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CONTRIBUTED PAPER

Identifying and prioritizing human behaviors that benefit biodiversity

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Abstract

The conservation profession is increasingly seeking effective ways to reduce societal impact on biodiversity, including through targeted behavior change interventions. Multiple conservation behavior change programs exist, but there is also great uncertainty regarding which behaviors are most strategic to target. Behavioral prioritization is a tool that has been used effectively to support behavior change decision-making in other environmental disciplines and more recently for a small sub-set of biodiversity behavior change challenges. Here, we use behavioral prioritization to identify individual behaviors that could be modified to achieve biodiversity benefits in the state of Victoria, Australia. We use an adapted nominal group technique method to identify potential biodiversity behaviors and, for each behavior, estimate the corresponding plasticity (or capacity for change) and positive impact on biodiversity outcomes. We elicited 27 behaviors that individuals could undertake to benefit or reduce their negative impact on biodiversity. This list was then used to prioritize 10 behaviors as determined by their likely effect(s) on biodiversity, plasticity, and current prevalence in Victoria. We take a first step in outlining a list of behaviors that can direct Victorian decision-makers toward increasing positive and reducing negative impacts of society on biodiversity, guide motivated individuals to reduce their own biodiversity footprint, and more broadly, develop a behavior change research agenda for behaviors most likely to benefit biodiversity.

KEYWORDS

behavior adoption, behavior change, behavior prioritization, biodiversity conservation, community-based social marketing, conservation psychology, nominal group technique, Victoria

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1 | INTRODUCTION

Human behavior is the major driver of biodiversity decline and extinction (Lenzen et al., 2012; Maxwell, Fuller, Brooks, & Watson, 2016; Driscoll et al., 2018). Altering this trajectory requires changing those behaviors with the greatest impact(s) on biodiversity (Schultz, 2011; Steg & Vlek, 2009). Yet, identifying the most important behaviors to target for change is not straightforward (Selinske et al., 2018). Prioritization methods have been used successfully over the past two decades to advance conservation planning (Margules & Pressey, 2000). Prioritization is also a potentially useful tool for systematically evaluating and informing decisions about which conservation-relevant behaviors should be the focus of conservation efforts (Schultz, 2011). Already established within social marketing (McKenzie-Mohr, 2011), behavioral prioritization has the potential to identify feasible, high-impact biodiversity behaviors that could: (a) direct policymakers and other decision-makers toward policy choices that have high efficacy in shifting behaviors of individuals that have high impact on biodiversity; (b) guide motivated individuals to seek effective ways to reduce their biodiversity footprints; and (c) form the basis of a behavior change intervention and evaluation research agenda among psychologists, conservation scientists, and behavior change specialists.

Behavioral prioritization is used to determine which of a range of possible behaviors should be targeted (McKenzie-Mohr, 2011). Environmental behavior prioritization has been applied to zoos research (Smith, 2009; Smith, Weiler, Smith, & Dijk, 2012), energy conservation (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009), water conservation (Kneebone, Smith, & Fielding, 2017), and more recently to specific threats to biodiversity conservation (Linklater, Farnworth, Heezik, Stafford, & MacDonald, 2019; Please, Hine, Skoien, Phillips, & Jamieson, 2018). These prioritizations have all been executed differently, but follow a common process of: (a) identifying a candidate set of behaviors; (b) determining the impact of each behavior; (c) assessing the plasticity (or capacity for change) of each behavior; and (d) assessing the current prevalence of each behavior among the target population (also known as the "penetration rate"; Figure 1). We outline the key steps to behavioral prioritization below.

1.1 | Identifying biodiversity behaviors

Prioritizing behaviors begins by identifying and defining those behaviors likely to have the greatest positive or negative impact on biodiversity (Clayton, Litchfield, & Geller, 2013; Schultz, 2011), a process determined in part by the objectives or scale of the behavior change program. For instance, previous conservation research has prioritized the most impactful cat-owner behaviors (e.g., cat containment and cat collaring) in New Zealand (Linklater et al., 2019), and individual behaviors to reduce the impact of wild dogs (e.g., trapping wild dogs and abstain from feeding wild dogs) in peri-urban communities of Australia (Please et al., 2018). These studies selected a subset of behaviors that addressed a specific conservation problem (e.g., cat predation of native animals) among a specific audience (e.g., cat owners in New Zealand). However, because the drivers of biodiversity loss are multiple, indirect, and vary spatially, temporally and among species and ecosystems, identifying the most impactful behaviors for a general population is challenging (Selinske et al., 2018). This challenge is further complicated by the overwhelming scale of the problem of human impact on biodiversity, rather than focusing on a specific species or biological community of interest (Maxim, Spangenberg, & O'Connor, 2009).

The human behaviors that influence biodiversity outcomes are multidimensional, requiring different types of engagement from a range of different audience segments (Larson, Stedman, Cooper, & Decker, 2015). These different behaviors can be classified as either public, private, or social sphere behaviors (Amel, Manning, Scott, & Koger, 2017; Landon, Kyle, van Riper, Schuett, & Park, 2018; Stern, Dietz, Abel, Guagnano, & Kalof, 1999), and are clustered within multiple behavioral "domains" (e.g., environmental activism, stewardship behaviors, donation of time and money, and consumption behaviors; Larson et al., 2015; Stern, 2000). Some behaviors are

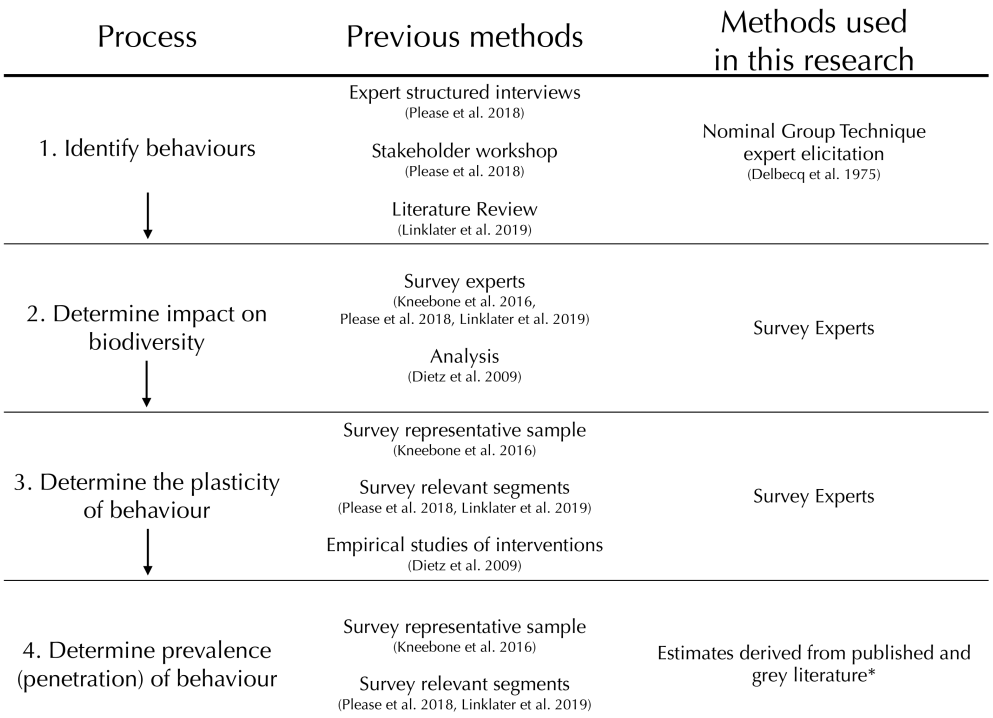

FIGURE 1 Process of behavioral prioritisation adapted from McKenzie-Mohr (2011). *Full sources and methods of derived prevalence estimates are included in Table S2

undesirable and behavior change programs encourage switching to a less undesirable behavior (i.e., that results in less adverse biodiversity outcomes), for example, switching from consuming beef to another animal protein (Searchinger, Waite, Hanson, & Ranganathan, 2018). Other behaviors are more desirable and may impact biodiversity positively, for example, through environmental volunteering (such as revegetation activities) or donating money to a conservation campaign.

Different behaviors will vary in their geographic proximity to affecting ecological outcomes, their scale of effect, and their impact on biodiversity (i.e., direct or indirect; Stern, 2000; Nilsson, Fielding, & Dean, 2020). For example, activist/advocacy behaviors may indirectly impact biodiversity by creating a social license for governments to fund projects that support conservation actions or better regulate industries that threaten biodiversity (Kendal & Ford, 2017). In contrast, volunteers planting trees or a pet owner containing their cat or dog may directly benefit specific species in that location. Additionally, it might be easier to identify conservation behaviors in rural areas where landowners directly influence their natural environment (e.g., a landowner fencing off a riparian area on their land; controlling invasive species), compared to the urban populaces that make up a majority of the world's population where impacts can be less direct (Soga et al., 2016). The vast majority of impacts on biodiversity result from the societal consumption of resources which can be either direct (e.g., overexploitation), or indirect (e.g., agricultural or waste impacts; Chaudhary, Gustafson, & Mathys, 2018; Kitzes et al., 2017; Marques et al., 2019). Individuals may also have different levels of impact on biodiversity depending on their spheres of influence and also their role within an organization or society (Amel et al., 2017). For instance, as a result of changing their own behavior, influential individuals may act as "champions" and influence their wider social network to act in a pro-environmental manner (Cinner, 2018). Given the indirect nature of social influence, there is greater uncertainty associated with its impact on biodiversity (de Lange, Milner-Gulland, & Keane, 2019).

1.2 | Estimating behavioral impact, plasticity, and prevalence

Estimating the exact effects of specific behaviors on biodiversity is inherently difficult because the threats to biodiversity are diverse, contextual, often difficult to quantify, and may have obscure links to the driving behaviors (Selinske et al., 2018). High impact biodiversity behaviors are behaviors that make a large difference to the persistence or conservation status of species and biodiversity (Clayton et al., 2013; Schultz, 2011). In previous behavior prioritizations, impact data have been derived from expert estimates of water reduction measures (Kneebone et al., 2017) and published global greenhouse gas emission reduction estimates of energy efficiency behaviors (Dietz et al., 2009). While energy and water consumption

have standard units of measurement, biodiversity impacts vary spatially and temporally, and among species and ecosystems of interest. They are therefore harder to measure and contain a higher degree of uncertainty (Butchart et al., 2010; Scholes & Biggs, 2005). To overcome the problem of a lack of a standard unit of measurement, Please et al. (2018) and Linklater et al. (2019) used expert estimates (measured by numerical scales) to determine the effectiveness of changing specific behaviors on targeted outcomes that benefit biodiversity.

Behavior prioritization is also informed by behavioral "plasticity" (Allen, Dietz, & Mccright, 2015; Dietz et al., 2009), that is, the probability or likelihood of a particular behavior change eventuating within a population (Kneebone et al., 2017; McKenzie-Mohr, 2011). While there is no universal approach to determining the plasticity of behavior, previous research assessed the plasticity of uptake of energy efficiency measures in US households by using uptake rates of multiple past interventions published in peer-reviewed literature or government reports (Dietz et al., 2009). Plasticity has also been measured by surveys of target communities. To generate plasticity scores, Kneebone et al. (2017) used a Likert-scale instrument to estimate the perceived ease of behavior adoption by the target audience, while Please et al. (2018) and Linklater et al. (2019) surveyed their respective populations for willingness to participate in a behavior.

The prevalence of a behavior within a population (i.e., the existing levels of participation) can provide insight into which behaviors will receive maximum net uptake from that population and therefore maximize benefit to biodiversity (McKenzie-Mohr, 2011). For instance, if a behavior has a large impact and high plasticity (likelihood of adoption) but is already pervasive in a population, it may be more advantageous to prioritize another high-impact, high-plasticity behavior with low prevalence (current participation), as there will be greater potential net uptake in response to an intervention (McKenzie-Mohr, 2011). While there are multiple ways to measure behavior (see Lange & Dewitte, 2019), prevalence in environmental prioritization research has been measured by surveying the target population to obtain a self-reported measure of the selected behaviors (Kneebone et al., 2017; Linklater et al., 2019; Please et al., 2018), and using estimates or synthesizing data from previous studies (Dietz et al., 2009).

Here, we take a first step toward identifying and prioritizing behaviors that have the biggest impact on biodiversity loss in the state of Victoria, Australia. We focus on multiple behaviors that any resident of Victoria (as detailed below) could undertake that would result in positive outcomes for biodiversity. We used the nominal group technique (NGT; Delbecq, van de Ven, & Gustafson, 1975) to engage experts to develop a list of candidate target behaviors. This list was then prioritized by perceived behavioral impact on biodiversity and behavioral plasticity, through expert elicitation. Prevalence was estimated from a range of grey and peer-reviewed literature.

2 | METHODS

2.1 | Context

Victoria is home to nearly 6.5 million people, with the majority (4.96 million) residing in the greater metropolitan area of Melbourne, the state's capital city (Australian Bureau of Statistics, 2019). The region comprises a diverse range of terrestrial and marine ecosystems, a number of which are vulnerable and severely degraded as a result of urban expansion, farm cropping, livestock pastoralism, and forestry (Sustainability Victoria, 2019). Two pieces of legislation govern threatened species listing: Victoria's *Flora and Fauna Guarantee (FFG) Act 1988* (this was the first legislation within Australia to protect biodiversity), and the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, which is the Australian Government's key piece of environmental legislation listing nationally threatened species and ecological communities. In total, 2,577 and 276 Victorian species are listed on the FFG and EPBC Acts, respectively (Australian Government Department of Environment and Energy, 2018; Department of Environment and Primary Industries, 2014; Department of Sustainability and Environment, 2009, 2013). The International Union for Conservation of Nature (IUCN) Red List of Threatened Species lists 729 assessed Victorian species (IUCN, 2019).

The Victorian Government committed to environmental protection with the release of *Protecting Victoria's Environment—Biodiversity 2037*, a 20-year strategy for conserving the state's biodiversity (DELWP, 2017). The plan includes the central message "*Victorians value nature*" and outlines state-wide targets to "*connect all Victorians with nature*" and for five million Victorians to be "*acting to protect the natural environment*" (DELWP, 2017). The latter reflects an implicit objective to encourage pro-biodiversity behaviors within the Victorian general public.

We sought to identify and prioritize behaviors that any Victorian could undertake to improve outcomes for Victorian species and ecosystems. As noted above, most Victorians live in Melbourne and its surrounding suburbs or other urban centers, so the focus was refined to behaviors that all Victorians could undertake including those living in urban or suburban environments. A recent

representative survey of Victorian residents found that most feel connected with nature and engage with nature in a diversity of ways, including through gardening, visiting national parks, and outdoor activities in regional and city parks (Meis-Harris et al., 2019). Additionally, a separate survey found that residents' cultural identities are tied to many of the ecosystems represented in Victoria (Kiley, Ainsworth, van Dongen, & Weston, 2017), but approximately half of Victoria's residents have little or no understanding of the term "biodiversity" (Kiley, Ainsworth, & Weston, 2019).

2.2 | Prioritization workshop

Candidate biodiversity behaviors were elicited in an expert workshop hosted by RMIT University and the Victorian Government Department of Environment, Land, Water and Planning (DELWP). The workshop took place in November 2018, and a subsequent online survey to elicit estimates of the impact and plasticity of individual behaviors was distributed to participants 1 week later. At the start of the workshop, prior to considering any high-impact biodiversity behaviors, participants were presented with three key pieces of information: (a) results from a recent representative survey of Victorian residents that assessed perceptions of nature, values toward nature and the frequency of engagement in 11 pro-environmental behaviors in the past year (Meis-Harris et al., 2019); (b) summarized information on the different types of behavioral domains (Larson et al., 2015), individual spheres of influence (Amel et al., 2017) and indirect and direct behaviors (Stern, 2000); and (c) results of an analysis of the greatest threats to Australian species listed on the IUCN Red List (Selinske et al. in preparation; Table S1) and the industries driving those threats and associated threats to Victorian EPBC-listed species (Brown et al. in preparation; Figure A1). The objective of the workshop was to identify and prioritize behaviors that most Victorians could participate in. For this reason, discussions were framed around how a "typical" Victorian could act for biodiversity, and the workshop participants refrained from selecting behaviors that could only be undertaken by rural landowning individuals (e.g., riparian fencing, in perpetuity protection). A typical Victorian was further defined as an individual that may or may not have pets and may rent or own the dwelling they reside in. Behaviors that only impact biodiversity through their influence on climate change were out of scope as these behaviors have been previously identified and had greater focus in terms of research and practice (Wynes & Nicholas, 2017).

We used the NGT to elicit high-impact biodiversity behaviors from experts at the workshop. NGT is a group consensus method used across multiple disciplines to elicit priorities (Delbecq et al., 1975). The NGT method involves four stages: (a) silent idea generation; (b) idea reporting; (c) clarification; and (d) a public or private ranking (Hugé & Mukherjee, 2018). To reduce facilitator bias, we divided the participants into four randomly allocated subgroups. In the subgroups, each participant privately listed five behaviors they believed that, if changed or engendered, could reduce biodiversity loss or lead to biodiversity gains. Taking turns in the subgroups, each participant read out one behavior per turn, until all behaviors were reported and recorded. All behaviors reported by each subgroup were then collated and reported back to the broader group. The group of participants then deliberated on the merits of the behaviors in terms of their impact and plasticity, the likelihood they could be undertaken by a typical Victorian resident and whether and how they grouped into identified domains of behavior (Larson et al., 2015; Stern et al., 1999).

2.3 | Participants

Thirty-five conservation experts were invited to attend the workshop. These individuals were selected jointly by DELWP and RMIT University and represented a diversity of expertise and organizations. Of those invited, 22 people attended, representing research institutions, conservation nongovernmental organizations, community groups, government departments, and statutory authorities. Participants included ecologists, behavior change specialists, psychologists, conservation scientists, threatened species specialists, social-ecological systems researchers, and science communication experts.

2.4 | Assessing impact and plasticity

Typically, the next and final step of an NGT is to survey the participants during the workshop, privately or publicly, about their preferences for behaviors by ranking them or measuring their preference with a Likert scale. As the method is flexible (Hugé & Mukherjee, 2018), we adapted it to suit the objectives of the workshop. In an emailed online questionnaire 1 week after the workshop, we surveyed participants to assess the impact on biodiversity and plasticity of each identified behavior using sliding scales of 0 (low) to 10 (high). When considering plasticity, experts were asked to consider potential barriers to engaging with the behavior (e.g., time, cost,

habits, and social norms). Additionally, participants were also asked to select five behaviors they would target based on their perceived impact and plasticity. The questionnaire was hosted on Qualtrics, a web-based platform for online surveys (Qualtrics, 2018; see Supporting Information for questionnaire). Notes from the workshop were made available to survey participants prior to answering the questionnaire. We averaged across respondents to generate behavior-specific impact and plasticity scores for each behavior (McKenzie-Mohr, 2011) and calculated the standard error for estimates of impact and plasticity.

2.5 | Behavior prevalence

We defined prevalence as the proportion of Victorians currently undertaking a particular behavior. To assess the prevalence of the identified behaviors in the general population of Victoria, we collated observed, self-reported, and willingness to participate data from previously published reports, market research and peer-reviewed literature (e.g., Essential Services Commission, 2019; Malek, Umberger, & Goddard, 2019; Meis-Harris et al., 2019; Smith & Weiler, 2011; van Eeden, Newsome, Crowther, Dickman, & Bruskotter, 2019). In cases where multiple estimates were derived, we adopted the most conservative prevalence estimate. Full sources and methods of derived prevalence estimates are included in Table S2.

2.6 | Prioritization matrix and score

As demonstrated in previous literature, there are two main ways to prioritize behaviors: (a) visually through a prioritization matrix (Kneebone et al., 2017); and (b) as a function of prevalence in the population, impact and behavioral plasticity (McKenzie-Mohr, 2011). We plotted the impact and plasticity scores to create a prioritization matrix to assist in visually communicating to decision-makers which behaviors to target (sensu Kneebone et al., 2017; Figure S2). This helped us identify high-ranking behaviors that are both likely to be impactful and have high plasticity, those behaviors that might require time and/or financial effort to engage people, and those behaviors that are likely to be less impactful but relatively easy to foster and which may also lead to spillover behaviors or support new social norms (Kneebone et al., 2017; Thøgersen & Crompton, 2009).

We further isolated potential priority behaviors by calculating a behavior prioritization score through integrating the scores of biodiversity impact, plasticity, and prevalence levels. To calculate the behavior prioritization score we used the following equation (McKenzie-Mohr, 2011):

$$\text{Prioritization score} = \text{Biodiversity Impact} \times \text{Likelihood of Adoption (Plasticity)} \times (1 - \text{Current Prevalence}).$$

All analyses were completed in statistical program software R, version 3.60 (R Development Core Team, 2019).

3 | RESULTS

3.1 | Workshop results

The initial behavior elicitation in subgroups resulted in a list of 74 target behaviors. These behaviors differed in their levels of specificity and scale; some were not behaviors at all (e.g., environmental education), and others were behaviors restricted to rural landholders. Some behaviors, such as wildlife gardening, political advocacy, and reducing beef or lamb consumption, were mentioned by all four groups. After combining each group's suggestions and removing those that were duplicated, were not behaviors, or were not relevant to the target population, 47 behaviors remained. Further discussion among workshop attendees about the practicality of addressing or promoting these behaviors and the similarity or overlap between some behaviors resulted in a refined list of 27 unique specific behaviors (Table 1). These were grouped into a simple classification of six domains of behaviors adapted from Larson et al. (2015) and Stern et al. (1999): Consumption behaviors, Social behaviors, Stewardship behaviors, Advocacy behaviors, Donation behaviors (time and financial), and Lifestyle behaviors. Some behaviors may be further divisible, but the group decided on the level of resolution appropriate for the objectives of this prioritization. For instance, the behavior *reduce beef/lamb consumption* could be divided into more specific behaviors based on the type of meat (beef or lamb), frequency (once a week or once a month) and location of consumption (at home or restaurant).

3.2 | Online survey results

When asked to list the five behaviors they perceived to have the highest plasticity and impact on biodiversity, 59% of survey participants selected *responsible cat ownership* (1) in their response, the highest percentage of all behaviors. *Voting for candidates based on biodiversity policies* (2), *wildlife gardening* (3), and *choosing Marine stewardship council (MSC) certified seafood products* (4) were selected by 47.0% of participants. *Reducing beef and lamb*

TABLE 1 List of behaviors developed during the workshop, categorized by behavioral domain, and justification for their inclusion

Behaviors	Justification, considerations, and supporting references
Consumption behaviors	
1. Choose Forest stewardship council (FSC) toilet paper products	Victorian forests are partly harvested for the production of wood chips that are manufactured into paper products, including toilet paper. The state forest industry has been denied FSC certification for sustainability issues (Anderson, 2018). Recycled toilet paper is readily available, with minimal cost difference and previous interventions likely have raised awareness level and increased uptake of behavior (Smith & Weiler, 2011).
2. Choose organic fruit, vegetables, and grain products	Organic farming benefits wildlife by eliminating synthetic pesticides and fertilizers (Hole et al., 2005). Impacts likely complex and vary depending on specific products and where grown.
3. Choose marine stewardship council (MSC) certified seafood products	Overfishing impacts sustainability of stocks and other species through by-catch (Edgar, Ward, & Stuart-Smith, 2018; Ward et al., 2017). Sustainable seafood apps specific to Victorian fisheries are available.
4. Choose a green energy supplier for home energy needs	Mining coal continues in Victoria (Victorian Government, 2019). Mining and coal plants impact biodiversity through pollution and future mining threats (Adams & Moon, 2013; Weng, Mudd, Martin, & Boyle, 2012). Behavior has co-benefits of reducing greenhouse gas emissions. Green energy providers are easily accessible.
5. Reduce beef and lamb consumption	Direct impact on biodiversity in cleared and/or overgrazed rangelands, wetland areas, predator conflict (Dorrough et al., 2004; Hansen, Fraser, & Jones, 2019; van Eeden, Smith, Crowther, Dickman, & Newsome, 2018). Nonmeat alternatives are increasingly available, "reduce" is easier than eliminate and swapping meat choices to MSC fish or chicken will also benefit biodiversity.
6. Choose local and seasonal produce	Globally sourced food has biodiversity and sustainability issues (Macdiarmid, 2014). Local produce is usually available at markets and farmers markets but sometimes hard to identify.
Social behaviors	
7. Tell positive nature stories within circle of influence	Telling positive stories about the environment, or behaviors that benefit the environment, is a potentially powerful tool to communicate awareness and knowledge between individuals (Goldstein, Wessells, Lejano, & Butler, 2015). Supports social norms building (Smith, Thomas, & McGarty, 2015).
8. Actively support those who are making biodiversity-friendly choices	Positive reinforcement encourages individuals/groups to continue with conservation behaviors (Schultz, 1999). Support can be provided in real life interactions or on social media, online behaviors.
9. Discuss origin of food consumed within circle of influence	Food choices have large impact on biodiversity (Poore & Nemecek, 2018) and discussions may increase knowledge of impacts, available choices, and build social norms (Culiberg & Elgaaied-Gambier, 2016). Message framing is likely to be important for this behavior (Kusmanoff, Fidler, Gordon, Garrard, & Bekessy, 2020).
10. Discuss pro-environmental attitudes/ behaviors within circle of influence	Increases knowledge of impacts and choices and may build social norms around behavior (Smith et al., 2015). Potentially effective if message is framed appropriately (Kusmanoff et al., 2020) and comes from influencers within social groups.
Stewardship behaviors	
11. Participate in citizen science projects	Direct impact depends on the location and objectives of specific project (Cooper, Dickinson, Phillips, & Bonney, 2007). Indirect impact by connecting people to nature and raising awareness (Wright, Underhill, Keene, & Knight, 2015).
12. Volunteer for activities that take care of the environment (e.g., participating in a local friends group)	Direct on-the-ground action and fosters connection with nature (Asah & Blahna, 2013; McDougle, Handy, Katz-Gerro, Greenspan, & Lee, 2015). There are more than 100 different groups helping Parks Victoria to maintain and protect the parks network (https://parkweb.vic.gov.au/get-involved/volunteer/friends-groups).

(Continues)

TABLE 1 (Continued)

Behaviors	Justification, considerations, and supporting references
13. Plant and maintain a wildlife garden	Australian urban environments support threatened species populations (Soanes & Lentini, 2019). Wildlife gardening helps address impacts of urbanization, by increasing connectivity and providing critical habitat (Belaire, Dribin, Johnston, Lynch, & Minor, 2011; Doody, Sullivan, Meurk, Stewart, & Perkins, 2010; Goddard, Dougill, & Benton, 2010). Ancillary benefits include increasing connection to nature of whole neighborhoods and potentially increasing time spent outdoors.
14. Forgo using nonnatural herbicides and pesticides in domestic gardens	Pesticides impact pollinators, other insects and ecosystem functioning (New, 2018; van der Sluijs et al., 2015) and reduce urban stream invertebrate diversity (Rippy et al., 2017).
Advocacy behaviors	
15. Advocate publicly for pest animal control including both native and alien species	Native and alien pest species have high impact on Victorian ecosystems (e.g., feral horses; Driscoll et al., 2019). Multiple species (e.g., deer, wild horse, and kangaroos) are highly-abundant. Different segments of society will have various attitudes towards its management depending on the species (van Eeden et al., 2019).
16. Advocate for intensification (infill) of urban areas rather than urban fringe expansion	Urban expansion threatens multiple ecosystems in Victoria (Llausàs, Buxton, & Beilin, 2016). Advocating for this issue is not a direct behavior but if objectives reached it could have high impact (Garrard, Williams, Mata, Thomas, & Bekessy, 2018; Villaseñor, Tulloch, Driscoll, Gibbons, & Lindenmayer, 2017)
17. Write to local members of parliament or local government about their environmental policies	Campaign focused on environmental issues. Tends to be issue-based but demonstrated impact in previous environmental issues in Victoria (Slattery, 2002).
18. Vote for political candidates based on environmental policies	Electing candidates who support the implementation of pro-environmental policies that benefits the structural changes needed (Novacek, 2008).
19. Advocate for "green" or "biodiversity-friendly" certification	An unknown impact. Need an appropriate labeling system, which currently does not exist. Also, this is likely to be difficult to measure (Boiral, Heras-Saizarbitoria, & Brotherton, 2018; Tayleur et al., 2018)
20. Campaign for local government on an environmental platform	Actively participate in governance processes in order to lift visibility of biodiversity issues (Mey, Diesendorf, & MacGill, 2016). The impact is indirect, variable and context specific. Potentially increases social responsibility and citizenship.
Donation behaviors	
21. Donate to private land protection organizations	Contributes to on-ground biodiversity management. Effective in protecting land in perpetuity and implementing management on private lands (Hardy, Fitzsimons, Bekessy, & Gordon, 2017; Selinske et al., 2019)
22. Donate to organizations that focus on threatened species advocacy	Donate to organizations that run threatened species advocacy campaigns. Organized, effective advocacy creates structural changes that benefit biodiversity (Woinarski, Garnett, Legge, & Lindenmayer, 2017).
23. Volunteer for a biodiversity conservation organization (including volunteering non"biodiversity" skills like graphic design, accounting, IT, logistics, etc.)	Job-matching frameworks direct people with needed skills to the right organization. Helps organizations prioritize the best use of their own staff's time. Engage interested people with skills not traditionally associated with conservation while expanding their knowledge of conservation challenges and solutions (Asah & Blahna, 2013; Shanahan, Ledington, & Maseyk, 2018)
Lifestyle behaviors	
24. Responsible dog ownership—Dogs on leashes in natural areas and picking up after your dog	Off-leash dogs disturb and predate native species (Glover, Weston, Maguire, Miller, & Christie, 2011; Stigner, Beyer, Klein, & Fuller, 2016). Impact may depend on location, if there are alternatives where dog can be off leash, and knowledge of impact to wildlife (Williams, Weston, Henry, & Maguire, 2009).
25. Responsible cat ownership—Keep cat fully contained	Free roaming pet cats kill millions of small mammals, birds and reptiles every year (Legge et al., 2020).

TABLE 1 (Continued)

Behaviors	Justification, considerations, and supporting references
26. Choose biodiversity-friendly investments (e.g. sustainable super funds)	Biodiversity-friendly personal investments help support structural change (Epstein, Elkington, & Leonard, 2018).
27. Spend regular time in nature	Spending more time in nature influences connection to nature behaviors (Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009). If localised may result in pro-biodiversity behaviors (Gosling & Williams, 2010; Mackay & Schmitt, 2019).

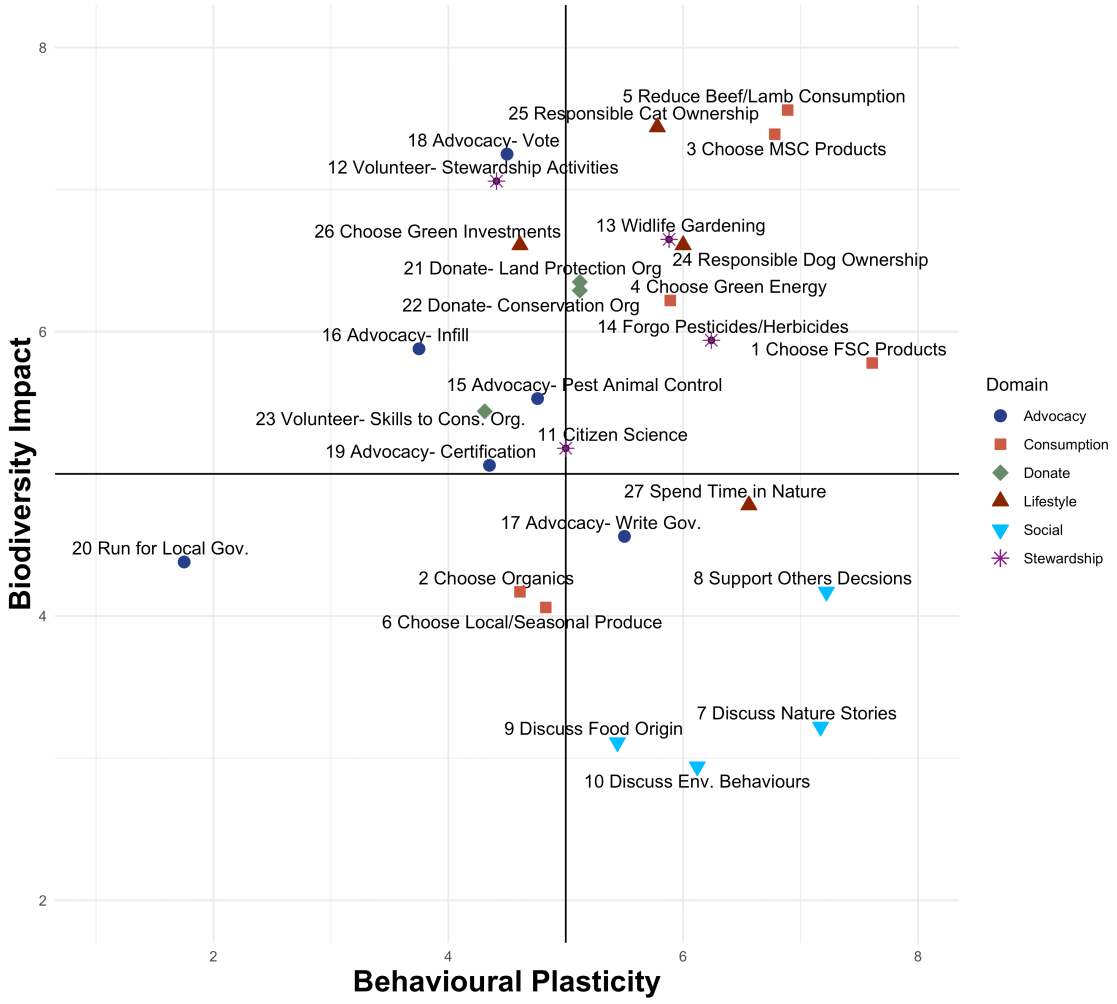

FIGURE 2 Prioritisation matrix for biodiversity behaviors (abbreviated for conciseness) that a typical Victorian individual could undertake. Biodiversity impact is plotted on the *y*-axis against behavioral plasticity scores plotted on *x*-axis. The upper right quadrant are those high priority behaviors that were assessed as having both high impact and high plasticity scores. Bold lines are midpoints (5) of the *x* and *y* axes. The numbers correspond with each behaviors' description in Table 1

consumption (5) was selected by 41.1% (see Table S3 for full results).

Behaviors that were considered to be both of high impact and high plasticity (>5 for each factor) and distributed in the top right quadrant of the prioritization matrix (Figure 2) include: reduce beef/lamb consumption, choose MSC-certified seafood, choose Forest Stewardship Council (FSC) certified toilet paper, responsible cat ownership, responsible dog ownership, donate to private land conservation organisations, donate to threatened species organisations, wildlife gardening, choose green energy, and forgo pesticide/herbicide use. The lowest scoring behavior, as measured for both impact and plasticity, was *campaign for local government on an*

TABLE 2 Behavior biodiversity impact (1 = lowest; 10 = highest), plasticity (1 = lowest; 10 = highest), prevalence, and prioritisation scores

Behaviors	Expert online survey		Prioritization score without prevalence	Victorian valuing nature survey (Meis-Harris et al., 2019)/literature review Prevalence	Prioritization score with prevalence
	Impact ± *SE*	Plasticity ± *SE*			
Choose Marine Stewardship Council (MSC) certified seafood products ■	7.39 ± 0.27	6.78 ± 0.30	50.1	0.15	42.6
Responsible dog ownership—Dogs on leashes in natural areas and picking up after your dog ▲	6.61 ± 0.41	6.00 ± 0.46	39.7	0.18	32.5
Reduce beef and lamb consumption ■	7.56 ± 0.30	6.89 ± 0.52	52.1	0.37	32.4
Donate to private land protection organizations ◆	6.35 ± 0.39	5.12 ± 0.43	32.5	<0.01	32.2
Choose biodiversity-friendly investments (e.g., sustainable super funds) ▲	6.61 ± 0.53	4.61 ± 0.41	30.5	<0.01	30.2
Donate to organizations that focus on threatened species and ecosystem advocacy ◆	6.29 ± 0.39	5.12 ± 0.43	32.2	0.07	29.9
Plant and maintain a wildlife garden ✳	6.65 ± 0.31	5.88 ± 0.47	39.1	0.24	29.7
Vote for political candidates based on environmental policies ●	7.25 ± 0.46	4.5 ± 0.50	32.6	0.1	29.4
Responsible cat ownership—Keep cat fully contained ▲	7.44 ± 0.44	5.78 ± 0.54	43.0	0.34	28.4
Advocate publicly for pest animal control including both native and alien species ●	5.53 ± 0.44	4.76 ± 0.50	26.3	<0.01	26.1
Forgo using chemical herbicides and pesticides in domestic gardens ✳	5.94 ± 0.54	6.24 ± 0.33	37.1	0.31	25.6
Choose Forest Stewardship Council (FSC) toilet paper products ■	5.78 ± 0.51	7.61 ± 0.54	44.1	0.42	25.5
Spend regular time in nature ▲	4.78 ± 0.50	6.56 ± 0.45	31.3	0.20	25.1
Volunteer for activities that take care of the environment (e.g. participating in a Local Friends Group) ✳	7.06 ± 0.32	4.41 ± 0.39	31.1	0.20	24.9
Write to local members of parliament or local government about their environmental policies ●	4.56 ± 0.51	5.5 ± 0.51	25.1	<0.01	24.8
Participate in citizen science projects ✳	5.18 ± 0.47	5.0 ± 0.40	25.9	0.14	22.3
Advocate for intensification (infill) of urban areas rather than urban fringe expansion ●	5.88 ± 0.49	3.75 ± 0.37	22.0	<0.01	21.8

TABLE 2 (Continued)

Behaviors	Expert online survey		Prioritization score without prevalence	Victorian valuing nature survey (Meis-Harris et al., 2019)/literature review Prevalence	Prioritization score with prevalence
	Impact ± *SE*	Plasticity ± *SE*			
Advocate for "green" or "biodiversity-friendly" certification ●	5.06 ± 0.45	4.35 ± 0.30	24.4	<0.01	21.8
Actively support those who are making biodiversity-friendly choices ▼	4.17 ± 0.49	7.22 ± 0.54	30.1	0.33	20.2
Choose a green energy supplier for home energy needs ■	6.22 ± 0.47	5.89 ± 0.46	36.6	0.54	19.8
Volunteer for a biodiversity conservation organization ◆	5.44 ± 0.33	4.31 ± 0.47	23.4	0.20	18.8
Discuss origin of food consumed within circle of influence ▼	3.11 ± 0.40	5.44 ± 0.51	16.9	<0.01	16.7
Choose organic fruit, vegetables, and grain products ■	4.17 ± 0.45	4.61 ± 0.39	19.2	0.14	16.5
Tell positive nature stories within circle of influence ▼	3.22 ± 0.49	7.17 ± 0.60	23.1	0.33	15.5
Choose local and seasonal produce ■	4.06 ± 0.55	4.83 ± 0.39	19.6	0.23	15.1
Discuss pro-environmental attitudes/behaviors within circle of influence ▼	2.94 ± 0.39	6.12 ± 0.44	18.0	0.33	11.5
Run for local government ●	4.38 ± 0.61	1.75 ± 0.30	7.70	<0.01	7.6

Note: Behaviors ranked by highest to lowest prioritisation score. Symbols represent behavioral domains (Consumption: ■, Social: ▼, Stewardship: ✳, Advocacy: ●, Donation: ◆, Lifestyle: ▲) and correspond with Figure 2 key.

environmental platform. See Figure A2 for confidence intervals of impact and plasticity estimates.

3.3 | Prioritization score

The current prevalence of behaviors within the population ranged from 54% of households (*choosing green energy*) to <1% for several behaviors such as *campaign for local government on an environmental platform*. When the prioritization score was calculated, three high priority behaviors featured in the prioritization matrix (*choose FSC-certified toilet paper*, *choose green energy*, and *forgo pesticide/herbicide use*) were demoted from the top ten behaviors as a result of their higher existing prevalence within Victoria (42, 54, and 43%, respectively; Table 2). Conversely, several behaviors increased in priority ranking due to a low prevalence: *choose biodiversity-friendly investments*, *vote for political candidates based on environmental policies*, and *advocate publicly for pest animal control*.

4 | DISCUSSION

4.1 | Prioritization process outcomes

Human behavior impacts biodiversity in multiple ways (Larson et al., 2015), yet it may not always be clear how to best make a positive contribution to biodiversity to those individuals motivated to do so (Selinske et al., 2018). This is especially true for inhabitants of suburban and urban environments (Uzzell, 2000). It is also unclear to conservation decision-makers which behaviors should be prioritized for behavior change interventions directed to individual citizens. In this paper, as part of an initial step toward a biodiversity behavior change program, we used an adapted NGT to develop a list of behaviors that covers the breadth of activities a typical individual can undertake for biodiversity in Victoria, Australia. Despite the diversity of expertise, knowledge and perceptions of behavioral impacts on biodiversity, there were multiple behaviors that the majority of experts agreed were priorities (e.g., *responsible pet ownership*, *voting for candidates based on biodiversity policies*, *wildlife gardening*, *reduce beef/lamb consumption*, *choose MSC-certified seafood*) and 10 behaviors were identified as having high impact and high plasticity (Figure 2).

Taking the additional step of including estimates of current prevalence in the population to weight individual behaviors provided information on the potential for uptake in the prioritization matrix, which led to a slightly different prioritization of behaviors (Table 2). However, while prevalence is a commonly used metric in behavior prioritizations (McKenzie-Mohr, 2011), the reliability of this approach might depend on other considerations, such as whether the behavior has the potential to encourage a social norm or spillover into other behaviors (Margetts & Kashima, 2017; Thøgersen & Crompton, 2009). For example, it may be more efficient to focus on behaviors that are already prevalent within a population by pushing the behavior toward a social norm threshold, rather than focusing on a behavior with little current engagement (Centola, Becker, Brackbill, & Baronchelli, 2018). Additionally, if a behavior already has a relatively high prevalence, then this potentially indicates a reasonable degree of plasticity, and a good opportunity to increase uptake through norm-based messaging. Future prioritization efforts should consider, or attempt to account for, this behavioral nuance.

Advocacy behaviors (e.g., *voting in consideration of biodiversity issues*, *campaign for local government on an environmental platform*) were generally associated with high impact but low plasticity. While there may be multiple barriers to the uptake of environmental activism (Paço & Gouveia Rodrigues, 2016; Schmitt, Mackay, Droogendyk, & Payne, 2019), advocacy behaviors have greater potential to generate transformational change than other categories of behaviors (Amel et al., 2017). While advocacy behaviors may not be appropriate behaviors for governmental departments to promote, NGOs or advocacy groups could drive participation in these types of behaviors. NGOs may generate activism and advocacy by highlighting issues and producing resources for those interested in participating but who are unsure how to engage (Hasler, Walters, & White, 2019). Further research that examines how personal, environmental, and social identity influences individual involvement in activism (Schmitt et al., 2019) or identifies key barriers to advocacy (Uusi-Rauva & Heikkurinen, 2013) is needed.

All social behaviors (e.g., discussing biodiversity, supporting others) fell into the lower right quadrant of behaviors: that is, easy to undertake but not highly impactful. This is likely due to the indirect links to biodiversity conservation outcomes, subsequent difficulty in measuring this impact, and the uncertainty about any actual impact, given that these actions require other individuals to change their behavior as a result of the social behavior (e.g., others changing their purchasing behavior following a discussion about the conservation value of purchasing MSC seafood). This does not mean that these behaviors should be ignored, as they could be effective in generating social norms, creating social expectations of behavior, or engagement in other behaviors (i.e., spillover behaviors) that have additional biodiversity impact (Maki et al., 2019; Nyborg et al., 2016; Thøgersen &

Ölander, 2003). Encouraging conscious engagement in any environmental behavior may change self-perception, efficacy, and identity, potentially fostering larger behavioral changes in the future, although the effectiveness of this approach may be limited (Maki et al., 2019; Thøgersen & Crompton, 2009). The three behaviors in the bottom left quadrant (i.e., low impact and low plasticity) are *choose organic food*, *choose locally produced food*, and *campaign for local government on an environmental platform*. Experts may have perceived that the benefits for biodiversity in Victoria from these behaviors have higher uncertainty as a result of contextual and efficacy issues and their low plasticity a result of a series of potential barriers to behavior engagement such as higher financial cost of organic food; accessibility of locally produced food for people not living near fresh food markets; time commitments and skill set barriers to campaigning for local council.

In Victoria, some of the prioritized behaviors are already targeted by relevant programs. For example, the Gardens for Wildlife (https://gardensforwildlifevictoria.com/) program, primarily supported by local communities, aims to encourage planting home gardens to benefit wildlife. Momentum in this area is something the Victorian Government could capitalize on (Shaw, Miller, & Wescott, 2017), as wildlife gardening generates direct benefits for biodiversity (Belaire, Whelan, & Minor, 2014; Goddard et al., 2010) and strengthens community engagement and connection to nature (Mumaw & Bekessy, 2017). Given that two of the Victorian Government's key policy targets in *Protecting Victoria's Environment—Biodiversity 2037* are to increase connection to nature and the number of people acting for nature, it may make sense to prioritize behaviors that can accomplish both (e.g., wildlife gardening and citizen science). Strengthening people's connection to nature is likely to increase the possibility of change for many of the other behaviors (Mackay & Schmitt, 2019; Whitburn, Linklater, & Abrahamse, 2020) and enhance environmental identity, a predictor of multiple types of conservation behaviors (Kashima, Paladino, & Margetts, 2014; Prévot, Cheval, Raymond, & Cosquer, 2018).

4.2 | Next steps, limitations and considerations for future prioritizations

Our research demonstrates an initial stage of a behavioral prioritization process identifying the behaviors that have both high biodiversity impact and high plasticity in Victoria, Australia. However, conservation behavior change programs globally could benefit from thinking strategically about and systematically selecting behaviors for intervention (Schultz, 2011). The prioritization reported here provides a foundation on which to further explore behavior change interventions. Below we outline opportunities for further improvement to the local case study, highlighting potential limitations while also providing general guidance for future prioritizations.

Future prioritizations could consider alternative methods to estimate prioritization parameters. We used expert estimations in this study, but there are multiple ways to measure behavioral impact, plasticity, and prevalence (e.g. Dietz et al., 2009; Kneebone et al., 2017; Linklater et al., 2019; Please et al., 2018). The expert estimations allowed for a more rapid assessment than a community survey, but doing it in conjunction with other methods, would allow for triangulation.

While there tended to be agreement among experts with respect to scoring estimates, research has shown that the public may perceive behaviors differently to experts (Truelove, Carrico, Weber, Raimi & Vandenbergh.,). Therefore, our results may not accurately represent public perceptions of the challenges of changing a behavior, which may influence the estimated likelihood of changing that behavior. As a next step for the Victorian case study, research should investigate perceptions of these behaviors and their perceived difficulty among the target population. However, it is worth noting that behavioral intention surveys of the public may also not be ideal measures for estimating plasticity and gathering this type of data from the public is challenging (Allen et al., 2015; Lange & Dewitte, 2019). Similarly, some of our prevalence estimates were based on self-reported data, potentially inflating the current levels of participation in a behavior (Kormos & Gifford, 2014).

The audience targeted in this study was broad. Ideally, future work would consider more specific audience segmentation for each of the behaviors selected and their potential interventions (Metcalf et al., 2019). Effective audience segmentation and targeting involves different interventions or messaging strategies for each audience segment (Kidd et al., 2019), as individuals have different motivations and barriers to participation (Asah & Blahna, 2012).

While we examined the likely impact, plasticity, and community prevalence of each behavior, additional factors may be important. For instance, the prioritization could also include the constraints on implementing the behavior, such as the cost of the proposed intervention, technical complexity of the behavior, whether it is a one-off action or longer-term behavioral shift, or community preference and acceptability (Michie et al., 2013; Selinske et al., 2020). Further steps could project and assess the relative effectiveness of the behavior change interventions (Law et al., 2017; Travers et al., 2019), mapping

exactly how the expected uptake of selected behaviors is likely to impact biodiversity, including the magnitude of change for specific species or ecosystems. Modeled predictions of expected impact may allow more refined prioritization of investment (Joseph, Maloney, & Possingham, 2009), and would facilitate the design of monitoring programs to evaluate the effectiveness of behavior change interventions.

Given the broad focus of the exercise, it was necessary to engage a group of experts with diverse expertise and varying levels of understanding of the identified behaviors, which may have increased uncertainty in key parameter estimates. Future elicitations could assess this uncertainty by asking participants to provide bounded estimates (sensu Hemming, Walshe, Hanea, Fidler, & Burgman, 2018). The experts who attended the workshops largely specialized in terrestrial systems, potentially biasing the focus toward terrestrial threats and behaviors rather than threats to marine and freshwater environments. Sustainable seafood consumption was the only identified behavior directly related to marine biodiversity, and this behavior is likely to be the most prominent way that the typical Victorian interacts with the marine environment. Other behaviors, such as those relating to the proper disposal of plastic waste, were discussed but not prioritized during the workshop. Given the disposal systems available in Victoria, experts may not have linked these behaviors to specific impacts within the State. Further research in Victoria, and future prioritizations elsewhere, could consider human behaviors impacting marine biodiversity in more detail (e.g., fishing behaviors and released balloons), by drawing specifically from marine science and conservation expertise.

For some of the selected behaviors the biodiversity impact may be muted in Victoria when global trade pathways are considered (Newbold et al., 2015), an important consideration when generating any regionally or locally-focused prioritization. For instance, while cattle and sheep grazing are a driver of biodiversity loss in Victoria (Hansen et al., 2019) and Australia more broadly (McAlpine, Etter, Fearnside, Seabrook, & Laurance, 2009), given the global supply chains of production, a proportion of beef and lamb produced in Victoria is consumed outside of the State. Therefore, Victorian pastoralists will likely still have demand from markets outside Victoria to compensate for any loss from Victorian consumers. Nevertheless, if reductions in beef consumption in Victoria are substantial, this will be important for biodiversity globally and perhaps lead to increased regulation of the Victorian beef/lamb industries and increased demand for environmentally or biodiversity-friendly beef and lamb.

In this prioritization, we focused on individual behaviors. While small changes by many individuals can result in large impacts (Dietz et al., 2009), organized collective actions are required to influence governments to prioritize reducing biodiversity loss (Amel et al., 2017). Advocacy behaviors were highlighted as important by our experts; however, effecting a paradigm shift will likely necessitate organized, nonviolent movements (Chenoweth, Stephan, & Stephan, 2011). Prioritization could potentially be used in future work to highlight effective organizational behaviors that act as leverage points for structural or systems change (Amel et al., 2017; Clayton et al., 2013). Given the contextual nature of biodiversity issues and the complexity of local culture, we also note that while behavior change agendas may be guided by global or national behavioral prioritizations, to truly engage local people with local problems for individual action, we need finer scaled prioritizations.

5 | CONCLUSIONS

Until recently there has been relatively little research into the behaviors that all individuals could adopt to benefit biodiversity (Cowling, 2014; Saunders, 2003). There is an opportunity for systematic application of behavioral science to this issue, mirroring the increased sophistication, and evolution of conservation planning. For greater impact, behavior prioritization could be implemented at multiple scales from international policy initiatives to social marketing within communities. Here we have developed a prioritization of biodiversity behaviors within Victoria, Australia, and provide a list for policymakers, behavior change specialists and concerned individuals, alike, to act upon. While this list of behaviors was developed for the State of Victoria, it provides a starting point that is likely to be useful in other jurisdictions. Given that global trends of biodiversity loss are primarily driven by human impacts, this approach for prioritizing behaviors is of broad relevance.

An effective behavior change program will incorporate multiple interventions (Dietz et al., 2009) and include interventions and messaging that strategically target audiences and their barriers to behavior change, whether they be structural, psychological, technical (Heberlein, 2012), or some combination of these. The method proposed here seeks to identify key human behaviors with the greatest potential to yield positive outcomes for biodiversity. Identifying these key behaviors provides a basis for future research and an evidence base for developing a suite of behavioral change interventions to reduce biodiversity loss and reinforce social and behavioral norms around the value of biodiversity.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTIONS

All authors participated in the workshop, contributed to the writing of the manuscript, and its revisions. Matthew J. Selinske, Sera Blair, and Georgia E. Garrard conceptualized the project idea and led the workshop. Matthew J. Selinske led the survey and ran analyses. Matthew J. Selinske led the writing of the manuscript and was responsible for submitting the manuscript and leading revisions.

ETHICS STATEMENT

RMIT University ethics approval was granted for this research (CHEAN A 21314–01/18). Free, prior, and informed consent was sought from participants prior to the start of workshop.

DATA AVAILABILITY STATEMENT

Data is not made available online. However, anonymous data can be requested from the authors via email.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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