- Planning
- TPO
- Safety Inspection
- Subsidence
- Litigation
- Design

Forbes-Laird Arboricultural Consultancy

Principal Consultant:
Julian Forbes-Laird
BA(Hons), MICFor, MEWI, M.Arbor.A, Dip.Arb.(RFS)

IN THE HIGH COURT OF JUSTICE,
QUEEN'S BENCH DIVISION

Claim No.

HQ10X1869 –

MULLINGER, BOWEN, FARLEY & FARTHING
AND
THE NATIONAL TRUST

EXPERT EVIDENCE (ARBORICULTURE)
OF
JULIAN FORBES-LAIRD

VOLUME 2 – APPENDICES & REFERENCES

Prepared for the Claimants, on instructions from:

Ellisons Solicitors

FLAC Instruction ref:

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VOLUME 2: APPENDICES & REFERENCE MATERIAL

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References cited in the text

No.	*On page*	*Source*
1	7	'Updated Field Guide for Visual Tree Assessment', Claus Mattheck, 1st edition 2007, p.2
2	7	The Body Language of Trees', Claus Mattheck & Helge Breloer, TSO 1st edition 1994
3	11	'The Face of Failure in Nature and Engineering', Claus Mattheck, 1st edition 2004, p.144
4	12	'Updated Field Guide...' op. cit. p.30
5	13	'The Face of Failure.,.' op. cit. p.141
6	14	'Updated Field Guide...' op. cit. p.21
7	15	Ibid. p.22
8	16	Ibid. p.23
9	17	'Stupsi Explains the Tree', Claus Mattheck, 3rd enlarged edition 1999, p.21
10	17	Ibid. p.22
11	22	'The Body Language of Trees' op. cit. p.1
12	22	Ibid. for example at p.36
13	33	'Principles of Tree Hazard Assessment & Management', David Lonsdale TSO 1999, p.331
14	34	Ibid. p.347

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APPENDIX JFL1

QUALIFICATIONS AND EXPERIENCE OF JULIAN FORBES-LAIRD

Forbes-Laird Arboricultural Consultancy Ltd

• Planning • TPO • Safety Inspection • Subsidence • Expert Witness • Design

Principal Consultant:
Julian Forbes-Laird
BA(Hons), MICFor, MEWI, M.Arbor.A, Dip.Arb.(RFS)

JULIAN FORBES-LAIRD

QUALIFICATIONS AND EXPERIENCE

Julian Forbes-Laird is Director and Principal Consultant of Forbes-Laird Arboricultural Consultancy Ltd (FLAC), a small but nationally reputed practice. He has over eighteen years' experience of undertaking a variety of arboricultural assessments for a wide range of public, corporate and private clients.

JFL started his career in arboriculture on the practical side of the profession, before completing a gradual transition to consultancy in 2000. After two years spent working as an independent consultant, he spent a further two years as Senior Consultant at CBA Trees, before establishing FLAC in 2004.

FLAC provides an efficient and approachable service to Expert Witness level, geared to securing our clients' objectives within the required timeframe in whatever area of arboriculture they may instruct us, though we specialise in planning and litigation matters. Notes on specific areas of the practice follow.

Having developed and lectured widely on a respected and peer-reviewed method designed to quantify the risk posed by defective trees (THREATS), JFL is a recognised authority on tree hazard assessment. He has undertaken several forensic accident investigations including in relation to fatalities caused by trees.

He has published a number of articles in the arboricultural and landscape press, variously covering tree risk assessment, legal aspects of liability for hazard trees, subsidence, and the arboricultural significance of certain wood decay fungi on trees. In addition, JFL is a well-known figure on the arboricultural lecture circuit.

FLAC has undertaken several projects concerning the assessment, management and preservation of veteran trees. Particular specialisations in this field are determining crown restoration needs, and the management/ restoration of historic avenues and landscapes.

FLAC has advised various landscape design projects focussing selection and establishment of woody plants These include both amenity woodlands and rural and urban planting schemes in the United Kingdom and abroad.

JFL is regularly instructed in the area of tree root damage to buildings, frequently acting as an expert witness in this demanding area of arboriculture.

A significant proportion of our work relates to Tree Preservation Orders. JFL has been instructed as an expert witness on several occasions to assist local authorities with prosecutions for offences under the relevant legislation, and has appeared for the prosecution in the Crown Court. Additionally, he is author of the TEMPO system for assessing whether trees merit TPO protection; TEMPO is used by over 60 local authorities and dozens of consultants.

Many of our instructions derive from the planning process such that we are very frequently asked to assist with all tree-related aspects of site development. As a natural consequence of this, we regularly contribute to all types of planning Appeals, representing both local authorities and also developers. JFL also undertakes advocacy at Public Local Inquiries on behalf of third party objectors.

JFL was a technical editor of BS5837:2005 and is now a technical editor of the emerging BS5837[2011]. For the 2005 edition, he was specifically responsible for preparing drafts of the sections relating to tree survey methodology and demolition and construction in proximity to trees.

JFL is senior technical editor for a new British Standard, BS8516 'Recommendations for Tree Safety Inspection'. He is also a member of the BSI technical committee, on trees, B/213.

Julian Forbes-Laird is a Chartered Arboriculturist and a member of the RICS Dispute Resolution Panel 'Expert Advisers in Planning Service', formed principally to advise the Planning Inspectorate. He is a member and Registered Consultant of the Arboricultural Association, a Member and Registered Consultant of the Institute of Chartered Foresters through examination at Masters level, a member of the Expert Witness Institute, and a Sweet & Maxwell 'Checked Expert Witness'. He is a member of the Royal Forestry Society and holds its 'Professional Diploma in Arboriculture', a degree-level professional qualification, and is also a member of the Arboricultural Journal peer referee panel.

JFL and FLAC have recently undertaken or have ongoing work on projects for/with the following:

Government infrastructure, Health & Education
Cambridge University
Cranfield University
Department of Children Schools & Families
East & North Herts PCT
Environment Agency
Greenwich Hospital
Itchen College
London Ambulance Service NHS Trust
Moorland Energy
Network Rail
Oxford University
Thames Water
Transport for London
University of Reading
Westonbirt School

Local Authorities
East Dorset District Council (Subsidence)
Forest Heath District Council *(PLI)*
Hart District Council *(PLI)*
King's Lynn & West Norfolk District Council *(Advice)*
Loch Lomond & The Trossachs NPA *(TPO review)*
London Borough of Camden *(Advice)*
Redcar & Cleveland Borough Council *(Litigation)*
Royal Borough of Kensington & Chelsea *(PLI)*
St Albans City & District Council *(PLI)*
St Edmundsbury Borough Council *(TPO prosecution)*
Welwyn & Hatfield District Council *(Tree assessment)*
West Lindsey District Council *(TPO prosecution)*
Wokingham Unitary *(Accident investigation)*
Wycombe District Council *(Development)*

Developers
Barratt
Bellway
Catesby Property Group
David Wilson
Fairview New Homes
Gladedale Group
Hermes
Laing O'Rourke
Marriott
Construction Martin
Grant Homes Peel
Holdings Persimmon
Taylor Wimpey

Solicitors
ASB Law *(Subsidence)*
Ellisons *(Litigation)*
Fields Fisher Waterhouse *(Litigation)*
Forsters *(PLI & Litigation)*
Freshfields Bruckhaus Deringer *(Litigation)*
Howes Percival *(Litigation)*
Masons *(Litigation)*
Plexus Law *(Litigation)*
Taylor Wessing *(Planning)*
Wedlake Bell *(TPO Appeal & Litigation)*
Weightmans *(Litigation)*

Planning Consultants
Barton Willmore
Broadway Malyan
Cluttons
Cushman & Wakefield
Drivers Jonas
Hives
RPS
Savills

Architects
Foster + Partners
Hamiltons
Hopkins
Stanton Williams
Wilkinson Eyre

Landscape Architects
Barton Willmore Design
Capita Lovejoy
Christopher Bradley-Hole
Cooper Partnership
Hankinson Duckett Associates
The Terra Firma Consultancy

And
Centre Parcs
Janine Stone Design
Maggie Centres
Mare Curie Cancer Care
The Crown Estate
The Diocese of Winchester
The Honourable Society of Gray's Inn
Tottenham Hotspur FC

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APPENDIX JFL2

NATIONAL TRUST
TREE INSPECTION POLICY, 1997

1. INTRODUCTION

The Trust has a statutory duty of care. Members of the public and staff must not be put at risk because of any failure by the Trust to take all reasonable precautions to ensure their safety.

A Risk Assessment is necessary. There is a need to inspect trees in or near public places, or adjacent to buildings or working areas in order to assess whether they represent a risk to life or property and to take remedial action where appropriate.

This Instruction acts out minimum standards of inspection, competence and record keeping.

In order to arrive at a Risk Assessment the two separate factors of Hazard and Risk must be addressed.

2. HAZARD AND RISK

Hazard is the potential to cause harm.

Like all living organisms, trees are subject to decline, senescence and collapse and they can be damaged physically or invaded by pathogenic organisms. As trees deteriorate so they are increasingly likely to shed limbs or fall in strong winds and the potential to cause ham increases.

Ancient and decaying trees are often beautiful and uniquely valuable as habitat for wildlife and, however poor the physical condition of a tree, remedial action is only necessary where there is a clearly perceptible risk to life or property. This might mean removing part of the tree or reducing the level of public access in the vicinity.

Risk is the level of likelihood that a hazardous tree will cause actual damage.

Risk is related to the location of the tree. It reflects the intensity of use of the immediate surroundings of the tree and the proximity of the tree to buildings or other structures.

3. THE TREE INSPECTION PROGRAMME

It is the responsibility of the Property Manager* (see note on page 4) to ensure that tree inspection procedures are in place and that they are undertaken only by staff or others who meet the requirements of competence set out in section 8.

The tree inspection programme has three stages;

- an assessment of risk;
- an assessment of hazard;
- a prescription for remedial action.

These need not all be undertaken by the same person.

4. ASSESSING THE LEVEL OF RISK

This is undertaken by the Property Manager* with advice from relevant Property Heads of Department.

For a programme of tree inspection to be manageable, most resources need to be directed to areas where there is potentially most risk to people and property. This is initiated by designating each part of a property to one of three Risk Zones. These should be clearly documented.

High Risk: car	e.g. close to main public areas, work yards, buildings, roads, parks, major footpaths, picnic areas etc.
Medium Risk:	e.g.- other footpaths, bridle ways etc in regular but not intensive public use, quieter areas of parks and gardens etc.
Low Risk:	e.g. farmland and woodland away from paths or only lightly used etc.

These zones will reflect normal usage but must be kept under review. The level of risk changes over time. For example, plans to hold an event involving many people in a medium risk zone will change its status to high risk for the duration of the event; new facilities or activities on a property may more permanently change the patterns of public usage and hence necessitate a review of the designated risk zone.

The designation of Risk Zones is a matter of informed judgement and periodic review. **It is the responsibility of the Property Manager* to ensure that Risk is periodically reviewed, realistically assessed and decisions documented.**

5. ASSESSING HAZARD

This is undertaken by a member of staff, volunteer or contractor (the Inspector) nominated by the Property Manager*.

It is the responsibility of the inspector to ensure that hazard is assessed to the best of his/her ability and recorded accurately.

Many trees are potentially hazardous but only the conditions most likely to lead to injury or damage to people or property can reasonably be addressed by inspectors. These are physical or physiological conditions which might lead to a break up or collapse of the tree. They are identified and recorded during a programme of inspection.

In practice only visible defects are likely to be identified. Techniques available to assess the structural integrity of standing trees, such as electronic sensors and hand operated borers, will not be used as a matter of course. Rather they will be used only where it is necessary to assess the extent of decay in particularly important trees already showing visible symptoms of decline.

Knowledge of the propensity of some species to break up or decay more rapidly than others is necessary but most property based staff who routinely work with trees would be competent to undertake this inspection after receiving basic introductory training.

The frequency and method of inspection will reflect the designated Risk Zones:

Risk Zone	Inspect	Method
High Risk	Annually in Autumn	Rapid but careful search for clear defects especially in the crown and around the base of the tree. Binoculars and probe required.
Retained trees in High Risk Zone showing significant defects	At least six monthly and after storms	Thorough inspection, monitoring rate of decline. Probe and ladder may be required.
Medium Risk	At least every two years	Rapid but careful search for clear defects.
Low Risk	During normal routine visits	No formal inspection, just observation and awareness of the general condition of the trees.

6. RECORD OF INSPECTION

Trees that appear to be sound during formal inspections require no documented record of their condition. Any omission from the record therefore implies that the tree has been judged to represent a negligible hazard.

Trees that are hazardous or potentially hazardous must be documented. A National Trust Tree Work Proposal Form (attached) has been developed to standardise the procedure. Soft ware is also available to store this data, e.g. National Trust Tree Condition Data base. It enables individual annual tree records to be viewed simultaneously, providing a means of monitoring changing tree condition. Electronic recording of tree inspection data should be introduced as soon as practicable. Records must be retained for at least seven years.

7. DETERMINING REMEDIAL ACTION

The appropriate remedial action must be prescribed by a competent person. The necessary level of competence is defined in section 8.

A record of action proposed and action taken must be maintained using the NT Tree Work Proposal Forms or the appropriate electronic means described above.

The priority for implementing remedial action will depend on both the assessment of risk and hazard.

In a high risk area trees which show obvious signs of imminent collapse or are otherwise seriously hazardous should be dealt with immediately on the best advice available.

Otherwise, once approved by the Property Manager*, remedial action must be implemented without unreasonable delay.

Provision must be made in property budgets for the implementation of tree inspection programmes and necessary remedial action on an annual basis as recurring expenditure.

8. COMPETENCE

Staff or volunteers undertaking the initial assessment of hazard should have some experience of tree work and must have received a minimum of one day's training in the. recognition of tree defects. These courses can be arranged by Forestry Advisers at the request of Regional Personnel Officers.

Staff determining the appropriate remedial action must have good basic forestry or arboricultural experience and, as a minimum, a four day training in tree assessment at an approved Arboricultural Training Establishment. This course can be arranged by the Head of Forestry at the request of Regional Personnel Officers.

Consultants should normally be registered as consultants by the Arboricultural Association. A list is published annually.

9. COMMISSIONING TREE WORK

There is a presumption against the employment of specialist tree climbers on the staff of the Trust. This is on grounds of cost as well as safety. Tree climbing work will normally be contracted out.

Contractors should normally be selected from amongst those listed in the Directory of Approved Contractors published by the Arboricultural Association.

Work must be carefully specified and will be subject to relevant National Trust contract documentation:

> 'The General Requirements and Conditions for Countryside and Garden Work'
> 'The Special Requirements and Conditions for Arboricultural Work'.

* If there is no designated Property Manager, the Managing Agent or Area Manager must nominate a competent member of staff to discharge the responsibilities of the Property Manager identified in this instruction.

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APPENDIX JFL3

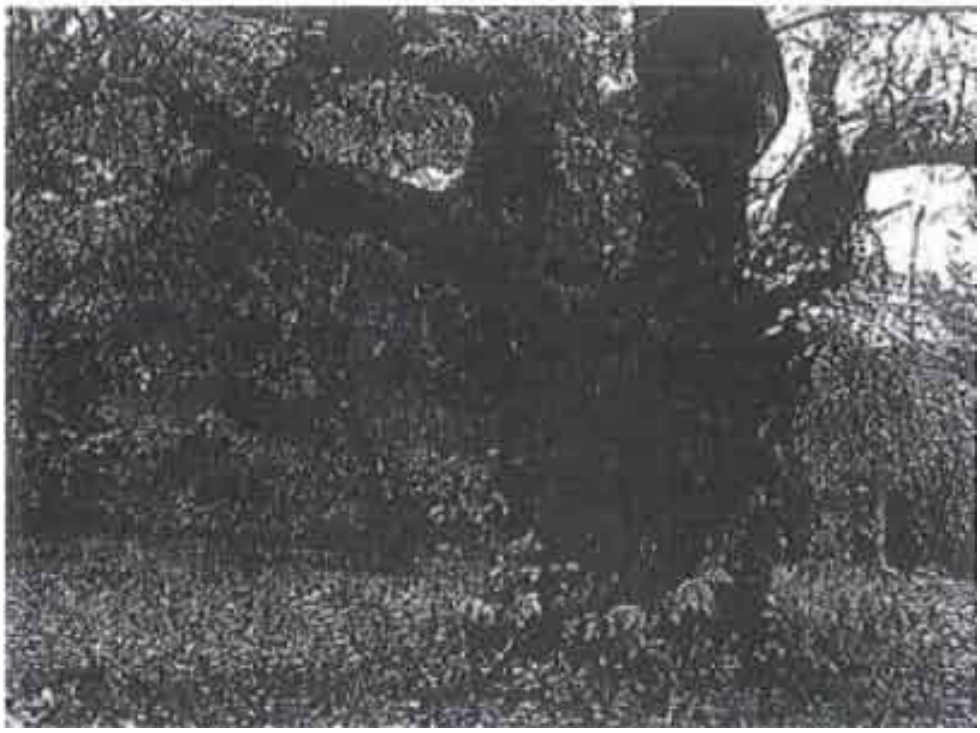
NATIONAL TRUST

TREE INSPECTION POLICY, 2007

THE NATIONAL TRUST

Health and Safety Instruction No. 11 and explanatory guidance

Tree safety management



Contents

MANDATORY REQUIREMENTS

Usage zones must be established for all properties (see 2.1)
Inspection of all trees must be carried out at the frequency assigned to the relevant usage zone (see 2.2)
Inspections must be carried out by persons with appropriate training and expertise (see 3)
Where hazards are identified, the risk must be assessed to determine what remedial action is necessary (see 2.3)
Remedial action must be taken within agreed priorities, where the individual tree risk assessment concludes that this is necessary (see 2.4)
Provision must be made in property budgets and staff work schedules for tree inspection programmes and necessary remedial action (see 2.5)
Records of inspection, remedial work and staff training must be kept (see 2.6)

EXPLANATORY GUIDANCE

1. INTRODUCTION

The Trust owns around 250,000 hectares of land in England, Wales and Northern Ireland and cares for millions of trees. These are highly valued for their natural beauty, the wildlife they support, and their importance in the landscape. The most important trees tend to be those of greatest size and age. In the UK as a whole, there are on average about 4-6 fatalities attributable to falling trees and branches each year, generally considered to be an acceptably low level of risk for the population as a whole.

However, there are risks of injury to staff, volunteers and the public from falling trees and branches. There are also risks of damage to buildings, property and vehicles. The Trust has a statutory duty to assess and manage these risks. The duty is established in criminal law under the Health and Safety at Work Act, and in civil law under the Occupier's Liability Act. The Trust must take all reasonable precautions to avoid risks to the safety of members of the public, staff and volunteers. There is a need to inspect trees in and near public places and adjacent to buildings and working areas, to assess whether they represent a risk to life and/or property, and to take remedial action as appropriate.

Tree safety management is one aspect of visitor safety management. The Trust's approach to visitor safety management is based on the guiding principles contained in the booklet "*Managing Visitor Safety in the Countryside - principles and practice*", published by the Visitor Safety in the Countryside Group (the National Trust is a member). The booklet was distributed to all Property Managers in 2003. An updated edition was published in 2005.

There are six key elements to tree safety management – each is considered in detail in the sections that follow.

- Establishing Usage Zones on the property
- Identifying hazards (through the process of regular tree inspection)
- Assessing risk (by considering the likelihood of failure and its consequences)
- Determining remedial action and priorities
- Implementing a prioritised work programme
- Recording Usage Zones, inspections and remedial work

This instruction sets out the required standards for tree safety management. It aims to develop the previous NT instruction and guidance (2001) to align with best practice in the arboricultural profession, while remaining practical and deliverable. Its principal objective is to provide pragmatic and effective procedures for managing the risk to people and property in the vicinity of trees. For detailed external guidance on tree inspection procedures, see the list of publications in Section 7.

2. TREE SAFETY MANAGEMENT PROCEDURES

It is the responsibility of the Property Manager to ensure that tree safety management procedures are in place and that they are undertaken only by staff or others who meet the requirements of training and competence set out in Section 3. If there is no designated Property Manager, and at tenanted properties open to the public (unless the lease explicitly states this is the tenant's responsibility), the Area Manager must nominate a competent member of staff to fulfil these responsibilities. For other tenanted properties, the lease may define or indicate where the responsibility for tree safety management lies. If it lies with the Trust, a competent member of staff must be appointed to fulfil these responsibilities; if it lies with the tenant, it would be advisable to remind the tenant of this. New leases in future should explicitly state where the responsibility for tree safety management lies.

2.1 Establishing and mapping Usage Zones

For a programme of tree inspection and management to be practical, most resources need to be directed to areas where there is greatest risk to people and property. This is initiated by designating each part of the property to one of five Usage Zones. At some properties, all five zones will be applicable; at others, three or four zones may be applicable. Assignment of usage zones is also the responsibility of the Property Manager, with assistance from property staff and functional advisers. The Usage Zone is based on the likelihood of people being injured, or buildings and other valued property being damaged in the event of failure of all or part of a tree.

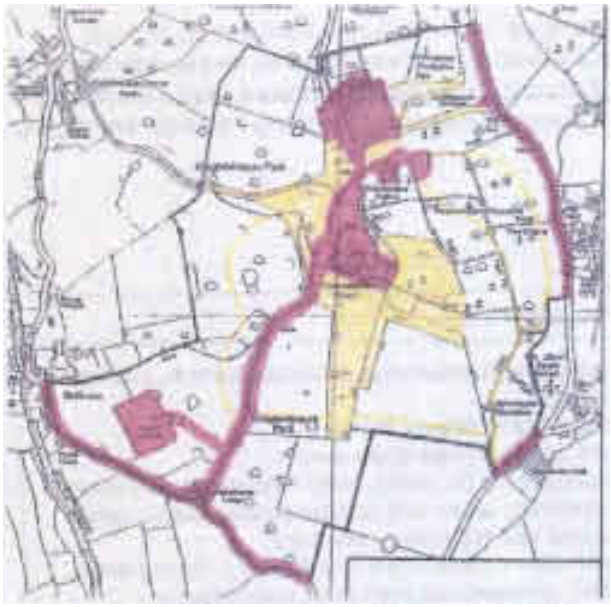
These zones take account of different levels of use and types of activity, reflecting the numbers of people that use a particular area and the time they spend in that area. Zones should also take account of the value of buildings, structures and property. Zones should be mapped and the rationale for their selection clearly documented. Table 1 below sets out the different Usage Zones.

These zones will reflect normal usage during the course of the year but must be kept under review. The level of risk may change over time. Note that temporary events can change the zone designation for a limited period. For example, plans to hold an event in a zone previously designated as medium will change its status to very high or high (depending on scale and type of event) for its duration. New facilities or activities at a property may change the patterns of public or staff usage permanently and hence require a review of the designated usage zone. Usage Zones should be reviewed at least every two years or more frequently if appropriate, and decisions should be documented.

At present, the establishment of Usage Zones is an informed judgement based on local knowledge, rather than precise measurement of visitor numbers or traffic levels, although where this information is already available, it should be taken into account. Area Managers and functional advisers can help to ensure a consistent approach among Property Managers to the designation of Usage Zones.

Table 1 - Usage Zones

Usage Zone	Level of use	Description
1 Very high	Very high volume road or rail traffic Very high levels of visitor use High likelihood of staff/volunteers/visitors gathering or staying in the area	Areas close to motorways, busy trunk roads, busy road junctions Areas close to railway lines Areas used for large-scale events Areas used for car parks, visitor entrances, adventure playgrounds, cafes with outside seating, picnic areas Gardens with high visitor numbers Areas close to residential buildings, e.g. base camps, holiday cottages, caravan sites, tenant farms Areas close to high value buildings, structures and other property
2 High	High-volume road traffic High levels of visitor use Some likelihood of staff/volunteers/visitors gathering or staying in the area	Areas close to well-used roads and junctions Footpaths, bridleways, way-marked trails, avenues with high levels of visitor use Areas used for small-scale events where visitors are dispersed Gardens with moderate visitor numbers Routes with high visitor numbers in parks and woods Areas close to staff working areas, e.g. estate yards, workshops
3 Medium	Moderate volume road. traffic Moderate levels of visitor use Visitors tend to disperse rather than gather	Areas close to local roads with moderate traffic levels Footpaths, bridleways, way-marked trails, avenues with moderate levels of visitor use Gardens with low visitor numbers Main routes in parks and woods, with moderate visitor numbers Areas close to farm buildings
4 Low	Low volume road traffic Low levels of visitor use Visitors well dispersed	Areas close to minor roads with low traffic levels Footpaths, bridleways, way-marked trails, avenues with low levels of visitor use Parks and woods with low visitor numbers Areas restricted for public access, or impeded by natural or planted vegetation
5 Very low	Very low level of visitor use	Areas of woodland and forest in more remote areas Areas restricted for public access, or impeded by natural or planted vegetation



Example of map of usage zones (Knightshayes), based on the previous system of three usage zones

Here, pink indicates the high usage zone, yellow is the medium zone, the uncoloured remainder is is the low usage zone

2.2 Identifying hazards

This is normally undertaken by a competent member of staff (the Inspector), as defined in Section 3. It is the responsibility of the Inspector to ensure that hazard is assessed to the best of his/her ability and recorded accurately.

Many trees are potentially hazardous but inspectors can only reasonably identify the defects most likely to lead to injury or damage to people or property. These are physical defects which might lead to the break up or collapse of the tree or its branches, and are identified and recorded during a programme of inspection.

The practice is to identify and record visible defects. This is referred to as Visual Tree Assessment or VTA - a system used to identify and evaluate structural defects and stability in trees. It includes visual assessment, usually from the ground, and some evaluation of visible symptoms, using hand tools if necessary. Techniques such as electronic sensors and decay detecting drills are available to assess the structural integrity of standing trees, but should be used only where it is necessary to assess the extent of decay in particularly important trees or to supplement the VTA for particular trees in Usage Zones 1 and 2.

Knowledge of the propensity of some species to break up or decay more rapidly than others is necessary, but most property based staff who routinely work with trees should be competent to undertake the initial inspection after receiving basic introductory training.

In addition to this formal process, general observations by staff during routine activities will contribute to the tree inspection process.

Table 2 - Usage Zone and frequency of inspection. This sets out the frequency and method of inspection for each designated Usage Zone - note that this is a summary, and more detail is provided on training courses.

Usage Zone	Frequency of inspection	VTA method
1 Very high	At least annually* and after severe weather events**	Thorough inspection for defects - with binoculars, tapping mallet and probe required to be available for use.
2 High	At least every two years* and after severe weather events**	Thorough inspection for defects - binoculars, tapping mallet and probe required to be available for use
3 Medium	Normally every three years (with discretion up to 5 years*) and after severe weather events**	Careful visual check for obvious defects
4 Low	During normal routine visits	No formal inspection - observation and awareness of the general condition of trees
5 Very low	No inspection required	No inspection required

* Depending on age, species and condition of trees, it may be appropriate to change the frequency or timing of inspection. The purpose of this discretion is to enable best use of available resources. The rationale behind the decision should be recorded.

The best time to inspect trees is in September and October (and sometimes November), as this is when fungal fruiting bodies can most easily be seen and identified, and deciduous trees still have sufficient foliage to enable their general health to be assessed. However, looking at trees in full leaf during the summer can also be helpful in assessing their general health, while inspecting deciduous trees in winter when leaves have fallen allows any physical defects in the upper tree parts to be observed more easily.

** Visual inspections after severe weather are usually restricted to obvious signs of physical damage, e.g. lifting roots, hanging branches, splits. Re-inspection after severe weather should be prioritised according to usage zone.

Retained trees***	Normally every six months	Thorough inspection, often requiring a higher level of expertise

*** **Retained trees.** Some of the most important trees on Trust properties are, due to their age, species or condition, likely to need more careful and frequent inspection. Trees which justify this extra level of care and protection should be elevated to a separate category, referred to as “retained trees”. They will be located in Usage Zones 1, 2 or 3. These trees will:

- receive more frequent and detailed inspections
- often have management decisions referred to someone with greater arboricultural expertise
- have an individual, ongoing record of inspection and management (see form TSM 4b)

2.3 Assessing risk.

There are two aspects of risk assessment that relate to trees.

Firstly, every property should have completed a site assessment of the risks to visitors, in accordance with H&S instruction No. 10 - see Health and Safety Instructions. This site risk assessment is aimed at identifying hazards and assessing risks to visitors arising from the nature of the property (particularly countryside, parks and gardens). It should record the existing precautions in place to manage and reduce those risks, and the additional measures deemed necessary as a result of the assessment. It therefore serves as a prelude to a visitor safety plan or the design and layout of the visitor route. The assessment of the risks arising from trees is one part of this overall site risk assessment.

Secondly, there is the assessment of risk in an individual tree - an integral part of the tree inspection process, and the focus of this section. Assessment of risk in an individual tree is based on three factors:

2.3.1 The magnitude of the hazard

Hazard is the potential to cause harm. Like all living organisms, trees are subject to decline, senescence and collapse. They can be damaged physically or invaded by pathogenic organisms. As trees age, they are increasingly likely to shed limbs or fail in strong winds and their potential for causing harm increases. The magnitude of the hazard can be estimated from the size of the part of the tree most likely to fall, and the distance it will fall.

2.3.2 The probability of tree failure

Assessing the probability that a tree or branch will fall is a matter of informed judgement. It depends on factors such as:

- the species, size, shape and growth characteristics of the tree and its position in relation to neighbouring trees;
- the type, position and severity of any defect;
- the tree's history;
- the nature and location of the site - site-specific factors include:
  - exposure to wind;
  - depth of soil;
  - the range of activities in the immediate vicinity (for example, vehicle use or car parking can increase soil compaction and risk of physical damage).

All these factors are taken into account during the tree inspection process.

2.3.3 The consequences of tree failure

This is closely linked to the establishment of Usage Zones. The consequences of failure will depend on factors such as:

- the location of the tree in relation to areas used by people;
- the anticipated direction of failure;
- the intensity of use (based on visitor numbers and the level of vehicle and pedestrian use);
- the type of use – for example, if people stay longer in an area because of the facilities provided, the probability of impact if failure occurs will be greater;
- the proximity and value of adjacent buildings and structures and their contents.

Note that the consequences are not confined to Trust properties, but include adjacent roads and property that could be affected by a failure of a tree on Trust land.

2.4 Determining remedial action and priorities

Deciding on the reasonable actions necessary to reduce risk needs to take account not only of cost, but also objectives relating to nature conservation, conservation of the historic landscape, the value of trees in learning and education, and their aesthetic qualities. The cultural, landscape and habitat value of trees should always be considered when deciding on remedial action. Old trees are often uniquely valuable as habitat for wildlife, and even if the physical condition of the tree is poor, remedial action should only be necessary where there is a clearly perceptible risk to life or property. This might mean managing public access in the vicinity, for example by re-routing a path, or if necessary removing part of the tree, or even felling it. See Section 4 for more details on risk control measures.

The appropriate remedial action must be decided by a competent person (see Section 3). Remedial action can also include more detailed investigation. In some circumstances, it will be necessary to bring in external consultants to use specialist techniques or provide advice on a particularly complex situation. Forestry Advisers can assist in the selection of consultants, and in preparing a brief for them. The Arboricultural Association has a list of registered consultants.

The priority for remedial action will depend on the risk assessment. The following categories are recommended:

Category A: Trees in very high, high and sometimes in medium usage zones, which are seriously hazardous and which pose a high risk should be dealt with immediately on the best advice available. Public access should be restricted until the work has been completed.

Category B: Once identified, remedial action must be implemented within 1 month. Where practicable, restrict public access until the work has been completed.

Category C: Once identified, remedial action must be implemented within 6 months. Consider restricting public access until the work has been completed.

Category D: Identified as not being a short-term safety concern, but proactive management may prevent problems developing, will benefit the tree and improve long-term safety.

Trees which require closer monitoring of specific features for change over time will normally be designated as **"retained trees"** - see section 2.2 above.

2.5 Implementing a prioritised work programme

Remedial tree work will often involve tree climbing. This work is normally contracted out for reasons of cost and safety. If the work is to be undertaken by staff, they should be trained and competent, holding relevant NPTC certificates. Work should be carried out in accordance with industry and HSE guidance and NT model risk assessments.

Contractors should be Arboricultural Association approved (see list of Arboricultural Association approved contractors), or judged to be competent and safe as a result of previous work for the Trust and having appropriate certificates of competence and insurance. Useful guidance is provided in the leaflet "*Choosing an arborist*" available from the Arboricultural Association or from Forestry Advisers.

Work must be carefully specified and will be subject to:

- NT H&S Guidance Note No. 18 – "*Managing Contractors*" (in preparation)
- NT Conservation Directorate document – "*General Requirements and Conditions for Countryside and Garden Work*"
- NT Conservation Directorate document – "*Special Requirements and Conditions for Arboricultural Work"*
- NT Record of Information Exchange for Contractors' Operations
- British Standard BS 3998 (1989) -"Recommendations for tree work" (revised version expected 'in 2007)

Before undertaking any tree work, reference should be made to:

- NT Guidance Note – "*Legal restrictions on tree and woodland work*"
- NT Guidance – "*Bats and trees*".

It is important that provision is made in property budgets for inspection and remedial work. Once priorities have been determined for remedial work, lack of available funding would not be accepted by external enforcing authorities as a valid reason for non-completion.

2.6 Recording

Accurate recording is essential, to enable the inspection record to be linked back to the individual tree(s). Records must be kept for at least seven years.

Standard NT recording forms (TSM 1-4, electronic or paper) are available from Forestry Advisers and will be placed on the Intranet shortly. There are four parts to the record:

TSM1 Map and record of Usage Zones

TSM1a This form is for recording the rationale for the designation of Usage Zones.

TSM1b This is the map of the property with the Usage Zones marked on it. This should be dated and reviewed at least every two years. The map should include a label with information recorded on the name of the property, the date the map was created, the name of the person who created it, the date the map was last reviewed and the person who reviewed it, and a key showing colours used.

TSM2 Record of tree safety inspection

This form is used to record the inspection of each area or site within the different Usage Zones. A date and name should be placed against each site once the inspection has been made.

TSM3 Visual tree assessment (VTA) form

This is a record of defects identified, remedial action recommended and work carried out. (TSM3 is available in two versions, 3a or 3b - version 3b allows notes to be inserted). The record of inspection should be as follows:

Usage Zone 1 Every tree must be inspected. There should be a record of every tree inspected, either as individual trees or as definable groups or lines of trees. The record will provide details of the condition of the tree, as well as specifying the remedial action required, or stating that no action is required.

Usage Zones 2, 3 Every tree must be inspected. There should be a record of all trees with identified defects that require remedial action. In these zones, trees that appear sound will not need to be recorded.

Usage Zone 4 A record of areas inspected and work carried out is sufficient.

TSM4 Retained trees
TSM4a This form is used to list all retained trees and record when they were inspected.
TSM4b Individual tree records are required for all "retained trees" This form is used to maintain an ongoing record of inspection and management for each retained tree.

Further details on how to use the forms are provided with the forms themselves and on training courses.

3. TRAINING, COMPETENCE AND SUPPORT

3.1 Training

The Trust runs its own internal courses, delivered by staff in the Forestry Section with assistance from external speakers. There is a one-day basic course in tree inspection and a four-day course in tree safety management. Details of the courses and course overview can be found on the Directory of Statutory Training pages, under Conservation. Regional Training Groups have a role in ensuring that there are sufficient trained personnel in each region.

One-day courses will be arranged by Forestry Advisers when required. All tree inspectors should attend a one-day updating course every five years. Forestry Advisers will arrange updating courses when required.

3.2 Competence

The Trust has defined two levels of competence for staff carrying out tree inspections,

Level.1: Staff who carry out initial tree safety inspections should have a reasonable knowledge of trees and must have completed the Trust's basic (one-day) tree safety inspection course. The one-day course provides information on the rationale for the Trust's tree safety management procedures and how they are implemented. It trains inspectors to recognise a specific list of hazards, to determine remedial action relating to this list of hazards to understand the limit of their knowledge, and to ask for further advice whenever they are unsure.

Level 2: Staff who manage large numbers of trees or important tree collections, or who provide advice to others carrying out tree inspections, should have a good working knowledge of trees and as a minimum should have completed the Trust's four-day training course in Tree Safety Management. This course is normally arranged annually in the autumn. Before attending the four-day course, they should have-attended the Trust's one-day course and have at least one year's experience of carrying out inspections using the Trust's system.

3.3 Support

Where further advice is needed, property staff should consult Forestry Advisers. In some circumstances, it will be necessary to bring in external consultants to use specialist techniques or provide advice on a particularly complex situation. The Arboricultural Association has a list of registered consultants.

Where these standards cannot be achieved immediately, Forestry Advisers should be consulted to help arrange for regional/national or external expertise to undertake tree inspections. Where tree inspection is a requirement of an individual's role, this should be included in the role profile.

4. RISK CONTROL MEASURES

A range of risk control measures can be applied to tree safety; as for any other aspect of visitor safety. The objectives of these control measures are to reduce risks to people from trees, while as far as possible:

- avoiding the unnecessary removal or disfigurement of amenity trees or trees with high wildlife value
- conserving habitats that are provided by trees including those that are old and decaying
- avoiding any restrictions on access

The range of measures (although not in order of priority) includes:

- eliminating the hazard, through remedial work or felling
- managing visitor access, by closure (permanent or temporary), path diversion, or signage aimed at managing the flow of visitors away from the hazard

Old beech tree on the Scotney Castle estate

Suggested wording of sign if the tree is next to a permissive route (the path ahead would be blocked)

Please follow the short diversion to avoid an important old beech tree with dead branches. This tree is valuable for nature conservation but may in future fall or drop branches on the path.

Suggested wording of sign if the tree is next to a right of way (the path ahead would not be blocked)

IMPORTANT - PLEASE STOP AND READ

The path ahead takes you under a very old beech tree. This tree is valuable for nature conservation but may in future fall or drop branches on the path. We can avoid the need to fell or prune the tree by encouraging walkers to stay clear of the risk by using the alternative path. Please help by following the short alternative diversion.

- providing information and promoting awareness of hazardous areas or individual trees through leaflets or warning signs
- considering closure of properties or areas in adverse weather, particularly in high winds see Conservation Directorate guidance "Managing access at Trust properties in high winds and storms – reducing the risk posed by trees".

5. AUDITING TREE SAFETY PROCEDURES

To help ensure that Tree Safety Management procedures are properly implemented, the property Health and Safety Audit (see H&S Instruction No. 5, via Health and Safety Instructions page) includes relevant questions, which should be answered at the annual audit. The Property Manager should ask to see evidence in support. The Area Manager has a role in checking that procedures are in place and that adequate resources are available for remedial action.

Forestry Advisers and Health and Safety Officers may also undertake periodic monitoring to ensure compliance.

6. REPORTING INCIDENTS INVOLVING FALLING TREES AND BRANCHES

Incidents where trees have fallen or shed limbs and where injury has occurred should be reported on the NT Accident/Incident Report form in the same way as any other accident.

Incidents where trees have fallen or shed limbs but no injury results should be reported as a near miss where the incident occurs in Usage Zones 1 and 2, in circumstances where serious injury could have occurred. Information should be provided on the species and age of the tree, the part that failed, and weather conditions.

7. REFERENCES

Detailed guidance:
For detailed guidance on Tree Inspection procedures, please refer to:

- "Hazards from Trees - a General Guide". David Lonsdale. Forestry Commission. 2000. This is downloadable from the Forestry Commission web site but note the very large file size 8.5 Mb – "*Hazards from trees - a general guide*".
- Chapter 5 of "The Principles of Tree Hazard Assessment and Management". David Lonsdale. Stationery Office Books. 1999.
- The CD Course Manual issued with all NT tree inspection courses since 2003.

Other useful references:
"Managing Visitor Safety in the Countryside". Visitor Safety in the Countryside Group. Revised edition 2005.
"The Body Language of Trees". Claus Mattheck and Helge Breloer. Stationery Office Books. 1995.
"Veteran trees - a guide to risk and responsibility" Caroline Davies, Neville Fay and Charles Mynors. English Nature. 2000. [Note file size – 1.5 Mb]

Useful web sites:
The Arboricultural Information Exchange
The Arboricultural Association
The Forestry Commission
The Visitor Safety in the Countryside Group
Health and Safety Executive (HSE) Forestry and Arboriculture pages

Managing access at National Trust properties in high winds and storms - reducing the risk posed by trees

This note accompanies the Trust's H&S Instruction on 'Tree Safety Management and provides additional guidance to properties on how to manage the health and safety risk posed by trees in high winds and storms. It is aimed at staff who have a responsibility towards managing and making our properties safe places to visit.

Key points

- Properties should have procedures in place to deal with foreseeable emergencies, including high winds and storms.
- The level of public usage and management control will determine whether we close parts of the property.
- Inform the public of the risk or take no action.
- The decision needs to be taken locally and rests with properties.
- The decision needs to be based on a written rationale.
- The decision needs to be made ideally in advance of severe weather, based on prior warnings issued by the Met Office, and occasionally during storms when damage is being sustained.
- A range of sources and information aid the decision making process.
- The actions of managing public access should be based on a written procedure.
- If in doubt further advice and information can be sought from National Trust Forestry Advisers.

Introduction

Most tree and branch failures occur during storm events, therefore if people are close to trees at these times the changes (or risk) of them sustaining an injury are higher than normal. The Trust as an organisation has a moral and legal duty to ensure its staff and the public are not exposed to risks as far as is reasonable and practicable. **Properties should have procedures in place to deal with foreseeable emergencies; including high winds and storms.**

The Trust can reduce the risk posed by trees in close proximity to people during storm events, by managing both the trees and the people. By managing public access the intensive management and felling of trees on Trust properties can be minimised. This benefits not only conservation but can reduce tree safety management costs.

Managing access

The Trust's approach to managing visitor safety is guided by a set of principles set out in the booklet 'Managing visitor safety in the countryside' published by the Visitor Safety in the Countryside Group (www.vscg.co.uk/) One of the underlying themes is that land owners should target the greatest amount of care and effort in areas of high public usage. This is reflected in the Trust's tree safety management instruction which requires properties to be designated into up to five 'usage zones'. The same principles apply in this case and we can assume our greatest efforts at controlling visitor access during storm events is in the higher usage zones - particularly usage zones 1 and 2.

Managing access can range from closing parts of properties, to informing people of the risks through signage or no formal control at all. The particular approach adopted by a property is guided by the degree to which any control is deemed reasonable and practicable. In general we would not be expected to exercise access control over public roads, public rights of way and open access land. In areas where we already control access, for example tariff areas with gated points of access, we would be expected to inform people of the risks or, where practicable, close parts of property.

The level of public usage and management control will determine whether we close parts of the property, inform the public of the risk or take no action. The relevant areas of the property in which these actions are to take place should be recorded in writing (see Appendix).

Making the decision

Where properties, in high winds and storms, determine to close parts of their site or undertake to inform the public of the risk through signage a decision needs to be made when to implement this control.

Prescribing standard rules for the whole of the Trust is not possible due to the variety of climate and site types throughout England, Wales and Northern Ireland. **The decision needs to be taken locally and rests with properties.** The decision making process will invariably fall to more than one person but should include those who have a good understanding of the factors involved, usually a warden, gardener or forester. **The decision making process should be based on a written rationale** (see Appendix).

There are two opportunities when a **decision can be made - in advance of severe weather based on prior warnings issued by the Met Office (proactive control) and during unpredicted storms when extensive damage is being sustained (reactive control).** The former, proactive case, is a clearer and more defendable decision and to be preferred. Unfortunately the weather is not entirely predictable add we may find ourselves in the latter, reactive situation, through no fault of our own. In either case the following **sources and information aid the decision making process:**

1. *Information from the UK Meteorological Office* (www.metoffice.gov.uk). The Met Office issues severe weather warnings which are very useful in predicting average and maximum gust wind speeds and giving examples of the types of damage to expect. This information is issued on a regional basis and is a useful guide to when to control access. The availability of this information means that properties can take a proactive role in managing access by putting themselves on high alert in the run up to predicted storms. Active monitoring of the predictions will then allow a property to make a decision in advance rather than trying to affect a closure when lots of people are on site and staff themselves may be put at risk in trying to take action. Decision makers should ensure they are suitably and regularly informed by consulting this professional weather forecasting service. If internet access is not available most local radio stations also broadcast these severe weather warnings.

2. *Having an understanding of the factors involved that make the probability of tree failure high*. Most tree failures in high winds have a biomechanical cause. If the forces generated by a high wind exceed the mechanical strength of the weakest part of the tree then failure will occur at that point. The following general factors will have an influence on whether tree failure due to mechanical weaknesses is expected.

a. *Average; wind speeds for the site*. Average wind speeds differ throughout the UK and what some sites experience as abnormal extremes are common occurrences elsewhere. Trees adapt their growth to site conditions and one can assume that on windy sites the trees are inherently more stable for a given size and shape.
b. *Wind direction*. It is winds coming from unusual quarters that usually cause the most damage. Swirling winds and tornadoes in particular cause unpredictable and severe damage.
c. *Duration of bad weather*. The cumulative effect of sustained high winds or several close episodes is liable to increase the incidence of tree failure.
d. *The nature of the trees on site is significant*. The species, age and size of the tree, together with the rooting substrate and location all have a bearing on whether it is more prone to biomechanical failure.
e. *Time of year*. One can assume that high winds in summer when trees are in full foliage are more likely to cause damage at a given wind speed than on the same site in winter.
f. *Precipitation*. If it has been raining the wet ground conditions are more likely to lead to a loss in rooting strength and the wet foliage will significantly increase the weight distribution within the crown.

3, *Personal observation of the weather on site*. The Trust does not expect properties to rely upon anemometer readings (wind speed) in making decisions on when to close or control public access. Where a property wishes to use wind speed readings to further understanding as part of their decision making process they need to demonstrate they are competent in the use of the equipment and the interpretation of the results. The Met Office website should be consulted to confirm that severe weather has been forecast and/or that it will worsen.

4. *Knowledge and past experiences of the site and weather conditions*. Where there are records of past weather conditions which relate to recorded tree failures this can help inform future predictions of the type and level of damage to be expected. The recording of weather conditions and tree failures, where practicable, is a useful record to maintain.

Implementing the decision and procedure

Once the property has made the decision to start managing public access because of high winds, their actions should be based on a **written procedure**. The procedure should follow the outline below.

1) *The decision to control public access is conveyed to all relevant staff*. The property should list who to notify and agree how this is to be done. It should be noted that the person responsible for making the decision to control access may not be the person responsible for managing the whole procedure as the final authority rests with the Property Manager.
2) *Actions required to control public access are implemented*. This will involve either closing parts of the property or putting out signage warning the public of the risk. The roles and responsibilities of the various members of staff who help implement these actions needs to be agreed.
3) *In the case of closure, the parts of the property affected need to have their access points blocked off and signed*. Where we are legally and physically able to stop access to parts of our property we should close access points as far is reasonably practicable. Signage should be posted informing the public of the cause of our action.

4) *Where we are informing the public we erect suitable signage at key access points*. Signage should help to inform the public of the high risk posed by trees in high winds and may advise them not to walk along certain paths or visit certain areas. The decision to visit ultimately rests with the member of the public.
5) *The need to control the risk posed during high winds and storms extends to own staff, volunteers and contractors as well as the public*. Our own staff, volunteers and contractors should not be expected to work in areas either closed to the public or restricted on safety grounds. Under no circumstances should tree related work be carried out during a storm event. Staff should not put themselves or the organisation at risk by 'taking a look' at trees during storms.
6) *Closed sites need to be inspected for storm damage and made safe prior to reopening*. *Warning signs should be removed from other areas*. Advice on tree inspection and recording following severe weather events is contained in sections 2.2 and 2.6 of the Trust's H&S Instruction on tree safety management.
7) *The procedure needs to be formally documented, be available to all relevant staff and should form part of training* (see Appendix).

Training and further advice

'Managing access at National Trust properties in high winds and storms reducing the risk posed by trees' forms part of the tree safety management training delivered by the Trust to its staff, both on the one day and four day courses.

- One day basic tree inspection course overview
- Four day advanced tree inspection course overview

Further advice and Information can be sought on an individual basis from National Trust Forestry Advisers

In the wider context the National Trust is working on completing guidance on a range of emergency procedures. It is also a partner in initiatives that produce guidance on managing health and safety in the countryside and two publications are available that contain sections on emergency procedures.

1. The Conservation Safety Manual, Chapter 3.3.
2. **Managing Visitor Safety in the Countryside: principles and practice** see the Visitor Safety in the Countryside Group web site

Conservation Directorate Guidance Note Information

Authors: Nick Walmsley
Contact: nick.walmsley@nationaltrust.org.uk
Tel: 01793 817726

Guidance Note No. **Date of issue:** May 2007

APPENDIX

DOCUMENTING THE HIGH WINDS & STORMS EMERGENCY PROCEDURE

The written emergency procedure should consist of the following:

1) A list and map of those areas in which access is to be managed by either closure or signage in the event of high winds and storms. This is done by identifying the higher usage zones on the TSM map, considering for these areas the level to which access can be controlled and then the capacity of the property to initiate any action.

2) The rationale behind the decision making procedure. This will include which members of property staff are consulted and what role they play in making the decision. It will also list the range of sources and information consulted in order to make the decision i.e. checking the Met Office website; the range of factors to consider that make the probability of tree failure high; observations on site and the experience of past weather conditions and tree failure.

3) The list of people to notify once a decision to control access has been made.

4) Roles and responsibilities of key members of staff and volunteers in carrying out the emergency procedure.

5) Access points and routes to close or control. Maps are a good way of conveying this spatial information.

6) Equipment needed to control public access, including signage. It should be made clear where this equipment is stored.

7) Details of how to reopen a site following severe weather. It must include the need to inspect for storm damage before reopening.

8) Contact details for the emergency services.

9) Contact details for external organisations, e.g. Highways Agency, Local Council, and Environment Agency.

10) Procedures for dealing with the media.

11) The procedure should be dated and the author/s identified. A revision date should be set.

On some properties this may be part of a more comprehensive emergency planning document.

Forbes-
Laird
Arboricultural
Consultancy

APPENDIX JFL4

SELECTION OF PHOTOGRAPHS
TAKEN BY JFL
ON SITE 03.10.07

P1 Decaying breakout wound from failure of B1 circled yellow
(BOW of B3 arrowed red)

P2 breakout wound from failure of B2 (circled red)

P3 B2 lying in adjacent undergrowth to where it was cleared following failure

P4 Proximal end of B2 (matches morphology of breakout wound on tree)

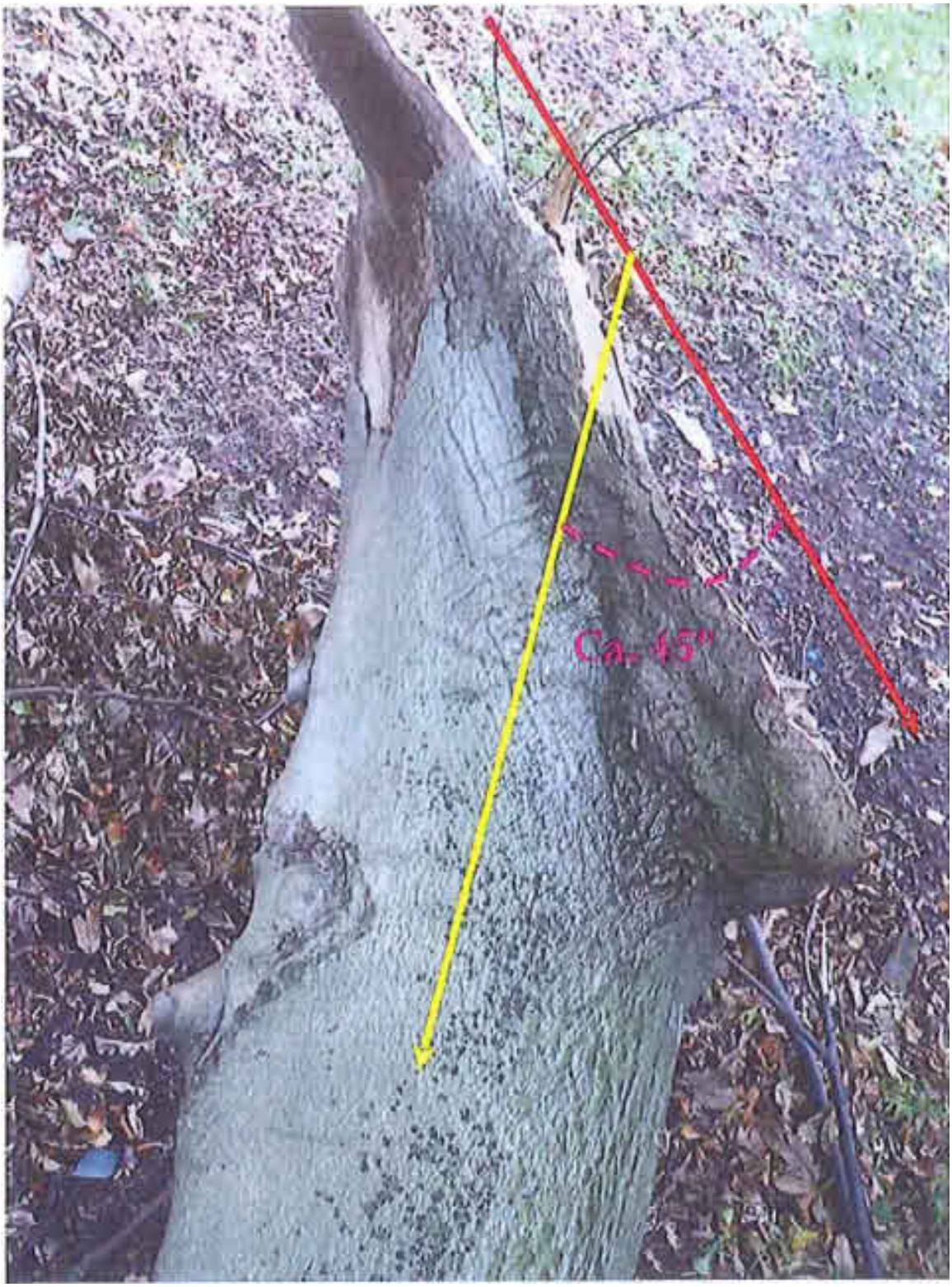
P5 Looking north towards subject tree, showing breakout wound of B3 (circled yellow)

P6 looking south (above); P7 looking east (below)
Fatal branch B3 arrowed yellow; den (adjacent to sweet chestnut) circled red
(Note: Pink arrows indicate branches that failed subsequent to the accident)

P8 B3 breakout wound
Southwest adaptive growth flare circled yellow; southeast adaptive growth flare circled red
Site of fissure in union arrowed pink
Note initial shearing across the grain to SW but along the grain to SE

P9 proximal end of B3
Southwest adaptive growth flare circled yellow; southeast adaptive growth flare circled red
Woundwood leading to bark inclusion along margin of fissure marked by dashed pink line
Note timber darkened by oxidisation & water ingress following opening of fissure

P10 (above left) Fibres at proximal end of B3 – see detail photographs. Woundwood arrowed yellow
P11 (opposite right) Failure initiation point (circled yellow) to SW when attached); tension-wood fibres shear across the grain
P12 (opposite middle) Shearing along the grain to SE
P13 (opposite below) Tension-wood fibres in central area of union forming knots and rolls indicating mid-term structural distress



P15 photograph taken to show angle of attachment to stem:
Plane of attachment shown by red arrow (point indicates upwards)
Direction of growth shown by yellow arrow
Approximate angle of attachment shown pink

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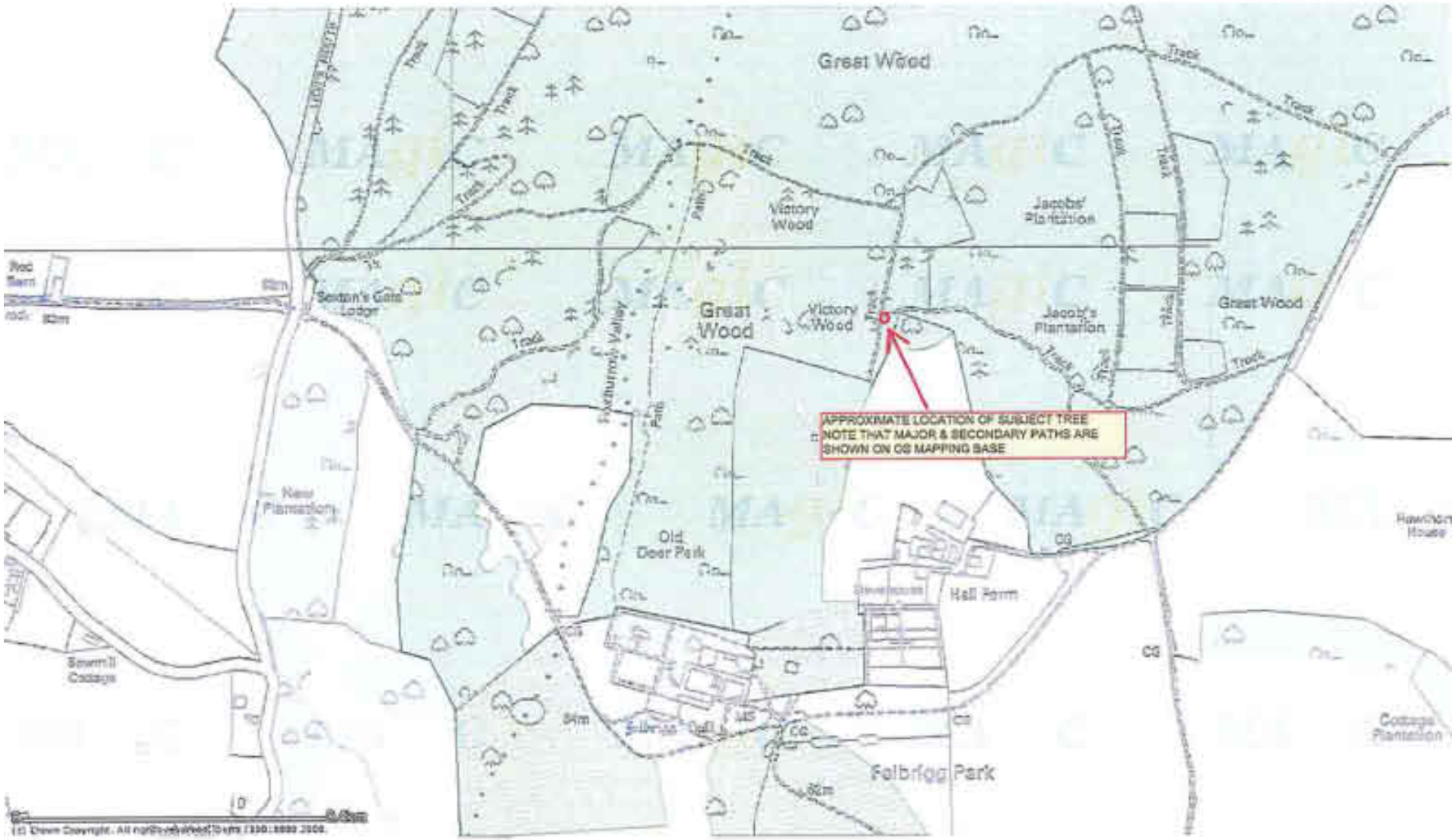
APPENDIX JFL5

MAP REPRODUCED FROM MAGIC DATABASE

MAP PRINTED FROM MULTI-AGENCY GEOGRAPHIC INFORMATION FOR THE COUNTRYSIDE (www.magic.gov.uk)



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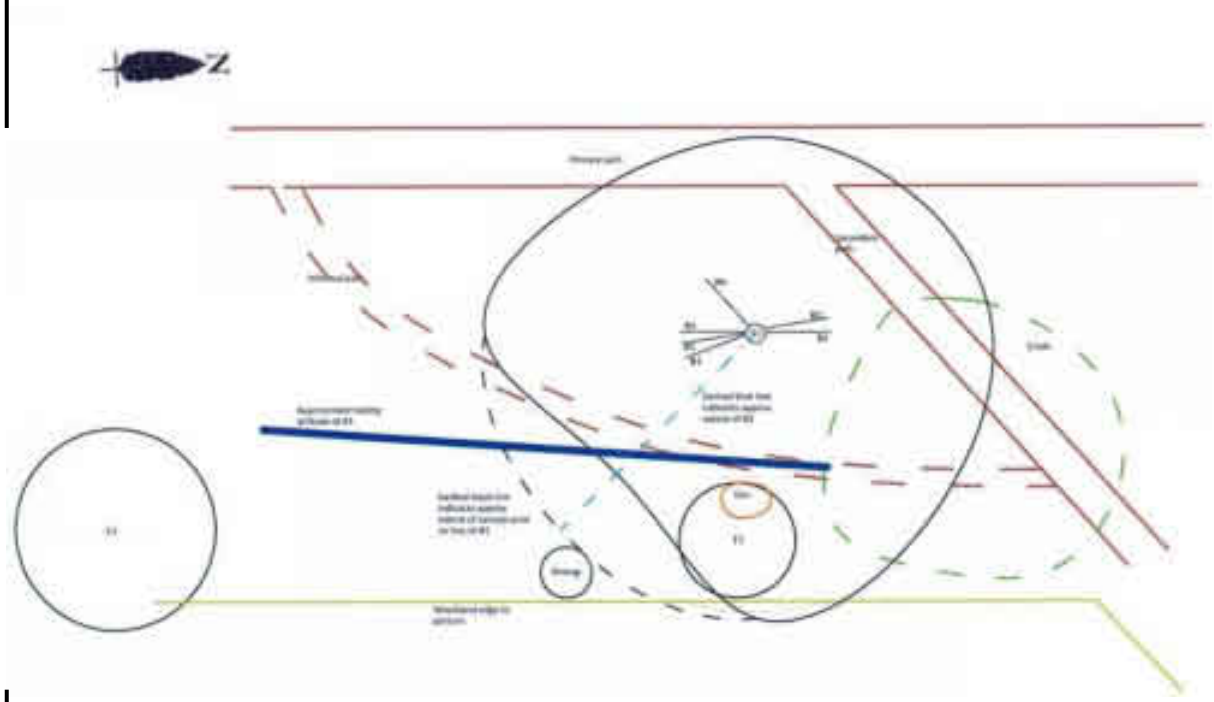
APPENDIX JFL6

SITE SKETCH PLAN

PREPARED BY JFL

FOLLOWING SITE VISIT



FORBES-LAIRD ARBORICULTURAL CONSULTANCY

Client
Ellisons Solicitors

Instruction
Felbrigg Hall

Instruction ref.
RC27

Dwg title
Site layout sketch

Dwg no.
27-1060.sk-1_A

Rev. A Date
09.06.11

Revision details
1. Plan redrawn with noted features approximately to given scale
2. Measured crown spread of T1 depicted based on site visit data
3. Approximate canopy spread shown prior to loss of fatal branch B3
4. Approximate resting place of branch B3 added

Approximately scaled
- T1 → T2 distance
- T1 crown spread
- B3 (blue line)

SCALE
Scaled items ca. 1:200 @ A3
Remainder NTS though relative locations correct to approximation

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APPENDIX JFL7

SELECTION OF POLICE CRIME SCENE PHOTOGRAPHS

PCS1 Looking south towards accident site; subject tree centre of shot, B3 left
Note glade in foreground

PSC2 View south towards informal path
Note breakout wound of B1 top right, B3 low left

PCS3 View south towards sweet chestnut tree
Note den made by children in centre of shot

PSC4 Close-up of proximal end of B3
Note much darker appearance of stained wood in contrast with unaltered wood, cf. JFL P9 in JFL4

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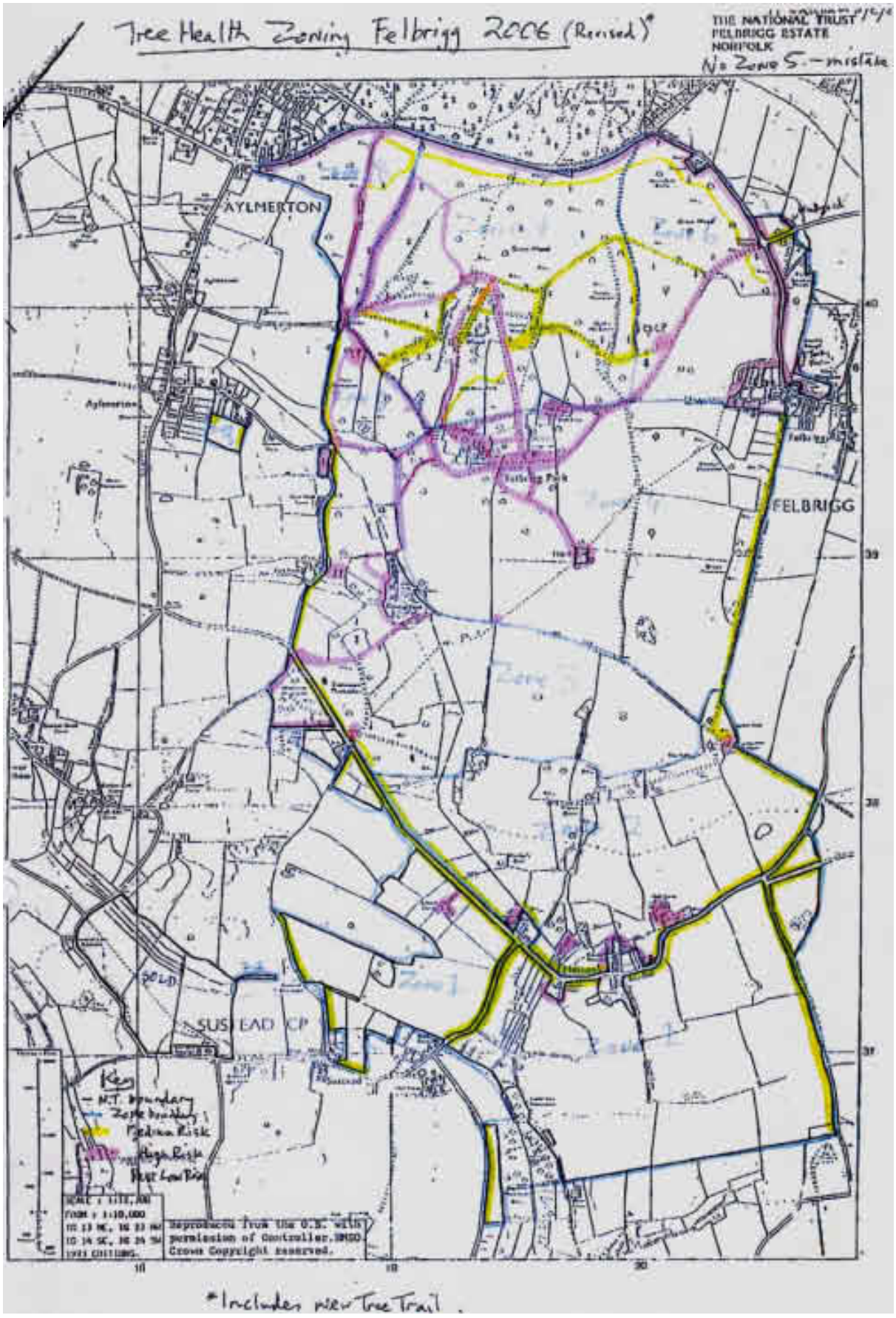
APPENDIX JFL8

FELBRIGG HALL
TREE HAZARD ZONING PLAN 2006
(REVISED)


Tree Health Zoning Felbrigg 2006 (Revised)*
THE NATIONAL TRUST
FELBRIGG ESTATE
NORFOLK
No Zone 5 - mistake
AYLMERTON
FELBRIGG
SUSTEAD CP
Key
N.T. Boundary
Zone boundary
High Risk
Low Risk
Reproduction from the O.S. with permission of Controller. HMSO
Crown Copyright reserved.
*Includes new Tree Trail.

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APPENDIX JFL9

NT TREE INSPECTION TRAINING SYLLABUS ONE DAY COURSE

Tree Safety Management

National Trust 1 Day Course

Course Content

- Why Tree Safety Management?
- A tree safety policy
- Who can do tree safety Inspections?
- Assessing the risk
- Assessing the hazard
- Tree inspection procedure
- Recording Information
- Remedial action
- Seeking further advice

Why Tree Safety Management?

Occupier's Liability Act 1957

"The occupier of premises owes a duty of care to all visitors: that is to take care as is reasonable in the circumstances to ensure the visitor's safety in using the premises for the purpose for which they are invited or permitted by the occupier to be there."

Occupier's Liability Act 1984

"The occupier owes a duty of care to persons other than visitors in some circumstances; this may extend to those who may not have lawful authority to be in a particular place where they may be exposed to danger."

Why Tree Safety Management?

Health and Safety at Work Act 1974

"a duty on employers to ensure, as far as is reasonably practicable, that in the course of conducting their undertaking, members of the public are not put to risk"

Highways Act 1980

Landowners have a statutory duty of care not to let vegetation obstruct or endanger an adjoining highway

Legal Cases

West Ashstead Primary School, Surrey - January 2003

Richmond Park May 2003

Birmingham - December 1999 - 3 killed

- Tree Inspection was responsibility of local authority under the Highways Act and H&S at Work Act.
- Criminal prosecution - £160,000 + costs
- No proper system in place for tree safety inspection.
- *Perenniporia fraxinea*

A tree safety policy is required

National Trust Tree Safety Management Instruction

Who should do the inspections?

Quinn v. Scott and Another 1965

"The National Trust owes a special duty of care. It is not expected to have the knowledge of an expert arboriculturist, but something more than the ordinary observant countryman."

NT Instruction defines two levels of competence:

- A reasonable knowledge of trees + 1 day course
- Good basic forestry or arboricultural experience - 4 day course

Assessing the Risk

- Knowledge of the site & usage
- Owner or manager is best placed

Managing Visitor Safety in the Countryside

Assessing the Risk

- Aim is to direct resources where there is most risk
  Three risk zones: high medium low
- Risk zoning carried out by Property Manager with advice from you
- Level of risk can change and should be kept under review

Assessing the Risk

1. **Map of risk zones**
2. **Checklist of sites** - to tick off and sign

Assessing the Risk

Risk zone will determine the frequency and type of inspection

Assessing the Hazard

To assess the hazard you need to know:

- Basic tree biology
- Species identification
- Reasonable understanding of ‘biomechanics’
- Signs for inspection and their significance
- Properties of different species - weak forks, decay
- Relationship between trees and decay fungi
- Fungi significant to tree safety
- Limit of your knowledge
- When and where to seek specialist advice

Basic Tree Biology

- stem
- branches
- roots

Biomechanics and Signs for Inspection

- Forks and other unions with included bark
- Weak and strong unions.
- Bark death and dysfunctional tissue
- Adaptive growth - response to damage / decay

- Previous Tree Surgery
- Splits and cracks (internal and external)
- End loading and exposure of previously sheltered trees
- Hollow trees - sound wood tolerance
- Crown condition
- Delamination, lever arm, hazard beam
- Summer branch drop - tendency to shed crown limbs
- Abrupt change in angle with old wound visible

Properties of Different Species

Refer to lists from ‘Lonsdale’

Relationship between trees and decay fungi

- Types of wood decay
- Compartmentalisation of decay in trees (CODIT)

Types of wood decay

Brown rot

- fungus breaks down cellulose, leaving lignin
- 70% weight loss. shrinkage and cracking
- immediate loss of tensile strength, finally crumbles to brown powder
-

White rot

- fungus degrades cellulose and lignin
- two types - simultaneous broken down at the same rate
  - selective or white pocket rot - lignin broken down first
- wood eventually becomes soft, fibrous and bleached

Soft rot (misleading name)

- first degrades and hollows out cellulose 'ropes', later attacks lignin
- framework of middle lamella no primary wall remains
- ceramic consistency, loss of strength, cannot be rubbed to powder

Compartmentalisation of decay in trees (CODIT)

Barrier between sound and dysfunctional wood can often be seen as a band of dark discoloration

- **Reaction zone (walls 1,2&3**
- temporary
- limits spread of decay within existing sapwood
- **Barrier zone (wall 4)**
- more permanent
- formed in new tissue laid down after wounding

Fungi significant to tree safety

Look at 'Fungi and Decay Guide' (Word Document in Course Manual)

References:

- 'Principles of Tree Hazard Assessment and Management - Lonsdale
- 'Manual of Wood Decays'- Weber and Mattheck
- 'Mushrooms and other Fungi- Phillips

Tree Inspection Procedure

- Visual Tree Assessment **(VTA)**
- Equipment for Visual Tree Assessment
- Routine for assessing trees
- Recording information

Visual Tree Assessment

Most types of hazard can be detected by regular inspection of trees for external signs of:

- decay
- physical damage
- growth related defects
- adverse site conditions and ill health
- (not forgetting broken branches and dead wood)

Referred to as Visual Tree Assessment

- provides the mainstay for tree safety management

  has proved to be a cost effective way of placing trees into categories for further action

Equipment for Visual Tree Assessment

Always needed

- binoculars
- probe
- map and checklist of sites
- recording method

Often needed:

- wooden or rubber mallet
- means of marking trees
- narrow trowel
- digital camera
- compass
- high vis. jacket

A routine for assessing trees

- Assess target & surroundings
- Rooting area & surface roots
- Buttressing / ingrown bark
- Trunk base / bark condition
- Main trunk
- Crown framework / branch unions
- Crown periphery
- Foliar condition

Recording Information

Look at NT Recording Forms

Remedial Action

Rationale - assess the need
Options - consider the options in a sensible order
Decide - what action is appropriate

Assessing the need for remedial action

Will failure to carry out such action leave an unacceptable risk to people or property (targets)?

You may want to ‘play safe’ by felling or lopping every tree that shows a defect - what would be the result?

Remember there can never be a 100% safe tree

Consider the options in the following order:

- Move target (least destructive)
- Remove part of the tree (or other work on the tree)
- Fell the tree (most destructive)

Also consider:

- Monitoring -what do we mean by monitoring?
- Changing the site/ground conditions

Move the Target:

- move a bench or light building
- divert a footpath
- discourage access - fencing, planting, sometimes signs
- move a boundary - of a car park or picnic area

Moving the target may be a permanent solution

Tree surgery is normally a temporary solution

If trees are ‘defective’ or likely to become so, don’t move targets closer to them.

Remove part of the tree:

- a broken branch
- a dead or partly dead branch
- cut a live branch to lighten the load
- balancing crown or overall crown reduction
- thin out selected branches?

Remember - cutting treatment may be a remedy for a hazard in human terms, but it is a form of wound as far as the tree is concerned.

Cutting branches - things to consider:

- sapwood in most species can respond actively to injury (compartmentalisation), but heartwood generally cannot
- wounds of more than one third diameter of main stem are likely to encourage extensive decay
- if several adjacent branches are removed, resulting zones of decay are likely to coalesce
- reducing the crown of a tree reduces photosynthetic capacity - when is this significant?
- **extent of decay will depend partly on species** (Lonsdale - Appendix 2)

Cutting branches - how and where to cut

If a hazardous branch is completely dead or broken near it's base,cut back to its junction with the parent stem using the '**natural target pruning method**'

If a hazardous branch is partly dead or partly broken

- consider cutting just beyond (distal) to a healthy side branch
  - more chance for tree to lay down protective barriers
  - help to keep xylem disfunction away from the main stem
  - may avoid a gap in the crown

- If a branch is dying back progressively, may need to remove dead portions if they present a hazard when just a dead stub remains, remove so that occlusion can occur. If left, it may become a foodbase for a decay fungus

Monitoring

- means monitoring change
- implies an individual tree record
- photographs often helpful
- Lonsdale describes various techniques for accurate monitoring

Before you do any work on trees

- Wildlife and Countryside Act 1981
- Countryside and Rights of Way Act 2000
- Tree Preservation Order
- SSSI
- Building Conservation Area
- Felling Licences
- Scheduled Ancient Monument

Working with Contractors

Look at information in Course Manual
Separate one day course – 'Contract Management'

Seeking Further Advice

- NT Forestry Adviser
- NT staff with Arboricultural experience and 4 day course
- Arboricutural expert / AA registered consultant
- Detailed Assessments - climbing inspection
  - diagnostic tests

Tree Safety Inspection - National Trust One Day Course

Summary

The course comprises a morning indoor session and an afternoon session out of doors, looking at trees.

Course Objectives

- Understand the NT Tree Inspection Procedure
- Be able to undertake basic tree safety inspections
- Be able to maintain records of tree safety inspections
- Know your level of competence and when/where to seek further advice

The following subjects are covered during the morning session:

- Health & Safety Instruction No. 11
- Establishing Usage Zones
- Identifying Hazards - through a process of regular tree inspection
- Usage zones and frequency of inspection
- Retained Trees
- Visual Tree Assessment - a systematic process
- Equipment for Visual Tree Assessment
- A routine for assessing trees
- Signs for Inspection
- Assessing the Risk
- Determine remedial action
- Risk control measures
- Legal restrictions on tree work
- Recording Information
- Training, Competence and Support
- Where to seek further advice

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APPENDIX JFL10

TABLE OF RELATIVE PROPENSITY FOR FAILURE OF DIFFERING TREE GENERA

DETR
ENVIRONMENT
TRANSPORT
REGIONS

Principles of Tree Hazard Assessment and Management

by David Lonsdale

Forestry Commission

Research for Amenity Trees No. 7 • Research for Amenity Trees No. 7 •

Propensity to form weak forks		**Propensity for weak fork failure**		**Propensity to fail due to decay**	
Genus	**MEAN**	**Genus**	**MEAN**	**Genus**	**MEAN**
CONIFERS					
Araucaria	1.05	Araucaria	1.00	Sequoia	1.04
Sequoia	1.31	Sequoia	1.19	Metasequoia	1.05
Picea	1.32	Larix	1.22	Taxodium	1.05
Larix	1.37	Metasequoia	1.27	Sequoiadendron	1.09
Sequoiadendron	1.40	Picea	1.28	Araucaria	1.11
Metasequoia	1.41	Taxus	1.29	Ginkgo	1.12
Pseudotsuga	1.46	Sequoiadendron	1.32	Taxus	1.17
Abies	1.60	Ginkgo	1.35	Pseudotsuga	1.33
Taxodium	1.70	Pseudotsuga	1.38	Thuja	1.38
Thuja	2.04	Abies	1.52	Picea	1.42
Pinus	2.11	Taxodium	1.57	Cupressocyparis	1.44
Taxus	2.21	Pinus	1.67	Abies	1.48
Ginkgo	2.52	Thuja	1.96	Pinus	1.48
Cupressus	2.74	Cupressus	2.64	Larix	1.50
Cupressocyparis	2.78	Cedrus	2.92	Chamaecyparis	1.68
Cedrus	2.96	Cupressocyparis	2.92	Cupressus	1.76
Chamaecyparis	3.17	Chamaecyparis	3.00	Cedrus	2.04
BROADLEAVES					
Platanus	1.32	Carpinus	1.32	Platanus	1.32
Carya	1.50	Alnus	1.35	Carya	1.50
Corylus	1.52	Corylus	1.44	Corylus	1.52
Pterocarya	1.57	Carya	1.60	Pterocarya	1.57
Eucalyptus	1.60	Juglans	1.62	Eucalyptus	1.60
Carpinus	1.60	Platanus	1.64	Carpinus	1.60
Zelkova	1.62	Pterocarya	1.67	Zelkova	1.62
Alnus	1.77	Magnolia	1.77	Alnus	1.77
Sophora	1.80	Zelkova	1.80	Sophora	1.80
Liquidamber	1.82	Quercus	1.81	Liquidamber	1.82
Magnolia	1.82	Pyrus	1.92	Magnolia	1.82
Gleditsia	1.91	Betula	1.93	Gleditsia	1.91
Quercus	1.93	Ulmus	2.00	Quercus	1.93
Castanea	2.00	Sophora	2.07	Castanea	2.00
Pyrus	2.12	Castanea	2.07	Pyrus	2.12
Sorbus	2.17	Prunus	2.12	Sorbus	2.17
Liriodendron	2.25	Liquidamber	2.14	Liriodendron	2.25
Ulmus	2.27	Sorbus	2.22	Ulmus	2.27
Tilia	2.32	Paulownia	2.31	Tilia	2.32
Ailanthus	2.36	Tilia	2.32	Ailanthus	2.36
Paulownia	2.42	Eucalyptus	2.33	Paulownia	2.42
Catalpa	2.44	Morus	2.43	Catalpa	2.44
Robinia	2.48	Catalpa	2.53	Robinia	2.48
Prunus	2.48	Gleditsia	2.55	Prunus	2.48
Morus	2.50	Acer	2.68	Morus	2.50
Betula	2.52	Fraxinus	2.76	Betula	2.52
Juglans	2.56	Liriodendron	2.79	Juglans	2.56
Acer	2.77	Ailanthus	3.00	Acer	2.77
Fraxinus	3.32	Robinia	3.04	Fraxinus	3.32
Aesculus	3.48	Fagus	3.54	Aesculus	3.48
Populus	3.56	Aesculus	3.54	Populus	3.56
Fagus	3.59	Populus	3.85	Fagus	3.59
Salix	3.71	Salix	3.92	Salix	3.71

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REFERENCE MATERIAL

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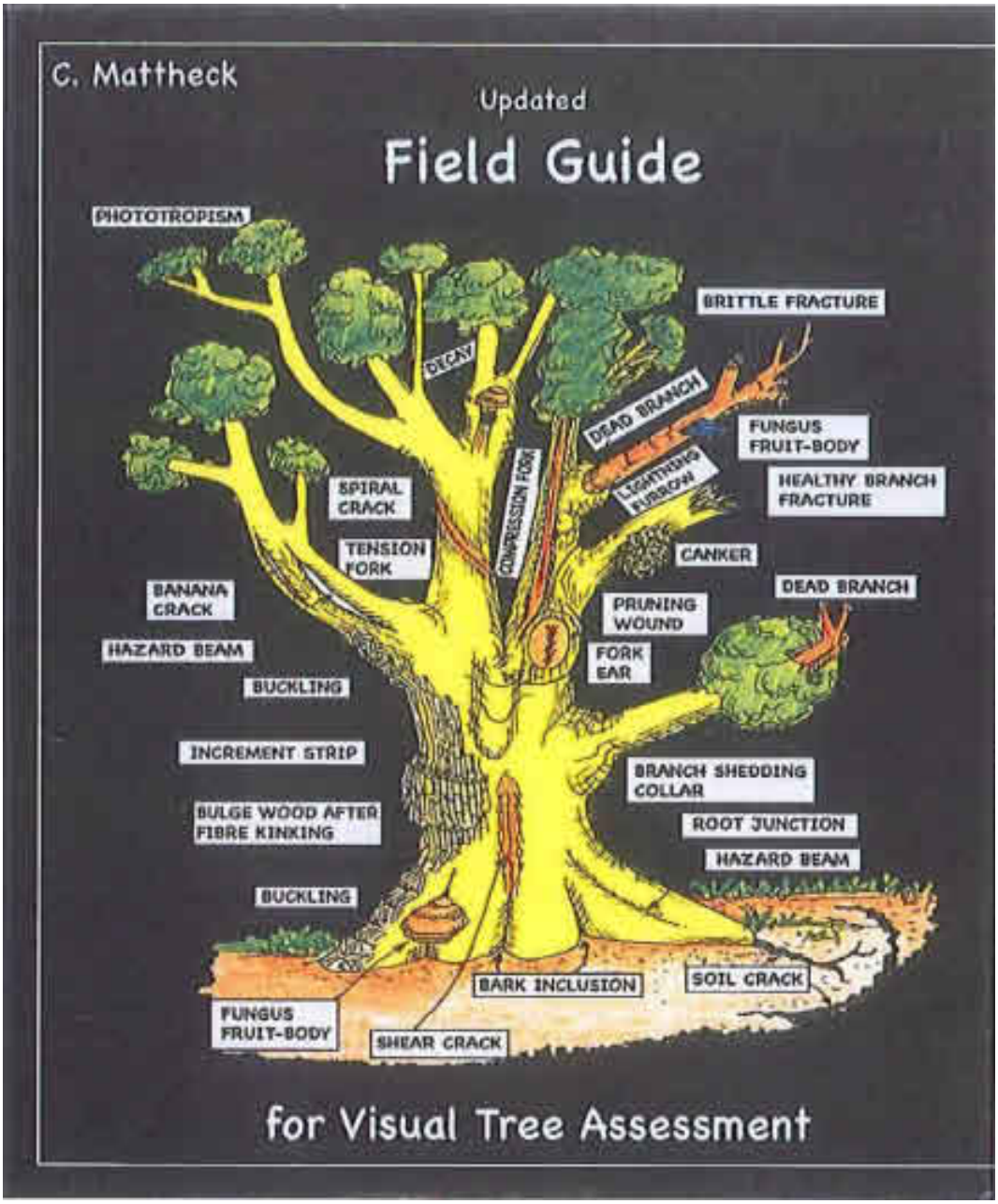
REFERENCE NO. 1

UPDATED FIELD GUIDE FOR VISUAL TREE ASSESSMENT,
CLAUS MATTHECK,
1ST EDITION 2007
P.2

CITED ON PAGE 7


C. Mattheck
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Field Guide
PHOTOTROPISM
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DECAY
DEAD BRANCH
FUNGUS FRUIT-BODY
LIGHTNING FURROW
HEALTHY BRANCH FRACTURE
SPIRAL CRACK
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TENSION FORK
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PRUNING WOUND
HAZARD BEAM
FORK EAR
BUCKLING
INCREMENT STRIP
BRANCH SHEDDING COLLAR
BULGE WOOD AFTER FIBRE KINKING
ROOT JUNCTION
HAZARD BEAM
BUCKLING
BARK INCLUSION
SOIL CRACK
FUNGUS FRUIT-BODY
SHEAR CRACK
for Visual Tree Assessment

VTA and the Body Language of Trees

Trees strive for uniform stress distribution over their surface. If this is disturbed by locally high stresses, then the tree will lay down thicker annual rings at this place. Conversely, if it is locally underloaded, it will make less increment. The form of trees is thus a record of their loading history, or a biography in wood. In contrast to bone, a tree cannot remove wood once it has been formed: it cannot efface its past.

The method of Visual Tree Assessment (VTA) described here is a method of tree diagnosis that is used world-wide and is legally accepted. It interprets the body language of trees, linking internal defects to the tree's own repair-structures, confirming and measuring these defects, and finally assessing them with failure criteria, and from this, deducing measures for the "therapy" of the tree. Accordingly, trees that are only apparently dangerous should be distinguished from trees that are really dangerous, thus avoiding unnecessary fellings and also accidents caused by tree failure.

The contents are presented in the form of a concise field guide. A comprehensive introduction into the body language of trees will be found in "Stupsi Explains the Tree", which is strongly recommended as supplementary reading. In addition, references to further publications are given where necessary. Please note, that even a healthy tree can fail because trees have a natural failure rate. They pay with losses of individuals to maintain the species with minimum weight.

Claus Mattheck
Karlsruhe Research Centre, Summer 2007

Forbes-
Laird
Arboricultural
Consultancy

REFERENCE NO. 2

THE BODY LANGUAGE OF TREES,
CLAUS MATTHECK & HELGE BRELOER,
TSO 1ST EDITION 1994

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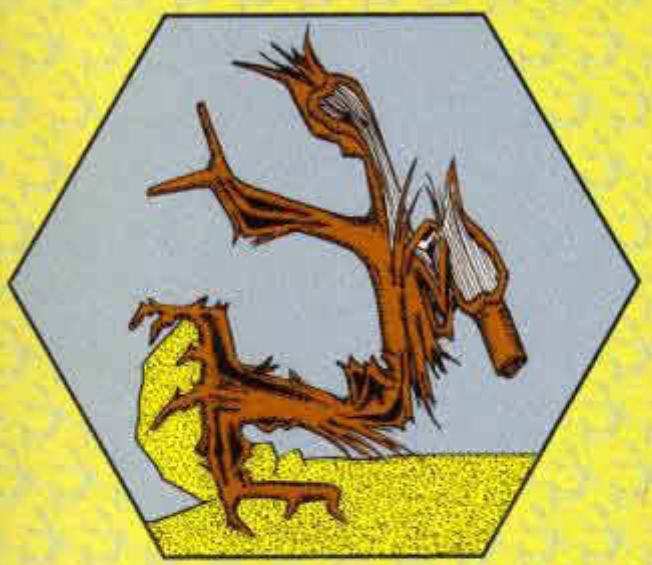
Department of the Environment



The body language of trees

A handbook for failure analysis

by Claus Mattheck and Helge Breloer

Edited by David Lonsdale
from a translation by Robert Strouts

No. 4 • Research for Amenity Trees No. 4 • Research for Amenity Trees

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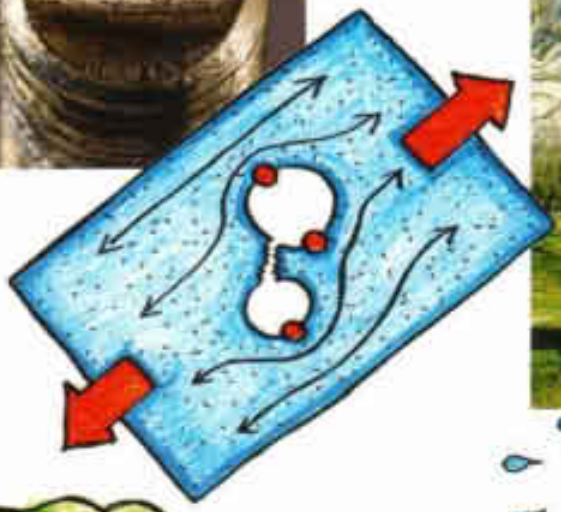
REFERENCE NO. 3

THE FACE OF FAILURE IN NATURE AND ENGINEERING,
CLAUS MATTHECK,
1ST EDITION 2004,
P.144

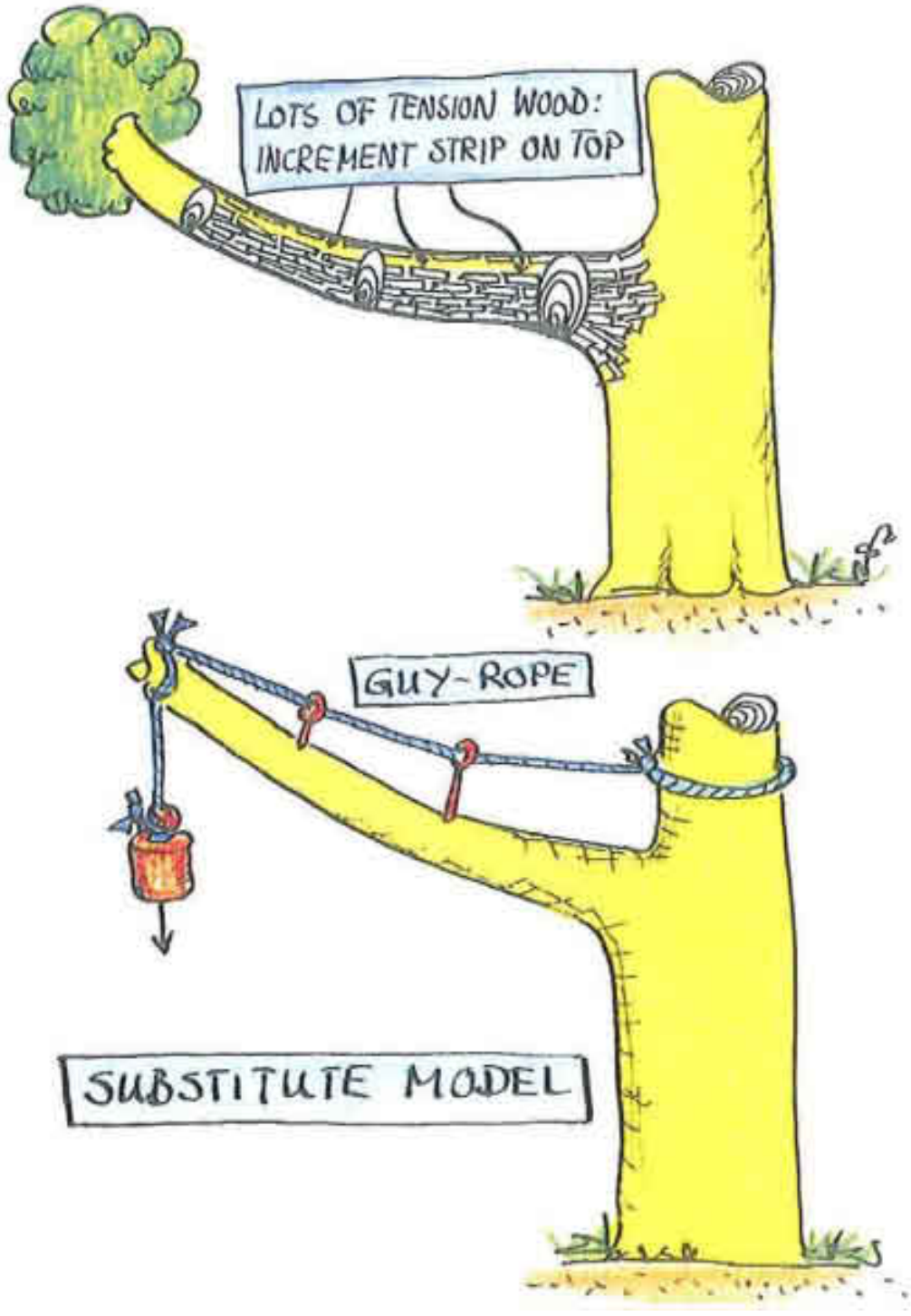
CITED ON PAGE 11

C. MATTHECK

THE FACE OF FAILURE



IN NATURE AND ENGINEERING



THE INCREMENT STRIPS ALSO SHOW THE LOAD ON BRANCHES. VIGOROUS BRANCHES OF BROADLEAVED TREES HAVE A 'MUSCLE' OF TENSION WOOD ON THE UPPER SIDE WHICH CONTRACTS AND THUS HOLDS THE BRANCH UP. GOOD BRANCHES LIKE THESE HAVE INCREMENT STRIPS ON THE UPPER SIDE.

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REFERENCE NO. 4

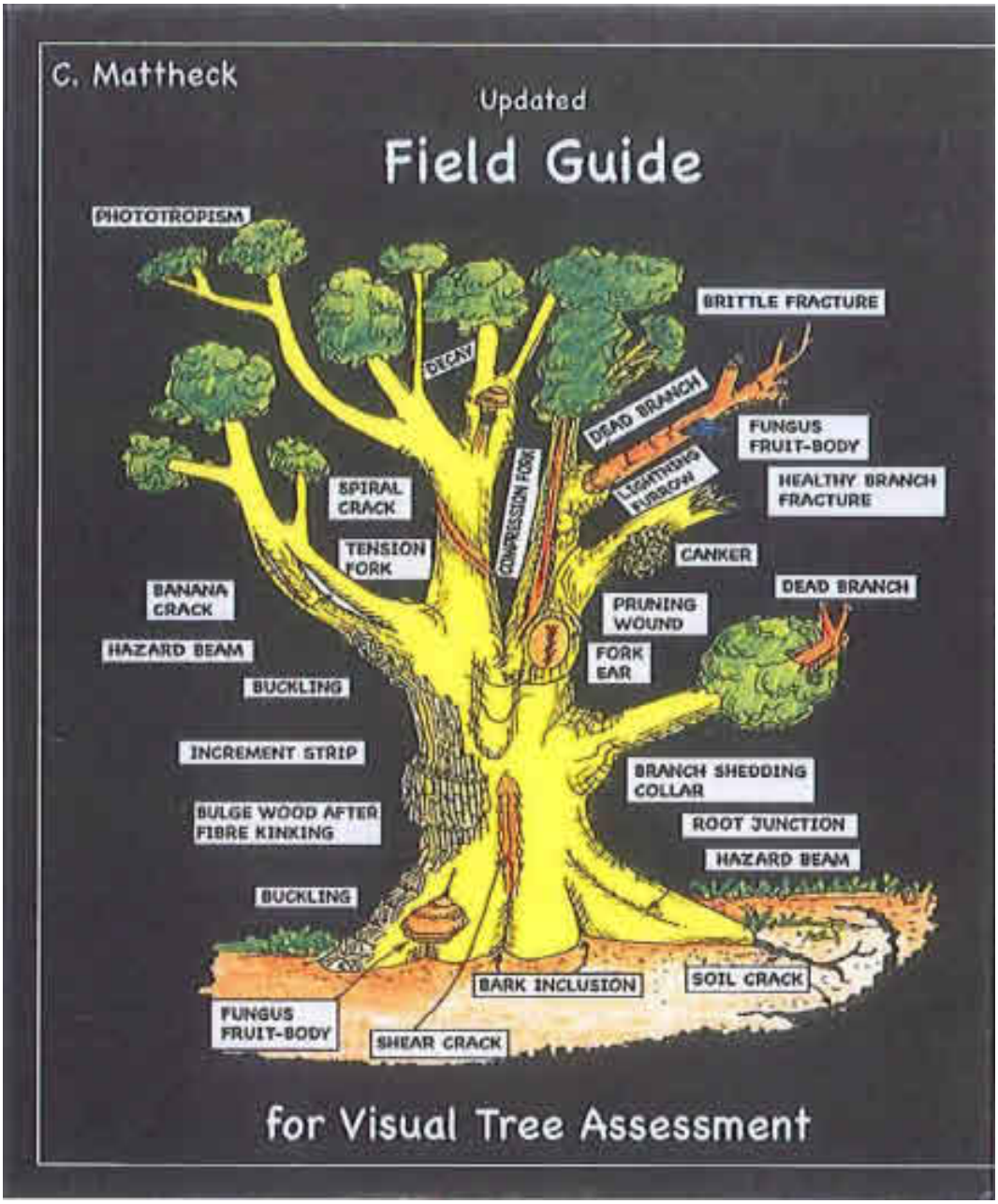
UPDATED FIELD GUIDE FOPR VISUAL TREE ASSESSMENT,

CLAUS MATTHECK,

1ST EDITION 2007

P. 30

CITED ON PAGE 12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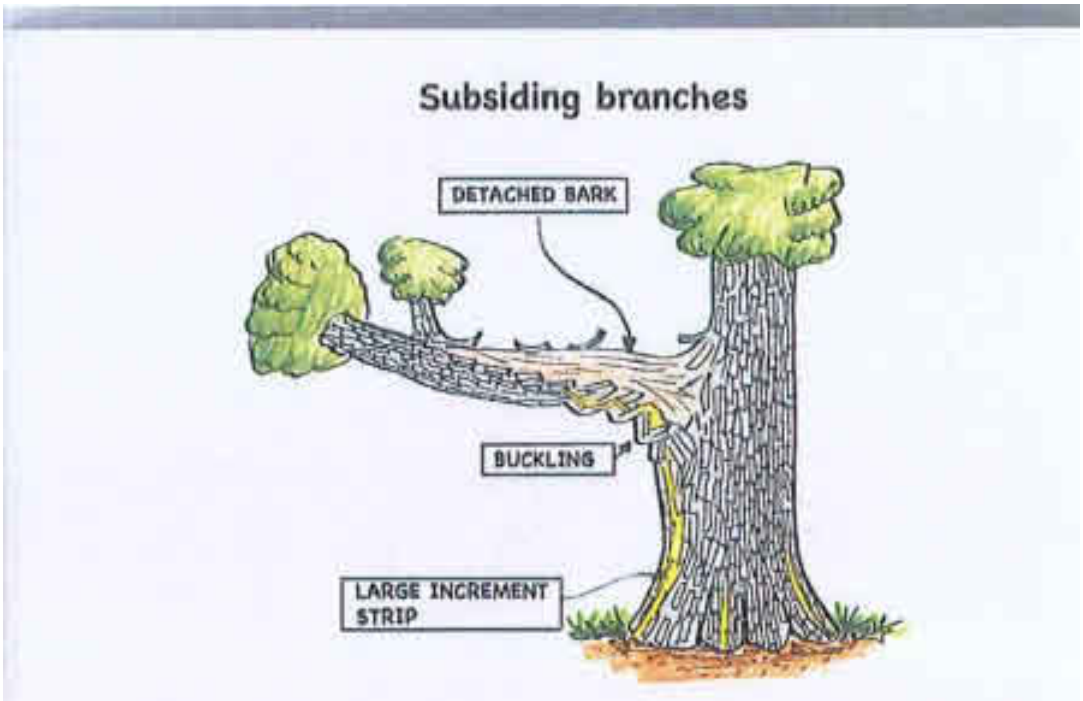
SHEAR CRACK
for Visual Tree Assessment



If the support wood on the under side of the branch also fails, so that pronounced buckling occurs or zig-zag patterns in the bark or the bark becomes detached on the upper side of the branch then it is high time to shorten the branch or, if that is not possible, to install an A-support which (in contrast to cabling the individual branch) will take not only the weight but will also cope with the side wind and thus can counter failure by "cupboard-door flapping" (windward-side splitting at the junction with the stem). In conifers, which only form compression wood on the under side of the branch, the increment strips are always found on the under side, even in branches that are not subsiding. There the bark becoming detached on the top is the only warning signal for the bending down.

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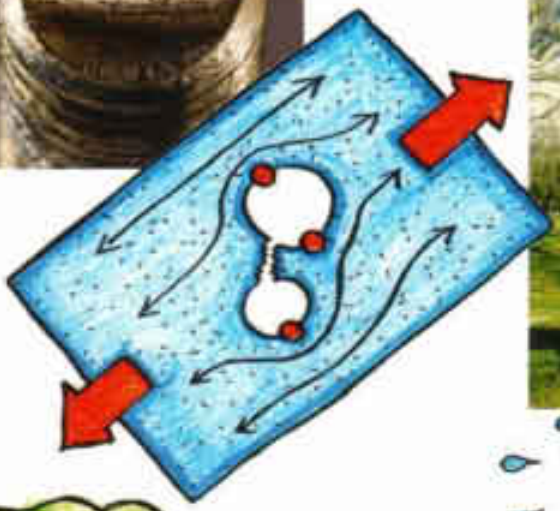
REFERENCE NO. 5

THE FACE OF FAILURE IN NATURE AND ENGINEERING,
CLAUS MATTHECK,
1ST EDITION 2004
P. 141

CITED ON PAGE 13

C. MATTHECK

THE FACE OF FAILURE



IN NATURE AND ENGINEERING

CRACKS IN THE TREE ALSO CAUSE EXTRAORDINARILY HIGH STRESSES BEFORE THE TIP OF THE CRACK. THE NEARER THE TIP OF THE CRACK IS TO THE CAMBIUM, THE THICKER ARE THE ANNUAL RINGS FORMED THERE AND THE WIDER ARE THE LIGHT-COLOURED INCREMENT STRIPS. WITH POINTY-NOSED RIBS THE INCREMENT STRIPS ARE EXTREMELY WIDE AND THE BARK ON THE RIB IS THIN. IF THE CRACK HAS ALREADY BEEN CLOSED BY SEVERAL ANNUAL RINGS, NARROWER ANNUAL RINGS WILL NOW BE FORMED BECAUSE OF THE SMALLER STRESS PERCEIVED BY THE CAMBIUM. THE INCREMENT STRIP WILL BE ABSENT AND COARSE BARK WILL COVER THE RIB (LEFT).

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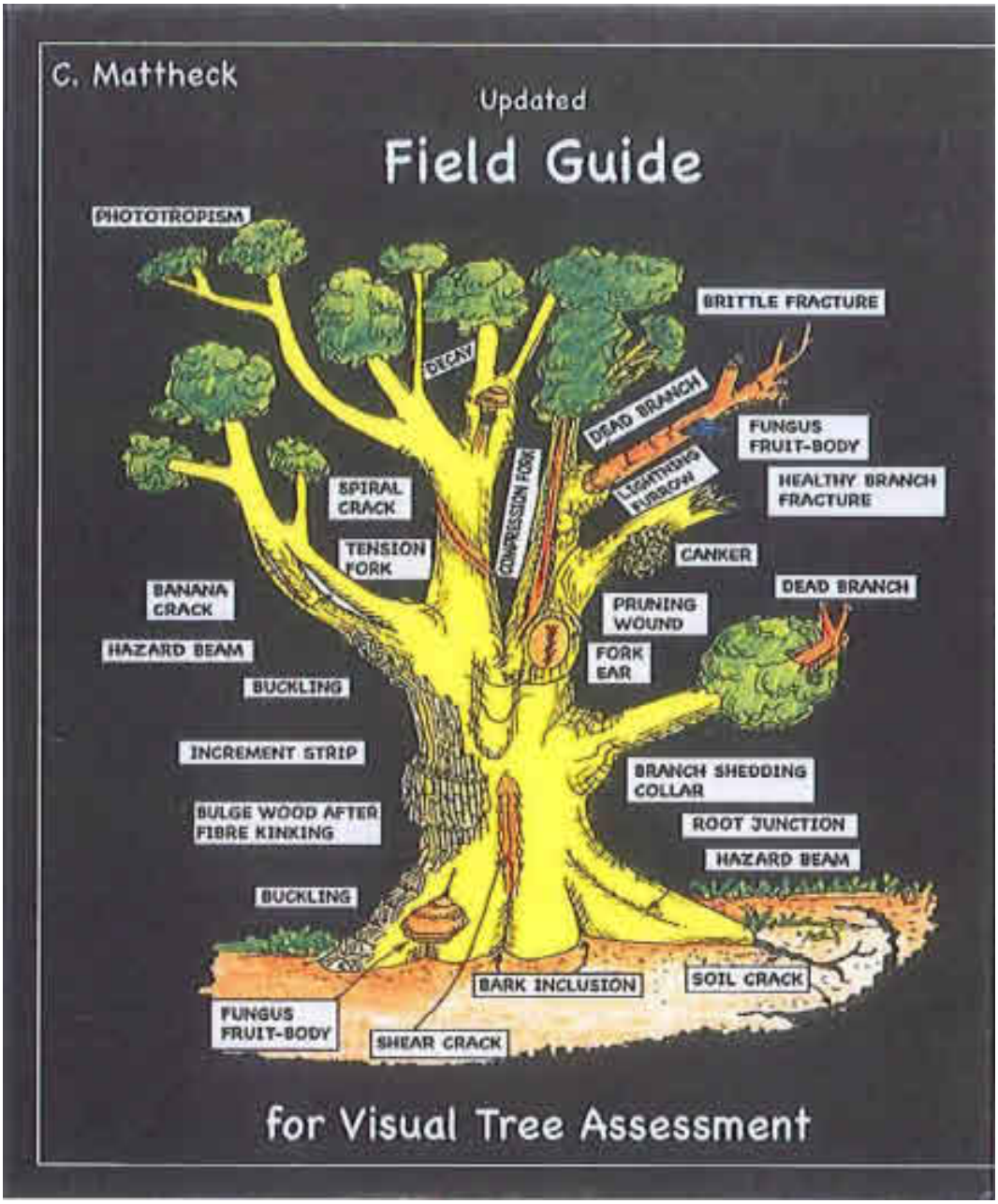
REFERENCE NOS. 6, 7 & 8

UPDATED FIELD GUIDE FOR VISUAL TREE ASSESSMENT,
CLAUS MATTHECK,
1ST EDITION 2007
P. 21, 22 & 23

CITED ON PAGES 14, 15 & 16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HAZARD BEAM
BUCKLING
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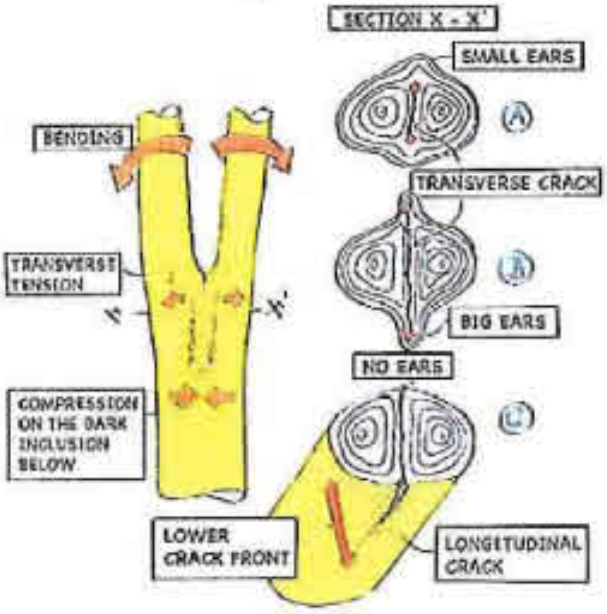
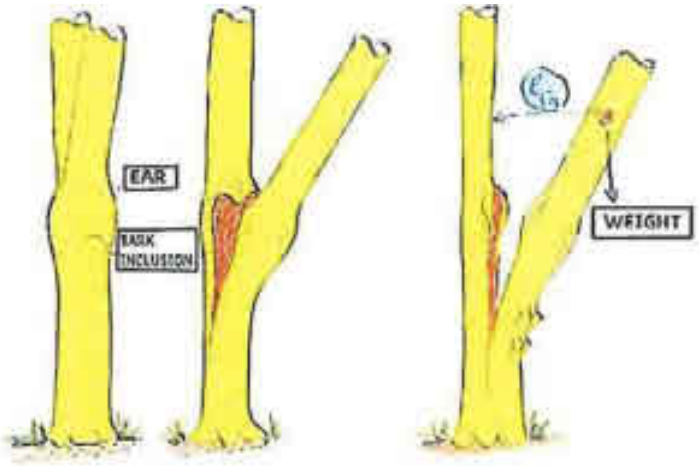
SOIL CRACK
FUNGUS FRUIT-BODY
SHEAR CRACK
for Visual Tree Assessment

The compression fork



The compression fork usually occurs in dense forest stands as a result of phototropic growth upwards to the light. The stems mutually crush themselves and enclose bark, which acts mechanically like a crack. The crack becomes enclosed by all-embracing annual rings, which weld the stems together. The welding seams on both sides are also called "ears". The safest compression fork, which as a rule will rarely fail, is the one with small ears (A) with many all-embracing annual rings and little included bark. (B) is the fork basically threatened by tear-out, with big ears and only a few welded annual rings, and (C) shows a fork without any welded annual rings, which is therefore not a transverse crack but a dangerous longitudinal crack.

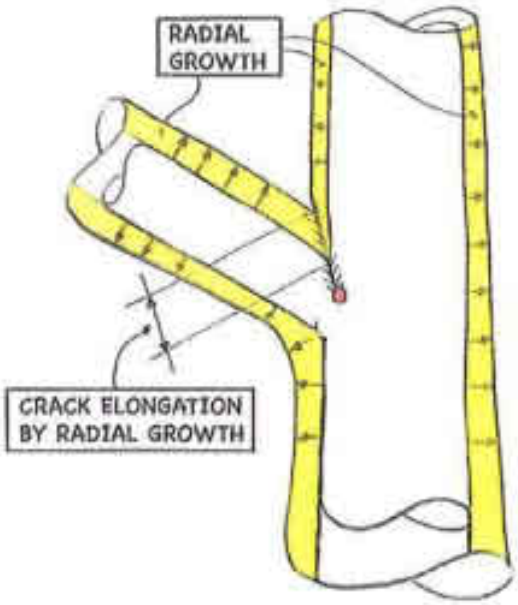
Compression Fork Failure



In normal compression fork fracture, the welded annual rings in the fork ears loaded by transverse tension will rupture first. The transverse crack ruptures from the inside outwards, and the lower crack tip, which has long been loaded in lateral compression, experiences tension and runs downwards. The semi-circular profile of the lower stem splitting off is weak in bending and inclines outwards because of the peripheral crown weight, the crack extends further and, at a critical crack length, transverse fracture of the stem occurs. The typical fork failure thus consists of the change from transverse crack to longitudinal crack:

1: Cracking through the ears.
2: Longitudinal splitting, as an elongation of the included bark.
3: Transverse fracture of one of the split-off halves of the stem.

Branch breakage as a consequence of bark inclusion



Steep branch attachments can also cause bark inclusions (crack!). Branches which are no longer forming welded annual rings with the stem wood along the bark inclusion are particularly vulnerable to tear-out. Here the ingrown crack becomes longer and longer with the radial growth of the branch, and thus more and more dangerous; moreover, the branch becoming increasingly thick will also become increasingly heavy. When the critical crack length is reached, the branch tears out, and this can even happen in calm weather. Reason: the radial growth of branch and stem is sufficient to cause bark inclusion by self-crushing, but is too small to produce the welding of branch-wood and stem-wood.

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REFERENCE NOS. 9 & 10

STUPSI EXPLAINS THE TREE,
CLAUS MATTHECK,
3RD ENLARGED EDITION 1999
P. 21 & 22

CITED ON PAGE 17

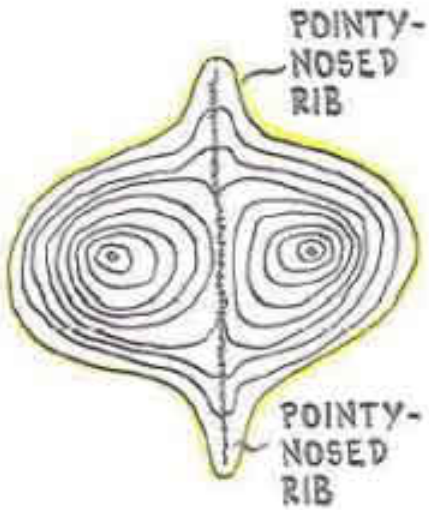
CLAUS MATTHECK:

STUPSI

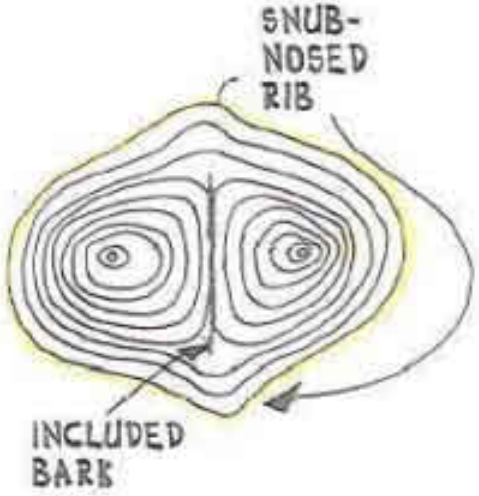
EXPLAINS THE TREE

A HEDGEHOG TEACHES THE BODY LANGUAGE OF TREES

3RD ENLARGED EDITION



IF SUCH AN ACUTE FORK HAS A LOT OF BARK BETWEEN THE TWO STEMS, AND ONLY A FEW ANNUAL RINGS BINDING THE TWO STEMS TOGETHER, THE FORK CAN EASILY BREAK APART. THE BARK BETWEEN THE STEMS ACTS LIKE A CRACK, AND THEREFORE A POINTY-NOSED RIB IS FORMED ON EACH SIDE. FROM THE SIDE THE TREE FORK THEN LOOKS AS IF IT HAS BIG EARS.



HERE THERE IS ONLY A LITTLE BARK ENCLOSED BETWEEN THE STEMS, AND THERE ARE MANY ANNUAL RINGS BINDING THE TWO STEMS OF THE FORK TOGETHER. THEREFORE THE RIBS IN FRONT OF THE ENDS OF THE INCLUDED BARK, WHICH IS ACTING LIKE A CRACK, ARE SNUB-NOSED. THE TREE FORK HAS ONLY LITTLE EARS AND IS MUCH LESS DANGEROUS THAN A FORK WITH BIG EARS. THE BEST TREE FORKS DO NOT HAVE ANY INCLUDED BARK BETWEEN THE STEMS AND THEREFORE DO NOT FORM ANY EARS.

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REFERENCE NOS. 11 & 12

THE BODY LANGUAGE OF TREES,
CLAUS MATTHECK & HELGE BRELOER,
TSO 1ST EDITION 1994
P. 12 & 36

CITED ON PAGE 22

Department of the Environment

The body language of trees

A handbook for failure analysis

by Claus Mattheck and Helge Breloer

Edited by David Lonsdale
from a translation by Robert Strouts

No. 4 • Research for Amenity Trees No. 4 • Research for Amenity Trees

3.2 THE AXIOM OF UNIFORM STRESS

An axiom is a precept which seems obviously true by virtue of its inherent plausibility, but cannot be generally proved. Dogma, by contrast, have more to do with belief than with fundamental truth. What is so inherently plausible about trees? As we shall explain below, and as forest scientists have to some extent known for many years [24,25] a tree

is a self-optimising mechanical structure. Its design therefore follows the rule for all such structures which, by definition, make as economic a use of their material as possible and are as strong as necessary. If such a structure is evenly loaded and if all points on its surface have to withstand the same stress, it will have no overloaded areas (breaking points) and no under-loaded areas (wasted material) [39]. *An optimal structure has a uniform stress over the whole of its surface.*

Mechanical optimisation determines biological design from the tusks of a wart-hog to a tree's root; from a tiger's claw to a chicken's leg; from the junction of a branch to our own bones, and yes, even to the finest microscopic 'half-timbering' with which they are filled. The one difference between bones and trees, as far as the *Axiom of uniform stress* is concerned, is that bones can atrophy as well as grow, whereas the tree does not actively dismantle underloaded areas, whatever their origin may have been. All the tree can do is to add extra wood preferentially to its more heavily loaded areas and to deprive less heavily loaded areas, that is the shirkers in its structure, by cutting back further wood production at these points until a state of uniform stress is achieved once more.

Incidentally, it is also shown in reference [39] that machine components can best be optimized by means of computer simulated growth; using this technique, many industrial undertakings already allow their components to 'grow' like trees, by which means they attain lightness and durability in the way that trees or bones do.

But what direct consequences does this wonderful biomechanical principle have for our understanding of trees in particular? Let us first consider for a moment the undisturbed growth of a tree, the unfettered development of its natural form, without having our convertible-driving show-off sharpen his bumper on it. We will not concern ourselves with the repair of such minor injuries until later.

5.1.6 Devil's ears and kinked tubes

In order to understand the principle, let's push a broom handle into our garden hose, which we have so mistreated in our demonstration of cross-sectional flattening. If we then bend it (Fig. 17) we see that, instead of flattening evenly along its length as it did without the broom handle, the hose kinks near the end of the broom handle. We suggest the term '*hosepipe kinking*' to describe this mechanism of local *cross-sectional flattening*. What makes it so much more dangerous than the cross-sectional flattening of completely hollow tubes? When there is a very abrupt transition from the hollow to the solid part of the stem, there is a deviation of the local force flow. As the fungi or other things attacking the tree give little thought to optimising the shape of the decay cavity but rather feast away merrily on the wood, the tree can be threatened by deadly points of stress within its interior. True, the cambium will always try to correct high stresses at the surface by adding new material, as described in Chapter 3, but it can only react to internal notch stresses in this way if they extend out to the surface. This highlights the great disadvantage a tree has compared to a bone: trees

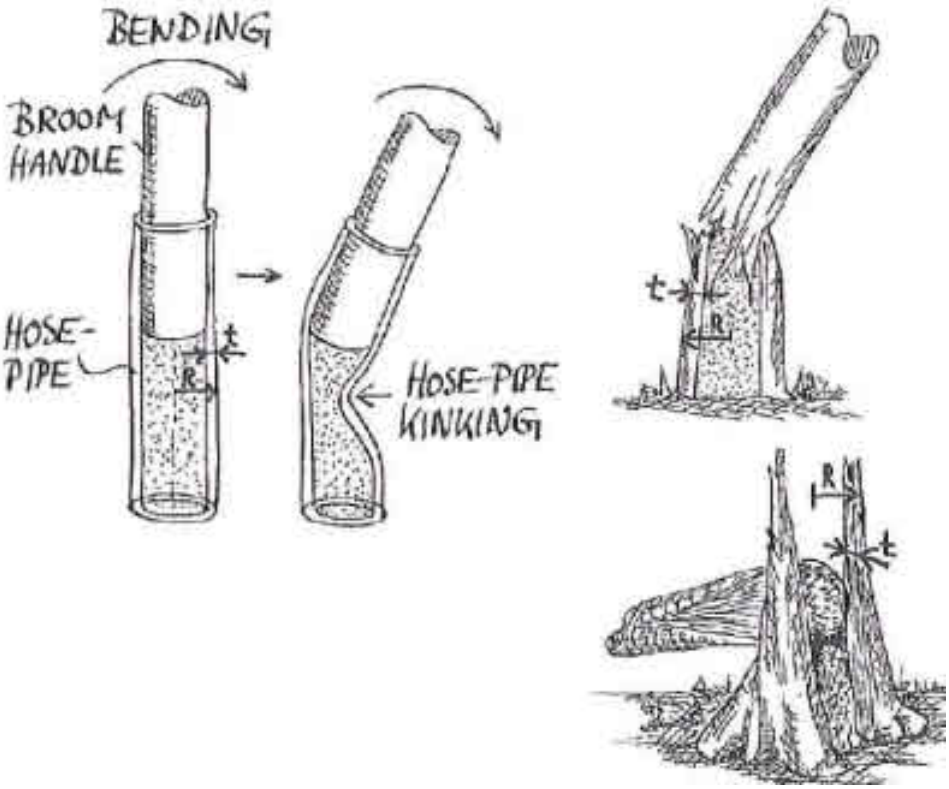

Fig 17. A bent garden hose kinks just below the end of a broom handle pushed into it. Hosepipe kinking in trees is the kinking of the decayed part of the stem immediately below the still solid part. In the case of Devil's ears, two wooden 'ears' split off from the sides of the stem. One-eared devils arise from a combination of bending and torsional loads.

Forbes-
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REFERENCE NOS. 13 & 14

PRINCIPLES OF TREE HAZARD ASSESSMENT AND MANAGEMENT, DAVID LONSDALE
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DETR
ENVIRONMENT
TRANSPORT
REGIONS

Principles of Tree Hazard Assessment and Management

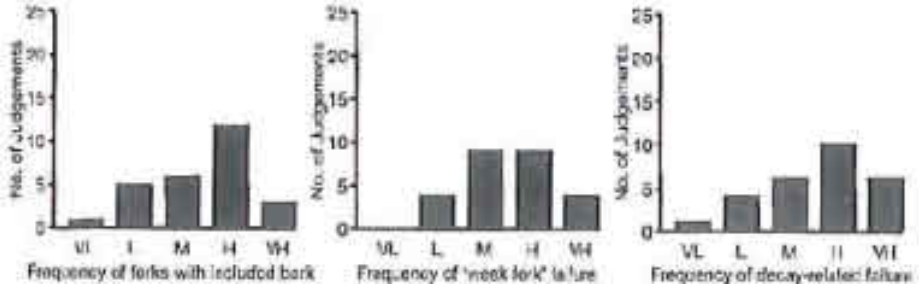
by David Lonsdale

Forestry Commission

Research for Amenity Trees No. 7 • Research for Amenity Trees No. 7 • Research for Amenity Trees No. 7

Propensity to form weak forks		Propensity for weak fork failure		Propensity to fail due to decay	
Genus	**MEAN**	**Genus**	**MEAN**	**Genus**	**MEAN**
CONIFERS					
Araucaria	1.05	Araucaria	1.00	Sequoia	1.04
Sequoia	1.31	Sequoia	1.19	Metasequoia	1.05
Picea	1.32	Larix	1.22	Taxodium	1.05
Larix	1.37	Metasequoia	1.27	Sequoiadendron	1.09
Sequoiadendron	1.40	Picea	1.28	Araucaria	1.11
Metasequoia	1.41	Taxus	1.29	Ginkgo	1.12
Pseudotsuga	1.46	Sequoiadendron	1.32	Taxus	1.17
Abies	1.60	Ginkgo	1.35	Pseudotsuga	1.33
Taxodium	1.70	Pseudotsuga	1.38	Thuja	1.38
Thuja	2.04	Abies	1.52	Picea	1.42
Pinus	2.11	Taxodium	1.57	Cupressocyparis	1.44
Taxus	2.21	Pinus	1.67	Abies	1.48
Ginkgo	2.52	Thuja	1.96	Pinus	1.48
Cupressus	2.74	Cupressus	2.64	Larix	1.50
Cupressocyparis	2.78	Cedrus	2.92	Chamaecyparis	1.68
Cedrus	2.96	Cupressocyparis	2.92	Cupressus	1.76
Chamaecyparis	3.17	Chamaecyparis	3.00	Cedrus	2.04
BROADLEAVES					
Platanus	1.32	Carpinus	1.32	Platanus	1.32
Carya	1.50	Alnus	1.35	Carya	1.50
Corylus	1.52	Corylus	1.44	Corylus	1.52
Pterocarya	1.57	Carya	1.60	Pterocarya	1.57
Eucalyptus	1.60	Juglans	1.62	Eucalyptus	1.60
Carpinus	1.60	Platanus	1.64	Carpinus	1.60
Zelkova	1.62	Pterocarya	1.67	Zelkova	1.62
Alnus	1.77	Magnolia	1.77	Alnus	1.77
Sophora	1.80	Zelkova	1.80	Sophora	1.80
Liquidamber	1.82	Quercus	1.81	Liquidamber	1.82
Magnolia	1.82	Pyrus	1.92	Magnolia	1.82
Gleditsia	1.91	Betula	1.93	Gleditsia	1.91
Quercus	1.93	Ulmus	2.00	Quercus	1.93
Castanea	2.00	Sophora	2.07	Castanea	2.00
Pyrus	2.12	Castanea	2.07	Pyrus	2.12
Sorbus	2.17	Prunus	2.12	Sorbus	2.17
Liriodendron	2.25	Liquidamber	2.14	Liriodendron	2.25
Ulmus	2.27	Sorbus	2.22	Ulmus	2.27
Tilia	2.32	Paulownia	2.31	Tilia	2.32
Ailanthus	2.36	Tilia	2.32	Ailanthus	2.36
Paulownia	2.42	Eucalyptus	2.33	Paulownia	2.42
Catalpa	2.44	Morus	2.43	Catalpa	2.44
Robinia	2.48	Catalpa	2.53	Robinia	2.48
Prunus	2.48	Gleditsia	2.55	Prunus	2.48
Morus	2.50	Acer	2.68	Morus	2.50
Betula	2.52	Fraxinus	2.76	Betula	2.52
Juglans	2.56	Liriodendron	2.79	Juglans	2.56
Acer	2.77	Ailanthus	3.00	Acer	2.77
Fraxinus	3.32	Robinia	3.04	Fraxinus	3.32
Aesculus	3.48	Fagus	3.54	Aesculus	3.48
Populus	3.56	Aesculus	3.54	Populus	3.56
Fagus	3.59	Populus	3.85	Fagus	3.59
Salix	3.71	Salix	3.92	Salix	3.71

FAGUS - BEECHES



- **Fungi causing decay.** *Armillaria* spp. (B), *Biscogniauxia nummularia* (T), *Bjerkandera adusta* (T), *Chondrostereum purpureum* (T), *Coriolus versicolor* (T), *Daedaleopsis confragosa* (T), *Diatrype* spp., *Datronia mollis* (T), *Eutypa spinosa* (T), *Fistulina hepatica* (T,B), *Fomes fomentarius* (T), *Ganoderma adspersum*, (B,T), *G. applanatum* (B,T), *Ganoderma pfeifferi* (B,T), *Heterobasidion annosum* (B), *Hypoxylon fragiforme* (T), *Lenzites betulina* (T), *Meripilus giganteus* (B), *Oudemansiella mucida* (T), *Perenniporia fraxinea* (B), *Pleurotus ostreatus* (T), *Polyporus squamosus* (T), *Pseudotrametes gibbosa* (T), *Schizophyllum commune* (T), *Stereum* spp. (T), *Ustulina deusta* (B)

- **Resistance to decay.** A true heartwood is not formed in *Fagus* spp., so that the innermost wood of old specimens consists of dysfunctional sapwood which is readily colonised by decay fungi as soon as it is exposed to the atmosphere by injury or disease. The outer living sapwood is relatively resistant to many decay fungi, but may be rapidly invaded by wound rot fungi such as *Bjerkandera* and members of the *Stereum* group when injured. Dysfunction and decay induced by topping or 'tipping' wounds can become very extensive in mature or old trees, which often lack existing branches or new growth proximal to such wounds. Such damage appears to occur less in *F. sylvatica* var. *atropurpurea* than in the ordinary form of the species.

- **Diseases leading to decay or other weakening.** Below ground, Phytophthora root killing may lead to secondary decay. Above-ground, beech bark disease caused by the fungus *Nectria coccinea* on stems infested by the scale insect *Cryptococcus fagisuga*, often leads to snapping of the stem due to decay by wound rot fungi. The related fungi *N. cinnabarina* and *N. ditissima* can also kill bark, occasionally encouraging decay. Canker rot, caused by *Stereum rugosum*, also affects *Fagus* occasionally.

- **Mechanical characteristics.** Individual trees show genetic variation in the propensity to form forks with included bark. Failure at such forks and at acute branch attachments becomes common in old specimens. Widely