GUIDELINES FOR URBAN FORESTRY TECHNICIANS

Erasmus Plus Project

VIRIDIS LOCI

An initiative from the following partners:

This document has been developed within the Erasmus Plus project “Viridis Loci” (2021 - 1 - IT01- KA220 - VET – 000025302).

Result type: Methodologies / guidelines – Methodological framework for implementation

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Background

The Viridis Loci (VL) project aims to provide specialized VET training/transfer of skills in the correct management of green areas and parks in municipalities to public technicians and private subjects who are interested in dealing with advanced professional management of urban nature in three European islands: Sardinia, the Balearic Islands and Madeira. The Czech Republic will contribute to the development of the project as one European country where 'the culture of well managed green areas in cities as providers of ecosystem and social services for the whole community' is deeply rooted, considering the role and the presence of Czech's partner too.

The project partners come from four European countries, Italy, Spain, Portugal and the Czech Republic. The Italian partners are ANCI Sardegna (project leader), Fito-consult and ATM Consulting; the Spanish partner is FELIB (Federation of municipalities of the Balearic Islands); the Portuguese partner is AREAM (Regional Agency of Energy and Environment of the Autonomous Region of Madeira). The Czech partner is ABA International (a 'nonprofit' international education association and certification body).

The consortium presented this project for three main reasons:

1) Environmental sustainability and the fight against climate change: it emphasizes the role of well-managed green areas/parks within cities and municipalities in general as providers of ecosystem services (benefits that people obtain from nature, e.g.,, climate regulation, CO2 capture, air quality improvement, cultural values, public health and biodiversity conservation).
2) Increase Inclusion. The project will operate in three island contexts in southern Europe, which, due to their geography, tend to be isolated and at a permanent economic disadvantage compared to other regions of the continent
3) Overcoming the knowledge gap with the use of ICT technologies to impart a highly technological and innovative working methodology.

The project will operate in three island contexts in southern Europe, which due to their geography, tend to be isolated and at a permanent economic disadvantage compared to other regions of the continent. Islands tend to lag behind in economic terms and innovation processes negatively impact the communities residing on the islands. Unemployment rates in the three islands are high with dramatic peaks among young people and in all cases higher than the respective national averages:

Sardinia (18% - youth unemployment around 45%), Balearic Islands (youth unemployment 17% - around 40%) and Madeira (10% - 50.5% youth unemployment).

Aim and structure of the document

The aim of the document is to provide new and updated knowledge and skills to technicians and arborists who deal with planning and managing urban greenery, in their every day working routine, devoting particular attention to urban trees.

Today greenery increasingly plays a central role in ensuring a greater quality of life for the increasing number of residents in urban areas, thanks to the provision of ecosystem services, also in light of the major changes underway at a global level. Indeed, the increase in urban population, and the corresponding urbanisation, has resulted in several challenges: for example, pollution has a negative impact on air quality and it represents a true health issue for citizens; meanwhile temperatures are rising within urban agglomerates, due to the so-called Urban Heat Island –UHI– effect and climate change.

These challenges require new and innovative solutions, as well as new and updated professional profiles, capable of developing and implementing new planning techniques and tools to overcome the current challenges and deliver more sustainable cities.

Starting from these assumptions and higher goals, this document faces the topic tackling precise technical points, aiming at serving as a first knowledge baseline for the technicians in need of solid solutions to be applied at different urban contexts. Because of that, the document is divided into different and independent chapters, with the following goals:

- Promote technically sound management techniques to maximize the benefits of urban trees within cities
- Plan properly, with comprehensive tree strategies, to maximize benefits and efficiency
- Preserve existing urban trees, with tailored actions and practices, to assure long-term results and maintain cultural bondages.

A comprehensive tree strategy & urban forestry plan

Having a deep knowledge on urban assets and a clear vision of goals and needs is the starting point for a successful inclusion of urban trees within our cities. This means that having an inventory of the urban forestry and a strategy for its future development: this is crucial to achieve a more sustainable and liveable city.

In this, an Urban Forestry Plan is the key document within a tree strategy.

What is an Urban Forest Master Plan? The Urban Forest Master Plan represents a unified vision for urban natural capital and green infrastructure. It provides a framework for developing and managing the urban forest, capturing the aspirations of stakeholders who benefit from a healthy, diverse, and green city. As a roadmap, the plan offers comprehensive guidance, recommendations, and resources to proactively manage and expand the city's tree canopy.

An Urban Forestry Master Plan should support the implementation of long-term strategies to inspire all involved with the urban forest to understand, respect, and enhance it. The Urban Forest Master Plan unifies existing policies, plans, guidelines, and frameworks into a single, cohesive document. It offers a comprehensive resource for all practices related to the urban forest, encompassing both green and blue infrastructure. The plan also aims to inspire further research into the urban forest—its needs, impacts, and progress—fostering a deeper understanding and support for sustainable urban growth.

A Master Plan should fully address the following questions:

- **What do we have?** Understanding the nature and scope of tree resources is essential for effective planning and management. This process involves assessing the overall value of the local tree population and describing its profile in quantitative, qualitative, and functional terms.
- **What do we want?** Clearly defined objectives, that outline what future success looks like and specify the benefits the urban forest should provide, are essential for guiding effective action. Establishing these objectives requires a wide partnership of stakeholders that extends beyond those directly managing trees.
- **What do we do?** To be effective, a Master Plan must outline both the policies and practical actions necessary to achieve each objective. This should include:
    - Addressing areas where tree coverage is low and may require canopy cover goals.

- Correcting imbalances in age demographics and species diversity within the tree population.
- Adopting clear, enforceable policies, and for local authorities, incorporating these policies into local planning documents.
- Establishing management standards that support the anticipated benefits of the urban forest.
- Developing a strong partnership and community engagement program to drive successful implementation.

- **Are we getting what we want?** Monitoring progress, identifying why certain efforts may not be achieving expected results, and adapting strategies accordingly are essential to meeting stated objectives. It is suggested conducting such a review process approximately every five years.

On the other hand, since it defines a vision for the development of the urban forest, a Master Plan should have a proper lifespan, at least a couple of decades: in some UK case studies, e.g. Birmingham Urban Forestry Master Plan, the time span has been defined in 30 years – period 2021-2051.

This specific UK-based case study, developed by Treeconomics and the Nature-based Solutions Institute among other key local stakeholders, defines a set of primary targets and goals, divided in three categories. This can be taken as a good practice that can be replicated in different areas:

1. **Trees and Urban Forest Structure:**

Key Performance Indicator	Priority	Possible performance level
T1 – Relative tree canopy cover	**High**	**Low - Optimal**
T2 – Age diversity	**High**	**Low - Optimal**
T3 – Species diversity	**High**	**Low - Optimal**
T4 – Species suitability	**High**	**Low - Optimal**
T5 – Publicly owned trees	**High**	**Low - Optimal**
T6 – Publicly owned natural areas	**Medium**	**Low - Optimal**
T7 – Trees on private property	**High**	**Low - Optimal**
T8 – Other green elements (shrubs, turf, etc)	**Medium**	**Low - Optimal**
T9 – Tree Benefits	**High**	**Low - Optimal**
T10 – Wider Environmental Considerations	**Medium**	**Low - Optimal**

2. Community Framework:

Key Performance Indicator	Priority	Possible performance level
C1- Governance	High	Low - Optimal
C2 – Cooperation	Medium	Low - Optimal
C3 – Utilities cooperation	Medium	Low - Optimal
C4 – Green industry cooperation	Medium	Low - Optimal
C5 – Landholders involvement	High	Low - Optimal
C6 – Neighbourhood involvement	High	Low - Optimal
C7 – Tree awareness	Medium	Low - Optimal
C8 – Regional collaboration	Low	Low - Optimal
C9 – International Reputation	Medium	Low - Optimal

3. Sustainable Resource Management Approach:

Key Performance Indicator	Priority	Possible performance level
R1 – Tree inventory	High	Low - Optimal
R2 – Management approach	Medium	Low - Optimal
R3 – Canopy cover assessment and goal	High	Low - Optimal
R4 – Tree justice	High	Low - Optimal
R5 – Plan review	Medium	Low - Optimal
R6 – Fundings	High	Low - Optimal
R7 – Program capacity	High	Low - Optimal

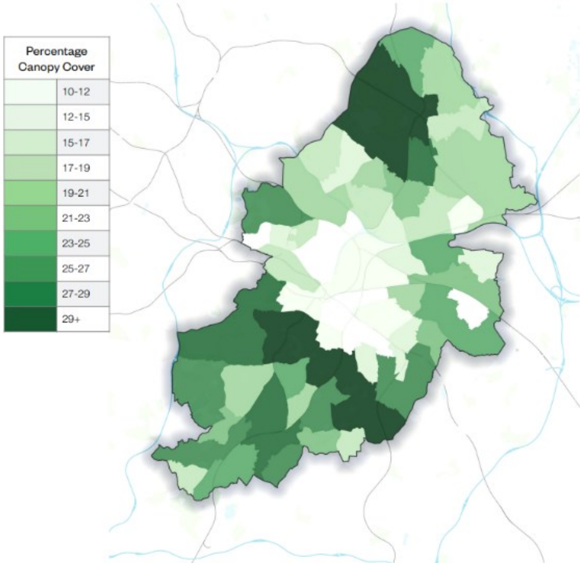
R8 – Tree establishment	**High**	**Low - Optimal**
R9 – Growing site suitability	**High**	**Low - Optimal**
R10 – Tree protection policy	**High**	**Low - Optimal**
R11 – Maintenance of urban trees	**Medium**	**Low - Optimal**
R12 – Maintenance of extensive areas	**Low**	**Low - Optimal**
R13 – Tree risk management	**Medium**	**Low - Optimal**
R14 – Biosecurity	**High**	**Low - Optimal**
R15 – Urban wood utilization	**Low**	**Low - Optimal**
R16 – Native vegetation	**Low**	**Low - Optimal**
R17 – R&D	**Medium**	**Low - Optimal**
R18 – Open data and maps	**High**	**Low - Optimal**

Source: An Urban Forest Master Plan for Birmingham 2021-2051 – Treeconomics

The Viridis Loci partnership strongly suggests the adoption of these targets, with a particular focus on the following indicators:

- **T1 - Relative Tree Canopy Cover:**

Canopy cover, also known as tree canopy cover or urban canopy cover, refers to the area of leaves, branches, and stems of trees that cover the ground in a specific area when viewed from above. This two-dimensional metric shows the extent of tree cover across an area. Canopy cover assessment is popular because it is relatively easy to measure using various methods and can often be calculated at a low cost.



Performance level	Performance Indicators			
	Low	Moderate	Good	Optimal
Data source decision required	The existing canopy cover equals 0–25% of the potential.	The existing canopy cover equals 25–30% of the potential.	The existing canopy cover equals 50–75% of the potential.	The existing canopy cover equals 75–100% of the potential.

Source: An Urban Forest Master Plan for Birmingham 2021-2051 – Treeconomics

- **T3 - Species Diversity:**

Diversity is a crucial element to monitor in the urban forest. Trees are categorized by families, genera, species, and varieties, and a balanced mix of these is essential to a resilient urban forest. High levels of both inter- and intra-species diversity enhance the forest's sustainability, making it more resilient to environmental stressors, pests, and disease. A diverse tree population is also better prepared to adapt to climate changes and external threats.

Ideally, a well-distributed variety of tree species should ensure that no single species comprises more than 5% of the overall tree population across the city or more than 10% within any neighbourhood. Species diversity is measured through both species' richness (the number of different species) and species evenness (the relative abundance of each species). These can be combined into indicators like Hubbell's dominance diversity curves or the Shannon Index, widely used in ecology.

- **C6 - Community Involvement and Neighbourhood Action:**

Citizens and groups must be encouraged to participate and collaborate in urban forest management activities – the picture shows a public event in this sense. Collaborating with these groups and encouraging further community involvement with projects in small neighbourhoods and wider district areas would benefit the whole city. Neighbourhood activities often help the community members to connect more with their urban forest, and encouraging communities to get involved will reduce the likelihood of conflict or opposition to tree planting.

- **R8 - Tree Establishment Planning and Implementation:**

Tree planting is often more complex than many realize; it involves much more than just putting trees in the ground. To ensure that trees survive, thrive, and reach their full potential in urban environments, it's essential to select the right species, plant them in suitable locations, for the right reasons, and with proper care and maintenance. This approach gives trees the best chance to survive and prevents the need for their removal at a later stage:

- Right reason: Tree planting efforts should prioritize quality, not just quantity. While there is a strong emphasis on increasing tree numbers, focusing solely on this goal may be counterproductive if the trees don't survive to maturity. The real value comes from planting trees that will thrive in the long term.
- Right place: The location of tree planting is crucial, especially in urban environments where conditions may not be ideal. Trees need space to grow both above and below ground. Planting too close to a building may block light or interfere with foundations,

causing subsidence. Placing trees too close together limits root space and light. Power lines, drains, pavements, and roads can also be negatively impacted if trees aren't given adequate space to grow.

- Right tree: The selection of tree species should consider a variety of factors, including site suitability, climate tolerance, size, rooting characteristics, aesthetic qualities (such as canopy, leaves, and flowers), ecosystem services, and biodiversity contributions.
- Right way: The method of planting will depend on the tree's location, but all trees require certain essentials: adequate soil volume for root establishment, water (especially for young trees in hot urban areas), air, and support to keep them upright as their roots take hold. They also need protection from damage and regular maintenance. Challenges like hard, impermeable surfaces can hinder tree growth by causing soil compaction, limiting nutrient recycling, and reducing water infiltration. These factors must be addressed to support the establishment of a healthy, long-lasting urban forest.

- **R9 - Growing Site Suitability:**

Trees are often chosen primarily for their aesthetic appeal, but this can lead to problems if the site conditions are not properly considered.

Site suitability should be assessed from the ground up, starting with the soil: as the picture shows, soil compaction is deadly threat for trees. Urban soils are frequently poor or even non-existent, so it's crucial to understand the existing conditions and what the tree will need before planting. Other factors to consider include the amount of sunlight the tree will receive—whether it will be in permanent shade from nearby buildings—and the extent of impermeable surfaces around the site, which can limit water infiltration to the roots. Additionally, there must be enough space both above and below ground to allow the tree to grow properly. Once these factors are assessed, the appropriate tree can be selected and planted in the right location.

- **R13 - Tree Risk Management:**

Risk management is essential in urban environments, where the high volume of daily interactions with trees increases the potential for incidents. Tree-related risks include falling branches, toxic or poisonous leaves, berries, seeds, and pollen, as well as issues like roots uplifting pavements (creating trip hazards) and pests such as the Oak processionary moth.

These risks must be evaluated, and a strategy implemented to minimize harm to people. One of the most effective ways to reduce risk is through careful species selection and planting. For example, avoid planting trees with toxic fruits in areas frequently visited by children or dog walkers. Some pests can be controlled early using pesticides, fungicides, or biological controls. Ensuring trees have enough space and deep soil to allow roots to grow freely can reduce the risk of upheaval.

Both existing and newly planted trees should be regularly monitored to detect potential issues early and prevent further risks. A system should be in place for routine tree assessments at regular intervals, with clear methods for risk reduction and management.

Zoning is a useful practice where landowners and managers categorize areas based on levels of use. This approach prioritizes the most frequently used areas, enabling a more cost-effective tree inspection process by focusing resources where they are most needed. The frequency and methods of inspection may vary depending on whether the management strategy is intensive or extensive.

Zone	Tree Locations	Inspection Frequency and Methods
Zone 1-High Risk	Park perimeter adjoining a major/busy highway; Park entrances; Buildings; Main/well used paths/ driveways and seating areas; Car parks; Play areas; Work yards.	Trees within this zone would be inspected on an **annual** basis by a local site manager or other client officer.
Zone 2-Medium Risk	Park perimeter adjoining private / residential properties; Secondary paths/desire lines/routes; Amenity and/or sports areas.	Trees within this zone would be inspected every **5 years** by a local site manager or other client officer.
Zone 3- Low Risk	Lightly used areas and routes; Designated woodlands (where conditions for Zone 1 + 2 do not apply); Any other areas not mentioned above	Trees within this zone will receive **no formal inspection** however for trees identified by local users as potentially hazardous an inspection record will be raised in POPI. This will be followed up by an inspection from a local site manager or other client officer.

Source: An Urban Forest Master Plan for Birmingham 2021-2051 – Treeconomics

Innovative planning rules for our cities

Urban planners and decision-makers keep on looking for specific guidelines for developing successful urban forestry programs. However, it is important to note that every city is different – from environmental, cultural and socio-economical points. This makes almost impossible to define transferable targets across various contexts and settings, copy pasting urban forestry plan from city to city.

From this general starting point, it is still possible to draw some high-level considerations, to drive decision-makers and planners with valid assumptions to be used as initial point for a technically-sound urban forest.

"A city without trees is dead" – A. Shigo.

In the last decades, several theories have been developed following this line.

Above others, **"10-20-30"** rule, one of the first to be theorized, has become well known and adopted, most likely having a positive effect on urban forest structure and diversity.

The rule, set by Frank Santamour, aims at ensuring tree species diversity: it states that no tree species should make up more than 10% of a municipality's urban forest, no genus should have a share larger than 20%, and no single family should make up more than 30% of the urban forest.

However, this rule does not have a specific focus on the benefits provided by urban forests. Given the renovated awareness around the role of urban greenery in making our cities sustainable, impacting human health as well, researchers have been focused on introducing guiding principles for urban forest programmes, and city greening across the world, that ensures that all residents have access to trees and green – and the benefits these provide. Cecil Konijnendijk, a well-known Dutch researcher, has proposed the so-called "**3-30-300**" rule. The baseline of this rule is the recognition of the need to bring nature all the way into people's neighbourhoods, streets, and on their doorsteps in order to capitalise on their many benefits.

Source: The 3-30-300 Rule for Urban Forestry and Greener Cities, Cecil Konijnendijk, Biophilic Cities Journal.

3 Trees from every home

The first element of the rule is that every citizen should be able to see at least three trees, of a decent size, from their home. Seeing green from our windows helps us keep in touch with nature and its rhythms. It provides important breaks from our work and can inspire us and make us more creative. We define the decent size of a tree as at least 8 meters in height or covers an area of at least 20 square meters (5m in diameter).

30% Tree canopy cover in every neighbourhood

Recent studies have shown an association between urban forest canopy and cooling, better microclimates, mental and physical health and possibly also reducing air pollution and noise. At the neighbourhood level, 30 percent should be a minimum, and cities should strive for even higher canopy cover when possible.

300 Metres from the nearest green space

Proximity and easy access to high-quality green space that can be used for recreation encourages the recreational use of green space with positive impacts for both physical and mental health. These green spaces must be at least 0.5 hectares in size and at least 20 meters wide.

The application of this rule is flourishing, and new examples can be seen in several part of Europe. Studies show that citizens living in areas where the 3-30-300 criteria are met reported better mental health, with a reduced use of antidepressants.

A first application to understand if a city is meeting 3-30-300 has been conducted in Brno, in case study focused on the district of Královo Pole, by the local company Asitis, with the goal of assessing the district’s compliance with the 3-30-300 rule to ensure that residents continue to benefit from accessible and sufficient urban greenery.

The assessment of the 3-30-300 rule can reveal both promising aspects and areas for improvement in urban green space planning and management. In example, it can represent an opportunity for urban planners to focus on increasing tree canopy in areas with low presence of trees, particularly in newer urban developments, implementing stricter green space requirements for new constructions, incentivizing the preservation of existing trees, and launching community tree-planting programs.

Asitis, in its case study, provided clear number around Královo Pole. The assessment has been conducted combining a set of different data, starting from a building basis, focusing on trees within a 50-meter radius to define the first rule, visibility from the building. Then, canopy coverage and proximity rules can be analysed relying on orthophotos and on GIS software, to set and define clear distances from each building.

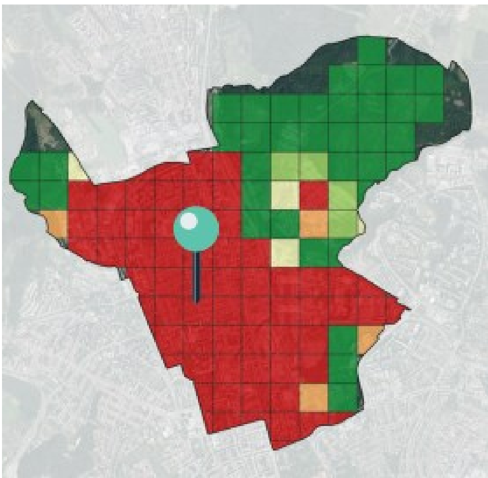
- Tree Visibility (Rule 3): 85% of buildings in Královo Pole met the visibility requirement, demonstrating relatively strong performance in this area. If compared to other European cities, this figure is notably higher than the average: for instance, a similar assessment conducted in Barcelona reported tree visibility compliance at just 43%, highlighting Královo Pole’s success in ensuring that the majority of its residents benefit from urban greenery (Nieuwenhuijsen, M. J. et al, 2022).

- Tree Canopy Coverage (Rule 30) The assessment in Královo Pole revealed that only 17.8% of buildings meet the 30% tree canopy coverage requirement. While this may seem like a shortfall, it reflects a common challenge faced by most urban areas across Europe. The 30% canopy coverage target in densely built environments is an ambitious goal, often difficult to realize due to spatial constraints, existing infrastructure, and competing land-use needs.

- Proximity to Green Spaces (Rule 300) The analysis of Rule 300 in Královo Pole revealed that 40.9% of buildings are within 300 meters of a qualifying green space. While this is a positive result, it means that the majority of buildings (59.1%) still lack easy access to nearby parks or green areas.

Graphically, these results are visualized with a GIS-based map, enabling to easily understand Královo Pole's buildings fully complaint with the three rules (green ones); partly complaint (yellow and orange ones), and not compliant (red ones):

The result can be further aggregated to show the overall situation across the city, to provide a broad outlook for decision-makers:



Source: Assessing the 3-30-300 rule in the Královo Pole District, Brno – Asitis.

Positive and negative examples

A crucial point that most of urban arborists and municipal technicians fail to understand is that trees are alive organisms, with a peculiar biology and physiology.

Being aware of this fact is the starting point for each management technique that is aimed at improving trees' health. Knowing how and when – and, most importantly, if – operate on an urban tree is a technical skill, based on practical and theoretical experiences and skills.

Beside some baseline principles, there are no fixed and standard rules that can be applied when managing a tree. Indeed, each specimen is different – due to different characteristics depending on species, individual traits, the surrounding environment and the previous tree management.

Some species, for pre-established anatomical and physiological reasons can tolerate specific biotic and abiotic stresses, while other species – e.g., beech – are much more sensitive to same actions, with negative results. Moreover, within the same species, there is a gradation of individual sensitivity: one individual reacts differently from another to an incorrect practice.

It should also considered that trees are living beings with a degree of "plasticity": if a particular management technique is adopted and repeated from their juvenile stages, different results can be achieved: let's simply think to bonsai, a proof of this. Of course this depends on the biological and physiological traits of each species. Studying the phenological curves of development can help in understanding when to operate and how, depending on the desired results: this is crucial when we approach a sensitive topic, such as pruning.

A dated commercial promoting tree topping. Unfortunately, still valid, based on what it is seen in our cities:

E.g., if you want to reduce the vigor of topped trees, it is best to intervene after the complete emission of the shoots, i.e. in full vegetation; otherwise in vegetative rest. It should be better to avoid pruning in two phenological states: leaf emission phase, when the internal energy levels of the trees are at a minimum, and leaf fall phase. In addition, for species with abundant flowering, absolutely not in full bloom.

Unfortunately, despite a growing movement adopting modern arboriculture techniques, with novel concepts defined by Alex Shigo in the US from the '70, we still experience wrong and old techniques put in place.

Among other, tree topping is the most recognizable error that most of technicians (or so-called) perpetrate to urban trees.

What is tree topping? There is a lot of confusion about the term topping and in fact there is no precise definition of what is technically meant: it is not so much the quantity of wood removed or the fact of removing a top that can define the term. Topping is not measured only by the aesthetic damage it produces and which rightly horrifies most people. We may define topping as any internodal cut that results in the development of new branches from adventitious, dormant buds or from internal meristematic points.

Why is topping done? There are several reasons, such as fix trees that interfere with electrical wires; shorten trees that grow too tall near their home; prevent the tall tree from coming down in a storm. It is widely believed that after the topping, a tree grows back more vigorously. These motivations and belief are totally wrong.

Indeed, tree topping causes the sudden removal of high percentage of the tree canopy, resulting in a disbalanced energetic status of the specimen. As every other living organism, a tree can not properly live when the supply of energy is unbalanced and not regular: when the parts of the system intended to produce energy (leaves and crown) are removed, the other parts of the system – even the roots – fall to a lower potential energy level. The different parts of the system, living at a lower level of energy, are no longer able to maintain order in the system that begins to roll towards a lower physiological state of life. And there, pathogens and parasites are much more aggressive, since they act on weakened organism.

Therefore, tree topping is not only an aesthetic damage, but also – and primarily – a huge biological and physiological stress for the tree. The effects are long-lasting and not always fixable: topping can lead a tree to death over the time. This due to biological damage, with the depletion and then the decline of the tree: in many cases it will take decades for this to happen. Also mechanical damages, that may end with tree failure, are due to topping: indeed, over the years, new vegetation develops and it relies on decaying wood. This ends up with breakages.

Of course, trees have their own strategies to limit damages, such as compartmentalization walls, or barrier zones. There are the answer after a wound or trauma by circumscribing the internal defects, but over time they represent internal points of friction, containing suberin, with the healthy xylem tissues. The final result will be, even after several decades, cracks that open outwards with consequent failure of entire branches or the entire tree. This is well visible when then a tree is cut down: looking at the picture, an expert eye will notice the signs of the action of different fungi, as well as the opposite reaction from the tree – in this case a monumental *Aesculus hippocastanum* felt during a storm.

Trees react in other ways too: it tries to defend itself and survive an "external attack", as a topping can be seen, when huge portions of the canopy are removed. In the search of finding a new energetic balance, and in desperate need for new energy, the topped tree, starting from dormant buds or adventitious buds, emits epicormic branches, as a reaction to the damage. The development of these buds is fast and requires a great expenditure of energy: to save itself, the tree dissipates a large part of its stored energy, putting itself in a critical situation if another emergency were to occur, e.g., parasites attack. A tree weakened by topping is a weak tree to deal with the hostile environment of the cities in which it lives.

Of course, some species – e.g. London Plane - genetically possess mechanisms of greater resistance and tolerance: this is why they are so widespread in our urban environment.

So all the pruning interventions are bad and unnecessary?

No, not at all. Pruning has specific and different purposes: it can regulate the development of a tree, intervene to lift the mature tree from excessive energy expenditure to support itself, eliminate dead wood, correct any planting errors that cannot be resolved by replacing the specimen, remedy pre-existing anatomical defects typical of horticultural varieties and much more. A well-done pruning is the one that won't give rise to the development of epicormic branches, because it means that the tree hasn't been stimulated to a reaction that involves energy expenditure.

In urban areas, the formative pruning of young trees is underestimated. Trees are planted and almost forgotten for about a decade: it would be important to intervene in this period because it is possible to direct the future development of a tree by going, in an economical way, to avoid in the future difficult cohabitation with infrastructures and buildings.

Urban trees can and must be pruned precisely, to direct their growth and to balance mechanical stresses from support that require a modification of the tree's energy balances.

Many times the operator and the technician are called to intervene on disastrous trees, ruined by previous mutilating interventions. The solution is not to eliminate the tree – by doing so I think that most of the trees in the city should be removed – but to minimize the damage suffered, to avoid that in the future the clumsy intervention carried out could evolve into loss of branches or even collapse of the tree.

Tree risks assessment: an introduction

The tree risk assessment is one of the most important areas in the work-life of urban arborist. Indeed, life in urban areas is complicated not only for humans, but for trees too: the conditions are far from the natural ones, and conflicts arise everyday.

The goal of a tree risk assessment is assuring a positive coexistence of trees in our cities, and not their elimination to get rid of potential dangers: urban forests provide us many benefits and every technician should remember this.

Experience, knowledge of tree biology, as well as technological and scientific innovation allow arborists to offer a precise assessment, aimed at safeguarding the tree.

Tree risk assessment usually follow definitive steps:

- the first step is the visual analysis, performed by a qualified arborist;
- then, it is possible to proceed with instrumental analyses, where deemed necessary by the technician.

The visual analysis is carried out according to the **VTA** (Visual Tree Assessment) protocol, a method based on the inspection of the primary structures of the tree.

This assessment is aimed at identifying the structural defects that can compromise its stability and establish the internal repercussions of the tree. It requires the evaluation of a trained and experienced technician who knows how to identify the timing of the re-check, the operations necessary to keep the plant healthy and the possible need for further instrumental investigation.

The **International Society of Arboriculture (ISA)** has put together the following Basic Tree Risk Assessment Form – the sheets to be compiled during the inspection. To perform a complete analysis, the technician needs to be properly trained and formed, and this is possible relying on specific courses and materials, as ISA proposes.

ISA Basic Tree Risk Assessment Form

Client ______ Date ______ Time ______
Address/Tree location ______ Tree no. ______ Sheet ____ of ____
Tree species ______ dbh ______ Height ______ Crown spread dia. ______
Assessor(s) ______ Time frame ______ Tools used ______

Target Assessment

Target number	Target description	Target zone: Target within drip line	Target zone: Target within 1 x Ht.	Target zone: Target within 1.5 x Ht.	Occupancy rate 1 – rare 2 – occasional 3 – frequent 4 – constant	Practical to move target?	Restriction practical?
1							
2							
3							
4							

Site Factors

History of failures ______ **Topography** Flat☐ Slope☐ ____% **Aspect** ____
Site changes None☐ Grade change☐ Site clearing☐ Changed soil hydrology☐ Root cuts☐ Describe ______
Soil conditions Limited volume☐ Saturated☐ Shallow☐ Compacted☐ Pavement over roots☐ ____% Describe ______
Prevailing wind direction ____ **Common weather** Strong winds☐ Ice☐ Snow☐ Heavy rain☐ Describe ______

Tree Health and Species Profile

Vigor Low☐ Normal☐ High☐ **Foliage** None (seasonal)☐ None (dead)☐ Normal ____% Chlorotic ____% Necrotic ____%
Pests ______ **Abiotic** ______
Species failure profile Branches☐ Trunk☐ Roots☐ Describe ______

Load Factors

Wind exposure Protected☐ Partial☐ Full☐ Wind funneling☐ ______ **Relative crown size** Small☐ Medium☐ Large☐
Crown density Sparse☐ Normal☐ Dense☐ **Interior branches** Few☐ Normal☐ Dense☐ **Vines/Mistletoe/Moss** ☐ ______
Recent or planned change in load factors ______

Tree Defects and Conditions Affecting the Likelihood of Failure

— Crown and Branches —

Unbalanced crown ☐ LCR ____%
Dead twigs/branches ☐ ____% overall Max. dia. ____
Broken/Hangers Number ____ Max. dia. ____
Over-extended branches ☐

Pruning history
Crown cleaned ☐ Thinned ☐ Raised ☐
Reduced ☐ Topped ☐ Lion-tailed ☐
Flush cuts ☐ Other ______

Cracks ☐ ______ Lightning damage ☐
Codominant ☐ ______ Included bark ☐
Weak attachments ☐ ______ Cavity/Nest hole ____% circ.
Previous branch failures ☐ ______ Similar branches present ☐
Dead/Missing bark ☐ Cankers/Galls/Burls ☐ Sapwood damage/decay ☐
Conks ☐ Heartwood decay ☐ ______
Response growth ______

Main concern(s) ______

Load on defect N/A☐ Minor ☐ Moderate☐ Significant☐ ______
Likelihood of failure Improbable☐ Possible☐ Probable ☐ Imminent ☐ ______

— Trunk —

Dead/Missing bark ☐ Abnormal bark texture/color ☐
Codominant stems ☐ Included bark ☐ Cracks ☐
Sapwood damage/decay ☐ Cankers/Galls/Burls ☐ Sap ooze ☐
Lightning damage ☐ Heartwood decay ☐ Conks/Mushrooms ☐
Cavity/Nest hole ____% circ. Depth ____ Poor taper ☐
Lean ____° Corrected? ______
Response growth ______
Main concern(s) ______

Load on defect N/A☐ Minor☐ Moderate☐ Significant☐
Likelihood of failure
Improbable☐ Possible☐ Probable☐ Imminent☐

— Roots and Root Collar —

Collar buried/Not visible☐ Depth ____ Stem girdling☐
Dead ☐ Decay☐ Conks/Mushrooms☐
Ooze ☐ Cavity☐ ____% circ.
Cracks☐ Cut/Damaged roots☐ Distance from trunk ____
Root plate lifting☐ Soil weakness☐

Response growth ______
Main concern(s) ______

Load on defect N/A☐ Minor☐ Moderate☐ Significant☐
Likelihood of failure
Improbable☐ Possible☐ Probable☐ Imminent☐

Risk Categorization

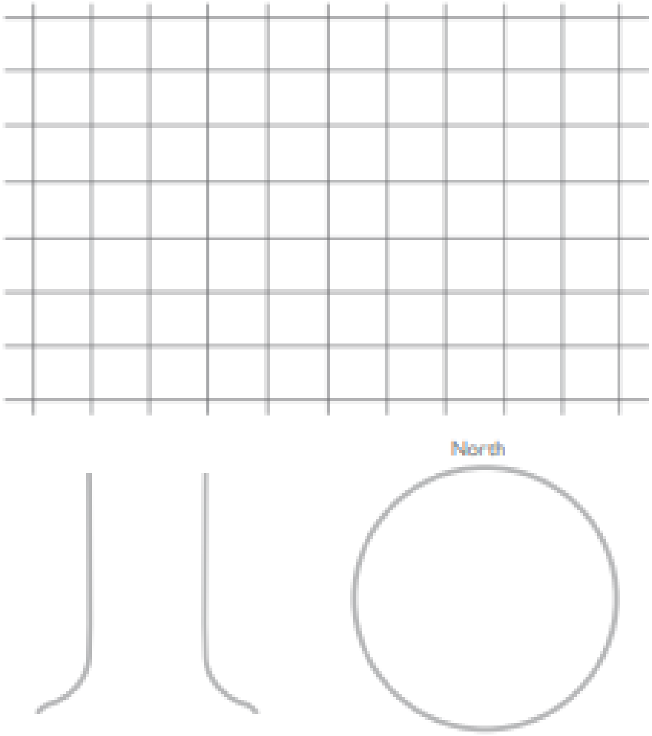
Condition number	Tree part	Conditions of concern	Part size	Fall distance	Target number	Target protection	Likelihood – Failure: Improbable	Failure: Possible	Failure: Probable	Failure: Imminent	Impact: Very low	Impact: Low	Impact: Medium	Impact: High	Failure & Impact (from Matrix 1): Unlikely	Somewhat	Likely	Very likely	Consequences: Negligible	Minor	Significant	Severe	Risk rating of part (from Matrix 2)
1							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
3							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
4							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	

Matrix 1. Likelihood matrix.

Likelihood of Failure	Likelihood of Impacting Target: Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Risk rating matrix.

Likelihood of Failure & Impact	Consequences of Failure: Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low



Notes, explanations, descriptions ______________________

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____

Mitigation options ______________________ **Residual risk** ________

______________________ **Residual risk** ________

______________________ **Residual risk** ________

______________________ **Residual risk** ________

Overall tree risk rating Low ☐ Moderate ☐ High ☐ Extreme ☐ **Work priority** 1 ☐ 2 ☐ 3 ☐ 4 ☐

Overall residual risk Low ☐ Moderate ☐ High ☐ Extreme ☐ **Recommended inspection interval** ________

Data ☐Final ☐Preliminary **Advanced assessment needed** ☐No ☐Yes-Type/Reason ________

Inspection limitations ☐None ☐Visibility ☐Access ☐Vines ☐Root collar buried Describe ________

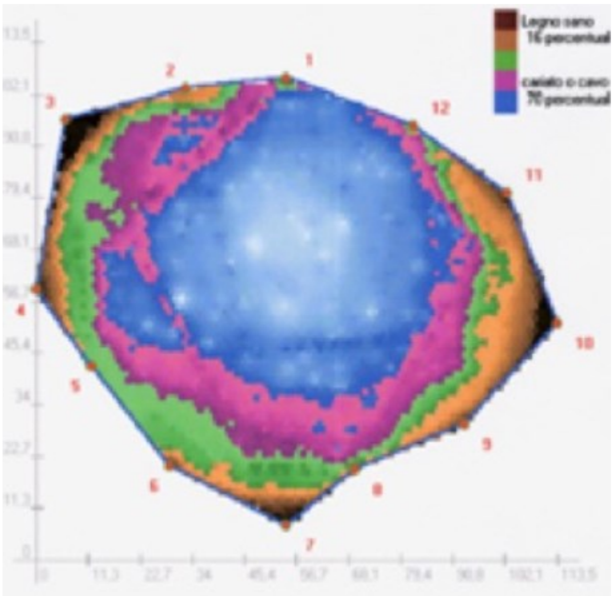
The form is organized in different sections, starting from:

- General information regarding the client and the tree, with the goal of clearly identifying the assessed tree – e.g., thanks to a number.
- Target assessment: this section is aimed at describing the surrounding of the tree, analyzing areas that could be interested by a potential failure, considering also occupancy rate. Indeed, it is different to evaluate the same tree if isolated, or if standing close to crowded areas.
- Site factors: useful to picture the particular conditions of the nearby environment, such as soil conditions and wind direction.
- Tree health and species profile: where to describe the presence/absence of specific pathogens and/or parasites, especially the ones usually found on that species.
- Load factors: here the arborist should report wind exposure, and also the main characteristics of the crown – that may offer resistance to wind passage.
- Tree defects and conditions: within this section, the technician needs to highlight the visible defects. These may be visible in the canopy, as well as in the trunk and in the root area and root collar. Also, tree pruning history should be flagged, since, e.g., tree topping causes decay in the mid-long term.
- In the second page, risk categorization is provided, based on a likelihood of failure and impact, and related consequences. This is then completed with a matrix, that allows a risk rating analysis.
- Finally, the assessment is completed with possible mitigation options, to reduce the risks – e.g., thanks to tree care operations, such as pruning, or tree cabling. Once these operations are in place, the arborist should be able to evaluate the residual risk.
- Some other information complete the form, also important, such as the recommended inspection interval – that, depending on the peculiarities, may span from few months, to 5 years.

If needed, the visual analysis can be fine-tuned with a further step, the instrumental analysis. This relies on the use of specifically developed tools, capable of assessing the internal conditions of the tree – e.g., the trunk and/or specific branches. Today, following decades of research and practical refining, arborists can leverage on highly sophisticated tools and techniques, that usually are non-invasive. This means that a tree can be assessed without causing specific damages.

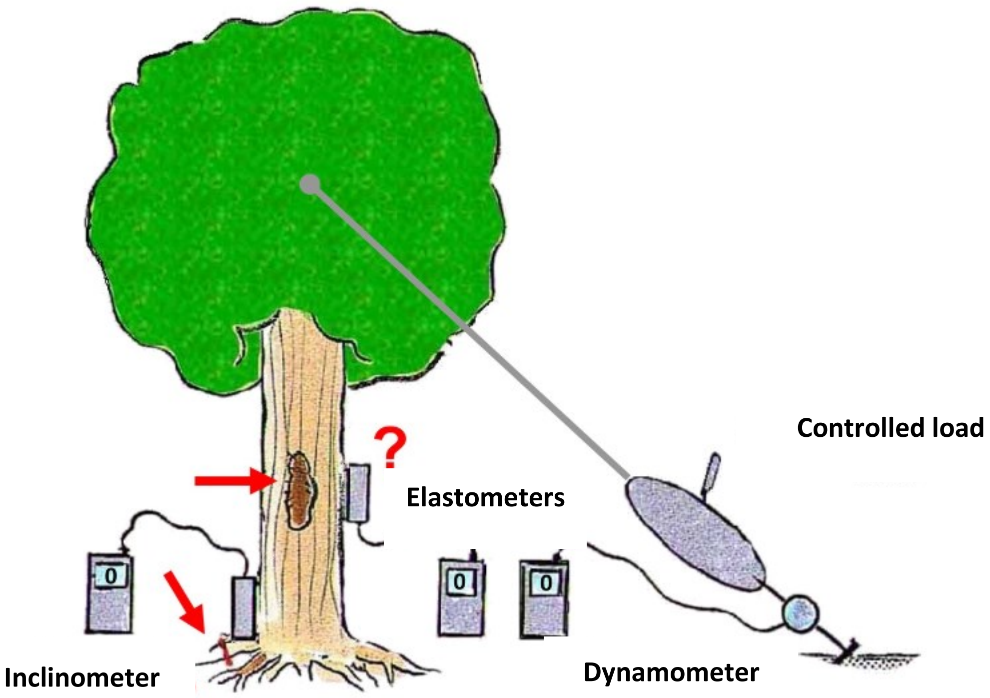
One of the most common and tested technique is the sonic tomography. It allows to measure the consistency of the wood inside the trunk. The measuring principle of tomography consists in tracking the time taken by the sonic impulse (generated with a hammer) to pass through the wood and to be heard by the receiving sensor.

This time depends on the distance between the sensors and the characteristics of the medium in which it spreads: slower in the presence of a vacuum or in disintegrated tissues, faster for compact tissues. The network of information obtained by generating impulses (an average of three for each point in order to obtain a statically significant analysis), on the entire circumference of the trunk, then allows the specific software to produce a two-dimensional colored tomogram, a graphic representation of the cross-section of the trunk at the level at which the investigation was conducted. Colors allow for an easier reading of the types of internal tissues: the brown color indicates compact and healthy tissues, the blue and fuchsia ones indicate disintegrated tissues or decay areas, the green parts indicate intermediate tissues. A legend is also provided with the percentages detected for each type of wood detected. The following pictures shows the correspondence between reality – a stump – and the relative tomography result, done before the tree cut.



On a further level, tree pulling test is currently a well advanced method for assessing the safety and stability of tree root systems. This technique involves applying a controlled load to the tree trunk using a cable, while monitoring the tree's response with an inclinometers, placed on a buttress, and an elastometers attached to the trunk.

Specialist software records the data and provides a picture of the tree, if it approaches critical limits, preventing potential damage. This is based on a complex database, with more than 15 000 investigations, allowing to obtain the percentage values of safety at breakage and safety at overturning. This methodology, known as **S.I.M. (Static Integrated Method)** has been developed by prof. Lothar Wessolly in over 30 years of specific research, acting a true benchmark for the sector.



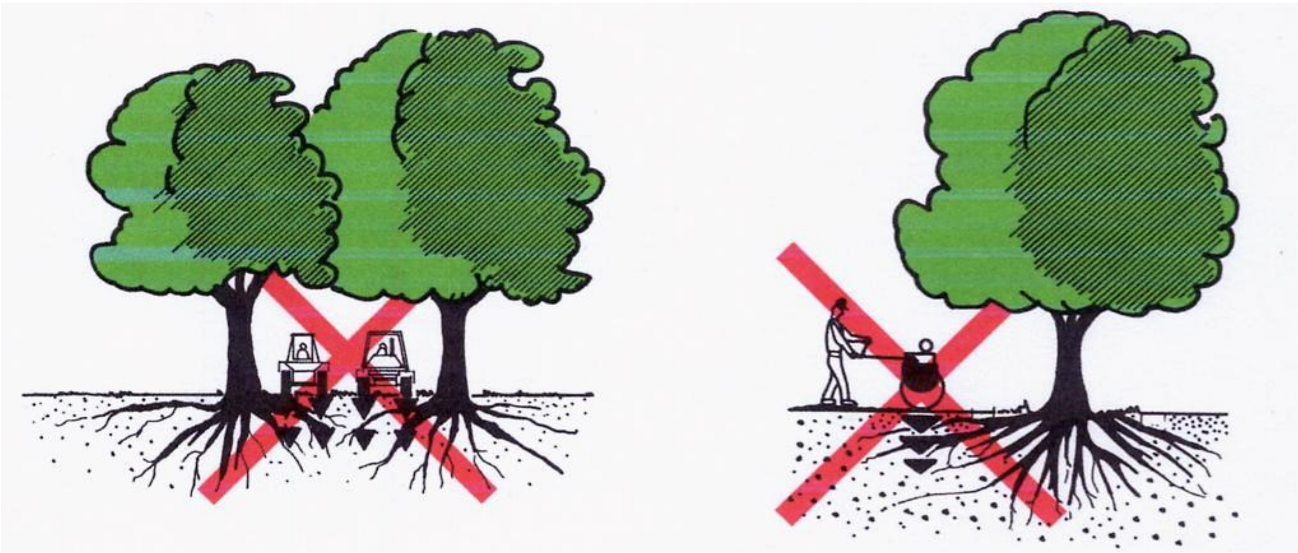
Therefore, tree risk assessment is an operation that must be performed following different and precise steps and, more importantly, from specialized and trained technicians. This allows cities to have safer green areas, while preserving urban forest assets.

Urban trees and construction sites

From previous stakeholders surveys within the Viridis Loci project, we aware that the development and maintenance needs of the city requiring excavations and other impactful operations, especially for the root systems of trees, are among the top concerns of urban arborists. If it is not possible to study alternatives - such as alternative routes for the passage of underground cables in order to keep the tree's buffer area intact -, it is a good idea to implement some techniques to limit the damage as much as possible. The following points should be put in practice by arborists, in close cooperation with construction companies.

- **Soil compaction**

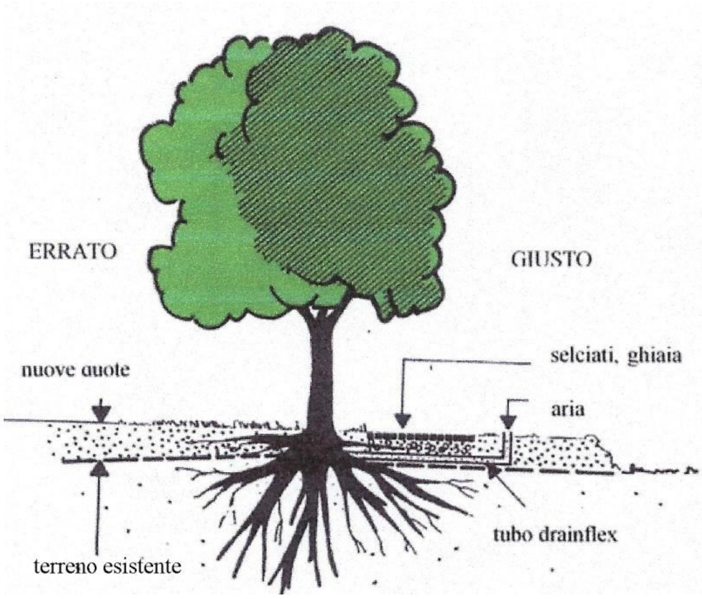
Compaction, e.g., due to rolling, in the root zone has to be avoided: the use of machines and vehicles to compact soil should be limited as much as possible. The work should be done manually.



The use of heavy machineries and the deposit of construction materials is often done without thinking to the long-term consequences to trees and soil. An increased awareness is needed among stakeholders.

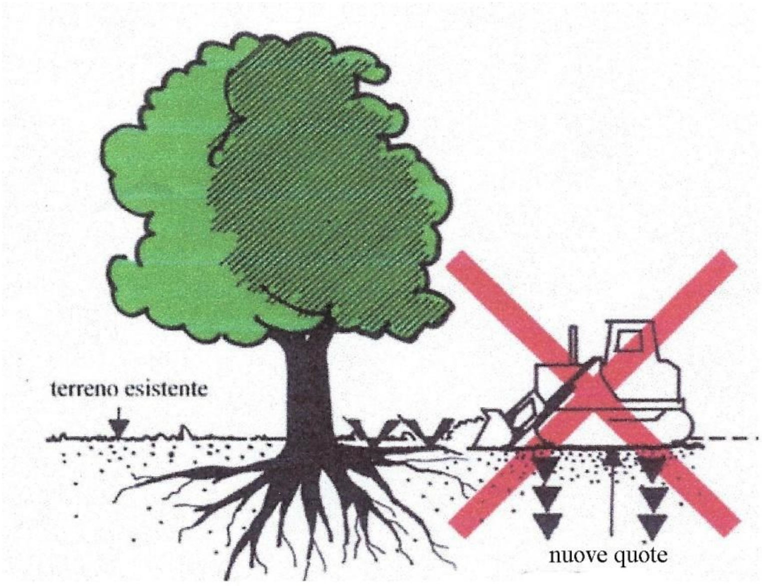
- **Top-up soil**

In the canopy area, the top up of soil must be avoided. Soil adds must be carefully evaluated and, if done, to be carried out avoiding to cover the collar of the tree. To assure an improved soil aeration, a system of gravel and drainage pipes must be prepared in the area occupied by the roots.



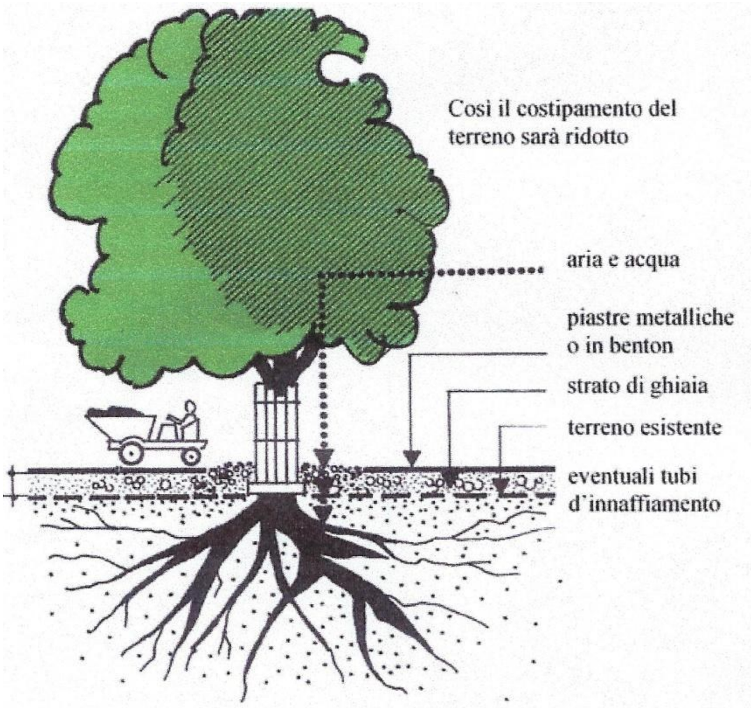
- **Lowering the ground**

Any removal of the soil surrounding the tree should be avoided, especially if done with machineries, because there is a high risk of cutting roots, in addition to compacting the soil.



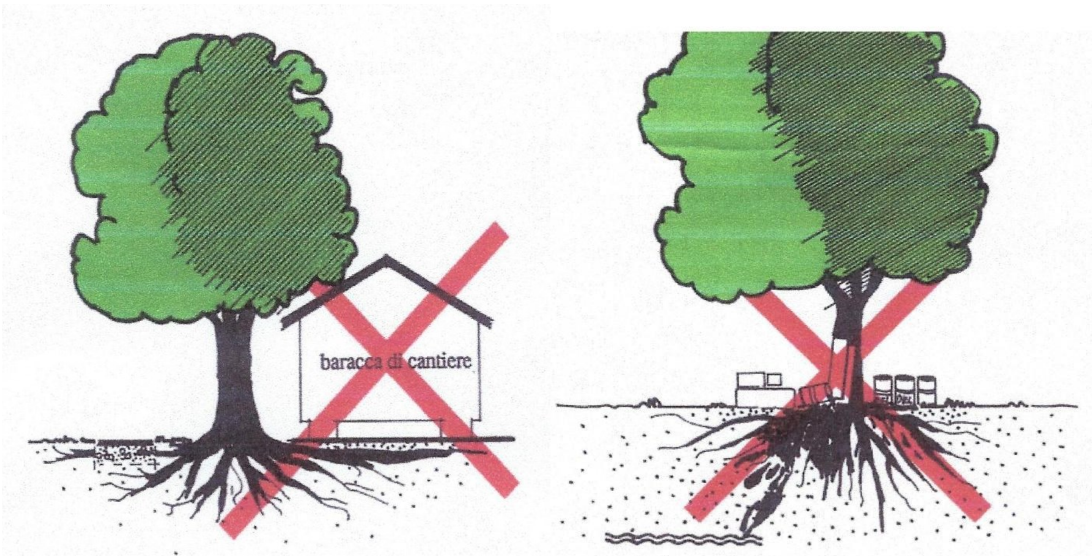
Construction site accesses

Vehicle and machinery traffic must be minimal near trees. Construction site accesses must be covered with steel plates or a layer of lean concrete, minimum thickness 20 cm, laid over a sheet of plastic.



- **Land occupation**

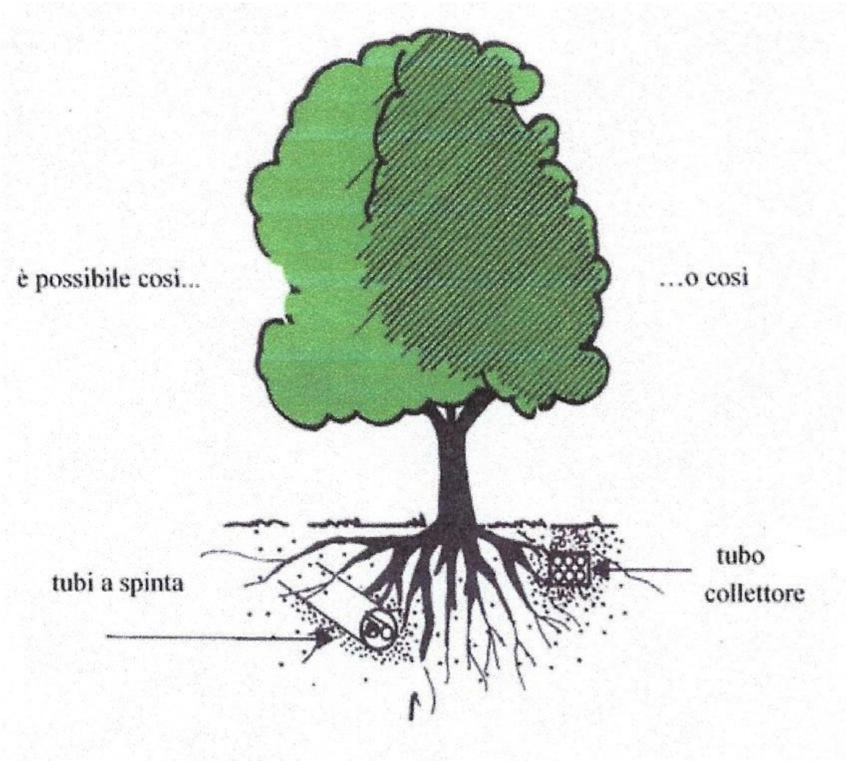
No construction material, fuel, construction machinery, and especially no cement mixers should be stored in the root zone: washing water, especially if containing cement dust, should be avoided. Oil drums and chemical products should be placed in special tanks that comply with the law. In the event of accidents, notify the Fire Brigade immediately. In the event of small leaks, the person carrying out the work is required to remove the contaminated material and destroy it properly and must notify the competent Parks and Gardens Service.



- **Excavation work**

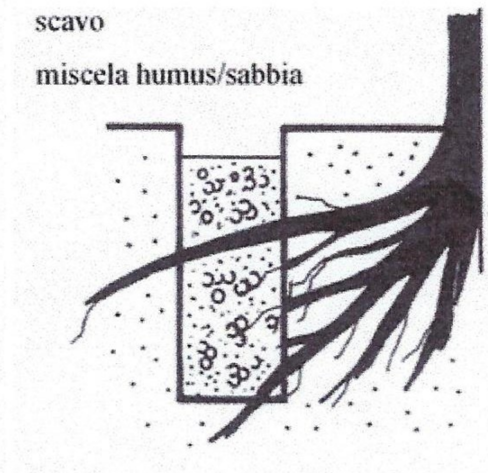
Excavation work in the root/canopy area must be done strictly by hand. Alternatively, it is possible to use push pipes or a collector pipe.

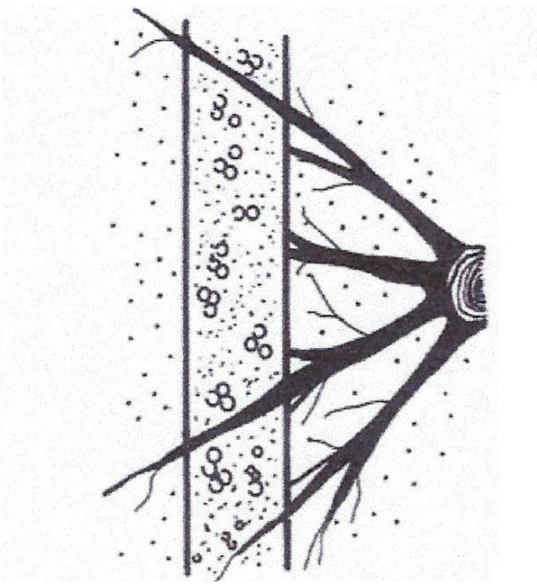
Excavations and removals of soil that affect the root area must not remain open for more than two weeks. If there are interruptions in the work, the excavations must be temporarily filled with a humus/sand mixture and kept moist by constant watering. Alternatively, the roots must be protected with a special mat and kept moist. If there is a risk of frost, the walls of the excavation in the root area must be covered with insulating material. The filling of the excavations must be done as quickly as possible and by hand.



- **Root cutting**

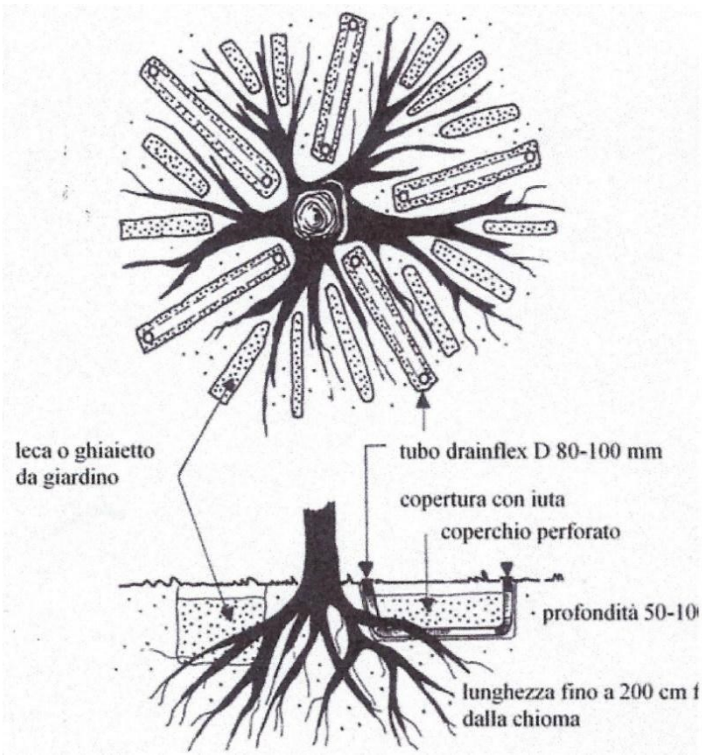
Roots up to 3 cm in diameter must be cut cleanly to promote healing and treated properly (a task to be performed by specialized arborists). Roots of larger dimensions must not be cut but, in the case of laying underground services, it must be passed under the pipes without causing wounds and must be protected from drying out with jute or PVC sheets. Subsequently, the excavation must be filled quickly by reusing the material available on site or with a mixture of humus/sand in a 2:1 ratio and kept wet. In the event of wounds to the roots or trunk, the agronomist must be promptly notified who will provide the necessary care.

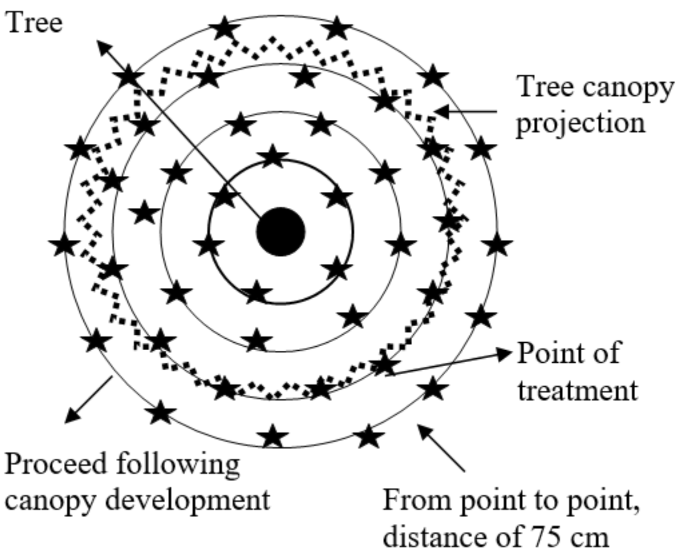




- **Root aeration**

To improve soil conditions, it is advisable to make aeration trenches that improve gas exchange, water infiltration during dry periods and promote the formation of an excellent root system. This technique consists of making holes in the soil 3-5 cm wide, about 50 deep, in circles up to 30-50 cm beyond the projection of the crown (where the absorbent roots are located). Then fill the holes with a mixture of equal parts of peat and draining materials.

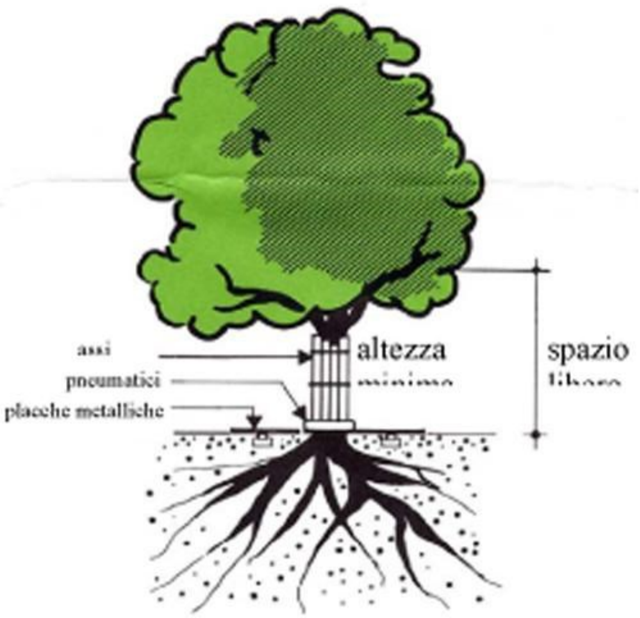




- **Trunk protection**

It is necessary to protect the trunks against injuries by delimiting a buffer area around the plant, making the most of the available space.

In cases of limited space, it is possible to resort to "bandaging" the trunk with wooden boards, foam rubber or other suitable material.



Urban forests, not only trees

In our growing urban areas, it is important to remember that cities are not only home of humans, but also habitat of many other animal species. In this, urban forestry is the key component to provide and assure valuable urban habitat and make up a significant and highly visible component of the urban biodiversity. Trees and shrubs also provide food for many animal, plant and fungi species, from non-vascular plants, such as mosses, to insects, birds and mammals. Many insects are supported by trees and shrubs. Some specialise on just a few tree species, whilst others are generalists that benefit from multiple tree and shrub species. Pollinating insects provide ecosystem services in urban areas by pollinating flowers and producing food. The diverse nature of urban land use offers a wide range of pollinator habitats, but trees offer an important source of pollen at particular times of year when other sources are unavailable.

Because of this, developing safe and welcoming habitats for urban fauna is mandatory to preserve and improve biodiversity levels within our urban agglomerates. This should leverage not only on green areas per se, but also on the built environment, that – thanks to specific technical choices – can host a wide range of species.

Source: Twenty ideas for integrating biodiversity in urban planning and development

One idea to integrate green areas in our cities is thanks to green roofs. Green roof are rooftops covered with vegetation, which may include plants, shrubs, and even small trees, growing in a layer of soil or growing medium. These roofs provide a sustainable solution for urban environments by integrating nature into the built environment, with direct benefits for butterflies, solitary bees, bats, among others. The benefits of green roofs in urban settings are numerous, from stormwater management to energy efficiency.

Another solution is represented by the so-called insect hotels, bee bricks and bat boxes.

These kinds of human-made structures can contribute to offer new habitats, especially to solitary bees and butterflies – key insects in the food chain, since they pollinate 60% of crops. Better to place them in safe locations, sheltering from wind, and rain, and close to pollen-bearing flowering species. They should be made of wooden materials, and filled with organic matter – small pieces of woods, hay, stones, soil etc. – to recreate natural conditions, as the ones in the pictures (from Vivara Pro).

These solutions go in the direction of a nature-inclusive urban design, that follows the path of Nature-based Solutions and expands the benefits that urban forests offer us.

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