Treework Environmental Practice

To: The Court

Re. Daniel Mullinger (Deceased) & Others v The National Trust
Location: Felbrigg Hall, Roughton, Norfolk
Incident date: 26 June 2007

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Report in relation to the inspection of trees at the above site

by: David Lonsdale BSc, PhD, FArborA (Hon.),
as an Associate of
Treework Environmental Practice (TEP)

Dated: 04 April 2011

Specialist Field: Tree risk assessment and management

On the instructions of: Weightmans LLP

Subject: The inspection and management of a beech tree at Felbrigg Hall, prior to a fatal incident on 26 June 2007

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1. Summary

1.1 This report concerns a beech tree, *Fagus sylvatica*, at the Felbrigg Hall Estate, Roughton, Norfolk, in relation to legal liability for harm caused by a branch failure on 26 June 2007. The report is based on an on-site inspection and a further site visit undertaken by the author on 26 October 2007 and 30 July 2010 respectively, together with the information listed below in Section 4.

1.2 The questions specifically addressed in this report are quoted in Section 3.2 and mainly concern the cause of the branch failure and the presence of defects that might have been detectable prior to the incident.

1.3 With regard to the detectability of defects prior to the incident, the assessment in this report is that some branches of the tree, including the branch that fell, were showing signs that they might be weakly attached but that, with reasonable interpretation, these signs did not indicate that the probability of failure was higher than in the case of many other branches of old beech trees.

1.4 Although the potential impact from failure of the branch was severe, the usage of the site was evidently so low that the risk of harm could reasonably have been assessed as having been very low.

1.5 On the basis of the above assessment, there would have been no need to have recommended remedial action prior to the branch failure on 26 June 2007.

1.6 The true condition of the branch was such that its probability of failure was much higher than could reasonably have been assessed from a visual ground-based inspection. If this had been known, remedial action could reasonably have been considered but not necessarily undertaken.

1.7 The system for tree inspections was in my view reasonable in all its key aspects.

1.8 The available evidence indicates that the individuals engaged in the various aspects of tree risk management on the estate were competent to do so.

1.9 Technical terms, or everyday words which are used in a technical sense, are underlined when first used in the report. These terms are defined in the glossary (Appendix 3).

2. Personal details

2.1 My name is David Lonsdale. I am a plant pathologist with 34 years' postdoctoral experience in tree pathology. Since 1981, I have specialised in tree decay research and in the development of procedures for tree hazard assessment and management. On the latter subject, I have written a textbook (Lonsdale, 1999) and a Forestry Commission Practice Guide (Lonsdale, 2000). I was also the editor of the English language edition of an earlier textbook (Mattheck & Breloer, 1994).

2.2 Over the last 27 years I have undertaken tree hazard and risk assessments for public and private landowners; until March 2002 as an employee of the Forestry Commission (Forest Research) and subsequently as a self-employed consultant. I also lecture on this subject to students and tree care professionals. Fuller details of my qualifications and experience are in Appendix 5.

2.3 I have been instructed to provide specialist advice on tree-related matters in the present case. I understand that this report may be used in litigation.

3. The brief: background, scope and purpose

3.1 Background

3.1.1 This report concerns a fatal incident involving tree failure at the Felbrigg Hall Estate, Roughton, Norfolk, which belongs to the National Trust (‘the Trust’). A group of 10 pupils from the Heathlands Church of England School, West Bergholt, Essex, were attending a residential course at an educational activity centre (the Aylmerton Field Centre). At approximately 3.15 p.m. on Tuesday 26 June 2007, the pupils were sheltering from rain near a beech tree (‘the tree’ or ‘the incident tree’) while following a trail known as the Monster Trail (Clarke, undated). A branch (‘the incident branch’) fell from the tree, with tragic consequences. One of the children, Daniel Mullinger, aged 11, was killed and three others, Harry Bowen, Max Farley and Katie Farthing, were injured.

3.1.2 On the instructions of the Trust’s insurers, Zurich Municipal (ZM), I inspected the tree on 26 October 2007 in order to assess its condition, as could reasonably have been accomplished by an inspector prior to the incident. I also made a further site visit on 30 July 2010.

3.2 The brief

3.2.1 I have been instructed:

a) to identify the likely cause of the failure of the incident branch;
b) to establish the conclusions that could reasonably have been reached following a visual ground-based inspection on 2 January 2007;
c) to determine whether a ground-based inspection on 2 January could have indicated the need for an aerial inspection or for any remedial action;
d) to consider to what extent, if any, the failure of the incident branch was foreseeable prior to the incident on 26 June 2007, taking account of any indications whether an aerial inspection should have been undertaken;
e) to provide an expert opinion as to whether the method of tree inspection adopted was reasonable and whether, in general, it is reasonable for inspections to be visual and ground-based unless the suspicion of a potentially serious defect indicates a need for further investigation;
f) to comment on the competence of the individuals who are involved in tree risk assessment and management at the property concerned.

3.2.2 While addressing the above brief, I have considered a number of additional points that have been identified as “other issues raised”. These are as follows:

a) Zoning of the area where the incident occurred, in relation to risks associated with site usage within the property;
b) Frequency of inspection, with regard to what is considered reasonable;
c) Recording of tree inspection data, with regard to the need or otherwise for records of individual trees.

3.2.3 In order to assess the significance of any visually apparent defects with regard to item (c) of the brief (above), I have quantitatively assessed the risk of harm, using the information that would reasonably have been available to a competent inspector with knowledge of the usage of the site.

4. Information received

4.1 I have received and taken account of the following information:

- Reports, dated 27 June, of the incident, from The Times, Sky News (27 June) and the Eastern Daily Press;
- A series of photographs, undated, taken by Norfolk Constabulary soon after the incident;
- A series of photographs, taken by Mr Richard Daplyn (forester at Felbrigg Hall) on 10 and 12 August 2010, showing a branch which fell from the tree two to three years prior to the incident;
- 'Trees and Woodlands Instruction 1' (1997[1]), issued by the Trust
- 'Health and Safety Instruction No. 11 and Explanatory Guide' (21st May 2007), issued by the Trust;
- Content-lists of the Trust's training courses for tree inspection;
- Maps of the property, showing the system of zoning for tree risk management;
- Letter from HM Coroner (Greater Manchester South District) to the Trust's CEO, dated 20 July 2006;
- Witness statements, accompanied by supporting exhibits, of the following Trust personnel –
    - Peter Griffiths (National Trust Regional Director for Eastern England), dated 9 March 2011
    - Mark Daniels (Head of Health and Safety for the National Trust from 1997 until 28 February 2011), dated 9 March 2011;
    - Keith Zealand (Head Warden of Felbrigg Hall and Sheringham Park), dated 8 March 2011;
    - Richard Daplyn, Forester at Felbrigg Hall, dated 8 March 2011;
    - Mary Ghullam (volunteer in the Woods and Countryside department at Felbrigg Hall[2]), dated 8 March 2011.
- Witness statement of David Dowson, dated 31 January 2011;
- Witness statement of Christine Clarke, dated 04 March 2011;
- Witness statement of Daisy Violet Spurgen, undated;
- Witness statement of Sally Pearl, dated 07 March 2011.
- Police statements, dated as shown, of the following individuals, as provided at the inquest of Daniel Mullinger:
    - Stephen Mullinger, father of Daniel Mullinger (27 June 2007);
    - Wendy Mullinger, mother of Daniel Mullinger (undated);
    - Daisy Spurgen, witness at the scene of the incident (28 June 2007);
    - PC 437 Simon Nash, police officer who attended the incident (27 June 2007);
    - PC 303 Gary Medler, police officer who attended the incident (27 June 2007);
    - PCSO 8240 Elaine Roberts, police community safety officer who attended the incident (28 June 2007);
    - Alan Marett, proprietor of the Aylmerton Study Centre (03 July 2007);
    - PC 426 Rachel Mayes, police officer who attended the incident (30 June 2007);
    - Richard Daplyn, Forester at Felbrigg Hall (undated);
    - Edward Boydell, tree surgeon, who was a visitor at Felbrigg Hall in October 2006 (undated);
    - Keith Zealand, Head Warden of Felbrigg Hall and Sheringham Park (undated);

[1] Reprinted 2001

[2] Mrs. Ghullam was a volunteer at the time of the inspection of the incident tree prior to 26th June 2007 but was later employed by the Trust during 2008-09 on a fixed contract.

- Statement of Sally Pearl, witness at the scene of the incident (undated);
- John Watts, Head Teacher for Heathlands C of E Primary School, West Bergholt (undated);
- Martin Newson, forest foreman at Felbrigg Hall (undated);
- Richard Cranfield, teacher at Heathlands School, involved in field trip at Felbrigg Hall (undated);
- Christine Clarke, teacher at Heathlands School, involved in field trip at Felbrigg Hall and witness of the branch failure (undated);
- Paul Bedford, senior instructor at the Aylmerton Field Study Centre
- Keith Zealand (2nd statement, undated);
- Carol Carter, teacher trainee at Heathlands School (undated).

5. Scope and limitations of this report and of any advice or recommendations contained herein

5.1 Terms and conditions

5.1.1 The provision and acceptance of this report are subject to the general terms and conditions of Treework Environmental Practice.

5.2 Scope

5.2.1 General notes on the scope of tree risk assessments are shown in Appendix 4.

5.3 Risk assessment: accuracy and period of validity

5.3.1 The present report includes a retrospective quantified risk assessment, using the specific method known as Quantified Tree Risk Assessment (QTRA©). The method is based on information about both the condition of the tree concerned and the presence of people and property within the '<u>target zone</u>' (Ellison, 2005). The report also includes an alternative risk assessment, based on a method published by Forbes-Laird (2010). There are certain limitations on the accuracy of such assessments. In particular, there is inherent subjectivity in estimating the probability of tree failure (*see* para. 8.3.2, below) and, to a lesser extent, the potential for harm to be caused in the event of failure. In principle, the usage of sites can be measured objectively but has to be estimated if survey data are not available. In this instance, the frequency of pedestrian usage prior to the incident is estimated (Daplyn, 2011) rather than measured.

5.4 Methods of assessment in the present report

5.4.1 The assessment presented in this report is based mainly on an inspection that I made on 26 October 2007, while accompanied by Mr. Keith Zealand, Mr. Richard Daplyn and Mrs. Mary Ghullam. I inspected the tree and its fallen branches visually while standing at ground level, using binoculars as an aid where appropriate. I used visual criteria in assessing the <u>mechanical integrity</u> of the aerial parts of the tree (Mattheck & Breloer, 1994). Additionally I used a sounding hammer as an aid in detecting any extensive <u>decay</u>, which might have been present within the stem, <u>buttress zone</u> or bases of roots.

6. Observations of the incident tree, in relation to risk assessment

6.1 Observations made on 26 October 2007 and thereafter

6.2 General information

General information about the tree, the tree population and the site is shown in Appendix 2.

6.2.1 The likely cause of the failure of the incident branch on 26 June 2007

6.2.1.1 The incident branch failed at its junction with the stem. The crotch was of the type

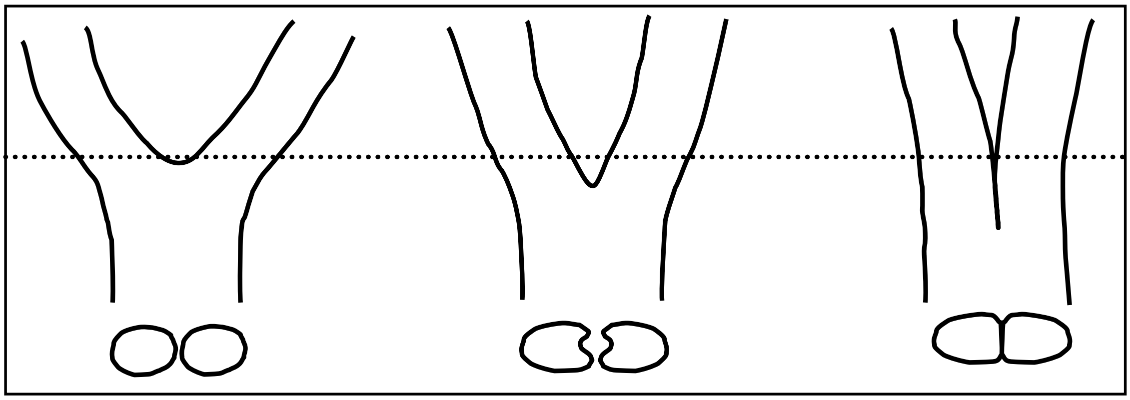

Fig. 1: Comparison of types of crotch – longitudinal and cross-sectional diagrams: (a) U-shaped crotch with unrestricted formation of wood between the branches; (b) Cup-shaped union with reduced formation of wood; (c) tight, V-shaped crotch with bark-to-bark contact: development of a bark inclusion. (The dotted line shows where the cross-sectional views belong.)

that is shaped like a flattened cup, in which there is less development of wood in the centre than around the periphery. Figure 1 shows a comparison of different types of crotch. A severe restriction of wood development can lead to weakness, but the overall strength of the branch attachment can be unimpaired if there has been compensatory development of the surrounding wood (Lonsdale, 1999). In this instance, there was a thick but somewhat irregular wall of wood around the cup-shaped centre of the crotch (Fig. 2). Nevertheless, the fracture-surface on the incident branch shows evidence that part of this wall had cracked before 2007. I therefore conclude that cracking had already weakened the attachment of the branch and acted as a trigger for its failure in June 2007.

Fig. 2. The arrows mark the rim of a cup-like depression in the crotch of the fallen branch.

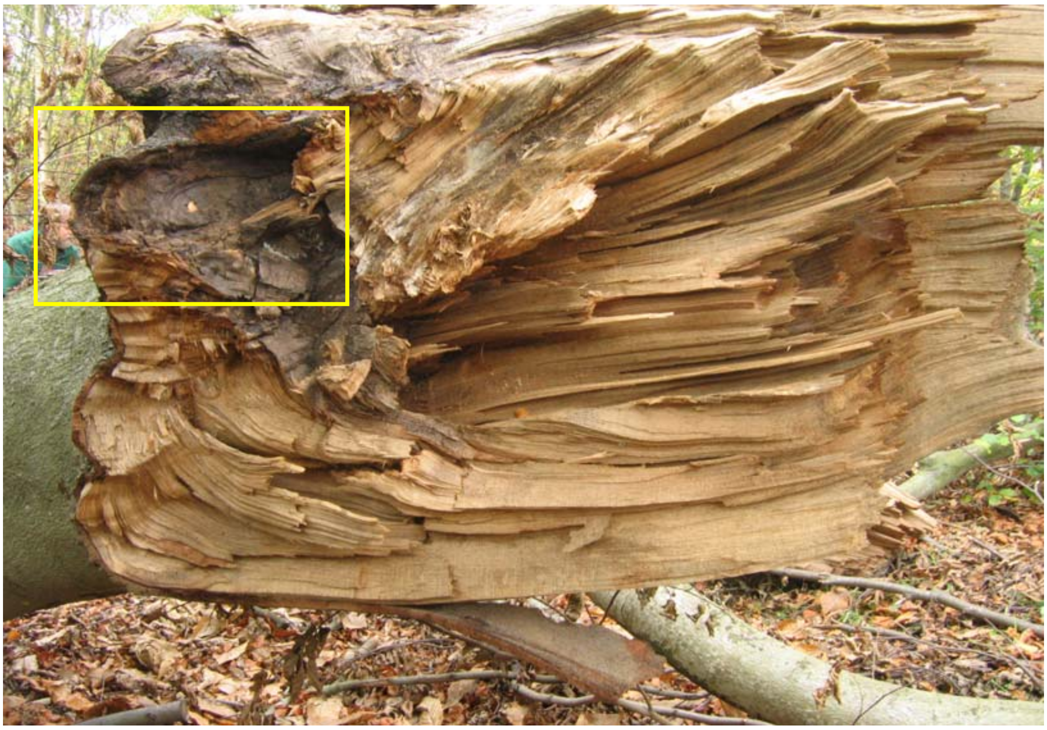

Fig. 3: The fracture-surface of the incident branch, showing an area (within the marked rectangle) where signs of previous cracking are visible.

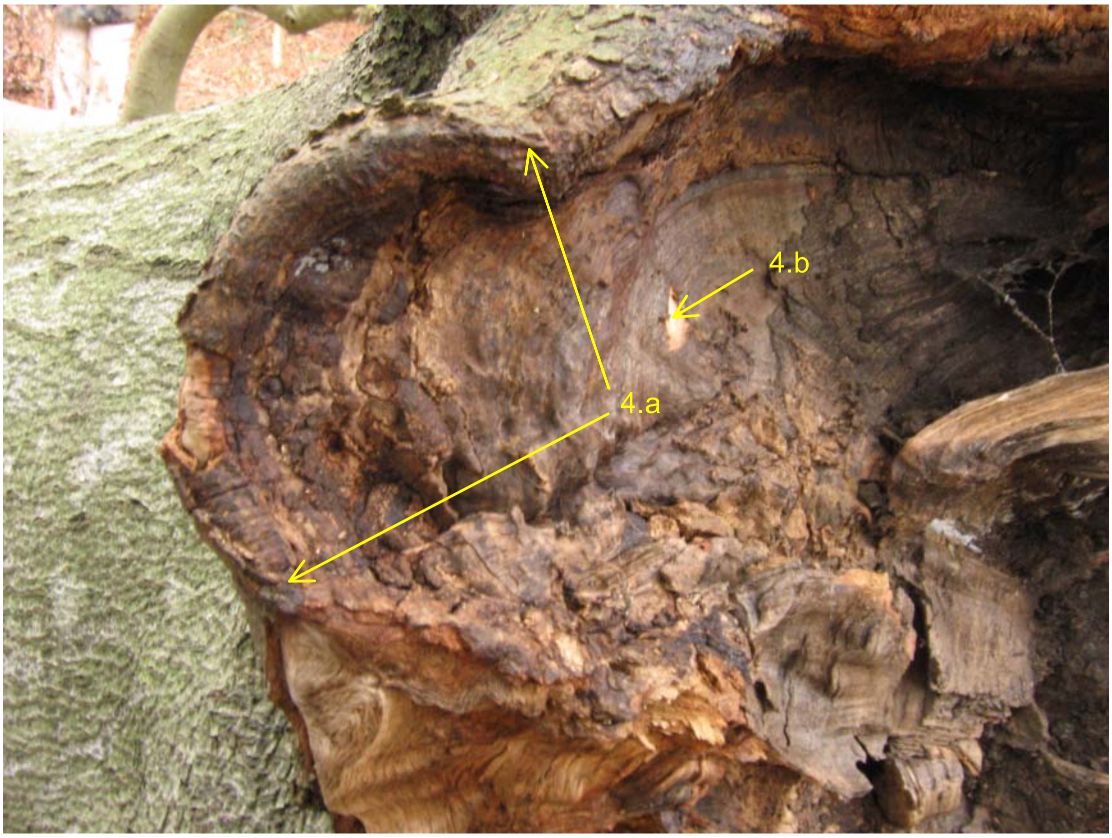

Fig. 4. The fracture surface of the fallen branch shows a zone of occluding tissues (4.a), which had formed in response to partial failure in the crotch. The tissues had extended some distance into the void created by the partial failure, indicating that the void had existed for a number of years. An area of dark, weathered but undecayed wood appears to indicate the extent of the void. A knife cut (4.b) shows the pale colour of the sound wood below the weathered surface.

6.2.1.2 The evidence for previous cracking is the presence of a narrow roll of new bark and wood (occlusion tissues or 'callus'), in the rectangle marked in Fig. 3. This roll, which can be seen more closely in Fig. 4, can have formed only in response to cracking. The formation of new bark appears also to have extended inside the crack that had been created by the partial failure. This indicates that crack had existed for a number of years. Irrespective of the exact manner in which the new bark formed, its presence is significant with regard to the failure of the incident branch, since there could have been no strength of attachment in the zone that it occupied

6.2.1.3 Near the roll of occlusion tissues, the fracture-surface of the wood shows areas of darkening, which has occurred owing to exposure to the atmosphere, leading to weathering but not decay. The darkening, which is shown in Figs. 3 and 4, appears also in the fourth photo in the bundled photos provided by the Norfolk Constabulary (Doc. D10), which were taken soon after the incident, before any subsequent weathering could have occurred. This sign of weathering prior to the incident is a further indication that these parts of the fracture-surface existed before the incident branch fell.

6.2.1.4 A very narrow layer of occluding tissues is present at some sections of the edge of the fracture-surface. This layer appears to have formed in 2007, after the incident branch had fallen but was still alive, and is of no diagnostic significance.

6.2.1.5 Another branch ("branch B), which had been attached above the incident branch failed, reportedly about ten days after the incident (Daplyn, 2011). As shown in a photograph taken on 26 October 2007 (Fig. 5), there was a slight cup-shaped hollow in the crotch of branch B but no sign of earlier partial failure. The failure of branch B could have been caused partly by an increase in wind-induced movements following the loss of the branch below. Also, there might have been some alteration of the growth stresses within the wood, owing to the loss of moisture via the socket of the failed branch below. Such changes do not, however, seem sufficient reason alone to explain the failure of branch B.

Fig. 5. The fracture surface of a branch that fell after the branch in question. The crotch is slightly cup-shaped but there is no sign of previous splitting. Dark areas of weathering probably developed after the branch fell.

6.2.1.6 A third branch ("branch C") is reported to have fallen from its place of attachment to the tree prior to the incident (Daplyn, 2011), when the locality was designated as being in the "low risk" zone of the estate. Branch C was not examined on 26 October 2007, but a photograph of its fracture surface was later taken and is shown in Fig. 8, below. The question as to whether the failure of branch C ought to have influenced the subsequent inspection and assessment of the tree is addressed below in Section 7.2.

6.2.1.7 The failure of branches that have not previously shown identifiable defects is often attributed to 'summer branch drop'. This is a poorly defined phenomenon, in which the main common factors are the absence of obvious defects and the occurrence of prolonged, hot, dry weather (or sometimes the occurrence of rain after such weather). When the incident branch failed on 26 June 2007, the weather conditions had not been such as to suggest a diagnosis of summer branch drop. Also, there appears to be no reason to invoke summer branch drop in this instance, since there was a pre-existing crack in the crotch which, despite not having been visible from the ground during the inspection, is sufficient to explain why the branch eventually fell.

7. Likely conclusions from a ground-based visual inspection on 2 January 2007

7.1 Inspection of the incident branch

7.1.1 A key question is whether a competent inspector would have been able to find whether the incident branch was showing significant defects on 2 January 2007. Defects that became evident only after the incident in June 2007 are not strictly relevant in this context, but they could be inappropriately cited as having been overlooked when the tree was last inspected.

7.1.2 It is essential not only to discount any signs that would not have been apparent at the time of the inspection, but also to consider what an inspector could reasonably have done at the time, when there were very many potential sequences of events; not the sole sequence which, in hindsight, can be identified as having led to harm (Adams, 2007).

7.1.3 The structure of branch attachments would have been among the features of the incident tree to be routinely observed during a ground-based inspection. The incident branch was one of several that did not have a fully formed branch bark ridge (Fig. 6). Such a ridge forms when there is annual growth of a strong woody connection within the crotch (Shigo, 1985). Where inrolled bark occurs instead of a branch bark ridge, there is a lack of wood development, leading to the formation of a bark inclusion or a cup-shaped crotch.

Fig. 6. Left: the arrow (6.a) shows an irregular groove near the socket of the incident branch; the groove has formed in place of a distinct branch bark ridge. A step-like bulge (6.b) lies to the left. Right: for comparison, another beech, showing two kinds of branch attachment; 6.c shows a groove, indicating a bark inclusion; 6.d shows a branch bark ridge, indicating a woody connection.

7.1.4 In many tree species, including beech, the crotches of a high proportion of branches contain bark inclusions or are cup-shaped. Such crotches can fail, especially in old trees whose branches have become long and heavy, but the great majority of them never fail. If such a structure is observed during an inspection, and if people or property would be at significant risk from its failure, there is a need to assess whether there is any real cause for concern. This can be done by searching for any signs of other contributory factors at or near the base of the branch being observed (e.g. an absence of signs of compensatory growth or the presence of cracking or decay). If such signs are observed by means of a ground-based inspection, there could be a need to consider either remedial action or further investigation, perhaps by means of climbing or the use of specialised equipment.

7.1.5 In the case of the incident branch, the cracking in the crotch would have been entirely out of the sight of a ground-based inspector. An additional feature that could, however, have been observed from the ground was a step-like bulge on the outer sides of the bases of some of the branches, including the incident branch (Fig. 7). Any such deviation from a smoothly curved branch junction might in principle have given some cause to have suspected the presence of a stress notch; i.e., a place where failure could occur owing to a localised concentration of mechanical stress (Mattheck, 1991; Mattheck & Breloer, 1994). On the other hand, as far as I am aware, there is no currently available guidance that specifically indicates whether bulges of this kind are recognised as being associated with failure. I consider, therefore, that there were no signs by which an inspector could reasonably have concluded that the branch was more likely to fail than most other branches of old beech trees.

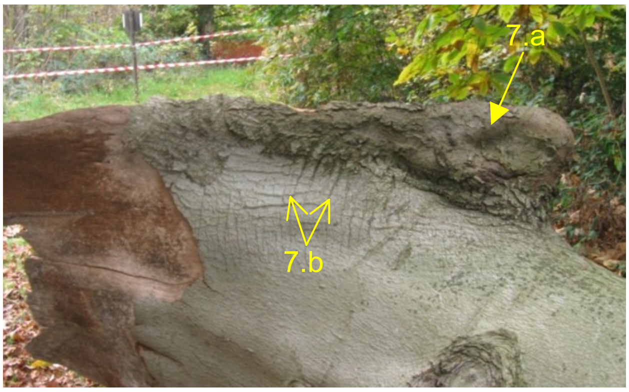

Fig. 7. The incident branch, showing the step-like bulge (7.a), which is inrolled near the crotch. The stem also shows the bulge (Fig. 6.b). See text re. "7.b"

7.1.6 The possible presence of decay would have been another consideration for an inspector, since it is certain to have developed at least superficially in association with a large wound that, according to Mr. Zealand, was created by the shedding of a major branch in 1987. Some decay is evident from the colour and texture of the surface of the exposed wood but decay visible at the surface is not necessarily internally extensive. For anatomical reasons (Lonsdale, 1999), decay associated with broken branches tends to develop downwards rather than upwards. In this instance, however, the possibility of upward development could not have been ruled out, since the failure of 1987 exposed a zone of wood that belonged anatomically to the main stem above the wound. No evidence of such development is, however apparent from the external appearance of the exposed, decaying wood. There would not, therefore, have been a *prima facie* cause for serious concern that the decay might have developed upwards so as to weaken the attachment of the branch now in question. It is now evident that this had not occurred, since decay was not present in the wood exposed by the branch failure in June 2007.

7.2 Knowledge of previous failures of the tree

7.2.1 By understanding the manner in which a tree has undergone failure, an inspector can sometimes recognise signs of potential failure of a similar type in the same tree or in others nearby. He or she should be aware of such signs during the regular inspection of trees that might pose a significant risk of harm to people or property.

Fig. 8. Branch C, which was observed to have fallen prior to the incident. The area marked by arrows shows a roll of bark and wood, which had evidently been forming in a crack that had occurred in the fork between this branch and an adjacent branch.

7.2.2 In the case of the incident tree, it was evident that a major branch had parted from the main stem many years previously. That event, according to Mr Zealand, occurred in the very extreme conditions of the Great Gale of October 1987 and can therefore be dismissed as indicating any inherent weakness in the tree. Additionally, however, Richard Daplyn (Daplyn, 2011) recalls that a limb ('branch C') had fallen between two and three years before the incident. At that time, the locality was included in the 'low risk' zone of the estate, and so there was no requirement to inspect the tree or to record any failure of its branches. During my inspection on 26 October 2007, Mr Daplyn's recollection was that branch C had failed distal to its place of attachment (i.e., unlike the incident branch). Later, in order to help ascertain whether this had been the case, he extricated branch C from surrounding undergrowth and sent me a series of photographs of its fracture-surface (taken on 10 and 11 August 2010). He also sent me photographs of a scar on the tree, which is evidently the matching fracture-surface.

7.2.3 Mr Daplyn's photograph in Fig. 8 indicates that branch C failed at its place of attachment. His photographs of the scar on the tree show that it was one of a pair of branches, which had been growing from a forked parent branch (Fig. 9). The other member of the pair remains attached. Figure 8 shows also that a roll of new wood and bark (occluding tissues) had formed in the angle between the pair of branches. The presence and position of these tissues indicate that a crack had been present. The branch can be regarded as having been weakly attached before it eventually fell, by virtue of the evident presence of the crack, together with the rolls of occluding tissues, which might have been forcing the crack open to some extent.

7.2.4 It is necessary to consider whether the failure and the manner of failure of Branch C should have been interpreted as a sign that other branches of the tree were attached so weakly as to have been likely to fall. It would have been reasonable to have taken this possibility into account, following the failure of a branch that had evidently been weakly attached.

7.2.5 The failure of branch C was not, in my opinion, a clear indication of a 'warning sign' at the time of the inspection in January 2007. I take this view partly because no other branch of the tree had apparently failed at its place of attachment, except under the exceptional conditions of the Great Gale of 1987. Also, branch C had particular characteristics that probably contributed to weakness and that were not typical of other branches on the tree. Unlike the incident branch, branch C was a secondary branch (i.e. it arose from a parent branch rather than from a primary stem). Furthermore, it was borne at a fork, as one of a pair of branches. Finally, whereas its parent branch is almost horizontal (Fig. 9), branch C appears to have been growing at an angle of approximately 20 degrees from the vertical and thus to have been liable to fail when subjected to rotational movements in a strong wind (Mattheck and Breloer, 1994). Although, from a biomechanical standpoint, branch C can be regarded as not having been typical of other branches on the tree. I consider that its failure raises the question of whether the tree should in future have been inspected with extra vigilance.

Fig. 9. The scar, high in the crown of the tree, that is believed to have been left by the failure of branch C

7.2.6 The need or otherwise for extra vigilance following a previous failure depends very much on the probability of a target being present. At one extreme (e.g. where a branch with a putatively weak attachment is overhanging a main road in a city centre), it might be appropriate to undertake an aerial inspection in order to find whether a crack has developed in the crotch. At the other extreme (e.g. far from any rights of way or buildings), the shedding of a branch, even if weakly attached, would not warrant any attention with regard to the mechanical integrity of other branches on the same tree.

7.2.7 In this instance, where the tree was adjacent to a footpath with relatively light user-occupancy, I consider that it was reasonable to have ensured that the tree was inspected regularly after its inclusion in the medium-risk zone and to have taken a customary degree of care to look for large branches with clearly weak attachments. As stated in para. 7.1.4 above, a branch attachment cannot generally be assessed as being clearly weak merely on the basis of its shape. In my opinion, it is reasonable to make such an assessment only if additional evidence is apparent during a general ground-based inspection.

8. Consideration of possible actions arising from a ground-based inspection on 2 January 2007

8.1 Principles by which a need for action should be determined

8.1.1 Any tree could be regarded as potentially hazardous, but not all trees are so hazardous or so close to people and property as to warrant detailed inspection and/or remedial action. Thus, hazard and risk need to be assessed in order to determine whether some form of action is required. On the Trust's properties, the assessment of hazard (the potential of a tree to cause harm) is the duty of inspectors. The assessment of risk (the probability of actual harm being caused by the tree) is the duty of the Property Manager (Anon., 1997, 2007).

8.1.2 Since any part of a tree could fail, depending on the physical conditions, it would clearly be impracticable to undertake a detailed investigation of every part of every tree. The widely accepted principle is to use a ground-based visual inspection to identify any parts of a tree that warrant such investigation or remedial action. The inspector needs, therefore, to gain a general idea of the magnitude of the potential hazard (usually on the basis of 'impact potential', as determined by the size of the tree or branch) and of the probability of failure. To assess the latter factor more rigorously would often require further investigation, but the visual inspection is usually sufficient to indicate whether such investigation is warranted.

8.2 Actions warranting consideration in respect of the incident tree

8.2.1 The visual ground-based inspection of the incident tree on 2 January 2007 would have revealed nothing more significant than the presence of branch attachments that were likely to have contained bark inclusions or cup-shaped crotches. As noted in para. 7.1.4, such formations are very frequent and should not be considered as likely to fail unless there is some sign of an additional hazard-factor or of partial failure having already occurred. Following the incident of 26 June 2007, it became possible to see that partial failure had occurred prior to the inspection in January, at which time it would have been concealed from the view of a ground-based inspector. In the light of retrospective knowledge that the incident branch was weakly attached, the previous failure of branch C and the subsequent failure of branch B could be regarded as evidence that the tree has a tendency, perhaps more than other beech trees of a similar age, to shed branches. Nevertheless, for the reasons stated in para. 7.2.5, I do not consider that any such evidence was clearly apparent at the time of the inspection in January 2007. My opinion is therefore that the visual inspection, even with knowledge of the previous failure, could not have revealed a need to undertake any detailed investigation or remedial action.

8.2.2 With regard to the action that was taken, the tree inspection records[3,4] indicate that Mary Ghullam and Richard Daplyn inspected the trees in the area concerned but did not observe any features of the incident tree that warranted the recording of a potential hazard (Ghullam, 2011). Given that the inspection system was based on

[3] supporting document: diary page of Mary Ghullam, containing an entry dated 2nd January 2007
[4] supporting document: Tree Work Proposal form, containing an entry made by Mary Ghullam and Richard Daplyn and dated 2nd January 2007

‘negative reporting’ and, given also that I consider such a system to be satisfactory (see para. 10.3.1.1, below), I conclude that it was reasonable not to have kept a specific record of the incident tree.

8.3 Risk assessment as a retrospective test of the need for further action

8.3.1 There is in my opinion no need to use formal risk assessment during general tree inspections. Inspectors should, however, understand the underlying principles sufficiently to be able to identify any trees that clearly warrant further attention. Also, tree risk assessment can be used retrospectively in order to help determine whether a previous general inspection has been appropriately conducted. On the basis of the visual evidence available on 2 January 2007, a retrospective assessment of the incident branch is presented in the following paragraphs, by multiplying numerical values for the three risk factors (A), (B) and (C) listed below[5]. General information about the estimation of each of the three values, both in QTRA© and in a modified version that can be alternatively applied[5], is given in Appendix 4.

8.3.2 Of the three risk factors, the probability of failure (Factor B) inherently involves a considerable degree of subjectivity in its assessment. It is therefore realistic, at least in the first instance, to refer to the five value-ranges that are defined in QTRA© and to decide which of them is appropriate, rather to attempt to estimate an exact probability, which might lend a false sense of accuracy.

8.3.3 The three risk factors can be defined as follows;

A: IMPACT POTENTIAL: the potential severity of impact, based on the size of the tree or part thereof. The QTRA© calculations (Anon., 2010) are based on the assumption that the odds of a fatal outcome occurring are 1 in 1 if the diameter of the tree or branch is 600 mm or more. For smaller-diameter parts, the probability is expressed as a fraction of the 1 in 1 odds, according to their weight, as estimated by the formulae provided by Tritton & Hornbeck (1982).

B: PROBABILITY OF FAILURE. The quantification of this risk factor is inherently more subjective than that of the other two factors. There is, however, a need to quantify each of the factors in order to assess risk by a probabilistic method. Although the use of a structured and reproducible method does not eliminate subjectivity, it makes use of the best available estimates and can therefore be preferred to an ‘unstructured’ exercise of personal judgement.

C: TARGET VALUE: as far as human targets are concerned, this is the probability of a person being within the impact zone[6]. This can be estimated on the basis of site-specific survey data, such as a traffic census on a road or path next to the tree

[5] In the opinion of the author of the present report, there are instances where a re-definition of the three risk factors in QTRA© would be appropriate. QTRA© Factor (A), Impact-potential, is based on the size of the tree or part thereof, but it does not always represent the likely severity of impact. Factor (B), Probability of failure, is straightforward, albeit inherently subjective in its assessment. Factor (C), Target value, incorporates a formula for including property as well as human life in the estimation of the probability of harm, but it might be more logical to re-configure factors (A) and (C) so that A is the potential outcome of impact (i.e. degree of harm) and (C) is simply the probability of the target being present. In the case under consideration, use of this modified approach would, however, not affect the calculation of the risk index, since the outcome of impact is simply related to the weight of the incident branch and the probability of a person being present.

[6] This factor is called “target value” in QTRA (rather than “occupancy”), because it includes an estimate of the risk of damage to property, which is valued in proportion to the notional pecuniary cost of a human life.

concerned. Failing that, estimation can be based on data obtained within a wider area around the tree or on national average data for the category of area (e.g. class of public highway) concerned (Anon., 2010). In QTRA©, the numerical value assigned to this risk factor is based on the "value of statistical life", which is currently up to £1 million (Ellison, 2005)[7].

8.3.4 Evaluation of the risk factors for the incident tree

Factor (A): Size of the tree or part of tree

8.3.4.1 According to the principles of QTRA© (Ellison, 2005), the impact-potential of a tree or, in this case, a branch is expressed as the probability of a fatal outcome in the event of impact with a person. In this instance the branch diameter is 497 mm (just beyond the basal flare) and therefore fits into the QTRA **Size Range 1 (>450 mm)**, for which the odds of a fatal impact are **1 in 1**. For greater accuracy, the narrower QTRA© size range **of 450 to 500 mm** applies, for which the fractional probability is **1 in 1.56**. In principle the odds could be adjusted to take account of other factors, such as the height of potential fall. In this instance, the height of fall was considerable: 11 metres (as estimated with a clinometer on 26 October 2007), together with the length of the branch, and so the odds of **1 in 1** (approximated range) or **1 in 1.56** (more exact) seem appropriate. The potential failure of this branch would have been the only factor to include in the assessment, since the tree would not have shown any other features of greater potential significance for safety (Ellison, 2005).

Factor (B): Probability of failure of the incident branch

8.3.4.2 The present report addresses the probability of branch failure, as could reasonably have been assessed prior to the incident. If I had been required to assess the probability of failure of the incident branch, having undertaken a visual ground-based inspection, I would have assessed this as somewhat higher than QTRA© 'Range 3' (i.e. 1 in 1,000) but considerably lower than QTRA© 'Range 2' (1 in 100). On that basis, I would have selected **Range 3**. In case of any need to attempt a more exact, albeit still subjective, assessment, I would have applied odds of **1 in 600** (= **0.0016667**), using my personal judgement.

Factor (C): Target value (presence of people and property in the <u>target zone)</u>

8.3.4.3 In estimating the occupancy of the target zone by people, it is necessary to define the target zone. For the tree in question, the target zone can be taken to comprise the portion of the footpath that lies beneath the branches of the tree. If whole-tree failure were being considered, the entire potential radius of fall of the tree would be the target zone. There were, however, no visible defects in the main stem or <u>buttress zone</u>.

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[7] For clarification, it should be noted that estimation of the probability of a fatality does not necessarily reflect the amount of insurance that might be considered appropriate. The possibility of serious but non-fatal injury should be considered in relation to potential compensation claims, since such an injury can be very traumatic for those concerned and can be far more costly than a fatality.

8.3.4.4 For use of the footpath, an estimate of fourteen users per day, averaged over an entire year (day and night) is applied here, on the basis of Mr Daplyn's estimate (Daplyn, 2011). Using typical data for the walking pace of a pedestrian and for the width of an impact zone (Ellison, 2005), the estimate of fourteen persons per day can be converted into a probability of human occupation of the impact zone. On this basis, a frequency of fourteen pedestrians per day lies within QTRA© **Range 4** (up to 24 persons per day). For a more exact calculation, an occupancy of 14 persons per day equates to a probability of occupancy of **0.00081** (approx. 1 in 1,234).

8.3.5 Calculation of risk of a fatality involving the incident branch

8.3.5.1 Using QTRA© Ranges 1, 3 and 4 for risk factors A, B and C respectively, the risk of a fatality in one year would have been estimated as **1 in 720,000**. In other words, if there were 720,000 trees in a similar condition and situation, one of them could be expected, on average, to cause a fatality during twelve months.

8.3.5.2 Odds of 1 in 720,000 would normally indicate that no need for remedial action is required, since the threshold for requiring action is normally set at 1 in 10,000, which is widely regarded as the maximum limit of tolerability in relation to everyday risks (Anon., 1989; 2001; Ellison, 2005). Under the "Tolerability of Risk Framework" (TOR) (Anon., 2001), there is, however, also a lower threshold of 1 in 1,000,000. Between the upper and lower thresholds, the risk should be kept "As Low As Reasonably Practicable" (ALARP). If the lower threshold is exceeded, there is deemed to be a need to balance risk against benefit in order to decide whether action is appropriate. In this instance, the odds would have been much closer to the lower threshold than to the upper. Also the tree was obviously of high value with regard to amenity, biodiversity and other attributes. There would therefore, in my opinion, have been no need to take remedial action, when invoking the "TOR" framework.

8.3.5.3 Since the lower TOR threshold would have been exceeded on the basis of using the QTRA© value-ranges, it is of some relevance to re-calculate the risk index using more 'exact' estimates of the three risk factors, while remaining aware of the inherent subjectivity in assessing the probability of failure.

8.3.5.4 As stated above, my more 'exact' estimates of factors A, B and C would have been as follows: **1 in 1.56** (= 0.64103), **1 in 600** (= 0.0016667) and **1 in 1,234** (= 0.00081). The product of these values is 0.00000087 which is equal to odds of **1 in 1,155,291** which, for purposes of accuracy, can be rounded to **1 in 1 million**. On this basis, there would have been no need to invoke the lower TOR threshold.

8.3.5.5 Since, in reality, the branch had already begun to fail, albeit without showing signs that could have been seen from the ground, the probability of failure was far higher than could reasonably have been assessed. If undertaking a risk assessment on this basis, I would have subjectively assessed the probability of failure as being considerably higher than 1 in 100 (QTRA© Range 2) but somewhat lower than 1 in 1 (QTRA© Range 1). I would therefore have selected Range 1 for my assessment.

8.3.5.6 If QTRA© Range 1 had been applied in respect of the probability of failure, together with Ranges 1 and 4 for the other two factors, the risk index would have been **1 in 720**, in which case remedial action would have been appropriate. Since however, Range 1 would have represented a higher probability than my assessment, I would have considered the 'exact' calculation method for comparison, while again bearing in mind the high degree of inherent subjectivity. On this basis, I would have applied an estimated probability of failure of **1 in 10** (= 0.1), together with the same 'exact values' for factors A and C as in paras. 8.3.4.1 and 8.3.4.4). The risk index would then have been 0.000052 (= 1 in 19,316), rounded to **1 in 19,000**). On this basis, even with the benefit of hindsight regarding the true condition of the branch attachment, remedial action would not necessarily have been appropriate unless, by invoking the lower TOR threshold of 1 in 1,000,000, the value of the tree had been deemed relatively low in relation to the risk.

8.3.6 Allowance for uncertainty about the exact usage of the footpath

8.3.6.1 The risk indices, as calculated above, are low because of the low estimated average daily number of pedestrian movements through the target zone. Since this usage is estimated and not measured, there could be reason to ask whether the true value, and therefore the risk, might have been higher. However, the risk index calculated above (i.e. 1 in 1 million is 100 times less than the 'intolerable' threshold of 1 in 10,000. In order to exceed this threshold, a daily average of approximately 1,623 pedestrian movements through the target zone (i.e. approx 68 per hour) would have been required. (See para. 8.3.5.2 for further information about thresholds of risk.)

8.3.7 Variations in the intensity or pattern of site usage

8.3.7.1 The incident occurred when ten schoolchildren and their teacher had been near the tree. According to Mr Daplyn's estimate of occupancy of the target zone, just over one person had been walking past the tree in two hours, as averaged over 24 hours (Daplyn, 2011). The Trust's guidance document current at the time of the inspection (Anon., 1997) stated that the risk status of an area would change during an event involving many people. Similar guidance is given in the latest version of the guidance (Anon., 2007). On the other hand, QTRA© is conducted according to the principle that risk should always be assessed over the entire period being considered (usually one year), even if occupancy varies considerably during this period (Ellison, 2005).

8.3.7.2 If it is intended to make a quantitative assessment of tree-related risk for the duration of a planned event, this could in principle be done by use of QTRA© or a similar probabilistic method, provided that the actual period of time is substituted for the customary twelve months in the calculation. Ellison (2005) does not, however, suggest that a special risk assessment is necessary in such circumstances. Also, if above-average usage occurs because of informal activity of site users, such an assessment would not in any case be feasible.

8.3.7.3 Aside from any considerations of the need or otherwise for special inspections before special events, it would normally be considered prudent to avoid creating 'static targets' at such times; for example as could happen as a result of establishing a meeting point or erecting a marquee underneath a large old tree. In this instance, the Trust does not appear to have contributed to the creation of any static target.

8.4 Retrospective risk assessment using a different method

8.4.1 The risk factors that are defined in QTRA© can to some extent be defined differently, as summarised in the footnote to para. 8.3.1. Owing to the nature of the hazard in this instance, however, the resulting index would then be exactly the same as if it had been calculated according to QTRA©.

8.4.2 Although there is scope for applying different definitions of the risk factors, there is essentially no scope for altering the underlying method, without deviating from a strictly probabilistic approach. There is, however, a system, known by the acronym THREATS©, devised by Forbes-Laird (2010), in which the three risk factors are similar to those defined in QTRA©. The key differences concern the numerical values of the three factors. These values, unlike those in QTRA©, are not continuously variable; instead each factor must be scored according to one of several pre-set values. The numerical value of each variable is based on an undisclosed algorithm (Forbes-Laird, *op. cit.*). Another key difference is that the probability ('likelihood') of failure is based on the time estimated to elapse before failure; i.e. it is not the estimated probability of failure within a fixed time.

8.4.3 The three risk factors defined in THREATS© (listing them in the same order as their QTRA© counterparts in Section 8.3) are as follows:

A: IMPACT SCORE: based on diameter as in QTRA©, but also taking account of other factors (as in para 8.3.1 of the present report), such as the potential height of fall of the tree or branch). This score can take any one of the following available values: Very minor = 1; Minor = 4; Moderate = 6; Severe = 10.

B: LIKELIHOOD OF FAILURE: the degree to which failure is likely to occur over an indefinite timescale. This factor is fundamentally different to the probability of failure occurring within one year, but the mathematical relationship is arguably similar (e.g. "imminent" failure equates to a very high probability within a year)[8]. This score can take any of five values as follows: None apparent = 0; Potentially with time = 0.8; Likely, foreseeable = 2; Probable/Soon = 8; Imminent/Intermediate = 50.

C: TARGET SCORE: as in QTRA©, based largely on the probability of a person being within the impact zone, explicitly taking account of modifying factors, such as the presence of unsupervised children or the visibility of a tree that has fallen on a road. This score can take any of six values, as follows: None = 0; Very low = 7; Low = 15; Medium = 20; High = 25; Very high = 40.

8.4.3.1 Using the THREATS© system, the three factors could, in my opinion, reasonably be scored for the incident branch as follows:

A: IMPACT SCORE: according to the THREATS© guidance notes (Forbes-Laird, 2010), a branch of 497 mm diameter belongs in the Large (**numerical score = 6**) category. There does not seem to be any reason to adjust the score to a lower category, since the height of fall (11 metres) was quite considerable. Also, there

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[8] One difference between this factor and the "probability of failure" in QTRA© is that the latter is based on an assessment of the relevant part of the tree in its current condition. In THREATS©, the possibility of a change in condition over a number of years is implied.

does not appear to have been much potential for the impact to be cushioned by other branches.

B: LIKELIHOOD OF FAILURE: the THREATS© guidance notes include a list of indicators of possible hazards. Of the indicators listed as follows[9], the following four were, in my opinion, conceivably relevant to the hazard assessment of the incident branch:

- **"Overweight, subsiding, or lion-tailed limbs"**
  - The incident branch was very long and heavy, but it had not shown any downward bending or widening of its angle with the stem and was therefore not subsiding. It had evidently grown within the overall profile of the crown of the tree, as indicated by Mr Daplyn's reconstructive diagram (Daplyn, 2011: Exhibit RD4). Also, there is no evidence that the branch was 'lion-tailed' (a term that describes a branch that is end-loaded because its side-branches and foliage are concentrated near its tip).
- **"Reactive growth"**
  - This term presumably refers to a local increase in the growth of wood, usually visible as a bulging or broadening of a structure. This often compensates for a lack of growth and/or of strength or stiffness in an adjacent part of the structure. The question is whether such compensation is adequate. With regard to the incident branch, this question is addressed in para. 7.1.5, above.
- **"Inclusive bark"**
  - This refers to bark inclusions, which in some instances impair the strength of attachment of branches. With regard to the incident branch, paragraphs 7.1.3 and 7.1.4 (above) address the question as to whether a ground-based inspector could have observed any signs of a bark inclusion and of any associated possible weakness.
- **"Fractured limbs; storm damage"**
  - This mainly refers (1) to branches that, having been damaged, are liable to fall and (2) to the crowns of trees that, having been disrupted, are liable to undergo further failure. Also, it could be taken to refer to the propensity of a tree to fail again in a manner that it has previously shown. In this regard, the previous failures of the incident tree are discussed in Section 7.2, above.

If there had been a reason to assess the "likelihood of failure" of the incident branch by reference to the indicators listed in the THREATS© guidance, the inspector could in my opinion reasonably have decided that "reactive growth" and "inclusive bark" were the most relevant of those indicators. On this basis, the "likelihood of failure" would in my opinion have been placed in the "Likely, foreseeable" category (**numerical value = 2**). A more severe score would have required the presence of a sign of greater concern than any of those that the inspector could have seen. For example, there was no sign commensurate with the THREATS© description of "severe inclusive bark". The signs of included bark (see para. 7.1.3, above, could reasonably have been interpreted as fitting the description of "early inclusive bark", which equates with the more favourable THREATS© category of "Potentially with time" (numerical value = 0.8). On balance, however, I conclude that the "Likely, foreseeable[10]" category (numerical

[9] The words shown here in quotation marks come from the list of indicators tabulated by Forbes-Laird (2010).
[10] Selection of this THREATS© category does not imply that risk of harm was foreseeable in a legal sense.

value= 2) would have been appropriate, taking account (1) of the uncertain significance of the putative "reactive growth" and (2) of the considerable length and weight of the branch.

C: TARGET SCORE: in view of Mr. Daplyn's (Daplyn, 2011) estimate of site usage, the footpath appears to fit the following description in the THREATS© guidance: "Infrequently used access/public right of way/bridleway", which falls into the "Low" category (**numerical value = 15**)

On this basis, the THREATS© "risk sum" (A x B x C) is **180**. THREATS© includes a system for deciding appropriate action for a tree with a given "risk sum". A risk sum of 180 places the tree in a "threat" category of "**slight**". Trees in the "slight" category are said to require re-inspection annually and after storms of Force 10+, with an expectation for work to be scheduled within two years.

If the THREATS© assessment is repeated as if it had been known that the branch attachment was already cracked at the time of the inspection, the Failure score would have probably have been in the "Probable/soon" category (**numerical value = 8**). A more severe score of "Imminent/immediate" would not, in my opinion, have been appropriate, since partially failed branches often persist for a number of years. On this basis, the THREATS "risk sum" becomes **720**, which places the branch in the "**moderate**" "threat" category. For trees in this category, some form of remedial work is said to be appropriate within 13 weeks, together with heightened criteria for the timing of further inspections.

8.5 Remedial action

8.5.1 With regard to the incident tree, it follows from the above analysis of probabilistic risk-based decision-making (Section 8.3) that remedial action could not have been justified on the basis of the evidence that was available, within reason, before the incident.

8.5.2 If the true condition of the branch had been known, my assessment of the risk would still have placed it below the upper threshold of TOR (see para. 8.3.5.2), but the lower threshold would have been considerably exceeded. It would therefore have been necessary to consider some form of action. At Felbrigg, the removal of trees or the closure of paths are the main options for remedial action and they both detract from the many benefits of the site. In this instance, the path concerned is relatively minor and could arguably have been closed if the true condition of the branch had been known, without undue loss of amenity. This has now been done, albeit partly for reasons other than risk assessment alone.

8.5.3 If THREATS© had been used to assess the risk as in Section 8.4 above, the TOR framework could not have been applied, since the THREATS© "Risk sum" is not expressed as a probability. The THREATS© method does, however, include its own guidance for remedial action. As shown in para. 8.4.3.1 above, my assessment using THREATS© would have indicated no need for remedial action on the basis of a ground-based general inspection prior to the incident. Action would, however, have been required on the basis of a THREATS© assessment, taking account of retrospective knowledge of the true condition of the incident branch. Thus, the retrospective use either of a probabilistic method, based on QTRA© or of THREATS© would have led to similar conclusions with regard to remedial action.

9. Foreseeability of failure of the incident branch

9.1 In the context of tree risk assessment, a failure can be regarded as foreseeable if there are any distinctly identifiable factors that are likely to contribute to its occurrence. It is considered reasonable to identify and assess such factors on the basis of whatever degree of investigation is appropriate; with the presumption that a ground-based visual inspection is sufficient unless such an inspection shows the need for a more detailed investigation (Mattheck & Breloer, 1994; Lonsdale, 1999).

9.2 With regard to the incident branch, the question of foreseeability is, in effect, addressed above (see paras. 7.1.3 to 7.1.5), in considering the observations and conclusions that could reasonably have been made during the inspection of 2 January 2007. On this basis, I conclude that the branch did not show any distinct signs of a propensity to fail. Although it showed signs of having a bark inclusion or a cup-shaped zone in the crotch (see 6.2.1), these signs did not indicate that any such feature was extensive enough to contribute to the probability of failure. I have also referred to the presence of a step-like bulge on the outside of the branch union, but I have pointed out that this particular kind of bulge is not among the signs of hazard that are recognised in currently published guidance on hazard recognition (see para. 7.1.5, above).

9.3 A branch (branch C) had been observed to have fallen prior to the inspection of January 2007 (see para. 7.2.2) but it was the only branch known to have failed at its place of attachment to the incident tree since the Great Gale of 1987. It had certain characteristics (paras 7.2.3 and 7.2.5) that evidently contributed to its failure but that were not shared by the incident branch. For these reasons, I do not consider that the failure of branch C should have led an inspector to conclude that the incident branch was likely to fail.

9.4 If, as argued above, there was no reason for a ground-based inspector to conclude that the incident branch showed any distinct defects, there was equally no good reason to investigate it further by means of an aerial inspection. Such an inspection might have revealed the presence of the crack that became evident after the incident (see 6.2.1), but this is not relevant to the question of foreseeability, given that an aerial inspection was, in my view, not justified.

9.5 On the basis of the information that could reasonably have been available from a ground-based visual inspection on 2 January 2007, I consider that the branch failure of 26 June was not foreseeable in the sense defined above in para. 9.1.

10. Appraisal of the method of tree inspection adopted

10.1 Guidance from the Trust

10.1.1 Written guidance from the Trust (Anon., 1997; 2007) explains the need to manage populations of old trees so as to protect people from harm, while also retaining the many benefits that the trees provide. There is therefore a requirement to inspect and, if appropriate, manage trees that are growing in areas where people or property could be at risk. The degree of inspection and management is determined according to a system of zoning of Trust properties, according to site usage (see para. 10.3). Inspectors are required to look for visible defects (Anon., 1997; 2007). Specialised diagnostic techniques may be used if considered necessary on the basis of the visual inspection.

10.2 Ground-based visual inspection

10.2.1 Although there is sometimes a need to climb trees in order to inspect defects or to use diagnostic devices for the assessment of their internal condition, a ground-based visual inspection is usually sufficient to indicate whether such a need exists. The Trust's instruction is that inspectors should look for clear defects; this is consistent with the widely accepted opinion that visual recognition is appropriate. There remains a small possibility that a serious defect might escape detection unless every tree is climbed and internally investigated, but it would clearly be impracticable to do so as a matter of routine. Such a procedure could also harm trees and create hazards for inspectors. Perhaps more importantly, it could lead to an increase in risk if the inspection procedure is so time-consuming that some trees are not inspected at a suitable frequency. Ground-based visual inspection, with the option to undertake more detailed investigation if appropriate, is therefore considered to represent a reasonable and highly effective method (Mattheck & Breloer, 1994; Lonsdale, 1999). At Felbrigg, there appears to be an extra safeguard against defects being overlooked, since the two inspectors are stated to work together on most occasions (Ghullam, 2011).

10.3 Other issues relating to the method of inspection

10.3.1 Zoning of the area where the incident occurred

10.3.1.1 Zoning (Lonsdale, 2000) enables the resources available for inspection and remedial action to be apportioned within an area of land, according to the local intensity of site usage. The number of zones and the relative intensity of usage represented by each zone should be decided in order to optimise the use of resources and will therefore vary according to the circumstances. For example, a city might be allocated more usage zones than a remote rural estate and will probably have one or more usage zones that are more intensively used than the rural estate's highest usage zone.

10.3.1.2 At the time of the inspection of 2 January 2007, the Trust was designating three zones for its properties: high, medium and low, with the added proviso that there was an enhanced frequency of inspection in the high-risk zone for trees with significant defects (Anon., 1997; 2004) and after storms (Anon., 2004).

10.3.1.3 The path next to the incident tree was in the medium-risk zone at Felbrigg, together with some of the other paths on the estate (Doc. B7; Zealand, 2011 – Exhibit KZ3). With reference to the overall spectrum of site usage across the UK, this path can be regarded as having low usage prior to the incident. According to Ellison (2005), constant occupation of a target zone by pedestrians is equivalent to 86,400 pedestrian movements through the zone in 24 hours. Daplyn (2011) has estimated that there had been just over one pedestrian movement in two hours (14 per day) on average through the target zone of the incident tree (i.e. 0.016% of Ellison's (2005) maximum frequency of 86,400).

10.3.1.4 Zealand (2011) has stated that the path in question was transferred from low-risk to medium-risk zone in 2006 to take account of the activities of the Aylmerton Field

Studies Centre, and of the creation of an all-weather pathway through Great Wood. Following this re-zoning, the usage of the path remained low according to Daplyn's (2011) estimate of approx. fourteen users per day on average, but there has not been any assessment as to whether its usage was even lighter beforehand. It might, in my opinion, have been reasonable to have kept the path in the low-risk zone, since this included some of the least-used footpaths, as well as areas that were not close to roads, regularly used paths, buildings or other facilities. By comparison, the high-risk zone at Felbrigg consisted mostly of strips along roads, including the A148 and the B1346 (Zealand, 2011: Exhibit KZ3). In this context, and taking account of the above comparison with the spectrum of site usage across the UK (Ellison, 2005), a medium-risk designation seems more than sufficient.

10.3.1.5 It is of some interest, but not of direct relevance in the present context, that the Trust has issued a new instruction (Anon., 2007), in which five categories of usage zone are defined, with the option to apply three, four or all five zones as deemed appropriate at different properties. The instruction is dated 21 May 2007; i.e. prior to the incident but after the inspection in January of that year. According to the new definitions of zones, areas close to minor roads with low traffic levels or to footpaths with 'low levels of visitor use' should be placed in the 'low usage' zone.

10.3.2 Frequency of inspection

10.3.2.1 There are currently no nationally accepted standards for the frequency of tree inspection. In principle, the frequency should be determined by the potential rate of change in the condition of the trees concerned, together with the usage of the area concerned. On this basis – and as a very rough guide – it is often considered appropriate to inspect large, old trees annually if they are in areas of relatively high usage. Less frequent inspection could therefore be considered sufficient in circumstances where the usage is lower or where the trees are less likely to undergo relatively rapid changes that could render them more hazardous. Additional *ad hoc* inspections are generally regarded as necessary following severe weather events that might have created new hazards.

10.3.2.2 The Trust prescribes frequencies of inspection according to zoning. These instructions were amended in May 2007 (Anon., 2007). At the time of the inspection of January 2007, the prescribed frequency of inspection for trees in a medium-risk zone was at least every two years (Anon., 1997). Prior to 2006, the incident tree was in a low-risk zone, where inspection was not formal but consisted of observation and awareness of trees in the course of normal routine visits (Anon., 1997). In my opinion, these instructions were reasonable according to the current practices of many other organisations. There was, however, room for some refinement of the instructions, as represented by some of the amendments made in May 2007. These include an increased need to inspect trees after storms and provision to vary the inspection frequency according to the age, species and condition of trees.

10.3.2.3 Since defects can become apparent in the intervals between formal inspections, it is very useful for people to be 'on the lookout' for such occurrences in the normal course of their work. Mary Ghullam states that she performs such a role and that she was probably looking at the incident tree on this basis every 4 to 6 weeks (Ghullam, 2011).

10.3.3 Recording of tree inspection data

10.3.3.1 A record of tree inspections is needed in order to demonstrate that they have been done. Depending on the general level of risk, as determined by site usage and the characteristics of the tree population, it may be sufficient to keep individual records only of trees that have required further action such as detailed investigation, monitoring or remedial action. For other trees, a written record that an inspection has taken place is, in my view, sufficient. Such a system (known as 'reporting by exception' or 'negative reporting') has been operating at the Trust's properties (Anon., 1997) and continues to apply, subject to a recent re-designation of categories of trees that require individual recording (Anon., 2007). On this basis, and also taking into account the signs that a competent inspector could have seen, I consider that there was no need to have made an individual record of the tree in question.

10.3.3.2 In July 2006, the practice of reporting by exception was called into question by Mr. John Pollard, the coroner in the inquest of a child (Timothy Sutton) who was killed by a falling tree on the Trust's property at Dunham Massey, Cheshire in 2005 (Doc. F13). The coroner was concerned that, in the absence of a record, a tree might be missed from the inspection or wrongly deemed not to warrant further action. Under the revised policy of May 2007, the Trust stipulated that trees in Usage Zone 1 (very high usage) must be recorded either individually or in definable groups or lines.

10.3.3.3 Mistakes of the kind envisaged by the coroner can be avoided if reporting by exception is implemented with due care. On the other hand, the absence of a record of inspection represents a potential lack of evidence in the event of litigation. In my view, one disadvantage of recording individual trees is that it might allow insufficient time to complete other work essential for risk management.

10.3.4 Competence of the individuals involved in tree risk assessment and management

10.3.4.1 Having had the opportunity to discuss technical matters over several hours with Keith Zealand, the Head Warden, my general impression is that he is very knowledgeable, competent and conscientious. Also, having met Richard Daplyn and Mary Ghullam during my inspection of the tree, I was satisfied that they were familiar with the principles of hazard recognition. Otherwise, I have not questioned the individuals concerned in a manner that would enable me to assess their competence. My comments, below, are therefore based only on the following:

- records of attendance at training courses;
- content of courses;
- statements about experience gained while carrying out inspections;
- statements about other qualifications;
- statements about inspection procedures.

10.3.4.2 The Trust provides a 1-day basic tree safety inspection course and a 4-day advanced course. At the time of the inspection on January 2007, attendance of the 1-day course was a requirement for every staff member or volunteer who does tree safety inspections, together with a reasonable knowledge of trees (Anon., 1997). Attendance of the 4-day course was a requirement for staff managing large or important tree collections or providing advice to other inspectors (Anon., 2004).

The requirements for course attendance were later updated (Anon., 2007), when two levels of competence (Levels 1 and 2) were defined in more detail. A 4-day course was attended by Keith Zealand (Head Warden) in 1989 (Zealand, 2011), and by Richard Daplyn, (one of the two tree safety inspectors), in October 2000 (Daplyn, 2011). One-day courses were attended by Richard Daplyn in December 2004 and by Mary Ghullam (the other tree safety inspector at Felbrigg) at the same time (Daplyn, 2011; Ghullam, 2011).

10.3.4.3 The content of the one-day basic course (Doc. C8) shows that it covered all the principal aspects of hazard recognition in trees. The content of the 4-day advanced course (Doc. C9) is, in my view, a good basis for developing knowledge of the principles of tree risk management. Hazard recognition is not specifically listed in the content of the 4-day course, but is presumably covered under topics such as "Visual Tree Assessment".

10.3.4.4 Although course attendance is very useful, inspectors need also to gain practical experience, in situations where they are able to discuss technical details with others. At Felbrigg, there seems to have been ample opportunity for the development of experience in this way. Keith Zealand has over 30 years' experience of working with trees (Zealand, 2011). Mr Zealand was also involved in implementing the Trust's tree safety inspection system at all the Trust's properties along the North Norfolk coast (Zealand, 2011). Mary Ghullam states that she normally works together with Richard Daplyn (Ghullam, 2011). In principle, I am therefore satisfied that the individuals involved in tree risk management have been aware of the need to develop their skills and have done so.

10.3.4.5 Richard Daplyn and Mary Ghullam have attended seminars and other events related to tree safety (Zealand, 2011; Daplyn, 2011; Ghullam, 2011). Attendance of such events is important in the development of competence, particularly with regard to the nurturing of enthusiasm, the further attainment of knowledge and the need to keep abreast of new thinking and techniques.

10.3.4.6 In my view, formal qualifications are not necessary for hazard recognition but they can be very helpful in the interpretation of signs observed during an inspection. Keith Zealand, Richard Daplyn and Mary Ghullam do not appear to have formal qualifications in forestry or arboriculture but, as noted above, they have attended courses on tree hazard recognition. Also, they have been working with trees for more than 30, 10 and 13 years respectively (Zealand, 2011; Daplyn, 2011; Ghullam, 2011).

10.3.4.7 In their witness statements, Richard Daplyn and Mary Ghullam list some of the signs that they look for when inspecting trees. Their lists are not intended to be exhaustive, but might provide some indication of their level of awareness of signs that could be important. In this context, Richard Daplyn includes 'conformation' among the features of a tree to be observed (Daplyn, 2011). This indicates that he looks for signs that the biomechanical development of a tree might not be optimal. The formation of weak branch attachments falls within this general category. Mary Ghullam does not refer to conformation or to 'body language', but she mentions important features such as cracks (Ghullam, 2011). The witness statements of both these inspectors indicate that they were also aware of the need to take account of past failures (Daplyn, 2011; Ghullam, 2011).

10.3.4.8 Overall, the available evidence does not give any reason to doubt the competence of the individuals who have responsibility for inspecting trees at Felbrigg.

10.3.5 Budget for inspection

10.3.5.1 The Trust's Regional Director (Griffiths, 2011) has stated that, under the budgeting process operated by the Trust, the costs of work connected with trees are covered according to estimates, which each property manager submits for approval. He is not aware of any tree work having being prevented by budgetary restrictions.

11. Conclusions

11.1 Prior to the incident, the branch that fell would have shown signs indicating a need to consider whether it was weakly attached. Due consideration would not, however, have led to any particular concern, given the information available from a ground-based inspection.

11.2 The tree had shown obvious signs of having previously shed a large branch, but this event had happened only under the exceptional conditions of the 'Great Gale' of 1987 and did not therefore indicate that the tree had any particular propensity to shed branches.

11.3 The tree had more recently shed a smaller branch, the remains of which show that it had been weakly attached in the crown. Recording of this failure had, however, not been appropriate, since it had occurred when the locality was designated as not requiring formal tree inspections. Also the biomechanical characteristics of the branch concerned were not typical of the other branches on the tree.

11.4 By taking account of previous failures and by conducting a ground-based visual inspection on 2 January 2007, a competent inspector could have reasonably concluded that the tree did not then show any signs that warranted more detailed attention, with regard to inspection, assessment or other action.

11.5 For the purposes of a retrospective risk assessment, based on the information available on 2 January 2007, it is in my opinion reasonable to estimate that there would have been a 1 in 600 probability of the incident branch falling on to the adjacent footpath during one year.

11.6 Taking account of the estimated probability of failure as stated in 11.5, the size of the branch (i.e. large) and the usage of the footpath (i.e. low on a universal scale of usage), the risk of harm to a user of the path could have been assessed as not exceeding the usual upper threshold of tolerable risk of 1 in 10,000). On the same basis, this threshold would have been exceeded only if there had been at least 1,623 pedestrian movements daily on average.

11.7 The site does not appear to have been managed so as to attract people to linger under the tree; if there had been such a pattern of site usage, the presence of 'static targets' could have led to an increased risk.

11.8 On the basis of the risk assessment that could reasonably have been made prior to the incident (as cited in conclusions 11.5 and 11.6 above), there was no need to have recommended remedial action. Equally, if the Trust's term 'negligible hazard' (Anon., 1997) is interpreted as 'negligible risk', there would have been no need to have recorded the condition of the tree according to the Trust's inspection procedures.

11.9 In reality, the branch had a far higher probability of failure (estimated in retrospect as having been approx. 1 in 10), since it had already begun to fail before the incident. An inspector could not reasonably have known about the partial failure, since no sign of it could have been seen from ground-level. Signs might have been seen from above, i.e. during a climbing inspection, but such an inspection is not generally considered necessary except so as to assess a potentially serious defect that is suspected on the basis of inspection from ground-level.

11.10 Although the true probability of failure was far higher than could reasonably have been estimated before the incident (i.e. approx. 1 in 10, as estimated in para. 8.3.5.6 above), the corresponding risk of harm would still have been below the usual upper threshold of tolerability (and hence of necessary action), assuming that there was an average of only 14 pedestrian movements daily. An average of 28 movements daily would have been required in order for this threshold to have been exceeded.

11.11 The above conclusions refer to the upper threshold of tolerable risk of harm (usually 1 in 10,000), above which remedial action is generally regarded as necessary. As assessed prior to the incident, the risk posed by the tree would not have exceeded the lower threshold (1 in 1,000,000), above which there is a need to assess whether it is reasonably practicable to mitigate risk. If the true condition of the branch could have been taken into account, some form of action (e.g. closure of the adjacent path) could reasonably have been taken.

11.12 The system for tree inspections was in my view reasonable with regard to (a) the use of ground-based visual observation, (b) the use of a system of 'reporting by exception' or 'negative reporting', (c) the frequency of inspection and (d) the zoning of the estate to apportion resources according to site usage.

11.13 The available evidence indicates that the individuals engaged in the various aspects of tree risk management on the estate were competent to do the work required.

DECLARATION

I, David Lonsdale, declare that:

I understand that my duty is to help the Court on the matters within my expertise and that this duty overrides any obligation to the person from whom I have received instructions or by whom I am paid. In order to fulfil my duty I have complied with, and will continue to comply with, the following requirements: (1) to provide objective, unbiased opinion on matters within my expertise, (2) not to assume the role of an advocate, (3) to consider all material facts, including those which might detract from my opinion, (4) to make it clear when a question or issue falls outside my expertise or when I am not able to reach a definite opinion and (5) to communicate to all the parties without delay any change of view on any material matter that I might reach after producing a report.

Signed and dated

....	....
David Lonsdale	4th April 2011

STATEMENT OF TRUTH

I confirm that I have made clear which facts and matters in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Signed and dated

....	....
David Lonsdale	4th April 2011

12. References

12.1 Publications

Adams, J. (2007). Dangerous trees? *Arboricultural Journal* **30**, 95-103.
Anon. (1989). *Quantified risk assessment: its input to decision making*. Health and Safety Executive, HSE Books, Sudbury, UK.
Anon. (1997). *Trees and Woodlands Instruction 1*. The National Trust (England, Scotland and Northern Ireland). (reprinted 2001). [Item A1 in the List of Documents]
Anon. (2001). *Framework for the tolerability of risk*. Health and Safety Executive, HSE Books, Sudbury, UK.
Anon. (2004). *Trees and Woods – Tree Safety Management* (revised version). The National Trust (England, Scotland and Northern Ireland). [Item A2 in the List of Documents]
Anon. (2005). *Quantified Tree Risk Assessment: user manual, version 09-05*. Quantified Tree Risk Assessment Ltd.
Anon. (2007). *Health and Safety Instruction No.11 and explanatory guidance: Tree Safety Management*. The National Trust (England, Scotland and Northern Ireland). [Item A3 in the List of Documents]
Anon. (2010). *Quantified Tree Risk Assessment Practice Note*, Version3.1(UK)08-10. Quantified Tree Risk Assessment Ltd., Macclesfield, UK.
Davis C., Fay, N. & Mynors, C. (2000). *Veteran Trees: a Guide to Risk and Responsibility*. English Nature, Peterborough, 7pp.
Ellison, M.J. (2005). Quantified tree risk assessment, used in the management of amenity trees. *Journal of Arboriculture* **31**, 57-65.
Forbes-Laird, J. (2010). *Tree Hazard: Risk Evaluation and Treatment System, a method for identifying, recording & managing hazards from trees: Guidance note for users*. Bedford, UK.
Lonsdale, D. (1999). *Principles of tree hazard assessment and management*. Research for Amenity Trees No. 7, The Stationery Office, London, 388 pp.
Lonsdale, D. (2000). *Hazards from trees: a general guide*. Forestry Commission Practice Guide, Forestry Commission, Edinburgh. 28 pp.
Mattheck, C. (1991). *Trees. The Mechanical Design*. Springer-Verlag, Germany, 121 pp.
Mattheck, C. & Breloer, H. (1994). *The Body Language of Trees: A handbook for failure analysis* (Research for Amenity Trees 4), HMSO, London, 240 pp.
Shigo, A.L. (1985). How tree branches are attached to trunks. *Canadian Journal of Botany* **63,** 1391-1401.
Tritton, L. M. and Hornbeck, J. W. (1982). *Biomass Equations for Major Tree Species*. General Technical Report NE69. United States Department of Agriculture.

12.2 Cited items other than publications

Clarke, C. (undated). Police witness statement
Daplyn, R. (2011). Witness Statement
Doc. B7 Letter from Keith Zealand to Weightmans LLP, dated 19 December 2008.
Doc. C8 Overview of 1-day basic Tree Inspection Course, with copies of all Powerpoint© slides used in the course
Doc. D10 Photographs taken by Norfolk Constabulary (undated)
Doc. F9: Programme for 4-day National Trust Tree Inspection Course at Fountains Abbey (also presented as Exhibit KZ2)
Doc. F13: Letter from J.S. Pollard, H.M. Coroner, dated 20 July 2006, to the National Trust.
Ghullam, M.P. (2011). Witness Statement
Griffiths, P. (2011). Witness Statement
Zealand, K. (2011). Witness Statement

Appendix 1 Comments on the Particulars of Claim

The following comments are provided by the author of the above report, David Lonsdale. As indicated by the headings below, these comments concern paragraphs 3 to 7 inclusive of the Particulars of Claim ('the Particulars'), Claim No. HQ10X1869, issued by Ellisons Solicitors, Colchester Essex (ref. 13JP/MUL13-1), dated 20th July 2010. Verbatim quotations from the Particulars are italicised and enclosed in double quotation marks.

Paragraph 3. This summarises the scene of the incident. The description is, as far as I know, correct.

Paragraph 4. The estimated age of the tree is stated here to be 160 years and is probably no less valid than the estimate of 180 years in my report, above. Also, the location of the tree is described in relation to seven other beech trees and to a junction of three footpaths.

The area around the tree is described as "*an obvious focal point*", by virtue of a "*natural glade*" at the confluence of the footpaths, together with a "*den*" in a nearby Sweet chestnut tree. There appears, therefore, to be an assertion that, people had been frequenting the area so much that the risk of harm from tree failure was significantly greater than elsewhere in the surrounding woodland.

Having visited the site in October 2007 and August 2010, I consider that the "*natural glade*" is an arguably nondescript small clearing that was created by the felling of a few trees. The "den" consists of a sparse group of sticks and is rudimentary, compared with many other dens that can be found in woodlands throughout Britain. I consider that children occupy dens when they build them and then seldom, if ever, return. I am therefore not aware of any evidence that either the glade or the den had been attracting visitors to the potential impact zone.

The key factor with regard to site usage is the average annual number of people who were passing through the potential zone of impact at the time of the tree inspection in January 2007. This number has been estimated by Mr Daplyn, taking account of all available statistics (Daplyn, 2011).

Paragraph 5. This states the dimensions and other characteristics of the incident branch.

When I inspected the branch on 26 October, I measured its diameter which, for the purposes of tree risk assessment, is the indicator of impact-potential (see para. 8.3.4.1, of my report above). Its length is stated, in the Particulars, to be 21.7 metres. I have no reason to doubt this, but I have commented below on the related allegation (in para. 7c of the Particulars) that the branch had "*extended well beyond the mean profile of the tree's crown*".

The stated details of the branch include its former height of attachment and the length and breadth of the fracture-surface. The height of attachment, as stated in the Particulars (i.e. 9 metres), is approximately correct. My own estimate, using a clinometer, was 11 metres, but I understand that a height of 9.4 metres has subsequently been confirmed by an employee of the Defendant. The height of attachment is significant, partly because of its influence on the severity of impact and also because of its relevance to the assertion (in para. 7c of the Particulars) that the branch had been projecting beyond the general profile of the canopy.

It is important to consider the assertion that "*Evidence of this weakness of the union would have been visible from ground level*". I agree that certain signs of possible weakness were visible from the ground but I disagree that those signs constituted any clear evidence of weakness. In particular, in para. 6.2.1.1 of my report, above, I refer to the cup-shaped formation of the crotch, which is a very frequent type of formation in beech and other trees. In my opinion, such formations fail only in a small minority of instances and cannot be regarded as diagnostic of weakness unless certain other signs are also present. In discussing such other signs (see para. 7.1.5 of my report, above), I refer to a "step-like bulge" at the junction of the incident branch with the parent stem. I think that this is the same as the "*pronounced adaptive growth flares*" described in the Particulars of Claim, and I therefore agree that an inspector should have noticed that the branch junction was bulging. I also agree that the bulge or flare would have been visible for a number of years, but I think that its earlier appearance has little relevance to the inspection of a tree that had not been designated as requiring formal inspection until 2006.

With regard to the significance, if any of the bulge, I have pointed out in para. 7.1.5 of my report, above, that there might be theoretical reasons for suspecting that bulges at branch junctions are associated with weakness. I have, however, explained there was no published guidance by which this particular bulge could reasonably have been recognised as anything more than an indication of a need to look for other signs in order to conclude whether the branch was likely to be weakly attached.

In my opinion, the crack in the crotch of the incident branch was the only feature by which a weak attachment could clearly have been recognised. Since this crack was not visible from the ground, the cup-shaped crotch and the bulge were the only signs that could have been observed during a ground-based inspection. I can therefore see no good reason to have undertaken a climbing inspection or remedial action (e.g. tree work or path closure).

Paragraph 6. This refers to the tree inspection regime at Felbrigg.

I agree that, according to the Defendant's records, the path next to the incident tree was categorised in the medium-risk zone at the time of the inspection in January 2007. It had, however, been categorised in the low-risk zone until 2006. In this context, I confirm that the guidance in "*The Inspection of Trees, Instruction 1*" is correctly quoted. I have, however, commented in para. 10.3.1.3 of my report, above, that, on the basis of Mr. Daplyn's estimation, the path in question can be regarded as having low usage with reference to the overall spectrum of site usage across the UK.

Paragraph 7.

General: For the reasons set out below, I do not agree with the general statement that "*The accident was caused by the negligence and/or the breach of the common duty of care under the Occupiers Liability Act of the Defendant, its agents or employees*".

7a: It is asserted that there was a failure to inspect the tree adequately.
I do not agree with the assertion that there was a failure to observe that the incident branch was weakly attached. My reasons for disagreeing are as follows: (1) I consider that the ground-based visual inspection was all that was reasonably required; (2) there is no evidence that the inspection was incompetently undertaken and (3) such signs of

possible weakness that could have been seen did not indicate a need for a more detailed inspection.

7b: It is alleged that there was a failure to "*appreciate the significance of and risks posed by the defects apparent on a visual inspection of the tree, which should have led a competent inspector to undertake further detailed inspection and remedial action*".

This allegation pre-supposes that a ground-based inspection could have revealed significant defects. To the best of my knowledge, there is a lack of experimental or statistical survey data that might show whether an increased probability of failure could be associated with structural features of the kind that were visible from a ground-based inspection of the branch in January 2007. Features such as these can be observed in many mature or post-mature beech trees and, in my opinion, are associated with failure only in a small minority of instances.

I consider that, according to currently available guidance, weakness in a branch attachment cannot usually be diagnosed unless there is either a sign of cracking or a combination of certain other signs (e.g. bark inclusions together with downward bending of the branch near its base). Signs that merely indicate the possibility of some degree of weakness do not, in my opinion, merit the costs and personal risks of actions such as climbing inspections and/or remedial tree work unless the underlying risk is high, owing to intensive site usage. In this instance, however, the site usage, as represented by the estimated the frequency of people using the adjacent path, was low.

Paragraph 7: Facts and particulars, in support of the allegations at 7(a) and 7(b)

First item: This concerns the tree's history of branch shedding "*going back over 25 years*".

I agree that there is a "*massive wound on the tree trunk*", which occurred when a branch failed, reportedly (see para. 7.1.6 of my report, above) in October 1987; i.e. about 20 years before the incident. I agree that, as far as can now be ascertained many years after the event, there might have been either a cup-shaped zone or a bark inclusion in the crotch of the former branch. I do not agree, however, that the branch failed "*due to weak fork formation*". As I have indicated in para. 6.2.1.1 of my report, above, many trees have branch attachments that, despite containing zones that could be regarded as structurally weak, are strong overall.

With further regard to the branch that reportedly fell in 1987, the description "*weak fork*" implies not only that there was proof of definite weakness, but also that the tree was forked; i.e. that the stem divided into two members of approximately equal size. If so, the disposition of the fibres between the two members might have caused weakness. As far as can now be ascertained, however, I think that there was no fork in this sense; i.e. the diameter of the branch was considerably less than that of the parent stem.

Since the "*first failure*" reportedly occurred in the Great Gale of 1987, I consider that the conditions were then so extreme that there is no basis for attributing the failure to "*a weakness*", in the absence of clear evidence that a significant weakness existed.

In this item in the Particulars, it is stated also that the wound resulting from the "*first failure*" was "*prone to decay and represented a weakness in the stem*". For the reasons stated in para. 7.1.6 of my report, above, I agree that decay was visible but I do not agree that the presence of the decay indicated "*that there was a clear potential for branch failure on the tree*", except in the context that any tree with branches obviously has some potential for branch failure.

In summary, I consider that the Particulars do not provide a valid argument that the massive wound constituted evidence of a potential for branch failure, except in the context that any branch on any tree could fail under an excessive load.

Second item:
This concerns a "*second branch*" that is stated to have fallen "*from the tree about 2-3 years before the accident, also as a result of weak fork formation*".

As stated in para. 7.2.3 of my report, above, the remains of the branch in question ("branch C") indicate that it had begun to fail by cracking before it eventually fell. I therefore agree that it was weakly attached. In this respect, its sequence of failure had some similarity to that of the incident branch. Nevertheless, for the reasons given further in para. 7.2.5 of my report, above, I consider that branch C had particular characteristics that probably contributed to its failure and that were not typical of other branches on the tree.

There is an assertion here that branch C "… *was cleared into adjacent undergrowth, so the Defendant's agents or employees knew or ought to have known about this branch failure and inspected the tree further*".

At a site where the presence of people contributes to a relatively high risk of harm in the event of tree failure, records of significant failures are helpful in reminding inspectors to look especially for signs of potential similar failure. In this instance, however, the area concerned was designated as "low-risk" when branch C fell and therefore did not require formal tree inspections.

In a "low-risk" zone, the tree inspectors were expected to be aware of hazards that they observed in the course of other duties, but I do not consider it necessary to have recorded the failure of branches in such a zone unless, owing to special circumstances, there was known to be a significant risk posed by potential failures of a similar type. In this context, it might be helpful to observe that Section 6 of the Defendant's current guidance (Anon, 2007), which took effect after the inspection of the incident tree, states the need to report incidents involving falling trees and branches (1) where injury has occurred and where (2) a serious injury could have occurred in a "very high" or "high" usage zone.

If the tree had been subject to formal inspection when Branch C was first observed to have fallen, some form of record of the failure could have provided helpful information for the next inspection. Nevertheless, the underlying risk of harm from other branch failures was, in my opinion, too small to have justified a detailed (i.e. climbing) inspection of the tree.

Third item:
This refers to "*the weak attachment of the branch and in particular the pronounced adaptive growth flares to either side of the fork*."

As stated above in relation to para. 5 of the Particulars, I think that the cup-shaped form of the branch attachment would have been apparent to a competent ground-based inspector. I do not, however, agree that this was necessarily a sign of weakness. I have, on the contrary, pointed out that such attachments are very common in beech trees and that, in my opinion, the great majority of them do not fail.

With regard to the "*pronounced adaptive flares*" (which I assume to be the "step-like bulges" described in para. 7.1.5 of my report, above), I agree that these features would also have been readily apparent. On the other hand, for the reasons stated above in relation to para. 7b of the Particulars, I consider that there was no evidence-based guidance by which weakness could reasonably have been diagnosed from the presence of the bulges.

On a matter of terminology, I think the word "adaptive" could be an incorrect description of the "flares" or bulge. Adaptive growth helps to compensate for a loss of strength or stiffness (Mattheck & Breloer, 1994). In this instance, I consider that the "flares" or bulges were not situated so as to have had such a compensatory role. Had they done so, as suggested by the term "adaptive", it could be argued that they could have been assessed as contributing to the strength of attachment of the branch.

Fourth item:
This refers to a "*further branch on the tree, which would also have been visible from ground level and which fell from the Tree in about July or August 2007*".

The failure of a branch after the accident is not relevant to the inspection that took place before the accident. Perhaps, however, there is an implication that, at the time of the inspection, the branch in question (identified in para. 6.2.1.5 of my report, above, as "Branch B") should have been recognised as showing signs of weak attachment and thus adding to an overall impression of a tree that required more detailed inspection. Such action would, however, not have been justified unless there had been a need to reduce an intolerable risk to people or to the tree. In the event (as stated in para. 6.2.1.5 of my report, above) Branch B failed at its place of attachment (where a slightly cup-shaped formation was present) but without any evidence of previous cracking.

Fifth item:
This refers to a "*further branch with a weak attachment to the stem*", which "*remained in October 2007*" and was "*also visible from ground level and which, if not reduced in length, was at risk of failure*".

As noted in para. 7.1.3 of my report, above, I have observed that a number of branches on the incident tree do not have fully formed branch bark ridges at their attachments to the trunk. This is a sign of possible weakness, but it is very frequent in beech trees and does not, in my opinion, justify action (e.g. a detailed inspection and/or tree work) unless other signs, such as cracking, are also present. In this instance, it has now become reasonable to regard as 'other signs' the previous failures of the incident branch and of branches B and C. On this basis, remedial tree work could in principle be justified, but only in order to mitigate an unacceptable risk. The risk has, in any case, been mitigated by the closure of the footpath following the incident.

Summary of the claimant's case, based on the above items:
The first point made in this summary is that "*a tree with the type of defects particularised above should be regularly inspected by a competent inspector if there is public access nearby*".

I agree that public access should be taken into account when deciding how often and how rigorously to inspect trees. In this instance the tree was included in a programme of regular inspection after the site was re-designated as "medium-risk" in 2006.

Although public access should be taken into account when deciding whether regular inspection is appropriate, the decision should in my opinion be based on the number of people likely to occupy the potential impact zone of the tree over a given period. The need to take account of occupancy in this manner is not stated in the Claimants' summary. Also, the word "*nearby*" does not accurately define the potential impact zone.

With regard to the "*type of defects*", it is essential to consider what could reasonably have been known about the tree prior to the accident, rather than to construct a retrospective chain of causation. It is true that a weakly attached branch (Branch C) fell 2-3 years before the accident. Its failure does not appear to have been recorded, but no such record was necessary at the time, since the site was not then subject to formal tree inspection. In this context, the usage of the site was, in my opinion, not high enough to have warranted formal inspection, even though the site was later re-designated to take account of a possible increase in usage.

Even if the failure of Branch C had been formally recorded, it would not in my opinion have been a basis for concluding that the tree was any more likely to shed branches than other old beech trees that grow next to roads and paths throughout much of the UK. It is only in retrospect; i.e. after the failure of the incident branch, that a possible case of propensity for failure seems to emerge.

The summary refers also to another beech tree, on the main drive to Felbrigg Hall, which is said to be in need of remedial work. The tree is not specifically identified in the summary but one of the trees along the drive seems to answer the description. On the assumption that this is the tree in question, I viewed it on 30 July 2010 and discussed its condition with Messrs Zealand and Daplyn. On this basis, I am satisfied that the tree has been adequately assessed and managed in order to ensure that any risk remains well within acceptable limits. It does not, in my view, provide evidence to support any allegation of deficiency in tree risk management on the Felbrigg Hall Estate.

Paragraph 7c:
This refers to the question of remedial action. It is alleged that the Defendant "*Failed to shorten the branch timeously and failed to pay adequate regard to the length of the branch (21.7m) and the fact that it extended well beyond the mean profile of the tree's crown, resulting in its bearing a considerable weight of foliage directly over a footpath.*"

As stated in para. 8.2.1 of my report, above, I do not consider that remedial action, such as shortening of the branch, would have been necessary on the basis of the information that was available from the inspection in January 2007. With particular regard to the length of the branch, I do not consider there would have been any indication of excessive leverage unless there had been additional signs, such as (1) any partial failure in the form of cracking (in reality present, but not visible from the ground), or (2) projection of the branch beyond the general profile of the canopy. (In woodland, the canopy includes the crowns of nearby trees as well as that of the tree in question.)

The question as to whether or not the incident branch was projecting in the manner asserted has been investigated, using the available evidence from (1) the length of the branch, (2) its estimated angle of attachment and (3) the height and shape of the tree. On this basis, a reconstructive diagram has shown that the branch was probably contained within the overall canopy (Daplyn, 2011: Exhibit RD4).

Paragraph 7d:
It is alleged here that the Defendant "*failed to subject the tree to an adequate programme of maintenance*". It is stated that "*in support of this allegation the Claimants will rely on the failure to prune out a secondary crossing branch near to the branch which fell*".

In formally managed locations, crossing branches are sometimes pruned either for cosmetic reasons or in order to help prevent eventual branch failure, which is a possible consequence of abrasion between such branches. I do not, however, regard such work as essential for adequate maintenance unless there is a particular reason for it. It is, as far as I know, very rarely undertaken in woodland areas.

Paragraph 7e:
It is alleged here that the Defendant had "*Implemented an inadequate and unsafe policy of risk assessment of tree safety by adopting a policy of assessing risk in relation to the location (i.e. the zone in which the tree was) as opposed to assessing risk in the light of the condition of the tree*". In particular, the Defendant's generic policy entitled the "Inspection of Trees, Instruction 1" is alleged to have been "*fundamentally flawed in this regard, as evidenced by the fact that the updated 2007 edition of the Defendant's policy on the Inspection of Trees now acknowledges that the condition of trees must be taken into account in addition to the location of the tree for the risk assessment to be of any value*".

I agree in principle that there is a need to adjust the frequency and/or level of tree inspection within a given usage-zone, in order to take account of particular trees that, by virtue of their size and general condition, have the potential to pose an atypically high or low risk. It is, however, important to be aware that the risk of harm depends not only on the size and condition of a tree or branch, but also on the usage of the site. If the usage is very low, the risk is also likely to be low, even if there is a high probability of failure of a large tree or branch.

I disagree that the 1997 Instruction is fundamentally flawed, as alleged in the Particulars. Under heading No. 5 ("Assessing hazard"), it states that the frequency of inspection for trees in the "medium-risk" zone should be "at least every two years". Although the 1997 Instruction does not explicitly state that the frequency should be increased in order to take account of the condition of particular trees, the phrase "at least" denotes the need to do so where appropriate. Under the same heading, there is an accompanying statement of the need to know about "…the propensity of some species to break up or decay more rapidly than others…". Also, there is an explanation of circumstances where, on the basis of a visual inspection, a more detailed inspection, using specialised techniques, might be required.

The need to modify inspections according to the condition of trees is stated somewhat more explicitly in the 2007 version of the Defendant's guidance (Anon., 2007) than in the 1997 Instruction. Section 2.2 of the 2007 version includes the following statement: "Depending on age, species and condition of trees, it may be appropriate to change the frequency or timing of inspection." The following sentence states: "The purpose of this discretion is to enable best use of available resources".

In addition to stating the need to modify the frequency of inspection where appropriate, both the 1997 Instruction and the 2007 guidance refer to a special category of "important" trees, known as Retained trees, for which a special regime of inspection, recording and management is specified. In the 2007 guidance, Retained trees are described as trees that are, "due to their age, species or condition, likely to need more careful and frequent inspection" and that will "be located in Usage Zones 1,2 or 3". I think that the designation of Retained trees can help to allocate resources appropriately and to ensure that important trees are managed in the interests both of their own care and of public safety. On the other hand, I consider that, with regard to woodland trees in general, public safety is adequately addressed by the Defendant's general provisions for zoning and inspection.

In the context of tree risk assessment, I agree that "*the condition of trees must be taken into account in addition to the location of the tree for the risk assessment to be of any value*". By definition, tree risk assessment undeniably takes account of the condition of the tree. Paragraph 7e of the Particulars is, however, not concerned with the assessment of the risk posed by trees that have been inspected. It is concerned with the need, in certain instances, to modify the frequency of inspection of particular trees within a usage zone. Any such modification should obviously take account of the condition of the trees concerned. If there is a failure to make an appropriate modification, an excessively long time might, in consequence, elapse before the tree(s) concerned were next inspected. It would, however, be completely mistaken to say that the process of risk assessment would thereby have no value.

In summary, the revision of the guidance in 2007 does not indicate that the 1997 version was deficient or "*fundamentally flawed*". There is, however, a need to recognise that tree risk management is a developing discipline and that guidance will need to be updated or clarified accordingly.

Paragraph 7f:
It is alleged here that the Defendant "*failed to ensure that the policy for tree management was implemented properly*".

I refer to my comments on other paragraphs of the Particulars, on which the allegation in para. 7f is based. I do not know of any evidence that the implementation of the Defendant's policy was deficient. Any deficiency would involve (1) failure to inspect trees at appropriate intervals; (2) lack of competence of inspectors and/or (3) failure to undertake remedial actions in a timely manner. In considering (1) and (2) in Section 10 of my report, above, I have not identified any deficiencies. Also, having examined records of remedial work that has been commissioned on the basis of tree assessments at Felbrigg, I am not aware of a failure to have taken remedial action where a need for it has been identified.

Paragraph 7g:
The Defendant is alleged here to have "*failed adequately to risk assess the tree*". In this regard, it is stated that the Claimants "*will contend that the tree should have been designated in the high risk category, rather than the medium category*". This contention is based on the assertion that: "*It was inadequate merely to the* (sic) *designate the tree as part of a medium risk woodland and doing so failed to take proper account of the confluence of paths around the tree, the glade and the den in the vicinity of the tree, which would encourage the congregation of groups, especially children*". Additionally, it is stated that: "*The Aylmerton Field Study Centre explicitly routed thousands of children along the confluence of paths adjacent to the tree each year, a fact which was well known to the Defendants*".

There is a difference between (1) risk assessment and (2) the zoning of an estate. In order to assess the risk posed by a tree or group of trees, a numerical value is estimated for each of three risk factors, as explained in Section 8.3 of my report, above. One of these factors is the specific usage of the potential impact zone. On the other hand, the zoning of an estate according to usage is based on broad categories, which in this particular instance were "low", "medium" and "high".

With regard to risk assessment, an under-estimation could have occurred if the usage of the potential impact zone of the tree had been greater than expected. I do not, however, consider that the Defendant failed to take account of the available information regarding site usage. I understand that Mr Daplyn's estimate (Daplyn, 2011) takes full account of the presence of members of the public and of the children who attend courses run by the Aylmerton Field Studies Centre. In this context, it should be appreciated that "thousands" of pedestrian movements can equate to low usage when averaged over an entire year.

For the reasons stated above in relation to para. 4 of the Particulars, I am not aware of any evidence that site usage was significantly affected by the presence either of the glade or the den.

With regard to zoning, a high-risk designation would have entailed inspection annually, rather than at least every two years. Also, the inspector would have been required to carry a probe and binoculars (Anon., 1997). In this instance, a period of only six months elapsed between the inspection and the failure of the branch. Also, a probe and binoculars would not have provided any additional diagnostic information. In any case, the designation of a medium-risk category was, if anything, a rather high categorisation, given that the 1997 Instruction indicated that major footpaths should normally be the category of path to be included in the high-risk category.

Paragraph 7h:
It is alleged here that the Defendant "*failed to undertake thorough and frequent Inspection of the tree given its age, condition, species and location*". It is alleged, in particular, that the Defendant "*failed to have any or any adequate regard*" to two bulleted items, as follows:

First item: "mature beech trees are prone to limb shedding".

I agree that inspectors should take account of the propensity of mature (or more particular post-mature) beech trees to shed branches and thus to be aware of any large branches that might show signs of potential failure. The risk of harm to people from such failure is, however, generally very low, since the vast majority of failures occur when no people are present. The risk of harm on a low-usage footpath, is of course greater than in a block of woodland out of falling range of any paths, but the risk is still too low to justify anything more than general ground-based inspections, coupled with remedial action in cases where intolerable risks are found.

Second item: "branch failure due to weak forking is common in mature beech trees".

I agree that weak forking (or more generally weak attachment) is one of the main (perhaps the most frequent) contributory causes of failure in mature beech trees, but this is not the same as saying that branch failure due to weak forking is common in mature beech trees. I do not think that there are any statistical data on the frequency of such failures. As I have pointed out in response to the third bulleted item in para. 7(b), there are a great many branch attachments that, despite showing morphological signs of possible weakness, do not fail (i.e. the tree dies and/or falls over first). Only if additional, more distinct, signs of weakness are detected, is there a reasonable case for further diagnostic and/or remedial action.

Paragraph 7i:
The Defendant is here alleged to have failed "*to keep adequate records relating to inspections of the tree or adequate records of the condition of the tree*". The basis of this allegation is that, "*given the age, species, location and condition of the tree, proper records should have been kept in order adequately to monitor its condition over time*".

> I agree that proper records are generally appropriate for trees that, by virtue of their size, condition and proximity to people or property, are assessed as potentially posing an intolerable risk of harm. For other trees that require inspection, I regard it sufficient to record that the inspection has taken place on a given date. A system of 'negative recording' is likely to provide less evidence for defence in the event of litigation, but it saves valuable time and thus enables resources to be allocated more effectively for tree risk management.
>
> I consider that there was no need to have recorded the condition of the tree in question, since the risk of harm to people would have appeared low, taking account of the site usage and of the information available from the visual ground-based inspection in January 2007.

Paragraph 7j:
The Defendant is alleged here to have failed "*to classify the tree as hazardous and to take appropriate measures to protect members of the public, including the children, from injury caused by failure of the tree*".

> It is incorrect to classify trees either as 'hazardous' or 'non-hazardous'. The hazards associated with trees, together with the corresponding risk of harm, exist on a continuous spectrum. If the risk of harm is found clearly to be very low during a general assessment, there is no need to assess it further in any formal manner. If, on the basis of a general assessment, the risk appears to be potentially unacceptable, it should be assessed by reference to the three key factors mentioned in Section 8.3 of my report, above. As stated in para. 9.1 of my report, above, I consider in this instance that no unacceptable risk could have been envisaged on the basis of site usage and of the signs that were visible during the inspection of January 2007. I therefore consider that there was no foreseeable reason to have taken measures to protect the public.

Paragraph 7k:
The Defendant is here alleged to have failed "*to ensure that the tree inspectors were trained adequately in tree risk assessment and/or had a proper understanding of adaptive growth morphology*".

> For the reasons stated in Section 10.3.4 of my report, above, I take the view that the competence of the inspectors was adequate, as far as can be assessed from their records of training and from their witness statements. The latter seem to confirm that they were aware of signs of adaptive growth. Whether or not they understood the underlying biological principles is probably not very relevant, provided that they were recognising the signs.

Paragraph 7l:
By "*implementing a system of inspection by in-house/resident tree inspection teams*", the Defendant is here alleged to have "*allowed a culture of excessive risk tolerance to develop*".

There is always a case for using external audit in order to test whether an organisation's in-house risk assessment is appropriate. Indeed, the Defendant's training scheme involves the participation of outside experts. With regard to the Felbrigg Hall Estate and to the Defendant's estates in general, I have not found any evidence of excessive risk tolerance.

Paragraph 7m:
It is alleged here that the Defendant failed "*to divert the path for walkers in the Great Wood away from the tree*".

It is true that the footpath was not diverted prior to the incident. Diversion of the path would, however, have not been appropriate unless the risk of harm had been assessed as being unacceptable.   Using the information that would have been available to the inspectors prior to the accident, I have shown that a formal risk assessment would have indicated that the risk was well within tolerable limits (see para. 8.3.5.4, of my report, above). I have, however, also shown that, taking account of a defect that could not have been seen from a ground-based inspection, the true risk (as assessed in para. 8.3.5.5 of my report, above) was much higher. On that basis, it would have been necessary to assess the costs and benefits of some form of action, such as closure of the path. This was done after the incident, by which time there was cause for concern that the tree had a particular propensity to shed branches.

Paragraph 7n:
The Defendant is alleged here to have failed "*to warn members of the public, including the children, of the danger posed by the tree*".

Warning signs or other instructions can be useful where the people being warned are able to understand and to comply (or choose whether to comply) with the warnings. Such warnings are, however, unnecessary unless the risk exceeds a certain level of tolerance. As stated above in my comments on para. 7m of the Particulars, I consider that, on the basis of the inspection in January 2007, the risk from the incident tree would have been assessed as being well within tolerable limits.

Paragraph 7o:
It is asserted here that the Defendant "*In the premises failed to take reasonable care to ensure that the children were safe when visiting the Estate*".

This is a general assertion, which could be tested with regard to particular aspects of safety management. In relation to tree safety and, more particularly, in relation to the incident tree, I am not aware of any evidence to support the assertion. In reality, a tragic accident occurred but it was, in my opinion, caused by a hazard that could not reasonably have been detected.

David Lonsdale
4th April 2011

Appendix 2 General information about the incident tree and the site

Location:	Felbrigg Hall Estate, Roughton, Norwich
Date of inspection by D. Lonsdale:	26th October 2007.
Viewing conditions on the above date:	Moderately good: dry but dull.

General information about the tree

Species: Fagus sylvatica (European beech)

Age and developmental stage: approx. 180 years (estimated): post-mature.

Stem diameter (at 1.4 m above-ground): 1.273 m

Form: The tree has a single main stem, which bears a crown typical of a beech tree growing in moderately open woodland.

Height: not assessed, since not relevant to the impact-potential of the incident branch.

Height of attachment of the incident branch: 11 m[11]

Growing conditions

There was no indication that the site had been managed so as to harm the condition of the tree. Any soil compaction is likely to have been slight and confined to the adjacent footpath, which has been lightly used.

Overall physiological condition

Vigour (capacity for growth): twig extension growth in the lower crown seemed normal for a post-mature woodland beech. The upper part of the crown could not be viewed sufficiently to assess the state of twig growth there.

Vitality (general health): As with the assessment of vigour, visual signs at the tops of tree crowns are important in assessing vitality. The parts of the upper crown that could readily be viewed did not show enough dieback or thinning to indicate any recent decline in health.

Overall mechanical status

General conformation and associated mechanical stresses: The tree has a single main stem, with a normal taper and arrangement of branches for a woodland beech. These characteristics do not indicate any obvious propensity for mechanical failure.

Lever arm (height/spread of tree or individual branches) and sail area: The tree does not show any characteristics of crown-shape or of branch-length that might suggest the presence of any excessive lever arm. The sail area, as represented by the size of the crown, appears to be proportionate to the height of the tree and the diameter of the stem.

Mechanical failures and pruning: A very large branch has failed at its junction with the stem; this reportedly happened in 1987 (para. 7.1.6) and has led to the development of decay in the vicinity of the fractured branch socket. Also, a number of relatively small branches have either been removed or have failed, so as to leave stubs.

Exposure to wind: The tree does not appear to be generally exposed to wind more severely than others of a similar size in the locality. The loss of large branches, both in the incident of 2007 and in 1987, has probably led to some locally increased wind-exposure within the lower part of the crown.

Branch attachments: the characteristics of the branch attachments are of specific importance in relation to the incident and are therefore discussed in para. 7.1.3.

[11] As measured on 26th Oct. 2007, using a clinometer

Appendix 3 Glossary of Terms, as used in this Report

Allometric	pertaining to the study of the relative growth of a part of an organism in relation to the growth of the whole
Bark inclusion	bark which is enclosed within wood or between woody parts of a tree which are in contact or fused together; a potential cause of weakness under some circumstances
Biomechanical	in trees, pertaining to mechanical properties or condition and therefore relevant to stability and strength (see also mechanical)
Branch bark ridge	the raised arc of bark tissues that forms within the acute angle between a branch and its parent stem
Buttress zone	the region at the base of a tree where the major lateral roots join the stem, with buttress-like formations on the upper sides of the stem-root junctions
Clinometer	a device for measuring angles of inclination and hence the heights of objects such as trees
Crown	in arboriculture. the main foliage-bearing portion of a tree
Crotch	the angle, facing the direction of growth, formed at a branching point of a tree
Decay	in the wood of trees, a process of breakdown of the components of cell walls, mainly caused by fungi, which results in a loss of stiffness and / or strength and which may culminate in cavity-formation owing to total destruction of wood
Growth stresses	internal mechanical stresses within the wood of a tree, which have the effect of pre-stressing the tree against wind-induced and weight-induced loading
Hazard	the disposition of a thing, a condition or a situation to produce injury
Impact zone	a potential area of impact within the target zone
Lever arm	a mechanical term denoting the length of the lever represented by a structure that is free to move at one end, such as a tree or an individual branch
Mechanical integrity	in a tree, the characteristics (e.g. adaptive growth and wood quality) which confer adequate resistance to the range of mechanical forces produced by the weight of the tree and by the normal range of weather conditions in the area concerned
Post-mature	in trees, a stage of development in which the crown is becoming smaller than the maximum that has been attained and in which the volume of successive increments of wood is declining

Quantified risk assessment	a process whereby the main components of risk are numerically estimated and then arithmetically multiplied so as to provide a measure of risk to people and/or property
Risk	the probability of the potential harm from a particular hazard becoming actual harm
Risk factors	factors which contribute to risk and are therefore taken into account for risk assessment
Risk index	the mathematical product of the three risk factors, representing the probability of occurrence of the type of harm under consideration (as applied in Quantified Tree Risk Assessment© and in the present report)
Sounding hammer	a hammer or mallet, usually made of plastic or wood which, by being tapped against a tree, produces sounds that can be interpreted so as to detect decay or cracks
Stress notch	a potential failure point in a structure, where mechanical stress is locally concentrated
Target	in tree risk assessment, and with slight misuse of normal meaning, persons or property or other things of value which might be harmed by mechanical failure of the tree or by objects falling from it ('target zone' = the area within which targets may be at risk)
Vigour	in tree assessment, an overall measure of the rate of shoot production, shoot extension or diameter growth
Vitality	a measure of the capacity of a living organism to maintain its essential physiological and biochemical functions

Appendix 4 The Scope of Tree Risk Assessments, as conducted for this report

The brief for a tree risk assessment is determined mainly from the client's instructions. These may, for example, specify a particular feature of a tree that is suspected of presenting a hazard. Alternatively, if the instruction is more general, there will be a primary visual inspection so that, if necessary, the brief for any further assessment can be determined. If additional trees with potentially hazardous features are noticed during a site visit, such observations will be included briefly in the report so as to state the desirability of any further investigation or action.

Primary inspection for potential signs of mechanical defect is done from ground level, where necessary with the aid of binoculars, measuring tapes and a sounding hammer. Also, climbing inspections may be done if there is reason to suspect the presence of defects that cannot be seen properly from the ground.

Internal inspection, if requested or found to be necessary, provides information about the position and extent of zones of wood affected by decay or having intrinsically poor mechanical properties. Inspection techniques are chosen on the basis of current knowledge of their efficacy and the harm (if any) that they might cause to the tree.

The accessibility of tree root systems tends to limit most assessments of suspected root decay, especially if paving or underground pipes and cables are present. Advanced decay in a root-plate often, but not always, extends into the stem base, at least near ground-level. For this reason, probing for root- and butt-rots is generally carried out as near to the ground as possible. Additionally, exposed roots are probed where possible with a micro-drill and/or a twist-drill, in order to record their condition below ground level. In order to gain further access or to expose other roots, soil usually has to be excavated; this is done only in certain instances, as stated in individual reports.

In order to indicate whether there is a need for remedial action so as to remove or mitigate a hazard, a form of quantified risk assessment is undertaken, according to general principles set out by Ellison (2005)*. The assessment is, if necessary, done so as to compare current risk with the predicted risk following remedial action. The risk assessment can be based on current guidance provided by Ellison under the licensed system known as Quantified Tree Risk Assessment (QTRA©), or on a slightly modified application of the same principles, by which the following risk factors are quantified:

a) The potential severity of the outcome of mechanical failure of the tree, taking account of the physical impact and of the nature of the most valuable of the 'targets'.

b) An assessment of the probability of mechanical failure.

c) Available knowledge of site usage (presence of people and property)

Any limitations on the availability or quality of the data required in respect of (a), (b) and (c) above are stated in the report.

Numerical values for each of the three factors used in risk assessment are estimated on a scale of zero to 1 and these are multiplied together so as to assess the risk of harm to people or property. If, instead of the QTRA© method of calculation, the slightly modified method (above) is applied, each of the three values (a), (b) and (c) is estimated as follows (with notes about the degree of subjectivity):

a) The potential severity of the outcome of mechanical failure of the tree. *As proposed by Ellison (2005), a human fatality is taken to represent the most severe potential outcome and is therefore assigned a value of 1.0 on the scale of zero to 1. The value is estimated by considering two contributory factors:*

* Ellison, M.J. (2005). Quantified tree risk assessment, used in the management of amenity trees. *Journal of Arboriculture* **31**, 57-65.

i. *The potential impact, assessed on the basis of:*

- *the size of the part of the tree concerned*
- *the height of fall*
- *other factors affecting the severity of impact (e.g. deflection or cushioning)*
- *the nature and potential consequences of the potential impact (e.g. impact from falling versus a road accident occurring after the tree failure). For example, in the event of a very heavy object (or a somewhat lighter one falling from a greater height) striking a person, the worst possible outcome (i.e. a fatality) is assumed to be the potential outcome. SUBJECTIVITY: The main element of subjectivity arises from the need to estimate how much harm is likely to occur from the potential impact. There are many different kinds of impact, including indirect ones, such as when vehicles drive into trees that have previously fallen or when road traffic accidents occur as an indirect result of tree failures. There are also different consequences for various categories of people and property (e.g. motorcyclists versus car drivers or pedestrians).*

ii. *The pecuniary value of the most valuable target (i.e. whether a human life, valued notionally at £1 million, or of various categories of property).*

b) Assessment of the probability of mechanical failure. *This probability is estimated on the same basis as proposed by Ellison (2005) and is thus the probability of a specified kind of failure occurring within the next year. Of the various kinds of failure that might occur, the one representing the greatest hazard is used in the formula for risk assessment. In order to identify this hazard, it is necessary to perform preliminary calculations, based on the potential physical impact as well as the probability of failure. SUBJECTIVITY: The main element of subjectivity arises from the need to use personal knowledge and experience for estimating the probability of failure.*

c) Available knowledge of site usage. *This can be estimated as proposed by Ellison (2005), or it may be possible to apply specific data (e.g. from a traffic census) for the site concerned. An estimate can be made, for example by applying national data for the vehicle occupancy of different categories of highway or by using traffic census data for the site concerned. SUBJECTIVITY: Of the three factors that are multiplied so as to assess risk, this is potentially the least subjective, but accuracy is limited if values of vehicle and pedestrian occupancy need to estimated in the absence of site-specific data.*

The licensed system of QTRA© differs from the method outlined above in two main ways. It integrates 'target' value with frequency of usage and it also employs published allometric data, which are used to estimate the weight of a branch or stem from its diameter (Tritton & Hornbeck, 1982), in order to assess 'impact potential' (as opposed to 'severity of outcome').

Appendix 5 D. Lonsdale – qualifications and experience

Current position:	Consultant, writer and lecturer in tree decay biology, tree diseases and tree hazard assessment, based at: 33 Kings Road, Alton, Hampshire GU34 1PX tel. +44 (0)1420 83742 e-mail d.lonsdale2@btinternet.com
Date of birth:	8 January, 1950
Nationality:	British
Qualifications:	BSc (Hons.) in Botany, University of Southampton, 1971 PhD on pink rot of potato, University of Manchester, 1975
Other education and training	attendance each year between 2000 and 2005 of the tree risk assessment course of the International Society of Arboriculture (UK & Ireland Chapter. Certified completion of a Forestry Commission course in risk assessment (2001). Certified licence-holder in the Quantified Tree Risk Assessment System (No. 1187), 2006
Membership:	British Society for Plant Pathology British Mycological Society (Vice-President in 2000) Arboricultural Association (Honorary Fellow since 1999) International Society of Arboriculture (Honorary Member since 2001)
Employment:	March 2002 to the present: freelance consultant, writer and lecturer, following early retirement from Forest Research Jan. 1982 to March 2002: Forestry Commission (Forest Research) project leader in tree disease, decay and safety research Dec. 1978 - Nov. 1981: postdoctoral research fellow at University of Surrey (Microbiology Department); contracted to work at Alice Holt Research Station Dec. 1975 to Nov. 1978: employment as Higher Scientific Officer with the Forestry Commission Research Division (now Forest Research) at Alice Holt Research Station Oct. 1971 to June 1974 (postgraduate period): part time demonstrator in plant pathology, ecology, genetics, data analysis and plant anatomy (Manchester University).

Relevant experience:

- nominated officer at Forest Research for managing ODPM (formerly DoE etc. and subsequently DCLG) projects on decay and safety in amenity trees and Condition Survey of non-woodland Amenity Trees.
- project leader or research student supervisor in programmes in several fields, including beech bark disease, poplar diseases, Phytophthora root disease of alder, the role of endophytes in xylem dysfunction, the detection of decay in trees and the modes of woody cell wall degradation by various fungi
- author of: *Principles of Tree Hazard Assessment and Management* (1999); over 60 scientific and general papers on tree disorders, diseases, conservation and safety issues; also editor of two other books on tree diseases and on safety, translated from the German, and co-editor of *Habitat Conservation for Insects – a Neglected Green Issue*, AES Publications, 1991, the world's first textbook on the subject.

Professional activities:

- former member of Programme Committee of British Society for Plant Pathology, representing the 'woody plant interest'
- Vice President of the British Mycological Society for 2000 and formerly co-opted on to its Conservation Committee
- examiner for the Royal Forestry Society - Professional Diploma in Arboriculture
- external lecturer for Royal Botanic Gardens, Kew - Diploma in Horticulture
- external lecturer for Imperial College - MSc Forest Protection and Conservation
- panel member for revision of British Standards 5837 (trees on construction sites) and 3998 (tree work)

Main arboricultural and scientific publications: (a list of publications on all subjects is available)

Benham, B.R., Lonsdale, D. & Muggleton, J. (1974). Is polymorphism in two-spot ladybird an example of non-industrial melanism? *Nature* **249**, 179-180.

Muggleton, J., Lonsdale, D. & Benham, B.R. (1975). Melanism in *Adalia bipunctata* L. (Col. Coccinellidae) and its relationship to atmospheric pollution. *Journal of Applied Ecology* **12**, 465-471.

Lonsdale, D. (1977). Beech barks disease. *Forestry Commission Research Information Note* **20/77/PATHS**.

Cunliffe, C. Lonsdale, D. & Epton, H.A.S. (1977). Transmission of *Phytophthora erythroseptica* on stored potatoes. *Transactions of the British Mycological Society* **69**, 27-30.

Houston, D.R., Parker, E.. & Lonsdale, D. (1979). Beech bark disease: patterns of spread and development of the initiating agent *Cryptococcus fagisuga. Canadian Journal of Forest Research* **9**, 336-344.

Lonsdale, D., Pratt, J.E. & Aldsworth, F.G. (1979). Beech bark disease and archaeological crop marks. *Nature* **277**, 414.

Lonsdale, D. (1979). Beech bark disease: one disorder or several? *The Ecologist* **9**, 136-138.

Lonsdale, D. (1979). Archaéologie et santé des hêtres. *La Recherche* **10**, 1137-1138.

Lonsdale, D. Cunliffe, C. & Epton, H.A.S. (1980). Possible routes of entry of *Phytophthora erythroseptica* Pethyb. and its growth within potato plants. *Phytopathologische Zeitschrift* **97**, 109-117.

Lonsdale, D. (1980). *Nectria coccinea* infection of beech bark: variations in disease in relation to infestation by *Cryptococcus fagisuga* Lindinger. *European Journal of Forest Pathology* **10**, 161-168.

Lonsdale, D. (1980). *Nectria coccinea* infection of beech bark: variations in disease in relation to predisposing factors. *Annales des Sciences Forestières* **370**, 307-317.

Lonsdale, D. & Pratt, J.E. (1981). Some aspects of the growth of beech trees and the development of beech bark disease on chalk soils. *Forestry* **54**, 183-195.

Lonsdale, D. (1983). Pruning: a rule of thumb. *Gardeners' Chronicle & Horticultural Trade Journal* July 8th, 18-19.

Lonsdale, D. (1983). Wood and bark anatomy of young beech in relation to *Cryptococcus* attack. *Proc. Conf. I.U.F.R.O. Beech Bark Disease Working Party*, Hamden, Conn., USA, 1982., *USDA Forest Service General Technical Report* **WO-37**, 43-49.

Lonsdale, D. (1983). Fungal associations in the build-up and decline of *Cryptococcus fagisuga* populations. *Proc. Conf. I.U.F.R.O. Beech Bark Disease Working Party*, Hamden, Conn., USA, 1982., *USDA Forest Service General Technical Report* **WO-37**, 99-104.

Lonsdale, D. (1983). Some aspects of the pathology of environmentally stressed trees. *International Dendrology Society Yearbook 1982*, 90-97.

Lonsdale, D. (1983). A definition of the best pruning position. *Forestry Commission Arboriculture Research Note*. **48/83/PATH**

Lonsdale, D. & Sherriff, C. (1983). Some aspects of the ecology of *Nectria* on beech. *Proc. Conf. I.U.F.R.O. Beech Bark Disease Working Party*, Hamden, Conn., USA, 1982., *USDA Forest Service General Technical Report* **WO-37**, 59-68.

Lonsdale, D. (1984). Available treatments for tree wounds: an assessment of their value. *Arboricultural Journal* **8**, 99-107.

Young, C.W.T., rev. by D. Lonsdale (1984). The external signs of decay in trees. *Arboric. Leaflet* **1**, Forestry Commission 10 pp.

Lonsdale, D. & Gibbs, J.N. (1985). Beech health study. *Arboriculture Research Note* **62/85/PATH**, Forestry Commission.

Lonsdale, D. (1986). Beech health study 1985. *Forestry Commission Research & Development Paper* **146**, 20 pp.

Lonsdale, D. (1986). Beech health study 1986. *Forestry Commission Research & Development Paper* **149**, 22 pp.

Anon (1987). (drafted by D. Lonsdale and J.N Gibbs) *The recognition of hazardous trees* (Forestry Commission/Dept. of Environment occasional leaflet)
Lonsdale, D. (1987). Prospects for long term protection against decay in trees. *Acta Horticulturae* **195**, 25-23.
Lonsdale, D. (1987). Prospects for long term protection against decay in trees. In: D. Patch, ed., *Advances in Practical Arboriculture, Proc. Arb. Assn./For. Comm. Conf. York, Apr. 1985.* **195**, 25-23.
Lonsdale, D. & Wainhouse, D. (1987). Beech bark disease. *Forestry Commission Bulletin* **69**, 15 pp.
Lonsdale, D. (1987). Treatment of storm-damaged trees. *Arboriculture Research Note*. **73/87/PATH**, Forestry Commission.
Wainhouse, D., Gate, I.M. & Lonsdale, D. (1988). Beech resistance to the beech scale: a variety of defenses. In: W.J. Mattson. J. Levieux & C. Bernard-Duggan, eds., *Mechanism of woody plant defenses against insects: search for pattern.* Springer, New York, 277-293.
Harding, P.T., Alexander, K.N., Anderson., M.A. & Lonsdale, D. (1988). Conserving insect habitats provided in dead broadleaved wood by the wind damage of 16th October 1987. *Forestry Commission Research Information Note* **136**.
Lonsdale, D. (1989). Pruning practice. In: B.G. Hibberd, B.G., ed., *Urban Forestry Practice, Forestry Commission Handbook* **5**, 94-100.
Lonsdale, D. (1989). Diseased and damaged trees. In: B.G. Hibberd, ed., *Urban Forestry Practice, Forestry Commission Handbook* **5**, 101-107.
Lonsdale, D. Hickman, I.T., Mobbs, I.D. & Matthews, R.W. (1989). A quantitative analysis of beech health and pollution across southern Britain. *Naturwissenschaften* **76**, 571-573.
Innes, J.L., Moffat, A.J. & Lonsdale, D. (1989). Weather conditions during the summer of 1989 and their effect on trees. *Forestry Commission Research Information Note* **162.**
Lonsdale, D. (1991). The kindest cut. *Landscape News* (35), February 1991, 4.
Lonsdale, D. (1991). Definition of callus. *Arboricultural Journal* **15**, 183-184.
Lonsdale, D. (1991). Pollarding success or failure; some principles to consider. In: H.J. Read, ed., *Pollard and Veteran Tree Management*, Proc. Corporation of London Meeting, Bucks., UK., Mar. 1991.
Fry, R. & Lonsdale, D. (1991)., eds., Habitat Conservation for Insects: a Neglected Green Issue. *Amateur Entomologists' Society*, 262 pp.
Lonsdale, D. (1992). Endophyten und ihre ökologische Bedeutung für Bäumen. In: Proc. 15th Bad Godesberg Gehölzseminar, Germany, Mar. 1992.
Lonsdale, D. (1992). Treatment of tree wounds. *Arboriculture Research Note* **109/92/PATH**, Arboricultural Advisory and Information Service, Farnham, UK
Lonsdale, D. (1992). Tree decay in relation to pruning practice and wound treatment: a progress report. In: S.J. Hodge, ed. *Research for Practical Arboriculture, Forestry Commission Bulletin* **97**, 177-187.
Lonsdale, D. (1992). Wertung von Schnittmaßnahmen und Wundbehandlungen im Hinblick auf Minderung des Risikos der Holzschädigung. In: Proc. 10th Osnabrücker Baumpflegetage, Germany, Sept. 1992.
Lonsdale, D. (1993). A comparison of `target' pruning, versus flush cuts and stubs pruning. *Arboriculture Research Note* **116/93/PATH**, Arboricultural Advisory and Information Service, Farnham, UK.
Hendry, S.J., Boddy, L. & Lonsdale, D. (1993). Interactions between callus cultures of European beech, indigenous ascomycetes and derived fungal cultures. *New Phytol.* **123**, 421-428.
Lonsdale, D. (1993). Choosing the time of year to prune trees. *Arboriculture Research Note,* **117/93/PATH**, Arboricultural Advisory and Information Service, Farnham, UK.
Lonsdale, D. (1994). Diagnoseverfahren zur Beurteilung der Stand- und Bruchsicherheit von Bäumen. In: Proc. 12th Osnabrücker Baumpflegetage, Germany, Sept. 1994.
Ferris-Kaan, R., Lonsdale, D. & Winter, T. G. (1993). The conservation management of deadwood in forests. *Forestry Authority Research Information Note*. **241**.
Lonsdale, D. (1994). The role of tree mechanics in hazard tree evaluation. *Arboriculture Research Note,* **127/94/PATH**, Arboricultural Advisory and Information Service, Farnham, UK.
Schwarze, F.W.M.R. Lonsdale, D. & Fink, S. (1995). Soft rot and multiple T-branching by the basidiomycete *Inonotus hispidus* in ash and London plane. *Mycol. Res.* **99**, 813-820.
Lonsdale, D. & Schwarze, F.W.M.R. (1995). Ein integrierter Ansatz zur Beurteilung der Verkehrssicherheit von Bäumen. *Das Gartenamt* **44**, 424-429.
Lonsdale, D. (1995). The management of ancient pollarded trees. *Arboriculture Research Note* **131-95/PATH**, Arboricultural Advisory and Information Service, Farnham, UK.
Lonsdale, D. & Gibbs, J.N. (1995). Effects of climate change on fungal diseases of trees. In: *Fungi and Environmental Change*, J.E. Frankland, N. Magan & G.M. Gadd, Eds., British Mycological Society Symp. Vol XX.
Schwarze, F.W.M.R., Lonsdale, D. & Mattheck, C. (1995). Detectability of wood decay caused by *Ustulina deusta* (Fr.) Petrak in comparison with other tree decay fungi. *Eur. J. For. Path.* **25**, 327-341.
Gibbs, J.N. & Lonsdale, D. (1996). Phytophthora disease of alder: the situation in 1995. *Forestry Commission Research Information Note* **277**.
Lonsdale, D. (1996). Pollarding success or failure; some principles to consider. In: *Pollard and Veteran Tree Management II*, ed. H. Read, City of London Corporation, 100-104.
Lonsdale, D., Dolwin, J. & Barrell, J. (1996). Diagnosis on the state of trees. In: *The Tree in its Various States*. Proc. 2nd European Congress of Arboriculture, Versailles, Sept. 1995, 16-25.

Fox, R.T.V. & Lonsdale, D. (1997). White rot symposium - University of Reading, 3-5 April 1995. *The Mycologist* **11**, 29-30.
Lonsdale, D. (1997). Das Zersetzungspotential verschiedener holzabbauender Pilze in Bäumen. Osnabrücker Baumpflegetage, 2-3 Sept., 1997 XI 12-22.
Schwarze, F.W.M.R., Lonsdale, D. & Fink, S. (1997). An overview of wood degradation patterns and their implications for tree hazard assessment. *Arboricultural Journal* **21**, 1-32.
Lawday, G., Dolwin, J., Barnett, J., Glover, R. & Lonsdale, D. (1997). An analytical use of stress-waves for the detection of defects in trees. *Proceedings of "Wave Analysis", Conference of the Institute of Electrical and Electronic Engineering*, Univ. Warwick, Aug. 1997.
Lonsdale, D. & Rose, J. (1998). Resistance of new Belgian poplar clones to British isolates of the bacterial canker pathogen *Xanthomonas populi* Ridé. *European Journal of Forest Pathology* **28**, 227-232.
Gibbs, J.N. & Lonsdale, D. (1998). Phytophthora disease of alder *Forestry Authority Information Note* **FCIN6**
Hendry, S.J., Lonsdale, D. & Boddy, L. (1998). Strip-cankering of beech (*Fagus sylvatica*): pathology and distribution of symptomatic trees. *New Phytologist* **140**, 549-565.
Dolwin, J.A., Lonsdale, D. & Barnett, J. (1998). Decay detection in trees. *Arboriculture Research and Information Note* **144/EXT/98**, Arboricultural Advisory and Information Service, Farnham, UK.
Dolwin, J.A., Lonsdale, D. & Barnett, J. (1998). Detection of decay in trees. *Commonwealth Forestry Review* **77**, 277-280.
Lonsdale, D. & Tabbush, P.M. (1998). Poplar rust and its recent impact in Great Britain. *Forestry Commission Information Note* **FCIN7**.
Lonsdale, D. (1998). Autumn may not be coming in as early as it seems. *Tree Damage Alert* No. 51, Arboricultural Advisory and Information Service, Farnham, UK
Gibbs, J.N., MacAskill, G.A., Lonsdale, D., Rose, D.R. & Tilbury, C.A. (1998). The health of non-woodland trees in England in 1998. *Arboriculture Research and Information Note* **147/PATH/98**, Arboricultural Advisory and Information Service, Farnham, UK
Lonsdale, D. & Tabbush, P.M. (1999). Approved poplar varieties. *Forestry Commission Information Note* **FCIN21**.
Lonsdale, D. (1999). Global warming: a threat to trees? *Tree Damage Alert* No. 54, Arboricultural Advisory and Information Service, Farnham, UK.
Dolwin, J.A., Lonsdale, D. and Barnett, J. (1999). Detection of decay in trees. *Arboricultural Journal* **23**, 139-150.
Tilbury, C. & Lonsdale, D. (1999). Brown leaves due to slugworm damage. *Tree Damage Alert* No. 56, Arboricultural Advisory and Information Service, Farnham, UK.
Lonsdale, D. (1999). *Principles of tree hazard assessment and management.* Research for Amenity Trees No. 7, The Stationery Office, London, 388 pp.
Lonsdale, D. (1999). Are you getting rust(y) on your poplars? *Tree Damage Alert* No 57, Arboricultural Advisory and Information Service, Farnham, UK.
Lonsdale, D. (1999). The gentle pitter-patter of spores on willow. *Tree Damage Alert* No 58, Arboricultural Advisory and Information Service, Farnham, UK.
Dolwin, JA. Lawday, G., Lonsdale, D., Barnett, J. and Hodge, P. (2000). Development and use of stress wave meter to detect decay in wood blocks. *Proceedings of the 12th Symposium on non-destructive testing of wood, Aug. 2000*. Ed. F. Divos, 187-196. University of West Hungary, Sopron.
Lonsdale, D. (2000). *Hazards from trees: a general guide.* Forestry Commission Practice Guide, Forestry Commission, Edinburgh. 28 pp.
Hendry, S.J., Boddy, L. and Lonsdale, D. (2002). Abiotic variables effect differential expression of latent infections in beech (*Fagus sylvatica* L.). *New Phytologist* **155,** 449-460.Lonsdale, D. (in press). Diseases in short rotation crops. In: *Short rotation woody crops.* P.M. Tabbush ed. *Forestry Commission Handbook*.
Lonsdale, D., MacAskill G. A., Rose, D.R., Tilbury, C & Thorpe, K. V. (2002). The Health of Non-Woodland Trees in England during 1999-2000. *Arboriculture Research and Information Note*. Arboricultural Advisory and Information Service, Farnham, UK.
Lonsdale, D. and Gibbs, J.N. (2002). Effects of climate change on fungal diseases of trees. In: BROADMEADOW. M. (ed.) Climate Change: Impacts On UK Forests, Bulletin 125, Forestry Commission, Edinburgh, 198 pp.
Lonsdale, D. (2004). Aging processes in trees and their relationship[s with decay fungi. In: *The trees of history: protection and exploitation of veteran trees*. Eds. G. Nicolotti and P. Gonthier, Proc. Conf. International Congress, Torino, Italy, 1-2 April, 2004. 23-30.
Holdenrieder, O., Pautasso, M., Weisberg, P.J. and Lonsdale, D. (2004). Tree diseases and landscape processes: the challenge of landscape pathology.*Trends in Ecology and Evolution* **19** (8), 446-452..
Cooper, N. and Lonsdale, D. (2004). Veteran Trees: a study in conservation motivation. ECOS: A Review of Conservation 25, 74-84.
Lonsdale, D. (2007). Current issues in arboricultural risk assessment and management. *Arboricultural Journal* **30**, 163-174.
Lonsdale, D., Pautasso, M. and Holdenrieder, O. (2008). Wood-decaying fungi in the forest: conservation needs and management options. *Eur J Forest Res* **127**,1–22.
Lonsdale, D. (2008). BS 3998 Recommendations for Tree Work: likely implications. *Arboricultural Journal* **31**, 19-31.