Proposal of a reinforced trees assessment method: The case of Aalborg

Master thesis

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COVID19 and the consequences of the lock-down of society and the university since March 13, 2020 have had influence on which activities that have been possible to stage and carry out as part of the project work. More specifically, this means that activities have been limited to online activities, and that activities such as Lab activities; surveying activities; on-site ethnographic studies and on-site involvement activities have not been possible.

When assessing this project, please bear this in mind.

With the emergency situation due to the Covid19 virus, several changes within the methodology of this paper had to be reconsidered in order to collect all the necessary information for the thesis. Unfortunately, the main issue that has been encountered was the inability to go out for undertaking physical interviews. Therefore, it has been necessary to switch to email interviews instead. Although this method has been effective and valuable information has been obtained, it contained several limitations, in particular, regarding the response time. Furthermore, some email interviews requests have been ignored. The only reachable participant in Aalborg has been the “park and nature” department. It has demonstrated interest and willingness to answer the questions, however, their responses have been rather slow. This lack of time and the quarantine partially limited the planned development of the thesis.

1. Introduction

In recent years, there has been a major understanding and respect for green areas in and around the cities (Secretariat of the Convention on Biological Diversity, 2012).
In fact, natural places can contribute to various benefits to both, population and environment.
With the increase of natural spaces in cities, it will require to ensure an adequate vegetation health in order to avoid compromising the safety of citizens. In fact, large trees in a precarious state of health have a major collapsing risk. This fall can damage people, vehicles and structures.
Different tools exist to assess the vegetation health and consequently reduce the trees impact risk. One of these methods is a visual tree assessment (VTA). The VTA practice can assess trees condition through
a visual inspection of plants' structure by revealing potential trunk and branch issues. In addition, it does not damage the plant in any way but it manages to analyse and predict the trees' health and consequently the trees' fall risk (Mattheck et al., 1995).
The method can be combined with a trunk instrumental analysis that will deepen the plant condition and a mobile application that allows to classify the condition of the trees through various measures and visible plants' symptoms. By doing that, it will be possible to create a tree catalogue and to plan immediate or further interventions for each plant.

Aalborg is a city in continuous development and expansion that particularly aims for a more sustainable evolution. For this reason, Aalborg Kommune is strongly dedicated to a city's general improvement, including the creation of new urban green areas (Aalborg Kommune, 2016). Nowadays, the Aalborg Kommune department involved in the green area's maintenance is adopting an approach that takes into consideration various information. This information also includes a tree health evaluation based on four levels. Therefore, the description of their vitality evaluation levels appears as vague, in particular when it comes to visible plans' symptoms.

Taking into consideration the fact that the above-mentioned methodology encountered limitations in points concerning a detailed trees' vitality evaluation, it is worth exploring the possibility of introducing a methodology that can reinforce this factor. Therefore, in the course of this project, there will be carried out research and analysis concerning the implementation of the VTA assessment method into the procedures used by the Aalborg Kommune department, which is involved in the

green area maintenance. Hereafter, there will be analysed the contributions this method could bring to the urban green assessment strategy. These improvements will lead to a major trees' structure understanding and it will be possible to discover their danger in an urban context.

There were identified issues that could arise regarding the implementation of the VTA method. They are mainly related to the approach transformation due to the introduction of a new methodology. Indeed, resistance to change may emerge due to the utilisation of a different method (Geels, 2014). In addition, some of the criticisms that have been mentioned regarding the VTA method need to be taken into account. In specific, Franz Gruber (2008) presumes that it is scientifically unproven, mono-causal and untenable failure criteria for trees (Gruber, 2008). Despite this, VTA is considered as a more suitable evaluation method as it allows to identify hidden signs of decay, which are not detected by means of the SIA method.

The process of upgrading the current methodology with a VTA method will be studied through the lens of a multilevel perspective theoretical framework. The MLP main characteristic is to visualize from an elevated point of view the social structure and specifically the unchanging and transformation factors (Geels, 2005a). In addition, it allows to understand the reasons why a socio-technical regime from a stable situation offered opportunities for a change and how the transformation occurred. In this paper, VTA will be considered as an innovation factor or niche that can lead to a stable structure transformation, in this case the current trees assessment system.

The chapters in this thesis are organized as follows:

Chapter two introduces the limitations regarding trees in urban environments and the reason why a healthy tree is less dangerous for a city. Successively, it has illustrated a comparison between two methods that assess plants' vitality and stability. In addition, it compares the trees' natural reaction to a forest and an urban environment by illustrating their differences. It will also analyse the reason why cities' environments cause a negative impact on plants. From these premises, it is introduced the VTA methodology and how it manages to assess trees' vitality and stability through the identification of visible signs. In addition, the general trees' maintenance treatments are analysed, in particular the pruning operation and the consequences of an incorrect intervention.

The chapter also defines the current situation in Aalborg municipality and therefore, which methodologies are adopted and their limitations. In this chapter there has been elaborated a research question by taking into consideration the problematics factors.

Chapter three presents the theoretical framework that has been utilised in order to elaborate a solution. Furthermore, it analyses the MLP methodology and explains how certain factors influence a social regime. Successively, the chapter explains the benefits this theory can bring to the discussion elaboration. The chapter introduces two examples where the MLP theory has been adopted as a tool in order to analyse social circumstances and the reasons why some factors limit alternative innovation emerging. The chapter also explains how the proposed methodology has been seen through the MLP lenses. At the end of this chapter, there have been analysed and described the social barriers that could block the introduction of an alternative trees' vitality and stability assessment methodology.

Chapter four presents the used methods and it explains how they helped to gather primary and secondary data that were required to obtain for answering the research question.

Chapter five analyses in detail the primary and secondary data acquired during the research process.

Chapter six presents the conclusion of the project.

Chapter seven consists of the discussion and reflection of the thesis.

2. Problem Analysis

As previously mentioned, it is necessary to understand plants' physical and structural conditions as in an urban environment it is crucial to prevent the risk of a tree or branch crush. In general, plants, and in particular trees, in urban environments suffer from various limitations and do not always face an adequate environment hosting them (Mattheck et al., 1995).

Many of these limitations are caused unknowingly since they are considered as part of an urban development plan. From this one can imagine, the constrained plants live in a continuous stressful condition. For this reason, trees try to readjust their structure and lifecycle to these particular situations (Mattheck et al., 1998). In spite of the fact that plants' adaptation capacities are strongly developed, the suffering plant easily tends to deteriorate, encounters structural collapses and in particular, experiences stress conditions that could lead to a fall. Indeed, a diseased plant can maintain stable conditions for a long time until the moment when extraordinarily adverse conditions take place (such as a strong wind or a storm). In that case, they possess a higher risk of breaking and falling on the ground (Mattheck et al., 1998).

For these reasons, it is necessary for the municipality or private companies in charge of the maintenance of the trees to investigate the trees' health conditions that live in an urban environment and assess the risk of a structural collapse. Therefore, it will be possible to grant a safer urban environment considering that it will be possible to prevent potential damage to the public, vehicles and urban structures.

Various methods could be utilised to assess the tree's vitality and stability, but they might be considered as inaccurate for plants in special conditions, such as an urban environment one. For instance, one of the most utilised trees stability assessment methods is the Static Integrated Analysis (SIA). This method takes into consideration the tree crown shapes and groups them into 4 different forms. In combination with this factor, a wind load value is acquired in order to create a simulation. The stronger the wind force is, the greater will be the load (Erb et al., 1998). This simulation is performed in order to understand the maximum load a tree can sustain before it collapses. The essential additional information included in the simulation are pre-existing experiments, visual values and measurements. For instance: tree species; diameter and height, bark thickness, crown shape, tree location (e.g. countryside, village, city) (Erb et al., 1998).

Despite the SIA method diffusion, this method also suffers from various critical points. The trees crown shapes that are examined are approximate and usually do not reflect those of the trees in an urban environment. Furthermore, this method considers the wind load factor to be identical for all

city's areas (Mattheck, et al., 2005). However, in a city the load factor is influenced by various conditions that can change wind impact on a tree (Mattheck, et al., 2005). For instance, the abovementioned urban conditions affecting the wind load could be represented by the presence of buildings or along a boulevard where vehicles transit. The main critical point lies in the omission of the essential information of any tree signs of decay. In fact, even if a tree assessed by the SIA method corresponds to the lowest falling risk, it could suffer anyway from various hidden structural defects and consequently, show signs of a decay (Mattheck et al., 2005). These signs are not included in SIA evaluation and therefore, a "safe tree" can experience an unanticipated structural collapse. These potential critical situations can be prevented through a VTA (Visual Tree Assessment) evaluation as its main characteristic is the study and identification of the trees' decay signs.

VTA is a visual investigation approach based on the evaluation of trees' structural conditions. The assessment takes into examination the biomechanics principles. It identifies trees' external signs by identifying various anomalies, such as fungi or wood cracks that can indicate an internal deterioration (Mattheck et al., 2000). If some defective signs have been detected, it will be necessary to analyse them in more detail and proceed with further non-destructive trees' examinations. For instance, there can be easily adopted several methods, such as a gum hammer or a Resistograph (electronic high-resolution needle drill resistance measurement device)

2.1 Situation in Aalborg

In order to understand according to which methods is the urban green in Aalborg handled, it was necessary to conduct an email interview. Indeed, six questions have been sent to the landscape architect working in the department of Park and Nature in Aalborg city Kommune.
The department of "park and nature" in Aalborg Kommune has the responsibility to maintain in positive conditions most of the green areas located in Aalborg municipality. The green maintenance activity includes a multitude of practices and tasks including the tree risk assessment (Park and nature department, 2020).
For evaluating plants' condition, trees within the municipality areas are recorded and evaluated. The methodology adopted by the "park and nature" department takes into consideration several factors and measures. For instance, there are noted information regarding arboreal species, trunk diameters and plant age among others (Park and nature department, 2020). In addition, in the evaluation there is included a parameter regarding the plants' health conditions. However, this information is not specifically detailed, however still takes into account a tree's general vitality visual inspection. Indeed,

the assessment considers only four levels of plant healthiness. The first level is a suitable condition with no significant plant damages, while the last level is a dying plant showing signs of deterioration (Park and nature department, 2020). Then, in the follow-up email from the park and nature department email was mentioned the use of VTA by some operators dealing with the tree's maintenance. In fact, the mentioned four trees' vitality levels are comparable to the classification grades provided by the VTA (Park and nature department, 2020). However, in the case of Aalborg, the classification does not include detailed information related to trees' symptoms. It also does not include any details regarding the potential cause of internal defects. As it will be discussed in section 2.3., it is fundamental to understand the cause of visible symptoms in order to understand how and which "enemy" is necessary to fight. Furthermore, there is not mentioned any type of an in-depth instrumental analysis, which is considered as an essential part for understanding the trees' stability.
The only documentation provided by the "park and nature" department concerns an evaluation method named VAT19. However, VAT19 takes into consideration only plants' aesthetic factors since it is aimed for an economical evaluation.

Although some notions of VTA are utilised, Aalborg's method looks limited to general factors, without including essential assessment elements such as examination of symptoms and deeper instrumental analysis. For this reason, the current Aalborg trees' vitality and stability assessment method does not express the full potential of VTA and therefore, it could be improved and aimed to be more accurate. An upgrade of the VTA method will ensure a more precise and safer methodology by avoiding accidental plant collapses.

Thus, in this thesis it has been decided to analyse the VTA methodology in order to understand its potentiality and upgrade the current assessment system in Aalborg.

2.2. Trees in urban environment

Urban green represents a public good and an essential urban resource considering the various benefits it provides to the community (Chiesura, 2010). Indeed, urban greenery manages to stabilize the imbalances occurring in urban areas and other environmental degradation factors. In addition, a natural environment can positively influence citizens' physical and psychological health (Tzoulas et al., 2004). Therefore, trees play a fundamental role in a sustainable urban development.
However, trees are able to grow and reach their maximum natural expression in a non-urbanized and open environment, such as forests or natural parks. For this reason, one can imagine how plants in an

urban environment are exposed to continuous stress (Duryeam et al., 2003). In fact, a non-natural system does not offer the same living conditions as a wilder one. Furthermore, trees dangerousness is higher in cities as its crash could damage people and infrastructures. A similar event in a forest would follow a natural process of vegetational evolution and certainly without a dangerous impact on the surrounding greenery. Quite the opposite, a tree structural fail can generate a risky situation on a traffic road or parking lots (Duryeam et al., 2003).

Thus, the artificial habitats created in cities are definitely different compared to trees' natural environments. In fact, an urban environment is not uniform and can generate various microhabitats. These unexpected conditions can be classified into 3 main habitats:

1. **Urban parks.** These urban green environments may not present so unfavourable trees' growth conditions considering that they usually offer sufficient space for the root's expansion. However, parks can represent some limitations, especially if they are highly frequented. For instance: a soil compaction phenomena or aquifer alterations due to pollution (Fini et al., 2007).

2. **Residential areas.** These microhabitats are characterized by air heating and presence of pollutants, both in soil and in water (Fini et al., 2007).

3. **Streets and roads.** These urban environments can negatively influence a tree's life due to various factors. For instance: high air heating, presence of particulate matter, heavy metals, fuels and during winter de-icing salt. In addition, humidity level is low and therefore, plants suffer more from drought. Furthermore, soil is compact and occluded limiting rainwater infiltration, causing worse plants' dehydration conditions (Fini et al., 2007).

The above described habitats are three general scenarios resulting from anthropic activities. Human actions have completely modified and transformed the original natural environment aspect and composition (Duryeam et al., 2003). The cities' building process have used and exploited the ground and by consequence, changed the chemical structure of soil. Indeed, urban soils are rich in accumulated debris and building materials (Duryeam et al., 2003). Hence, the organic matter is drastically reduced or completely absent as well as soil ventilation, drainage and water redemption are limited. In addition, it is possible to identify toxic products present in an urban soil (Foster et al., 1978). Furthermore, it is noticeable as in the second and third urban scenario trees are planted in narrow holes, surrounded by concrete that do not grant enough space for optimal roots' growth

(Grabosky et al., 1998). As a result, the root system often comes into contact with buildings, streets or pedestrian paths (Grabosky et al., 1998).

Hence, there can be identified the negative influences of an urban environment on trees' eco-physiological processes. In addition, it is necessary to specify that plants are not subjected to individual and distinct stress factors, but rather to several circumstances acting in synergy. Indeed, it is possible to recognise long term factors, such as unfavourable climate, pollution, soil conditions and short-term factors like drought or sudden cold. These factors do not directly kill the plants, but weaken them by consuming their energy reserves. An unsteady tree will be more vulnerable to diseases and by consequence, it will present decay signs (Creggb et al., 2001). Therefore, this weakening condition will easily permit the access into the plants' structure of complementary factors such as fungi, insects and diseases (Creggb et al., 2001).

Either a combination of the abovementioned factors or even a single one could lead to a tree's death. On the figure 1 are illustrated the factors that influence vegetation in an urban environment and this is compared to a forest one.

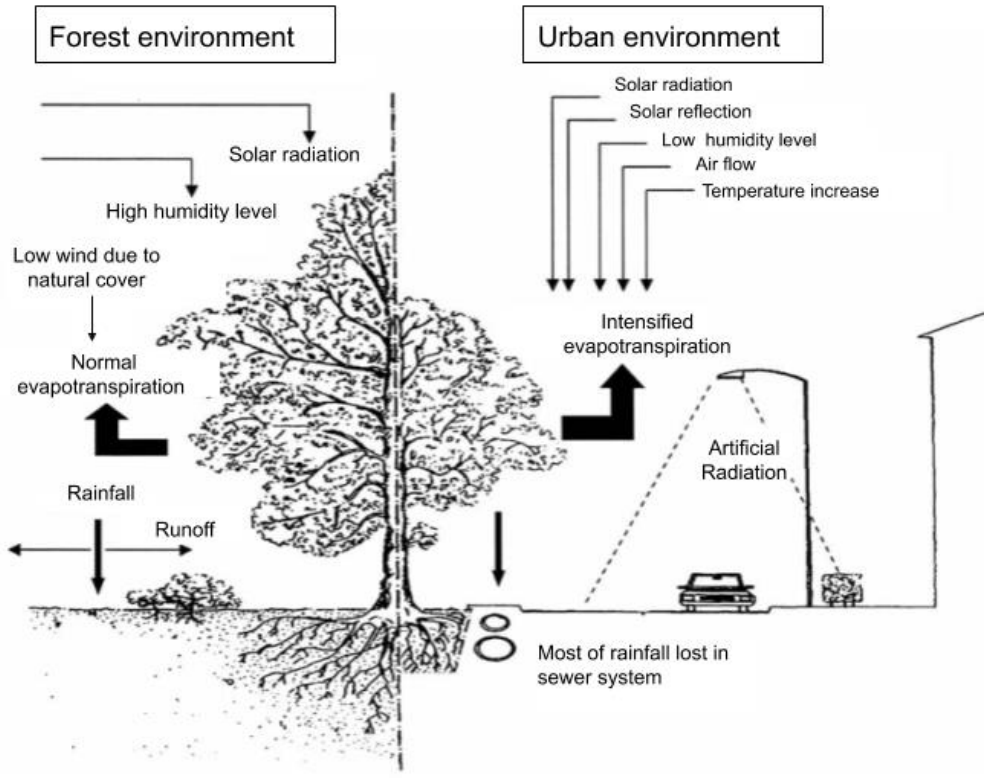

Figure 1 Comparison between forest and urban environment influences (Fini et al., 2007) with own addition.

Aalborg is an expanding city involved in various sustainability planning projects and creation of green areas. Despite its effort, in the city there can be found trees subjected to urban environment problems (Aalborg Kommune, 2013). As mentioned above, the urban environment is able to create distinctive microhabitats where trees can suffer from different stressors, so Aalborg does.
As it is possible to notice on figure2, due to reconstruction works, there is exposed a part of soil, which is usually covered by street asphalt. There is evident a very compact soil containing debris from actual and probably previous constructions, dust and it is not possible to distinguish the typical soil horizons.

Figure 2 Exposed urban soil.

2.2.1 Trees resilience

In the section 2.2., there has been described the negative influence that an urban environment causes on the trees' growth. However, it is necessary to specify that unfavourable conditions can arise also in a natural environment with different disturbing or stress factors impacting a tree (Linnakoski et al., 2019). These circumstances are often connected to plants' life competition and natural events. Therefore, both in a forest or in an urban environment a plant can be subjected to limitations. Despite unfavourable conditions, a tree is able to adapt its structure to the most disparate situations (Mattheck, 1991). Indeed, one could notice quite frequently that trees grow in an unusual or peculiar shape and therefore, not in line with harmonious straight trees. These structural modifications are due to a natural mechanism called “adaptive growth factor” (Mattheck, 1991).
Trees are well balanced plants that do not modify their structure without reasons. A modification can occur only if a plant requires it or is disturbed by various factors. In fact, particularly when stress factors arise, trees are forced to restore their balance by adapting its structure to a new condition. In

these cases, the adaptive growth will restore the natural trees design (Mattheck et al., 2004). However, this mechanism of self-regeneration and self-compensation requires energy. In case when additional material production is needed, the plants have to utilise supplementary energies in order to restore its natural balance. For instance, a plant can be attacked by various fungi that penetrate into the trunk and can compromise plants' vital functions. For this reason, the external threat has to be embanked through a technique called compartmentalization (Shigo et al.,1977). This self-defence mechanism creates different barrier zones with different security levels depending on disturbance grade. Compartmentalization has the capability to isolate the fungi damage on wood and therefore, limit the expansion of a contamination. By consequence, at the end of this defensive process the fungi will be isolated and therefore, the infiltration and damage contained (Shigo et al.,1977). This healing process could leave some visible signs on the trees' structure due to the addition of a new material. For instance, there could be noticed some bulges or cracks.

The second most immediate example is the tree inclination that is forced to adopt if living in a strongly windy area. In this condition, its crown is inclined differently compared to calm wind areas and almost seems to assume an aerodynamic shape (England et al. 2000). This peculiar shape was not evolved randomly, thus, it effectively reduces the wind load on plants and therefore, modifies its structure more appropriately to that specific condition. In addition, the trunk will be reinforced around the zone, where it is more prone to a structural failure (England et al., 2000). For this reason, the addition of more wood around that trunk zone will result in a thicker layer and more resistant to strong wind loads. So, this self-balance mechanism creates a peculiar shape easy to identify. Figure 3

Figure 3 Tree subjected to wind load (shorturl.at/nvw27)

Author and tree expert C. Mattheck define trees growing life as a “constant body effort" (Mattheck, 1991). In fact, for each external disturbance that trees undergo, there will be an internal reaction of self-regulation. This is an extremely functional self-preservation, self-regeneration and self-healing mechanism that makes trees to be resilient plants. The limitations connected to this mechanism are related to defensive slowness that prevents an immediate reaction to disturbance events (Mattheck et al., 2004). Therefore, a plant weakened by unsuitable environmental conditions or by external stress factors, is not capable of inducing a decisive reaction when threatened. As a result, it will be more prone to diseases and structural failures.

2.3. Analysis of VTA

As it has been described in previous chapters, trees are strong and well-structured plants. They manage to resist disturbance and external attacks and are able to self-regulate their structure in order to adapt to different environments. Despite their impressive adjustment, trees are frequently unable to react effectively, their structures weaken and trees or their branches can fail and crash.

In a forest environment, these accidents are considered as a natural process and do not involve any risks to people or buildings. On the contrary, a tree death and collapse is a forest's fundamental evolution growth process. For instance, a fallen tree can offer a refuge and it can be utilised as a shelter by wild animals. In addition, their decomposition process is a nourishment source for future plants generations.

One of the first experts that have investigated trees' reaction mechanism is an arborist Claus Mattheck. In fact, from his field studies and practical applications, Mattheck has developed his own methodology. For this reason, nowadays he is considered as the author and father of VTA (visual tree assessment) methodology. Presently, it is common to affirm one of the most important principles regarding plant adaptation that describe a tree as a “self-optimizing mechanical structure”. However, this is possible thanks to Mattheck studies since he has been the very first expert that discovered the reason why trees make rigorous and sparing use of their material. This concept leads to a self-optimization theory where the trees' material is utilised during the adaptive growth. This additional material is in the form of wood, which is created in case of disturbance and is named “reaction wood”. The reaction wood is an abnormal wood formed in response to environmental changes and it can actively modify trees’ shape and alignment (Lonsdale, 1999). For instance, it is necessary to rebalance and reinforce different zones of a tree trunk or branches in case of disturbance circumstances (e.g. trees located in windy areas or in slope).

VTA method encodes a series of plant observations that target these visible external defects. The operator through an analysis of specific signals manages to assess trees vitality and stability. In order to understand Mattheck VTA method it is necessary to describe its fundamental theorems regarding trees adaptation mechanisms:

- **Minimisation of lever arms:**

  This theorem is based on trees' capability of reducing the length of their arms (e.g. a branch) in case of excessive load (e.g. crown) figure 4. This mechanism is carried out by active self-bending of stiff parts by producing the reaction wood or by passively flexing the tree parts. In the event that a tree loses its leading shoot, the side branch will straighten in order to take over the lost part (Mattheck et al., 2004b). It is important to notice that this mechanism is activated exclusively when the leading shoot has been damaged and therefore, it is not intact. The factor that dictates the selected branch that turns into the leading shoot is called apical dominance, while the growth direction is guided by the negative gravitropism. Hence, the apical dominance and negative gravitropism are fundamental factors that regulate the angle between branch and stem in order to obtain an appropriate structural balance (Mattheck et al., 2004b). In addition, their influence on trees is evident on slopes. Indeed, when plants grow in an inclined area, their inner factors will lead it to straighten the structure and proceed their development with a correct direction. This process is achieved through the formation of reaction wood (Mattheck et al., 2004a).

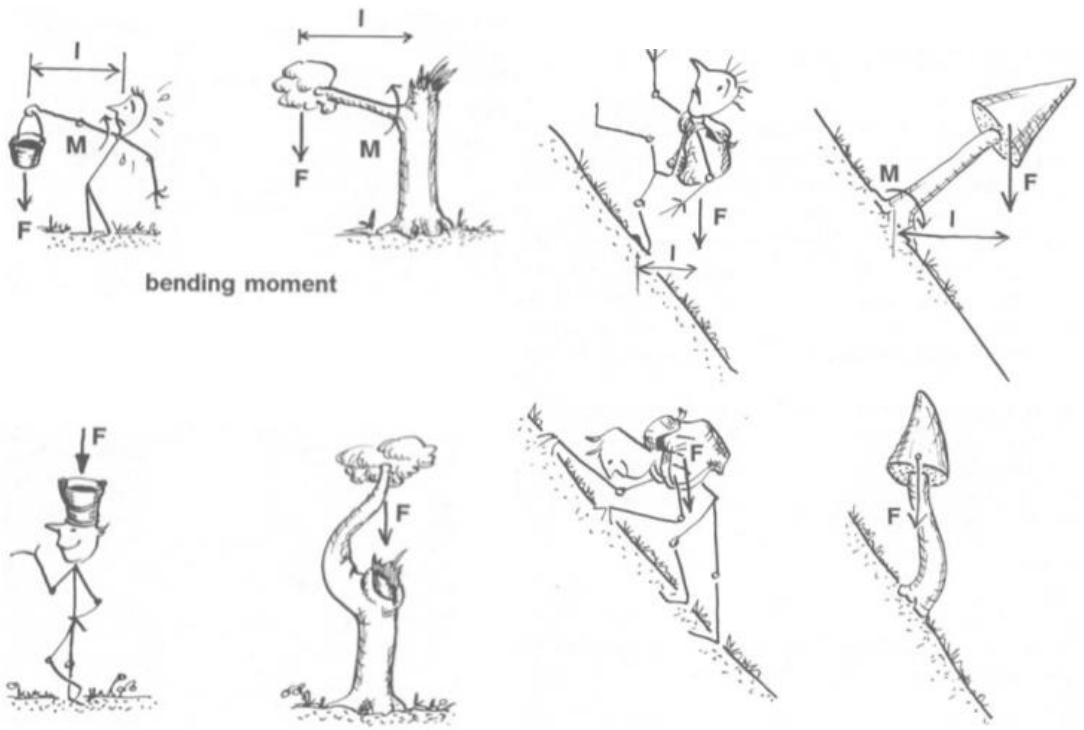

Figure 4 Draws illustrating apical dominance and negative gravitropism factors (Mattheck et al., 1997).

- **Axiom of uniform stress:**

  Trees are natural structures characterized by the homogeneous distribution of loads that allow the plants to avoid stress concentration that would negatively influence their architectural balance. Trees' growth is defined by the limitation of local high stresses (potential failure points) and local small stresses (unsuitable use of self-produced material). Therefore, trees try to efficiently grow evenly by avoiding stressors. In the event that some stressors occur, trees will continually identify a mechanism to self-balance and persist in their growing process (Mattheck et al., 2004b).

- **Adaptation of the strength of wood to mechanical stresses:**

  Tree wood is flexible and resistant and therefore, an excellent material able to support various loads to which it is subjected during its development. Indeed, the most suitable example explaining wood adaptability is exemplified by branches. On figure 5 is illustrated a branch

cross section where is noticeable a process of the wood expansion expressed by annual rings; on one side the rings are more compressed than on the opposite one. This evident difference between the two sides is due to a pressure variation that the branch has had to apply in order to avoid structural failure. By consequence, the formation of additional material is essential to maintain the tree's structure intact (Mattheck et al., 2004b).

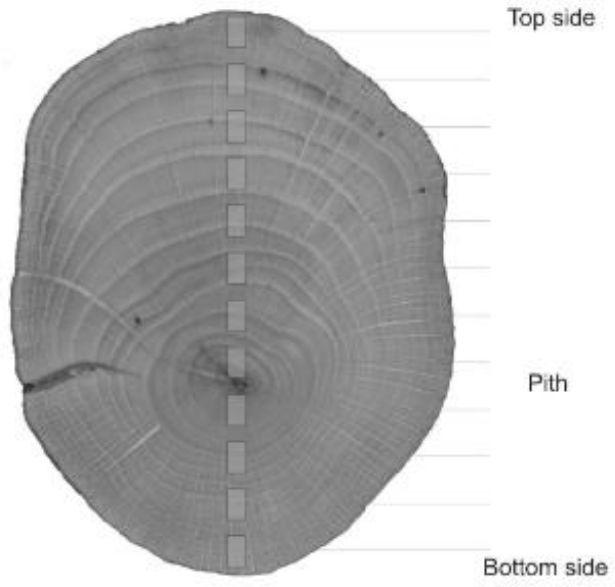

Figure 5 Cross section of a branch (Mattheck et al., 2004a).

- **Minimisation of critical shear stresses:**

  Wood is a material formed by fibrous structures. In the trees' case there are microscopic fibrils. These fibrils are aligned according to the force flow, however, when subjected to stress they are forced to search for a different alignment orientation. This type of reorganisation causes fibres misalignment and creates high local tensions, which can cause wood failure (Mattheck et al., 2004b).

These fundamental theorems show the natural defensive reactions that trees implement when they undergo stressors, damages or external disturbance factors. In particular, when plants grow in a complicated environment such as the urban one, where conditions and habitats are completely diverse from natural ones, trees are forced to self-regulate more frequently. Furthermore, it is necessary to understand that when more stressors influence a tree, its change reaction frequency is thus likely to

be higher. By consequence, a plant is forced to invest more energy, which means that becomes weaker and slower to future reactions. Therefore, an unsteady tree is more prone to single or combined pathogens attack and consequently incline to a structural fail (Shigo, 1986).

The VTA method is based on the identification of trees' visible reaction signs, activated in order to restore its structure or as a protection. Indeed, depending on cases a tree can form reaction and repair materials. For instance, in the event that a wood-decay fungus penetrates the trunk causing an internal deterioration, it will be visible on the wood as a swelling. This structural adaptation is due to the reaction wood production in order to isolate the foreign body and therefore isolate the damage (Shigo, 1986).

The external symptoms visible on trees' structure are varied and are classified by VTA based on their appearance. Thus, each defect corresponds to an internal damage that could compromise the structure and by consequence decrease its stability.

An example of the various defects can be seen in the figure 6.

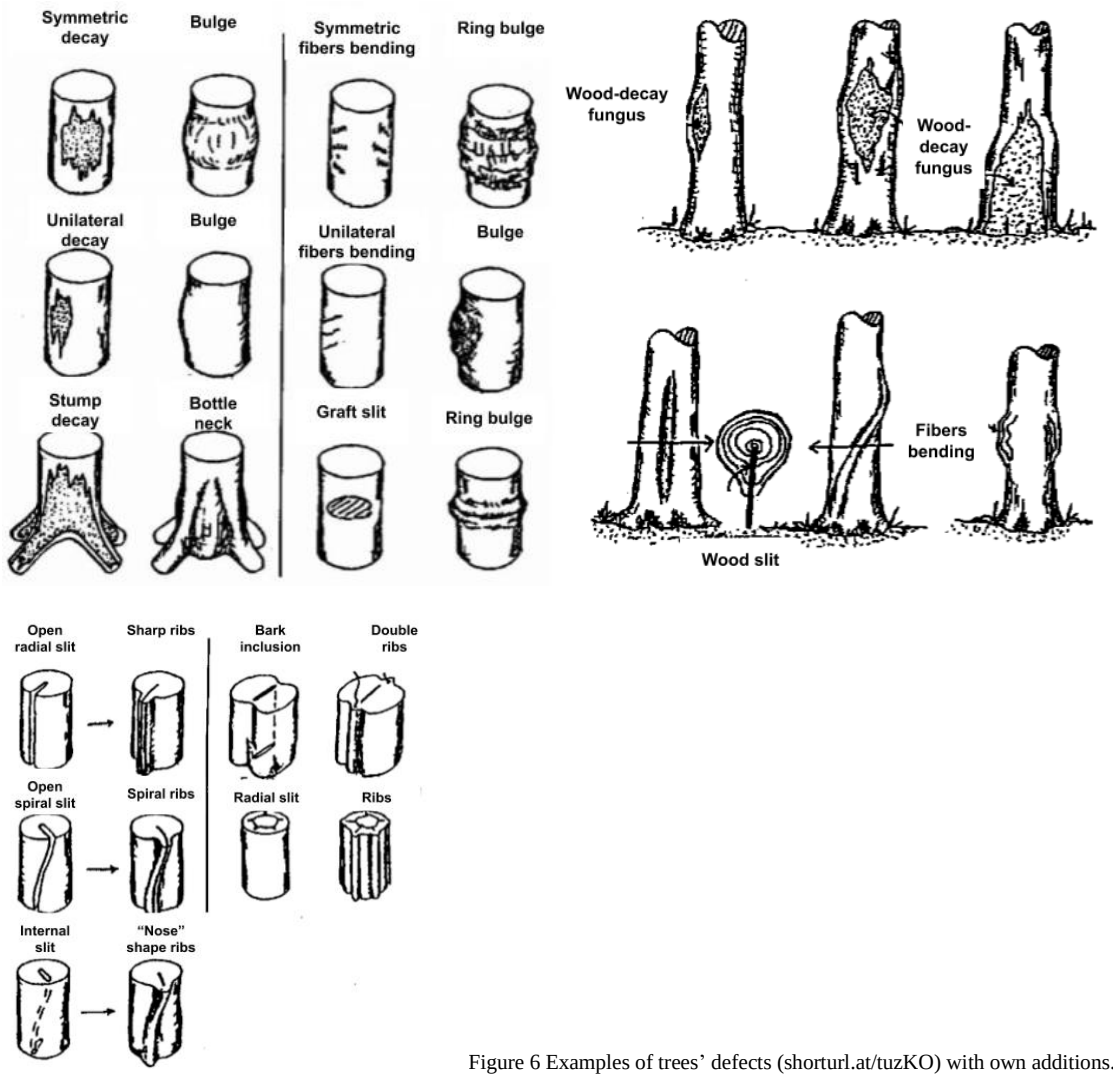

Figure 6 Examples of trees' defects (shorturl.at/tuzKO) with own additions.

Indeed, in the above illustrations there are noticeable various trunk reactions that correspond to a different corruption inflicted by pathogens, fungi or insects. In addition, in an urban environment it is necessary to include anthropic actions as a possible source of damages. For instance, even affixing a plaque on trees' trunk can provoke a reaction that englobes the foreign body in order to decrease the pressure exerted. Figure 7.

Figure 7 Englobe reaction (Sterken, 2005).

As it will be described in section 2.4., also an inappropriate pruning can cause an additional source of stressors and instability.

2.3.1. Trees assessment through VTA

Considering VTA as an evaluation method, it is necessary to follow certain steps in order to achieve a great assessment. Therefore, the visible symptoms analysis through the VTA methodology consists of 3 phases:

- The tree is visually inspected for external symptoms that can lead to internal defects (Mattheck, 1994). These signs may be due to the production of additional wood such as bulges, depressions or ribs.

- In the event that symptoms are detected, it is necessary to conduct a deeper examination through instrumental analysis (Mattheck, 1994). For instance, the most used tools are the Metriguard stress wave timer, which measures the speed of a sound wave through a wood cross section (Bethge et al., 1995) or with the resistograph, which through a thin needle penetrates the wood

in order to obtain its density. Indeed, a different density can mean variation in wood's hardness and therefore, the inner trunk is probably undergoing a process of degradation due to pathogens (Rinn et al., 1990). Figure 8.

- When the damage extension and the quality of the wood are understood, a crash prediction assessment is carried out in order to determine whether the tree is dangerous or not (Mattheck, 1994).

It is necessary to remember that VTA is a non-destructive method based on a visual inspection. Exclusively, in case of an investigated tree is considered to be in unstable conditions, the operator is allowed to inspect it thoroughly by the instrumental analysis. Despite the use of tools, it is necessary to keep the wounds less impactful as possible in order to avoid creation of further stressors (Mattheck, 1994).

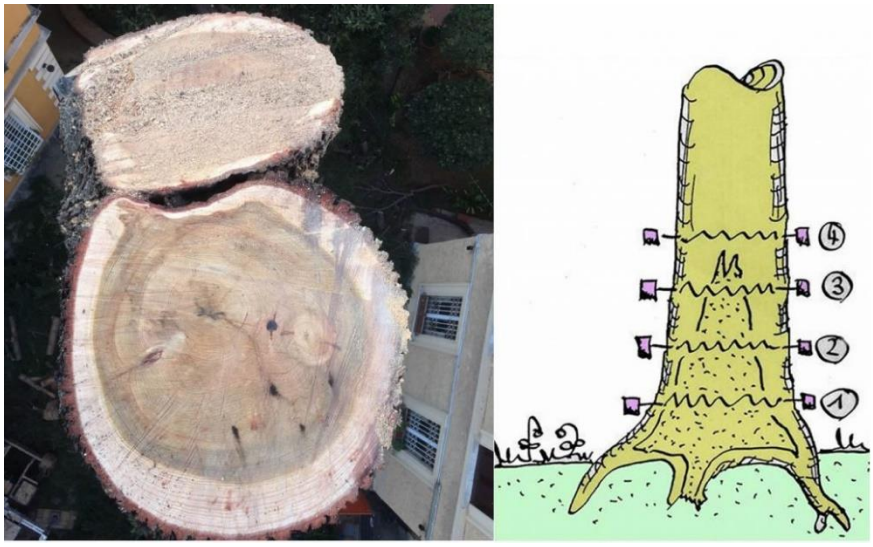

Figure 8 Resistograph function (shorturl.at/npsY0).

Therefore, once the plant's vitality has been evaluated, it is possible to assess its stability. A tree that has presented multiple symptoms attributable to internal deterioration will be more unstable and therefore, more dangerous (Mattheck et al., 1994).
The tree is thus classified according to an F.R.C. Failure Risk Classification:

- **Class A**: Group of trees that do not show defects or structural anomalies detected with instrumental analysis. Visual inspection is indicated every two years. The risk of a crash is linked to unpredictable factors.

- **Class B**: Group of trees with slight defects and small structural anomalies. The biennial visual analysis needs to be more accurate compared to the class A. Crash risks are linked to unpredictable factors.

- **Class C**: Group of trees with defects and structural anomalies verifiable through an instrumental analysis. The visual inspection must be carried out annually with a further instrumental investigation.

- **Class C/D**: Group of trees with serious structural anomalies. The chopping down of these plants can be avoided through careful safety operations, such as a crown reduction. The check-up should be executed every six months to evaluate potential worsening conditions.

- **Class D**: Group of trees with serious structural defects that seriously compromise their structure. Security operations would be useless, for this reason the plants in this class must be chopped down.

Furthermore, the assessment is based on the possible impact site. The greater the dangerousness of the tree, the more sensitive the impact site is. For example, areas extremely frequented by people are considered highly sensitive (Mattheck et al., 1994).

2.4. The dangerousness of pruning

As mentioned above, trees in an urban environment are indirectly or directly affected by anthropic influence and impact. Some involuntary factors, such as trees alongside roads, have already been described. On the other hand, direct factors can be addressed to vandalism, trunk attached plaques and maintenance procedures including pruning (Gilman, 2002).
In general, maintenance and pruning operations can be decisive factors for a tree's great prosperity and growth, however, they can seriously damage plants if carried out incorrectly.
For instance, pruning in an urban environment is usually performed in the case that a tree interferes with city activities or due to aesthetic factors. While, in a forest environment a sort of "pruning" is part of a natural growth process based on a gradual loss of old branches. Despite the open wound, due to branch cracks, trees progressively manage to effectively start an auto-healing process. Therefore, incorrect cutting of a branch does not adequately activate the healing process and by

consequence, it increases the risk of pathogen ingress into the wound (Gilman, 2011). For this reason, it is crucial to analyse and comprehend this natural process in order to reproduce the natural cut during the maintenance operations.

For instance, in a forest environment it is possible to note that branch cracks are never “flush with the trunk”. Therefore, by not reproducing this natural law and by cutting without respect, it is likely to end up damaging a plant. In order to realize a correct cut, it is advised to review the illustration in the figure 9. So, it is requested to respect the part called “branch collar” in order to allow trees to a correct and fast healing process.

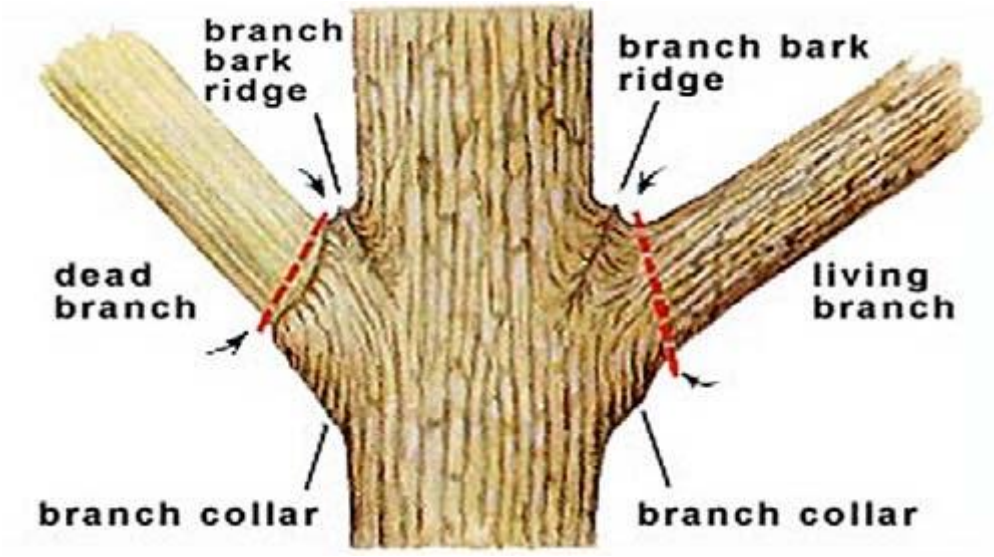

Figure 9 Details of trunk and branches parts (shorturl.at/aCFW7).

Tree pruning consists of various operations needed to achieve different functions. For instance, pruning to reduce the foliage in case of building or other structures' proximity or a pruning to remove all dry dead branches that have suffered from pathogens’ attack or other damages. A cleaning pruning is also appropriate to prevent the falling of damaged and potentially dangerous branches.

However, pruning should be carried out considering and respecting plants’ structure and their vegetative activities. Unfortunately, a common practice is the tree topping. This technique absolutely does not reflect a fair and respectful pruning procedure (Kaiser et al., 1986). In fact, as it is possible to notice on the figure 10 with the tree topping techniques, the entire crown has been removed. A rational pruning approach should not remove more than 30/40% of the leaf surface (Gilman, 2002). In this case, the "bare" tree is completely exposed to direct sunlight and therefore its inner temperature will increase. By consequence, the tree is forced to recreate the entire crown in order to shade its structure and reactivate its photosynthesis process as well, which is fundamental for plants’ life. For

this reason, a tree will be forced to stimulate an emergency mechanism by quickly emitting thin and long branches that will permit the recreation of its crown (Kaiser et al., 1986).

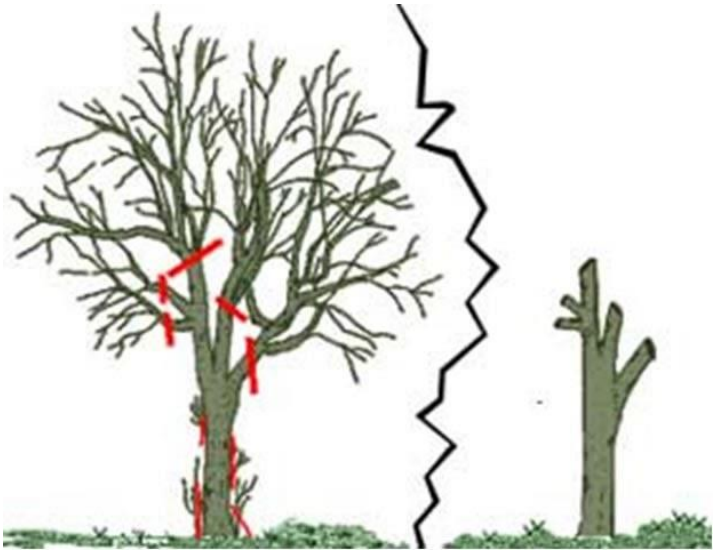

Figure 10 Tree topping consequences (shorturl.at/yzFVW).

Trees manage to survive for years this unrespectful procedure at the expense of the energies accumulated over the years. Therefore, the plant will be weaker and susceptible to external attacks. In addition, the cuts are open wounds and therefore are an easy entry for fungus pathogens (Shigo, 1984). It has been also noticed that plants subjected to trees' topping usually develop a limited and weak root system and therefore, they will be more prone to fall (Coder et al., 1997).
As it can be seen in the figure 11, also in Aalborg can be found trees that underwent the tree topping.

Figure 11 Example of tree topping in Aalborg

Alternative approaches to this arguable technique are well-known and utilised. For instance, a correct pruning treatment is aimed at clear, and not a complete removal of trees' crown as it has a double benefit (Purcell,2015). Indeed, if pruning is performed by respecting the plants, as shown in the figure 12, despite the saw process on the branches, the damages are limited to smaller wounds and the re-growth becomes gradual and more natural. Therefore, the energy utilized for reforming their foliage will be minor compared to trees topping procedure. So, through an appropriate pruning there will be respected the plants' biology and their structural balance will be maintained (Purcell, 2015). Thus, by maintaining enough energies to use for activating defence mechanisms, trees will be less vulnerable to pathogens ingress. In addition, a respectful pruning will achieve the purpose of limiting plants' growth, which will consequently interfere less with urban activities.

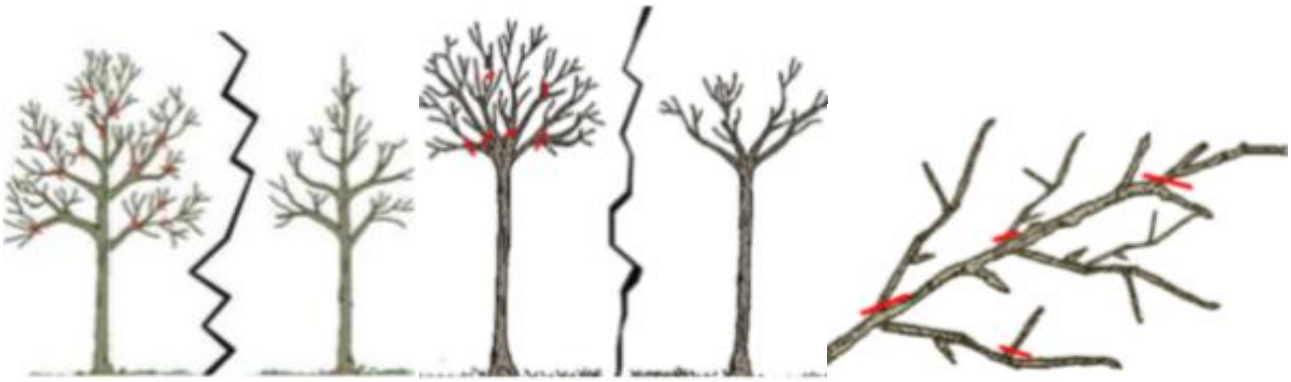

Figure 12 Correct pruning examples (shorturl.at/hxHQ6).

In the figure 13 one can notice how, during the years, a correct pruning can benefit both plants and a final consumer (in our case Aalborg Kommune). Indeed, trees will maintain their structural balance and will grow gradually and naturally. Therefore, the temporal interval necessary between pruning interventions, will be longer compared to a tree topping one (Campanella et al., 2009). Besides the subjective aesthetic point of view, in which the tree correctly pruned would be more pleasing than the topped one, the economic factor also should not be neglected. Indeed, a tree pruned by respecting its biology and structure will reduce the maintenance interventions and therefore, obtain an economic saving (Campanella et al., 2009)**.**

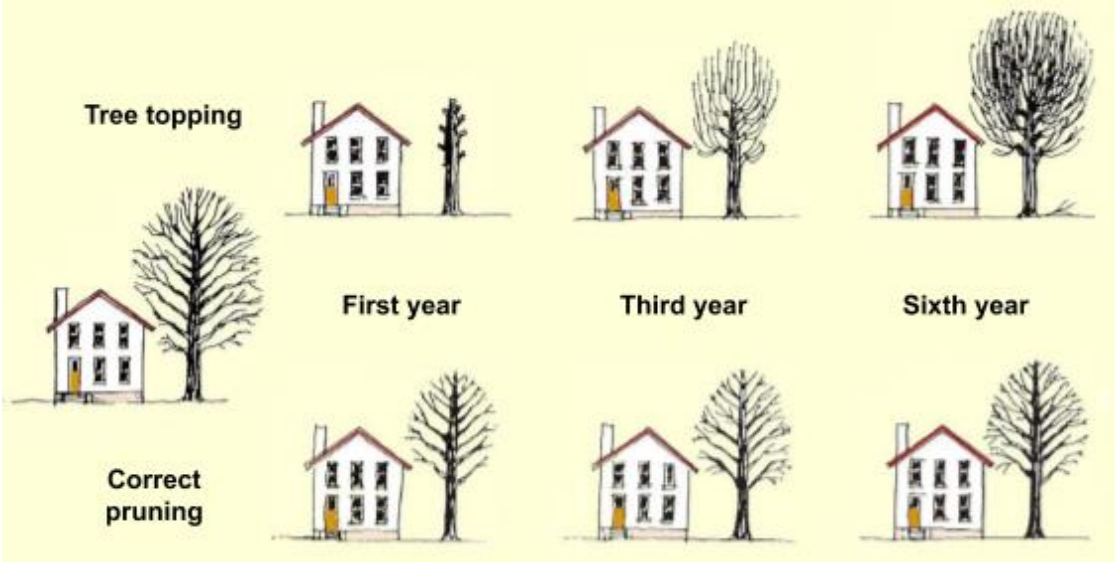

Figure 13 Tree topping compared with correct pruning during the years (shorturl.at/oMWY7) with own additions.

Unfortunately, tree topping does not require deep plant studies. This means that even unqualified operators are able to carry it out. In addition, for the public who barely see the final result, new emergency branches and leaves created by the topped tree appear lush and colourful (Dublin City Council, 2016). For the above described reasons, this is not lushness, but an emergency mechanism activated by a suffering plant.
The VTA does not deal directly with pruning approaches, however, if erroneously performed, they can negatively influence plants, by causing stressors. Consequently, trees show symptoms connected to the damages that can be identified and analysed by the VTA evaluating their stability.

2.5. Problem statement and research question

The current trees' vitality assessment method adopted by Aalborg Kommune appears general and missing some important evaluation factors. However, this situation offers new opportunities for improvements and changes towards a more complete and effective trees evaluation system.

In order to find a solution to the above-mentioned problem statement, this research question has been posed:

In which ways the current tree vitality assessment methodology can be reinforced in order to evaluate plants stability and consequently minimize trees or branches falling risk?

This research question aspires to provide an improved version of the actual trees vitality approach by integrating a particular and innovative method. The selected method takes into consideration factors that in the current approach, utilised by the municipality, are not evaluated in detail. Therefore, the innovation ensures that trees collapsing exposure is prevented and consequently limits potential accidents.

3. Theoretical framework

As previously mentioned, the process of upgrading the current assessment method in Aalborg will be studied through the lens of a Multilevel perspective (MLP) theoretical framework. This framework is explained in the following chapter, as well as some examples are provided of how it has been utilized. The chapter concludes with an explanation of how the MLP framework is intended to be used in this project.

3.1 Multi level perspective (MLP)

Multi level perspective (MLP) is a theory based on the concept of transition and it is often correlated to a socio technical approach (Geels 2005a).
The key point of this theory is to explain how a transition from a specific socio-technical regime into another regime can occur. Indeed, how the interplay between various innovation niches at different levels can lead to a different prevailing perspective. Therefore, the socio-technical transition shows a broad view of a complicated and potentially unstable system, considering that it takes into consideration a multitude of studies and disciplines. The MLP approach permits to analyse and study complex cases by adopting a view from above (Whitmarsh 2012).

The MLP is structured into three different socio-technical levels:

- Micro level based on technological innovation niches.
- Meso level based on socio technical regimes.
- Macro level based on a sociotechnical landscape.

Niches (micro-level)

The niches are the starting point for radical innovations that can emerge and are potential cause for future profound changes. Initially their social impact is very low considering that they are quite new ideas and they have to compete with a firm and strong regime. For this reason, the niches do not affect the traditional market and they maintain a protected condition against its pressure (Geels 2005a).

Despite the lack of influence, niches can play a crucial role as they act outside the box and by consequence, they can provide a new emerging learning process at the micro level (Geels 2005a).
These new processes can perform in different dimensions and fields, such as technological, regulation, infrastructure, production systems, etc. The micro level is identified as unstable and marginal (Geels 2005a).

Regime (Meso level)

The sociotechnical regime is the central level placed exactly in between the upper landscape and niches, the lower ones. It is usually defined as "Technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures are an arrangement of dominant technology, industry, consumers and market science, culture and policy." (Kemp, Rayner and Rip 1998, p.340).
Thus, the meso level primary attribute is to be driven by social habits, rules and institutions that regulate and constrain actors' behaviours. For this reason, meso level is more inclined to be dynamically stable and durable. Its dynamism is outlined by the continuous and progressive flow of time and involved actors' actions, without undergoing any change or radical interruption (Geels 2005a).
The only factor able to disarray a socio technical regime and push for a radical modification is the micro level. The pressure is applied by technological innovations coming out from the micro level and mutates their niche status into a more decisive condition. Their force alignment leads to a strong pressure for an irreversible change into the meso level (Geels 2005b).

Landscape (Macro level)

The highest level, from the multilevel perspective is called landscape. This level is the least prone to any variety of change. The landscape structure is constituted of socio-technical factors and abstract general contexts, such as social codes, global expectation and political ideologies. It is also composed of tangible factors, such as commercial activities, institutions, market shares, and financial values among others (Geels 2005a).
It is a vast concept and it can directly influence socio-technical regime evolution. For this reason, landscape is the most stable level and the least prone to transformation. This level is even more

difficult to modify than the meso level, therefore, there are necessary more determined and incisive pressure factors in order to create a mutation on its shape.

The landscape cannot be directly influenced by the meso or the macro level. However, the landscape can externally influence innovation niches through a construction of expectations and networks (Geels 2005a).

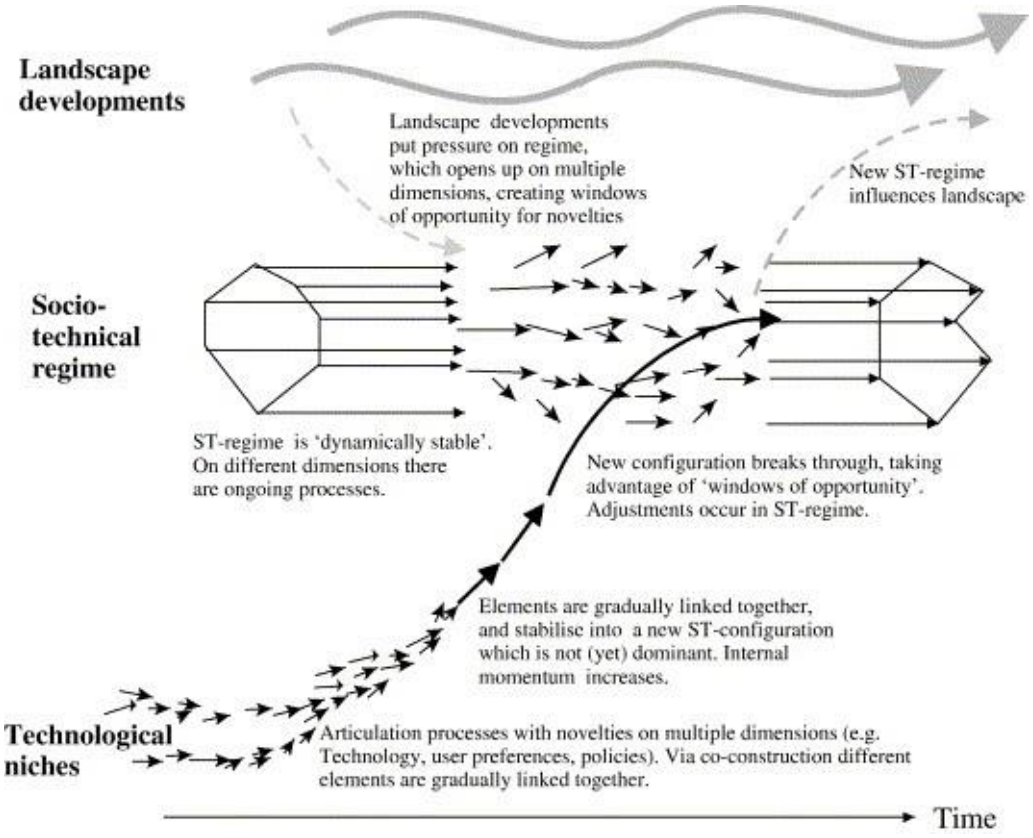

Figure 14 Multi level perspective (Geels, 2007).

From Niche-innovation to regime

As mentioned above, the regime is a stable, durable and well-regulated level. By consequence, it is not prone to change. In this solid state, the regime inhibits niche innovations, which do not possess a significant influence on the market. If the niches persist in this state of non-influence for a long time, they are destined to fade and then disappear (Geels 2005a).

However, misalignments can arise in regime stability leading to the production of "windows of opportunity". These regime level breaches can be utilized by niches to penetrate into meso level and compromise the regime stability (Geels 2005a). At this point, there can be noted a favourable situation

to initiate a replacement and transformation process that involves the socio-technical regime. So, niche condition innovations are irrelevant until the state when they increasingly acquire power. When this process starts, they are able to conduct the influence necessary to completely transform the stable dynamic system (Geels 2005b).
This long and complex process can be divided into 4 phases:

Phase one: In the background of a landscape and a regime in continuous progression and development, innovations begin to emerge as niches on the micro level, but they still do not possess enough influence and power to act in the main market (Geels 2005a). Indeed, in this first phase various innovations exist in an experimental model and are not fully developed. In addition, several novelties can rise at the same time and consequently compete with each other. However, innovations have potential to compete with the stable regime (Geels 2005b).

Phase two: In this phase the innovations are improved by the developers and become part of a niche market. In this micro level market, users acquire a crucial role in novelties growth (Geels 2005a). In fact, consumers evaluate the most stimulating innovations and which one has the greatest growing chance in the socio-technical regime. Furthermore, by the user's inclination, developers can understand their requests and therefore improve their innovations. In this phase novelties do not represent yet a threat to the regime as it persists in its state of stability (Geels 2005b).

Phase three: This third phase is represented by production of "windows of opportunity" utilised by innovations to penetrate into the regime. Indeed, misalignments can occur both at meso and macro level (Geels 2005a). The critical issues can arise at a meso level by consequence of internal problems or complication related to the technology currently in use (Geels 2005a). In addition, landscape can also have an impact on niches emerging by pressing the regime for radical changes. In this phase, the regime is more unstable and therefore innovations can take advantage of "windows of opportunity" and contest the main regime (Geels 2005b).

It is crucial to underline that during the three phases process previously mentioned, more niche elements have been combined in order to reinforce the innovations. Thus, disconnected elements now acquired a collective connection. This network is essential to establish a stable niche. Only stable innovation is able to contest the regime (Geels 2005b).

Phase four: The innovations gained enough influence and have successfully penetrated in the socio-technical regime market (Geels 2005a). Therefore, novelties through a new competition, pressed the regime and consequently generated misalignments. This radical transformation is capable of consolidating or reconstructing the regime (Geels 2005a). After the transition period, the innovations will replace the preceding regime, which will undergo socio-technical changes. From this point, a new period of stability will be established and simultaneously the regime will restore its social alignments. This radical transformation period is a long process that will take place slowly and gradually over time. It is remarkable that if the radical change has a considerable impact on the regime, this one is capable of influencing the landscape level (Geels 2005b).

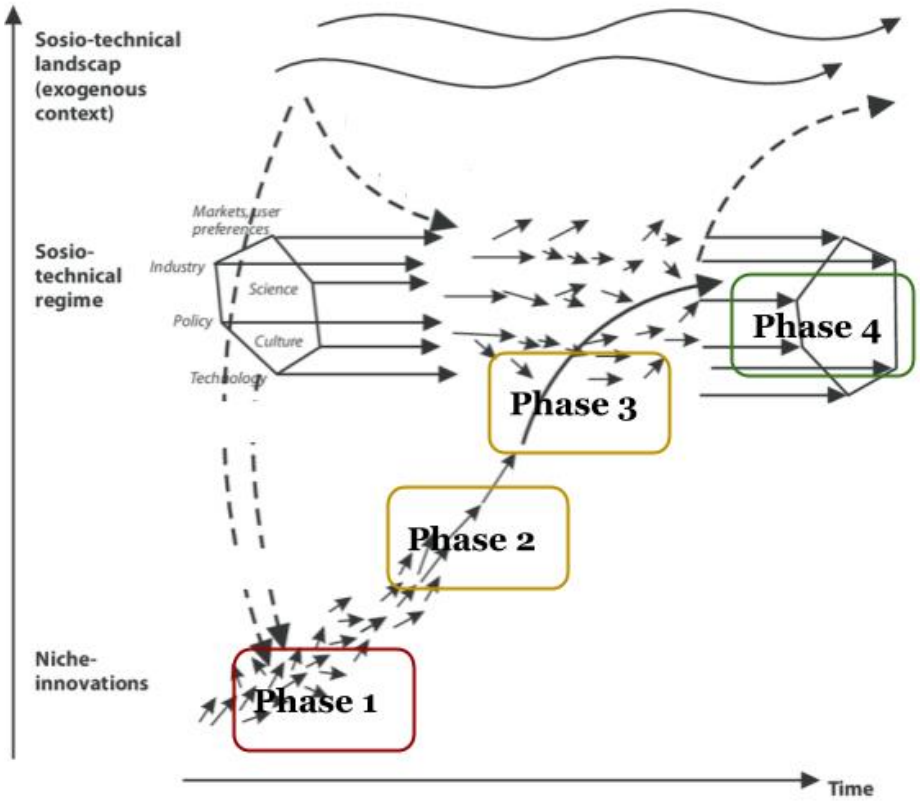

Figure 15 Multi level perspective phases (Geels 2007) with own addition.

3.2 MLP in urban green sector

As written in the previous chapter, MLP theory is mostly used to observe the continuous society transformation from a helicopter view.
In fact, from an elevated and wider position it is achievable a greater analysis of a technological niche movement towards the socio-technical regime (Geels 2005a).
Therefore, this theory simplifies the vision of this broad and complex sociological system that implies a multitude of factors. Indeed, it is possible to follow and understand in detail the succession of events that, in a micro-level, led to a particular technological niche development. In addition, it will be possible to comprehend the events that led to a "window opening" and the process that consent the innovation infiltration into the socio-technical regime and consequently the regime modification (Geels 2005a).
These types of system alteration have occurred repeatedly throughout history and are still presently in action. For this reason, it is possible to identify various cases whereby MLP theory has been utilised as a framework in order to understand the succession of events that led to a particular niche development, to comprehend the events that led to a "window opening", explain how a transition took place from a specific socio-technical regime into another regime , all from a "helicopter" point of view. Such is the case of transformations in the urban planning field as it will be explained next.

3.2.1 MLP framework cases

The first case concerns the French sewage system and how it has been reconstructed and its evolution over time. Throughout history, this essential technology has been subjected to countless changes and innovations due to social pressures. For instance, during industrialization French society demands urban sanitization. Nowadays, major changes are guided by sustainability and waste reduction. However, in any case the adjustments are limited by several factors (Patouillard et al., 2011). These circumstances are usually complex and consequently complicated to overcome in a short period. Indeed, Despite the desire for an innovative change of an essential system for the vital functioning of a city, alternative techniques usually encounter several limitations that arrest their expansion. The main obstacles are given by the low propensity to transformation of socio-technical regime and landscape. Indeed, in French sewer system case, some barriers have been identified that block innovations at micro level. At this level they are inactive and do not have any influence neither on socio technical regime nor on landscape. So, it can be noticed how the MLP methodology is necessary to understand which are the mechanisms and the involved actors limiting the affirmation of an

alternative innovation in a socio technical regime. for instance, the limitation barriers in this case have been identified in behaviour change limitation of local population and authorities. Indeed, technical, aesthetic and individual needs must be taken into account (Patouillard et al., 2011).
A second barrier is represented by the replacement time. A sewer is an essential and vital system for daily life and therefore it cannot be replaced instantly.
A third barrier is due to management costs and how to share it. Indeed, the sewer innovation work is still considered as a private. Therefore, if a French citizen would innovate his system, firstly he should handle the construction and maintenance expenses and secondly he will be obliged to contribute to the " public old sewer system" As it is easily understandable, driven by this social behaviour an ordinary citizen is not willing to add extra costs to innovate his system. Therefore, the innovation will remain in his niche shell.
The last barrier is represented by the actors involved in the maintenance process (Patouillard et al., 2011).

In the second case, MLP framework has been utilised in order to analyse a broader scenario involving several wide factors. The case under consideration is the city sustainable development. In this situation, limiting factors, to take into consideration, are multiply (Næss et al., 2012). If in the sewage example limitations were many but all connected to a single technology, in a city transformation process the involved technologies are numerous and therefore the limiting factors numbers are incredibly higher (Næss et al., 2012). In conclusion, this case analyses the reason why a radical change is conditioned by a non-incisive political decision. Indeed, in order not to privilege one condition to another, compromises are necessary. This situation, induce the regime to be not inclined to any profound transformation and force the innovation to stand in their niche state (Næss et al., 2012). Also, in this case, a complex system such as a city is, thanks to the MLP approach it has been observed from an elevated view. By consequence, it has been possible to analyse the barriers blocking at a niche level the emerging alternative innovations.

3.2.2. MLP application in this thesis

During this thesis process it has been necessary to identify the social barriers that limit the emerging of alternatives or innovations into the meso level. Therefore, the limitations found and that will be analysed in chapter 5.3. are mainly related to social concepts in which trees are treated as objects and not as a living being. Consequently, the interventions on trees are not carried out by respecting plants' needs and forgetting their biology.

4. Methods

This section describes the methods utilised to acquire all the necessary information for the author to be able to answer the research question and consequently, to develop this thesis work. As above mentioned, the framework of this document is the MLP theory. It was taken into consideration the fact that it is necessary to understand the social structure from an “helicopter view” (Geels, 2005a).

The data required to develop this paper was of quantitative nature collected through email interviews, photos analysis and desk research.

4.1 Data collection

Before proceeding with a detailed description of methods, it is necessary to be familiar with the interviews’ participants.

- **Park and nature Aalborg department**

The Park and Nature department in Aalborg manages a total of 2823ha of urban land. They perform various tasks, from trees’ evaluation to their maintenance with different operators active on the field. Green experts operating in Aalborg were chosen to participate in the email interview. In order to be able to answer the research question it was necessary to comprehend the maintenance system in the Aalborg urban context through interviewing the staff from The Park and Nature department.

- **Arborist Rocco Sgherzi**

Rocco Sgherzi is a professional arborist who graduated in forest science. His primary responsibilities are concerning the trees’ vitality and stability assessment through the VTA methodology including an instrumental analysis. He has been working and dealing with the assessment of urban green spaces in Rome and its province since 1998 (Sport e salute, 2016). In

2016, Sgherzi opened a technical study of arboriculture named Urban tree based in Viterbo (Rome) (Urban tree, 2018).

Given his long experience in the field of urban green, the author decided to take his knowledge into consideration in this thesis process.

4.1.1. Primary data collection

The data regarding Aalborg current situation were collected by enquiring one the Aalborg Kommune landscape architects from the Park and Nature department.

During this gathering process, it was crucial to adopt an alternative method to the most frequent one, face-to-face interviews. In fact, it was indispensable to utilise an email interview. As already mentioned in the initial disclaimer of this paper, this alternative method was required mainly due to the emergency condition created by Covid-19, which did not permit direct social contact. In second place, the professional from the Green and Nature department preferred this method as she felt more comfortable with written rather than spoken English.

The investigation questions concerned rules and techniques utilised in urban green spaces assessment and regarding intervention plans.

Additional information was collected through another email interview with an Italian arborist Rocco Sgherzi. Some questions were asked regarding the VTA methodology and what potential barriers are likely to encounter during a presentation or partial introduction of an alternative methodology.

Despite the fact that the direct interview method is the most popular and utilised, the potential of email interviews should not be underestimated.

Along with the email interviews, the author took several pictures of the trees that were considered relevant for this thesis. The purpose of these photos was to check their condition in an urban environment, such as Aalborg and if there are visible damages or symptoms attributable to an internal corruption. Thanks to this data, it was possible to identify if trees' evaluation and maintenance conducted from the municipality express the full VTA potential.

4.1.2. Interviews

Generally, the most adopted method for collecting data through interviews is to conduct it face-to-face. This interview model is characterised by having a synchronous conversation in time and place. Qualities of this model consist of the interviewer and interviewees proximity. Indeed, it is possible to indirectly capture additional information from speaker voice intonation and his body language (Emans, 1986). Furthermore, there does not take place an interval between one question and the next one, therefore, the researcher is able to reach a live reaction discussion. In addition, one of the main face-to-face interview distinctive features are follow-up questions that allow a deeper topic investigation. Indeed, follow-up questions can expand a discussion through real time feedback analysis.

One of the main issues in conducting a face-to-face interview is determined by the “double attention” factor (Wengraf, 2001). As matter of fact, the interviewer must pay attention to his question exposure and in the meantime mentally anticipate his next question by keeping in mind essential details and points required for his research. This mental mechanism is processed while the interviewee is responding. By consequence, it is crucial to maintain the concentration in order to not misplace essential information. If the interviewer’s focus is not high, it is easy to miss or misunderstand some key points and details. If this happens, there would be a potential interview compromise (Bryman, 2001). This problem can be solved for instance through a recorder adoption, but also this solution could undergo some limitations. In the first place, it is indispensable to obtain interviewee recording consent and secondly, it is possible that a researcher forgets to start the recording or the file or tape could get corrupted. In addition, if some of these issues occur and the interviewer does not take notes, the risk of compromising the whole interview is elevated (Bryman, 2001).

4.1.3. Email Interview

Through technology and internet connection development, it was possible to create alternative social interaction methods. For instance, there are available various digital communication approaches, such as email communication or video calls.

With these additional communication techniques, it was possible to establish an alternative interview approach that did not require a face-to-face meeting.

As one could see, these new opportunities imply some inquiry approach revisions. Indeed, one of the main divergent points that mark a line between direct interviews and those conducted via email are follow-up questions (Lokman, 2006).

In fact, this continuous question deepening can be carried out only in a direct conversation. Unfortunately, email interviews do not allow a real time interaction, however, in order to obtain some additional in-depth answers it is necessary to wait for a response.

However, the waiting time may be necessary for the participant to elaborate in a detailed and deepened answer (Curasi, 2001). In fact, if the interviewee feels to compose an accurate and information-rich email, the information obtained could be considered as more in-depth than the follow up questions (Meho et al., 2003).

Some studies also point out that data acquired from an email interview are almost equivalent to the ones collected from a more traditional method (Murray et al., 2004). Indeed, the interviewees are more concentrated than in a direct interview and by consequence, less inclined to be mistaking (Karchmer, 2001). In addition, the participants can have control on the interview flow and respond when they feel most comfortable (Bowker et al., 2004). Thus, they have the opportunity to reread and correct their written elaboration (Levinson, 1990).

4.1.4. Photo collection and visual analysis

Photos' analysis is a visual inspection method that is part of "non-destructive testing" approaches. The main feature of a non-destructive test is to not cause in any way damage or alteration to the inspected area or object. For this reason, photos are an essential visual assessment method applied in many aspects of an investigation (Bohnsack, 2008). The principal characteristic regarding the photos is their capability to capture an image of a specific situation in a specific location. Successively, the captured detail can be analysed and studied at a later time without the necessity to physically be in the investigation site (Bohnsack, 2008).

In this thesis it was considered to photograph some examples of the trees within Aalborg city. The purpose of the photo analysis carried out was to verify that although Aalborg municipality uses a trees' assessment methodology, some of the plants' present symptoms of diseases. Therefore, their condition is unstable or has undergone incorrect pruning. These situations can create a precarious trees' situation, which could lead to potential damage to citizens or vehicles.

4.2. Secondary data collection

In support of primary data, secondary information was acquired through the method of desk research. In detail, documents concerning VTA and other methodologies were analysed through a web research. It became a valuable support of the arboriculturist Sgherzi who provided technical documentation. In addition, information concerning the greenery and its assessment in Aalborg municipality was analysed.

4.2.1 Desk research

Desk research methodology was based on an investigation and consultation of existing materials that could be used to obtain indications and suggestions regarding the requested topic. Despite the reachable enormous number of information, the searches usually do not provide a direct answer (Hague et al., 2013). The answer may be still in the process to be studied or unpublished. Despite this, desk research has a fundamental role in an elaboration process as it is capable to indicate a possible outcome to pursue. In the end, the achieved result, influenced by the research can appear as expected or experience a variation and reach an alternative solution (Hague et al., 2013).

For this thesis, desk research was a fundamental technique in order to obtain technical documentations concerning the existing trees' viability and stability assessment methodologies, in particular the VTA. It was also essential to investigate the MLP method and its application by discovering the social barriers at meso level that limit innovations' implementation. In addition, documents from Aalborg Kommune concerning urban green plans were studied to obtain an interpretation of the current situation.

5. Analysis

In this chapter, there will be analysed the information obtained through the utilised research methodologies.

5.1. Analysis of interviews

In order to obtain a better understanding and view on in which way the urban green evaluation is performed in Aalborg city and to investigate certain technical aspects regarding assessing methodologies and their development, it was necessary to conduct with two different participants email interviews. These interviews will be analysed in the following chapters.

5.1.2. Analysis of Aalborg park and nature department email interview

This interview started by asking questions regarding the operational areas that the "park and nature" department is in charge of to deal with and if they include only the central urban part of the city. The answer was that 2823 hectares are under their intervention and it combines all the green areas inside and outside the city as it is possible to notice from the map provided below figure 16 (Park and nature department, 2020).

Figure 16 Park and nature operational areas (Park and nature department, 2020).

The operational areas include: road trees, solitary trees, tree groups, avenues, tree rows and fruit trees. These areas are distributed between 7 employees who manage plants' maintenance and assessment.

Subsequently, it was asked what methods were applied and which parameters are included in their plants' assessments. The methodology was not expressed directly, but researcher from the the listed parameters identified following: tree species and variety names, the age or planting time of the tree, planting hole size, plant hole structure, the health condition of the tree, tree trunk diameter measured at 1m height from root neck (Park and nature department, 2020).

The purpose of these assessments is to locate dangerous trees, the ones which need pruning and trees that suffered from vandalism or traffic damage. In this reply, there was mentioned an evaluation method called VAT19. This method assesses purely aesthetic factors in order to obtain an economic value of a tree (Park and nature department, 2020).

The next question investigated whether evaluation systems are similar in Denmark or may vary between regions or cities. It was found out that norms and regulations regarding green and plants are applied in the whole Denmark, while the methodologies can vary depending on the municipality.

Afterwards, it was significant to research on possible risks concerning trees or branches fall and the level of involved damage. The department replied that there exists a potential risk level. However, they stated that in Aalborg the cases have never been highly significant and the damage has never been excessive.

Last question was concerning pruning and in which manner are these interventions carried out. The response was that pruning is performed for various functions on all trees living in the operating areas (Park and nature department, 2020).

In the second email interview, the inquiry was mostly regarding the employee's' knowledge about application of VTA as a tree assessment methodology. Their comment expressed that notions of VTA are included in their evaluation work, but regrettably, no more details were added.

Unfortunately, although additional details and explanations were requested, no further response was obtained.

5.1.3. Analysis of arborist Rocco Sgherzi email interview

The second email interview participant was the arborist Rocco Sgherzi. The questions mainly focused on his assessment activities and the methodologies he adopts during his urban green

evaluation in Rome and its province. The response technically explained the VTA through his field experiences and through additional documentation provided (Sgherzi, 2020). In addition, Sgherzi mentioned his constant work and contribution to future improvement of the tree assessment methodologies. An essential contribution to this thesis was made regarding the illustration of the barriers that Sgherzi has encountered and still continues to confront in his job as an arborist (Sgherzi, 2020). These barriers will be analysed in chapter 5.3.1.

5.2. Analysis of the collected visual materials

In order to verify the tree's condition in Aalborg city, it was decided to collect some visual materials through photos. Theretofore, there were taken pictures illustrating examples of the trees that show visible symptoms of decay.

The photos were taken in various areas in the central part of Aalborg city. This method was chosen as it can be utilised as a visual examination to ascertain whether despite the activities done by the Aalborg Kommune there are present any trees in a potential critical situation or if those trees were damaged.

In the figures 17-18-19 taken in Saxogade of a central road of Aalborg, one can immediately notice the slanted position towards the road of this couple of maples. In addition, it is evident that the root ball is raised on the opposite side of the inclination. The raised soil is a consequence of a weakly supported roots system from the ground. In case of extreme conditions occurring, the plant would not be correctly sustained and therefore, would result as prone to collapse. In this case, the danger is even higher considering the neighbouring road. Furthermore, in figure 17 the plant vitality seems mediocre as the leaf production is minimal. On the other hand, in figure 19, despite the adequate leaf production, at the trunk base there is evident a partial plant re-growth, which indicates a stressful situation. Indeed, this emergency re-growth is a similar process activated when a plant is "topped"; a pruning technique that was already described in 2.4. section.

Figure 17 Tree in Saxogade.

Figure 18 Tree in Saxogade.

Figure 19 Detail on re-growth.

Additional examples of trees with limited leaf production activity are presented in the figures 20-21-22. Figure 20 shows the red circled two broadleaf trees, where the conifer appears to have undergone a similar stressor. Considering that the plants in its vicinity are not so bare, the disturbance that negatively influenced the three plants can be limited to that area. Also, this could be caused for instance by a crack on underground pipe that created water stagnation.

In the figures 21-22 as well, there can be noted the plant's weakening. The reason why they were considered as the cases to be included in this analysis are in virtue of the areas in which the trees are located. Indeed, they are respectively situated in a playground figure 21 and near a road figure 22. In these two cases, the potential danger is higher as the impact sites are sensitive and therefore, they should require a deeper analysis on their stress causes.

Figure 20 Two broadleaf trees and one conifer.

Figure 21 Conifer in playground area.

Figure 22 Tree incline towards road.

Also, in figure 23, illustrating a couple of the same type broadleaves, there is evident a disparity in their vitality. Also, in this case there would be suggested an in-depth analysis on the potential stressors causes as they could spread to all the plants in the area.

Figure 23 Two broadleaves and their disparity.

The linden in figures 24-25 can be considered as a typical example of a tree living in an urban environment surrounded by buildings. The tree's vitality, despite the fact that foliage appears luxuriant, it presents weakness signs. Although, on these photos there are not clearly evident broken branches, the red circle highlights a large one. Instead, there are evident multiple cuts cicatrized in an optimal and non-optimal manner. The closed wounds can be addressed to a general anthropogenic damage or to pruning figure 25. Furthermore, the root ball does not have enough space for a proper roots' expansion compared to the plant size. In addition, the soil around the tree appears particularly compact. Multiple stressors can lead this linden to be weaker and unstable, therefore, more subjected to pathogens ingress. Furthermore, the impacted site can be considered sensitive as it is close to buildings and a road.

Figure 24 Tree surrounded by buildings.

Figure 25 Details on broken branch and wounds.

In the examples provided in the figures 26-27, there can be observed a poor vitality of these young trees that most likely have been planted recently. Their planting locations probably are not adequate to their growth requirement or some inaccuracies during the planting process were made. It is also probable that the plants were already debilitated from their nurseries and by consequence, they were not able to survive the transportation and planting stressors.

Figure 26 Young trees during roadwork

Figure 27 Young tree with dead branches

The last two figures 28-29 display the technique considered to be incorrect and not entirely respecting the tree's biology named "tree topping" already described in section 2.4. Sadly, the plants cut with this method rarely manage to survive for a long period as they gradually become weaker because of the continuous drainage of their accumulated energies by the production of new shoots.

Figure 28 Example of tree topping with leaves in Aalborg

Figure 29 Example of tree topping in Aalborg.

5.3. Analysis of VTA under MLP lenses

In this thesis it was decided to analyse the VTA methodology through the multi-level perspective lenses. The decision was taken because of the reason that the research was aimed at discovering possible barriers that do not allow a potential innovation to emerge. Therefore, the VTA is considered as a valid upgrade of the current evaluation methodology. By consequence, it is necessary to recognize primary barriers from the socio technical regime that potentially limit the VTA development.

The arborist Sgherzi in a written paper explains the obstacles and limitations evolving from his experience to present an alternative conception regarding trees' life and biology. By consequence, his aim was to demonstrate the value of a different assessment methodology of trees' stability and vitality taking into consideration trees as living beings.

Before illustrating the barriers that Sgherzi experienced, it is necessary to spend a few words on arboriculture historic background because it represents the stable socio-technical regime.

5.3.1. Stable socio technical regime: present and past of arboriculture

Throughout history, the development and creation of green areas in urban environments together with arboriculture have undergone several modifications. Indeed, the role of trees in human activities has continually played a major function. It is possible to imagine the importance of wood during the past just by thinking of all the utilisations in today's society (Sgherzi, 2020).

Therefore, the trees' supervision has been entrusted to arboriculturists who studied, pruned and cared for the plants. At the time, the techniques utilised to heal trees were in line with the first discovered human biology concepts. Such concepts were considered as valid in the past, however, nowadays, modern studies have improved including research regarding the plants' biology. For instance, many arboriculturists used to seal trees' wounds by applying some glues or mastics as they thought that it was the water that caused fungus attacks (Sgherzi, 2020). Despite the fact that it was discovered that this technique is not capable of efficiently healing damages, there was understood that this occlusion can worsen the situation, since it creates humidity and a favourable environment that facilitate pathogens attacks. In spite of these studies, this disputable technique is still used today, as well as pruning operations, which were already discussed in section 2.4. This stable situation where trees were taken care of and became treated with certain approaches could be considered as a socio-technical regime, not being prone to changes.

5.3.2. Existing barriers

The barriers experienced and described by Sgherzi reside in social and cultural factors and in particular, in the conception between trees' care and their exploitation. Unfortunately, history teaches us in what manner trees were repeatedly mistreated for several reasons by man (Sgherzi, 2020). Indeed, for years trees were seen as an enemy to fight and were usually associated with bulky and disturbance elements. Therefore, plants were sawed, cut down, ruined and used for human purposes (Sgherzi, 2020).

Even some studies carried out in the past regarding plants took into consideration only the wood of trees and therefore, the analyses were performed in a laboratory without considering the trees' biology in their natural environment (Sgherzi, 2020).

In the socio-technical regime, the barrier of the trees' conception as an object and not as a living being plays still an integral role in the maintenance practices. In addition, increasing innovations in the field of forestry equipment facilitated and speeded up human works on tree structure, but also increased some inappropriate practices. The practices still utilised can be named as: flush with the trunk cuts (already discussed in section 2.4) with glue applications and treatments with insecticides to kill pathogens. In addition, the innovation introduced new disease treatments that are adopted, such as spraying on the trees (until dripping of chemicals) designed to kill insects and pathogens, without however taking into consideration a potential soil contamination. Subsequently, there were introduced injection techniques, where liquid chemical products are directly injected through massive needles inside the trunk. Regrettably, this technique does not consider that if the products are poisonous for the pathogens, they might be dangerous for the tree as well. From these disrespectful techniques towards the trees' biology, it can be noticed where the attention is paid regarding the results of the treatment and without considering potential plants' repercussions (Sgherzi, 2020). Indeed, these treatments are effectively killing their targets and therefore, are considered as effective by (as in the example of the technique already illustrated in section 2.4 named “tree topping”) creating the illusion of a colourful and luxuriant trees' crown. Furthermore, trees are not immediately negatively affected by these poisonous treatments, which means the job can be evaluated as efficient. However, by applying these treatments, the biology of the plants is omitted and trees will suffer from the consequences in the future (Sgherzi, 2020).

Thus, arborists that are using these techniques decided to pursue rather short-term treatments and are completely omitting the trees' biology in their works. Therefore, the barrier is represented by the conclusion, which is to have a "healthy" tree in a rather short period rather than growing and caring for a tree from a long-term perspective. This attitude supports the fact that replacing a sick

tree is easier than safeguarding it. An additional barrier connected to the last one can be found in the physical limitation and human conception of life. This conception lies in inability to see beyond our own lives; therefore, it can be difficult to imagine that a tree is a live organism and requires long-term maintenance. In addition, a man rarely exceeds the age of hundred years, while a tree can live thousands of years (Sgherzi, 2020). For humans it is challenging to conceive such a long process of life and therefore, to understand that trees' healing operation is slower and that a negative treatment can influence a plant's life for hundreds if not thousands of years (Sgherzi, 2020).

5.4. Analysis of addition findings

During the conducted research process in order to answer the thesis research question, there were detected additional valuable materials that will be analysed in the following sections.

5.4.1. I-tree Eco

The first additional material that is deemed interesting is a mobile application named "I-tree eco". This application permits, in addition to other functions, the user to note certain information regarding the trees' structure, For instance, height, diameter, crown size, etc. Then, the added information will be saved and available for future access or other colleagues. In addition to the function of these measures' storage, it would be interesting to implement a feature where the users could note information regarding trees' visible symptoms and the availability to attach some photos as evidence. By implementing this feature, there would be achievable a sort of a "tree medical records", where all the discovered symptoms would be stored. The next step would be to create a more social app with a friendly interface that would easily be accessible to all the users or citizens. The basic idea is to allow, other than technical operators, citizens that are interested in some tree's particular formation to search via the app any observed symptoms. Alternatively, it would be also possible to directly search for a tree and explore its growth history. In this way, the users would be able to research information regarding trees in cities and their life history. In case the users notice a defect that has not been reported, they would be able to take a photo and send a notification. Consequently, the report would be analysed by experts that are able to evaluate potential danger. In addition, a database would be available with basic explanations regarding the main trees' defence reaction and which attack or damage could cause it. Thus, it is expected that the citizen would feel more involved and closer to the trees' growth and maintenance. This would be reached

by citizens' understanding of how plants can react to any suffering stressors and finally the user might perceive trees more as "living beings" rather than as inanimate aesthetic objects.

5.4.2. The ARCHI method

The second relevant material discovered during the research, which was considered to be interesting and is integrated into this thesis is a methodology named ARCHI. This method, like the VTA, is based on a plant's visual evaluation and it is projected for the trees' vitality assessment. Despite these similarities, ARCHI takes into account additional principles. Indeed, the aim of this method is the understanding of a tree's vitality and life expectancy by the analysis of its resilience capacity and growing phases. A tree does not have linear growth since during its development it continuously transforms the architecture by adapting it to different environmental conditions. By analysing the development phases, it is possible to trace a "reference sequence" that is distinctive for each tree species. This peculiar sequence is taken as an indication to describe an optimal plant development. Therefore, the trees' reference models would not be generalized, however, they would rather be specific for different species. Therefore, various species would have a distinctive "reference sequence". Furthermore, this growing path is considered as an endogenous part of the plant and thus independent from environmental factors. Thanks to this feature, when some variations are visible, the sequence allows the researcher to comprehend if stressors have occurred during the growth progression or if the trees' conditions are caused by natural life stages, such as aging.

In addition, the ARCHI method is able to evaluate the plants' vulnerability according to two parameters: trees' resistance (ability to withstand extreme climatic factors) and resilience (ability to recover its vital state prior to extreme events). In order to achieve this assessment, ARCHI analyses the emergency branches produced by the plants in stressful situations (similar to the branches described in section 2.4.). In fact, depending on the vigour and the growth direction of these new branches, it would be possible to evaluate whether the tree still has resilient capacity or not and therefore, its probability of survival. Also, this factor depends on the plant species as they have different reaction capacities.

In conclusion, the ARCHI method bases its evaluation on the analysis of specific identification keys that vary between different tree species. This results in the solution, that each tree would have its own reading key and a separate level of evaluation.

For the moment the ARCHI method is still limited as it studied evaluation keys only for six tree species.

6. Discussion

The focal point of this thesis was the refinement of Aalborg Kommune trees' evaluation method.

Through interviews conducted via email, it was achievable to deepen the method, in which trees are assessed in an urban environment. Although it emerged from Kommune's responses that their assessing methodology includes notions of the VTA, some limitations were identified. Hence, the VTA is not applied to its full potential. Indeed, the main issue was that the interviews did not emerge any evaluation model attributable to the plants' symptoms, which is the basic concept of the VTA method. Therefore, the first suggested modification was to introduce a form where it would be possible to note all the visible symptoms that can lead to internal deteriorations. The form allows a detailed trees' vitality evaluation since by identifying the pathogen or the damage cause, the required operation will result as more targeted and effective. Furthermore, no mention regarding the use of an instrumental analysis was found, such as through resistograph or Metriguard stress wave timer. These tools manage to examine a tree's trunk density and therefore obtain a more in-depth stability assessment, without causing serious wounds to the plant.

Additionally, thanks to the collected visual material, it was possible to ascertain that potentially dangerous trees located in sensitive areas are present in the city. The presence of dead broken branches that could fall at any time, suggest that the tree has not been examined for a considerable period of time. However, this could be addressed to the emergency condition due to Covid19 and since the vehicles and inhabitants traffic flow has decreased significantly, the situation might have been considered as less urgent.

On the other hand, incorrect pruning and planting operations were highlighted in the visual material. In fact, in Aalborg city there are noticeable several trees pruned with the "tree topping" technique. Despite the fact that it is considered as a not respectful operation when it comes to plants' biology, it is evident that it was performed. Perhaps the tree topping technique was used due to its ease to carry out or because of the reason that results are visible in a short period of time. Results that, as already discussed, lead the plant to consume its accumulated energies and consequently to a rapid deterioration. In addition, the photos show young trees that have been recently planted already in a condition of decay. It is necessary to note that these plants may have previously been compromised in their origin nursery or during transport. However, in the case of figure 26 in the background are clearly visible road maintenance works. The reconstruction with consequent use of heavy machinery can mean stressors for plants as they can be hit, damaged and by digging process it is likely to risk that the roots could get cut. Therefore, it would have been more appropriate to delay the plantation operation of these young trees in order to avoid disturbances from roadworks. Furthermore, the root ball base is restricted and therefore limits

radical expansion. Figure 27 shows the identical situation of space limitation, in this case possibly aggravated by the build park inclination. Indeed, this young larch is placed at the base of a recently inclined build park and therefore the runoff could accumulate under its roots causing a water stagnation.

By consequence, the combination of base restriction, which for a tree like larch able to grow up to 40 meters height is very limited and the needless water has compromised the plant's vitality.

These oversights can be addressed to the conceptual social barriers considering a tree as an object convenient for its aesthetic factor, but easily replaceable. It would give the impression that during the creation of an urban green area it is not given much attention regarding the trees' needs, by virtue of it can be easily replaced when dead. By omitting the trees' necessities, it is impossible to achieve a healthy urban green, especially if considering that each species has their own needs to grow healthy and vigorous.

Changing of a social conception is a complicated process, however, in order to overcome this barrier, there has been conceived the implementation of an additional feature in an application similar to the I-tree one. The extra element would lead citizens to be more aware regarding trees in their vicinity or city. By managing to actively contribute to plants' protection and by accessing their growth history, the users are able to consider a tree not just like a thing present in their city, but rather like their own living plant. After all, many people become attached to their garden or balcony plants. So, when people will understand that the planting place is not suitable or that the pruning is disrespectful, it is likely that the urban green design plan will be more inclined to change. In addition, an application able to monitor the plant growth sequence matches with the ARCHI method principles. Indeed, by recognizing the trees' "reference sequence" (section 5.4.2.) it is achievable to gather information on probable stress factors that occurred during plants' growth. By consequence, this would lead to obtaining a more elaborate and precise assessment method.

It is necessary to specify that, despite the collected visual material, various trees living in the urban area of Aalborg city present good condition health and adequate spaces, however a room for improvements is always available. Therefore, if the listed above factors are applied, they could lead to a change and reinforcement of the current Aalborg trees' assessment methodology and therefore a healthier urban greenery.

6.1 Reflection

Despite the fact that it has been possible to obtain valuable information from the email interviews, this thesis could have had a different aspect if the quarantine condition had not taken over. Indeed, it would have been feasible to perform face-to-face interviews that would have allowed the author to deepen topics that could not be dug out due to the lack of time while waiting for email responses. These undug topics could vary from for instance, socio-technical barriers specific for Aalborg, the reason why there are no symptoms forms or the lack of an instrumental analysis. Furthermore, it would have been possible to arrange an evaluation together with the park and nature department operators in order to personally verify the vitality and stability assessment carried out in Aalborg.

7. Conclusion

From the information that was obtained from the “park and nature” department email interviews, the current vitality and stability assessment procedure of the Aalborg Kommune is not used to its full potential. In particular, despite the integration of notions of a method such as the VTA that would guarantee an adequate assessment, several limitations were recognized.

In response to this consideration, the following research question was created:

“In which ways, the current tree vitality assessment methodology can be reinforced in order to evaluate plants stability and consequently minimize trees or branches falling risk? “

The answer to the above-mentioned research question was elaborated through the analysis of several factors that could improve the current situation. Therefore, the outcome of this paper and answer to the research question is as follows:

Aalborg Kommune does not integrate in its tree’s evaluation procedure a detailed form where it would be possible to collect and note information concerning exclusively the plants’ visible symptomatology. The trees’ symptoms are a fundamental part for the understanding of pathogens that penetrate the plant. Also, it enables designing of the extent of the internal damage. By perceiving the internal deterioration, one could understand the potential trees' falling risk. In addition, thanks to the detailed form there would be available clearer and more accurate trees' maintenance and care planning.

Furthermore, the combination of additional methods such as instrumental analysis and ARCHI method could highly improve the assessment procedure. Through the instrumental analysis it is achievable to verify in depth the information obtained with the VTA in particular, regarding trees’ trunk density and therefore improve the stability assessment.

On the other hand, the ARCHI method would provide a more specific plants' assessment and maintenance as the trees’ growth would be tracked and noted all along its process. Furthermore, ARCHI bases its vitality evaluation on specific growth factors peculiar for individual tree species.

Moreover, in order to reduce the social barrier according to which trees are perceived as objects and not as living beings, there has been suggested an implementation of the social application. This mobile application would allow citizens to send reports regarding a tree that might present a

dangerous symptomatology. The users would be able to access understandable explanations concerning the meaning of the found symptoms and how they could affect the plant. This would display to citizens the trees' defence mechanisms and that for every suffered damage there could be a reaction. Therefore, the users might perceive trees from a more "humanistic" point of view.

8. References:

1. Aalborg Kommune, (2013). Fysisk 2025 Vision, Hovedstruktur 2013.
2. Aalborg Kommune, (2016). Grøn-blå Struktur 2.0 - en strategi for landskabelige interesser i og omkring Aalborg by.
3. Bethge, K., Mattheck, C., (1995). New methods for the assessment of wood quality in standing trees. In M. Coutts & J. Grace (Eds.), *Wind and Trees* (pp. 227-234). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511600425.014
4. Bohnsack, R., (2008). The Interpretation of Pictures and the Documentary Method. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 9(3), Art. 26, http://nbn-resolving.de/urn:nbn:de:0114-fqs0803267.
5. Bowker, N.,Tuffin, K., (2004). Using the online medium for discursive research about people with disabilities. Social Science Computer Review, 22(2), 228–241.
6. Bryman, A., (2001). Social research methods. Oxford: Oxford University Press.
7. Campanella, B., Toussaint, A., Paul, R., (2009). Mid-term economical consequences of roadside tree topping, Urban Forestry & Urban Greening, Volume 8, Issue 1, https://doi.org/10.1016/j.ufug.2008.11.001.
8. Chiesura, A., (2010). Verso una gestione ecosistemica delle aree verdi urbane e periurbane. Analisi e proposte, Rapporti Ispra 118/2010. Ispra, Roma.
9. Coder, K. D., Blackburne-Maze, P., Cracknell, M., Bentley, R., (1997). Crown pruning effects on roots. In: Proc. 3rd European Arboriculture Congress.
10. Creggb, M., Dixm, E., (2001). Tree moisture stress and insect damage in urban areas in relation to heat island effects.J. of Arboriculture, 27: 8-17.
11. Curasi, C.F., (2001). A critical exploration of face-to-face interviewing vs. computer-mediated interviewing. International Journal of Market Research, 43(4), 361–375.
12. Drénou, C., (2014). I quattro principi del metodo ARCHI. <http://www.architetturadeglialberi.it/wp-content/uploads/2015/05/4principi-del-metodo-ARCHI.pdf>
13. Dublin City Council, (2016). Dublin City Tree Strategy 2016 – 2020.
14. Duryeam, L., Malavasim, M., (2003). How trees grow in the urban environment. http://edis.ifas.ufl.edu/TOPIC_Urban_Landscapes.

15. Emans, B., (1986). Interviewen; theorie, techniek en training. Groningen: Wolters-Noordhoff.

16. England, A.H., Baker, C.J., Saunderson (2000). A dynamic analysis of windthrow of trees. Forestry, 73(3): 225-237.

17. Erb, M., Wessolly, L., (1998). Handbuch der Baumstatik und Baumkontrolle. Patzer Verlag

18. Fini, A., Ferrini, F., (2007). Urban environment effects on physiology and growth of ornamental trees.

19. Foster, R.S., Blaine J., (1978). Urban tree survivor: Trees in the sidewalk. J. of Arboriculture 4:14-17.

20. Geels, F. W., (2005a). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological Forecasting and Social Change.

21. Geels, F. W., (2014). 'Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective', Theory, Culture & Society, 31(5), pp. 21–40. doi: 10.1177/0263276414531627.

22. Geels, F.W., (2005b). "The dynamics of transitions in socio-technical systems: a multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860-1930)". English. In: Technology Analysis and Strategic Management.

23. Gilman, E. F., Lilly, S., (2002). Best Management Practices Tree Pruning. International Society of Arboriculture. Champaign, IL.

24. Gilman, E., (2011). An illustrated guide to pruning: Third edition. Delmar Publishers, Albany, NY.

25. Grabosky J., Bassuk N., Irwin L., Vanes H., (1998). Structural Soil investigations at Cornell University. In: D. Neeley e G.Watson ed., The landscape below ground II, proceedings of Second International Workshop on tree root development in urban soils, Int. Soc. Arboriculture: 203-209.

26. Gruber, F., (2008). Untenable failure criteria for trees: i. The residual wall thickness rule, Arboricultural Journal, 31:1, 5-18, DOI: 10.1080/03071375.2008.9747514

27. Hague, P.N., Hague, N., Morgan,C.A., (2013). Market Research in Practice: How to Get Greater Insight From Your Market.

28. I-tree, (nd), i-Tree Eco: Application overview, viewed 31 May 2020, <https://www.itreetools.org/tools/i-tree-eco/i-tree-eco-overview>

29. Kaiser, C.A., Witt, M.L., Hartman, J. R., McNiel, R.E., Dunwell, W.C., (1986). “Warning: Topping is Hazardous To Your Tree's Health!" In Journal of Arboriculture.

30. Karchmer, R.A., (2001). The journey ahead: Thirteen teachers report how the Internet influences literacy and literacy instruction in their K–12 classrooms. Reading Research Quarterly, 36(4), 442–466.

31. Kemp, R., Rayner, S., in: and Rip, E., L., Malone A., (1998). Technological, Change, in Human Choice and Climate Change. Battelle Press. Columbus, OH.

32. Levinson, P., (1990). Computer conferencing in the context of the evolution of media. In L.M. Harasim (Ed.), Online education: Perspectives on a new environment (pp. 3–14). NY: Praeger.

33. Linnakoski, R., Kasanen, R., Dounavi, A., Forbes, K.M., (2019). Editorial: Forest Health Under Climate Change: Effects on Tree Resilience, and Pest and Pathogen Dynamics.

34. Lokman, M.I., (2006). E-Mail Interviewing in Qualitative Research: A Methodological Discussion. Journal of the American Society for Information Science and Technology. 57. 10.1002/asi.20416.

35. Lonsdale, D., (1999). *Principles of Tree Hazard Assessment and Management*. The Stationery Office.

36. Mattheck C., Breloer H., (1994). FIELD GUIDE FOR VISUAL TREE ASSESSMENT (VTA), Arboricultural Journal, 18:1, 1-23, DOI: 10.1080/03071375.1994.974699

37. Mattheck C., Kubler H., (1997). The Principle of Minimum Lever Arms. In: Wood - The Internal Optimization of Trees. Springer Series in Wood Science. Springer, Berlin, Heidelberg

38. Mattheck C., Tesari I., (2004b). Uniform Stress - A Design Rule for Biological Load Carriers, Optimisation Mechanics in Nature. eds M.W. Collins, D.G. Hunt & M.A. Atherton., WIT Press, Southampton, pp. 15-34.

39. Mattheck, C., (1991). Mechanical Classification of Adaptive Growth. In: Trees. Springer, Berlin, Heidelberg.

40. Mattheck, C., Bethge, K., (1998). The structural optimization of trees. Naturwissenschaften 85:1-10.

41. Mattheck, C., Bethge, K., (2000). Simple mathematical approaches to tree biomechanics. Arboricultural Journal 24(4):307-326.

42. Mattheck, C., Bethge, K., (2005). A critic of the static integrated analysis (SIA) method. *Arboricultural Journal*, *28*(3), 191–199. https://doi.org/10.1080/03071375.2005.9747419

43. Mattheck, C., Breloer, H., (1995). The Body Language Of Trees: A handbook for failure analysis. Department of the Environment. Research for Amenity Trees #4. HMSO, London.

44. Mattheck, C., Kubler, H. (1995). Wood - The Internal Optimization of Trees. Springer Verlag, New York.

45. Mattheck, C., Tesari, I., (2004a). The mechanical self-optimisation of trees, Institute for Materials Research II, Forschungszentrum Karlsruhe GmbH, Germany.

46. Meho, L.I., Tibbo, H.R., (2003). Modeling the information-seeking behavior of social scientists: Ellis's study revisited. Journal of the American Society for Information Science and Technology, 54(6), 570–587.

47. Murray, C.D., Harrison, B., (2004). The meaning and experience of being a stroke survivor: An interpretive phenomenological analysis. Disability and Rehabilitation, 26(13), 808–816.

48. Næss, P., Vogel, N., (2012). Sustainable urban development and the multi-level transition perspective.

49. Park and nature department, (2020). Email interview.

50. Patouillard, C., Forest, J., (2011). The spread of sustainable urban drainage systems for managing urban stormwater: A multi-level perspective analysis. Journal of Innovation Economics.

51. Purcell, L., (2015). Tree Pruning Essentials, Forestry and Natural Resources

52. Rinn, F., Becker, B., Kromer, B., (1990). Density Profiles of Conifers and Deciduous Trees. Report of the Symposium on Tree Rings and Environment of Lund University, Ystad, South Sweden, September 1990.

53. Secretariat of the Convention on Biological Diversity, (2012). Cities and Biodiversity Outlook, A Global Assessment of the Links between Urbanization, Biodiversity, and Ecosystem Services Action and Policy.

54. Sgherzi, R., (2020). Internal document <http://www.urbantree.it>

55. Shigo, A. L., (1984). Tree decay and pruning. Arboricult.l J. 8:1–12.

56. Shigo, A., (1986). A New Tree Biology Dictionary: Terms, topics, and treatments for trees and their problems and proper care. Shigo and Trees Associates.

57. Shigo, A., Harold M., (1977). Compartmentalization of Decay in Trees. US Department of Agriculture, Forest Service.

58. Sport e salute, (2016). Curriculum Dott. For. Rocco Sgherzi, viewed in 26 May 2020, <https://www.sportesalute.eu/images/atrasparente/2016/atrasparente_nov2016/RoccoSgherzi/cv.pdf>

59. Sterken, P,. (2005). A Guide For Tree-stability Analysis.

60. Tzoulas, K., James, P., (2004). Finding links between urban biodiversity and human health and well-being. In: 4th International postgraduate research conference in the built and human environment. University of Salford, Greater Manchester.

61. Urban tree, (2018). Chi siamo, viewed in 26 May 2020, <http://www.urbantree.it/chi-siamo.html>

62. Wengraf, T., (2001). Qualitative research interviewing. London: Sage.