Shifting baseline syndrome: causes, consequences and implications

Running head: Shifting baseline syndrome

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IN A NUTSHELL (100/ 100 words)

- Shifting baseline syndrome (SBS) describes a gradual change in the accepted norms for the condition of the natural environment due to a lack of human experience, memory and/or knowledge of its past condition.
- Consequences of SBS include an increased tolerance for progressive environmental degradation, changes in people's expectations as to what is a desirable (worth protecting) state of the natural environment, and the establishment and use of inappropriate baselines for nature conservation, restoration and management.
- Researchers and policy makers need to focus more attention and efforts on understanding, and planning how best to limit and reduce SBS.

ABSTRACT (145/ 150 words)

Shifting baseline syndrome (SBS) is a psychological and sociological phenomenon whereby each new human generation accepts as natural or normal the situation in which it was raised. With ongoing local, regional and global deterioration in the natural environment, this results in a continued lowering of people's accepted norms for these environmental conditions. SBS is thus increasingly recognized as one of the fundamental obstacles to addressing a wide range of global environmental issues faced today, yet knowledge about the phenomenon remains incomplete and limited. Here, we provide an overview of the nature and extent of SBS, propose a conceptual framework for understanding its causes, consequences and implications, and suggest future research directions. Our review illustrates that there are key feedback loops by which consequences of SBS accelerate further SBS through progressive environmental degradation. We finally make several strategic recommendations to prevent, and ultimately reverse, this phenomenon.

MAIN TEXT (3,862/ 4,000 words)

Environmental degradation and shifting baselines

The magnitude, rate and extent of the changes that humans have wrought on the earth's natural environment are hard to comprehend. Quantitative estimates increasingly abound. For example, over the last few decades almost a quarter of all primary production has gone for human use (Haberl *et al.* 2007), half of wildland has been lost (Ellis *et al.* 2010), and wildlife populations have fallen by a half (Dirzo *et al.* 2014). However, these estimates are inevitably for many people quite abstract, and repeatedly discourse on these topics makes reference to personal, usually local scale, anecdotes and examples of environmental change (e.g., Al-Abdulrazzak *et al.* 2012; Ziembicki *et al.* 2013; Jabado *et al.* 2015). Unfortunately, there are good reasons to believe that such contextualizing can serve to understate the changes that have taken place.

In his essay *"Anecdotes and the shifting baseline syndrome of fisheries,"* Daniel Pauly elucidated the concept of "shifting baseline syndrome" (SBS). He pointed out that fishers and marine scientists tend to perceive faunal composition and stock sizes at the beginning of their careers as the unaffected baseline condition against which catch quality change is subsequently judged, and that this is likely to result in a gradual accommodation of the loss of fish species (Pauly 1995). Thus, a fish species that was widespread and abundant hundreds of years ago may have experienced a large population decline over the period since, but most of the current researchers incorrectly consider that the population status in recent past decades is the appropriate baseline (Bonebrake *et al.* 2010). By way of a terrestrial example, we can consider change in the forest environment of Japan, one of the world's most heavily forested countries: more than 70 percent of its land area is covered by forest. For those who were born five or ten generations before us, old-growth (primary) forests were the most predominant component of the landscape (**Figure 1**). With each passing generation, modified forests (e.g., timber forests) gradually expanded across the landscape, and by 2000 the large proportion of old-growth forests had been transformed into such human-modified ones (**Figure 1**), establishing a new norm. In the field of psychology, SBS is otherwise referred to as *"environmental generational amnesia"* (Kahn 2002), whereby each generation grows up being accustomed to the way their environment looks and feels, and thus, in a system experiencing progressive impoverishment, they do not recognize how degraded it has become over the course of previous generations.

Simply put, SBS can be described as a gradual change in the accepted norms for the condition of the natural environment due to a lack of experience, memory and/or knowledge of its past condition. It implies that with ongoing global and regional deterioration in the natural environment, our baseline standards for environmental health will continue to decline, which represents an enormous challenge for the conservation, restoration and management of that environment. Despite this, however, environmental scientists have, to date, paid remarkably little attention to SBS. Indeed, although evidence suggesting the occurrence of SBS is rapidly accumulating, its nature (especially causes and consequences) and extent are still poorly understood. While SBS is likely to be associated with a wide range of global environmental issues faced today, such as defaunation (Lotze and Worm 2009; Corlett *et al.* 2013), loss of natural habitats and processes (Humphries and Winemiller 2009), and increased levels of pollution (Lyytimäki 2013), the debate on this topic has thus far largely centered on fisheries (Sáenz-Arroyo *et al.* 2005; Ainsworth *et al.* 2008; Lozano-Montes *et al.* 2008). Furthermore, how SBS is best prevented or limited has been little discussed. In this review, we first present evidence of SBS, then describe a conceptual framework for understanding its causes, consequences and implications, and finally make several strategic recommendations required to reduce, and ultimately reverse, SBS. We also outline several key areas in which future research ought to be directed to improve understanding of SBS. For this overview, we did not perform a formal systematic literature search because study of the topic of SBS is too fragmented and transdisciplinary (appearing in multiple guises) for such an approach to be feasible. The material we draw on was identified through a purposefully broad literature search (using a combination of Google Scholar, Web of Science, and Google) of both peer-reviewed and other sources to minimize publication bias.

Evidence

There is an increasing body of empirical evidence that indicates the occurrence of SBS. The majority comes from fisheries science (**Figure 2**). For example, in Raja Ampat archipelago, Eastern Indonesia, where there has been a steep impoverishment of biodiversity over the past 30 years, Ainsworth *et al.* (2008) observed that younger fishers recalled less past abundance of wildlife and thus perceived a lower degree of population decline (**Figure 2a–d**). In the upper Gulf of California, Mexico, where fishery resources have declined by at least 60% over the past 50 years as a result of intense fishing and habitat degradation, Sáenz-Arroyo *et al.* (2005) reported that the number of fishing sites and fish species mentioned as depleted by younger fishers was approximately one quarter of that reported by older ones (**Figure 2e, f**). Likewise in Tanga, Tanzania, Katikiro (2014) showed that compared to older fishermen the younger ones were less likely to perceive that the current size of the fish catch has declined and that fish stocks were overexploited.

Evidence of SBS has also been documented in other contexts (**Figure 3**). In a rural village in Yorkshire, UK, Papworth *et al.* (2009) found that younger residents, compared to older ones, were less aware of changes in the abundance of common bird species over the past 20 years (**Figure 3a**). In the Department of Beni, Bolivian Amazonia, where rapid defaunation has occurred due to deforestation, habitat degradation and hunting, Fernández-Llamazares *et al.* (2015) observed that the perceived number of locally-extinct tree and fish species and the magnitude of changes in composition of local wildlife (birds and game vertebrates) were lower for younger respondents compared to older ones (**Figure 3b–e**). In the Seward Peninsula, Alaska, US, where rapid environmental change in a hydrological system is occurring, Alessa *et al.* (2008) found that younger people were less aware of changes in the availability of the local water resource and its quality (**Figure 3f, g**). Finally, Herman-Mercer *et al.* (2016) conducted interview surveys in indigenous communities in subarctic Alaska, and revealed that the levels of respondents' perceptions of climate change vary between generations, with older generations identifying more overall change (e.g., increased temperatures, decreased snow cover) than younger ones (**Figure 3h**).

Causes

Basically, SBS occurs when conditions of the natural environment gradually degrade over time, yet people (e.g., local citizens, natural resource users and policy makers) falsely perceive less change because they do not know, or fail to recall accurately, how the natural environment was in the past. Given this, SBS may result from three major causes, namely (1) lack of data on the natural environment, and (2) loss of interaction and (3) loss of familiarity with the natural environment (**Figure 4**). We do not regard environmental degradation *per se* as a cause of SBS, although it is obviously a key condition for it to occur (see Papworth *et al.* 2009).

Lack of data on the natural environment. Arguably, the fundamental driver of SBS is the lack, or paucity, of relevant historical data on the natural environment. Most time series data are relatively recent, and this is often particularly true for those regions with the greatest biodiversity and abundance of life (Bonebrake *et al.* 2010). Indeed, a recent analysis shows that the majority of biodiversity monitoring schemes in Europe were initiated late in the 20th century, i.e., well after anthropogenic impacts had already reached more than half of their current magnitude (Mihoub *et al.* 2017; **Figure 5a**). Without reliable historical environmental data, people cannot infer whether, and to what extent, long-term environmental changes have actually occurred, and thus they have little choice but to define baselines according to their own knowledge and experiences; clearly, from both scientific and practical standpoints, there is no single "correct" or "desirable" baseline (i.e., the state of the natural environment that we should target for conservation and restoration), and identifying appropriate baselines is a substantial challenge (Campbell *et al.* 2009; Lotze and Worm 2009).

One might of course counter that the availability of, even very good, empirical evidence has not always been sufficient to convince people of historical trends in environmental conditions. Indeed, recent examples of belief rather than evidence-based environmental policy making raise the spectre that SBS could become accelerated rather than mitigated in an age of increasing data availability (c.f., Sutherland and Wordley in press).

Loss of interaction with the natural environment. In much of the world people, especially children, currently spend considerably less time interacting with the natural environment than they did in previous generations (**Figure 5b**). Louv (2005) coined the term "nature-deficit disorder" to describe the increasingly common tendency for children to have little contact with nature and to spend more time indoors with television, computers, and video games. This progressive loss of human-nature interactions, the "extinction of experience" (Pyle 1993; Miller

2005), is another key driver of SBS. Indeed, direct interaction with natural environments is important, and perhaps essential, for people to recognize (i.e., store an appropriate memory about) the condition of these environments, and thus, in a system experiencing progressive impoverishment, extinction of experience is likely to accelerate the loss of their memory about earlier (more intact) environmental states.

There are two major factors that lead to extinction of experience (Soga and Gaston 2016). The first is the loss of opportunity to interact with nature, which is driven by the loss of natural environments, and by the greater proportion of the human population that is living in urban areas where opportunities for interacting with nature are limited (Miller 2005). The second factor is the loss of orientation toward engaging with nature (Lin *et al.* 2014), which is associated with the rise in alternative leisure time activities (e.g., social media, television, internet), and the possibility of vicarious interactions with nature (e.g., through books, television).

Loss of familiarity with the natural environment. As well as direct engagement with the natural environment, familiarity with it is also crucial for people accurately to assess its condition. One of the key measures of people's familiarity with the natural environment is their level of natural history knowledge, e.g., identification skills for plants and animals in the surrounding environment (Bebbington 2005; Leather and Quicke 2010). Yet, this type of knowledge is increasingly disappearing from the populace, especially in developed countries (Pilgrim *et al.* 2008; Tewksbury *et al.* 2014). Indeed, in many parts of the developed world, exposure to natural history in the educational sector has declined significantly over the last few decades (Leather and Quicke 2010; Tewksbury *et al.* 2014) (**Figure 5c**). This rapid decline in people's natural history knowledge would also accelerate the occurrence and progress of SBS. Indeed, those who have poor natural history knowledge are less likely to recognize changes in the condition of the natural environment (Dallimer *et al.* 2012; Shwartz *et al.* 2014), and may have lower perceived environmental baselines.

Of course, there are still groups of people in society who are exceptionally familiar with the natural environment, including ecologists, nature reserve managers, nature guides and amateur naturalists. Given that these kinds of people have a great potential for fostering people's natural history knowledge through educational, recreational and cultural programs (e.g., environmental education in schools, tour guides in natural history museums and national parks), they will play an important role in efforts to prevent SBS (see the section "Preventing SBS").

Consequences and feedback loops

SBS has three key consequences (**Figure 4**). The first, and most immediate, is an increased societal tolerance for progressive environmental degradation, such as decline in wildlife populations, loss of natural habitats, and increasing pollution. Indeed, people generally evaluate the presence and severity of environmental degradation based on how different current environmental conditions are from their own “cognitive baselines” (Lozano-Montes *et al.* 2008). Thus, as people become more accustomed to a degraded environment they will perceive future environmental degradation as less significant.

Second, SBS is also likely to alter people’s expectations as to what is a desirable (i.e., worth protecting) state of the natural environment. This is not surprising as most people’s beliefs about what is a “right” or “healthy” condition for the natural environment will be shaped by their personal experience, particularly during childhood, and earlier states are unimagined (Kahn 2002). For instance, in north-central Arizona, US, where there has been considerable change in the structure of ponderosa pine forests (increasing tree density and mature trees) over the last century due to the exclusion of fire, Ostergren *et al.* (2008) determined local residents’ attitudes toward forest restoration programs which aimed at decreasing forest tree density, such as mechanical thinning and prescribed burning. Results showed that rural residents, i.e., those living near forests, were less likely to agree to restoration actions. Ostergren *et al.* (2008) inferred that rural residents *“are accustomed to relatively dense forest stands and thus may have difficulty perceiving a heavily thinned forest as a ‘healthy’ forest.”*

Third, with false perceptions of past environmental conditions, policy makers may set inappropriate targets for environmental conservation, restoration and management programs (Humphries and Winemiller 2009; Bonebrake *et al.* 2010; Bilney 2014). The Dogger Bank in the North Sea, a candidate Special Area of Conservation under the EU Habitats Directive, represents a good example of this issue. Although historical records indicate that the Dogger Bank has been subject to anthropogenic activities from before the 16th century and that there have been prolonged declines in fish abundance, conservation targets for marine protected area management in this region have been developed using only present-day environmental data (Plumeridge and Roberts 2017), which may hinder the establishment of suitable (i.e., ambitious) conservation/restoration targets. Unfortunately, given the long history of anthropogenic impacts on the earth’s ecosystems and the paucity of relevant historical data, this kind of issue may be common in many parts of the world (Lotze and Worm 2009; Bilney 2014; Mihoub *et al.* 2017).

Unfortunately, there are several feedback loops by which the consequences of SBS accelerate further SBS through progressive environmental degradation (**Figure 4**). First, increased tolerance for incremental environmental degradation is likely to diminish people’s motivations to alleviate further degradation of the natural environment. To quote Papworth *et al.* (2009), *“if you are unaware of the change around you then how can you be expected to engage with the conservation of that environment?”* Second, changes in people’s expectations for what is a healthy state of the natural environment may, at least partially, affect their decision-making processes regarding its conservation and restoration (Ostergren *et al.* 2008), which may in turn affect the future environmental state. Third, if improper baselines are used as a target for nature conservation, restoration and management, the desirable conservation outcome will not be achieved because policy makers and resource managers might be more likely to become satisfied, and complacent, with the present state of the natural environment, and their current conservation efforts, and consequently feel less motivated to undertake further actions to improve the condition of that environment ("conservation complacency"; Bilney 2014).

Preventing SBS

We propose four, not mutually exclusive, key strategic recommendations to prevent, and ultimately reverse, SBS.

Restoring the natural environment. As the decline in the state of the natural environment is the fundamental trigger of SBS, restoring the natural environment is crucially important in its prevention (albeit, in principle, SBS can occur not only when the state of the natural environment is progressively degrading, but also when it is improving – "lifting baselines"; Roman *et al.* 2015). One of the most obvious approaches is that of rewilding (i.e., restoring wild and nearly wild environments), which serves practically to demonstrate more closely historical baselines for natural environments to those whose perceptions are potentially affected by SBS. Increasingly, the notion of rewilding is popular and being implemented as a major conservation approach, especially in Europe and North America (Lorimer *et al.* 2015). For example, the *Rewilding Europe* initiative aims to restore one million hectares of land, and large native missing herbivores, spread across ten different locations in Europe by 2020 (www.rewildingeurope.com). Rewilding efforts are also increasingly spreading in urban areas where day-to-day contacts with nature will primarily take place. One of the most advanced urban rewilding projects is *Zealandia* in the city of Wellington, New Zealand (www.visitzealandia.com), which comprises a 225 hectare ecosanctuary in the city intended to be returned as closely as possible to its pre-human state.

Monitoring and collecting data. Further progressive SBS may be limited by accumulating more data about the natural environment (Lister *et al.* 2011; Mihoub *et al.* 2017). One powerful tool to collect large-scale and long-term environmental data is citizen science - the practice of public participation and collaboration in scientific research (McKinley *et al.* 2017; Dennis *et al.* in press). There are currently several large-scale citizen science projects of this kind. *eBird*, which is one of the largest, has collected more than 300 million bird observations across the world, allowing scientists to develop predictive models of bird distribution and abundance (ebird.org/content/ebird). It is notable that these projects contribute not only to accumulating environmental data but also to reducing the extinction of experience and forging people's familiarity with nature (Dennis *et al.* in press).

As well as monitoring the current environment, reconstructing historical conditions using existing data is also valuable for preventing SBS (Lotze and Worm 2009; Bonebrake *et al.* 2010; Gatti *et al.* 2015). Indeed, recent progress in molecular and isotope techniques, combined with statistical modeling, has increasingly allowed accurate and detailed reconstruction of past environmental conditions (Christensen *et al.* 2014; Matsuzaki and Kadoya 2015). Christensen *et al.* (2014), for example, built a statistical model that predicts change in global fish biomass and reveals that the biomass of predatory fish (i.e., the large-bodied fishes that humans tend to eat) has declined by two-thirds over the last 100 years.

Reducing the extinction of experience. Promoting people's positive interactions with natural environments would be beneficial to limiting SBS. Indeed, studies have shown that participating in firsthand experiences with nature, such as visiting urban greenspaces and observing local fauna and flora, increases people's levels of understanding of the condition of their surrounding natural environments (Lindemann-Matthies 2002; Shwartz *et al.* 2014).

There are broadly two major approaches to increase people's direct experiences with nature (for details see Soga and Gaston 2016). The first is to increase people's opportunity to interact with nature by providing more natural environments in their neighborhood environment. Indeed, the positive relationship between the amount of nearby natural environments and the frequency of its use has repeatedly been demonstrated (Soga *et al.* 2015). The second is to increase people's orientation to engage with natural environments. Although the relative influence of nature orientation on people's use of natural environments is still poorly known, recent studies suggest that its contribution is comparable to, and sometimes stronger than, that of opportunity (Lin *et al.* 2014). If we are to limit the extinction of experience, therefore, both the opportunity and the orientation components need to be enhanced in tandem.

Education. Education has two important roles in limiting or preventing SBS, first to forge and reinforce people's familiarity with the natural environment (i.e., increasing their natural history knowledge) and second accurately to communicate to them about both its current and past condition. The former can contribute to the reinforcement of people's ability accurately to assess the condition of the natural environment and the latter to the transmission of environmental knowledge from older to younger generations.

Although much attention is being focused on school education, these actions can be promoted and actively practiced by various organizations, such as natural history researchers, museums, ecotourism tour guides, botanical gardens and zoological parks. Indeed, Shwartz *et al.* (2012) reported that participating in even a one-day educational program in urban gardens increased adults' knowledge and awareness of the local fauna and flora. Given this, future educational policy will need to target adults as well as children, which in turn can create positive "spillover" to the children.

Future research directions

There are several key areas in which research effort could usefully be focused to improve understanding of SBS. First, it is crucial to determine under what conditions, and over what spatial scales, SBS is both likely to occur and to progress more rapidly. Indeed, while evidence for SBS is increasingly accumulating, there is currently a clear bias toward studies reporting fishers' perceptions of changes in fishery resources (e.g., Sáenz-Arroyo *et al.* 2005; Ainsworth *et al.* 2008; Lozano-Montes *et al.* 2008). Given that the presence, and magnitude, of SBS might depend on the contexts, settings and cultures in which it is examined, future studies ought to investigate SBS across various environmental conditions, ecosystems, stakeholders, and populations as well as over different spatial scales (from local to regional and national levels). Second, from a conservation viewpoint, there is an urgent need to accumulate more detailed information on how, and to what extent, SBS actually affects the implementation process, and eventual outcomes, of conservation and environmental management policies. Although it has long been thought that SBS can make policy makers and resource managers feel less inclined to achieve more ambitious conservation goals (Humphries and Winemiller 2009; Bilney 2014; Plumeridge and Roberts 2017), to the best of our knowledge there is currently no quantitative analysis on this issue. Third, at present very little is known about the nature and strength of the feedback loops of SBS (**Figure 4**). In this review we identified three key feedback pathways by which consequences of SBS accelerate further SBS through progressive environmental degradation, but it is still poorly understood how they operate, interact with each other, and together contribute to the progress in SBS. Thus, more empirical research, particularly from long-term studies, on this issue is required. Undoubtedly, addressing the above-mentioned research directions will require a multi-disciplinary approach, including social science, psychology, politics, and environmental science.

Conclusions

At a time when the earth's ecosystems are being degraded and lost at an accelerated pace, the existence of SBS poses clear challenges for environmental conservation and management; it could be one of the fundamental reasons that our society tolerates continued destruction and degradation of the natural environment and does not always support, and understand the need for, conservation and restoration efforts to protect our ecosystems. Indeed, the evidence presented here shows that SBS is potentially widespread and associated with various major environmental issues faced today, such as defaunation, loss of natural habitats and processes, natural resource depletion, and increased levels of pollution. Our proposed framework also illustrates that there are key feedback loops by which consequences of SBS accelerate further SBS through progressive environmental degradation. These serious implications highlight an urgent need to focus more attention and efforts on planning how best to prevent SBS, as well as to communicate to a broad audience, such as policy makers, resource managers, conservationists, and educational practitioners, about the significance of this phenomenon. Understanding and successfully addressing SBS will contribute greatly to the long-term conservation and sustainable management of the earth's natural systems on which we all depend.

Acknowledgements

We are grateful to Y. Yamaura for providing the land-use data shown in Figure 1. M. Akasaka kindly provided useful comments on an earlier draft of this paper. MS was supported by the Japan Society for the Promotion of Science (grant no. 16K00631), and KJG by the Natural Environment Research Council (grant no. NE/J015237/1).

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Figure Legends

Figure 1: 600-year change in the forest environment of Japan. The upper panel shows the compositional change in the types of forests (old-growth; coppice; modified; and planted forests). A modified natural forest is a natural forest with clear visible human activities, such as saw-timber natural forest and abandoned coppice. The lower panel shows the composition of the forest environment at five different time points: 0, 1, 5, 10, 20 generations back from the present (the period of one generation was defined as 30 years). Reproduced with permission from Yamaura *et al.* (2012).

Figure 2: Empirical evidence suggesting the occurrence of SBS that has been reported in fisheries science. Younger fishers, compared to older ones, (a–d) perceived a lower degree of population decline of wildlife species (birds, invertebrates, reef fish, and turtles) and (e and f) mentioned a lower number of fishing sites and fish species as depleted. Data from (a–d) Indonesia (Ainsworth *et al.* 2008) and (e and f) Mexico (Sáenz-Arroyo *et al.* 2005).

Figure 3: Empirical evidence suggesting the occurrence of SBS that has been reported in other than fisheries science. Younger residents, compared to older ones, perceived (a) a lower degree of population changes of common bird species, (b–e) a lower number of locally-extinct tree and fish species and magnitude of changes in composition of local wildlife (birds and game vertebrates), (f and g) a lower degree of change in the availability of the local water resource and its quality, and (h) a lower degree of climate change (e.g., increased temperatures, decreased snow cover). Data from (a) the UK (Papworth *et al.* 2009), (b–e) Bolivia (Fernández-Llamazares *et al.* 2015), (f and g) the US (Alessa *et al.* 2008), and (h) the US (Herman-Mercer *et al.* 2016).

Figure 4: The causes and consequences of SBS. SBS can result in a feedback loop in which the consequences accelerate further SBS through the decline in the progressive environmental degradation. Note that environmental degradation itself does not automatically result in SBS.

Figure 5: Evidence demonstrating (a) the lack of data on the natural environment and (b) loss of interaction with and (c) familiarity with the natural environment. Panels show (a) the starting year of biodiversity monitoring schemes in Europe (filled circles: median values; horizontal bars: 1st and 3rd quartiles; vertical dashed line: the overall median value across eight taxonomic groups), (b) change, between 1998 and 2009, in the percentage of Japanese children who have never experienced mountaineering, camping and birdwatching, and (c) a 50-year change in the minimum number of natural history-related courses required for a BS degree in biology in US institutions (median values with standard deviation), respectively. Data from (a) Mihoub *et al.* (2017), (b) Soga and Gaston (2016), and (c) Tewksbury *et al.* (2014).