

BS 3998:2010



BSI Standards Publication

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This British Standard supersedes BS 3998:1989, which is withdrawn.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

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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

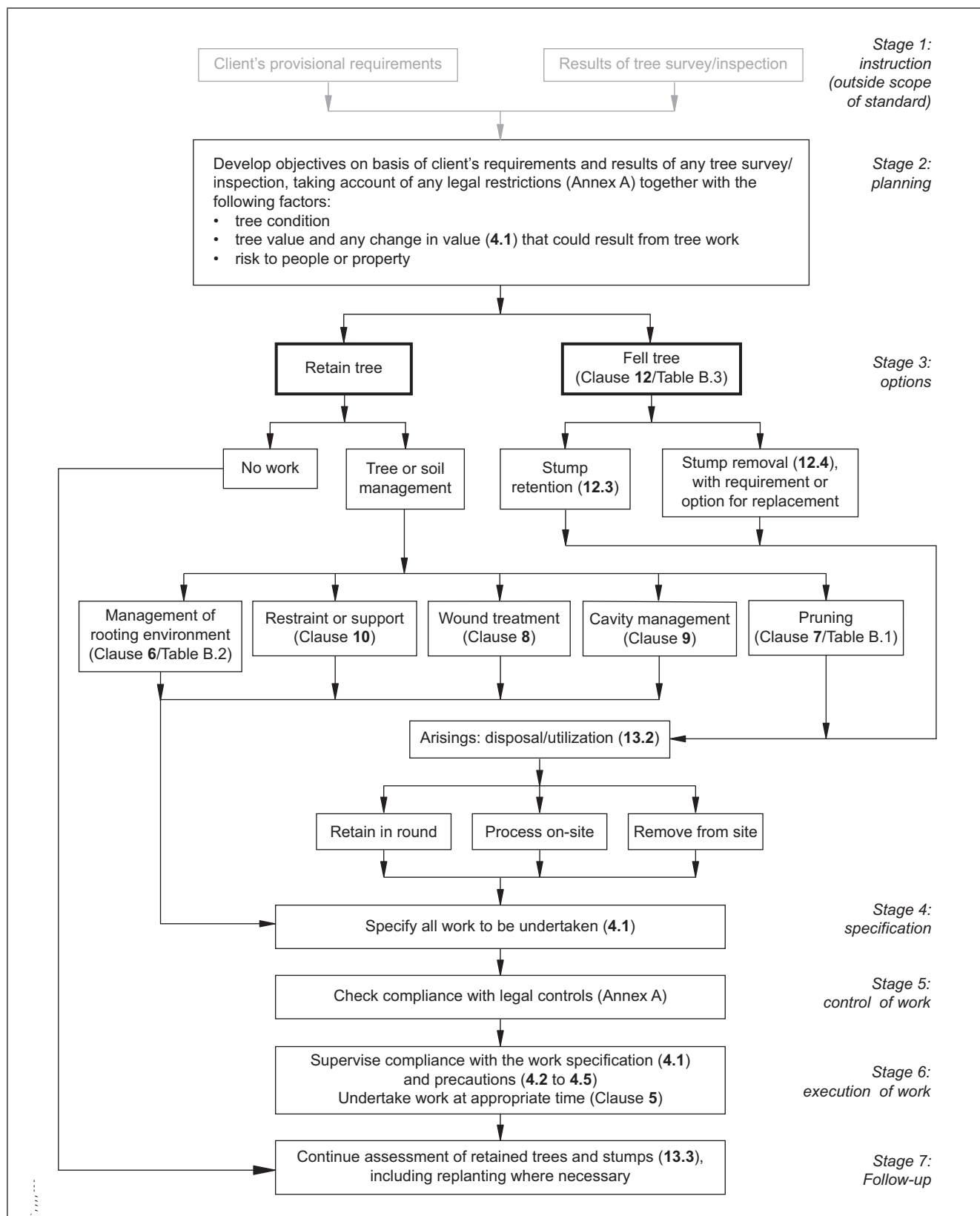
While tree work can be desirable to accommodate people's requirements from the tree and the land around it, any work that exposes the woody tissues is a form of damage that can be detrimental to the tree in the long term.

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)

where available. Care should be taken when using inorganic fertilizers to ensure that roots and associated mycorrhizal fungi are not killed or inhibited by localized high concentrations of nutrients. Non-bulky organic fertilizers (e.g. bonemeal) can be useful in providing a sustained supply of nutrients in a non-toxic form.

NOTE 2 Applications of fertilizers to trees have traditionally been made into holes augered into the soil, but soil injection of liquid fertilizers might provide a more effective distribution.

NOTE 3 Fertilizer applied to a site with herbaceous plants growing on it, particularly grass, is likely to benefit those plants in preference to the tree. Chemical removal of a sward might be appropriate as a short-term cultural operation to allow fertilizers to be available to the tree.

6.7 Other treatments

6.7.1 Soil additives

Organisms should be added to a soil only if there has been a rigorous investigation of conditions for root development and function, showing that this action could be beneficial. If the conditions are unfavourable, they should be ameliorated (see Annex B, Table B.2).

NOTE There are commercially available soil additives that contain preparations of mycorrhizal fungi. If such products contain fungal species that are suited for local conditions and compatible with the tree species concerned, they might help the establishment of newly planted trees in soils that are deficient in mycorrhizal fungi. At the time of publication of this edition of BS 3998, however, definitive evidence is lacking as to whether they will benefit established trees. They will not be of benefit if soil conditions are hostile to mycorrhizal development.

6.7.2 Treatment of contaminated soil

Where soil has been contaminated, expert advice on diagnosis and treatment should be obtained and appropriate action taken.

NOTE Treatments include application of water to advance the leaching process, application of materials to counteract the contaminant or, in severe cases, replacement of the contaminated soil (see Annex B, Table B.2).

Precautions should be taken, where soil needs to be replaced, to avoid damage to roots (see 6.4).

7 Pruning and related work

7.1 General

NOTE The principal options for addressing a range of management objectives are given in Annex B, Table B.1. It is expected that a choice from these options will have informed the work specification (see 4.1).

During the course of pruning, any work that would adversely affect the structural integrity and sustained growth of the subject tree or neighbouring specimens should be avoided as far as practicable. The work should be planned so as to minimize any potential diminution of the tree's aesthetic, ecological or other value (see Clause 4).

In order to help ensure that the tree has enough energy and remains sufficiently intact to resist disease and decay satisfactorily, the amount of leaf-bearing twig structure removed and the size of pruning cuts – both individually and collectively – should be kept to the minimum required to achieve the objectives (see Figure 1 and Annex B). If, on this basis, it would still not be possible to retain enough leaf area for satisfactory physiological function, the work should if possible be done in phases (see 5.4) to allow refoliation.

The work specification (see 4.1) should be observed with regard to any contingencies that might arise while the work is in progress.

The guidance in Annex C should be followed in cases where relatively severe pruning might be appropriate.

Except in specialist veteranization pruning (Annex C), care should be taken to avoid tearing or compressing retained wood and bark when a cut is made, and to prevent falling branches from harming other parts of the tree (including its roots), its surroundings, people or property.

7.2 Minimizing the potentially undesirable effects of pruning

COMMENTARY ON 7.2

The effects of pruning are influenced by many factors, of which some are related to the tree, and others to its environment or to the tools and techniques used. Potentially adverse effects include the development of disease, dieback, decay or future structural problems.

7.2.1 General

The timing (see Clause 5) and extent of pruning (especially regarding the number and size of wounds; see 7.2.4) should be determined by both the management objectives (see Annex B) and an assessment of the likely effects on the tree and its surroundings. The assessment should take account of species tolerances, the tree's age and condition (see 7.2.3) and any implications for the safety of other trees.

Where it is important to assess the energy levels of the tree, this may be done by means of a simple iodine staining test (see *A new tree biology/Modern arboriculture* [30, 31]). This test ascertains the concentration of starch in a sample from the last three sapwood increments taken from small cores representative of the whole tree.

7.2.2 Species and cultivars

The degree of pruning should be controlled according to the ability of the species to react defensively against wounding.

Members of the family Rosaceae, *Eucalyptus* spp. and other species with high susceptibility to the silver-leaf fungus (*Chondrostereum purpureum*) should be pruned only when their starch reserves are high, following good growing conditions during summer. (Information about the time of cutting and about a test for starch reserves is given in Clause 5 and 7.2.1 respectively.)

Except where the probability of structural failure would otherwise be unacceptably high, the following guidance should be observed when pruning species that are relatively susceptible to wound-induced decay.

- Wherever practicable, pruning should be restricted to healthy, small-diameter parts of the tree, as this will minimize the size of the resultant wounds and provide the greatest opportunity for these to be occluded (see 7.2.4).
- Species of *Betula*, which generally have particularly weak defences against the development of decay, should be pruned as sparingly as possible and without exposing heartwood or ripewood.
- The above guidance for *Betula* should be observed for any other species or cultivars known to have similarly weak defences.

In species which have relatively strong defences against decay but which produce non-durable heartwood or ripewood, at least two-thirds of the diameter of any cut should consist of wood that, according to characteristics of the species concerned, is assessed as still containing living tissue.

The shade-tolerance of the species being pruned and of any neighbouring trees should be taken into account, so that the tree(s) do not become excessively overshadowed by other foliage or by buildings as a result of being subjected to crown reduction (e.g. *Fagus sylvatica* is more shade-tolerant than *Fraxinus excelsior*). Conversely, pruning should be avoided if, by the removal of shading foliage, it would expose extensive areas of thin bark (including the bark of a neighbouring tree) to a high probability of sunscorch.

When there is a need to prune species which tend to produce a proliferation of very dense growth of weakly attached shoots from around each wound, the resulting branches should be managed by cyclic cutting at appropriate intervals, or selectively pruned while time is allowed for a stronger branch structure to develop (see also Annex C).

NOTE Selective pruning of densely growing new branches is, for example, often advisable in species of *Salix*, *Populus* and *Tilia*.

The capacity of the species or cultivar to retain viable shoots or dormant buds on increasingly old stems and branches, and/or to produce adventitious buds, should be taken into account when deciding where and how much to prune (see 7.2.4), so that the tree is more likely to develop new branches near all the pruning cuts.

7.2.3 Individual tree condition

7.2.3.1 Environmental and seasonal factors

Wherever feasible, pruning should be avoided at times when the disease- and decay-resistance of the tree is likely to be impaired by physiological stress induced by previous tree work, construction damage, or seasonal or weather-related factors, e.g. during or soon after a drought or when starch reserves have been depleted by spring flushing and flowering (see 5.2).

7.2.3.2 Age-related factors

NOTE Age is used as a loose term to reflect physiological condition and stage of tree development.

In deciding whether and how much to prune (see 7.2.4), the following considerations should be taken into account, in order to

make allowances for the likely influence of the age of the tree on the outcome of the work.

- Very extensive wound-induced decay can develop in older trees of species that contain a large proportion of ripewood or non-durable heartwood (see 7.2.4).
- In species that are highly susceptible to particular canker diseases, older trees can be especially vulnerable to infection by the pathogens concerned. A tree could, however, survive such infection if its stem is too large to be easily girdled by the cankers.
- Mature and old trees generally have a reduced capacity to tolerate the potentially adverse effects of wounding, especially with regard to the development of physiological dysfunction and decay.
- The older the stem or branch, the less capacity it generally has to produce new shoots from dormant or adventitious buds after pruning. The decline in this capacity varies greatly according to species (see 7.2.1).

If, due to site constraints or management objectives, there is a need to prune a tree so as to manage the size or shape of its crown, this should be started when it is young (formative pruning; see 7.4), so as to reduce the need for pruning in later life.

7.2.4 Deciding where and how much to prune

In order to ensure that the potentially adverse effects of pruning are avoided as far as possible (see 7.2 and 0.3), the cross-sectional area of the cuts individually and in total should be minimized as follows.

- Each final cut should be kept as small as possible, e.g. by cutting at an optimum angle (see 7.2.5).
- In order to select a branch for removal, the diameter of the final cut should generally not exceed one-third of that of the parent stem or branch. If the tree is old or declining, the maximum diameter of individual cuts should be even smaller, to allow for the relatively small proportion of sapwood and the slow rate of wound occlusion. This recommendation cannot be fulfilled in the case of co-dominant stems, but the removal of such a stem may be undertaken if the wound is small enough to become occluded rapidly.
- The number and size of cuts should generally be limited so that their total cross-sectional area does not exceed one-third of that of the stem, when measured at 1.5 m above ground level, as in the examples shown in Table 1, where the stem-diameter is 600 mm and the cuts are all equal in size. A lesser proportion should generally be adopted when pruning large-diameter veteran trees (see Annex C).
- If a stem or branch is to be shortened, the cut should be made distal to a union or group of unions where one or more healthy lateral branches bear enough foliage to sustain the parent stem or branch. If there is only one such union near the intended cut, the lateral branch should have as large a diameter as possible (i.e. at least one-third and preferably more than half that of the removed portion).
- In species which lack a durable heartwood or which have particularly weak defences against wound-induced decay, the guidance in 7.2.2 should be followed regarding the need to avoid, as far as possible, the exposure of the older, central wood.

Table 1 Maximum recommended number of cuts, according to size, on a tree of stem-diameter 600 mm

Size of cut (diameter in mm): four examples	Maximum recommended number (approx.) of cuts, for each size in the left-hand column (on this basis, no cuts of any other size could be created)
50	48
100	12
150	5
200	3

The removal of branches which are close together on a parent stem or branch should be avoided, unless the tree is young (see 7.4) or the cuts are so small as to be capable of being fully occluded, and therefore resistant to decay, within a few years. If such work cannot be avoided, the branches selected for removal should not be closely aligned within the tree's vascular system (e.g. in a vertical line). If this precaution is not compatible with long-term management objectives, the work could be phased over several seasons with a view to lessening its damaging effects.

NOTE If axially adjacent branches are removed, the resulting zones of dysfunction (and of any associated decay) often merge into an extensive column. This is especially likely to occur in species that often become rapidly and extensively decayed (e.g. species of *Aesculus*, *Salix*, *Populus* and some *Acer* spp.). In addition, the excessive removal of lower branches from a parent stem or branch might lead to increased swaying (see also 7.5 and 7.6).

For most forms of crown management, pruning cuts should normally be made at branch or stem unions so as to avoid the retention of stubs, which can die back and inhibit wound occlusion, or give rise to an undesirable proliferation of new shoots, e.g. in *Tilia* spp. Stubs may, however, be retained in order to encourage the formation of shoots in old trees, lapsed pollards (see 7.10) or damaged trees with conservation value. For these and certain other categories of tree, it is appropriate to use special procedures such as retrenchment pruning, for which the guidance in Annex C should be followed.

7.2.5 Deciding where to make the final cut (natural target pruning)

When a branch is removed at its point of attachment, injury of the wood and bark of the parent stem or branch above the cut should be avoided (see Figure 2) in order to help avoid colonization by decay organisms and pathogens. If a branch collar is visible, the final cut should be just outside it [Figure 2, R(a)]. If there is a branch bark ridge but no visible collar, the cut should be made with its top edge just outside the ridge and at right angles to the grain, unless experience indicates the need for a steeper angle (e.g. when the species or cultivar concerned tends to die back below right-angled cuts). The cut should in any case be more acutely angled where a co-dominant stem or branch is being removed, or where there is an acute union with included bark.

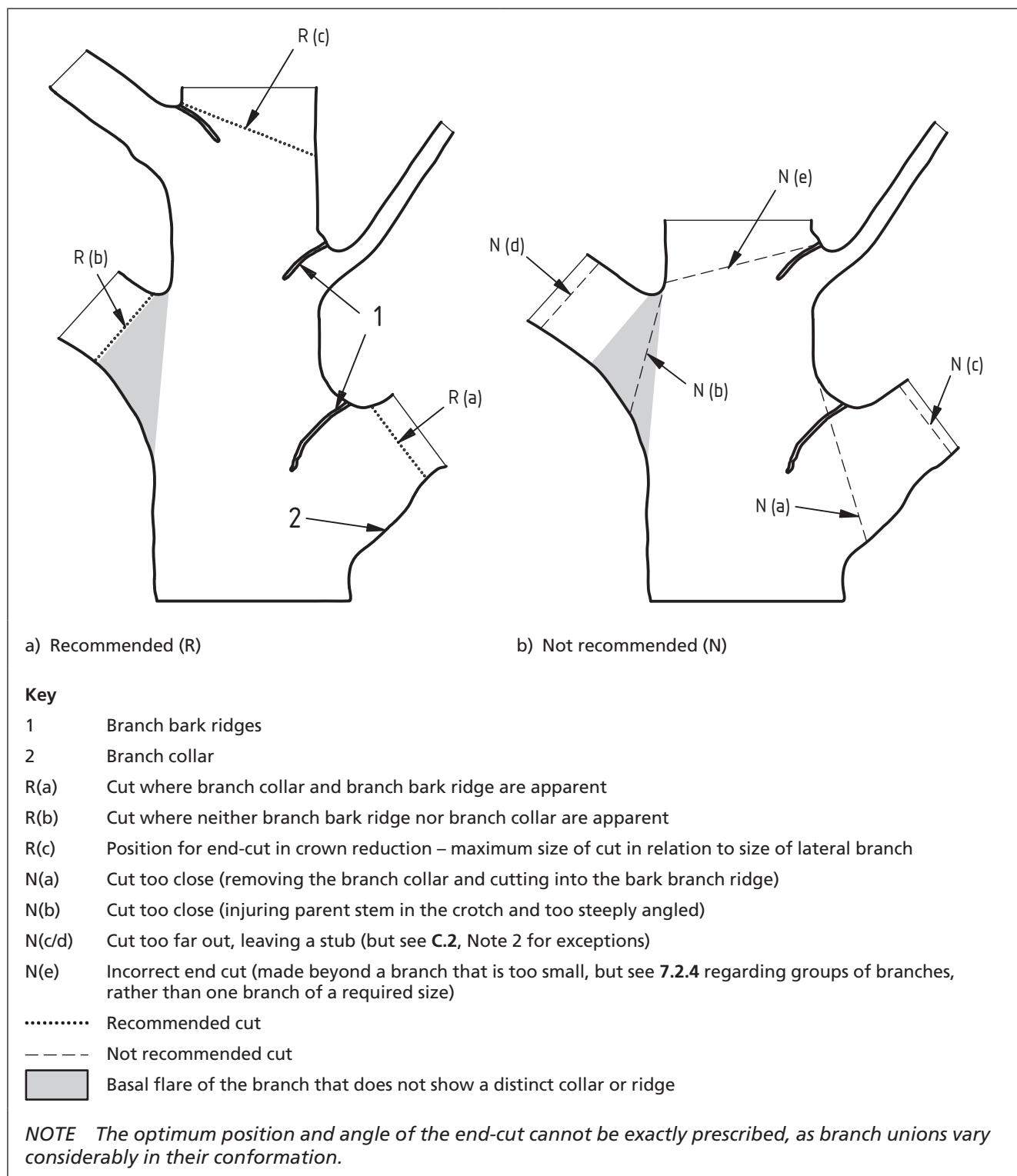
If neither a collar nor a ridge is obvious (e.g. on a tree with very fissured bark), the top edge of the cut should be just outside the basal flare of the branch and at right angles to the branch being removed [Figure 2, R(b)]. When shortening a stem or branch, the final cut should be just beyond and parallel to the distal end of the bark

ridge (if apparent) of a branch chosen for retention as indicated in Figure 2, R(c). If the species has whorled branches (e.g. *Pinus* spp.), the final cut should be at right angles to the grain, just distal to a whorl.

NOTE 1 Further guidance on natural target pruning is given in *A new tree biology* [30] and in *Modern arboriculture* [31].

NOTE 2 The treatment of pruning cuts is covered in Clause 8.

Figure 2 Positions of final cuts



7.3 Risk management of deadwood

7.3.1 General

When deciding whether dead branches or dead trees should be retained and, if so, to what extent they might need to be pruned, a balance should be made between mitigation of risk and the maintenance of wildlife habitats. The unnecessary loss of deadwood habitats should be avoided when specifying pruning or other works, particularly if legally protected species are using the tree (see Annex A). The following risk factors should be taken into account:

- the location (e.g. whether the deadwood overhangs a target that cannot be readily moved, such as a highway);
- the wood properties and decay-characteristics of the species concerned;
- the size of the deadwood.

7.3.2 Dead branches

COMMENTARY ON 7.3.2

The dieback and shedding of branches are natural processes within the development and ageing of trees, and provide essential habitats or places of shelter (i.e. decaying wood and cavities) for many species of fauna and flora.

In species that lack a durable heartwood, decay is likely to be rapid, whereas in species such as Pedunculate and Sessile oak, Sweet chestnut and yew, dead branches often remain hardened and undecayed for many years.

*If branches have died due to disease or to a pest infestation, their removal might be justifiable for sanitation in certain circumstances. There are, however, very few harmful organisms that can survive for long on dead branches and so it is generally not appropriate to remove them in the hope of removing an infection source ("sanitation pruning") except on specialist advice. In contrast, the sanitation pruning of living branches is an accepted means of controlling various diseases, such as cankers caused by *Nectria spp.**

Dead branches should be shortened or if necessary removed if they pose an unacceptable risk to people or property, and if other options (e.g. diverting a footpath) are not practicable. In assessing risk, attention should be paid to the rate of wood decay, particularly at the bases of the branches.

If it is appropriate to cut any dead branches, this should be done so as to avoid injury to living bark or sapwood, which could lead to the development of further dysfunction and colonization by decay fungi or pathogens.

7.3.3 Standing dead trees

Where standing dead trees are retained, their height should be reduced if this is required for mitigation of present or future risks. They should be inspected periodically and further work should be undertaken (either felling or progressive reduction, depending on practicability) if necessary to keep risks within acceptable limits.

7.4 Formative pruning

COMMENTARY ON 7.4

The main aim of formative pruning is to produce a tree which in maturity will be free from any major physical weaknesses and which will complement the management objectives for the site.

The term "formative pruning" can also be applied to more specialized practices, e.g. utility pruning (7.9.2), pollarding (7.10), cutting overgrown hedges (7.11), pleaching, the results of which are sometimes likened to a hedge on stilts, and more formal types of pruning, e.g. cloud pruning.

If, in order to influence the structure, shape or size of a tree crown, formative pruning has been started in the nursery, any pruning at or soon after planting should be kept to a minimum in order to retain an adequate leaf area. Formative pruning should normally be resumed three to five years later, but if the tree has been allowed to develop an unsuitable branch structure, some of the branches may be shortened or removed at an earlier stage of establishment. The early removal of all the lowermost branches should, however, be avoided if possible, as it could impair the development of a sturdy taper in the stem.

If branches need to be removed or shortened to deal with undesired patterns of growth, this should be done in stages so as not to remove too much leaf cover at any one time. Ideally, none of the selected branches to be removed should exceed 20 mm in diameter at the point of attachment to the stem. At least two-thirds of the height of the tree should always consist of live crown.

Within areas of high usage or formal plantings, potentially weak unions in young trees should be managed so that only one dominant stem or branch continues to grow from such a union. Where the total removal of an unwanted co-dominant stem or branch would create a large wound, it should instead be shortened, thus causing it to lose dominance.

NOTE 1 *Failure to manage co-dominant leading shoots might eventually lead to compression fork weakness and thereby necessitate premature felling so as to safeguard people and property.*

If two branches are crossing each other and likely to rub together, one of them should be removed or cut back so that further contact between the branches is avoided (see Clause 10 for restraint and support systems as an alternative).

NOTE 2 *If crossing branches are in contact with each other, frictional damage or altered growth patterns could eventually lead to loss of strength or possible fracture. When one of a pair of crossing branches is cut and the remaining branch would be left weakened and/or exposed and therefore likely to break, it might also need to be cut.*

7.5 Crown thinning

In crown thinning, an even density of foliage should be retained throughout a well-spaced and balanced branch structure which could, if required, provide an adequate framework for a possible future crown reduction. If the objective is to lessen the overall loading on a defective branch or stem, crown reduction and reshaping (see 7.7) should be chosen in preference to crown thinning.

NOTE 1 *Crown thinning is not the most suitable method of reducing the overall loading on a defective branch or stem, since it does not reduce leverage and sometimes increases the probability of branch failure. It*

is rarely a once-only operation. Repeat pruning might be necessary, particularly on species that tend to produce abundant epicormic shoots.

The percentage of the leaf-bearing twig structure to be removed in crown thinning should be kept to the minimum required to achieve the objective (see Annex B) and in any case should not exceed 30%. This percentage should be stated in the work specification. Material should be removed systematically from throughout the tree rather than from the inner crown only. Cutting branches back to the main stem should generally be avoided, although structurally weak or hazardous branches should be removed if there is no alternative. (See 7.4 regarding crossing branches.)

NOTE 2 Uneven thinning or over-thinning increases the probability of branch failure, either by creating gaps in the crown, or by removing shoots and secondary branches from the proximal parts of a branch and leaving twigs and foliage only at the tip (this is also known as lion-tailing).

7.6 Crown lifting

COMMENTARY ON 7.6

Crown lifting involves pruning to achieve a desired vertical clearance above ground level or other surface (see Figure 3). This is sometimes necessary to facilitate site usage.

If crown lifting involves the removal of branches which form a substantial proportion of the lower crown of a mature or old tree, the resulting wounds on the stem(s) have the potential to become the seat of extensive decay, which could lead to mechanical failure. Failure could also become likely in the short term, since branch removal can cause an immediate impairment of biomechanical properties.

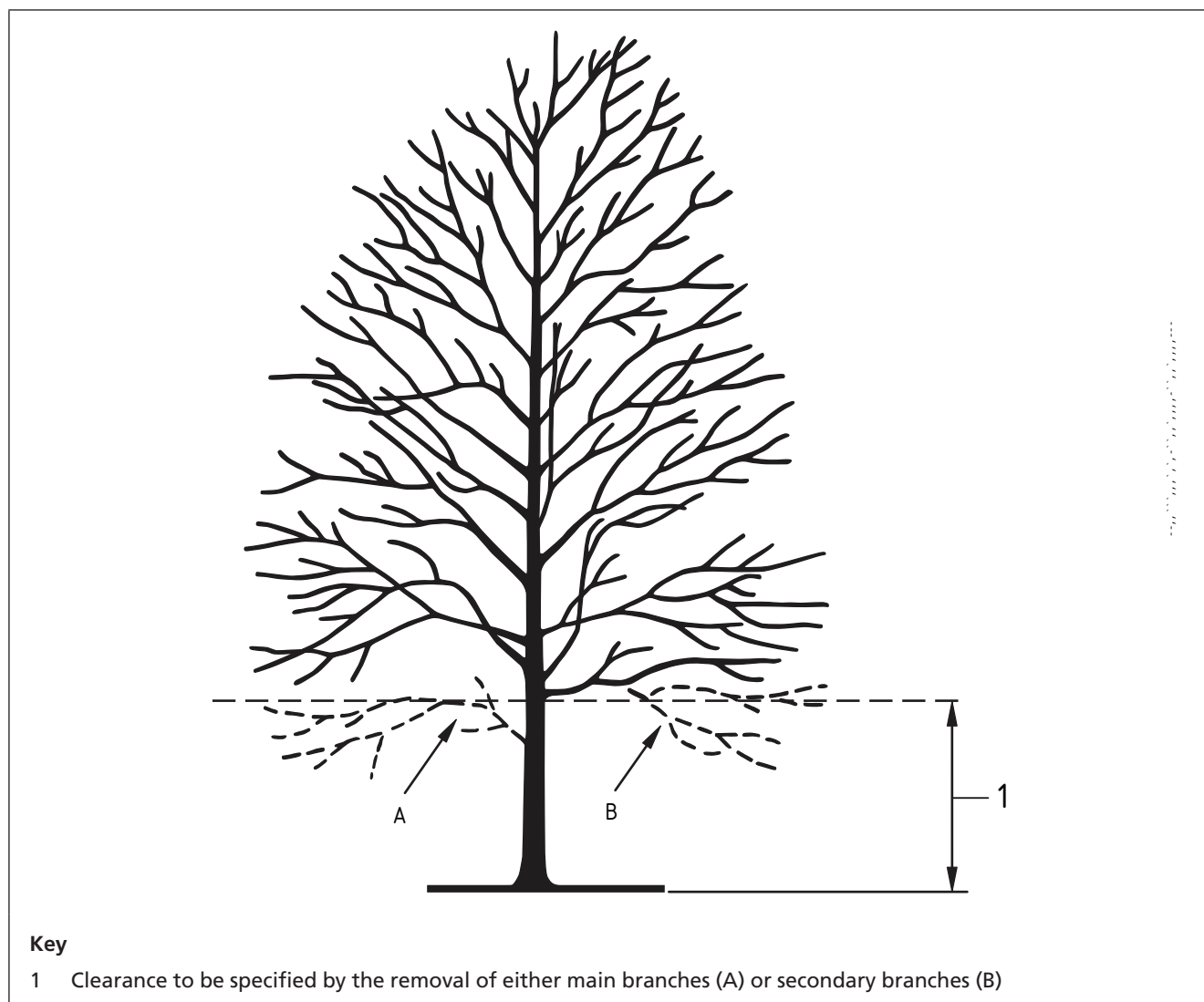
Extensive crown lifting should if possible be phased over a number of years, with a view to providing some opportunity for physiological and biomechanical adaptation to the resulting wounding and branch removal.

Crown lifting should be avoided or minimized in mature or old trees if possible, since it can increase the probability of stem failure. If it cannot be avoided, it should preferably involve the removal of secondary branches or branch shortening rather than removal of branches back to the stem, provided that the desired clearance can thereby be achieved. The choice of these options should take account of factors such as the size, growth-potential, branching habit and shade tolerance of the tree.

Crown lifting that involves cutting back branches to the stem(s) should preferably not result in the removal of more than 15% of the live crown height. Also, the remaining live crown should make up at least two-thirds of the height of the tree. Unless the objectives change, there should be no further crown lifting (except in the case of a young tree undergoing formative pruning; see 7.4), which would increase the effect of wounding on the stem(s) and the impairment of biomechanical properties.

NOTE For example, if the stem of a 20 m-high tree is branch-free to a height of 5 m, 15% of its live crown height (15 m) is 2.25 m. On this basis alone, the tree could be crown lifted to a height of 5 m + 2.25 m = 7.25 m, but the overall maximum is one-third of tree-height; i.e. 6.7 m.

Figure 3 Crown lifting



When specifying crown lifting, the points between which the clearance will be measured should be stated; for example, this may be from ground or roof level to the point of origin of the lowest remaining branch or the lowest remaining foliage.

7.7 Crown reduction and reshaping

COMMENTARY ON 7.7

Crown reduction alleviates biomechanical stress by reducing both the leverage and the sail area of the tree, and can allow retention of a tree in a confined space. It can also be used to create a desired appearance or to make the tree more suited to its surroundings. Unlike topping (see 3.28 and Annex C), it retains the main framework of the crown and therefore a high proportion of the foliage-bearing structure, which is important for the maintenance of vitality. Not all species or individual trees are appropriate candidates for reduction.

In crown re-shaping, the height and/or spread of one or more portions of the crown are selectively reduced, while not necessarily reducing the height and spread of the tree as a whole (see also 7.8 and 7.9.2 regarding the selective pruning of individual branches).

7.7.1 General

When assessing the suitability of a tree for crown reduction, particular regard should be paid to the characteristics of the species as well as the physiological condition of the individual tree. The extent of crown reduction should be determined on the basis of the management objective (see Annex B) and on an assessment of the ability of the tree to withstand the treatment.

The general principle is that, following reduction, there should still be a strong framework of healthy small-diameter branches and twigs (leaf-bearing structure), capable of producing dense leaf cover during the following growing season. In order to apply this principle, each tree should first be assessed so as to decide how much and where to cut (see also 7.2.4).

A crown should normally be reduced in proportion to its original shape, so as to avoid altering the balance of the tree as a whole, but the objective should not be to achieve symmetry for its own sake. The shape of the crown may be altered if there is a specific need to do so, e.g. for biomechanical integrity.

Due to its potentially negative effects, crown reduction should not usually be carried out in addition to other crown pruning operations, which would add to the amount of wounding and leaf loss.

NOTE 1 Although crown reduction should not be combined with systematic crown thinning, it often entails some degree of thinning due to the selective removal of branches at their points of origin.

Within the context of crown reduction, as opposed to topping, the cuts would normally expose a much smaller proportion of heartwood or ripewood than of sapwood and should not exceed 100 mm in diameter except on very large trees.

NOTE 2 Guidance on situations where a more severe crown reduction might be necessary is given in Annex C.

NOTE 3 Figure 4 shows a diagrammatic illustration of a tree before and after crown reduction, with the peripheral branches shortened or removed in a uniform and systematic manner, whilst preserving as natural a shape as possible.

7.7.2 Specification for crown reduction and/or reshaping

The specification should be accurate and clear, so that the desired result is achieved. To avoid ambiguity, the specified end result can be stated either as the tree-height and branch-spread which are to remain, or the average equivalent in branch length (in metres). End results should be specified for individual branches if the growth pattern of the tree creates a need for this, or where clearance from a specific object is required (see 7.8).

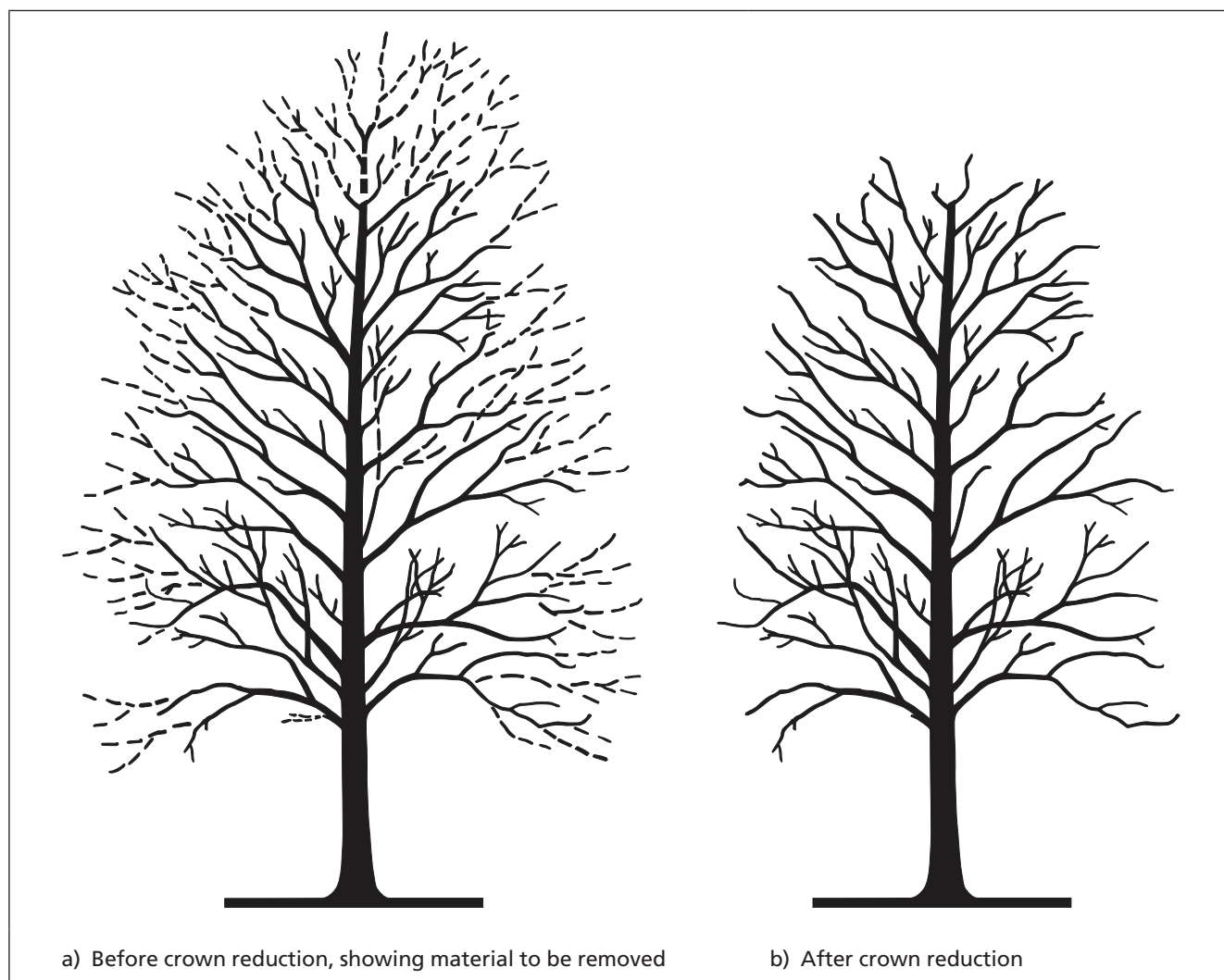
NOTE 1 Specifications for a percentage reduction are imprecise and unsatisfactory without reference to length, height, spread etc. A 30% reduction in crown volume can be considered to be approximately equivalent to a 12% reduction in overall branch length (i.e. radial distance).

NOTE 2 Specifications which state what will remain are normally used to enable verification, but, to assist implementation, may also be translated into what is to be removed (e.g. length of branch).

Annotated photographs should be provided where this would be helpful in describing the desired result.

When specifying crown reduction and/or reshaping to create clearance from another structure or tree (see 7.8 and 7.9), the points between which the clearance will be measured should be stated.

Figure 4 Diagrammatic illustration of crown reduction



7.7.3 Follow-up work after crown reduction or reshaping

Following crown reduction or reshaping, the crown should generally be managed in accordance with one of the following objectives:

- to continue a phased programme of further crown reduction (see also Annex C);
- to maintain the reduced crown as a framework for cyclic management, whereby the new branches are periodically cut back close to their points of origin (as in pollarding; see 7.10);
- to establish a new framework by "shoot renewal pruning", so that the crown attains a relatively natural appearance but remains smaller than before the reduction or reshaping.

To achieve the last of the above objectives, the new branches should be tip-pruned and thinned so as to encourage the growth of secondary branches, which should in turn be pruned and thinned as required to maintain the desired shape, size and density of crown.

The interval between the first crown reduction and the pruning of the new branches should be determined according to the following factors:

- the species of tree;
- the expected rate of shoot production, extension or growth of the individual tree;
- site-specific objectives, including any requirement to help prevent the biomechanical failure of any new branches that have become weakly attached.

7.8 Selective pruning

Branches should be individually removed or shortened only if a need is clearly established (in contrast, see 7.7.1 regarding symmetry for its own sake and see 7.9 for other options in relation to clearance from infrastructure). If such work is necessary, the amount of material to be removed and the diameter(s) of the pruning cut(s) should be the minimum required for the purpose. If selective pruning is assessed as adversely affecting the overall stability of the tree, additional pruning should be undertaken to alleviate this problem.

NOTE Specific objectives might include the removal or shortening of branches on one side of the crown interfering with buildings, landscape features or other structures, or the removal or shortening of branches that would otherwise probably fail.

If individual branches need to be shortened or removed so as to increase horizontal or vertical clearance from another feature, the work specification (4.1) should state the feature and the clearance to be achieved.

7.9 Pruning for infrastructure

7.9.1 General

In order to prevent trees from interfering with the efficient and safe use of infrastructure (e.g. utilities, street furniture and transport routes) pruning for clearance may be undertaken, according to the guidance for selective pruning (7.8). Other options should, however, be chosen if such pruning would make the shape of a tree so unbalanced as to compromise its mechanical integrity, or if it would be impracticable, even if repeated, for achieving the required clearance for trees directly underneath an overhead installation. The other options that may be chosen in such circumstances, depending on feasibility, are felling (see Clause 12), coppicing or moving the overhead installation.

7.9.2 Utility pruning

In areas where overhead electric conductors are present, trees may be subjected to crown reduction, reshaping and/or directional pruning so as to prevent interference with the electrical apparatus, or to remove an easy means of unauthorized access to electrical hazards (see Clause 4 and Engineering Recommendation G55/2 [32]).

NOTE Attention is drawn to the Electricity Act 1989 [33] in respect of the requirement to notify the electricity company or licence holder of any tree work to be undertaken within specified distances of overhead power cables. This Act also requires licence holders to follow good arboricultural practice when felling or cutting trees (or their roots). Guidance on working near overhead power cables is given in HSE Guidance Note GS6 [34].

Directional pruning should be chosen when the objective is to reduce or remove branches growing towards fixed apparatus or structures, while retaining other branches and helping to encourage new growth in the desired direction.

Utility pruning should follow the recommendations in 7.1 to 7.8, with particular regard to branch stubs from which newly developing shoots could soon interfere with overhead lines.

7.9.3 Thoroughfares and watercourses

Pruning on thoroughfares (including footpaths, bridleways, highways and railways) and watercourses should follow the recommendations in 7.1 to 7.8.

Cyclical pruning should be carried out where necessary to prevent obstruction to vehicular and pedestrian access or visibility, e.g. periodic removal of basal shoots and/or epicormic growth.

If, instead of pruning individual branches, mechanized cutting equipment is used to create or maintain clearances, caution should be exercised to minimize adverse impact on trees and to avoid creating hazards, e.g. by leaving partially torn-out branches or by injuring stems and thus creating conditions in which extensive decay can develop.

7.10 Pollarding

If pollarding is to be carried out, it should preferably start soon after the tree has become established and is between 25 mm to 50 mm in diameter at the selected height of pollarding (often 2 m to 3 m). The initial pollarding cut should be made at a height which reflects site usage but which, if possible, allows some of the pre-existing foliage to be retained, in order to maintain physiological function and thus reduce the probability of dieback or death.

If the tree divides into a number of stems or branches below a height of 3 m, these should be individually cut so as to initiate a “candelabra” framework.

If the stem has attained a diameter of more than 50 mm, but less than about 200 mm at 2 m to 3 m height, pollarding may still be initiated. The tree should be cut at or near the same height as a younger tree, but extra care should be taken to retain some existing branches. Larger trees should not normally be treated in this way (see Annex C for severe cutting for special purposes).

Once initiated, a pollard should be maintained by cutting the new branches on a cyclical basis. The frequency of the cycle should be decided according to site management objectives, species, age, condition and/or any product that might be required. Selective cutting, whereby some of the pollard branches are retained within each cycle, should be chosen if this would help to prevent dieback and decay in the stem.

Branches that grow after pollarding should normally be cut at their bases in order to encourage the formation of a knuckle after a number of cycles. If, however, the pollard cycle has been allowed to lapse over many years, the crown should instead be reduced (see 7.7) to the minimum necessary to fulfil current objectives. These could include the relief of any mechanical stress that would otherwise be likely to cause the stem to split apart.

Even if the stress on an old pollard branch is severe, it should not be cut back to the knuckle, since the removal of all its attached foliage would probably lead to physiological dysfunction and decay. It should instead be shortened by cutting just above a suitable lateral branch [see Figure 2, R(c)], or failing that, by retaining a live stub from which new shoots could grow.

If crown reduction would be insufficient to safeguard those branches that are most likely to fail, they may be reduced to stubs in one operation (a “pole thin”), while the remaining branches are shortened so as to retain enough of the leaf-bearing twig structure to sustain the tree.

NOTE Retention of live stubs on lapsed pollards will often help to reduce the risk of serious dysfunction and hence decay and weakness developing below the knuckles.

Cuts should be made below the knuckles only in exceptional circumstances, e.g. to prevent catastrophic failure.

7.11 Pruning of overgrown hedges

Pruning of overgrown hedges should be carried out in such a way as to minimize disfigurement and prevent dieback, and to allow the production of new foliage. Final pruning cuts should be made in accordance with 7.2.5. The timing of the work, and its impact on habitat and wildlife, should be determined in accordance with Clause 5.

NOTE Excessive pruning can be detrimental to certain species of hedging plants, especially conifers. BS 7370-4 gives recommendations for the routine maintenance of hedges.

7.12 Climbing plants

The control of plants climbing on or over trees should not be a routine aspect of crown maintenance. They may, however, be removed or cut back if this is considered necessary in the light of any of the following circumstances:

- a) the plant is hindering the visual inspection of a tree that could be posing a risk to people or property by virtue of site usage and the suspected presence of weak or decaying structures;
- b) the plant is growing high into the crown of a tree, so as to increase resistance to the wind;
- c) the plant is significantly weighing down a branch or a leaning tree;
- d) the tree is otherwise likely to be smothered (e.g. by *Clematis*, Russian vine or, occasionally, ivy), especially if it is old and therefore unlikely to outgrow the climbing plant;
- e) retention of the plant would be incompatible with the management objectives where trees are being managed in formal situations;
- f) there is potential for dead stems of the plant to become a hazard.

Any form of control of climbing plants should be undertaken with care so as to avoid undue damage to the tree (e.g. sunscorch) and/or the wildlife that might use the habitat (see 5.3). If a climbing plant is to be controlled, this should be done by removing it if necessary or otherwise by periodically cutting selected stems, so as to cause them to die back. Where it is desirable to prevent regrowth, chemical treatment might be appropriate (see 12.3.3).

NOTE For guidance on the management of ivy, the commonest climbing plant found on mature trees in Britain, see APN 10 [35]. Further guidance will be available in Ancient and other veteran trees: Further guidance on management [36], which is in preparation at the time of publication of this British Standard.

7.13 Removal of inappropriate objects

Objects which could harm the tree, or which are unsightly (e.g. wires, clamps, boards or old cable ties), should be removed whilst other arboricultural works are being undertaken, when this can be done without inflicting even greater damage on the tree.

8 Treatment of wounds and other injuries

COMMENTARY ON CLAUSE 8

This clause covers wounds caused by mechanical force, both intentional (including gnawing by animals) and accidental, and other injuries caused by, for example, extremes of temperature and agents such as pathogens and chemicals. Cankers (see 8.5) are often similar in appearance to wounds (8.2) but they are caused by bark-killing pathogens rather than by mechanical force. Also, a pathogen might colonize the tissues around a wound, so as to cause the formation of a canker larger in size than the original wound.

Injuries that affect the woody parts of a tree fall into two main categories.

- a) *Bark injuries, in which the underlying sapwood is exposed but not directly damaged (see 8.2).
A bark injury usually allows the affected area to dry out, so that the cambium and the outermost part (at least) of the sapwood become physiologically dysfunctional. The inner, living tissues of the bark around the injury also become dysfunctional. Fungi, bacteria and insects can readily colonize dysfunctional tissue.*
- b) *Injuries in which both bark and wood (sapwood, or sapwood and heartwood/ripenwood) have been cut, or where wood has been broken, splintered or otherwise damaged (see 8.3).
Such injuries are potentially more harmful than injuries in category a), since they damage the water-conducting cells of the sapwood. It is useful to subdivide such wounds that extend:
 - 1) *only into sapwood;*
 - 2) *into durable heartwood;*
 - 3) *into non-durable heartwood/ripenwood.**

For advice on decay and cavities, see Clause 9.

8.1 General

In dealing with injuries in a particular tree species, account should be taken of the resistance of the older central wood to fungal colonization (see 7.2.4).

If there is a high risk of an injury being colonized by a pathogen such as a canker fungus (e.g. *Nectria* spp. on rosaceous trees), an approved wound protectant (see 8.3) may be used, where available and proven to be effective for the tree species and type of pathogen.

NOTE 1 Wood decay is generally less significant for young trees (if well established) than for mature specimens, since young trees have greater potential to lay down new decay-free wood around a decayed zone.

NOTE 2 Provided that the tree is annually producing substantial increments of new wood, it will have the capacity to occlude wounds by the growth of new wood and bark around the wound edges. If in the meantime the exposed wood has become colonized by decay organisms, any decay will tend to be arrested when occlusion occurs. Occlusion of very large wounds is, however, not usually a realistic prospect.

8.2 Treatment of bark wounds

Wounds that involve the removal or displacement of bark at the base of the tree, e.g. by glancing blows or by gnawing mammals such as rabbits, may be treated in order to help prevent colonization by certain organisms, which could cause serious physiological dysfunction or decay. The extent of a basal bark wound should be taken into account when deciding whether to treat it, since harmful organisms are generally unlikely to colonize the wound unless it occupies a very large proportion of the circumference of the tree. A bark wound on a high branch is more likely to lead to significant dysfunction or decay, and treatment might therefore be justifiable if the wound is assessed as having potentially serious consequences for the health or biomechanical integrity of the tree.

If a large area of bark has become detached very recently, it should be held in place or replaced by a moisture-retentive wrapping in order to enhance the possibility of tissues regenerating naturally on the exposed surface(s). The wrapping should be removed when the outcome of the treatment has become apparent (i.e. the bark has reunited, callus has developed on the exposed wood, or the treatment has been unsuccessful).

Except when wrapping recently detached bark, any treatment of bark wounds should generally begin only when the position of occlusion growth is obvious. Any dead or loose bark should generally be retained as a potential wildlife habitat, unless it is restricting the growth of the occluding tissues, in which case it may be gently removed. If the margin shows any abrupt indentations or corners, these should be scribed with a sharp blade so as to create a smooth outline and thus to help avoid the development of bark inclusions, which could otherwise eventually trigger structural failure. The wound should not otherwise be enlarged.

Whether or not a bark wound is treated, any bark inclusions that are later found to have been initiated may be scribed. Also, any dead bark that has remained in place on an untreated wound may be carefully removed if it is later found to be assisting the development of potentially harmful organisms such as canker fungi.

If a wound girdles the stem or affects most of the circumference (as sometimes happens, for example, due to animal browsing, rubbing or fraying), it may be treated by bridge grafting, for which specialist skill is required (see *The grafter's handbook* [37]). In order to decide whether this is appropriate, the likelihood of success should be assessed by taking account of the tree species, the length of time since the wound occurred and the time of year (this method often succeeds best when undertaken during the dormant season).

8.3 Treatment of injuries that involve the wood

Generally, exposed wood should be left untreated. If, however, wounded sapwood is at risk of being colonized by a fresh wound pathogen, such as *Chondrostereum purpureum* (the cause of silver

leaf disease in rosaceous trees), an approved wound protectant should be applied to the fresh wound promptly; immediately if possible, in order to provide short-term protection while the wound remains susceptible. Such treatment should not generally be attempted on wounds older than about one month, since they are likely either to have been colonized already or to be no longer susceptible. Long-term protection against decay-causing organisms should not be attempted in the absence of any protectant that can provide adequate long-term persistence, penetration or adhesion.

If an injury has involved heat [e.g. from sunscorch following removal of shade (see 7.2.2) or from a badly-sited bonfire (see Clause 4.5)], the future management of the tree should take account of the possible development of extensive decay. The same applies if there has been a severe crushing impact (e.g. from a vehicle impact), or if the tree has been damaged by lightning and if such damage is assessed as creating conditions for the extensive development of decay.

If an injury involves cracking of wood sufficient to compromise the biomechanical integrity of the tree, a system of artificial support or restraint (see Clause 10) may be chosen in order to reduce the probability of structural collapse.

8.4 Exudation

The exudation of liquid from any part of a tree, often called “bleeding” (see APN 8 [28]) should be investigated, if necessary by a specialist, in order to ascertain whether control measures are appropriate. If the fluid is found to be xylem sap exuding from an injury, no attempt should be made to stop the flow, since such action is normally impracticable and could generally bring no benefit other than a reduction in the possible depletion of dissolved sugars (see Clause 5 for information on the season of pruning). Similarly, no action should be attempted if the exudation is occurring in response to fluid pressure within the sap stream. If, however, the cause is a disease such as a bleeding canker (see 4.3), sanitation (see 7.3.2) or other action may be undertaken according to specialist advice. If the cause is bacterial wetwood, diversion of the flow of fluid, which could be toxic, may be attempted in order to help protect susceptible tissues.

8.5 Cankers

Where an active canker has developed around an injury, and if treatment would be of benefit either in reducing the expansion of the canker or in reducing the production of inoculum, the dead tissues and a surrounding margin of apparently healthy bark should be removed with a sharp blade. Sufficient healthy bark should be left intact to maintain adequate translocation of sap.

Wood should generally not be removed in order to eliminate a canker pathogen. Such action may, however, be attempted according to specialist advice if it is ascertained that the pathogen is one of a number that can spread in the outermost part of the sapwood.

Care should be taken to avoid the transmission of pathogens (see 4.3).

If decay has been found during inspection of a canker, appropriate action should be determined (see Clause 9).

8.6 Root injuries

If, as a result of root damage, a tree has been assessed as posing an unacceptable risk to people or property, appropriate action should be taken (see 9.1). If the assessment has shown the tree to be suitable for retention, exposed damaged roots or those that have to be pruned should be cut so that the final wound is as small as possible and free from ragged torn ends.

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

9 Management of decay – cavities and water pockets

9.1 General

Where a tree is found to be so physically weakened, by cavity formation or other decay, that it poses an unacceptable risk to people, property or its own integrity, appropriate action should be taken to reduce the risk to an acceptable level. The management options available in such circumstances include:

- moving or modifying the target;
- tree work such as pruning (see Clause 7) or providing artificial support (see Clause 10);
- in the event of all other options being impracticable or otherwise inappropriate, felling (see Clause 12).

Additionally, cavity treatments (see 9.2) may be undertaken in order to help reduce the rate of further decay if this objective is assessed as being feasible and of significant benefit for the structural integrity of the tree. Where there is a need to deter human access to a cavity, some form of artificial closure or filling may be installed (see 9.3).

NOTE Filling cavities is not generally considered to improve the structural integrity of the surrounding wood and indeed might inhibit the development of pillar-like rolls of occluding wood, which provide natural strength at the edge of a cavity opening. A filling can also reduce the habitat value of the tree and/or hamper future inspection.

9.2 Management of cavities and water pockets

COMMENTARY ON 9.2

Once decay has begun in a tree, some forms of management might help to limit the rate or the eventual extent of the decay, while others might accelerate the process.

9.2.1 Dry cavities

If a cavity is dry it may be cleared of loose rubbish and rotten (soft) wood in order to assess its extent and the need for any further work.

NOTE Partly decayed wood can provide a food base for the survival and further development of wood-rotting fungi. Its removal or partial removal might therefore be of some benefit to the tree.

There should be no attempt to cut into or expose sound wood since the resulting wounds are likely to breach the tree's natural defences against wood-rotting fungi.

Decaying wood surrounding the cavity should be retained if it is likely to be the habitat of any rare or endangered species, especially those protected by law (see Annex A).

9.2.2 Wet cavities

NOTE See also 9.2.3.

Water-filled cavities should not be drained, since drilling drainage channels will breach defensive barriers, allowing decay to extend into previously sound wood. The retention of continuously wet and stagnant conditions helps to deter decay.

If the walls of a wet cavity are to be strengthened by the insertion of bolts (see 10.5), this should be done above the level at which water accumulates.

9.2.3 Water pockets

If a water pocket (3.32) is free from decay, no action should be taken.

If decay is present, the water pocket should be treated in the same way as a wet cavity (see 9.2.2).

9.3 Control of access to cavities

COMMENTARY ON 9.3

Open cavities are not a biomechanical problem in themselves, provided that the width of the cavity opening is judged to be within current biomechanical failure criteria (see Updated field guide for visual tree assessment [38]). Also, they provide essential habitats for many forms of wildlife (see 5.3).

If an open cavity is assessed as potentially attracting arson or other vandalism or as posing an unacceptable risk of harm to small children, some form of barrier may be installed so as to deter human access. Any such barrier (e.g. stout wire netting) should be inserted so that it cannot easily be removed. It should also, as far as possible, be designed and installed so as not to have any adverse effects on the tree (e.g. by interfering with natural occlusion of the cavity) or on wildlife that might be using the cavity. For these reasons, fillings should not generally be used to deter access. If, however, a filling has to be chosen as the only effective deterrent, it should be composed of non-toxic material.

10 Management of weak structures

COMMENTARY ON CLAUSE 10

Trees can develop in such a manner that they become increasingly susceptible to structural failure, possibly rendering them hazardous to people and property (see 7.4 for formative pruning). Weaknesses in a tree might develop because of damage caused by human activity (e.g. incorrect pruning), natural events (e.g. storms, damage to the bark by grey squirrels) or growth characteristics (e.g. tight forks, included bark). Eventual failure, if it occurs, is frequently precipitated by subsequent events, particularly wind and snowfall.

Where the problem cannot be addressed by pruning alone, the introduction of physical restraint into a tree, typically in conjunction with pruning, might reduce the risk of structural failure and/or lessen the risk of harm to people and property in the event of the restrained part failing. Such intervention can also help conserve the integrity of a tree's structure and appearance.

10.1 General

Structural weaknesses that have been identified should be evaluated in relation to their potential for failure, the target at risk, and the potential long-term effect of physical restraint on the tree.

To address the risk posed by a weak structure, one or more of the options described in the Note to **10.2** should be chosen to achieve an acceptably safe remedial treatment. Where remedial work would not allow the tree to be retained with acceptable safety for people or property, it should be felled (see Clause **12**).

10.2 Factors to be taken into account when choosing a restraint or support system

The following factors should be taken into account to determine which, if any, physical restraint or support is appropriate and how it should be installed:

- characteristics of the tree species;
- cause of the weakness;
- commitment and availability of resources to undertake the required continuing maintenance of the restraint or support system;
- current condition of the wood at the proposed attachment point(s) for the restraint;
- design of an effective system and how it could affect the movement of the restrained/supported part(s);
- load (e.g. imposed by the weight of the part of the tree that might need to be restrained/supported in the event of failure);
- physical properties of materials to be used (e.g. strength and durability) (see **10.3**);
- potential for damage to the tree;
- potential for future adaptive growth of the tree;
- probability of failure with or without the restraint.

NOTE *Appropriate restraint may be provided by one of the following:*

- a) *flexible restraint (10.4) – the installation of a flexible material, either synthetic fibre ropes or steel cables, to reduce dynamic loading on potentially weak structures and thereby to restrain excessive movement. This operation is normally accompanied by pruning to reduce the loading on weak structures in the tree (see Clause 7);*
- b) *rigid bracing (10.5) – the installation of solid rods or bolts into the tree to limit movement or to help support a weak structure;*
- c) *propping (10.6) – the provision of support from the ground or a solid structure to the underside of a branch or to a stem, sufficient to reduce the risk of fracture or uprooting of the tree;*
- d) *guying (10.7) – the provision of support for leaning trees and those with insecure rooting.*

Since this is a specialist area of arboriculture, the design, materials selection and installation of any form of physical restraint (particularly in the case of a complex installation, e.g. a multiple cable/rope system) should be undertaken only by an arboriculturist with relevant experience, an in-depth understanding of tree anatomy and physiology, and a working knowledge of the engineering principles.

10.3 Construction of restraint systems

A restraint system should have appropriate characteristics and strength, in order to ensure that the anticipated maximum mechanical stresses do not exceed the stated safe working load of the system or of the individual components.

Where more than one cable/rope is to be attached to a single bolt or sling, the components will need to be stronger than if only one attachment is made. The loads being supported should be calculated and appropriate components selected. Any such calculations should be retained in case of future issues to be addressed (e.g. following failure).

The component parts of a restraint system should be compatible, such that their strength properties are maintained for at least twice the stated inspection interval (see 10.9).

Where a multiple restraint system is used, the cables/ropes should be positioned so that they are opposed in a triangular configuration to distribute the loads evenly, but not so as to transfer excessive loads into the stem or a weak structure.

10.4 Flexible restraint systems

10.4.1 General

COMMENTARY ON 10.4.1

A flexible restraint is a system of cables, ropes or belts constructed within the crown of a tree to reduce the probability of failure of one or more structurally weak elements under excessive movement. Where desirable for the stimulation of adaptive growth, a degree of movement (low-load oscillation) can be maintained by the use of synthetic ropes or belts, rather than steel cables, possibly in conjunction with an energy-absorbing device.

The method of securing the restraint can be non-invasive (10.4.2) or invasive (10.4.3). At the time of publication of this edition of BS 3998, custom and practice are increasingly favouring the use of non-invasive systems, although only limited research has been carried out on the durability of the materials and the long-term effects of such systems on the tree.

A flexible restraint system should be designed to help prevent excessive movement [see 10.2, Note (a)] of a weak structure and, in the event of failure, to have sufficient strength to support the detached part of the tree.

NOTE 1 *Flexible restraint systems may be constructed using either ad hoc engineering components or proprietary systems, which are tailored on-site.*

Attachment of a flexible restraint to the vulnerable branch or stem should normally be approximately two thirds of the distance out from its base to its tip. The angle of the attachment should, as far as possible, be such as to minimize the stresses imposed on both the tree and the system. The stems or branches should be strong enough to withstand the maximum loads transmitted by the system (see 10.4.3, regarding the strength of wood at the places of attachment).

NOTE 2 *If a supported lateral branch is lifted by the wind, high snatch loads can occur in the cable or rope when it drops back into place.*

NOTE 3 *A flexible restraint attached to a lateral branch will provide support in a falling vertical plane, but the branch could remain susceptible to excessive side loading from the wind.*

When a flexible restraint system is installed, the vulnerable branch or stem should not be displaced from its resting position but, when the restrained part of the tree is at rest, the cable or rope should not be visibly slack at any time of the year.

Cables or ropes should not rub against each other or against fixings, or any part of the tree.

10.4.2 Non-invasive flexible restraint systems

Securing belts and slings should be positioned and constructed so that they do not slip or cause abrasion or constriction of the stem or branch to which they are attached.

Where a synthetic fibre rope forms part of a manufactured kit, it should be secured strictly in accordance with the manufacturer's recommendations.

Synthetic fibre ropes should incorporate some form of wear/damage indicator to assist with safety inspections.

The individual components used should be compatible with each other, and should have strength and elasticity that are appropriate for the total load to be supported and for the degree of restraint required.

NOTE 1 Some synthetic fibre ropes can stretch by up to 20%, making them unsuitable for certain installations.

Where the objective is to minimize outward movement between the supported sections of the tree, a steel cable may be used instead of a synthetic fibre rope, since steel will stretch less under tension.

NOTE 2 The properties of a synthetic fibre rope will to some extent relieve stresses that would be transferred to the tree during windy weather if a steel cable were used instead. This will generally allow more dynamic movement, which can stimulate supporting adaptive growth. These properties are, however, material-specific. To make additional allowance for seasonal weight variations and growth, and for forces imposed in the event of failure in the tree, some flexible restraint systems include an appropriately specified spring or shock absorber (energy absorber).

NOTE 3 Annex D illustrates the typical arrangement of components used in two alternative non-invasive restraint systems.

10.4.3 Invasive flexible restraint systems

Either of two types of invasive fixing may be used: eyebolts, which extend through the stem or branch, and screw eyes, which rely on gripping wood through part of the cross-section.

An eyebolt should be attached only where the strength of the wood is sufficient to prevent the assembly of eyebolt, washer(s) and nut(s) from being pulled out when the system is under load (see Annex D). In order to assess the strength of the wood in a partly decayed cross-section, use should be made of information obtained while drilling the hole for the eyebolt. In particular, the width of the residual wall of sound wood (see *Updated field guide for visual tree assessment* [38]) should be taken into account.

Screw eyes should not be used in large-diameter branches and stems, in decayed or damaged wood, or in soft-wooded trees (e.g. *Populus* spp., *Salix* spp. or *Aesculus* spp.) because, as they extend only part-way through the wood, there is greater potential for them to pull out of the wood and cause the restraint to fail.

NOTE 1 Annex D illustrates a typical arrangement of components in an invasive restraint system, and describes a method of attachment.

NOTE 2 Methods for securing eyebolts in woody cross-sections affected by decay are described in Modern arboriculture [31].

Pre-existing invasive flexible restraints should be appropriately maintained, and replaced if necessary (see 10.9).

10.5 Rigid bracing

COMMENTARY ON 10.5

A rigid brace involves the use of bespoke steel components inserted into a tree to prevent the independent movement of adjacent parts of the tree that form a weak structure. This helps to relieve stress on the weak structure, as in the case of a tight fork with included bark, or a split along the axis of a stem or branch (10.5.1). Rigid bracing may also be used to prevent movement of branches where they rub together (10.5.2) or to brace the walls of a cavity (10.5.3).

Parts of a tree that contain decayed wood are often unsuitable for bracing together using a rigid system, since the bracing rods are likely to pull out if the decay spreads into the sound wood in which the rods have been secured.

10.5.1 Tight forks and splits

If a tight fork or a split has developed (or is developing) at a fork, the rod(s) should where practicable be inserted at a point distal to the split, so that it does not pass through areas where the tree has formed internal barriers against dysfunction. Where installation through the split is unavoidable, nuts and washers may be used within the split as well as on the outside, if necessary.

When a tree would be disfigured or become unbalanced by the removal of one branch forming a tight fork, or by the shortening of a branch which has split axially, the two parts may instead be either held apart or bolted together (see 10.5.2).

10.5.2 Rubbing branches

COMMENTARY ON 10.5.2

Where branches grow close together, they can eventually start to rub as they increase in diameter or bend closer to each other. Movement of the branches in the wind then results in abrasion, which can eventually lead to fracture of one or both of them.

Where removal or pruning of one or both rubbing branches is unacceptable because of its impact on the structural integrity or appearance of the tree, abrasion should be limited either by securing the branches together, or by holding them apart using a metal rod or bolt.

A guide hole for the rod or bolt should be drilled in line through the two branches. The branches should then be either bolted together or kept apart either by locking nuts and washers, or by a spacer which should sheath the bolt. The bolt in turn should be secured on the outside by nuts tightened over washers. Ideally, all these washers should be countersunk on to the surface of the wood.

NOTE Annex D illustrates typical systems for securing rubbing branches.

10.5.3 Cavities

When bracing the walls of a cavity, the bolts or rods should be secured using nuts and washers. If there is a need to prevent inward collapse, the nuts and washers should be used inside, as well as outside, the cavity. Such work should not be undertaken without an assessment both of the mechanical effects of the brace and of the probable spread of decay via the holes needed to insert the bolts or rods.

10.6 Propping

10.6.1 General

Propping should be used to provide physical restraint where the alternative of removing a tree or branch would conflict with other management objectives or site usage.

Excessive upward support should not be applied, since it could adversely affect adaptive growth.

NOTE Further guidance is given in Principles of tree hazard assessment and management [22].

10.6.2 Propping branches

Propping may be used instead of pruning to manage long, heavy, low branches that are liable to fail. When deciding between these options, the factors to be taken into account should include not only the visual impact but also the size and location of the pruning wounds that might need to be created (see Clause 7).

Where a prop is used to restrain and support a structurally weak branch, it should be designed to reduce the probability of failure; not to replace the support of the branch in its entirety. The natural position of a branch to be supported should not be altered to accommodate a prop.

A soil mound may be installed in place of a conventional prop, if the circumstances are appropriate, in order to support a low branch, which could thereby serve as a natural prop for the tree, and to provide conditions whereby the branch might layer itself by producing adventitious roots. A low mound not in contact with the branch may be constructed if the objective is to allow the branch to come to rest naturally on the ground by bending but not so far as to snap off.

NOTE The retention of major branches that would otherwise fail or be pruned can be a critical factor in extending a tree's longevity.

10.6.3 Propping leaning trees

NOTE Some trees grow with an apparent lean, but they are usually stable if the prevailing environmental conditions do not change. However, many trees develop a lean as a result of sudden exposure to unusually strong winds or root damage. They can sometimes become stable, unaided, over a period of time but this process can be assisted by propping or guying (see 10.7), perhaps in combination with pruning (see Clause 7).

Where a leaning tree which has become unstable (e.g. a partially windblown tree) is to be propped, a firmly founded prop should be inserted, under sufficient compression to stabilize the tree. If practicable, the tree should be raised while the prop is positioned to ensure that it rests firmly on the prop when lowered back into its final position.

10.6.4 Prop design and materials

The design of a prop should take account of the location, appearance and other relevant site factors, and of all anticipated loads, both vertical and lateral.

A prop should be designed, founded and installed to restrict displacement of itself and the propped branch or tree. Abrasion or dislodgement should be prevented by appropriate design of the prop head, e.g. a cushioned "U" shape form.

The materials used should be durable, but should not constrict the propped part of the tree. The life expectancy of materials should be at least twice the stated inspection period.

NOTE Materials commonly used for propping trees or parts of trees include timber; scaffold poles and engineered devices, both of which can be adjustable; and built structures.

10.7 Guying unstable trees

COMMENTARY ON 10.7

In some instances (e.g. because of the height of the tree) it might be impracticable to use a rigid prop to support an unstable tree. A system of cables might then be an option if site usage permits.

Where the upper crown of a tree has flopped over as a result of wind or snow loading, it is unlikely that any form of visually acceptable artificial support can be designed that will overcome the distortion.

Any guying system should be designed in consultation with a specialist engineer. In order to provide adequate support, a system should usually include two anchor points with a 60° to 90° radial separation. Proprietary cables and anchors should be installed in accordance with the manufacturer's specification.

The cables should not cause damage to the tree at the point of attachment (see 10.4.1).

10.8 Fallen trees

Trees that have been partially uprooted may be managed so that they continue to grow. This may be achieved by means of pruning and/or artificial support.

NOTE Root plates left exposed are of benefit to local habitat even if the tree dies. Further guidance will be available in Ancient and other veteran trees: Further guidance on management [36], which is in preparation at the time of publication of this British Standard.

When determining options for management of fallen trees, the following factors, in addition to those in 10.2, should be taken into account:

- a) safety of people or property during the work and thereafter;
- b) available space, access to the site and land use (particularly if space is needed to accommodate guy ropes/wires or props);
- c) soil conditions;
- d) client's wishes and expectations (including cost);
- e) amenity or other value (e.g. wildlife value) of the tree.

Management of fallen trees should be undertaken by appropriately trained workers, because such work can be particularly hazardous

owing to the unpredictability of movement of the tree and the root plate as the weight distribution is changed.

The following options for management progress from minimal intervention to removal of the tree.

- 1) **Retention of the tree with root plate left in the upturned position.**
 - i) Where space and site usage permit and it is acceptable, fallen trees should be retained and allowed to regrow from the stem and main branches. In the long term, such trees should be encouraged to develop adventitious roots in a natural process of layering (phoenix regeneration) by mounding soil around branches and/or the stem.
 - ii) If the whole tree cannot be retained in its entirety, the root plate should be stabilized in the upturned position by filling the hole, possibly mounding the soil against the underside of the root plate, and retaining a long stump.
- 2) **Restoring the tree towards its original position.** Before attempting to re-erect a tree there should be excavation to accommodate the exposed roots. For larger trees, the crown should be reduced or removed in such a way as to allow the root plate to fall back into its hole. The root plate should be stabilized by either underground or overhead guying (see 10.7).
- 3) **Propping the tree.** If it is not possible to reposition a tree completely, propping should be employed where practicable to prevent or restrict movement, and to support the tree at an angle (see 10.6).
- 4) **Removing the tree.** If space is not available or other works are not practicable, then the tree should be removed (see Clause 12).

10.9 Inspection and maintenance of restraint and support systems

All forms of restraint in a tree should be inspected at intervals determined according to the materials used and the structure(s) supported, the condition of the tree and site usage. Additional inspections should be made in particular circumstances (e.g. after heavy snow and high wind events or after a change in site usage). When the initial installation of support is being considered, the client should be advised of these requirements and of the recommended frequency of the regular inspections. The default frequencies should be annual for a general ground-based inspection, using binoculars if required, and five-yearly for a detailed aerial inspection.

During each inspection, the following should be assessed:

- wear and tear or damage (e.g. slippage of wire rope grips, photo-degradation of soft materials or squirrel damage) affecting the materials used and their continuing fitness for purpose;

NOTE The frequency of inspection of synthetic fibre materials will normally be determined by the manufacturer's recommendations. Some materials will photo-degrade more rapidly than others, and this will have an effect on the safe useful life of the system.

- evidence of recent deterioration in the supported or supporting structure(s);

- adverse effects of the attachments of the restraints on the tree (e.g. chafing or constriction damage);
- the presence and extent of decay.

If a system is found not to be meeting the specified objectives, it should be adjusted, repaired or replaced as appropriate or alternative management options implemented.

11 Other attachments to trees

COMMENTARY ON CLAUSE 11

Trees have long been used, inappropriately, as convenient supports for fences (particularly wire fences wrapped around the stem), notice boards etc. More recently the items being supported have, for example, included CCTV cameras and security and ornamental lights. Also, lightning conductors are sometimes installed in order to protect valuable trees from damage during thunderstorms. If any of these items are incorrectly attached and then allowed to remain without routine inspection and adjustment, the tree can be progressively damaged (e.g. by constriction leading to dieback and even fracture of part of the tree distal to the attachment).

When making an attachment to a tree, whether for the benefit of the tree [e.g. restraining a wind-blown or unstable tree (see Clause 10)], or to secure a fixture, allowance should be made for radial growth in the part of the tree to which the attachment is made. Accordingly, there should be provision for necessary adjustments to be made, based either on annual inspections or a specified maintenance system.

Where lightning conductors are fitted to a tree, other metal components (e.g. metal bolts and cables used in a flexible restraint; metal rigid restraints; metal fixings for lights and cameras) should be connected to the conductor(s) to provide earthing for electrical currents that occur in a lightning strike.

12 Tree felling and stump management

12.1 General

Trees should be felled only if their removal or coppicing is assessed as providing the best solution in the circumstances. In making this assessment, account should be taken of:

- the potential impact of exposing retained trees;
- the potential for indirect damage, e.g. to underground services, or to built structures including archaeological features;
- destabilization of slopes due to the removal of support from tree roots;
- the potential for direct damage caused by either tree felling or stump removal;
- the potential for tree failure.

Since it is difficult to predict the occurrence of indirect damage, appropriate specialist advice should be sought.

NOTE 1 *Consents might be required from the relevant authority before trees are felled, e.g. protected trees and in relation to protected species, e.g. bats and the Violet click beetle (see Annex A).*

If a tree is to be felled, an appropriate stump management option should be chosen, taking account of the client's wishes, the expected future use of the site and the advantages and disadvantages of stump retention. Particular account should be taken of trip hazards, conditions favouring development of pests and pathogens, and retention/creation of habitats. The options are:

- a) stump retained:
 - 1) alive (12.3.2);
 - 2) dead (12.3.3);
- b) stump removed (12.4).

NOTE 2 The options for stump management, with a description of the advantages, disadvantages and possible management implications, are given in Annex B, Table B.3. It is expected that a choice from these options will have informed the work specification (see 4.1).

NOTE 3 Where the objective is removal of a tree but retention of the stump and major roots, the production of root suckers from the remaining root system (e.g. in various species of Prunus, Populus and Robinia) might be a problem (see 12.3.1 and Annex B, Table B.3).

NOTE 4 Guidance on fallen trees is given in 10.8.

12.2 Tree felling

NOTE 1 Standing trees may be treated before felling to prevent root sucker development (see also 12.3.3). Guidance on treatment is given in The use of herbicides in the forest [39].

A tree should be felled in one piece only when there is no significant risk of damage to people, property or protected species (see Annex A). Where restrictions (e.g. lack of space, buildings, other features, land ownership or use, or other trees which are to be retained) cannot be overcome, trees should be dismantled in sections (see 4.4). This also applies where a tall stump is being retained but where branches are to be removed/pruned.

Extensively decayed trees can be unpredictable when they are being felled, and special precautions should therefore be taken, such as the use of a winch to guide the direction of fall.

NOTE 2 Guidance on the use of winches is given in AFAG 310 [14].

12.3 Stumps to be retained

12.3.1 General

Stumps may be either retained alive, in order to allow regrowth to occur (12.3.2), or killed (12.3.3).

Stumps for long-term retention should be cut at a height and left in a condition determined by the management objectives and/or site-specific restrictions.

NOTE 1 This will often involve cutting as close to the ground as possible, e.g. in order to prevent a trip hazard or form a new coppice stool (12.3.2). Retention of taller stumps can be appropriate in other circumstances (see Annex B, Table B.3).

NOTE 2 Most broadleaved tree species and a few coniferous species (e.g. yew) will produce new shoots when stumps are retained after felling. Such regrowth might be acceptable, or even desirable in some situations,

but if left unchecked the shoots will develop into mature trees similar in proportion to, or even larger than, the original tree. These could be coppice shoots (i.e. from the cut stump) or root suckers.

12.3.2 Stump retained for coppice regrowth

COMMENTARY ON 12.3.2

Coppicing is a traditional method of managing certain species (e.g. Sweet chestnut) in order to promote the formation of multiple stems from near ground-level for use as wood products. (See The silviculture and management of coppice woodlands [40].) Some of these species (e.g. Common hazel) often grow naturally in this manner. In lapsed coppice, i.e. where stems have not been cut for a long time (e.g. more than 50 years for most species; 40 years for hazel), the stems can fail, thus weakening the physiological condition of the stool. Coppice that has been managed on a regular cycle is not expected to pose any problems, provided the cycle is maintained and cuts are made above the origin of each stem.

In order to create a coppice stool, a maiden tree should normally be cut near ground-level, unless experience (e.g. with particular species, on sites subject to flooding or with trees over a certain age) indicates that this would result in little or no new growth.

NOTE *Where coppice stems originate at or below ground-level, they are likely to develop their own roots and thus to have good stability. Also, by cutting the maiden stem near ground-level, the foodbase for butt-rot fungi is minimized.*

When the regenerated stems are subsequently managed for coppice, they should generally be cut just above the height of the last cuts, leaving short stumps. The creation of new coppice stools and cutting of existing coppice shoots should be undertaken during the dormant season (between late autumn and early spring), as this tends to give the best results with regard to the survival of new growth.

Appropriate protective measures should be taken where necessary to prevent animals from browsing the new coppice shoots.

12.3.3 Stump killed and retained

Where it is desirable to kill the stump, one of the following options should be used.

- a) Apply translocated herbicide directly to the stump surface (including the bark) as soon as possible after felling, and also to any new shoots that might develop. All herbicides should be used strictly in accordance with manufacturers' recommendations, and also with extreme caution where there is a risk of other plants being affected.

WARNING. Those chemicals capable of killing trees or other plants could also be toxic to humans, livestock or other non-target species.

NOTE 1 *Guidance is given in The use of herbicides in the forest [39]. Translocated herbicides only act with sap flow, and will not work in the dormant season.*

NOTE 2 *Attention is drawn to the Control of Pesticides Regulations 1986 [41]. The list of currently approved pesticides for this use can be checked against the latest Pesticides Safety Directorate (PSD) list (see*

www.pesticides.gov.uk). Attention is also drawn to the Control of Substances Hazardous to Health Regulations 2002 [24].

NOTE 3 Some chemicals entering the soil will migrate and could be absorbed by plants including trees to be retained, which could be killed as a result. Plants receiving a sub-lethal dose could produce abnormal growth and progressively recover over two or more years.

- b) Remove any new growth from the stump (e.g. cut or break off) as soon as it appears. This should be continued (if necessary over several years) until shoots are no longer produced.

A tree stump may be retained as a habitat or a carved or sculpted feature, provided that it is appreciated that, even if such an object is treated with preservatives, it will have a limited life because of the development of decay-causing organisms via the roots.

12.4 Stumps to be removed/destroyed

12.4.1 General

If, owing to its location, a stump is considered to be a significant trip hazard or a source of a pathogen (e.g. certain *Armillaria* spp.) that could affect retained trees, it should be either removed or destroyed. If there is a delay between felling and stump removal, the stump should meanwhile be left in a condition that keeps the site safe. Destruction of the stump by burning is not recommended.

NOTE 1 Attention is drawn to wildlife protection legislation (see Annex A).

NOTE 2 It is not normally practicable to remove the whole root system or even all of the major roots. The methods detailed in 12.4.2 to 12.4.4 might be appropriate in different situations. Dead roots rot slowly and their place is usually taken by fine soil particles. Soil collapse is therefore very unlikely to occur.

12.4.2 Digging out stumps

Stump removal by digging out should include disposal/utilization of the woody material (see Clause 13).

NOTE Whether done by hand or machine, digging out can cause severe disturbance of the site.

Where possible, when winching out a stump, a ground or other anchor should be used rather than a tree to be retained. If there is no alternative to using such a tree as an anchor, appropriate protective measures should be adopted.

12.4.3 Stump grinding

The reason for grinding the stump should be ascertained and the appropriate depth of operation agreed. Stump grinding should normally extend through the base of the stump leaving the major roots disconnected if the intention is to reduce the potential for the spread of Honey fungus.

The grinding residue should be treated as arisings (see Clause 13) and their use or disposal specified.

NOTE Mechanical destruction of a stump by stump grinding is less disruptive to the site than digging out.

12.4.4 After stump removal

The hole left by stump removal, whether by digging out or grinding, should be filled with soil or other material. The filling should be appropriate for future site usage, and for any surface treatment that is to be installed.

Where future plant growth is desired, the backfill material should be firmed in 150 mm layers by treading, avoiding excessive compaction and destruction of the soil structure.

13 Completion of work

13.1 General

The site, including any retained arisings, should be left in a condition appropriate for its intended usage as specified and agreed with the client, and with attention being paid to safety (see Clause 4).

13.2 Disposal, utilization and retention of arisings

COMMENTARY ON 13.2

Retaining arisings on or near the site can have conservation benefits and allows the gradual recycling of the mineral nutrients and carbon that they contain.

Before any work on a tree commences, it should be agreed what is to happen to the arisings (e.g. retained or removed from site). Any arisings remaining on the site should be stored safely in locations agreed with the client.

The following should be taken into account when deciding what is eventually to be done with the arisings:

- a) site usage: access, space and safety;
- b) scope for utilization (e.g. use of woodchip for fuel);
- c) wildlife and habitat, particularly where veteran trees are present;

NOTE 1 The presence of veteran trees, especially those that are ancient, is a factor in decision-making because certain invertebrates and fungi associated with fallen or cut deadwood occur only where such trees have been continuously present for centuries.

NOTE 2 Wherever wood stacks are created, they are attractive to deadwood-inhabiting insects. Where these are likely to include endangered species and where the material is to be used as firewood, it needs to be located away from sources of potential colonization. See Annex A. Further guidance will be available in Ancient and other veteran trees: Further guidance on management [36], which is in preparation at the time of publication of this British Standard.

- d) amenity;
- e) pest and disease management/encouragement of beneficial organisms;
- f) potential for damage to the site and adjacent property.

Arisings may be retained intact, utilized (e.g. by chipping) or stored for composting and/or mulching, or converted into a useable product, preferably on site. If practicable, arisings, particularly large-diameter timber, should be retained intact in order to avoid destroying potential wildlife habitats.

Arisings should not be disposed of by burning on site (see 4.5 for precautions) unless:

- 1) other options are impracticable; or
- 2) the material is affected or likely to become affected by a disease or pest for which sanitation is a necessary form of control.

NOTE 2 Attention is drawn to regulations made under the Plant Health Act 1967 [42], the Weeds Act 1959 [43] and the Wildlife and Countryside Act 1981 [44], in respect of prevention of the spread of plant and soil pests. See also Annex A.

13.3 Follow-up work

If follow-up work is appropriate, it should be specified (see 4.1) and recorded for the client's information. Examples of follow-up work include the inspection of trees and stumps, observed defects or restraint and support systems.

Annex A (informative) The law affecting tree work

A.1 General

Trees in any location might be protected by legislation for various reasons including amenity, biodiversity or to avoid unnecessary tree loss. Work to or near trees might also be affected by legislation (e.g. to avoid disturbance to bats or birds) or codes of practice (e.g. NJUG guidelines to avoid damage to trees during installation of underground or overhead services [45]). Summary information on legislative controls is given in Table A.1.

Substantial penalties can be incurred for contravention of legal protection.

Attention is also drawn to legal rights and liabilities under common law, which need to be considered when proposing tree work or developing management plans.

Where tree work is associated with proposed development, see BS 5837.

Table A.1 Tree and habitat protection – Legislation and sources of information

Subject	Applicable legislation/sources of information (all legislation as amended)		
	England and Wales	Northern Ireland	Scotland
Tree preservation orders and conservation areas	Town and Country Planning Act 1990 [46] (and associated regulations)	The Planning (Northern Ireland) Order 1991 [47] (and associated regulations)	Town and Country Planning (Scotland) Act 1997 [48] (and associated regulations)
Felling licences	Forestry Act 1967 [49] Forestry Commission (www.forestry.gov.uk)	N/A	Forestry Act 1967 [49] Forestry Commission (www.forestry.gov.uk)
Habitats regulations	Wildlife and Countryside Act 1981 [44] Conservation of Habitats and Species Regulations 2010 [50] Countryside and Rights of Way Act 2000 [51]	Wildlife (Northern Ireland) Order 1985 [52] Conservation (Natural Habitats, etc) Regulations (Northern Ireland) 1995 [53] Environment (Northern Ireland) Order 2002 [54]	Wildlife and Countryside Act 1981 [44] Conservation (Natural Habitats etc.) Regulations 1994 [55] Conservation of Habitats and Species Regulations 2010 [50] Nature Conservation Act (Scotland) 2004 [56]
Statutory nature conservation organization ^{A)}	Natural England (www.naturalengland.org.uk) Countryside Council for Wales (www.ccw.gov.uk)	Northern Ireland Environment Agency (www.ni-environment.gov.uk)	Scottish Natural Heritage (www.snh.org.uk)

^{A)} For information on bats and birds, see A.2.2.

A.2 Statutory legislation

A.2.1 Trees and hedgerows

Local planning authorities can make tree preservation orders (TPOs) to protect trees in the interests of amenity¹⁾. TPOs can protect individual

¹⁾ www.communities.gov.uk/treesandhedges

trees as well as woodlands. The orders have the effect of preventing the cutting down, topping, lopping, uprooting, wilful damage or wilful destruction of trees, except in certain circumstances, other than with consent of the local planning authority. The relevant local planning authority can be contacted for further information.

In conservation areas, trees of a diameter greater than 75 mm, measured at a height of 1.5 m, are automatically protected. Except in certain circumstances, notice of intent is required to be given to the local planning authority before work is carried out. The relevant local planning authority can be contacted for further information.

Even when no specific legal protection exists, it might be necessary to obtain a felling licence (see Table A.1) or consent under the Hedgerow Regulations 1997 [57]. Felling licences are required (except in certain circumstances) if the volume of timber to be felled exceeds specified amounts.

A.2.2 Hedges

Disputes can arise where the height of a neighbouring hedge adversely affects the reasonable enjoyment of a domestic property²⁾. Guidance is available (*Hedge height and light loss* [58]) which will help to assess an appropriate height for evergreen hedges to avoid undue restriction of light in a domestic situation.

A.2.3 Wildlife, habitat and plant health

Legislation protects species of flora (e.g. lichens) and fauna, including bats and birds.

Where there is evidence that bats, birds or other protected species are present, the statutory nature conservation organization needs to be consulted before starting any work. General advice on bats can be obtained from the Bat Conservation Trust (www.bats.org.uk) and on birds from the Royal Society for the Protection of Birds (www.rspb.org.uk). Guidance is also given in Arboricultural Association Guidance Note 10 [59].

Orders can occasionally be made, under the Plant Health Act 1967 [42]³⁾ (for Northern Ireland: Plant Health Act (NI) 1967 [60]), to control the spread of specified pests and pathogens. Orders can control the movement of plants and material and impose fees for certain work. For up-to-date information, refer to the websites of the Plant Health Service (www.fera.defra.gov.uk/plants/plantHealth/) and the Forestry Commission (www.forestry.gov.uk/forestry/HCOU-4U4J4J).

A.2.4 Development and planning conditions

Even where planning consent has been granted, local planning authorities might need to be consulted before work is carried out on, or affecting, trees that are protected by a tree preservation order, growing in a conservation area or are protected by a planning condition. Guidance is given in *Tree preservation orders: a guide to the law and good practice* [61] and Circular 11/95 [62].

²⁾ www.communities.gov.uk/treesandhedges

³⁾ www.forestry.gov.uk/forestry/inf-d-5azlca

A.3 Common law claims and litigation concerning trees

A.3.1 General

Problems caused by trees can result in disputes giving rise to common law claims and litigation, especially where trees grow across the boundaries of properties. These problems can result from root activity, from branches touching buildings and from the failure of structural weaknesses in the tree, which might sometimes result in harm to people or property. Foliage can restrict sunlight and/or natural light or be overbearing, or branches can interfere with the use and enjoyment of neighbouring land.

There are established legal remedies to deal with branches growing over neighbouring land. These might still require consent through other protection regimes. Legal advice needs to be sought when trees could, or have, become a problem.

Planned management can minimize the possibility of litigation in the short term. As trees grow, mature and decline, their condition can change and their management might need to be reviewed.

A.3.2 Trees on boundaries

The potential for future conflict can be reduced if new planting is planned to anticipate both the likely encroachment of roots and the overhang of branches of the fully grown tree, relative to the site boundary.

The possibility of direct physical damage to boundary fences and walls can be avoided by allowing room for growth and movement.

Annex B (informative) Management options

B.1 Deciding which type of pruning is appropriate

Table B.1 presents a number of pruning options, with cross-references to the relevant subclauses in this British Standard, and suggests how appropriate these might be to meet a variety of stated management objectives. The ratings shown in the table reflect only the ability of each pruning option to meet the management objectives; in practice the option selected, and the degree to which it is carried out, will need to be balanced by other considerations such as the health, longevity and amenity value of the tree.

B.2 Soil amelioration or remediation

Table B.2 presents a number of options for soil amelioration or remediation, with cross-references to the relevant subclauses in this British Standard, and suggests how appropriate these might be for a range of problems.

B.3 Tree felling and stump management

Table B.3 presents the options for stump management, showing the advantages and disadvantages of each option together with possible management implications.

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
	disease or pest control	—	**	—	—	**	**	—	—	—
To protect people or property from:	tree failure	***	***	—	***	X	***	***	**	X
	storm-damaged branches	*	***	—	—	X	X	**	X	—
	subsidence of land	—	—	—	**	X	***	***	X	—
	roads, paths, railways, waterways and signage	—	—	***	***	X	***	**	X	—
To prevent interference between trees and infrastructure, in particular:	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									

Key

*** Often appropriate

** Occasionally appropriate

* Done mainly for other reasons but of indirect value

X Inappropriate

— Not applicable

^{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).

Table B.2 Root and soil problems: options for amelioration or remediation

Problem ^{A)}	Options for amelioration or remediation						
	Mulching (see 6.2)	Aeration/ decompaction (see 6.3)	Removal/ replacement of soil (see 6.4)	Irrigation (see 6.5)	Drainage (see 6.5)	Fertilizer application (see 6.6)	Other treatments (see 6.7)
Contamination of the soil							
Pesticides	**	**	*	**	—	—	*
Pollutants	**	**	**	**	—	*	**
Excess fertilizers	**	—	*	**	—	—	*
Soil–water relations							
Flooding	—	**	—	—	**	—	—
Drought	**	—	—	**	—	—	—
Alteration of soil level							
Compaction of the soil	**	**	—	—	—	—	—
Raised soil levels	—	**	**	—	—	—	—
Erosion of the soil	*	—	**B)	—	**	—	—
Impermeable sealing of the soil	—	**	*	—	—	—	—
Localized fire	*	—	—	*	—	—	—
Pests and diseases	*	*	—	*	*	*	—
Nutrient deficiency	*	*	*	—	—	**	*
Key							
**	Established practice						
*	Less well proven treatment that might provide benefit						
—	Not applicable						
^{A)} Root severance is not covered in this table. Guidance is given in 8.6.							
^{B)} Replacement only.							

Table B.3 Stump management options

Type of stump	Advantages	Disadvantages	Possible management implications
Stump retained – long term – alive (12.3.2) or dead (12.3.3)			
All stumps – general	No costs in removing stump Wildlife habitat retained Mineral and nutrient recycling Natural biological control of pathogens No disturbance of underground structures No physical damage to roots of nearby plants No ground disturbance/compaction	Continuing need for hazard management (e.g. trip hazard) Potential host for pathogens Limits the choices for future use of the area Appearance Potential for regrowth	Pre- and post-felling treatments to prevent regrowth Specification of height of retained stump Safety survey Further work as stump decays
Coppice stump	Natural regeneration Replacement tree Greater range of wildlife and greater longevity of habitat	Maintenance costs	Cyclical cutting Singling stems
High stump	Greater range of wildlife and greater longevity of habitat Plant support Sculpture potential	Potential hazard to a larger area for a longer period	Safety survey over longer period
Stump removed/destroyed (12.4)			
All stumps	No future management No/reduced regrowth Space for other land use Reduced source for pests and/or pathogens No safety hazard	Costs of removal and reinstatement Loss of wildlife habitat Loss of minerals and nutrients Root suckers	Ground investigations e.g. underground structures Specification of height of stump prior to removal Pre-/post-felling treatment to prevent regrowth Method of removal Hole treatment and reinstatement

Annex C (normative) Crown management – specialized practices

NOTE Detailed guidance can be found in Veteran trees: a guide to good management [1]. Further guidance will be available in Ancient and other veteran trees: Further guidance on management [36], which is in preparation at the time of publication of this British Standard.

C.1 Reduction of crown size and subsequent management

If, owing to decay or structural weakness, there is a need to prevent failure in a veteran tree, lapsed pollard or lapsed coppice stool, some kind of crown reduction (see 7.7) should normally be adopted as the main solution. Conventional reduction techniques may be employed if the tree shows good vitality and an abundance of branches or potential branches in its lower crown but poor vitality in its upper crown, combined with a sparse branch structure that could lead to major break-up or dieback, rather than natural retrenchment.

C.2 Retrenchment pruning of veteran trees and lapsed pollards**COMMENTARY ON C.2**

Retrenchment pruning is a phased form of crown reduction, which is intended to emulate the natural process whereby the crown of a declining tree retains its overall biomechanical integrity by becoming smaller through the progressive shedding of small branches and the development of the lower crown (retrenchment). This natural loss of branches of poor vitality improves the ratio between dynamic (biologically active) and static (inactive) mass, thus helping the tree as a whole to retain good physiological function. This natural process is not, however, always sufficient to prevent trees from falling apart or from posing unacceptable risks to fixed targets (e.g. roads, pavements etc.).

Retrenchment pruning should be chosen as the main option for managing lapsed pollards that would otherwise tend to break up and that, because of an inadequate lower crown, might not have enough leaf area to survive (see 7.1) if reduced to the ultimately intended height and spread in a single operation. It may also be used for managing coppiced trees that have remained uncut for so long that they are unlikely to survive re-coppicing.

NOTE 1 Pollarding is a traditional form of sustainable tree management that originally provided a product (fodder, timber pole or firewood) as part of a silvopastoral system of land management (typified by wood-pasture). It is also a system for managing trees in formal situations, either so as to control their size or for cultural reasons.

The tolerance of the tree to loss of leaf area and wounding should be assessed before retrenchment pruning is started. If, because of its species and condition, it is unlikely to respond by producing new branches, any pruning should be kept to the absolute minimum required in order to gain any biomechanical benefit at this initial phase. The pruning should be implemented by shortening heavy, long or weakened branches throughout the crown, while retaining as much leaf area as possible and encouraging the development of new secondary branches from epicormic shoots or from dormant or adventitious buds.

The second and any subsequent pruning treatments should take place only when newly developed branches suitable for retention have become strongly established. After the final phase of progressive reduction, a cyclic pruning of new growth should continue, so as to avoid the excessive loading of extensively decayed branches.

If there is a need to encourage the production of a dense lower crown, the development of shoots from dormant and/or epicormic buds should be stimulated by retaining stubs when branches are pruned. The length of the stubs should be about three to five times their basal diameter. Since epicormic branches tend to be weakly attached, any such branches that subsequently develop should if necessary be pruned (subject to inspection) in order to help prevent biomechanical failure.

NOTE 2 A long stub is likely to bear a number of dormant buds or (in some species) potential sites for adventitious bud formation. Also, adventitious shoots sometimes form near natural fractures in which bark has been torn, leaving jagged edges. This is a natural survival mechanism after storm damage. In order to encourage the formation of such shoots for the purpose of crown retrenchment, pruning may be undertaken by means of partial cutting followed by controlled fracture. Also, the bark may be scored, with the intention of stimulating such growth.

NOTE 3 The technique of "coronet cutting" produces a stub-end that consists of an irregular series of acute axial V-cuts, rather than a flat surface. This technique is mainly suited to the creation of natural-looking fractures on trees that have been reduced to tall stumps ("monoliths"). Since there are particular hazards associated with this type of pruning, it requires specialist training.

To specify the details and timing of retrenchment pruning, an individual tree management plan may be drawn up and later modified as appropriate over the duration of the programme. If possible, the details of the work and of the condition of the tree should be recorded throughout the duration of any such plan, to improve knowledge for future application. The plan should be based on the following decisions:

- a) the objectives of retrenchment pruning for the tree concerned (with respect to its structural integrity, desired crown shape and size, vitality etc.);
- b) the suitability of pruning as a means of improving or safeguarding the biomechanical integrity of the tree, taking account of its predicted tolerance to pruning, by virtue of its species, age and the current vitality and expected response to the pruning;
- c) the number of phases of work, the predicted details and timing of each phase and overall duration of the programme;
- d) the time for starting the work (assessment of priority for different trees).

c.3 Ground-support for branches and encouragement of layering

Where it is desirable to prevent breakage, low branches may be allowed to rest on the ground if site usage allows, so as to provide them with support. Layering (the production of roots and of new shoots where soil contact is established) may be encouraged by protecting the low branches from browsing by livestock. Where a low branch has the potential to layer but is not quite in contact with the ground, a mound may be created beneath it, so that its underside is brought into contact

with the soil (see also 10.6.2 regarding mechanical support). The bark in the intended contact-area may be scribed prior to the creation of the mound in order to assist in promoting the development of adventitious roots. To prevent movement whilst the roots develop from the point of contact, the branch may be secured with stakes driven into the ground on either side of the mound. The branch should be inspected periodically and, if necessary, re-secured to maintain contact with the soil mound.

C.4 Severe cutting for special purposes

NOTE Severe cutting is any cutting undertaken in excess of the guidance in Clause 7.

C.4.1 Extreme crown reduction, topping and re-coppicing

It is generally undesirable to wound trees so severely that major dieback or extensive decay are likely to ensue. Accordingly, severe crown reduction, which at its most extreme equates to topping, should be used only as a last resort for retaining a valuable tree which would otherwise pose an unacceptable risk to people or property, or would be susceptible to loss due to structural collapse.

Lapsed coppiced trees may be re-coppiced if they are assessed as being likely to survive this form of severe cutting, taking account of the age of the stems, the species of tree and the site conditions (see C.2). If, because of these factors, it is doubtful whether new shoots would develop from cuts made near ground-level, the stems may be reduced in phases, or the cuts may be made above the origins of the stems on the stool, in order to provide a larger surface for shoot-production. The retention of stumps in this manner helps to reduce the loss of wildlife habitats associated with lapsed coppice. New stems may subsequently be thinned (or the stumps shortened) so as to retain selectively any stems that have originated near ground level and that are thus likely to become stabilized by the formation of new roots.

C.4.2 Veteranization

COMMENTARY ON C.4.2

Trees may be wounded in order to encourage the development of decay and other features characteristic of veteran trees when a major age gap in the tree population would otherwise lead to a break in the continuity of the wildlife habitats and shelter provided by such trees, especially in decaying wood and cavities.

A major age gap in the tree population prevents the natural replacement of the desired habitats and shelter currently provided by the older trees.

Veteranization may be initiated, for example, by the removal of large branches (or perhaps the creation of stem wounds, which may take the form of V-shaped notches or auger holes).

If some trees are to be veteranized, others (normally a majority) within the population should be left intact and indeed protected so as to maximize their longevity. Veteranization should be done only in carefully selected locations where it will be compatible with site usage and with future management requirements. The wounding should not compromise the retention of trees in the short to medium term.

NOTE 1 Veteranization requires specialist guidance regarding its suitability and the techniques available. Further guidance will be available

in Ancient and other veteran trees: Further guidance on management [36], which is in preparation at the time of publication of this British Standard.

NOTE 2 Some attempts have been made to introduce desired species of decay fungi (e.g. *Laetiporus sulphureus*) into veteranization wounds. The decay produced by such fungi provides good habitats and tends not to shorten the life of the tree by extending into functional sapwood.

Annex D (informative) Attaching restraint systems

D.1 Attaching non-invasive flexible restraints

Figure D.1 and Figure D.2 show diagrammatic illustrations of components used in two alternative non-invasive restraint systems.

Figure D.1 Diagrammatic illustration of components used in a non-invasive restraint system: double belt system with hollow braid polyester rope

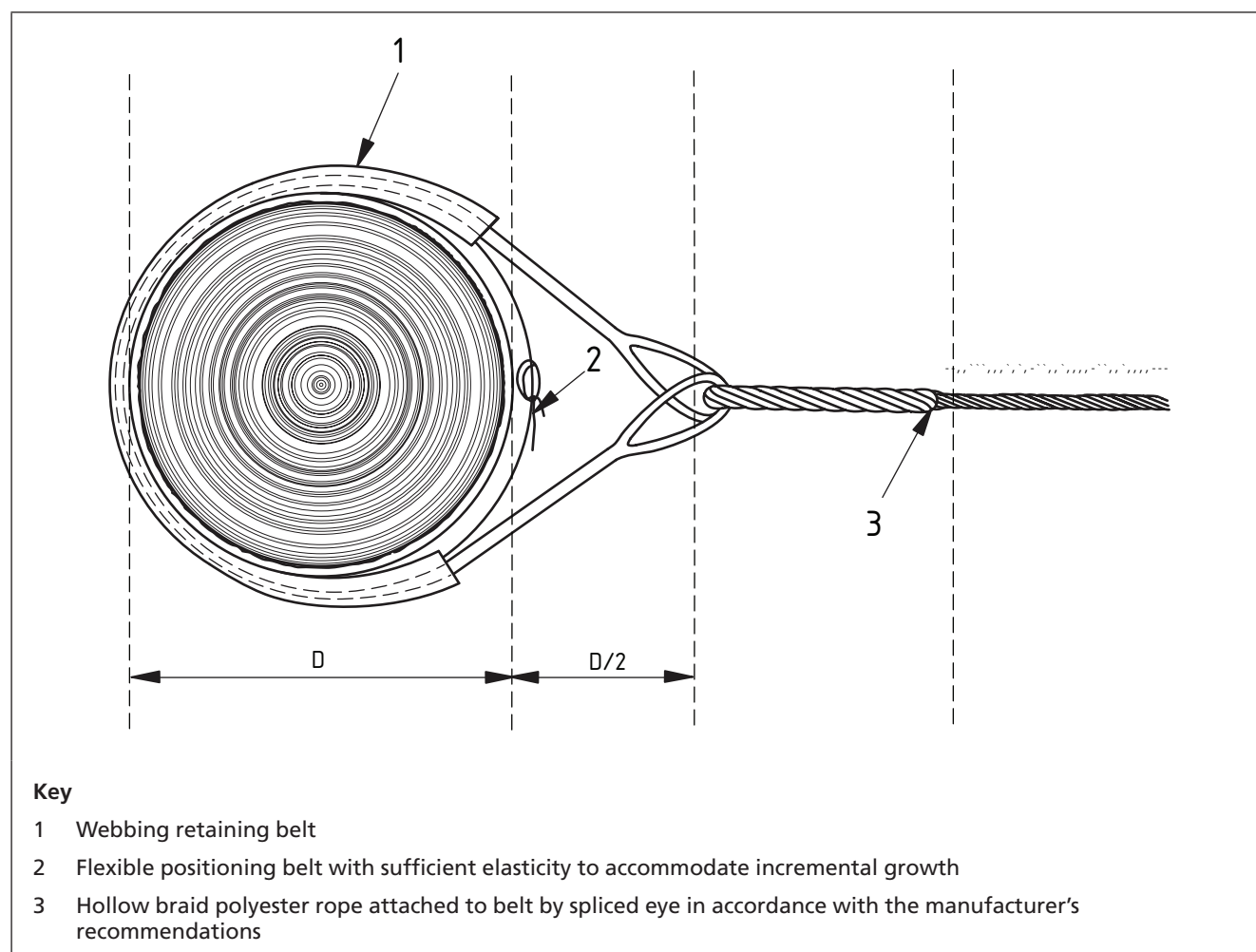
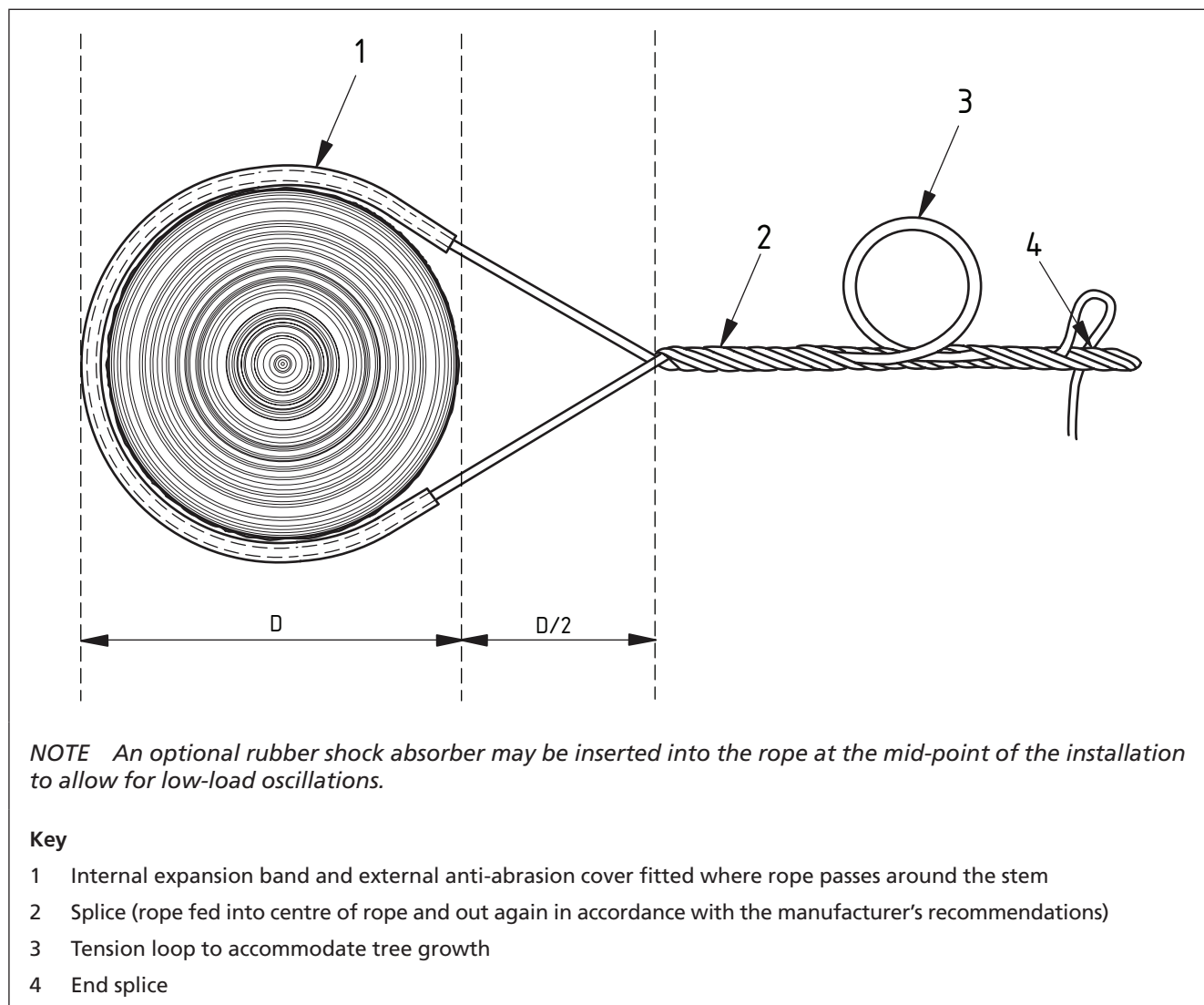


Figure D.2 Diagrammatic illustration of components used in a non-invasive restraint system: monofilament polypropylene hollow rope system



D.2 Attachment of invasive restraint systems

Figure D.3 shows a diagrammatic illustration of ad hoc components used in an invasive restraint system.

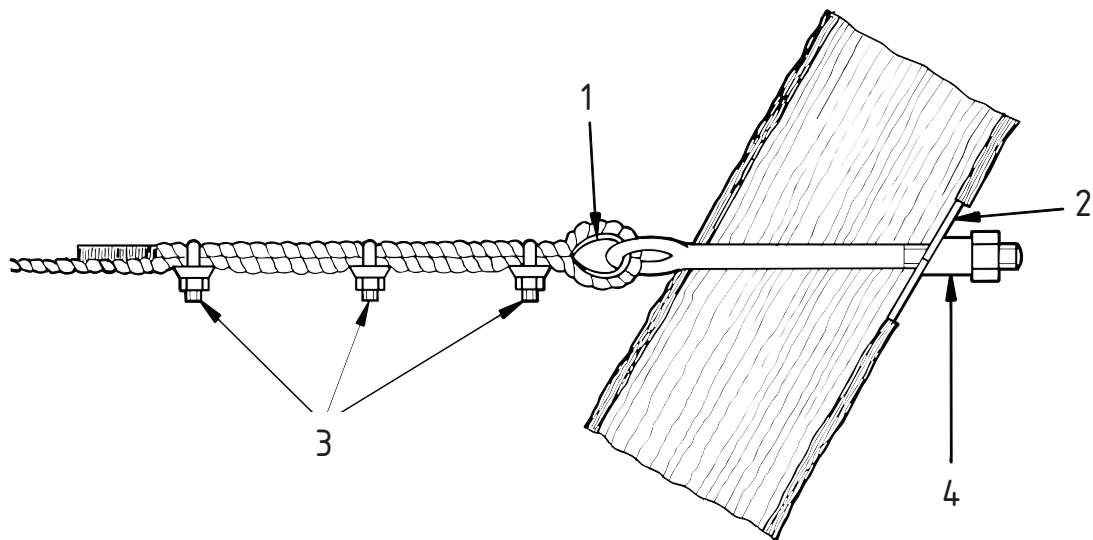
The size of any guide holes drilled into the tree will relate to the attachment to be used; i.e. slightly oversized for an eyebolt and slightly undersized for a screw eye.

In order to minimize any bending forces that might cause failure of an eyebolt, the cable and the eyebolts are normally attached in a straight line. Where a cable is attached other than in a straight line (e.g. because it would be impracticable to insert an eyebolt through a stem or branch at a very oblique angle) it is necessary to ensure that an eyebolt of appropriate strength is selected.

Eyebolts are fitted using oval or circular washers and, where appropriate, spacers (see Figure D.3). The washers are countersunk on to the surface of the wood and are of sufficient diameter to resist being pulled through the stem or branch.

It is necessary to make the attachment only into wood that has enough strength to hold the assembly securely under load, as described in 10.4.3.

Figure D.3 Diagrammatic illustration of components used in an invasive restraint system



Key

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

NOTE 1 This diagram shows a straight-line assembly, in which the eyebolt is not at right angles to the grain. The other option, as described above, is to insert the eyebolt at a less oblique angle, while ensuring that it is of suitable strength.

NOTE 2 An angled spacer (4) will usually be required when the bolt is not at right angles through the branch; this will help to ensure that the pressure applied by the nut on the washer is evenly distributed.

Two or more attachments inserted into the same branch or stem, placed either in the same radial alignment or less than 500 mm longitudinally apart, can induce cracks to develop in the wood between them.

Generally, only one cable is attached to an eye, unless the system is specifically designed to be strong enough for two or more.

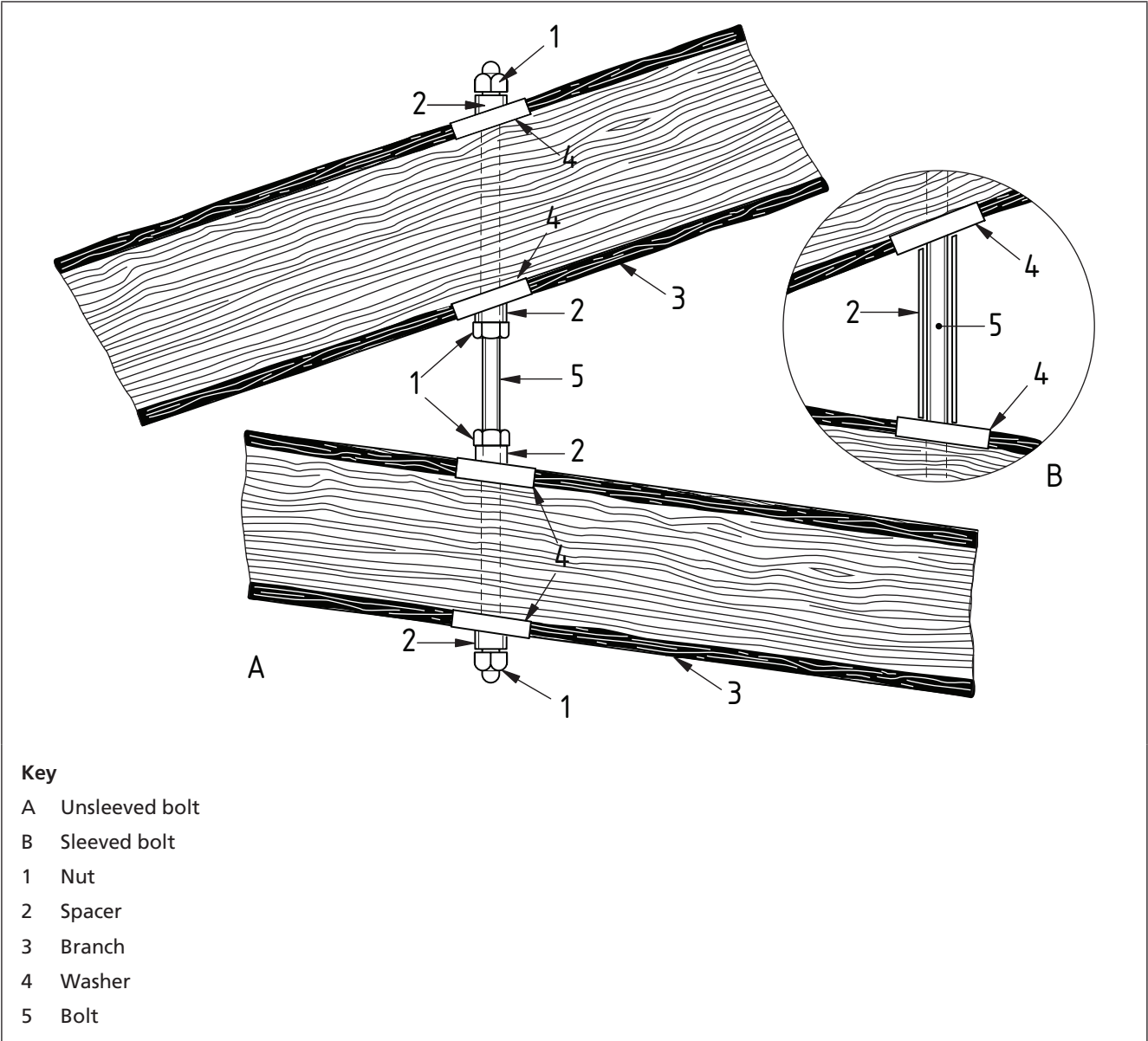
The ends of the cable are secured with proprietary fixings, e.g. wire rope grips, to prevent slipping.

NOTE BS 462 specifies requirements for wire rope grips.

D.3 Securing rubbing branches

Figure D.4 shows diagrammatic illustrations of two systems for separating two branches that have been rubbing together.

Figure D.4 Diagrammatic illustration of systems for separating and securing rubbing branches



Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 462, *Specification for wire rope grips*

BS 5228-1, *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*

BS 7370-4, *Grounds maintenance – Part 4: Recommendations for maintenance of soft landscape (other than amenity turf)*

Other publications

- [1] READ, H. *Veteran trees: a guide to good management*. Peterborough: English Nature, 2000.⁴⁾
- [2] GREAT BRITAIN. Management of Health and Safety at Work Regulations 1999. London: The Stationery Office.
- [3] NEILAN, C. *CAVAT (Capital Asset Value for Amenity Trees) full method: user's guide*. Revised edition. London: London Tree Officers' Association, 2008.
- [4] HELLIWELL, D.R. *Visual amenity valuation of trees and woodlands (the Helliwell system)*. Guidance Note 4. Cheltenham: Arboricultural Association, 2008.
- [5] COUNCIL OF TREE AND LANDSCAPE APPRAISERS (CTLA). *Guide for plant appraisal*. 9th edition. Champaign, IL, USA: International Society of Arboriculture, 2000.
- [6] GREAT BRITAIN. Health and Safety at Work etc. Act 1974. London: HMSO.
- [7] HEALTH AND SAFETY EXECUTIVE. *Using petrol-driven chainsaws*. AFAG301. Sudbury: HSE Books, 2003.
- [8] HEALTH AND SAFETY EXECUTIVE. *Basic chainsaw felling and manual takedown*. AFAG302. Sudbury: HSE Books, 2003.
- [9] HEALTH AND SAFETY EXECUTIVE. *Chainsaw snedding*. AFAG303. Sudbury: HSE Books, 2003.
- [10] HEALTH AND SAFETY EXECUTIVE. *Chainsaw cross-cutting and manual stacking*. AFAG304. Sudbury: HSE Books, 2003.
- [11] HEALTH AND SAFETY EXECUTIVE. *Chainsaw clearance of windblow*. AFAG306. Sudbury: HSE Books, 2003.
- [12] HEALTH AND SAFETY EXECUTIVE. *Chainsaw felling of large trees*. AFAG307. Sudbury: HSE Books, 2003.
- [13] HEALTH AND SAFETY EXECUTIVE. *Top-handled chainsaws*. AFAG308. Sudbury: HSE Books, 2008.
- [14] HEALTH AND SAFETY EXECUTIVE. *Use of winches in directional felling and takedown*. AFAG310. Sudbury: HSE Books, 2003.

⁴⁾ Out of print. Available as a set of free pdfs from www.naturalengland.gov.uk.

- [15] HEALTH AND SAFETY EXECUTIVE. *Tree-climbing operations*. AFAG401. Sudbury: HSE Books, 2009.
- [16] HEALTH AND SAFETY EXECUTIVE. *Aerial tree rescue*. AFAG402. Sudbury: HSE Books, 2003.
- [17] HEALTH AND SAFETY EXECUTIVE. *Mobile elevating work platforms (MEWPs) for tree work*. AFAG403. Sudbury: HSE Books, 2003.
- [18] HEALTH AND SAFETY EXECUTIVE. *Wood chippers*. AFAG604. Sudbury: HSE Books, 2003.
- [19] HEALTH AND SAFETY EXECUTIVE. *Electricity at work: forestry and arboriculture*. AFAG804. Sudbury: HSE Books, 2003.
- [20] HEALTH AND SAFETY EXECUTIVE. *Training and certification*. AFAG805. Sudbury: HSE Books, 2003.
- [21] DEPARTMENT FOR TRANSPORT. *Safety at street works and road works – A code of practice*. Second edition. London: Department for Transport, 2005.⁵⁾
- [22] LONSDALE, D. *Principles of tree hazard assessment and management*. Research for Amenity Trees No. 7. London: The Stationery Office, 1999.
- [23] GREAT BRITAIN. Lifting Operations and Lifting Equipment Regulations 1998. London: The Stationery Office.
- [24] GREAT BRITAIN. Control of Substances Hazardous to Health Regulations 2002. SI 2002, No 2677. London: The Stationery Office.
- [25] GREAT BRITAIN. Control of Noise at Work Regulations 2005. London: The Stationery Office.
- [26] GREAT BRITAIN. Environmental Protection Act 1990. London: HMSO.
- [27] GREAT BRITAIN. Highways Act 1980. London: HMSO.
- [28] PATCH, D. *Trees bleeding*. Arboricultural Practice Note 8. Farnham, Surrey: The Tree Advice Trust, 2004.
- [29] ROBERTS, J. et al. *Tree roots in the built environment*. Research for Amenity Trees No. 8. London: The Stationery Office, 2006.
- [30] SHIGO, A.L. *A new tree biology*. Durham, NH, USA: Shigo and Trees Associates, 1986.
- [31] SHIGO, A.L. *Modern arboriculture*. Durham, NH, USA: Shigo and Trees Associates, 1991.
- [32] ENERGY NETWORKS ASSOCIATION. *Safe tree working in proximity to overhead electric lines*. Engineering Recommendation G55/2. Issue 2. London: Energy Networks Association, 2008.
- [33] GREAT BRITAIN. Electricity Act 1989. London: HMSO.
- [34] HEALTH AND SAFETY EXECUTIVE. *Avoidance of danger from overhead electric power lines*. HSE Guidance Note GS6. Third edition. Sudbury: HSE Books, 1997.
- [35] PATCH, D. *Ivy – Boon or bane?* Arboricultural Practice Note 10. Farnham, Surrey: The Tree Advice Trust, 2004.

⁵⁾ Under review. Current version available as a free printable document from www.dft.gov.uk.

- [36] LONSDALE, D. (ed.) *Ancient and other veteran trees: Further guidance on management*. Grantham, UK: Ancient Tree Forum.⁶⁾
- [37] GARNER, R.J. *The grafter's handbook*. ISBN 978 1844 0303 92. London: Cassell & Co., 2003.
- [38] MATTHECK, C. *Updated field guide for visual tree assessment*. Karlsruhe: Forschungszentrum Karlsruhe GmbH, 2007.
- [39] WILLOUGHBY, I. and DEWAR, J. *The use of herbicides in the forest*. Forestry Commission Field Book 8. London: HMSO, 1995.
- [40] HARMER, R. and HOWE, J. *The silviculture and management of coppice woodlands*. Edinburgh: Forestry Commission, 2003.
- [41] GREAT BRITAIN. Control of Pesticides Regulations 1986. SI 1986, No. 1510. London: HMSO.
- [42] GREAT BRITAIN. Plant Health Act 1967. London: HMSO.
- [43] GREAT BRITAIN. Weeds Act 1959. London: HMSO.
- [44] GREAT BRITAIN. Wildlife and Countryside Act 1981. London: HMSO.
- [45] NATIONAL JOINT UTILITIES GROUP. *Volume 4: NJUG Guidelines for the planning, installation and maintenance of utility apparatus in proximity to trees*. London: National Joint Utilities Group, 2007.
- [46] GREAT BRITAIN. Town and Country Planning Act 1990. London: HMSO.
- [47] NORTHERN IRELAND. Planning (Northern Ireland) Order 1991. SI 1991, No. 1220 (N.I. 11). London: HMSO.
- [48] SCOTLAND. Town and Country Planning (Scotland) Act 1997. London: The Stationery Office.
- [49] GREAT BRITAIN. Forestry Act 1967. London: HMSO.
- [50] GREAT BRITAIN. Conservation of Habitats and Species Regulations 2010. London: The Stationery Office.
- [51] GREAT BRITAIN. Countryside and Rights of Way Act 2000. London: The Stationery Office.
- [52] NORTHERN IRELAND. Wildlife (Northern Ireland) Order 1985. SI 1985, No. 171 (N.I. 2). London: HMSO.
- [53] NORTHERN IRELAND. Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995. SI 1995, No. 380. London: HMSO.
- [54] NORTHERN IRELAND. Environment (Northern Ireland) Order 2002. SI 2002, No. 3153 (N.I. 7). London: The Stationery Office.
- [55] GREAT BRITAIN. Conservation (Natural Habitats etc.) Regulations 1994. SI 1994, No. 2716. London: HMSO.
- [56] SCOTLAND. Nature Conservation (Scotland) Act 2004. London: The Stationery Office.
- [57] GREAT BRITAIN. Hedgerow Regulations 1997. Hedgerows Regulations 1997 SI 1997, No.1160. London: The Stationery Office.

⁶⁾ In preparation at the time of publication of this British Standard. When published, it will be available from the Ancient Tree Forum at www.ancient-tree-forum.org.uk.

- [58] OFFICE OF THE DEPUTY PRIME MINISTER. *Hedge height and light loss*. Revised edition. London: ODPM, 2005.⁷⁾
- [59] ARBORICULTURAL ASSOCIATION. *Protected species and arboriculture*. Guidance Note 10. Cheltenham: Arboricultural Association: 2010.
- [60] NORTHERN IRELAND. Plant Health Act (Northern Ireland) 1967. London: HMSO.
- [61] DEPARTMENT FOR ENVIRONMENT, TRANSPORT AND THE REGIONS. *Tree preservation orders: a guide to the law and good practice*. London: DETR, 2000.⁷⁾
- [62] DEPARTMENT OF THE ENVIRONMENT. *Use of conditions in planning permission*. Circular 11/95. London: HMSO, 1995.⁸⁾

⁷⁾ Available as a free printable document from www.communities.gov.uk.

⁸⁾ Under review.

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