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NATURE AND LANDSCAPE MANAGEMENT STANDARDS

ARBORIST STANDARDS	ALTERATION OF TREE AND SHRUB HABITATS	SPPK A02 007:2020
SERIES A		

Úprava stanovištních poměrů dřevin

Strauch- und Baumstandort optimierung

This standard is designed to define technical and work procedures for alternation of habitats for trees and shrubs growing in non-forest environments.

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Decree no. 377/2013 Coll. on storage and use of fertilisers, as amended.
Decree no. 474/2000 Coll., defining requirements for fertilisers, as amended.
Decree no. 83/1996 Coll. on Development of territorial forest development plans and definition of management units.

Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended.
Act no. 156/1998 Coll. on fertilizers, auxiliary soil agents, auxiliary plant preparations and substrata, and on agrochemical testing of agricultural soils (Fertilisers Act), as amended.
Act no. 185/2001 Coll. on Waste and on amendment of certain acts, as amended.
Act no. 258/2000 Coll. on Public Health Protection and on amendment of certain acts, as amended.
Act no. 326/2004 Coll. on Phytosanitary Care and on amendment of certain acts, as amended.
Act no. 334/1992 Coll. on Agricultural Land Fund Protection, as amended.
Act no. 44/1988 Coll. on Protection and Use of Mineral Resources (Mining Act), as amended.
Act no. 89/2012 Coll., the Civil Code, as amended.

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Developed for the NCA CR by the Faculty of Forestry and Wood Technology, Mendel University in Brno, in 2014–2019.
External examiner:
Faculty of Horticulture and Landscape Engineering, Slovak Agricultural University in Nitra.
Authorial collective:
Ing. Aleš Kučera, Ph.D., David Hora, DiS., Prof. Ing. Klement Rejšek, CSc., Ing. Jaroslav Kolařík, Ph.D., doc. Ing. Pavel Šimek, Ph.D., Ing. Petr Kotyza, DiS., Ing. Miroslav Ezechel, Ing. Barbora Vojáčková, DiS.
Illustrations:
Mgr. Alena Klimešová, DiS.

Documentation for the standard development is available in the NCA CR library.
Standard approved by:

RNDr. František Pelc
Director of NCA CR

Contents

1 Purpose and contents of the standard

1.1 Standard purpose

1.1.1 The standard "*Alteration of tree and shrub habitats*" defines interventions in habitat conditions of existing non-forest trees and shrubs in order to optimise them. Among the habitat conditions, the standard only deals with the soil environment.

1.1.2 The standard does not deal with large-scale land reclamation or large-scale land alteration, e.g., after mining.

1.1.3 The standard does not deal with special techniques for cultivation of trees and shrubs under extremely limited habitat conditions, such as growing containers, roof gardens, hydroponics, etc.

1.1.4 The standard designs assessment of current status and proposes alterations and improvement of habitat conditions.

1.2 Qualifications of persons

1.2.1 Designs for intervention in habitat conditions of trees and shrubs should be made by professionally qualified persons educated in the area of horticulture, forestry or agriculture at least at the level of completed secondary school in the discipline.

1.2.2 Persons handling herbicides and arboricides have to meet requirements for professional qualification for handling plant protection products pursuant to Section 86 of Act no. 326/2004 Coll. and Decree no. 206/2012 Coll. and attain at least the first degree of professional qualification.

1.2.3 Laboratory jobs on collected soil samples have to be entrusted to either an accredited laboratory or a university laboratory. The laboratory should meet general requirements for qualifications of test and calibration laboratories pursuant to ČSN EN ISO/IEC 17025 for the purposes of analysis of soils, substrates and organic materials.

1.3 Legal framework

1.3.1 **Act no. 114/1992 Coll.** on Nature and Landscape Protection defines the legal framework for protection of non-forest trees and shrubs. Pursuant to Section 7, Para. 1 of the Act, trees and shrubs are protected from damage and destruction. Memorial trees and specially protected species (hereinafter, SPS) are subject to stricter protection (Sections 46 and 48 of the Act). Moreover, trees and shrubs protected pursuant to special legal regulations are exempt from general protection under Section 7. Damaging non-forest trees and shrubs is a misdemeanour.

1.3.2 **Decree no. 189/2013 Coll.** on tree protection and felling permission, Section 2 defines unpermitted interventions in trees and shrubs that are in contravention of requirements for their protection. They include interventions causing damage or destruction to trees and shrubs which lead to substantial or permanent reduction in their ecological or social functions or cause their immediate or subsequent death. An intervention is not unpermitted if done for the purpose of retention or improvement of a function of a tree or shrub, as part of management of a specially protected plant or animal species, or done in accordance with the management plan of a specially protected area.

1.3.3 **Act no. 156/1998 Coll.** on Fertilisers. Organic fertiliser, as a result of a composting process, that is brought into circulation, has to meet criteria for registration pursuant to the Act. The basic characteristics and parameters of compost as organic fertiliser are defined by requirements for standard fertiliser in Annex 3 to Decree no. 474/2000 Coll., as amended, under type number 18.1. The contamination parameters for compost for agricultural uses are defined by the same Decree.

1.3.4 **MoE Methodological Instruction on Pollution Indicators (2014).** The Instruction criteria should be met by artificially produced land reclamation materials in connection with the specific site and with respect to the target use of the area. The Methodological Instruction uses the term earths to cover rocks, soils and anthropogenic backfills, and is recommended by the MoE primarily for assessment of contamination of soils, groundwater, soil gases (soil air) and construction substances in connection with their use for land reclamation jobs, landscaping and similar activities.

1.3.5 **Decree no. 153/2016 Coll.** on details on protection of agricultural soil quality and on amendment to Decree no. 13/1994 Coll., specifying some detail on agricultural land fund protection. Annex 1, Fig. 1 and 2 And Annex 2, Tables 2, 3 and 4 define preventive and indicative values of contents of hazardous elements and substances in soil. Annex 4 defines the procedure for collection of soil samples and minimum numbers of mixed samples to be collected depending on the size of the area studied.

1.3.6 **Act no. 326/2004 Coll.** on Phytosanitary Care and on amendment of certain acts. Sections 86, 86a and 86b define professional qualifications for handling plant protection products.

1.3.7 **Decree no. 2006/2012 Coll.** on professional qualification for handling of products. Defines methods and extent of examinations taken for obtaining professional qualification.

2 Terms and definitions for the purposes of the Standard

2.1 **Basic saturation –** degree of saturation of the soil sorption complex with basic cations.

2.2 **Wilting point** – soil hydraulic limit expressing the water content no longer accessible to plants.

2.3 **Degraded soil** – seriously deteriorated soil in terms of plant growth possibility.

2.4 **Non-forest trees and shrubs** – trees or shrubs growing individually or in groups in open country and settled areas on plots not registered as forest land.

2.5 **Horizon** – discernible soil layer produced by either a pedogenic (soil-formation) process or material accumulation.

2.6 **Humus** – soil organic matter of different degrees of transformation and stability. Typically of a dark colour.

2.7 **Hydraulic conductivity** – ability of a liquid (soil solution) to pass through the solid soil phase.

2.8 **Infiltration** – descending direction of entry of water into soil. For the purposes of this Standard, it means infiltration of water into soil.

2.9 **Cation exchange capacity** – total maximum amount of cations that can be bound to the soil sorption complex.

2.10 **Consistency** – physical property of soil expressing its compactness (cohesiveness of soil particles).

2.11 **Root path** – well aerated linear soil segment serving growth of roots underneath structures in order to connect different rootable areas.

2.12 **Tree root zone** – area of soil surface under a tree crown defined for natural crown shapes by the circumference of a circle 1.5 m larger in radius than the radius of the plan view projection of the crown; for columnar shapes, the radius of the plan view projection is increased by up to 5 m depending on the taxon and age.

2.13 **Maximum capillary capacity** – soil hydraulic limit expressing volume shares of capillary and a part of semicapillary pores.

2.14 **Mineral substrates** have a minimal share of organic components (up to 10%) and a prevailing share of non-nourishing particles such as sand, gravel or other materials (ceramic rocks, expanded clay, recycled brick, etc.).

2.15 **Minimum structurally important root plate –** circle around the trunk of an adult tree the radius of which equals the trunk diameter.

2.16 **Minimum air capacity** – volume of soil pores not filled with water if soil is saturated with water up to the maximum capillary capacity. Expresses the volume share of non-capillary pores.

2.17 **Non-destructive excavation method** – method of removing earth from the tree root area without damaging the roots. The most common method is the supersonic spade (syn. Air Spade), applying compressed air, or systems that wash the roots with pressurized water.

2.18 **Organic substrates –** substrates with a prevalence of organic components (notably compost, composted bark, peat) that can be used for soil improvement in the upper layer 200–400 mm. Compost added to substrates has to be well decomposed.

2.19 **Soil reaction (pH)** uses concentration of acidic ions (incl. hydrogen H^+) to express the degree of acidity, neutrality or alkalinity of the soil solution or soil infusion, either in water (pH/H_2O) as active soil reaction, or in 0.2M KCl (or 0.01M $CaCl_2$) as potential exchange soil reaction.

2.20 **Rootable area** – area usable for growth of the plant root system; its volume has to be sufficient to permit the taxon individual to attain its adult size without dependence on additional irrigation or nutrition. The rootable area comprises earth meeting requirements for soil vegetation layer.

2.21 **Redoximorphic features –** features typical or alternating oxidising and reducing conditions, such as marbling (alternating brown and grey-blue patches) and formation of manganoferrous pellets (neoformations).

2.22 **Reductomorphic features –** features typical of stagnant water and permanently reducing conditions in soil: continuous grey-blue colour with a low share of rusty oxidised patches.

2.23 **Water retention capacity** – soil hydraulic limit expressing volume shares of capillary pores.

2.24 **Shared rootable area –** area for routing technical utilities and existing or future rootable area of trees.

2.25 **Skeleton** – solid soil particles or mineral origin sized above 2 mm.

2.26 **Irrigation bowl** (syn. root bowl, watering basin) – adjusted surface in immediate vicinity of tree base producing best possible conditions for water infiltration and soil air exchange, frequently the same size as the planting hole.

2.27 **Structure** – mutual arrangement of soil particles.

2.28 **Structural substrates –** substrates with a high share of skeleton (gravel particles) up to 80% that permit root growth even after compaction required for structural carrying capacity.

2.29 **Substrate** – artificial mixture of inorganic and organic materials with appropriate biological, physical and chemical properties suitable for plant growth and development.

2.30 **Texture (grain)** – percentage of grain fractions of clay (< 0.002 mm), dust (0.002–0.05 mm) and sand (0.05–2 mm). Defines the **soil type**.

2.31 **Soil vegetation layer** – topmost soil layer, suitable for plant growth with a view to its composition and properties; it can be the top layer of soil of the original genetic horizon or newly spread top layer of soil, substrate, etc.

2.32 **Planting site –** place intended for planting a tree (most commonly in a street profile) irrespective whether existing or designed.

2.33 **Planting strip –** continuous strip delineated in a street area providing minimum space necessary for future establishment of a street avenue.

2.34 **Usable water capacity** – water content in soil expressed in mm between the wilting point and the water retention capacity for 20 cm of soil.

3 Properties and parameters of rootable area

3.1 Indicators for assessing quality of rootable area

3.1.1 The rootable area comprises soils and substrates, the quality of which conforms to the below qualitative parameters and characteristics for the soil vegetation layer (see Annex 1).

3.1.2 Rootable area quality is assessed using parameters comprising physical, physical-chemical and chemical properties identified in soils and organic substrates.

3.1.3 The parameters are identified by:
- a) research (from existing studies on the site, if any),
- b) field survey,
- c) laboratory examination.

3.1.4 **Field survey** identifies parameters:
- a) using visual characteristics,
- b) using approximate indication techniques using chemicals,
- c) using field instruments.

3.1.5 **Laboratory examination** identifies parameters if required by the task. The determination concerns primarily:
- physical and hydrophysical parameters and water-to-air ratios,
- physical-chemical and chemical parameters,
- suspicion of contamination with hazardous elements and substances,
- suspicion of contamination with herbicides.

3.1.6 **Physical and hydrophysical properties** of soils:

3.1.6.1 Specific weight. The optimum ranges are:
- without organic matter from 2.5 $g \cdot cm^{-3}$ to 3.0 $g \cdot cm^{-3}$,
- with organic matter from 1.5 $g \cdot cm^{-3}$ to 2.0 $g \cdot cm^{-3}$.

3.1.6.2 Reduced volume density. The optimum ranges are:
- without organic matter from 1.1 $g \cdot cm^{-3}$ to 1.6 $g \cdot cm^{-3}$ (above 1.8 g cm^{-3} for sandy soils),
- with organic matter more than 0.5 $g \cdot cm^{-3}$.

3.1.6.3 Porosity. The optimum ranges are:
- without organic matter between 40% and 65%,
- with organic matter between 45% and 75%.

3.1.6.4 Texture (grain). Differentiating the grain fractions of clay (< 0.002 mm), dust (0.002–0.05 mm) and sand (0.05–2 mm), the optimum ranges are:
- clay content 20–40%,
- dust content 20–60%,
- sand content 20–50%;

Pursuant to the triangle diagram (see Annex 1, Fig. 1), soil types included are: loam, sandy loam, clayey loam, silty loam, sandy clayey loam.
Pursuant to terrain classification (see Annex 4, Table 1), soil types included are: loamy-sandy, sandy-loamy, loamy, marginally clayey-loamy.

3.1.6.5 Skeleton content (content of grain fraction > 2 mm). The optimum range is 21–50%.

3.1.6.6 Structure. The optimum structure is:
- medium to cloddy for aggregated, spherical structure with aggregate size > 2 mm,
- fine to coarse for segregated (prismatic, polyhedric) with segregate size > 5 mm.

3.1.6.7 Minimum air capacity. The optimum range is 8–20% vol.

3.1.6.8 Consistency. Optimum categories are very loose, loose, slightly compacted.

3.1.6.9 Soil compaction. The upper limits are:
- 2.5 MPa for heavy and medium soils,
- 2.8 MPa for light soils.

3.1.6.10 Mechanical loading. Expressed as specific pressure on soil primarily due to machinery movements with optimum below 0.8 $kg \cdot cm^{-2}$ (approx. 80 kPa).

3.1.6.11 Infiltration and hydraulic conductivity. The optimum values are in the range 0.00087–0.0012 $cm \cdot s^{-}$

[1].

3.1.7 **Physical-chemical and chemical properties** of soils

3.1.7.1 Soil reaction. The optimum values are in the range:

- 4.0–7.0 for pH/KCl (pH/$CaCl_2$),
- 4.4–7.2 for pH/H_2O.

3.1.7.2 Basic saturation (BS). The optimum values are higher than 20%.

3.1.7.3 Acceptable nutrient content (according to Mehlich). The optimum values for the different nutrients are in the range:

- Ca 1601–2100 $mg \cdot kg^{-1}$,
- K 101–210 $mg \cdot kg^{-1}$,
- P 31–60 $mg \cdot kg^{-1}$,
- Mg 81–160 $mg \cdot kg^{-1}$.

3.1.7.4 Carbonate content ($CaCO_3$). The optimum range is 0.3–10%.

3.1.7.5 Water-soluble salt (primarily chloride) content. Expressed as electric conductivity with maximum values:

- 10 $\mu S \cdot cm^{-1}$ for very light soils,
- 60 $\mu S \cdot cm^{-1}$ for medium weight soils,
- 160 $\mu S \cdot cm^{-1}$ for heavy soils.

3.1.7.6 Soil sorption complex sodium saturation. Expresses signs of salinity above electric conductivity at Na^+ content of more than 8% of total CEC.

3.1.7.7 Organic matter (combustible) content with a dominance of humus substances. The optimum range is 1.5–20%.

3.1.7.8 Hazardous element content. The upper bound is defined as the preventive value for each element in $mg \cdot kg^{-1}$ of dry matter when extracted by aqua regia:

- for normal soils (sandy-loamy, loamy, clayey-loamy and clayey): As – 20.0, Be – 2.0, Cd 0.5, Co – 30.0, Cr – 90.0, Cu – 60.0, Hg – 0.3, Ni – 50.0, Pb – 60.0, V – 130.0, Zn – 120.
- for light soils (sands, gravels with max. share of fine particles up to 0.01 mm): As – 15.0, Be – 15.0, Cd 0.4, Co – 20.0, Cr – 55.0, Cu – 45.0, Hg – 0.3, Ni – 45.0, Pb – 55.0, V – 120.0, Zn – 105.

3.1.7.9 Hazardous substance content. The upper bound is defined as the preventive value for each substance in $mg \cdot kg^{1}$ of dry matter:

- PAU – 1.0, PCB – 0.02, DDT – 0.075, HCB – 0.02, HCH – 0.01, hydrocarbons C10–C40 – 100.

3.3 Volume parameters of rootable area

3.2.1 The size of the rootable area differs in relation to spatial requirements of different taxa.

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

3.2.3 Alterations that lead to optimisation of rootable area should promote natural physiological root depth and distribution.

3.2.3 The size of the minimum tree bowl is a function of the expected size of root tapers and minimum structurally important root plate of an adult tree of the taxon, and is quoted as the distance of the nearest obstacle from the trunk axis for simplification.

3.2.4 From this point of view, trees and shrubs can be divided into the following categories (see Annex 6, Fig. 1)[1]:

Category	Minimum rootable area volume	Minimum open tree bowl diameter
Large-crown trees	25 m^3	1.2 m
Medium-crown trees	16 m^3	0.75 m
Small-crown trees	8 m^3	0.5 m
Large shrubs	1 m^3	-
Smaller shrubs	0.25 m^3	-
Climbing plants	0.5 m^3	-

3.2.5 Interaction between the rootable area and construction works is handled by SPPK A01 002 Tree protection during construction work.

3.3 Rootable area properties in relation to trees and shrubs

3.3.0 Characteristics of rootable area describe the site in terms of limitations to the rootable area and soil conditions for tree and shrub growth and development. Growth conditions are assessed visually in the area equalling the ground projection of the crown of an adult individual of the given taxon. Detailed characteristics of a specific site can be extended with additional parameters, describing rootable area quality and extent (e.g., observable signs of contamination, special interventions modifying rootable area size, etc.).

3.3.1 **Stratigraphic properties of rootable area as a soil profile**

3.3.1.1 Rootable area assessment uses different parameters separately for discernible horizons.

3.3.1.2 Assessment of rootable area properties considers marginal and optimal values of their parameters, their mutual relationships and influences and variations within the profile.

3.3.1.3 Assessment of rootable area properties proceeds:

a) at a general level as assessment of soil properties,
b) in relation to the tree or shrub taxon,
c) in relation to the tree or shrub age and intended length of its existence on the site.

3.3.1.4 Assessment of rootable area properties proceeds:

a) using a pedological excavation probe,
b) using soil augers or groove probing machines (priority),
c) considering root distribution.

3.3.1.5 Rooting is assessed using criteria for depth levels differing in root density by estimating the quantity per dm^2, differently for:

a) quantity of fine roots (< 2 mm),
b) quantity of coarse roots (< 2 mm).

3.3.2 **Rootable area properties in terms of hydric influence, water-to-air ratios and mechanical properties**

3.3.2.1 Determination of the degree of water influence is advisable primarily before planting trees and shrubs in habitats where either temporary water accumulation or stable high water levels can be expected. The groundwater table usually oscillates during the year, frequently influenced by the season.
The influence of stagnant water can also be estimated from a pedological probe (presence of gleyed horizons, etc.).

3.3.2.2 The degree of influence of water is determined:

a) visually based on signs of gley (marbling and redoximorphic[2] features, Mn-Fe neoformations (pellets) or the gleying process (continuous reductomorphic[3] features);
b) using indicators: development of characteristic blue colouring of the sample that has not been in direct contact with any metal, e.g., a field instrument, shovel, etc., either as Turnbull blue (using 3% potassium ferricyanide – detection of reduced iron Fe^{2+}, detection of reducing conditions), or as Berlin blue (using 3% potassium ferrocyanide – detection of oxidized iron Fe^{3+}, detection of oxidising conditions) always after at least 1 minute of

[1] Approximate classification of taxa into the categories can be found in some expert publications (e.g., Hurych, V.(2003): Okrasné dřeviny pro parky a zahrady, Květ, ISBN 80-85362-19-8, Vlasák, M. (2012): Okrasné dřeviny, Vyšší odborná škola zahradnická a Střední zahradnická škola, Mělník, ISBN 978-80-904782-9-9, etc.).

previous acidification with 12.5% HCl;

c) with a view to local conditions (terrain forms, watercourse proximity, evident waterlogging, etc.).

3.3.2.3 Hydric influence can be defined at the following levels:

a) no hydric influence (anhydromorphic environment);
b) soil material is the original colour, but there are fuzzy rusty stains by the soil surface;
c) soil material has different textures in various depths, with lighter and paler (bleached) grain by the soil surface and heavier and darker grain deeper down with bleached patches and rusty patches;
d) soil material is markedly marbled, with coloured veins (redoximorphic), and may be continuously grey, grey-blue, blue or greenish deeper down with rusty tubes along roots;
e) soil material is under permanent hydric influence, without marbling, of continuous grey, grey-blue, blue or greenish colour and sporadic presence of rusty patches.

3.3.2.4 The degree of influence of water is determined by stating:

a) depth range (in cm from soil surface),
b) intensity (gleyed, gleying in process).

3.3.2.5 Detailed hydropedological examination may employ analysis of intact samples (Kopecký physical cylinders) collected from different horizons. They are collected by a trained person and analysed at a specialised laboratory. The parameters are used to determine reduced volume density, porosity (after specific weight), maximum capillary capacity, water retention capacity, wilting point, usable water capacity, minimum air capacity.

3.3.2.6 The speed of water infiltration into the soil and movement of water through the soil is assessed using infiltration tests on the soil surface (see Annex 2).

3.3.2.7 Compaction is measured:

a) penetrometrically (using a light soil penetrometer),
b) deflectometrically (using a portable deflectometer).

3.3.2.8 The scales for assessment of soil compaction differ depending on method chosen and on:

- soil texture in the city (clayey vs. sandy soils),
- groundwater table (habitats with vs. without waterlogging),
- habitat orography (plain vs. slope),
- current meteorological conditions, where soil moisture conditions reversible vs. irreversible (at high soil moisture) compaction of surface soil horizons.

3.3.2.9 Signs of inappropriate consistency and structure are assessed in light of the following factors:

- soil compaction due to dominance of clay texture fraction at reduced moisture (material hard when dry, glossy and brittle when wet);
- soil compaction due to cementing: (a) increased carbonate concentration under semihydromorphic conditions; (b) ferrous spodic horizon;
- soil compaction due to accumulation of mineral fertilisers,
- soil compaction due to mechanical compaction (e.g., walking, machinery travel),
- reduced carrying capacity due to waterlogging – when trod on, soil material is gradually filled with water and turns to slush between fingers,
- impaired consistency on light-texture soils without compacted soil cover – sliding, unstable material with a tendency to dry;
- impaired structure and crusting on soils dominated by the dust fraction and alkaline chemism due increased concentration of water-soluble salts – erosion-prone, with reduced infiltration.

3.3.3 Rootable area properties in terms of chemism

3.3.3.1 From a practical perspective, trees and shrubs are divided according to their relationship to pH and soil chemism into:

- acidophilous,
- basiphilous,
- calciphilous,

[2] see 2.21 above.
[3] see 2.22 above.

- halophobic,
- halophilous (or tolerant to salinity).

3.3.3.2 Planting of ***acidophilous trees and shrubs*** cannot be recommended if the active soil reaction (pH/H_2O) rises above 5.5 and the potential exchange soil reaction (pH/KCl) rises above 5.1. Planting of ***basiphilous trees and shrubs*** cannot be recommended if the active soil reaction (pH/H_2O) drops below 5.5 and the potential exchange soil reaction (pH/KCl) drops below 5.1.

3.3.3.3 Active soil reaction can be determined in a field test using an indicator slip dipped for 10-15 seconds in a soil sample suspension mixed with distilled water at a ratio of 1 : 2.5 or, optimally, in an infusion obtained by filtering.

3.3.3.4 For a list of trees and tree-shaped shrubs by their relationship to habitat pH, see SPPK A02 001 Planting of trees (Annexes 1 and 2).

3.3.3.5 The humus content in the surface soil horizon is one of the factors determining the degree of satisfaction of plant growth requirements. Intensity of the dark colours conditioned by horizon humus content is a proof of two facts:

a) accumulation of humus substances in progress,
b) eluviation of humus substances in progress (wash-out, depletion, shift from upper parts of the profile to lower horizons).

3.3.3.6 Humus content is assessed primarily for surface horizons, but optimally for the whole profile, in the field, using the scale:

1. slightly humous (< 1.5% of organic matter in mostly humified state) – dominated by pale grey colour and low structure (pearly, fine crumb structure);
2. humous (1.5–3.0% of organic matter in mostly humified state) – dominated by grey to dark grey colour and medium structure (fine to medium crumb structure);
3. strongly humous (> 3.0% of organic matter in mostly humified state) – grey-black colour and higher structure (medium to coarse crumb to lump structure).

3.3.3.7 Humous content is assessed from the shade of the grey colour. That said, consideration is given to soil moisture (soil becomes paler with lower moisture and vice versa; it is optimally assessed for fresh moist material) as well as:

a) texture (soil type) – the heavier the soil horizon grain (i.e., the higher the content of clay particles), the more difficult it is for the colouring agent to show; thus, light-grain soils can be very striking in their colours even at a minimal content of colouring agents;
b) presence of dark-coloured soil components of inorganic nature (cinders, ash, reduced forms of sulphur due to extreme hydric influence, etc.).

3.3.3.8 Presence of carbonates, notably calcium carbonate ($CaCO_3$), is assessed using 12.5% hydrochloric acid (HCl), which detects carbonate with typical "fizzing" – material foaming and release of carbon dioxide (CO_2) due to chemical decomposition of carbonates:

a) approximately in the field (on the scale: < 1% of carbonates means barely perceptible fizzing; 1–3% of carbonates means slight fizzing; 3–5% of carbonates means strong but short fizzing; > 5% of carbonates means strong and longer-lasting fizzing),
b) laboratory examination.

3.3.3.9 The degree of salinity can be determined approximately in the field by application of 2% (0.1M) silver nitrate to the soil sample infusion mixed with distilled water at 1:10 (approx. 3 g of sample) following infusion acidification with 5% nitric acid (HNO_3). Presence of salts is then manifested with a milky colouration of the produced suspension due to coagulation.

3.3.3.10 Sampling (both soil and assimilation organs of trees and shrubs) in order to determine the degree of salinity has to be done within a few weeks after the end of winter road maintenance using road salt.

3.3.3.11 The field conductivity test is made with 20 g of mixed soil sample. The suspension is diluted with demineralized water and shaken thoroughly. The suspension conductivity is measured according to the instruction manual for the conductometer used.

3.3.3.12 Conductivity can be measured using a portable field conductometer with a measuring range from 1 $\mu S.cm^{-1}$. A recommendation for the analysis is to use PE containers with a capacity of 250 cm^3.

3.3.3.13 Soil electrical conductivity is the standard assessment criterion for negative impact of contamination with road salt. If the soil conductivity increases, it can be interpreted as a manifestation of increased entry of chlorides in the soil solution.

3.3.3.14 Visual symptomatic assessment of plants damaged with salinity is specific in that:

- visual symptoms of this type of contamination (primarily impacts of physiological drought, water deficiency) in the urban environment are extremely problematic, since

browning, defoliation and necroses from this contamination may be blocked out completely by symptoms of other urban stressors,
- different plant species respond quite differently to identical quantities of identical substances,
- some road and pavement winter maintenance products are essentially chemical defrosting materials, others are coarsening inert materials, and the consequences of their use are very diverse.

3.3.3.15 Assessment of soil conductivity values obtained cannot be made without knowledge of the soil type of the surface organomineral humous horizon.

3.3.3.16 The assessment of this potential contamination (interpretation of laboratory analysis results) is based on the following facts:
- The salt concentration can be expressed from electrical conductivity differentially based on the conductivity value – by multiplying the electrical conductivity measured [$mS\cdot cm^{-1}$] with the coefficient 640 [mg^{-1} or ppm],
- chlorine content in the dry matter of assimilation organs documents salinity contamination on sites in built-up settlement areas from as low as 1% (i.e., twice stricter limit compared to sites outside built-up areas),
- increased soil conductivity documents contamination:
  1. in sandy, very fine-grain horizons, soil salinity is indicated by conductivity above 10 $\mu S.cm^{-1}$,
  2. in medium-grain horizons, presence of increased concentration of road salt ions can be stated if the conductivity is above 60 $\mu S.cm^{-1}$,
  3. actual damage to physiological functions of plants occurs only at conductivity above 120 $\mu S.cm^{-1}$ (in heavy-grain soils, where the assessment is the most difficult due to extremely high exchange sorption, soil salinity is manifested by hundreds of $\mu S.cm^{-1}$),
- increased share of sodium in the cation exchange capacity above 8%.

3.3.4 Symptoms of herbicide contamination

3.3.4.1 The general symptoms of damage to assimilation organs is presence of irregular and non-contrasting yellowish stains between veins of broadleaved trees and shrubs (the veins themselves remain naturally green) and yellowing of whole needles distributed irregularly on the branch (the middle three centimetres of a ten-centimetre annual shoot may become yellow) of coniferous trees and shrubs.

3.3.4.2 An approximately identical deficiency manifestations are described for plants rooting in soil with a significant deficiency of accessible magnesium (or zinc). The phenological phase of the trees and shrubs is a possible guidance for differentiation: herbicides are mostly not used in the second half of the growing season, whereas Mg and Zn deficiency is typical of older leaves and needles.

3.3.5 Toxic contaminants

3.3.5.1 The notable contaminants are:
- hazardous elements: As, Be, Cd, Co, Cr, Cu, F, Hg, Mo, Ni, Pb and Zn,
- hazardous substances: persistent organic pollutants (POPs), including:
  1. polycyclic aromatic hydrocarbons (PAH),
  2. polychlorinated biphenyls (PCB),
  3. persistent organochlorine pesticides (OCP).

Presence of these types of substances may be long-term (in that case, a certain adaptation of trees and shrubs to the burden can be expected), or they occur suddenly as a consequence of contamination. In cases of acute occurrence, physiological stress symptoms may be manifested in trees and shrubs.

3.3.5.2 Legislation in force is of key importance in this area; it shall aim at precautions eliminating the risk of contamination of urban soils.

3.3.5.3 The issue is specific in that:
- allochthonous (foreign/non-indigenous) pedogenic substrate is a significant source of contamination (use of urban space has led to significant accumulation of contaminants, not only in the surface layer of present-day soil),
- in chronic contamination with small quantities of pollutants, urban trees and shrubs play a very positive role (due to the decontamination effect of the quantity and quality of their waste and its subsequent decomposition).

Due to the impossibility of predicting entry of contaminants into the urban habitat soil, their effects combine individually with significant seasonal dynamics of many soil processes and highly individual sensitivity of tree and shrub species going through their phenological phases with diverse specific requirements for soil and its cleanness.

4 Field surveys

4.1 Purpose of field surveys

4.1.1 Identification of tree and shrub habitat condition can be made in justified cases as part of surveys (pursuant to SPPK A01 001 Tree assessment). The surveys are made primarily using visual methods, alternatively using instruments and chemicals usable in the field (without the need for laboratory analysis) and involves primarily the following parameters (determination method in Annex 4):

- rootable area parameters,
- humous content in surface soil horizons,
- root system distribution, degree and causes of its reduction,
- extent and intensity of compaction,
- hydric influence and water-to-air ratios,
- pH value,
- carbonate content,
- degree of salinity (content of water-soluble salts),
- degree of contamination (environmental burden),
- signs of interventions (excavation, backfill) in the protected root area (see SPPK A01 002 Tree protection during construction work).

4.1.2 Field surveys are made in order to identify growth conditions for trees and shrubs on the site in terms of rootable area (soil environment) and determine potential limiting factors reducing the tree or shrub health, vitality and stability.

4.1.3 Detailed habitat condition assessment is made based on discernment of rootable area stratigraphy (in the sense of soil profile with discerned horizons):

1. for different discerned horizons,
2. for the rootable area as a whole,
3. for the rootable area as a part of the tree habitat.

4.2 Main principles of field surveys

4.2.1 **Descriptive part of field survey**

4.2.1.1 As part of the rootable area assessment, the different horizons are discerned using parameters defined in the field and, additionally, based on laboratory analysis of soil samples.

4.2.1.2 Field surveys are made in order to collect data and information about habitat growth conditions by:

1. field visual assessment, detection of parameters and features and discernment of characteristic horizons in the rootable area profile,
2. approximate field chemical tests,
3. field instrumental data collection.

4.2.1.3 Identified soil parameters are recorded in a suitable field log book (design in Annex 5). The basic parameters of description of different horizons of the rootable area profile are:

- horizon thickness (lower and upper bounds),
- colour,
- texture,
- structure (size and shape of structural aggregates and segregates),
- skeleton content (size and frequency),
- humidity,
- consistency,
- rooting (density of fine and coarse roots),
- horizon transition nature (shape, sharpness),
- development of neoformations,
- other remarks.

4.2.1.4 The horizon boundary depths are determined in cm from the soil surface, which also includes superstratum humus horizons if present, but not living vegetation.

4.2.2 **Collection, storage and modification of soil samples**

4.2.2.1 Soil samples are collected as soon as possible after the soil probe from non-frozen soil is opened.

4.2.2.2 Soil samples can be collected as:

a) mixed,
b) intact.

4.2.2.3 Mixed soil samples are collected:

a) from the cleaned front of the soil probe – the sample collection procedure is from the bottom of the excavation (soil probe) towards the soil surface, taking the horizons one by one (prevent sample contamination by earth collapsing); samples are collected from the whole width of the soil probe front from the most typical zone for the horizon (see Annex 6, Fig. 3);
b) from the probing machine groove for non-silty earths;
c) from the soil auger (Edelman auger, etc.).

4.2.2.4 Mixed soil samples are stored in thick-walled HDPE bags or special two-layer waxed bags with unique identification of sample collection date and code (linking it to the collection point and depth).

4.2.2.5 Intact soil samples are collected using Kopecký physical cylinders, proceeding from the soil surface towards lower horizons. It is desirable to make the collection using a special ram and in multiple iterations for each horizon (if conditions permit).

4.2.2.6 Collection of intact samples is typically possible with a maximum skeleton content of 40–50% and if rooting density permits it (notably thick roots). With higher skeleton content or denser rooting, the sample may be poured in the cylinder for approximate determination of hydrophysical properties with adequate compaction. For the purposes of assessment, this process step has to be recorded and reflected (taking the measured values are purely approximate).

4.2.2.7 Mixed samples are stored in a dry ventilated place at room temperature. The maximum drying temperature is 40°C.

4.2.2.8 It is advisable to transport intact samples for laboratory analysis immediately. Storage is only possible if moisture loss is minimised (wrapping in an airtight bag, etc.) at reduced temperatures (4°C). Sample freezing has to be prevented.

4.2.2.9 Samples are modified for laboratory analysis in the form of:

a) fine earth I (dry sample sifted through a 2 mm sieve – determination of grain, specific weight, pH, cation exchange capacity (CEC), nutrient content, humus substances, carbonates, hazardous elements, hazardous substances);
b) fine earth II (representative sample of approx. 5 g of fine earth I brayed in an agate bowl and transferred completely through an 0.25 mm sieve – determination of oxidisable carbon and total nitrogen).

5 Tree and shrub habitat alteration

5.0 The objective of alteration of habitat of adult trees and shrubs is particularly to:

- reduce the degree of compaction in the root zone,
- improve rainwater infiltration and reduce evapotranspiration in the root zone,
- replace degraded soils (e.g., due to construction work or contamination),
- increase the rootable area in strongly compacted or degraded soils.

The appropriate habitat alteration technique is based on previous examination and assessment of habitat conditions, leading to identification of main limiting factors for root growth.

5.1 Blanket mulching

5.1.1 Trees and shrubs can be mulched with organic materials in an 80 – 100 mm layer, inorganic materials in a 50 – 80 mm layer or a suitable *mulching textile* (use of synthetic textiles is not recommended). The above methods can be combined.

5.1.2 Contact between the mulch and the tree trunk has to be minimised; the tree trunk must not be buried in the mulch deliberately.

5.1.3 The mulch materials must not prevent entry of water into the soil and the soil-air gas exchange. Use of mulching textiles between soil and mulch is undesirable due to the need for long-term good soil gas exchange.

5.1.4 Mulching with fresh plant leftovers is not advisable, as they ferment and the mulch has low permeability for water and air.

5.1.5 Organic mulch is gradually decomposed and has to be replenished continuously. The replenishment is usually done once a year, optimally at the start of the growing season.

5.2 Additional irrigation, rainwater retention and infiltration

5.2.1 Additional irrigation is recommended for trees showing symptoms of drought stress; it should be applied as needed on a one-time basis, repeated in light of climate conditions. Permanent and regular irrigation extending over several growing seasons may change the root distribution undesirably.

5.2.2 Additional irrigation for existing trees should moisten evenly the rootable area or at least that part where it is technically feasible.

5.2.3 During after-planting management of young trees, it is advisable to maintain a functional irrigation bowl throughout the additional irrigation period.

5.2.4 Infiltration grooves filled with gravel can be built for easier application of additional irrigation. Infiltration grooves in the tree root zone have to be built using a non-destructive excavation method.

5.2.5 It is advisable to promote infiltration and use of rainwater in the tree root zone. However, use of rainwater from adjacent areas must not lead to permanent waterlogging or inundation of the tree rootable area.

5.2.6 Use of the rootable area for water retention and infiltration as part of blue and green infrastructure solutions must not lead to its permanent inundation for periods longer than 24 hours.

5.3 Mechanical loosening of compacted soils

5.3.1 The actual alteration of surface-compacted soils consists in their mechanical loosening (hoeing) and aeration.

5.3.2 Loosening is done to a depth of 30 mm in a way not to damage the root collar and larger roots of the tree or shrub and any undergrowth planting. Loosening is most commonly done in beds at tree bowls, etc.

5.3.3 Aeration reduces the degree of compaction and promotes infiltration; it is typically done using machinery in grass areas. Machine aeration cannot be done closer than 3000 mm from the base of the trunk of adult trees and where large roots show on the surface.

5.4 Change of vegetation cover

5.4.1 To reduce competition and the degree of compaction, intensive lawns in tree root zones can be replaced with extensive grassland, herb mixtures or shrubs with lower total evapotranspiration.
5.4.2 When changing the vegetation cover, the planting technique chosen must not cause significant damage to the tree root zone. Use of machinery in the tree root zone is not permitted.
5.4.3 When removing existing lawn, manual peeling of the turf is permissible to a max. depth of 20 mm
5.4.4 When sowing in the tree root zone, its blanket covering with a suitable (permeable) substrate is permissible up to a max. height of 50 mm or as per provisions of SPPK 01 002 Protection of woody plants during development activities.

5.5 Radial mulching

5.5.1 Done to improve conditions in the tree root zone by way of local replacement of some of the soil with suitable vegetation substrate.
5.5.2 Soil replacement is done in radial or parallel-running grooves down to a depth of approx. 300 mm, covering up to 20% of the root zone (see Annex 6, Fig. 2).
5.5.3 Digging of grooves is only permissible using non-destructive excavation techniques, and it must not lead to damage or interruption of roots larger than 10 mm.
5.5.4 Radial mulching must not lead to compaction of the remaining part of the tree root zone by travelling machinery.
5.5.5 Any uncovered roots have to be kept moist for the entire duration of the works.
5.5.6 The type and structure of substrate used to improve habitat conditions are a function of the degree of risk of resulting compaction.
5.5.7 Use of soil grooving machines and other machine excavation in the tree root zone is prohibited.

5.6 Vertical mulching

5.6.1 It involves point improvement of habitat conditions by soil replacement in dug or drilled aeration probes in the tree root zone.
5.6.2 The depth of aeration probes is typically up to 300 mm, depending on the degree of compaction, averaging from 100 to 200 mm.
5.6.3 Aeration probes are filled with suitable, usually very easily permeable substrate.
5.6.4 Vertical mulching must not lead to compaction of the protected root system of a tree where the work is done by travelling machines.
5.6.5 Probe excavation or drilling places are chosen so as to minimise collisions with large roots (avoiding surface roots); the nearest permissible distance to the tree is 2500 mm.

5.7 Depth injection

5.7.1 Depth injection provides aeration of the soil profile up to 400 or 600 mm deep by pressurised air.
5.7.2 Besides aeration, injection can be used to apply fertilisers or other supporting products to roots of tall-grown trees based on a need determined by previous analysis.
5.7.3 The treatment (puncture) is made at a distance from the tree trunk equalling the projection of the tree crown (see Annex 6, Fig. 4).
5.7.4 Treatment places are chosen so as to minimise collisions with large roots; the nearest permissible distance to the tree is 2500 mm.

5.8 Soil replacement in root zone

5.8.1 In justified cases, blanket replacement of degraded soil is possible in the tree root zone or its parts. Depending on the rooting extent, degree of compaction, etc., the replacement is usually done down to a depth of 150–300 mm.

5.8.2 Removal of existing earth from the root zone is only possible using non-destructive excavation techniques.

5.8.3 Earth replacement is done in stages with intervals of at least two months for active root growth. One stage can involve replacement of soil over no more than 50% of the tree's root zone.

5.8.4 The tree roots have to be kept moist for the entire duration of the soil replacement.

5.9 Application of fertilisers and substances improving the habitat

5.9.1 **Fertilisation** should only be done to the necessary extent depending on the nutrient content in the soil, determined by analysis, and manifestations of tree or shrub vitality (increment length, leaf size and colour, annual shoot maturity, etc.). The use of slow-dissolving fertilisers is preferable. If quick fertiliser effect is necessary, fertilising watering or leaf fertilisation can be used.

5.9.2 Fertilisers for reserve fertilisation have to conform to ČSN 65 4802. Nutrients have to be released slowly, nitrogen in particular.

5.9.3 Always consider the correct method of application and correct dosage based on the fertiliser type used a deficit of respective substances.

5.9.4 Other auxiliary components may be added to the soil (substrate), such as water absorbents, root stimulators or mycorrhizal products, based on results of previous analysis.

5.9.5 **Mycorrhizal products** enable plant roots to better accept water and nutrients and improve their resistance to stress factors and pathogens.

5.9.6 **Water absorbents** improve water management on the site. Their use is effective primarily on sandy soils or on altered sites with limited water ingress.

5.9.7 **Stimulators** promote root growth and accelerate the development of a new root system, recovery and resistance.

5.10 Increasing rootable area under structures

5.10.1 Rootable area increase is made where the tree's root system is limited by degraded or heavily compacted unrootable soil.

5.10.2 Increasing rootable area is done preferably using measures that lead to interconnection of root zones of adjacent trees into planting strips.

5.10.3 If trees cannot be connected with a planting strip, the rootable areas of planting spots can be connected with a root path.

5.10.4 The rootable area under structures has to be modified using suitable technical measures to receive rainwater to provide for the tree's basic living needs.

5.10.5 The rootable area has to be protected with a suitable drainage system from inundation due to impermeable subgrade. Use for rainwater retention shall follow provisions of 5.2.6 above.

5.10.6 Structural elements interfering with the rootable area (foundations of root bridges, foundation shoes of protective grilles, etc.) must not prevent rooting into the adjacent natural ground.

5.10.7 All measures increasing the rootable area are effective in combination with the maximum possible tree bowl size.

5.10.8 Measures increasing rootable area of existing trees can only use non-destructive methods of removal of existing earth in the potential rooting area.

5.10.9 Roots implemented root paths or growing into other parts of deliberately provided rootable area must not be broken or damaged by excavation works while laying utility networks, etc. Where utility networks run parallel, such damage has to be prevented, which is possible by simultaneously laying reserve protective sleeves or collectors in the area.

5.11 Structural substrates

5.11.1 A layer of structural substrates is laid under structures that enable permeability for water and soil gas exchange. If the permeability is not assured naturally by the cover, it has to be enabled using a technical measure.

5.11.2 The usable layer of structural substrates shall not exceed 1 m, and the surface area is a function of the required cubic capacity of rootable area.

5.11.3 Structural substrate is compacted in layers to the required value to support the structure.
5.11.4 Transport and spreading of the structural substrate must not cause separation of fine and coarse components, and it has to have a homogeneous texture after laying.
5.11.5 An example of use of structural substrate in a street avenue is shown in Annex 6, Fig. 5.

5.12 Soil cells

5.12.1 Soil cells are mechanical elements (most commonly plastic) assembled repeatedly to produce a load-bearing structure, in between which substrate with optimal properties for the tree species is laid.
5.12.2 The substrate so aid must not be compacted, and a ventilation gap has to be left between the substrate surface and the soil cell structure.
5.12.3 Soil cells are installed in accordance with the system manufacturer's specifications.
5.12.4 An example of use of soil cells in a street avenue is shown in Annex 6, Fig. 6.

5.13 Root zone bridges

5.13.1 Root zone bridges are structures that permit the existence of a rootable area under structures without undesirable compaction.
5.13.2 Root zone bridges most commonly serve to protect planting strips connecting planting points.
5.13.3 Bridge anchors are placed on compacted solid ground or on foundation shoes. The foundation structures must not preclude rooting into the surrounding ground.
5.13.4 Ventilation elements have to be placed under structures made of impermeable covering to enable air exchange and water infiltration.
5.13.5 An example of bridging a root zone in a street avenue, as one possible solution to root paths, is shown in Annex 6, Fig. 7.

Annex 1 Characteristics of soil vegetation layer

Table 1: Assessment of potential effects of movement of people and vehicles in urban environment on physical, hydrophysical and mechanical soil properties in terms of marginal critical values of **reduced volume density ($g.cm^{-3}$) and porosity (%) per moment of compaction** of soil surface horizons.

Soil type (texture)	clay, clayey	clayey-loamy	loamy	sandy-loamy	loamy-sandy	sandy
Reduced volume density ($g \cdot cm^{-3}$)	>1.35	>1.40	>1.45	>1.55	>1.60	>1.70
Porosity (% v/v)	<48	<47	<45	<42	<40	<38

Table 2: Assessment of potential effects of movement of people and vehicles in urban environment on physical, hydrophysical and mechanical soil properties in terms of marginal critical values of **natural soil volume density ($g.cm^{-3}$) and porosity (%) per moment of restriction to plant root growth**.

Soil type (texture)	Minimum volume density
sandy, loamy-sandy	1.8
very fine sands and loamy sands	1.77
sandy-loamy	1.75
loamy, loamy-clayey-sandy	1.70
clayey-loamy	1.65
clayey-sandy	1.60
silty, silty-loamy	1.55
silty-clayey-loamy	1.50
silty-clayey	1.45
clay	1.40

Table 3: Criteria for soil porosity assessment.

Structural condition of humous horizon	Porosity
excellent	>54
good	46-54
non-compliant	39-46
non-structural	31-39

Table 4: Assessment of soil weight moisture (w).

Light soils	Medium soils	Heavy soils	Moisture classification
w [%]			
2-4	4-8	8-15	dry
4-8	8-15	15-25	moderately moist
8-12	15-25	25-35	freshly moist
12-18	25-35	35-45	moist
18-30	35-45	45-55	wet
> 30	> 45	> 55	muddy

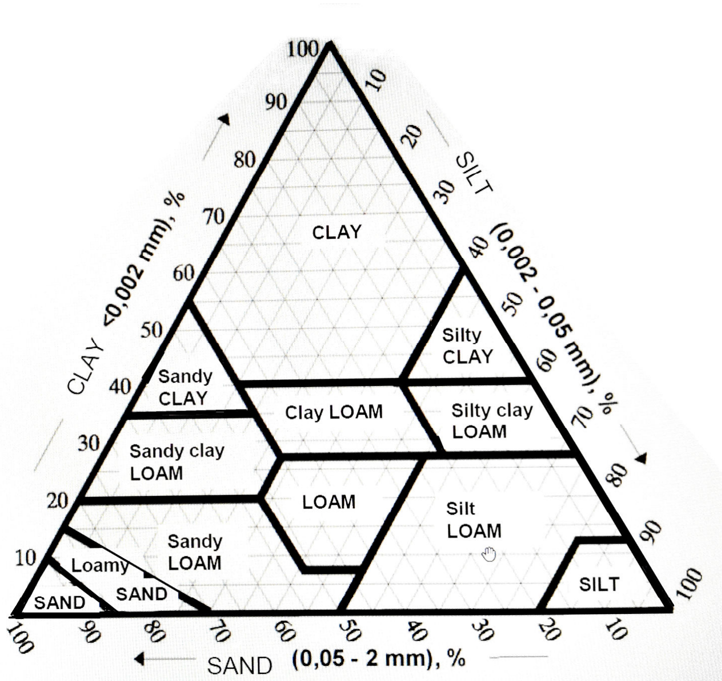

Fig. 1: Criteria for grain (soil type) assessment

Table 5: Soil type texture classes (Němeček et al., 2011).
Identification of grain fractions:
P – sand; H – loam, J – clay, R – silt, p – sandy earth, h – loamy earth, r – silty earth.

Soil type	Earth classification	Texture class
P, hP	light earth	1
pH	lighter medium earth	2
H, rH, R	medium earth	3
pjH, jH, rjH	heavy earth	4
pJ, rJ, J	very heavy earth	5

Table 6: Criteria for assessment of minimum soil air capacity (Vavříček and Kučera, 2017).

A_{MKK} [% vol.]	Characteristics of minimum air capacity
3	Ecological risk limit, limited root development of most trees and shrubs, frequently anaerobic conditions
5	Limit minimum value, soils tending to waterlogging and worse aeration
8	Lower limit value (risky for trees and shrubs requiring aerated soils)
10	Average values for forest soil (marginal for agriculture)
20	Soils tending to drying; may be transiently to permanently dry
25	Upper limit value – significant drying, very low retention

Table 7: Criteria for assessment of soil compaction by means of penetration resistance (Sáňka et al., 2018).

Penetration resistance class	Penetration resistance [MPa]
extremely low	< 0.01
very low	0.01-0.1
low	0.1-1
medium	0-2
high	2-4
very high	4-8
extremely high	> 8

Table 8: Criteria for assessment of porosity (Vavříček and Kučera, 2017).

Share of pores (%)	Porosity classification
25-30	very low
30-35	low
35-45	moderate
45-55	medium
55-70	high
> 70	very high

Table 9: Critical soil compaction values by soil type (Sáňka et al., 2018).

Indicator	j	rJ, jH	H	pH	hP	P
volume density ($g \cdot cm^{-1}$)	> 1.35	> 1.40	> 1.45	> 1.55	> 1.60	> 1.70
porosity [%]	< 48	< 47	< 45	< 42	< 40	< 38
minimum air capacity [%]	< 10	< 10	< 10	< 10	< 10	< 10
penetration resistance [MPa]	2.8-3.2	3.3-3.7	3.8-4.2	4.5-5.0	5.5	6.0
at moisture [%]	28-24	24-20	18-16	15-13	12	10

Table 10: Criteria for assessment of soil hydraulic conductivity (Vavříček and Kučera, 2017).

Permeability velocity [$cm \cdot h^{-1}$]	Assessment
> 25	very fast
12.7-25	fast
6.4-12.7	moderately fast
2.0-6.4	medium
0.5-2.0	moderately slow
0.13-0.5	slow
< 0.13	very slow

Table 11: Criteria for assessment of soil exchange reaction (pH/KCl) (Sáňka et al., 2018).

pH/KCl value	Humus reserve
< 4.5	extremely acidic
4.6-5.0	very acidic
5.1-5.5	acidic
5.6-6.5	slightly acidic
6.6-7.2	neutral
7.3-7.7	alkaline
> 7.7	very alkaline

Table 12: Criteria for assessment of cation exchange capacity and basic saturation (Sáňka et al., 2018).

Cation exchange capacity (T)		Basic saturation (BS)	
Assessment	**T value [$mmol \cdot kg^{-1}$]**	**Assessment**	**BS value [%]**
very low	< 80	extremely unsaturated	< 30
low	80-130	unsaturated	30-50
medium	130-240	slightly unsaturated	50-75
high	240-300	saturated	75-90
very high	> 300	fully saturated	> 90

Table 13: Criteria for assessment of content of acceptable nutrients bound to the soil sorption complex as per Mehlich 3 (assessed as for permanent grassland pursuant to Decree no. 275/1998 Coll., as amended). (Sáňka et al., 2018).

Contents	Phosphorus		Potassium			Magnesium		
	SP[1]	ICP-OES[2]	light	medium	heavy	light	medium	heavy
low	< 25	< 25	< 70	< 80	< 110	< 60	< 85	< 120
compliant	26-50	26-55	71-150	81-160	111-210	61-90	86-130	121-170
good	51-90	56-100	151-240	161-250	211-300	91-145	131-170	171-230
high	91-150	101-165	241-350	251-400	301-470	146-220	171-245	231-310
very high	> 150	> 165	> 350	> 400	> 470	> 220	> 245	> 310

1) determined spectrophotometrically
2) determined volumetrically

Table 14: Criteria for assessment of organic matter content in soil (Sáňka et al., 2018).

Humus content [%]	Humus reserve
< 0.5	extremely low
0.5-1.0	very low
1.0-2.0	low
2.0-3.0	medium
3.0-5.0	good
> 5.0	very good

Table 15: Criteria for assessment of calcium content in soil for different soil types (Sáňka, 2018).

Contents	Ca content [$mg \cdot kg^{-1}$]		
	light	medium	heavy
very low	< 500	< 900	< 1600
low	501-1000	901-1400	1601-2100
medium	1001-1600	1401-2100	2101-2800
good	1601-2100	2101-3000	2801-3900
high	> 2100	> 3000	> 3900

Table 16: Criteria for assessment of carbonate content in soil.

Carbonate content [%]	Assessment of carbonate content (incl. $CaCO_3$)
0	none
0.1-0.5	low
0.6-3.0	medium
3.1-5.0	high
> 5.0	very high

Table 17: Criteria for assessment of soil electric conductivity / salinity (adapted from Pokorný and Šarapatka, 2003).

μS/cm	Salinity	Agroecological specification
<30	low; salt concentration < 500 mg/l	Most agricultural soils, minimum salt loading. Normal agroecological interventions and fertilising.
30-60	slightly increased; salt concentration 500–1000 mg/l	Mineral-rich soils, no negative effect of salt. Medium fertilising and liming intensity.
60-120	increased; salt concentration 1000-2000 mg/l	Soils on mineral-rich substrates with high salt loads. Loamy and clayey soils without negative effects. Intensive fertilising.
>120	extremely high; salt concentration > 2000 mg/l	Soils with high salt loads with negative effects on vegetation. Required application of gypsum or liming to eliminate chloride salts.

Table 18: Criteria for assessment of soil sorption complex sodium saturation by means of ESP. ESP (Exchangeable Sodium Percentage) is expressed from ESP = (exchangeable Na^+ / T) · 100 [%], where Na^+ is content of sodium cations bound to the soil sorption complex [mmol · kg^{-1}] and T is the cation exchange capacity [mmol · kg^{-1}]. (Vavříček and Kučera, 2017).

ESP [%]	assessment of Na content
< 6	no content
6-10	slightly increased content
10-15	increased content
15-25	high content
> 25	extreme content

Annex 2 General principles for laboratory analysis and field survey

Conversion of analysis results to unified comparable level. Identical values from one analysis of identical soil horizons on two urban sites need not mean the same amount of a substance detected by laboratory analysis; the reasons are highly changeable skeleton content in urban soils and different volume densities of horizons with and without composted material.

Conversions **between two sites, identical soil horizon**:

- ignoring a high skeleton content on a site where trees and shrubs root in backfilled demolition rubble would significantly distort the actual meaning of laboratory analyses;
- take the example of determination of percentage of humous substances in a surface horizon A of a site X with a high proportion of demolition rubble in the root area, and a site X without such material. The fine earth from site X made up 20%; the fine earth from site Y was 80%. The share of humous substances present is determined from the fine earth from both horizons A of both soil types. The two analyses yield two approximately identical sets of data,
- a schematic interpretation leads to the conclusion that the humous substance content in the two soil units is approximately identical. Naturally, however, that is not true, because the siftings from the site with demolition rubble were 20 weight percent of the backfill, and the siftings from the site without demolition rubble were 80 weight percent. To achieve an objective result, therefore, we have to consider the skeleton percentage: if we ignore this factor schematically, we consider the 20% of the matrix from the horizon A of the site X identical to the 80% of the matrix from the horizon A of the site Y.

Conversions **between surface and subsurface horizons, identical site**:

- ignoring a noticeably lower volume density of soils from a surface organic-mineral humous horizon would significantly distort the actual meaning of laboratory analyses;
- take the example of determining the amount of available magnesium for shallow-rooting and deep-rooting trees and shrubs. A shallow-rooting taxon is in physiologically crucial contact with the surface horizon A; a deep-rooting one with subsurface horizons B and C/M. The volume density of horizon A from an urban site with compost applied was 1.0 $g \cdot cm^{-3}$, for horizon B it was 1.7 $g \cdot cm^{-3}$. The acceptable magnesium content is determined from the fine earth from both horizons of one soil body; it is extracted routinely from a uniform weight of the soil sample. The two analyses yield two approximately identical sets of data,
- a schematic interpretation leads to the conclusion that the available magnesium content in the two soil horizons is approximately identical. Naturally, however, that is not true, because the extracting agent acted on a much greater volume of fine earth for the light horizon A than for the heavier horizon B: that could lead to both extremes, i.e., extraction of a larger quantity of nutrient from a larger volume, as well as the converse failure of the extracting agent to penetrate the larger volume of matrix from the horizon A.

Penetration tests to express the degree of soil compaction can be done in the field using:

- a light soil penetrometer,
- a portable deflectometer.

Infiltration tests can be done in the field using:

- the two-cylinder infiltrometer method as saturated hydraulic conductivity (URL [1]),
- the MiniDisk infiltrometer method as unsaturated hydraulic conductivity (URL [2]).

Annex 3 Assessment of site use history

a) Assessment of site use history

Site use history is unthinkable without a thorough pedological survey. Besides, a number of pedological surveys are done without wider integration, as a survey of soil conditions in an area, as a survey caused by specific pedological assignment.

The objective of site pedological survey is to obtain properly evaluated and correctly interpreted information from both the field and the pedological laboratory.
To obtain laboratory analysis results, it is first necessary to collect soil samples from soil sampling probes. Layout of the probe grid and their excavation are preceded by preparatory works, intended to gather all the necessary information about the study area.
Respecting goals of the assignment of a comprehensive site pedological survey, the basic stages in identifying soil properties are as follows:

1. preparatory works,
2. actual field work,
3. field survey and collection of soil samples,
4. laboratory analyses,
5. evaluation of results.

Laboratory work
Pedological laboratory analyses follow the field survey and sample collection. Soil samples from different horizons have to be:

- collected properly,
- stored properly,
- processed properly, namely:
  - before analysis,
  - during analysis.

b) Site use history in terms of soil body features

People have been influencing soil in Central Europe for many centuries. The most important set of problems is connected with reducing the proportion of forest in the Czech landscape as a consequence of the settlement process in originally forested territory, charcoal production and timber extraction for mining. Simultaneously, coppices led to increased waste mineralization, increased nutrient and water extraction as a consequence of intensive repeated logging. and drying of the surface horizon due to lower shading and historical negative effect of livestock grazing.
Attention simply has to be paid to habitat conditions in light of site use history. Ignoring possible human effects on a study area may lead to quite erroneous interpretation of both site and soil profile description and laboratory analysis results. This is particularly important in the case of afforestation of non-forest land, formerly farmed as arable land, where ignoring human activity on present-day forest land leads to a fundamental distortion of causes of the soil condition described and its properties.

Four factors are of crucial importance here:

4. climate factors,
5. area morphology (slope gradient and exposure) and altitude,
6. bedrock chemism, site skeleton content and humus form,
7. species composition of trees and shrubs.

From the point of view of site use history, interpretation of field survey and laboratory analysis results is complicated by the impacts of atmospheric pollutants particularly in the 1970s and 1980s:

- firstly, we need to distinguish between chronic (long-term, repeated) and acute (temporary, single) effects of the pollution,
- secondly, we have to consider that the air pollution impact is a function of three variables:
  1. exposure time (exposure to pollutant effects),
  2. amount of pollutant or its concentration,
  3. time period for activation of physiological purification mechanisms (and subsequent recovery of forest stands), consisting in time delays between effects of higher pollutant concentrations.

Human influences on soil have additional manifestations today: primarily, the effect of extensive technical interventions in landscape, consisting in dumping of removed earth and waste, mining for minerals, road construction, urbanization effort, etc. There are many additional sources of human influence on soil: we cannot ignore mass use of pesticides (insecticides, acaricides, herbicides, rodenticides and fungicides) and environmental accidents with an impact on soil (petroleum products, chemical compounds of heavy metals, radioactive materials), etc.

c) Site use history in terms of site evolution

Assessment of soil profile without considering its long-term evolution and knowledge of actions progressing over time is impossible.
In terms of broader context and pitfalls of assessing properties and condition of soil profile, the time factor acts at two levels:

- a soil property is a property showing a given value only at the time of assessment,
- a soil property is a property acquired and conditioned by the time of soil evolution.

It can thus be concluded that:

- the value of each soil property analysed changes in time,
- the value of each soil property analysed depends on the duration of time for which it has been generated by comprehensive action of soil formation factors.

Interpretation of field survey and laboratory analysis results in light of the time concept is particularly necessary considering the glaciation of Europe in the Pleistocene.
The soil-forming substrate of Czech towns and cities underwent very important changes in the Quaternary due to both transportation and sedimentation. Thick layers of cold period sediments (loess, glacial and alluvial sediments) were fresh substrates for soil formation in interglacial periods (interglacial soil formation). Simultaneously to that, extensive erosion exposed fresh outcrops of older rocks, which then produced new soil-forming substrate, all that under significant temperature oscillation.
In order to assess site use history from the point of view of site evolution, it is also worth noting that when evaluating time as a soil formation factor, we always need to consider the fact that the actual profile thickness is the result of accumulation and erosion phenomena in landscape.
This in fact means that the soil matter of a site profile both increases and decreases and transforms. On some sites, the processes of mineral and organic component formation equal those of their loss, and on others, one category of the processes prevails. From this point of view of soil evolution (older pedology textbooks use personified stages of growing, maturing, ageing and expiry of soil; modern literature links this concept primarily to the earth ethics theory), perception of time as a significant and non-neglectable factor for responsible interpretation of field survey and laboratory soil analysis results is extremely important.

Annex 4 Instructions for field determination of soil parameters

Table 1: Texture / grain (soil type) identification

soil type	clay particle content	moist	dry
sandy	0-10 %	non-cohesive, rough, creaks when rubbed between fingers, cannot be shaped	loose, non-cohesive, creaks when rubbed
loamy-sandy	10-20 %	rough, signs of cohesion, sand felt, creaks when rubbed, rolls into short, rough cylinders	little cohesion, rough, any aggregates disintegrate fast
sandy-loamy	20-30 %	more cohesive sand grains still felt between fingers, can be formed but disintegrates fast	forms aggregates easy to break, rough edges of scratches
loamy	30-45 %	cohesive, low sand content, can be formed, breaks when twisted into a ring	aggregates disintegrate under pressure, dusty
clayey-loamy	45-60 %	cohesive, viscous, sticky, fine particles can be formed, cracks when twisted but does not break	larger aggregates, hard to crumble, straight edges of scratches
clayey	60-75 %	viscous, very sticky fine particles can be formed without cracks	forms lumps and clods, cannot be crumbled

Table 2: Skeleton content identification – fraction size (a) and skeleton volume content (b) compared to soil fine earth (particles > 2 mm)

(a) fraction size
2–5 mm coarse sand 5–10 mm fine gravel 10-30 mm medium gravel 30-50 mm coarse gravel 50–300 mm stones > 300 mm boulders

(b) skeleton content
Soil (rootable area) skeleton content: 0–20% *low skeleton content* 20-50% *medium skeleton content* > 50% *high skeleton content* **Skeleton content (in soil horizon):** 0–5% very low; 5–15% low; 15–20% medium; 20–40% moderately high; 40–80% high; 80% very high

Table 3: Soil structure categories

elementary	**grainy** – mainly sandy materials **silty** – mainly materials dominated by silty sand **floury** – mainly materials dominated by coarse dust **merged** – soil particles stuck together
aggregated	**spherical** – aggregates of round shapes with bumpy surface in all three directions
aggregated / segregated of flat shape	**crumbly / laminated:** very fine / thin ≤1 mm (prevalence) fine / thin 1–2 mm medium 2–5 mm coarse 5–10 mm very coarse ≥10 mm lumpy 10–50 mm (for crumbly) cloddy 50 + (for crumbly)
segregated with elongation along vertical axis	**prismatic, columnar:** very fine ≤ 10 mm fine (tiny) 10–20 mm medium 20–50 mm coarse 50–100 mm very coarse 100–500 mm extreme ≥ 500 mm

segregated without significant elongation	**polyhedric, cubic** – polyhedral aggregates, irregular shape (more or less regular for cubic) with smooth facets and sharper edges as well as lumps: very fine ≤5 mm fine 5–10 mm medium 10-20 mm coarse 20-50 mm very coarse 50-100 mm

Two structures are possible if percentage of individual structural shapes and their sizes are quoted.

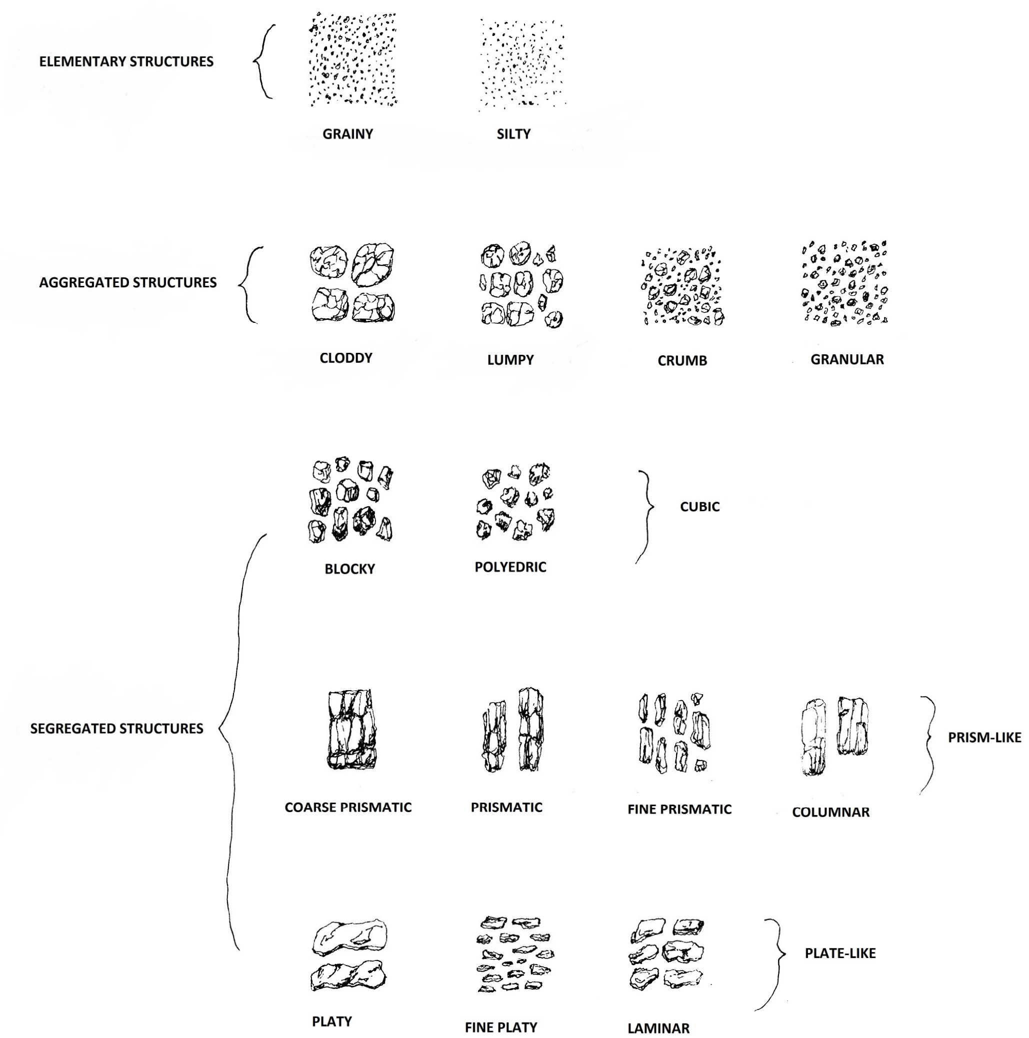

Fig. 1: Soil structure categories (adapted from Vavříček and Kučera, 2017).

Table 4: Soil moisture identification for different soil types

soil moisture	water content in soil (%)		
	light soils	medium soils	heavy soils
dry (firm hard prisms with sandy engraving)	2-4	4-8	8-15
moderately moist (feels cool when pressed)	4-8	8-15	15-25
medium moist (moistens the palm, retains shape)	8-12	15-25	25-35
moist (moistens the palm and fingers, retains shape)	12-14	25-35	35-45
wet (wet palm sticky, grimy, glossy edges)	18-30	35-45	45-55
muddy (runs)	30 +	45 +	55 +

Table 5: Rooting density identification

root diameter	**rooting (pcs/dm²)**			
	very low	low	medium	high
≤ 2 mm	1-20	20-50	50-200	200 or more
≥ 2 mm	1-2	2-5	5-20	20 or more

	root size			
	very fine	fine	medium	thick
root diameter [mm]	≤ 0.5	0.5-2	2-5	≥ 5

Table 6: Soil consistency identification

powdery	non-coherent earth, aggregates disintegrate when touched, slushy with water
very loose	aggregates (crumbs, lumps) crumble under light pressure, they agglutinate under heavier pressure, sharp objects make a vertical cut at the front of the probe
loose	aggregates crumble partially when rubbing the front of the soil probe with fingers, sharp objects penetrate the soil
slightly compacted	very viscous, sticks to work tools, difficult to carve
very compacted	coarse cracked aggregates, resists carving strongly
caked	sharp objects do not penetrate

Table 7: Identification of type of transition between horizons

Transition shape	**Transition speed**
level	sharp (colours alternating within 2 cm)
undulating	distinct (colours alternating within 2–5 cm)
tongue	gentle (colours alternating within 5 cm)
slit	diffused (indistinct colour alternation)
pocket	(e.g., undulating distinct colour transition)

Annex 5 Template field log for assessment of soil parameters

<table>
<tr><td colspan="4">Location:</td><td colspan="6">Elaborated by:</td><td colspan="4">Exposure</td></tr>
<tr><td colspan="4">Point of consumption:</td><td colspan="6">Altitude</td><td colspan="4">Inclination</td></tr>
<tr><td colspan="4">Probe number:</td><td colspan="6">GPS – N</td><td colspan="4">Ground topography</td></tr>
<tr><td colspan="4">Date</td><td colspan="6">GPS – E</td><td colspan="4">Note:</td></tr>
<tr><td colspan="4">Soil unit name:</td><td colspan="6">Humus form:</td><td colspan="4">Sequence of horizons:</td></tr>
<tr><td colspan="2">Total depth</td><td colspan="2">Physiological depth</td><td colspan="2">L:</td><td colspan="2">F:</td><td colspan="2">H:</td><td></td><td></td><td></td><td></td></tr>
<tr><th>Horizon – name</th><th>Horizon – upper bound (cm) /transition</th><th>Horizon – lower bound (cm) /transition</th><th>colour</th><th>texture</th><th>structure</th><th>moisture</th><th>consistency</th><th>skeleton (degree)</th><th>skeleton (fraction)</th><th>edaphon</th><th>rooting (root hairs (< 2 mm)</th><th>rooting thick roots (> 2 mm)</th><th>remark</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="14">Field assessment:</td></tr>
</table>

Annex 6 Illustrations

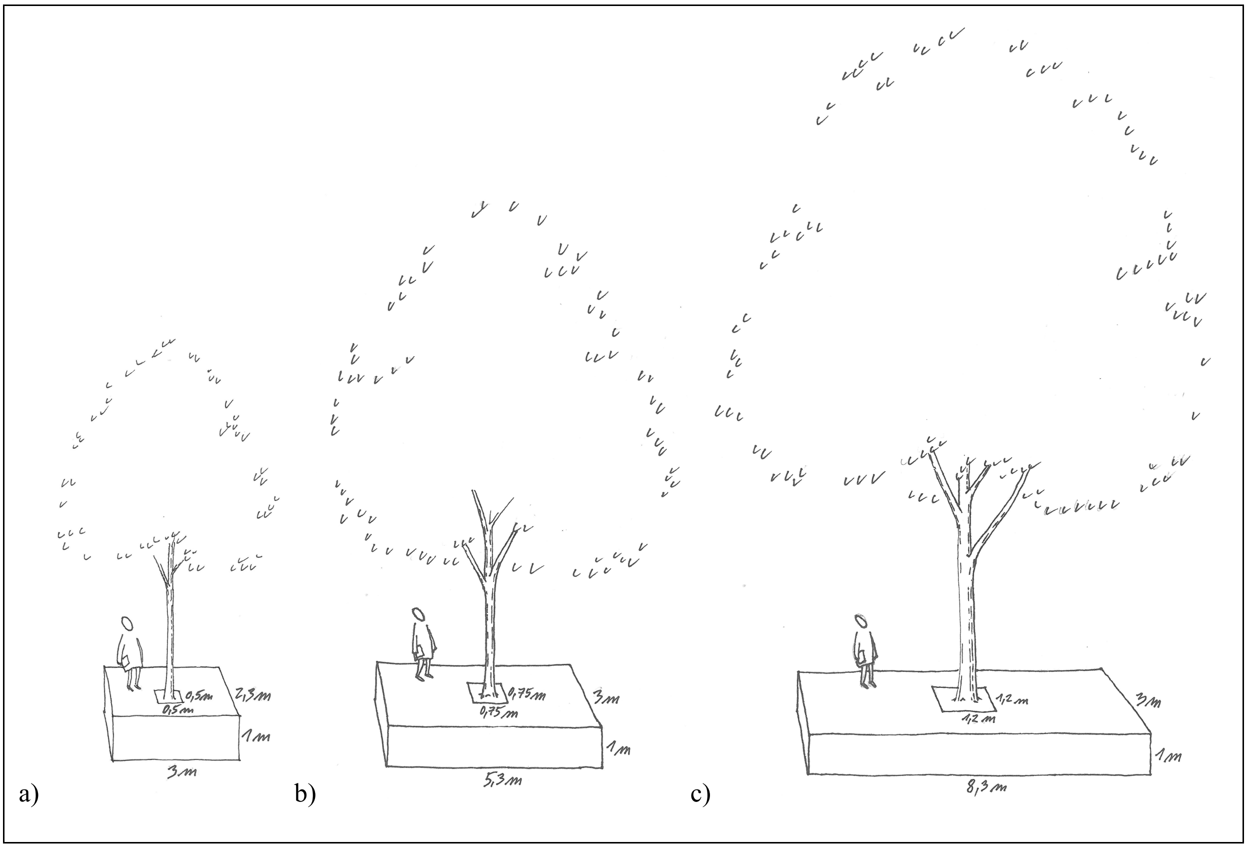

Fig. 1 Minimum rootable area volume and minimum open tree bowl diameter (3.2.4):
a) small-crown trees, b) medium-crown trees, c) large-crown trees.

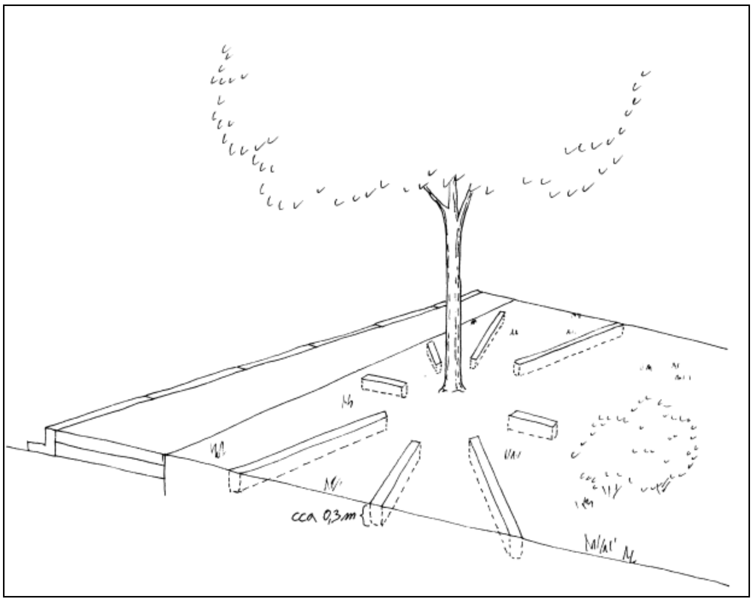

Fig. 2 Radial mulching (5.5)

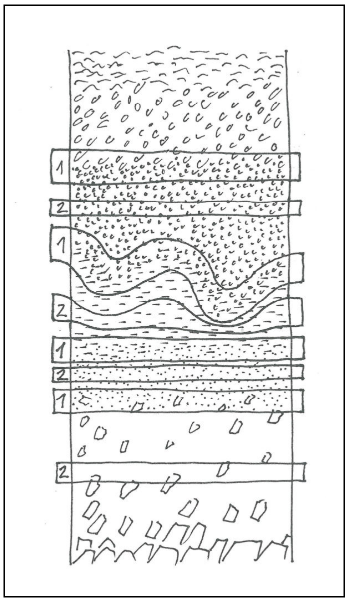

Fig. 3 Soil horizons, soil sample collection points shown (2.2.2):
1 – transition zone (unsuitable for sampling), 2 – typical soil horizon section (sampling point).

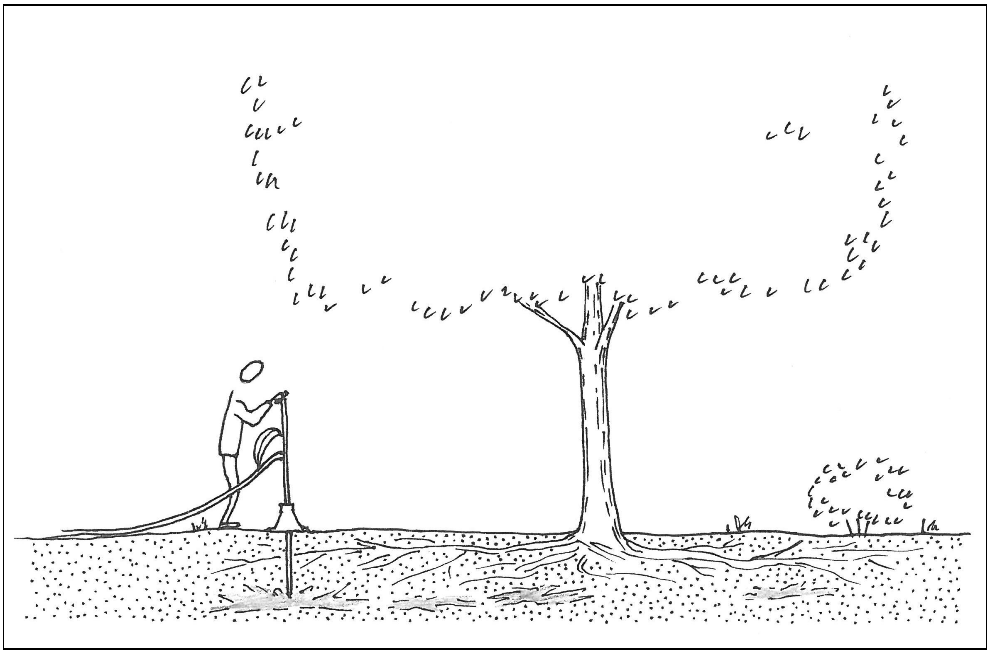

Fig. 4 Depth injection (5.7)

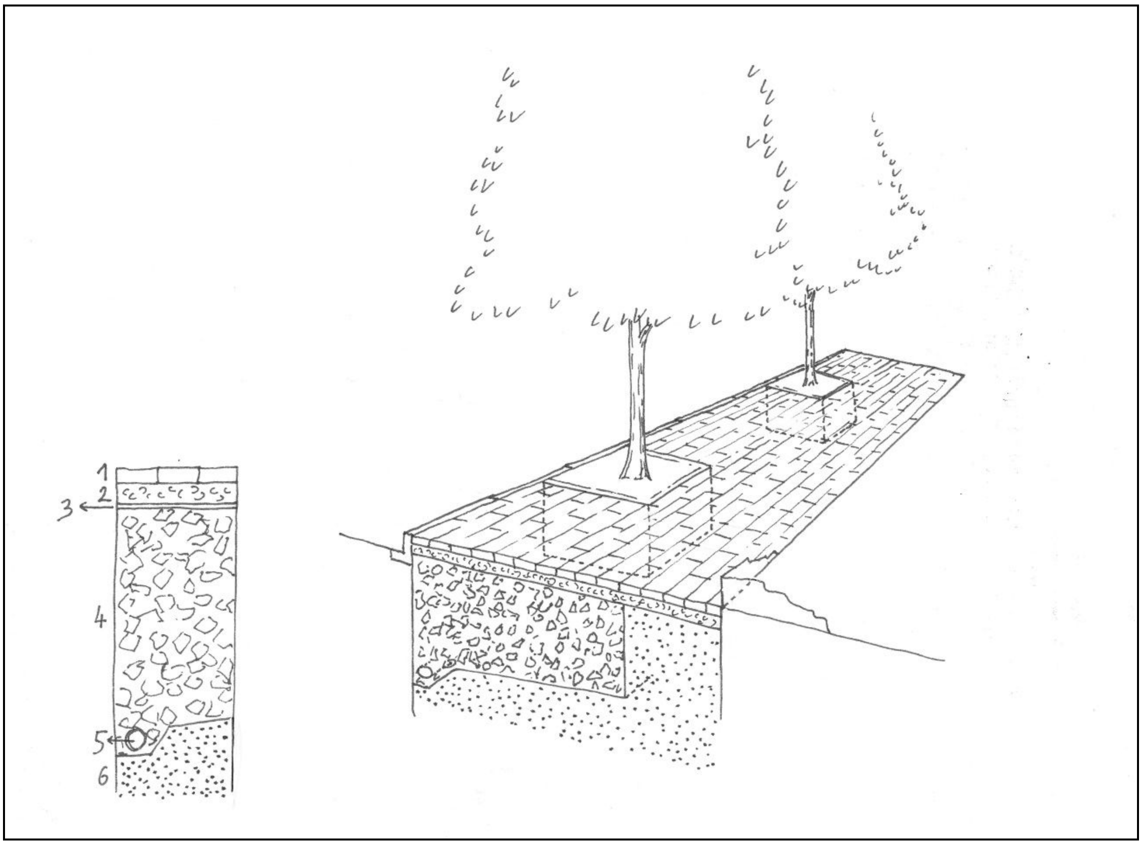

Fig. 5 Example of use of structural substrate in street avenue (5.11): 1 – pavement, 2 – gravel bed, 3 – geotextile, 4 – structural substrate, 5 – drainage, 6 – natural earth.

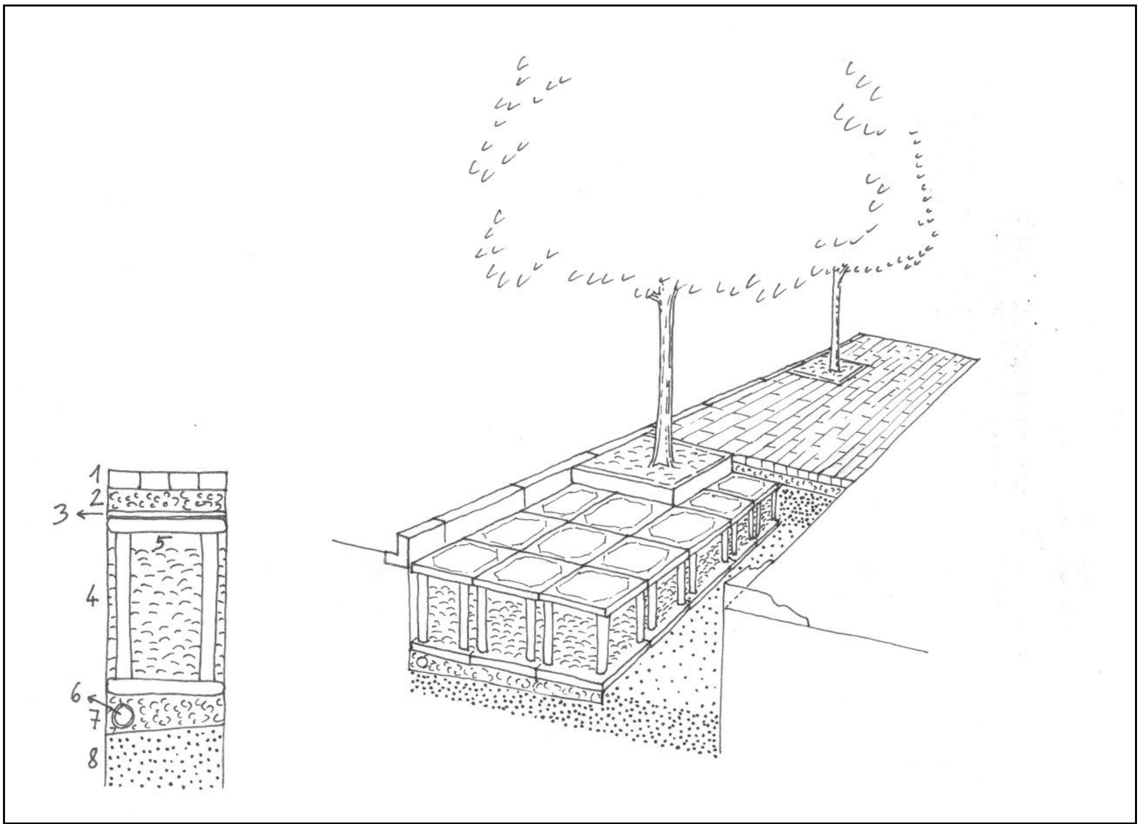

Fig. 6 Example of use of soil cells in street avenue (5.12): 1 – pavement, 2 – gravel bed, 3 – geotextile, 4 – soil cell filled with cultivation substrate, 5 – ventilation gap, 6 – drainage, 7 – gravel bed, 8 – natural earth.

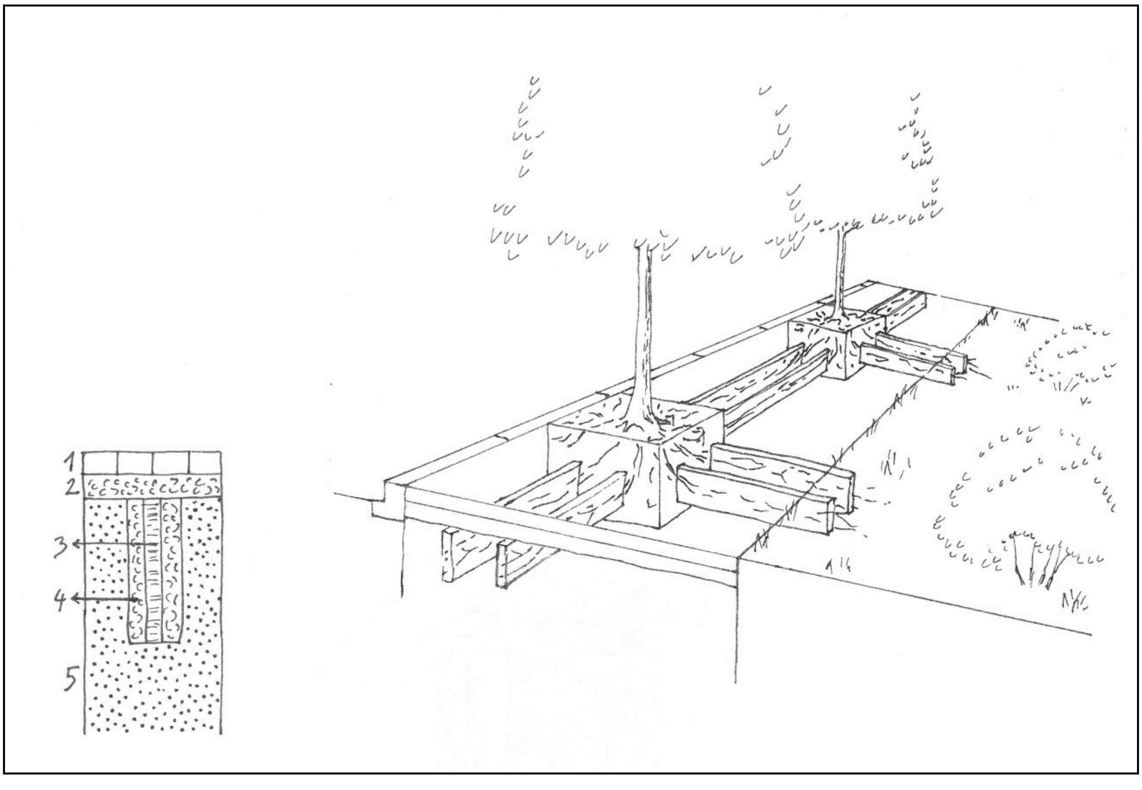

Fig. 7 Example of root zone bridging in street avenue – one possible type of root path (5.13): 1 – pavement, 2 – gravel bed, 3 – drainage, 4 – cultivation substrate, 5 – natural earth.

Annex 7 List of Nature and Landscape Management Standards (Arborist Standards) developed

01 Inspection, assessment, planning

01 001	Tree assessment
01 002	Protection of woody plants during development activities

02 Work procedures

02 001	Planting of trees
02 002	Pruning of trees
02 003	Planting and pruning of shrubs and climbing plants
02 004	Crown security systems (cabling / bracing)
02 005	Tree felling
02 006	Protection of trees against lightning strike
02 007	Alteration of tree and shrub habitats
02 008	Woody plant stand establishment and management
02 009	Special tree treatment
02 010	Management of woody plants along public transport infrastructures
02 011	Care of woody plants along utility lines

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Faculty of Forestry and Wood Technology
Zemědělská 3
613 00 Brno

© 2020 Nature Conservation Agency of the Czech Republic
Kaplanova 1931/1
148 00 Praha 11

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