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Preventing death and serious injury from falling trees and branches.

Andrew Brookes

La Trobe University, Bendigo

Abstract

Of 128 outdoor education related deaths examined since 1960, 14 have been due to falling trees or branches. This article examines the grounds on which death or serious injury due to falling trees or branches can be regarded as an inherent risk in outdoor education, and the extent to which such incidents can be regarded as preventible. It compares alternative approaches to prevention, and draws conclusions about how best to reduce the risk in the future.

Introduction

Of the 128 outdoor education related deaths since 1960 that I have studied (Brookes, 2003a, 2007), 14 have been due to falling trees or branches – about 11%. Of the 17 deaths that have occurred at the time of writing since January 2000, 5 (29%) have been due to falling trees or branches. While this much higher proportion of the recent deaths is almost certainly random, the recent cluster of incidents has served to highlight the potential danger of activities in treed areas. In this article I examine the grounds on which death or serious injury due to falling trees or branches can be regarded as an unavoidable inherent risk[1] in outdoor education, and the extent to which such incidents can be regarded as preventible. I consider alternative approaches to prevention, and conclude how best to reduce the risk in the future.

This study draws on my previous study of fatal incidences (Brookes, 2003a, 2003b, 2004, 2007), and examines additional incidents not associated with schools found by a literature search. Table 1 lists school and youth group related deaths due to falling trees and branches since 1960. The list is almost certainly incomplete, especially for incidents prior to about 1990[2]. Table 2 lists incidents in Tasmanian forestry operations between 1987 and 1995. Table 3 lists some reported deaths and serious injuries from trees in NSW and Victoria since 1998, excluding the outdoor education related incidents, derived from news reports, and two incidents from WA. This table is also probably not complete, and so provides information on certain incidents, but not on accident rates.

Incident patterns

Preventing fatal incidents around trees depends on the ability to determine what circumstances have been linked to fatal incidents in the past. Examining a set of incidents for patterns can throw some light on these patterns of circumstance. If there is no pattern, the events can be considered random without further investigation, and therefore part and parcel of being around trees.

Only a small number of incidents seem to be attributable without further discussion to an inherent risk around trees. Two of the 45 incidents considered involved a tree or branch falling on a windless day and striking a person or vehicle that just happened to be passing at that moment. In areas where there are too many trees for a landowner or manager to be reasonably expected to assess and remove all hazardous trees, such incidents could be prevented only by avoiding all trees of any size, including those that line roadsides. The incidents at Steavenson Falls in 1968 (Table 1) and near Port Macquarie in December 2004 (Table 2) fit this category. It is no great insight that there is some inherent risk around trees, which after all balance or suspend tonnes of material overhead, much of which eventually falls. What might be surprising is how few incidents can be readily attributed solely to this inherent risk, without the inclusion of some more specific, and therefore possibly more avoidable, circumstance.

Deaths related to forestry or similar activities such as land clearing were overwhelming related to the activity, rather than just the environment. It is evident that any inherent risk due to being around trees is small, if not tiny, compared to the risks of forestry and related activities. While it is obvious that pushing over or cutting down trees is more dangerous than leaving

[1] By inherent risk I mean a risk that is part and parcel of (in this case) proximity to trees, which cannot be reduced without avoiding all large trees.

[2] Post about 1990 many newspaper archives can be search electronically. Prior to that microfilms have to be scanned, a process which is too time-consuming without some prior knowledge that an incident occurred about a certain time.

Table 1. Outdoor education related fatalities.

Incident	Deaths	Date	Location	Institution	Brief description	Weather W Tree health or structure H Tent T	News ref.
Steavenson Falls 1968	M19 M18 F15 F13	9/1 1968	Steavenson Falls, Marysville Vic.	Group of seven teenagers	Party of 7 teenagers bushwalking on well-used track on steep slope. Top of Mountain Ash snapped off (no wind) 12m up. Broken section, 1m in diameter, broke on impact and rolled down the hill, killing 4 and injuring 3.	H Inherent Risk?	Herald 9/1/68 p.1 final ed.
Two Scouts Track 1975	M16 M16	19/9 1975	Towimbuk State Forest, Bunyip Vic.	Scouts	Group of 6 Venturer scouts bushwalking (Armstrong 500 competition). Light wind. Tree (23m 2.2 girth) fell across a tent, killed both occupants.	H T	Sun 22/9/75 p.5
Meander Falls 1993	M17 M38*	17/8/1993	Meander Falls TAS	Hellyer College	5 students, 2 teachers, bushwalk in forest. Severe weather, very high winds. Tree snapped at base, fatally injuring 1 student 1 teacher. Remaining teacher injured, students went for help.	W	Hobart Mercury 19/8/1993 1st ed. p.1
Rowallan 1998	M12	11/9 1998	Rowallan Camp, Riddells Creek, Vic.	Scouts	7 scouts asleep in tents (150 at camp). 3m Stringybark branch fell on tent, 1 killed, 1 injured (broken leg). Heavy rain after dry spell.	W T	Sunday Herald Sun 13/9/98 p.3 ed.3
Crosslands Reserve 2001	F15 F15	3/12 2001	Crosslands Reserve, Hornsby Heights NSW	William Clarke College	10 adults, 39 students. Camping, severe storm. 15 m branch fell from 5m onto tent. 2 occupants killed, 2 survived. D of E expedition. Unclear if adults present at the time.	W T	Daily telegraph 5/12/01 p.9 ed.1
Carnarvon Gorge 2002	F?*	23/10 2002	Carnarvon Gorge, QLD	Urangan State High School	3 teachers 52 students on music camp. Large eucalyptus tree fell on group swimming. 1 teacher killed, 2 students injured.		Age 24/10/02 p.6
Wombeyan 2005	F16	2/2/2005	Wombeyan Caves area, 15km west of Mittagong, NSW	Queenwood (Sydney) (Wombaroo Adventure Centre)	Wilderness component of whole school camp. 16 yo leading 15 year-8 girls, supervised by teacher and 1 camp staff. Severe storm, large tree fell on tent, 1 killed, 1 survived.	W T	Sydney Morning Herald 3/2/05 p. 3. Coronial findings.
McKillops Bridge 2005	F16	31/8/2005	McKillops Bridge Vic	Toorak College/The Outdoor Education Group	11 female students, with one teacher and two OEG staff on first night of rafting trip. Camped in forest day use area. Severe weather, very high winds, tree twisted and broke onto tents around 1.45 am, killing one, others uninjured. Staff had sat phone but had not accessed severe weather warning information. Police contacted 3.25 am.	W T	The Age 1/9/2005 p.1 Coronial findings.

them alone, it is interesting that the activity is so prominent. By comparison, in outdoor education *environmental* circumstances are usually a more important consideration for fatality prevention than activity related factors (although the two categories clearly overlap) (Brookes, 2004). Except for outdoor education programs that involve forestry or land clearing operations, the forestry related incidents could therefore be considered as a separate category[3]. However, these incidents (in Tables 2 and 3) do provide one more insight:

Experienced and inexperienced forestry workers alike were victims of forestry related incidents. Several workers killed (Table 2) appear to be older, more experienced workers (most victims seem to be male, which I assume is because there have been more male workers in that industry). The ages of the victims appear to be fairly evenly spread, which might indicate that some risks associated with forestry-type operations are

[3] *I have not found incidents involving tree climbing, using trees for belays, or swings attached to trees.*

Table 2. Fatal incidents in Tasmanian forestry operations 1987 – 95 (Tuffin, 1996).

Date	Incident
June 16, 1987	19-year-old feller hit on head and killed by limb from damaged standing tree.
June 19, 1987	25-year-old feller found on ground behind fall line of tree. Believed struck by falling limb.
June 20, 1988	63-year-old truck driver was killed when a log rolled off a landing.
July 12, 1988	46-year-old truck driver killed when two logs rolled off load while he was removing the load-binder chains.
July 28, 1988	21-year-old feller killed when excavator operator felled tree the wrong way.
August 3, 1989	43-year-old commercial firewood cutter killed when a ``stag'' (unproductive tree) he was felling fell backwards.
August 15, 1989	log skidder driver killed when log fell on him.
February 5, 1990	47-year-old self-employed contractor died after being struck by the limb of a tree he was felling.
March 6, 1990	trainee practising on stump downhill from where trainer and fellow trainee were felling tree. Trainee struck on head.
October 30, 1990	34-year-old commercial woodcutter killed instantly when struck by tree limb.
February 6, 1991	60-year-old feller attempted to bring down wattle lodged in a standing tree by felling another tree across its stem. The falling tree slid down wattle stem and struck feller, causing fatal injuries.
February 16, 1991	13-year-old boy struck on the head by logs that fell from a truck when he was trying to bind load.
August 8, 1992	tree fell about 90 degrees to the intended line of fall, and struck a second feller 23 metres away.
April 19, 1993	40-year-old forest worker crushed by a rolling log on a log stack.
June 7, 1993	34-year-old truck driver fatally injured when log rolled off load as he was removing binder chains.
June 8, 1993	experienced bushman killed instantly when struck by a stag which fell backwards after contacting the tree he was felling.
July 19, 1993	feller hit on the head by a green branch which broke from the tree he was felling.
January 6, 1995	skidder driver killed when he was struck by a log which moved while he was hooking it to the skidder.
August 22, 1995	49-year-old feller killed when a stag crashed to the ground unexpectedly.

unavoidable, even with experience. It is also possible that experience on its own is not sufficient to avoid incidents that usually *don't* happen (something that might also apply to outdoor education) – experience can positively reinforce practices with a latent fatality risk[4]. Experience and knowledge need not automatically be directed at fatality prevention – it might be used for other ends, or not used at all. Especially in circumstances in which there is production pressure, experience might be used to produce more while maintaining a constant safety margin, rather than to produce the same with an improved safety margin (Perrow, 1999). Outdoor educators cannot be assumed to automatically become safer with more experience, for the same reasons.

Fires can render trees hazardous. The three fire-related deaths were all of fire-fighters; I assume outdoor education groups would try to avoid fires. However, fires may damage trees and leave a lingering hazard, although none of the deaths I examined were attributed to previous fire damage.

It seems reasonable to now separate incidents related to forestry-type work and fire fighting from other incidents, which I will refer to as outdoor education/recreation, because there are important differences. It is possible that prevention of certain kinds of incidents – trees falling on individuals resting or camping, or those due to severe weather – have been effectively prevented in forestry and related incidents, but that would be a matter for another study. Certainly trees sometimes fall on people who happen to be forestry workers[5]. Two documents I consulted (Workcover NSW, 2002; Worksafe Victoria, 2001) refer to suspending operations in high winds, and to the provision of safe rest areas, but not in any detail[6].

Turning to the incidents more directly relevant to outdoor education / recreation:

About half outdoor education/recreation related deaths occurred when a tree or branch fell on a tent. Five of the eight outdoor education-related incidents involved a tree or branch falling on an occupied tent. Table 3

[4] Most fatal incidents involving experienced groups or organizations involve something that is usually free from tragedy. Reading through many reports of tragedies, which often report a reaction from organisers, it is my impression that some kind of statement that a program has been running a certain way/in a certain place a long time without incident is second only to references to "freak accidents" that "no body could have predicted" in frequency.

[5] See Forestry men hurt as tree falls on cars (No author, 2003).

[6] Borderline weather conditions would be one circumstance where productivity and safety might be in conflict in forestry related activities. I did not delve into this; wind and weather might have been more significant than I allowed.

Table 3. Some deaths and injuries from falling trees and branches in NSW and Victoria.

Date	Deaths or injuries and brief description	Place	Weather W Tree health or structure H Tent T	News reference
15/10/1988	*Tree fell on water tanker killing firefighter male 35 yo.*	*Audley Weir, Royal National Park*	*Fire damage?*	*Sydney Morning Herald, 16/10/88, p. 4*
14/08/1993	Tree fell killing man (?age) and injuring woman 30 during storm 100 kmh winds. Later awarded damages against Department of Natural Resources and Environment, award of damages reversed on appeal.	Toorongo Falls	W	The Age, 15/08/93 p. 1, The Age, 30/03/2000 p. 8
4/01/1994	*Volunteer firefighter male 53 yo killed, 4 others injured by falling tree during mop up operations*	*State forest near Grafton*	*Fire damage?*	*Sydney Morning Herald, 5/01/94, p. 1*
?/05/1995	*Tree feller (male ? age) had retreated to his escape route after felling a tree. Vibrations caused the felled tree hitting the ground caused a damaged tree to fall. A branch struck and killed the worker. Rain softened soil*	*Northcliffe*	*Forestry W*	*www.safetyline.wa.gov.au*
30/12/1996	Man 56 yo killed by tree which fell on his tent while he was sleeping. 10 m Banskia snapped off at ground.	Walkerville North Caravan Park	T	The Age, 31/12/96, p. 3
7/02/1998	Nine month old baby boy killed by falling tree branch. Camping trip, group trying to find shelter in storm. Wild storm.	Willbriggie State Forest	W T* *Not in tent	Illawarra Mercury, 9/02/98, p. 7
7/06/1998	Gum tree fell across highway, killing male driver 21 and female passenger 21 in moving vehicle. High winds for two days, rain softened soil.	Devlin's Bridge, Melba Highway	W	The Age, 8/06/98, p. 1
?/08/1998	*Self-employed firewood cutter killed by tree he felled. Walked into hazardous area, did not leave sufficient hinge wood.*	*Boddington WA*	*Forestry*	*www.safetyline.wa.gov.au*
20/07/1999	*Workman killed by falling tree.*	*Spreyton Racecourse*	*Forestry*	*Hobart Mecury, 21/07/99, p. 6*
24/01/2000	*Tree removal contractor male 26 yo killed and colleague seriously injured when section of tree dead tree being removed fell the wrong way onto a cherry-picker*	*Chittaway*	*Forestry*	*Newcastle Herald 25/01/00, p. 1 - 2*
26/12/2000	Tree fell on tent killing male 30 yo; wife 29 serious spinal injuries. Windless day. Very old melaleuca. Extensive reporting of inquest	Myall Lakes National Park	H T	Newcastle Herald, 21/06/02, p. 1
14/08/2001	*Tree fell on car and crushed male (?age) driver during land clearing operations. Pushed over by bulldozer*	*Calderwood*	*Forestry*	*Illawara Mercury, 15/08/01 p. 1*
24/03/2002	Four year old boy killed, his sister critically injured when a tree fell on a group of children playing Tree was rotten, disintegrated.	Dondingalong	H	
8/05/2003	*State Emergency Services volunteer male 53 yo killed by a branch falling from a burning tree*	*Warbuton Highway, Launching Place*	*Fire damage*	*The Age, 9/05/03, p. 6*
1/12/2004	Man 75 yo killed when a tree fell on his moving car. No wind.	Battar Ck Rd, Port Macquarie	Inherent risk?	Newcastle Herald, 3/12/04, p. 18
4/02/2005	*Tree-feller male 37 killed while working. Tree he was felling hit dead tree, which fell on him.*	*Clyde State Forest.*	*Forestry*	*Illawarra Mercury, 4/02/05, p. 3*
5/03/2005	Woman 73 critically injured by tree branch that crushed her tent. Strong winds.	Bermagui caravan park	W T	Illawarra Mercury, 7/03/05, p. 2
15/03/2005	*Forestry worker male 41 yo killed by falling tree while felling trees*	*Lansdowne State Forest*	*Forestry*	*Newcastle Herald, 16/03/05, p. 6*

includes an additional four such incidents among the general public (although one of those involved occupants attempting to escape a windstorm, and one involved serious injury but not death).

About half of the outdoor education/recreation related deaths occurred during or immediately after windy or wet conditions. It is not the purpose of this paper to examine whether or not any particular past incident could or should have been prevented, and I caution readers about forming such conclusions, especially without very detailed evidence about the weather at the site, and without knowledge of the site and its surrounds. However, weather must be an important focus of any future prevention strategy.

Rot or damage of some form was reported in some incidents. In each case the rot or other damage was evident after the incident. There was insufficient information in any report to determine how evident the rot or damage might have been prior to the incident. Similarly, there was insufficient information reported

on structural weaknesses (such as a lean, or uneven wind loads) to be able to discuss whether this was a factor in any of the outdoor education/recreation incidents. I will return to the question of assessing hazards.

Outdoor education/recreation victims were of all ages and both sexes. In incidents that involve some kind of conscious or unconscious risk-taking – for example falls around cliffs – young males have been the main victims (see Brookes, 2003b). The comparison suggests to me that tree related fatalities occur in circumstances in which the victims were either not aware of the hazard, felt the hazard was slight, or were unable to diminish the hazard successfully. (The latter almost certainly applies to incidents in which strong winds were bringing down trees and branches all around, as in the Meander Falls 1993 incident.)

The strongest conclusion from examining the pattern of tree related fatalities that do not involve cutting or other disturbance of the trees (Table 1 plus non-italicised incidents in Table 3) is that the main foci of prevention should be on assessment of campsites and attention to weather (Table 4). Only four of the 16 incidents involved neither camping nor wind/rain.

Table 4. Outdoor education/recreation incidents by circumstance.

	In tent	Other activity
Wind or rain involved	6	3
Still, dry weather*	3	4

*Also includes incidents where the involvement of wind or rain could not be determined from available sources.

It is fairly common knowledge that one should check overhead trees and branches when camping, and that trees and branches come down in storms. What I am interested in here is whether safety is a matter of checking the obvious, in which case safety depends on remembering to check and taking action having checked, or, as I intend to argue, that observing and responding to what is observed is more complex, and requires outdoor leaders to have some specific expertise and knowledge.

Safety around trees in outdoor recreation/ education. Out of step with community expectations?

It is not difficult to find outdoor recreation or education guidelines that treat safety around trees lightly, or not at all. For example, the Victorian Adventure Activity Standards for bushwalking[7] (Outdoor Recreation Centre Inc., 2005), neglect this particular hazard completely. The national competency standards for outdoor recreation are almost as poor (Service Skills Australia, 2003); I could find a few mentions of overhanging branches, as dot points, but nothing that could be read as defining (or even discussing) competency in assessing hazards from trees. I could not be certain whether references to overhanging branches alluded to danger posed by overhanging branches that participants might collide with, or to overhanging branches that might fall. The Victorian Ministry of Education *Safety Guidelines: Camping and Bush Activities* are better, but hardly exhaustive. They advise: "select a campsite that is flat and sheltered from the wind, but away from hazards such as dead trees and overhanging branches" (Department of Education Victoria, 1998, p. 39).

It may be that the above examples do not fairly represent common practice. The examples I chose might reflect some flaw in the process of compiling the guidelines themselves, rather than a widespread problem in the field[8]. Nevertheless, a cluster of fatal incidents, combined with evident weaknesses in what a naïve observer might take to be authoritative standards for the field, are reasons enough to look closely at tree safety, especially given the ready availability of more developed approaches outside the outdoor education field.

Debate about tree safety in managed environments, such as parks and gardens has long moved beyond "checking the obvious" to more detailed prevention strategies. Following the death of a ten year old boy on November 5 2004, on a school excursion in the botanic gardens in Hamilton, Ontario, a Coroner's jury made eighteen recommendations, including inspection of trails every morning, every trip to proceed only after properly trained individuals determined whether weather conditions were suitable, and assessments annually or twice a year (depending on the use of a trail) by qualified tree risk assessors (Wolksi, 2005). Most of the jury's advice was intended for the land manager, rather than teachers taking excursions to the gardens. This does raise the possibility that in some locations an outdoor educator could argue that safety around trees is the responsibility of the land manager. That aside, I have in mind that away from managed areas some of what land managers have been expected to do, at least in some circumstances, might be seen as the outdoor educator's responsibility. I think this is a reasonable expectation, and I will return to the question of how outdoor educators should understand tree hazards later in this article.

In highly managed environments, such as urban areas, approaches to prevention by those responsible for the trees, as distinct from visitors, can

[7] *Edition 2 August 2005.*

[8] *For example, see criticism of the Outdoor Recreation Centre bushwalking guidelines (Adventure Victoria, 2005).*

be even more elaborate than those recommended in Ontario. The City of Sydney employed consultants to assess individual fig trees in Hyde Park, who in turn recommended a second opinion on one tree. The Council them employed another consultant to review and assess the original consultants' reports (Fakes, 2005). Clearly this kind of detail is applied only where there is strong tension between safety and the amenity or heritage values of the trees. Assessments of the kind employed in Hyde Park include diagnostic elements that are not relevant to field assessment of trees by outdoor educators, for example strength calculations or laboratory identification of fungi. However, the relevance of at least some of the visual observation protocols that are more or less standard among arborists to outdoor education must be considered. It is conceivable that professional outdoor educators might be expected to demonstrate comparable expertise in 'reading' trees as some might exhibit judging a river rapid, interpreting weather observations, or assessing a surf beach.

The Hamilton case perhaps marks an outer limit of what might be expected of a land management authority. Outdoor education excursions commonly use public or private land on which there are far too many trees lining roadsides, tracks, and campsites for the kinds of detailed inspection recommended by the jury in the Hamilton case to be practical[9]. A Victorian case put more onus on the visitor to assess any risk themselves (and by implication on any person who took it upon themselves to guide other visitors). A woman injured at Toorongo Falls in 1993 (Table 3) was awarded over $300 000 damages from the (Victorian) Department of Natural Resources and Environment in 1998. The claim was not that the hazard should have been removed, but that there should have been warning signs. The injured woman (and her companion, who was killed) was exploring a riverbank, in forecast gale force winds, when the tree came down. She was not, in other words at a designated campsite or other more closely managed sited, but was in a forested reserve. The Victorian Court of Appeal overturned the award of damages:

> Justice Clive Tadgell said in the appeal court judgment that the area was not a cleared camping area and could not be compared with a metropolitan park or municipal playground. He said it was hardly reasonable to expect a warning covering the whole forested area of the reserve. Justice John Batt said the department was entitled to expect adults to know that trees fell randomly in windy conditions. "To enter a forest or its immediate surrounds, like entering the surf, is to take a risk of injury, albeit a remote risk," he said. Justice Frank Callaway also upheld the appeal, but said forests were more dangerous than an increasingly urban population appreciated. (Gregory, 2000, p. 8)

Justice Callaway's comments seem pertinent to outdoor education. When visitors to a forest are school children under the care of an outdoor education teacher, it is reasonable to ask whether teaching and learning about the dangers of trees should be part of the curriculum, and not something left entirely to the land management authority.

Designated campsites in national parks sit between natural forest at one extreme and parks and gardens at another, and are therefore more of a grey area. The death of a camper at Myall Lakes in December 2000 gave rise to intense and detailed argument about how far the NSW National Parks Service should go in protecting campers at designated campsites. The jury had to consider hundreds of pages of testimony and expert opinion. The Parks service engaged consultants who produced a multi-volume report. The jury found the tragedy could not have been predicted, but recommended future action to reduce the likelihood of similar incidents occurring (Wendt, 2002). In response to the tragedy the Parks Service put to the Coroner the following changes:

- Change the layout of recreation areas to deter visitors from camping and picnicking in areas crowded with very high-hazard trees;
- Reduce the number of campsites in high-hazard areas;
- Provide signs advising park visitors of risks associated with trees, particularly melaleucas;
- Conduct routine and systematic inspections of high-risk areas, particularly during high-use periods;
- Selective tree de-limbing or removal;
- Create exclusion zones or fence areas around very high-hazard trees;
- Create conservation zones to preclude camping and allow natural regeneration of melaleucas and other endemic species;
- Implement a system that records tree-falls. (Wendt, 2002, p. 1)

[9] *While it might be argued that very large scale hazard assessment and reduction is possible – for example the management by electricity authorities in Victoria of trees potentially contacting power lines following the Ash Wednesday fires of 1983 – this involved an industry with deep pockets and the risk of massive damages. Potential damages from trees falling on individuals are several orders of magnitude less, and public land managers do not have the income of electricity suppliers.*

Professional outdoor education leaders/guides/teachers who camp with groups away from highly managed campsites might have an increasingly hard time trying to argue that they do not need a level of knowledge of tree safety, or detailed strategies for fatality prevention. The path towards understanding tree hazards is a well-trodden one, at least outside the outdoor education field; what remains, at least for some outdoor education programs, is to develop an approach that fits outdoor education practice, rather than other professions. Tree safety is a highly developed field; outdoor educators have arguably been somewhat slow to draw on and adapt its expertise.

The most recent relevant judicial comment, finalised just as I submitted the first draft of this article, goes directly to the responsibilities of outdoor educators. The coronial finding on the McKillops Bridge 2005 incident recommended the following:

1. That outdoor educators venturing into isolated locations have access to reliable two-way communication so that they are contactable at all times, and so that they can access current weather information and other emergency warnings proactively, and police and emergency services without undue delay if required.

2. That outdoor educators generally, promote a greater understanding of the tree hazard in the Australian bush, particularly as it impacts on safe campsite selection. (Spanos, 2007, p. 7)

Towards fatality prevention

What approach should outdoor educators take to understanding tree hazards? Expert assessment of tree hazards is a complex mixture of natural history, engineering, biology, mycology, and experience (see, for example Serken, 2005). Here I will focus on some aspects of hazard recognition and prevention that could reasonably be acquired by outdoor educators, based on my reading of some of the tree hazard literature, and on insights derived from my observations as I have attempted to develop better approaches to teaching about tree hazards with my own students over the last few years.

There is no single approach to hazard assessment in the literature. There are variations due to differences between forms of management (in urban areas, parks, forestry, and so on) and between species. Some differences seem to reflect the personal experiences and preferences of the authors. This is not surprising for a field whose origins are in practical natural history, however, all approaches centre on visual assessment. Although outdoor educators might not be able to assess structural weaknesses in any detail, or to identify particular pathogens, this might not be necessary. Arborists in many cases have to balance protecting trees with protecting persons and property (Lonsdale, 2000), and therefore, where there is doubt, conduct detailed assessments. For outdoor educators the aim should be to identify camp sites and resting places as free from doubt as possible; in other words, their aim is more to recognise and then avoid trees which might be particularly hazardous than it is to develop an elaborate understanding of tree defects, bearing in mind that:

> No tree is entirely safe, given the possibility that an exceptionally strong wind could damage or uproot even a mechanically 'perfect' specimen. It is therefore usually accepted that hazards are only recognisable from distinct defects or from other failure-prone characteristics of the tree or of the site. (Lonsdale, 2000, p. 3)

The importance of understanding local weather, the particular site, alternative sites if a hazard is detected, and the characteristics of local trees emphasises, yet again, the contribution of environmental knowledge, and in particular local experiential knowledge, to outdoor education safety. It might be helpful to obtain expert advice on how to assess trees in a particular location, although I doubt that would be practical in most cases.

How then should outdoor educators acquire knowledge of tree failures in the area in which they will be guiding students? In my experience evidence of past tree failures is all around in forests and woodlands that have not been extensively scavenged for firewood. Simple observation of these past failures can reveal a great deal about a particular location. For example, in my own experience, the kinds of failures observed in alpine ash forest, box ironbark forest and woodland, and snowgum forest and woodlands respectively are quite different. To understand the reason why a particular failure occurred, the protocol used to assess standing trees can be used to provide some guidance.

Table 5 provides a suggested outline for a protocol that can be applied to potential campsites. It can also be used as a guide for observing evidence of past failures in a forest or woodland to develop local knowledge about tree hazards. While not definitive, and probably not optimal for particular locations, it is reasonably consistent with the literature I have examined, and represents an improvement on the cryptic or non-existent approaches identified in at least some outdoor recreation or education guidelines.

Table 5. A suggested protocol for assessing tree hazards around campsites (sources: Fakes, 2005; Johnson, 1981; Lonsdale, 2000; Serken, 2005; USDA Forest Service & Minnesota Department of Natural Resources, 1996).

Assessing trees:

- Tree health
  - Is the tree alive or dead?
  - Are there dead branches or other visible signs of ill-health – dead leaves or twigs at the end of branches?
  - Are there visible signs of rot or fungal attack on the trunk?
  - Are there dead or sagging branches?
  - Are there signs of ageing?
  - Are there signs of coppicing or epicormic regrowth?[10]
- Tree structure
  - Is the tree balanced or leaning? Is any lean due to damage?
  - Assess the size and relative weight.
  - Are there structural weaknesses such as co-dominant forks with included bark[11]?
  - Are there visible signs of damage to roots, trunk, or branches, such as wounds, cracks, or bulges?
  - Does any damage observed compromise structure (for example root damage on one side, or loss of branches on one side)?
  - Has the soil been softened by rain?
  - Is the soil cracked or bulging?
  - Are there any loose branches suspended in the canopy?

Assessing location

- What areas are at risk from falling branches?
- What areas are at risk from the whole tree falling? (Distance estimation)
- Is the tree particularly susceptible to wind loading from any particular direction?
- Does the tree have a large "sail" area (wind load)?
- Have tracks, clearing, or other works changed the way the tree has grown, or altered wind loads?

Weather

- What is the forecast
  - Rain softening the ground
  - Snow or ice loading
  - Wind loading
  - Rain loadings on canopy
  - Wind direction
- What previous weather events might have affected trees
  - Long dry spells
  - Sodden ground

Local, experiential knowledge of an area that might help reduce the risk of tree related incidents, includes not just knowledge needed to assess the hazards around a campsite, but also knowledge of the surrounding area. (Some of this knowledge can be 'corporate' knowledge, communicated to leaders as needed, but personal local experience seems important[12]). There might be alternative sites or locations, where the trees are spaced differently, are younger, or of different species. There might be large clearings beyond the reach of the tallest trees, or areas of woodland with many clearings. There might be sites where logs on the ground, rocks, a tree leaning away from the tent, or road cuttings offer a measure of physical protection. There might be thickets in the lee of which wind will not be a problem. There might be local circumstances, such as the build up of ice (rime) on leaves leading to widespread failures. There might be an escape route for circumstances where forecast wind speeds exceed the threshold decided by the leader, although the latter might be less straightforward

[10] *Branches that have grown following damage or stress might be more weakly attached than branches that form part of a tree's original structure (see Commissioner Hodgson, 2005).*

[11] *Alpine Ash trees, for example, normally grow with a single trunk. When they fork to form two trunks, there can be a potential failure point at the apex of the fork, especially if both trunks are nearly vertical and have grown over bark at the apex – the "in grown" bark can be a source of decay.*

[12] *In my experience it is useful to introduce students new to an area by showing them examples of what to look for, but they should then spend time making their own observations.*

than, say, river level thresholds applied to river trips, because escape might expose a group to risks of trees falling across a track or road. Knowledge of sheltered locations, including stands of trees likely to withstand high winds (for example snow gums can be very wind tolerant), or an area clear of trees (such as a logging coupe) might form part of the plan.

In moving a group to a safer location in hazardous weather conditions, leaders should consider spreading the group out to ensure that any incident will only claim a single victim.

I hope it is clear that safety around trees is not a matter of having a protocol somewhere in a risk management plan. Rather, the protocol provides some assistance in building local knowledge, mostly on the part of the leader, through experience and observation. There might be a role for organisational policy here, but that requires further discussion.

Conclusion

If outdoor education involves healthy young people under expert supervision in an environment familiar to the teacher, there is every reason to expect that the rate of fatal incidents will be lower than the already low rate of accidental death for young people in the wider community. Although incidents involving trees are likely to be regarded as 'freak' accidents, the possibility of such incidents is certainly foreseeable, and most are preventible in the sense that they are associated with specific, recognisable hazards. (Having said that, the risk from falling trees and branches could only be eliminated entirely by avoiding all trees; there is some inherent risk around trees.) Moreover, I have never seen an educational aim for outdoor education that would be compromised by choosing a safe tent site over an unsafe tent site. Educational goals might have to be relinquished or postponed in severe weather; but that is matter of 'safety first.'

Although I have described a 'protocol' for assessing trees, this should be taken as a guide for expertise that must be gained experientially – that is by practising – and that should be considered as local knowledge more than expertise in a generic procedure. Although assessment of campsites (and resting places) is crucial, as is awareness of severe weather conditions, I contend that safety around trees, like vigilance for loose rock or the possibility of snake-bite, is more a matter of constant awareness than a procedural or technical matter.

Teaching each student to be aware of safety around trees might save their life or someone else's in the future. Although the number of tree related deaths is not large, the tragedy of a preventible death is not lessened by the element of bad luck involved. In the case of preventing deaths due to tree failures, the essence of prevention is better awareness and understanding of the environment in which outdoor education takes place.

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About the Author

Andrew Brookes PhD teaches and researches in the School of Outdoor Education and Environment, La Trobe University, Bendigo, Australia. In addition to his research on fatal incidents and safety, he has interests in outdoor environmental education, and examining the validity of claimed aims and purposes for outdoor education. He is presently completing a study examining some educational aspects of long term travel in remote Australia by families. Email: a.brookes@latrobe.edu.au