Interpretive Signage in Nature Sites: Practices for Encouraging Environmental Behaviour Change and an Evaluation of Their Presence

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Abstract

An important role of environmental education is to encourage people to adopt Environmentally Responsible Behaviours (ERB). Research has progressed greatly since early behavioural models that inaccurately suggested that the simple provision of environmental knowledge would lead to ERB adoption. However, such updated research may be inaccessible to environmental educators. In response, this project reviewed recent literature (published 2006 and after) and sourced from them recommended practices applicable to promoting ERBs with interpretive signage — a popular communication method that educators use in various settings. From 60 publications — chosen as they relate to Australian nature-related sites — we identified 114 recommended practices organized into eight dimensions based off pre-existing frameworks (e.g. Community-based Social Marketing). We highlighted dimensions that should be prioritized for inclusion in future compilations of interpretive signage design guidelines because they may not be commonly known to environmental educators. These dimensions included *Call to Action*, *Perceived Behavioural Control*, *Attitudes/Beliefs*, *Message Framing*, and *Message Propagation* as their associated practices were under-used in the signage of nature sites that we surveyed and/or were specific to promoting ERBs. By informing the development/updating of future signage design guidelines, we hope to advance educators' knowledge and support efforts to effect ERB uptake in their audience.

Keywords: Interpretive Signage, Environmental Education, Nature Sites, Environmentally Responsible Behaviours, Behaviour Change

1. Introduction

In recent decades, there has been a growing acknowledgement that there is one key driver behind many conservation issues: unsustainable human behaviour (Thøgersen, 2014, Veríssimo, 2013). Such problems can still be addressed if individuals change their lifestyles and adopt Environmentally Responsible Behaviours (ERB) — behaviours that moderate one's own environmental impact (Alonso-Vazquez et al., 2019; Dietz et al., 2009). ERBs can be public actions — e.g. signing environmental petitions — or private ones — e.g. using fewer plastic products (Dean et al., 2018; Stern, 2000). However, even with this variety, people may not be fully aware of ERBs they can take on to help the environment (Ballantyne et al., 2007; Ballantyne, Hughes, Lee, Packer, & Sneddon, 2018). To tackle this knowledge gap, various entities — from community groups (Dean et al., 2018) to local/federal governments (Australian Department of Environment, Water, Heritage and the Arts, 2009; City of Sydney, 2017) to the international political community

(Convention on Biological Diversity, n.d.) — have created a multitude of plans/programs to promote widespread environmental behaviour. Such efforts will require supporting knowledge from academia.

1.1 Academic Frameworks for Promoting Environmentally Responsible Behaviours

Research identifying the psychosocial factors influencing ERB action has progressed greatly in recent decades. Initial models from the 1970s assumed that environmental educators could simply provide environmental knowledge to make their audience have more conservation-aligned attitudes and subsequently act environmentally (Kollmuss & Agyeman, 2000). Current studies now show that this is inaccurate, with widely-used behavioural models such as the Theory of Planned Behaviour (Azjen, 1991), Norm Activation Theory (Schwartz & Howard, 1981), and Value-Belief-Norm Theory (Stern, 2000) attributing behavioural change to other factors. Further research has led to the Comprehensive Action Determination Model of Klöckner & Blöbaum (2010).

With the Comprehensive Action Determination Model, the three aforementioned behavioural models have been amalgamated. Several psychosocial factors have been linked to ERB performance, with these factors including:

- habits;
- individuals' beliefs on whether they can carry out the ERB (i.e. perceived behavioural control);
- beliefs about how others would react if the individual performed the ERB (i.e. social norms);
- environmental attitudes and values (i.e. New Environmental Paradigm);
- personal values (e.g. doing ERBs to help others, doing ERBs for nature's sake, not doing ERBs for personal gain);
- awareness of their responsibility/moral obligation to perform ERBs; and
- awareness of how ERBs can help others (Klöckner, 2013).

While explicit knowledge of such factors may be beneficial for researchers planning their own projects, educators may be unsure of how to apply it to their communication efforts and successfully elicit behavioural uptake in their audience.

Accordingly, several studies provide research-informed suggestions that educators can make use of (e.g. Ballantyne & Hughes, 2003; Ballantyne, Packer, Hughes, & Gill, 2018; Hughes, 2011; Jarreau et al., 2017). Of note is a meta-analysis conducted by Osbaldiston & Schott (2012) that has distilled pre-existing research into several explicit actions and their associated efficacy in various practical contexts — e.g. presented subject (such as climate change or water pollution) and ERB type (such as recycling). However, some barriers may prevent educators from harnessing these studies — for example, a lack of subscriptions to

academic journals. Educators may also not utilize literature if they over-use jargon or concentrate too heavily on concepts/frameworks that are too theoretical (i.e. completely disconnected from any practical application) (Gupta, 1999; Roux et al., 2006).

1.2 Practical Frameworks for Communicating Conservation

Improving accessibility, commercial handbooks have been published that translate academic knowledge into a more practical format. One of the more popular handbooks describes the Community-based Social Marketing framework (CBSM) of McKenzie-Mohr (2011). Stemming from the Theory of Planned Behaviour, CBSM emphasizes that educators need to identify and target barriers to ERBs in order to foster their adoption. While CBSM has been shown to improve behavioural uptake in various real-world locations (Hughes, 2013), some suggested actions involve directly changing government policies/infrastructure. Consequently, its scope may be beyond some environmental educators, particularly those that only concern themselves with individual sites. For them, there is an alternative method for encouraging behavioural change: interpretive signage.

1.3 Practical Frameworks for Designing Interpretive Signage

Interpretive signage is a popular option for educators who wish to communicate environmental messages to visitors of nature areas, zoos, or other locations. Their ubiquitous presence in sites can be attributed to their low cost, constant availability for perusal, and ability to be read by large audiences simultaneously (Moscardo et al., 2007). As such, they are also an attractive alternative for educators who do not have enough resources to implement other interpretation features, such as human guides or presentations (Moscardo et al., 2007). With a well-designed network of interpretive signage, educators can engage with their visitors and facilitate learning even in those that may not be well-versed in the subject matter (Wandersee & Clary, 2007). Such engagement can carry over into inspiring visitors to take conveyed messages to heart (Ballantyne & Hughes, 2003), and some of these messages — as suggested by Moscardo (1996) and Moscardo et al. (2004) — should be about convincing visitors to behave sustainably. Accordingly, they have been implemented at many sites with ultimate goals of inspiring visitors to act environmentally. Such employment is justified by studies demonstrating that visitors can recall messages about and/or engage in ERBs based on the information they acquired from reading signs (Ballantyne and Packer, 2016; Ballantyne, Packer, & Sutherland, 2011; Hughes et al., 2014; Marschall et al., 2017). However, this is moreso a best-case engagement scenario.

While the self-paced nature of interpretive signage may be convenient for visitors (Wandersee & Clary, 2007), it means they can spend less than a minute browsing a sign or even outright ignore it (Hughes et al., 2014; Ross & Lukas, 2005). This underscores how important it is that educators employ signs that are

well-designed. Low-quality signs will impede their efforts to promote ERBs — efforts that are already hampered by an already-reduced audience size. Thus, educators need to be provided design practices that are effective in order to make the most out of this diminished potential (Ballantyne & Hughes, 2003; Moscardo et al., 2007). One resource addressing this need is the handbook of Moscardo et al. (2007) and its collection of design guidelines, but it itself has some issues. Its suggestions are not particularly related to eliciting ERB uptake and it is not based on current knowledge — many new studies have been published since its release.

1.4 Significance and Project Aims

Drawing together the shortcomings of Moscardo et al. (2007), Community-based Social Marketing, and Osbaldiston & Schott (2012), there is a need for an updated compilation of research-informed practices for interpretive signage design, specifically in the context of guiding educators in promoting ERBs. However, such an update may require significant effort given the various topics and dimensions that a new list may need to touch upon. Some parts of this effort may prove redundant, given that educators may be aware of some practices and are already implementing them. Thus, there is a concurrent need to optimize the updating process in order to support those who wish to develop new comprehensive signage design guidelines that educators can harness.

This project will fulfill this need — specifically focusing on an Australian context— but doing so will require the achievement of two aims. For the first of these aims, this project will need to identify what the current research-recommended practices are for designing interpretive signage in the context of promoting ERBs to Australians. To do this, this project will gather a variety of recent literature that contain suggestions applicable to environmental education and summarize them into a single list. This list would serve as a foundation for the second aim — to identify priority recommendations for designing interpretive signage in the context of promoting ERBs to Australians. This will be accomplished by using the list to evaluate interpretive signs at four nature sites in the Brisbane region. Practices and dimensions from the list that are not well-represented in these sites will be designated as priority areas for updating design guidelines as educators may be unaware of them. With this, we will be able to guide future development of practices for signage design and subsequently support the ERB-promoting efforts of environmental educators.

2. Methods

2.1 Aim 1: Identifying Current Research-Recommended Design Practices

2.1a Gathering Academic Resources

A systematic search was conducted on Google Scholar for literature with suggestions that were applicable to designing ERB-promoting interpretive signs at nature-related and/or environmental education sites. Given their research in applied environmental education, publications involving one or more of the following researchers were shortlisted: Drs. Roy Ballantyne, Angela Dean, Kelly Fielding, Karen Hughes, Gianna Moscardo, and Jan Packer. Results were reviewed if they referred to an Australian context — accounting for inter-cultural differences in reactions to conservation learning experiences (e.g. Xu et al., 2013) — and were published between 2006 and 2019 — referring to current knowledge acquired since Moscardo et al. (2007). An exception was made for Ballantyne & Hughes (2003) given that they published a wide range of over 100 suggestions for educators at nature sites (more than any other selected study). In total, 60 publications were selected to form the list's academic foundation.

2.1b Compiling Recommendations

Relevant recommended practices for interpretive signage design and/or ERB promotion were manually found and extracted from the 60 publications with their original, raw wording. Duplicate practices were eliminated and the rest were organized into ten different dimensions based off of the CBSM framework:

- Selection of ERBs by educators,
- Visitor-made commitments to performing ERBs,
- Social norms associated with ERBs,
- Social diffusion as a method for propagating ERBs,
- Prompts as a reinforcement for ERBs,
- Communication principles, and the
- Implementation of signage.

While the list's final framework would not include these dimensions, they allowed us to visualize common themes amongst practices, facilitating the merging of those that overlapped. The merged practices were then organized into eight new dimensions (and sub-dimensions) somewhat based on the frameworks of CBSM, the Comprehensive Action Determination Model, and Osbaldiston & Schott (2012). Such merging was required to translate the over 1,100 initial raw practices into a list of more manageable size. Any

details/recommendation lost in this merging were noted and included in supplementary footnotes associated with relevant individual practices.

2.1c Ensuring the List's Comprehensiveness

Applicable practices from the aforementioned three frameworks were added to the list to augment its comprehensiveness.

Furthermore, a Google Scholar literature search was performed with the boolean conditions '"Australia" AND "interpretive signage" AND "environmentally responsible behaviour" OR "environmentally responsible behavior" OR "pro environmental behaviour" OR "pro environmental behavior"', taking into account different spellings and an alternative terminology for ERBs. The first ten articles/results were compared to the list to check if their suggestions were already present. A second search was conducted but with 'signage' instead of 'interpretive signage' to expand the search's scope. For this search, the first twenty articles/results were used instead of ten.

2.2 Aim 2: Identifying Priority Recommendations for Designing Interpretive Signage

2.2a Study Sites and Data Collection

Nature-related sites where educators mostly depended on interpretive signage to communicate messages were shortlisted for study. Of these sites, four popular areas in the Brisbane region were selected — Mt. Coot-tha Forest, Toohey Forest, Tinchi Tamba Wetlands, and Boondall Wetlands.

At these sites, we photographed/recorded signs from each site's three of the most popular tracks (as noted by Brisbane City Council's brochures) along with any other locations incidentally visited when traversing between the three tracks. These signs represented those that visitors may read on a typical visit. Visited tracks/locations are listed in **Table 1**.

2.2b Data Analysis

This project follows Moscardo et al. (2007) in that interpretive signage was defined as signs that aided visitors in appreciating, understanding, and/or enjoying the site's content. All recorded signs were categorized as either non-interpretive (e.g. wayfinding, warning, or law signs) or interpretive. Interpretive signs were further classified as behavioural (those that describe ERBs) or non-behavioural (those that do not). By calculating the percentage of behavioural signs out of all interpretive signage, the extent to which the sites' educators focused overall interpretive messages on behaviours could be determined. The relative amounts of different sign types are compiled in **Table 2**.

For each sign, we calculated the proportion of practices for each dimension that were explicitly present, treating it as a presence index. All dimensions were also combined to calculate an overall proportion for the list's total practices. All signs across all sites were aggregated into a single pool, and the mean presence index for each dimension and overall was determined.

When aggregating results, the mean presence indices for behavioural signs and non-behavioural signs were separately calculated. The two types were not combined to account for how some of the list's dimensions were more focused on behaviours. More specifically, scores of non-behavioural signs may dilute those of behavioural signs and lead us to believe that these dimensions were not as well-represented as they actually were. Proportions for behavioural and non-behavioural signs were compared with un-paired two-tailed t-tests conducted with Microsoft Excel and an alpha value of 0.05.

3. Results

3.1 Aim 1: Identifying Current Research-Recommended Design Practices

Over 1,100 raw research-sourced recommendations were extracted from 60 studies and merged into 114 individual practices (**Figure 1**). These practices were spread across the following eight dimensions:

- *Calls to Action* — do signs present ERBs and link them to issues?
- *Perceived Behavioural Control* — do signs address behavioural drivers/constraints relating to their audience's perceptions of the feasibility of the behaviour? In essence, do they refer visitors to supportive resources and target beliefs that individuals cannot adequately perform the behaviour?
- *Attitudes/Beliefs* — do signs target their audience's attitudes and beliefs, given that theoretical models such as the Comprehensive Action Determination Model have linked them to drivers/constraints of ERBs?
- *Message Framing* — do signs frame their messages in a manner that can connect with visitors?
- *General Content* — do signs provide engaging information, messages, and images?
- *General Presentation* — do signs present content that is understandable and engaging?
- *Implementation* — how have signs themselves been designed, and how do they present their content?
- *Message Propagation* — do signs ensure that messages stay with their audience and support actions by individuals that can spread them out beyond the site?

For these dimensions, the former four (*Calls to Action, Perceived Behavioural Control, Attitudes/Beliefs*, and *Message Framing*) are dominated by research-informed practices that are directly related to the presence of ERBs and their attributes (**Appendix A - D**). The latter four (*General Content, General Presentation, Implementation, Message Propagation*) do not contain any practices specific to

behaviours, with the exception of one in *Message Propagation* (**Appendix E - H**). These two groupings will be referred to as behaviour-dominated and non-behaviour-dominated dimensions respectively.

3.2 Aim 2: Determining the Presence of the List's Practices

3.2a The Presence of Behavioural Signs amongst Interpretive Signage

Interpretive signs represented 36.3% of all signs observed across the four sites (**Table 2**). Of them, 38.6% (34 signs) described behaviours while the remaining 61.4% (54 signs) did not. This proportion varied across the four sites, although Mount Coot-tha Forest had fewer behavioural signs (only two) than the others.

3.2b The Percentage of The List's Practices That Were Explicitly Present

The presence index (i.e. percentage of practices being explicitly present) for each of the dimensions was calculated for each sign. The mean presence index for each of the four behaviour-dominated dimension was higher in behavioural signs compared to non-behavioural signs (**Figure 2**), and these differences were significant (un-paired t-test, t = 31.2, 13.2, 4.1, and 10.6; df = 33, 39, 39, and 54; and $p = 4.7 \times 10^{-26}$, 5.5×10^{-16}, 2.2×10^{-4}, and 8.1×10^{-15} for *Call to Action*, *Perceived Behavioural Control*, *Attitudes/Beliefs*, and *Message Framing* respectively). Further illustrating this difference, the highest mean presence index achieved by non-behavioural signs in the context of these four dimensions was 9.0% (N = 54, S.E. = 1.0%) for *Attitudes/Beliefs*. Meanwhile, the lowest mean presence index achieved by behavioural signs out of these four dimensions was 19.6% (N = 34, S.E. = 2.2%).

The mean presence index for each of the non-behaviour-dominated dimensions was also higher in behavioural signs than in non-behavioural signs (**Figure 2**) — with the exception of *Message Propagation*. However, these differences were not significant (un-paired t-test, t = 0.5, 1.3, 1.9, and -1; df = 70, 67, 43, and 52; and $p = 6.1 \times 10^{-1}$, 1.9×10^{-1}, 6.6×10^{-2}, and 3.2×10^{-1} for *General Content*, *General Presentation*, *Implementation*, and *Message Propagation* respectively).

Comparing between the two types of dimensions, non-behaviour-dominated dimensions are generally associated with higher mean presence index, with values for the four dimensions (except for *Message Propagation*) being over 50% regardless of sign type (**Figure 2**). Behaviour-dominated dimensions are generally associated with lower mean presence index, as values for the four dimensions (except for *Call to Action*) are under 35% regardless of sign type (**Figure 2**).

Combining all dimensions, the overall mean presence index was significantly higher for behavioural signs compared to non-behavioural signs (un-paired t-test, t = 10.7, df = 41, $p = 1.8 \times 10^{-13}$).

3.2c The List's Practices That Were Absent at One or More Site

Practices that were not present on any behavioural sign (either overall or just at one site) were identified and listed in **Table 3**. Nine practices associated with *Perceived Behavioural Control* were present in **Table 3**, and they mainly revolved around educators:

- Using commitments, prompts, incentives, and feedback to foster ERB uptake, and
- Generally addressing common barriers of ERBs.

Twelve practices of *Attitudes/Beliefs* were also in **Table 3**, and they mainly suggested that educators refer to:

- Benefits of ERBs and/or harms of environmental inaction to visitors and others,
- Visitors' responsibilities for being environmental,
- Visitors' environmental values,
- Environmental consequences of visitors' actions,
- Social norms associated with ERBs

Nine practices from *Message Framing* were included in **Table 3**, and they related to specific emotional frames or topics that educators could utilize/discuss.

4. Discussion

In this project, we sought to support environmental educators in their promotion of ERBs by identifying current research-informed practices for designing interpretive signage. Namely, we created a foundational list of practices that interested parties (referred to as signage design practitioners) could use if they wished to develop compilations of guidelines for informing educators' interpretive signage design. From a collection of 60 studies, we produced a list of 114 suggestions (**Figure 1**). They were compartmentalized into eight different dimensions to facilitate users' navigation of them. We further streamlined the list by using it to evaluate interpretive signs at four nature sites. From the results of this evaluation, we concluded that the interpretive signage design dimensions related to *Call to Action, Perceived Behavioural Control, Attitudes/Beliefs, Message Framing,* and *Message Propagation* were under-represented (i.e. their respective practices were not commonly used), identifying them as priority areas. More specifically, we recommended that signage design practitioners ensure that guidelines they develop/update inform educators of these dimensions. The reasoning for such recommendations relates back to a key theme that arose multiple times throughout this project's progression: redundancy.

4.1 The Issue of Redundancy

Redundancy was a key driver for the list's various development stages, beginning back to when we first extracted suggestions from the 60 publications. From these, over 1,100 raw practices were sourced, and many were redundant duplicates. Even when we removed them and organized the remaining practices according to different CBSM dimensions (e.g. 'communication', 'behavioural commitments', individuals' 'perceived social norms', 'social diffusion'), the issue still remained in this preliminary list. In addition to some dimensions being disproportionately over-/under-represented (i.e. 'communication' had hundreds of entries while 'behavioural commitments' only had 20), many practices matched with multiple dimensions, meaning they were repeated multiple times. Consequently, there were still hundreds of entries in the list. Hence, we developed new dimensions that were discrete (i.e. no practices would be included in multiple dimensions) while still being based off of the CBSM framework. For example, 'communication' was divided into different dimensions like *Message Framing* and *General Presentation*, 'social norms' was merged with others into *Attitudes/Beliefs*, and 'social diffusion' was adapted into *Message Propagation*. As we also merged together practices with overlapping themes, we produced the final list of 114 entries. However, the issue of redundancy still remained — environmental educators may already know some of the list's practices. Thus, any signage design practitioner using the list to update/develop guidelines may find themselves failing to enhance their audience's current knowledge. While it is important that educators follow all of the list's practices as they can help with engaging their audience, we needed to identify priority areas to direct design practitioners' focus towards dimensions that may not be common knowledge to educators and thus are not redundant. Such identification was made possible by our organization of dimensions into those dominated by behaviours and those that were not.

4.2 Some Dimensions Are Not Specific to Promoting ERBs

Of the eight dimensions, four — *Call to Action, Perceived Behavioural Control, Attitudes/Beliefs, Message Framing* — were comprised mostly of practices that specifically involve ERBs, leading to their classification as behaviour-dominated dimensions. As the opposite was true for the other four — *General Content, General Presentation, Implementation,* and *Message Propagation* — they were categorized as non-behaviour-dominated dimensions.

Such a distinction is further demonstrated by their presence (i.e. the number of their practices that are explicitly present) on interpretive signs that are behavioural (i.e. describe ERBs) and non-behavioural. Behaviour-dominated dimensions have a significantly higher presence on behavioural signs (**Figure 2**), showing that they are more specific to promoting ERBs. Meanwhile, non-behaviour-dominated dimensions do not have a significantly different presence between the two sign types (**Figure 2**), indicating that they are

more generic and not specifically relevant to signs that describe/promote ERBs. It should be noted that this line of reasoning may not be applicable to the dimension of *Message Propagation* as both sign types have practically none of its practices. Accordingly, the other non-behaviour-dominated dimensions — specifically *General Content, General Presentation, and Implementation* — should not be prioritized as they may not be relevant for signage design practitioners.

4.3 Some Non-behaviour-dominated Dimensions Are Relatively Well-represented on Signs

Another reason for not prioritizing the three non-behaviour dominated dimensions is that they are relatively well-represented. On average, behavioural and non-behavioural signs fulfill approximately or over 50% of their practices (**Figure 2**). Therefore, they may already be common knowledge as some are common sense (e.g. make sure the text is of a readable size). Additionally, all of them are already present in older literature/design guides such as Moscardo et al. (2007) and Ballantyne et al. (2003). As a result, they should not be prioritized as signage design practitioners may find them redundant.

4.4 The Dimension of *Message Propagation* Can Enhance Promotion of ERBs

On the other hand, *Message Propagation* should be prioritized. As previously discussed, the communication efforts of educators who employ interpretive signage are limited by how visitors may either not thoroughly read or even ignore signs (Hughes et al., 2014; Ross & Lukas, 2005). However, with this dimension, educators would be supporting and guiding visitors in discussing communicated messages both on-site with their companions and off-site with other acquaintances. This would open up a new channel for educators to spread their messages, augmenting their ability to promote ERBs and demonstrating their importance in any set of guidelines being updated/developed by signage design practitioners.

4.5 The Dimension of *Message Propagation* Is Poorly Represented on Signs

Another reason for why this dimension should be prioritized is its under-representation. Practically all signs — regardless of whether they are behavioural or non-behavioural — do not fulfill any of their practices (**Figure 2**). This may be attributed to how several of the dimension's practices relate to supporting visitors in using their phones during the interpretive experience (e.g. by guiding visitors in taking photos of signs and other site features or by encouraging visitors to share with others photos and knowledge they have learned). Some educators may not support the usage of phones during visits as they feel they take visitors away from being engaged with the interpreted content (Hughes & Moscardo, 2017). However, some studies show the opposite — using devices can help individuals become more engaged with the site (Hughes and Moscardo, 2017; Moscardo & Hughes, 2016, Pearce & Moscardo, 2015). Given how such literature was

published in recent years, *Message Propagation* must be prioritized to ensure this knowledge gap is quickly addressed.

4.6 Some Behaviour-dominated Dimensions Are Poorly Represented on Signs

The behaviour-dominated dimensions of *Perceived Behavioural Control*, *Attitudes/Beliefs*, and *Message Framing* are also not well-represented. Fewer than 35% of their practices were explicitly present on the average sign (behavioural or non-behavioural) recorded at the four sites (**Figure 2**). These missing practices suggest that there is a gap between academic knowledge and actual practices, especially as many of the 60 studies informing the list were published in the past five years. Thus, educators may not have been able to keep pace with the advice of current literature. This could be due to how educators may not access academic literature and how available commercial resources such as Moscardo et al. (2007) and CBSM — last edition in 2011 — are unable to better inform them due to lack of recent updating. Given that they may not be common knowledge, these dimensions should be prioritized and taken into account when developing/updating guidelines. However, it should be noted that not all under-representation may have been due to these described factors.

While some of the practices associated with *Message Framing* are not well-addressed — some are completely absent from the signs of one or more site (**Table 3**) — it may be because of how they relate to various specific emotions (e.g. hope, despair) and topics (e.g. nature as a home, science as a way for improving the environment). As signs only have so much space to build on messages, suggesting that they need to include all research-recommended emotions and/or topics may not be feasible. However, this dimension should still be prioritized. With how none of these practices were explicitly present on signs, concerns about the feasibility of simultaneously fulfilling multiple recommended practices are irrelevant until educators demonstrate that they know to incorporate at least one of them.

Regardless of why they are under-represented, it is still important that these dimensions are prioritized given that some of their practices have been linked — and not simply theorized to be linked — to ERB uptake. For example, there were nine different *Perceived Behavioural Control* practices listed in **Table 3**, recognizing them as absent from the signs of at least one site. These practices referred to the utilization of concepts such as commitments, prompts, and incentives to foster ERB uptake. Given that another **Table 3** entry suggests directly addressing common barriers to ERB action, this set of under-represented practices are similar to those proposed by Osbaldiston & Schott (2012) — who demonstrated their efficacy with statistical analyses — and CBSM — which has a history of successfully fostering environmental behaviour adoption (Hughes, 2011; Hughes, 2013). Likewise, the *Attitudes/Beliefs* practices listed in **Table 3** (e.g. refer to the consequences of ERBs, refer to social norms) are related to some of the Comprehensive Action

Determination Model's components, whose validity is supported by the statistical meta-analyses of Klöckner (2013).

4.7 The Dimension of Call to Action is Specific to Promoting ERBs

While the fourth behaviour-dominated dimension — *Call to Action* — is not under-represented, it should still be prioritized. The dimension deals specifically with ensuring that behaviours and associated conservation issues are explicitly described. Given this specificity, any interpretive sign will need to fulfill a majority of its practices to promote ERBs in any capacity. This is shown by how the average behavioural sign fulfilled over 70% of its practices while non-behavioural signs fulfilled 0% (**Figure 2**). Accordingly, *Call to Action* can be treated as a threshold that practitioners must pass and should take it into account when updating/developing guidelines.

4.8 Overall Thoughts

In this project, we developed a list of research-informed practices for designing ERB-promoting interpretive signage. Subsequently, we identified dimensions of the list that should be prioritized and used as a basis for future guidelines developed/updated by signage design practitioners. These were *Call to Action*, *Perceived Behavioural Control, Attitude/Beliefs, Message Framing, and Message Propagation*. Their priority was designated on the basis of their under-representation or their being specific to ERB promotion, but some concerns arise.

Firstly, we were limited to only surveying signs at four different sites in the Brisbane region (all managed by the Brisbane City Council). Accordingly, our conclusions on which practices to prioritize may have been based on interpretive signage following a specific design philosophy that differs from other sites. Addressing this, future projects should expand beyond this region and survey sites in other parts of Queensland or Australia. Should identified prioritized areas be consistent across different regions, this would validate conclusions made here and increase the confidence of guidelines basing themselves on this project.

Secondly, we were limited in the amount of literature that we based the list on (e.g. shortlisted authors). Future projects can extract more practices from a greater number of studies (e.g. by expanding beyond the shortlisted authors) and improve on the list's comprehensiveness.

By addressing these, a future iteration of this project (and guidelines based on it) can assist educators with designing interpretive signs that have the highest chance possible to elicit ERB uptake in their audience. However, there is a major caveat that should be acknowledged

Not all educators may be interested in fostering ERB uptake. For example, Mount Coot-tha Forest, despite having the most surveyed locations of all sites (**Table 1**), only had two behavioural signs (**Table 2**). Furthermore, only 38.6% of interpretive signs seen across all sites were behavioural (**Table 2**). However, it should be noted that not all signs at a site need to describe ERBs in order to influence their adoption. Stemming from this, a future project should search for studies suggesting when it would be most suitable to include ERBs/not include them in a site's overall interpretive experience (e.g. at the start, at the end). Nevertheless, some educators may still be interested moreso in letting visitors experience the site and/or, at the very least, providing a few signs that label surrounding flora and fauna. This list is still somewhat applicable for them; they can just prioritize the non-behaviour-dominated dimensions (aside from *Message Propagation*) and the generic communication practices that are not specific to environmental behaviours. However, for the other educators that wish to promote ERBs, we hope that this list can aid them in their efforts to foster environmental engagement in their audiences.

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7. Conflicts of Interest

None.

8. References

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Table 1. The four main study sites -- along with the specific trails and locations that were visited – where signs were sampled.

Site			
Mount Coot-tha Forest	**Toohey Forest**	**Tinchi Tamba Wetlands**[c]	**Boondall Wetlands**
Discovery Trail	Nathan Ridge Track[a]	Birdhide Track[a]	Billai dhagun Circuit[a]
Mahogany Trail[a,b]			
Mount Coot-tha Lookout	Sandstone Circuit[a]	Island Circuit Track[a]	Tabbil-ban dhagun Boardwalk[a]
Simpsons Fall Trail[a,b]			
Summit Track[a]	Toohey Ridge Track[a]		Tulla-yugaipa hagun Track[a]

[a] This trail/location was advertised as popular by the Brisbane City Council's promotional track maps.

[b] No signs were found in this trail/location.

[c] There are no further walking trails available.

Table 2. The amount of non-interpretive and interpretive signs sampled at the four study sites.

Site	Non-interpretive Signs[b]	Interpretive Signs[a]		All Signs
		Behavioural Signs[c]	Non-behavioural Signs[c]	
Mount Coot-tha Forest	32	2	8	42
Toohey Forest	49	13	3	65
Tinchi Tamba Wetlands	22	10	9	41
Boondall Wetlands	51	9	34	94
Cumulative (All Sites)	154	34	54	242

[a] Following Moscardo et al. (2007), interpretive signage is defined as signs that aid visitors in learning about, appreciate, understanding, and/or enjoying the interpreted content.

[b] Non-interpretive signs include wayfinding, warning, and law signs.

[c] Behavioural signs are defined as signs that mention/promote any environmental behaviours to their readers. Non-behavioural signs are those that do not.

Table 3. A list of recommended practices that were not explicitly present on any interpretive signage describing environmental behaviours (specifically at one or more site).

Criteria[c]	Site[a] TF[b]	TT[b]	BW[b]
Dimension: Call to Action			
Have visitors been encouraged to develop their own response/solution to the described environmental issues, especially if behaviours have not been provided?	X	X	X
Dimension: Perceived Behaviouaral Control			
Are visitors encouraged and asked (i.e. not forced) to make a verbal or written commitment/plan to engage in the behaviour and associated lifestyle changes?	X	X	X
Do signs refer visitors to resources that can hold them accountable for following commitments…?	X	X	X
Do signs address common perceptions of barriers to the behaviour?	X	X	X
Do signs convince visitors that they can make a difference by adopting the behaviour?	X		
Do signs empower visitors, convincing them that they are able to perform the behaviour?	X	X	X
Are visitors referred to larger programs for feedback on the behaviour?	X	X	X
Do signs suggest how the behaviour can be incorporated into the elements/experiences of visitors' everyday lives and/or their local environment?	X		
Are visitors referred to larger programs for rewards that can support/encourage uptake of the behaviour?	X	X	X
Do signs suggest that visitors should make regular reminders about performing the behaviour…?	X	X	X
Dimension: Attitudes/Beliefs			
Do signs provide factual information about the behaviour's long and short-term benefits?	X		
Are benefits and harms described as affecting the visitors…	X		
… and are they linked to other people, such as future generations or children…	X		X
… and have they been linked to both visitors and other people?	X		X
Is factual information on the rationale/justifications behind the behaviour provided?	X		
Do signs shift responsibility for being environmental to visitors themselves…?	X	X	X
Do signs encourage visitors to adopt the behaviour based on feelings of responsibility?	X	X	X
Do signs facilitate and/or encourage visitors to experience, appreciate, and reflect on the interpreted environment/wildlife and its special/unique characteristics?	X		
Do signs encourage visitors to reflect on their personal environmental values/attitudes?	X	X	X
Do signs prompt visitors to reflect on their own actions and their environmental impact?	X	X	X
Do signs make credible claims about the behaviour's social desirability?	X	X	X
Do signs encourage visitors to adopt the behaviour based on social norms?	X	X	
Dimension: Message Framing			
Are messages framed with emotions that are negative or positive?	X		
If hope-related messages are used, are they balanced with negative reminders about the current reality?	X	X	X
If despair-related messages are used, are they balanced with hope-related messages?	X	X	X
If negative fear-eliciting messages about environmental issues are used, are they accompanied by messages about visitors' efficacy in addressing them?	X	X	X
If negative messages are used, are they paired with positive ones?	X	X	X
Do messages prompt visitors to reflect on their emotions towards the interpreted environment/wildlife?	X	X	X
Do messages frame the interpreted environment as a home…?	X		X
If growth-related messages about science are used, are they not over-stating…?	X	X	X
Are messages framed around possible environmental behaviours that can be performed on-site, beyond the site, and in private contexts like home or work?	X	X	
Do messages connect to the wider context?	X	X	
Dimension: General Content			
Do messages reaffirm that displayed wildlife/environment have not been harmed by the site's processes?	X	X	X
Do messages interlink scientific and folk/cultural knowledge?	X	X	X
Do signs present a range of narratives, societal viewpoints, and/or perspectives?	X	X	X
Do signs encourage visitors to actively process and engage in the presented content/be mindful?	X	X	X
Do signs encourage visitors to take and record notes with their phones?	X	X	X
Dimension: Implementation			
Are signs supported by multiple forms of media?	X	X	X
Do signs have any interactive, moving, and/or multi-sensory elements?	X	X	X
Do signs present content in at least one language?	X	X	X

[a] Mount Coot-tha Forest is not included in this table as only two signs describing environmental behaviours were found.
[b] TF = Toohey Forest || TT = Tinchi Tamba Wetlands || BW = Boondall Wetlands
[c] The dimension of Message Propagation is not included as none of its practices were present on any sign.

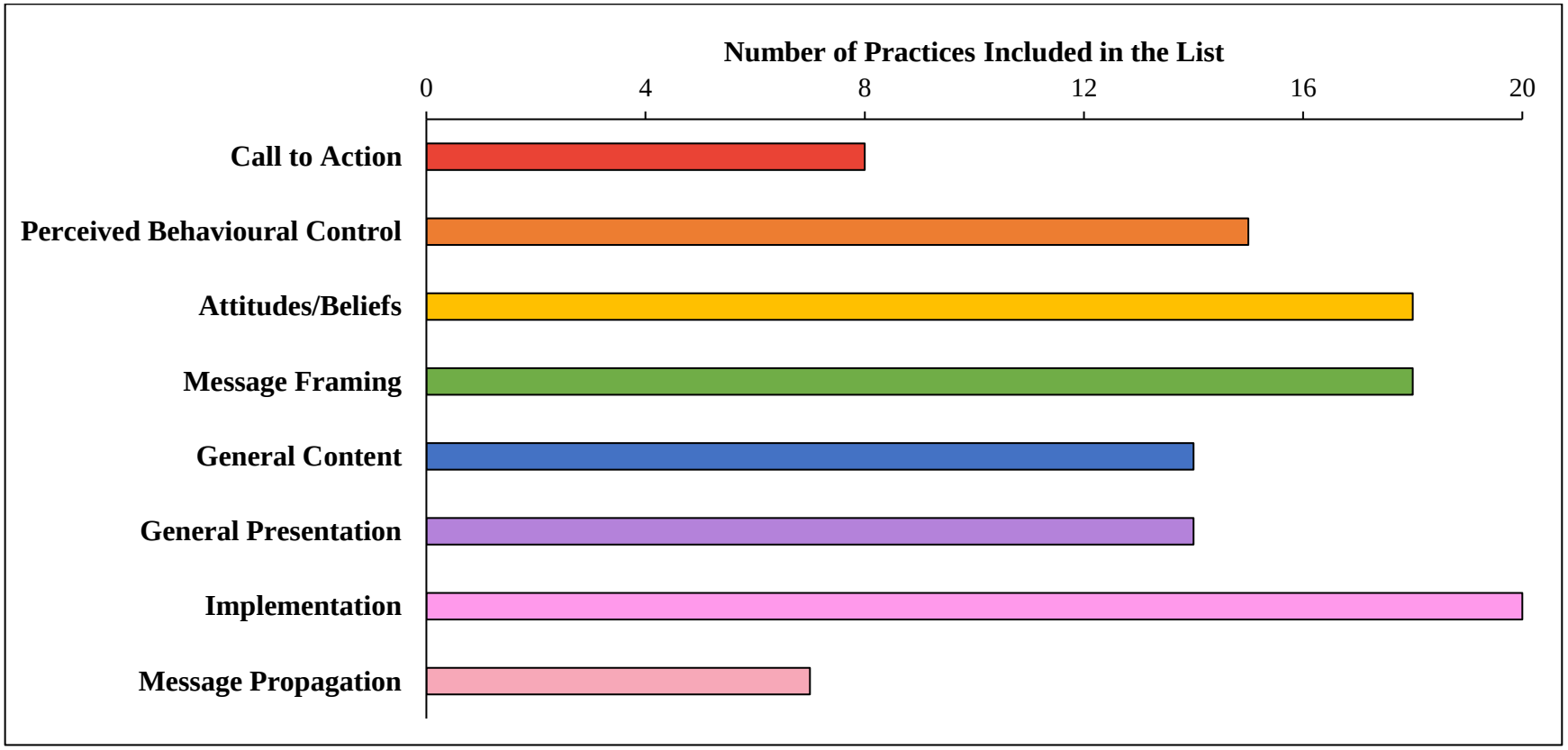

Figure 1. The relative number of research-informed practices belonging to each dimension of the list. Each of the dimensions relate to an aspect of designing interpretive signage for the purpose of promoting environmental behaviours. In total, there are 114 practices.

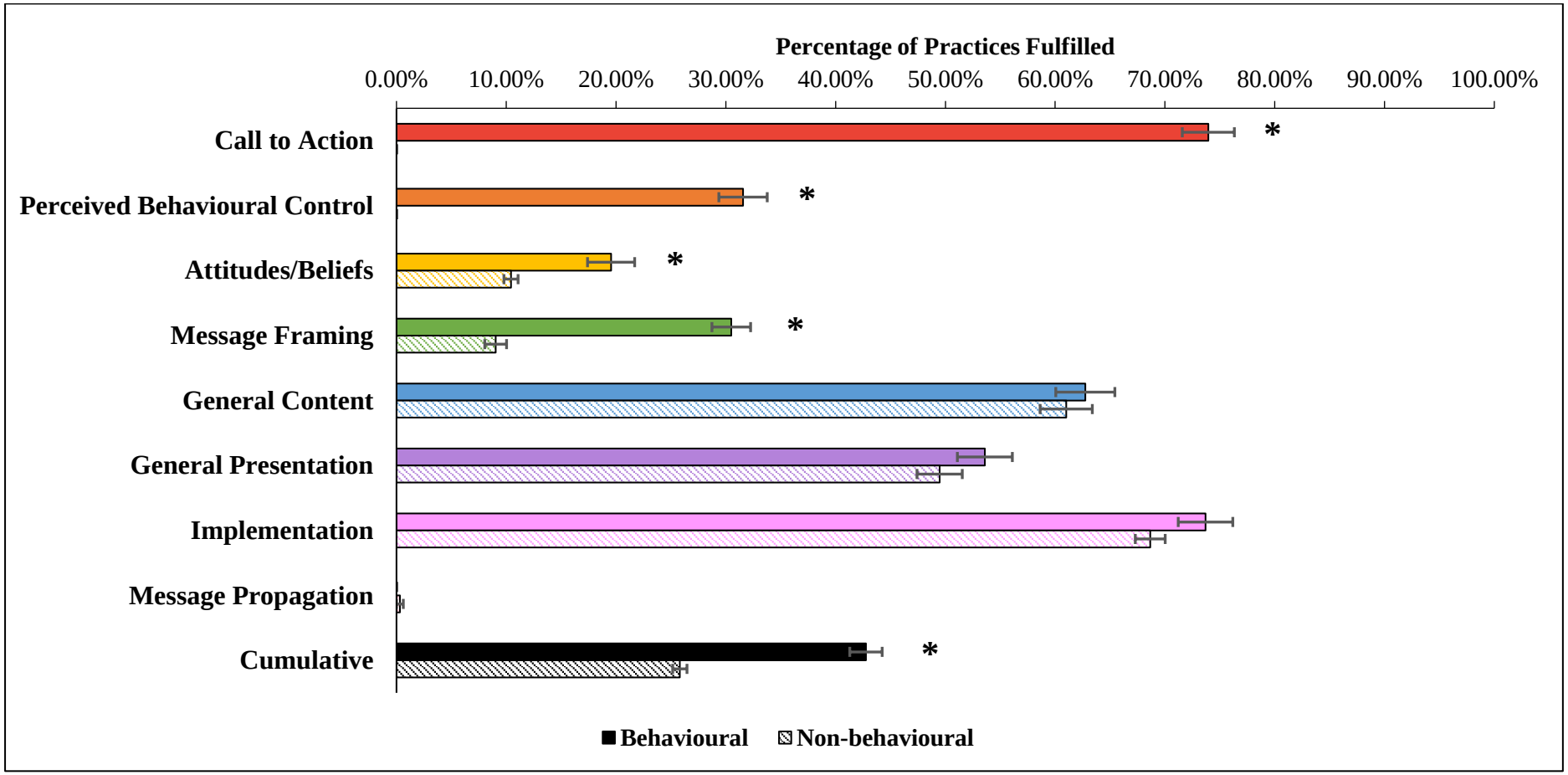

Figure 2. The mean percentage of practices (for each of the list's dimensions and overall) that were explicitly present on all recorded signs. Asterisks denote dimensions where signs describing environmental behaviours (i.e. behavioural) achieved significantly higher mean percentages than those that do not (i.e. non-behavioural). N = 34 and 53 respectively for behavioural and non-behavioural signs. Signs were recorded at four different sites — Mount Coot-tha Forest, Toohey Forest, Tinchi Tamba Wetlands, and Boondall Wetlands.

Appendix A. A list-based evaluation for the interpretive signage dimension Call to Action (i.e. do signs present ERBs and link them to issues).

Criteria [1]	**Yes/No**[2]

Sub-dimension: Behavioural Selection[3]
• Is there a specific, non-divisible[4] Environmentally Responsible Behaviour?
• Is there an end-state[5] behaviour?
  ○ ...and is its potential impact high[6]...
  • ...or can it make a positive difference at all, even if it is small?
Sub-dimension: Communication[1]
• Has the behaviour been linked to/presented alongside real-life environmental issues and/or broader conservation goals?
• Has the behaviour been linked to helping specific interpreted environment/wildlife on the site, in general, and/or in visitors' local context?
• Have visitors been encouraged to adopt or increase the frequency at which they perform the behaviour, especially in light of the described environmental issues?
• Have visitors been encouraged to develop their own response/solution to the described environmental issues, especially if behaviours have not been provided?	

[1] Criteria are based off of the conclusions of 60 studies.
[2] Interpretive signage should aim to achieve affirmative responses for each practice.
[3] This sub-dimension is based off of the framework of Community-based Social Marketing (McKenzie-Mohr, 2011).
[4] Non-divisible, meaning that the behaviour cannot be divided further
[5] End-state, meaning the behaviour will result in desired positive conservation outcomes
[6] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

Appendix B. A list-based evaluation for the interpretive signage dimension Perceived Behavioural Control (do signs address behavioural drivers/constraints relating to their audience's perceptions of the feasibility of the behaviour).

Criteria[1]	**Yes/No**[2]
Sub-dimension: Commitment[3,4] • Are visitors encouraged and asked (i.e. not forced) to make a verbal or written commitment/plan to engage in the behaviour and associated lifestyle changes[5]? • Do signs refer visitors to resources[6] that can hold them accountable for following commitments to adopt the behaviour? Sub-dimension: Convenience[2,3] • Is the behaviour intuitively practical, achievable, easy-to-undertake, time-efficient, and simple or described as such? • Do signs provide alternate behaviours (but not too many) with a mix of difficulties and applicability to visitors' situations (i.e. social[7], economic, and environmental ones)? • Can visitors be realistically expected to adopt the behaviours[8]? • Can visitors be realistically expected[9] to be able to address the environmental issue/fulfill conservation goals? • Do signs address common perceptions of barriers[10] to the behaviour? • Do signs convince visitors that they can make a difference by adopting the behaviour?[11] • Do signs empower visitors, convincing them that they are able to perform the behaviour? • Are visitors given clear instructions[12] on how to perform the behaviour (along with other conservation lifestyle changes)? • Are visitors referred to larger programs for feedback on the behaviour? • Do signs refer visitors to and encourage them to repeatedly utilize resources[4] that can be accessed during and after the visit for further information[13] and long-term support[14] about the behaviour and environmental issue? Sub-dimension: Habits[2,3] • Do signs suggest how the behaviour can be incorporated into the elements/experiences of visitors' everyday lives and/or their local environment?[15] Sub-dimension: Incentives/Rewards[2,3] • Are visitors referred to larger programs for rewards[16] that can support/encourage uptake of the behaviour? Sub-dimension: Prompts[2,3] • Do signs suggest that visitors should make regular reminders about performing the behaviour at the time and place they should be performed?	

[1] Criteria are based off the conclusions of 60 studies.
[2] Interpretive signage should aim to achieve affirmative responses for each practice.
[3] This sub-dimension is based off of the framework of Community-based Social Marketing (McKenzie-Mohr, 2011).
[4] This sub-dimension is based off of the framework of Osbaldiston & Schott (2012).
[5] Lifestyle changes can include being more aware of and exploring/investigating local environmental issues.
[6] Resources can include websites, television programs, movies, resource kits, newsletters/emails, external conservation organizations, and other sites.
[7] For example, can some provided behaviours be performed collectively as a family while others are moreso individual behaviours?
[8] For example, are behaviours not too restrictive of visitors' their current lifestyles?
[9] For example, are the conservation goals of the behaviour too dependent on the actions of anyone else other than the visitor? Are issues addressed by the behaviour too wide in scope and/or beyond the capacity of individuals to address?
[10] Barriers can relate to, for example, infrastructure (such as nearby recycling centres) or the perceived difficulty of the behaviour.
[11] For example, do signs provide examples, stories, and/or information that demonstrate how and why behaviours will result in positive conservation outcomes.
[12] Instructions can include images of people demonstrating how to perform the behaviour.
[13] Information can include descriptions of the outcomes of environmental action, the inter-dependence between humans and the natural environment, and the reasons why individual actions are important?
[14] Support can entail strategies/tips on how to adapt the behaviour into visitors' existing routines or the provision of motivation. Support can also include the reinforcement of the site's messages (e.g. via encouraging visitors to reflect on them).
[15] In essence, do signs explain how the behaviour is relevant to visitors? For example, have various specific examples, contexts, scenarios, and/or experiences been provided illustrating how the behaviour can be integrated into daily routines (including at work and/or at home)?
[16] For example, programs can include government subsidies for recycling containers.

Appendix C. A list-based evaluation for the interpretive signage dimension Attitudes/Beliefs (i.e. do signs target their audience's attitudes and beliefs).

Criteria[1]	**Yes/No**[2]
Sub-dimension: Awareness of Consequences[3] • Do signs provide factual information about the behaviour's long/short-term benefits[4]? • Do signs provide factual information about the long and short-term harms[15] of non-adoption of the behaviour and/or the continuation of specific pre-existing non-environmentally responsible visitor behaviours (including everyday ones)? • Are benefits and harms described as affecting the visitors… o … and are they linked to other people, such as future generations or children… o … and have they been linked to both visitors and other people?[5] o Is factual information on the rationale/justifications behind the behaviour provided? o Do signs mention and refute common misconceptions about the behaviour/issue, subsequently encouraging visitors to question their attitudes and beliefs?[6] o Do signs encourage visitors to adopt the behaviour in the context of consequences?	
Sub-dimension: Awareness of Responsibility[3] • Do signs shift responsibility for being environmental to visitors themselves or their communities as opposed to governments?[7] • Do signs encourage visitors to adopt the behaviour based on feelings of responsibility?[8]	
Sub-dimension: New Environmental Paradigm/Environmental Values[3] • Do signs facilitate and/or encourage visitors to emotionally connect with the interpreted environment/wildlife?[9] • Do signs facilitate and/or encourage visitors to experience, appreciate, and reflect on the interpreted environment/wildlife and its special/unique characteristics?[10] • Do signs encourage visitors to reflect on personal environmental values/attitudes? • Do signs prompt visitors to reflect on their own actions (and the actions of society in general) and their environmental impact?[11] • Do signs encourage visitors to use their feelings/values about the interpreted environment/wildlife to adopt the behaviour?[12]	
Sub-dimension: Social Norms[3] • Do signs make credible claims[13] about the behaviour's social desirability? • Do signs refrain from portraying harmful behaviours as socially desirable?[14] • Do signs encourage visitors to adopt the behaviour based on social norms[15]?	

[1] Criteria are based off the conclusions of 60 studies.

[2] Interpretive signage should aim to achieve affirmative responses for each practice.

[3] This sub-dimension is based off of the framework of the Comprehensive Action Determination Model (Klöckner & Blöbaum, 2010).

[4] Benefits and harms can be social, cultural, lifestyle, and/or economic and have a personal or wide-scale scope.

[5] Note: In some contexts, describing only consequences to visitors may be better than describing only consequences to other people.

[6] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

[7] For example, do signs provide examples about and highlight how the community can influence governments and corporations?

[8] For example, do signs encourage visitors to reflect on how the behaviour and other forms of environmental action are needed?

[9] For example, do signs ask visitors to use their imaginations to experience the natural world and explore alternate perspectives when reflecting on the possible consequences of different actions? Do signs encourage visitors to be empathetic/identify with interpreted animals? Do signs foster concern or appreciation for them? Do signs introduce displayed animals as individuals and facilitate visitors in anthropomorphizing them? Do signs refer to everyday concepts that both visitors' and interpreted wildlife share (e.g. diet, home, activities)? Do signs assign human or animal characteristics to the interpreted landscape (e.g. point out that mountains look like an animal)? Do signs refer to how visitors may feel a sense of wonder, awe, excitement, and privilege when interacting with the interpreted environment/wildlife? When encouraging visitors to make behaviour-related commitments, do signs frame it as making promises to displayed animals?

[10] For example, do signs encourage visitors to think about issues facing the interpreted environment/wildlife, personal feelings about them, and new ideas/information about them that the sign has also provided? Do signs reaffirm that the interpreted environment/wildlife inherently has value outside of human needs and that humans do not own them? Do signs guide visitors in using various senses around the site to fully experience it?

[11] For example, prompts can be via explicit encouragement from the signs or from presented questions. Signs can ask visitors to think twice before next performing actions that can harm the environment. Signs can describe the relationship between the health/state of the environment and human actions (possibly referring to the notion of "think global, act local"), and how humans are interconnected with nature.

[12] For example, do signs highlight how visitors may already be environmentally concerned or help them view themselves as such? Do signs prompt visitors to adopt the behaviour due to feelings of guilt over environmental issues being faced by the interpreted environment/wildlife?

[13] Such claims can include statements that the majority of visitors believe in doing the behaviour or that most visitors approve of it. Furthermore, signs can refer to respected in-group members endorsing the behaviour/message.

[14] For example, signs stating that there is a litter problem at the site may imply many people litter, resulting in perceptions of it as acceptable.

[15] For example, do signs elicit shame and guilt in visitors for not performing the behavior? Likewise, do signs elicit pride in behaviour-performing visitors for acting in the interests of others and contributing to societal wellbeing?

Appendix D. A list-based evaluation for the interpretive signage dimension Message Framing (i.e. do signs frame their messages in a manner that can connect with visitors)

Criteria[1]	**Yes/No**[2]

Sub-dimension: Emotions
• Are messages framed with emotions that are negative[3] or positive[4]...
  ○ ...and if hope-related messages are used, are they balanced with negative reminders about the current reality?
  ○ ...and if despair-related messages are used, are they balanced with hope-related messages?
  ○ ...and if negative fear-eliciting messages about environmental issues are used, are they accompanied by messages about visitors' efficacy in addressing them?
  ○ ...and if negative messages are used, are they paired with positive ones?
  ○ ...and if negative messages are used, do they refrain from being too extreme to the point of disempowering visitors (especially children) and creating intense fear/denial of ecological issues?[5]
• Do messages prompt visitors to reflect on their emotions towards the interpreted environment/wildlife?
• Do messages frame the interpreted environment as a home to encourage visitors to feel a sense of place attachment to it?[6]
• Are messages framed around visitors' pre-existing concern/support/love for nature?[7]
• If emotions are used, do signs refrain from presenting only emotional messages?[8]
Sub-dimension: Gain/Loss
• Are behaviours framed as something that allows something to be gained or prevents something from being lost[9]...
• ...and if growth-related messages about science are used, are they not over-stating it as something that has progressed so much that they can or will enable society to control the extent of environmental issues and human health problems in the future?
Sub-dimension: Scope
• Are messages framed around specific impacts of environmental issues affecting the site?
• Are messages framed around specific impacts of environmental issues on a local context to which visitors can link their own experiences/interests?[10]
• Are messages framed around possible environmental behaviours that can be performed on-site, beyond the site, and in private contexts like home or work?[11]
• Do messages connect to the wider context[12]?
Sub-dimension: Emphasis Frame
• Do messages refrain from utilizing only economic frames[13] about the behaviour and/or issue?
• Do messages utilize sustainability-related frames about the behaviour and/or issue?	

[1] Criteria are based off the conclusions of 60 studies.

[2] Interpretive signage should aim to achieve affirmative responses for each practice.

[3] For example, have threat and fear appeals been used? Do messages provoke sadness and anger about issues? Are messages pessimistic?

[4] For example, are message optimistic or hopeful? Note: A positive emotional frame may be more conducive to promoting behaviour over a negative one.

[5] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

[6] For example, have messages highlighted the interpreted environment's uniqueness/significance?

[7] For example, are messages framed around visitors' connection to nature? Do messages suggest that visitors already care about the environment or treat them as conservation partners? Do messages refer to religious and philosophical values of harmony between humans and nature?

[8] In essence, do signs refrain from leaving visitors feeling persuaded rather than educated? Are emotional messages accompanied by logical ones?

[9] In essence, are behaviours framed around growth (gain) or the avoidance of negative, safety-related outcomes (loss prevention)? There is no recommended frame for every issue; some issues may be better suited with a growth-related frame while others should be given a loss-related frame.

[10] In essence, how has the environmental issue been made relevant to visitors? For example, have local examples been used? Have local impacts of the issue been described? Have relevant local historic events been referred to? Does the behaviour allow visitors to use their local environment sustainably?

[11] Behaviours should be framed around these three scopes to facilitate visitors in adopting them.

[12] For example, do signs link displayed animals to their non-captive counterparts? Do signs refer to the concept of "think global, act local"?

[13] An economic frame could be, for example, about how visitors' wealth and health depend on looking after the environment.

Appendix E. A list-based evaluation for the interpretive signage dimension General Content (i.e. do signs provide engaging information, messages, and images).

Criteria[1]	**Yes/No**[2]
Information • Are messages based on accurate and up-to-date information?[3] • Do signs provide believable information and/or refrain from providing information that is sensationalist or extreme? • Do messages not focus on presenting information that visitors are already aware of and instead build on[4] a range of pre-existing knowledge, beliefs, or experiences[3,5]? • Do messages reaffirm that displayed wildlife/environment have not been harmed by the site's processes, as visitors may have misconceptions on its happiness, health, and care? • Do messages include information about the issues[6] and/or promote behaviours even if they are controversial?[3] Messages • Are messages consistent? • Do messages focus on a central theme/big idea instead of individual facts? • Do messages interlink scientific and folk/cultural knowledge? • Is there more to the messages than just scientific information and technical details?[7] Images • Do messages utilize images or other visual aids in addition to the textual content... o ...and are they intuitively or explicitly stated to be relevant to the interpreted content? o ...and are they personally relevant, familiar, or local to visitors?[8] o ...and do they refrain from eliciting disgust in visitors?[3] o ...and are they aesthetically pleasing?[3]	

[1] Criteria are based off the conclusions of 60 studies.

[2] Interpretive signage should aim to achieve affirmative responses for each practice.

[3] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

[4] In essence, do signs mix new, unusual, or unexpected information with those already known/familiar to visitors? The familiar information provides a foundation that helps visitors develop their own understanding and opinions on the interpreted issues, environment, and wildlife.

[5] Experiences include everyday ones and even those that visitors may have had at other sites/attractions in the area.

[6] For example, have the impacts of specific human actions been described even if they are controversial?

[7] For example, have visitors been provoked to feel surprise or other emotions (either positive or negative) as opposed to simply taking in facts? Do signs have social/cultural elements? Do signs refrain from just presenting labels about the interpreted wildlife/environment? Do signs present human stories?

[8] For example, do some images depict people or have human elements? Do signs refrain from utilizing images that might be iconic but are also seen to be over-used and clichéd, resulting in possible perceptions that they are not relevant to visitors?

Appendix F. A list-based evaluation for the interpretive signage dimension General Presentation (i.e. do signs present content that is understandable and engaging).

Criteria[1]	**Yes/No**[2]
Sub-dimension: Readability • As quantified by the Flesch Kincaid Reading Ease index, how readable[3] are the presented messages and will children[4] be able to easily understand the messages, meaning the index is greater than 60? • Do signs refrain from utilizing specific acronyms, technical terms, and uncommon concepts that may not be understood... o ...and if they are used, do signs explain them in laypeople's terms/everyday language? • Are messages worded in a way that cannot be interpreted with unintended meaning? Sub-dimension: Visitor Engagement • Are signs fun to learn from?[5,6] • Do signs use stories[7], questions, metaphors, analogies, scenarios (hypothetical or real), and/or references to culture[8] or daily life to provide clear visual images, reference points, and frameworks for visitors to reflect on and connect to the interpreted content, environmental issue[9], and behaviour? • Do signs present a range of narratives, societal viewpoints, and/or perspectives? • Do signs target and build on[10] the various interests[11], motivations, identities, worldviews, ideologies, and values[12] of visitors?[6,13] • Do signs encourage visitors to actively process and engage in the presented content/be mindful?[14] • Do signs contain titles that entice visitors to read them further by having interesting, catchy, and thought-provoking titles that are not trite, clichéd, or loaded with jargon?[6] • Do signs use descriptive language with many adjective-containing phrases?[6] • Do messages have a conversational tone?[15] • Do signs respect visitors and have a polite tone? • Do signs encourage visitors to take and record notes with their phones?	

[1] Criteria are based off the conclusions of 60 studies.

[2] Interpretive signage should aim to achieve affirmative responses for each practice.

[3] For a higher readability index, signs should use fewer total words, sentences, and syllables.

[4] Signs should try to be understandable to 10-12 year olds (i.e. the index should be above 70).

[5] For example, do they contain humourous elements, do not repeat uninteresting content, present odd content, or use vivid words? Do they evoke a sense of discovery or fascination? Do they appeal to children (and even adults)? Do they have provocative or catchy messages? Do they contain activities (for example, cognitive activities such as quizzes)?

[6] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

[7] To better engage visitors, provided stories can be related to families, heroism and altruism, concepts of standing up for justice, and reputation. Stories can also frame the behaviour as socially desirable.

[8] For example, are there references to cultural heritage, art, traditional teachings (such as philosophies or religions), and stories, especially those related to the site and those that describe and exaggerate the beauty of the interpreted environment? Do signs mention important historical figures and figures associated with the site? Note: Pop culture media may have led to a negative perception of certain species (e.g. hyenas in *The Lion King* or leopard seals in *Happy Feet*); sites displaying such species should address such perceptions.

[9] For example, does the content foster empathy towards the interpreted environment/wildlife or draw visitors into their world?

[10] Build on, meaning that signs work with such factors and do not attempt to change them or threaten them too much.

[11] For example, if the sign is located inside a botanic garden that is popular with visitors for their role in providing relaxation opportunities, signs can highlight the importance of the behaviour in preserving the garden's health and its associated ability to provide such opportunities.

[12] Values correspond to Schwartz's basic orientations (Openness to Change, Self-enhancement, Conservation, and Self-transcendence).

[13] Note: Designers may need to conduct research to identify such factors in their audience before being able to follow this practice.

[14] For example, do signs encourage visitors to reflect on what they had seen at the site and what it means for their everyday lives? Do signs discuss how reflection is important in making sure visitors remember key information and make the interpretive experience meaningful?

[15] For example, do they use active tense and personal nouns ("you" and "we")?

Appendix G. A list-based evaluation for the interpretive signage dimension Implementation (i.e. how have signs themselves been designed, and how does it present its content).

Criteria[1]	**Yes/No**[2]
Sub-dimension: Accessibility • Are signs physically accessible to children and those with disabilities? Sub-dimension: Materials • Have signs been maintained, taking into account vandalism and longevity? • Are signs constructed of materials that match the aesthetics/tone of the content?[3] • Are signs durable enough to withstand the environment it is in?[3] • Are signs supported by multiple forms of media? • Do signs have any interactive, moving, and/or multi-sensory elements?[4] Sub-dimension: Placement • Are signs placed in locations that allow comfort[5] when reading? • Are signs clearly matching to the wildlife/environment they are interpreting? • Are signs not placed too closely to one another in large clumps? • Are signs placed where visitors will see them[6]? Sub-dimension: Readability • Is the sign's text readable to all visitors (including children) in terms of font type, font size, font colour, and text-spacing? • Do signs utilize the concept of fluency (i.e. using a font size, type, and colour that can be readable against the sign's background; bullet points; short phrases; and numbers written in numerical form instead of words)? • Do signs highlight key information with design[7]? • Does the sign have extreme and contrasting elements[8] in its design that can stand out amongst its surroundings? • Do signs present content in at least one language? • Do signs refrain from containing any typos? • Do signs balance the placement of illustrations and text and are generally organized in a consistent and structured manner? • Are the sign's images clear and easy-to-see? • Is there minimal reflection from natural and artificial light? • Have the sign's colour choices allowed the content to be readable in the available lighting conditions?	

[1] Criteria are based off the conclusions of 60 studies.

[2] Interpretive signage should aim to achieve affirmative responses for each practice.

[3] This practice is subjective and/or requires external research, so it does not need to be evaluated. However, interpretive signage should still aim to incorporate it.

[4] For example, do signs have any textured sections, models, boxes containing objects that can be felt, recordings of sounds, or elements scented with odours related to the interpreted wildlife/environment? Do signs have windmills or wheels that spin? Do signs have replicas or specimens that can be interacted with?

[5] For example, do sign locations have seating for visitors (where appropriate) or enough space for multiple readers?

[6] For example, are signs in visitors' direct line of sight or at natural stopping points? Are they in areas where there will be visitor traffic?

[7] For example, has the information been highlighted with font and colour and/or by being in larger print (like in a newspaper or magazine)? Has less-important information been placed in smaller print?

[8] For example, do signs have large, loud, and/or colourful components that can stand out?

Appendix H. A list-based evaluation for the interpretive signage dimension Message Propagation (i.e. do signs ensure that messages stay with their audience and support actions by individuals that can spread them out being the site).

Criteria[1]	**Yes/No**[2]
Sub-dimension: On-site Discussions • Do signs encourage and facilitate cooperative learning about the behaviour, the issue, and the site between visitors... ○ ...and can these discussions accommodate different types of visitor groups such as families or students/teachers on a field trip?[3] • Do signs refer to environmental issues in order to stimulate discussions between visitors about the behaviour? Sub-dimension: Off-Site Discussions • Do signs encourage visitors to share on-site experiences and/or the behaviour with others[4] via texting (during or after their visit) or physical means of communication? • Do signs encourage[5] visitors to create posts on social media where they can share (during or after their visit) their on-site experiences or thoughts/feelings and potentially promote the behaviour? • Do signs assist/instruct visitors on using devices (e.g. phones, cameras) to safely take appropriate photographs of the experience for the purpose of sharing acquired knowledge/experiences and/or promoting the behaviour via image posts on social media?[6]	

[1] Criteria are based off the conclusions of 60 studies.
[2] Interpretive signage should aim to achieve affirmative responses for each practice.
[3] For example, can topics be easily discussed amongst family members and/or be taught to children?
[4] For example, are visitors encouraged to share their new knowledge/experiences with those in their home and community? Are visitors encouraged to attend events for environmental community groups?
[5] For example, do signs promote the taking and posting of selfies as a form of self-reflection?
[6] For example, do signs refer visitors to designated spots with appropriate objects/site elements they can take photos of and/or provide interesting facts, key messages, taglines, and specific stories about the behaviour/issue that visitors can use when posting their photos?