Forestry Commission

PRACTICE GUIDE

HAZARDS FROM TREES

A General Guide

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Cover photograph: Hazardous tree showing co-dominant forking of the main stem - a significant point of weakness - with included bark and cracking below the fork.

Tree hazard illustrations: Carol Bramley

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INTRODUCTION

Most woodland managers have responsibility for land that is accessible to the public or that is adjacent to public rights-of-way. Many are involved in the management of woodland sites for recreation, amenity and conservation and in some cases, their responsibilities extend to buildings and urban sites. While trees have many values - social, environmental and economic - they may, if suffering from certain mechanical defects, represent a hazard in areas where people and property are present. It is therefore important for managers to be aware of tree-related hazards.

This Practice Guide indicates the responsibilities of owners and managers for assessing the risk of hazards from trees, and considers what inspection procedures might be appropriate. Preventive care of young trees and methods of protecting trees from wildlife damage are described. Details of tree hazards, signs of their occurrence, and options for remedial work are presented.

MULTI-PURPOSE MANAGEMENT OF TREES: DEFINING OBJECTIVES

Although trees may be planted for one principal purpose, there are usually other respects in which they have value, whether positive or negative. The management of trees should therefore embrace a number of objectives which, for example, may relate to timber production, amenity, wildlife conservation and the control of hazards. In the case of hazard management, it is necessary to take reasonable steps to identify trees which represent a significant risk to people or property and to deal with them accordingly. This should, however, be done in a way which minimises the loss of value for people and wildlife.

To this end, a number of objectives relevant to hazard management can be listed as follows:

- to control risks to people who work with trees or who may be close to them;
- to avoid the unnecessary removal or disfigurement of amenity trees or of trees with high wildlife value;
- to conserve habitats that are provided by trees, including those that are old and decaying.

LIABILITY OF SITE OCCUPIERS

Where a tree is hazardous because of decay or structural weakness and shows external signs of being in such a condition, the occupier of the land on which it stands is normally liable under UK laws for any personal injury or other damage it causes by breaking or falling. This liability arises from provisions by which the occupier has a common duty of care to others who enter the land or its vicinity. The occupier is defined as the person 'occupying or having control of the premises', and this effectively means whoever has possession of and controls the land. For example, the Forestry Commission is, in law, the occupier of the forest it manages, although there may be certain circumstances where a forestry contractor who is in control of a particular area could be considered to be the 'occupier'.

In England and Wales, liability is governed by the Occupiers' Liability Act (1957) and (1984). The earlier Act deals with liability relating to visitors; i.e. persons who enter land or premises either by invitation or by permission. The later Act deals with liability relating to other persons, including trespassers and it should thus be noted that owners can be held negligent in their duty of care even if injury or damage occurs on land where people do not have access by right or by invitation. In Scotland, the Occupiers' Liability Act (Scotland), 1960, makes no distinction between different categories of visitor, so that the occupier has an equal duty of care towards all of them. Although there are occasional cases in the Courts in which occupiers are found liable for injuries sustained by uninvited or unauthorised visitors, such cases are most likely to

arise when there are insufficient signs and/or barriers to indicate clearly that public access is not permitted. It should, however, be noted that, within the provisions of the above Acts, the Courts expect occupiers to be prepared for children to behave less carefully than adults; for example, by climbing trees which may have weak branches. It is especially important to consider this when designing and managing sites such as recognised play areas, where parents can reasonably expect children to play unaccompanied. The Courts expect occupiers to make regular inspections of trees that, by reason of their position, could place people or property at risk. It is also expected that they should, if necessary, obtain specialist guidance on the interpretation of symptoms and assessment of tree safety and to take reasonable steps to reduce risk where appropriate.

If specialist advice is sought, it should be followed: failure to do so could be interpreted as negligence.

The most critical questions to answer in making decisions on whether to inspect trees and whether remedial action is required are:

Can a problem be foreseen? If so,

- What is its likelihood of occurring?

- What is the likely consequence of its occurrence?

- Is it reasonable to protect against it?

Some guidance on answering these questions is provided below under the headings 'Risk assessment', 'Deciding which trees to inspect', and 'Reducing the risk from a mechanically defective tree'.

It should be noted that the present Guide deals only with hazards relating to the mechanical failure of trees. There are various other possible hazards, for example those associated with poisonous species or with work being carried out on trees.

RISK ASSESSMENT

No tree is entirely safe, given the possibility that an exceptionally strong wind could damage or uproot even a mechanically 'perfect' specimen. It is therefore usually accepted that hazards are only recognisable from distinct defects or from other failure-prone characteristics of the tree or of the site. The assessment of risk is based on:

- The value of whatever is judged to be at risk, and the **likelihood of its being harmed** in the event of mechanical failure in the tree, as estimated by:

  - what is at risk - people, buildings, vehicles, etc.

- the probability of impact, based on duration of occupation - for example, in relation to a permanent structure or a given number of people using a path during a given period of time.

(These considerations are clearly linked to the location of the tree, which is a key factor in deciding whether inspection is required in the first place.)

- **The magnitude of the hazard**, as estimated from the size (diameter) and height of the part of the tree most likely to fail.

(There are standardised assessment systems used by specialist assessors, which place the size of trunks or branches in a series of categories.)

- **The probability of failure**, based on the type, position and severity of the defect concerned, the species or cultivar of tree and the nature of the site. The following need to be taken into account:

  - some types of defect are more likely than others to lead to failure; for example, forks with included bark account for a high proportion of above-ground failures, whereas zones of decay in stems and branches generally cause serious weakening only if they occupy a large proportion of the cross-sectional area. The assessment of decay generally requires a measurement of the extent and position of the remaining sound wood;

  - if the defect is associated with decay, identification of the fungus responsible may be desirable. There are a number of types of decay (including the broad categories of 'white rots' and 'brown rots') whose mechanical properties are different enough to affect the likelihood of failure in some cases;

  - some species or cultivars of tree are known to be weakened more than others by certain types of growth-related defect or by particular species of decay fungus;

  - a number of site factors affect the likelihood of failure, including exposure to wind (especially any recent alteration in exposure) and the depth of the soil available for rooting.

DECIDING WHICH TREES TO INSPECT

The need for a particular tree or group of trees to be inspected depends on the usage of the area within their potential falling distance. Inspection is unquestionably necessary within zones where people, or high-value items of property, are continuously or frequently present close to trees which are capable of being hazardous. Clearly, however, there are remote areas where tree failures are very unlikely to cause injury or damage, even though the risk of such an outcome cannot be entirely disregarded. Even at a more heavily used site, it could be that the risk is currently very low by virtue of the size

and species of the trees present. There cannot, therefore, be a hard and fast distinction between sites where inspection is essential and where it is entirely unnecessary. Occupiers must decide what is reasonable, because the Courts expect them to take 'reasonable steps' to inspect their trees and to remove or reduce hazards to people and property. Specialist advice can be sought on the zoning of areas where inspections should be made.

The key consideration is foreseeability; if it can be reasonably foreseen that anyone (guest or trespasser) could be at risk, the occupier has a duty of care to reduce that risk within reason.

THE LEVEL OF INSPECTION

It is sufficient initially to look for external signs that may indicate that a hazard exists. If no significant hazard is revealed, further action is not generally required until the next inspection. If evidence of a hazard is found, more detailed investigation by a specialist would be advisable where:

- the full extent of the suspected hazard is not clear from external examination;

- the tree is of high value (e.g. for amenity or wildlife) and there is reason to believe that it cannot be made safe without significantly lessening its value.

FREQUENCY AND TIMING OF INSPECTION

A general principle to be observed is that, in areas where people or property could be at risk from tree failure, routine inspections should be carried out frequently enough to detect any hazards that may have recently developed. Hazards from large old trees sometimes develop quite rapidly, for which reason an inspection frequency of one year or more is generally advisable where such trees occur on high-usage sites. Inspections should also be made immediately after any exceptionally severe weather event that might have caused damage to trees. Also, on the basis of expert advice, it may be necessary to make detailed inspections of particular trees at prescribed intervals if they have been found to show signs of progressive deterioration in their condition. Many signs of possible weakness are externally visible throughout the year, but the best time for inspection is during clear weather at the beginning of the autumn. It should then be relatively easy to see premature autumn colouration or shedding of foliage, which could be due to root damage, and there is also a good chance of seeing the non-perennating fruit bodies of certain decay fungi.

'ZONING' A SITE

The proximity of trees to people and property is a major factor in deciding how rigorously they need to be inspected (if at all) and what sort of remedial action (if any) is appropriate if significant hazards are found. Where substantial numbers of trees are under consideration, the concept of **zoning** is an important principle of hazard management.

For example, there might be a large block of planted woodland containing the following features:

- a public road;
- several forest rides and footpaths open to the public;
- an amenity site with car park and visitor centre.

Much of the woodland block would typically be well away from access routes, where a zone of lowest risk could be designated. In many instances it may be regarded as reasonable not to carry out regular inspection of the trees in such areas.

Other areas, which are within 'falling distance' of regularly used rides and footpaths, will usually need to be classed within a zone of somewhat higher risk, with a consequent need for a periodic general inspection, followed up by remedial action where appropriate. Depending on the size and species of trees present, and on local conditions, it might be decided that it would be sufficient to make this inspection at fairly infrequent intervals; perhaps after periodic forest thinning operations and episodes of windthrow.

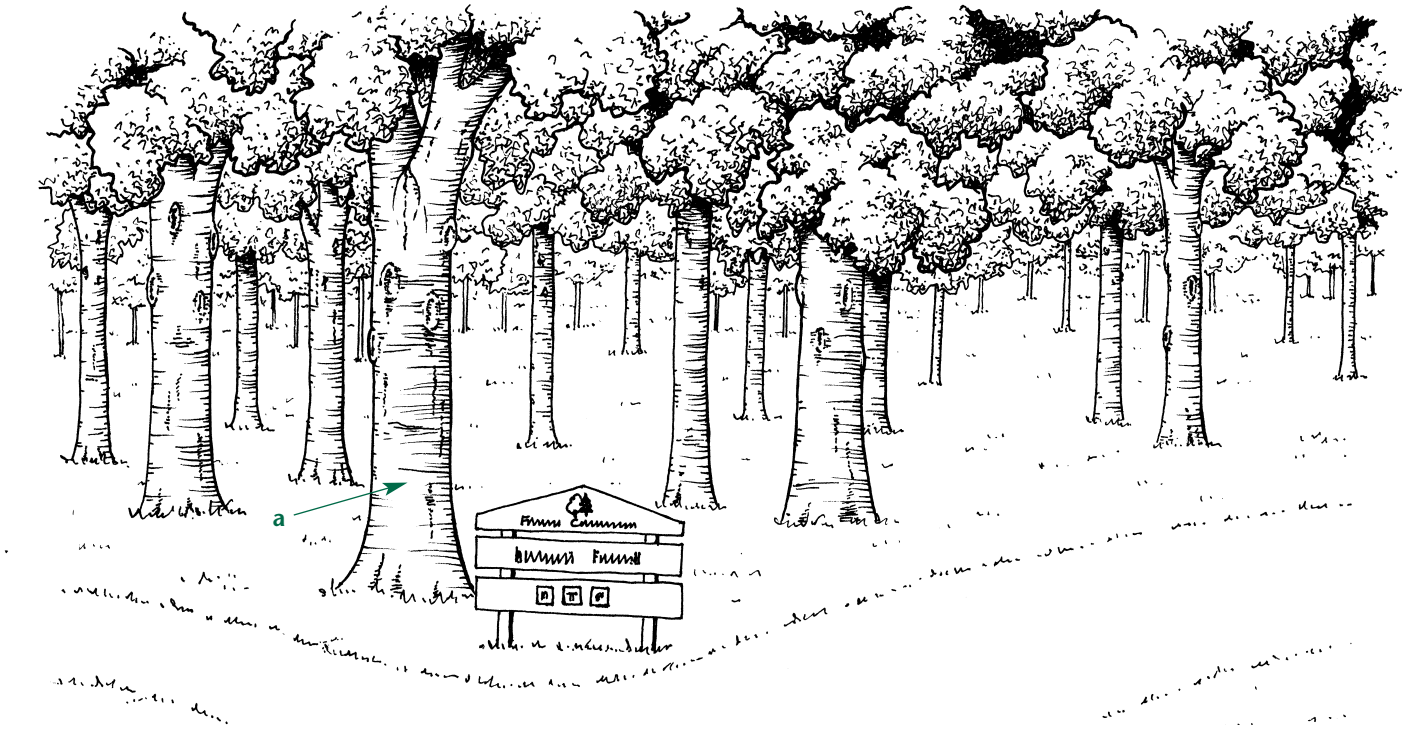
A third zone, representing a need for inspection to be carried out more frequently as well as after severe storms, may be appropriate for the strip along the public road. The need for such a zone applies especially if the road is busy and if the trees are large or old enough to represent a significant potential hazard. The same category of zoning for inspection may also be satisfactory for the amenity and car-parking area, where people and property are close to trees for much or all of the time. However, this area will probably need to be placed in a somewhat higher category, to take account of the need for inspections to be done with especial rigour. Also, the usage of this zone may be more conducive to trees becoming hazardous, for example due to vehicle impacts and soil compaction.

TRAINING AND EQUIPMENT

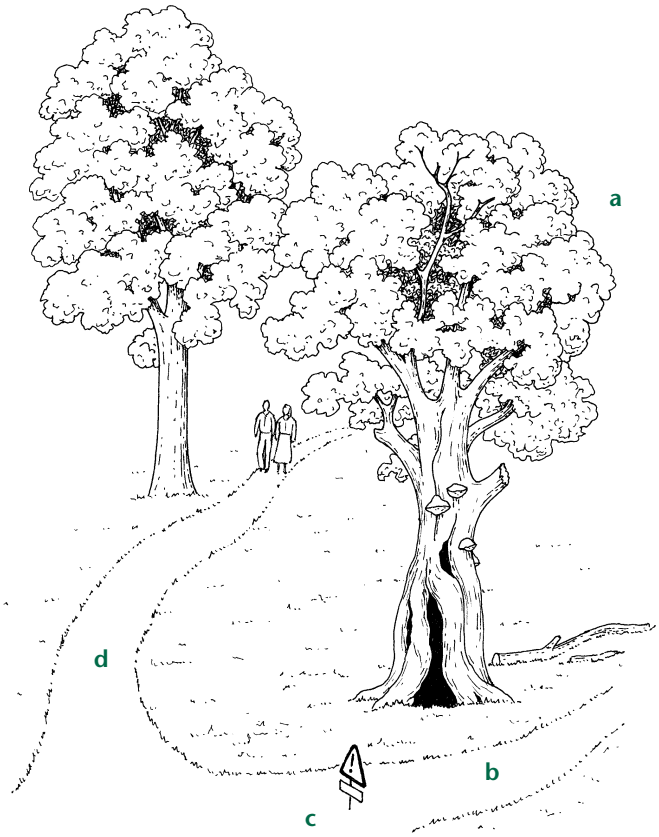
It is possible to recognise signs of possible weakness without detailed training, but owners are expected to seek expert advice if they themselves are not able to recognise all these signs. The further investigation of such signs and the assessment of hazard requires specialist knowledge and experience. It is worthwhile to re-emphasise that, if expert advice is sought, it should be followed. For the basic inspection, it is generally regarded as reasonable to view trees from ground level, provided that binoculars are used for examining the crowns of large trees. If a ground-based inspection reveals potentially significant features that cannot be properly seen from a distance, it may be necessary to complete the inspection by climbing or from a hoist.

REDUCING THE RISK FROM A MECHANICALLY DEFECTIVE TREE

The risk that a tree poses to people and property can sometimes be reduced by modifying the usage of the immediate surroundings; for example by moving a path or car-parking spaces. In other cases, the risk can be reduced by tree surgery. Branches weakened by decay or cracks may be pruned, and trees with defective main stems or root systems may be made safer by crown reduction. Excessive movement in some types of weak structure can be restrained by bracing or propping. However, in severe cases on high-usage sites, felling may be the only reasonable option. In a woodland area where the individual tree concerned is known to be of no special value for amenity or wildlife, felling will generally be regarded as a more realistic option than costly arboricultural procedures which are suited mainly to sites where trees are managed on a more individual basis.



Plantation tree (a) adjacent to a woodland path: visual inspection of the main stem reveals a likely hazard due to co-dominant forking with included bark. The tree is one among many and has no special value; e.g. as a specimen or 'veteran'. Thus, felling may be the pragmatic option in preference to elaborate investigative and remedial work.



MOVING THE 'TARGET'

If hazards are posed by trees of high value for wildlife, amenity, or local history, the risk to people and property can be kept within acceptable limits by such measures as diverting access routes or relocating facilities. In the adjacent diagram, the footpath has been diverted to take it away from a 'veteran tree' which has high conservation value but which is liable to drop branches. The warning sign is a sensible precaution but does not absolve the owner from liability.

a. Veteran tree of wildlife value, but liable to drop branches

b. A diverted footpath

c. Warning sign (although this does not absolve the owner from liability)

d. New route

LEGAL RESTRICTIONS ON TREE WORK

In cases where remedial action is being considered, occupiers should be aware that, with certain exceptions, it is an offence to uproot, fell, lop or top a tree[1]:

- **subject to a Tree Preservation Order***, without permission from the local planning authority responsible for the Order;
- **in a Conservation Area**, without giving the local planning authority at least six weeks' notification of intention to do the work;
- **if the work affects a Site of Special Scientific Interest (SSSI)**, and the owner has not written to the statutory nature conservation agency and obtained its written consent.

In addition, and also with certain exceptions, it is an offence to fell trees **greater than 5 cubic metres** in total volume without a Felling Licence† from the Forestry Commission.

If in any doubt as to whether any of these restrictions applies, and before starting the work, check as appropriate with the statutory nature conservation agency[2], the local planning authority or the local Conservancy Office of the Forestry Commission, who can advise on the latest regulations.

[1]See reference list for: *DETR leaflet on tree preservation orders and †FC leaflet on tree felling licences.

An offence may also be committed if the work affects a site or a biological species which is protected by law, and if any necessary consent has not been obtained from the statutory authority concerned[2,3]. Such situations fall into the following categories:

- the work affects a Scheduled Ancient Monument or is in the vicinity of one, and **Scheduled Monument Consent**[2] has not first been obtained where this would have been necessary;
- the work damages a **bat roost**, disturbs bats, damages or obstructs a **badger sett** which shows signs of current occupation, or disturbs a **badger**[3] **in a sett;**
- damage or disturbance is knowingly caused to a place of shelter or protection used by any species which is protected from such harm under the Wildlife and Countryside Act (1981).

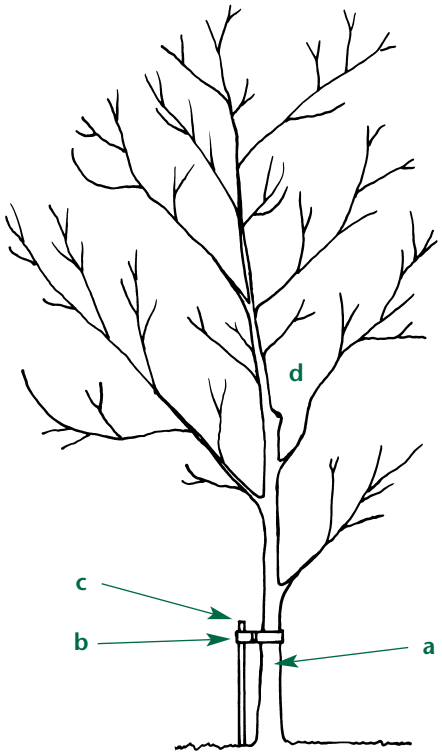
PREVENTING THE DEVELOPMENT OF HAZARDS

A high proportion of hazards are due to defects which are a result of unsuitable practices (e.g. excessive wounding leading to extensive decay), or of the failure to manage trees appropriately when they are young. The latter is well understood by those who manage urban trees; it should equally be a consideration in highly used amenity areas in woodland. Preventive actions include: the appropriate choice of species for site when planting, formative pruning, the use of proper pruning practices and avoidance of damage from harvesting or construction work.

PREVENTIVE CARE OF YOUNG TREES

Where trees are planted as individual specimens, it is appropriate to stake and tie them according to arboricultural standards. Important things to do are:

- At sites where branch failure would constitute a high risk in future, remove low branches selectively and progressively;
- Adjust ties regularly so that they do not cause constriction or chafing;
- Use low staking so as to encourage sturdy taper, which should be initiated by good pre-planting care;
- Prune co-dominant leading shoots before they form weak forks.



a. Selective and progressive removal of low branches, if necessary, to avoid future hazards when they grow heavy

b. Regular adjustment of tie to prevent constriction or chafing

c. Low staking to encourage sturdy taper, which should be initiated by good pre-planting care

d. Early prevention of weak formation

[2]Relevant national authorities to be consulted for advice or consent include the following: a) regarding SSSIs and bat roosts - English Nature, Scottish Natural Heritage or Countryside Commission for Wales; b) regarding Scheduled Ancient Monuments - English Heritage, Historic Scotland or Cadw.
[3]For information on agencies which must be consulted about potential harm to badgers, see the reference list for the Forestry Commission booklet on forest operations and badger setts.

HARVESTING AND CONSTRUCTION DAMAGE

The risk of losing timber quality is a good commercial reason for minimising tree wounding during forestry operations or from mammal damage. Another consideration, which is important within parts of all forests, is that wounding can also make trees hazardous. Close attention should be paid to the need to avoid inflicting severe harvesting wounds on trees near roads and paths. Also, if there are trees which already have such wounds, their presence should be borne in mind when laying out new paths or access routes into woodland.

During commercial forestry operations special measures for the protection of individual trees are likely to be warranted only for high value specimens unavoidably close to extraction routes. Such measures are, however, needed routinely in areas in high-access or recreational areas whenever there is to be any building work or the laying of underground utilities. These activities can be extremely damaging to trees and can make them very hazardous. Before such operations begin, any trees that are to be retained should be enclosed within an adequately-sized zone from which machinery and building materials are excluded (British Standard 5837). It is especially important to avoid compaction of the soil over rooting areas, as this may lead to general decline and dieback or to root decay. Soil contamination and physical damage to root and stems should also be prevented.

TREES AND WILDLIFE

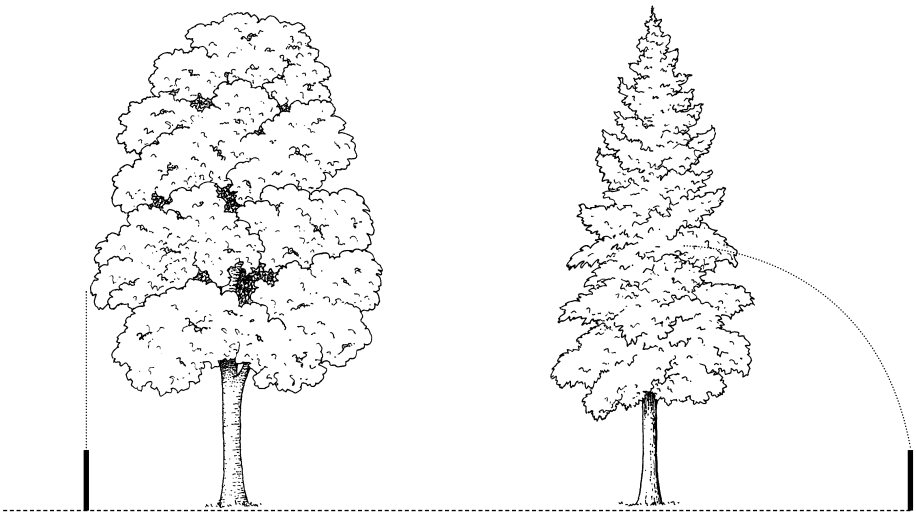
It is widely appreciated that trees are vital for many forms of wildlife, although the importance of habitats which develop in dead and decaying wood has only recently begun to come to public attention. The wildlife value of trees can often be identified only with difficulty, so that specialist help may be required - especially with invertebrates, fungi, mosses and lichens. It is important that trees, especially 'veteran specimens' should not be felled unnecessarily. This may happen if decisions are made on the basis only of initial observations, such as the presence of fungal fruit bodies, rather than a detailed risk assessment. If there is a need to carry out other kinds of remedial work on veteran trees or other individuals of acknowledged wildlife value, it should be done with great care. However, there is a need to emphasise that the wildlife value of a tree does not lessen the need for safety inspections and for remedial action if such action is found to be necessary. The choice of appropriate remedial action, such as judicious pruning or diversion of access routes can, however, often allow a tree to be retained with its associated habitats intact. Woodland managers are referred to publications by English Nature (Anon., 1996; Read, 2000) for further guidance on the recognition and management of veteran trees.

Table 1 Protection of trees: minimum distances for protective fencing around trees

Tree age	Tree vigour	Trunk diameter (mm)	Minimum distance (m)
Young trees (age less than 1/3 life expectancy)	Normal	<200 200–400 >400	2.0 3.0 4.0
Young trees	Low	<200 200–400 >400	3.0 4.5 6.0
Middle age trees (1/3–2/3 life expectancy)	Normal	<250 250–500 >500	3.0 4.5 6.0
Middle age trees	Low	<250 250–500 >500	5.0 7.5 10.0
Mature trees	Normal	<350 350–750 >750	4.0 6.0 8.0
Mature trees and overmature trees	Low	<350 350–750 >750	6.0 9.0 12.0

Note 1. It should be emphasised that this table relates to distances from centre of tree to protective fencing. Other considerations, particularly the need to provide adequate space around the tree including allowances for future growth and also working space will usually indicate that structures should be further away.

Note 2. With appropriate precautions, temporary site works can occur within the protected area, e.g. for access or scaffolding.



Branch spread (whichever is greater) **Half height**

SOURCES OF ADVICE

The Arboricultural Association, the Institute of Chartered Foresters and the International Society of Arboriculture maintain lists of practitioners who have experience in assessing tree safety. Qualified arboriculturists are employed by many local authorities. General information on questions of tree health and safety can be obtained from Forest Research, based at Alice Holt Research Station and at the Northern Research Station at Roslin.

Conservancy and national offices of the Forestry Commission (listed in the telephone directory) can advise on regulations applicable to felling and on the requirements for Felling Licences; the local planning authority can advise on Tree Preservation Orders or Conservation Areas.

ADDRESSES

Arboricultural Advisory and
Information Service
Alice Holt Lodge
Wrecclesham
Farnham
Surrey
GU10 4LH

Tree helpline: 0897 161147
(premium rate - £1.50 per minute)

Institute of Chartered Foresters
7a St Colme Street
Edinburgh
EH3 6AA

Telephone: 0131 225 2705

Forest Research

Alice Holt Lodge
Wrecclesham
Farnham
Surrey
GU10 4LH

Telephone: 01420 22255

Northern Research Station
Roslin
Midlothian
EH25 9SY

Telephone: 0131 445 2176

Arboricultural Association
Ampfield House
Ampfield
nr. Romsey
Hampshire
SO51 9PA

Telephone: 01794 68717

International Society of
Arboriculture
Troy House Chambers
Elmgrove Road
Harrow
HA1 2QQ

Telephone: 0208 8616852

English Nature
Northminster House
Peterborough
PE1 1UA

Telephone: 01733 455101

FURTHER INFORMATION

Research for Amenity Trees
a series of books published by The Stationery Office (formerly HMSO) for DETR (Department of the Environment, Transport and the Regions):

- No. 2 (1994, revised 2000)
  Diagnosis of Ill-health in Trees,
  by R.G. Strouts & T.G. Winter

- No. 4 (1995)
  The Body Language of Trees: A Handbook for Failure Analysis,
  by C. Mattheck & H. Breloer

- No. 7 (1999)
  Principles of Tree Hazard Assessment and Management,
  by D. Lonsdale

Guide for Trees in Relation to Construction (BS 5837).
British Standards Institution, London.

Recommendations for Tree Work (BS 3998).
British Standards Institution, London
(with 1990 amendment).

Tree Work and Employing a Contractor.
London Tree Officers' Association,
Islington, London UK.

Guide to the Care of Ancient Trees (1996).
Veteran Trees Initiative,
English Nature, Peterborough.

Veteran Trees: A Guide to Good Management,
by Helen J. Read (2000).
Veteran Trees Initiative,
English Nature, Peterborough.

FORESTRY COMMISSION (1995).
Forest Operations and Badger Setts.
Forestry Practice Guide,
Forestry Commission, Edinburgh.

R. FERRIS-KAAN, D. LONSDALE, AND T.G. WINTER (1993).
The conservation management of deadwood in forests.
Forestry Commission
Research Information Note 241.

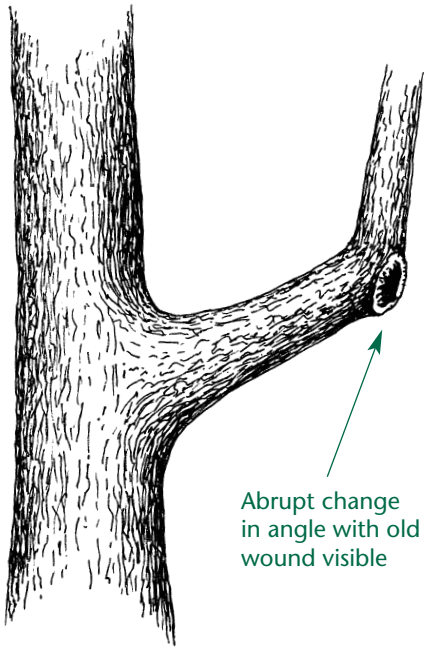
**Protected Trees* – a guide to tree preservation procedures, a free leaflet issued by DETR and available from your local planning authority or from the Arboricultural Advisory and Information Service, address on page 12.

†*Tree Felling - Getting Permission*, free booklet available at any Conservancy office of the Forestry Commission.

APPENDIX 1

Tree Hazards: Recognition and Recommendations

1. Abrupt bends in branches



An abrupt or 'dog-leg' bend is likely to mark the point where a side shoot has replaced a pruned, broken or dead portion of the branch. A combination of localised stress and decay, associated with the old wound, can sometimes lead to failure.

Possible signs of significant hazard:

- **Signs of decay at the 'elbow':** this may need detailed assessment.

Options for remedial work on the tree, if needed

- Cable or belt and/or rod bracing of the branch.
- Branch reduction or removal.

Prevention

- Avoidance of cutting back branches.
- Avoidance of creating large wounds if branches do have to be cut back.

2. Brittle decay

The most dangerous form of decay is brittle decay, caused by fungi which degrade the rope-like cellulose content of wood ('brown rot'). The tree retains its rigid strength (conferred by lignin) so that warning signs of increased flexure and cracking are usually absent. Snap can occur suddenly. Identification of fungal fruit bodies indicates the type of decay that is likely to be present.

Possible signs of significant hazard:

- **Fruit bodies of fungi associated with brittle decay.** Those commonest on woodland trees and most likely to be associated with brittle failure are:

  - *Laetiporus sulphureus* (on some broadleaved trees and yew)
  - *Sparassis crispa* (on conifers)
  - *Phaeolus schweinitzii* (on conifers)
  - *Ustulina deusta* (on many broadleaved trees)

Options for remedial work on the tree, if needed

- Cable or belt and/or rod bracing for affected branches.
- Crown reduction.
- Felling, if other options are not adequate or feasible.

3. 'Bottle-butt' ('Butt-swell')

Certain types of decay at the stem base, if extensive, may increase flexure sufficiently to stimulate extra growth of wood and create a bulge. In many cases, the extra growth is enough to maintain adequate support, but investigation is needed to ascertain this.

Possible signs of significant hazard:

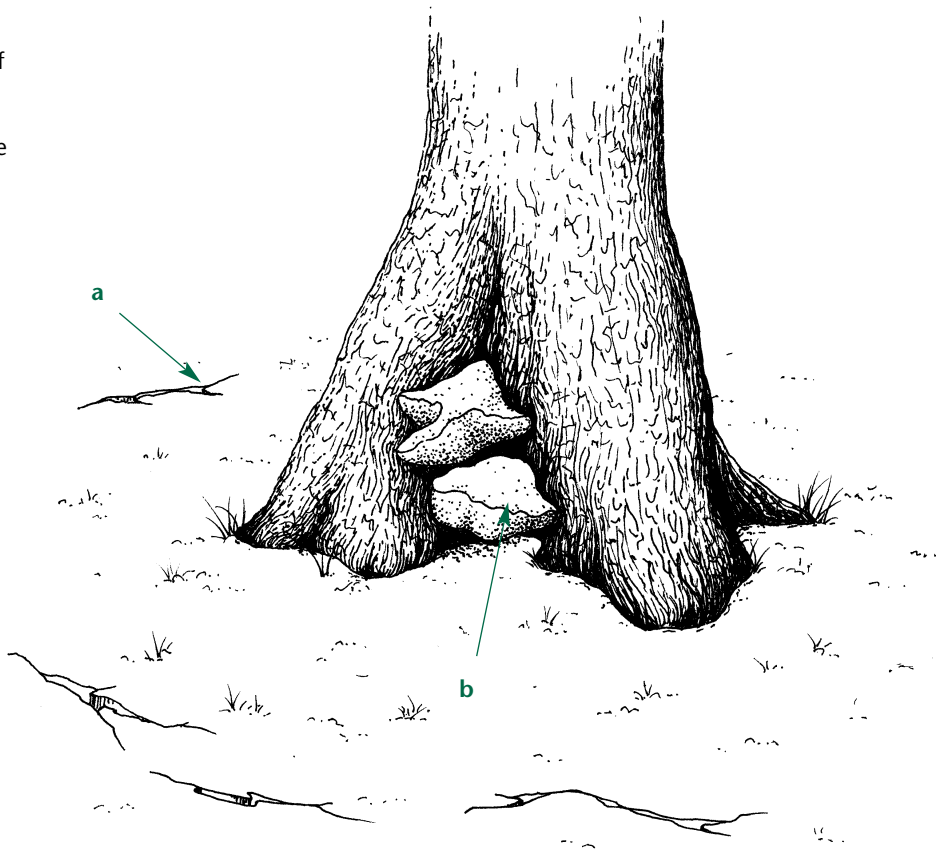
- **Cracking in the stem:** if more than two-thirds of the stem radius is hollow, cracks may develop as a warning of likely future collapse.
- **Cracking in the ground:** if roots are seriously decayed or otherwise lacking anchorage, cracks in the ground, around part of the edge of the root-plate area, may sometimes form due to wind-rock.
- **Insufficient sound wood:** detailed assessment is needed to determine this.

Options for remedial work on the tree, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.

a. Cracks in the ground, around part of the root-plate area

b. Fungal fruit bodies sometimes visible



4. Excessive sinking down of branches

In many conifers, most of the branches tend to sink down progressively as growth increases their weight. In most broadleaves (and some conifers) most of the branches remain at their original angle or sink down only very slowly due to the formation of 'reaction wood' which has a natural bracing effect. However, in some cases the bracing may not be enough to support heavy limbs, especially those that start low down on the trunk, and they eventually snap. A big change of angle may be indicated by bark plates looking buckled on the under-side and stretched apart on the upper side of the branch.

Possible signs of significant hazard:

- **Cracking on the lower side of the branch:** this shows that partial failure has occurred, although it may be very localised and not necessarily serious.

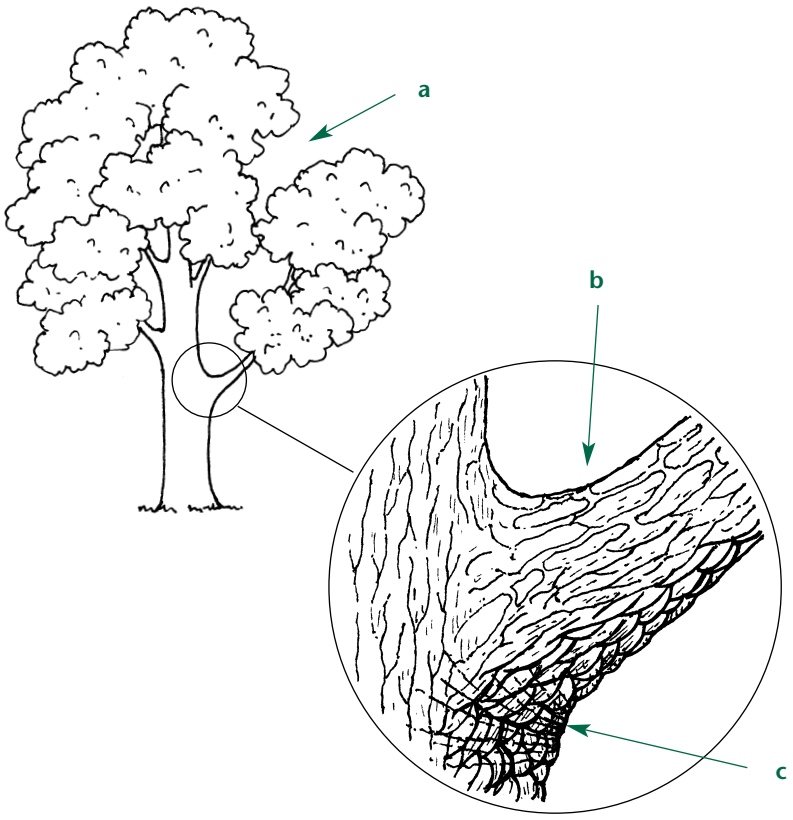
- **A gap in the crown:** this may show that a major branch has sunk down so fast that the foliage has not had time to grow into the resulting gap.

Options for remedial work on the tree, if needed

- Cable or belt and/or rod bracing.
- Branch reduction.
- Felling, if other options are not adequate or feasible.

Prevention

- Formative pruning of lower branches in young trees in high risk situations.



a. Gap in crown

b. Bark plates stretching on upper side

c. Bark plates buckling on underside

5. End-loading (top-heaviness) due to excessive pruning and multiple pruning wounds as source of a central decay column

The removal of many branches from a stem, or of many side branches from a main branch, alters the pattern of loading which may increase the amount of wind-sway and perhaps lead to an increased chance of snap. Moreover, decay associated with numerous wounds tends to coalesce to form a central decay column instead of small individual pockets of decay. If such a decay column occupies more than two-thirds of the stem cross-section, the stem could fail by buckling.

Possible signs of significant hazard:

- **Excessive swaying** in the wind.
- **Cracks** or other signs of partial failure.
- **Signs of extensive decay**, such as fungal fruit bodies in several places.

Options for remedial work on the tree, if needed

- Topping, if the tree is young and can be permanently managed as a pollarded specimen.
- Felling, in severe cases.

Prevention

- Better planning and site management to avoid the need for this undesirable treatment. In particular, trees should not be planted where they will eventually have to be heavily cut back to allow access; adequate space should be left between existing trees and new roads or buildings.

Features of a top-heavy tree (left):

a. Relatively pronounced taper, indicating that the tree was open-grown, and that its bare lower stem is the result of excessive pruning; not of competition within a dense forest stand

b. Numerous and perhaps large pruning wounds

c. Broad, truncated crown, indicating removal of lower portion

Features of a tree previously in a more shaded and sheltered situation (right):

a. Little taper

b. Stem may be unusually free from algae and lichens

c. Small branch scars, indicating natural pruning

d. Suppressed lower branches

e. Narrow crown

6. Exposure of previously sheltered trees

Trees that have grown in a closed-canopy stand are not mechanically adapted to strong wind exposure and can easily snap or blow over. The features shown in the illustration may aid identification of such trees when site history (e.g. nearby felling) is not known.

Possible signs of significant hazard:

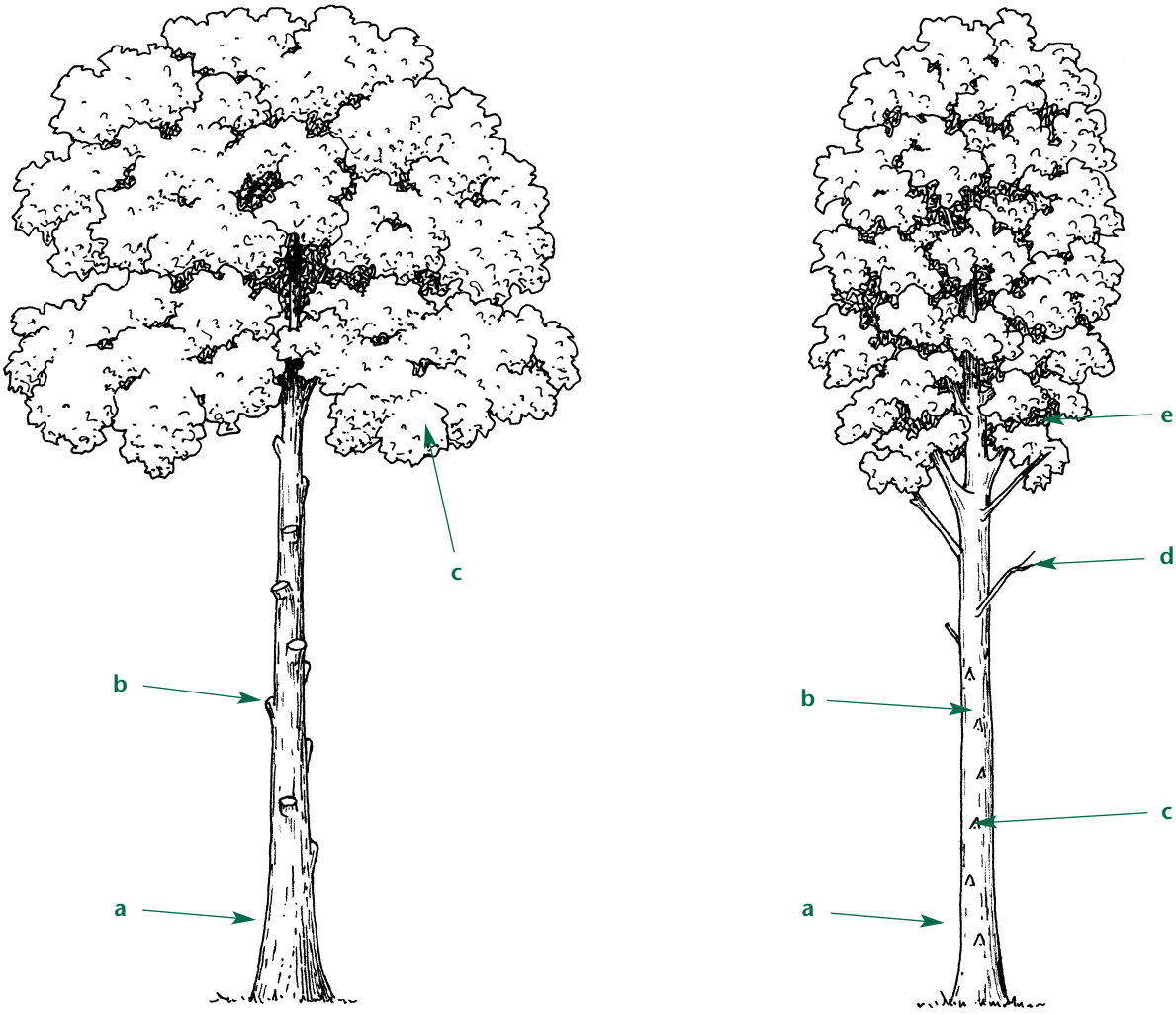
- **High exposure** to wind.
- **Cracks** or other signs of partial failure, including bending of stem.

Options for remedial work on the tree, if needed

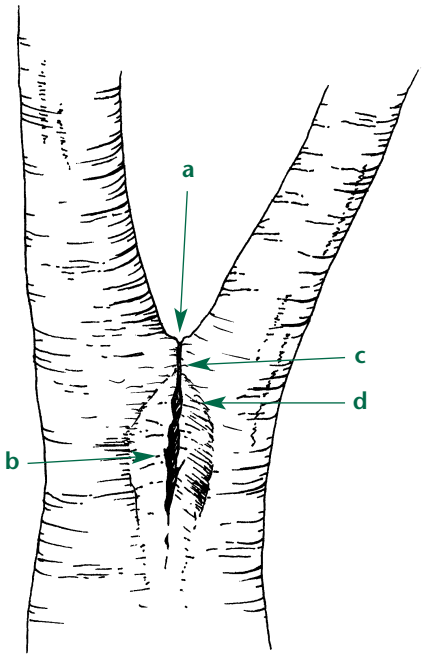
- Crown reduction.
- Felling, if other options are not adequate or feasible.

Prevention

- Maintenance of shelter, such as graded height of forest edge or avoidance of unnecessary removal of nearby trees.



7. Forks and other unions with included bark



a. Bark-to-bark contact may be most obvious here, or there may be a cup-like hollow, perhaps water-filled

b. Typical bulging growth at right-angles to the union

c. Branch bark ridge; lip-like zone, where little or no woody connection exists

d. Branch bark ridge; zone of 'gaping', where the bark inclusion is surrounded by wood

A union with a very acute crotch angle is likely to contain a region of bark-to-bark contact, which contributes nothing to its strength. Such unions often occur at forks (i.e. between co-dominant stems). Even if there is no included bark between such stems, their internal structure usually allows them to be pulled apart rather more easily than a branch from a main stem. In many tree species, weak forks appear to be the most frequent contributory factor to major failure above ground level. They are thus probably more important than decay as a cause of hazard, although decay can be very dangerous when combined with a weak fork.

Possible signs of significant hazard:

- **Structure of the branch bark ridge:** the ridge which is a normal feature of a union, becomes a double ridge where there is a bark inclusion. It looks like two lips pressed together (c). The 'lips' usually gape apart at zone (b), where the bark inclusion is surrounded by wood. The longer the proportion occupied by the parallel 'lips', the weaker the union.

- **Angle above the union:** co-dominant stems often curve upwards to a near-vertical orientation just above the union. If, however, they diverge up to a considerable height, they may be bearing excessive leverage from the weight of the crown.

- **Species or cultivar of tree:** weak fork failures are more common in some species and cultivars of trees than in others. Examples of trees with a high risk of this type of failure include various species of willow and poplar, horse chestnut, beech, ash and true cedars. Examples of relatively low-risk trees include hornbeam, alder and many conifers, including most kinds of larch, spruce and redwood.

- **Splitting and decay:** if there is a crack below zone (c), the union has partially failed and could easily split completely apart, especially if decay has set in at this point.

- **Wind exposure:** unions with included bark are most likely to fail in trees on exposed sites (especially if exposure has increased, as when surrounding trees are removed), or in dominant trees whose height makes them rather exposed. Gusts blowing between the forks are most likely to cause failure.

Options for remedial work on the tree, if needed

- Cable or belt and/or rod bracing.
- Crown reduction.
- Felling, if other options are not adequate or feasible.

Prevention

- On high-risk sites, choose species or cultivars less liable to form these unions (see examples above and Lonsdale [1999] in reading list, page 13).
- Formative pruning.

8. Grafts, showing incompatibility

Grafted trees are less common in woodland than in other situations but are by no means rare in, for example, policy woodlands and arboreta. They may have a weak union between stock and scion due to genetic incompatibility or reaction to a virus infection. The stem may therefore break at the old graft line.

Possible signs of significant hazard:

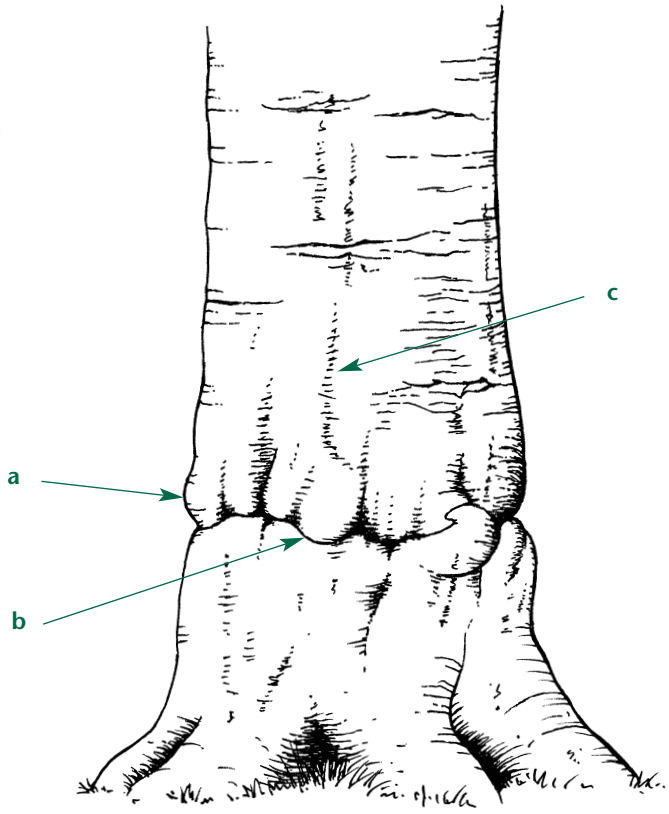
- **Irregular graft line**, associated with local bulging growth of the stock and scion.
- **Strong stem fluting** above and below the graft line: another sign of incompatibility.
- **Species or cultivar of tree**: some trees, especially species of *Sorbus*, fail more often at grafts than others.
- **Decay**: If decay is present in the graft zone, failure is more likely.
- **Wind exposure**: Weak grafts are most likely to fail in trees on exposed sites (especially if exposure has increased as when surrounding trees are removed), or in dominant trees which are more exposed than their neighbours.

Options for remedial work on the tree, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.

Prevention

- Use of non-grafted specimens if feasible.
- Choice of suitable stock and scion.

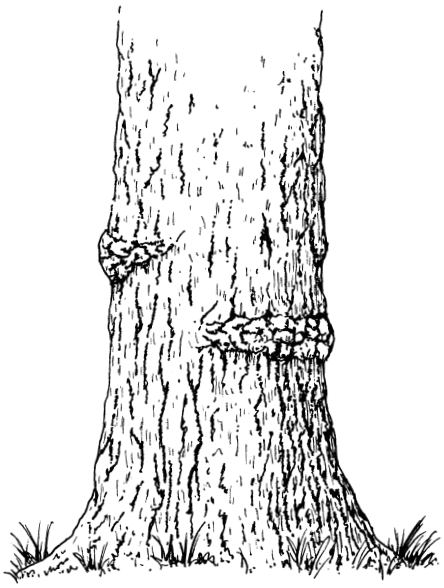


a. Bulging growth near graft line

b. Irregular graft line

c. Stem fluting near graft

9. Incipient failure of the main stem



Tyre-like bulges, which may either occur on one side of the stem or completely surround it

Young trees may flex so much in the wind that the wood fibres buckle in places, even though the stems stay otherwise intact. Subsequent compensatory growth produces horizontal tyre-like bulges which may occur on one side of the stem or completely surround it, and which may continue enlarging indefinitely. In trees with dense wood, such as native oaks, these signs are no cause for concern, but snap can occur at old buckling points in poplars and other species with less dense wood.

Possible signs of significant hazard:

- **Tree species:** knowledge of tree species can aid an expert assessment of potential hazard.
- **Wind exposure:** for failure-prone species, wind exposure needs to be considered.

Options for remedial work on the tree, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.

10. Instability due to restricted rooting

Tree species differ in their ability to root into poorly aerated soil. If the well-aerated zone of the soil is shallow, some species may become inherently unstable when they reach a certain height. They may to some extent compensate for this by producing wide, though flattened, root-plates but such lateral development is restricted by competition in forest stands. Thinning of the stand or exposure by partial clear-felling is then especially liable to lead to windthrow. (See also ‘Exposure of previously sheltered trees’, page 19.)

Possible signs of significant hazard:

- **A known history of windthrow** at the site, perhaps involving particular species, such as spruces, western hemlock or red oak.
- **Cracking in the ground:** if roots are lacking anchorage, cracks in the ground around part of the edge of the root-plate area may sometimes form due to wind-rock.

Options for remedial work on individual trees, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.

11. Neglected pollards

Trees that are pollarded when young often live longer than is usual for the species concerned, but their branches can become excessively crowded and heavy if regular re-cutting lapses. Neglected pollards are common in urban streets and parks but they also occur in woodland and rural parkland, where ancient specimens usually have extremely high conservation value and younger trees are valuable for succession. Failure in pollards often involves snap of top-heavy new branches, rather than splitting at the pollard point. Crown removal in older trees (sometimes called topping, rather than pollarding) can cause problems as the new branches are likely to fail as soon as they grow heavy.

Possible signs of significant hazard:

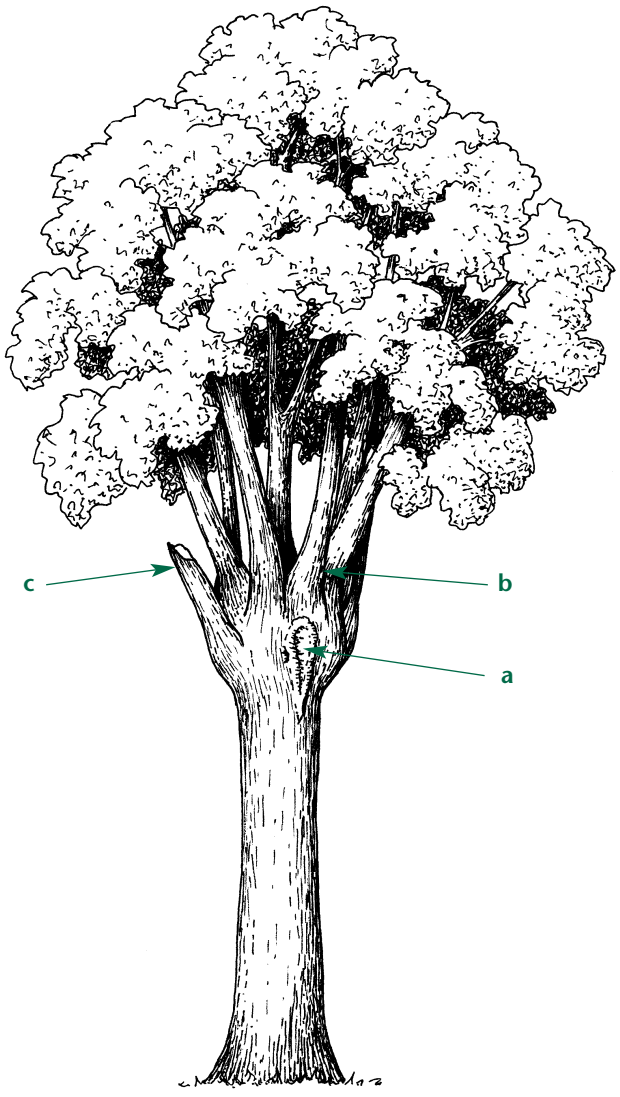
- **Branches with their bases pressing against a dead snag** left by topping an already mature tree: such branches are often poorly attached.
- **Species of tree:** fast-growing broadleaved species with relatively soft wood, especially poplars, willows and horse chestnut, are much more prone to fail when pollarded and then neglected than are many other species.
- **Wind exposure:** as with other types of weakness, the exposure of the site is a major consideration.

Options for remedial work on the tree, if needed

- Re-cutting above old pollard points.
- Felling, if other options are not adequate or feasible.

Prevention

- Avoidance of topping semi-mature or older trees.
- Regular re-cutting of pollards.



a. Tear-out wound of weakly attached branch: a site of potential decay in the main stem

b. Overcrowded and heavy branches

c. Mechanically weak branch broken above pollard point

12. Poor crown condition

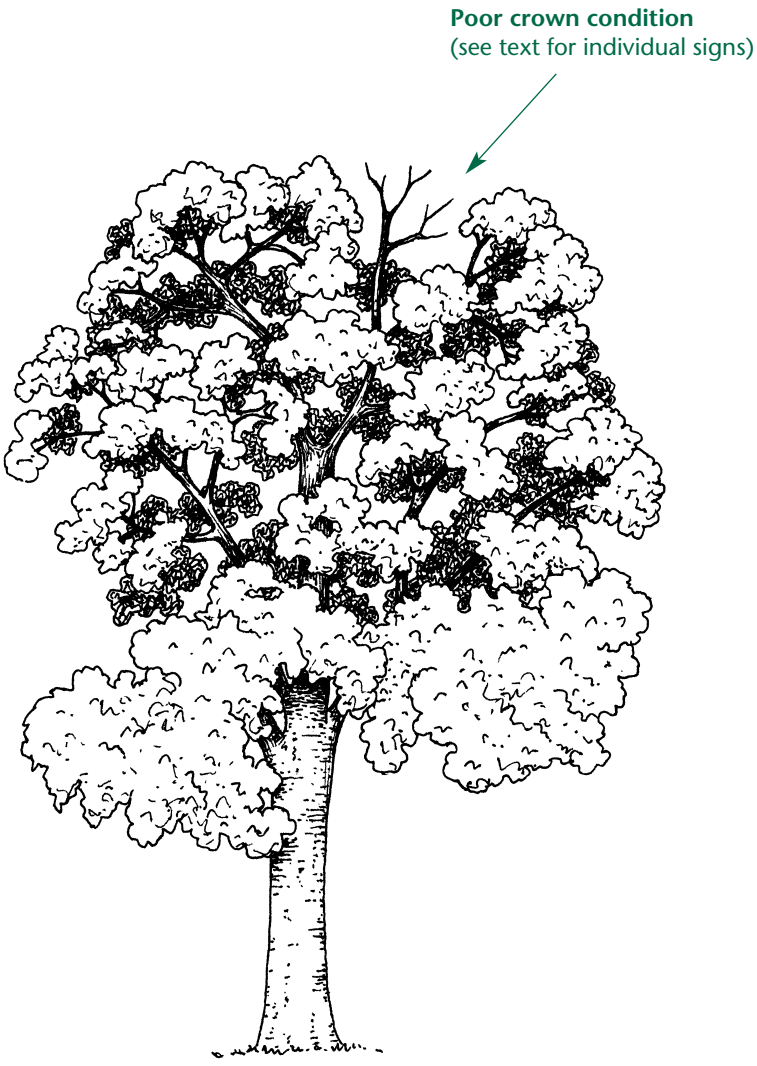
Small, dead, sparse or abnormally yellowish leaves or needles, especially when in the upper crown and associated with twig dieback, may indicate root-rot or other root injury which has weakened the tree's anchorage. A reduction in shoot extension growth often precedes obvious crown thinning or dieback. Expert assessment may be needed to confirm whether such signs indicate a root problem.

Possible signs of significant hazard:

- **Soil cracks:** these may indicate wind-rock due to poor anchorage.
- **Fungal fruit bodies at or near base of stem:** identification of fungi may be necessary to help decide whether decay is present and whether detailed assessment is required.

Options for remedial work on the tree, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.



13. Ribs and open cracks on stems and major branches

Ribs are often a sign of cracking, being produced by the tree's attempts to seal over cracks with new wood. Although cracks represent partial failure, this is not necessarily a serious problem. Expert examination may be needed to evaluate the hazard associated with a particular crack.

Possible signs of significant hazard

- **Shape of the rib:** sharp-nosed ribs usually indicate that the crack has not been successfully occluded owing to continuing movement of the wood either side. Blunt-nosed ribs often indicate that the crack is overlain by a number of intact annual rings.

- **Position of ribs or of visible cracks:** major failure is most likely to be associated with ribs or visible cracks on opposite sides of a main stem. Other aspects of position are important in evaluating risk but require expert interpretation.

- **Species or cultivar of tree:** Some types of tree, such as native oaks, often form localised cracks which are seldom, if ever, associated with major failure. A similar crack on, for example, a horse chestnut, could be a more serious matter.

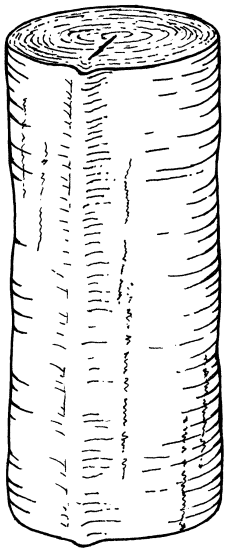
Options for remedial work on the tree, if needed

- Cable or belt and/or rod bracing.
- Crown reduction.
- Felling, if other options are not adequate or feasible.

Prevention

- Avoidance of harsh pruning, which leads to the formation of localised stresses in subsequently formed wood.

a



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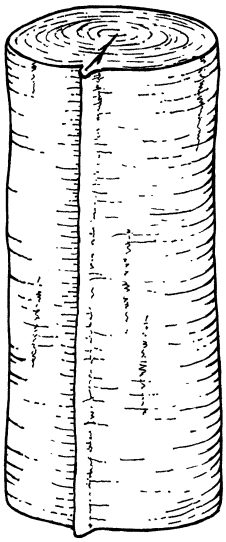


a. Blunt-nosed rib showing occluded crack covered by intact annual rings

b. Sharp-nosed rib showing crack extending to the outside

14. Target canker

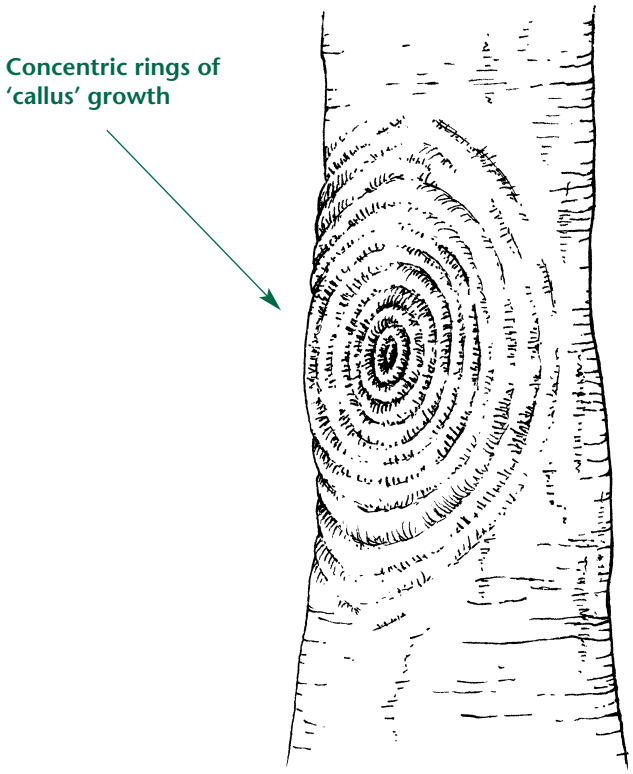
Some types of canker persist for years, with successive periods of healing growth and then killing of the new tissues. Mechanical stresses become concentrated around the canker, and this can cause snap. For further information on target cankers, caused by fungi such as *Nectria* spp. or *Stereum rugosum*, see Strouts & Winter (1994).

Possible signs of significant hazard:

- **A canker occupying a substantial part of the stem circumference:** there is not enough evidence to give an exact limit, but experience suggests that 25% or more should be regarded as suspect.
- **More than one canker present on a stem.**
- **Wind exposure:** cankered stems are most likely to fail in trees on exposed sites (especially if exposure has increased as when surrounding trees are removed), or in dominant trees which are more exposed than their neighbours.

Options for remedial work on the tree, if needed

- Crown reduction.
- Felling, if other options are not adequate or feasible.



15. Wounds

If wood loses its protective cover of bark, it can become decayed. The decay may be apparent at the surface but it is not uncommon for there to be a 'case-hardened' layer of apparently sound wood over the decayed zone.

Possible signs of significant hazard:

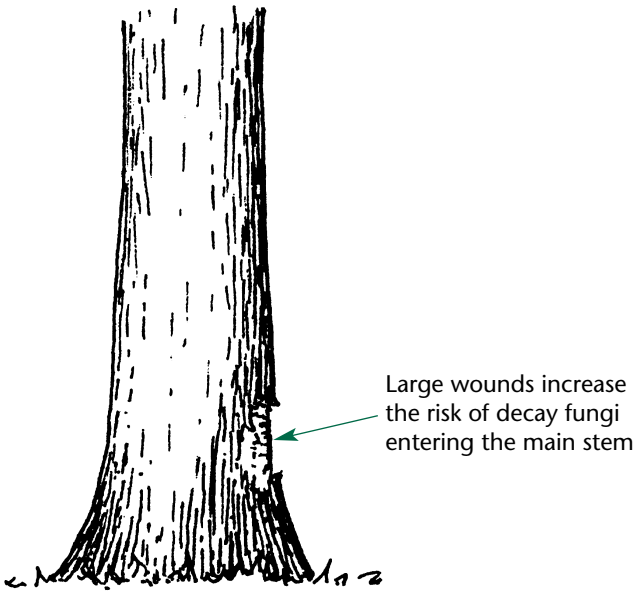
- **Size of wound:** large wounds are more likely than small ones to lead to extensive decay.
- **Depth of wound:** wounds in which the wood is scored or splintered are more likely to lead to decay than skinning wounds.
- **Fungal fruit bodies:** on wounds indicate that decay is at least superficially present.

Options for remedial work on the tree, if needed

- Crown reduction if decay from wounds or dieback is extensive.
- Felling, if damage is extensive and other options are not adequate or feasible.

Prevention

- Use working practices that minimise stem and root wounding.
- Avoid unnecessary pruning.
- Protect high value trees.



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