

Alignment of ordinal and quantitative species abundance and size indices for the detection of shifting baseline syndrome

PHIL O'B. LYVER ^{1,3}, PUKE TIMOTI,² SARAH J. RICHARDSON ¹ AND ANDREW M. GORMLEY¹

¹Manaaki Whenua Landcare Research, PO Box 69040, Lincoln 7640 New Zealand

²Tūhoe Tuawhenua Trust, Private Bag 3001, Ruatāhuna, via Rotorua, New Zealand

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Abstract. Loss of knowledge about historical environmental conditions and species' abundances threatens how new generations potentially perceive their environment and take action. The intergenerational shift in perceptions of environmental thresholds is a phenomenon frequently termed *shifting baseline syndrome* (SBS). The goals of this study were (1) to determine relationships between ordinal scores (e.g., few, many) and quantitative measures (e.g., estimates of population size) used by members of a Māori community in New Zealand to score indicators for understanding the abundance of forest resources, and (2) to then analyze these relationships according to people's age to detect the effects of SBS and the rate that this shift was occurring for each indicator. We detected consistent relationships between the ordinal scores and quantitative measures for six forest indicators provided by community members. However, there was only a high degree of confidence about the direction of the age effect for three abundance indicators (Kererū [New Zealand Pigeon], *Hemiphaga novaeseelandiae*, 15% increase [CI = 5.1–27.1%] in flock size for any given ordinal category for each decade increase in age; long-finned eel, *Anguilla dieffenbachia*, 30% decrease [CI = –45.1% to –11.3%] in the distance (m) walked along a riverbank between observations of an eel for any given ordinal category for each decade increase in age; and Australian brush-tailed possum, *Trichosurus vulpecula*, 27% decrease [CI = –38.9% to –13.9%] in the distance (m) walked through forest between observations of possum sign for any given ordinal category for each decade increase in age), but the effect was statistically strong for all three. The decoupling of indigenous peoples and local communities (IPLC) from their traditional lands and biodiversity by an array of political, environmental, social and economic drivers and feedback mechanisms have contributed to and exacerbated the conditions for SBS. However, the protection of customary practices to engage with the environment, including the harvest of natural resources, community-based environmental monitoring initiatives, and cultural immersion education programs offer opportunities for IPLC to mitigate the often deleterious effects of SBS.

Key words: forest; indicators; indigenous peoples; monitoring; shifting baselines syndrome.

INTRODUCTION

Global biodiversity losses due to human activities have been more rapid in the past 50 yr than at any time in human history (MEA 2005, Brown et al. 2015, IPBES 2019). In response to international goals and commitments to sustainability (e.g., Convention on Biological Diversity 1992 Aichi Targets; IPBES 2012), governments are increasingly establishing monitoring and reporting schemes to understand spatial and temporal changes in the biophysical environment and associated human well-being (Sterling et al. 2017). These schemes are being used to develop management interventions and to allocate fiscal and human resources (Ministry for the

Environment and Stats NZ 2019). However, our capacity to understand changes in the biophysical environment and human well-being relies on reliable, robust, and systematic data collection systems that deliver relevant, meaningful, and cost-effective information. These data collection systems are a critical part of the monitoring—management cycle because they allow managers to determine the outcomes of management interventions by tracking change across time and space (Hewitt et al. 2005, Lee et al. 2005, Parry and Peres 2015).

Ecological indicators based on western science (e.g., size class structure of a threatened tree species) are predominant features of monitoring and reporting schemes used to understand environmental change, but increasingly, a wider range of indicators, including those used by Indigenous Peoples and Local Communities (IPLC), are being recognized and adopted (Sutherland et al. 2013). IPLC knowledge and approaches bring added

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³ E-mail: lyverp@landcareresearch.co.nz

dimensions of values and cultural settings to monitoring that provide opportunities to connect a wider section of society with the environment through a “biocultural lens” (Ens et al. 2015, McCarter et al. 2018, DeRoy et al. 2019, Hill et al. 2020). Impressions formed by IPLC about the state of the environment are formed either directly through interaction with a natural resource (e.g., harvest), or general observations as individuals travel on the land- or seascape (Moller et al. 2004). Monitoring and evaluation by IPLC are often done using language concepts and ordinal scores (e.g., few, many, too many; Lyver et al. 2018), but these systems can be vulnerable to intergenerational shifts in how individuals perceive, experience, and remember past natural resource state (Hellier et al. 1999, Lund et al. 2010, Soga and Gaston 2018). Persistent gradual changes in the environment can mean that the reference point used by one generation to determine change in a resource will differ significantly from the next generation. This concept has been termed “shifting baseline syndrome” (SBS) or “ecological amnesia” (Pauly 1995, Seidensticker 2008). In this, the lack of experience, knowledge, contact with others in your community, and/or recollections of past state or condition create new accepted norms for the natural environment and difficulty with inferring the extent of long-term environmental changes (Soga and Gaston 2018).

Oral transmission of knowledge within IPLC can buffer against large-scale shifts in memories of environmental baselines (Jardine 2019). However, tracking change or recognizing shifts in baselines at finer temporal scales requires regular interaction with the environment by community members so that they can constantly form, validate, and update their impressions of indicators. Moreover, if fewer community members are interacting with the natural environment on a less frequent basis, this can exacerbate shifts in environmental baselines, despite mechanisms for the intergenerational transfer of knowledge. As a result, with persistent global biodiversity loss and environmental deterioration, there is an increasing body of evidence demonstrating that younger generations are less aware of what has been lost than older generations (Sáenz-Arroyo et al. 2005, Ainsworth et al. 2008, Alessa et al. 2008, Katikiro 2014).

In this study, our objective was to determine whether there had been an intergenerational shift in how the abundance or body size of forest species was measured by members of a Māori community in New Zealand. For this, we (1) determined relationships between language concepts, hereafter referred to as ordinal scores (e.g., few, many, a lot) and quantitative measures (e.g., estimates of population size) used by community members to score indicators for understanding the abundance of forest resources; and (2) then analyze these relationships according to people’s age to detect the effects of SBS and the rate that this shift was occurring for each indicator. The community had expressed interest in developing an ordinal indicator-based monitoring

system to track forest and community well-being (Lyver et al. 2018). However, local forest managers and community members were concerned about the effect that a diminishing pool of knowledge through the loss of elders and declining regularity of interaction with the forest would have on the way the community understood and assessed the indicators out into the future. By addressing our two study goals, we sought to test for and understand SBS in this community, and identify mitigating measures to safeguard against the loss of historical ecological knowledge.

METHODS

Study area and background

We worked with Tuawhenua Māori from the community of Ruatāhuna located within the Te Urewera ranges in the North Island, New Zealand. Tuawhenua is part of the larger Tūhoe tribe, an indigenous Māori group whose traditional territory largely overlaps with the heavily forested Te Urewera mountain ranges in the North Island of New Zealand (Fig. 1; Binney 2009). Most Tūhoe (~80%), including those of Tuawhenua descent, now live outside their traditional territory (Nikora et al. 2004), with the rest in small, isolated villages. Ruatāhuna has about 72 households clustered around 10 marae (traditional meeting places) established by eight different, but related, sub-tribes within the heart of this region (Morunga and Tahi 2013).

Ruatāhuna is surrounded by mixed, oceanic temperate rain forest (McGlone et al. 2016) owned by the people of the Tuawhenua, with most blocks vested in the Tūhoe Tuawhenua Trust.

Forest canopies on Tuawhenua lands are dominated by evergreen angiosperms and conifers in the Podocarpaceae, with a subcanopy of tree ferns, and a diverse understorey of ferns. Selective logging between 1950 and 1975 by a private forestry company removed a large proportion of these conifers (>30 m height, >1 m stem diameter), particularly those found on alluvial terraces and accessible toe slopes. However, post-logging recovery of the Tuawhenua forests has been slow, and the regeneration of conifers poor, with forests becoming dominated by tree ferns (e.g., *Dicksonia squarrosa*) and shade-tolerant angiosperms, particularly tawa (Carswell et al. 2007). The rivers and forests around Ruatāhuna provide the community with a valued source of native and introduced plants and animals for food (kai), traditional medicine (rongōā), building, clothing, weaving (raranga), and carving materials (whakairo), firewood, and cultural, recreational and commercial activities. The hunting (e.g., red deer, *Cervus elaphus*; rusa deer, *Rusa timorensis*; feral pig, *Sus scrofa*) and commercial trapping (e.g., Australian brushtail possum, *Trichosurus vulpecula*, hereafter referred to as possums) of some introduced species are also highly valued as sources of protein and income through fur markets and guided

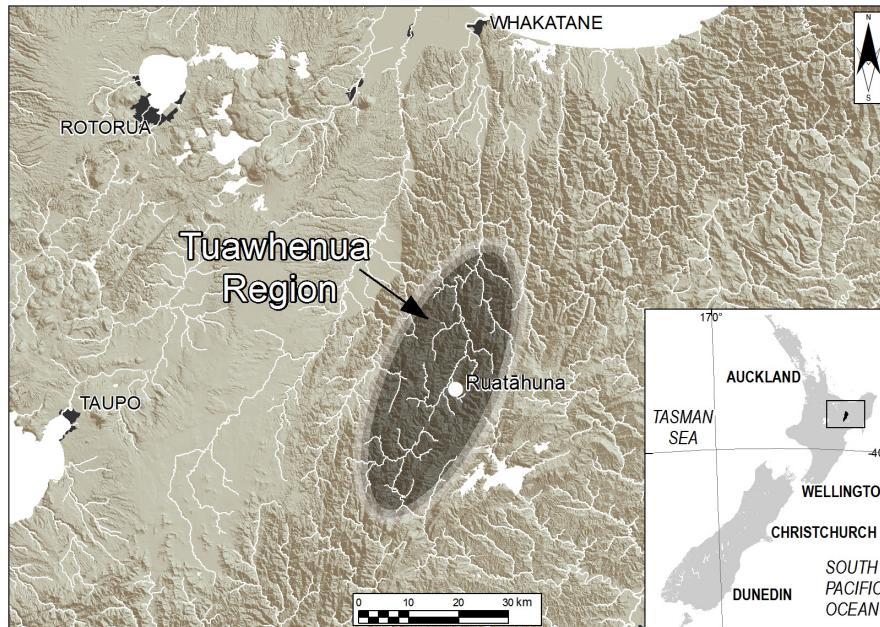


FIG. 1. Location of the Tuawhenua region and community of Ruatāhuna within the Te Urewera mountain range, New Zealand.

hunting. Local economic developments in and around the forest include eco-tourism specializing in guided treks and honey production (e.g., mānuka *Leptosurmum scoparium*; tāwari, *Ixerba brexioides*; and rewarewa, *Knightsia excelsa*).

Data collection

We initially selected 36 indicators and their ordinal categories of forest structure and aural cues and species abundance, density, and size from previous interviews conducted with the Tuawhenua community (Lyver et al. 2017). The indicators were selected based on species or attributes of the forest that Tuawhenua frequently observed, heard, encountered, and/or harvested. To be selected, each indicator had to use a gradient of ordinal categories that were quantifiable and easily repeatable. Indicators that could be applied during “observational” surveys without the harvest of a species were also prioritized because conservation and wildlife laws in New Zealand prohibit the customary harvest of many native species (e.g., Kererū, New Zealand Pigeon, *Hemiphaga novaeseelandiae*), and limit opportunities to interact with the species using harvest-based methods. A glossary of ordinal categories was developed based on how the indicators were described by respondents in the interviews. As a result, the states of some indicators were described using four ordinal categories while others were described using seven categories.

To further refine the number of indicators on which to focus the study, pilot interviews were conducted with six Tuawhenua respondents (four women and two men; age range 44–80 yr; mean interview time = 58 minutes) to

assess the quantifiability of ordinal categories for each indicator. Initially, as an introduction, each respondent was asked about their relationship with the forest, the regularity of their visits, and their purpose for visiting the forest. Questions then became more directed about their familiarity with each of the indicators, and how they would describe the abundance, density, or size of that indicator. Prior descriptions of ordinal categories (Lyver et al. 2017) were used by the interviewer to provide prompts to the respondent for quantitative measures that described the state of the indicator. Not all respondents provided information for every indicator. Also, all the respondents only provided quantitative measures for one or two ordinal categories for any given indicator.

From the pilot survey, 23 indicators (Appendix S1) were selected and surveys conducted with 43 respondents (11 women and 32 men; age range 25–81 yr) between September 2017 and March 2018. Again, each respondent was first asked about their familiarity with each indicator, and how they understood its state using ordinal categories. If each respondent referred to an ordinal category for an indicator, they were then asked to provide a quantitative measure for that category. If respondents demonstrated familiarity with an indicator, interviewers would provide ordinal category options for the respondent to align quantitative measures. Ordinal categories that were assigned two or more quantitative measures by the respondent were averaged. Surveys with each respondent resulted in a data set for indicators comprising ordinal category scores and corresponding quantitative measures (Table 1). Again, based on response rates of respondents and those indicators with

the greatest number of quantitative measures recorded against ordinal categories, six indicators were selected for analysis (Table 2).

A range of measures were used to estimate quantitative measures for ordinal categories. Flock sizes were used to estimate the abundance of Kererū; the number of calls heard while standing at one site for 10 minutes was used to estimate North Island Brown Kiwi (*Apteryx mantelli*) abundance; the distance (m) walked along a riverbank between observations of long-fin eels (*Anguilla dieffenbachia*; hereafter referred to as eels); the distance (m) between mauku (hen and chicken fern, *Asplenium bulbiferum*); and the distance (m) walked through forest between observations of possum sign were used to measure abundances in those three species. A range of human anatomical features and everyday household items were used to estimate the diameter of the widest point of eels (Table 3). These human anatomical features and household items were measured by researchers to obtain the diameter in millimeters.

Data analysis

For each indicator, the quantitative measures were analyzed using a linear mixed-effects model with the log of the quantitative measure as the response variable and

TABLE 1. The number of ordinal categories each respondent scored for each of the six indicators.

Indicators	No. categories scored				
	1	2	3	4	7
Kererū abundance					
No. respondents	1	17	10	11	2
Kiwi abundance					
No. respondents	9	12	12		
Eel abundance					
No. respondents	9	14	2		
Eel diameter					
No. respondents	14	7	5		
Mauku abundance					
No. respondents	10	14	1	1	
Possum abundance					
No. respondents	16	7	3		

Note: Indications are Kererū (New Zealand Pigeon, *Hemiphaga novaeseelandiae*) abundance; North Island Brown Kiwi (*Apteryx mantelli*) abundance; long-finned eel (*Anguilla dieffenbachia*) abundance; mauku (hen and chicken fern, *Asplenium bulbiferum*) abundance; and Australian brush-tailed possum, (*Trichosurus vulpecula*) abundance.

TABLE 2. Delta AIC scores for four candidate models for each of the six indicators.

Species	Null	Ordinal	Age	Ordinal + Age
Kererū abundance	200.8	3.7	195.9	0.0
Kiwi abundance	79.3	0.5	77.9	0.0
Eel abundance	60.9	4.3	58.5	0.0
Eel diameter	37.4	0.0	37.7	1.2
Mauku abundance	82.2	0.9	83.7	0.0
Possum abundance	39.5	8.7	37.2	0.0

Note: Delta AIC is defined as the difference between AIC values for all candidate models and the model with the lowest AIC, for each separate indicator.

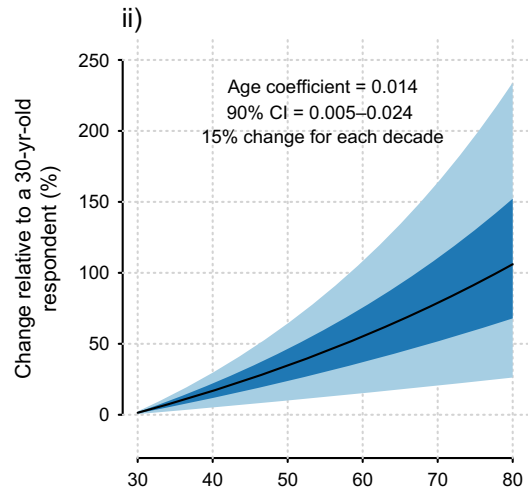
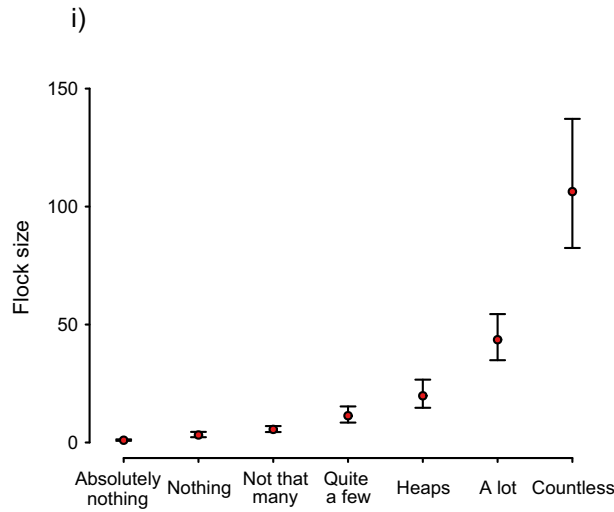
TABLE 3. Examples of human anatomical features and objects and their associated measures used by Tuawhenua respondents to gauge the diameter of long-finned eels (*Anguilla dieffenbachia*) at their widest point.

Object description for eel diameter	Approximate diameter (mm)
One finger, adult male	20
Two fingers, adult male	40
Three fingers, adult male	60
Wrist, adult male	70
Can of peaches	75
Closed fist, adult male	80
1.5 Coke bottle	90
2-L milk bottle	100
Forearm, adult male	100
Dog sausage roll	110
Calf muscle, adult male	110
Milo tin (900 g)	130
Length of a BIC ballpoint pen	130
Large enamel cup	150
Car tire inner tube	190
Thigh, adult male	200
Camp oven, Campmaid 12 quart	380

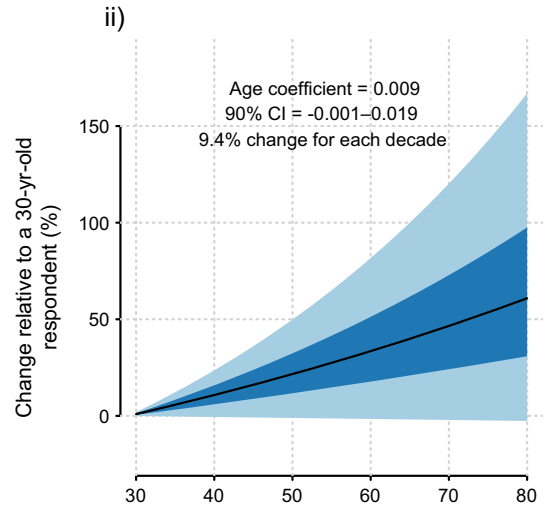
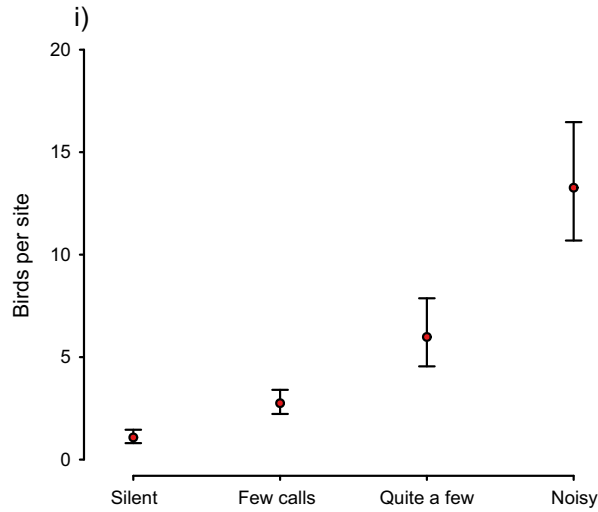
individual respondent included as a random effect. Four models were fitted for each indicator: an age-only model, an ordinal-only model, a full model that included the age of the respondent and the ordinal category, and a null model (i.e., just the random effect of individual). Models were compared with the Akaike information criterion (AIC) to find the most parsimonious model for each indicator. For model with the ordinal variable, we preserved the ordinal structure of the score rather than treating them as continuous or categorical. Models were fitted in R 3.6.0 (R Core Team 2019) using the function lmer from the package lme4 (Bates et al. 2015). Predictor

FIG. 2. Predicted relationship from Ordinal + Age model for selected species abundance or size: (i) modeled relationship between ordinal category and quantitative measure of selected species abundance or size (the red dot and vertical whiskers indicate the median and the 90% confidence interval [CI], respectively); and (ii) percentage change in quantitative measure relative to age 30, for ages 30–80 yr (the dark blue shaded area indicates the 25% and 75% CI, the light blue shaded areas indicates the 5%, and 95% CI). The quantitative measures are (a) Kererū (New Zealand Pigeon, *Hemiphaga novaeseelandiae*) flock size, (b) Kiwi (*Apteryx mantelli*) calls per site per 10 minutes, (c) long-finned eel (*Anguilla dieffenbachia*) distance (m) of river walked per eel observed, (d) long-finned eel (*Anguilla dieffenbachia*) diameter (mm), (e) Mauku (hen and chicken fern, *Asplenium bulbiferum*) distance (m) between plants, (f) Australian brushtail possum (*Trichosurus vulpecula*) distance (m) between possum sign encountered.

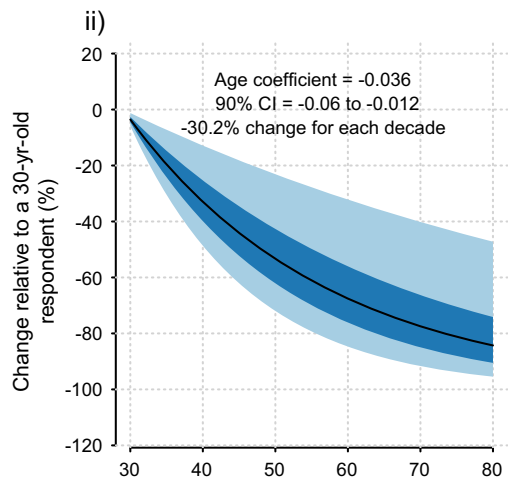
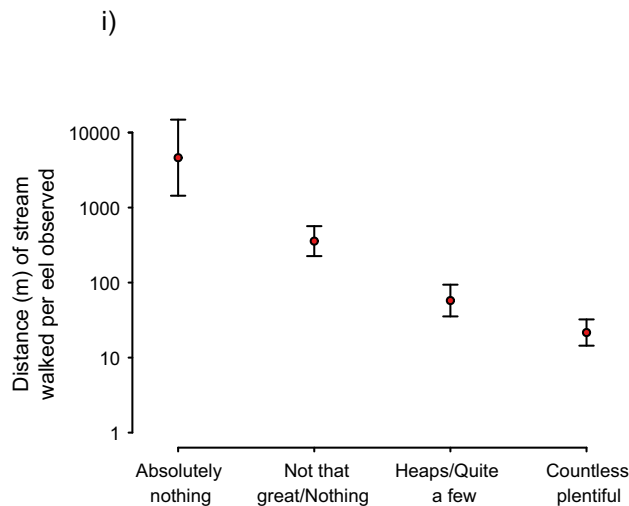
a) Kererū abundance



b) Kiwi abundance



c) Eel abundance



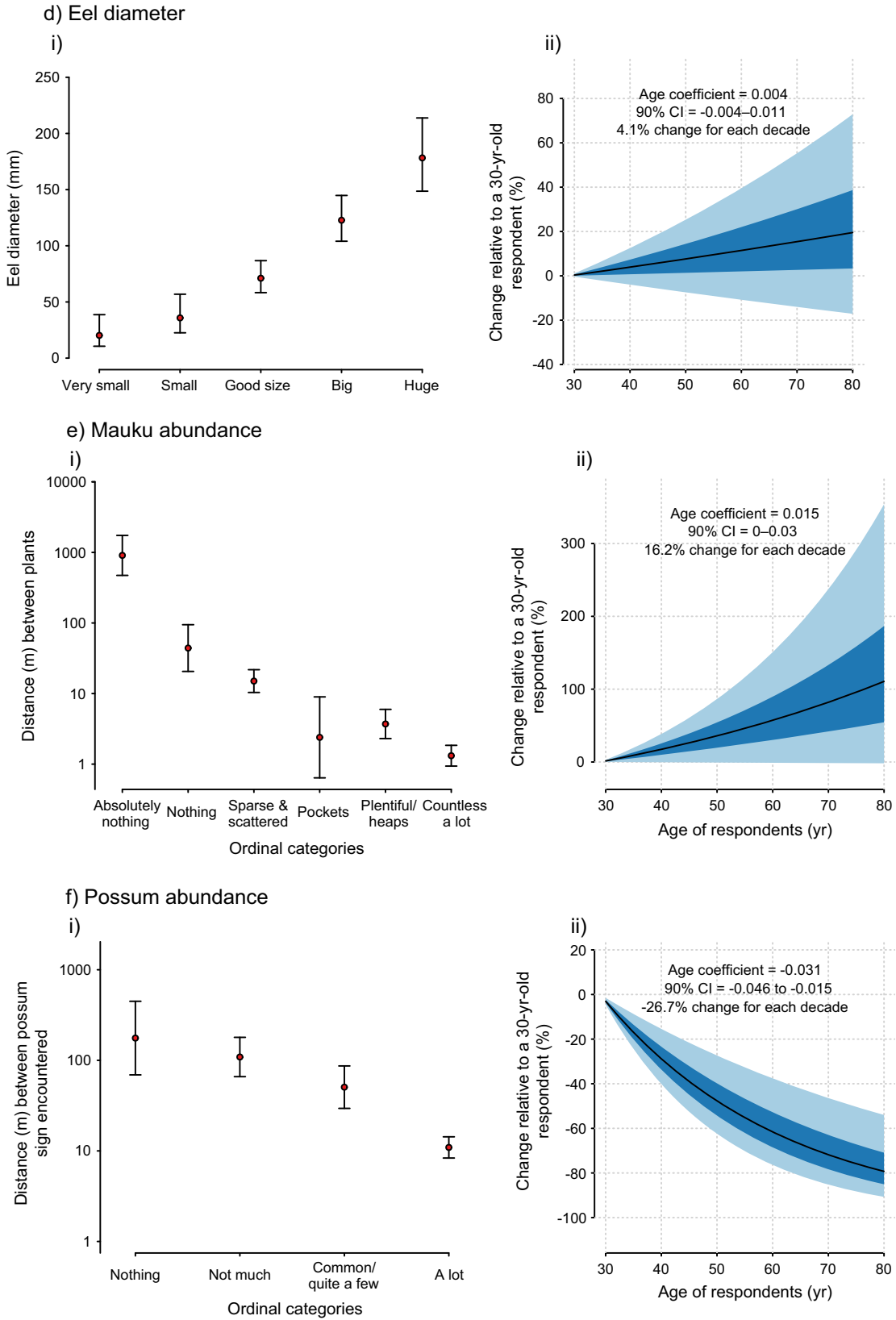


FIG. 2. Continued

effects were calculated using the function `predictorEffects` from the package `effects` (Fox and Weisberg 2019). All confidence intervals (CI) were specified at 90% coverage due to the 5% tails of the distribution being more stable especially considering the relatively small sample size (McElreath 2015).

To compare the effect of a “shifting baseline” among indicators, we used the Ordinal + Age model. We converted the coefficient associated with age to reflect the percentage change for each 10-yr increase in age (θ) defined as

$$\theta = \left(\exp(\beta_{\text{Age}})^{10} - 1 \right) \times 100.$$

We specified an equivalence interval (McBride et al. 2013) of $\pm 5\%$ with the 10-yr increase in age to reflect an “important” difference. Specifying an equivalence interval has an advantage over the null hypothesis significance test as it allows us to differentiate between those statistically significant differences that are inconsequential (in this case a difference of less than $\pm 5\%$), and those that are considered biologically or ecologically important.

RESULTS

Model selection

For all indicators, the two models that included the ordinal score had AIC values that were at least 30 points lower than models that did not (Table 2), indicating that there were strong relationships between the ordinal scores and quantitative measures for each indicator (Fig. 2a–f(i)). The Ordinal + Age model had the lowest AIC for five of the six indicators and differed by $\Delta\text{AIC} = 1.2$ for the sixth (Table 2). However Ordinal only and Ordinal + Age had very similar AIC scores

(i.e., $\Delta\text{AIC} < 2$) for three indicators, moderately similar scores for two indicators (i.e., ΔAIC between 2 and 5), with only the models for possum abundance strongly favoring the Ordinal + Age model over the Ordinal only model (Table 2).

Determining the effect of shifting baseline

For each indicator, the relationship between all the ordinal categories and quantitative measures were consistent within respondents. For example, for the Kererū flock size indicator, a given respondent that scored the ordinal category “A lot” always assigned a larger flock size than the ordinal category “Not that many.” However, among respondents there were differences in the relationships between ordinal categories and quantitative measures. For example, respondent A may have assigned a larger flock size to the category “Not that many” while respondent B may have assigned it to “A lot.”

For Kererū abundance, each decadal increase in respondent age corresponded to a 15% increase (CI = 5.1–27.1%) in the quantitative measure for any given ordinal category (Fig. 2a(ii)). This result gives a high degree of confidence in the direction of change, as well as the importance of the difference (i.e., the lower limit of the confidence interval is outside our predefined equivalence interval of $\pm 5\%$; Fig. 3).

For Kiwi abundance, each decadal increase in respondent age corresponded to a 9% increase (CI = -1.0 –20.9%) in the quantitative measure for any given ordinal category (Fig. 2b(ii)). This result gives only a low degree of confidence in the direction of change, as well as the importance of the difference (i.e., much of the confidence interval includes the equivalence interval; Fig. 3).

For eels, the pattern was mixed. For eel abundance, each decadal increase in respondent age corresponded to a 30% decrease (CI = -45.1% to -11.3%) in the

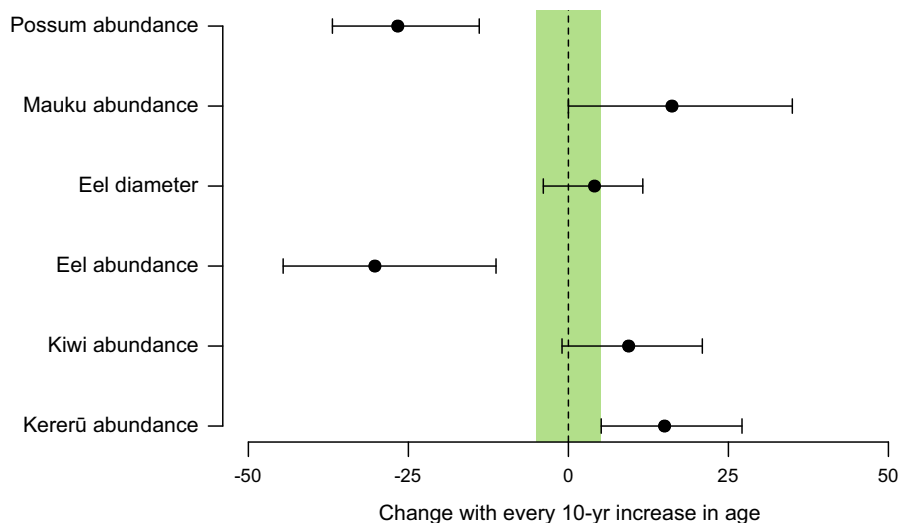


FIG. 3. Coefficients (mean and 90% CI) of the age effect converted to percentage change with every 10-yr increase in age from the Ordinal + Age model for each indicator. The green shaded area indicates the equivalence interval ($\pm 5\%$).

quantitative measure for any given ordinal category (Fig. 2cii). This result gives a high degree of confidence in the direction of change, as well as a very high degree of confidence in the importance of the difference (i.e., the lower limit of the confidence interval is outside our predefined equivalence interval of $\pm 5\%$ and exceeds $\pm 10\%$, Fig. 3). For eel diameter, however, each decadal increase in respondent age corresponded to a 4% increase (CI = -3.9 – 11.6%) in the quantitative measure for any given ordinal category (Fig. 2dii). This result gives no confidence in the direction of change, nor in the importance of the difference (i.e., the confidence interval includes nearly the entire equivalence interval; Fig. 3).

For mauku abundance, each decadal increase in respondent age corresponded to a 16% increase (CI = 0.0 – 35.0%) in the quantitative measure for any given ordinal category (Fig. 2eii). This result gives a high degree of confidence in the direction of change, but not in the importance of the difference (i.e., the confidence interval includes much of the equivalence interval; Fig. 3).

For possum abundance, each decadal increase in respondent age corresponded to a 27% decrease (CI = -38.9% to -13.9%) in the quantitative measure for any given ordinal category (Fig. 2fii). This result gives a very high degree of confidence in the direction of change, as well as a very high degree of confidence in the importance of the difference (i.e., the lower limit of the confidence interval is outside our predefined equivalence interval of $\pm 5\%$, and even exceeds $\pm 10\%$; Fig. 3).

DISCUSSION

We found clear evidence for shifting baseline syndrome in a suite of indicators used by a Māori community who live within a forested ecosystem. We detected consistent relationships between ordinal scores and quantitative measures for all six forest indicators provided by Tuawhenua respondents, and strong evidence for an age effect on three of these indicators (Kererū, eel, and possum abundances). For Kiwi and mauku abundance, there a moderate degree of confidence about the direction of the age effect, however, we cannot be sure of the importance of the effect. For eel diameter, there is not enough data to be sure of any age effect or its importance.

Interpreting shifts in baselines

The overall pattern observed in this study was that for any ordinal score, older respondents have a higher abundance in mind. Perhaps the most striking example captured in this study came from Kererū, a bird species that is highly treasured by Tūhoe Tuawhenua. Few of the younger Tuawhenua respondents could comprehend the size and scale of the Kererū flocks that congregated in Te Urewera during the toromiro fruiting season prior to the 1950s. In fact, few people remained in the Ruatāhuna community that had observed the sun being shrouded

by Kererū flocks as they flew overhead; or experienced the noise of flocks approaching as if it was a passenger jet or wind storm coming up the valley; or witnessed the violent thrashing and breaking of branches as flocks of Kererū alighted into the forest canopy; or the forest canopy taking on the appearance of being dusted by snow from the white breast feathers of countless Kererū settling onto the outer branches; or the constant rain of guano down through canopy from the multitude of Kererū perched in the canopy above (Lyver et al. 2008). Confronted by these flocks, Tuawhenua hunters would describe the *wehi* (awe, reverence, or fear) of the experience where hair on their heads would stand erect. This was represented in the *ihi*, which described the vitality or energy of the forest (Timoti et al. 2017). Similarly, but at a larger scale, observers described a single flock of Passenger Pigeons (*Ectopistes migratorius*) passing over Cincinnati on the Ohio River, USA in 1870 as being “one mile wide and 320 miles long, containing an estimated two billion birds” (Davis 2018). Earlier accounts from that century described flocks of passenger pigeons as “blocking the light of the noonday sun as it was obscured by an eclipse”; “roosting and nesting sites where trees two feet in diameter broken off at the ground by the weight of birds”; “dung so deep on the forest floor that it was mistaken for snow”; and the “noise of the birds taking flight to that of a gale, the sound of their landing to thunder” (Davis 2018). Historical accounts of hyper-abundance of biodiversity are common around the world (Seton 1927, Soper 1941, Matthiessen 1978, Hamilton 2007), however, for many generations, it is difficult to comprehend this level of biological abundance and productivity. Loss of species and declines in populations represent profound shifts in human–environment interactions, but also point toward pervasive and substantial changes in many inter-related biophysical processes. For example, Tuawhenua elders linked changes in the browse patterns of Kererū to delays and greater unpredictability in the ripening of some tree fruits (e.g., toromiro, *Podocarpus ferrugineus*) caused by increased climatic variability and warming (Lyver et al. 2008). In the Kererū example above, while the indicator is focused on the abundance of the bird, and how Kererū abundance has clearly shifted in the last century, it also carries subsumed information about diminished or lost seed dispersal and tree regeneration processes (Kelly et al. 2010); tree nutrient cycling through guano and canopy disturbance and forest litterfall rates; and interactions between Kererū and their array of competitors, parasites, and predators (Valiente-Banuet et al. 2015, Ceballos et al. 2017). In this regard, not only is there intergenerational diminishment of understanding around the abundances of species, but also a reduced capacity of IPLC to link the species with ecological processes and/or formulating hypotheses relating to the species or environment (Lyver et al. 2019).

The method that community members use to “quantify” a gradient of ordinal scores is also important to

consider. Changes in the abundance of a species were not always expressed as increases or decreases in the number of a species, but rather indirect methods of measurement. For example, changes in eel and possum abundance were better understood as whole numbers such as the distance (e.g., 100 m per eel observed) walked along the riverbank or traversed through a forest, respectively, rather than fractional numbers of an organism (e.g., 0.01 eels per meter). It was important that these indicators and ordinal scores were described and presented to the community in a way that related to their experiences and their way of knowing. Additionally, respondents quantified eel diameter using human anatomical features and objects used in everyday life (Table 3). While these provide a relatively standardized unit of measure for eel diameter, the lack of evidence for an intergenerational shift in how this indicator is assessed was attributed to the longevity of eels, and the difference between witnessing a full breadth of abundances vs. the full breadth of possible sizes for an animal. While the abundance of eels may have declined, there was still the opportunity for younger generations to observe very large individuals in some remote lakes or stretches of rivers, and therefore have an understanding of how to describe a very large eel. A parallel would be very large trees; while many people may encounter isolated individuals of very large trees, it is much less likely that they will encounter multiple stands of very large trees (Blicharska and Mikusiński 2014).

Factors creating conditions for shifting baseline syndrome in IPLC

Arguably, factors that create conditions for the emergence of shifting baseline syndrome in IPLC can be aligned with three major causes described in Soga and Gaston (2018): (1) lack of data on the natural environment; (2) loss of interaction with the natural environment; and (3) a lack of familiarity with the natural environment. IPLC rely heavily on the use of natural resources to gauge, interpret, and respond to new and changing environmental conditions (Berkes et al. 2000, Holling and Gunderson 2002). Furthermore, the transmission of intergenerational Indigenous and local knowledge (ILK, defined as a “body of knowledge, practice and belief, evolving by adaptive processes and handed down through generation by cultural transmission . . .”; Berkes 2012) about the state of the environment relies heavily on the engagement of IPLC with nature. Similarly, community-based monitoring systems require regular interaction with the environment, and regular interactions among generations and other members of their community, so that ordinal methods for perceiving environmental state can be reinforced, cross-checked, and updated. The decoupling of IPLC from their traditional lands and biodiversity by an array of political, environmental, social, and economic drivers and feedback mechanisms (Tang and Gavin 2016) have

provided the ideal conditions for SBS to establish and thrive (Pauly 1995, Soga and Gaston 2018, Jardine 2019). Moreover, these drivers inhibit the capacity of resource users to update and affirm how particular ordinal scores relate to specific abundances and densities and, importantly, limit the capacity of knowledge holders to transmit knowledge about changing environmental condition and how to perceive and measure it. Deterioration in processes for gauging elements in the environment can occur rapidly, within a generation, once isolation or disconnection from their environment and the IPLC occurs. Indigenous and local knowledge is commonly transferred through observation, practice, and experience (Berkes 2012), therefore, isolation from the environment or opportunities to engage in customary practices by IPLC can also have the effect of fixing knowledge in time, including methods for measuring the state of the environment. Cumulatively, the loss of knowledge holders, which can be especially acute for IPLC who often have a lower life expectancy, and increased time out of context, can result in the intergenerational loss of knowledge. These factors can also prevent ordinal scoring systems used to measure change from being appropriately updated and transmitted through socioecological processes (McCarter et al. 2014). As a result, the ability to recognize the extent of environmental degradation may be lost when the degraded state becomes perceived and accepted as “the new norm” resulting in ecological amnesia.

Drivers such as colonialism in new settler states have commonly resulted in the imposition of another culture’s laws, which have eroded local cultural institutions (Jones 2016) and undermined IPLC connections with the environment. In countries like New Zealand, Australia, and Canada, conservation and wildlife laws have instituted prohibitions and/or restrictions relating to the use of native biodiversity and occupation of traditional customary landscapes. The introduction of these policies criminalized IPLC for accessing traditional lands and using customary resources (Gombay 2014), which forced a dislocation from their local environments. These new conservation laws imposed by Eurocentric governments restricted how IPLC interacted with their environment and contributed to an “extinction of experience” (Millar 2005). As a result, colonial legal processes have reduced the responsiveness and resilience of ILK, which manifests in a shift in how IPLC measure and understand resource abundance and density. Increased sedentarization and urbanization of IPLC away from traditional lands over the last half century (Robson and Berkes 2011) has also added to this dislocation and loss of understanding about historical state of the environment. This has been compounded by changing expectations about what constitutes a healthy environment, an increased tolerance for a degraded environment, and complacency around initiatives to restore it (Gorenflo et al. 2012, Sutherland and Wordley 2017).

A loss of biodiversity in a local area can foster the establishment of feedbacks that reduce the inclination of younger generations in first-world countries to interact with the environment. Such feedbacks can be rapidly exacerbated by alternate foods, materials, and leisure-time experiences, such as virtual activities (Ballouard et al. 2011, Soga and Gaston 2016). In many instances, it can be quicker, easier, and cheaper to acquire food from stores or markets, rather than harvesting wild foods (Kuhnlein and Receveur 1996). Over time, this can result in a changing palate and a reduced desire to acquire traditional foods and the experience that accompanies those activities. Contamination of plants and animals with heavy metals or organic pollutants can diminish the consumptive appeal of traditional foods, create distrust in those foods, and facilitate changes in palate often in favor of high fat, salt, and sugar in western processed foods. These shifts can be further exacerbated when resource scarcity increases (due to species decline or human population growth and increasing demand) and perceived or real contamination levels increase.

Consequences of shifting baseline syndrome

Species extinctions and declines in biodiversity have been linked to erosion of cultural diversity globally (Nettle and Romaine 2000, Tauli-Corpuz 2009, Reyes-García et al. 2013, Kai et al. 2014, IPBES 2019). Wild and domesticated biodiversity is essential to many IPLC subsistence and traditional livelihoods, therefore, the deterioration of ecosystems and loss of species frequently challenges elements of cultural integrity such as food security, the maintenance, transmission, and adaptation of ILK, customary management structures, and linguistic diversity (Harmon 1996, Maffi 2002, Gorenflo et al. 2012, IPBES 2019). Regions of high biological diversity often contain considerable linguistic diversity: ~70% of all languages (Sutherland 2003). However, at the current rate of loss in languages, it is postulated that between 50% and 90% of the world's languages will be gone by 2100 (Nettle and Romaine 2000, Gorenflo et al. 2012). As biodiversity declines or species are extirpated from areas over generations, it is expected that the aspects of language used to gauge abundance or density will be diminished or even lost, especially those terms used to describe abundance or density at the higher end of the spectrum. In addition, words that are species specific and only used in reference to a particular species, would also be at a greater risk of loss if the species declined or disappeared. Lack of understanding and the loss of appropriate descriptions around the meaning of some words used in an ordinal scoring system would also be challenged. For example, Tuawhenua respondents used the term, "kore," which signifies "nothing," however, this does not mean there are zero individuals, rather it refers to there being only a few individuals remaining. The term "korekore," however, refers to zero abundance and means "absolutely nothing" or extirpation. Terms used

to describe abundance can be also specific to plants or animals, such as when Tuawhenua elders used phrase "haruru ana te ngahere" (the forest is thundering) to describe a large flock of Kererū; or "matomato ana" referring to lush and flourishing vegetation; or "makuru" which refers specifically to fruit in the state of profusion (Lyver et al. 2018).

One of the risks of highlighting SBS is that people focus on the past, on the magnitude of biodiversity loss and environmental degradation, and this exposes the significant restoration work that would be required to reclaim those lost resources. False perceptions of environmental quality can be compounded by improper aspirational targets or baselines designated by policy makers and resource managers within conservation or restoration programs (Humphries and Winemiller 2009), or central or territorial governments legislating a shift in how the quality or abundance of a natural resource is assessed and scored (e.g., changing of national water grading standards in New Zealand so that poorer water quality receives a higher grade than before; Hansford 2020). However, the alternative scenario, that we accept SBS, results in complacency and ongoing environmental degradation. Consequently, a general population may become apathetic about the environment around them, taking a perception that the "system" is too hard to fight to change conditions, or affect the causes degrading the environmental state around them. In contrast to this perspective, however, an awareness of potential error (overestimation) associated with historical baseline population or range size estimates is needed when considering restoration targets. Issues around the reliability of, and guesswork in, the historical methods used to determine estimates have been raised (Wiersma and Sandlos 2011). The concern is that the repeated transmission of historical speculative figures of abundance and/or range size through time could raise unrealistic expectations for environmental management and restoration efforts. However, the novel application of methods such as genetic analyses, paleo-ecological evidence (e.g., sediment cores), and tree ring records provide alternate approaches for assessing past populations and habitats, and supporting or challenging historical estimates (Alter et al. 2007, Wilmshurst et al. 2014).

Opportunities for mitigating shifting baseline syndrome in IPLC

Our study has demonstrated that IPLC are not immune to the effects of SBS. However, we believe there are opportunities specific to IPLC to lessen or combat some of the deleterious effects of SBS on communities. ILK is typically an oral knowledge system relying largely on a range of cultural expressions (e.g., narrative and stories, prayer, songs, dance), but also physical forms (e.g., carving, beading, weaving, painting) to transmit information about cultural heritage, genealogy, and environmental condition. These knowledge-transmission

mechanisms seldom operate in isolation, but are rather interwoven with each other, reinforcing how the information is recollected and communicated. In more recent times, the written knowledge has become an important means in which to communicate environmental condition across generations. Tītī (Sooty Shearwater; *Puffinus griseus*) harvest diaries of Rakiura Māori birders have been instrumental in tracking change in this seabird population over the last century, and even linking fluctuations to climate patterns (Humphries and Moller 2017). ILK is a “living” knowledge system based in experience, therefore, the continuation of customary practices, including harvest, is fundamental to cultural transmission of knowledge. Government environmental and conservation policies should, therefore, take a precautionary approach to ward against the “extinction of experience,” and support the continuation of customary practices where they exist. In countries, like New Zealand where the harvest of much of its native fauna has been prohibited, the hunting of introduced mammalian and game bird species provides a surrogate opportunity for both Māori and non-Māori to interact and maintain a connection with the environment, albeit without the cultural heritage values and significance of native species. Hunting is commonly an intergenerational activity that takes people into the environment on a regular basis where they observe abundances, not only in the species they might be targeting, but also other plant and animal abundances and distributions. Even if harvesters are targeting introduced species, the sharing of knowledge between older and younger generations while out harvesting helps maintain and calibrate observational skills between generations. This interaction between generations also facilitates a quantitative understanding of historical biological abundances, compared with contemporary states.

Where natural resources have declined to a point where a customary use cannot be sustained, other opportunities to transmit knowledge are potentially available. IPLC-led initiatives to manage and restore environmental conditions provide opportunities to engage elders and youth together and apply ILK, including the setting of recovery targets. The contribution of historical and current ecological abundances can also provide avenues for IPLC to engage in government-led state-of-the-environment monitoring, conservation strategies, or restoration plans (e.g., Environment Aotearoa; Ministry for the Environment and Stats NZ 2019) or Iwi environmental management plans. Whether it is within IPLC- or government-led initiatives, IPLC-based monitoring programs can also offer opportunities for keeping community members in touch with the environment and for ecological baselines to be portrayed intergenerationally. For some indicators, it will be possible to align more quantitative measures to ordinal scoring systems to mitigate shifts in how the resource is perceived over time (Moller et al. 2004). Elders can provide a range of numerical values

(e.g., encounter rates, harvest rates, flock size) that best quantify a gradient of ordinal scores. This approach also offers opportunities to engage and revive local language using terms and references that relate specifically to a species and level of abundance. Alternatively, the alignment of plot- or transect-based ecological measures with IPLC ordinal scoring systems could provide numerical estimates for different ordinal scores, and still allow traditional terms for understanding environmental state to remain in use and meaningful to the community (Lyver et al. 2018). The provision of quantitative estimates alongside qualitative scores would provide a level of certainty that would assist a new generation of IPLC practitioners with their understanding of biodiversity abundance and density in accordance with their elders’ understandings. This would allow the state of biodiversity to be interpreted in way that the community is familiar with and can relate to. This approach could also mitigate biases in measuring natural resources that potentially occur with community-based approaches (e.g., harvest rates). For example, humans often adjust their behavior and/or practice as a resource declines in order to maintain a catch (Moller et al. 2004). A weakness in this approach is that with the degraded state of many environments, quantitative measures for ordinal scores of higher abundances will not be possible since long-term quantitative data sets are rare.

The support or reestablishment of IPLC education institutions or cultural immersion programs have an important role in the delivery and operationalization of ILK and the mitigation SBS. Teaching and training on the land or sea offer ways of re-engaging IPLC youth with biodiversity and restoring intergenerational knowledge and relationships. These approaches could employ both ILK and scientific systems to gauge and understand environmental conditions, with the potential to transform and innovate the acquisition and maintenance of this information. Such programs would also benefit from virtual technology that allows the information and experiences to be recorded and shared on age-specific media platforms (e.g., Facebook, Youtube, Instagram, Twitch, and Mixer).

CONCLUSION

Declines in biodiversity, the application of government policy and regulation that prohibit access to biodiversity, and changes in lifestyles and livelihoods can alter how IPLC measure and comprehend change in their environments. While we observed a significant intergenerational shift in how members of an Indigenous community understood the abundance and size of a selected group of species, the relationships between ordinal scores and quantitative measures remained consistent across all age classes. This suggests that individuals do adjust their impressions and scoring system relevant to the abundance or size of the species. Mitigation of

SBS, however, will be a critical aspect in how Tuawhenua, other IPLC, and wider society in general, perceive change in their environments and determine the scale and level of action and investment required to recover those ecosystems and populations. The co-production of knowledge through the complementarity of scientific and ILK offers new opportunities and ways to understand and track historical and present-day environmental condition. Since the earth has experienced an accelerated rate of decline in biodiversity over the last century, elders from IPLC can offer valuable accounts of past ecological thresholds. Conservation and restoration initiatives stand to benefit from these insights through strong intergenerational knowledge transfer mechanisms (e.g., hunter training programs) and community-focused education institutes (Hellier et al. 1999, Lund et al. 2010, Soga and Gaston 2018). It gives IPLC an important stake in future environmental interpretation and decision-making processes, while ensuring ILK relevant to their people is protected and maintained. Participation in environmental monitoring is also the key to making long-term “environmental citizens” from all types of knowledge holders. Their environmental values, beliefs, and awareness are key components of the social capital that is needed to protect and restore the full diversity of biota and ecosystem services.

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SUPPORTING INFORMATION

Additional supporting information may be found online at: <http://onlinelibrary.wiley.com/doi/10.1002/eap.2301/full>

DATA AVAILABILITY

Data are available from Manaaki Whenua Landcare Research in their DataStore repository: <https://doi.org/10.7931/jetp-2706>