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The effectiveness of safety signs in outdoor recreation settings

A research synthesis and annotated bibliography

Prepared for the Land Safety Forum

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Contents

Executive Summary	3
Figures and tables	4
Acronyms used in this report	4
Introduction.....	5
Approach.....	6
Databases and search terms	6
Determining relevance	7
Annotations.....	7
Literature review.....	8
Introduction	8
General observations about the research literature	8
Factors influencing effectiveness of warning signs	11
Colour, signal words, symbols/icons	11
Signage is more effective when relevant to core beliefs.....	12
Signage is effective when it communicates the rationale for desired behaviours	13
Components of effective safety signage in the outdoors.....	14
The research is not always in agreement	17
The choice is the recreationists to make.....	18
Recreationists <i>choose</i> to ignore or follow safety signs.....	18
Explanations for non-compliance with safety messages.....	19
Off-trail and ‘intentions’ studies.....	20
Conclusion	22
Avenues for future research.....	22
Annotated bibliography.....	24
Additional references	53

Executive Summary

The Land Safety Forum (LSF) is a sector-wide land-safety network, comprising 17 agencies and organisations within Aotearoa New Zealand. LSF provides a mechanism for inter-agency coordination and integration aimed at reducing preventable Search and Rescue (SAR) incidents. The purpose of the Land Safety Forum is to collaborate on complex land safety issues that require networked and systemic solutions.

One focus area for the LSF is hazard and risk communication and, in particular, the signs used to warn people about hazards in recreation contexts. Signs are widely used around New Zealand when visitor safety is identified as an issue, and occasionally recommended by coronial inquiries following accidents in such settings.

Recognising the lack of agreed best practice in outdoor safety signage in New Zealand, and the inconsistency in messaging styles, in 2023 the LSF commissioned Lincoln University to prepare a literature review to document and synthesise available research on the effectiveness of outdoor safety signage. A key purpose of the review was to identify factors that impact signage effectiveness.

The resulting research synthesis and annotated bibliography includes available books, book chapters, reports, journal articles, theses and other research outputs pertaining to the use of hazard and safety signs in outdoor recreation settings. Approximately 90 individual English-language works authored between 1990 and 2023 were identified, summarised and evaluated.

The research synthesis reveals that:

- While a wide range of research has been conducted, there is limited specific data on the effectiveness of signs used to convey safety messages in New Zealand outdoor recreation settings.
- There is a strong North American bias in the available literature - possibly the result of the particular socio-legal character of that community, as well as the long-standing importance of outdoor recreation research in the USA.
- It is critical to acknowledge the limitations of signs and multiple studies demonstrate the ineffectiveness of these message formats.
- Notwithstanding this, the available literature does allow the identification of key principles most likely to maximise effectiveness in the development of warning signs.
- Effective signage is also highly dependent on situational variables, including the nature of the outdoor setting and the characteristics of those engaging with the sign.

It is intended that this research synthesis and annotated literature review will be used to:

- Develop best practice guidance for outdoor safety signage in New Zealand, made widely available for end-users;
- Advise organisations wishing to address a visitor safety risk about the most effective interventions;
- Evaluate the appropriateness of existing signage and make recommendations for potential improvements; and
- Identify avenues for future research to support the development of effective safety messaging for outdoor recreation settings in Aotearoa New Zealand.

Figures and tables

Figure 1. Process used to determine the relevance of English language publications on the research topic post-1990

Table 1. Components of effective safety signage in the outdoors

Acronyms used in this report

DOC	Department of Conservation
ELM	Elaboration Likelihood Model
NPS	National Park Service
NZ SAR	New Zealand Search and Rescue
SAR	Search and rescue
TPB	Theory of Planned Behaviour
US NPS	United States National Park Service

Introduction

Outdoor recreationists in Aotearoa New Zealand are subject to a range of risks that are not only linked to dynamic landscapes and changeable weather but also with experience levels and location familiarity of recreationists. Growing numbers of international visitors combined with increased exposure of visually appealing locations on social media have led to increasing numbers of recreationists heading into the outdoors, some of whom are likely to be inexperienced and poorly prepared for the conditions (Edward-Jones, Chester, and Donovan 2022; Harris 2020; NZ SAR and DOC 2020). As a result, the number of those being injured while participating in outdoor recreation is increasing (NZ MSC 2016) as is the number of recreationists requiring rescue or assistance (Harris, 2020; NZ MSC 2016). To reduce the associated social and financial costs of such incidents, it is important to ensure the risks and hazards associated with outdoor recreation are communicated effectively. This is particularly important for organisations who manage land, coastal areas or water on which recreation activities take place, who may have both legal and perceived moral obligations to mitigate harm.

It follows that those who know about hazards and risks are better equipped to make informed judgements when recreating outdoors, and safety signs are a widely used communication strategy to disseminate safety messages in such settings. Owing to their potential to reach a high proportion of people at the location of interest, low relative cost, and perceived alignment with legal obligations, safety signs have become ubiquitous in outdoor recreation safety globally (Saunders et al. 2019). Despite their widespread use, however, questions remain about how effective signs are as a communication tool in outdoor recreation settings. People in a wide variety of situations fail to respond to warnings directed at them, implying lack of awareness, poor comprehension, and/or limited confidence in the credibility of the message. This report aimed to document the evidential basis for the use of outdoor safety signs and identify factors influencing their effectiveness.

The report begins with an outline of the approach used to generate the literature database that informs the subsequent discussion. The literature review itself is a relatively short synthesis of key themes in, and reflections on, the published research, which concludes with the identification of avenues for future empirical enquiry. Beyond this research synthesis is an extensive annotated bibliography containing approximately 90 entries. This bibliography should provide a useful resource for those readers interested in understanding the detail behind specific facets of warning signs in outdoor recreation settings. Readers should also note that the report includes an additional reference list in order to document citations used to support the wider commentary.

Approach

This project used a document search to find relevant research and evidence-based reports on the topic of *effectiveness of safety signage in outdoor recreation*. This section outlines the ways in which this process was undertaken.

Databases and search terms

A literature search was carried out in May and June 2023. To find relevant articles, reports, research and documents on the topic, the following key words and phrases were entered (in a variety of combinations) into multiple search engines and databases.

Variable one	Variable 2	Variable 3
Outdoor recreation	Safety	Signage/signs
Natural/nature setting	Risk	Communication
Outdoors	Hazards	Messages/messaging
Nature-based recreation	Injury prevention	Risk management strategies
Protected area	Accident prevention	Visual representation
National park	Risk prevention	Persuasive messaging
Countryside	Visitor behaviour	
Wilderness	Behavioural intentions	
Backcountry		

In addition to internet searches (primarily using the Google search engine), searches were made on the following databases: Google Scholar, Science Direct, Taylor and Frances Online, Scopus, and Web of Science.

As the database of publications grew, the most relevant research articles became a valuable resource for identifying related works. Literature that cited the most relevant documents were noted, as were 'related articles' (a function available on Google Scholar). The reference lists of the most relevant documents were also searched. This entailed visual scanning of reference lists for key words/concepts (including the key search terms where applicable as well as prominent author names).

As a part-way sweep for relevant literature, CHAT GPT was used to generate a list of key phrases and topics related to "the effectiveness of safety signage in outdoor recreation". This exercise resulted in the following list, the entirety of which was entered into the Google Scholar search engine once it was considered that the bulk of relevant academic and other documents had been found.

1. Outdoor recreation safety signage
2. Effectiveness of safety signage
3. Signage impact on behavior
4. Safety communication in outdoor environments
5. Risk perception and signage
6. Visual communication in outdoor recreation
7. Interpretation and understanding of safety signs
8. Signage design and effectiveness
9. Safety signage in hiking/trail settings
10. Safety signage in national parks/forests

11. Human factors and safety signage
12. Behavioral responses to safety signs
13. Evaluation of safety signage programs
14. Signage and accident prevention in outdoor activities

This was done to ensure that the search terms previously used had indeed captured most of the relevant material. Just one additional report was found in this 'sweep'.

Determining relevance

Inclusion and exclusion criteria were applied to assess the relevance of documents based on the key concepts of interest according to the research agenda: that is, the *effectiveness of safety signage in an outdoor recreation setting*.

The chart shows the process applied to assess documents in the first instance. Documents were then read in greater detail to assess the degree of relevance.

Exclusions were those documents not written in the English language and those published prior to 1990, as well as those whose quality was considered by this report's authors as dubious (such as issues with coherence or reputability of source).

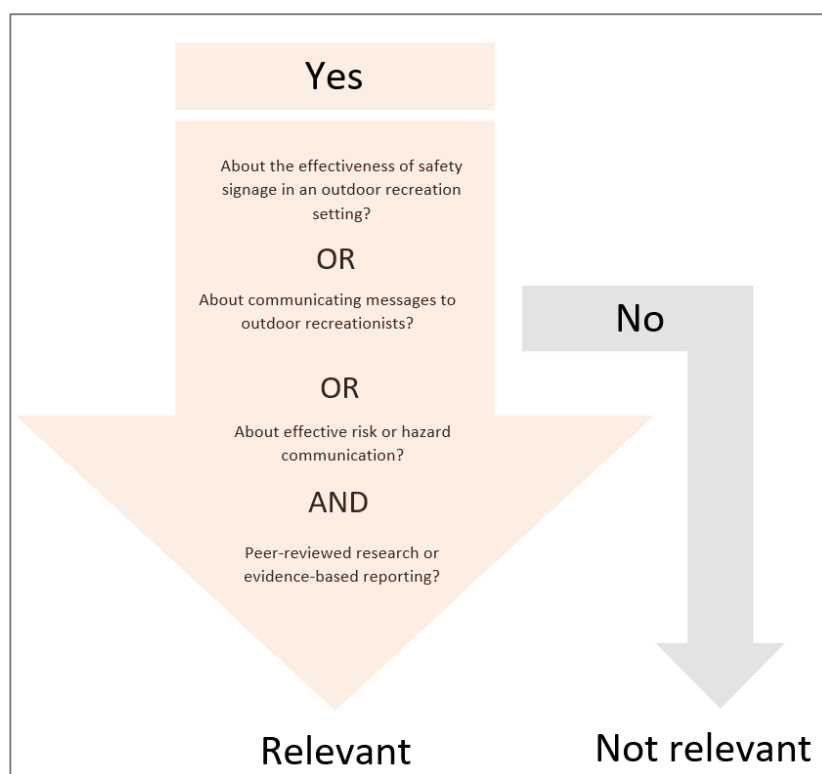


Figure 1: Process used to determine the relevance of English language publications on the research topic post-1990

Annotations

Once the database was complete, each relevant document was reviewed and a short summary prepared in accordance with the project specifications. Each entry has a short accompanying commentary (approximately 150 words), describing and evaluating the source in language appropriate for a non-academic audience. The annotations are organised alphabetically and use Chicago style referencing.

Literature review

Introduction

Following the literature search and annotation process, key themes were identified and collated as a research synthesis. This section of the report begins with some general observations about the literature before discussing components of the research more specifically. In this latter section, we start by looking at where the greatest degree of agreement exists in the literature, a commentary that culminates by documenting many of the key components of designing for effectiveness in outdoor recreation signs (Table 1). The discussion then turns to an acknowledgement that the literature is not always in agreement about the effectiveness of safety signs, emphasising that some conclusions remain contested. This is followed by a synthesis of the research evidence that shows how and why signs are often ignored in recreation settings, underscoring the reality that this is ultimately the recreationist's prerogative. Ahead of a short conclusion, we examine research that identifies some of the threats and opportunities for visitor safety messaging associated with new technologies.

General observations about the research literature

Before delving into the specific themes that characterise our review of the literature, it is important to outline several broad observations of the current state of the research literature pertaining to the effectiveness of outdoor recreation signs.

More than 30 years ago, McCool and Braithwaite (1992, 319) observed that:

Message effectiveness with regard to hazards in dispersed and natural recreation settings remains a largely ignored area of inquiry.... [The lack of] hazard/risk research is unfortunate because the consequences of ineffective messages can be significant in terms of injury or death to visitors as well as financial loss to recreationists and to managing agencies.

Since that time, there have been a number of excellent empirical and meta review publications on the topic, although few of these have been undertaken in New Zealand. Furthermore, while we have amassed around 90 research annotations, there remains a dearth of studies that specifically set out to examine the efficacy of safety warning signs in situ. In our review, we have often needed to extrapolate from studies that canvass elements of message effectiveness in contexts other than safety or beyond the outdoor recreation context.

Further to the above point, we also note that a significant proportion of the research literature identified for this review is North American in origin. There are likely to be several explanations for this, including the strong outdoor recreation research tradition in the US (Manning 2022); the deep institutional investment in national parks and visitor management; and (in relation to visitor safety specifically) a comparatively litigious socio-political context.

As a consequence of this North American dominance, the themes that emerged from the literature on safety signage in outdoor recreation must be considered in the context that a large proportion of the studies target hiker behaviours within the highly managed and monitored US National Park Service (NPS) environment. This outdoor recreation environment is characterised by bio-physical, socio-cultural, fiscal and regulatory contexts that differ from those in Aotearoa New Zealand. The relative absence of European or UK research on the effectiveness of warning signs in outdoor

recreation is perhaps the result of a greater emphasis on personal responsibility in those regions – particularly in case of the former.

Based on this, findings about the effectiveness of safety signage in the US context cannot necessarily be extrapolated to Aotearoa New Zealand where a lot of outdoor recreation takes place in terrain that is remote, rugged, and unmanaged (NZ SAR and DOC 2020). Expectations among recreationists about the extent of hazard warnings are likely to be different in New Zealand than they are in the US. In this regard, Youngs (2020) laments that in the US NPS context perceptions of safety are such that park visitors have almost come to expect a hazard-free environment. Furthermore, Youngs (2020, 315) notes:

Creating universally applied policies and consistent warning sign system is no easy task, especially when one considers the tremendous physical geographic variation found at the 419 units of the US national park system.

Signs and waivers are now a required component of organisational risk management in outdoor recreation in the US (Hutson and Howard 2018), and SAR costs can be recouped in certain states where the recreationist has knowingly entered a closed area - including those marked by a sign (Villegla and Keen 2014). These conditions, alongside the litigious nature of the US more broadly, provide incentives for land managers to place warning and closure signage even if its behavioural effectiveness is not always proven.

While the New Zealand socio-legal context is very different from the US, this domain has still been an important feature governing the available literature. Adequacy or lack of signage has been pointed to as one of a range of factors in several outdoor recreation deaths (NZ SAR 2020). These were primarily in swimming incidents, but also tramping, hunting, boating, climbing and hunting. No warning signs, no signage, inadequate signage, lack of signage, no danger signage, no hazard signs, and signs that were vandalised or in poor condition were all cited in this context. However, it is noteworthy that recreational tramping/hiking fatalities is typically attributed to falls, and a lack of signage is not often noted as a factor in these contexts. The practicalities of locating signs in high-risk spots is virtually impossible given that the New Zealand Mountain Safety Council (NZ MSC 2016) cites falls as the most common reason for fatalities in tramping, mountaineering, hunting, mountain biking and trail running. Similarly, New Zealand Search and Rescue (NZ SAR 2018) reports that falls and slips are the most frequent reason for requiring activation of a search and rescue operation.

Finally, we note the significance of several theoretical frameworks that dominate the research literature on the effectiveness of communication in outdoor recreation settings. Many of the key research articles reference theoretical concepts in their studies about how to influence the behaviour of outdoor recreationists (safety-oriented or otherwise); these include: persuasive messaging (Brown, Ham and Hughes 2010; Orams 1996); Theory of Planned Behaviour (TPB) (Edward-Jones, Chester, and Donovan 2022; Ham et al. 2009; Reigner and Lawson 2009); Extended Parallel Process Model (EPPM) (Witte 1995); and Attribution Theory (Bradford 2007). Additionally, the Elaboration Likelihood Model (ELM) is used (Schoenleber 2022; Ham et al. 2009), as is Recreational Safety Climate (RSC) (Cheng 2022) and lastly, McGuire's (1978) Information-Processing Model guided the research of Cole et al. (1997).

As such, the literature draws heavily on concepts and theories that have been developed within the social psychology discipline and later adapted to the outdoor recreation context. It is also important to emphasise that few studies have evaluated actual behavioural compliance in warning situations,

owing to the ethical difficulties associated with exposing people to potentially dangerous situations, and the highly labour-intensive nature of observation research.

Factors influencing effectiveness of warning signs

In order to evaluate the research literature pertaining to the efficacy of warning signs in outdoor recreation settings, it is important to first establish what it means for communication to be effective. Decades of scholarly works in the discipline of communication and persuasion have shown that message effectiveness can take several forms. To be effective, a message must be recognised and attended to by its intended recipient. Without this awareness, the communication will not proceed. Hence, designers of advertisements will use eye-catching colours, phrases, or imagery to attract the attention of their target markets. The second stage in effectiveness is the ability of the recipient to comprehend successfully (or decode) the message. If the people for whom the message is intended are unable to decipher its meaning, the communication will be unsuccessful. A third critical point, only reached if the initial criteria are met, is the extent to which the message is accepted, believed, or acted upon by the recipient. Message effectiveness can, therefore, be measured along several dimensions, including awareness of the message, recall of the message content, attitude change, and observed behaviour change (Espiner 2001).

Hence, for safety signs to be effective, three steps are required: noticing the sign, comprehending the information on the sign, and lastly, complying with or taking heed of the information on the sign (Rosseau and Wogalter 2006). There are a wealth of studies showing the effectiveness of various components of signage in outdoor settings that help achieve these three steps. The most prevalent of these are summarised here and outlined in Table 1, alongside the evidential literature.

Colour, signal words, symbols/icons

Red is the colour most often associated with hazard, danger or risk, and is near-universally recognised as such on safety signage (Saunders et al. 2019). Second to this, yellow has been found to be effective in getting the attention of viewers (Crowly-Cyr 2018) and has the additional benefit of contrasting with darker colours, such as those found in bush or forested areas (Aley, Espiner, and MacDonald 2023). To a lesser degree, the use of orange in signage has been found to be effective (Laughery and Wogalter 1994). Research consistently advocates for the use of these bright colours in combination with other signage features as a standard for the communication of important or safety information.

Equally, the use of clear, concise signal words are a point on which most research appears to agree; specifically, that the terms 'danger', 'hazard', 'warning', and 'caution' are important to alert the viewer that attention should be paid. Research on signal words, colour, text size and legibility are prevalent within the literatures of safety science and industrial ergonomics, and these aspects have tested successfully in studies of outdoor recreation safety signs (Saunders et al. 2019).

The use of icons is similarly accepted as a useful way to communicate across languages, particularly when simple and easily identifiable and when used within a 'circle slash' to communicate prohibited activities. Symbols, however, are not always relevant or consistently understood across cultures (Mitchell and Haddrill 2004). Illustrations and other imaging have been found to be effective to varying degrees and in combination with a range of other features; the key aspect of illustration use is to capture and retain the attention of the viewer (Parkin and Morris 2005).

Other message characteristics that have been found to influence visitor engagement with signs in outdoor recreation settings, include the number of warnings presented and novel message formats (Cole, Hammond and McCool 1997; Espiner and Weiss 2010). Beyond the outdoor recreation

context, McCarthy, Ayres, Wood and Robinson (1995) found that the effectiveness of warnings (product labels) is likely to decline when they compete with many other warning messages. In addition, some research has indicated that out-of-the-ordinary labels and signs may be more likely to gain attention and obtain compliance than those conforming to standards (Hathaway and Dingus 1992; Wogalter and Young 1994).

Signage is more effective when relevant to core beliefs

A prevalent theme within research on the effectiveness of safety signage in the outdoors is the central importance of messaging that appeals to the viewers' core or salient beliefs. When combined with the related concept of personal relevance, this constitutes a key point on which much research agrees.

The point has been repeatedly made in the literature that personal relevance has significant influence on the ways in which people interpret messaging (Youngs 2020), and that risk communication more broadly is filtered "through the receiving audiences' own selective lenses" (Balog-Way, McComas, and Besley 2020, 2249). Reiterating this point, Hall and Ham (2010) suggest that homogenous groups may process or receive messages in a more uniform way. This finding reinforces the value of clearly identifying and understanding the intended audience of any given communication effort.

Studies on the following safety aspects of outdoor recreation have either included as a finding or noted the importance of personally relevant messaging on signage: rock- and ice-fall related hazards for day walkers in New Zealand's glacier country (Espiner and Weiss 2010); reducing off-trail walking among visitors to an Australian national park (Goh 2023); and rip current safety at Texan (US) beaches (Brannstrom et al. 2015). As to targeting salient beliefs, McCool and Braithwaite (1992) draw on the psychology, marketing/consumer behaviour, health, and sociology canons to present the array of factors that outdoor recreation safety messaging must address in order to be effective, one of which is salient beliefs. This is supported in successive outdoor recreation studies such as that of Hayes (2008) who found that non-compliance with safety signage was prompted by scepticism about the viability of the hazard, and that as such, the real nature of the hazard should be emphasised in communications. Similarly, a US NPS study recommended targeting specific visitor populations (and the particular beliefs that they share) to reduce risks to day hikers whose beliefs that they were safe prevented them from following safety advice and prohibitions (Girasek, Marschall, and Pope 2016).

Lastly, two Australian evidence-based reports offer guidelines to land managers on promoting persuasion in protected areas: a key recommendation from Ham et al.'s 2009 report was to isolate and understand visitor beliefs so that messaging can be targeted accordingly. This Australian report used the Theory of Planned Behaviour (TPB), which addresses changing, reinforcing, or creating new behaviours, and the Elaboration Likelihood Model (ELM), which reinforces the that the basis of impacting people's beliefs is in highly thought-out and evidence-based messaging. Similarly, the framework developed by Saunders et al. (2019) presented a set of field-tested best practice principles (BPPs) for safety signs in parks. This included identifying the target audience and messaging accordingly. The best practice principles (Saunders et al. 2019) are well cited in the literature and have formed the basis for other authors' recommendations and research.

There is evidence within communication literature to support the idea that appealing to the intended message recipient in personally meaningful ways is the key to effective signage (Albers 2012) and several studies, even while reporting findings about which aspects of signage are more effective than others, have noted the highly personalised ways in which people absorb, process, and

react to information. For Moscardo (2014), this idea was expressed in the context of interpretive signage in its broadest sense, and a comprehensive review of research on warning signs (not necessarily in an outdoor recreation context) concluded the same with authors Rousseau and Wogalter (2006, 155) arguing that “compliance rates can be affected not only by the noticing and comprehension stages, but also by people's personal beliefs and motivations and situational and environmental factors”.

From this we deduce that, as the groups that participate in outdoor recreation become increasingly diverse, it will become increasingly difficult to produce in-place safety signs with broad appeal that translates to the desired behavioural responses. This presents a challenge for land managers however, if user-group typologies are developed and updated, safety messaging can be developed that targets the most prevalent attitudes and behaviours.

Signage is effective when it communicates the rationale for desired behaviours

An additional key theme in the research is that signs that communicate the rationale for the desired actions or behaviours is more effective than messaging where no rationale is offered. Research has used a number of terms to describe the practice of explaining the reasons for a desired behaviour in messaging; these include teleological (Marschall, Granquist, and Burns 2017), expository (Towner 2019), awareness-of-consequences (Gramann, Bonifield, and Kim 1995), educative (Guo et al. 2015), and injunctive-proscriptive (i.e., “please don’t... *in order to*...”) (Winter 2006, 38, emphasis added).

A 2014 study found that explicitness of content in signage leads to compliance and that where this included consequences (i.e., the ‘why’) such as penalties or the potential for injury- the higher severity of which promote greater compliance, there was increased compliance (Laughery 2014). Similarly, in a backcountry skiing/boarding study, those who were exposed to graphic messaging prior to riding were more likely to make an accurate assessment of the avalanche risk (Silverton, McIntosh, and Kim 2009).

According to the existing literature, to be effective, warnings need to be conspicuous relative to their context, with factors such as novelty, size, and contrast likely to affect salience. Signal words or icons, and pictorials also attract attention and can be used to convey the consequences of non-compliance. Other components of the communication process are important in persuasion and compliance. Factors such as source credibility, and the psychological disposition of message recipients will influence the efficacy of warning messages. So too will the perceived compliance costs and benefits and normative influences operating. These factors are considered in the following section of the report.

Components of effective safety signage in the outdoors

COLOUR	Description	Citation
Red	Encourages the most compliance	• Saunders et al. 2019
	Universally communicates hazard	• Shibata 2023
	Indicates the highest level of hazard	• Chapanis 1994
	Standard indication of risk (when combined with a signal word)	• Saunders et al. 2019
Orange	Effective at communicating risk	• Laughery and Wogalter 1994
Yellow	Effective at communicating risk	• Espiner 1999
	When combined with black is consistent with bio-hazard warnings (in NZ)	• Aley, Espiner, and MacDonald 2023
	Synonymous with 'warning'	• Crowley-Cyr 2018, 182
	Suitable for general warning (US)	• US Federal Energy Regulatory Commission 2001
Miscellaneous	Standard indication of risk (when combined with a signal word)	• Saunders et al. 2019
	Colours which stand out from their environment are effective	• Laughery and Wogalter 1994
SIGNAL WORDS	Description	Citation
'Danger'	Most effective (in combination with red)	• Chapanis 1994
	'Danger' effective when accompanied by exclamation point icon	• Rosseau and Wogalter 2006
'Warning', 'caution'	Second and third most effective respectively	• Chapanis 1994
Strong signal words	Strong signal words such as 'hazard', 'warning', 'danger', or 'deadly' are effective	• Nguyen 2017
	Strong signal words such as 'hazard', 'warning', 'caution' are effective	• Saunders et al. 2019
	Strong signal words such as 'danger', 'warning', 'caution' are effective	• Towner 2019
	Strong signal words such as 'deadly' and 'danger' are effective	• Williams and Noyes 2017
IMAGES	Description	Citation
'Circle slash' with icon	Effective to indicate prohibitions	• Espiner and Weiss 2010;
		• Meeker & Associates 1994;
		• Saunders et al. 2019
		• Dodd 2019
Symbols	When directly representational succeed in attention getting and compliance	• Laughery and Wogalter 1994

	Effective when the symbol used has cross-cultural relevance	• Moscardo, Woods, and Pearce 1997
	Easily recognisable symbols essential for comprehension	• Meeker & Associates 1994
Images, illustrations	Illustrations more effective to communicate risk (than explanatory text which while was more effective in educating or promoting safe intentions).	• Towner 2019
	Illustration on signage succeeds in increasing awareness of a safety issue	• Parkin and Morris 2005
	Poor or difficult to interpret images confuse and can disassociate viewers with the issue	• Brannstrom <i>et al.</i> 2015
TONE/ LANGUAGE	Description	Citation
Unambiguous	Messaging that clearly articulates risks and consequences is effective	• Deanne and Gísladóttir 2020 • Espiner and Weiss 2010 • Hayes 2008
	‘Graphic’ avalanche warning signs most effectively translated to correct assessment of risk for backcountry skiers/boarders	• Silverton, McIntosh, and Kim 2009
	Signage is effective when un/desirable behaviours clearly described	• Saunders <i>et al.</i> 2019
	Universally understood terms are the most effective	• Shibata 2023
	Simple and direct water-safety messaging was better understood (by a Chinese-Australian cohort)	• Mitchell and Hadrill 2004
	For the communicated hazard to be considered viable, the difference between a ‘hazard’ and ‘information’ must be explicit	• Espiner 1999
	Areas clearly marked as prohibited (as opposed to messaging warning of the risks of entering) more likely to stop recreationists accessing areas	• Girasek, Marschall, and Pope 2016
Empathetic	An empathetic tone is most effective in attracting attention	• Hall, Ham, and Lackey 2010
	Interpretation experts prefer the use of encouraging tone to proscriptive tone	• Winter <i>et al.</i> 2000
Negative	A negative tone is most effective in deterring intentions to behave in risky ways (when combined with explanations of what to do)	• Kortenkamp <i>et al.</i> 2021
	Negative messaging is more effective than positive messaging in cases of serious rule violation or life-threatening situations	• Winter <i>et al.</i> 1998
Appeals to fear	Articulating negative consequences/penalties is effective in eliciting rule-following	• Gramann, Bonifield, and Kim 1995
	Articulating penalties (fines) most effective in eliciting rule-following behaviour	• Johnson and Swearington 1992
	Increased levels of explicitness increases likelihood of rule-following behaviour (as pertaining to sanction or likely injury)	• Laughery and Wogalter 1994
Explanatory text	More effective than instructional (as rationale is clear to viewer)	• Marschall, Granquist, and Burns 2017 • Towner 2019

	'Please don't do X' when accompanied by explanatory text the most effective in deterring off-trail use	• Winter 2006
	Educational signage (that which explains 'why') performed best to deter off-trail use (when accompanied with physical barriers)	• Schwartz, Lawhon, and VanderWoude 2018
	Narrative messaging is effective (in deterring actions that impact wildlife)	• Schoenleber, D'Antonio, and Hall 2022
	Story-telling narrative with image effective in increasing awareness of risk	• Parkin and Morris 2005
	Persuasive messaging with clearly defined purpose (the 'why') is effective	• Orams 1996
	Narrative text is effective at capturing attention	• Hall, Ham, and Lackey 2010
Target salient beliefs	Signage needs to address underlying beliefs to be effective	• Hayes 2008 • McCool and Braithwaite 199 • Park <i>et al.</i> 2008 • Ham <i>et al.</i> 2009
	Signage with personal relevance relating to core values is effective	• Goh 2020
	Personally meaningful content is effective	• Lackey 2003
	Personalised messaging is more effective than generic	• Guo <i>et al.</i> 2015
	Signage that describes the issues and makes it personal is effective	• Bradford and McIntyre 2007
	Signage that taps into the viewers' passion or interest is most effective	• Taff <i>et al.</i> 2017
	Signage targeting <i>specific</i> beliefs most effective in prompting desired behaviour	• Brown, Ham, and Hughes 2010

Table 2: Components of effective safety signage in the outdoors

The research is not always in agreement

Although many studies conclude that the presence of signs is generally better than the absence of signs in prompting specific desirable behaviours (Bradford and McIntyre 2007; Brown, Ham, and Hughes 2010; Espiner 1999; Gstaettner et al. 2019; Kratochvil and Schwammer 1997; Park et al. 2008; Parkin and Morris 2005; Winter 2006; and Winter et al. 1998), it is also widely acknowledged that signs do not always directly translate to safer outdoor recreation outcomes (Edward-Jones, Chester, and Donovan 2022; Girasek, Marschall, and Pope 2016). The complex relationship between safety signage and safer outcomes is underpinned by the array of factors which influence decision-making (including cognitive processing and personal peculiarities) as well as the range of factors that pertain to the signage itself (including the features noted in Table 1 above, as well as sign placement, proliferation, and size).

Our review identified a number of studies where the results, when compared, offered sometimes contradictory conclusions, meaning that findings can be challenging to generalise. For instance, while Johnson and Swearingen (1992) found that signs warning of penalties (i.e., a common 'fear appeal') for off-trail use was the most effective when compared with an appeal to emotion and direct prohibition with use of the 'circle slash' design, other studies report the opposite (Espiner and Weiss 2010; Meeker & Associates 1994; Saunders et al. 2019). Similarly, albeit in a non-recreation context, Witte (1995) found people who are exposed to fear-arousal messaging were more likely to *minimise* the seriousness of the risks to control their fear – a supposition supported by psychological literature, in particular Protection Motivation Theory (Norman et al. 2015).

Other work supports Johnson and Swearingen's (1992) finding that appeals to fear are effective, including Gramann, Bonifield, and Kim (1995) whose study found that warnings about fines and personal injury were more effective than signage which explained the reasons for the desired behaviour. However, as discussed earlier, there is much stronger consensus around the importance of including the rationale for desired behaviours on safety signs.

In another contrasting scenario, Hendricks (2001), in a study of mountain bikers showed negligible difference in fear appeal versus moral appeal messaging (delivered verbally), whereas Wallace and Gaudry (2002) found that fear appeals (authoritative and punitive messaging) were less effective than the use of an educative messaging to prompt behaviour change in the US backcountry.

Illustrative of the seeming disagreement about the best approach so far as tone is concerned, a 2000 study by Winter and colleagues asked members of the National Association for Interpretation their preference in the use of encouraging (prescriptive) or discouraging (proscriptive) language in signage in a recreation setting and the clear preference was for prescriptive language, a finding that is in contrast to the preponderance of negatively framed signage that exists in such settings (Winter et al. 2000).

The apparent contradictions in findings between some of these studies probably also reflects the range of variables that are difficult to control for, especially in field study situations – that is, the findings are highly context-dependent. For those designing safety messages intended for outdoor recreation settings, the applied value of individual studies is likely to be highest where the attributes of the outdoor recreation setting closely resemble those of the intended case.

The choice is the recreationists to make

One of the most appealing and highly valued features of outdoor recreation is the freedom it offers participants to engage in natural resource settings without the perception that overly prescriptive parameters are constraining their choices. Making decisions and judgements based on one's own assessment of the conditions is a hallmark characteristic of outdoor recreation practice – especially for more seasoned recreationists (Wray 2009). Hence the introduction of warning signs into outdoor recreation settings is sometimes unwelcomed by visitors, complicating the response to such messages.

Notwithstanding the points made earlier in relation to awareness and comprehension (prerequisites in persuasion), there are several other reasons why a warning sign might not be heeded in any given outdoor recreation setting. The wider communication literature suggests that people often ignore messages and fail to comply with written instructions (Meis and Kashima 2017). Multiple explanations for this phenomenon include limited awareness or comprehension, the perceived costs of compliance, over-confidence in personal ability, lack of personal relevance, and lack of confidence in the communicator.

Recreationists *choose* to ignore or follow safety signs

The current review revealed multiple examples of research that provided evidence that outdoor recreationists had either not noticed, or not followed the messages on safety signage in recreation settings. As Meis and Kashima (2017, 3) noted, once a sign's message is comprehended, "a decision is made to act or not to act"; and, crucially, the list of factors influencing a person's willingness to act on safety messages is long.

In a highly managed US NPS recreation setting with barriers and warning signs to indicate prohibited zones and hazards respectively, hikers still entered dangerous areas (Girasek, Marschall, and Pope 2016). In New Zealand, observations at two South Island glaciers showed visitors routinely not registering or simply ignoring restricted access signs to gain closer access to glacier faces (Espiner 2010; Hayes, 2008). When asked about their actions, recreationists in both studies explained their behaviour was on the basis that they did not believe the situation was unsafe. An Australian beach study found that almost half of survey respondents did not recall even seeing safety signage, and quarter did not recall what the hazard signs at the beach were warning about (Matthews, Andronaco, and Adams 2014). Lastly, despite signs alerting visitors to the dangers and hazards of entering Hawaiian natural pools, "a large number of visitors choose to explore and/or swim in the pools" (Reigner and Lawson 2009, 23).

Also channelling this individual choice theme, several studies in our review emphasised the limited empirical evidence that signs work to keep outdoor recreationists safe (Moran et al. 2011; Saunders et al. 2019; Scholl-Grissemann et al. 2022). In particular, the more recent research reviewed made this point explicitly. For example: "evidence for messaging effectiveness is inconsistent" (Schneider et al. 2021, 4), and that "often, in close proximity to a person participating in an outdoor recreational activity, is their engagement or lack of with a hazard sign" (NZ SAR 2020, 6).

This theme in the research literature emphasised how the onus is on the recreationist, and it is often their ability or willingness to act on the safety information that most influences outcomes (Espiner 1999; Hall and Ham 2010; Ham et al. 2009; Nguyen 2017; Orams 1996). Safety signage cannot ensure appropriate behaviour, it can only seek to persuade (Girasek, Marschall, and Pope 2016; Orams 1996; Saunders et al. 2019).

Explanations for non-compliance with safety messages

Factors that impact on recreationists' willingness or ability to follow messages on safety signs include situational factors such as weather, views, sign type and proliferation, terrain, and the presence of visible hazards (Espiner 2001; Scholl-Grissemann 2022; Tsakakis and Schneider 2021), as well as individual factors such as perceptions of risk (Espiner 2001; Gramann, Bonifield, and Kim 1995; Mata 2022), assessments of the credibility of risks (McCool 1992; Williams 2007), familiarity with the recreation activity and location (NZ SAR and DOC 2020), commitment to continuing with or completing the activity (NZ SAR and DOC 2020), and the range of broad salient beliefs touched on above (Brown, Ham, and Hughes 2010; Lackey 2003). There are also some demographic characteristics that have been found to correlate with non-compliant behaviour in outdoor recreation settings, including being male, young, and visiting alone (Espiner and Weiss 2010; Girasek, Marschall, and Pope 2016; Moran 2006; Towner 2019) – findings that underscore the importance of communicators properly understanding their target audience before designing warning messages.

In the wider communication literature, a range of social and psychological factors are offered as explanations for non-compliance with messages. For instance, effectiveness can be a function of the message recipient's assessment of the costs of compliance, and the role of normative influences. McCarthy et al. (1995) argued that warning compliance imposes a 'cost' on those at whom it is targeted. Costs can include time, money, effort, lost opportunity and so on. Where the cost of compliance is low, a greater proportion of people are likely to adhere to warning messages. Where the compliance cost is perceived to exceed the potential compliance benefit, individuals are less likely to act in accordance with the warning message, than if the benefits outweigh the costs (Hathaway and Dingus 1992; Wogalter and Laughery 1996).

Normative explanations for non-compliance were a common feature of studies identified for the current review. Multiple studies provided evidence that seeing others go off-trail or into prohibited areas encourages others to do the same (Girasek, Marschall, and Pope 2016; Gstaettner et al. 2019; Hayes 2008; Saunders et al. 2019; Schwartz et al. 2018). In the context of Aotearoa New Zealand glaciers, Espiner (1999) found that even when authorised personnel entered roped-off zones, this led others to believe it was safe enough to do so. Similarly, Goh (2020) found that Australian day walkers felt at ease disregarding signs and going off-trail when witnessing others walking off-trail, and Carter (2019) suggested that social sanctioning is effective in maintaining rules and norms in the context of rock climbing.

There is also some evidence in the literature to suggest that, beyond the site-specific and personal characteristics, broader socio-cultural factors may play a part in how recreationists respond to warning signs in the outdoors (also see Cui, Fountain and Espiner 2023). Recent socio-demographic changes in Aotearoa New Zealand, for instance, are likely to bring new users into the outdoors, many of whom may lack the familiarity with New Zealand's topography and weather, in particular (Espiner, Stewart and Apse 2021). Changes in the ways that people perceive and react to institutional messages have been observed, which, when coupled with a growing emphasis on personal freedoms, may have significant influence on outdoor recreation attitudes and behaviours in future. Along these lines, in a study of Canadian hikers, Harris (2020) reported that hikers disregarded safety signage feeling the messages just didn't apply to them.

Off-trail and 'intentions' studies

Much of the research on adherence to signage in recreation settings focussed on 'off-trail' behaviour (also referred to as 'social trail use'). A significant number of US-based studies address the use of messaging (including signs) to reduce incidence of hikers walking off trail¹. While studies examining off-trail behaviour and the effects of messaging are often designed with environmental protection in mind, the serious consequences that can result when walkers leave marked trails make such studies relevant to outdoor recreation safety. Off-trail use can result in walkers getting lost or disoriented, encountering hazardous areas such as cliffs or drop-offs, and entering terrain that the recreationist is not experienced or provisioned to cope with.

The current review found evidence that recreationists leave the defined track (trail) for a variety of reasons including: for a shortcut/ shorter route (Goh 2023); to get a better view (Espiner 1999; Girasek, Marschall, and Pope 2016); to get close to wildlife (Towner 2019); and to pick up or touch natural objects (Espiner 2001; Winter 2006). Taking photographs is another commonly reported reason for recreationists to leave a trail (Park et al. 2008; Espiner 2010), and the 'selfie' phenomenon whereby distinctive or dramatic scenes are sought for images to share on social media is a well-documented safety issue (Harris 2020; Weiler, Gstaettner, and Scherrer 2021). Activities that are shocking or provocative in some way, and that lend themselves particularly well to social media, present an interesting issue for outdoor safety, a recent example of which is 'extreme ironing' (Ainge-Roy 2023).

Schwartz et al. (2018), Johnson and Swearingen (1992), and Bradford and McIntyre (2007) all tested the effectiveness of signage in deterring social trail use. These studies found that incidence of people walking off-trail was reduced by the presence of educational signage (combined with barriers), signage that warned of fines, and signage that was persuasive in style.

There is also a cluster of recent studies that have used behavioural intentions as a focus of enquiry into the effectiveness of messages aimed at outdoor recreationists, including Guo (2015) who used a laboratory setting to test off-trail hiking intentions. Similarly, studies have measured the intentions of hikers based on their exposure to a variety of scenarios such as incoming inclement weather (Scholl-Grissemann et al. 2022), proximity to dangerous wildlife such as bison (Kortenkamp et al. 2021), and whether or not recreationists would obey rules when enticed (Gramann, Bonifield, and Kim 1995). While Scholl-Grissemann et al. (2022) found the influence of on-site signage was limited in effectively warning hikers, the latter two studies showed that effectiveness was increased where it focussed on informing people about what *to* do, what *not* to do, and the consequences and penalties for non-compliance.

Behavioural intention studies certainly have their place, and can reduce the myriad ethical and logistical issues associated with testing behavioural compliance in warning situations. Such approaches allow for a range of scenarios to be explored without exposing people to potentially dangerous situations and avoid the highly labour intensive nature of observation research (Espiner 2001). It is important to note, however, that the results of intentions studies must be treated with caution as it has been shown that stated intentions do not always translate to actual behaviours (Marschall, Granquist, and Burns 2017).

¹ Note that studies frequently reference 'trails', a term which in some cases refers to a well-defined roped or paved path but can also refer to a bush track that is less well defined.

New communication technologies imply both threats and opportunities

A small number of research papers were identified where the focus was on the use of digital communication in outdoor recreation contexts, with several studies aiming to compare the benefits of new and traditional formats. Hutson (2018), for instance, found static signs less effective in promoting safety in outdoor recreation when compared with social media and stakeholder engagement, and Wolf (2013) reported that, although signs outperformed pamphlets in visitor education, modern media was more popular with visitors and had the potential to provide personalised information that engaged visitors. Scholl-Grissemann et al. (2022) suggested that digital safety information on trails was potentially the most effective and called for more research on the potential for real-time communication with hikers. Several other authors noted a need for a future emphasis on digital communication observing that technological devices will soon play a greater role in the communication of safety messages in outdoor recreation (Bethune et al. 2022; Buhalis and Sinarta 2019; Cui et al. 2023; Huyong 2017; Scholl-Grissemann et al. 2022).

Another tranche of research illustrated the value of online (website) platforms in pre-visit safety education and awareness. NZ SAR and DOC (2020) found that Facebook, You Tube and Instagram are the top three social media platforms/ user generated content (UGC) sites used by both domestic and international visitors for hiking information. Such formats may not be universally effective, however, with a New Zealand Mountain Safety Council report finding that the more experienced ('seasoned veteran') demographic group are the least likely group to consult social media or the internet to increase their knowledge of avalanches (NZ MSC 2023). Similarly, Tsakakis and Schneider (2021) acknowledged that although social media sites did engage target audiences on the topic hazards and risks, personal perceptions of safety were ultimately the key influence on-water unsafe behaviours among the kayakers in their study.

While empirical research is scarce to date, there is emerging reference to 'smart warnings' in the literature, leveraging mobile technologies and the increasingly bespoke and tailored curation of content of social media (Bohlin and Brandt 2014; Moscardo 2014; Shultis 2015), with the added benefit that such tools can reduce the desensitisation that can result from an over-abundance of warning signs (Williams and Noyes 2007), or when signs warn of conditions that may not be uniformly present. Furthermore, new technologies may also begin to disrupt the traditional uni-directional nature of risk communication. Fang, Yamanaka, and Trencher (2021) and Harrop (2012) found that communication styles other than one-way (described by Fang et al. as "unilateral preaching") may have considerable utility.

The popularity of social media, and the ubiquity of the smart phone, in particular, is altering outdoor recreation habits and potentially opens these settings to less well prepared and inexperienced participants (Depatie et al. 2016; Espiner, Stewart and Apse 2021; Harris 2020). While these devices provide security to recreationists in terms of access to help in the event of emergency (Shultis 2015), some research suggests that reliance on smartphones and other digital technologies can result in complacency and inadequate preparation for outdoor excursions (Harris 2020; Depatie et al. 2016; Nielsen, Palmatier and Proffitt 2019). Harris (2020) noted that her study respondents believed that SAR operations could be easily activated if required, and they therefore paid less attention to safety messaging on-site, and frequently dismissed this as not applicable to them.

Conclusion

Risk communication in outdoor recreation settings is an increasingly important focus for agencies and businesses with responsibility for visitor safety. In Aotearoa New Zealand, the situation is complex owing to the growing diversity of users, an entrenched aversion to risk among many members of the community, and a common expectation that the outdoors should allow a high degree of freedom from constraint.

Signs have been used for decades as a simple and affordable tool for managers to communicate critical messages specific to the setting. As noted in this literature review, however, signs are not necessarily adhered to and their overall effectiveness in improving safety outcomes for recreationists has been questioned.

In traversing the literature, it is possible to conclude that signs do play an important part in the risk communication 'eco-system', but they should be considered as only one part of the suite of available messaging tools, alongside sector safety campaigns and personally delivered messages. A consistent finding in the research literature internationally is that personal (typically verbal) communication of safety information is most effective way to ensure behavioural compliance (see, for instance, Aley, Espiner and MacDonald 2023; Hendricks et al. 2021; Hockett, Marion and Leung 2017; McCool and Braithwaite 1992; Moscardo 1999), although in many hazard situations, it is simply not practical to employ staff to deliver these messages. The literature is also clear in its identification of key design characteristics that have been shown to work best, should it be determined that a sign is an appropriate solution to a visitor safety challenge.

The effectiveness of signs has also been shown to be highly context dependent (Girasek, Marschall, and Pope 2016; Scholl-Grissemann et al. 2022; Towner 2019; Williams and Noyes 2007; Youngs 2020). Outdoor recreation settings are dynamic environments and the ways in which visitors interpret safety and risk on any given day is likely to vary considerably (Espiner 2001). Factors such as the weather conditions, who people are visiting with, the number of other visitors present, disposition towards the management agency etc. all impact if (and how) messages are noticed, comprehended, accepted and acted upon.

New developments in digital and mobile technologies may offer the best opportunities to advance the practice of risk and hazard communication in natural resource settings. Messages tailored to individual visitor profiles or at least to specific condition status (rainfall, temperature, wind speed, river levels etc.), albeit via an 'opt in' basis, have considerable potential to maximise the personal relevancy and condition-specific character of safety communication.

Avenues for future research

This review project has raised a number of potential avenues for future research. Given that the majority of the existing literature does not derive from Aotearoa New Zealand, it is important to test the validity of many of the accepted components of message effectiveness in a New Zealand context. Also critical is the need to understand the views, perspectives and responses of the increasingly diverse outdoor recreation 'community'. As noted in the discussion above, Aotearoa New Zealand is undergoing rapid socio-demographic change, and alongside increasing awareness of and access to outdoor recreation settings, this is likely to introduce many new users to these environments. These new recreationists need special consideration in future research focussed on

risk and safety communication in the outdoors. This emphasis ought to be kept in mind when considering the following list of potential research topics.

- Site-specific observational studies to accurately document visitor interactions with signs - especially in known visitor safety 'hot spots';
- Qualitative research to gain deep insights about recreationists' expectations, awareness and comprehension of, as well as response to, signs in outdoor recreation settings;
- The potential for novel message formats, including geo-targeting;
- Recreationist appetite for opt-in messaging apps that would permit real time messaging;
- Pre-testing of sign designs with relevant audiences to maximise comprehension;
- Understanding more about the sources recreationists use for information, including when this is accessed in relation to their visits;
- Anthropological study of the culture of signs (and risk communication more generally);
- Understanding more about agency / manager expectations around signs.

Annotated bibliography

A **Acuña, Kierstin, Jack Colbert, Christina Garvey, Briley Hebner, Katie Joy, Jordan Plotkin, and Christiana Wilhelm-Glab. Flooding in Patapsco Valley State Park: Recommendations for Signage and Communication Materials. Partnership for Action Learning in Sustainability (PALS), 2020. Accessed June 14, 2023. <https://drum.lib.umd.edu/handle/1903/26336>**

This report presents research and recommendations for appropriate and effective flood warning signage and educational material for Patapsco Valley State Park (Maryland, US). The risk focus of the research is a natural hazard (flooding), with the goal of improving existing signage to better inform and appeal to park visitors and to better target the increasing number of Spanish-speaking visitors.

The authors followed the recommendations of Saunders et al. (2019) in the development of their improved signage (see below in this bibliography for summary), using simple and direct messaging. However, their improved signage was not tested. Further, information that informed both signage and education materials was derived solely from material available from Zion National Park (Utah, US), the justification for which was simply that it existed in sufficient detail. Consequently, this report adds little in terms of empirical value.

Aley, Joanne P., Stephen Espiner, and Edith MacDonald. "Behaviour change interventions to facilitate forest trail users' biosecurity compliance." *Journal of Sustainable Tourism* (2023): 1-22.

This article reports on a large-scale research project in which the behaviours of 10,536 outdoor recreationists were observed and the opinions of 3,061 recreationist respondents were gathered via intercept surveys. The broad aim of the research was to examine the ways in which recreationist behaviour could be modified to reduce the spread of kauri dieback. Five behaviour change interventions were tested on two visitor groups (locals and visitors from farther afield), and it was found that the use of ambassadors – that is, a person stationed at the trail who advised visitors of the correct protocol – was the most effective behaviour change intervention. Other interventions were all visual - in three cases signage (normative messaging, 'watching eye' signage, hazard/biosecurity signage) and in the final case a pledge board. The effectiveness of the visual messaging interventions was varied: the pledge board was more effective with locals, while the normative messaging was more effective at one location.

Andronaco, Robert, Bernadette Matthews, S. Grace, Austin Adams, and C. Arrowsmith. "Aquatic Safety Signage Recognition and Comprehension." *Injury Prevention* 18, no. Suppl 1 (2012): A136-A136.

This research surveyed 531 beachgoers at Victorian beaches (Australia) where different signage conditions were present (no signage, composite or single signs, and 'broken down' signage). Respondents were asked questions to measure the extent of their recognition and comprehension of aquatic safety signage. Results showed that under half of beachgoers (45%) noticed a sign where it was present, and that signage type and the shape of the hazard symbol did not affect recognition. The authors note the limited research that exists regarding effective aquatic safety signage and the extent of compliance with warning/safety signage.

B Balog-Way, Dominic, Katherine McComas, and John Besley. "The Evolving Field of Risk Communication." *Risk Analysis* 40, no. S1 (2020): 2240-2262.

This paper comprehensively reviews risk communication literature published between 2010 and 2020. Its scope is broad however, two key conclusions were that a multifaceted approach is required to effectively communicate risk and, the ability of audiences to absorb messages is highly dependent on individual circumstance, is often indirect, and is cumulative. Additionally, the review recognised use of social media in risk communication as a key theme in recent literature. They suggested that there are many unknowns in this aspect of risk communication and that this warrants further research into the role of social media and the consequences of adopting this method to communicate risk.

Bird, Eric C. F. "Cliff Hazards and Coastal Management." *Journal of Coastal Research Special Issue No. 12* (1994): 299-309.

This piece summarises cliff hazard management for a special issue of the Journal of Coastal Research. It categorises the four main types of hazards that humans face in coastal cliff areas and broadly addresses some management practices from a local authority perspective. Warning signage is discussed in this context as having the overarching goal to deter risky behaviours; however equally emphasised is the legal protection that signage confers on local authorities. The article tone suggests an acceptance that signage is not fail-safe, and this is backed by cited research (pre-1990) to that effect. The article concludes with questions about degrees of danger and the extent to which signage versus fencing can be most effectively used.

Bird, Deanne K., and Guðrún Gísladóttir. "Enhancing Tourists' Safety in Volcanic Areas: An Investigation of Risk Communication initiatives in Iceland." *International Journal of Disaster Risk Reduction* 50 (2020): 101896.

This longitudinal study tested risk communication initiatives to assess effectiveness and offered recommendations relevant to the volcanic tourist area in Þórsmörk, Iceland. Datasets collected in 2009, 2010, 2016 and 2017 were analysed to assess hazard perceptions and preparedness of visitors and stakeholders. So far as signage is concerned, it was found that less than half of tourists (n=124) reported seeing hazard warning signs, and even fewer reported reading them (42%). Results also suggested confusion from visitors about the signage (e.g., that signage was not detailed enough *and* that it was too detailed), as well as that signage did not clearly communicate the potential severity of the hazard. They found that visitors do not often seek information about hazards and recommended (amongst other things) that location-specific information be provided and that a broader, sector-wide approach be taken to disseminate information about volcanic hazards. They noted this could include tourism operators, guides, agents, hospitality and accommodation staff, and promotional agencies acting as spokespeople.

Bradford, Lori E. A., and Norman McIntyre. "Off the Beaten Track: Messages as a Means of Reducing Social Trail use at St. Lawrence Islands National Park." *Journal of Park & Recreation Administration* 25, no. 1 (2007).

Observations and Attribution Theory were used to assess the effectiveness of messaging types on signage to deter off-trail (social trail) use in a Canadian national park. In the context of this study, Attribution Theory states that for messaging to be persuasive, it must create awareness (of a

problem), be personal (to internalise causality), and allow the viewer to feel a sense of control (over the problem). Consequently, messaging of this and other types was posted at the start of social trails and at the entry point to the island and was found to reduce social trail use by 36-44%. Attribution messaging was more effective than 'plea' messages ("please don't...") no matter where it was placed but all signage was more effective than none. Note that 80% of visitors were in groups of two or more people, which may have positively impacted on rule-following.

Brannstrom, Christian, Heather Lee Brown, Chris Houser, Sarah Trimble, and Anna Santos. "You Can't See them from Sitting Here": Evaluating Beach User Understanding of a Rip Current Warning sign." *Applied Geography* 56 (2015): 61-70.

This study tested the effectiveness of rip current warning signs at three Texas (US) beaches. A total of 392 beach goers were surveyed and two main issues with the signage were found. First, almost half of those surveyed did not notice warning signs when they approached the beach; second, owing to the image used in signage depicting an aerial view, its meaning was disconnected from 'real life'. Respondents also felt that as it did not explain or show *how to identify* a rip current, the messaging was most useful to those who already knew about rips. The authors of the report acknowledge that in the context of saving lives, this finding may not be applicable as the most important piece of information in a rip is how to escape it, however in the context of preventing people entering rip currents the finding has use. A key recommendation from the research was to construct messaging that is more meaningful to the viewer.

Brown, Terry J., Sam H. Ham, and Michael Hughes. "Picking up Litter: An Application of Theory-Based Communication to Influence Tourist Behaviour in Protected Areas." *Journal of Sustainable Tourism*, 18, no. 7 (2010): 879-900.

This Australian research used the Theory of Planned Behaviour (TPB) to examine how to target behaviour-change messaging to visitors of protected areas. The authors first tested the salient beliefs of visitors and then, having isolated two popular beliefs, designed two types of signage messaging to target these. While the research specifically addressed the behaviour of picking up litter, persuasive messaging was a key component and authors found through observation that signage that targeted specific beliefs was most effective in prompting the desired behaviour.

Both sign types tested were text-based and began with a question to encourage the visitor to read on. Signage that appealed to altruistic norms ("do the right thing") was found to be more effective than that in which a specific behaviour type was prompted with the question "What will you do when you see it?" but both interventions increased compliance.

C

Chapanis, Alphonse. "Hazards Associated with Three Signal Words and Four Colours on Warning Signs." *Ergonomics* 37, no. 2 (1994): 265-275.

This study evaluated the perceptions of hazard levels when three signal words (caution, warning, and danger) with four background colours (white, yellow, orange, and red) were combined. The use of the word 'danger' with a red background was found to indicate the highest level of hazard, with orange, yellow, then white successively less. The word 'danger' was found to indicate the highest threat level, with 'warning' and 'caution' pointing to similar threat levels, each of which was perceived to be lower than 'danger'.

Cheng, Tien-Ming, Mei-Tsun Chen, Ci-Yao Hong, and Tzu-Yu Chen. "Safety First: The Consequence of Tourists' Recreation Safety Climate." *Journal of Outdoor Recreation and Tourism* 37 (2022): 100471.

This article reports on research undertaken at a Taiwanese beach to assess the ways in which a recreation activity's climate of safety can contribute to recreation satisfaction. While the effectiveness of safety signage was not tested, the study noted several times that signage – as one aspect of creating a safe climate – was an effective way to reassure visitors that recreation managers have considered this aspect. It was found that where perceptions of a 'recreation safety climate' existed, recreationists had greater levels of recreation satisfaction, were more likely to return, and had increased feelings of place identity. Data was composed of the opinions of 342 surfers, who appeared (from the questions asked) to be using a commercial operator to carry out their recreation activity; hence, the recreation environment under study was one that can be considered highly managed (e.g., a licenced operator, provision of equipment, and safety demonstrations).

Cole, David N., Timothy P. Hammond, and Stephen F. McCool. "Information Quantity and Communication Effectiveness: Low-impact Messages on Wilderness Trailside Bulletin Boards." *Leisure Sciences* 19, no. 1 (1997): 59-72.

This research tested six hypotheses related to the ways in which recreationists comprehend and retain low-impact hiking messages posted on a trail-side message board. The research site was a popular hiking/horse riding trail in Montana, US, where six messaging treatments were tested. These were a mix of 2 – 8 messages and the presence and absence of an accompanying map. Five hundred and six recreationists were observed looking at (or not) the posted messaging and were later quizzed on their contents. Results showed a positive association between attention paid to messages and the retention of content; however, information overload was apparent. For example, where eight messages were displayed, visitors acquired no more new knowledge than where just two were displayed. It appeared that 25 seconds was the maximum time that most visitors stopped to read demonstrating that critical messages must be prioritised on signage.

Crowley-Cyr, Lynda. "Are Warning Signs Effective in Communicating Jellyfish Hazards?." *Journal of Health, Safety and Environment* 34, no. 2 (2018): 181-197.

The research reported in this article assessed the effectiveness of two jellyfish warning sign types located at Palm Cove (Queensland, Australia) and Waikiki Beach (Hawaii). Just over 100 participants were interviewed on-site at each location and were assessed on three aspects of the signage: did they notice it, did the sign increase their awareness of the hazard, and did it influence their water activities. Findings indicated that even where signage was well-noticed this did not translate to a high degree of correct interpretation of the extent of the hazard for one of the signage types. Consequently, the authors emphasise that messaging must be clear and meaningful to be effective but, even so, they caution that safety perceptions, familiarity with location, and a range of other aspects influence people's decision to regard or disregard warning signs.

Dann, Graham M. S. "Noticing Notices: Tourism to Order." *Annals of Tourism Research* 30, no. 2 (2003): 465-484.

This article argues that visitors are subject to social control through signage and, that signage and notices designed to control people's behaviour constitutes an assault on personal freedoms. While

this contemplative article targets tourism, the points made around people's desire to be away from the constraints of a society in which many of their actions are dictated or managed are relevant to the type of person who seeks solace in nature via outdoor recreation. The piece raises points about purpose of notices to lure, or to dictate or prohibit behaviour, and the interruption that this represents to the visual experience of the tourist. Additionally, the article describes a taxonomy of signage which includes petitionary (that in which the message is delivered with politeness), advisory (that which offers counsel), obligatory (that in which moral pressure is present), hortatory (that which is imperative or commanding), and minatory (that which describes penalties).

Dodd, Ken. *Managing Visitor Safety in the Countryside: Principles and Practice*. 3rd. ed. UK: Visitor Safety Group, 2019. www.visitorsafety.group.

This e-book (PDF) presents a broad set of principles and practice as to managing risks associated with visiting the UK and Ireland countryside. In addition to sections on visitor safety plans, risk assessments, and legal matters, the chapter entitled "The Role of Information and Education in Risk Control" emphasises that advising visitors of risks is required to enable them to take responsibility and act in safe ways. It is stressed that information should be provided at strategic places along the journey that the visitor is anticipated to take, and that information should be "clear, well-designed" (51). Safety signage is directly addressed on pages 56-57, with four signage types recommended: prohibition ('circle slash'), mandatory (blue: circular, prescribes desired behaviours), warning (yellow: triangular), and emergency escape/ first aid (green: rectangular). The advantages and limitations of signage are outlined, and signage types, style, and use are based on the UK Health and Safety (Safety Signs and Signals) Regulations 1996 and the Irish equivalent.

Donnelly, Roarke E., Alex Prots, and Christl A. Donnelly. "Better Educational Signage could Reduce Disturbance of Resting Dolphins." *PLoS ONE* 16, no. 4 (2021): e0248732.

This research advocates for signage as an educational tool to reduce the interference of recreationists with Hawai'ian dolphins, whose habitual resting behaviours have been negatively impacted. The study surveyed 351 recreationists (including kayakers, walkers, hikers, swimmers, wildlife watchers, and fisherpeople) at three bays in which dolphins are known to rest. Responses were used to assess how recreationists would react to signage with various components, how much they knew and how they learned about the dangers to dolphins. Recommendations included that informational signage of sufficient quantity, size, legibility (large, well-spaced text), and quality (i.e., with rationale for its messaging) be placed. Note that the authors suggest following the guide for Best Practice Principles (BBPs) prepared by Saunders et al. (2019) (also summarised in this bibliography). It was also noted that signage ought not replace other behaviour-change initiatives (such as in-person information in the case of guided tours) and, additionally, that more research should be carried out to test the ways in which human behaviour is impacted by signage.

E

Edward-Jones, Emma, Martin Chester, and Paul Donovan. "Development of Guidance to Support Behaviour Change Signage and Hazard Communication: Report for the Visitor Safety in the Countryside Group." UK Visitor Safety Group (2022): 1-86. Accessed August 2, 2023.

This privately commissioned study compiles relevant theory and research on elements of effective behaviour-change signage and effective hazard communication. It reports the models of behaviour change (collectively referred to as behaviour change science) alongside research and case studies

from the literature, and interview and survey data that was gathered as a preliminary step to gain familiarity with the needs of the Visitor Safety Group- for whom the report was prepared.

The report offers evidence-based guidance for organisations to develop effective hazard communication strategies. It presents findings with a caution that safety signage is but one component of a recreationist safety and that behaviour change depends on a range of factors. The 86-page report represents a comprehensive and recent account of the effectiveness of safety signage in an outdoor recreation setting.

Espiner, Stephen R. "The Use and Effect of Hazard Warning Signs." Department of Conservation Science for Conservation 108, New Zealand, 1999. Accessed May 5, 2023. <https://www.doc.govt.nz/documents/science-and-technical/Sfc108.pdf>

This study examined awareness of hazards and the effectiveness of signage (both existing and new) on visitors to two New Zealand glaciers. A questionnaire was completed by 378 visitors and behavioural observations complemented survey data. Findings showed that there was little awareness of hazards among visitors (just 19% could recall noticing a hazard on the walk), but that over 90% of respondents reported noticing a hazard sign. Going beyond roped closures was admitted by almost a quarter of those who walked to the end of the track, and this behaviour was observed in greater numbers by researchers (40% of visitors). The presence of new signage at the sites improved compliance by almost 20 percentage points; the dramatic improvement was attributed to clearer messaging which included explanatory text and images.

Espiner, Stephen, R. The phenomenon of risk and its management in natural resource recreation and tourism settings: A case study of Fox and Franz Josef Glaciers, Westland National Park, New Zealand. Doctoral thesis, Lincoln University, New Zealand, 2001. https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/638/Espiner_PhD.pdf?sequence=6

This study investigates the nature and relevance of risk in natural resource recreation and tourism settings and assesses the risk perceptions of visitors to the Fox and Franz Josef glaciers, popular tourist attractions on the West Coast of New Zealand's South Island. Of particular relevance is the emphasis on risk communication at these two sites, and the degree to which existing hazard messages are successful at encouraging appropriate visitor behaviour. As part of the study, pictorial hazard warning signs are introduced at the glacier sites and their effectiveness evaluated. The findings show that many visitors have relatively poor awareness of natural hazards and behave in ways which potentially compromise physical safety. The author argues that perceptions and behaviour are a consequence of diverse individual and situational factors including limited knowledge of the sites, beliefs about management, poor comprehension of hazard warning signs, and freedom from the normative constraints of everyday life.

Espiner, Stephen R., and Robinne Weiss. "Evaluating Aspects of Hazard Awareness, Safety Message Effectiveness and Behavioural Compliance among Visitors to the Glaciers, Westland National Park, New Zealand." Department of Conservation, New Zealand, 2010. Accessed May 31, 2023. <https://www.doc.govt.nz/Documents/about-doc/role/visitor-research/hazard-awareness-glaciers.pdf>

This multi-faceted study assessed visitor behaviour and hazards awareness at two glacier walkways on New Zealand's West Coast. It also tested the effectiveness of new signage in prompting safe

intentions. Researchers used observation (over 4,000 visitors in total) and a survey of 203 visitors. Findings included that although 95% of people were aware of warning signs along walks, three quarters did not observe anything they would characterise as a danger or hazard. This indicates a gap in actual and perceived hazards which can impact on people's willingness to heed safety messaging. However, there was high compliance observed at track closure points (95%), and the most common reason for entering restricted areas (by the 6% who admitted not complying) was to get a better photo.

Signage testing showed that the most effective sign in communicating the importance of staying behind safety barrier was one in which there was clear presentation of the risks, potential consequences, and of what not to (indicated using a 'circle slash' image).

F

The Federal Energy Regulatory Commission. "Safety Signage at Hydropower Projects". The Federal Energy Regulatory Commission, United States, 2001. Accessed May 10, 2023.

<https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=62c16abe92d95c8c48b6285e45a82eedd0a4bf1c>

This document was compiled using best practice warning signage guidelines combined with the expertise of various representatives including US Army Corps of Engineers, US Bureau of Reclamation, US Coast Guard, and the US NPS. It outlines the elements of effective safety signage as relevant to hydropower setting (including recreation activities that take place there). Elements such as establishing the need for signage, signage design, standardised format and message, placement, location, and maintenance are outlined in technical detail (to the degree of itemising the font sizes required for visibility at particular distances and speeds at which the viewer is traveling).

Though somewhat dated, the report is thorough, and reiterates many components necessary for effective signage, particularly around the importance of visibility, legibility, and communicability (to a wide audience). Recreation-wise, the report addresses hazards and signage related to fishing, swimming, canoeing, kayaking, cross-country skiing, ice-skating, snow-mobiling, and boating.

Fang, Chongbo, Yasuhiro Yamanaka, and Gregory Trencher. "Arrival Briefings as an Effective Interpretation Strategy in Tourist Destinations: The case of Daisetsuzan National Park, Japan." *Journal of Outdoor Recreation and Tourism* 33 (2021): 100363.

This study assessed the efficacy of an oral briefing delivered to park visitors in Japan on its ability to impact message retention and behaviour change, and on how visitors rated its appeal. The behaviour-change element and the portion of the briefing that pertained to "hiking manners and safety" (which, according to the transcript took up almost half of the two minutes allocated for the briefing) are where the relevance lies.

The authors found that oral briefings may be superior to signage owing to the enhanced information retention and increase in desired behaviours that the researchers observed (not all safety related). Around 90% of people surveyed recalled information about six of the seven topics they were told about in the briefing (with 'surprising' content the most memorable). Note however that the study site is a highly managed environment, and although safety is frequently mentioned in the study, the portions of the briefing related to safety appear to be things like wayfinding, taking care over uneven ground, and staying within the roped confines of trails.

Girasek, Deborah C., Joy S. Marschall, and Dov Pope. "Patterns of Behaviour that Pose Potential Drowning Risk to Hikers at Yosemite National Park." *Journal of Travel Medicine* 23, no. 1 (2016): tav016.

This study used observation methods to count people going against visible warning signs and entering or going near water in which drownings have occurred. The data were collected over 32 days at two sites along a popular walking trail within Yosemite National Park, California (US). Hikers who were seen to enter pre-defined risk zones were counted and asked to complete a questionnaire. It was found that predictors of hazardous behaviour were warmer temperatures, lone hiking, being male, and impulsive or unplanned decisions (e.g., to wash hands or cool feet).

The questionnaire revealed that those who entered the risk zones (one of which was fenced and both of which featured hazard signs) expressed confusion about whether or not the area was prohibited (although, it is noteworthy that this could be due to respondents' desires to give socially acceptable answers, in this case reluctance to admit intentional rule breaking), and, 92% stated they felt safe within the risk zone. Results point to the difficulty in persuading safe hiker behaviour.

Goh, Edmund. "Walking off-trail in National Parks: Monkey see Monkey do." *Leisure Sciences* 45, no. 1 (2020): 1-23.

This study assessed off-trail use amongst 325 Australian survey respondents to examine which factors influence off-trail intentions. The study was framed with the safety of trail users in mind and while it used TPB as a theoretical framework was highly statistical in its analysis. Findings included that pro-environmental beliefs did not stop people from going off-trail, and that seeing others go off-trail was a factor that influenced that same behaviour in others. Additionally, they found that going off-trail was viewed as a non-serious action and 'easy' act. Recommendations included that signage would help, but there was little basis provided for the efficacy of this, particularly considering that signage and barriers were already installed in some places of the study area. However, the study does show that to motivate people to take certain actions, there needs to be personal relevance that relates to core values.

Gramann, James H., Rhonda L. Bonifield, and Yong-geun Kim. "Effect of Personality and Situational Factors on Intentions to Obey Rules in Outdoor Recreation Areas." *Journal of Leisure Research* 27, no. 4 (1995): 326-343.

This study sought to examine the impact of being socially responsible on rule-following in a hypothetical outdoor recreation setting. The study used 120 subjects whose levels of social responsibility were assessed as either relatively high or low and exposed them to a range of scenarios in which there was a personal advantage to breaking a known rule. In various iterations of scenarios, messaging around rules differed according to the presence/absence of: rationale for the rules (educative), the potential consequences of rule-breaking (fear appeal), and penalties for rule-breaking (fear appeal). The study concluded that fear appeals were more effective in encouraging rule following, especially for socially responsible participants. Interestingly, in scenarios that seemed to pose significant safety threats to participants if rules were *obeyed*, no factors affected participants' intentions to break rules.

Gstaettner, Anna M., Halina T. Kobryn, Kate Rodger, Michael Phillips, and Diane Lee. "Monitoring Visitor Injury in Protected areas: Analysis of Incident Reporting in two Western Australian Parks." *Journal of Outdoor Recreation and Tourism* 25 (2019): 143-157.

This study examined the patterns of recreation visitor injury and fatalities in the six years to June 2017 in two Western Australian protected areas. The study examined 104 recorded recreational incidents, coding them to type, location, and severity. While findings honed in on incident reporting practices, an associated relevant finding was that, at one of the sites, 89% of incidents occurred within 250m of park access roads where visitor information and hazard signage were located. Warning signage had been successively placed there throughout the period of the study, and, as incident numbers were fewer in the second half of the study period than in the first, the placement of hazard signage in proximity to incident clusters was deemed an effective safety measure.

Gstaettner, Anna M., Diane Lee, and Betty Weiler. "Responsibility and Preparedness for Risk in National Parks: Results of a Visitor Survey." *Tourism Recreation Research* 45, no. 4 (2020): 485-499.

This study surveyed 1,059 visitors to four Western Australian recreational protected areas to assess their views on where safety responsibilities lie. Questioning focussed on perceptions of risk and safety, and who has control over these dimensions. Responses were statistically analysed to reveal four cohorts whose attitudes to responsibility were characterised as the duty of: individual, management, shared, and an indifference to responsibility. Those who were indifferent to responsibility were more likely to be younger, and disagreed both that they are responsible for safety, and that management are.

While 41% of all respondents had checked safety advice on the relevant website before their visit, respondents who perceived park management agencies to have greater responsibility for safety were more likely to have done so. Differences were seen between the identified cohorts in their recreation preparedness, and in their perceptions of risk and the extent to which they feel they can control risks.

Guo, Tian, Jordan W. Smith, Yu-Fai Leung, Erin Seekamp, and Roger L. Moore. "Determinants of Responsible Hiking Behavior: Results from a Stated Choice Experiment." *Environmental Management* 56 (2015): 765-776.

This laboratory-based study examined the intended hiking behaviours of research participants by showing images of degraded trails (in both 2D and 3D), having images of informational signage displayed ('Please stay on the trail') and measuring stated intentions (e.g., carry on through muddy sections, turn around, go off-trail, or keep to the immediate left/right of muddy sections). The authors state that one of three key findings of the study is that "Typical injunctive-prescriptive educational messaging does not influence responsible hiking behavioral intentions" (p. 773). While they note that such signage appears to *increase* off-trail use, they go on to recommend the placement of a *different style* of signage in advance of degraded trail sections to deter off-trail hiking by frequent hikers (whose tendency to hold pro-conservation views was said to make them more likely to comply). This points to a high degree of context dependency for signage, and that highly personalised messaging is required to affect behaviour change for hikers.

Hall, Troy E., Sam H. Ham, and Brenda K. Lackey. "Comparative Evaluation of the Attention Capture and Holding Power of Novel Signs aimed at Park Visitors." *Journal of Interpretation Research* 15, no. 1 (2010): 15-36.

The study tested four experimental sign-types (with moral appeal, humorous appeal, narrative story, and telegraphic title) against standard signage at Yosemite National Park, California, to assess the level of attention each was paid by park visitors. The narrative format was found to be the most effective in capturing attention, though few visitors were seen to fully process the messaging (which was about food storage to reduce bear interactions). The authors note several factors that contribute to visitors not paying attention to signs, these include: visitor indifference (e.g., due to individual ideas about risk or adherence to long-held routines/habits), poor sign placement, insufficiently eye-catching design, and competition between either views or other signage. The authors make no claims that attention to signage results in adherence to the message displayed, rather, they suggest further study in this area is required. In addition, they note that attention-paying behaviour is likely shaped by highly personal factors such as fears, needs, and wants.

Ham, S., T. J. Brown, Jim Curtis, Betty Weiler, Michael Hughes, and Mark Poll. "Promoting Persuasion in Protected Areas: A Guide for Managers who want to use Strategic Communication to Influence Visitor Behaviour." *Sustainable Tourism Cooperative Research Centre, Australia* (2009).

This technical report, funded by the Australian Government through the Sustainable Tourism Cooperative Research Centre, outlines ways in which communication through signs can persuade visitors to outdoor recreation and tourism spaces to behave in certain ways. It uses the Theory of Planned Behaviour (TPB) as a basis for the development of persuasive messaging.

Referencing a range of academic and other research, this report suggests that the most effective communication is based on understanding visitor beliefs and targeting messaging accordingly. The authors note that non-compliers are the most important group to target and that single specific undesired behaviours that are or have been witnessed occurring are actions that are the most easily 'reversed' through messaging. Several points are made regarding signs including to place them close to where problem behaviour is occurring, ensuring that most visitors can see messaging, and removing or altering old or ineffective signs. It is noteworthy that this report pays little attention to safety messaging overall.

Harris, Amy. "Search (and Rescue) for the Ultimate Selfie: How the use of Social Media and Smartphone Technology have affected Human Behaviour in Outdoor Recreation Scenarios." *Master's thesis, Simon Fraser University, Canada, 2020.*
https://summit.sfu.ca/_flysystem/fedora/sfu_migrate/20262/etd20776.pdf

This thesis argues that Canadian recreationists' social media use has had an impact on outdoor recreation safety. The link between accident/injuries and digital technology use is made explicit via the argument that people wishing to emulate (or see for themselves) images seen on social media put themselves in danger by being either inexperienced or unprepared for their outdoor recreation experience. Data was gathered via stakeholder interviews with SAR personnel, and a survey with 1,150 respondents active on Facebook, Meet Up, and other online platforms.

Recommendations of safety messaging suitable for dissemination by signage is offered and includes essential safety equipment to carry and display of realistic hiking timeframes. However, the author notes that signage already in place is not always heeded and cited respondents' feelings that casual

hikers do not necessarily like to think about the potential for danger. Although the research does not focus solely on safety signage, it constitutes a valuable and recent resource detailing the ways in which social media is influencing participation in outdoor recreation.

Harrop, Paddy. "Communicating Risk in Outdoor Recreation: How is Signage used to Meet the Risk Communication Needs of Land Managers and Mountain Bikers in the UK?" Master's dissertation, Leeds Trinity University College, United Kingdom, 2012.

https://www.paddyharrop.org/uploads/4/0/2/8/4028338/communicating_risk_full_report.pdf

This master's thesis examined the risk perception and signage needs of mountain bikers compared with those who manage two Irish mountain bike parks. The research used stakeholder interviews and an online survey (n=154) with mountain-bike park managers and mountain bikers, as well as content analysis of signage at parks.

Mountain bikers were inclined to feel they understood the risks and resisted the idea that their riding environment be interrupted with signage (particularly non-specific signage about the activity being risky); in addition, they felt the trail head was loaded with information and suspected this was for legal reasons. Indeed, the researcher surmised that one important function of signage for managers was to reduce civil liability claims, even if this did come alongside a genuine wish for injury reduction. Given the majority of signage at parks was informational (as opposed to safety related), the findings are mostly relevant in the context of the reduced efficacy of signs where signage is prolific.

Hayes, Derek G. "An Investigation of Visitor Behaviour in Recreation and Tourism Settings: A Case Study of Natural Hazard Management at the Glaciers, Westland National Park, New Zealand."

Master's dissertation, Lincoln University, New Zealand, 2008.

https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/942/Hayes_MAppSc.pdf;sequence=3

This master's thesis examined visitor compliance with safety recommendations at two New Zealand glaciers. Using TPB to contextualise observations and questionnaire results, the research found that non-compliance with safety messaging was motivated by a belief that the situation encouraged it, seeing others non-comply, and seeing no obvious consequences of non-compliance. Additionally, the study found that there are a range of situational factors that play into non-compliance, including ambiguous signage. Signage that was open to misinterpretation was pointed to by respondents in some cases as contributing to uncertainty around prohibitions, and non-compliance was viewed as acceptable due to under-estimation of the risks.

Hendricks, William W., Roy H. Ramthun, and Deborah J. Chavez. "The Effects of Persuasive Message Source and Content on Mountain Bicyclists' Adherence to Trail Etiquette Guidelines."

***Journal of Park & Recreation Administration* 19, no. 3 (2001).**

This California (US) research assessed the efficacy of two types of message delivery (moral appeal and fear appeal) delivered verbally by three types of on-site volunteer (uniformed hiker, and an un-uniformed biker and hiker). The research tested which messages, delivered by which messengers were most effective in prompting appropriate mountain biking behaviours, which included staying on trail, dismounting for closed sections, and speed reduction). Findings showed that there was negligible difference in the message type used, and that the most effective messenger was the (un-uniformed) biker. In all behaviours assessed, the uniformed messenger was the least effective.

Although no signage was tested, owing to others' findings that source credibility (e.g., by way of uniformed personnel) impacts positively on rule compliance, this study is of interest. Additionally, that the most effective messenger was a mountain biker themselves suggests that this type of recreationist at least, may respond better to those undertaking the same activity.

Hockett, Karen S., Jeffrey L. Marion, and Yu-Fai Leung. "The Efficacy of Combined Educational and Site Management Actions in Reducing off-trail Hiking in an Urban-Proximate Protected Area." *Journal of Environmental Management* 203 (2017): 17-28.

This US study assessed the off-trail hiking behaviours of over 9,000 people (8,045 observations and 1,205 surveys) and found that of all five interventions tested, the presence of a steward onsite who personally relayed information to hikers was the most effective. The presence of a steward performed better than the following tested interventions: educational signage at the trail head, symbolic "no hiking" signs placed along informal trails (boot mark inside a 'circle slash' icon), concealment of informal trail heads with leaf litter and branches, and the placement of low fencing on existing trails. However, the authors stated that more complete compliance was achieved when *all* site management actions were present, suggesting that it is a range of interventions that, combined, result in higher levels of visitor compliance.

Hutson, Garrett, and Ryan Howard. "Protected Area Risk Communication: Baseline Practices for Outdoor Recreation." *Journal of Outdoor Recreation, Education, and Leadership* 10, no. 3 (2018).

This research reviewed existing protected area documentation and academic literature to provide a baseline of best practices for risk communication in an outdoor recreation context. The document was compiled for the Canadian Wildlife Service and examined academic and grey literature from the US and Canada. The report summarises the literature on communicating risk via: physical signage, technology-based means, face-to-face interactions and waivers, and direct communication with stakeholder groups. The authors recognise the importance of signage and waivers in risk management, particularly regarding liability matters, but noted that social media engagement and one-on-one communication strategies may have more influence on visitor behaviours.

J

Johnson, Darryl, and Thomas C. Swearingen. "The Effectiveness of Selected Trailside Sign Texts in Deterring Off Trail Hiking at Paradise Meadows, Mt Rainer National Park." In *Vandalism: Research, Prevention, and Social Policy Management*, edited by H. Christensen, D. Johnson, & M. Brooks, 103–120. US Oregon: Department of Agriculture Forest Service, 1992. Accessed May 5, 2023. <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=5e2ebd7f8a39c5fc1b547b7dd01eca460e52a627#page=113>

This research used observations of over 14,000 US NPS visitors in Oregon to assess the effectiveness of a range of signage types in deterring off-trail use. Note that in this project off-trail refers to the use of informally made paths that have formed over repeated use and on-trail refers to a boarded or paved path. The signage that was most effective was that warning of sanctions: 'Off-trail hikers may be fined', and signage with an ethical appeal ('Stay on the trail and help preserve the meadow') also reduced off-trail use by a significant margin. Other signage types, including appeal to humour, prohibition symbol ('circle slash' design) and the original signage used did not result any statistically significant differences in off-trail use. The research, though dated, is comprehensive but the outdoor setting in which the study takes place is highly managed and, to some extent modified, so findings may not be transferrable to many New Zealand settings.

K

Kortenkamp, Katherine V., Colleen F. Moore, Ellie M. Miller, and Kathryn V. Truell. "DANGER! NO HIKING! Risky Hiking Decisions, Framing of Normative Warning Messages, and self-exempting Beliefs." *Journal of Outdoor Recreation and Tourism* 35, (2021): 100415.

This recent study explored which types of signage encourage safe hiking intentions in the context of keeping away from cliff edges and bison. Researchers exposed 198 US college student hikers to types of messaging and then, to examine individual differences in responses to safety warnings, they measured participant risk perception (i.e., their salient beliefs about risk).

Findings showed that signs using descriptive norms (what most people do in a situation) and negative framing (telling people what *not* to do) were most likely to elicit safe hiking intentions. Perhaps unsurprisingly, those who scored high on the 'scepticism about real dangers' metric and the 'bulletproof' metric (feeling immune to danger) were more likely, even in the presence of signage, to state the intention to go closer to the cliff edge and, to feel they would not fall. It is important to note that the study captured the reported intentions of study participants based on hypothetical scenarios.

Kratochvil, Helmut, and Harald Schwammer. "Reducing Acoustic Disturbances by Aquarium Visitors." *Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association* 16, no. 4. (1997): 349-353.

This Austrian study assessed the effectiveness of various signage types on reducing glass tapping at an aquarium. Though neither outdoors nor recreation related, the findings that signage with wording that appeals to emotion was the most effective are relevant. Specifically, of the four scenarios tested, appeals to pride and compassion were more effective than no signage or a simple prohibition request to "Please don't knock on the glass". The researchers note that the most effective sign, "Only loonies would knock", may have had more appeal for younger visitors who were the demographic that most visited on days when most knocking occurred. Consequently, the results may not translate to the broader population.

L

Lackey, Brenda K. "Contextual Analysis of Interpretation Focused on Human-black Bear Conflicts in Yosemite National Park." *Applied Environmental Education and Communication: An International Journal* 2, no. 1 (2003): 11-21.

This research examined the salient beliefs of overnight visitors to Yosemite National Park (California, US) and inventoried park messaging (37% of which was signage) that warns visitors of human-bear interactions, to ascertain the best ways in which to reduce bear encounters. In the context of signage, park messaging around how improper food storage can attract bears was assessed using Flesch Readability Analysis (in which human interest level and reading ease levels are assessed), with 75% of messages found to be easy to read, but of low interest. Ideally, according to the readability analysis, messaging should be easy to read and high interest. Consequently, based on the Theory of Planned Behaviour which suggests targeting salient beliefs is effective in managing problem behaviour, the research recommended messaging include more active language, use personal referents (like 'you', 'we' etc.) and that it should ask questions. This was deemed likely to increase the interest (and therefore appeal) of messaging (including on signs).

Laughery, Kenneth R., and Michael S. Wogalter. "A three-stage Model Summarizes Product Warning and Environmental Sign Research." *Safety Science* 61 (2014): 3-10.

This article presents a summary of the most effective ways to communicate warnings. The psychological basis of how people process information and how this leads to behaviour modification is described, as are the necessary components of warning signs. The article emphasises the multiple aspects that impact on a person's ability and willingness to comply with safety messaging and, importantly, states that non-design factors (such as context, location and distraction) can be more important than design factors in the effectiveness of warnings. Although the article is largely targeted at industrial safety, the emphasis on "environmental safety" has relevance to outdoor recreation. Additionally, its basis in the psychological processing of information is broadly applicable.

M **Manfredo, Michael J., and Alan D. Bright. "A Model for Assessing the Effects of Communication on Recreationists." *Journal of Leisure Research* 23, no. 1 (1991): 1-20.**

This somewhat dated US study tested the efficacy of informational brochures for persuasive impact on recreationists in the context of promoting behaviour change. Data were collected 1988 by means of an on-site interview and a mail-back questionnaire that assessed 368 respondents' reactions to brochure information (some of which was related to personal safety, e.g., boating safety, bear safety, and first aid). Over a quarter of the respondents "devoted no thought" to the contents of the brochures (a high proportion of which were those familiar with the area) and, significantly, 89% of those who recalled the brochures stated their behaviour had not changed due to its information. The findings suggested that information distributed to recreationists needs to be novel (particularly where users are regular users or if the information is new), and that to be more effective, information ought to target specific undesirable behaviours.

Marschall, Sarah, Sandra Magdalena Granquist, and Georgette Leah Burns. "Interpretation in Wildlife Tourism: Assessing the Effectiveness of Signage on Visitor Behaviour at a Seal Watching Site in Iceland." *Journal of Outdoor Recreation and Tourism* 17 (2017): 11-19.

This research article is based on the primary author's 2014 PhD research in which the behaviour of 2,440 visitors to a seal watching peninsula in Iceland was assessed according to exposure to two signage types (and, as a control, a group who were exposed to no signage). Findings showed that explanatory, "teleological" signage (as opposed to purely instructive signage) performed better in prompting desired seal watching behaviours. Additionally, they made the point that, to be most effective, information should target groups who 'need' it the most; in this case, family groups were most likely to disturb wildlife, so signage that appeals to families would translate to the greatest benefit.

The authors note the lack of empirical studies on the impact of signage on behaviour change in a non-captive wildlife setting (areas in which recreation also takes place). The article concludes with recommendations to prioritise informational/explanatory signage, and to design signage to target certain groups. They reiterate the highly personalised ways in which signage is viewed and interpreted.

Martin, Bill, and Sandra Mason. "Current Trends in UK Leisure: New Views of Countryside Recreation." *Leisure Studies* 12, no. 1 (1993): 1-6.

This review of trends in UK countryside recreation was produced in the early 1990s and described the most popular recreation activities as informal, specifically, walking, "open-air outings" and cycling. It highlighted golf and cycling as trending upwards but characterised recreation activities more broadly as fragmented but expanding. The main issues identified in the review are public access and land-use conflict (e.g., the unwillingness of managers of agricultural and environmentally sensitive land to allow access to recreationists). Recreationist safety was notably absent, as was any mention of signage or other means of communicating with recreationists other than in matters around wayfinding.

The review points to community forests and country parks as recreation places with high visitor numbers; these appear to feature modified and conserved landscapes as well as being managed as visitor destinations (e.g., in some cases featuring historic buildings, playgrounds, gift shops, education centres, and cafes).

Mata, Carlos, Catarina Pereira, and Luís Carvalhinho. "Safety Measures and Risk Analysis for Outdoor Recreation Technicians and Practitioners: A Systematic Review." *Sustainability* 14, no. 6 (2022): 3332.

This literature review returned a conspicuous absence of information about the efficacy of signage in its results. The objective of the review was to lay out existing knowledge of recommended safety measures and risk assessment for outdoor recreation technicians and practitioners, with ten relevant studies evaluated (published 2005-2020).

The report tabulates the main results, conclusions, safety measures, and recommendations of each study and, although 'education' and 'informing participants' about risks were noted, the cited studies were either of little relevance (e.g., pertaining to guided outdoor activities, or passive adventure tourism activities such as tidal bore watching) or did not mention signage as a safety intervention. Rather, studies pointed to broader aspects such as the need to develop effective strategies to educate visitors about risks.

Matthews, Bernadette, Robert Andronaco, and Austin Adams. "Warning Signs at Beaches: Do they Work?" *Safety Science*, 62 (2014): 312-318.

This study used four Victorian (Australia) locations to assess 472 beach-users on hazard sign recollection and recognition. Almost half of the research participants did not report observing any signage, however, when signage was recalled, the hazard related symbol signs were the most frequently recalled. There was negligible difference for whether the hazard sign was triangle or diamond shaped.

While this study further supports evidence that hazard symbols succeed in gaining attention, the authors queried the broader efficacy of these signs in translating to safer outcomes, seeing as less than a quarter of participants recalled specific symbol signs (i.e., what the hazard pertained to). Their findings reinforce the view that signage is less effective than previously thought, particularly in un-patrolled or un-controlled environments. On the basis that study participants who had not noticed signage often appeared to know about risks, the authors suggest that public awareness campaigns have been effective.

McCool, S.F. and A. M. Braithwaite. "Persuasive Messages and Safety Hazard in Dispersed and Natural Recreation Settings" in *Influencing Human Behaviour: Theory and Applications in Recreation, Tourism and Natural Resource Management*, edited by M. J. Manfredo, 293-326. Illinois: Sagamore Publishing Inc., 1992.

This chapter, though somewhat dated, is highly relevant to the New Zealand context given its focus on 'dispersed and natural recreation settings'. The chapter is a comprehensive review of mostly 1980s literature encompassing types of recreational hazard, recreationist characteristics (including that risk is sometimes what is sought), and hazard management approaches. The chapter includes research from the disciplines of psychology, marketing/consumer behaviour, health, and sociology to address, in particular, perceptions and behaviour. However, the core relevance is in the presentation of research addressing the range of factors that influence the effectiveness of hazard communication messages. These include messaging content, source credibility, the importance of multi-channel messaging, visitor characteristics, and how their attitudes, attributes, beliefs, and knowledge impact on the ways in which messages are acted on (or not). The chapter concludes with a research agenda and the reiteration of statements to the effect that there are large gaps in the knowledge on this topic.

McKay, Campbell, Robert W. Brander, and James Goff. "Putting Tourists in Harms Way—Coastal Tourist Parks and Hazardous Unpatrolled Surf Beaches in New South Wales, Australia." *Tourism Management* 45 (2014): 71-84.

This research examined the issue of coastal drownings in New South Wales, Australia, and argues that signage (as well as beach safety information in other forms) is not a sufficient safety measure. The study investigates the extent of lifeguard patrols and the hazard ratings of beaches in close proximity to coastal tourist parks. While main findings of the research are around the high risk to visitors at unpatrolled beaches, it is noted in several sections that signage has been installed to little effect at hazardous beaches and the inference is made that is due to both resourcing limitations and litigation avoidance.

Meeker & Associates. Yosemite National Park Sign Study: Final Report- Stage C, Sign System Design and Schematic Details. California: Meeker & Associates, 1994. Accessed May 10, 2023. <http://npshistory.com/publications/yose/sign-study-1994.pdf>

This 1994 report was prepared by a graphic design firm as part of a process to design a system that would fulfil the aesthetic and functional requirements for signs in Yosemite National Park (California, US), one aspect of which was "rules and regulations, protection and safety".

Though somewhat dated and largely technical and graphic design focussed, the report addresses elements of signage for ease of reading and comprehension including: use of simple, recognisable recreation/activity symbols; the importance of consistency both throughout park signage and with other park materials (brochures etc.); use of the 'circle slash' design to indicate prohibitions; and, the need for durable and vandal-resistant sign materials. Lastly, the use of different fonts for traffic related signage and other park signage was endorsed to denote the difference in setting and safety messaging requirements.

Meis, Julia, and Yoshihisa Kashima. "Signage as a Tool for Behavioral Change: Direct and Indirect Routes to Understanding the Meaning of a Sign." *PloS ONE* 12, no. 8 (2017): e0182975.

This research presents a psychological model about what occurs with the viewer once a sign is comprehended. The model was tested with the ultimate findings showing that clarity of purpose is the greatest indicator of signage effectiveness when seeking to influence behaviour. Specifically, the research found that while the purpose of familiar signage (such as the 'STOP' sign) is well understood the challenge lies with developing unfamiliar signs which communicate a clear purpose. The authors also note that increasingly diverse communities may require a revaluation of existing signage and that universal familiarity is a difficult but worthy goal. The paper contributes to the literature on the psychological processing of messaging.

Mitchell, Rebecca, and Katrina Haddrill. "Working in Partnership with the Chinese Community in NSW to Develop Appropriate Strategies to Target Water Safety." *Health Promotion Journal of Australia* 15, no. 1 (2004): 38-43.

This Australian research used interviews (n=50) and focus groups (n=45) with members of the Chinese community living in or visiting NSW, Australia to assess their awareness and comprehension of existing and test water safety signage.

Just 35% of those interviewed recognised the meaning of existing signage for prohibited swimming, and fewer than that recognised other safety signs/indications including: flags (for swimming between) and signage indicating diving prohibited, fishing prohibited signage, surfing prohibited, and beware of sharks. Focus groups with Chinese-speaking water users revealed socialising as a key component of recreation (and that the risks associated with rock fishing contributed to enjoyment of that activity), while test water safety messages were best understood when they were simple and direct. Lastly, there was a preference from respondents that safety messaging be delivered via TV campaigns.

Moore, Colleen F., and Katherine V. Kortenkamp. "No Hiking Beyond this Point: Analysis of Outdoor Risk Prevention Recommendations." *Education* 149, no. 552: 27.

This review summarises outdoor accident prevention recommendations from 88 peer-reviewed publications on accidents. The authors concluded that the majority of prevention recommendations addressed changing the hiker's decisions and behaviour (including adhering to the messages on warning signage, though, other hiker behaviours are not described), followed by a focus on institutional management (such as increasing ranger patrols). They concluded that effective accident prevention should address multiple aspects of a system and that such as systems approach should target physical, social, environmental, and institutional factors.

Moran, Kevin. "Re-thinking Drowning Risk: The Role of Water Safety Knowledge, Attitudes and Behaviours in the Aquatic Recreation of New Zealand Youth." PhD thesis, Massey University, New Zealand, 2006. <https://scholarworks.bgsu.edu/cgi/viewcontent.cgi?article=1156&context=ijare>

Moran's doctoral research involved 2,177 youth participants whose risky swimming behaviours in New Zealand were assessed by questionnaire. While several risky swimming behaviours were assessed, the one of relevance to safety signage is the test statement "ignored safety directions" which was referred to in the body of the thesis as safety signage.

The author found that 6.4% had *often* ignored safety signage and 32.7% had *sometimes* ignored safety signage. Demographically, females were twice as likely as males to have *never* ignored safety signage (58% vs 27%), and there were fewer Māori and Pacific students that *never* ignored safety signage (49% and 55% respectively) than there were Pākehā and Chinese (63% and 74% respectively). Low risk perception was found to be one of several factors that contributed to risky water behaviours.

Moran, Kevin, Linda Quan, Richard Franklin, and Elizabeth Bennett. "Where the Evidence and Expert Opinion Meet: A Review of Open-Water Recreational Safety Messages." *International Journal of Aquatic Research and Education* 5, no. 3 (2011): 5

This review covers literature from 1990-2010 seeking evidential support or otherwise for the 16 non-boating open-water safety messages formulated by the International Task Force on Open Water Drowning Prevention (ITFDP). It found literature in strong support of messages regarding the importance of supervision and alcohol avoidance, with life guarding, life-jacket use and CPR training also supported. However, other messaging including 'Obey All Safety Signs and Warning Flags', lacked a strong evidence base.

The review concluded there is a lack of evidential support in scientific literature for the efficacy of water safety signage and suggest that signage alone is not effective enough to warrant its sole use as a safety measure. This was particularly the case given the literature in existence that shows the extent to which people unintentionally and intentionally ignore signs and the extent to which locations or activities increasingly attract culturally and linguistically diverse populations.

Moscardo, Gianna, Barbara Woods, and P. Pearce. Evaluating the Effectiveness of Pictorial Symbols in Reef Visitor Education. Australia: CFC Reef Research Centre Technical Report, 1997.

This study used 727 reef visitors to assess both their knowledge of appropriate reef behaviours, and their understanding of images and symbols used in signage. The study divided respondents into several cohorts to assess understanding on the basis of English as a first or second language for overseas visitors, and on the basis of respondents being Australian residents, or being Japanese or Cantonese speakers. Results suggested that there were good levels of understanding of appropriate behaviours and, consequently, signage would be effective when it reminded visitors of appropriate behaviours. Additionally, the study showed that there are differences in the ways in which different cultures understand symbols and that where nuanced ideas are being communicated, multiple messaging channels could be more effective.

Moscardo, Gianna. "Interpretation and Tourism: Holy grail or Emperor's Robes?." *International Journal of Culture, Tourism and Hospitality Research* 8, no. 4 (2014): 462-476.

This report reviews the literature on interpretation in tourism, seeking evidential bases for the efficacy of interpretation (including signage). While the review addresses heritage interpretation and tourism, given that one of the aims of interpretation is to influence behaviour, the findings have relevance.

The author questions the acceptance of tropes around the effectiveness of interpretation and argues that it is too big an expectation that interpretive materials (such as signage) will result in behaviour change. The author notes the complex psychological processes by which information is absorbed, and the array of highly personalised factors that impact on how a person may or may not act on

information presented to them (including their values, perceptions, intentions, experience, and attitudes). The report presents a critical assessment of what the author says are assumptions about the effectiveness of interpretive materials.

N

NZ MSC. "There and Back: An Exploration of Outdoor Recreation Incidents in New Zealand". New Zealand Mountain Safety Council, New Zealand, 2016. Accessed May 3, 2023. <https://www.mountainsafety.org.nz/explore/there-and-back/>

This published report examines outdoor recreation incidents in New Zealand and uses datasets provided by partner organisations for injuries, searches, and fatalities (occurring in different timespans) between January 2004 and June 2015. The outdoor recreation activities covered are limited to tramping, mountaineering, hunting, mountain biking, and trail running. Statistics are divided between New Zealanders and International visitors, and show that falls accounted for 51% of all fatalities, that overall, men were more likely to die in the outdoors than women (84% of fatalities were male), that women were slightly more likely to be injured than men, and that injuries are increasing faster than growth in population would suggest they should.

NZ SAR. "Literature Review Coronial Recommendations (Pertaining to SAR & Recreational Safety) 2008-2019". New Zealand Search and Rescue, New Zealand, 2020. Accessed May 3, 2023. <https://nzsar.govt.nz/assets/Downloadable-Files/Coronial-Literature-Review-Final.pdf>

This literature review compiles the coronial recommendations offered as a result outdoor recreation deaths in New Zealand. Despite the finding that that stakeholder groups are proactive in promoting safety messages in their respective areas of responsibility or interest, the most hazardous recreational activities are still those that are water related. This is followed by mountaineering, tramping, and hunting. The point was made that: "Often, in close proximity to a person participating in an outdoor recreational activity, is their engagement or lack of with a hazard sign" (p. 6), indicating that safety signage is not always heeded.

According to the review, the coroner most often recommended improved signage in reaction to swimming incidents (16 recommendations). In contrast to that, recommendations for signage to address tramping, hunting, climbing, and boating incidents totalled one each in the period 2008 to January 2019.

NZ SAR. "Rescued Persons Research Study". Distill Research Agency for New Zealand Search and Rescue, New Zealand, 2018. Accessed May 3, 2023. <https://nzsar.govt.nz/assets/Downloadable-Files/2018-Rescued-Persons-Research-Study.pdf>

This commissioned study reported on the actions and perceptions of 224 recreationists assisted by NZ Search and Rescue (SAR) in the two years to August 2018. Respondents' incidents were land (72%), boating (21%), or water related (7%). Results showed that leading causes of a land-based SAR operations were a slip or fall leading to injury, second that that, becoming lost and poor/extreme weather were prevalent. Boating SAR operations were most often prompted by equipment failure.

Of relevance to safety signage, when asked about sources of information used to plan and prepare for outdoor recreation activities, just 10% cited signage; this was listed eighth with websites and friends and family the most popularly reported information sources (followed by DOC, locals, information centre, brochure, and a guide). Of the 144 additional comments (shown in an appendix,) just 2 mention that signage might have prevented their need for a SAR operation.

NZ SAR and DOC. "Visitor Risk Perception and Messaging Influence: Research and Programme Report 2020". New Zealand Search and Rescue and Department of Conservation, New Zealand, 2022. Accessed 26 June, 2023. <https://nzsar.govt.nz/assets/Downloadable-Files/Visitor-Risk-Perception-and-Messaging-Influence-Research-Programme-Report-2020.pdf>

This study used data from 1,423 surveys and demographic information collected from 2,899 hikers to examine risk perceptions and the influence of risk-related messaging on hiker behaviour. The report constitutes a useful guide to hiker demographics and presents insights into the decision-making processes and information-gathering habits of hikers in Aotearoa New Zealand. Results showed that Facebook, YouTube and Instagram were the top three social media platforms used by both international and local hikers, and that international visitors' use of 'Campermate' was thirteen times higher than for New Zealanders. Trusted sources of information were similar for both international and local hikers, with DOC and MSC both ranked high. The risk profiles for international versus local (NZ) hikers were found to be of negligible difference, however, there were differing levels of familiarity and experience hiking in New Zealand terrain, and in the expectations of international and local cohorts.

Nguyen, Huong. "An Overview of Trails and Trail Signs in Outdoor Recreation." Bachelor's Thesis, Lapland University of Applied Sciences, Finland, 2017. www.theseus.fi/bitstream/handle/10024/137543/Huong-Nguyen-thesis-FINAL.pdf?sequence=1

This undergraduate thesis argues that an internationally consistent trail signage system would improve access to and safety at popular recreation sites. The author used Utah (US) as a study site and defines 'trail' broadly to include those for hiking, trekking, walking, cycling, climbing, canoeing and skiing. The thesis cites research in support of using simplified symbols for universal comprehension, using strong signal words (such as hazard, warning, danger, or deadly), and combining text with images to further promote comprehension. They posit that consistently formatted signage will increase conspicuity and report that interviewed stakeholders agreed that universality for trail signage would be beneficial.

O **Orams, Mark B. "Using Interpretation to Manage Nature-based Tourism." *Journal of Sustainable Tourism* 4, no. 2 (1996): 81-94**

Orams argued that messaging that targets tourist behaviour in the outdoors needs to do more than be informative, it needs to prompt the desired behaviour change by convincing visitors of the reasons for it. The article presents a strong argument for the merits that persuasive messaging has on eliciting desired behaviour from tourists. In the case of this article, it is pro-environmental behaviour that is discussed, however, the principles can be applied more broadly. The article concludes with a 5-step process by which managers can implement an interpretive programme for clients, beginning with devising a clear and communicable purpose.

p **Park, Logan O., Robert E. Manning, Jeffrey L. Marion, Steven R. Lawson, and Charles Jacobi. "Managing Visitor Impacts in Parks: A Multi-method Study of the Effectiveness of Alternative Management Practices." *Journal of Park & Recreation Administration* 26, no. 1 (2008).**

This study assessed the effectiveness of a range of signage types and barriers on promoting on-trail use at a mountain summit within Acadia National Park (Maine, US). The study observed and surveyed recreationists on their behaviour when exposed to both different signage types and on

fenced sections of trail. While all of the strategies reduced off-trail use, fencing the trail was most effective, yet even this did not eliminate off-trail use to the extent that no environmental damage would occur. The authors recommend that a range of management practices would likely be the most effectively way to keep recreationists from going off trail and that regulation and enforcement form a part of this. Off-trail use was most often for explorative and photo-taking reasons and people who followed the rules most often did so due to inward-oriented feelings associated with fairness and justice (doing the 'right thing').

Parkin, Danny, and Kim Morris. "Pete's Story: Interpreting the Consequences of Risk-Taking Behavior." *Applied Environmental Education and Communication* 4, no. 2 (2005): 139-150.

This study evaluated the effectiveness of a story-telling safety sign at a natural swimming spot in Queensland, Australia. The trial signage warns of the likelihood of injury if diving; it is image- and text-based and invites the reader to imagine diving in and being unable to move to save yourself in the water. The text is accompanied by an image of a young man in a wheelchair. A questionnaire was completed by 169 swimmer and sightseer respondents, the largest demographic group within which was young swimmers aged 17-24 years (24%). Findings included that the signage was effective in increasing the awareness of visitors to the dangers, but that this did not always translate to the desired behaviours (i.e., not jumping). The authors point to signage as a useful though imperfect mechanism by which safe recreation behaviour can be achieved.

R

Reigner, Nathan, and Steven R. Lawson. "Improving the Efficacy of Visitor Education in Haleakalā National Park using the Theory of Planned Behavior." *Journal of Interpretation Research* 14, no. 2 (2009): 21-45.

This study examined which messaging type more effectively deterred visitors exploring rock pools at an Hawaiian (US) national park. Researchers observed and surveyed 997 participants who were exposed to one of three message types: fear arousal (104 words, emphasising the potential for injury and illness), encouraging (116 words, emphasising negative impact on environment and the potential for indigenous use) and, no signage. Findings showed that fear arousal messaging was less effective than that which outlined the resource impacts of exploring the pools. Findings suggested that, even with the messaging, a "substantial proportion" of park visitors will explore pools; this is based on survey results that determined visitors are highly influenced by travel companions whose collective expectations and assessments of 'it is OK to explore' are the greatest predictor of behavioural intention. (Such beliefs were said to be supported by guidebook and brochure discourses of exploration.) The recommendation was made to include in education and messaging the express point that the NPS discourages exploration.

Rice, William L., Jeremy Shellhorn, Victoria Bloomgren, Lily Booth, Sarah Duncan, Jazzelle Elias, Keaton Flowers et al. "The Impact of Graphic Design on Attention Capture and Behavior Among Outdoor Recreationists: Results from an Exploratory Persuasive Signage Experiment." *Journal of Outdoor Recreation and Tourism* 42 (2023): 1-11.

This exploratory research examined the role of signage's graphic design components in capturing the attention of outdoor recreationists and in influencing behaviour in protected areas (Montana, US). Note that the study addressed two undesirable behaviours, neither of which are related to outdoor recreation safety (these were dogs off leash, and the shoe-spread of invasive plants). The authors found that minimal capture of visitors' attention can dramatically increase the odds of influencing

behaviour, and that if time is taken by visitors to read on, the odds are further increased that behaviour change will result.

Rousseau, Gabriel K., and Michael S. Wogalter. "Research on Warning Signs." *In Handbook of Warnings*, edited by Michael S. Wogalter, 147-158. New Jersey: Lawrence Erlbaum Associates, 2006.

This review of empirical research on warning signs addresses the topic from an occupational health and safety perspective. However, the piece focuses on the ways in which warning signs are processed, dividing research into three clear sections: noticing the warning, comprehending the information, and complying with the warning. This arrangement allows for clear articulation of the different functions that a sign must perform to effectively prompt safe behaviour. The authors point out that the results of studies which do not address all three processing factors cannot be confidently relied upon. Additionally, they reiterate the personalised ways in which the sign reader processes and acts on information.

S

Saunders, Rob, Betty Weiler, Pascal Scherrer, and Heather Zeppel. "Best Practice Principles for Communicating Safety Messages in National Parks." *Journal of Outdoor Recreation and Tourism* 25 (2019): 132-142.

This study reviewed existing safety signage research to develop a set of best practice principles (BBPs) for effective safety signage in national parks in Australia. The study field tested the BBPs and identified several sign characteristics that improved their ability to convey messages effectively. Signs were found to most effectively encourage compliance when one or more of the following aspects was present: located close to the decision point, assessed by the viewer as credible, included solid red colouring or a 'circle slash' design, or when the intended behaviour is "clearly described or modelled by others" (p. 136).

The authors note, however, that compliance with signage ultimately relies on the viewer whose behaviour is subject to various external (e.g., what is happening around them) and internal factors (e.g., their own informed or uninformed assessments of risk, safety, and their assessment of the credibility of the warning). Note that a technical report reporting this same research is included in this bibliography; see Weiler et al. (2015).

Schneider, Ingrid E., Megha Budruk, Kim Shinew, Christopher J. Wynveen, Taylor Stein, Deonne VanderWoude, William W. Hendricks, and Heather Gibson. "COVID-19 Compliance among Urban Trail Users: Behavioral Insights and Environmental Implications." *Journal of Outdoor Recreation and Tourism* (2021): 100396.

The researchers observed physical distancing on recreational walking trails to assess compliance with COVID-19-related distancing rules. Although the research focused on keeping recreationists safe from COVID-19, the impact of signage on recreationist behaviour is of relevance. The authors found that compliance varied according to a range of factors, including trail width and location, the presence of signage, and density of visitors; consequently, they note the importance of site-specific information and suggest that optimising signage placement and content may improve its effectiveness. They note that signage, while not the focus of this study, was clearly specific to COVID-19 (potentially increasing its effectiveness) and that trailhead signage was frequently difficult to see

(potentially decreasing its effectiveness). The study reiterates the inconsistency of findings in the area of signage effectiveness.

Schoenleber, Carli, Ashley D'Antonio, and Troy E. Hall. "Are Signs Enough? Using Normative and Narrative Messaging to Protect the Western Snowy Plover (*Charadrius nivosus*) in coastal Oregon." *Journal for Nature Conservation* 69 (2022): 126251.

The messaging of concern to this study pertains to protecting wildlife however, its relevance lies its efforts to ascertain the best ways to communicate messages to outdoor recreationists and in its recent publication. The study observed visitor adherence to two types of signage messaging to assess narrative styles in their ability to prevent negative wildlife impacts. Narrative messaging is argued by the authors to be more persuasive and be capable of influencing attitudes which, in turn, can positively influence behaviour.

Findings showed that though none of the tested signage types were frequently read to completion and did not result in complete compliance, the narrative sign prompted a decreased in non-compliant behaviour. This was consistent with the Elaboration Likelihood Model of Persuasion (ELM) which suggests that narrative messaging can promote desired behaviours.

Scholl-Grissemann, Ursula, Mike Peters, Bernhard Fabian Bichler, and Elisabeth Happ. "Hiking Tourism: Educating Hikers through the Interpretation of on-site Information and Predicting Precautionary Behavior." *Tourism Review* 77, no. 6 (2022): 1436-1454.

This study used 181 primarily German participants to examine how risk-taking behaviour was impacted by both variable on-site conditions (mainly signage) and personality traits. The research took place online with paid participants shown a photograph of a hiking scenario with six variables to assess their intention to either continue hiking or to turn around. Images included the presence or absence of: approaching inclement weather, a simple image-based triangular weather warning sign, and the same sign with additional text information.

The authors concluded overall that the influence of on-site information (signage) is limited and noted that fieldwork or augmented or virtual reality scenarios could better simulate real-life conditions. Additionally, the risk perceptions of participants (measured separately) were shown to influence risk-taking behaviours. It is noteworthy that the sole risk presented to participants was inclement weather, shown by way of threatening skies or warning signage showing a dark rain cloud.

Schwartz, F., B. D. Taff, B. Lawhon, and D. VanderWoude. "Mitigating Undesignated Trail use: The Efficacy of Messaging and Direct Site Management Actions in an Urban-proximate Open Space context." *Environmental Management* 62, no. 3 (2018): 458-473.

This study examined the effectiveness of barriers and signage to reduce off-trail use in 20 sites managed by Open Space & Mountain Parks, located adjacent to Boulder Colorado's (US) outer suburbs. It used both observation (the behaviours of 2,232 visitors were observed) and surveys (147 collected surveys) to assess which actions by park managers would best predict on-trail use.

While undesignated trail use was mostly deterred for reasons of environmental protection, the study noted that safety is also a consideration for park managers. Trails of interest to the study included those that had formed from repeated (unsanctioned) use, as well as 'short-cuts' and forays off-trail for photo opportunities. The study found that a combination of physical barriers (examples shown

were rustic branch structures around the same size and shape as a farm gate, with no extension beyond the structure) and educational signage performed best.

Selvaag, Sofie Kjendlie, Rose Keller, Øystein Aas, Vegard Gundersen, and Frode Thomassen Singsaas. "On-site Communication Measures as a Tool in Outdoor Recreation Management: A Systematic Map Protocol." *Environmental Evidence* 11, no. 1 (2022): 1-11.

This study described the process of reviewing studies in which visual intervention measures to change behaviour (including to encourage safe behaviour) were used in natural settings. Its broad aim was to identify which communication measures are used most frequently to address which behaviours, and ultimately, to discover what evidence there is that on-site communication can change behaviour in outdoor recreation. The study is focussed on the process of systematically mapping existing studies rather than what results showed, therefore, the reader should seek out forthcoming publications in which findings will be reported.

Shibata, Masaki. "Exploring International Beachgoers' Perceptions of Safety Signage on Australian Beaches." *Safety Science* 158 (2023): 105966.

This Australian research used the survey responses of 167 people at Bondi Beach, New South Wales about the ways in which they interpreted existing beach safety signage according to their being an Australian citizen or being overseas-born. The high proportion of overseas-born drowning fatalities was part of the basis for this research which found that there are comprehension issues with some terminology used on beach safety signage, and that this applied to both respondent groups.

Around a quarter of all beachgoers reported not reading safety signage at the beach, and over 70% of overseas-born respondents did not understand some of the terminology used in signs. The author recommends both more attention-getting signage, and some grammatical changes to make the language used on signs more widely understood (e.g., instead of *bluebottle*, use *jellyfish*).

Silverton, Natalie A., Scott E. McIntosh, and Han S. Kim. "Risk Assessment in Winter Backcountry Travel." *Wilderness & Environmental Medicine* 20, no. 3 (2009): 269-274.

This study surveyed 353 backcountry mountain users (US) asking them to rate avalanche dangers at their present location. Researchers then used Avalanche Centre data to measure the risk assessment of backcountry users and findings showed that avalanche risk was generally underestimated.

Relevant to the topic of the efficacy of signage is that, owing to one of the study areas being adjacent to a managed ski-resort, one third of participants needed to pass by "graphic" avalanche warning signage to carry out their backcountry skiing or snowboarding. The skiers within this group returned the second highest percentage of correct estimations of avalanche danger (only the under 20 years-of-age demographic returned a higher percentage of correct estimations) and snowboarders who passed by signage were not far behind. This suggests that the signage may have had a positive impact on their ability to more correctly assess risk.

Taff, Brendan Derrick, Heather Costigan, Peter Newman, Andrew Mowen, Joshua Morrison, and Sara B. Newman. "Civil War Buff, to just Buff: Examining Communication Strategies to influence Physical Activity Behaviors in Gettysburg National Military Park." *Recreation, Parks, and Tourism in Public Health* 1, no. 1 (2017): 81-102.

This research looked at two types of signage designed to promote physical activity amongst visitors to a site of historic value, Gettysburg National Military Park (Pennsylvania, US), where the usual mode for viewing the fragmented sites is vehicular. The signage tested was developed using focus groups and emphasised benefits to the reader of engaging in the desired activity, which, in this case was to walk instead of drive between sites. Messaging also followed US NPS guidelines, specifically it aimed to constitute a trusted source, be concise and brief, and to be personally relevant. A total of 8,514 park visitors were observed and results were statistically analysed to show that the sign which implored visitors to 'walk in the footsteps of the Confederate soldiers...' was far more effective than the one which encouraged visitors to 'fully experience Gettysburg while improving your health...'. The first example resulted in 9% increase in walking while the latter produced no significant difference. The success of the first sign was attributed to its personal relevance to visitors who, visiting a historic battle site, could reasonably be expected to be invested in that association.

Towner, Emil B. "Danger in Public Spaces: Strengths and Limitations of Image-and Text-based Warning Signs." *Business and Professional Communication Quarterly* 82, no. 1 (2019): 53-73.

This research tested the effectiveness of images and text in warning signs based on those in use at Yellowstone National Park (Wyoming, US). Online surveys were completed by 749 participants whose intentions with regard to proximity to bison and assessments of what constituted safe behaviour were captured and measured against the type of warning sign they were exposed to. Signs were black and white, with various combinations of images of: a simple bison silhouette or the depiction of a bison attacking a person, and text: "Danger do not approach wildlife" and the more descriptive detailing that attacks have occurred and the speed capabilities and strength of bison.

Findings suggested that images were more effective at communicating risks and dangers, while text-based explanatory signage was more effective for promoting safe intentions. Towner also found that young people and males were more likely to engage in somewhat/very dangerous activities, and those with graduate degrees were less likely to engage in the same.

Tsakakis, Elena, and Ingrid E. Schneider. "Water-Based Safety Issues and Communication Opportunities." *Journal of Park & Recreation Administration* 39, no. 4 (2021).

This research compared observed water safety behaviours on a well-used Wisconsin (US) river and online safety messaging to see if and where discrepancies lie between the two. A supplemental survey was issued to 42 river paddlers to assess perceptions of hazards and safety. Observations showed that completely safe kayak launching behaviour (in one example) was observed in just 4% of paddlers, and almost one-third of kayaks and one-fifth of canoes were observed tipping during launching or landing, yet, very few people reported witnessing or being in unsafe conditions. The researchers concluded there is a large gap between perceptions of safety and the realities of water hazards. Another relevant finding is that river users are most likely to seek online information prior to a trip and that this provides opportunity for targeted safety messaging.

V

Villella, Anne, and T. K. Keen. "Into the Wild: Can Regulation of Wilderness Recreational Activities Improve Safety and Reduce Search and Rescue Incidents?." *Jeffrey S. Moorad Sports Law Journal* 21, no. 2 (2014): 323.

The authors assessed a range of ways in which to reduce incidence of recreationist search and rescue callouts in the US. They outline the ways in which various states approach the issue, including recouping SAR costs (e.g., in instances where the recreationist has entered a signposted prohibited area) the use of PSAR programmes (Preventive Search and Rescue) which involves a suite of measures including signage posted at trailheads targeted towards specific safety issues in that location, and mandating the carrying of particular gear by recreationists. Ultimately, educative measures were preferred over both mandating the use of certain equipment and passing SAR costs on to recreationists. The authors concede that regulation cannot eliminate all risk and that the risks in outdoor recreation are inherent. Importantly, while arguments for recommendations were well argued, they were not based on the authors own empirical research.

W

Wallace, George, N., and C. James Gaudry. "An Evaluation of the "Authority of the Resource" Interpretive Technique by Rangers in Eight Wilderness/Backcountry Areas." *Journal of Interpretation Research* 7, no. 1 (2002): 43-68.

This study tested the effectiveness of authoritative messaging (delivered verbally) to backcountry users in the US versus a newly defined, evolved version of this, characterised as the Authority of the Resource technique (ART). ART minimises the authoritative component of in-person messaging (one that is characterised by regulations, warnings, and citations each backed by delivery from a uniformed official) and uses instead conversational and educational methods that highlight the reasons behind regulations. The study used 25 rangers trained in the use of ART; they conversed with 242 recreationists over eight locations who had engaged in undesirable behaviours (including dogs off leash, camping in unsuitable locations, campfires, collecting natural resources, and poor human waste management). Findings showed that the use of ART (i.e., emphasis on enlightening, educative communication over punitive measures) returned high rates of observed and communications of intended compliance. The study contributes to research on the importance to recreationists of personalised and meaningful messaging.

Weiler, Betty, Anna M. Gstaettner, and Pascal Scherrer. "Selfies to Die for: A Review of Research on Self-photography Associated with Injury/Death in Tourism and Recreation." *Tourism Management Perspectives* 37 (2021): 100778.

This review summarises relevant research on the dangers associated with selfie taking in tourism and recreation settings. The phenomenon of self-photography as an increasingly popular and increasingly risk-taking activity is described as is the most common management response, communication, within which signage is situated. Research has suggested warning signs be used in conjunction with an array of other visitor education and communication means (brochures, visitor centre information such as fliers, and face-to-face communication) to reduce the negative impacts of unsafe selfie taking behaviours. Importantly, other management response suggestions include limiting protected/wildlife area visitor numbers, using fencing or barriers, and the creation of viewing areas from which photographs might be taken. Selfies with wildlife was often the focus of research reviewed here, although, cliff edges, waterfalls, and other recreational settings were also noted.

Weiler, Betty, Heather Zeppel, Rob Saunders, and Pascal Scherrer. "A Review of Safety Signage for Queensland Parks and Wildlife Service: Report 1 (Literature review)." School of Business and Tourism, Southern Cross University, Australia, 2015.

<https://researchportal.scu.edu.au/esploro/outputs/991012821011002368>

This evidence-based report brings together relevant literature on safety signage that informed the development of a set of Best Practice Principles (BPPs). It is a technical report based upon the research reported elsewhere in this bibliography; see Saunders et al. (2019) "Best Practice Principles for Communicating Safety Messages in National Parks".

Whitfield, Rebecca, and Ronan Roche. "UK Personal Watercraft Management: A User Perspective." *Marine Policy* 31 no. 4 (2007): 564-572.

This qualitative study examined the perceptions of 55 personal watercraft (PWC: jet ski) users and operators in the UK on matters of PWC management and issues that impact their use. The research found that 18% of respondents felt that insufficient signage and information was a main issue affecting PWC operators in the UK. This was ranked seventh, with the top issue being a lack of launching areas. Sixty percent of respondents supported the use of signage (to 'provide good information') as a management tool but 36% considered good signage existed at their main launching area. Removing all other water users from jet skiing areas was deemed by respondents as an effective way to improve safety.

Williams, Damien J., and Jan M. Noyes. "How does our Perception of Risk Influence Decision-making? Implications for the Design of Risk Information." *Theoretical Issues in Ergonomics Science* 8, no. 1 (2007): 1-35.

This report presents a review of the literature on risk perception, decision making, and designing risk information to good effect. The review explores the role that risk perception plays in regard to decision making and on the ways in which the communication of risk can affect the ways that individuals receive and absorb messaging. It concludes that several key components of warning signs must be considered (signal words, colour, sign shape, message framing, and the use of different combinations of these) and, crucially, that all of this is context dependent. The authors touch on the role that "smart warnings" might play in the communication of risk, the stated benefits of which include personalised messaging and as a way to combat desensitisation to signage.

Winter, Patricia L. "The Impact of Normative Message Types on off-trail Hiking." *Journal of Interpretation Research* 11, no. 1 (2006): 35-52.

This study assessed the language used on signage for its effectiveness in managing tourist behaviour, specifically reducing off-trail use to protect giant Sequoia at two California (US) national parks. Four sign types were tested that featured different combinations of language and tone, with no sign as a control, and 2,897 visitors were observed. The most effective in deterring off-trail use used injunctive-proscriptive messaging, this combination politely admonished against the undesired behaviour ("Please don't go off the established paths and trails") and explained why ("In order to protect the Sequoias and natural vegetation in this park").

While this study was conclusive in its findings, the author notes that there are mixed results in studies that assess the effectiveness of messaging on signage.

Winter, Patricia L., Brad J. Sagarin, Kelton Rhoads, Daniel W. Barrett, and Robert B. Cialdini. "Choosing to Encourage or Discourage: Perceived Effectiveness of Prescriptive versus Proscriptive Messages." *Environmental Management* 26 (2000): 589-594.

This study assessed the perceived effectiveness of encouraging versus discouraging messaging in deterring depreciative acts in recreation sites (that is, those that have a negative environmental impact- including littering, extinguishing fires, and staying on designated roads). It used a survey mailed to 146 random international members of the National Association for Interpretation. Findings showed a preference for encouragement-based, prescriptive messaging; this is in contrast to the preponderance of negatively framed/discouraging/proscriptive messaging found in recreation settings (see the 1998 study below by the same lead author).

Possible explanations for this discrepancy were provided, including the traditional approach of natural resource managers, the constraints of sign size (favouring proscriptive messages), or the need to address significant environmental violations. The study stated that, while signs are widely used, the most effective ways to frame messages and how visitor characteristics and settings impact their effectiveness are not well understood.

Winter, Patricia L., Robert B. Cialdini, Renee J. Bator, Kelton Rhoads, and Brad J. Sagarin. "An Analysis of Normative Messages in Signs at Recreation Settings." *Journal of Interpretation Research* 3, no. 1 (1998): 39-47.

This research undertook a systematic evaluation of signs and messages at 42 California and Arizona (US) recreation sites to find out how messages deterring depreciative acts (those that have a negative environmental impact) were framed. Specifically, the study looked at descriptive (how something 'is') versus injunctive (how something 'ought' to be) messaging and prescriptive (positive) versus proscriptive (negative) messaging. The study found that prescriptive messages should be emphasised over proscriptive ones, except in cases of serious rule violations or life-threatening situations. The authors explain the prevalence of negatively worded signs as often being created in response to problems or anticipated problem behaviours, and that this leads to a negative context and a proscriptive response. Operating with the premise that messaging prompts desirable behaviours, they suggest positively worded signage can achieve that and contribute to positive recreation experiences.

Witte, Kim. "Generating Effective Risk Messages: How Scary Should your Risk Communication be?" *Annals of the International Communication Association* 18, no. 1 (1995): 229-254.

This study reports on the efficacy of fear-arousing messaging in risk communication. It reported a case study involving 146 US college students whose attitudes and behaviour intentions were measured before and after viewing various messaging types – one which aroused fear, and one which described ways to avoid the risk. Results, cautioned as preliminary, were described in the context of the Extended Parallel Process Model (EPPM) which suggests that when faced with risks, people either attempt to control the danger or control their fear. Participants that sought to control the danger were more likely to try and avoid risk (i.e., take precautions) while those who were inclined to control their fear were more likely to minimise the seriousness of risks. Consequently, to be most effective, messaging should enable to viewer to feel they can have some control over the risk described. Although not related to outdoor recreation, this study further contributes to literature on the individualised ways in which people process risk messaging.

Wolf, Isabelle D., Heidi K. Stricker, and Gerald Hagenloh. "Interpretive Media that Attract Park Visitors and Enhance their Experiences: A Comparison of Modern and Traditional Tools Using GPS Tracking and GIS Technology." *Tourism Management Perspectives* 7 (2013): 59-72.

This research assessed the efficacy of various interpretation modes in Australian parks in the context of their ability to attract and engage visitors. It employed a mixed-method approach, combining surveys and analysis of visitor movements to assess the performance of interpretive media (consisting of a GPS-triggered multi-media tour, MP3-player audio tour, and text-rich versus image-rich pamphlets and signs).

Bearing in mind that the focus of the interpretive material was visitor education, signage was found to outperform pamphlets (it had stronger attracting and holding powers) while modern media was more popular, appealed to multiple senses, held visitor attention the longest, and was less prone to vandalism. Findings address the effective dissemination of messaging to recreationists, including via digital technology. Interestingly, the potential for digital technology to provide personalised information on an individual basis was noted, which is a key aspect of engaging visitors.

Y Yang, Byungmo, Jooyong Lee, Jin Sang Hwang, Hyuck Min Kweon, and Jung Lyul Lee. "Quantitative Risk Assessment for Beach Drowning Management." *Journal of Coastal Research*, (2014): 117–21.

The authors outlined a rating scale to measure the vulnerability risk of beach drownings at four Korean beaches. They present a system to quantify the drowning risk at each beach which was developed by cross-referencing metrics including: beach length; lifeguards and lifeguards per meter; warning signage and signage per meter; number of visitors; and beach characteristics (including currents, wave heights, reefs etc.). The study concludes that three of the four beaches would have reduced drowning incidents if there were a greater presence of professional staff, and, if there were more warning signs. Note that the study does not examine the efficacy of warning signage, it simply uses signage as one measure of risk avoidance.

Youngs, Yolonda. "Danger Beyond This Point: Visual Representation, Cultural Landscapes, and the Geography of Environmental Hazards in US National Parks." *GeoHumanities* 6, no. 2 (2020): 314-346.

This research was carried out under the banner of geohumanities and sought to categorise danger signage types within US national parks. It was undertaken to describe the approaches in use and to evaluate patterns of danger. The author used mixed methods including passive observation, collecting photographs of signage and natural features (for context), counting danger signs, and analysis of what danger signs represent. Danger signage of the following types were described: trail safety (e.g., steep drop-offs), wildlife (e.g., bison charging), dynamic earth (e.g., rockfalls), water hazards (e.g., drowning), disrespect (e.g., of historic sites), and overconfidence (e.g., assuming hazards don't apply).

Images of signage are shown with descriptions of intended audiences and information about messaging presentation (pictograms, photography, text-based, shock-value, sign placement etc.). The author concluded that, owing to the range of messaging types and hazards being warned of, it is unrealistic to expect safety to be managed to the extent that no incidents occur; she also raised the question of role of personal responsibility in places where hazards exist.

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