



A review of safety signage for Queensland Parks and Wildlife Service

Report 1

LITERATURE REVIEW

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Prepared for: Queensland Parks and Wildlife Service
- Department of National Parks, Recreation, Sport and Racing

MAY 2015

ACKNOWLEDGEMENTS

This work was funded by Queensland Parks and Wildlife Service – Department of National Parks, Recreation, Sport and Racing and received substantial in-kind and infrastructure support from Southern Cross University.

The authors also wish to acknowledge Kate Rodgers, Anna Gstaettner & Michael Hughes (Murdoch University), Liam Smith (Monash University), Brent Ritchie & Karen Hughes (University of Queensland), Sally Gainsbury (Southern Cross University), Damian Morgan (Federation University), Brett Ellis (Surf Life Saving Victoria), Shaun Sweet (Department of Conservation, NZ), Kerry Gunther (National Park Service, Yellowstone National Park, USA), Jeffrey Trust (National Park Service, Yosemite National Park, USA), Rie Usui (Hiroshima University, Japan), & Environmental Protection Authority Victoria and Parks Canada.

Finally, nearly all state and territorial agencies responsible for managing national parks in Australia responded to our request for their current visitor risk management and safety sign policies and practices: thank you to QPWS, Parks Victoria, WA Department of Parks & Wildlife, SA Department of Environment, Wildlife & Natural Resources, NT Parks & Wildlife Commission and ACT Parks.

SUGGESTED CITATION

Weiler, B., Zeppel, H., Saunders, R., & Scherrer, P. (2015). A review of safety signage for Queensland Parks and Wildlife Service: Report 1 (Literature Review). School of Business and Tourism, Southern Cross University, Coolangatta, QLD.

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We value your feedback. If you have any comments/ suggestions please send them to betty.weiler@scu.edu.au

Front cover photograph:

Warning sign at Mossman Gorge, North Queensland. Andrew Growcock, 1 May 2015.

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1 INTRODUCTION AND CONTEXT

Keeping visitors safe in natural environments is a very high priority for Queensland Parks and Wildlife Service (QPWS) and other park agencies responsible for managing these reserves. A number of critical incidents (deaths and serious and permanent injuries) have occurred on QPWS managed land in recent years. Safety signs are written, designed and installed as per departmental policy (QPWS Sign Manual and Risk Management Policy) to advise park visitors about potential hazards and their associated risks and the appropriate actions visitors should take to avoid those risks. The presence and effectiveness of these signs also minimises departmental liability during litigation.

This report is in part a response to recommendations that QPWS engage a professional contractor to review its policies and practices with respect to safety signage. In April 2015, a team from Southern Cross University was engaged to:

- review the latest research on visitor management and safety signs;
- identify best practice guidelines for safety signs;
- assess current QPWS policy that guides development of safety signs and existing QPWS protocols for risk assessment and sign production; and
- assess specific examples of QPWS safety signs at locations where critical incidents have occurred.

The results of this literature review and these assessments are intended to provide rigour in the use of safety and warning signs and ensure they meet the highest possible standards. As such, they may underpin improvements to the QPWS Sign Manual and other QPWS policies and practices such that they promote appropriate visitor behaviours and help keep visitors safe, reduce the likelihood of serious incidents occurring in future and minimise departmental liability.

This report addresses the first of the three project deliverables, which are:

- **A report reviewing latest literature and research regarding visitor safety, visitor behaviour and safety signs in natural areas, such as parks and beaches;**
- A report including recommendations, assessing current QPWS policy guiding the production and installation of safety signs in protected natural areas; and
- A report including recommendations, assessing safety signs and their installation in specific QPWS locations where critical incidents have occurred.

2 SCOPE OF THE REPORT

This report provides a desktop review of available literature on research into visitor safety, visitor behaviour and safety signs in risky situations in natural areas around the world. It focuses in particular on safety signage in visitor nodes and on walking tracks in national parks, and aims to: 1) identify current practices in similar environments; 2) collate current knowledge of effective park safety signs, and warning signs in general; and 3) recommend best practice principles against which to evaluate current QPWS policy.

The literature review focused in particular on safety and warning signs for 1) recreation and adventure activities, 2) natural hazards (including wildlife) and 3) risky visitor behaviour in terrestrial national parks and associated inland waterways. The literature review also included safety signs at coastal beaches as the jurisdiction for QPWS extends down to the low water mark of coastal areas, including inter-tidal areas. It excluded the following areas: road safety,

pest management, fire management, natural disasters, public health and safety (e.g. contaminated water), occupational health and safety (i.e. park employees), asset management, ocean safety and marine activities.

The report summarises key findings of empirical studies about effective warning signs and provides an overview of current best practice principles for safety signs. An annotated bibliography accompanies this report (an Appendix under separate cover) with details of 200 studies, all of which have at least some relevance to safety signage in parks. The present report seeks to assist QPWS in their efforts to continually improve their visitor safety signage and facilitate a current best-practice baseline for the use of visitor safety and warning signs.

It is worth noting that, while there are different definitions of risk, there is general agreement about the meaning of hazard and risk especially in the context of managing visitors in parks, as stated in the current QPWS Signs Manual (QPWS, 2014, p. 5):

A hazard is something with the potential to cause harm.

Risk is the likelihood that death, injury or illness might result because of the hazard.

Risk is analysed by combining estimates of *consequence* and *likelihood* in the context of existing control measures.

Furthermore, compliance with signage standards such as Australian Standards appears to be common practice among park management agencies, but this is not necessarily 'best practice', as standards are not always up-to-date nor written necessarily for managing or communicating with visitors in natural settings. It is commendable that QPWS seeks to assess its performance against the latest best practice principles for safety signage and this is the focus of the present study. This study does not seek to assess QPWS's compliance or performance of risk management more broadly.

Finally, it should be noted that while the scope of this project is limited to the use of safety signs, rarely can signs be used in isolation to manage risk. The discussion section of this report examines safety signs within the broader communication and visitor management contexts.

3 METHODS

The review located and assessed studies related to communicating safety and warning messages in parks, especially by means of signs, using keyword searches on research databases and selected park agency websites. The keywords used, either as a single word or in word combination(s), were: *National Parks, Safety Signs, Warning Signs, Tourist Injuries, Risk Management, Natural Hazards, Visitor Safety, Recreation, Beaches, and Adventure Tourism*. Keyword searches were conducted in:

- A. research databases, including *Google Scholar, Science Direct, Taylor and Francis Online, Wiley Online Library, Hospitality and Tourism Complete, ProQuest, Expanded Academic ASAP, Emerald, and Informit*;
- B. the online versions of twelve key journals, namely *Applied Environmental Education and Communication, Australasian Parks and Leisure, Environmental Hazards, Human Dimensions of Wildlife, Human Factors, International Journal of Wilderness, Journal of Interpretation Research, Journal of Risk Research, Parks, Risk Analysis, Safety Science, and Wilderness and Environmental Medicine*; and
- C. on park and recreation agency websites, including Department of Conservation (New Zealand), National Park Service (USA), Parks Canada, Parks & Leisure Australia, Sport NZ (Sport & Knowledge Recreation Library), Surf Lifesaving Australia (Research Projects & Publications), International Federation of Parks & Recreation Associations (Best Practice & Benchmarking), National Recreation & Park Association (USA) (Publications and Research, Parks & Recreation), American Trails-National Trails Training Partnership (USA) (Safe Trails Forum), Interpretation Australia Association, and the Australian and New Zealand Association for Leisure Studies (ANZALS).

In addition, ten key researchers in Australia and New Zealand were contacted by email to enquire about recent research, reports or articles related to safety signs in parks. Selected park agencies were also contacted by email regarding reports and studies of safety messages and warning signs in parks (e.g. Department of Conservation, New Zealand, and Yosemite National Park, USA). A request-for-information-article targeted at interpretation practitioners was posted in the Interpretation Australia Newsletter (5 May, 2015). Finally, a question was also posted on the academic online network ResearchGate (28 April, 2015) asking 'How effective are visitor safety and warning signs in National Parks?' A number of studies were identified from these multiple sources.

The literature review was conducted over three weeks during April/May 2015 and located some 200 articles and reports about effectively communicating safety messages and warnings via signs in parks. The review covered articles published from 1990 to 2015, with a few articles and reports from the mid to late 1980s included if they were highly relevant. The review included only published and publicly available studies, but not internal reports to park agencies.

The literature was compiled into an annotated bibliography with full reference details and abstracts for the studies. It covered four main themes:

Section 1. Warning Signs in Parks: 41 articles

Section 2. Wildlife Warning Signs: 24 articles

Section 3. Beach Safety Warning Signs: 45 articles

Section 4. Warning Signs: Content, Design and Evaluation: 90 articles

The latter category included experimental studies conducted outside parks that tested comprehension and effectiveness of elements such as warning signs and symbols, but includes many findings and best practice principles applicable to warning signs in parks. The main empirical findings on effective safety messages and warning signs from selected key studies (n=59) were then summarised in a table for each of the four themes (see Tables 1.1 through 1.4 in section 4 Literature Review).

4 HIGHLIGHTS FROM THE REVIEW OF LITERATURE

Around one third of all the studies focused on warning signs in parks and for wildlife (n=65), about one quarter of the studies were on beach safety warnings (n=45), while almost half of all studies (n=90) were about the effective design and content of warning signs in general (i.e. not in parks). Excluding the areas of beach safety and human-wildlife conflicts (i.e. dangerous animals, feeding wildlife), there are few empirical studies specifically about safety and warning signs in parks.

Key studies about natural hazards and risky visitor behaviour in the first three areas (parks, wildlife, beaches) reported research findings on the effectiveness of safety messages and warning signs in parks or recreation areas. These field studies were based on visitor interviews or surveys, on-site observations of visitor behaviour, pictorial tests (photos of sites or signs), and auditing the content of safety signs or brochures used by park agencies.

The general (non-park) studies about warning signs (content, design) were based on experimental studies of students and other participants that tested comprehension, with subjects rating the effectiveness of warning labels, symbols, colours, text and design. Only one study was conducted outdoors, interviewing people near a high-risk rock fall area (Aucote et al., 2012). A few studies reviewed other empirical research on warning signs and risk communication.

Just one prior report examined key factors for visitor safety, in the US national parks system (Tuler et. al., 2002). This report assessed research on definitions and hazard classification, and contributory factors to visitor accidents such as visitor and social characteristics, environmental conditions (i.e. natural hazards, wildlife), infrastructure and equipment characteristics, and hazard management including risk communication by park agencies. The report listed

over 130 general references plus 31 references specific to US national parks. These studies focused on recreation activities, risky behaviour and natural hazards in parks; only three studies evaluated interpretive signs in parks and one study reported on techniques to deter visitor behaviour such as off-trail hiking. None of these studies assessed warning signs. A New Zealand report reviewed glacier hazards, warning signs, and risky visitor behaviour (i.e. crossing barriers) with findings from visitor interviews and observations (Espiner, 1999).

4.1 Warning Signs in Parks

The 41 articles about warning signs in parks addressed hazards, behaviour and messages, including:

- rock falls (Aucote et al., 2010)
- glaciers (Corbett, 2001; Espiner, 1999, 2001; Hayes, 2008)
- volcanoes (Heggie, 2005; Heggie & Heggie, 2004; Heggie et al., 2009)
- water safety (Barss et al., 2008; Attarian, 2015; Parkin & Morris, 2005)
- hiking/off-trail hiking (Bradford & McIntyre, 2007; Johnson & Swearingen, 1992; Sperlich et al., 2010; Swearingen & Johnson, 1995; Winter, 2006)
- park or site management (Bullock & Lawson, 2008; Findlay & Southwell, 2004; Martin et al., 2009; Park et al., 2008; Tuler et al., 2002; Wade, 2010)
- visitor behaviour (Lalasz, 2013; Marion & Reed, 2007; Martin, 1992; Vande Kamp et al., 1994)
- risk perception (Wachinger et al., 2013)
- interpretation and persuasive communication (Bitgood, 2000; Christensen & Dustin, 1989; Cialdini, 1996; Davis & Thompson, 2011; Manning, 2003; McCool & Braithwaite, 1992; Reigner & Lawson, 2008; Skibins et al., 2008)
- messages and symbols on signs (DLNR, 2005; Duncan & Martin, 2002; Mendis, 1986; Winter & Cialdini, 1998; Winter et al., 2000; Zafren, 2001).

This research on park warning signs occurred in North America, Australia, and New Zealand. Case studies reviewed the effectiveness of interpretive safety signs about risky behaviour at swimming holes in Queensland (Parkin & Morris, 2005), interpretive and sanction messages (Bradford & McIntyre, 2007; Duncan & Martin, 2002; Johnson & Swearingen, 1992; Manning, 2003; Winter et al., 2000; Zafren, 2001), and normative messages on signs (Cialdini, 1996; Winter 2006; Winter & Cialdini, 1998). These studies highlight the critical role of messages, sign design and placement in deterring risky behaviour by park visitors. The research findings for 16 key studies about warning signs in parks are listed in Table 1.1.

4.2 Wildlife Warning Signs

The 24 articles about wildlife warning signs addressed danger, behaviour, and messages:

- feeding wildlife (Ballantyne & Hughes, 2006; Hockett & Hall, 2007)
- wildlife-human conflicts (Bath & Enck, 2003; Beckmann, 2009; Moscardo et al., 2006; Olliff & Caslick, 2003; Rickard et al., 2013)
- wildlife interpretation (Moscardo et al., 2004)
- dingo education (Beckmann & Savage, 2002; Burns, 2009; Burns & Howard, 2003; Hytten & Burns, 2007; Porter & Howard, 2002; Thompson et al., 2003)
- cougar education (Greeson & Jurin, 2012)
- crocodile education (Moscardo et al., 2010)
- bison management (Davenport et al., 2002)
- bear education/management (Gniadek & Kendall, 1998; Hall et al., 2001; Lackey, 2010; Lackey & Ham, 2003a,b,c; McCool & Braithwaite, 1989).

This research on wildlife warning signs was conducted in North America and Australia. Case studies reviewed education campaigns and warning signs for dangerous wildlife such as dingoes and crocodiles in Australia, and bears, cougar and bison in North America. Detailed studies have analysed the effectiveness of safety messages on signs, brochures and in talks or videos for black bears in Yellowstone (USA), and dingoes on Fraser Island (Australia). Two

wildlife feeding studies analysed the impact of fear and moral appeal messages on visitors. The research findings for eight key studies about wildlife warning signs are listed in Table 1.2.

4.3 Beach Safety Signs

The 45 articles about beach safety signs addressed danger, behaviour, and messages:

- beach accidents (Grenfell & Ross, 1992; Manolios & Mackie, 1999; Moran & Webber, 2014; Morgan, 2003; Morgan et al., 2009; Petronis et al., 2009; Pikora et al., 2011; Sherker et al., 2008)
- beach management (Cantrill, 2008; Frampton, 2010; James, 2000; McKay et al., 2014; Morgan, 2006; Staines et al., 2005; Wilks & Atherton, 1994; Wilks et al., 2005)
- beach safety knowledge (Sherker et al., 2010; White & Hyde, 2010; Williamson et al., 2012)
- beach warning signs (Brannstrom et al., 2015; Matthews et al., 2014; Morgan, 2014)
- rip currents (Brander & MacMahan, 2011; Brannstrom et al., 2014; Brighton et al., 2013; Caldwell et al., 2013; Fletemeyer & Leatherman, 2010; Hatfield et al., 2012; Houser et al., 2011)
- risky beach behaviour (Ballantyne et al., 2005; Nixon et al., 1995; McMurdo, 2008)
- sand and rocky coast hazards (Heggie, 2013; Kennedy et al., 2013; Maron et al., 2007)
- water and sun safety guidelines (Australian Water Safety Council, 2012; Cortes et al., 2006; NPS, nd; NSW Government, 2012; Peattie et al., 2005; Surf Life Saving Australia, 2010; Surf Life Saving Western Australia, 2013; Tourism Queensland, 2010; Wilks, 2007, 2008).

This research on beach safety and warning signs was conducted in Australia, America and New Zealand. The main focus was on beach accidents, beach management, and water safety guidelines. A few studies address beach hazards of rocky coasts and collapsing sand, but not being sucked in by waves on rough surf beaches. Case studies have evaluated the effectiveness of beach safety signs with signs identifying rip currents not being well understood (Brannstrom et al., 2014). Three studies evaluated the messages, pictures and symbols used on beach warning signs in terms of user attention and comprehension (Brannstrom et al., 2014; Matthews et al., 2014; Morgan, 2014). The research findings for five key studies about beach safety signs are listed in Table 1.3.

4.4 Warning Signs: Content, Design and Evaluation

The 90 general (non-park) articles about warning signs covered the content, design and evaluation of effective safety messages for attention, comprehension and recall elements. This included the design and placement of text messages, pictorial symbols, colour and other sign aspects.

These articles mainly included laboratory and experimental studies, with just two on-site studies conducted: one assessed the impact of safety signs on visitors in a rockfall area (Aucote et al., 2012), while the other evaluated aquarium signage (Kratochvil & Schwammer, 1997). This research on the effective design and comprehension of warning signs was located in broader literature on safety science, ergonomics, risk management, psychology and other sources. Much of this research on safety labels and signs was conducted through the 1990s, with a seminal study reviewing key variables in the warning process (Rogers et al., 2000). Some studies assess interaction among key sign features (e.g. colour, text size, signal word). More recent studies assess visual perception (Changizi et al., 2014); multi-modal warnings (Haas & van Erp, 2014); design and non-design factors (Laughrey & Wolgalter, 2014); colour highlighting on pictorials (McDougald & Walter, 2013); structured dynamic warning design (Schall, Doll & Mohnen, 2014), hazard mapping (Severtson & Burt, 2012), and pictograms (Siswandari et al., 2014). Two recent studies (Duarte et al., 2014; Siswandari et al., 2014) assessed comprehension of pictograms against ANSI and ISO Standards for graphical symbols and safety signs. These are important safety studies with practical outcomes for the design of safety signs in parks (see Table 1.4). This includes the use of signal words, colour labels (especially red), larger text size, and pictorial icons/symbols. The research findings for 30 key studies about effective warning signs are listed in Table 1.4.

Table 1.1: Key Studies – Warning Signs in Parks

Author, Year	Context	Purpose	Research Methods Used	Communication Media	Behaviour Type	Key Findings	Best Practice Principles
Bradford & McIntyre, 2007	St. Lawrence Islands National Park, Canada	effectiveness of message text, & sign location in reducing social or off-trail hiking	Covert observational study of hikers & signs:	Signs at social trailheads & visitor entry points to park Messages- Attribution messages (personal responsibility) & Plea messages (hiking impacts)	Off-trail hiking impacts	Attribution message more effective than a plea; Signs at social trailheads more effective than entry points to National Park	Use attribution messages on signs (personal responsibility); locate signs at site of impact/hazardous area
Bullock & Lawson, 2011	Acadia National Park, USA	Test impact of barriers & signs about off-trail hiking on visitors	30 visitor interviews & shown 6 pictures of sites: wood barrier, tripod sign, rail fence, rock border, 2 signs for off-trail hiking	Signs : educational, regulatory message Trail structures: Wooden barrier & tripod sign Wooden rail fence, rock border	Off-trail hiking impacts	Natural barriers preferred: Rock border, wooden barrier & wood tripod sign (not a metal sign, colour); Educational sign preferred	Use natural barriers around hazard areas Use 'care' words on educational signs -'please, preserve, fragile'
Davis & Thompson, 2011	City of Fort Collins, Colorado, USA	assess impact of interpretive signs on visitors in urban park	475 in park observations (time reading signs) 46 interviews & knowledge test of signs	Interpretive signs	Recreational users	78% repeat visitors, first time visitors learnt more ; just 26% briefly read signs; preferred 3D objects, pictures, large title	Locate signs at natural rest stops & trailheads Use 3D objects, photos, large titles, & illustrate hidden hazards on signs
Duncan & Martin, 2002	Wilderness users, USA	Test behaviours in 4 scenarios of wilderness trips (237 surveys)	Laboratory experiment – wilderness slides for 3 groups (control, sanction, interpretation)	Slides of wilderness & photos of messages on signs for 4 issues	Human waste disposal, cultural artifact removal, firewood collection, food scrap disposal	Interpretation & sanction messages both effective (3 issues), interpretation more effective on 1 issue (firewood collection)	Use both interpretation & sanction messages: desired & undesired visitor behaviours
Espiner, 1999	Franz Josef, & Fox Glaciers, New Zealand	Assess effect of hazard warning signs at glaciers	Survey of 378 visitors, behaviour observations Test signs - existing & introduced (pictorial)	Hazard warning signs - existing & introduced (pictorial, Bright yellow triangular shape): Hazards present & identified, present & unidentified, not present & unidentified	Crossing barrier & walking up to glacier terminus	19.3% saw no hazards, 60% had low hazard awareness (31% icefall), 40% ignored restrictions ; new pictorial signs increased hazard awareness and compliance behaviour	Use pictorial hazard warning signs (explain restricted access) Use increased signage of varied types & locations Differentiate warning signs from other signs
Espiner, 2001	Franz Josef, & Fox Glaciers, New Zealand	Assess hazard messages and perception & beliefs of visitors & park staff	Survey of 378 visitors, behaviour observations Test signs - existing & introduced (pictorial)	Hazard warning signs - existing & introduced (pictorial, Bright yellow triangular shape): Hazards present & (un)identified, present & unidentified, not present & unidentified	Crossing barrier & walking up to glacier terminus	Poor visitor awareness of glacier hazards and warning signs; pictorial hazard signs increased hazard awareness and compliance behaviour	Consider individual and situational factors of risk Use pictorial hazard warning signs (explain restricted access) On-site risk assessment
Findlay & Southwell, 2004	Forestry Commission sites, UK	Assess visitor wayfinding of first-time users at forest sites	Semi-structured interviews, route and spatial analysis, audit signs and environmental cues	Road signs, information boards	Visitor wayfinding	Wayfinding problems related to context and location of signs , rather than the materials and details of sign design	Provide contextual wayfinding information related to sign location, Assess/address user needs for information
Hayes, 2008	Franz Josef, & Fox Glaciers, New Zealand	Assess visitor behaviour & compliance with warning signs	quantitative measure & interview responses	Hazard warning signs	Crossing barrier & walking up to glacier terminus	Situational factors influence park behaviour: proximity of track end points, other visitors, age, time, weather conditions	Target visitor beliefs, and perceived hazards, Increase enforcement, Focus on consequences to self or others
Johnson & Swearingen, 1992	Paradise Meadows, Mt Rainer National Park, USA	effectiveness of selected trailside sign texts in deterring off-trail hiking	Observed 14,000 people at popular subalpine day-use area	trailside sign texts : sanction (OFF-TRAIL HIKERS MAY BE FINED), ethical appeal (STAY ON PAVED TRAILS, PRESERVE THE MEADOW), & symbolic	Off-trail hiking	Sanction sign reduced off-trail hiking 75%, ethical appeal sign reduced it 52%	Use sanction signs at trails/trailheads Sanctions & symbolic signs more effective than standard signs

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Manning, 2003	Wilderness, USA	Education in wilderness management	Review empirical studies	Brochures, Signs, Visitor Centres, Rangers	Illegal, careless, unskilled, uninformed, unavoidable actions (camping, hiking)	Messages & posters at trailhead bulletin boards (max. two key messages) effective for safe hiking (e.g. heat kills hike smart)	18 BP principles e.g. mixed media, credible sources, strongly worded, cover impacts, costs & consequences
Martin, 1992	Mt St Helens, USA	Effect of 3 signs & 1 brochure	4,688 visitors observed over 6 weeks, 25 marked pumice stones along Meta Lake trail	3 signs (standard, sanctions, social influence) & 1 brochure about not removing pumice	Removal of pumice, mainly young families & older females	Sanctions sign very effective (97% reduced), other 2 signs & brochure moderately effective	Use signs (sanctions, standard) & brochures; Depict target people in posters & brochures
Park et al., 2008	Acadia National Park, USA	Test effect of trail educational messages	Test 5 trail management practices-signs, fences, education, control group; Behavioural observations 596 visitor surveys	Trail management - 3 educational signs (plant impacts), prompter signs ('no walking' graphic), trail fencing, personal message by bus driver	Off-trail hiking	Education sign 3 reduced walking of trail to 24.3%; >90% supported signs; Off-trail hiking mainly by family/friendship groups, & if other visitors seen	Signs refer to resource impacts, protection, & duty (moral appeal); Add prompter signs (no walking) at key locations Widen trails for groups
Parkin & Morris, 2005	Springbrook NP, Qld, Australia	Evaluate interpretive safety sign at swimming area	169 questionnaires (63 swimmers)	Interpretive safety sign on platform above rock pool 'The power to change lives: Pete's Story' – paraplegic victim of swimming-related accident	Risky behavior at rock pool swimming area (jumping, diving at cascades, rock pools)	79% noticed safety sign ; 86% stated sign effective; 35% swimmers influenced (cautious, check safety) ; or rely on others/no action	Present victim's story; List key injury statistics (paraplegia, drowning); Use warning symbols + interpretive safety signs
Reigner & Lawson, 2008	Haleakala National Park, Hawaii, USA	Assess efficacy of visitor education at the Pools of Oheo	Survey of 947 visitors (control group, fear & warm glow group), and behavioural observation	Safety warning signs (along trails, & at visitor centre) Fear message-danger & hazards Warm glow message-resource & cultural impacts of visitors	Trampling, rock hopping, cliff jumping at the Pools of Oheo	Both messages reduced visitor exploration; warm glow (resource impacts) more effective than fear message that had no overall change	Focus on resource stewardship & social responsibility at sites & harness visitor desire to comply with park rules
Winter, 2006	Sequoia, USA	Test impact of normative messages on signs	Tested normative messages on signs at sequoia trees	Messages-"ought" (injunctive) "is" (descriptive); positive (prescriptive) or negative (proscriptive)	Off-Trail Hiking	Injunctive-proscriptive messages most effective , descriptive- proscriptive message least effective	Use injunctive (ought)-proscriptive (negative) messages on signs about undesired behaviours
Winter et al., 2000	USA	Most effective message type	Survey of NAI members	Messages on signs	Signs mainly discourage negative visitor conduct	Encouragement based proscriptive signs seen as more effective	Use encouragement based proscriptive signs for desired behaviours

Table 1.2: Key Studies – Wildlife Warning Signs

Author, Year	Context	Purpose	Research Methods Used	Communication Media	Behaviour Type	Key Findings	Best Practice Principles
Ballantyne & Hughes, 2006	Brisbane Forest Park, Australia	Test bird feeding warning signs	134 questionnaires test key beliefs in 3 bird signs (rational-plan behavior), protect self-protection, & moral-constructivist)	Warning Signs (bird feeding) Evaluate 3 bird feeding signs	Feeding birds	Most persuasive sign was about bird health & safety 48% chose moral appeal , 28% chose rational sign & 24% chose protection sign	Focus on health & safety (people, wildlife) in signs Give clear reasons to alter behavior, & strong title & text for attention
Beckmann & Savage, 2002	Fraser Island, Australia	Review dingo education strategy	Review signs, brochures, engage park personnel, literature review	Warning signs & brochures (dingo education program)	Feeding dingoes, food scraps attract dingoes	Gap in visitor knowledge on location of dingoes; Multiple use of signage & personal ranger messages reinforce safety messages	Be locality specific (i.e. dingoes patrol here) Alternative headlines on signs & updateable signs Refer to ranger on signs
Greeson & Jurin, 2002	Colorado, USA	Hiker response to cougar signs	Interviews with 58 hikers (sign reading/perception, attitudes to cougars)	Cougar signs & pamphlets (trails & trailheads information, warning sign – actions to take)	Backcountry hiking in cougar habitat	78% hikers not concerned 61% needed more facts 47% didn't read signs 31% own responsibility	Target education to address visitor beliefs; Include updated data, pictures, key actions
Hall, Ham & Lackey, 2001	Yosemite National Park, USA	Test effect of varied bear signs on food storage	Observe 963 people at signs & interview 163 visitors in 2 locations	Warning signs (food storage): 1 standard & 4 experimental (moral appeal, humorous, narrative story, telegraphic title)	Visitors not storing food & attracting bears	Narrative sign most effective, empathetic & narrative most positive Location affects reading	Sign reading depends on audience & site location Use narrative story & empathy appeal in signs
Hockett & Hall, 2007	Shenandoah National Park, USA	Test 3 messages on deer feeding	Test 2 messages (fear & moral appeal), 1 control; Camper questionnaires	Written messages (deer feeding) Fear & moral appeal + control	Campers feeding deer	Deer feeding reduced Fear appeal changed beliefs (physical harm)	Use fear appeals in signs Employ moral appeal for impacts on others
Lackey & Ham, 2003	Yosemite National Park, USA	Test black bear communication (469 messages)	Survey 62 park visitors message recall, content, media, delivery, talks	Signs, flyers, brochures, media 141 written messages about proper food storage (sanctions, narrative story signs)	Human-black bear conflicts	Bear sign messages were: low interest -70% easy & 17% difficult; high interest-7% easy & 2% difficult	Present easy rules and narrative story signs Refer to approval from others (rangers, visitors)
Moscardo et al., 2010	North Qld, Australia	Effectiveness of Croc Wise education campaign	Focus group, interviews, survey at 11 sites, audit of Croc Wise materials (content, message)	'Croc Wise' education program (Be Croc Wise in Croc Country) Poster, brochures, warning signs for boating, camping, & fishing	Human-crocodile conflicts	Printed materials impact on safer behaviours; Add 'Croc Danger is Real', refer to legislation & fines; Use 4-6 safety actions & set distances in metres	Use multiple materials to communicate safety Highlight danger, backed up by legislation & fines List key safety actions & specific instructions
Porter & Howard, 2002	Fraser Island, Qld, Australia	Assess 'Be Dingo-Smart' communication (brochure, warning signs, posters on toilet doors; wayside stations)	Survey of 412 campers (dingo message recall)	'Be Dingo-Smart' program: dingo dangers & warnings (not feeding dingoes, proper food storage & disposal; always stay close to your children)	Human-dingo conflicts Visitors feed dingoes	Message recall varied by age, group type, & media (64% brochure, 33% signs) 50% read dingo brochure 37% read toilet posters 32% recalled no media	Use a range of media targeted to specific groups for key messages Used mixed media (brochure, signs, poster) Post safety warning posters on toilet doors

Table 1.3: Key Studies – Beach Safety Warning Signs

Author, Year	Context	Purpose	Research Methods Used	Communication Media	Behaviour Type	Key Findings	Best Practice Principles
Brannstrom et al (2015)	Texas beaches, USA	Test beach user understanding of rip current warning sign (graphically & textually)	Survey of 392 beach users from 4 heavily used public beaches in 2012	Rip Current Warning Signs - danger of rip currents & how to identify & avoid rip currents	Rip-currents (Beach users understood need to swim parallel to shore to escape rip currents)	Nearly half did not notice rip current warning sign ; 44.5% found the sign was “helpful” or “very helpful”; Nearly half could not use graphic image to identify rip currents from beach	Many beach users will respond to a warning sign showing the rip current seen from shore rather than from the ocean aerial view; User view of pictorials
Cantrill, 2008	Australia	Place of warning signs in averting risks at beaches	Review beach safety law Civil Liability Act	Beach Warning Signs	Beach hazards & risks to swimmer safety	Signs necessary when places are actively managed as recreational spots; duty to intervene when risk taking behaviour takes place despite erected warning signs	Balance magnitude of risk with expense, difficulty, inconvenience of alleviation action; Duty to warn of obvious risks to beach users
Hatfield et al., 2012	Beaches	Test education campaign to improve visitor recognition of calm rip currents	Interview beachgoers –test beach & control area Follow-up questionnaires sent after 6 months	Posters, postcards & brochures ‘Don’t get sucked in by the rip’	calm-looking rip currents at beaches (beachgoers could not identify a rip current, or erroneously believed they could identify a rip)	Rip print media improved user intentions : to swim away from a calm-looking rip, ability and confidence in identifying a rip, not to swim at unpatrolled beaches, and responses to being caught in a rip	Print-based campaign effective in warning beachgoers about calm-looking rips - improved beachgoer swimming choices and rip current awareness
Matthews et al., 2014	Victoria, Australia	Test perceived beach hazards & recognition of warning signs	Interviews with 472 beach users at 4 beaches (hazard identification, signage recalled, signage comprehension & shape of warning signs-triangle or diamond), Tested for: no signage, a single standard signboard, and signage of four types	Aquatic safety signs at beaches for strong currents (rips), submerged rocks, dangerous marine life. single standard composite signboard, and signage of four types: location name & emergency information, safety hazard symbols, lifeguard service information, prohibitions	Beach hazards-rips, rocks, marine life	Currents/rips was the foremost hazard regardless of signage ; just 45% reported observing any signage; majority noticed hazard related symbol signs ; Recognition not affected by composition of the sign or symbol shape	se hazard symbol signs for currents/rips Directed strategies for beachgoers to read and heed the information on beach safety signage
Morgan, 2014	Victoria, Australia	Laboratory eye-tracking of looking at water quality safety signs (test visual attention, recall)	measure eye-tracking of participants looking at water quality signs, & 30 participants self-rating the most effective water quality safety signs	Water Quality Signs at Beaches (16 images varied by distance, type, level of distraction;; 18 images varied by text messages & water quality ratings	Water Quality	Water quality signs supported by symbols more often observed; Arrow indicators to the current water quality rating guided attention	Use safety signs with symbols & arrow indicators for rating; Ask participants to rate the most effective beach safety signs

Table 1.4: Key Studies – Warning Signs: Content, Design, Evaluation

Author, Year	Purpose	Research Methods Used	Communication Media	Key Findings	Best Practice Principles
Adams & Edworthy, 1995	Test text display (font size- signal word, white space around, border width), & colour of label (red vs black)	Tested 24 students on 7 size levels of each text display variable, & red versus black labels	Warning labels	Text size had greatest effect, then border width ; increase of 4 points in text size & increase in border width of 2-3 points-same increase in urgency rating; black label signal word had to be twice as big for urgency compared to red label	Use larger font text, wider border width, & red on black for perceived urgency to emphasise warning
Aucote, Miner & Dahlhaus, 2012	Investigate the factors for non-adherence to warning signs about rockfalls	62 interviews near a high-risk rockfall area: attention to and comprehension of warning signs, & beliefs	Warning signs about falling rocks from coastal cliff faces	Less than half correctly interpreted rockfall signage; Warning signs did not provide enough detail on perceived danger and safe behaviours at rockfall areas	Text & pictorials need to highlight dangers of rock falls & potential injuries, Signs need to increase perceptions of danger
Braun & Clayton Silver, 1995a	Test interaction of signal words & colour on warning labels	30 students rated the perceived hazard of signal words in 5 colours; Test of 65 students for 3 colour pool test warnings	Warning labels Signal words in 5 colours (red, orange, black, green, blue) Pool test warning in 3 colours (red, green, black)	Highest perceived hazard: red, orange, black, green, blue. Green Deadly word seen as less hazard than word in red; red pool warning twice as effective as green + black	Red warnings/signal word for highest perceived hazard & behavioural compliance
Braun & Clayton Silver, 1995b	Test interaction of signal word, legibility, colour	34 participants rated perceived level of hazard	Warning labels 2 products, 3 signal words (Danger, Caution, Notice), 2 levels of legibility (Helvetica, Arabia), 4 colours (red, orange, green, black)	3-way factor interaction of key warning features; in conditions of reduced legibility, colour may be the only source of hazard information	Colour is critical to perception of product hazard on warning labels
Braun, Mine & Clayton Silver, 1995	Test influence of colour of signal word on warning labels	33 participants rated 24 labels for perceived hazardousness & perceived readability	Warning labels Product class, Signal word (Danger, Warning, Caution), Chromaticity (colour of word)	Color labels perceived to be more hazardous and more readable than those in black-and-white; perceived readability from width-to-height ratios	Use colour for signal words on warning labels
Changizi et al., 2014	Test warning symbols for 3 areas of vision perception	How warning signs can mimic ancestrally alerting stimuli in nature	Warning Symbols (colour perception, evolution of writing & typography, & visual illusions i.e. radial line stimuli)	Colour and geometry of an angry face may underly superiority of red colour and V shapes in warnings; Radial line stimuli capture attention of observers & also deter moving closer	Use red colour & V shapes in warnings; Use radial line stimuli on signs
Chapanis, 1994	Test 3 signal words & 4 colours	Rating of perceived hazard level, seriousness & probability of injury	Warning signs (3 signal words-Caution, Warning, Danger; 4 colours-white, yellow, orange & red)	Hazard level- Signal Word: Danger (high) , Warning (intermediate), Caution (low); Caution & Warning seen as similar; Colour: red, orange, yellow, white, Danger word with red background best	Use signal word Danger in red on warning signs
Haas & van Erp, 2014	Assess multi-modal warnings that incorporate audio &/or tactile cues		Multimodal warning displays (visual, audio, tactile) and their role in risk communications	Visual-auditory and visual-tactile displays can be significantly more effective than visual displays alone	Use auditory &/or tactile elements in warning signs Signal design guidelines
Helier et al., 2007	Analyse warning signal words	Multidimensional analysis of similarity ratings of 17 signal words	Warning Signal Words (Danger, Warning, Caution)	Two main dimensions of signal words – level of hazard , & extent to which they explicitly implied a risk . Less focus on explicitness of the instruction given.	Use signal words to connote Level of Hazard & Explicit Risk
Kline et al., 1993	Test colour & achromatic versions of warning labels	33 students rated 3 levels of signal words on 6 key attributes	Warning labels	Colour labels perceived as more readable and hazardous than achromatic labels	Use colour warning labels
Kratochvil & Schwammer, 1997	Test effectiveness of signs to reduce knocking on aquarium	Record visitors knocking on aquarium glass before & after 3 signs on exhibit	Signs placed on one exhibit: #1. 'Knocking kills fish' #2 'Only loonies would knock', & #3 'Please don't knock on the glass	Knocking rate reduced after signs: 10% (#2), 18% (#1), 28% (#3) Sign 2 with pride stigma most effective Sign 3 with polite appeal least effective	Appeal to visitor emotions: Target youth pride with stigma words and adults with responsibility messages

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Author, Year	Purpose	Research Methods Used	Communication Media	Key Findings	Best Practice Principles
Laughrey & Wolgalter, 2014	Presents 3-stage model of effective warnings: attract attention; elicit knowledge, and enable compliance behaviour	Assess design factors & non-design factors in warnings	Warnings Design - size, colour/contrast, signal word, graphics, format Non-Design - context, location, and distraction	Design factors- explicit wording and pictorials to provide hazard, consequences and instructional content. Non-design factors- familiarity and perceived hazard (knowledge stage) , Modelling behaviour of others, & cost	Consider design and non-design factors in warnings; Explicit wording & pictorials; Refer to safe behaviours; List the cost of rescue, injury
Laughrey et al., 1993	Assess effects of product warning explicitness	Subjects rated product perceptions & intent to act cautiously	Explicitness in Warnings 'the specificity or detail with which potential injury consequences were described'	Explicit warnings associated with greater levels of perceived dangerousness, hazard understanding, & injury severity. Users more likely to exercise caution.	Product warnings should be explicit regarding injury consequences
McDougald & Walter, 2013	Test comprehension of colour highlighting on warning pictorials (symbols)	Participants described impact of colour highlighting on pictorials (no highlighting, most relevant, least relevant)	Pictorial symbols -warning signs	Comprehension of pictorials best with most relevant parts colour highlighted ; Highlighting less relevant parts of pictorials led to poorer comprehension than no highlighting at all	Colour highlight (circle) relevant parts of complex pictorial symbols on signs (hazards, body injury sites)
Murray et al., 1998	Assess circle-slash negation symbols (red circle and 45° left-to-right slash)	60 participants viewed 16 pictorial symbols with 4 circle-slash types	Pictorial symbols in warnings (circle-slash negation) 4 types (slash over, slash under, partial slash, translucent slash)	Over and under slashes were preferred to the translucent or partial slashes; Orientation and slash type influenced preference for non-symmetrical symbols	Use circle-slash negation symbols on warnings
Rogers et al., 2000	Assess influence of particular variables on warning process	Empirical review of the warning literature	Warning Process-4 key complements: notice, encode, comprehend, and comply	Warning process has person variables (individual characteristics) & warning variables (warning itself, & context)	Principles of warning process; Guide for warning analysis; Improve design of warnings
Schall, Doll & Mohnen, 2014	Assess warning designs to reduce overconfidence	static & dynamic designs, 3 warning conditions: unstructured, structured static, structured dynamic	Warning Design	Structured dynamic warning design has a significantly higher reduction of overconfidence for safer behaviour	Use structured dynamic warnings in signs
Severtson & Burt, 2012	Test risk reliefs against perceived proximity to mapped environmental hazards	447 students assessed risk beliefs for 24 dot maps on 4 key attributes of proximity-based risk	Environmental Hazard Maps (water test results in wells): hazard value, proximity, prevalence, and dot patterns	Numerical susceptibility related to map attributes & proximity-based hazard/risk Risk beliefs affected by hazard value , clustered dot pattern (in/out), & distance	Use dot patterns on signs to indicate high risk areas & number scale for hazard level (large vs small hazard values)
Siswandari et al., 2014	Test comprehension of pictograms on water-sport prohibitive signs in Korea	40 western participants rated 14 pictograms on 5 cognitive sign features; ISO/ANSI standards for safety symbols used	Water sport safety signs	Only three signs conform to both ISO and ANSI requirements for safety symbols ; Best cognitive pictogram features were meaningfulness & semantic closeness ; Pictograms redesigned on water signs	Use internationally recognised pictograms or symbols on warning signs Adopt ISO/AS standards for safety symbols on signs
Williams & Noyes, 2007	Perceptions of risk & design of risk information	Literature review of risk communication	design of risk messages	Key factors: message (colour, signal word, surround shape, framing effect), the source of message (credibility, trust), and target of the message (risk target)	Consider key factors in design of risk messages (message type, source, & target)
Wogalter & Clayton Silver, 1995	Evaluate warning signal words	4 groups assessed warning words (primary & tertiary students, elders, non-English)	Warning Signal Words (danger, warning, caution)	Rank ordering of 3 signal words (Danger, Warning, Caution) consistent across four participant groups	Short list of signal word terms understood by 95% of young students & 80% of non-English speakers
Wogalter et al., 2002	Guidelines for warning design and evaluation	Review of empirical research on warnings	Warning Design (signal words, colour, symbols, text/content), placement (location within instructions), & evaluation (communication, compliance)	Recall of safety warning information aided by repetition , warning relevance , pictorials , & presence of injury statistics	Use pictorials & injury statistics on warning signs Warning design guidelines and evaluation approaches
Wogalter, Jarrad & Simson, 1995	Test influence of signal words on perceived hazard level	135 people rated 16 product labels on 6 areas, e.g. hazard level	Warning labels Signal words - NOTE, CAUTION, WARNING, DANGER, LETHAL Signal icon-exclamation point in triangle	Signal word increased perceived hazard, Significant differences between extreme terms (NOTE and DANGER) but not Caution & Warning seen as similar	Use key signal words in labels Use signal word DANGER for high hazard, and WARNING for medium hazard

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Author, Year	Purpose	Research Methods Used	Communication Media	Key Findings	Best Practice Principles
Wogalter et al., 1993, 1994	Effects of warning signs on compliance behaviour	Observe participants at chemistry task	for last 2 words Printed instructions, pictorials, voice warning, strobe light Posted sign vs task instructions Personal sign vs Caution sign	Signal icon no effect on hazard level Warning compliance greater with uncluttered environment, voice warning , warning embedded in task instructions, personally relevant (name)	Include warnings in task instructions (trail notes), Post warning signs in clear areas, Use personally relevant signs (e.g. YOU are at risk here)
Wogalter et al., 1995	Test warning sign features against standard (ANSI Z535)	Rating & ranking of warning sign features	Warning signs-colours, signal words, shapes, configurations	Perceived hazard highest for colour red & skull icon to right of signal word	Use red colour and skull icon on danger warning signs
Wogalter, Kalsher & Rashid, 1999	Test effect of signal word & source attribution on warnings	Rating of signal words & source attribution on 3 product warning labels, Explicit source vs. general (health) warning	Warning labels signal words: Warning, Government, US Federal, US Food and Drug Administration, American Medical Association (AMA)	Higher warning ratings for signal word & adding more specificity/length to source; specific credible sources (US agency, AMA) had higher ratings compared to a signal word (WARNING) alone	Include credible agency source on warning signs
Young, 1991	Test warning effects of colour, pictorial, signal icon, border	Subject recognition of 96 simulated alcohol labels	Warning label features (colour, pictorial, signal icon, border)	Pictorial, colour or signal icon had significantly faster response times, border had no effect on response	Pictorials, colour and signal icons enhance recognition of warning signs
Young & Wogalter, 1990	Test conspicuous print & pictorial icons in instruction warning manuals	Rating of 8 warning messages with/out larger print & pictorial icons	Warning manual- Conspicuous print (larger text with colour highlighting), Pictorial icons	Higher recognition & recall of warnings with conspicuous print & pictorial icons	Use conspicuous print (larger text, colour highlighting) & pictorial icons in signs
Young & Wogalter, 1998	Test hazard-level information in warnings	Rating of 18 warning statements & 5 variables: exposure & injury level	Warning statements Exposure to hazard Level of Injury	Injury severity & duration rated highest on recognition of warning statements	Refer to injury severity on warning signs related to level of hazardousness
Young et al., 1995	Test relative order & size of message components in hazard warning signs	Subjects designed hazard warning signs using 4 components- examined use, size, order in signs	Warning Signs 4 components: signal word, hazard, consequence and instruction statements	Signal words placed at the top of signs. Participants enlarged certain statements, added pictorials & omitted other less-important elements/information in signs	Increase the size of more relevant verbal information on signs (or add pictorials). Eliminate or make smaller less important information

5 BEST PRACTICE PRINCIPLES

The best practice principles (BPP) for warning signs, derived from the literature review, address a range of elements such as sign content/messages, sign design issues and sign location/context. These have been captured at three levels in Table 2: BPPs as they related to *on-site safety signs*; principles for communicating safety messages in association with *other types of communication* such as interpretation; and safety signage within a *broader visitor risk management context*. In the case of the on-site safety sign category, the BPPs are presented using Rogers et al.'s (2000) four stages of the warning process: notice, encode, comprehend and comply.

Table 2. Best practice principles for safety signs in parks

Category	Characteristic	Specific guidelines (and source)
1 On-site safety signs		
	<i>Noticeable</i>	<p>To be noticed, safety signs should be:</p> <ol style="list-style-type: none"> Of a shape, size and colour that contrasts with surroundings and attracts attention (Williams & Noyes, 2007). Separated from surrounding information (Rogers <i>et al.</i>, 2000). Located close to the centre of vision as visitors approach (Moscardo <i>et al.</i>, 2004). Orientated perpendicular (rather than parallel) to major visitor pathways (Moscardo <i>et al.</i>, 2004).
	<i>Readily encoded</i>	<p>To be readily translated into an internal representation, safety information should include:</p> <ol style="list-style-type: none"> A graphic visual demonstration of the hazard (Matthews <i>et al.</i>, 2014; Rogers <i>et al.</i>, 2000). Short, familiar words (Moscardo <i>et al.</i>, 2004) including signal words (DANGER, WARNING) denoting the level of hazard (Hellier <i>et al.</i>, 2007; Wogalter, Jarrad & Simson, 1995). Large and well-spaced text which can be read from a comfortable viewing distance (Morgan, 2014), with a mixture of upper and lower case (Tinker, 1963) in easily read fonts (such as Helvetica or Times). Signal words should be larger than text, and in colour (Braun & Clayton Silver, 1995b). Languages in addition to English where appropriate (Moscardo <i>et al.</i>, 2010).
	<i>Easily comprehended</i>	<p>To ensure comprehension, safety signs must have four key elements (Moscardo <i>et al.</i>, 2004):</p> <ol style="list-style-type: none"> The signal word DANGER or WARNING, highlighted in specific colours to denote the level of hazard (Hellier <i>et al.</i>, 2007; Wogalter, Jarrad & Simson, 1995). Red and yellow are standard risk level indicator colours which should be used consistently. A statement of the hazard (with symbol if possible). Messages should be limited to a small number of issues, perhaps as few as two (Manning, 2003). An example of the possible consequences. The potential severity of outcomes is critical to risk perception (Young & Wogalter 1998). Simple instructions on how to avoid the hazard. Use injunctive (ought) or proscriptive (do not) messages (Winter, 2006).
	<i>Compliance inducing</i>	<p>To encourage compliance, safety signs should:</p> <ol style="list-style-type: none"> Be located near the site of the hazard (Bradford & McIntyre, 2007). Be authorised by a credible source (Espiner, 1999; Williams & Noyes, 2007). Include circle slash negation symbols (Murray <i>et al.</i>, 1998), however these must not conceal critical features of symbols with the slash. Describe the intended behavioural response (Hatfield <i>et al.</i>, 2012).

Table 2. Best practice principles for safety signs in parks (continued)

2 Associated interpretation and other communication

<i>Co-ordinated</i>	<p>To enhance the effectiveness of on-site safety signs, key messages may be co-ordinated with associated visitor communications. This could include:</p> <ul style="list-style-type: none"> a) Multiple media (including non-agency media) delivered at different stages of the visitor experience. In particular, communication delivered during trip planning could encourage appropriate expectations and preparation (Manning, 2003). b) Messages targeted to specific audiences, recognising that different visitors may be at different stages of development (Manning, 2003). c) A focus on social norms regarding desired behaviours (Skibins, Powell & Stern, 2012). d) The use of narrative stories to appeal to empathy (Hall, Ham & Lackey, 2001; Parkin & Morris, 2005). e) Statistics about accidents (Wogalter et al., 2002). f) Interactive elements to generate response and engage mindfulness (Moscardo, 1999). g) Role modelling of appropriate behaviours through training of commercial operators, volunteers and others active in problem areas; and personal contact with visitors by rangers or other (preferably uniformed) employees (Manning, 2003). h) Clear statements of safe alternatives to popular but potentially hazardous activities or locations.
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3 Organisational risk management system

<i>Visitor risk management context</i>	<p>To ensure a comprehensive approach to visitor safety, visitor safety signage and communication should be managed within an appropriate risk management system (ANZECC, 1998). This may include:</p> <ul style="list-style-type: none"> a) A risk management policy compliant with AS/NZS ISO 31000. b) Risk management procedures which specifically address visitor risk management. c) Guidelines and tools (e.g. manuals, training courses) to guide staff in their response to serious incidents. d) Monitoring and evaluation of the effectiveness of responses to serious incidents. e) Detailed understanding of factors influencing visitor expectations and preparation. f) Engagement with stakeholders to help manage visitor expectations and preparation. g) Clear choices available to visitors and clear directions to appropriate locations for preferred activities. h) Regular inspection and maintenance of signs, and adjustment as required (e.g. due to changing conditions).
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6 DISCUSSION AND SUMMARY

Table 2 seeks to capture BPPs that are applicable in a wide range of contexts and at a broad level but does not provide consideration of people-related factors (Williams & Noyes, 2007). Some examples of differences among target audiences that may need to be considered in safety signage include the following:

- Whether the visitor's behaviour is intentional or unintentional. Persuasive communication is seldom effective on its own for impacting behaviour that is malicious or intentionally illegal or high-risk (Manning, 2003)
- Whether the visitor is a regular or a first-time visitor. Regular visitors familiar with an area and/or activity are less likely to read signs; first-time visitors are more likely to read signs and learn more (Davis & Thompson, 2011)
- Cross-cultural factors. They are widely thought to be relevant to risk perception but appear to be not well researched (Weber & Hsee, 1999; Riley, 2014)
- Over-confidence. This has been found to bias individuals' risk assessment (Schall, Doll & Mohnen, 2014)
- Age, gender and other socio-demographic attributes. For example, age can affect visual acuity which can in turn influence warning sign effectiveness (Shorr, Ezer, Fisk & Rogers, 2009). Males are more likely to engage in high-risk behaviour, and older adolescents appear less risk-averse than younger children (Goldhaber & deTurck, 1989).
- Those who "held negative attitudes towards cautionary signs" were more likely to believe sign-posted high-risk areas were not dangerous (Aucote, Miner & Dahlhaus, 2010)

Context factors may influence the application of best practice principles in specific park settings. Moreover, hazards are not always constant – they can be variable (e.g. due to changing weather and visibility) and they are not always obvious (e.g. underwater hazards). For these and other reasons, relying on signs to communicate risk has its limitations, and we also caution against blanket application of BPPs that may or may not be appropriate in all situations for all audiences.

Warning signs and safety messages in parks are generally communicated within a risk management paradigm, particularly where deaths and serious injuries are known to occur. This is evident, for example, in Surf Life Saving's Aquatic and Recreational Signage Manuals for beach safety and in QPWS's own Sign Manual. However, there may be a place for embracing other paradigms such as interpretive communication and persuasive communication, and thus invoking best practice principles within these paradigms. Not all of the BPPs within these other paradigms have been captured in this report, as most have not been tested in the context of safety messages and risk communication.

Research in park settings in many aspects of safety signage captured in this report is conspicuously absent, and would add considerably to further understanding of how best to communicate safety and warning messages to park visitors.

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