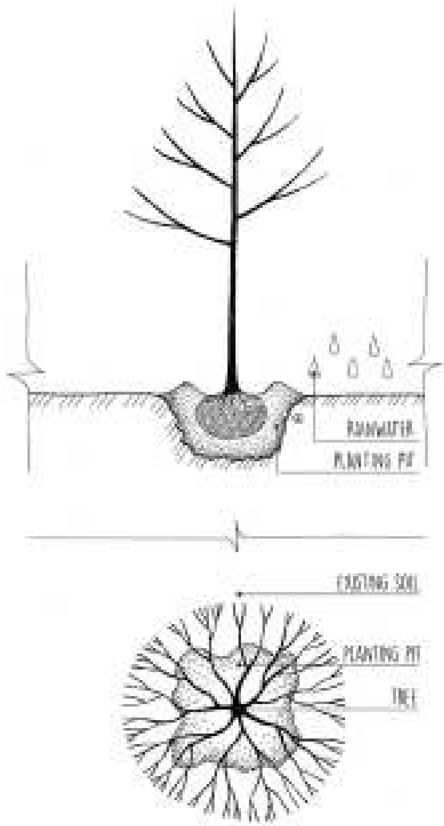

Figure 2: Planting trees into open growing sites.

3.8 Degraded soil conditions

3.8.1 Degraded conditions can occur in soils that are otherwise suitable for planting but where rooting space is significantly limited by compaction or deposition of heterogeneous layers.

3.8.2 After assessing the main causes of the degradation, soil improvement must be implemented to restore site conditions suitable for planting trees, as described above. This can include:
- increasing rootable volume,
- decompaction,
- mixing heterogenous, obstructive soil layers,
- soil amendments (e.g. compost (tea), sand, clay, lava, biochar, limestone – depending on the problem),
- soil replacement by suitable high-quality planting substrate (only if it is impossible to sufficiently improve the current soil).

3.8.3 Soil improvement must be carried out in the full rootable volume, as indicated in 5.5., not just in the planting pit.

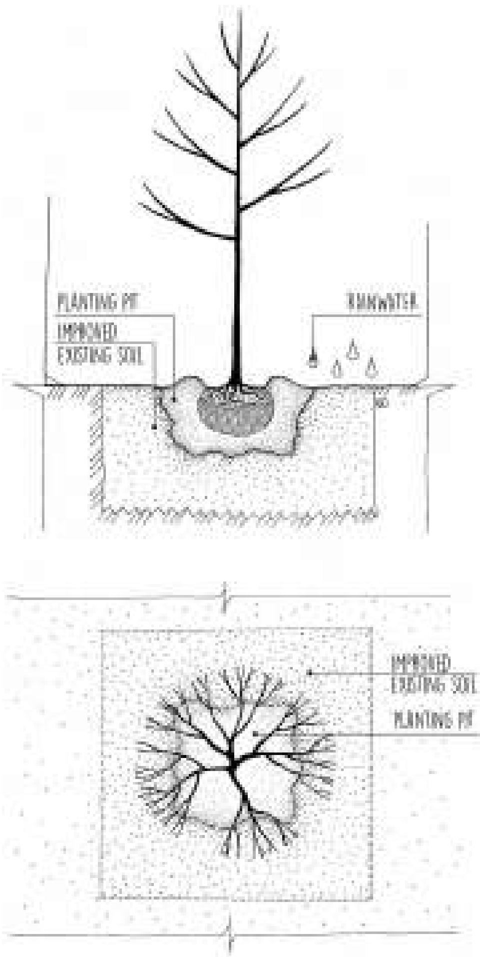

Figure 3: Planting trees into degraded soil conditions

3.9 Planting in hard surfaces

3.9.1 As a result of traffic load, planting locations under hard surfaces are often too compacted. To avoid compaction of the rootable volume, auxiliary technical solutions can be used to accommodate tree growth, such as structural soils, soil cells, etc. (See section 6.)

3.9.2 A specific concern in relation to rootable volume under hard surfaces is the availability of gas exchange between the soil and the outside air to supply sufficient oxygen to the tree roots.

3.9.3 **Pavements with an open structure**. This kind of pavement has sufficient joints between the elements for water and air to infiltrate the soil.

3.9.4 However, pavements with an open structure (green pavements) often need a higher level of subsoil compaction, which can negatively impact root growth. Also, the water and air infiltration capacity of these open pavements often degrades over time due to the accumulation of dirt in the upper layers of open joints.

3.9.5 Often the only surface free of paving is the tree pit itself, which limits the availability of water and air infiltration. To meet the needs of the tree, the open area around the tree pit should be as large as possible.

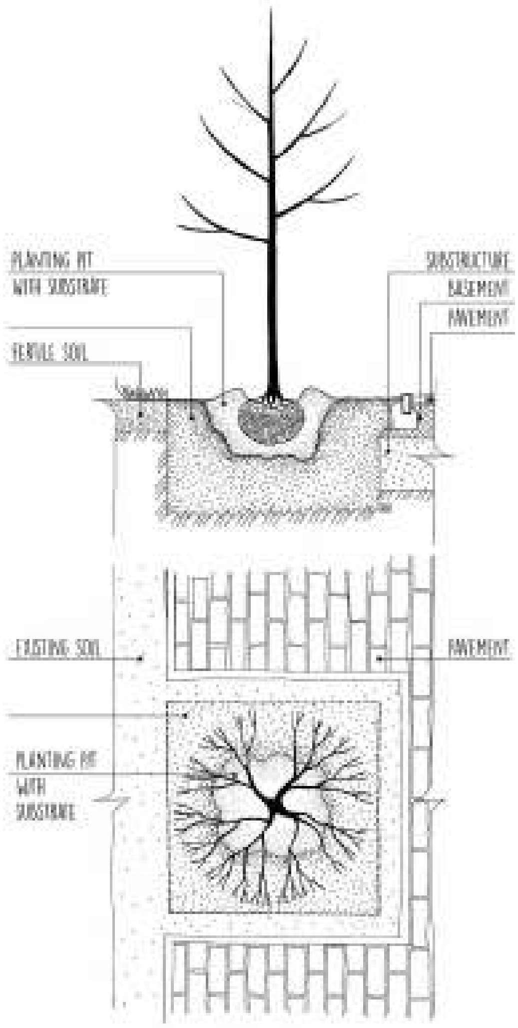

Figure 4: Planting trees into hard surfaces

4. Tree stock quality

4.1 Introduction

4.1.1 Trees can adapt to local environmental conditions. This adaptability is partly genetic and partly linked to the individual tree. The younger the tree, the greater its ability to adapt to its environment.

4.1.2 In some cases, a tree's adaptation to nursery conditions (climate, soil, etc.) can reduce its capacity to grow well in other environmental conditions. Trees from nurseries might need some time to adapt to the environmental conditions of the new planting position.

4.1.3 It is preferable to obtain trees from a nursery with similar environmental conditions to those of the planting site. If there is no nursery nearby or with similar conditions, it is better to maximise the capacity for adaptation by specifying very young trees; it is also possible to produce adapted trees from cuttings or seeds and grow them on in final environmental conditions.

4.1.4 The most important features for adaptability in urban trees are:
- drought resistance,
- frost resistance,
- heat resistance,
- preference for soil pH (this is not only genetic but also related to mycorrhiza and other soil food web partners).

4.1.5 The current trend in urban forestry is to plant increasingly large tree stock. However, it is recommended that smaller trees are planted in general (preferably between 12–16 cm stem circumference), as these will:
- suffer less from planting shock,
- require a less intensive and shorter aftercare period,
- demonstrate better hierarchy (forming one dominant leader),
- resume growth faster,
- exhibit less quality loss related to nursery practice (e.g., topping, fertilising)
- adapt better to the local environmental conditions.

4.1.6 The size of a tree is specified in terms of circumference class (e.g. 12/14), which sets out the minimum and maximum stem circumference in cm, measured at 1 m above root collar level (except for multi-stemmed trees, which are specified in height classes, see section 4.4).

4.1.7 Where an immediate visual impact is required, e.g when restoring tree avenues, or to reduce the risk of vandalism and other types of damage, larger tree stock dimensions may be preferred, but these larger trees will require a longer maintenance (acclimatisation) period to become established and grow normally.

4.2 Essential features of trees accepted for planting

4.2.1 Data on labels or tags (species, cultivar, size, quality, number of transplants, number of units in pack, total number) must be accurate. Plants must be delivered in accordance with the purchase order and delivery note.

4.2.2 The **stem** must be solid and have a normal taper (thicker below than above).

4.2.3 The stem must have no bruising, open stem wounds or any other damage.

4.2.4 All trees must be delivered to site unpruned (no fresh cuts). Pruning can only take place after quality control and at the instruction of the leading official or client.

4.2.5 All historical pruning cuts must be surrounded by callus (note that the cuts do not need to be completely occluded). Pruning cuts must be maximum of 3 cm in diameter (4 cm in diameter for fast-growing species like *Populus* spp., *Salix* spp., *Platanus* spp., *Fraxinus* spp. and *Ulmus* spp.).

4.2.6 Trees must be free of branches with weak forks (in particular with included bark).

4.2.7 No diseases, pests or invasive plant species must be present on the above-ground or below-ground parts of the tree. There must be no sunburn necrosis, fruit bodies of wood-decay or parasitic fungi, or signs of boring insects or cankers.

4.2.8 To avoid frost damage, the annual twigs must be completely hardened off (fully lignified) at delivery.

4.2.9 All branches, including the top of the tree, must show a normal development pattern for the species (no weakened growth increment, stagnation or regression).

4.2.10 On grafted trees, there must not be a bulge or kink at the grafting site, or a noticeable difference in rate of growth; only a slight bend is acceptable. The graft and the rootstock must be well fused and of known compatibility.

4.2.11 The crown must be balanced: the tree must have branches on all sides.

4.2.12 The root collar must be straight and undamaged.

4.2.13 In order to have sufficient fine roots, the tree must have been transplanted regularly once every 3–5 years (see 4.2.21). The most recent transplanting date must be at least 2 years before delivery (except container-grown trees – see 4.2.23).

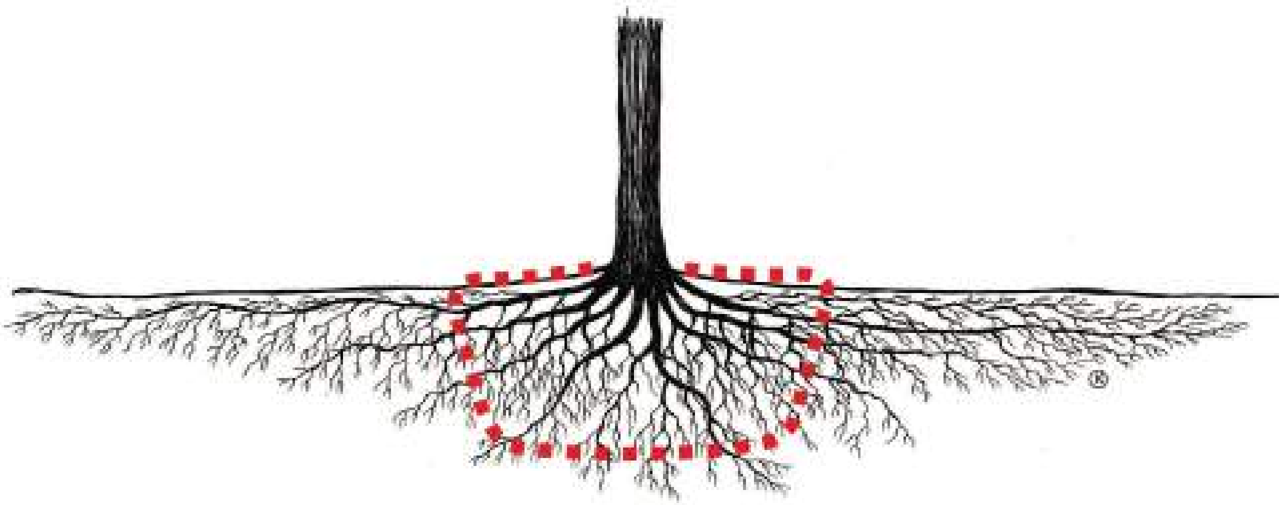

Figure 5: The root ball of a nursery tree consists of only approximately 5–10% of the overall root volume the tree would have achieved if it had been planted in the ground.

4.2.14 The **root system** must have both structural roots and fine roots. The root system must be:
- well branched and healthy,
- not dried out,
- with regularly distributed (360°) and continuous structural roots,
- without evidence of circling roots or repetitive cuts in the same spot,
- without girdling roots,
- without roots that have kinks or turns of less than 90°,
- densely rooted, with abundant and regularly distributed fine roots.

4.2.15 There must be no root wounds exceeding 2 cm diameter.

4.2.16 For **bare-rooted** trees up to a circumference of 14 cm, roots must be at least 25 cm long. For trees above a circumference of 14 cm, the minimum root length is double the circumference class's lower limit (e.g. 20/25 cm circumference: minimum root size 2 × 20 = 40 cm).

4.2.17 For **root-ball** trees, the root ball must be compact, fully rooted and cohesive: the roots and the soil must form a whole.

4.2.18 The root ball must be wrapped in pure jute (hessian, sackcloth) or a similar completely biodegradable material (which biodegrades completely after a maximum of 1.5 years).

4.2.19 If the root ball is wrapped in a wire basket, this must consist of non-galvanised, annealed wire mesh.

4.2.20 The root collar must be visible above the root ball.

4.2.21 The root ball must have the following minimum size and number of transplantings[7]:

Size class[8]	Min. root ball diameter [cm]	Number of transplantings
10/12	30	2
12/14	40	3
14/16	45	3
16/18	50	3
18/20	55	3
20/25	60	4

4.2.22 For **container-grown** trees, the container must consist of plastic (solid pot or woven bag) or a rootable, biodegradable material, which must remain intact until planting.

4.2.23 The tree must not be freshly potted: it should have grown in the container for at least a full growing season before delivery, but no longer than 2 growing seasons in the same container. Trees must not be grown in containers, air pruning pots or similar systems for extended periods as these are not suitable for development of a natural root system.

4.2.24 Tree should not have circling roots. However, if circling roots are present, their diameter must not exceed 0.5 cm and they can only be present in the outer 2 cm of the root ball so they can be shaved off or cut at planting without significant root damage.

4.2.25 The container substrate must be fully rooted, without circling roots or roots that have developed outside the container.

4.2.26 The container substrate must be in full contact with the container (not dried out).

4.2.27 The root collar must be visible above the substrate level.

4.2.28 The container must have the following minimum volume for the tree size class[7]:

Size class[8]	Min. container volume [litres]
10/12	25
12/14	50
14/16	50
16/18	65
18/20	65
20/25	100

7 European Nurserystock Association (ENA Edition 2010).
8 Size class indicates circumference of stem in 1 m height.

4.3 Desired aspect of adult tree

4.3.1 The quality requirements for trees depend on the desired aspect of the adult tree. Quality requirements are more specific for some categories of tree than for others. The following categories are identified:

- **Open-grown tree (natural tree architecture from the base of the tree):** the tree will have the natural habit of the species and is allowed to grow freely, without a single stem and without (or with only minimal) pruning.
- **Park tree (short single stem, permanent crown):** the tree will have a short single stem (usually already established in the nursery), above which the tree can take on the natural habit of the species, with minimal pruning.
- **Avenue tree (high single stem, temporary crown):** the tree will have a single stem for desired clearance (normally between 4.5 and 6.5 m[9]), which is usually higher than the height of the tree at delivery. These trees will need repetitive structural pruning to consolidate the dominant leader and establish a tall single stem.

4.3.2 Note that tree species or cultivars without apical dominance (e.g. weeping or globose) cannot be specified with all the quality requirements of an avenue tree.

4.4 Additional quality requirements for open-grown trees

4.4.1 Additional quality requirements can be specified in relation to crown form, crown width, number of main branches, maximum height of the lowest branch, etc. As these additional quality requirements are case specific, they cannot be defined in general.

4.4.2 Multi-stemmed trees are a specific type of open-grown tree which have multiple equivalent stems that originate below 0.5 m (measured above the root collar).

4.4.3 **Multi-stemmed trees** are not specified in stem size classes in cm (e.g. 20/25), but in height classes in cm (e.g. 350/400), often including the number of stems.

4.4.4 Multi-stemmed trees must originate from a single tree. They cannot be the result of planting multiple trees together.

4.4.5 The stems of a multi-stemmed tree must be equivalent in size and vigour.

4.4.6 The stems of a multi-stemmed tree must have a good connection, without any signs of a weak fork (in particular with included bark).

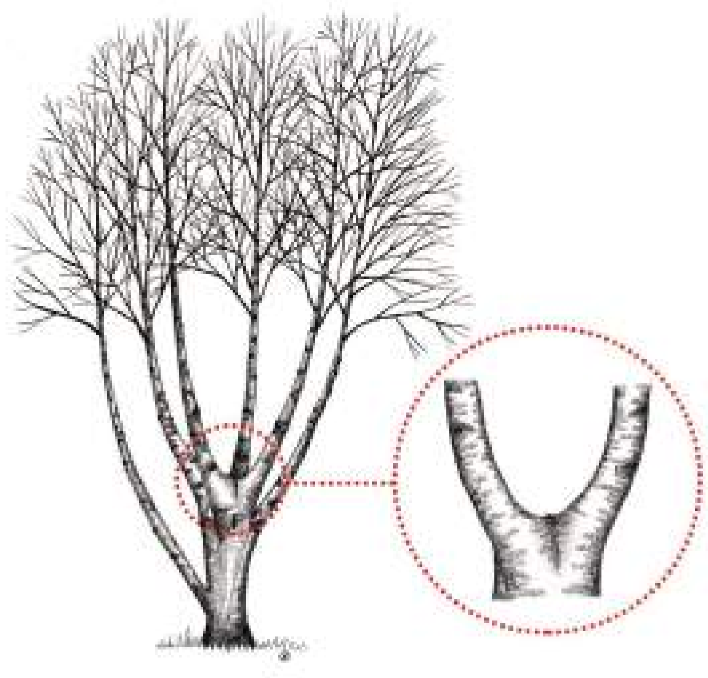

Figure 6: Open-grown tree with a standard well-formed fork.

9 National regulations apply.

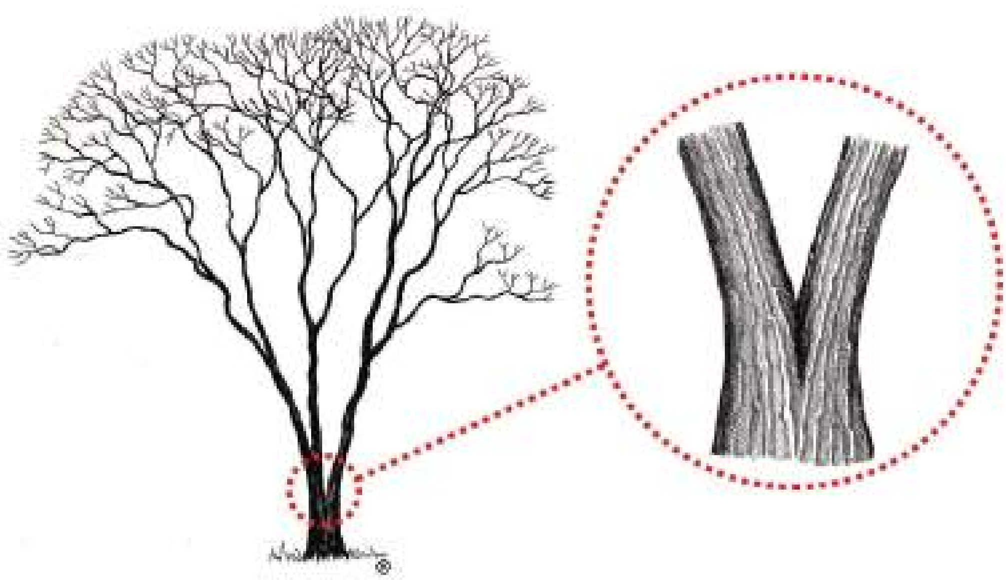

Figure 7: Open-grown tree with a weak fork with included bark.

4.5 Additional quality requirements for park trees

4.5.1 Park trees have a single stem with a branch-free trunk. The stem length is usually measured from the root collar to the first main branch. The minimum and maximum length depends on the size class of the tree (see table below for indicative stem lengths).

Size class[8]	Min. stem length [m]	Max. ratio stem:crown	Max. height range[10] [m]
12/14	1.5	1:1	3.60–4.20
14/16	1.5	1:1	4.20–4.80
16/18	1.5	1:1	4.80–5.40
18/20	1.8	1:1	5.40–6.00
20/25	2.0	1:2	6.00–7.50

4.5.2 Trees must have a good height:stem circumference ratio (slenderness), see Figure 8. The distance (L) between the root collar and the middle of the leader's annual shoot should be a maximum of 30 times the stem circumference at 1 m (35 times is acceptable for fast-growing species).

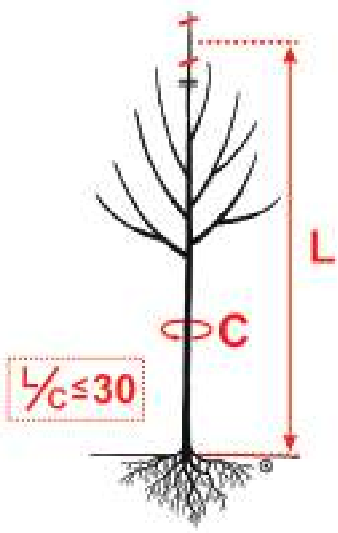

Figure 8: Representation of height: stem circumference ratio (slenderness) of a nursery tree.

10 Measured up to ½ of the last year's terminal shoot.

4.6 Additional quality requirements for avenue trees

4.6.1 In addition to the quality requirements for park trees (4.5), avenue trees must comply with the following quality requirements.

4.6.2 The tree must have only 1 stem and only 1 dominant, perennial leader, which forms the normal extension of the stem, according to the natural architecture of the species. (For an indicative list of species in each of the categories below see Appendix 8.)

4.6.3 For tree species of category **A**, a straight stem and leader must be present.

4.6.4 For tree species of category **B** or **C**, straightness of stem and leader are not required, but there must be clear apical dominance.

4.6.5 For tree species of category **C**, the slant of the leader must not be the result of a lack of strength in the stem or leader.

4.6.6 There must be no codominant leaders or branches, or dead, diseased or damaged branches in the crown. For tree species in category **B** or **C** (see Figure 9), remnants of recurrent forks or dominated main axes are acceptable provided they are clearly subordinate to the main leader.

4.6.7 The branches' diameter, measured just outside the branch collar, should not exceed the stem diameter at the height of attachment.

4.6.8 The leader must be undamaged and should not have been topped.

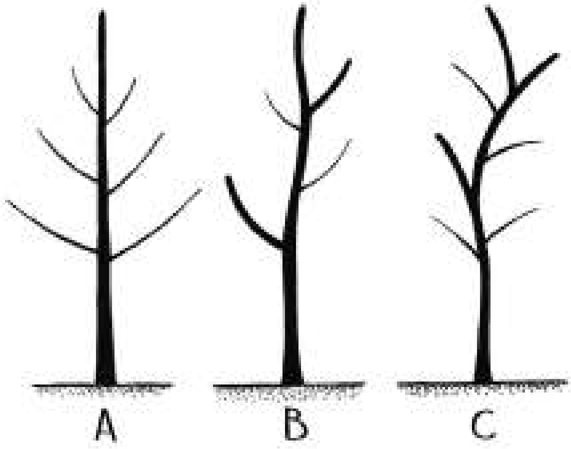

Figure 9: Tree architecture models according to the basic hierarchy strategy in young trees.

4.6.9 If the tree has been topped or lost apical dominance during nursery cultivation, the apical dominance must have been restored before the tree is delivered.

4.6.10 If, as a result of the topping, a kink or a bend arises in the main stem or leader, this can be a maximum ⅓ of the diameter (see Figure 10).

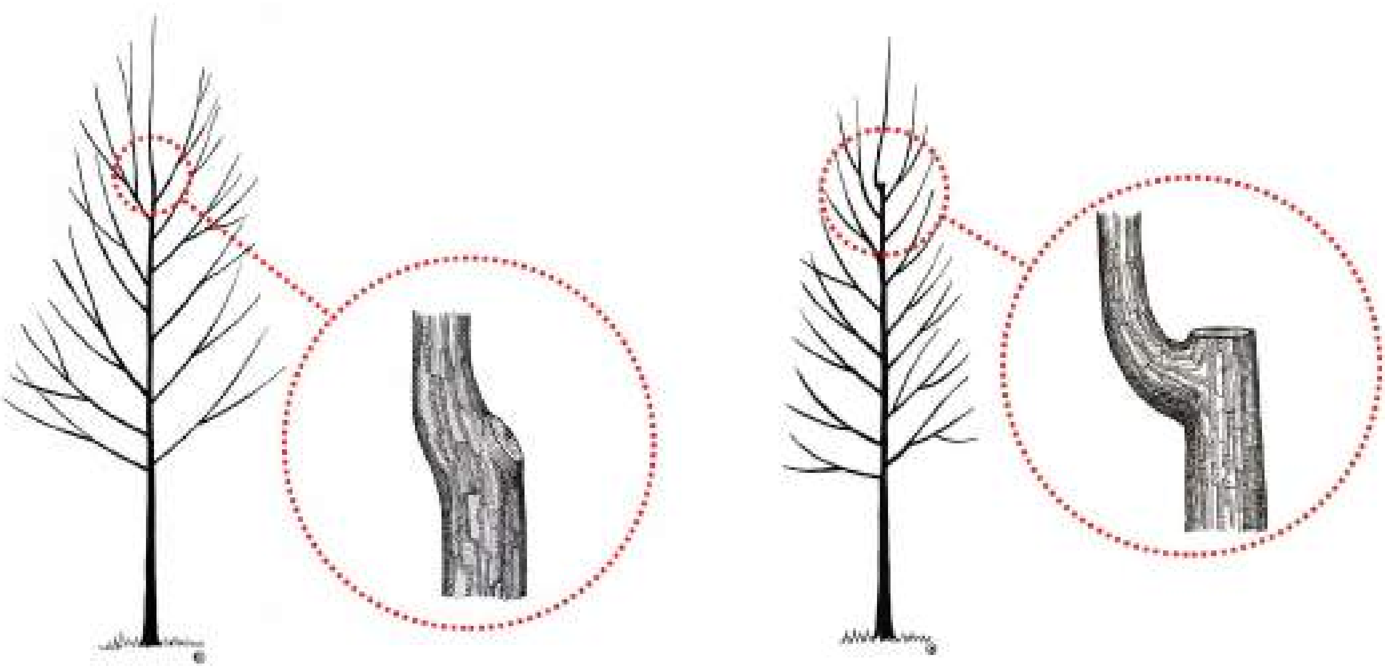

Figure 10: Acceptable (left) and non-acceptable (right) forms of bend in a tree's top.

4.7 Procedure for tree hand-over

4.7.1 At delivery, the client or his/her representative must check if the delivered trees meet the quality requirements defined in the purchase order. A preliminary selection of trees in the nursery does not replace this quality control at delivery (but might simplify it).

4.7.2 Quality control can be carried out on every individual tree or by selecting a random sample (for larger deliveries).

4.7.3 Increased attention must be paid to roots, root ball and root collar. Trees selected randomly from the delivery (1 tree of each group/species/type) should be carefully checked and inspected. For trees supplied in containers or with a root ball, this might include disassembly of the root ball or container.

4.7.4 The nursery must give at least 5 working days' notice of delivery to allow sufficient time for a detailed inspection to be organised and carried out. Partial deliveries must require the consent of the client.

4.7.5 The client or his/her representative has the authority to decide on the level of tolerance for minor deviations from the quality standards. Trees with minor deviations might be acceptable, but only if these deviations do not compromise the final desired aspect of the tree. Generally, a price reduction should be applied to compensate for the extra aftercare required to rectify any deviations from the quality standards.

5. Standard planting procedure

5.1 Introduction

5.1.1 The following procedures are intended for planting trees under normal conditions in urban situations, including beside roads and paths, in parks and related urban areas.

5.2 Time of planting

5.2.1 Bare-rooted trees and trees with a root ball should be planted when the tree is in dormant period. Root growth activity in general occurs over a much longer period than above-ground growth.

5.2.2 Planting during frost and in frozen soil is not recommended.

5.2.3 It is not advisable to plant trees in full growth at high temperatures.

January	February	March	April	May	June	July	August	September	October	November	December
Trees planted in Atlantic climate											
Bare-rooted broadleaved trees											
Broadleaved with root ball											
Evergreen and conifer trees with root ball											
Broadleaved, evergreen and conifer trees planted in container											
Trees planted in Continental Pannonian climate zone											
Bare-rooted broadleaved trees											
*	*										*
Broadleaved with root ball											
*	*										*
Evergreen and conifer trees with root ball											
*	*										*
Broadleaved, evergreen and conifer trees planted in container											
*	*										*

	January	February	March	April	May	June	July	August	September	October	November	December
Temperate or Mediterranean climate trees planted in Mediterranean climate												
Bare-rooted broadleaved trees	Optimal period	Optimal period	Optimal period	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Optimal period	Optimal period
Broadleaved with root ball	Optimal period	Optimal period	Optimal period	Optimal period	Possible period, but with special care	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Possible period, but with special care	Optimal period	Optimal period
Evergreen and conifer trees with root ball	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Possible period, but with special care	Not advisable to plant	Not advisable to plant	Optimal period	Optimal period	Optimal period	Optimal period
Broadleaved, evergreen and conifer trees planted in container	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Possible period, but with special care	Possible period, but with special care	Optimal period	Optimal period	Optimal period	Optimal period
Subtropical climate trees planted in Mediterranean climate												
Bare-rooted broadleaved trees	Not advisable to plant	Not advisable to plant	Possible period, but with special care	Optimal period	Optimal period	Possible period, but with special care	Not advisable to plant	Not advisable to plant	Optimal period	Optimal period	Possible period, but with special care	Not advisable to plant
Broadleaved with root ball	Possible period, but with special care	Possible period, but with special care	Optimal period	Optimal period	Optimal period	Optimal period	Possible period, but with special care	Possible period, but with special care	Optimal period	Optimal period	Optimal period	Possible period, but with special care
Mediterranean or subtropical trees planted in subtropical climate												
Bare-rooted broadleaved trees	Possible period, but with special care	Optimal period	Optimal period	Optimal period	Optimal period	Possible period, but with special care	Possible period, but with special care	Possible period, but with special care	Optimal period	Optimal period	Optimal period	Possible period, but with special care
Broadleaved with root ball	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period	Optimal period
Trees planted in Nemoral or Boreal climate zone												
Bare-rooted broadleaved trees	*	*	Optimal period	Possible period, but with special care	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Possible period, but with special care	Optimal period	Optimal period	*
Broadleaved with root ball	*	*	Optimal period	Optimal period	Possible period, but with special care	Not advisable to plant	Not advisable to plant	Not advisable to plant	Possible period, but with special care	Optimal period	Optimal period	*
Evergreen and conifer trees with root ball	*	*	Optimal period	Optimal period	Not advisable to plant	Not advisable to plant	Not advisable to plant	Not advisable to plant	Possible period, but with special care	Optimal period	Optimal period	*
Broadleaved, evergreen and conifer trees planted in container	*	*	Optimal period	Optimal period	Possible period, but with special care	Possible period, but with special care	Possible period, but with special care	Possible period, but with special care	Possible period, but with special care	Optimal period	Optimal period	*

Optimal period

* Possible period if the soil is not frozen

Possible period, but with special care

Not advisable to plant

5.3 Transport

5.3.1 Handling, loading and transporting trees from nursery to planting site, unloading trees and their storage must be carried out without causing any damage. Preservation of the terminal leader is of fundamental importance.

5.3.2 Trees with a root ball should ideally be handled by the root ball. If they are gripped by the stem (just above the root ball), the stem must be protected from mechanical damage.

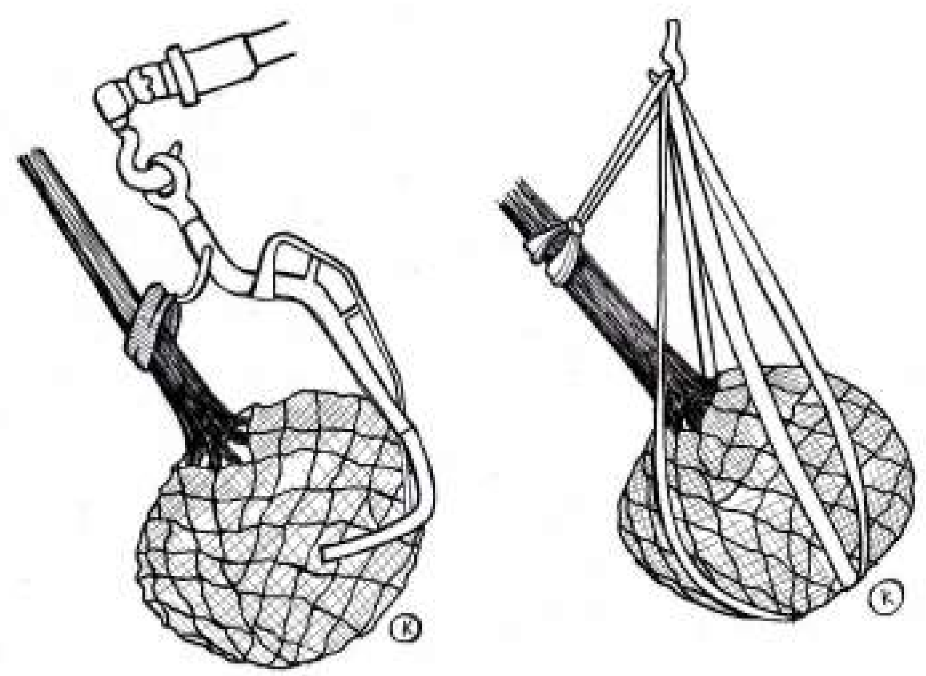

Figure 11: Examples of securing trees during lifting.

5.3.3 Trees should be protected from direct sun, wind, frost, drying out and mechanical damage.

5.3.4 In particular, trees must be protected from drying, overheating or frost during transport.

5.3.5 Trees may only be shipped during frost or heatwave conditions with the consent of the recipient.

5.3.6 Temporary storage of trees must include covering the root system with soil/mulch or similar material.

5.3.7 Stored trees must be watered sufficiently (depending on the weather and cover material used) and protected from damage by wild animals (depending on the site).

5.3.8 Bare-rooted trees must be properly stored or planted immediately after transport. The only exception to this is if the root systems are protected against desiccation, and these trees must be stored or planted within 24 hours. Trees with root balls and in containers must be temporarily stored or planted within a maximum of 48 hours after transport.

5.4 Root management

5.4.1 When bare-rooted trees are planted, damaged roots must be removed or shortened. Circling/strangling roots should not be present (see 4.2), but if a tree is accepted for delivery in this condition, these must be removed or shortened.

5.4.2 Roots must not be pruned unnecessarily, e.g. because they do not fit in the planting pit. In such cases the planting pit must be widened.

5.4.3 Water the tree roots properly. If roots of bare-rooted trees show signs of drying, they must be dipped in water, for a maximum of one hour, before planting.

5.4.4 In container-grown trees, small roots curving along the container circumference must be cut in at least three places on the sides and at the bottom or by shaving the outer 2 cm of the soil mass. Roots growing out of the container must be removed.

5.4.5 Root management should be done immediately prior to planting.

5.4.6 It is not necessary to treat wounds left after root shortening.

5.5 Site and soil improvement

5.5.1 The future rootable space on the site must be properly prepared before planting. On most sites, preparation mainly involves the following:

- removal of persistent weeds, including the parts capable of regeneration,
- removal of undesirable materials.

5.5.2 Removal of competing vegetation before planting is advisable.

5.5.3 A frequent problem associated with urban soils is their level of compaction. There are a range of specialist solutions for this problem (see section 6).

5.5.4 The terrain should be levelled to the desired shape before tree planting starts.

5.5.5 In good soil conditions, there is no need to replace or improve the soil in the planting pit.

5.5.6 When soil conditions are insufficient for sustainable tree growth, it is advisable to improve the soil. In general, this means that part of the original soil is preserved and a small percentage of new substrate is added.

5.5.7 More significant soil improvements are necessary only in case of its contamination.

5.5.8 Soil **improvements** are focused on structural, chemical and biological changes in the soil.

- Structural properties refer to aeration of the soil and water retention.
- Chemical properties refer to pH, mineral availability and similar soil characteristics.
- Biological properties refer to nutrient retention and management and biological organisms that live in soil.

5.5.9 **Mineral substrates** are based on sand, gravel, lava or other rock-based materials mixed with existing soil. These materials must not fundamentally alter the pH.

5.5.10 **Organic substrates**. These are substrates with a predominance of organic components (particularly compost and composted bark). They can only be used for soil improvement in the top layer, up to 50 cm depth. Compost added to the substrates must be well decomposed. Peat should not be used because of its impact on climate and habitat destruction.

5.5.11 Only use good-quality compost for site improvements. Points to consider include:

- The composted materials and their proportion: good-quality compost is made from a mix of natural materials with high carbon content, like woodchip, straw, etc., and natural materials with high nitrogen content, like farmyard manure, fresh hay, clover, etc. Composts made of slurry, household green waste, etc. are to be avoided.
- Good-quality compost is the product of aerobic composting. Note that large-scale industrial composting may lead to anaerobic conditions and detrimental components in the end-product.
- The temperature during the first phase of the composting process should be well controlled, avoiding excessive heat.
- The composting process should be terminated before the compost is used, so no (or only very limited) temperature increase in the heap is acceptable.
- Good-quality compost must accommodate a healthy soil food web.

5.5.12 The compost quality can be certified or tested if appropriate.

5.5.13 Chemical fertilizers should not be used, because of their impact on the soil food web (mycorrhizae etc.).

5.5.14 Other auxiliary components may be added to the soil (substrate), after detailed analysis, to improve the soil food web:

- compost extract (tea),
- plant extracts,
- biological nutrients,
- bacteria and fungi/mycorrhizae.

5.5.15 Water absorbents adjust the hydraulic regime, increase sorption of water and nutrients, and promote microbiological activity in soil. They improve water management on the site. Their use is effective primarily on sandy soils or on altered sites with limited water supply.

5.5.16 Stimulators promote root growth and accelerate the development of a new root system.

5.6 Planting pit

5.6.1 Planting into trenches is better than planting into individual pits.

5.6.2 The diameter of the planting pit must be at least 1.5 times larger than the width of the root system of a bare-rooted tree or the diameter of the root ball.

5.6.3 The final volume for root development is much larger than the planting pit. All resources must be used to support root development from the planting pit.

5.6.4 The depth of the planting pit depends on the root system or root ball height. The bottom of the planting pit must be loosened.

5.6.5 In heavily compacted soils, an angular or radial -shaped planting pit is more appropriate.

5.6.6 The shape of planting pits in sandy or medium to heavy soils is not important.

5.6.7 In clay, loam and compacted soils the planting pit should not be augered due to the risk of compaction of the pit wall.

5.6.8 During excavation, different soil layers must be stored separately so that they are not mixed during planting.

5.6.9 The walls of the pit must be loosened and must not pose an impermeable obstacle for root development.

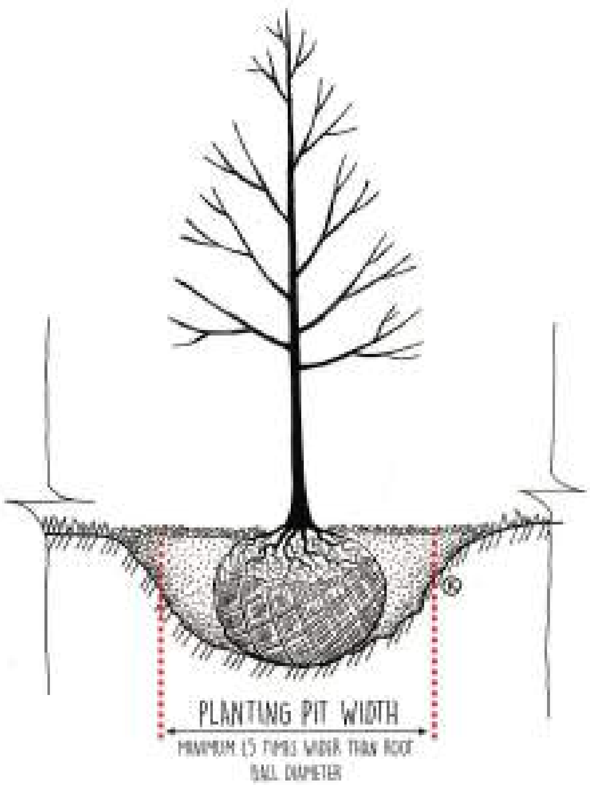

Figure 12: Minimum size of the planting pit.

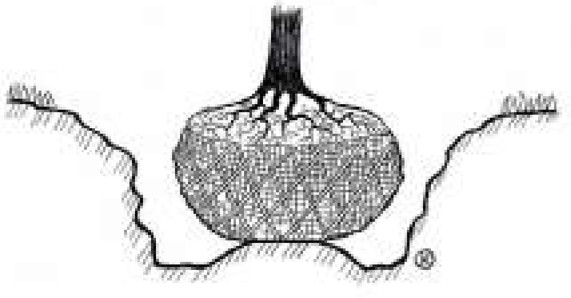

Figure 13: Location of the root ball in the planting pit.

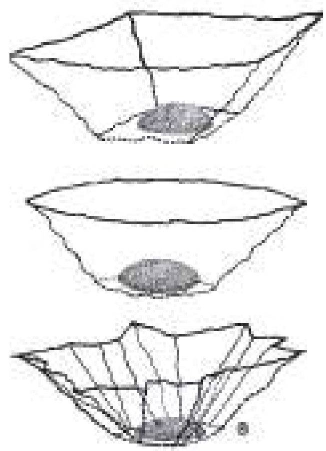

Figure 14: Various shapes of planting pit.

5.6.10 If the soil properties are not suitable, follow instructions in section 5.5.

5.6.11 It is not necessary to install aeration and irrigation systems in open growing sites or if the situation does not demand it.

5.6.12 For tree rows in paved areas, the individual planting pits should be made larger and/or to connected to each other, e.g. by root trenches, root pathways or by maximising the available soil volume outside the planting pits.

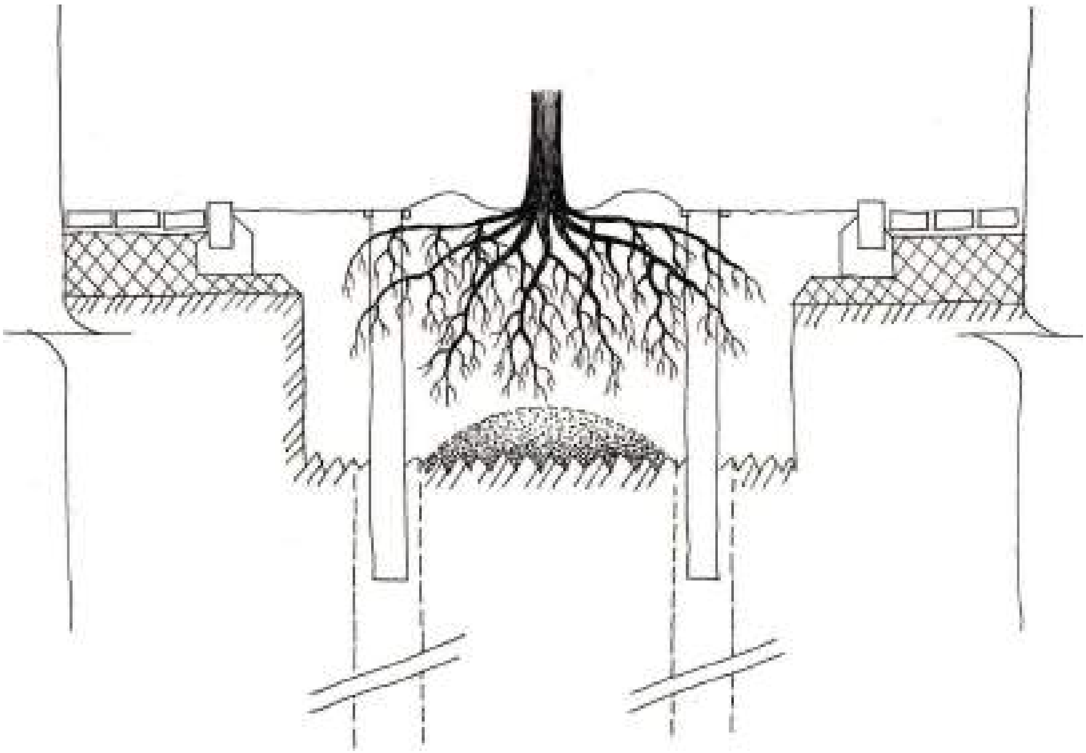

Figure 15: Example of an aeration system.

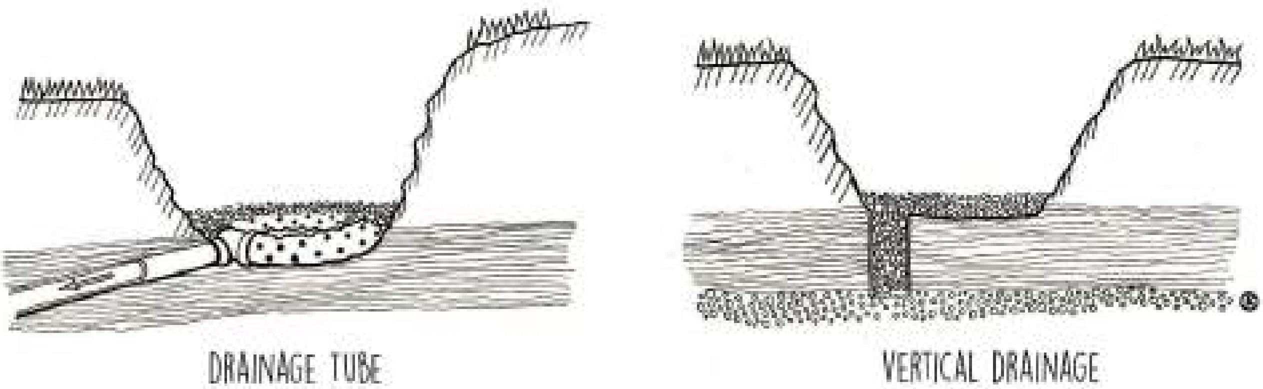

Figure 16: Various types of drainage systems in the planting pit.

5.6.13 The use of (heavy) equipment for planting trees can lead to increased compaction of the soil, which hinders root growth or makes it impossible. Prevent soil compaction by staying out of planting pits and above the rootable volume by using road plates or equivalent materials. Soil compaction can easily occur in wet soils and in clay or peat soils.

5.7 Tree placement/planting

5.7.1 At planting, place the tree in the centre of the planting pit.

5.7.2 The level of the root collar must be checked, so that after planting the root collar should be a few cm higher than the level of the surrounding terrain. This is to avoid the root collar sinking with natural soil settling.

5.7.3 The root collar of a tree **planted on a slope** must be located at upper edge of the lower -lying pit wall. Trees planted on a slope must be protected from water erosion.

5.7.4 Modification of the slope above the tree and special irrigation measures are necessary in most cases.

5.7.5 Roots of bare-rooted trees must be evenly spread by hand.

5.7.6 For trees with a root ball, the upper part of the wire basket needs to be removed or released sufficiently to allow root collar growth.

5.7.7 At this stage the anchorage system should be installed (see 5.8).

5.7.8 During planting, it is best to irrigate the open pit to minimise the formation of air pockets. Irrigation must evenly saturate soil volume throughout the planting pit.

5.7.9 Water used for the irrigation must not be contaminated. Regenerated (recycled, gray) water must have sufficient quality to support healthy tree life.

5.7.10 Backfill the pit in layers and ensure that the tree remains upright. At each stage, the filling must be gently compacted to avoid any open spaces under and around the root system. Be careful not to over-compact the soil.

5.7.11 Soil from the lower layers should be used for backfilling in the deeper parts of the pit. Top-layer soil should be used for backfilling the upper levels.

5.7.12 Immediately after planting, the location must be thoroughly irrigated.

5.7.13 Where possible, build an irrigation wall to improve irrigation efficiency. Make sure that water does not leak and infiltrate into the surrounding area.

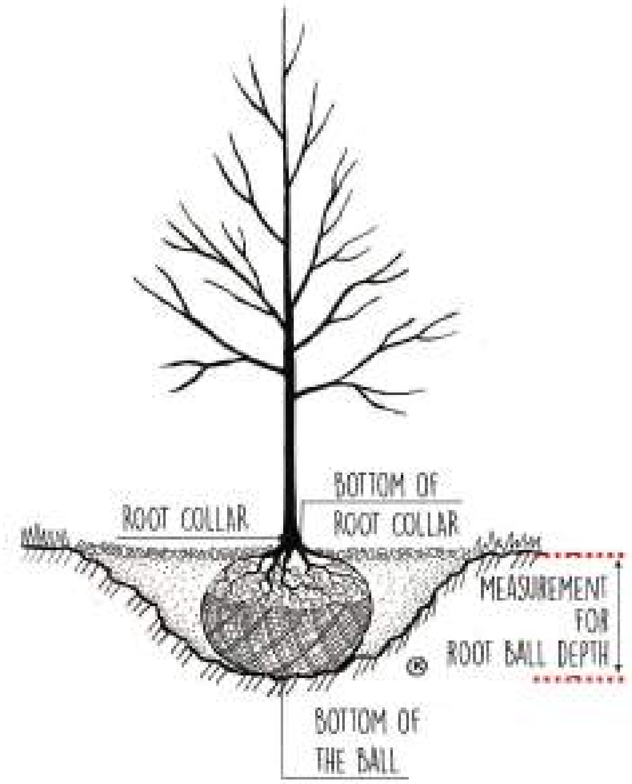

Figure 17: Placement of the tree into planting pit.

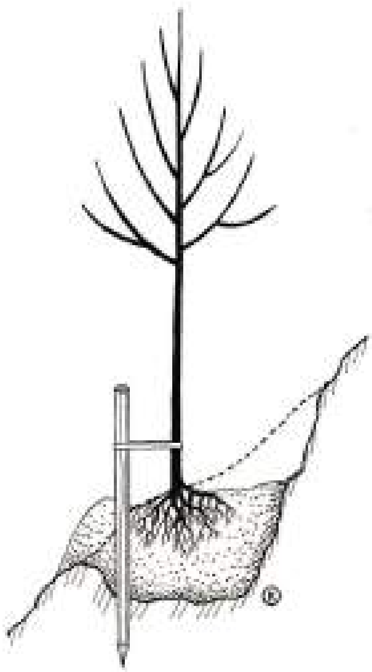

Figure 18: Planting trees on a slope.

5.7.14 Any interference that might damage the root system after planting is undesirable.

5.7.15 After backfilling, the upper surface of the planting pit must be at exactly the same level as the surrounding soil. The irrigation wall should be located just outside the outer border of the planting pit.

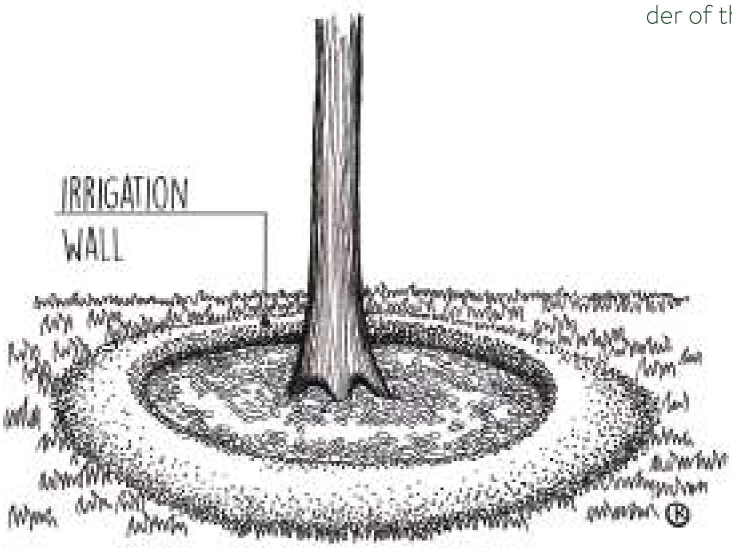

Figure 19: Irrigation wall around a newly planted tree.

5.8 Anchorage systems

5.8.1 The objective of anchorage systems is to stabilise the root system and to allow for movement of the above-ground parts. Trees that are 1.5 m or more in height and trees with cultivated crowns must be firmly anchored during planting.

5.8.2 The type of anchorage and the size and strength of stakes should be chosen in relation to the tree's size and the expected duration of use on the site (e.g. road safety requirements).

5.8.3 The anchorage system should be sufficient to support the tree while allowing a certain amount of trunk movement so that lateral anchor roots can develop.

5.8.4 The anchorage system must be installed so that the tree is not damaged by direct contact, abrasion or rubbing.

5.8.5 Anchoring is usually kept in place for 2–3 growing seasons. Exceptions are plantings of large trees or plantings on windy or otherwise exposed sites.

5.8.6 Anchoring is typically done using 1–3 stakes or by underground anchors and its dimensions are determined by the size of the tree.

5.8.7 Stakes used for anchoring must be debarked, and preferably should not be impregnated (treated with preservatives). They have a service life of 2–3 years.

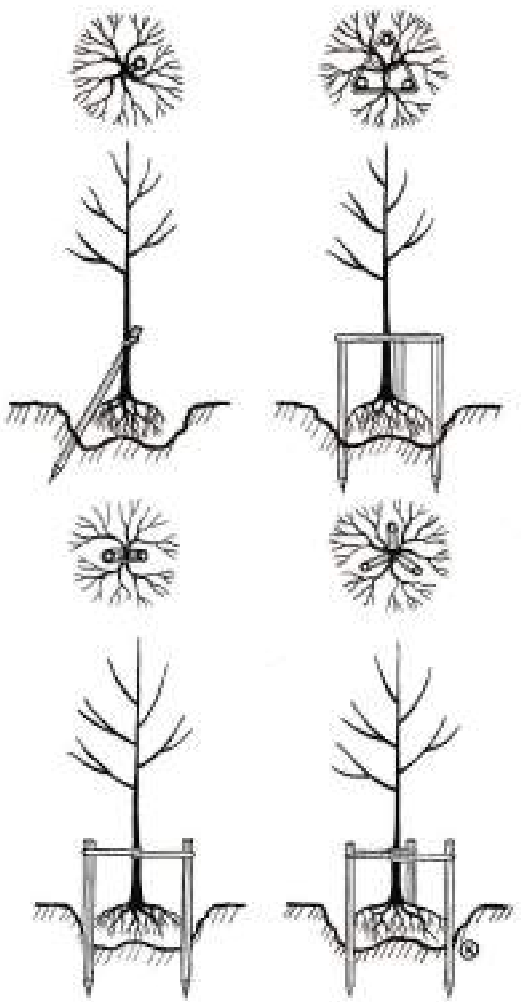

Figure 20: Various types of anchorage systems using stakes.

5.8.8 Stakes should be installed in an open planting pit so as not to damage roots. Stakes must be embedded below the planting pit bottom.

5.8.9 To be stable, the tree needs stem support at around 50–60 cm above ground. If the anchoring system is also designed as a means of protection for the stem, or in windy situations, it may be advisable to use higher stakes.

5.8.10 To increase the stability of systems with 3 or more stakes, it is possible to join the ends of the stakes together with suitably cut semi-circular battens so that they stabilize each other.

5.8.11 Consider adding one or more levels of battens installed on the bottom of the system to protect the lower part of the stem against lawn mowers/grass trimmers and dog urine.

5.8.12 Ties must be secured against slipping on the stakes. Ties must not damage the bark or hinder trunk growth. Use of ties made from organic materials is advisable.

5.8.13 Underground anchors can only be used in trees supplied with an intact root ball or with a container. Anchoring components must not be in direct contact with the roots of the tree.

5.8.14 Underground anchors must be installed in the planting pit before it is backfilled.

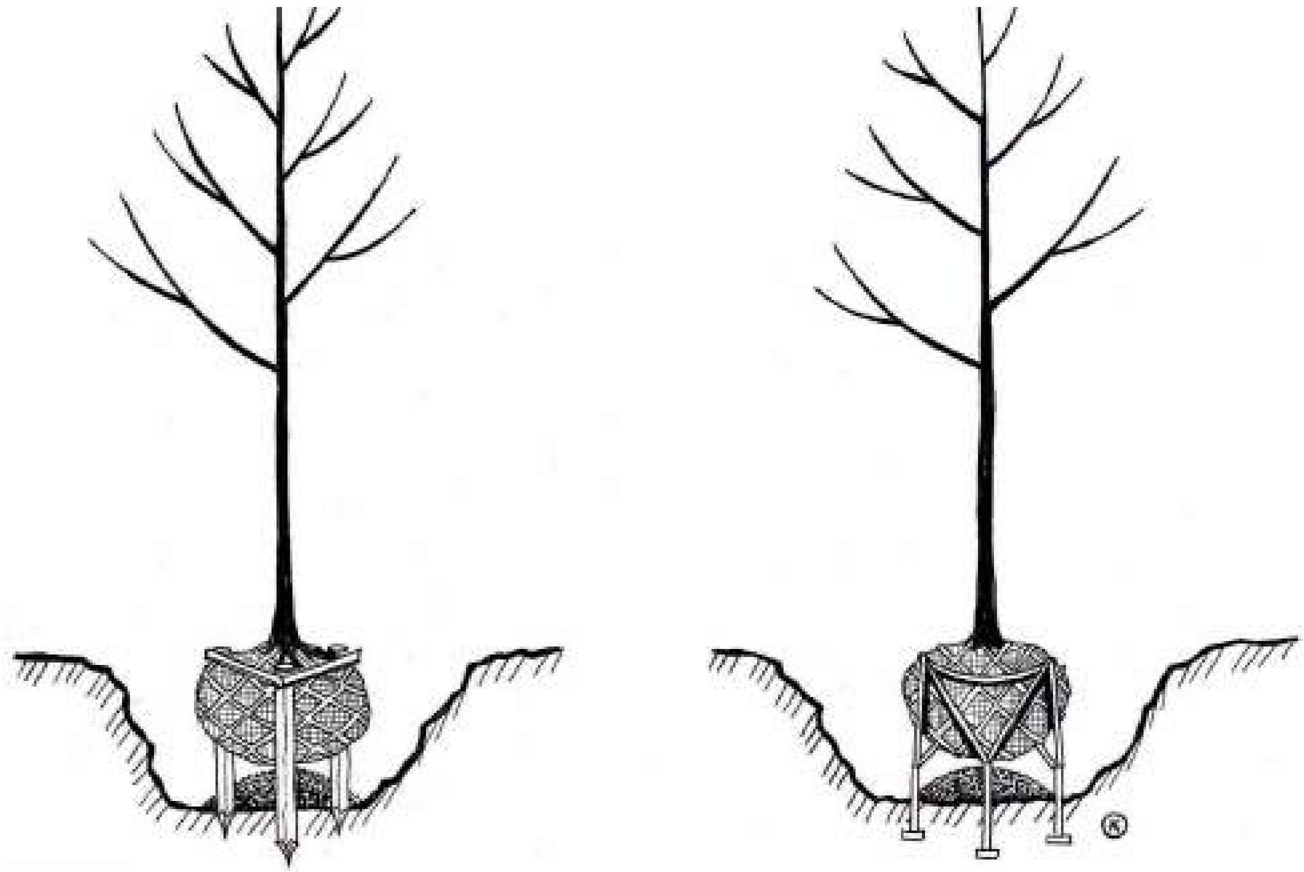

Figure 21: Various types of underground anchorage system.

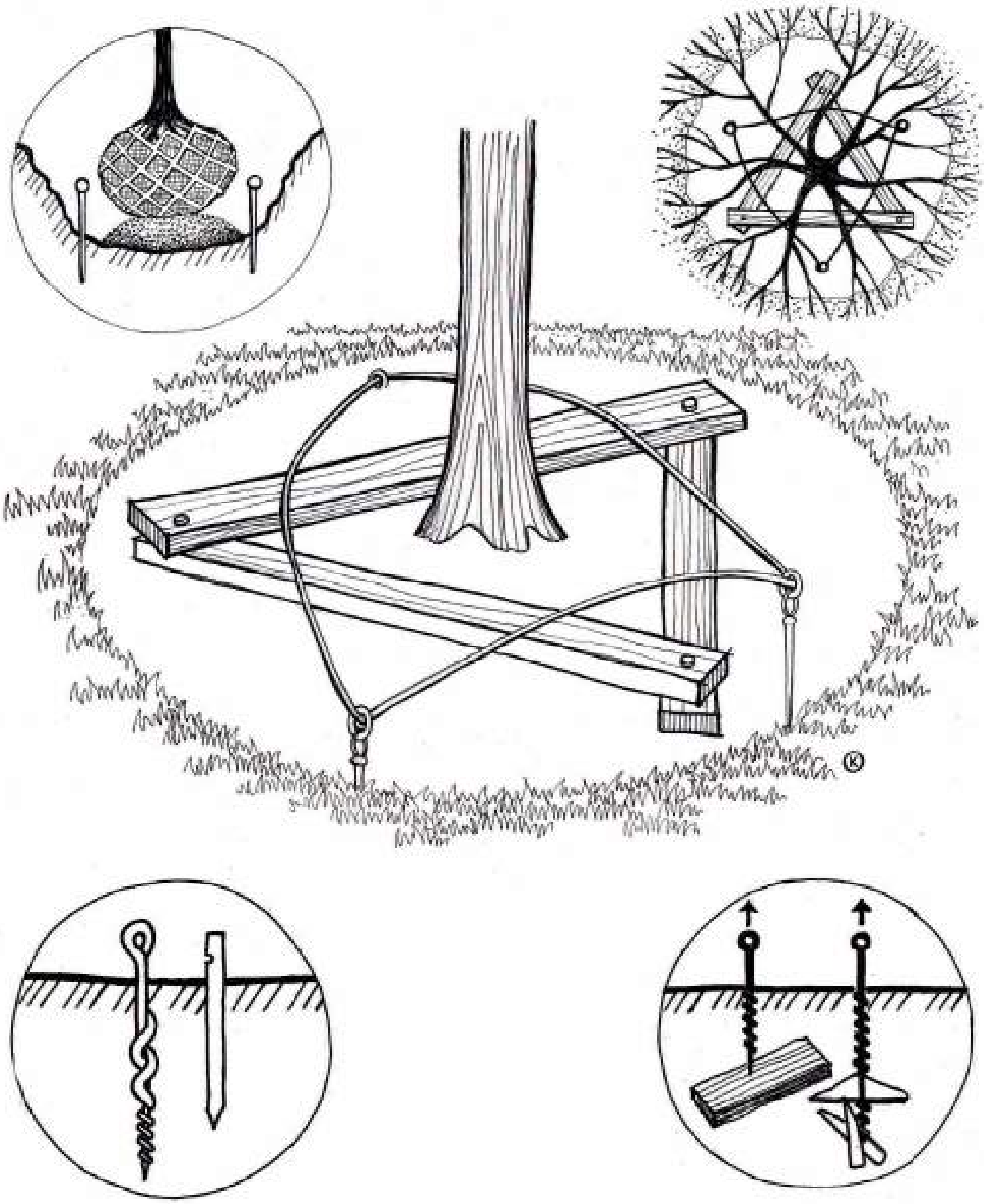

Figure 22: Details of an underground anchorage system.

5.9 Stem and crown protection

5.9.1 Consider installing adequate stem protection on when planting trees with distinct trunks.

5.9.2 Protection from **sun scorch** is achieved usually by reed or split bamboo mats or using jute wrapping.

5.9.3 Trunks can also be coated with white paint to increase the reflection of sunlight (the albedo of the stem). Paints should be specifically designed for the purpose or of mineral origin (chalk, loam, clay etc.).

5.9.4 For specific tree species with thin bark which is susceptible to sun scorch (like *Fagus* spp. and *Carpinus* spp.), small twigs may be attached to the stem to protect it from excessive sunlight (unless specified otherwise). These twigs must be distributed regularly over the stem and must be stocky and not older than 2 years.

5.9.5 In areas where planted trees are threatened by **gnawing, browsing or antler damage**, the trees must receive suitable protection. In addition to mechanical protection (such as sleeves, fences etc.), repellent coating or spray is also possible. Coats or sprays must be applied in accordance with the public health regulations and traffic safety principles that apply to the site.

5.9.6 In lawned areas, it is advisable to install protection against **trunk damage by mowers or grass trimmers**. Maintaining a protective area around the trunk (e.g. by application of mulch) offers appropriate protection from trunk damage by mowers.

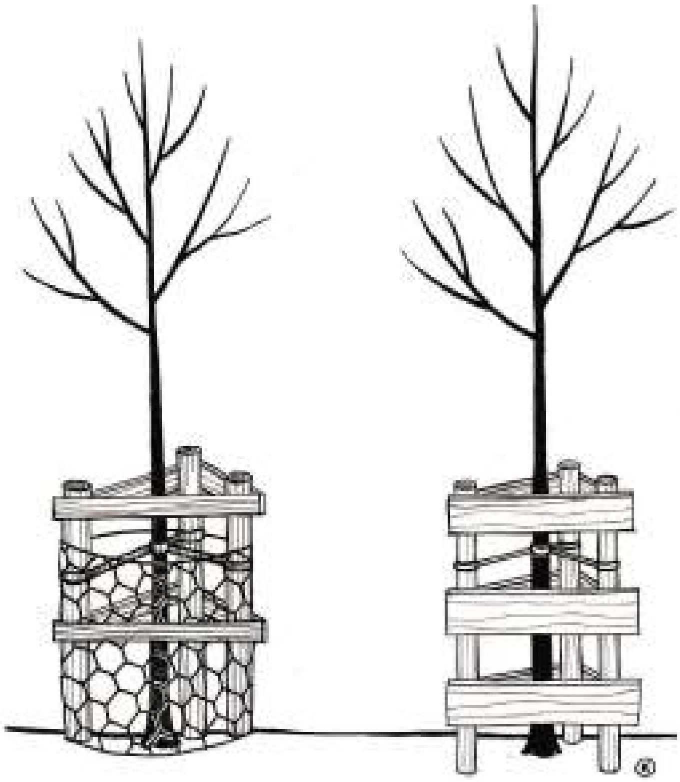

Figure 23: Examples of stem tree protections

5.9.7 Any trunk protection system must not damage the tree and must be installed with sufficient leeway to permit trunk growth and movement.

5.10 Mulching

5.10.1 It is highly advisable to mulch planted trees with a layer of material of maximum 5 cm depth (in dry climates and with coarse material max. 10 cm). The mulch layer should be kept away from immediate contact with the tree root collar.

5.10.2 Mulching materials must not damage the tree and their properties must not prevent air and water absorption by the soil.

5.10.3 For mulching the following organic materials could be used, for example:

- bark,
- woodchips,
- straw.

Grass and other fresh plant materials are not suitable, as they ferment.

5.10.4 It is possible to use seasoned (partially decomposed) mulch. However, to avoid having to move plant material (for biosecurity reasons and to reduce carbon footprint), it can be better to use fresh woodchip if it is available on the site.

5.10.5 Using inorganic material as a mulch is possible, even if it does not fulfil all the functions of organic mulch. It is possible to use it on sites with a low risk of soil compaction. It must not be used with a geotextile below.

5.11 Water supply systems

5.11.1 Where possible, create a natural irrigation wall (see 5.7.13). This makes irrigation easier by keeping the water in the rootable area. It may offer additional protection against road salt and mowing damage.

5.11.2 A constructed watering ring should have a diameter about 1–1.5× the size of the root ball. It should be placed around the tree and submerged to a depth of approximately 10–15 cm with the rest forming the watering rim above ground. The overlapping ends should be fixed to the tree stakes to keep the watering ring stable. Watering rings should preferably be made of biodegradable material.

5.11.3 Where required, slow-release irrigation sacks can be used. These should be placed around the trunk and then filled with water. The filling quantity varies depending on the trunk diameter of the tree. To avoid damaging the tree's stem, irrigation sacks can be secured around the stakes where appropriate.

5.11.4 In some cases, a watering system consisting of in-situ irrigation pipes can be used. The irrigation pipes should be positioned around the root ball, in the upper half of the planting pit. Note that such irrigation pipes generally can only hold a limited amount of water, making watering time consuming or insufficient.

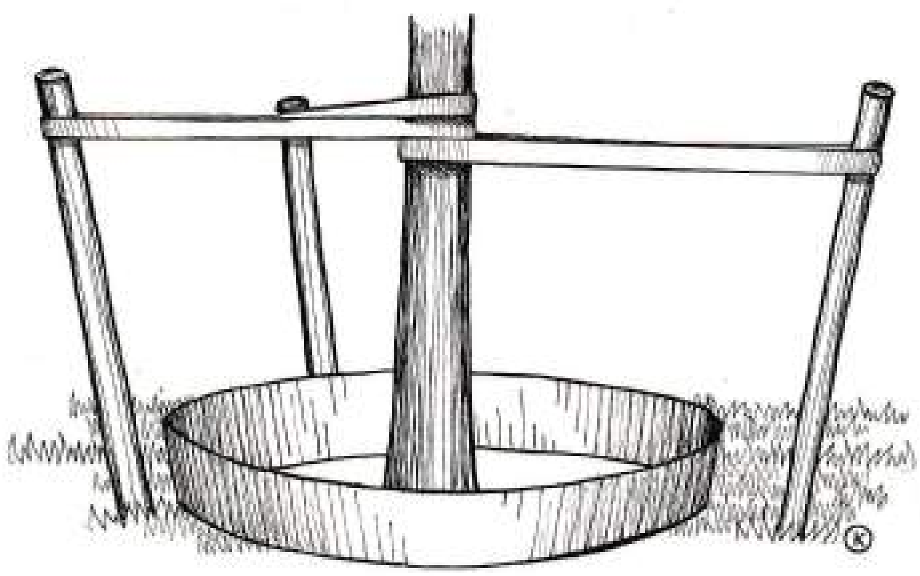

Figure 24: Watering ring.

5.12 Tree pruning at planting

5.12.1 Any minor damage to the above- or below-ground parts of the tree incurred during transport can be rectified by pruning.

5.12.2 Pruning in general follows principles described in EAS 01:2021 – European Tree Pruning Standard.

5.12.3 Quality trees (nursery stock) should not require pruning at the time of planting. Contractors must not carry out pruning at the time of planting without a specific order.

5.12.4 Compensating for bad-quality nursery stock by pruning at planting is not advisable. Such trees do not fulfil the quality expected of nursery stock (see section 4).

6. Additional technical solutions

6.0 Introduction

6.0.1 Trees should preferably be planted in areas that allow open growth, without any limits to the development of their roots. Hard surfaces should be avoided whenever possible. However, when it is necessary to plant trees in hard-surface surroundings, additional technical solutions can be used.

6.0.2 The preconditions for the use of additional technical solutions and the guidelines for their application must be defined during a well-considered urban planning and design process.

6.1 Compaction for infrastructure

6.1.1 In urban environments, subsoil is often compacted before the installation of infrastructure in order to avoid subsidence, e.g. for roads, footpaths etc. Usually this is carried out throughout the whole street profile, which makes the subsoil unsuitable for tree root growth. In order to keep the subsoil rootable without having to use structural soils or underground installations for tree growth, the following can be implemented:

- Limit compaction to the minimum necessary to avoid subsidence, both in depth and in degree of compaction. For example, the subsoil under footpaths does not need the same depth and degree compaction as the subsoil under roads used by heavy traffic roads.
- Create root pathways below the hard surface (see section 6.6) which can guide the tree roots to surrounding areas (this is not possible if all surrounding areas are also compacted). This measure could be accompanied by creating small islands of good, uncompacted soil throughout the hard surface, connected by root pathways.
- Create a network of thin trenches (3–5 cm) in the compacted soil after compaction. This does not really make the subsoil rootable, but it allows small tree roots to explore a bit more of the soil volume.
- Extend the depth of planting pits (down to 1.5 m or more), allowing tree roots to explore deeper soil layers below the artificially compacted subsoil. The success of this measure depends on the local soil conditions and layers.

6.1.2 Note that the above measures are most successful in well-aerated sandy or stony soils without high groundwater levels.

6.2 Structural soils

6.2.1 Structural soils are artificial soil-substituting substrates that combine load-carrying capacity and rootable volume. They can be used under all hard surfaces, e.g. footpaths, roads and parking areas. Note that structural soils allow root growth but are a compromise material for use under hard surfaces and thus they are suboptimal for root development. For this reason, structural soils must not be used in open planting areas.

6.2.2 All structural substrates consist of a load-bearing matrix of monogranular[11] material with voids that are filled with a soil with high loam/clay and organic material content to accommodate root growth.

6.2.3 Depending on the required load-bearing capacity, the matrix can consist of sand or crushed rock (e.g. gravel, lava or recycled materials) of differing dimensions (typically between 0,2 and 15 cm, but monogranular). The material must be sufficiently hard not to crumble under compaction and load. The elements must be angular, not round, to be compactable.

6.2.4 The physicochemical composition of the matrix and its solubility can influence pH and mineral composition in the substrate. For this reason, a recycled material like crushed concrete is generally not suitable for making structural soils due to its high alkalinity.

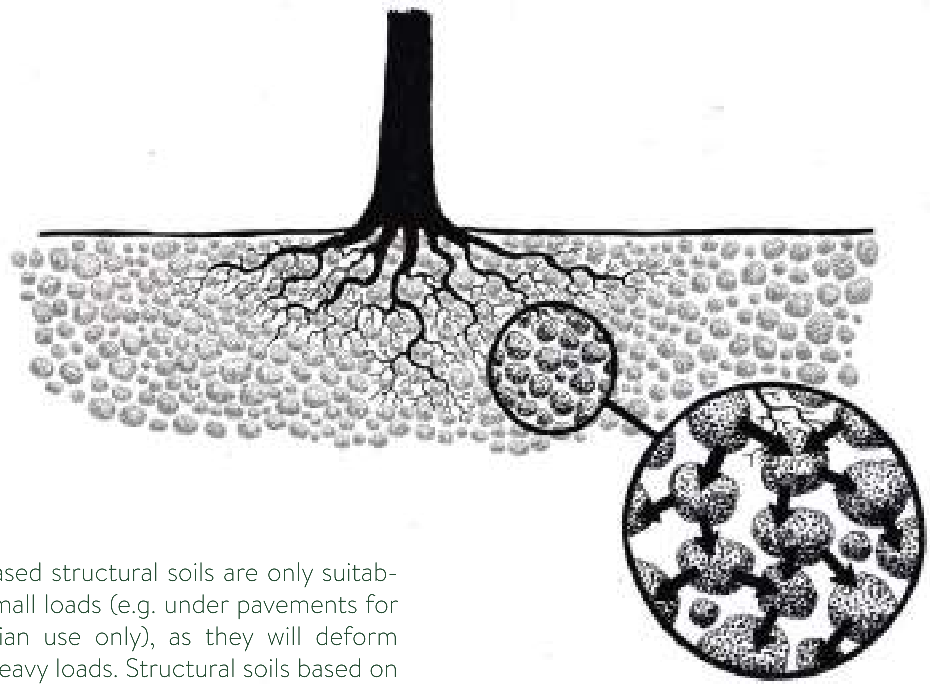

Figure 25: Principle of a structural soil.

6.2.5 Sand-based structural soils are only suitable for small loads (e.g. under pavements for pedestrian use only), as they will deform under heavy loads. Structural soils based on crushed rock are suitable for all load categories without deformation, including heavy traffic.

6.2.6 Structural soils must be installed according to the manufacturer's guidelines. Generally, structural soils must be installed when they are dry and compacted in layers of around 20 cm.

6.2.7 Most of the volume in a structural soil (over two-thirds) consists of the load-bearing matrix. So only about one-third of the volume consists of void space suitable for root growth. This means that structural soils have low efficiency: 10 m^3 of structural soil is the equivalent of around 3 m^3 of good-quality, non-compacted soil.

6.2.8 Structural soils can limit the development of the large structural roots of the tree (depending on the composition). Root pathways are therefore recommended in large planting sites on structural soils.

6.2.9 Structural soils that are in contact with the outside air can have increased evaporation rates, which could be problematic for arid regions.

11 Materials with grains or granules of the same size.

6.3 Pressure distribution systems

6.3.1 Pressure distribution systems can be used to mitigate soil degradation under load, by spreading the load over a larger area and thus lowering peak loads.

6.3.2 Pressure distribution systems generally consist of hollow plastic sandwich panels that are linked together to form a continuous layer under a hard surface.

6.3.3 When connected to the outside air, hollow plastic sandwich panels can contribute to soil aeration under a hard surface.

6.3.4 Pressure distribution systems can also reduce root damage to hard surfaces by spreading root pressure over a larger area.

6.3.5 Hollow plastic sandwich panels can be (partly) filled with high-quality compost or organic soil and act as a nutrient supply for the underlying (structural) soil.

6.4 Soil cells and tree bunkers

6.4.1 Soil cells and tree bunkers are systems used under hard surfaces to separate the load-carrying function from the tree root space. They consist of a hollow load-bearing construction that transfers the load to the underlying soil and is filled with high-quality, non-compacted soil which accommodates tree roots. When these constructions are correctly designed and installed, they are suitable for all load categories, including heavy traffic.

6.4.2 Soil cells consist of prefabricated plastic elements that can be positioned and stacked to form a load-bearing construction. The (reinforced) plastic lids generally need considerable cover in order to bear the highest load categories.

6.4.3 Tree bunkers or tree boxes consist of precast concrete modules that form a load-bearing construction. They are covered with a reinforced concrete lid.

6.4.4 Concrete tree bunkers can be poured on site, using a lost mould made from plastic pipes and covers in the form of a vault. This method is more flexible than precast concrete modules and can be installed around existing trees, as the pillars can be installed in between tree roots, using non-destructive excavation methods.

6.4.5 Due to the settling of the non-compacted soil within the construction, an air layer (artificial secondary ground level) forms below the lid in these systems. This needs to be connected to the outside air to allow for aeration of the soil in the construction.

6.4.6 Irrigation and drainage are major points to consider when designing these systems (see Figure 26).

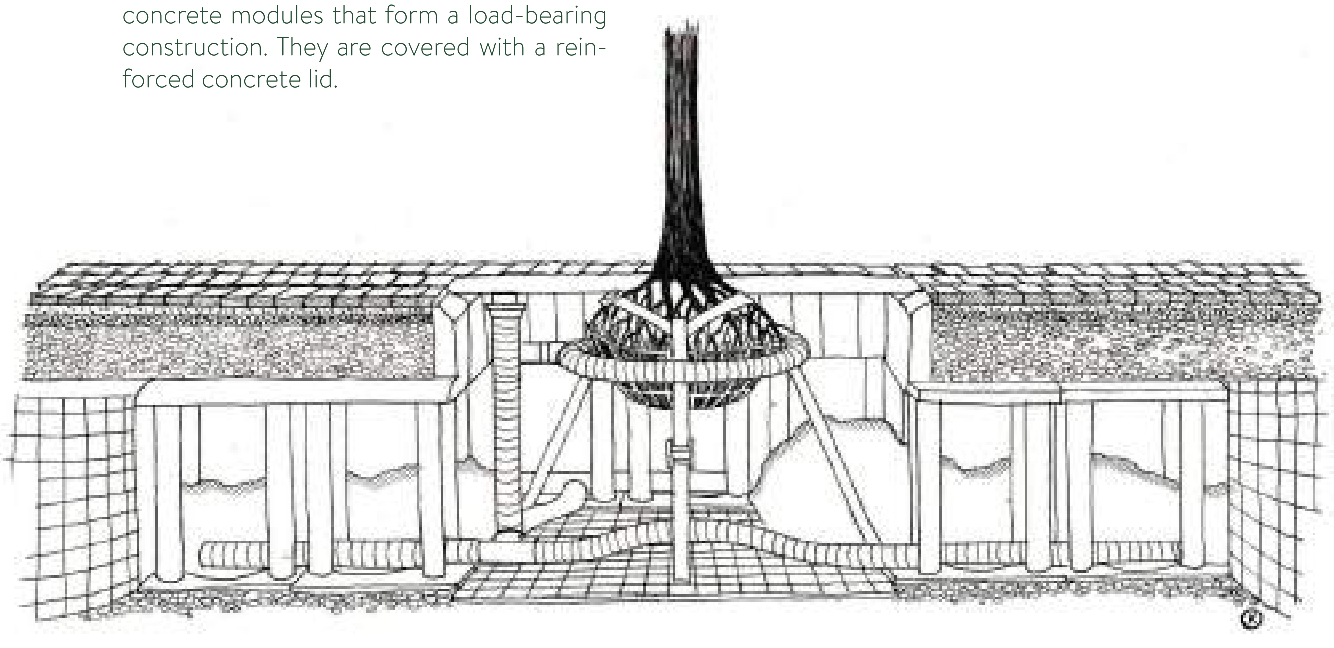

Figure 26: Example of installed soil cells system around a newly planted tree.

6.5 Root bridges

6.5.1 Root bridges or guides are systems that guide root growth away from undesirable areas (e.g. just below the pavement) into a more suitable area (e.g. a structural substrate under the pavement).

6.5.2 Root bridges can be a local solution to an underground problem, e.g. an individual structural root that damages a pavement or driveway that needs to be installed in the root area of the tree.

6.6 Root pathways

6.6.1 Root pathways under hard surfaces are used to guide tree roots to a more appropriate (open) rootable area.

6.6.2 Root pathways are typically narrow trenches of structural soil or plastic/concrete pipes filled with soil which run below a hard surface.

6.6.3 When root pathways are installed in the root zone of existing trees, non-destructive excavation methods must be used.

6.7 Sustainable urban drainage systems (SUDS)

6.7.1 The underground rooting volume of trees in urban areas can have an important role in urban stormwater management, for the benefit of both the trees and the urban water management system.

6.7.2 SUDS include all systems that allow for rainwater infiltration into the soil, mostly in urban green spaces. An additional rainwater supply can improve tree growth. Diverting rainwater to green spaces also alleviates peak pressures on the rainwater drainage or sewage system during heavy rain events, allowing these systems to be more modest in size.

6.7.3 SUDS must be custom designed to function optimally in the given circumstances. They must be dimensioned and designed to have fast permeability in order to work optimally during heavy rain events (so called T20, T30, T50 events, which occur once every 20, 30 or 50 years).

6.7.4 The major point to consider when including tree-growing spaces in SUDS is that the design and dimensioning of the system should focus on avoiding too much water collecting in the tree root volume for extended periods of time. Waterlogged soils will negatively impact a tree's physiological condition and can potentially kill it.

6.8 Aeration systems

6.8.1 The installation of aeration systems might be applicable on (urban) sites where the soil surface is heavily compacted and/or paved, to allow for sufficient gas exchange in deeper soil levels. In open planting spaces, aeration systems are not necessary.

6.8.2 Aeration systems can consist of plastic aeration tubes or holes filled with gravel, reaching to the desired depth (typically around 1 m).

6.8.3 Aeration systems generally get clogged with soil particles after a time and thus have a limited functional lifespan (typically around 5–10 years).

6.8.4 The increased aeration of the soil can also cause increased desiccation. This must be taken into account, especially in arid climates.

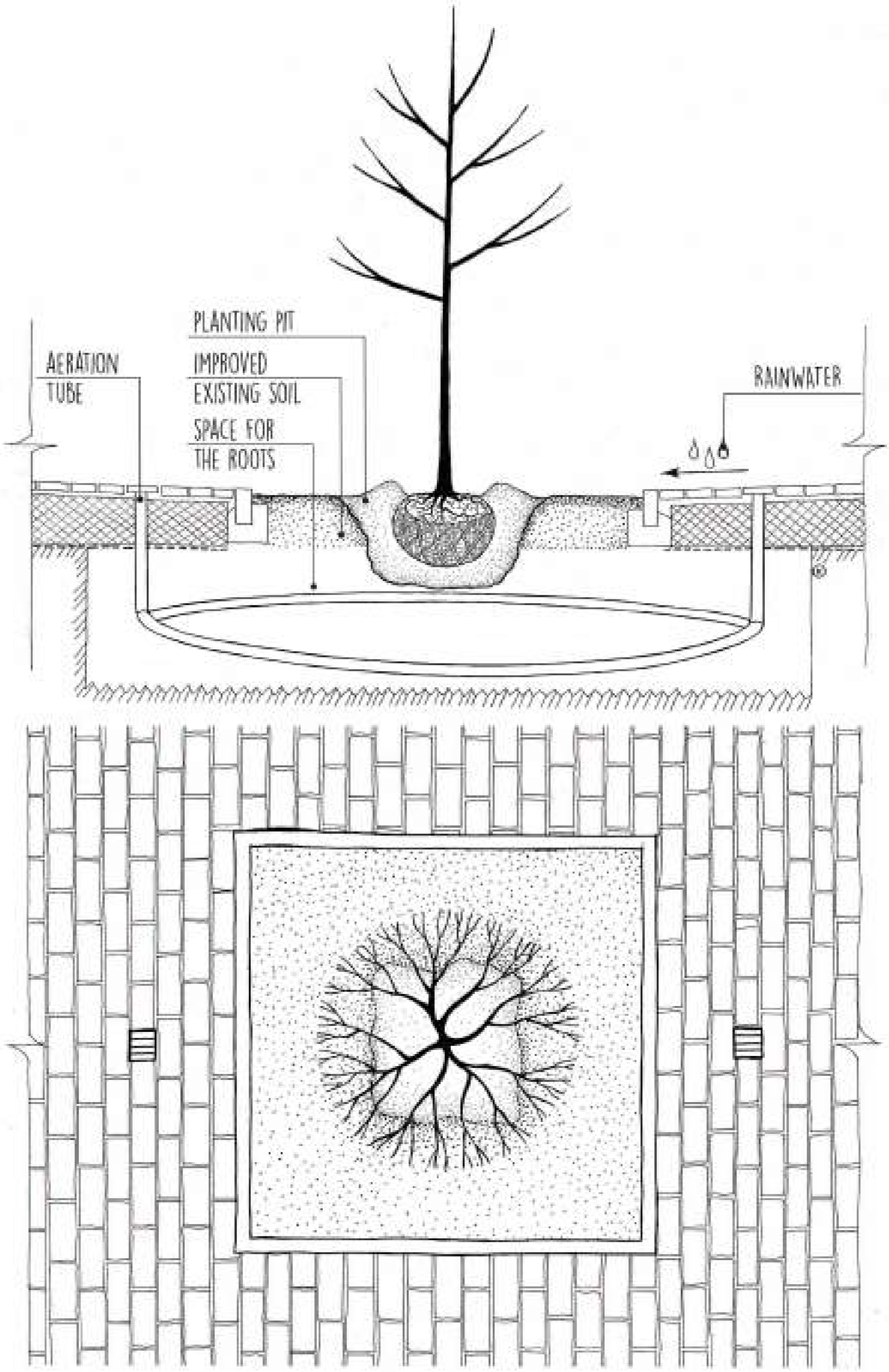

Figure 27: Example of an aeration system.

6.9 Grilles

6.9.1 Grilles are installed as one of the measures to prevent soil compaction in areas with intensive pedestrian traffic.

6.9.2 The size of the grille depends on the target size of the planted tree. For larger trees, split grilles are preferable as they allow the space for the trunk to be enlarged as the tree grows.

6.9.3 The grilles must be fastened in a way that does not prevent roots from growing into the surrounding soil. Grilles are usually mounted on beams laid on footings.

6.9.4 Grilles must be sufficiently permeable for water and air, and must permit inspection of the root area, removal of litter and tree care. They should allow for disassembly, but should be secured against theft.

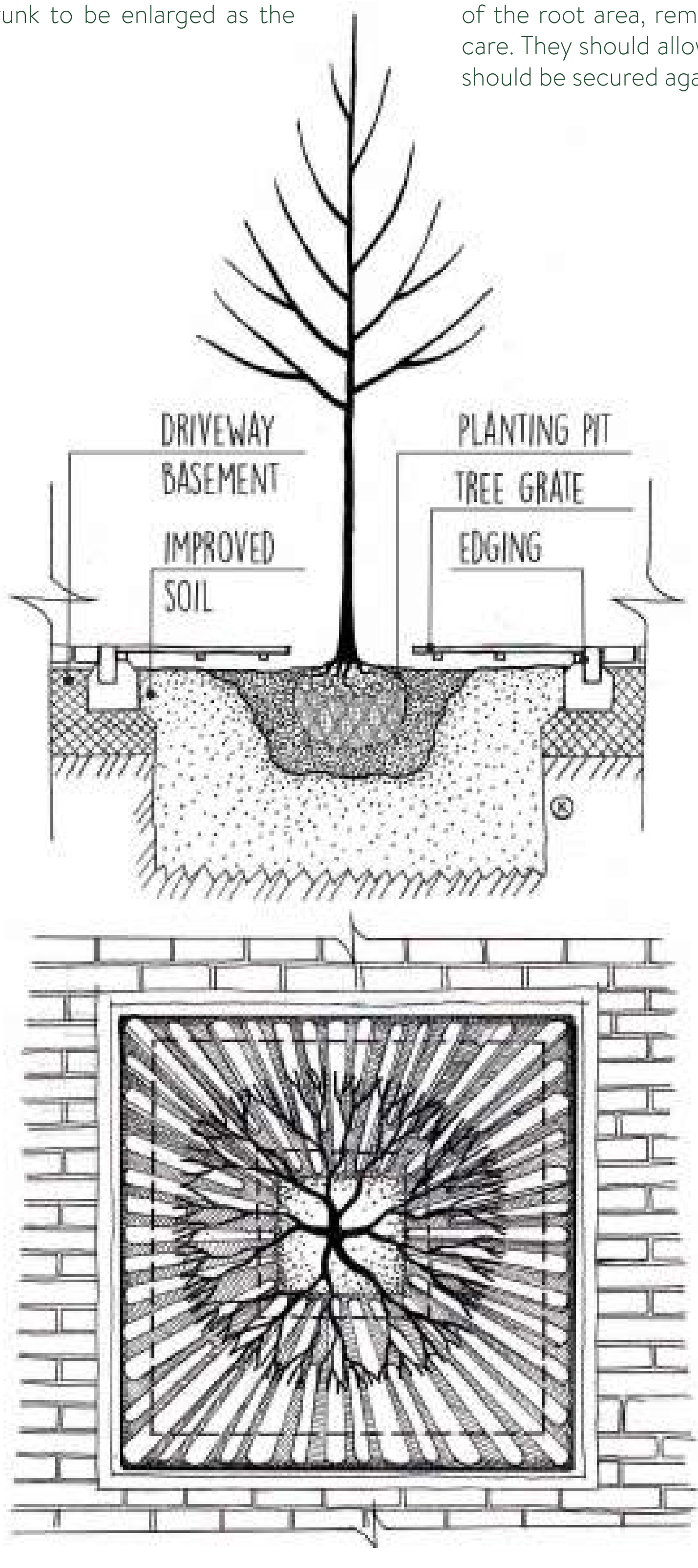

Figure 28: Example of grille installation.

6.10 Modifications of the immediate surroundings of trees

6.10.1 Advantages and disadvantages of specific landscaping around planted trees are summarized in the following overview table.[12]

Criteria	Characteristics	Gravel – Resin -bound	Gravel – Self-binding	Rubber crumb	Asphalt
Tree criteria	Permeability for air and water to reach the rooting volume if correctly maintained	HIGH	MEDIUM	HIGH	LOW
	Flexibility of material	MEDIUM	HIGH	HIGH	MEDIUM
	Risk of damaging young trees if incorrectly installed	HIGH	HIGH	MEDIUM	HIGH
	Risk of damaging established trees if incorrectly installed	LOW	LOW	LOW	MEDIUM
	Risk of damaging young/established trees if unmaintained	MEDIUM	LOW	MEDIUM	MEDIUM
	Potential to improve soil fertility	LOW	LOW	LOW	LOW
	Suitability for installation up to the base of a young tree	LOW	MEDIUM	MEDIUM	LOW
Site criteria	Tolerance to regular pedestrian traffic	HIGH	MEDIUM	LOW	HIGH
	Resistance to street sweeping machines/animal excavation	HIGH	LOW	LOW	HIGH
	Effectiveness at suppressing weed growth	MEDIUM	MEDIUM	LOW	HIGH
	Availability of different colours/styles	HIGH	LOW	LOW	MEDIUM
Installation and maintenance criteria	Suitability for installation immediately after tree planting	MEDIUM	MEDIUM	HIGH	LOW
	Likelihood of requiring a sub-base prior to installation	HIGH	LOW	LOW	HIGH
	Level of experience/competence required to correctly install and maintain	HIGH	MEDIUM	LOW	MEDIUM
	Expected lifespan of material	MEDIUM	MEDIUM	LOW	HIGH
	Whole-life cost of material, including purchase, installation, maintenance and disposal	HIGH	MEDIUM	LOW	LOW

POSITIVE

NEGATIVE

12 LTOA 2015, Surface materials around trees in hard landscapes, London Tree Officers Association, London.

6.11 Root barriers

6.11.1 Root barriers are systems that stop roots from growing into a particular area.

6.11.2 Root barriers can be used for one-sided prevention of root growth (e.g. towards underground utility lines). They must be installed at a sufficient distance from the tree so that they will not impact (future) tree stability.

6.11.3 Installation of root barriers all around the circumference of a tree at close proximity is not advisable as this will compromise the tree's future stability.

6.12 Car protection

6.12.1 Car protection systems are used in areas where vehicles pass and park close to trees.

6.12.2 Any car protection system must be installed so as not to damage the tree (including its root system) and must allow for future tree growth. The system must be anchored sufficiently, outside of the planting pit.

6.12.3 Any restriction on the rootable volume should be minimised. Car protection systems should be installed near an existing tree only after careful root inspection and in a way that avoids substantial root damage.

6.13 Planting in waterlogged soils

6.13.1 When it is impossible or undesirable to improve the hydrology of the site, it is advisable to only use tree species that are tolerant to waterlogged soils and high groundwater levels rather than relying on drainage (which generally has a limited functional lifespan).[13]

6.13.2 To aid establishment of a young tree, it can be planted above the soil level, in a raised planting pit. This creates slightly dryer local conditions for the tree to get settled and avoids the root ball being waterlogged.

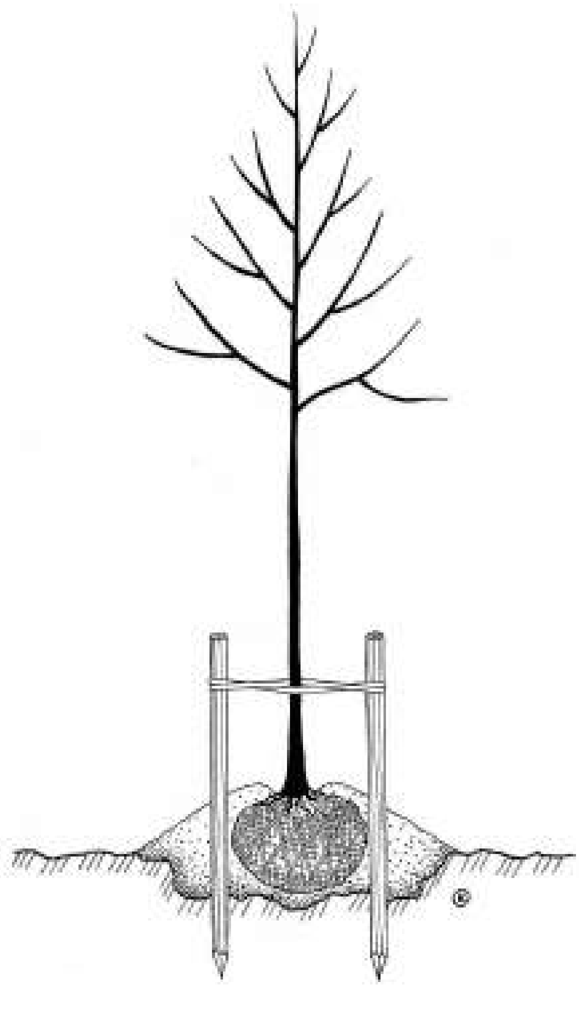

Figure 29: Example of planting a tree on a waterlogged site.

13 For example *Populus* (section Nigra), *Salix*, *Alnus*, *Taxodium*, *Metasequoia* etc.

7. Post-planting tree care

7.0 Introduction

7.0.1 Completion management proceeds from planting to handover and acceptance by the contracting authority.

7.0.2 Development management proceeds from handover and focuses on minimising post-transplant shock. In a reduced form, this continues throughout the tree's further growth until it becomes fully functional.

7.0.3 Development management is followed by standard tree management, which is provided throughout the tree's life.

7.1 Inspection and removal of anchoring and protection

7.1.1 Above-ground anchoring systems must be inspected at least once a year for at least 2 years. Inspection includes repairs or adjustments to prevent damage to the trunk and to ensure optimal functioning. Anchoring is usually removed within 3 years.

7.1.2 Trunk protection should be inspected at least once a year. It should be repaired and loosened. Coating and spraying against browsing damage should be renewed annually.

7.1.3 Shading mats are usually removed after 2 years; they can be left for longer period in justified cases (e.g. along roads with chemical winter maintenance regimes).

7.1.4 Protection from browsing, gnawing and antler damage should be maintained for longer (until the tree produces a coarser bark), particularly in sensitive tree species such as apples (*Malus* spp.).

7.2 Tree pruning

7.2.1 Pruning interventions, where required, should not start until at least 1–2 growing seasons after planting.

7.2.2 The focus and scope of pruning interventions are defined by EAS 01:2021 – European Tree Pruning Standard.

7.3 Water supply

7.3.1 The irrigation wall must be maintained for at least 2 years, or throughout the irrigation period.

7.3.2 Irrigation should be provided for the period required to minimise post-transplant shock.[14] This rule does not apply to extreme sites, where specific conditions dictate provision of irrigation until proper rooting takes place. In some cases (e.g. sites without a connection between the root volume and natural ground), irrigation will be required throughout the entire existence of the tree on the site.

7.3.3 Soil moisture should be checked before irrigation.

7.3.4 Irrigation must be adjusted to the climatic conditions, the site (e.g. the effect of site exposure to wind or sunshine), current weather, the size of tree planted, soil moisture, date of execution (some species require abundant watering before winter) and taxon-specific requirements. Higher-frequency irrigation is needed in the first year; frequency decreases in the following years. Some trees need to be irrigated in the summertime for the first 3–5 years.

7.3.5 Water should penetrate the depth of the rootable volume (depending on tree size) throughout the planting pit. This must be reflected in the quantity of water in each water delivery.

[14] The length of the post-transplant shock can be determined approximately as 1 year per 8 cm of trunk circumference (rounded upwards).

7.4 Weeding

7.4.1 Weeds are natural plants which can be important for site biodiversity and phytopathology. If necessary, weeding is done to remove undesirable plants from the planting area.

7.4.2 Weeding should be done using purely mechanical removal methods. Chemical weeding is not advisable.

7.4.3 In mechanical weeding, undesirable plants are:
- plucked,
- the above-ground portion is separated from the roots by hoeing,
- the weeds are mowed.

7.4.4 The work must always be carried out carefully to avoid damage to the root collar or the roots of the tree.

7.5 Protection against pests and diseases

7.5.1 The overall condition of the trees must be regularly inspected during the growing period.

7.5.2 If any symptoms of pest/disease infestation are detected, the organism must be identified and adequate measures must be taken, depending on its type and the degree of threat it poses.

7.6 Mulch replenishment

7.6.1 Natural products (particularly of organic origin) used for mulching gradually decompose and should be replenished during post-planting care.

7.6.2 Mulch replenishment up to the original level should be carried out once a year, ideally at the beginning of the growing season.

8. Palm tree planting

8.1 Palm tree specifics

8.1.1 Palms have an adventitious root system composed of numerous fibrous primary roots with little branching. These roots arise continuously from the root initiation zone at the base of stem.

8.1.2 For most species, a root ball of 30 cm radius (off the stem) and 30 cm deep is adequate for small palms. Big palms (trunk height > 1.5 m) need a deeper root ball (normally > 80–100 cm) and a radius of 30 cm from the surface of the trunk. Above a certain height (1 m of trunk) the root ball size does not increase with the height; palm crowns are constant so the root ball can be the same.

8.1.3 Palms planted as street trees must have adequate trunk height to allow the leaves to reach over the required clearance (normally > 3.5 m).

8.1.4 Palms should not be planted in a container, except in special cases where temporary planting in a container is acceptable (for up to 6 months).

8.1.5 The stem diameter of a palm tree depends on its physiology. Temporary reduction in vitality results in a portion of the trunk with a smaller diameter. Nursery conditions must be appropriate to develop the full stem diameter, depending on palm species.

8.2 Palm planting procedure

8.2.1 The small size and weight of a palm's root ball offers no means of lifting by the ball. Palms are transported by a strap or sling placed on the trunk just above the estimated balance point. Adequate padding must be used. Palms are commonly planted at larger sizes than normal trees.

8.2.2 For most palm species, 5 cm of root initiation zone (often visible as a portion of the trunk, where roots form above ground) should remain above the soil surface. Some palms make adventitious roots higher than the collar. These roots should not be buried.

8.2.3 In sandy soils (aerobic conditions) palms can be planted at varying depths to level crown heights. However, in normal soils (not sandy), palms are very sensitive to anaerobic conditions and deeply planted palm trees can die (or struggle). Also, specific fungi (*Thielaviopsis* sp.) can affect palm wood and cause their static failure years later.

8.2.4 It is not necessary to remove fronds from **container-grown palms** at planting. Careful protection of the terminal bud is essential. To prevent frost damage or desiccation of the meristematic tissues, palm leaves must remain attached.

8.2.5 For **field-dug palms**, some or all fronds can be removed before transport to reduce transpirational water loss. Especially for sabal palm (*Sabal palmetto*), this improves survival of planted trees.

8.2.6 Large palms should be supported by props or guys after planting. No nails, screws or mechanical devices may be inserted into the trunk.

8.2.7 Palms have similar planting requirements to trees. Plantations (nurseries) must let palms to grow normally as fast as possible, because existence of periods with limited growing conditions implies that trunk cannot reach the normal diameter. This affects the future stability of palms (specially in *Phoenix dactylifera*).

8.2.8 Palms come from different climate zones. Planting must respect the palm's ecological zoning.

8.2.9 Planting operations must be carried out during the period with high temperatures (April to August/September).

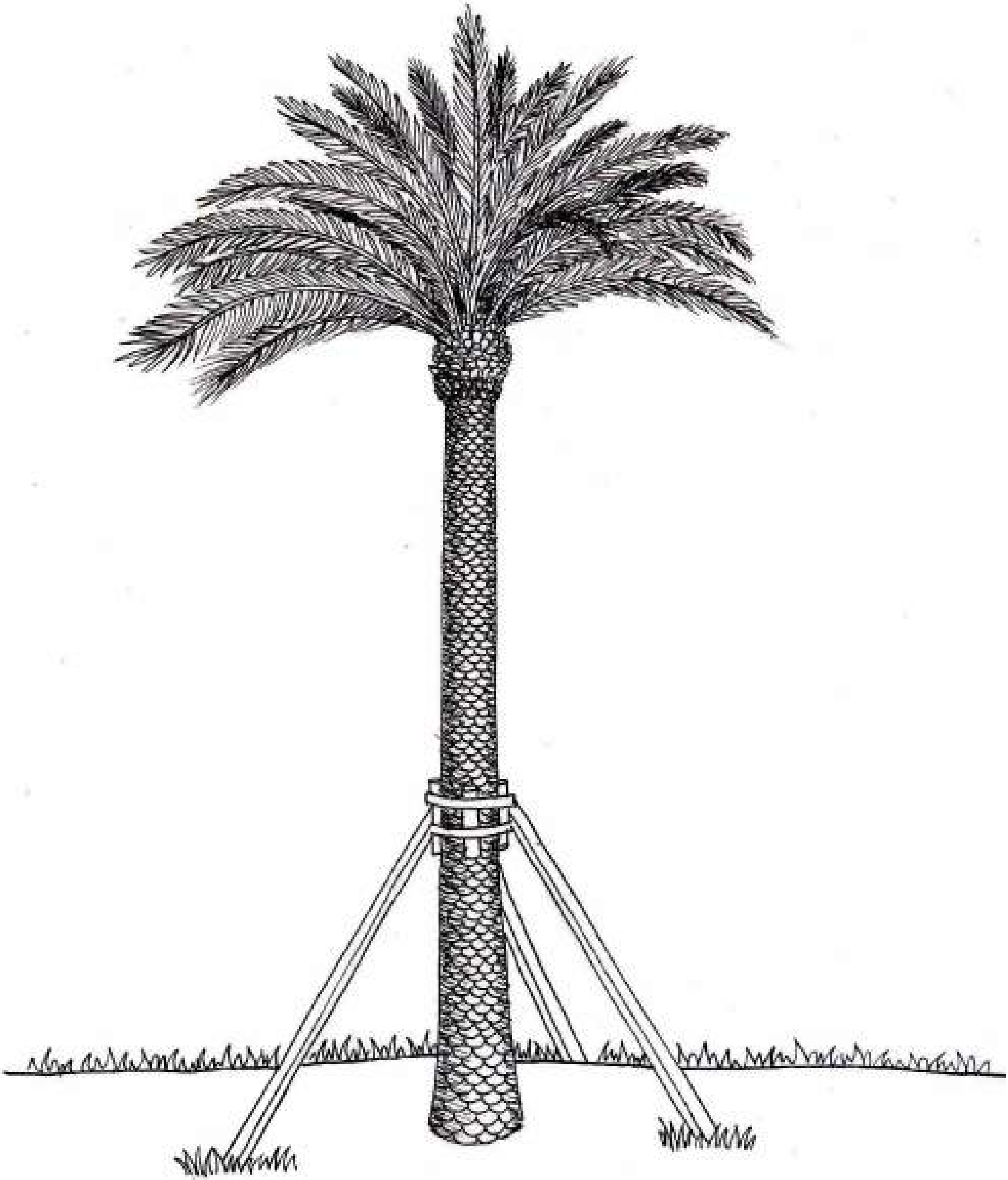

Figure 30: Example of supporting a palm tree.

APPENDICES

9.1 Appendix 1: List of trees and tree-formed shrubs tolerant of alkaline soils (above pH 7)

Latin name	Common name
Acer campestre	Field maple
Amygdalus communis (Prunus amygdalus)	Almond
Armeniaca vulgaris (Prunus armeniaca)	Tibetan apricot
Calocedrus decurrens	Incense cedar
Carpinus betulus	Common hornbeam
Cedrus atlantica	Atlas cedar
Cedrus libani	Lebanon cedar
Cerasus avium (Prunus avium)	Wild cherry
Cerasus mahaleb (Prunus mahaleb)	Mahaleb cherry
Cornus mas	European cornel
Cupressocyparis × leylandii	Leyland cypress
Elaeagnus angustifolia	Russian olive
Fagus sylvatica	European beech
Fraxinus excelsior	Common ash
Fraxinus ornus	Manna ash
Ginkgo biloba	Ginkgo
Juglans regia	Persian walnut
Koelreuteria paniculata	Varnish tree
Laburnum anagyroides	Common laburnum
Larix decidua	European larch
Morus alba	White mulberry
Morus nigra	Black mulberry
Ostrya carpinifolia	European hop-hornbeam
Paulownia tomentosa	Foxglove tree
Picea omorika	Bosnian spruce
Pinus heldreichii	Bosnian pine
Pinus nigra	Black pine
Pinus ponderosa	Western yellow pine
Platanus × hispanica	London planetree
Platycladus orientalis (Thuja orientalis)	Oriental arborvitae
Populus alba	Silver poplar
Populus simonii	Simon poplar
Pyrus pyraster	European wild pear
Quercus frainetto	Hungarian oak
Quercus pubescens	Downy oak
Rhamnus cathartica	Common buckthorn
Robinia pseudoacacia	Black locust
Salix alba	White willow
Salix babylonica	Weeping willow
Salix daphnoides	European violet willow
Sophora japonica	Japanese pagoda tree

Latin name	Common name
Sorbus aria	Common whitebeam
Tamarix spp.	Tamarisk
Taxus baccata	European yew
Tilia platyphyllos	Large-leaved lime
Ulmus glabra	Wych elm
Ulmus laevis	Spreading elm
Ulmus minor	Field elm

References:

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.

KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323- 117-4.

9.2 Appendix 2: List of trees and tree-formed shrubs tolerant of acidic soils (below pH 4)

Latin name	Common name
Abies alba	European silver fir
Abies grandis	Grand fir
Abies homolepis	Nikko fir
Abies koreana	Korean fir
Abies nordmanniana	Caucasian fir
Abies procera	Noble fir
Abies veitchii	Veitch's fir
Acer saccharinum	Silver maple
Betula pendula	Silver birch
Betula pubescens	Downy birch
Castanea sativa	Sweet chestnut
Chamaecyparis nootkatensis	Nootka cypress
Chamaecyparis pisifera	Sawara cypress
Juniperus chinensis	Chinese juniper
Juniperus communis	Common juniper
Juniperus virginiana	Virginian juniper
Larix sibirica	Siberian larch
Liriodendron tulipifera	Tulip tree
Magnolia spp.	Magnolia
Nyssa sylvatica	Black tupelo
Padus avium (Prunus padus)	European bird cherry
Picea abies	Norway spruce
Picea glauca	White spruce
Picea mariana	Black spruce
Picea sitchensis	Sitka spruce
Pinus banksiana	Jack pine
Pinus cembra	Swiss pine
Pinus koraiensis	Korean pine
Pinus parviflora	Japanese white pine
Pinus sylvestris	Scots pine
Pinus uncinata ssp. *uliginosa*	Mountain pine
Populus tremula	Quaking aspen
Pseudolarix amabilis (P. kaempferi)	Golden larch
Quercus palustris	Pin oak
Quercus rubra	Northern red oak
Salix pentandra	Bay willow
Sciadopitys verticillata	Japanese umbrella-pine
Sorbus aucuparia	Mountain ash
Taxodium distichum	Swamp cypress
Tsuga canadensis	Eastern hemlock
Tsuga heterophylla	Western hemlock

References:

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.
KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323-117-4.

9.3 Appendix 3: List of tree species sensitive to salinity

Latin name	Common name
Abies spp.	Fir
Acer negundo	Ash-leafed maple
Acer pensylvanicum	Striped maple
Acer platanoides	Norway maple
Acer pseudoplatanus	Sycamore
Acer rubrum	Red maple
Acer saccharinum	Silver maple
Acer saccharum	Sugar maple
Aesculus × carnea	Red horse chestnut
Aesculus hippocastanum	Horse chestnut
Alnus spp.	Alder
Betula spp.	Birch
Carpinus betulus	Common hornbeam
Castanea sativa	Sweet chestnut
Catalpa bignonioides	Southern catalpa
Cedrus atlantica	Atlas cedar
Cercidiphyllum japonicum	Katsura tree
Cercis canadensis	Judas tree
Cornus mas	Cornelian cherry
Corylus colurna	Turkish hazel
Chamaecyparis spp.	Cypress
Crataegus laevigata	Midland hawthorn
Crataegus × lavallei	Hybrid cockspur thorn
Crataegus monogyna	Single-seeded hawthorn
Fagus sylvatica	European beech
Juglans spp.	Walnut
Laburnum × watereri ‚Vosii‘	Voss's laburnum
Larix decidua	European larch
Liquidambar styraciflua	American sweetgum
Liriodendron tulipifera	Tulip tree
Magnolia spp.	Magnolia
Malus spp.	Apple
Mespilus germanica	Common medlar
Metasequoia glyptostroboides	Dawn redwood
Morus alba	White mulberry
Picea spp.	Spruce
Pinus cembra	Swiss pine
Pinus peuce	Macedonian pine
Pinus strobus	Weymouth pine
Pinus sylvestris	Scots pine
Pinus uncinata	Mountain pine
Platanus × hispanica	London plane
Populus balsamifera	Balsam poplar
Populus nigra	Black poplar

Latin name	Common name
Populus simonii	Simon poplar
Populus tremula	Quaking aspen
Prunus spp.	Plum
Pseudotsuga menziesii	Douglas fir
Quercus rubra	Northern red oak
Sorbus spp.	Rowan
Taxodium distichum	Swamp cypress
Taxus baccata	European yew
Thuja spp.	Arborvitae
Tilia spp.	Lime
Tsuga canadensis	Eastern hemlock
Ulmus glabra	Wych elm

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9.4 Appendix 4: List of invasive tree species[15]

Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.

Acacia saligna
Ailanthus altissima
Prunus serotina

15 National/regional regulations apply.

9.5 Appendix 5: Minimum rootable volumes required for trees

Tree size class	Expected turnaround time (age)	Minimal rooting volume in normal soil, with groundwater contact[16]	Minimal rooting volume in normal soil, without groundwater contact[16]
Tree > 16 m height	80–120 years	40 m^3	70 m^3
	60 years	30 m^3	50 m^3
	40 years	20 m^3	35 m^3
	20 years	10 m^3	20 m^3
Tree 8-16 m height	60 years	25 m^3	40 m^3
	40 years	12 m^3	25 m^3
	20 years	7 m^3	15 m^3
Tree < 8 m height	not defined	10 m^3	20 m^3
Pollard tree	not defined	5 m^3	8 m^3

Table: Indicative minimum tree rootable volumes for normal soil. (For poor soil or structural soil, the minimum rootable volumes must be raised according to the equivalent mineral and water holding capacity of the substrate.)

16 Groundwater contact refers to a situation where a tree can access the groundwater table for the entire growing season (groundwater table typically between 1 and 2 meters below ground), so water is not a limiting factor for its growth. Without groundwater contact, a tree must rely on the water holding capacity of the soil, making water a limiting factor for its growth. The required soil volume is larger in this situation.

9.6 Appendix 6: List of tree species (examples) according to expected crown size in maturity

Large-crown tree species (>16 m height)	
Acer platanoides	Norway maple
Acer pseudoplatanus	Sycamore
Acer saccharinum	Silver maple
Aesculus hippocastanum	European horse chestnut
Cedrus libani	Lebanon cedar
Celtis occidentalis	Hackberry
Fagus sylvatica	European beech
Fraxinus excelsior	Common ash
Juglans cinerea	Butternut
Juglans nigra	Eastern black walnut
Liquidambar styraciflua	Sweetgum
Platanus spp.	Plane tree
Quercus spp.	Oak
Salix alba	White willow
Ulmus spp.	Elm

Medium-crown tree species (8–16 m height)	
Abies spp.	Fir
Acer negundo	Ash-leafed maple (Box Elder)
Aesculus x flava	Yellow buckeye
Alnus glutinosa	Black alder
Betula pendula	Silver birch
Catalpa ovata	Chinese catalpa
Ginkgo biloba	Ginkgo tree
Phellodendron amurense	Amur cork tree
Picea abies	Norway spruce
Pinus spp.	Pine
Robinia pseudoacacia	Black locust
Sorbus domestica	Service tree
Tilia spp.	Lime

Small-crown tree species (<8 m height)	
Abies veitchii	Veitch's silver-fir
Chamaecyparis pisifera	Sawara cypress
Juniperus spp.	Juniper
Malus spp.	Apple tree
Picea mariana	Black spruce
Sorbus spp.	Whitebeam
Thuja occidentalis	White cedar

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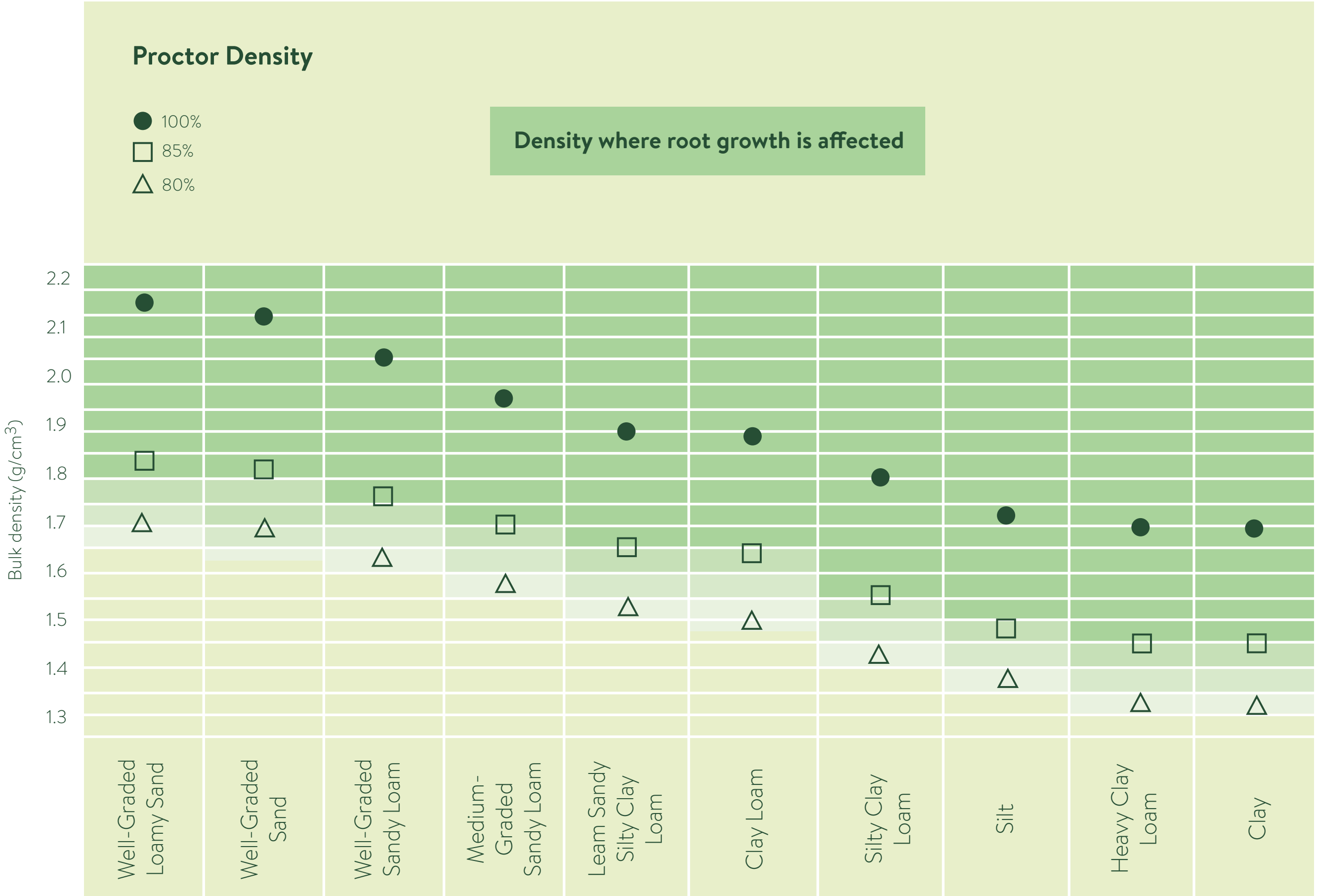
9.7 Appendix 7: Relationship of Proctor density to bulk density of soils



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9.8 Appendix 8: Indicative list of tree species according to strategy model

Strategy model A	Strategy model B	Strategy model C
Abies spp.	*Acer saccharinum*	*Acer pensylvanicum*
Acer pseudoplatanus	*Acer saccharum*	*Albizia julibrissin*
Aesculus spp.	*Ailanthus altissima*	*Carpinus* spp.
Alnus spp.	*Fraxinus pennsylvanicum*	*Fagus* spp.
Betula spp.	*Quercus robur*	*Gleditsia triacanthos*
Castanea sativa		*Morus* spp.
Fraxinus excelsior		*Nothofagus antarctica*
Juglans spp.		*Phellodendron amurense*
Liriodendron tulipifera		*Pterocarya fraxinifolia*
Pinus spp.		*Robinia pseudoacacia*
Platanus spp.		*Tilia* spp.
Populus spp.		*Toona sinensis*
Prunus avium		*Tsuga canadensis*
Salix alba		*Ulmus* spp.
		Zelkova serrata

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ABBREVIATIONS

CE	Conformité Européenne (administrative marking that indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area)
EAC	European Arboricultural Council
EAS	European Arboricultural Standards
ETT	European Tree Technician
ETW	European Tree Worker
EU	European Union
ISA	International Society of Arboriculture
pH	potential of hydrogen (pondus hydrogenii)
PPE	personal protective equipment
SSRA	Site-specific Risk Assessment
SUDS	Sustainable urban drainage systems
TeST	Technical Standards in Treework

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