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THREATS

Tree Hazard: Risk Evaluation and Treatment System

A method for identifying, recording & managing
Hazards from trees

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To be read in conjunction with the THREATS pro forma, included at the end of this document

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1 Preamble

1.1 Development history

1.1.1 Work started on THREATS in 1998, when the author was engaged as a part-time highway tree surveyor/manager, on a consultancy basis. A need was identified early in this commission for a method of quantifying the risk posed by trees identified as having structural defects. This method had, so it was considered, to have several characteristics:

- It had to mirror and be in sympathy with typical tree assessment processes
- It had to record and analyse tree defects in such a way that it could be used for tree inspections without impeding data collection
- It had to offer consistency of approach, definition and outcome
- It had to stratify tree risk such that intervention could be programmed as to urgency, roughly according to: immediate, scheduled and deferred
- It had to be transparent and comprehensible to non-specialists

1.1.2 The framework was laid down based on a two-page data collection pro forma which:

- Recorded the fact of inspection
- Listed any observed defects
- Assessed the three components of tree risk (defect, target and impact – after Matheny & Clark (1994)¹)
- Contained an algorithm that provided for a relatively subtle interaction between these three components
- Arrived at a conclusion which was in tune with what could be termed ‘unassisted arboricultural decision making’ (aka gut instinct)
- Established a defensible hierarchy of response that included phased reinspection

1.1.3 Since its inception, THREATS has enjoyed several iterative amendments, chiefly based on feedback both from peer review (conducted in 2002 under the auspices of the Arboricultural Association), and from registered users of the method (who have always been encouraged to offer suggestions for improvement). However, it should be stressed that the framework and algorithm have not been altered since their inception: these aspects of THREATS are at its heart, they are what make it, in the author’s opinion, fit for purpose, and they have not been found wanting under increasingly extensive application over the past ten years.

1.1.4 The tenth anniversary of THREATS occurs this year (2008), and to mark this and also to update it in anticipation of BS8516 [2008], which has been co-authored by the designer of THREATS, the method has been renamed ‘Tree Hazard: Risk Evaluation and Treatment System’. In addition, it has also undergone a few minor amendments; however, its functionality remains as before.

1.2 Introduction

1.2.1 The THREATS method has been designed to offer all those who have responsibility for evaluating and managing trees a means of assessing them in a consistent fashion. THREATS also assists in determining the appropriate response to the level of identified risk.

1.2.2 THREATS can be applied in a number of ways, making it a versatile tool for tree managers:

- a) In its full form, most suited for smaller numbers of trees, THREATS is a detailed record of complaint and response; it can also be used in a compressed form to give Hazard Ratings as an extra data column in larger tree surveys (see part 3)
- b) It provides a framework for defining a defensible, phased response to identified defects, where the immediate rectification of all defects picked up by a survey is not always possible
- c) It can be used to reassure an anxious party that a tree is ‘undangerous’, or to demonstrate to a complacent party that a tree in fact is not, and that intervention is required

- d) It can be used as part of a desk study to prioritise tree inspections, by means of Target Zoning treed areas as type-diverse as large gardens, woodlands, country parks and even towns (see part 4)
- e) It can be used retrospective to a tree failure to assess foreseeability

1.2.3 THREATS takes established methodology for considering potential hazards from trees and puts this into a user-friendly framework by cross-referencing the factors that, in combination, define the level of hazard for any given tree defect. In order to achieve this, THREATS relies on craftsman-level arboricultural knowledge, in the form of familiarity with tree defects, together with an experienced-based assessment of the likelihood of any given defect actually failing for the tree being assessed. In this context, the species of tree and, where pathogens are present, host/agent combinations, are frequently important.

1.2.4 THREATS deliberately relates back to the authoritative work by Lonsdale (1999)². Any further clarification required as to the nature of tree defects and the likelihood of them failing should lead the enquirer directly to this book.

1.2.5 It is stressed that THREATS is not designed to provide 'The Answer' to the question of tree safety, and is not, therefore, a substitute for arboricultural judgement. Instead, it aims to offer a framework for systematically and consistently quantifying this judgement, allowing tree managers to arrive at their decisions through a logical, defensible and transparent process.

1.2.6 When the method was being constructed, the interaction between the Hazard Rating Calculation (THREATS section 7) and the Appropriate Response (section 8) was mapped out into 140 possible outcomes (5 x 7 x 4 possibilities). These were grouped into seven 'Threat Categories' that reflected, in the author's opinion, a satisfactory range of responses to any given outcome. In order for any derived set of possibilities to result in the 'correct' response (i.e. a response that matched up with unassisted arboricultural decision making), a weighting score was attached to each option within the three factors. Ensuring that this algorithm worked was beyond the author's limited mathematical capabilities, and was delegated to his wife (who is quite literally a rocket scientist (retired)).

1.3 Legal framework in the UK

This is well-trodden ground, so only the briefest of summaries is offered here³:

1.3.1 There is an obligation of reasonable safety owed by site owners both to visitors and to those adjacent to a site under the Occupiers' Liability Act 1957 (i.e. the principle of Duty of Care) and 1984, such that an occupier may be held liable for losses (physical harm to life and/or property) arising from an accident to a third party, where the cause of the accident was both reasonably foreseeable and reasonably preventable, bearing in mind all the circumstances pertaining to the situation.

1.3.2 A considerable body of case law has established that, in order to be in a position to foresee and indeed to prevent harm arising from a tree failure, it is necessary to subject the tree or trees in question to 'regular inspection', with this inspection undertaken by someone competent both to identify any defects present and to interpret their significance for public safety.

1.3.3 Regular inspection is a notoriously vague concept, with intervals applied ranging from every six months to five years. The author considers that the former is unworkable and the latter potentially ineffective. The definition that this author proposes is that:

'A tree should be inspected at a regularity that is appropriate to its condition, within its context, with a maximum interval between systematic expert inspections of five years where there is public access'⁴

For this definition to work in practice, and indeed for the occupier to discharge his Duty of Care at all, a baseline knowledge of the tree stock for any given site is essential.

2 Notes on applying the method

2.1 Completing the tree inspection record: PART I of THREATS

2.1.1 Survey details

This section serves as the log of complaint where a problem tree is reported to the tree manager, and/or a record of inspection, is a mix of desk- and fieldwork.

The 'surveyor details' box should be initialed on completion of the survey, as prompted, as well as having the surveyor's name and position recorded in full.

The 'origin...' box fixes the time of the incoming complaint, though it can also identify a more routine survey, such as "storm damage inspection".

The 'survey date & time' box effectively pegs the response time to the log of complaint; this should prompt the tree manager to consider carefully how urgent the complaint sounds...

The 'weather conditions' box notes the weather both at the time of the log of complaint, e.g. "strengthening wind", as well as when the tree is inspected.

'Other notes' should cover any other information provided by the complainant, such as "reports ground moving at base of tree".

2.1.2 Description of tree

'Owner...' & 'tree no...' are self-explanatory

'Location' could be "outside No.21 Acacia Avenue", a GPS waypoint reference (see section 3), a highway chainage and so on.

'Species' & 'age class' are self-explanatory.

'Size category' refers to the stem size bandings listed in section 6 of THREATS under 'Agents' (see 2.2.3).

2.1.3 Description of problems

The prompt in brackets tells the user how to deal with a tree that has more than one defect: all defects should be recorded, but the most hazardous one should be scored in Part II of THREATS. The list of defects is taken from Lonsdale (ibid.). Whilst it is hoped that the THREATS list is exhaustive, as with all the best pro forma there is an 'other' box provided.

It is important that every visible defect is recorded. However, the defect that requires the most urgent attention is the one that should be scored (first) in Part II (though of course any other defects that might be present should be considered for remediation at the same time).

The nature of the hazard from each defect is explained very briefly, to assist the user in his/her assessment of their significance. Identified defects should be flagged in the tick-boxes provided. Field use of THREATS suggests that it is helpful to record the precise nature of the defect(s) identified and also, at this stage, to suggest what target might be vulnerable should the defect(s) fail, hence the notation space provided.

This section completes the written tree inspection record and could, if required, stand alone.

2.2 Performing the Risk Evaluation Sum: PART II of THREATS

The Note is of critical importance: the given examples are just that and **must not** be treated as a substitute for good judgement based upon sound arboricultural knowledge.

2.2.1 Failure Score

The prompt directs the user to consider known data on relative vulnerability of tree species to failure from observed defects, as well as the possibility of seasonal pre-disposing factors.

Examples of the former would include the differing persistence of dead wood on pedunculate oak (*Quercus robur* L.) and common ash (*Fraxinus excelsior* L.), and examples of the latter would include humidity during the high photosynthetic period (as an agent involved in summer branch drop), and autumnal gales (storm damage, windthrow, etc).

Thus a horse chestnut (*Aesculus hippocastanum* L.) with a heavily end-loaded limb surveyed in December might require a different entry in the 'Likelihood of failure' range than would the same tree if inspected in May.

Also important at this stage is a consideration of failure criteria, such as *t:r* ratio⁵. Where the tree's condition relative to failure criteria has yet to be established, the assessor should err on the side of caution (though overreaction to uncertainty should be avoided).

When considering 'Likelihood of failure', it is important to bear in mind two (almost) conflicting issues:

- Defects that might appear at risk of impending collapse often remain sound for years
- As well as the protection of life and property, another purpose of the survey is frequently to protect owner liability: the user should not take unnecessary chances – an identified defect is a 'foreseeable danger'

The numerical weighting of the score for each failure category gives an indication as to the approach required. The user should reserve 'Imminent/Immediate' for only the most hair-raising of defects, as suggested in the examples given.

The failure category 'Probable/Soon' might seem to cover many tree defects, though actually it should be reserved only for clearly identified ones. This is where the oak/ash deadwood example is useful: on pedunculate oak it is not usually 'probable' that dead wood will detach 'soon', this process generally takes years and frequently occurs by a piecemeal crumbling from the branch tip, and bark and sapwood disintegration to leave a robust desiccated heartwood spar. Ash trees, of course, shed their dead wood much more readily, and thus it *is* 'probable' that dead wood recorded on ash will detach 'soon'.

The failure category 'Likely, foreseeable' is the one that field use suggests most often applies to tree defects, and it is designed to reflect a failure timeline in the two- to three-year range.

'Potentially with time' covers emergent defects that are slow to become hazards. A good example of this is given as 'robust dead wood', where we are thinking of pedunculate oak again.

'Unlikely ever' is a category that becomes increasingly used the more trees one surveys with THREATS...

The important issues to consider are:

- How far advanced is the defect? (Returning to our dead oak branch, it may indeed take many years to shed, but this tree inspection may be taking place years towards the end of that period)
- How frequently and why do trees of various species, or their constituent parts, actually fail, and where does the identified defect fit into this dataset?
- How does the defect relate to established failure criteria? If this is not known and cannot be established by visual inspection alone, then the correct 'Control Measure' selection (see 2.3.1) will often be 'Further investigation'

Again, sound arboricultural judgement is essential in making the appropriate selection, and in avoiding either complacency or over-reaction.

2.2.2 Target Score

There are two prompts here:

- The first is a reminder that, for example, the now well-known dead oak branch is unlikely to hit a target far outside its vertical drop zone (though the possibility of ricochet off other branches should not be ignored)
- The second prompt is designed to highlight cases where people are at elevated risk: those 'trapped' in cars or unsighted whilst driving, the relative naivety of children to danger, whereby a higher Duty of Care pertains to them⁶, and those whose physical or mental functions are impaired, with a consequent decline in their ability to be aware of or to react to/evade imminent danger. THREATS addresses this by upgrading any given target value by one level if, for example, unsupervised children are likely to be the human component of the target. A little common sense is necessary here: children ubiquitously traveling in cars, for example, would not warrant a rise in the target value of a road

The targets are divided into two groups: Static and Target Occupancy. This is designed to help the user to identify the appropriate Target Score and has been field tested quite exhaustively.

- The 'Static target examples' presuppose a cross-reference between the monetary value of the structure and the presence of people. This would not always be the case, so these examples should be used with some caution: a park bench is a low-cost item, but it may be that the one under consideration is frequently occupied by old ladies feeding squirrels
- The 'Target Occupancy examples' are included to guide the user through the park bench dilemma: the bench is properly scored as a low-cost item, rating a '7', but the old ladies would probably rate '20' (or perhaps '25' if very persistent), being 'frequent use' and 'constant traffic- pedestrian' respectively. With this example of course, the Control Measure would probably be the relocation of the bench

2.2.3 Impact Score

The prompt is designed to help the user focus on the actuality of the impact potential of any given defect, once failed. For example, an unstable tree adjacent to a busy highway is obviously less hazardous if it leans heavily over the adjoining field, than the same tree would be if it inclined the other way.

The list of 'Agents' has been re-worked several times but ultimately, in the author's view, remains somewhat unsatisfactory: attempting to equate tree size with limb size is unavoidably problematic, though it is considered necessary to try. As such, this list represents the best iteration to date and the author would welcome any suggestions for improvement.

The agent to be scored will be either a whole tree or a part of the crown (single branches included), so the surveyor should use either the stem size millimeter range (estimated at 1.5m above ground level), or the approximate weight of the vulnerable section.

Because of this difficulty, more so than with the two sections above the examples listed under 'Degree of harm' are a good guide as to the appropriate Score, though care is needed to avoid over-reacting to the possibility of fluke injuries. In this connection, the user should remember that Duty of Care is discharged by mitigating 'reasonably foreseeable' dangers.

The impact score is necessarily weighted to give low importance to a 'recoverable injury': the point being that a balance should be struck between the retention of desirable trees with public safety. Whilst the thought of a collapsing tree injuring or killing someone should give the surveyor pause, the possibility of a minor injury ought not to lead to mistimed intervention: especially in large, district-wide surveys, not all defects identified can be remediated at the same time.

2.2.4 Risk Evaluation Sum

This is the heart of the THREATS method: by mirroring the established decision making process employed by arboriculturists, the method takes the three scores from sections 4-6 to transform the surveyor's arboricultural judgement concerning the relative safety of a tree into a number capable of further manipulation.

2.3 Implementing Control Measures: PART III of THREATS

2.3.1 Appropriate Response

Very simply, the number derived above is compared with the 'Score range' column to arrive at a Threat Category: this is the ultimate goal of THREATS, and providing the user with a quantified assessment of the risk.

The 'Threat Categories' are both numbered and described, so one might refer equally to a Category 3 tree, or to the same tree posing a 'Slight' threat. The word description is designed to give the user a convenient means of defining the risk to a non-specialist. Users report that this is a very helpful feature.

The 'Action Required' is deliberately prescriptive: too often unsafe trees are not afforded the intervention priority that they require to discharge Duty of Care (usually for fiscal reasons). The balance between intervention and deferred action through reinspection shifts from the lower end of the scale where it restrains over-reaction, to the higher end where it requires a decisive response.

Occasionally, typically when first using THREATS, the user discovers on cross-referencing the Hazard Rating with the Threat Category, that an 'Action Required' seems at odds with his/her expectation. Repeated field-testing has suggested that this is due to an incorrect category assignment in Part II and not a flaw in the algorithm itself. Accordingly, if the derived outcome fails to match gut instinct, it is necessary to recheck the assigned categories to see which one has been incorrectly attributed. In any event, if disagreement persists the author always recommends following the latter (though currently there are no instances of this reported from practiced users).

At the lower end of the scale where, of course, by far the majority of trees are found, THREATS guides the user towards a more routine approach to Control Measures. However, THREATS stresses the need to reinspect a defective tree following circumstances that might cause its condition to deteriorate. The obvious example of this is high wind speeds, and THREATS suggests what response should be appropriate following strong winds of different velocities, listed according to the Beaufort Scale (see Table 1).

Table 1: Beaufort Scale, Specification on Land⁷



The Beaufort Scale was originally developed for the Royal navy in 1805 (by one captain Francis Beaufort) and was adapted for use by 'land-based observers' in 1906. As can be seen from the descriptions in Table 1, the land version relies on the behaviour of trees under wind action (instead of on waves), such that, at higher wind speeds, the observations define failure thresholds. The UK Meteorological Office uses the land version of the Beaufort Scale in issuing severe weather warnings to predict the likely level of damage from forecasted high winds. Thus the Beaufort Scale can be used to identify a measure of foreseeability of tree failure.

Concerning reinspection and possible future work to a tree, it is important to realise that the first time a tree is assessed using THREATS is not necessarily the last: in other words, a defect can and potentially should be re-evaluated at each successive regular inspection. By this means, the deferring of intervention, as opposed to reinspection, can be rolled on such that a defect may never, in fact, reach the state where intervention is required during the life of the tree. This recognizes the fact that trees exist on a very different timescale to people: what might appear a defect with, for example, a three-year critical time, in reality might never require remediation. By using THREATS, the surveyor is given a framework that justifies doing nothing.

In this way, hazard tree mitigation can be systematised towards proactive intervention based on necessity, rather than either the ‘fire brigade tactics’ of reactive response, or the frequently wasteful policy of cyclic pruning regardless of need.

2.3.2 Outline of Work Required

The prompt is designed to make the user consider the suitability of non-arboricultural solutions: can the target score of the old ladies’ park bench be reduced, preferably to zero, by relocating it? The suggestions for remedial measures are not in any way intended to cover all the options, but merely to offer a few possibilities. In fact, no formal attempt has been made to tie this section into the method as a whole, as individual tree problems demand tailored solutions. Notation space is provided so that the surveyor can enter a more detailed description of the necessary work.

However, the practiced user will soon develop a correlation between the nature of the defect and the work required. Indeed, someone ticking the ‘Tree removal’ box having scored only an end-loaded limb should look again! The main intention of this section is to show how the level of tree work should be graded, with wholesale removal clearly identified as the measure of last resort.

It may be that more than one defect was originally identified: where this is the case, it may be advisable to score other defects using THREATS, as a guide to whether it is appropriate to prescribe additional treatments while the contractors are on site.

3 Threats as Part of Large Scale Tree Surveys

3.1 Up to now, we have examined THREATS as a stand-alone method for assessing individual trees, and it is obvious that the use of the full pro forma for a tree survey covering numerous specimens would be cumbersome. However, THREATS can readily be adapted for large survey use. By producing a laminated (i.e. all-weather) version of PART II & III for ready reference, the surveyor can ‘score’ each tree, adding the ‘Hazard Rating’ and ‘Threat Category’ to any existing tree survey data sheet pro forma as extra columns.

3.2 ‘Action required’ and the ‘Priority’ for this would, in any case, be standard columns in any tree safety survey (albeit perhaps under different headings). The advantage of using THREATS in this context is that outcomes in the method provide a guide as to the appropriate entries in the columns that deal with recommended treatments and priority. For these reasons, the author and other THREATS users have found large tree surveys to be the most useful application of THREATS to date. In fact, practiced users find that the method actually speeds up the decision-making process and takes if anything less time than surveying without it.

3.3 Finally, local authorities who have used THREATS for district-wide safety surveys can benchmark the effectiveness of their tree risk management regime by comparing total accrued and/or hazard ratings every five years (the recommended interval for baseline inspections). This is a helpful tool when approaching considerations of Best Value.

4 Threats as Part of a Desk Study: Target Zoning & Tree Inspection Priorities

Even where the existing level of knowledge of the tree stock's condition is low (and likewise, perhaps, the resources for its inspection), THREATS can assist in the prioritizing of tree inspections, and can do so in two ways:

4.1 By considering the Target Score

The tree manager can evaluate his area of responsibility in the context of varied target value. At the larger scale this will be a fairly blunt tool, but even so a useful one. By referring to the target examples, and producing one's own list tailored to the locality, it is possible to arrive at a prioritised schedule of areas for inspection.

4.2 By considering the Impact Score

Cross-referencing known size of any trees present with their locations can further prioritise the inspections: clearly the damage potential from young *Sorbus* is much lower than from mature *Platanus*, and even in areas where baseline knowledge of the stock is low managers usually have *some* idea of the nature of the population.

4.3 Example

Based on these factors, a THREATS-prioritised list for a locality could look something like this:

- a) Various mature trees adjacent to playground
- b) Raywood ash avenue along dual carriageway
- c) Lapsed pollards in pedestrian precinct
- d) Mixed age/species planting in hospital grounds
- e) Several mature horse chestnuts in public parks
- f) 30-40 year old trees at lower school
- g) Mature pines lining roads in Victorian residential district
- h) Trees flanking cycle-way through park
- i) Area of woodland designated as a Public Open Space

5 Conclusions

5.1 THREATS has been designed as a way of utilizing existing arboricultural knowledge, not replacing it. Essentially, THREATS is therefore a codification of gut instinct, a basic tool that tree managers use every day.

5.2 THREATS is a consistent, logical and transparent way of standardizing the assessment of tree risk, and in describing that risk to non-specialists. It will also assist the tree manager in justifying works budgets.

5.3 THREATS restrains over-reaction to some hazards, whilst demanding a rapid response for others. As such, it can highlight a dangerously slow response, hopefully in time to put in place the necessary control measures.

5.4 THREATS is an evolving system and no doubt it will continue to be subject to occasional minor alterations. However, at its core is an algorithm that works: THREATS is fit for purpose in its present form.

5.5 The most important letter in THREATS is the 'S' for 'System': having a system in place is essential to enable Duty of Care to be discharged.

Note

The publication of the full THREATS pro forma as an adjunct to this article marks its free release into the public domain, thereby ending the licensed release which operated until 2006. Whilst competent arboriculturists are encouraged to try the method for themselves, the author and Forbes-Laird Arboricultural Consultancy Ltd wish to stress that they accept no responsibility whatsoever for any consequences arising, whether directly or indirectly, from management decisions arrived at using the method.

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References

- 1 'A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas', NP Matheny & JR Clark, ISA Books 1994
- 2 'Principles of Tree Hazard Assessment & Management', Dr D Lonsdale, TSO 1999
- 3 For further reading see 'The Law of Trees, Forests & Hedgerows', Charles Mynors, Sweet & Maxwell 2002*
- 4 Definition provided by the author; see also BS8516 [:2008] 'Recommendations for Tree Safety Inspection'
- 5 'The Body Language of Trees', C Mattheck & H Breloer, TSO 1994
- 6 Mynors, op. cit. p. 142ff
- 7 Revised from the original by George Simpson, 1906

* BS8516 is likely to contain a summary of the legal context of tree safety inspection at Annex A