

BS 3998:2010



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Tree work – Recommendations

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 68, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard was published by BSI and came into effect on 31 December 2010. It was prepared by Technical Committee B/213, *Trees and tree work*. A list of organizations represented on this committee can be obtained on request to its secretary.

Technical Committee B/213 takes collective responsibility for the preparation of this British Standard. The committee wishes to acknowledge the personal contribution of David Lonsdale.

Supersession

This British Standard supersedes BS 3998:1989, which is withdrawn.

Information about this document

This is a full revision of the standard, which has been updated and expanded to incorporate changes in the law and working practice concerning established trees, especially with regard to:

- safety of people and property;
- decision-making criteria for tree work;
- wildlife and habitats;
- veteran trees.

This revision also takes account of underlying issues such as tree longevity, value for local amenity, landscape, biodiversity and heritage.

Use of this document

This British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

This document provides guidance for tree owners and their agents, and all others whose activities might affect trees.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

The word "should" is used to express recommendations of this standard. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Attention is particularly drawn to the legislation referred to in Annex A.

0 Introduction

0.1 Trees as self-optimizing organisms

Trees are dynamic, continually self-optimizing organisms, i.e. each year, by producing new shoots, roots and radial increments of wood and bark, they maintain both their physiological functions and their structural integrity. Thus, the often massive structure of a mature tree above ground, consisting of the stem, branches, twigs and the attached foliage, is highly efficient in intercepting, using and storing solar energy, while also bearing its own weight and dissipating the potentially damaging forces of the wind. Below ground, although far less obvious, the extensive root system is equally efficient both in providing anchorage and in pervading the soil in order to absorb the water and mineral nutrients that are essential for survival, growth, flowering and fruiting.

0.2 Reasons for carrying out tree work

Generally, trees develop in balance with their environment both above and below ground. Conflicts with people and property can, however, result from natural processes of growth and dieback or from the effects of damage caused by severe weather, pests or diseases. Equally, human activities can lead to conflicts, if these activities affect the growth or structural integrity of trees, or increase or adversely modify their exposure to the wind by the removal of other trees or the demolition or construction of buildings. Human activities can also bring people and other targets (see 3.27) closer to trees. Any such conflict can have serious implications for the health and welfare of the tree(s) concerned and/or the safety of people and property. Resolution of conflicts can be achieved by tree work, but there is often a need to consider other measures such as modifying the use or management of the surrounding land.

The need for tree work will sometimes become self-evident to tree owners and site managers in the course of their regular duties. In many circumstances, however, there will be a need for systematic surveys and inspections to be conducted by competent persons, including where appropriate external experts with skills in areas such as the recognition and interpretation of the origin and significance of symptoms caused by damage or physiological stress.

This standard does not cover the specific processes for surveying and inspecting trees; it starts at the point where the requirement for some kind of action has been identified but the work has not yet been specified (see Figure 1). On this basis, it is assumed that a tree survey or tree inspection will normally have been conducted according to a clear brief, prepared in discussion with the client or employer, in order to take account of all relevant factors, including the safety of people and property.

A client's initial desire for tree work, often based on particular circumstances, might not necessarily be appropriate in other respects. In particular, when specifying tree work, there is always a need to take account of the effects of the work on the long-term growth and the future management needs of the tree. Equally, before work commences, it is important that its appropriateness is verified in the light of any change in circumstances that might have occurred in the

meantime. This standard therefore calls for understanding of trees as species, individuals and populations (groups of trees), and for caution in deciding the kind of tree work, if any, to be done.

Tree work ideally forms part of a planned programme of management, which includes the successional planting of trees well-suited to their surroundings. In particular, new plantings or replacements after felling (12.1) can be carefully planned in order to minimize the need in the future for work on trees that are to be established near utilities, buildings or other infrastructure (7.9).

Principles for assessing the potential advantages and disadvantages of various aspects of tree work are stated, where appropriate, in this standard. Where work is required, it is important for clients to be aware of both the advantages and disadvantages before deciding the course of action to follow.

Figure 1 outlines the management process and shows the various options at each stage, with cross-references to the appropriate clauses.

0.3 Potential consequences of tree work

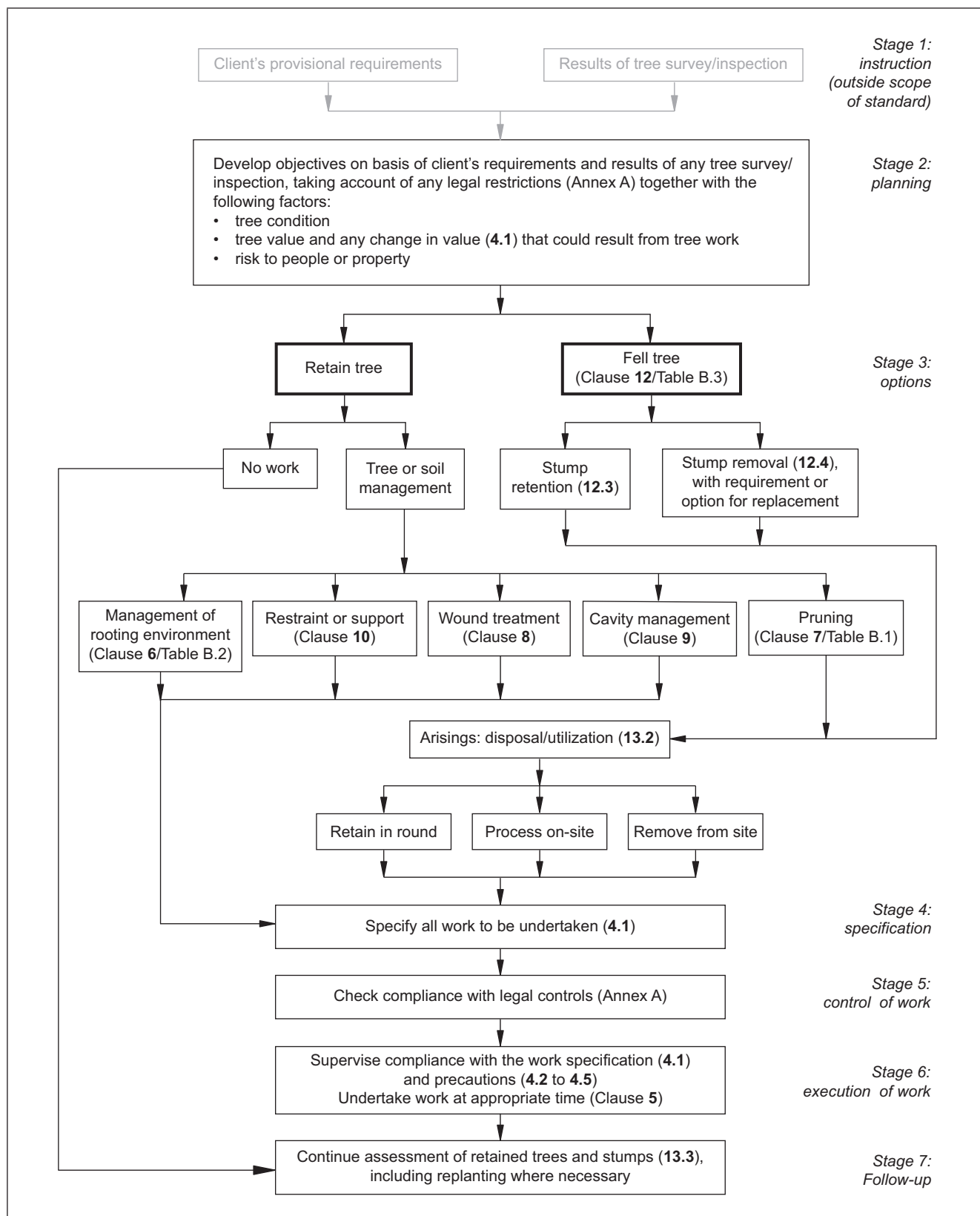
While tree work can be desirable to accommodate people's requirements from the tree and the land around it, any work that exposes the woody tissues is a form of damage that can be detrimental to the tree in the long term.

Various organisms (e.g. certain fungi and bacteria) can destroy (decay) woody tissues in a tree. Decay is a normal process in the ageing of trees but it can be accelerated, with potentially serious consequences, if a substantial proportion of the cross-section of a stem or major branch is injured, e.g. by pruning wounds (see Clause 8). This can happen either if the organisms gain entry via wounds, or if they have previously been latent within the tissues and later become activated as a result of injury. Inappropriate tree work or site disturbance, leading to injury or physiological stress, can make roots susceptible to a range of organisms that can sometimes kill and/or decay them (see Clause 6).

Decay induced by excessive pruning can eventually impair the structural integrity of a tree, but, in many instances, the affected zone becomes compartmentalized within a wall of sound wood, which is often strong enough to provide adequate support. Also, any loss of structural integrity might be countered by compensatory growth in the tree. The rate and the eventual extent of decay depend on many factors, including the species of tree and of the decay-causing organism(s) involved. Some forms of tree management (see Clause 9) might help to limit the rate or the eventual extent of the decay, particularly if they involve remedial work following storm or other damage, but none will arrest the decay. Other forms of management might accelerate the process (e.g. infliction of further damage by pruning). Artificial restraint (see Clause 10), often undertaken together with pruning, can help to prolong the safe useful life of the tree.

Clause 7 includes guidance on the precautions by which the potentially harmful effects of pruning can be minimized. In order to help ensure that decay, when detected, does not develop to the extent that a tree becomes significantly weakened, the relative extent of the decayed zone and of the sound wood needs to be monitored and, when necessary, action taken to manage the tree.

Figure 1 Overview of standard and decision-making process



0.4 Categories of tree work: purposes and principles

The management of trees and of the surrounding land needs to be planned in order to maintain the multiple values of the trees, while safeguarding people and property in instances where significant tree-related risks occur.

This standard gives guidance on the main tree work operations. For those listed below, it is particularly important to take account of their purposes and of the underlying principles.

- **Care of the rooting environment.** The main requirement is to ensure that tree roots and their associated beneficial mycorrhizal fungi can grow and function properly. This is important for the stability of the tree, which can be compromised by damage to or death of the roots (see also BS 5837).

The key requirements for the healthy growth and function of roots are a soil texture that they can easily penetrate, together with a supply of oxygen, moisture and nutrients. Reduced availability of oxygen, e.g. as a result of soil compaction or waterlogging, can result in a reduction in growth and, in extreme cases, crown dieback or even tree death. Other factors, such as pH, influence the suitability of soil for different species.

In less than ideal conditions, trees might be healthy but tend to grow slowly. Where it is important to improve growth, this might be achieved by modifying the soil conditions; e.g. soil structure and nutrient status (see Clause 6).

- **Pruning.** The various forms of pruning (e.g. crown reduction, thinning or lifting) are the most frequently practised tree work operations, since a wide range of aims and objectives can thereby be achieved. These objectives relate, for example, to the structural integrity of the tree, the safety of people and property, access, obstruction, light and aesthetic value (see 7.1 and Annex B). Pruning falls into two main categories: formative pruning, whereby mainly young trees are encouraged to grow in a desired form, and remedial and restorative pruning, whereby the existing form of the crown (particularly in older trees) is managed or modified.

Well planned and properly executed pruning can reduce the probability of structural failure and so reduce risk to people and property, while sometimes prolonging a tree's safe life. However, pruning is also a form of damage, which removes foliage and locally disrupts columns of liquid and the network of living cells, so that zones of sapwood become physiologically dysfunctional. Decay tends to develop in the affected wood and can extend further within the tree, sometimes causing weakness. The amount of pruning and the size of the resultant wounds therefore need to be kept to the minimum required for the particular objective.

- **Restraint and support.** Where a tree poses an unacceptable risk to people and property, either due to the development of a structural weakness or the integrity of its root system being compromised, management to reduce the risk might be justified. This could involve pruning (see Clause 7) to reduce the load on the weak parts of the tree, or provision of an artificial restraint or support (see Clause 10).

Artificial supports cannot be relied upon to prevent a structure failing but the area at risk in the event of failure can be reduced.

Where support and pruning are considered inadequate to reduce a risk to a reasonable level, the only option might be to fell the tree and establish a new tree on the same or a nearby site.

- **Felling and related options.** Where a tree has to be felled there are a number of options for how much of the stump, if any, is to be retained. It may be removed completely, or a portion of the stem may be retained as a tall stump, whether living or dead. This standard provides guidance on the advantages and disadvantages of these options.

Even after felling a tree, the stump and associated woody roots can provide benefits or cause hazards. What is to be done with a stump after felling is therefore an integral part of the decision process when a tree is to be felled (see Clause 12).

1 Scope

This British Standard gives general recommendations for tree work.

It gives guidance on management options for established trees (including soil care and tree felling) and overgrown hedges.

NOTE The principles of this standard may also be applied to some shrubs, which can have similar characteristics to trees.

This British Standard does not give guidance on carrying out tree surveys or tree inspections. It considers the impact of work on an individual tree in relation to neighbouring trees, but does not cover overall management of tree populations.

2 Normative references

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5837, *Trees in relation to construction – Recommendations*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 adaptive growth

process whereby the rate of wood formation in the cambial zone, as well as wood quality, responds to gravity and other forces acting on the cambium

NOTE This helps to maintain a uniform distribution of mechanical stress.

3.2 adventitious bud/root/shoot

bud/root/shoot that forms other than through primary development

NOTE For example, shoots which develop other than from terminal or axillary buds, or roots which are initiated within the mature tissues of a stem or woody root. See also 3.15.

3.3 arboriculturist

person who, through relevant education, training and experience, has gained recognized expertise in the care of trees

3.4 arisings

any parts of a tree, including stem, roots, branches (brushwood), bark, other woody material and foliage, derived from the tree during tree work operations

3.5 canker

area of dead cambium and overlying tissues killed by a pathogen

3.6 cavity

hole in a woody part of a tree caused by decay or damage

NOTE Cavities can hold water (wet cavity) or be dry.

3.7 co-dominant stem/branch

upward growing stem/branch with a similar height and disposition as another stem/branch

NOTE Where such stems/branches arise from the same union, their stability or the integrity of the attachment of the stems/branches could be compromised. See also 3.17.

3.8 competent person

person who has training and experience relevant to the matter being addressed and an understanding of the requirements of the particular task being approached

NOTE A competent person is expected to understand the hazards pertinent to the task being carried out and the methods to be implemented to eliminate or reduce the risks that can arise. For example, when on site, a competent person is able to recognize at all times whether it is safe to proceed.

3.9 coppicing

cutting trees close to ground level with the intention of encouraging regrowth of multiple shoots

3.10 crotch

forked region formed by the junction of a branch and the stem, or by two branches

3.11 crown

main foliage-bearing part of a tree

3.12 crown lifting

removal of lower branches to achieve a stated vertical clearance above ground level or other surface

NOTE The vertical clearance will usually be stated in the work specification (4.1).

3.13 crown reduction

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

3.14 crown thinning

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

3.15 epicormic branch/bud/shoot

branch/bud/shoot initiated on a mature woody stem or branch

NOTE Shoots can form in this way from dormant buds or be adventitious (see also 3.2).

3.16 heartwood

dead or predominantly dead central wood of tree species whose sapwood has a finite and pre-determined lifespan

NOTE In some species heartwood is highly durable because it contains pre-formed defensive substances. In certain others, it remains chemically reactive when exposed to air and/or fungal colonization. It is sharply delineated from the sapwood (3.24) because the sapwood–heartwood conversion involves the death of most of the sapwood cells at about the same time (c.f. ripewood, 3.23). It can be harder than the sapwood and/or distinctly coloured.

3.17 included bark

bark tissue lodged in the union between a branch and the parent stem, in the crotch of two branches, or between the bases of co-dominant stems, indicating potential weak attachment

3.18 knuckle

swelling that forms at a pollard point, especially after repeated cutting

3.19 lapsed coppice/lapsed pollard

tree that has been coppiced/pollarded but has not been maintained by cycles of cutting

NOTE See also 3.9 and 3.20.

3.20 pollard

tree that has formed a crown consisting of numerous branches arising from the same height on a main stem or principal branches

NOTE This can be by natural process or by pollarding (3.21).

3.21 pollarding

cutting a tree so as to encourage formation of numerous branches arising from the same height on a main stem or principal branches

NOTE 1 This process is initially carried out on trees that have not yet reached maturity. The form of the tree can then be maintained by cycles of cutting. This is not the same as topping (3.28).

NOTE 2 The pollard heads collectively, and the framework of a pollarded tree, are both known as the bolting.

3.22 retrenchment pruning

form of crown reduction (3.13), intended to encourage development of the lower crown, which emulates the natural process whereby the crown of an ageing tree retains its overall biomechanical integrity by becoming smaller through the progressive shedding of small branches

3.23 ripewood

older central wood of those tree species in which sapwood gradually ages without being converted to heartwood

NOTE Ripewood is usually not durable since it lacks both pre-formed defensive substances and an ability to react to wounding. It is not sharply delineated from the sapwood because the cells die gradually over many years. See also 3.16 and 3.24.

3.24 sapwood

outer, living, water-conducting part of the wood of a tree

NOTE See also heartwood (3.16) and ripewood (3.23).

- 3.25 stem**
principal above-ground structural component of a tree that supports the branches
- NOTE 1 This either extends throughout most of the height of the tree (primary stem), or is one of a number of such components (secondary stems) which divide from each other either near the ground or at a higher level.*
- NOTE 2 Trees comprising two or more stems arising from, or immediately above, ground level are commonly referred to as "twin-stemmed" or "multi-stemmed".*
- NOTE 3 "Stem" is synonymous with "trunk" for single-stemmed trees, particularly those of a large diameter.*
- 3.26 stub**
broken or severed short remaining section of a branch extending beyond a crotch
- NOTE Also known as a "snag" or "noggin".*
- 3.27 target**
person or object, whether mobile or fixed, within the potential zone of impact of a tree or its branches, which might be harmed as a result of the partial or total failure of the tree
- NOTE The term can also refer to a pedestrian or vehicular route where harm might thus occur.*
- 3.28 topping**
removal of most or all of the crown of a mature tree by indiscriminately cutting through the main stem(s)
- NOTE This is not the same as pollarding (3.21).*
- 3.29 veteranization**
controlled infliction of damage on a tree to achieve a specific habitat objective
- NOTE This is undertaken to promote or emulate the development of some of the features of a veteran tree, especially the wildlife habitats and shelters that are provided by decaying wood and cavities (see Veteran trees: a guide to good management [1]). When undertaken, it is usually on young or early-mature trees.*
- 3.30 veteran tree**
tree that, by recognized criteria, shows features of biological, cultural or aesthetic value that are characteristic of, but not exclusive to, individuals surviving beyond the typical age range for the species concerned
- NOTE These characteristics might typically include a large girth, signs of crown retrenchment and hollowing of the stem.*
- 3.31 vitality**
overall measure of physiological and biochemical processes, in which high vitality equates with near-optimal function
- 3.32 water pocket**
natural depression or crotch in a tree that holds water
- 3.33 wetwood**
condition in living trees where the wood develops an abnormally high water content and water-soaked appearance

3.34 work area

area designated for the safe execution of the specified work

3.35 wound

injury in a tree caused by a physical force

NOTE Examples of forces that can cause wounds include cutting and abrasion. Agents such as extremes of temperature and pathogens can cause injuries but these are not regarded as wounds.

4 Tree work safety and planning

4.1 Work specification

NOTE 1 The recommendations given in this standard are based on the assumption that a tree survey/inspection will already have been carried out, or that the need for some form of intervention will otherwise have been determined. Guidance on deciding the work to be undertaken and the means of its execution is given in the relevant subsequent clauses of this standard.

A competent person should prepare a work specification, based on the results of a survey or inspection, and/or on the client's objectives (the brief). This should include the details of the tree work to be undertaken and the purpose of each aspect of the work in relation to the objectives (see Annex B, Table B.1). The reasoning for the work specified should be made clear to the client and to the workers involved. Details of how the work will be implemented should normally be provided in a written method statement. Detailed decisions (e.g. relating to timing or in response to contingencies) should if appropriate be made at a later stage; see individual clauses for specific guidance.

NOTE 2 Attention is drawn to the Management of Health and Safety at Work Regulations 1999 [2] in respect of the requirement for a safe system of work.

The specification should be designed so as to minimize adverse effects on the tree; in particular any avoidable development of biomechanical weakness. Options other than tree work should therefore be specified where appropriate; e.g. moving a target such as a footpath or a bench, or moving an installation such as an aerial or street sign. Also, as far as is feasible, a specification for work should seek to minimize any potential negative impact (e.g. on the tree's aesthetic or ecological value or on other trees in the surrounding area). Any expectation of unavoidable adverse consequences or impacts of the work should be brought to the client's attention before the specification is made.

NOTE 3 There are a number of methods that can be used to evaluate individual trees and/or populations of trees for the various benefits that they provide. These include CAVAT [3], Helliwell [4], CTLA [5] and i-Tree (see <http://www.itreetools.org>).

The work specification should include an unambiguous identification of the tree(s), e.g. on a site plan, and/or by reference to marking or tagging on site. It should give clear details of access to the site (see 4.5), and of disposal or utilization of arisings (see 13.2).

It should also identify any limitations to the execution of the work, with provision for specific contingencies. For example, in the event of the following being found during the course of scheduled work, the

work should be stopped and the discovery should be reported to the client and, if necessary, to the relevant statutory body:

- a defect that would compromise the safety of the worker(s) or the tree, e.g. a major split or extensive decay; or
- a protected species (see Annex A).

Consequent modifications to the work specification should have any consents that might be required (see Annex A regarding legal consents).

Where amendments to the work specification are agreed, including statutory agreement, these changes should be documented and communicated to those undertaking the work.

4.2 Safety planning prior to carrying out tree work

There are a number of risks inherent in any tree work operation:

- the risks associated with the work itself, e.g. use of chainsaws;
- impact of action in one part of the tree on the rest of the tree/the surrounding tree population, e.g. structural weaknesses;
- specific medical risks to the operator, e.g. allergic reactions.

All risks associated with the work should be identified by carrying out a site-specific risk assessment, and managed by the use of appropriate safe working procedures.

NOTE Attention is drawn to the Health and Safety at Work etc. Act 1974 [6], Management of Health and Safety at Work Regulations 1999 [2], AFAG leaflets [7–20] and the Safety at street works and road works code of practice [21].

Before work commences, all workers should understand their roles in the safe system of work. Tools and equipment needed for all aspects of the work should be checked for safety and should be serviceable and fit for purpose.

Where there are specific seasonal problems (e.g. the wood of beech can be brittle in winter weather; birch and pine pollen can trigger hay fever; farina on London plane and certain pests, e.g. Oak processionary moth or Brown-tail moth, can cause irritation), the work should be timed (see Clause 5) so that people and property are adequately protected.

4.3 Avoiding transmission of pests and pathogens

Extreme caution should be exercised to prevent the introduction of pests and pathogens into the UK on tools and equipment that have been previously used abroad.

Measures should be taken to avoid transmission of pests and pathogens from tree to tree and from site to site.

NOTE 1 Within the UK, the pathogens most likely to be transmitted on tools, equipment and vehicles are Phytophthora spp. causing various diseases, and the following bacteria: Erwinia amylovora causing fireblight, Erwinia salicis causing watermark disease of willows, and Pseudomonas syringae pv. aesculi causing bleeding canker of Horse chestnut. Up-to-date information can be obtained from the Plant Health Service and the Forestry Commission (see Annex A).

Chainsaws are a common cause of transmission, so hand tools should be used (where practicable) when working on trees infected with any of these pathogens, in order to allow disinfection to be carried out effectively.

In the case of particularly high-risk pathogens, disinfection should be carried out on anything that might come into contact with another tree [e.g. tools, hands, clothing, personal protective equipment (PPE)]. When disinfecting PPE and climbing/rigging equipment, the manufacturer's guidance should be taken into account to avoid degradation of the equipment.

NOTE 2 Guidance on disinfection is given in Principles of tree hazard assessment and management [22].

4.4 Avoiding damage from tree work operations

Tree work should be conducted and completed in a manner that avoids or minimizes the creation of new hazards. For example, inappropriate crown lifting can cause a crown to become top-heavy (see 7.6).

NOTE 1 Poor and inappropriate tree work, misuse of climbing irons and other equipment might impair the health and biomechanical integrity of the tree, including its roots (see Clause 6).

NOTE 2 Friction from ropes can overheat the bark and cambium. This damage can be avoided by using a cambium saver.

When pruning or felling trees, steps should be taken to minimize damage from falling branches or large pieces of wood, by removing or shortening the branches in a controlled manner and not allowing the cut sections to fall freely unless an assessment has shown that there is no significant risk of damage or injury occurring. To avoid any such risk, a system that controls the safe transfer of branches and large pieces of wood to the ground should be adopted.

NOTE 3 Various approved systems involving the suspension of branches and lowering them safely to the ground are available. These involve static and dynamic pieces of equipment (e.g. ropes, pulleys) that are subject to safety regulations. Particular attention is drawn to the Lifting Operations and Lifting Equipment Regulations 1998 [23].

Where any part of a tree that is to be retained is used to redirect a load (e.g. when using a rigging system), or as an anchor (e.g. when winching out a stump; see 12.4.2), precautions should be taken to avoid damaging it.

4.5 Site management

Tree work should be effectively organized and conducted so as to minimize any adverse effects on the trees, the site and their surroundings. With regard to the potential impact of the proposed work, the following specific measures should be taken. The guidance in BS 5837 should also be followed where appropriate.

- Access, egress and parking arrangements for the site and work area should be agreed, including arrangements for monitoring and enforcement.
- Where cranes and hydraulic platforms are used, they should be sited and operated so as to avoid damaging trees or other property, e.g. by use of temporary ground protection (see BS 5837).

- Areas should be designated for the storage and maintenance of equipment and materials, particularly chemicals and fuel.

NOTE 1 Attention is drawn to the Control of Substances Hazardous to Health Regulations 2002 [24].

- Care should be taken to avoid contamination or disruption of the ground or water courses, e.g. by oil or chemicals.
- Care should be taken to minimize noise and other nuisance caused by tree work operations.

NOTE 2 Attention is drawn to the Control of Noise at Work Regulations 2005 [25] and to the Environmental Protection Act 1990 [26]. Guidance on noise on construction sites is given in BS 5228-1.

- Fires on sites should be avoided if possible. If they are permitted, care should be taken to minimize the risk of harm to people, retained trees and shrubs (including their roots), wildlife, structures and installations (e.g. power lines), etc.

NOTE 3 Attention is drawn to the Highways Act 1980 [27] regarding distance of fires from public highways, rights of way and footpaths, and to the Environmental Protection Act 1990 [26].

- Whenever the site is left unattended, at the end of each day's work and upon completion of the work, it should be left in a safe condition (e.g. by extinguishing any fires).

5 Scheduling tree works

NOTE This clause gives guidance on a number of factors that frequently influence the timing of tree work. Other factors, on which this clause does not elaborate, might include site-specific characteristics and site usage (e.g. seasonal access, use for special events). Client priorities might also need to be taken into account.

5.1 Risk control

If the purpose of the tree work is to control risks to people or property, the relative priority of the work should be determined by a tree failure risk assessment.

Decisions about priority should take account of any relevant factors that vary with the time of year, such as site usage, windiness, occurrence of drought or waterlogging, the potential for snowfall and unseasonal frost, or hazards associated with certain species at particular times of year (see 4.2), that are likely to influence the degree of risk to people, including operators, and property.

5.2 Season, weather and past damage

5.2.1 Scheduling of work affecting the soil

Where trees are to be retained, tree works should be timed so as to minimize the passage of machinery or repeated trampling on soft landscape areas during wet ground conditions, particularly where tree roots are likely to be present. If the work cannot be timed in this way, ground protection should be provided over the vulnerable sections of the work area, within a radial distance equivalent to 12 times the

stem diameter of each of the trees, when measured at 1.5 m from the ground (see BS 5837 for information on ground protection).

Guidance on managing the rooting environment is given in Clause 6.

5.2.2 Scheduling of pruning

The effects on the tree of both seasonal factors and weather conditions should be taken into account before pruning is undertaken (see Clause 7). Ideally, as a general principle for maintenance of vitality, trees should not be pruned during periods of water stress or during spring growth (when sugar and starch reserves are depleted), until new leaves have fully expanded and matured, or starch reserves have been replenished. Sufficient time (e.g. at least a growing season following major pruning or an episode of defoliation, or several years following major damage to the root system) should be allowed for a tree to recover following any damage or adverse management that might have increased its vulnerability to physiological dysfunction, before carrying out any further pruning.

NOTE 1 In many species, pruning causes least harm/stress to the tree if done during late winter or early spring. However, some species tend to "bleed" sap, and therefore can lose sugars, when pruned at certain times of the year (see APN 8 [28] for times of year and other causes of liquid exudation from trees).

For tree species whose defences against various wound-related diseases depend partly on the production of gum or resin (e.g. *Prunus* spp. and many conifers), pruning should preferably be done when these processes are at their most active (e.g. June to August for *Prunus* spp.).

As a general rule, pruning should be timed so as to avoid the exposure of tissues to severe conditions, e.g. due to season, weather or known seasonal presence of pathogens, taking into account the tolerance of the species concerned to such conditions (see 7.2).

*NOTE 2 Previously shaded bark and sometimes underlying sapwood can be damaged by sudden exposure to direct sunlight, particularly on old trees of most species and on thin-barked trees [e.g. rowan (*Sorbus aucuparia*), beech (*Fagus sylvatica*) and maples (*Acer* spp.)] of any age, while freshly wounded live tissues might be damaged by frosts.*

5.3 Habitat and wildlife

Prior to work commencing, the tree and its surroundings should be assessed for the presence of protected species (see Annex A), some of which are subject to season-specific legislation.

Any works should be planned so as to limit their potential adverse impact on wildlife generally. The timing of works should take account of the seasonal cycles of the species of fauna and flora concerned (including the nesting habits of birds and the egg-laying habits of insects).

5.4 Phased work

If it is determined that undertaking tree work in a single operation would lead to significant adverse impact relating to any or all of the factors identified in 5.1 to 5.3, the work should be phased where practicable, e.g. managing only a proportion of the relevant tree

population in any one year, or phasing the management of an individual tree over a number of years (see also 7.1 and 7.2.4).

NOTE Such an approach might be particularly appropriate for habitat management (see 5.3), visual impact or provision of shade (e.g. in coppice, avenues, groups of pollards), or risk management.

6 Management of the rooting environment

6.1 General

NOTE 1 The principal options for amelioration or remediation are given in Annex B, Table B.2. It is expected that a choice from these options will have informed the work specification (see 4.1).

NOTE 2 Detailed guidance can be found in Tree roots in the built environment [29]).

Adverse changes in the soil and damage to a tree's roots can lead to decline or, in extreme cases, instability or death, and should therefore be minimized. The cause(s) of any such problem should be established before any treatment is formulated: in some instances the cause will be known, whereas in other cases a tree could have been damaged by unrecorded events, possibly many years previously.

Investigations should determine the presence of naturally occurring adverse conditions as well as those related to human activity, and assess the potential impact of these in relation to the species, age and location of the tree. The investigations should be undertaken in such a way as to minimize adverse effects on the roots and rooting environment of any adjacent trees.

Where survival of a tree is in doubt, a decision should be taken as to whether intervention is likely to be successful or if it would be more appropriate to plant one or more new trees in advance of its planned removal. Depending on the nature of the problem, soil remediation measures should be implemented as necessary to ensure the successful establishment of any replacement trees.

6.2 Mulching

An area of ground over the root system of a tree or group of trees may be mulched in order to provide the following benefits, which would occur under natural conditions where organic matter (e.g. dead leaves) accumulates on the ground under trees:

- moisture retention;
- weed suppression;
- encouragement of beneficial soil flora and fauna;
- relief from or prevention of compaction (especially by encouraging earthworm activity);
- mitigation of extremes of soil temperature;
- absorption of toxic materials;
- release of nutrients into the soil.

The materials that may be used for mulching include coarsely divided plant matter, such as wood chip, pulverized bark, or leaf mould, any of which may be combined with well-rotted animal manure. If the sole intention is to conserve moisture, a layer of gravel or well-secured sheets of material such as perforated plastic film, geotextile fabric, carpet or cardboard may be used, and may be covered for cosmetic purposes. Any such sheets should be maintained to avoid damage to the tree (e.g. by clogging, weed growth, restriction of air movement or constriction of the stem).

Materials derived from plant species that have naturally occurring toxicity, such as couch grass or black walnut, should be composted for at least a month, preferably at a high temperature (c. 60 °C), in order to make them innocuous. High-temperature composting should also be used to kill pests and pathogens. Materials that cannot be detoxified, including those that have been contaminated by herbicides or other chemicals, should not be used for mulching.

The mulched area should extend over as much of the root system as can be allowed by other site-usage requirements. The depth of an organic mulch should not be so much as to inhibit aeration of the root system or to cause overheating of uncomposted material (normally no more than 80 mm to 100 mm). The mulch should be periodically replenished as it decomposes, so that it does not become depleted.

NOTE 1 Mulches that retain water encourage the development of roots near the soil surface and in the mulch itself. This can become a disadvantage owing to desiccation if the mulch is removed or not replenished.

Mulches should be kept away from direct contact with the bark of the stem, or of major roots, since this might encourage infection by pathogens by maintaining wet conditions.

NOTE 2 Although, by improving the soil texture and acting as a buffer for rainfall, mulches generally help to prevent extremes of soil wetness and dryness, they can prolong waterlogging on sites where drainage is seriously impeded. This in turn can harm tree roots and make them more susceptible to certain pathogens such as Phytophthora spp.

6.3 Aeration/decompaction

Where soil compaction and physical conditions are thought to be limiting tree growth, soil conditions in the area of the root system should be investigated by excavating small pits or by use of a soil sampler and/or a percolation test, so that problems can be identified and appropriate treatments determined and implemented.

NOTE A soil bulk density above 1.25 g cm^{-3} is generally too high for optimal root growth. Root growth is unlikely to occur where the bulk density exceeds 1.6 g cm^{-3} .

Soil compaction may be relieved by eliminating the cause of the compaction and allowing natural processes to operate. Such natural decompaction may be hastened by covering the area of the root system with an organic mulch (see 6.2). This should be done on the basis that it might take several years for the full benefits of treatments designed to improve a tree's rooting environment to be realised.

Mulching is the recommended method for improving soil physical conditions. There are a number of other options that may be used

under appropriate conditions, provided that care is taken to avoid severance of woody roots; these include:

- a) use of a soil auger, puncturing the soil throughout the root system to improve soil aeration;
- b) localized cultivation, e.g. by hand tools or air lances, involving backfilling with loose material;
- c) injecting bursts of compressed gas into the soil to alleviate compaction.

Any attempt to break up compaction in the soil could damage roots; disturbance of the soil should, therefore, be controlled so that major roots (i.e. 25 mm and greater diameter) are retained undamaged. Extensive cultivation such as ploughing or rotovation can cause severe damage to root systems and should be avoided within trees' rooting zones.

If infilling or backfilling is needed in association with the implementation of measures to relieve compaction, this should be with a coarse inert material (e.g. coarse sand, pea gravel, horticultural grit), possibly enriched with slow release organic fertilizer. The filling material should not be compacted but allowed to settle naturally and, as necessary, topped up to the desired level.

6.4 Removal/replacement of soil

Where the soil level has been altered within the rooting area of a tree, the following factors should be taken into account to determine whether any soil needs to be removed or replaced:

- a) the age, condition and species of tree and its tolerance to soil level changes;

NOTE 1 Some species, notably poplars, willows, London plane and the cypress-type conifers, can tolerate some soil being placed over their roots and they might respond by producing adventitious roots from the buried tissue.

- b) the length of time that the altered soil level has been in place;

NOTE 2 Removal of added material that has been present for a long time around a tree might result in water stress or bark and root death.

- c) the nature of any added material and how it was placed (i.e. loose-tipped or compacted by heavy machinery).

Investigation by hand tools should determine whether a healthy root system has extended into any added material; if so, the material should be left intact.

Where the alteration of the soil level has led to impairment of aeration, the soil in the affected area should be covered with organic mulch (see 6.2) or mechanically decompacted (see 6.3).

Where roots have been exposed or severed by removal of soil (i.e. by lowering the ground level), the tree should be assessed for stability. If the tree is found to be unstable, then appropriate action should be taken, e.g. pruning (Clause 7), propping (10.6), guying (10.7) or (if other measures prove impracticable) felling (Clause 12). If the tree is to be retained, the soil level should be restored to cover the exposed roots without compacting the soil. Mulch may be used where shallow coverage is required (see 6.2).

6.5 Irrigation/drainage

COMMENTARY ON 6.5

Established trees generally develop roots where water is available in the soil and can often thereby satisfy their water needs. In periods of drought they are generally able to adapt: some trees might shed their leaves earlier than usual, whilst others might be able to extract water from other parts of the soil.

The symptoms of too much water and too little water in the soil are generally similar; site investigations can help to identify the cause.

Excess water in the soil could occur due to unnecessary irrigation combined with natural precipitation, or from the inappropriate or excessive addition of bulky organic matter to the soil as a soil improver or as a mulch.

*This, particularly over a protracted period, can favour pathogens (e.g. *Phytophthora* spp.) that can kill roots and even whole trees.*

Irrigation should be applied to an established tree only when there is evidence that its root system is so short of water that the survival of the tree is threatened.

Irrigation should be applied so that it wets the greatest practicable proportion of the tree root volume over a period of several hours, by means of a controlled delivery system.

NOTE *Flooding water onto the soil surface leads to run-off, a waste of water and the tree remaining short of water.*

Where soil becomes persistently waterlogged due to impeded drainage or changes in site conditions, the excessive water should be removed from the soil either by the installation of a drainage system or by improving the movement of water through the soil by addressing causal factors such as compaction (see 6.3).

6.6 Nutrient deficiency

If there are symptoms of poor growth or decline, thorough investigations should be undertaken to find whether the soil conditions are inhibiting root activity, in which case the addition of nutrients would probably fail to provide any lasting benefit on its own. The potentially adverse factors to be investigated should include waterlogging, compaction, anaerobic conditions and the presence of toxins.

NOTE 1 *Poor growth in trees is often attributed to a deficiency of available nutrients in the soil. However, other causes can produce similar symptoms. These can include:*

- *pathogen activity killing roots;*
- *poor soil physical conditions;*
- *physical damage to roots, particularly during construction or engineering works;*
- *toxic chemicals in the soil;*
- *tree species unsuitable for the site;*
- *shortage of water.*

Chemical analysis of the soil will generally indicate which (if any) nutrient is lacking, or present at a level that could be limiting to growth, but does not necessarily show whether the nutrient is readily available. Chemical analysis of the foliage sometimes indicates an imbalance of nutrients in the tree.

Where chemical analysis of the soil has confirmed a nutrient deficiency, this may be addressed by an appropriate fertilizer regime, with materials being applied at the manufacturer's recommended rate(s)