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Principles of Tree Surgery Operations
Unit Code: L/602/3956
UNIT GUIDE 2023-24

LO 1. Understand the principles of tree surgery operation

BS3998 is a British Standard that provides guidelines and recommendations for tree work operations, encompassing tree cutting, felling, and maintenance. Published by BSI, this standard became effective on December 31, 2010 and was developed by Technical Committee B/213, Trees and Tree Work.

Analysing the Condition and Durability of Trees
According to BS 3998, it is crucial to assess the durability and condition of trees before taking any action. This involves examining the overall state of the tree, identifying any defects, and estimating the extent of its deterioration. Through a thorough evaluation of the tree, we can safeguard its well-being and determine whether it necessitates pruning, removal, or any other form of maintenance. These standards serve as a reference for ensuring the safety of individuals and property, establishing criteria for decision-making regarding tree work, protecting wildlife and habitats, and preserving veteran trees.

Any user who asserts compliance with this British Standard is required to substantiate any deviations from its guidelines.

<u>The importance of tree work</u>:

Trees, being living organisms, undergo continuous changes and rely on various processes to maintain their health and structure. They produce new shoots, roots, bark, and wood each year to sustain themselves. However, trees are also vulnerable to various hazards, like any other living organism. By conducting proper tree work, the risk of failure can be significantly reduced in certain situations.

<u>Extreme weather conditions</u>, such as extremely high or low temperatures, can cause harm to a tree's structure. Trees that are top-heavy, poorly shaped, have existing structural faults, are unhealthy or dying, or have been affected by construction activities are more prone to breaking or failing under added stress from severe weather. To mitigate this risk, techniques like pollarding, crown thinning, cable bracing, weight reduction, and crown reduction are employed. Pruning plays a crucial role in reducing the likelihood of failure.
Regular tree inspections are essential, particularly if any unusual symptoms are observed, such as early leaf drop, foliage discoloration, fungal fruiting bodies, or bleeding from stems. These indicators can be recognised by professionals during inspections. When a tree is in an area frequented by people or near valuable structures that could be damaged, there is a potential risk of structural failure, leading to falling branches, limbs, or even complete tree failure, which can have disastrous consequences. However, early diagnosis can prompt necessary actions to improve the tree's health or prevent the spread of invasive problems.

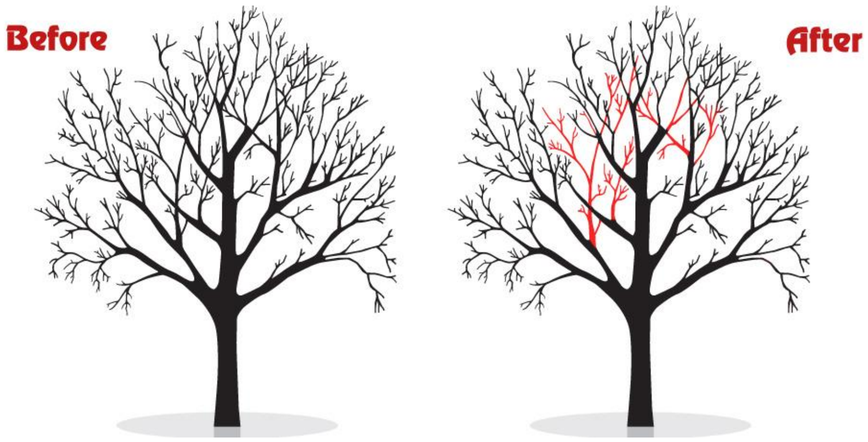
<u>Conflicts with individuals</u>
Typical grievances involve the shedding of leaves, the potential risk of falling, bird droppings, and insufficient sunlight. Conflicts arise due to the increasing scarcity of land for construction, resulting in residences being squeezed into smaller areas where people and trees must coexist in close proximity.
To manage trees in limited spaces and prevent the destruction of valuable trees in urban environments, various methods can be employed, such as crown reduction, crown lifting, crown thinning, and pollarding. Pruning is often utilised to resolve conflicts between tree owners and disgruntled neighbours.

<u>Construction</u>
Ironically, construction poses one of the greatest threats to trees, even though existing trees are highly valued in this context.
Despite being subject to planning regulations and receiving explicit instructions on how to handle trees when they intersect with construction, many developers show insensitivity towards tree preservation and care.
Plants face risks such as severe root cutting, root compaction from dense vegetation, and contaminated soil due to construction activities. The effects of these risks may not become apparent for years, often resulting in partial dieback on one side of the crown before complete dieback occurs, which is frequently associated with utility

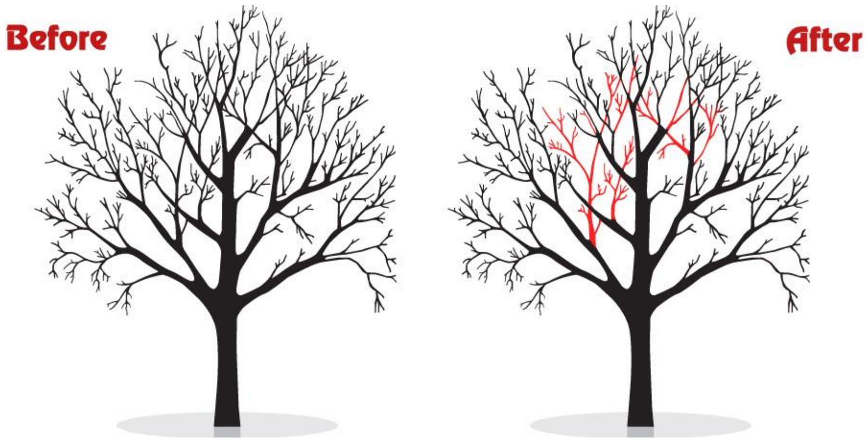
trenches, footings, or new roads. Several strategies can be implemented to prevent such harm, including root pruning, fencing off root protection zones, and, most importantly, training and educating site managers.

<u>1.1. Define the following terms</u>:
• crown lifting
• crown thinning
• crown reduction and re-shaping
• formative pruning
• pollarding

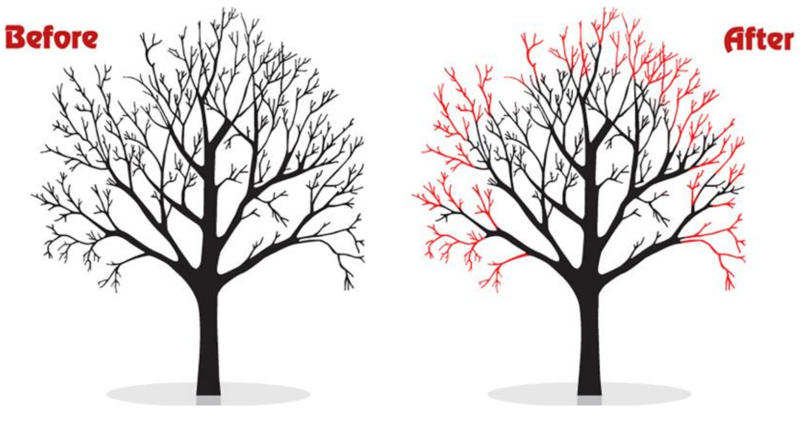
BS3998 3.12 defines crown lifting as "**crown lifting -** removal of lower branches to achieve a stated vertical clearance above ground level or other surface".



BS3998 3.14 defines "**crown thinning** as removal of a proportion of small, live branches from throughout the crown to achieve an even density of foliage around a well-spaced and balanced branch structure."

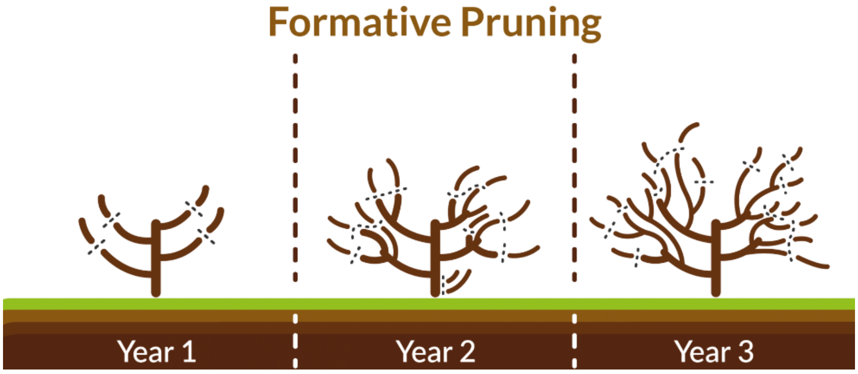


BS3998 3.13 defines "**crown reduction** as operation that results in an overall reduction in the height and/or spread of the crown of a tree by means of a general shortening of twigs and/or branches, whilst retaining the main framework of the crown".



BS3998 7.4 defined as pruning young trees to change their shape at maturity, either to avoid future structural faults (such as singling a twin-stem) or to achieve a desirable cultivated tree form. The phrase is reserved for young trees because any trimming can be considered to modify form.

The term "**formative pruning**" can encompass various specialised practices such as utility pruning, pollarding, cutting overgrown hedges, pleaching, which can resemble a hedge on stilts, and more formal types of pruning like cloud pruning.



A "**pollard tree**" is defined by BS3998 3.20 as a tree that has developed a crown with several branches that start at the same level on the main stem or major branches.

BS3998 3.21 defines **pollarding** involves the deliberate pruning of a tree to stimulate the growth of multiple branches that emerge from the same level on the main stem or primary branches. It is important to note that this technique is typically applied to young trees before they reach full maturity. By periodically cutting the tree in a specific manner, its desired shape and form can be preserved over time. It is crucial to distinguish pollarding from topping (3.28), as they are not the same. The collective term for the branches resulting from pollarding, as well as the overall structure of a pollard tree, is referred to as the Bolling.

<u>1.2. Describe tree pruning operations as per BS 3998</u>

1. It is essential to carefully examine the stability and health of trees before engaging in any activities, as emphasised in BS 3998. This involves evaluating the overall health of the tree, identifying any defects, and determining the extent of decay. By conducting a thorough assessment, we can maintain the tree's well-being and determine whether pruning, removal, or other interventions are necessary.
2. Prior to commencing any tasks, it is imperative to assess the stability and health of trees, as highlighted in BS3998. This includes evaluating the tree's general health, identifying any weaknesses, and determining the level of deterioration. Through proper assessment, we can preserve the tree's health and determine if pruning, cutting down, or other actions are required.

Pruning Objectives are:

- Reduce potential for tree or branch failure
- Clearance
- Reducing wind resistance
- Maintain tree health
- Influence fruiting or flowering
- Improve a view
- Improve aesthetics

There are two primary categories of pruning: <u>formative pruning</u>, which focuses on shaping young trees into a desired form, and <u>remedial and restorative pruning</u>, which involves managing or altering the existing crown structure, especially in older trees.
The most common performed tree work operations involve different types of pruning, such as crown reduction, thinning, or lifting. These pruning techniques are widely practiced because they can help achieve a variety of goals and objectives. These objectives are related to the tree's structural integrity, the safety of individuals and property, accessibility, obstruction, light, and aesthetic value.

Determining the Suitable Pruning Method
Table B.1 illustrates several pruning alternatives, along with references to the corresponding subclauses in this British Standard. It also provides suggestions on the suitability of each option for achieving various management objectives. The ratings displayed in the table solely indicate the capability of each pruning method to fulfil the management objectives. However, the chosen option and the extent to which it is implemented should be carefully weighed against other factors, including the tree's health, lifespan, and aesthetic value.

Table B.1 **Management objectives and commonly applied pruning options**

Management objectives		Pruning options and related subclauses/annexes									
		Pruning of selected branches or stems				General pruning of the tree					Habitat enhancement/ maintenance (Annex C)
		Reducing leverage (7.3.2/7.8/C.2)	Removing individual dead, defective or diseased parts (7.3.2/7.5/7.8)	Removing/shortening obstructive branches A) (7.4/7.6/7.8/7.9)	Formative pruning (7.4)	Crown thinning (7.5)	Crown lifting (7.4/7.6)	Cyclic cutting of established trees (7.5/7.7/7.9 to 7.11/12.3.2)	Crown reduction/ reshaping/pollarding (7.7/7.9/7.10/C.1/C.4.1)	Phased retrenchment) pruning of lapsed pollards/orchard trees (7.7/C.1/C.2)	
To maintain health or longevity by means of:	good structural integrity	***	***	—	**	X	X	***	***	***	X
	disease or pest control	—	**	—	—	**	**	**	—	—	—
To protect people or property from:	tree failure	***	***	—	***	**	X	***	***	**	X
	storm-damaged branches	*	***	—	—	X	X	X	**	X	—
	subsidence of land	—	—	—	**	X	X	***	***	X	—
To prevent interference between trees and infrastructure, in particular:	roads, paths, railways, waterways and signage	—	—	***	***	X	***	***	**	X	—
	aircraft flight paths	—	—	—	***	—	—	***	***	—	—
	overhead cables and supporting structures	—	—	***	***	X	***	***	**	X	—
	aerials and signals B)	—	—	***	***	**	**	***	***	X	—
	buildings	—	—	***	***	X	**	***	*		—
To conserve:	deadwood habitats C)	*	*	—	*	—	—	**	**	***	**
	other habitats	—	*	—	*	**	**	**	*	**	—
To manage:	light and shade	—	—	***	***	***	***	***	***	—	—
	visual amenity	—	—	**	***	**	**	**	*	—	*
To produce:	fruit	—	*	*	***	**	*	**	***	*	—
	wood or other products	*	*	*	***	X	***	**	*	X	X

Key

***	Often appropriate	X	Inappropriate
**	Occasionally appropriate	—	Not applicable
*	Done mainly for other reasons but of indirect value		

A) Including branches that are shedding unwanted fruit or foliage, etc.
B) There is no legal right to a telecommunications signal over a third party's land.
C) The objective of conserving deadwood habitats can apply at any site. It is particularly relevant at sites where such habitats have existed continuously by virtue of the presence of ancient veteran trees (see *Ancient and other veteran trees: Further guidance on management* [36], which is in preparation at the time of publication of this British Standard).

The primary goal of formative pruning is to cultivate a tree that, upon reaching maturity, will be devoid of any significant structural weaknesses and will align with the management objectives of the location. The concept of "formative pruning" can encompass various specialized techniques, such as utility pruning, pollarding, trimming overgrown hedges, pleaching, which can resemble a hedge on stilts, and more formal methods like cloud pruning. If formative pruning has been initiated in the nursery to influence the structure, shape, or size of the tree crown, any pruning immediately after planting should be minimal to maintain sufficient leaf area. Typically, formative pruning should be resumed three to five years later. However, if the tree has developed an inappropriate branch structure, some branches may need to be shortened or removed earlier during the establishment phase. It is advisable to avoid removing all lower branches, if possible, as this could hinder the development of a strong taper in the stem. When removing or shortening branches to address unwanted growth patterns, it should be done gradually to avoid excessive leaf cover removal at once. Ideally, branches to be removed should not exceed 20 mm in diameter at the point of attachment to the stem. Additionally, at least two-thirds of the tree's height should always be comprised of live crown. In areas with high foot traffic or formal plantings, weak unions in young trees should be managed to allow only one dominant stem or branch to grow from such unions. If the complete removal of an unwanted co-dominant stem or branch would result in a large wound, it is better to shorten it to reduce its dominance.
Failure to properly manage co-dominant leading shoots can result in the development of compression fork weakness, potentially leading to the need for premature tree removal to protect individuals and property. If two branches are crossing and at risk of rubbing against each other, it is advisable to remove or trim one of them to prevent further contact and potential damage. This can help avoid issues such as frictional damage, altered growth patterns, and ultimately loss of strength or even branch fracture. In cases were cutting one branch leaves the other weakened or exposed, it may also be necessary to remove the remaining branch to prevent any safety hazards.

Pruning time

The determination of the optimal pruning season is based on the objective of minimising physiological stress and promoting natural wound reactions and/or the regrowth of trees. It is important to avoid pruning during certain periods. These periods include the post-dormancy (spring) period, which is the time between bud breaking and full development of leaves, as well as the pre-dormancy (autumn) period, which is when leaves start to change colour until they are shed or fully dysfunctional. Pruning should also be avoided during long periods of drought. Additionally, tree species with high sap flow should not be pruned during the dormant period. The optimal pruning season is also influenced by the specific pruning operation being performed.

TABLE 2: Optimal pruning seasons for major pruning operations.

Structural pruning	Pruning during the growing season is preferred.
Lateral crown reduction	
Upper crown reduction	Optimal season cannot be specified as this depends on local habits in relation to specific conditions (see national appendices).
Shaping	Pruning is generally done during the dormant period. Trimming can be done during the growing season.
Restorative pruning	Pruning during the growing season is preferred.
Always avoid pruning during long periods of drought.	

European Tree Pruning Standard

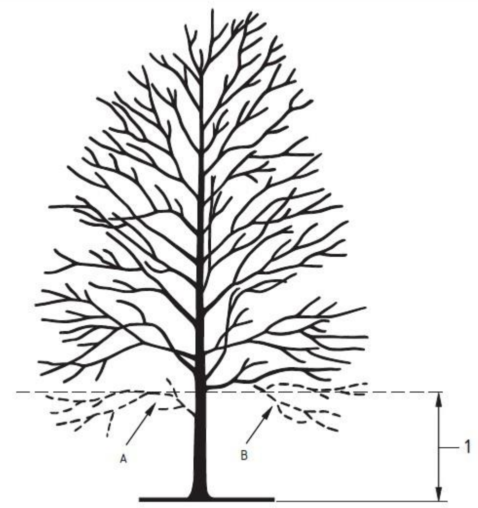
Different tree species and climate conditions may require different recommendations for the optimal pruning season. Factors such as periods of drought or frost can influence the timing of pruning. It is important to consider these variations when determining the best time to prune trees. Additionally, it is worth noting that certain countries may have legislative restrictions in place regarding tree pruning.

The frequency of pruning should be thoughtfully planned, considering the tree's physiological stress and the potential impact on important micro-habitats and associated organisms. The recommended pruning intervals are as follows:
- For young trees: prune regularly with minor interventions every 2-3 years,
- For semi-mature trees: extend the interval allowing the tree to grow more naturally,
- For mature trees: only prune when absolutely necessary,
- For veteran trees: only prune when absolutely necessary.

When conducting any pruning activity, it is important to consider the potential effects on biodiversity. It may be necessary to adjust the timing, method, or extent of foliage removal to preserve or enhance biodiversity.

<u>Crown Lifting or Crown Raising</u>

Figure 3 Crown lifting



Key
1 Clearance to be specified by the removal of either main branches (A) or secondary branches (B)

Please ensure that the points at which the clearance will be measured are clearly stated when specifying crown lifting. For instance, this could be from the ground or roof level to the point where the lowest remaining branch or foliage originates.

Crown lifting involves the removal of lower branches or the preparation of lower branches for future removal. It is crucial to avoid directly removing large branches from the trunk to prevent decay and instability. When dealing with older trees, crown lifting should be limited to secondary branches or shortening primary branches. This method effectively increases light transmission and access under the tree, but should not exceed 15% of the live crown height and leave at least two-thirds of the total tree height. Specify crown lifting with reference to a fixed point for accuracy. It is advisable to conduct extensive crown lifting gradually over several years to allow for physiological and biomechanical adaptation to the resulting wounds and branch removal. However, for mature or old trees, it is best to avoid or minimize crown lifting as it can heighten the risk of stem failure. If crown lifting is necessary, it is preferable to remove secondary branches or shorten branches rather than removing them all the way back to the stem, if the desired clearance can still be achieved. When making these decisions, factors such as the tree's size, growth potential, branching habit, and shade tolerance should be considered.

For instance, let us consider a tree that is 20 meters tall. If the lower part of the tree, up to a height of 5 meters, does not have any branches, then 15% of the remaining live crown height (15 meters) would be equal to 2.25 meters. Based solely on this information, the tree could be pruned to have a crown lift up to a height of 5 meters + 2.25 meters = 7.25 meters. However, the maximum allowable crown lift is limited to one-third of the tree's total height, which in this case would be 6.7 meters.

There may also be pragmatic justifications for crown raising. To increase visibility for both cars and pedestrians, trees that are close to roads or walkways may require a crown lift. There is more open room to view any possible dangers when the crown is raised.

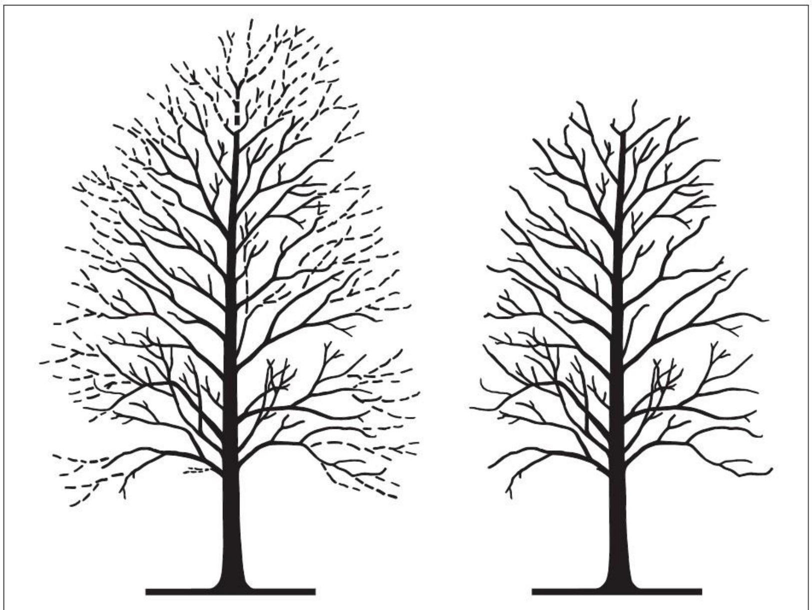
Crown thinning

Before After

In the process of crown thinning, it is essential to maintain an even density of foliage throughout a well-spaced and balanced branch structure. This structure can potentially serve as a suitable framework for any future crown reduction, if necessary. When the goal is to reduce the overall load on a defective branch or stem, it is advisable to opt for crown reduction and reshaping over crown thinning. Crown thinning is not the most appropriate method for reducing the overall loading on a defective branch or stem, as it does not decrease leverage and may even increase the risk of branch failure. It is often not a one-time procedure, and repeat pruning may be required, especially for species that tend to produce numerous epicormic shoots. The amount of leaf-bearing twig structure removed during crown thinning should be minimised to achieve the desired outcome and should not exceed 30%. This percentage should be clearly specified in the work description. Material should be systematically removed from various parts of the tree rather than solely from the inner crown. While cutting branches back to the main stem should generally be avoided, structurally weak or hazardous branches must be eliminated if there are no other options available. Uneven thinning or excessive thinning can increase the risk of branch failure by creating gaps in the crown or by removing shoots and secondary branches from the lower parts of a branch, leaving only twigs and foliage at the tip (also known as lion-tailing).

Crown Reduction

Figure 4 **Diagrammatic illustration of crown reduction**



a) Before crown reduction, showing material to be removed b) After crown reduction

Crown reduction involves decreasing the height and/or spread of a tree's crown to alleviate mechanical stress, improve its adaptation to the environment, or mitigate shading and light loss. The goal is to maintain the main structure of the crown while achieving a smaller outline, without necessarily aiming for perfect symmetry. It is important to keep reduction cuts minimal, ideally not exceeding 100mm in diameter unless absolutely necessary. Measurements should be precise and reflect the desired outcome, such as 'reduce crown height by 2.0m and lateral spread by 1.0m, all around, resulting in a final crown size of 18m in height by 11m in spread (measurements approximate)'. Not all tree species are suitable for crown reduction, and it should not be mistaken for the harmful practice of 'topping'.

The specification must be precise and unambiguous to achieve the desired outcome. To avoid any confusion, the desired end result can be expressed either as the height and spread of the tree that should be maintained, or as the average branch length (in meters). If the growth pattern of the tree necessitates it or if clearance from a specific object is required (refer to section 7.8), the end results should be specified for individual branches.

Please note that specifying a percentage reduction without referencing length, height, spread, etc., is vague and inadequate. For example, a 30% reduction in crown volume can be approximately equivalent to a 12% reduction in overall branch length (i.e., radial distance).

Specifications that indicate what will remain are typically used for verification purposes, but they can also be translated into what needs to be removed (such as the length of a branch) to facilitate implementation.

If it would be helpful in describing the desired result, annotated photographs should be provided. When specifying crown reduction and/or reshaping to create clearance from another structure or tree (refer to sections 7.8 and 7.9), please state the points between which the clearance will be measured.

Following crown reduction or reshaping, there are several objectives to consider for managing the crown. One option is to continue with further crown reduction in a phased approach. Another approach is to maintain the reduced crown as a framework for cyclic management, similar to pollarding. Lastly, a new framework can be established through "shoot renewal pruning" to achieve a natural appearance while keeping the crown smaller than before. To achieve this, new branches should be tip-pruned and thinned to encourage the growth of secondary branches, which should be pruned and thinned as needed to maintain the desired shape, size, and density of the crown. The timing of pruning new branches should be based on factors such as the tree species, the rate of shoot production, and site-specific objectives to prevent biomechanical failure of weakly attached branches.

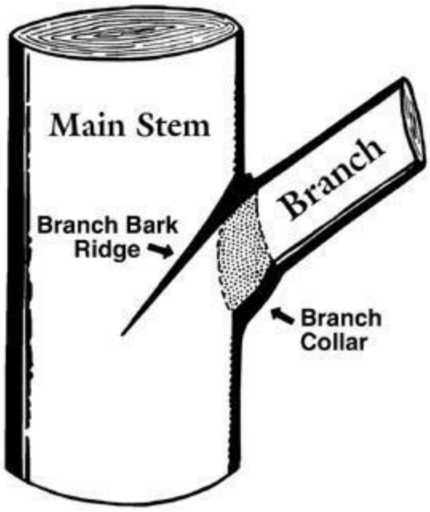
<u>Selective Pruning</u>

If there is a clear need, branches should be either individually removed or shortened. However, it is important to note that symmetry, for its own sake, and other options for clearance from infrastructure should be considered as well. In cases where such work is necessary, the amount of material to be removed and the diameter(s) of the

pruning cut(s) should be kept to a minimum, only removing what is necessary for the intended purpose. If selective pruning is found to negatively impact the overall stability of the tree, additional pruning should be carried out to address this issue.
It is worth noting that specific objectives may include the removal or shortening of branches on one side of the crown that are obstructing buildings, landscape features, or other structures. Additionally, branches that are likely to fail should also be considered for removal or shortening.
If individual branches need to be shortened or removed to increase horizontal or vertical clearance from another feature, the work specification should clearly state the feature and the desired clearance that needs to be achieved.

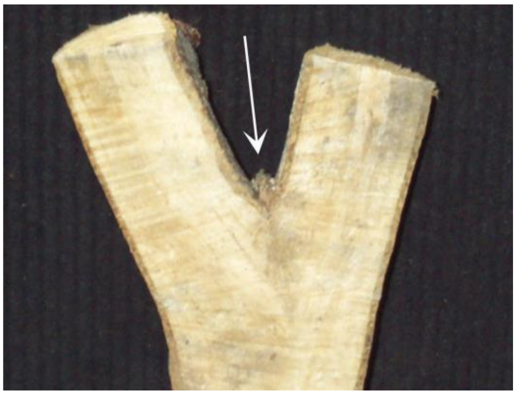
<u>Target Pruning</u>

Alex Shigo's definition and description of natural target pruning presents a significant departure from the traditional approach employed by arborists for removing branches from hardwood and coniferous trees since the introduction of the chain saw. The goal of natural target pruning is to retain the branch collar on the main stem or tree trunk while eliminating the rest of the branch. Arborists refer to precise pruning cuts as natural target cuts, utilizing the branch collar and branch bark ridge as guides for making the cut on the tree.

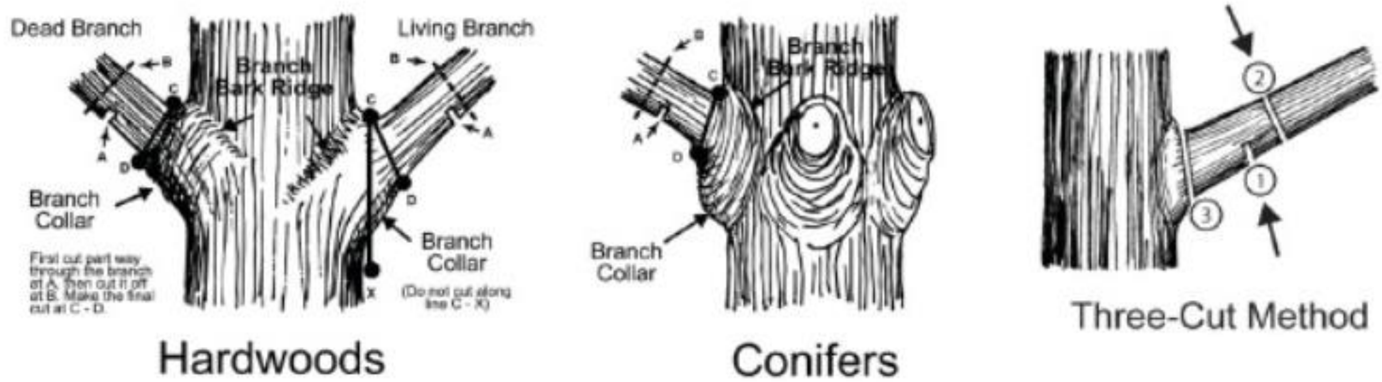


Each branch possesses internal tissues that serve to distinguish it from the trunk. These tissues play a crucial role in the healing of wounds and defence mechanisms; therefore, they require protection and careful maintenance during pruning activities. As these internal tissues develop, the bark is pushed upwards to create a raised ridge on the trunk, effectively separating the branch from the main trunk. This raised ridge is known as the branch bark ridge.

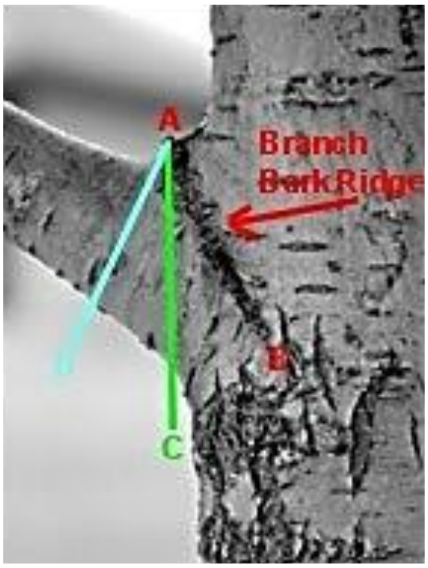
The branch bark ridge is a region of surplus bark that gathers at the junction of two branches. It stretches along the branch or trunk on both sides of the branch crotch.



The branch bark ridge and branch collar on the tree remain intact without any stub when a precise cut is made. The cut is positioned slightly beyond the branch bark ridge at the top and typically slopes outward and downward, resulting in a raised area but no leftover stub (as shown in the diagram). The cut is executed on the outer side of the branch collar.



It is crucial to avoid harming, cutting, or compromising the branch collar in any manner. While identifying the "targets" on most broadleaved trees is usually straightforward, certain trees such as sycamores consistently shed bark and lack a branch bark ridge. Conifers may also lack a typical branch bark ridge. In such instances, always make cuts beyond any swollen or wrinkled branch collar.
The branch collar can be easily identified on various tree species. While some trees may pose a challenge in locating the branch collar and the target cut, Dr. Alex Shigo has developed a general rule of thumb to assist in such cases. Locate the top of the branch bark ridge (A) and make the cut at the same level as the top of the branch bark ridge. Imagine a vertical line extending from the top of the branch bark ridge straight down to the ground (line A-C). Next, determine the angle between this vertical line and the bottom of the branch bark ridge (angle C-B). Mirror this angle on the opposite side of the vertical line (angle C-D) and make the natural target cut along the line of this reversed angle (line A-D).



Proper pruning involves the careful removal of branches without causing harm to the branch collar. It is crucial to avoid making cuts that begin behind the branch bark ridge. When cutting dead branches, it is important to avoid damaging the callus tissue that has developed at the base. Cut the branch beyond the callus ridge to prevent any harm to living material. Three key factors contribute to achieving a proper pruning cut:
1. Retaining the Branch Bark Ridge.
2. Keeping the Branch Collar intact.
3. Ensuring the final cut line is properly aligned.
There is no universal pruning angle that applies to all trees, only specific targets - the branch bark ridge and branch collar. By using these targets as guides, the correct final cut can be achieved consistently.

Pruning for Infrastructure / Utility pruning

In areas where there are overhead electric conductors, it may be necessary to perform crown reduction, reshaping, and/or directional pruning on trees. This is done to prevent any interference with the electrical equipment or to eliminate unauthorized access to electrical hazards. It is important to comply with Clause 4 and Engineering Recommendation G55/2. Additionally, it is crucial to be aware of the Electricity Act 1989, which requires notifying the electricity company or license holder before conducting any tree work near overhead power cables. License holders are also obligated to follow proper arboricultural practices when cutting or felling trees (including their roots). For guidance on working near overhead power cables, refer to HSE Guidance Note GS6. When the goal is to reduce or eliminate branches that are growing towards fixed apparatus or structures, directional pruning should be applied. Directional pruning removes branches growing toward the power lines while leaving those that are growing away. It is the most appropriate pruning method for utility line clearance.
This method allows for the retention of other branches while promoting new growth in the desired direction. Utility pruning should adhere to the recommendations outlined in sections BS 3998 7.1 to 7.8, paying special attention to branch stubs that may produce new shoots that could potentially interfere with overhead lines.

Thoroughfares and watercourses

Pruning along main roads (such as sidewalks, bridle paths, highways, and railways) and waterways should adhere to the guidelines outlined in sections 7.1 to 7.8. Regular pruning must be conducted as needed to prevent any hindrance to the passage of vehicles and pedestrians, as well as to maintain visibility. This may involve the periodic removal of lower shoots and/or epicormic growth. In cases where mechanised cutting equipment is used instead of pruning individual branches, caution must be taken to minimise any negative impact on the trees and to prevent hazards. This includes avoiding leaving partially torn branches or causing damage to stems, which could lead to extensive decay.

Pruning of overgrown hedges

It is important to conduct the pruning of overgrown hedges in a manner that minimises disfigurement and prevents dieback while also promoting the growth of new foliage. The final pruning cuts should be made following the guidelines stated in Section 7.2.5. The timing of this pruning work, as well as its potential impact on habitat and wildlife, should be assessed in accordance with Clause 5. It should be noted that excessive pruning can have negative effects on certain species of hedging plants, particularly conifers. For routine maintenance of hedges, BS 7370-4 provides recommendations.

Climbing Plants

The management of plants climbing on or over trees should not be a regular part of crown maintenance. However, they can be removed or trimmed, if necessary, under certain circumstances. These circumstances include:
a) When the plant obstructs the visual inspection of a tree, that may pose a risk to people or property due to weak or decaying structures and site usage.
b) When the plant grows high into the crown of a tree, it increases its resistance to wind.
c) When the plant significantly weighs down a branch or a leaning tree.
d) When the tree is at risk of being smothered, especially by Clematis, Russian vine, or ivy, particularly if the tree is old and unlikely to outgrow the climbing plant.
e) When keeping the plant is incompatible with the management objectives in formal settings.
f) When there is a potential for the dead stems of the plant to become a hazard.
Any control measures for climbing plants should be carried out with caution to avoid causing excessive damage to the tree or the wildlife that may use the habitat. If control is necessary, the plant should be removed or selected stems should be periodically cut to cause them to die back. In cases where preventing regrowth is desired, chemical treatment may be appropriate.
For specific guidance on managing ivy, the most common climbing plant found on mature trees in Britain, refer to APN 10. Additional guidance on the management of ancient and veteran trees will be available in the future publication of "Ancient and other veteran trees: Further guidance on management" at the time of this British Standard's publication.

Removal of inappropriate objects

While conducting arboricultural work, it is advisable to eliminate any objects that may pose a threat to the tree or are visually unappealing. This includes wires, clamps, boards, or old cable ties. However, it is crucial to ensure that their removal does not cause further harm to the tree.

Pollarding

Cases of pollarding that keep trees at a constant height. Every year, new shoots are cut down to the pollard head at the same location. In the image on the left, the trees are 140 years old.

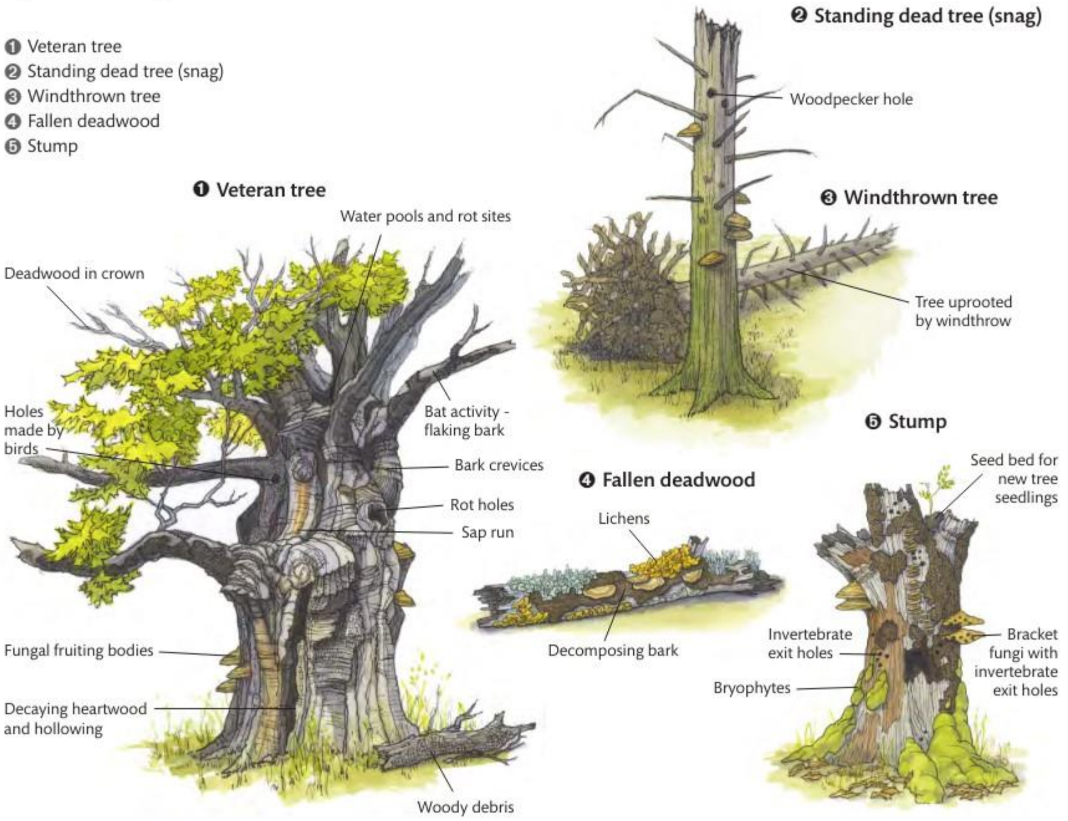
Pollarding - Single 'Knuckle'	Pollarding Multiple 'Knuckles'
	

Pollarding is a practice that serves multiple purposes, such as controlling the growth of trees and shrubs, reducing shade, and ensuring street trees do not interfere with infrastructure. To effectively carry out pollarding, it is recommended to start the process soon after the tree has matured and when it reaches a diameter of 25 mm to 50 mm at the desired height for pollarding (usually between 2 m and 3 m). The initial cut should be made at a height that considers the site's purpose while still maintaining some foliage. This is crucial for the tree's health and to prevent dieback or death. If the tree has multiple stems branching out below 3 m, each should be pruned individually to create a "candelabra" shape. Even if the stem exceeds 50 mm but is below 200 mm at 2 m to 3 m, pollarding can still be done. Larger trees, however, are not recommended for this method. Once pollarded, the tree needs regular maintenance by cutting new branches periodically. The frequency of this maintenance should be based on management goals, species, age, condition, and desired outcomes. It is important to selectively cut branches to prevent decay and promote healthy growth after each cycle. If the pollard cycle has been neglected for an extended period, it is necessary to minimize the crown to achieve current objectives. These objectives primarily involve relieving mechanical stress that may cause the stem to split. However, it is not recommended to cut back an old pollard branch to the knuckle, even if it is under significant stress. This is because removing all attached foliage in such a manner can potentially led to physiological problems and decay. Instead, it is advised to shorten the branch by cutting just above a suitable lateral branch. If that is not possible, leaving a live stub from which new shoots can emerge is a preferable alternative. In cases where crown reduction alone is insufficient to protect branches at risk of failure, they can be reduced to stubs in a single operation, known as a "pole thin." Meanwhile, the remaining branches should be trimmed to maintain enough leaf-bearing twig structure to support the tree. By keeping live stubs on pollards that have not been regularly maintained, the likelihood of severe issues like decay and weakness forming below the knuckles can be reduced. Trimming below the knuckles should only be considered in rare situations, such as when avoiding complete failure is necessary.

1.3. Distinguish when deadwood removal is appropriate and inappropriate

BS3998 7.3 Risk management of deadwood
Risk management of deadwood should consider the balance between risk reduction and wildlife habitat preservation. It is important to carefully consider whether dead branches or trees should be kept and how much pruning is necessary without needlessly destroying habitats, especially if protected species are involved. Factors such as the size of the deadwood, its placement, and the characteristics of the wood and species should be considered. Laws protect certain plant and animal species, so consulting with the appropriate nature protection organisation is essential before any work begins, especially if bats, birds, or other protected species are present. The Bat Conservation Trust and the Royal Society for the Protection of Birds are valuable sources of information, and Arboricultural Association Guidance Note 10 provides further guidance.

Figure 2 Different types of deadwood found in forests and woodlands.



Decomposing and deceased trees play a crucial role in maintaining a healthy forest ecosystem by facilitating energy flows, including hydrological processes in streams and rivers, promoting biodiversity, and enhancing soil fertility. Deadwood is indispensable for the overall well-being of forests and, by extension, humans. It is vital for the nutrient recycling process. In a natural environment like a forest, where plants like trees are allowed to grow and decompose, the decaying dead wood releases nitrogen into the soil, benefiting other plants. Dead or dying wood also provides essential habitats and food sources for various plant and animal species. Many of these species, which are rare or endangered due to their limited ability to colonise new areas, are often found in remnants of historic parklands, wood pastures, aspen, and boreal pine woods where deadwood has been preserved over centuries through careful management.

Figure 3a The larvae of cardinal beetles feed on deadwood.

Figure 3b Bryophytes growing on a log.

https://www.britishbryologicalsociety.org.uk/learning/about-bryophytes/

Deadwood plays a crucial role in storing carbon by locking in the carbon absorbed by trees throughout their lifespan. This prevents the release of carbon into the atmosphere, thus helping to combat artificial global warming.
Deadwood removal is necessary in specific situations:

1. Falling Branches: Deadwood is prone to breaking and falling during storms, strong winds, or snowfall, posing a threat to nearby buildings, vehicles, and other trees.
2. Property Damage: Falling deadwood can cause significant damage to fences, vehicles, roofs, and other property components, leading to costly repairs.
3. Safety Concerns: Deadwood falling on humans or animals can result in serious injuries or even fatalities. Therefore, prioritising safety when dealing with deadwood is essential.

If dead branches present an unacceptable risk to individuals or property and alternative solutions are not viable, it is recommended to either trim or remove them as needed. The speed at which wood decomposes must be considered when assessing the level of danger, particularly around the bases of the branches. When trimming dead branches becomes necessary, it should be done to prevent harm to the sapwood or living bark, which could lead to further issues and potential colonisation by pathogens or decay fungi. While there are situations where removing branches affected by disease or pests may be necessary for hygiene purposes, it is generally not advisable to remove dead branches solely to eliminate a source of infection (referred to as "sanitation pruning") unless directed by a professional. Conversely, the sanitary pruning of live branches is a recognised method for managing various diseases, such as cankers caused by Nectria spp.
When it is deemed safe, it is advisable to leave dying or already dead trees standing. Whenever possible, efforts should be made to ensure their safety without resorting to cutting down the main stem. Fallen deadwood should ideally be left undisturbed, unless it obstructs access. If it needs to be moved, it should be stacked securely in damp, shaded areas. In areas where wind-blown trees have uprooted and exposed the soil, they provide valuable habitat. Ideally, branch wood resulting from felling operations should be left in piles that can be gradually reduced through further chopping. If fallen deadwood does not interfere with other land-use activities, it should be left under hedgerows and in-field trees. However, an excessive amount of dead wood can negatively impact conservation efforts, such as by hindering access, increasing the risk of forest fires, and altering the characteristics of the woodland. Insufficient dead wood can also lead to a reduction in biodiversity, particularly among lower plants, fungi, and invertebrates, which can ultimately affect bird and mammal populations. The recommended minimum requirement for all other sites is to have 5–10% dead wood or notable decaying wood features, or 20 m3 per hectare, based on the average stand volume.

<u>1.4. Describe the treatment of cavities and water pockets</u>

A tree cavity, also referred to as a tree hole, forms because of tree injury. Trees can sustain injuries due to various reasons, including improper pruning techniques, tree topping practices, and mechanical damage caused by equipment or vehicles. Improper pruning cuts can leave open wounds that attract pests and diseases, posing a threat to the tree's health. Tree topping, which involves cutting off the top of the tree, places stress on the tree and leads to the growth of weak branches when the tree tries to produce leaves for photosynthesis. Additionally, mechanical injuries can occur when trimmers, lawnmowers, cars, or other vehicles damage or tear off sections of the tree's bark. Furthermore, animals such as woodpeckers, deer, and carpenter ants can also cause damage to trees by drilling holes, rubbing antlers on tree bark, or burrowing into the tree.

Woodpecker holes

Additional incidents of tree damage involve individuals purposefully cutting into tree bark, unintentional or intentional peeling off of bark, and various scenarios where trees endure wounds, cuts, or bark loss. The final two primary factors contributing to tree damage, which often lead to the formation of cavities, are storms and severe weather conditions.

Lightning can cause harm to a tree, tearing off its bark and leaving an internal wound.

Powerful winds have the potential to break branches and remove bark.

When temperatures drop quickly, trees can split (a phenomenon known as frost cracking).

BS3998 9 Management of decay – cavities and water pockets

In situations where a tree's physical weakness is caused by decay or the formation of a cavity, and this poses a significant risk to people, property, or the tree itself, appropriate actions must be taken to reduce the risk to a manageable level. In such cases, there are several management options available. These include relocating or modifying the target, performing tree work such as pruning or providing artificial support, and, if necessary, cutting down the tree if all other options are not feasible or suitable.

Furthermore, if it is determined that achieving this goal is possible and will greatly improve the tree's structural integrity, cavity treatments can be implemented to slow down the rate of further decay. In situations where it is necessary to prevent human access to a cavity, artificial closure or filling can be used.

It is important to note that filling voids is generally not considered to enhance the structural integrity of the surrounding wood. In fact, it may even hinder the natural formation of occluding wood rolls, which provide strength at the edge of the cavity. Additionally, filling a cavity may reduce the tree's habitat value and make future inspections more challenging.

Decay resulting from previous injuries can lead to the formation of cavities and hollows in tree trunks and branches. These injuries often occurred a significant amount of time ago. Various actions, such as removing a large branch, breaking off a substantial branch, topping off the trunk or branches, cutting off a major root or cluster of roots, or damaging the trunk, can all contribute to tree injuries. It is essential for an arborist to thoroughly examine a tree with a hollow or cavity and conduct a risk assessment to determine if the tree poses a hazard when in close proximity to a structure or populated area. While hollow trees are not always at risk of falling, they may collapse if they lack sufficient sturdy wood to support their weight. The presence of enough wound wood growth on both sides of the hollow can help counterbalance the weakness caused by decay. This type of wood is often more resilient than the typical wood found in tree trunks.

Approximately 25 feet above the top of the image, a significant trunk injury occurred, resulting in the creation of this hollow. A ring crack emerged in the barrier zone, followed by a ray crack extending from the ring crack to the outer edge of the bark. Subsequently, decay contributed to the formation of the hollow visible in the image.

This is a growing hollow that was caused by a previous trunk injury. The above photo would resemble a cross-section of the above photo. In the middle of the cross section, a core of dead wood is seen, surrounded by the dark barrier zone. There is a hollow trunk because of the rotting wood inside the barrier zone. Cracks in the trunk are likely to form when the two sides of the hole grow together, further weakening the tree.

The tree can isolate the damaged area and form a barrier between the cavity and the remainder of the tree if it is generally healthy, gets enough water and nutrients, and is not overly stressed.
Partitioning serves as the tree's main defence mechanism against deterioration. Trees can enclose damaged areas, preventing access to the remainder of the tree. In this manner, decay cannot pass through the tubes that transport nutrients and water to other sections of the tree if it enters the damaged area.

The cambium layer, a thin layer of vascular tissue crucial for nutrient and water flow, can be damaged by trunk wounds that penetrate the bark. The tree's chances of recovery are high if the damage to the bark surrounding the trunk is less than 25%. When new cuts are visible on the trunk, it is important to carefully remove the damaged bark, leaving the healthy bark intact. Tree paint or wound treatment is unnecessary. Over time, you will notice the incision closing from the edges each year as the tree grows. If an older wound is discovered, reattach the dried and loose bark to the area where the wound borders indicate new wood growth. Untreated trunk wounds can pose a hazard in the long run. Once a wound is present, decay may begin as decay-causing fungi can enter the heartwood. Trees have a unique defence mechanism. To create a barrier and isolate the infected area, the wood surrounding the lesion starts producing special chemicals in the wood cells. This process is known as compartmentalization. A healthy tree continues to produce new growth, strengthening the sound timber. Once contained, decay and discoloration cannot spread unless one of the barriers is breached. It is not recommended to remove decaying wood from cavities, as it may breach the compartment wall and lead to further trunk deterioration. To expedite the healing process, branches damaged by storms should be pruned properly. Avoid pruning too close to the trunk, as flush cuts can cause significant damage. Remove any hazardous branches promptly.

BS3998 Commentary on 9.2
Once a tree begins to deteriorate, specific management methods can be employed to decelerate the rate or ultimately minimise the extent of decay, whereas alternative techniques may expedite the process.

BS3998 9.2.1 Cavities that are dry
In order to assess the size of a cavity and determine if additional work is required, it is possible to remove loose debris and decayed (soft) wood from it when it is dry. It is important to note that wood-rotting fungi may still be able to survive and continue growing on partially decomposed wood. Consequently, the removal or partial removal of the wood may benefit the tree in some way. However, it is crucial to consider that the tree's natural defences against wood-rotting fungi could be compromised if any attempt is made to cut into or expose sound wood. If the decaying wood surrounding the cavity is expected to provide support for any rare or endangered species, particularly those that are legally protected, it should be left undisturbed (refer to Annex A).

BS3998 9.2.2 Wet cavities
It is not advisable to drain water-filled hollows, as it can cause the defence barriers to break and allow decay to spread to unaffected wood areas. Maintaining a consistently moist and calm environment is an effective method to prevent deterioration. If it is necessary to strengthen the walls of a damp cavity by inserting bolts, they should be placed above the level where water accumulates.

BS3998 9.2.3 Water pockets
If a water pocket is free from decay, there is no need to take any action. However, if there is degradation present, the water pocket should be treated in the same manner as a moist cavity (refer to 9.2.2).

Water-holding tree cavities are typically created when a branch dies and leaves behind a hollow space with a solid base that can retain water. These cavities can be found at various heights along the tree's trunk, but we are more likely to notice the ones that are closer to the ground. As time passes, dead leaves and other debris accumulate, along with rainwater that seeps into them from the tree's trunk. This creates a mixture of decomposing organic matter, with denser material settling at the bottom and looser material on top. While a pool of water may form after heavy rainfall, not many tree cavities remain filled with water permanently.
These aquatic microhabitats harbour a remarkably diverse population of aquatic animals, including microorganisms such as bacteria, fungi, and tiny single-celled organisms. Many creatures found in tree cavities are aquatic fly larvae. These larvae possess specialised appendages that enable them to access the atmosphere, allowing them to thrive in environments with limited or no oxygen. One well-known example is mosquito larvae, which utilise breathing tubes lined with fine hairs to reduce water surface tension and remain suspended while keeping their tubes open to the air. By utilising telescoping breathing tubes, they can access the abundant organic resources present deep within their preferred habitats, such as seeps and tree cavities.

BS3998 9.3 Control of cavity access
If the width of the cavity opening is found to be below the current biomechanical failure standards, open cavities are not considered biomechanical issues. They also provide essential habitats for various wildlife species. In cases where an open cavity poses a risk of arson, vandalism, or harm to children, a barrier can be constructed to prevent human access. This barrier, such as sturdy wire netting, should be difficult to remove and designed to minimise negative impacts on the tree and potential wildlife users. Fillings are generally not recommended for access prevention but, if necessary, they should be made of non-toxic materials.

<u>1.5. Identify the principles of fitting a brace or a prop in a tree</u>

BS3998 10 Management of weak structures
Trees can develop structural weaknesses that increase the risk of failure, posing a threat to both individuals and property. Factors such as natural disasters, human interference, and growth patterns can contribute to a tree's vulnerability. In cases where trimming alone is not enough to address the problem, combining pruning with physical support can reduce the likelihood of failure and minimise the potential harm to people and property. This intervention can also help preserve the tree's structural integrity and visual appeal.

BS3998 10.1 General
When evaluating structural weaknesses in a tree, it is important to consider the target at risk, the probability of physical failure, and the potential long-term consequences of the tree. One of the solutions outlined in Note 10.2 should be chosen to implement a suitable remedial treatment to reduce the risk associated with a weak structure. If addressing the issue does not ensure the safety of individuals or property, the tree must be removed as per Clause 12. Note 1: It is crucial to consider the potential impact on the target, the likelihood of structural failure, and the possible long-term effects on the tree when identifying structural weaknesses. Selecting one of the solutions provided in Note 10.2 is necessary to apply an appropriate remedial treatment to minimise the risk associated with a weak structure. If addressing the problem does not guarantee the safety of people or property, the tree must be cut down in accordance with Clause 12.

BS3998 10.2 Factors to be considered when choosing a restraint or support system
To determine the appropriate physical support or restraint for a tree, several factors must be taken into consideration. These factors include the species of the tree, the cause of its weakness, the availability and commitment of resources for maintenance, the condition of the wood at the proposed attachment points, the design of an effective system, and how it may impact the movement of the supported or restrained parts. Additionally, the load, such as the weight of the tree part that may require support or restraint in case of failure, and the physical properties of the materials to be used, such as strength and durability, should be considered. It is also important to assess the potential for causing damage to the tree and the potential for damage to occur.
Note: There are several options for appropriate restraint, including the installation of a flexible material like steel cables or synthetic fibre ropes to limit excessive movement and reduce dynamic loads on vulnerable structures. Pruning is often performed in conjunction with this method to alleviate strain on weak tree structures. Another option is rigid bracing, which involves inserting solid rods or bolts into the tree to restrict movement or support weak structures. Propping is another method that provides support from the ground or a solid structure to the underside of a branch or stem, reducing the risk of breakage or uprooting. Guying is also used to assist leaning trees or those with unstable roots. It is important to note that this is a specialised field of arboriculture, and only an arboriculturist

with relevant experience, a comprehensive understanding of tree anatomy and physiology, and knowledge of engineering principles should design, select materials for, and install any type of physical restraint. This is especially crucial for complex installations, such as multiple cable or rope systems.

BS3998 10.3 Construction of restraint systems

In order to ensure that the anticipated maximum mechanical stresses do not exceed the specified safe working load of either the system or its individual components, it is essential for a restraint system to possess the appropriate properties and strength. When multiple cables or ropes are to be fastened to a single bolt or sling, the components must be stronger than they would be if only one attachment were made. After calculating the loads being supported, suitable components should be selected. It is important to keep records of these calculations in case they need to be referred to in the future, such as after a failure. The component pieces of a restraint system should function together in a manner that preserves their strength characteristics for a minimum of twice the specified inspection period (refer to 10.9). When utilising a multiple restraint system, the cables or ropes should be arranged in a triangular formation with each other to evenly distribute the loads. However, caution should be exercised to avoid positioning them in a way that would transfer excessive loads onto the stem or a weak structure.

BS3998 10.4.1 General

A flexible restraint is a system of cables, ropes, or belts that is installed within the crown of a tree. Its purpose is to reduce the risk of structural failure during extreme movement. Instead of using steel cables, synthetic ropes or belts can be used to allow for some movement, particularly when promoting adaptive growth.

There are two methods of securing the restraint: non-invasive and invasive. While there is limited research on the longevity and long-term effects of these systems on trees, current practices support the use of non-invasive solutions, according to BS 3998.

A flexible restraint system should be designed to be strong enough to support any detached portion of the tree in the event of failure and to minimise excessive movement of weak structures.

Note 1: Customised proprietary systems or engineering components can be utilised to construct flexible restraint systems. Generally, the restraint should be attached to the susceptible branch or stem at approximately two-thirds of the total length between the tip and base of the branch. The attachment angle should be chosen to minimise strain on both the tree and the system. According to Section 10.4.3, which discusses wood strength at attachment points, the stems or branches should be capable of supporting the maximum weight of the system.

Note 2: When a lateral branch supported by the restraint system returns to its original position after being lifted by the wind, there may be significant loads placed on the cable or rope.

Note 3: While a flexible restraint attached to a lateral branch provides stability in a vertical plane, the branch may still be susceptible to heavy wind loads from the side. It is important not to move the vulnerable branch or stem from its resting place when a flexible restraint system is installed.

BS3998 10.4.2 Non-invasive flexible restraint systems

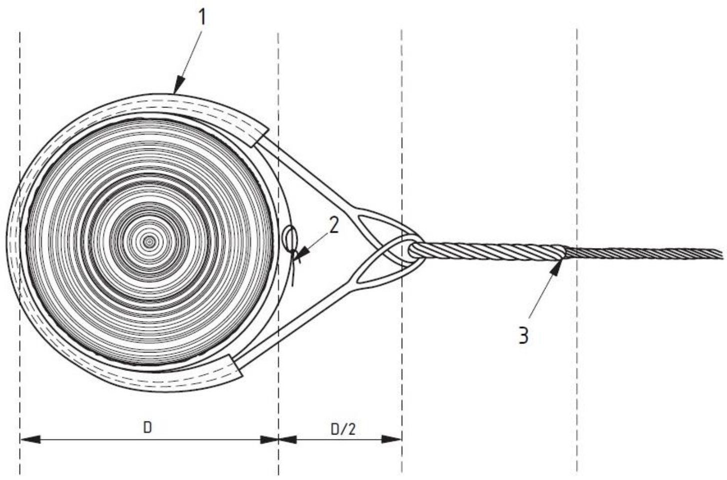
The arrangement and layout of fastening belts and slings should be designed in a way that prevents slipping, abrasion, and constriction of the stem or branch they are attached to. When a prefabricated kit includes a synthetic fibre rope, it must be securely fastened according to the manufacturer's guidelines. Synthetic fibre ropes should have indicators of wear or damage to facilitate safety checks. Each component used should have the appropriate strength and elasticity to support the entire weight and the necessary level of constraint while also being compatible with one another.

Note 1: Synthetic fibre ropes that can stretch up to 20% should not be used in certain setups. In such cases, steel cables can be used instead to minimise outward movement between the supported parts of the tree, as steel stretches less under tension.

Note 2: If a steel cable is used instead, the qualities of a synthetic fibre rope can partially alleviate the pressures exerted on the tree during windy conditions. This can potentially allow for more dynamic mobility and encourage supportive adaptive growth. However, these characteristics may vary depending on the specific material. Some flexible restraint systems incorporate a specified spring or shock absorber (energy absorber) to accommodate seasonal weight changes, growth, and stresses caused by tree breakdowns.

Note 3: The typical configuration of the components used in two different non-invasive restraint systems is illustrated in Annex D.

Annex D (informative) Attachment of restraint systems D.1 Attachment of non-intrusive flexible restraints Illustrations in Figure D.1 and Figure D.2 depict diagrammatic representations of components utilized in two different non-intrusive restraint systems. Figure D.1 Diagrammatic representation of components utilized in a non-intrusive restraint system: dual belt system with hollow braid polyester rope 1 2 3 D D/2



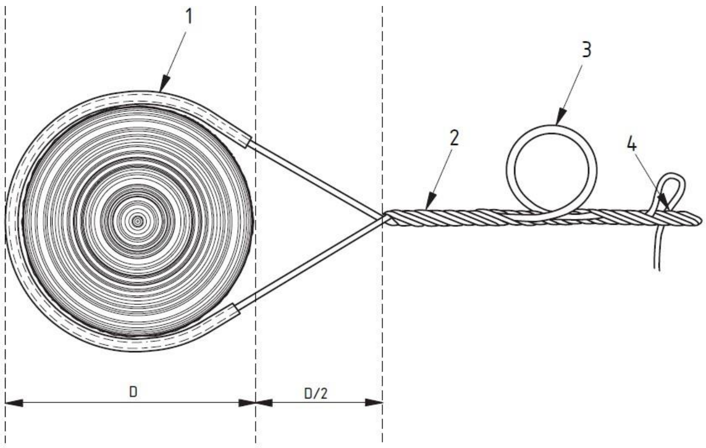
Key

1 Webbing retaining belt

2 Flexible positioning belt with sufficient elasticity to accommodate incremental growth

3 Hollow braid polyester rope attached to belt by spliced eye in accordance with the manufacturer's recommendations

Illustrated in Figure D.2 is a diagrammatic representation of the components employed in a non-intrusive restraining system. This system comprises a monofilament polypropylene hollow rope, denoted as 1, with two additional components, labelled as 2 and 4. The midpoint of the installation, marked as D/2, allows for the insertion of an optional rubber shock absorber into the rope. This rubber shock absorber serves the purpose of accommodating low-load oscillations.



NOTE An optional rubber shock absorber may be inserted into the rope at the mid-point of the installation to allow for low-load oscillations.

Key

1 Internal expansion band and external anti-abrasion cover fitted where rope passes around the stem

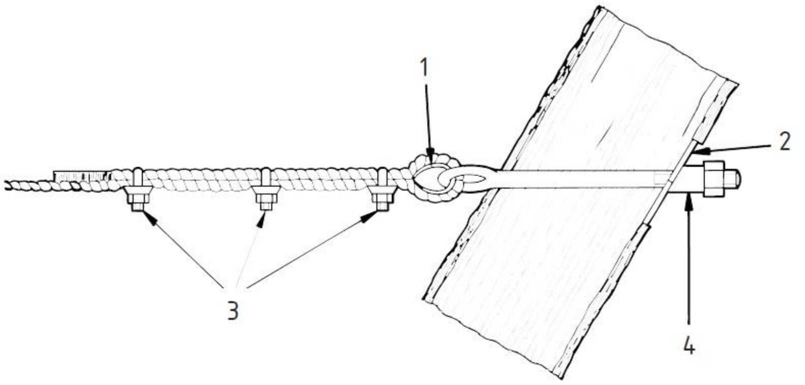
2 Splice (rope fed into centre of rope and out again in accordance with the manufacturer's recommendations)

3 Tension loop to accommodate tree growth

4 End splice

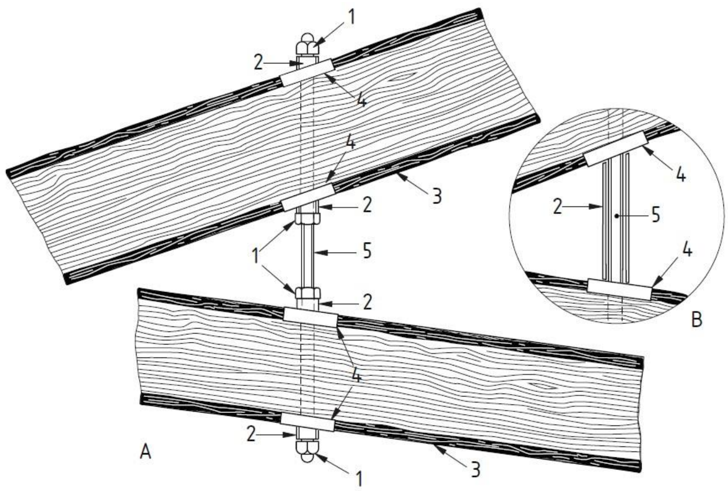
Inserting two or more attachments into the same branch or stem, whether they are aligned radially or longitudinally within 500 mm of each other, can lead to the formation of cracks in the wood between them. Typically, an eye is used to attach only one cable, unless the system is explicitly engineered to withstand the load of multiple cables. To prevent slipping, the ends of the cable are securely fastened using specialised fixings, such as wire rope grips. Note BS 462 specifies requirements for wire rope grips.

It is imperative to ensure that the attachment is made only into wood that possesses sufficient strength to securely hold the assembly under load, as detailed in section 10.4.3.
The diagram in Figure D.3 provides a visual representation of the components utilized in an invasive restraint system.
Please take note that this diagram depicts a straight-line assembly, where the eyebolt is not positioned perpendicular to the grain. Alternatively, as mentioned earlier, the eyebolt can be inserted at a less oblique angle, while still ensuring that it possesses the necessary strength.
Furthermore, when the bolt is not at right angles through the branch, it is typically necessary to utilize an angled spacer (4). This spacer aids in evenly distributing the pressure exerted by the nut on the washer.



Key
1 Thimble
2 Oval washer countersunk to wood
3 Wire rope grips
4 Angled spacer

D.3 Securing rubbing branches
Diagrammatic illustrations of two systems for separating two branches that have been in contact are depicted in Figure D.4.
Diagram D.4 depicts the visual representation of mechanisms used to separate and secure rubbing branches.



Key
A Unsleeved bolt
B Sleeved bolt
1 Nut
2 Spacer
3 Branch
4 Washer
5 Bolt

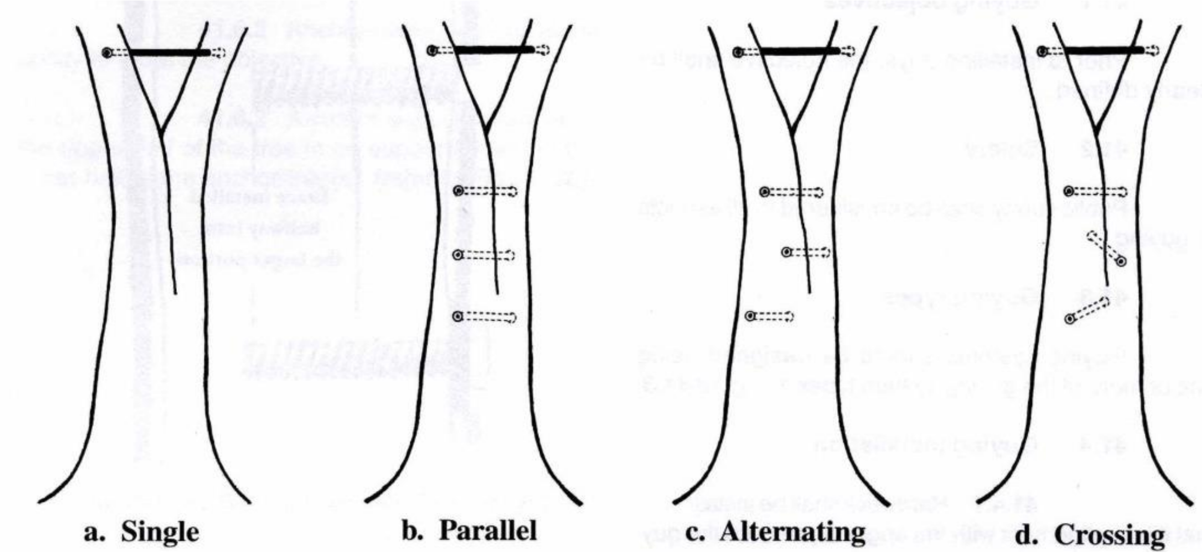
1.6. Identify the British Standard advised inspection period for a bracing system

BS3998 10.9 Inspection and maintenance of restraint and support systems
Restraints installed on trees should be regularly inspected to ensure their effectiveness and safety. The frequency of inspections should be determined based on the materials used, the structure supported, the condition of the tree, and the usage of the site. In certain circumstances, such as heavy snow or high wind events or a change in site usage, additional inspections should be conducted. It is important to inform the client about these requirements and the recommended frequency of regular inspections when considering the initial installation of support. By default, a general ground-based inspection should be conducted annually, with the use of binoculars, if necessary, while a detailed aerial inspection should be conducted every five years. During each inspection, the condition of the materials used should be assessed, including any wear and tear, damage, or deterioration that may affect their fitness for purpose. The attachments of the restraints on the tree should also be examined for any adverse effects, such as chafing or constriction damage. Additionally, the presence and extent of decay should be evaluated. If a system is found to be not meeting the specified objectives, appropriate adjustments, repairs, replacements, or alternative management options should be implemented.

BS3998 11 Other attachments to trees
Trees have historically been inappropriately utilised as convenient supports for various structures such as fences, notice boards, and more. In recent times, this practice has extended to include the installation of CCTV cameras, security lights, and decorative lights. Additionally, lightning conductors are sometimes added to protect valuable trees from thunderstorm damage. However, if these attachments are not properly installed or regularly inspected and adjusted, they can gradually harm the tree, leading to issues like constriction, dieback, and even fractures in the tree beyond the attachment point. When attaching anything to a tree, whether it is for the tree's benefit (such as stabilising a wind-blown or unstable tree) or to secure a fixture, it is crucial to consider the tree's radial growth. Therefore, provisions should be made to allow for necessary adjustments, either through annual inspections or a specified maintenance system. In the case of lightning conductors, it is important to connect other metal components (such as bolts, cables, restraints, and fixings) to the conductor(s) to ensure proper grounding for electrical currents that may occur during a lightning strike.

1.7. Indicate in what circumstances the use of a bracing or propping system is appropriate

Supplemental physical support is frequently required for urban trees to minimise the likelihood of crown or root system failure. Implementing techniques such as cabling, bracing, guying, and staking can effectively address these potential tree failures. By employing tree-support systems, the movement of branches, leaders, or the entire tree can be restricted, thereby mitigating the risk of harm to individuals and property. These systems offer additional support to structurally vulnerable areas of the tree, reducing the chances of injury and property damage.
The primary risk associated with tree breakage is the existence of one or more codominant stems (Figure 1). Codominant stems, also known as "v-crotches," are structurally weaker in comparison to a single stem. This weakness is attributed to the absence of connective tissue securing a stem to the tree trunk and the presence of included bark between the stems. The wider the angle of the "v-crotch," the higher the likelihood of structural failure. The most effective solution to address issues related to codominant stems is to purchase and plant trees with a single leader. Another option is to eliminate one of the codominant stems at the earliest stage of the tree's growth, allowing for the formation of a single leader. Otherwise, bracing or cabling will be necessary to reinforce the vulnerable section of the tree.



Structural problems often arise from the presence of long, heavy, or "overextended" limbs. These limbs are either unusually long for the tree species or grow horizontally or downward, with most of the foliage concentrated towards the end of the branch. Breakage typically occurs at the junction of the branch and stem due to these conditions. Alternatively, the branch may crack due to tension and compression forces. These failures commonly happen when the branch is subjected to heavy loading, such as wind, snow, or ice. To avoid the need for extensive pruning, cables can be installed. However, early corrective pruning is the most effective approach to preventing this condition. Another issue that arises is the inadequate anchoring of trees. Trees with weak anchoring are typically the consequence of transplanting a tree with a subpar root-ball, a compromised root system due to damage or decay, or planting in shallow or compacted soils. To address this problem, it may be advisable to consider pruning, removal, installing support devices like cables, brace bolts, and guys, or a combination of these techniques. Brace rods are implemented in cases where there are multiple leaders in the tree. These rods help minimise the risk of the leaders moving apart or shifting sideways in relation to one another. Additionally, brace rods are utilised to mend a split crotch or branch. Typically, brace rods are paired with at least one cable to provide extra support. They can be installed in either a through-rod configuration (where the rod is bolted with a nut on the other side of the tree or branch) or a dead-end configuration (where the rod is threaded into the tree). The choice of configuration depends on factors such as tree size, the presence of decay in the tree, and the specific structural issue at hand.

Brace rods in a Marple tree

Cabling is used to limit the movement of branches in a tree. It is installed in weak areas to prevent branches from breaking and to provide support for overextended branches. Multiple cables, along with brace rods, are often needed for installation. The cable system consists of anchors, cables, and termination hardware for connecting to the anchor. Cable anchors are typically placed about 2/3 of the way from the weak crotch to the branch ends, based on the tree's structure. Different configurations, such as direct, triangular, box, and hub and spoke, can be used for multiple cable systems. If a lightning protection system is present in a tree with cables, the cables must be connected to the lightning protection system.

There are different methods of cabling trees, depending on the desired level of support. One method is direct cabling, which involves using a single cable to connect two tree parts such as limbs, stems, or a trunk and a limb. This method is commonly represented by three cables. Another method is triangular cabling, where three tree parts are connected in various combinations. This method is preferred when maximum support is required, and it is often represented by two triangular systems. Hub and spoke cabling is another technique that involves a central attachment called a hub, with cable spans radiating out to three or more leaders, known as spokes. This method should only be used when other installation techniques are not feasible. Lastly, there is box cabling, which involves connecting four or more tree parts in a closed series. This method is suitable when minimal support is needed. Overall, these different cabling methods offer varying levels of support, depending on the specific requirements of the trees.

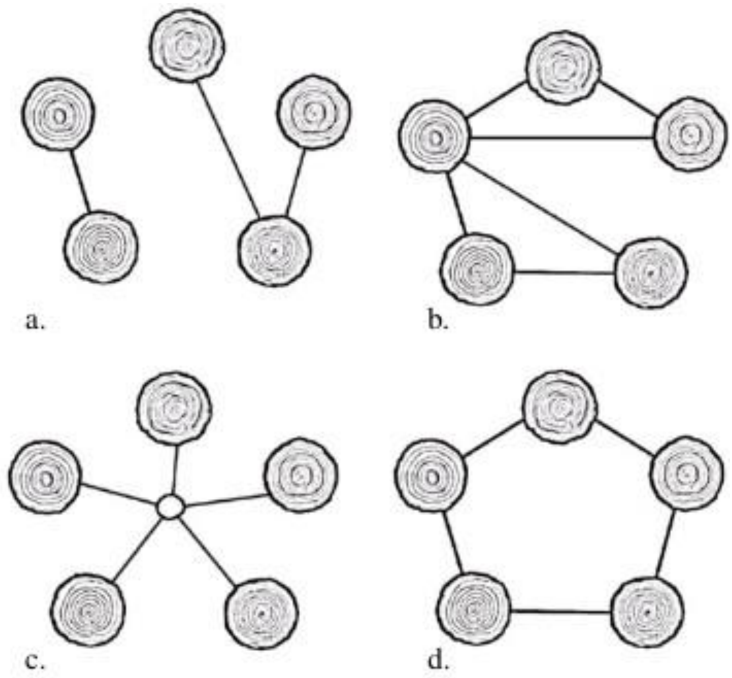


Figure 2. Cabling system types: (a) Direct, (b) Triangular, (c) Hub and Spoke, (d) Box.

<u>direct cabling</u>, which involves using a single cable to connect two tree parts such as limbs, stems, or a trunk and a limb.

Guying involves the installation of a cable between a tree and an external anchor. This cable serves to provide additional support and minimise the movement of the tree. In cases where trees have root issues, guying is employed to keep them upright and safeguard potential targets in the event of failure. Additionally, established trees that have experienced tipping due to wind throw may require guying to ensure they receive the necessary support. There are two types of anchor systems commonly used for established trees: soil anchors and utilising another tree as an anchor (refer to Figure 3).

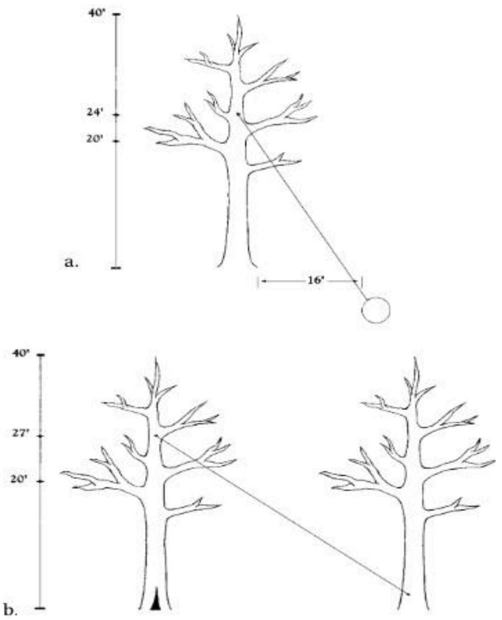


Figure 3. Guying system types: (a) Tree-to-Ground. (b) Tree-to-Tree

In the tree-to-ground scenario, the anchors would be positioned at least 16 feet from the base of the tree if the point of attachment is 24 feet up the trunk. In the tree-to-tree case, the point of attachment is in the upper half of the supported tree and the lower half of the anchor tree.

It is recommended to install a ground-anchored system with the anchor point positioned at a distance from the trunk equal to the height of the attachment in the tree. This distance should not be less than 2/3 of the height of the tree attachment. In the case of a tree anchor system, the anchor tree should be larger than the guyed tree and have an attachment point located in the lower half of the trunk, at least 7 feet from the ground. The guy should be placed at least halfway up the tree, preferably higher, to effectively anchor it. The anchor tree must have the capacity to support both the weight of the guyed tree and its own weight. It is advisable to have a qualified arborist inspect the trees to ensure that the anchor tree has the necessary structural integrity to support the guyed tree.

Tree staking serves the purpose of keeping the tree upright and securing the root-ball until the roots establish themselves in the surrounding soil. It can also be employed to straighten the trunk of a young tree or safeguard the lower trunk against harm. Generally, staking is not recommended, as most trees with well-developed root systems do not require staking during planting. However, trees planted on steep slopes, in loose or crumbly soil, or with top-heavy, large crowns may need staking to maintain their upright position. In such cases, regular inspection and adjustment of the stakes are necessary to prevent any damage to the staked tree. In most cases, stakes are necessary for the first year after planting. However, it may take two or more years for larger trees to develop a strong root system that can adequately support the tree. Staking, though, can have negative effects on the tree, including less trunk taper or reverse taper, an increased risk of rubbing and grinding injuries from the stakes and ties, uneven xylem growth around the trunk, the trunk growing or bending away from the stake, and a reduced ability to stand independently once the stakes are removed. Staking is typically unnecessary for most shrubs, evergreen trees, or trees with low-hanging limbs. However, protective staking can help prevent damage from mowing equipment, vehicles, or vandalism. In high-traffic areas, a metal or wooden frame can encircle the tree for added protection.

Staking can be done aboveground or belowground, with aboveground staking placed as close to the base of the tree as possible. It is important for the treetop to have some movement in the wind to promote taper growth while restricting root-ball movement in the soil. Depending on the tree size and planting location, support can be provided by a single stake, a double stake, or three short stakes. Anchoring the root-ball below ground by driving stakes along the sides deeper than the root-ball can eliminate the need for above-ground staking and ongoing maintenance.

Staking, Anchoring, Guying

Maintenance of Tree Support Systems
Tree support systems need regular inspection by a qualified arborist. The inspection schedule should be determined prior to the installation of the support system. All support systems have a limited-service life, and hardware adjustments will be necessary. Steel cables can last between 20 and 40 years, depending on environmental factors. Synthetic-rope cable systems do not have a known service life but should be inspected every 10 years. Staking and guying systems for newly planted trees should be removed within a year once the tree has established a sufficient root system. Mature trees may require permanent guying systems. The service life of a guying system is like that of steel cables.
If any of the following conditions are observed, it is necessary to replace or repair tree support systems:
1. The system shows signs of excessive wear, corrosion, or other forms of degradation.
2. The tree has grown beyond the end of the steel cables or fabric slings.
3. Tree growth has caused the cable to hang too low in the canopy, rendering it ineffective.
4. There is excessive slack in the cable.
5. The cable is rubbing against any part of the tree.
6. The anchors or terminations are substandard due to overgrown tree growth or have lost their effectiveness.

It is crucial to prioritise safety when providing assistance to damaged trees. Support structures are at risk of failure under severe circumstances. Regular inspections are necessary, with the frequency depending on the tree, support mechanism, and location. Any issues identified should be promptly addressed to prevent additional harm to the tree and to ensure the safety of individuals and property in case of support system failure.

Source:

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