Is there evidence of shifting baseline syndrome in environmental managers? An assessment using perceptions of bird population targets in UK nature reserves

Jones, L.P. [a,b] *, Turvey, S.T.[b] and Papworth, S.K.[a]

[a] *School of Biological Sciences, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, U.K.*
[b] *Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, United Kingdom*

Keywords: bird population trends, conservation targets, environmental management, decision-making, experience, local ecological knowledge, shifting baseline syndrome.

Total number of figures and tables: 6 (4 Tables = B&W, 3 Figures = all colour)

Corresponding author details:

- **Mailing address:** School of Biological Sciences, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, U.K
- **Phone:** 07548 103657
- **Email:** lizzie.jones.2017@live.rhul.ac.uk

Is there evidence of shifting baseline syndrome in environmental managers? An assessment using perceptions of bird population targets in UK nature reserves

Abstract

Shifting baseline syndrome (SBS) describes changing perceptions of biological conditions due to a loss of historical knowledge. Perceptions of ‘normal’ environmental conditions are continually updated, leading to underestimation of the true magnitude of long-term ecological change and potential setting of unambitious management targets. There has been speculation as to the presence and impacts of SBS within conservation management since Daniel Pauly’s seminal paper in 1995, which outlined the potential effects of SBS on target-setting in fisheries management. Previous case studies have suggested that SBS may not occur in management, despite empirical evidence of SBS in other systems. In this study, 44 professionals and volunteers involved in bird species management, monitoring and target-setting across England were interviewed. Interviews asked for personal perceptions of current, maximum and target abundance, long-term trends, and perceived conservation priority for six bird species. Using paired tests, this study found no significant effect of experience on perceptions of current, maximum or target abundance of all species, despite differences in national abundance and trends, and differences in participant experience. Further power analysis indicated that even if SBS was statistically detectible with a larger sample, the practical implications of the syndrome would be minimal due to small effect sizes. Finally, the effect of experience on individual perceptions of species conservation priority varied between species, with generational amnesia in the form of ‘lifting baselines’ suggested for only one of the six species. This study suggests that shifting baseline syndrome may not be as significant a threat in conservation management as first thought.

1. Introduction

Evidence-based decision-making is increasingly recognised as standard practice for conservation management, championing the use of robust scientific data on which to base effective research and action (Sutherland et al., 2004; Christie et al., 2020; Downey et al., 2021). Such approaches seek to close the 'research-implementation gap' between conservation science and real-world management (Knight et al., 2008; Dubois et al., 2020). The rise of open-access publishing and free-to-use data repositories enables access to global research but has also led to the expectation for conservation professionals to utilise and learn from cutting-edge research from around the world (Fuller et al., 2014; Sutherland and Wordley, 2017). Furthermore, increasingly dynamic conservation management, policy and decision-making is required to keep pace with unprecedented rates of ecological change and unpredictable new threats (Steffen et al., 2015; Canessa et al., 2020). For on-the-ground conservation managers, these challenges are compounded by the translation of high-level international research and policy into locally relevant targets and decisions (Pullin et al., 2004), and a relative shortage of research and funding in some of the world's most biodiverse regions (Wilson et al., 2016). Conservation researchers, managers and practitioners are therefore under increasing pressure to drive positive change, despite additional time and resource pressures acting upon them. However, studies investigating the importance of evidence in decision-making often overlook the underlying cognitive and psychological processes that drive current conservation decisions, and their influence on the direction and effectiveness of future initiatives (Kørnøv and Thissen, 2000; Clayton et al., 2013; Osbaldiston, 2013; Papworth, 2017).

In psychology, multiple theories have been described to explain the decision-making process, based on the reasoning, beliefs, values and experience of the decision-maker (Evans, 2008). In conservation, it is theorised that younger or less experienced decision-makers are more likely to make slower, evidence-based decisions, while older and more experienced decision-makers are more commonly associated with fast-paced decisions, often based on personal experience and intuition (Papworth, 2017). Although evidence-based decisions are thought to be less influenced by personal opinion and emotion, professional time pressures alongside limited resources and inaccessible information (via barriers to both accessing and assimilating information) can lead conservation managers to rely more heavily on personal, experience-based knowledge for decision-making (Walsh et al., 2015). In conservation this issue has been termed ‘evidence complacency’, leading to criticism of current management systems and the level of pressure on decision-makers and practitioners, due to the potential introduction of inefficient practices and a ‘post-truth’ ethic (Sutherland and Wordley, 2017). However, others argue that the inherent complexity and non-linearity of decision-making makes evidence complacency unavoidable, and overlooks the implicit, unquantifiable knowledge of experienced decision-makers (Fazey et al., 2006; Evans et al., 2017).

Decision-making is made more complex through the influence of cognitive and social biases, such as shifting baseline syndrome (hereafter SBS). SBS is a socio-psychological phenomenon, previously shown to significantly impact perceptions of both current and past ecological conditions and the perceived need for future conservation interventions (Jones et al., 2020). SBS describes the discrepancy between an individual’s perceived environmental baseline used to measure change, and the true environmental ‘starting point’ (Pauly, 1995). It is thought to arise from a loss of historical ecological knowledge due to a lack of intergenerational communication, extinction of experience, and distortion of personal memories (Miller, 2005; Soga and Gaston, 2018). The loss of knowledge regarding past conditions results in a persistent downgrading of perceived ‘normal’ environmental conditions over time, rendering people unable to perceive the true extent of ecological change (Fernández-Llamazares et al., 2015). SBS can occur via two mechanisms: generational amnesia, which occurs when the baseline for ‘normal’ ecological conditions shifts with each successive generation; and personal amnesia, in which individuals forget their past experiences and accept current conditions as the new normal (Papworth et al., 2009).

The conceptual foundations of SBS lie in the field of conservation management. In 1995, Daniel Pauly first defined SBS in the context of fisheries science and possible impacts on “targets for [environmental] rehabilitation measures” (Pauly, 1995). Pauly realised that scientists often tended to compare current conditions to those experienced at the beginning of their career, rather than to a systematic biological baseline. Since Pauly’s highly influential paper (2471 citations – Google Scholar, June 2021), evidence for the phenomenon has been reported in a range of ecological contexts across both marine (e.g. Ainsworth et al., 2008; Daw et al., 2011; Plumeridge and Roberts, 2017) and terrestrial ecosystems (Papworth et al., 2009; Jones et al., 2020), and has been the subject of many commentaries on the possible impacts of SBS in biological conservation and restoration (e.g. Wu et al., 2011; Soga and Gaston, 2018). According to Papworth et al. (2009), in order to investigate evidence of SBS, perceptions-based data must be statistically compared to biological data on the same temporal scale in order to confirm age- or experience-related differences in perceptions of biological change. The conditions to confirm SBS are that all participants have experienced biological change during the study period and have a similar perception of current biological conditions (Papworth et al., 2009). A lack of long-term biological data against which to directly compare perceptions of biological change is the most common barrier preventing empirical examination of SBS (see Thurstan et al., 2016; Guerrero-Gatica et al., 2019).

However, although over 25 years have passed since Pauly's formative paper was published (Pauly, 1995), there is still a lack of evidence for the existence of SBS within conservation management. Furthermore, no study has yet investigated evidence regarding the potential effects of SBS on the effectiveness and ambitiousness of conservation decisions. Plumeridge and Roberts (2017) are one of few studies to investigate evidence of SBS in a management scenario, focussing on manager perceptions of the Dogger Bank region of the North Sea. This study interprets a lack of change in recorded perceptions of ecological conditions as evidence of SBS, leading to unambitious modern-day conservation management targets and underestimation of the extent of long-term biological change. However, these findings are suggestive of change blindness rather than SBS (as described by Papworth et al. 2009), due to the lack of age- or experience-related differences in perceptions of change. Under change blindness, people do not notice change occurring and believe current conditions to match those of the past (Simons and Rensink, 2005; Plumeridge and Roberts, 2017), as opposed to SBS, in which change is forgotten over time (Papworth et al., 2009).

By contrast, Muldrow et al. (2020) explored evidence for SBS in the context of coral reef conservation in Florida, interviewing 54 local experts regarding perceptions of current and past coral cover. Experience was quantified as the number of hours dived on the reef; as previously recommended by Papworth et al. (2009), diving provides a "discrete event that can only be 'on' or 'off' and there is no leakage into everyday life". The study found no evidence for SBS among the sample, as both age and experience had no significant effect on perceived baselines, and only 17% reported the use of personal perceptions over secondary data sources for decision-making. Similarly, while not focussing explicitly on SBS, Cook et al. (2014) systematically investigated the accuracy of conservation practitioners' judgements in line with the criteria of Papworth et al.

(2009). This study compared the accuracy of practitioners' knowledge of vegetation condition within the areas of their management constituency against a condition assessment tool. Interestingly, in this case little evidence of SBS was indicated, as approximately 60% of practitioners were found to have an accurate current perception of vegetation condition, despite most only using personal experiences to inform their judgments. The remaining 40% tended to be conservative in their estimates of condition, and no significant effect of practitioner experience, level of education, or gender was found (Cook et al., 2014). Previous studies of SBS in conservation management have thus found little or no evidence to suggest the existence or effects of SBS, and none have yet investigated the potential effects of SBS on target-setting.

The lack of evidence of SBS in previous studies of management contexts is therefore in contrast to Pauly's original paper (Pauly, 1995). We hypothesise that conservation managers, for whom monitoring ecological change is a key part of their job, are likely to be acutely aware of ecological change (Cox and Gaston, 2016). Due to their career choice, it is unlikely that differences in perceptions of change between conservation professionals are due to lack of interest or exposure (as is often cited regarding 'the extinction of experience'; Miller, 2005; Gaston and Soga, 2020), but if found, differences could be due to variability in experience leading to generational amnesia, or memory loss with increasing age leading to personal amnesia (Papworth et al., 2009). Alongside experience, connection to nature (CTN) and interest in nature inherently influence people's perceptiveness of changes in the natural world (Soga and Gaston, 2016; Chawla, 2020). Perceptions of change are also likely to depend on the rate and magnitude of change, and the 'prominence' of multiple components of biodiversity (e.g., rare and rapidly declining species may be more frequently monitored and discussed). Figure 1 shows a pair of theoretical 'assessment matrices' representing the probability of SBS occurring and the potential risks posed by SBS in a given scenario. Scenarios involving very rare species (therefore, unlikely to be experienced) or species with rapidly changing status, and involving people with low connectedness to or interest in nature, are at highest 'risk' of SBS. Conversely, situations involving stable ecological conditions or species populations, and people who are highly connected to and interested in nature, are at low risk of SBS. Limited risk may explain the lack of previous evidence of SBS in conservation managers. However, due to variation in experience, CTN and species population change, managers may still be at risk of SBS.

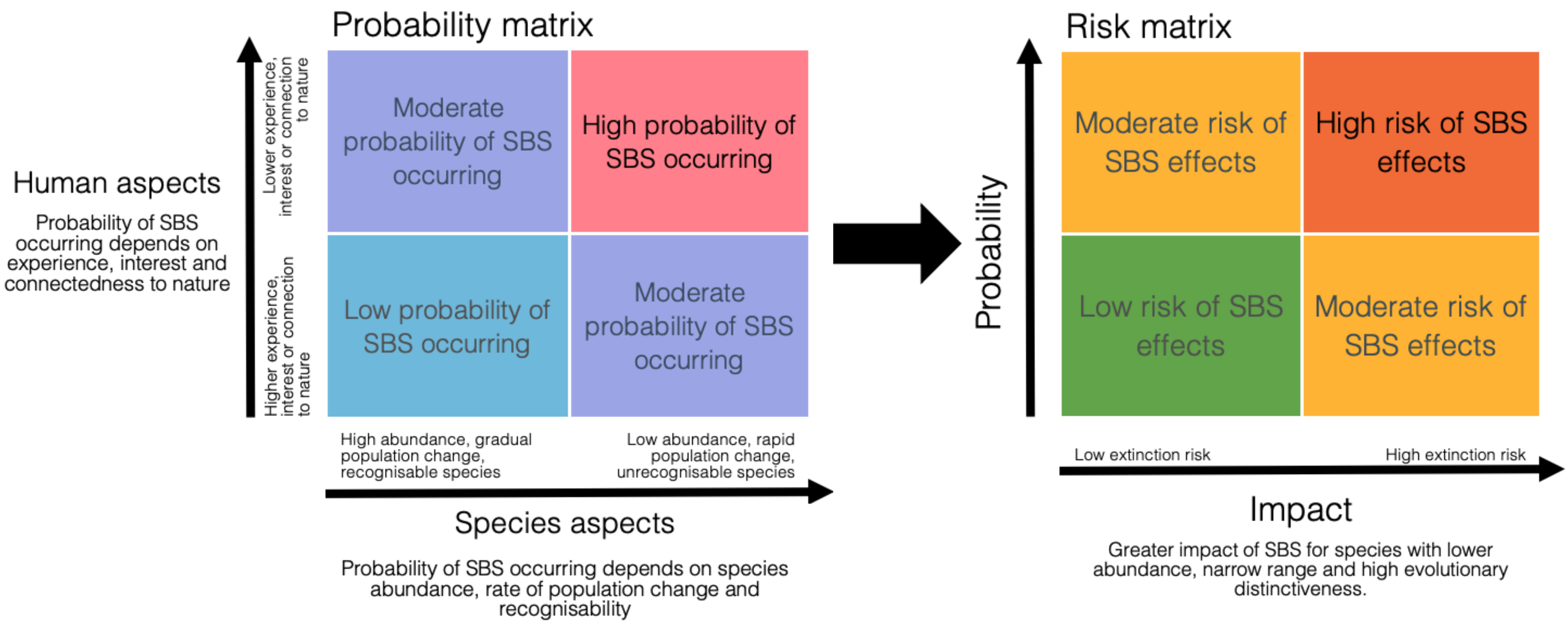


Figure 1: Two theoretical assessment matrices indicating the potential risk of the effects of SBS occurring in a given situation. The probability matrix (left) outlines human and species-level factors that influence the likelihood that SBS may occur, which provides one axis of the SBS risk matrix (right). The other axis of the risk matrix, impact, represents the severity of potential environmental impact of SBS; for example, SBS may have greater impacts on very rare species or threatened habitats.

This study aims to investigate evidence of SBS in the field of conservation management and provides the first examination into the impact of the syndrome on conservation target-setting and decision-making. We interviewed 44 conservation professionals and volunteers involved in bird species management and monitoring across England, from a range of organisations, collecting participants' perceptions of current and maximum possible species abundance and long-term species trends within their local reserve (Cook et al., 2014; Plumeridge and Roberts, 2017; Muldrow et al., 2020). Two 'paired' participants were interviewed from each reserve and were asked a series of questions about the site or reserve they currently worked on most frequently (focal reserve). Personal perceptions of current, maximum and target abundance, long-term population trends and relative conservation priority were collected for six species in each interviewee's focal reserve, as well as demographic and experience-related information.

Through this study we aim to investigate whether evidence for SBS exists in conservation management, and if so, whether it holds the power to impair the effectiveness of conservation targets. Our findings thus provide important practical guidance into whether methods to combat SBS in conservation management are required.

2. Methods

2.1. Study hypotheses

Under SBS, all individuals should have a similar perception of current population abundances; however, their perceptions of maximum population abundances are likely to be based on past experiences and knowledge, which form an individual's personal baselines (Papworth et al., 2009). Our first hypothesis states that there will be no significant difference in the perceptions of current abundance between paired individuals. However, we expect to find a significant difference between perceptions of maximum abundance within each pair. This would suggest SBS in the form of generational amnesia. If a significant difference between perceptions of maximum abundance is found, we hypothesise that the effect of past experience on these differences will depend on the historical population trend of the species. Under generational amnesia, we would expect more experienced participants to perceive greater maximum abundance than less experienced participants for declining species, as they have prior knowledge of historical abundance levels and population trends. Conversely, for increasing species, we expect more experienced participants to perceive lower maximum abundance compared to less experienced participants. We also explore paired differences in perceptions of species trends and examine whether greater differences in experience between paired individuals coincide with greater differences in perceptions of all measures of species abundance and trends.

The impacts of SBS on conservation decision-making are investigated using perceptions of species abundance targets and ranked species conservation priority on participants' focal reserves. We hypothesise that more experienced conservation participants in this study would be significantly more likely to set more optimistic targets (higher abundance) and attribute greater priority to species that are declining nationally, compared to less experienced participants. We hypothesise the opposite trend for increasing species, as more experienced participants are likely to perceive lower, less optimistic target abundances and lower priority, reflecting a lower baseline species abundance.

2.2. Species and area selection

We selected six bird species, either currently or historically found in inland environments across much of England: three with populations that have been consistently declining during recent decades (skylark *Alauda arvensis*, marsh tit *Poecile palustris*, nightingale *Luscinia megarhynchos*), and three that have been consistently increasing (blackcap *Sylvia atricapilla*, nuthatch *Sitta europaea*, buzzard *Buteo buteo*), according to the British Trust of Ornithology's (BTO) Common Bird Survey (CBC) and Breeding Bird Survey (BBS) data for England (see Table 1). Within each set of three, species varied by relative abundance from abundant to rare (Woodward et al., 2018). A focus on inland species (as opposed to coastal or wetland birds) reduced potential variability between species and sites.

Table 1: Biological long-term population data used to inform selection of the six bird species included in this study. Species are separated by trend and listed according to national abundance. Long-term trend is the percent change in the number of CBC/BBS plots in which the species was identified in England. Data gathered from BTO BirdTrends (Woodward et al., 2018) and BTO BirdFacts (Robinson, 2005) in England.

Group	**Species name**	**Scientific name**	**UK red list status**	**Abundance (in 2009)**	**Long-term trend (% change)**
Declining	Skylark	*Alauda arvensis*	Red	1.5 million territories	-63% (1967-2016)
	Marsh tit	*Poecile palustris*	Red	~41,000 pairs	-76% (1967-2018)
	Nightingale	*Luscinia megarhynchos*	Red	~5,500 territorial males (2012)	-93% (1967-2016)
Increasing	Blackcap	*Sylvia atricapilla*	Green	1.2 million territories	+288% (1967-2016)
	Nuthatch	*Sitta europaea*	Green	220,000 territories	+257% (1967-2016)
	Buzzard	*Buteo buteo*	Green	~70,000 pairs	+844% (1967-2016)

Interviews were completed with employees and volunteers of nature and bird reserves throughout England. Selected reserves were run by any conservation or wildlife management organisation, charity or governmental organisation. Conducting a national-level study ensured a large potential sample size, but required the selection of bird species that are currently or were historically (within living memory) found across the study area.

2.3. Participant sampling strategy

Ethical approval was granted by the ethical committees of the Zoological Society of London and Royal Holloway, University of London (see ethics statement). The survey was piloted with three colleagues in March 2020. Data collection interviews were conducted from March 23rd to December 15th 2020, with a hiatus from April to July and in November due to participant furloughing and lack of availability during the first and second Covid-19 pandemic lockdown periods in the UK. Due to a limited sample pool, participants were contacted opportunistically via email; some participants were also subsequently introduced via chain referral (Huntington, 2000). Eligible participants were any person whose role directly and regularly contributed to the data collection, surveying and management of local bird species populations, and/or in making management decisions as local experts or facilitating the decision-making process (Davis and Wagner, 2003). This includes but is not limited to: site managers, reserve wardens (including seasonal, assistant, and volunteer wardens), volunteers and ecologists. Participants under the age of 18 were not accepted. Relevant job roles were dependent on reserve management authority (e.g., RSPB or Wildlife Trusts). If possible, we requested to interview the youngest and oldest people working at any given reserve as a pair of interviews; however, in many cases any available staff were invited for interview.

In order to approximate potential sample size, the number of inland reserves (including local and national nature reserves, Sites of Special Scientific Interest, and Special Areas of Conservation) with permanent staff was estimated at ~300 inland/non-wetland reserves using Natural England’s Designated Sites Search tool (Natural England, 2021). Many UK reserves have multiple staff (e.g., RSPB reserves), but smaller reserves are often staffed by regional teams who manage multiple reserves. We therefore estimated total sample frame as approximately 250 pairs.

2.4. Interview outline

Interviews were split into three sections (Supplementary S1 for questionnaire transcript and Table S1 for question rationale). Section one of the questionnaire collected participant demographic data, local conservation experience (current role, employer, years of experience in current role, years of conservation experience, years since first visit to the reserve that the interview focussed on) and birding interest and experience (proportion of time spent at the reserve/bird watching). Section two asked participants three questions for each of the six species: their perceptions of the maximum possible abundance on the reserve if all management was tailored toward that species, the current abundance on the reserve, and a desirable target abundance which balanced management for other desirable species and processes on the reserve. The final section asked participants for their perceptions of long-term trends on the reserve for each species, from their first experience of the reserve to the time of the interview (from the following categories: 'increased', 'no change', 'decreased', 'not present,' and 'don't know'), and to rank species in order of conservation priority (1= highest, 6 = lowest), considering the answers given in the previous section and on long-term trends. Having completed this final section, participants were then given the opportunity to change their earlier answers regarding perceived abundance; however, none of the participants chose to change their answers.

Interviews were conducted either by phone or video call, using semi-structured interview techniques. As face-to-face interview techniques can provide lower non-response rates (Heerwegh and Loosveldt, 2008) and highly representative results (Szolnoki and Hoffmann, 2013), video calls were preferred over phone calls wherever possible. When participants consented, interviews were recorded to allow future reference to anecdotes and details mentioned during the interview. Interview results, data and key notes about perceived reasons for species population change were written on pre-printed interview sheets (see supplementary S1) and transcribed into a spreadsheet after each interview. All participants confirmed that they recognised all of the species by name at the start of the interview and confirmed that they were based on conservation sites or reserves in England.

2.5. Data analysis and statistics

A total of 45 participants were interviewed, with 44 participants completing the full questionnaire. Participants were paired according to their focal reserve and categorised into 'high' or 'low' groups according to each measure of experience (age, years in current role, years on reserve, years of conservation experience, years since first memory of reserve). A single participant was sampled for six of the reserves, so these unpaired participants were not included in any subsequent analyses. Three participants were interviewed for two reserves, so the oldest and youngest were paired and the third participant was excluded. The final paired sample size comprised of 36 individuals, or 18 pairs (Table 2).

Statistical analyses were conducted using R software version 3.6.2 (R Core Team, 2019). To explore the relationship between age and experience for each pair, we counted the number of pairs in which age and each measure of experience were congruent (i.e., the oldest member of the pair was also the most experienced). For years of experience on reserve, years of experience on reserve in conservation, and years since first visit to the reserve, the older participant had fewer years of experience than the younger participant in two pairs, while for experience in role, the oldest participant had fewer years of experience in three pairs. Therefore, for all measures of experience, age and experience were not statistically substitutable. However, Pearson correlations indicated a strong correlation ($r > 0.75$, $p < 0.05$) between age, years in conservation, and years since baseline (Table S2). We therefore chose to run all subsequent analyses for number of years since each participant's first visit to the reserve (chosen to represent total time each participant had experience of the focal reserve); all subsequent references to 'experience' refer to this metric.

Perceptions of abundance and long-term trends

Prior to statistical analysis, pairs where both participants stated that the species in question was not present on the reserve currently and was unlikely to ever occur on the reserve (and therefore gave zero values for maximum, current and target abundance) were removed from subsequent paired analysis of abundance. Subsequent sample sizes for each species are given in Table S3. A two-way ANOVA was used to explore the significance of the relationship between experience, professional role and gender.

Differences in perceived current, maximum and target abundance were calculated within each pair by subtracting the perceived value provided by the more experienced participant from the value perceived by the less experienced member of each pair. A mean paired difference was then calculated across all pairs, for each measure of abundance. Similarly, differences in perceptions of species trends were calculated per pair as a measure of pairwise agreement. Paired agreement of perceptions of species trends were reported as three categories: 'total agreement' (both reported the same trend), 'adjacent trends' (one participant of a pair reported no change and the other reported increasing or decreasing), and 'no agreement' (one participant of a pair reported an increase and the other reported a decrease).

Significant differences in the perceptions of each measure of abundance (maximum possible population size, current population size, target population size) were tested between paired experience groups for each of the six species. The assumption of normally distributed difference scores between paired groups was first examined per species using Q-Q plots of the residuals and the Shapiro-Wilk normality test from the 'rstatix' package (Kassambara, 2020), adjusted using the Bonferroni correction for multiple comparisons. Paired t-tests were then used for normally distributed data and paired two-sample Wilcoxon tests were used for non-normal data. The null hypothesis for all tests predicted no significant difference in the paired means (in the case of t-tests) or medians (for Wilcoxon tests) between more and less experienced participants.

Linear models were used to investigate the relationship between paired differences in years of experience and perceptions of maximum, current and target abundance for each species. Similarly, the relationship between paired differences in experience and differences in levels of agreement of perceived trends was investigated using an ordinal logistic regression using the 'MASS' package (Ripley et al., 2021).

Generational differences in target-setting

The impact of years of experience and personal perceptions of local trends on perceived ranked species conservation priority was investigated at the individual-level, using cumulative link ordinal logistic regression mixed models (CLMMs) from the 'clmm' function in the 'ordinal' package (Christensen, 2019). A mixed model approach was used to group participants by reserve as a random effect to account for perceptual similarities within pairs. Trend factor levels with fewer than three participants were dropped to prevent rank deficiency, and perceived species priority ranks were binned into three groups (1|2 = ‘high’, 3|4 = ‘medium’, 5|6 = ‘low’) to ensure a sufficient sample size per priority level. The proportional odds assumption was met for all species except buzzard and marsh tit, and so the results for these species were not included in the following analyses.

Power analysis

Power analyses were used to exclude the effect of small sample sizes on the insignificance of the paired test results for all species and estimate the necessary sample size required to find a significant mean difference between paired groups for perceptions of maximum, current and target abundance for each species. For species with a normally distributed response variable, Cohen’s *d* effect size was calculated using the ‘pwr.t.test’ function from the ‘pwr’ package (Champely et al., 2018) at the 80% statistical power threshold, which commonly benchmarks a ‘high’ effect size (Cohen, 1992; Miciak et al., 2016). Power was simulated at sample sizes ranging from 0 to 250 pairs (representing the approximate maximum sample frame), at intervals of 25 pairs for each species for each measure of abundance using the ‘wp.t’ function from the ‘WebPower’ package (Zhang et al., 2018), producing predictive power curves. High sample sizes indicate high levels of variability between pairs and *vice versa*. For species with a non-normally distributed response, study power was computed using Monte Carlo simulations at the same range of sample sizes using the ‘sim.ssize.wilcox.test’ function from the ‘MKpower’ package (Kohl, 2020).

3. Results

3.1. Demographics and experience

An overview of the sample size and the demographic characteristics, experience and interest in bird watching of participants in the full and paired samples is given in Table 2.

Table 2. Overview of participant demographics for all participants that completed the questionnaire (n=44) and the paired sample used in subsequent paired data analysis (n=36), separated into high and low experience groups.

	Full Dataset	Paired Dataset	
	Full (N=44)	High (N=18)	Low (N=18)
Age			
Mean (SD)	44 (14)	52 (11)	36 (12)
Median [Min, Max]	42 [23, 73]	54 [31, 71]	33 [23, 73]
Gender			
Female	9 (20.5%)	2 (11.1%)	4 (22.2%)
Male	35 (79.5%)	16 (88.9%)	14 (77.8%)
Job Role			
Area manager	3 (6.8%)	3 (16.7%)	0 (0%)
Assistant warden	4 (9.1%)	0 (0%)	4 (22.2%)
Ecologist	5 (11.4%)	1 (5.6%)	0 (0%)
Senior site manager	2 (4.5%)	1 (5.6%)	1 (5.6%)
Site manager	8 (18.2%)	4 (22.2%)	3 (16.7%)
Volunteer	7 (15.9%)	5 (27.8%)	2 (11.1%)
Warden	15 (34.1%)	4 (22.2%)	8 (44.4%)
Years in current role			
Mean (SD)	8.0 (9.6)	13 (13)	5.1 (4.9)
Median [Min, Max]	5.0 [0.33, 45]	9.0 [0.75, 45]	3.5 [0.33, 18]
Years on current reserve			
Mean (SD)	11 (11)	18 (14)	6.1 (5.6)
Median [Min, Max]	5.8 [0.50, 47]	16 [1.0, 47]	4.5 [0.50, 18]
Years since first visit (baseline)			
Mean (SD)	16 (13)	26 (14)	7.4 (5.4)
Median [Min, Max]	11 [1.0, 47]	28 [3.0, 47]	6.0 [1.0, 18]
Years in conservation			
Mean (SD)	19 (13)	29 (13)	11 (8.2)
Median [Min, Max]	17 [0.75, 49]	30 [0.75, 49]	10 [2.0, 36]
Prop. of time on reserve			
Mean (SD)	0.61 (0.27)	0.63 (0.33)	0.64 (0.22)
Median [Min, Max]	0.60 [0.10, 1.0]	0.75 [0.10, 1.0]	0.60 [0.30, 1.0]
Missing	1 (2.3%)	1 (5.6%)	0 (0%)
Frequency bird watching			
Daily	36 (81.8%)	14 (77.8%)	16 (88.9%)
More than once a week	8 (18.2%)	4 (22.2%)	2 (11.1%)

A mean difference in years of experience of 18.8 ± 8.8 years (range = 46 years) was found between the high and low experience groups (mean per group: high = 26.2 ± 14.3 years, low = 7.4 ± 5.5 years). We found a significant relationship between experience and gender ($F(1, 26) = 6.78$, $p < 0.05$), but not between experience and role ($F(6, 26) = 1.75$, $p = 0.15$) or the interaction of role and gender ($F(2, 26) = 0.66$, $p = 0.52$), indicating that male participants tended to have more years of experience but did not necessarily hold higher positions within reserve pairs. All participants stated that they watched birds at least once a week, indicating a high level of interest in and exposure to birds.

3.2. **Investigating evidence for SBS**

Paired tests found no evidence for significant differences in perceptions of current abundance between experience groups for any of the six species (Table 3). This result indicates that both members of each pair had a similar perception of current conditions, in line with the criteria required to provide evidence of generational amnesia. However, we also found no significant experience-related difference in paired perceptions of maximum abundance for all species, despite paired differences in number of years of experience (Table 3). These results are substantiated by Figure 2, in which differences in perceptions of maximum and current abundance between pairs are very low for all six species, relative to mean perceived maximum and current abundance for each species, across all participants of each experience group (see Table S3). Furthermore, there was no significant effect of paired differences in years of experience and paired perceptions of current or maximum abundance for any species (Table S4).

No significant effect of paired differences in experience on the level of paired agreement of perception trends was found for any species (Table S5). However, buzzard showed the highest frequency of 'total agreement' between pairs (12 of 18 pairs), and skylark showed the highest frequency of 'no agreement' between pairs (2 of 15 pairs) (see Figure S2 for full results).

Table 3. Mean paired differences in perceptions of species abundance for: maximum, current and target abundance, comparing high and low experience groups per reserve, and paired test results testing for a significant difference between pairs for each measure of perceived abundance. Abundance refers to number of bird pairs. Increasing species are shaded white, and decreasing species are shaded grey.

Measure of abundance	Species	Mean difference in perceived abundance within each pair	Test	d.f.	t-value	V-value	P-value
Maximum abundance	Skylark	+10.80	Wilcoxon	14		56	0.85
	Marsh tit	-5.24	T-test	16	-0.85		0.42
	Nightingale	-3.21	T-test	13	-0.74		0.47
	Blackcap	-6.44	Wilcoxon	17		68	0.70
	Nuthatch	-7.94	T-test	16	-0.42		0.68
	Buzzard	-1.61	T-test	17	-1.10		0.29
Current abundance	Skylark	-13.93	Wilcoxon	14		67	0.71
	Marsh tit	0.00	T-test	16	0		1.00
	Nightingale	0.07	T-test	13	0.06		0.95
	Blackcap	-9.56	Wilcoxon	17		34	0.08
	Nuthatch	-4.19	T-test	16	-1.29		0.22
	Buzzard	-0.78	T-test	17	-1.10		0.29
Target abundance	Skylark	-4.93	Wilcoxon	14		58.5	0.73
	Marsh tit	-2.00	T-test	16	-0.74		0.47
	Nightingale	3.86	T-test	13	0.81		0.43
	Blackcap	-7.19	Wilcoxon	17		45.5	0.25
	Nuthatch	-4.50	T-test	16	-0.73		0.48
	Buzzard	-0.67	T-test	17	-0.83		0.42

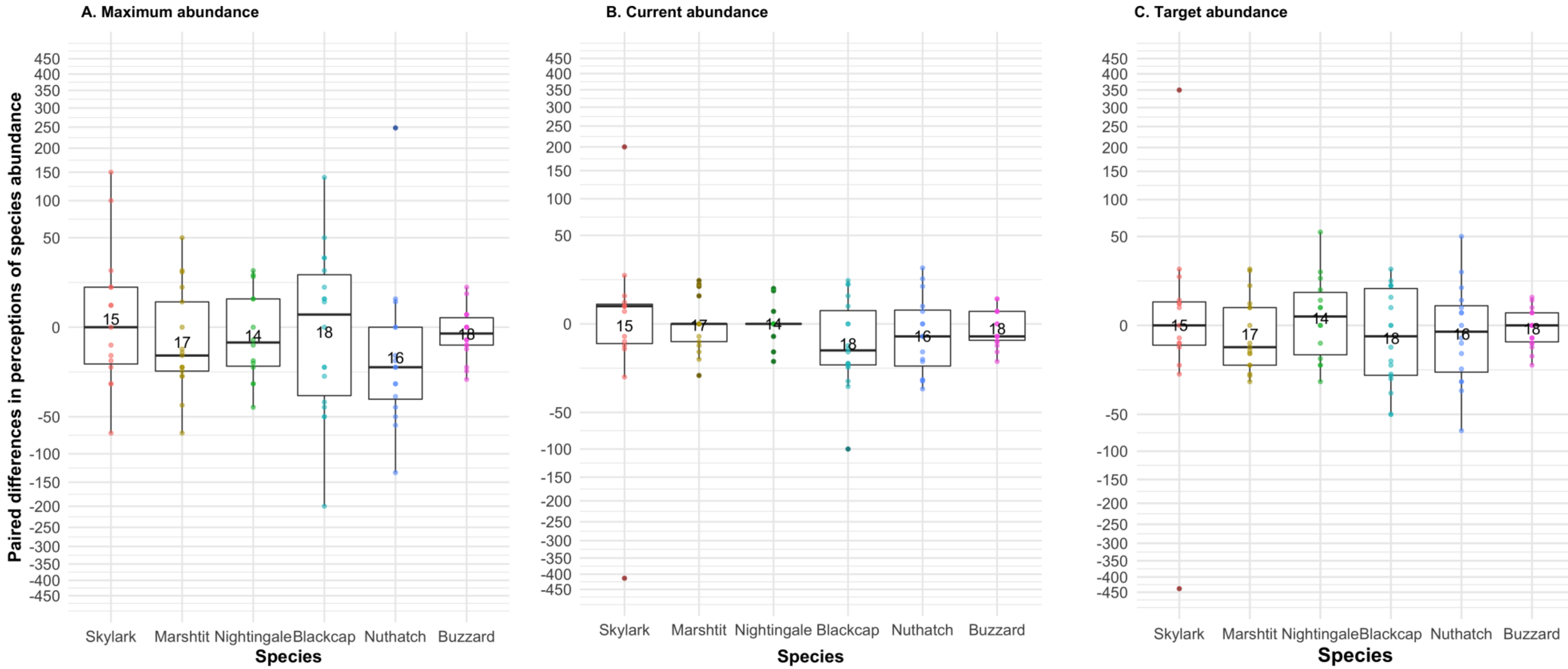


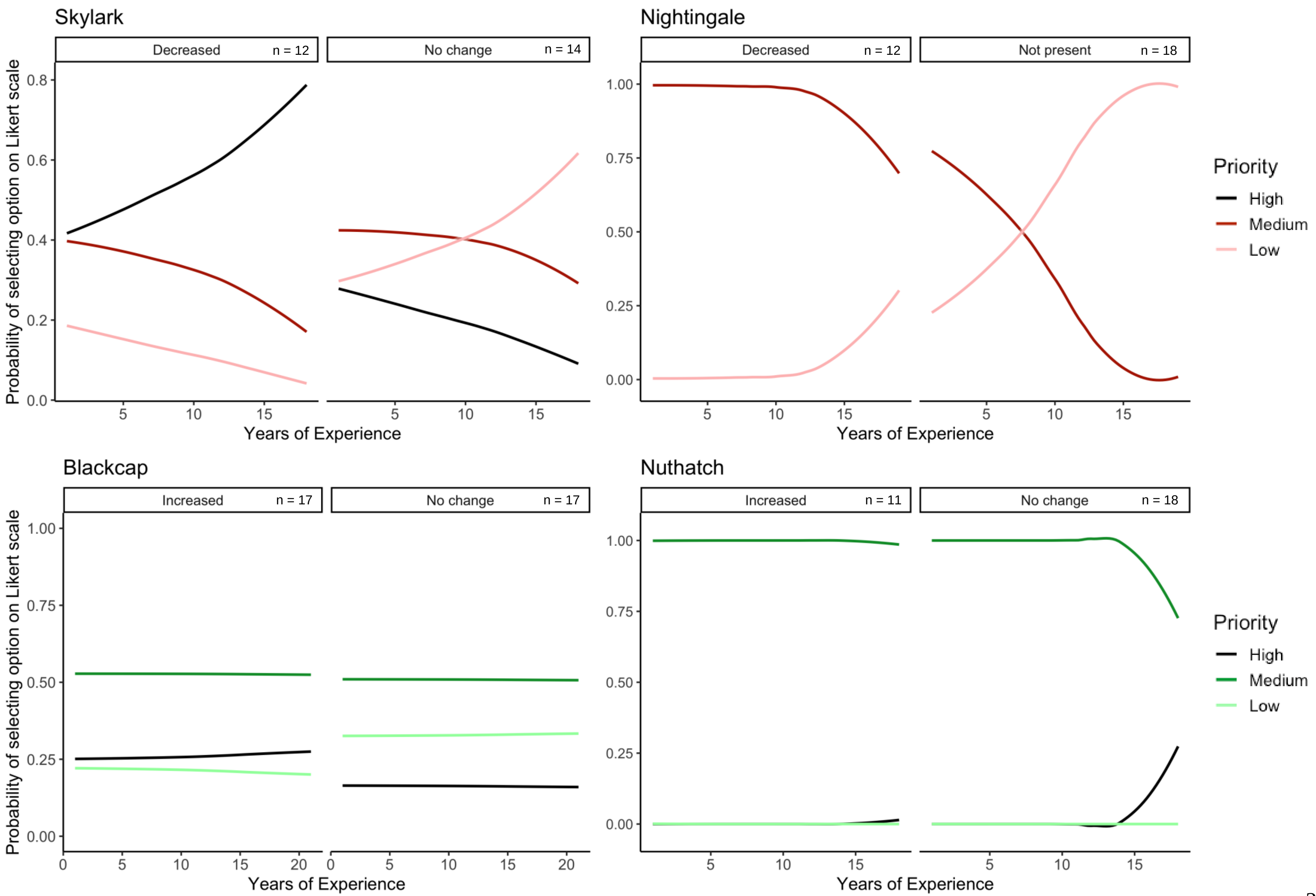
Figure 2: Paired box and whisker plots comparing paired differences in perceived abundance between paired high and low experience groups for each species (high group – low group = differences). Box and whisker plots show the median, IQR and outliers (>2 standard deviations outside mean) of the perceived differences between paired perceptions for all pairs for: A, Maximum abundance; B, Current abundance; and C, Target abundance. Abundance refers to number of bird pairs. Sample sizes (number of pairs) are shown at the mean of each boxplot.

3.3. Generational differences in target-setting

No significant differences were found in perceptions of target abundance between experience groups, for any species (Table 3 and Figure 2), meaning that experience has no significant effect on perceptions of desired target abundance for species with either increasing or declining national population trends. Furthermore, paired differences in years of experience did not significantly explain variation in paired perceptions of target abundance for any species (Table S4).

Of the three species experiencing national decline, nightingale was perceived as ‘high’ priority by the highest number of participants across all species (21 of 35), followed by marsh tit (Table S6). However, neither experience, trend, nor an interaction between experience and trend significantly predicted perceived species rank for skylark or nightingale. Perceived species priority levels are given in Table S6, and full results for all species are given in Table S7 & S8. The majority of participants perceived the nationally increasing species as ‘medium’ priority (blackcap = 16 of 35, nuthatch = 19 of 35, buzzard = 22 of 35), while skylark, blackcap and nuthatch were perceived as ‘low’ priority by the highest number of participants across all species (11 of 35). Neither experience nor perceived trend significantly predicted perceived rank for blackcap. For nuthatch, the odds of awarding a higher priority level increased by 38.7% for each year of increasing participant experience between each level of perceived conservation priority, independent of perceived trend (odds ratio = 0.613, $p = <0.01$, $n = 29$). Perceived trend also had a significant effect for nuthatch (Figure 3), as participants who perceived a stable population trend were 76.1% more likely to award a higher priority than those who perceived an increasing population trend (odds ratio = 0.239, $p < 0.01$, $n = 29$). However, a significant interaction effect of experience and trend indicated that for every year of increasing experience, participants were 1.9% less likely to give nuthatch a higher priority when an increasing trend was perceived rather than a static trend (odds ratio = 0.981, $p < 0.01$, $n = 29$).

Figure 3: Interaction effects of participant experience and perceived species trends on perceptions of conservation priority at the participant's focal reserve, represented by conservation priority. Significant results are found only for nuthatch, with a significant effect of experience, trend, and the interaction of experience and trend. For full CLMM results see Tables S7 & S8.



3.4. Effect of sample size on study conclusions

Mean sample sizes required to find a significant mean difference between higher and lower experience groups at the 80% threshold varied between species and abundance measures, with the greatest overall range seen for current abundance (Table 4). Given an approximate maximum sample size of 250 reserves in our study area, our results suggest that a significant difference between groups for all measures of abundance is only statistically possible for buzzard (Table 4). Across all species and if sampling all 250 reserves, a significant difference would be least likely to be detected in maximum abundance, and most likely to be detected in target abundance. Power analyses indicate that 250 would be a sufficient sample size to detect differences in target abundance for all species except skylark. Full power curves and predicted power at abundance intervals can be found in supplementary Figure S2 and Table S9.

Table 4. Required sample size (pairs) to find a significant mean difference between higher and lower experience groups using paired t-tests at power = 0.80, and associated effect sizes. A value could not be estimated for current abundance of marsh tit, as Cohen's *d* effect size was equal to zero.

Abundance measure	**Sample size (pairs) required for power = 0.8**					
	Skylark	**Marsh tit**	**Nightingale**	**Blackcap**	**Nuthatch**	**Buzzard**
	Wilcoxon	T-test	T-test	Wilcoxon	T-test	T-test
Maximum	225	185	204	850	728	119
Current	775	N/A	26,227	55	77	119
Target	9600	244	175	65	239	206

4. Discussion

In 1995, Daniel Pauly coined shifting baseline syndrome in the context of conservation managers and academics working within fisheries ecology, citing the possible impacts that SBS may have on perceptions of fisheries conservation targets (Pauly, 1995). In this study, we explore evidence to support or contest Pauly's original hypothesis in the context of bird species population management on reserves across England, focussing on six species with varying relative national abundance and trends. Our results do not support Pauly's original hypothesis, as we find little evidence to suggest that SBS is occurring in this case study. Pairing participants according to higher and lower experience, we found no significant differences in paired perceptions of either current and maximum possible species abundance on local reserves. Most importantly, we are the first to investigate the possible effect of SBS on target-setting within conservation management. We found some individual variation in perceptions of species conservation priority when comparing between species, driven by amount of participant experience and perceptions of species trends since their first visit to the reserve, indicating possible evidence for generational amnesia for one species. However, when individuals were asked to set target abundances if conservation was directed for a single species, we find no significant effect of experience on paired perceptions of target abundance for any of the six species included in our study. Our results suggest that SBS may not be a significant issue in conservation management, but generational differences in target-setting may occur when individuals must choose between species.

According to the definitions outlined by Papworth et al. (2009), the first two criteria required to indicate evidence of SBS are demonstrated in this sample. First, all participants have been exposed to, and have experience of, biological change, as evidenced by the documented abundance changes across all species (Table 1) and high participant interest and exposure to nature (Table 2). Second, despite differences in experience of biological change within each pair (measured as number of years since each participant's first visit to the reserve) we found no significant differences between paired perceptions of current abundance for all species (Papworth et al., 2009). However, the lack of experience-related differences between paired perceptions of maximum abundance demonstrates that years of experience, and therefore differences in personal baselines and experiences of long-term population change, have no significant effect on perceptions of maximum possible species abundance (Table 3).

Furthermore, mean differences in paired perceptions of current and maximum abundance between experience groups were not only statistically insignificant (Table 3), but also very low compared to the mean perceived abundance for each species (Table S3). Finally, no significant effect of paired differences in experience was found for any species, either for differences in perceived maximum and current abundance (Table S4), or for the level of paired agreement of perceived long-term trends (Table S5). This suggests that experience has little effect on perceptions of species population change, despite differences in experience of past population change. These findings therefore suggest that there is no detectible effect of SBS in this sample.

Evidence of the effects of SBS on target-setting was explored using experience-related differences in paired perceptions of target species abundance, again finding no significant difference between perceptions of experience groups (Table 3 and Table S4). At the individual-level, ordinal logistic regression analysis tested the effects of experience and perceptions of species trends on perceived conservation priority (Figure 3 and Tables S7 & 8) and found significant effects for nuthatch, but not for three other species. We found more experienced participants tended to attribute higher priority for this nationally increasing species (Figure 3). Although contrary to our original hypotheses, this result may be attributed to greater number of years of experience of population change and, as the nuthatch is a rapidly increasing species across the UK, a lower 'baseline' population size in more experienced participants. According to the BTO, national nuthatch populations have increased by nearly 70% since 1966, with some declines in Cornwall, Kent and Wales (Woodward et al., 2018). Therefore, compared to less experienced participants, those with greater experience may be more cautious in their future target-setting, given knowledge of much smaller populations in the past. As generational amnesia is a key mechanism driving SBS (Papworth et al., 2009; Jones et al., 2020), characterised as age- or experience-related differences in perceptions of change, these generational differences in targets may also be indicative of generational amnesia in the form of 'lifting baselines', as more experienced participants may be basing decisions on past experiences of historical declines, despite recent increases in national nuthatch abundance (BTO, 2010; Roman et al., 2015). However, experience-related differences may also be reflective of generational differences in the factors driving personal perceptions of change outside personal experiences, such as education curricula and alternative knowledge sources such as social media (Soga and Gaston, 2018).

Focussing on participant perceptions of species abundance and trends, our results are in agreement with previous studies of conservation managers (e.g., Cook et al., 2014; Muldrow et al., 2020), as we find little evidence to suggest that SBS occurs in this sample. However, our study goes beyond the scope of previous research by investigating the impacts of SBS on conservation target-setting, indicating that generational differences in experience and knowledge may influence perceptions of species conservation priority for increasing species, but with no evidence for an effect for declining species. As SBS is likely to have more significant negative effects for declining species (see Figure 1), these results suggest that SBS is not a significant conservation concern in this case study. Furthermore, especially when combined with the findings of previous studies of SBS in conservation management, our results support the theory that conservation experts are at low risk of SBS (Figure 1), especially when compared to previous evidence of the effects of SBS in other stakeholder groups (e.g., Papworth et al., 2009; Turvey et al., 2010; Jones et al., 2020).

Finally, power analyses showed that based on the data collected in this study, even if the estimated maximum sample frame of 250 pairs of conservation managers on UK reserves were sampled, it would not be possible to detect a statistically significant difference in perceptions of abundance or targets for half of the species studied here (Table 4). Even if SBS was statistically detectible in this larger possible sample, the practical effects and implications of SBS would be minimal, as the differences in perceived abundance are low for all species, across all measures of abundance (Table 3). The minimal effects of SBS are signified by low predicted effect sizes (Table S9) which translate into high predicted sample sizes required to find a significant statistical effect. These results are likely due to high agreement between pairs, despite differences in years of experience, which may be driven by many factors, including communication, access to datasets and written records, and/or connectedness to nature (Zelenski and Nisbet, 2014; Soga and Gaston, 2018).

Our results, and those of previous studies (e.g., Cook et al., 2014; Muldrow et al., 2020) may be explained by multiple factors that enable the retention of knowledge through generations. Effective training and the co-development of species targets by more and less experienced members of the reserve management team may lead to the homogenisation of perceptions on the reserve as a result of communication and knowledge-sharing, despite variation in age or experience (Fazey et al., 2006). In addition, open communication about the past and open access to local and national historical data on species population change may enable participants of any age to gain knowledge of past ecological conditions and shift the temporal 'position' of their baselines to encompass historical ecological change. At the national scale, long-term biological datasets such as the BTO CBC/BBS, as well as bird guides and books (e.g., Cocker and Mabey, 2005; Macdonald, 2019), provide a rich, open-access history of bird species population change, while volunteer-led citizen-science datasets held by experienced individuals can also provide access to in-depth local knowledge (e.g., Treswell Wood, 2021). However, relevant local ecological knowledge is often not recorded, as stated by one participant: "Things that we think we will remember are never recorded", risking effects of SBS in future due to loss of knowledge through memory loss or distortion (Barthel et al., 2010). Additionally, three participants in this sample cited a lack of funding and paid positions as current and future barriers to communication and knowledge-sharing between generations in the sector, as unpaid internships may disincentivise young people from joining the profession (Fournier et al., 2019).

Some limitations in this study should be addressed in future research. This case study is constrained to England and focuses only on birds, primarily to maximise sample size, as bird conservation is represented by some of largest conservation charities in the UK (e.g., the RSPB and BTO), and to minimise travel time and costs for interviews. To ensure the generalisability of conclusions, future studies should seek to expand this research to other areas of conservation, including fisheries, to verify our findings in relation to Pauly's original hypothesis (Pauly, 1995). Face-to-face interviews were prevented by the global Covid-19 pandemic, which alongside persistent time pressure on conservation managers (e.g., Canessa et al., 2020) may have prevented measurement of the full extent of managers' implicit experiential knowledge (Fazey et al., 2006). Our questionnaire was also designed to minimise the time-cost for time-pressured interviewees, meaning that questions were constrained to 'closed' formats. Although notes were taken during interviews, the full extent of implicit knowledge was therefore not assessed due to a lack of more 'open' questions such as free listing (Newing, 2010). Furthermore, we found that more experienced participants were more likely to feel uncomfortable when asked to hypothetically estimate the maximum possible abundance of a species on the reserve, if all management was tailored towards that species. This may have introduced bias into their answers towards what they thought was acceptable, rather than their true perceptions (Grimm, 2010). By basing decisions more on experience, more experienced managers may also be more unwilling to consider a hypothetical scenario compared to less experienced managers, who could be more likely to utilise abstract thinking based on learned knowledge to estimate possible future scenarios (Evans, 2008).

Future studies should consider the use of participatory group methods, in addition to individual interviews, to encourage open discussion between experience groups and observe differences in opinion about current and past ecological conditions (Newing, 2010). Further research should also explore variation in the presence of SBS across all areas of environmental management (e.g., policy, academia and ecological consultancy) and across a variety of taxonomic groups, countries, cultures and management sectors (Soga and Gaston, 2018). Factors other than the duration of personal experience (e.g., type of personal experiences, preferences and values towards individual species, and local resources) may also drive conservation priorities and decision-making, and future exploration of such factors and how they influence personal perceptions of conservation prioritisation may reveal predictors of conservation effectiveness or success (Cook et al., 2014). More broadly, while the use of past baselines is useful in many circumstances, including to set targets for ecological restoration and species conservation, in the face of novel ecological conditions future studies may need to shift focus away from the effects of experience on predicted, towards the use of alternative baselines. For example, Hirsch (2020) identified the need for anticipatory practices and targets using a case study of the Columbia River Basin, especially in the face of accelerating land-use and climate change. The study highlights the importance of baselines for future target-setting but recognises the need for adaptive predictions of future change based on emerging ecological threats (Hirsch, 2020).

Growing evidence suggests that SBS is less of a threat to conservation management than previously hypothesised (Pauly, 1995; Cook et al., 2014; Thurow et al., 2019). Using a case study within bird species conservation management in England, we found no significant experience-related differences in paired perceptions of current and target abundance, indicating little evidence to suggest that SBS is occurring in this sample. Differences in perceived conservation priorities when selecting between species highlight the influence of multiple factors when choosing conservation targets. By empirically testing the influence of factors such as communication of past knowledge and experiences, connection to nature and access to historical data on preventing the occurrence of SBS, we might hope to map out potential methods to combat the negative effects of SBS on conservation in other areas (see Jones et al. 2020). In the face of accelerating ecological change, conservation managers and practitioners face an increasingly difficult task when attempting to assess and conserve the state of current ecosystems. However, this study suggests that SBS may not be as significant a threat in conservation management as first thought.

Data availability statement

All anonymised social data are available from Royal Holloway Figshare Digital Repository are available from Royal Holloway Digital Repository (https://figshare.com/s/c58a76407509d5267fe0; Jones & Papworth, 2021). Please contact corresponding authors for more information. Please contact the corresponding author for more information.

Acknowledgements

We thank the respondents of this study for their time, knowledge and enjoyable conversations. L.P.J. receives PhD funding from the Royal Holloway, University of London Reid Scholarship. Funding sources were not involved in study design or interpretation of results.

Conflict of interest

The authors declare no conflict of interests.

Author contributions

L.P.J., S.K.P. and S.T.T. conceived the project idea, developed methods and discussed results; L.P.J. collected questionnaire data and performed analyses. All authors contributed to and authorized the final manuscript.

References

Ainsworth, C.H., Pitcher, T.J., Rotinsulu, C., 2008. Evidence of fishery depletions and shifting cognitive baselines in Eastern Indonesia. Biological Conservation 141. https://doi.org/10.1016/j.biocon.2008.01.006

Barthel, S., Folke, C., Colding, J., 2010. Social–ecological memory in urban gardens—Retaining the capacity for management of ecosystem services. Global Environmental Change 20, 255–265. https://doi.org/10.1016/j.gloenvcha.2010.01.001

BTO, 2010. BirdFacts [WWW Document]. BTO - British Trust for Ornithology. URL https://www.bto.org/understanding-birds/birdfacts (accessed 3.2.20).

Canessa, S., Sluijs, A.S. der, Stark, T., Allen, B.E., Bishop, P.J., Bletz, M., Briggs, C.J., Daversa, D.R., Gray, M.J., Griffiths, R.A., Harris, R.N., Harrison, X.A., Hoverman, J.T., Jervis, P., Muths, E., Olson, D.H., Price, S.J., Richards-Zawacki, C.L., Robert, J., Rosa, G.M., Scheele, B.C., Schmidt, B.R., Garner, T.W.J., 2020. Conservation decisions under pressure: Lessons from an exercise in rapid response to wildlife disease. Conservation Science and Practice 2, e141. https://doi.org/10.1111/csp2.141

Champely, S., Ekstrom, C., Dalgaard, P., Gill, J., Weibelzahl, S., Anandkumar, A., Ford, C., Volcic, R., Rosario, H.D., 2018. pwr: Basic Functions for Power Analysis.

Chawla, L., 2020. Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. People and Nature 2, 619–642. https://doi.org/10.1002/pan3.10128

Christensen, R.H.B., 2019. ordinal R package. https://cran.r-project.org/web/packages/ordinal/ordinal.pdf.

Christie, A.P., Amano, T., Martin, P.A., Petrovan, S.O., Shackelford, G.E., Simmons, B.I., Smith, R.K., Williams, D.R., Wordley, C.F.R., Sutherland, W.J., 2020. Poor availability of context-specific evidence hampers decision-making in conservation. Biological Conservation 248, 108666. https://doi.org/10.1016/j.biocon.2020.108666

Clayton, S., Litchfield, C., Geller, E.S., 2013. Psychological science, conservation, and environmental sustainability. Frontiers in Ecology and the Environment 11, 377–382. https://doi.org/10.1890/120351

Cocker, M., Mabey, R., 2005. Birds Britannica. Random House.

Cohen, J., 1992. Statistical Power Analysis. CDPS 1, 29–101. https://doi.org/doi:10.1111/1467-8721.ep10768783

Cook, C., Wardell-Johnson, G., Carter, R., Hockings, M., 2014. How accurate is the local ecological knowledge of protected area practitioners? Ecology and Society 19. https://doi.org/10.5751/ES-06341-190232

Cox, D.T.C., Gaston, K.J., 2016. Urban Bird Feeding: Connecting People with Nature. PLoS One 11. https://doi.org/10.1371/journal.pone.0158717

Davis, A., Wagner, J.R., 2003. Who Knows? On the Importance of Identifying “Experts” When Researching Local Ecological Knowledge. Human Ecology 31, 463–489. https://doi.org/10.1023/A:1025075923297

Daw, T.M., Robinson, J., Graham, N.A.J., 2011. Perceptions of trends in Seychelles artisanal trap fisheries: Comparing catch monitoring, underwater visual census and fishers’ knowledge. Environmental Conservation 38, 75–88. https://doi.org/10.1017/S0376892910000901

Downey, H., Amano, T., Cadotte, M., Cook, C.N., Cooke, S.J., Haddaway, N.R., Jones, J.P.G., Littlewood, N., Walsh, J.C., Abrahams, M.I., Adum, G., Akasaka, M., Alves, J.A., Antwis, R.E., Arellano, E.C., Axmacher, J., Barclay, H., Batty, L., Benítez-López, A., Bennett, J.R., Berg, M.J., Bertolino, S., Biggs, D., Bolam, F.C., Bray, T., Brook, B.W., Bull, J.W., Burivalova, Z., Cabeza, M., Chauvenet, A.L.M., Christie, A.P., Cole, L., Cotton, A.J., Cotton, S., Cousins, S.A.O., Craven, D., Cresswell, W., Cusack, J.J., Dalrymple, S.E., Davies, Z.G., Diaz, A., Dodd, J.A., Felton, A., Fleishman, E., Gardner, C.J., Garside, R., Ghoddousi, A., Gilroy, J.J., Gill, D.A., Gill, J.A., Glew, L., Grainger, M.J., Grass, A.A., Greshon, S., Gundry, J., Hart, T., Hopkins, C.R., Howe, C., Johnson, A., Jones, K.W., Jordan, N.R., Kadoya, T., Kerhoas, D., Koricheva, J., Lee, T.M., Lengyel, S., Livingstone, S.W., Lyons, A., McCabe, G., Millett, J., Strevens, C.M., Moolna, A., Mossman, H.L., Mukherjee, N., Muñoz-Sáez, A., Negrões, N., Norfolk, O., Osawa, T., Papworth, S., Park, K.J., Pellet, J., Phillott, A.D., Plotnik, J.M., Priatna, D., Ramos, A.G., Randall, N., Richards, R.M., Ritchie, E.G., Roberts, D.L., Rocha, R., Rodríguez, J.P., Sanderson, R., Sasaki, T., Savilaakso, S., Sayer, C., Sekercioglu, C., Senzaki, M., Smith, G., Smith, R.J., Soga, M., Soulsbury, C.D., Steer, M.D., Stewart, G., Strange, E.F., Suggitt, A.J., Thompson, R.R.J., Thompson, S., Thornhill, I., Trevelyan, R.J., Usieta, H.O., Venter, O., Webber, A.D., White, R.L., Whittingham, M.J., Wilby, A., Yarnell, R.W., Zamora, V., Sutherland, W.J., 2021. Training future generations to deliver evidence-based conservation and ecosystem management. Ecological Solutions and Evidence 2, e12032. https://doi.org/10.1002/2688-8319.12032

Dubois, N.S., Gomez, A., Carlson, S., Russell, D., 2020. Bridging the research-implementation gap requires engagement from practitioners. Conservation Science and Practice 2, e134. https://doi.org/10.1111/csp2.134

Evans, J.St.B.T., 2008. Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 59, 255–278. https://doi.org/10.1146/annurev.psych.59.103006.093629

Evans, M.C., Davila, F., Toomey, A., Wyborn, C., 2017. Embrace complexity to improve conservation decision making. Nature Ecology & Evolution 1, 1588–1588. https://doi.org/10.1038/s41559-017-0345-x

Fazey, I., Fazey, J.A., Salisbury, J.G., Lindenmayer, D.B., Dovers, S., 2006. The nature and role of experiential knowledge for environmental conservation. Environmental Conservation 33, 1–10. https://doi.org/10.1017/S037689290600275X

Fernández-Llamazares, Á., Díaz-Reviriego, I., Luz, A.C., Cabeza, M., Pyhälä, A., Reyes-García, V., 2015. Rapid ecosystem change challenges the adaptive capacity of local environmental knowledge. Global Environmental Change 31, 272–284. https://doi.org/10.1016/j.gloenvcha.2015.02.001

Fournier, A.M.V., White, E.R., Heard, S.B., 2019. Site-selection bias and apparent population declines in long-term studies. Conservation Biology 33, 1370–1379. https://doi.org/10.1111/cobi.13371

Fuller, R.A., Lee, J.R., Watson, J.E.M., 2014. Achieving Open Access to Conservation Science. Conservation Biology 28, 1550–1557. https://doi.org/10.1111/cobi.12346

Gaston, K.J., Soga, M., 2020. Extinction of experience: The need to be more specific. People and Nature n/a. https://doi.org/10.1002/pan3.10118

Grimm, P., 2010. Social Desirability Bias, in: Wiley International Encyclopedia of Marketing. American Cancer Society. https://doi.org/10.1002/9781444316568.wiem02057

Guerrero-Gatica, M., Aliste, E., Simonetti, J.A., 2019. Shifting Gears for the Use of the Shifting Baseline Syndrome in Ecological Restoration. Sustainability 11, 1458. https://doi.org/10.3390/su11051458

Hirsch, S.L., 2020. Anticipatory practices: Shifting baselines and environmental imaginaries of ecological restoration in the Columbia River Basin. *Environment and Planning E: Nature and Space, 3*(1), pp.40-57.

Huntington, H.P., 2000. Using traditional ecological knowledge in science: Methods and applications. Ecological Applications 10(5):1270-1274. 2000.

Jones, L.P., Turvey, S.T., Massimino, D., Papworth, S.K., 2020. Investigating the implications of shifting baseline syndrome on conservation. People and Nature 2, 1131–1144. https://doi.org/10.1002/pan3.10140

Kassambara, A., 2020. rstatix: Pipe-Friendly Framework for Basic Statistical Tests.

Knight, A.T., Cowling, R.M., Rouget, M., Balmford, A., Lombard, A.T., Campbell, B.M., 2008. Knowing But Not Doing: Selecting Priority Conservation Areas and the Research–Implementation Gap. Conservation Biology 22, 610–617. https://doi.org/10.1111/j.1523-1739.2008.00914.x

Kohl, M., 2020. MKpower: Power Analysis and Sample Size Calculation.

Kørnøv, L., Thissen, W.A.H., 2000. Rationality in decision- and policy-making: implications for strategic environmental assessment. Impact Assessment and Project Appraisal 18, 191–200. https://doi.org/10.3152/147154600781767402

Macdonald, B., 2019. Rebirding: Rewilding Britain and its Birds. Pelagic Publishing Ltd.

Miciak, J., Taylor, W.P., Stuebing, K.K., Fletcher, J.M., Vaughn, S., 2016. Designing Intervention Studies: Selected Populations, Range Restrictions, and Statistical Power. J Res Educ Eff 9, 556–569. https://doi.org/10.1080/19345747.2015.1086916

Miller, J.R., 2005. Biodiversity conservation and the extinction of experience. Trends in Ecology & Evolution 20, 430–434. https://doi.org/10.1016/j.tree.2005.05.013

Muldrow, M., Parsons, E.C.M., Jonas, R., 2020. Shifting baseline syndrome among coral reef scientists. Humanities and Social Sciences Communications 7, 1–8. https://doi.org/10.1057/s41599-020-0526-0

Natural England, 2021. Designated Sites View [WWW Document]. Designated Sites View Natural England home. URL https://designatedsites.naturalengland.org.uk/SiteSearch.aspx (accessed 4.9.21).

Newing, H.S., 2010. Conducting research in conservation: a social science perspective. Routledge, London and New York.

Osbaldiston, R., 2013. Synthesizing the Experiments and Theories of Conservation Psychology. Sustainability 5, 2770–2795. https://doi.org/10.3390/su5062770

Papworth, S., 2017. Decision-making psychology can bolster conservation. Nature Ecology & Evolution 1, 1217–1218. https://doi.org/10.1038/s41559-017-0281-9

Papworth, S.K., Rist, J., Coad, L., Milner-Gulland, E.J., 2009. Evidence for shifting baseline syndrome in conservation. Conservation Letters 2, 93–100. https://doi.org/10.1111/j.1755-263X.2009.00049.x

Pauly, D., 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology & Evolution 10, 430. https://doi.org/10.1016/S0169-5347(00)89171-5

Plumeridge, A.A., Roberts, C.M., 2017. Conservation targets in marine protected area management suffer from shifting baseline syndrome: A case study on the Dogger Bank. Marine Pollution Bulletin 116, 395–404. https://doi.org/10.1016/j.marpolbul.2017.01.012

Pullin, A.S., Knight, T.M., Stone, D.A., Charman, K., 2004. Do conservation managers use scientific evidence to support their decision-making? Biological Conservation 119, 245–252. https://doi.org/10.1016/j.biocon.2003.11.007
R Core Team, 2019. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.
Ripley, B., Venables, B., Bates, D.M., Firth, D., 2021. MASS: Support Functions and Datasets for Venables and Ripley's MASS.
Roman, J., Dunphy-Daly, M.M., Johnston, D.W., Read, A.J., 2015. Lifting baselines to address the consequences of conservation success. Trends in Ecology & Evolution 30, 299–302. https://doi.org/10.1016/j.tree.2015.04.003
Simons, D.J., Rensink, R.A., 2005. Change blindness: Past, present, and future. Trends in Cognitive Sciences 9, 16–20. https://doi.org/10.1016/j.tics.2004.11.006
Soga, M., Gaston, K., 2016. Extinction of experience: the loss of human–nature interactions. Frontiers in Ecology and the Environment 14, 22.
Soga, M., Gaston, K.J., 2018. Shifting baseline syndrome: causes, consequences, and implications. Front Ecol Environ 16, 222–230. https://doi.org/10.1002/fee.1794
Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S., 2015. Sustainability. Planetary boundaries: guiding human development on a changing planet. Science (New York, N.Y.) 347, 1259855. https://doi.org/10.1126/science.1259855
Sutherland, W.J., Pullin, A.S., Dolman, P.M., Knight, T.M., 2004. The need for evidence-based conservation. Trends in Ecology & Evolution 19, 305–308. https://doi.org/10.1016/j.tree.2004.03.018
Sutherland, W.J., Wordley, C.F.R., 2017. Evidence complacency hampers conservation. Nature Ecology & Evolution 1, 1215–1216. https://doi.org/10.1038/s41559-017-0244-1
Thurow, R.F., Copeland, T., Oldemeyer, B.N., 2019. Wild salmon and the shifting baseline syndrome: application of archival and contemporary redd counts to estimate historical Chinook salmon (Oncorhynchus tshawytscha) production potential in the central Idaho wilderness. Can. J. Fish. Aquat. Sci. 77, 651–665. https://doi.org/10.1139/cjfas-2019-0111
Thurstan, R.H., Buckley, S.M., Ortiz, J.C., Pandolfi, J.M., 2016. Setting the Record Straight: Assessing the Reliability of Retrospective Accounts of Change. Conservation Letters 9, 98–105. https://doi.org/10.1111/conl.12184
Treswell Wood, 2021. Treswell Wood Integrated Population Monitoring Group [WWW Document]. Treswell Wood Integrated Population Monitoring Group. URL https://www.treswellwoodipmg.org (accessed 2.9.21).
Turvey, S.T., Barrett, L.A., Yujiang, H.A.O., Lei, Z., Xinqiao, Z., Xianyan, W., Yadong, H., Kaiya, Z., Hart, T.O.M. and Ding, W., 2010. Rapidly shifting baselines in Yangtze fishing communities and local memory of extinct species. Conserv Biol. 24(3), 778-787.
Walsh, J.C., Dicks, L.V., Sutherland, W.J., 2015. The effect of scientific evidence on conservation practitioners' management decisions. Conserv Biol 29, 88–98. https://doi.org/10.1111/cobi.12370
Wilson, K.A., Auerbach, N.A., Sam, K., Magini, A.G., Moss, A.S.L., Langhans, S.D., Budiharta, S., Terzano, D., Meijaard, E., 2016. Conservation Research Is Not Happening Where It Is

Most Needed. PLOS Biology 14, e1002413. https://doi.org/10.1371/journal.pbio.1002413
Woodward, I.D., Massimino, D., Hammond, M.J., Harris, S.J., Leech, D.I., Noble, D.G., Walker, R.H., Barimore, C., Dadam, D., Eglington, S.M., Marchant, J.H., Sullivan, M.J.P., Baillie, S.R., Robinson, R.A., 2018. BirdTrends 2018: trends in numbers, breeding success and survival for UK breeding birds (No. 708), Birdtrends. BTO, Thetford, UK.
Wu, T., Petriello, M.A., Kim, Y.-S., 2011. Shifting Baseline Syndrome as a Barrier to Ecological Restoration in the American Southwest. Ecological Restoration 29, 213–215. https://doi.org/10.3368/er.29.3.213
Zelenski, J.M., Nisbet, E.K., 2014. Happiness and Feeling Connected: The Distinct Role of Nature Relatedness. Environment and Behavior 46, 3–23. https://doi.org/10.1177/0013916512451901
Zhang, Z., Mai, Y., Yang, M., 2018. WebPower: Basic and Advanced Statistical Power Analysis.