The Quantified Tree Risk Assessment (QTRA) System
A New Approach to Tree Safety Management

Developed by UK arborist Mike Ellison, QTRA is being brought to Australia and Singapore in November 2006 when training workshops are planned for Brisbane, Melbourne, Perth, Sydney and Singapore.

Historically, arborists have been relied upon to make judgements about the safety of trees. The tree owner or manager's expectation is often that the arborist will provide a definitive opinion as to whether or not trees are safe. Arborists seem to accept this position and often yield to the demands of clients and lawyers by stating that "this tree is safe", "that tree is unsafe." Would a doctor assure you that you will not become ill this year, or a motor engineer that your car won't be involved in an accident? No, of course not. There are degrees of risk and benefit associated with trees as there are with other health and safety issues and trees can seldom be described as either safe or unsafe.

How then do arborists avoid making unqualified judgements on tree safety? All arborists must provide guidance to clients but without a method of measuring the comparative risks from tree failure, advice is likely to err heavily on the side of caution and result in unnecessary tree removal or other remedial measures.

For a tree-failure hazard to exist there must be potential for failure of the tree, and potential for injury or damage to result. Many tree owners and managers have no policies or procedures for the management of tree safety and react to only the most extreme situations as they arise. Others do nothing more than clear fallen trees. At the other end of the scale, owners' set large budgets for tree safety management that may be disproportionate to the risks being managed. Some managers rely on the subjective judgement of a succession of arborists who each in turn recommend work with a view to being seen to be doing something. The issue that the tree manager should address is the likelihood, or risk, of a combination of factors resulting in harm, and the likely severity of harm.

QTRA presents a new opportunity to apply tree safety management resources to a structured risk assessment program. Starting with an overview of land use and tree distribution, classified by gross features such as age class and species, we can prioritise risk assessments and refine them to greatest effect according to the availability of resources.

Balancing Risks with Benefits

There is often a need to reconcile different management objectives, especially in populations, which include old structurally unstable trees. As trees age, they increasingly develop features that might compromise their mechanical integrity whilst at the same time providing increasingly diverse wildlife habitats and visual interest. A large proportion of higher value habitat trees occur in rural areas, but there are also many on the streets of our towns and in gardens, churchyards and city parks.

It is necessary to maintain a balance between the benefits of risk reduction and the potential loss of amenity and other tree related benefits.

Do we have Reasonable Expectations of Tree Safety Management?

Property owners and managers, from single householders to municipalities, have a duty of care under the laws of most developed countries to ensure that people and property are not exposed to unreasonable levels of risk from the failure of their trees.

To provide an adequate defence in the event of harm resulting from tree failure, it is usually necessary to demonstrate that you have not been negligent and have acted reasonably in the management of your trees and that you have thus discharged your duty of care. In most circumstances, to do absolutely nothing is probably unreasonable. Conversely to throw money at tree safety management is usually unnecessary. Tree managers are generally expected to manage risks associated with trees to maintain them as low as is reasonably practicable.

The concept of 'Reasonable Practicability' is embodied in English law. In essence, 'Reasonable Practicability' is the principle of doing as much or as little as a reasonable person might be expected to do in any particular circumstances. If an owner or manager establishes that a risk is small, but that the measures necessary to reduce or eliminate it are great, he or she may be held to be exonerated from taking steps to reduce or eliminate the risk on the ground that it was not reasonably practicable to do so.

In respect of trees, the concept of 'Reasonable Practicability' can be embraced by considering together the degrees of both risks and benefits associated with trees. Paine (1971) wrote, "It is high time we admit that we cannot achieve complete safety – and still provide a desirable product – any more than industry can". This statement captured the essence of 'Reasonable Practicability' and holds true to the present day. It is time to acknowledge that tree safety management should not require us to minimise the risks associated with trees or to make unsupportable or unqualified statements such as 'this tree is safe' or 'that tree is unsafe'. Instead, risk of harm from tree failure should be managed at acceptable levels whilst maintaining the multitude of tree benefits.

Acceptable Risk

We are constantly exposed to and accept or reject risks of varying degrees. For example, if we desire the convenience of electric lighting, we must accept a low risk of electrocution or fires; this is an everyday risk taken and accepted by millions of people.

Having considered The British Medical Association Guide "Living with Risk" (Henderson 1987) and with particular reference to the conclusion "few people would commit their own resources to reduce an annual risk of death that was already as low as 1/10,000", Helliwell (1990) suggests that 1/10,000 might be a suitable figure to start with as a limit of acceptable risk. To put the 1/10,000 risk of significant harm into perspective, table 1 is reproduced from the British Medical Association Guide and illustrates the risk of death (in 1987) from a range of hazards.

Activity	Risk of an individual dying in any one year (UK)
Smoking 10 cigarettes a day	1 in 200
Influenza	1 in 500
Road accident	1 in 8,000
Playing football	1 in 25,000
Accident at home	1 in 26,000
Accident at work	1 in 43,000
Hit by lighting	1 in 10,000,000
Release of radiation from nearby nuclear power station	1 in 10,000,000

Table 1. ("Living with Risk", British Medical Association, 1987)

Quantified Tree Risk Assessment

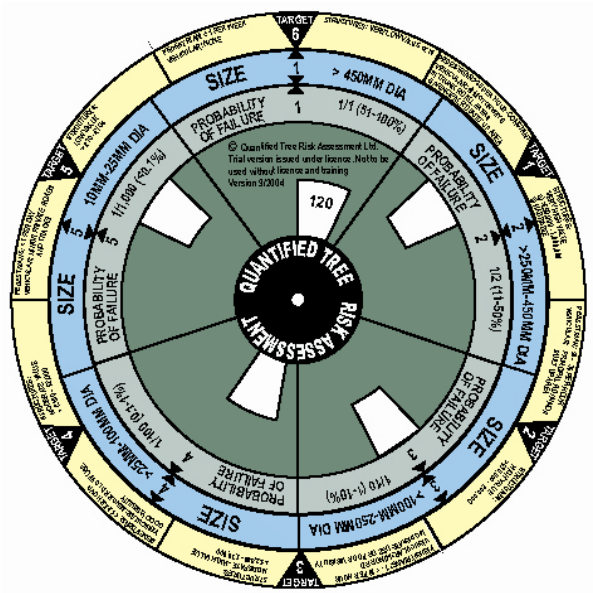
QTRA is a probabilistic method of assessing the risk of significant harm from the mechanical failure of trees and expands concepts proposed by Paine (1971), Helliwell (1990, 1991) and Matheny and Clark (1994). QTRA provides a framework for the assessment of the three components of tree-failure risk – Target Value, Probability of Failure and Impact Potential. By first assessing the value or usage of targets upon which trees might fail, tree owners and site managers can establish whether or not and at what degree of rigour tree surveys are required. Where necessary, trees are then considered in terms of both impact potential (size) and probability of failure. Values derived for these three components are then multiplied together and their product is the probability of death or significant harm.

Tree managers should consider first the usage of the land on which trees stand and this in turn will inform the assessment of the trees themselves. Common sense tells us that a large unstable tree located in a remote wilderness might represent a very low risk of harm to people and property but as the interface between trees and human activity becomes more intimate, the risk of harm from tree failure will increase. QTRA measures harm from tree failure in terms of loss of life or serious injury, or as monetary loss from damage to property.

QTRA moves the management of tree safety away from considering trees as either "safe" or "unsafe" and eliminates the need for such definitive judgements by tree surveyors or managers. QTRA is used to quantify the risk of significant harm from tree failure in a way that enables tree managers to operate to a predetermined limit of reasonable or acceptable risk. The system proposes adoption of 1/10,000 as a reasonable limit of acceptable risk from tree failure, although a property owner or manager might choose to operate to a higher or lower level.

Calculating the Risk of Harm

Target Evaluation. A target is anything of value, which could be harmed in the event of tree failure. Target value is the most significant and most easily quantified component of the assessment. Using QTRA we evaluate the nature of the targets within a survey area before assessing trees. This approach provides a justifiable method for the prioritisation of tree surveys.



To simplify practical field assessment, a calculator (Fig. 1) has been developed to calculate the product of the three component probabilities. Having assessed the target and the hazard, the three component probabilities are selected from the ranges 1-6 on the calculator and the three vanes are aligned to display the result in a window. The result is termed the 'Risk Index,' (one thousandth of the reciprocal of overall probability). For example, if Risk Index is 10, the risk of harm is 1/10,000 (10,000/1,000). Alternatively, a digital calculator has been developed for use on a PC or with data capture devices.

Often the nature of a defect is such that the probability of failure is greater during windy weather, whilst the probability of the site being occupied during such weather conditions is considerably reduced, e.g. woodland, park or private garden. Weather conditions may be so extreme that the risk of harm from the failure of not only trees but the collapse of buildings and other storm related hazards is such that to venture out at all would be foolhardy. QTRA includes a facility for considering this scenario.

Impact Potential. The system categorises impact potential by the diameter of tree stems and branches. An equation derived from weights of trees of different stem diameters is used to produce a data set of comparative weight estimates of trees ranging from 10 to 600 mm diameter. The system uses a fraction of the weight of the 600 mm diameter tree in calculating probability of harm. Expressed in this way, a 10mm diameter tree is 1/23,505 and a 250mm tree is 1/8.6 of a 600mm diameter tree.

Probability of Failure. Accurately assessing the probability that a tree or branch will fail is highly dependant upon the skill and experience of the assessor. Having assessed the tree, the assessor visualises 10,000, 1,000, 100, or 10 similar trees in a similar environment and estimates how many would be likely to fail during the coming year.

QTRA significantly reduces the influence of assessor subjectivity upon the outcome of the risk assessment and applies a robust structure to the assessment procedure, requiring detailed assessment of the tree only where there is a significant likelihood of unacceptable risk.

Training

To ensure, insofar as practicable, that the value of the system is maintained through consistent application, training and ongoing development through a licensing programme is being developed in the United Kingdom.

Examples

Example 1

A highly unstable English oak (*Quercus robur*), stem diameter 900mm, in a low use area of woodland. The most significant part likely to strike the target area is the stem or part of the crown with the weight of the whole tree behind it.

	Target Value		Impact Potential		Probability of Failure		Risk of Harm
Probability Ratio	1/120,960	x	1/1	x	1/1	=	1/120,960

The absence of structures and the very low level of public access indicate that detailed assessment of the tree is not essential. If it could be established that pedestrians are 10 times less likely to visit the woodland in very windy weather, when failure is most likely, the overall probability of harm could be reduced to 1/1,209,600.

Example 2a

(before remedial action)

A mature beech (*Fagus sylvatica*) overhanging a minor road of moderate use. The crown of the tree contains long unstable dead branches up to 100mm (4") diameter. The most significant part likely to strike the target area is dead branchwood up to 100mm diameter.

	Target Value		Impact Potential		Probability of Failure		Risk of Harm
Probability Ratio	1/72	x	1/82	x	1/1	=	1/5,904

Removal of dead branches greater than 50mm (2") diameter overhanging the target should reduce the risk to an acceptable level. We might also consider the reduced mass of the dead branches (see example 3).

Example 2b *(after remedial action)*

	Target Value		Impact Potential		Probability of Failure		Risk of Harm
Probability Ratio	1/72	x	1/450	x	1/1	=	1/32,400

Example 3.

A mature sycamore (*Acer pseudoplatanus*) with a dead branch of 250mm dia. overhanging a thoroughfare with pedestrian occupancy of 9 per hour. The most significant part likely to strike the target is the 250mm dia. dead branch

	Target Value		Impact Potential		Probability of Failure		Risk of Harm
Probability Ratio	1/72	x	1/8.6	x	1/10	=	1/6,192

However, by shedding subordinate branches, the dead branch has degraded to less than half of its original mass. To reflect a mass reduced to 50% or less, the Risk Index 6.19 is multiplied by 2 to produce a revised Risk Index of 12.38 (Risk of Harm 1/12,380).

For further information please refer to Ellison (2005).

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