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Social valuation of biodiversity relative to other types of assets at risk in wildfire

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Article impact statement: Regarding protection from wildfire, respondents prioritized protection of 1 human life even if the choice led to extinction of a species.

Abstract

Environmental crises, such as wildfires, can cause major losses of human life, infrastructure, biodiversity, and cultural values. In many such situations, incident controllers must make fateful choices about what to protect—and hence what to abandon. With an online representative survey of >2000 adult Australians, we investigated social attitudes to this dilemma. We used best–worst scaling to assess preferences across a set of 11 assets representing human life, infrastructure, biodiversity, and cultural values. Survey respondents overwhelmingly prioritized a single human life (best–worst score of 6647 out of possible score ranging from −10695 to 10695), even if that choice resulted in extinction of other species. Inanimate (replaceable) objects were accorded lowest priority (best–worst scores of −4655 for a shed and −3242 for a house). Among biodiversity assets, respondents prioritized protecting a population of the iconic koala (*Phascolarctos cinereus*) (best–worst score of 1913) ahead of preventing the extinction of a snail (score −329) and a plant species (−226). These results variably support current policy in that they emphasize the importance the community places on protection of human life, but results diverged from conventional practice in rating some biodiversity assets ahead of infrastructure. The preference for protecting a population of koalas ahead of action taken to prevent the extinction of an invertebrate and plant species corroborates previous research reporting biases in the way people value nature. If noncharismatic species are not to be treated as expendable, then the case for preventing their extinction needs to be better made to the community. Given the increasing global incidence of high-severity wildfires, further sampling of societal preferences among diverse asset types is needed to inform planning, policy, and practice relating to wildfire. Other preemptive targeted management actions (such as translocations) are needed to conserve biodiversity, especially noniconic species, likely to be imperiled by catastrophic events.

KEYWORDS

best–worst scaling, disaster, extinction, prioritization, sacred values

INTRODUCTION

In response to accelerating rates of biodiversity loss, there are increasing global commitments to conservation, including goals to prevent further extinctions (CBD, 2022). However, global climate change is escalating the frequency of severe environmental disturbances, including catastrophic wildfires (Abatzoglou et al., 2019). Such events can cause major losses of biodiversity and human life and infrastructure. The latter asset types may compete for protection with biodiversity assets. In many cases, those responsible for attempting to control such events must make fateful choices about what to protect and hence what not to protect (Woinarski et al., 2023). These choices become more difficult and consequential as the scale and severity of such disasters increase, as human populations and infrastructure increase and spread, and as depletion of biodiversity continues.

Where asset types are highly disparate (e.g., a school building or the last population of a threatened orchid), choices about what to protect are complex and difficult. This is especially so for tragic trade-offs, which pit one set of values considered sacred, such as human life, against another set, such as a species extinction (Tetlock, 2003). Conventionally, such choices are made by crisis managers, nominally representing societal values and sometimes operating under legal constraints or directions. These decisions are also typically made under urgent pressures.

The Australian Black Summer wildfires of 2019–2020 are an example of such a catastrophe, causing major losses of human life, property, and biodiversity (Rumpff et al., 2023). Inquiries made after the fires reviewed the basis and process of decision-making during the fires by fire controllers. One such inquiry, a national Royal Commission, reported that "In responding to disasters, … emergency services agencies have primary responsibility for protection of people, property and the environment—they provide protection in that order" (Royal Commission into National Natural Disaster Arrangements, 2020). In contrast, a New South Wales government inquiry noted "there was no system in place for determining or ranking priorities when multiple assets of value are threatened by fire" and concluded that "to avoid uninformed decisions during a fire event on what to protect, a formal mechanism is needed for working out in advance the relative value of different assets," with the mix of assets considered explicitly including different components of biodiversity (Government of NSW, 2020).

We took up the suggestion resulting from the New South Wales inquiry that such relative valuation among disparate assets—and hence their prioritization for protection—should be established prior to a wildfire or other disturbance event (Woinarski et al., 2023). Such prioritization should reflect societal values and then be established in relevant fire management planning, policy, and protocols. However, to date, few studies have considered how society ranks disparate assets that may be at risk in environmental disasters or of the extent of variation among sectors of society in such a valuation (Williams et al., 2018).

We aimed to assess societal valuation for protection of disparate assets in a hypothetical wildfire scenario through an online survey. We applied a stated-preference best–worst scaling (BWS) experiment to the survey.

Our scenario stipulated that action could be taken to protect only one asset and that the action would successfully protect the asset and detailed the consequences of not protecting other assets. Our candidate assets ranged from human life to property, biodiversity, and Indigenous culture (Table 1). The number of assets considered was capped to what we considered a manageable choice for respondents.

There are contrasting perspectives in society on the relative value accorded to diverse assets, and many factors may influence variation among individuals in the choices they make (Williams et al., 2018). A second aim was therefore to examine whether variation among respondents in preferences of what assets to protect was associated with demographic, locational, or attitudinal factors.

Our study is explicitly Australian in scope. However, comparable high-severity wildfires (and other environmental catastrophes) are increasing across much of the globe; hence, the issues of what to save in such disasters and the basis of such choices are of increasing concern and consequence and are being considered across the world (Otero et al., 2018).

METHODS

Menu of assets considered for choice

The choices offered in our survey included to rescue a person not warned about imminent wildfire and a person repeatedly warned and advised to evacuate but who had not done so (and hence had taken responsibility for their own safety). Most Australian fire operations protocols and policies emphasize the provision of safety advice to communities under imminent risk of fire and typically include early calls for evacuation and warnings that if they choose to stay, fire fighters may be unable to save them (Inspector-General for Emergency Management, 2020). In practice, considerable effort is often spent in attempting to rescue those who have not heeded early evacuation advice; such efforts use limited resources and come at the expense of safeguarding other assets (Whittaker et al., 2020). We limited infrastructure and human property assets to a single house and a farm shed (containing a tractor and hay bales) because we considered them representative of the most common infrastructure or property types lost and targets of much protection in the Black Summer wildfires.

People use a range of factors in valuing biodiversity assets, including economic value, iconic status, threatened status, familiarity, and appearance (e.g., Bakhtiari et al., 2014; Jacobsen et al., 2008; Varela et al., 2018). A greater awareness of a species' conservation status influences people's willingness to provide donations to conservation efforts (Tisdell et al., 2007), and there are strong biases toward caring or conservation for charismatic species (especially mammals) (Colléony et al., 2017; Miralles et al., 2019; Pearson et al., 2022; Tisdell et al., 2006). In contrast, previous choice surveys show that invertebrates—including threatened species—are consistently rated of low priority (Pearson et al., 2022) and may even be disliked by the majority of respondents (Woods, 2000). The biodiversity assets we included in our survey were selected to test valuation across a range of perceptions (iconic koalas [*Phascolarctos cinereus*] and wallabies vs. a nondescript plant and native snail), endangerment status (loss would not significantly affect the persistence of a species, would further imperil it, or would cause extinction), and animal welfare considerations (e.g., fires may cause injuries and suffering to koalas or sheep [*Ovis aries*]).

With respect to biodiversity impacts, the consideration of extinction caused by a single fire event is realistic. The Black Summer wildfires resulted in at least one extinction (the *Bankia montana* mealybug *Pseudococcus markharveyi* [Moir, 2021]) and probably many more. These fires burned the entire known range of more than 500 plant and animal species and at least 50% of the distributions of more than 100 species already listed as

TABLE 1 Eleven assets offered as choices in the best-worst scaling experiment.

Item (variable name)	Description	Justification
A person with a car stuck behind a fallen tree, whom you know had not received advice to evacuate (person not warned)	Single human life	In practice policy and law typically prioritized ahead of infrastructure or biodiversity
A person with car stuck behind a fallen tree, whom you know had ignored repeated advice to evacuate beforehand (person ignoring advice)	Single human life; who has chosen to take responsibility for their safety	In practice, policy and law typically prioritized ahead of infrastructure or biodiversity
A house that you know has no people in it (house)	Example of infrastructure; burning would result in no loss of life; inanimate asset	Potentially feasible to reconstruct if destroyed
A farm shed with some hay bales and a tractor (shed)	Example of infrastructure; burning would result in no loss of life; inanimate asset	Potentially feasible to reconstruct if destroyed
A flock of 50 sheep—a few of which will be killed by fire, but survivors are likely to be badly injured (sheep)	Property loss; animal welfare issues	No conservation loss
A population of 50 koalas—a few of which will be killed by fire, but survivors are likely to be badly injured (koala)	Iconic species; animal welfare issues	Loss not likely to significantly affect conservation status
The last population of a native snail species for which the fire will kill all individuals, thereby causing the species' extinction (snail)	Noniconic species; not an animal welfare issue	Extinction would be an unrecoverable loss
The last population of a small native shrub, for which the fire will kill all plants, thereby causing the species' extinction (shrub)	Noniconic species; not an animal welfare issue	Extinction would be an unrecoverable loss
One of only 2 populations of a rare wallaby for which the fire will kill all individuals of one of the populations (but not affect the other), thereby making it more endangered (wallaby)	Somewhat iconic species; not an explicit animal welfare issue	Loss would cause significantly greater imperilment but not cause extinction
Ancient rock art that will be destroyed if fire gets into the weeds now growing in the rock shelter (rock)	Cultural value; inanimate asset	Not feasible to reconstruct if destroyed
An old tree with an ancient Aboriginal carving on the trunk (tree)	Cultural value	Not feasible to reconstruct if destroyed

Note: Survey respondents were tasked with selecting the asset they most wanted and the asset they least wanted to protect in a hypothetical wildfire scenario. Choices were sought repeatedly for subsets of 5 assets.

threatened (Rumpff et al., 2023). Intimation that society supports some attempt to prioritize biodiversity assets in disaster management comes from social surveys that show that communities are prepared to accept fire management practices that provide for explicit protection of biodiversity, even if such practices lead to reduced effort allocated to protecting human life or infrastructure (Moskwa et al., 2016, 2018). Furthermore, surveys of the Australian public show that a large majority of people believe society should attempt to prevent extinction regardless of the cost (Zander et al., 2021, 2022), indicating that in an emergency setting, protecting a species that would otherwise become extinct should be accorded a high priority. The Australian Black Summer wildfires also demonstrated that some biodiversity assets, such as the critically endangered and highly localized Wollemi pine (*Wollemia nobilis*), can be prioritized for protection during wildfire and that such protection can be achieved through intensive targeted responses made during wildfire (Gallagher et al., 2023).

Sampling and data collection

We aimed to sample adult people living in Australia. We designed a structural questionnaire in Qualtrics, which was first tested with 30 people across Australia for its clarity and ethical aspects about framing the BWS experiment. Minor refinements in survey design and wording were adopted in response to feedback from this trial, but the feedback indicated the questions and options for answers were appropriately interpretable to respondents, the 11 assets chosen for the BWS were relevant, and the design with the specific combinations and repetitions was manageable (see "BWS design").

For the main survey, we paid a marketing research company (Dynata) to distribute the link to the survey. Following standard practice, the research company randomly selected 20,000 respondents from their panel of about 400,000 potential respondents without informing them of the content of the survey. We aimed to obtain around 2000 completed responses and the expected response rate was approximately 10%, as advised by the marketing company. Assuming that a small percentage would not complete the survey, we set the quota at 2500 responses. This meant that the first 2500 respondents who started the survey, and learned of its subject area, were recorded, all others were eliminated, and the survey was closed once 2500 respondents started the survey. Of those 2500 responses, we excluded 304 (12.2%) respondents who did not complete their surveys and 57 (2.3%) who completed it in <3 min and were assumed not to have applied themselves sufficiently for their results to be valid given an average completion time of 12 min. The final data set contained 2139 complete and valid responses. The survey was conducted in January 2023, about 12 months after the Black Summer wildfires. Ethical approval for this research was obtained from Charles Darwin University ethics committee (H22088).

Questionnaire

The questionnaire contained 5 parts (Appendix S1). The first part included an introduction to the research project and team, instructions for completing the survey, and a screening question to ensure respondents were at least 18 years old.

The second part included the BWS text and tasks. The third part included questions about respondents' attitudes about the environment and engagement with nature (not considered further here). The fourth part had questions about respondents' experiences with natural hazards and their preparedness. The fifth part contained demographic questions (gender, age, identification as Indigenous, education, income, location).

BWS design

Because we sought to assess people's preferences for assets they wanted saved by fire managers, we applied a method that let respondents compare and trade off different assets. We opted for the BWS method because it has many advantages over conventional ranking and rating measurements. For example, BWS provides more reliable and reproducible results than Likert ratings (Burton et al., 2021). Results are also of better quality because BWS minimizes response fatigue and cognitive burden on respondents by limiting the number of items to be assessed to a few in respondent-friendly tasks (Chrzan & Peitz, 2019). The BWS method was developed by Finn & Louviere (1992) and has been applied in many disciplines, including conservation (e.g., Bhatta et al., 2022; Lewis-Brown et al., 2021; Zander et al., 2021). There are 3 different approaches to the BWS (Louviere et al., 2015). We applied the case-1 approach (the most commonly applied), which is the simplest of the 3 cases and is most appropriate when the aim is to assess preference among different statements or items (Louviere et al., 2013). In this type of BWS, respondents are asked to state which item among a set of items they consider as best and worst (Louviere et al., 2013). In our survey, *best* meant the asset the respondent most wanted to save and *worst* meant the asset the respondent least wanted to save.

We chose and offered 11 items that represented different types of assets to be saved (Table 1). The researcher's task is to strike a balance between obtaining comprehensive data (i.e., as many different assets as possible to be offered as choice) and ensuring that the survey remains manageable for respondents. Our 11 assets represent only a very small set of all possible assets at risk in wildfire; however, we capped this list at 11 to ensure our survey was manageable to respondents. The list of assets was broadly derived from inquiries following the Black Summer wildfires into policy and outcomes. The BWS approach required an experimental design that grouped these 11 assets to respondents in a way that was not cognitively overloading. Two design considerations needed to be made: the number of assets shown in one BWS task and the number of BWS tasks to be presented to each respondent. There is limited evidence about how many items in a BWS task is optimal, but 3–6 items are common in the literature, so we opted for 5 items (here assets for potential protection during fire) in each BWS task. A longer list of assets would have required many more choices per person with a greater probability that fatigue would lower response quality (Chrzan & Peitz, 2019). The case-1 BWS experimental design is a balanced incomplete block design (BIBD). The BIBD is used to balance the allocation of items in the design so that each item occurs the same number of times and the same number of times together with the other items (co-occurrence) (Louviere et al., 2013). There is a finite number of possible BIBDs that fulfill the combinations of the number of items in total, the number of BWS tasks per respondent, and the number of items per task (Louviere et al., 2015). Bearing in mind these constraints and our 11 assets, we blocked those into a design with 5 assets each in 11 different tasks (so 11 tasks per respondent). Each asset co-occurred with another asset twice and each asset appeared 5 times across the 11 tasks (Appendix S2). This meant that each respondent could choose an asset as most important (best) or as least important (worst) a maximum of 5 times. This allowed trading off one asset with others multiple times. The design was created using the R package crossdes (Sailer, 2015). To avoid position bias (i.e., respondents being more likely to choose the top asset from the list), we randomized the order in which the assets in a task occurred (Campbell & Erdem, 2015).

Data analyses

Data from a BWS experiment can be analyzed using 2 broad approaches: counting best-minus-worst approach and a model approach (Louviere et al., 2015). For designs that are BIBD, Marley and Louviere (2005) found that results from the counting approach are nearly exactly the same as results from the model approach. We opted for the counting approach to show the relative rating of the 11 assets. The BWS data were analyzed using the R package support.BWS (Aizaki, 2023). We calculated the number of times respondents chose an asset as highest priority (best) and the number of times they chose that asset as lowest priority (worst), across the 5 sets of choices offered with that asset. The BW scores were calculated by subtracting the worst score from the best score. A positive BW score indicated that an asset was chosen more often as being of highest than lowest priority. This was done on an aggregated level first, meaning across all respondents not accounting for the fact that each respondents made 11 choices. The aggregated BW scores were then standardized by dividing the BW score of each asset by the number of times the asset occurred over the whole data set, which was 5 times per respondent (i.e., 10,695 times in total [5 × 2139]).

Because BW scores can be positive and negative and therefore also sum to zero, they might be difficult to interpret (Loose & Lockshin, 2013). Rescaling of the BW scores is often done to facilitate interpretation of the importance rating of items and to compare importance ratings across items (Loose & Lockshin, 2013). We calculated the ratio score by taking the square root of the aggregated best score divided by the aggregated worst score as indicated in Equation (1) for each asset *i*. The resulting coefficient indicated the choice probability relative to the most highly

valued asset (Marley & Louviere, 2005).

$$\text{Ratio scale}_i = \sqrt{B_i/W_i}. \quad (1)$$

The ratio scale for each asset was then scaled by a factor equal to the maximum square root of (B/W) so that the most valued asset was assigned a value of 1 (Equation 2). This provided a standardized ratio scale for asset *i*, which can be interpreted as the percent value of each asset relative to the highest ranked asset.

$$\text{Standardized ratio scale}_i = \sqrt{\frac{B_i/W_i}{\max \sqrt{B/W}}} \quad (2)$$

Apart from the aggregated scores, we also calculated individual scores, also referred to as disaggregated, to explore preference heterogeneity for specific subgroups of the sample, such as men and women (Finn & Louviere, 1992). The BW scores were divided by the number of respondents to obtain the individual mean BW scores. Given each asset was included in 5 different sets, the mean BW score for each asset could range from −5 (asset chosen as lowest priority 5 times) to +5 (asset chosen as highest priority 5 times). The 95% confidence intervals of BW scores were also calculated. To test for significant differences among assets in BW scores across respondents with different social and attitudinal context, Kruskal–Wallis rank tests (*H*) were applied. To test for overall differences among assets in their rankings, we used Kolmogorov–Smirnov tests between pairs of assets in the cumulative frequency of rankings.

RESULTS

Sample description

The demographic and other characteristics of the 2139 respondents are summarized in Appendix S2. Given the random selection of these respondents among the panel of 400,000 people within the market research company's list, the characteristics of respondents broadly matched that of the adult Australian population as a whole, although our sample had marginally higher proportions than the Australian population of young people (18–40 years old), a lower proportion of people with low incomes (<AUD 25,000), and a higher proportion living in nonurban areas. For 27% of respondents, wildfires were the natural hazard of the most concern to themselves, their family, and community, followed by heat waves (19%) and floods (19%) (Appendix S3). Fourteen percent of respondents had been affected greatly by wildfires.

BWS results

Survey respondents gave the highest ranking to the 2 assets of protecting people, and 42% of respondents chose *person not warned* as the most important asset to save each time this asset occurred (score of +5) (Figure 1). In terms of relative importance, saving a person who ignored evacuation advice was rated 57% as important as saving a person who had not received warnings (i.e., standardized ratio scale of 57) (Table 2). Saving the koala population was rated slightly lower (56% as important as saving a person who had not received warnings). Saving the wallaby population was 45% as important as saving a person who was not warned. Saving the house and shed had the lowest rankings (14% and 9%, respectively, as important as saving a person who was not warned).

The mean individual BW score of *person not warned* was 3.37, and that of *person ignoring advice* was 1.47 (Table 2; Figure 2). Saving koalas had the third and wallabies the fourth highest mean BWS scores. The remaining assets all had negative scores, meaning that respondents were more likely to choose them as least important than most important. The 95% confidence intervals were narrow for all assets, suggesting a relatively high level of consistency in preferences within the sample (Figure 2). The cumulative frequency distribution of BW scores (Figure 1) varied significantly ($p < 0.01$) between all pairs of assets (Appendix S4).

Gender had the most significant impact on the mean BW scores (Table 3; Appendix S5). Female respondents placed higher importance than male respondents on the protection of the rare wallaby population, the koala population, the sheep, and the tree carving and lower importance than male respondents on the protection of the house, shed, native shrub, and rock art. Of those characteristics for which our sample was most divergent from the Australian population as a whole, there was relatively little difference in asset rankings between urban and nonurban respondents. Older respondents (>65 years) rated protecting people more highly than younger respondents, but rated the tree carving less highly than younger respondents. People with low incomes prioritized protecting the unwarned person higher than did those with a higher income (Table 3; Appendix S5).

Survey respondents affected by wildfires and those assessing themselves as being prepared for wildfires were less likely to save a person who had not received warnings than those with high income and those living in urban areas (Table 3). Those who rated themselves as prepared for wildfire were also less likely to save a person who ignored warnings, whereas those who had been affected by wildfire were more likely to do so. Those who had been affected by wildfires were also more likely to save the threatened wallaby population. Those who felt prepared for wildfire were more likely to choose the shed and house as most important.

Respondents who self-identified as Indigenous placed a higher score on protecting the rock art and tree carvings than those identifying as non-Indigenous. They also placed relatively high priority on protecting the house and shed and lower value on the protection of people (although these results should be treated with caution because of the small number of Indigenous respondents).

With respect to prioritization of actions taken to prevent the extinction of the snail and shrub species, there was little variation associated with characteristics of the respondents.

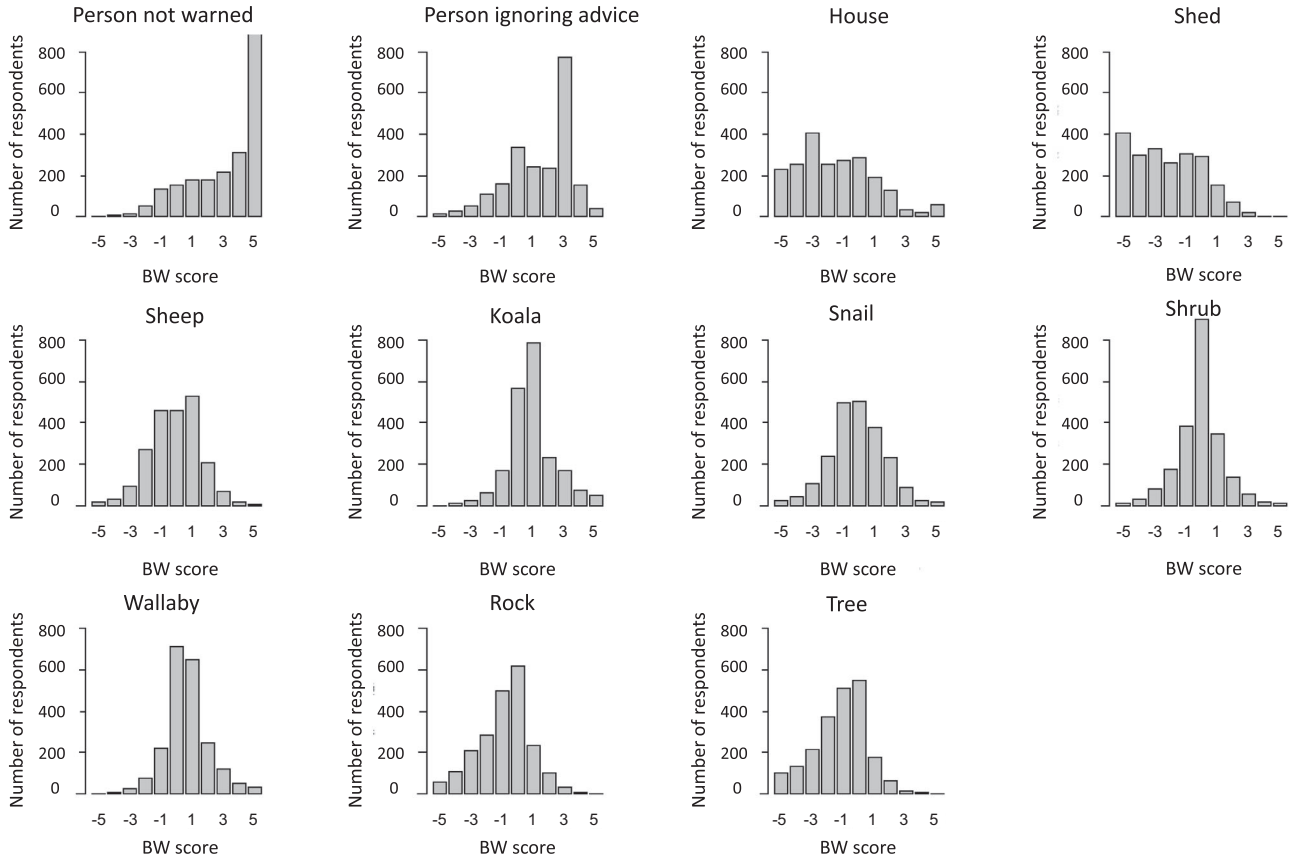

FIGURE 1 Best–worst (BW) scores for each asset across all survey respondents. Tallies in each graph sum to the total number of respondents (2139), with the scores calculated as the number of times (out of 5 possible choices offered for that asset) respondents chose an asset as highest priority (best) minus the number of times they chose that asset as lowest priority (worst). A positive BW score indicates an asset was chosen more often as being of highest than lowest priority.

TABLE 2 Summary results indicating prioritization given by survey respondents among the set of 11 assets offered.

	Aggregated[a]					Individual		
Asset	**B**	**W**	**BW[b]**	**Ratio scale**	**Standardized ratio scale[c]**	**Mean B**	**Mean W**	**Mean BW[b]**
Person not warned	7199	552	6647	3.61	1	3.37	0.26	3.11
Person ignoring advice	4121	982	3139	2.05	0.57	1.93	0.46	1.47
Koala	2533	620	1913	2.02	0.56	1.18	0.29	0.89
Wallaby	2197	818	1379	1.64	0.45	1.03	0.38	0.64
Shrub	1154	1380	−226	0.91	0.25	0.54	0.65	−0.11
Sheep	1544	1781	−237	0.93	0.26	0.72	0.83	−0.11
Snail	1630	1959	−329	0.91	0.25	0.76	0.92	−0.15
Rock	779	2630	−1851	0.54	0.15	0.36	1.23	−0.87
Tree	541	3079	−2538	0.42	0.12	0.25	1.44	−1.19
House	1234	4476	−3242	0.52	0.14	0.58	2.09	−1.52
Shed	597	5252	−4655	0.34	0.09	0.28	2.46	−2.18

[a]Aggregated best (B) and worst (W) scores tally the total number of times the asset was selected across all 2139 respondents as their most preferred (best) and least preferred (worst) asset, respectively, to protect in a hypothetical wildfire scenario. The maximum possible tally is 10,695 (i.e., 5 × 2139).
[b]Best tally minus the worst tally for that asset.
[c]Square root of the aggregated best score divided by the aggregated worst score.

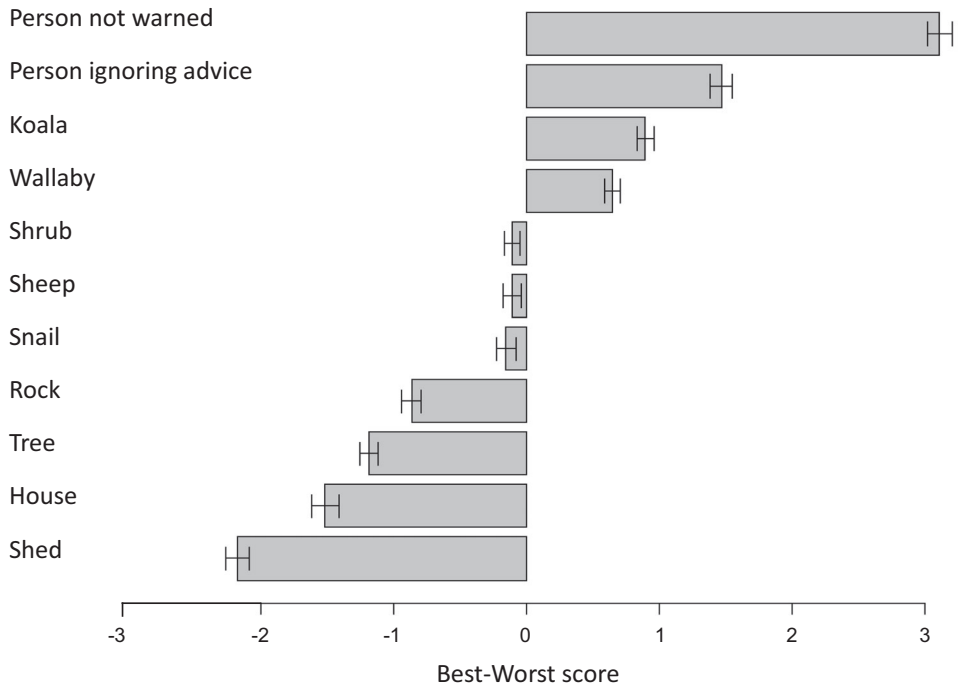

FIGURE 2 Individual mean best–worst scores for each of the 11 assets offered in the choice survey and their 95% confidence intervals. Scores are calculated as the number of times a respondent chose the asset to be their highest priority for saving in wildfire minus the number of times the asset was chosen as the lowest priority for saving across the 5 subsets of assets offered that contained the asset.

Males, older people, non-Indigenous people, those with a lower income, and those with lower risk perception for wildfire had marginally higher prioritizations for the protection of the shrub, and people living in urban areas, not prepared for wildfire, and with higher risk perception for wildfire had marginally higher prioritization for the protection of the snail.

DISCUSSION

The increasing incidence and severity of environmental crises, driven by climate change, will result in escalating losses of human life, property, and natural values (biodiversity) (Canadell et al., 2021; Kelly et al., 2020). Agencies responsible for managing these crises have some influence in determining the relative proportional tally of losses among these disparate values. Currently, natural assets are typically prioritized last (Royal Commission into National Natural Disaster Arrangements, 2020). The implementation of such prioritization will likely lead to a recurring pattern of acute biodiversity losses, including extinctions, with such episodes of loss superimposed on and ratcheting up the extent of current chronic biodiversity decline (Rumpff et al., 2023).

Our survey format did not provide for respondents to describe the rationale for their decision-making, so our explanation of results represents our interpretation. Our survey results provide mixed support for current policy and practice of what should be protected in natural disasters and variable support for commitments to biodiversity conservation in general and prevention of extinction in particular. Consistent with convention (Royal Commission into National Natural Disaster Arrangements, 2020), there was a very strong preference for prioritizing the protection of human life, with a clear choice made to protect a single person ahead of preventing our examples of the extinction of a plant or animal species. Although still rating higher than all the nonhuman asset choices, survey respondents gave lower priority to the protection of an individual person who had remained in a fire-risk area despite warnings to evacuate than to one not warned. This recognition by the respondents of less obligation to save warned people matches and reinforces the message expressed by fire management agencies in fire-prone areas: people in those areas need to take some responsibility for their actions, especially once warned about imminent danger (Inspector-General for Emergency Management, 2020).

In general, survey respondents ranked actions taken to prevent loss of life (including animals and plants) ahead of actions taken to protect inanimate objects, most of which could be reconstructed if destroyed. Our respondents prioritized protection for each of the 4 biodiversity assets higher than that of the 2 property assets considered, in contrast to current policy. This suggests that current policy and practice may not well reflect societal values and should be reviewed. We offered limited choices (with both property assets we included being privately owned), and some infrastructure—and possibly especially public good assets, such as schools—may be valued more highly by the community. Indeed, the nominal losses of the 2 property assets we offered as choices (house, farm shed) would largely affect only the individuals owning those assets, whereas it could

TABLE 3 Summary results (*p* values from nonparametric Kruskal–Wallis tests) of variation in best–worst scores for individual assets in relation to demographic and other characteristics of respondents.

Asset	Characteristic of respondents							
	Older (>65 years)	High income (>AUD 125,000)	University educated	Female	Urban	Indigenous	Prepared for fire	Previously affected by fire
Person not warned	<0.001 (+)	<0.001 (−)	ns	ns	<0.01 (−)	<0.001 (−)	<0.001 (−)	<0.001 (−)
Person ignoring advice	<0.001 (+)	ns	ns	ns	ns	<0.001 (−)	<0.01 (−)	<0.001 (+)
Koala	ns	ns	<0.01 (−)	<0.001 (+)	ns	ns	<0.01 (−)	<0.001 (−)
Wallaby	<0.05 (−)	<0.01 (−)	ns	<0.001 (+)	ns	<0.05 (−)	<0.01 (−)	<0.001 (+)
Shrub	<0.05 (+)	<0.01 (+)	<0.001 (+)	<0.001 (−)	ns	<0.01 (+)	ns	ns
Sheep	<0.01 (−)	ns	<0.05 (−)	<0.001 (+)	ns	ns	ns	ns
Snail	ns	ns	<0.001 (+)	ns	<0.01 (+)	ns	<0.05 (−)	ns
Rock	ns	<0.05 (+)	<0.001 (+)	<0.001 (−)	ns	<0.001 (+)	<0.05 (+)	ns
Tree	<0.001 (−)	<0.001 (+)	<0.01 (+)	<0.01 (+)	ns	<0.001 (+)	<0.01 (+)	<0.01 (+)
House	ns	ns	<0.001 (−)	<0.001 (−)	<0.01 (−)	<0.01 (+)	<0.01 (+)	<0.001 (+)
Shed	ns	ns	<0.001 (−)	<0.001 (−)	ns	<0.001 (+)	<0.001 (+)	<0.001 (+)

Note: Sign in brackets indicates the direction of variation: +, class given in the column header (e.g., older) scores higher than its complement; - indicates the opposite. Full results are presented in Appendix S5. Demographic and other variables for which there were no significant associations with best−worst scoring are not included.

be argued that the loss of any of other infrastructure assets considered affects the whole community. Nonetheless, loss of major public assets is relatively uncommon in Australian wildfires; many schools, medical facilities, and recreation grounds were designated as "safer places" during fires (Royal Commission into National Natural Disaster Arrangements, 2020).

Among biodiversity assets, our respondents showed a strong preference for protecting a population of koalas ahead of the other options. This is consistent with previous research that shows strong biases toward conservation of such charismatic species (especially mammals and explicitly including koalas) (Tisdell et al., 2006). In the case of the koala, this preference may have been further influenced by animal welfare concerns fueled by the significant media attention directed at the suffering of koalas affected by the Black Summer wildfires (e.g., Thomson, 2021) and much media reporting of attempts to save injured koalas (Sherwin et al., 2023). Nonetheless, animal welfare concerns were not pervasive among our respondents, who rated protection of a comparable number of sheep (also stated as likely to be subject to similar levels of suffering and injuries) appreciably lower than for the koala.

Among the biodiversity assets, the rankings provided by respondents were not consistent with conservation consequences (i.e., preventing the extinction of the snail and plant species first, then the loss of one of only 2 populations of the wallaby, then a relatively less consequential loss of koalas). In part, the high priority accorded to the protection of the koala may be because the imperilment and ongoing decline of koalas are widely publicized and so well known in the community (The Senate Environment & Communication References Committee, 2011); therefore, any losses of koalas may have been seen by our respondents as a highly undesirable conservation outcome.

Notwithstanding previous research that shows the community wants authorities to prevent extinction (Zander et al., 2021) and that greater awareness of a species' conservation status influences the valuation given by people (Tisdell et al., 2007) and recent high-profile commitments by the Australian government for zero extinctions (Commonwealth of Australia, 2022), our survey respondents showed only low to moderate preference for actions taken that would prevent the extinction of a native snail and native plant species. Many factors may have contributed to such disregard. Our description of these 2 assets was brief, featureless, and anonymous. More care for them may have been given by respondents if we had selected a particular plant or snail species, illustrated it, and provided some narrative about it (Gregg et al., 2022; Kusmanoff et al., 2020). Furthermore, although our scenario stipulated that, unless given protection, the wildfire would cause the extinction of the snail and plant species, it is possible that respondents had some uncertainty about the totality of loss. It may be easier to conceptualize a house being destroyed by a fire than it is to conceptualize all individuals of a snail or plant species being killed by fire and there being no seedbank or other basis for recovery from such loss. Most respondents were likely unaware of the imperilment of many native snail species and their susceptibility to wildfire (Decker et al., 2023).

Survey respondents may also have made their choices for koala and against preventing the extinction of the plant and snail species with some consideration to taxonomic distinctiveness. For example, there are hundreds of similar Australian native land snail species (Stanisic et al., 2010), so any one may be considered expendable. More broadly, this relative unconcern for the extinction of a plant or snail species is consistent with a pervasive conservation bias in Australia (Walsh et al., 2013) and, globally, against poorly known and uncharismatic species, especially invertebrates. This disinterest has contributed to exceptional rates of loss (Régnier et al., 2009, 2015) and allowed authorities to take actions that result in high probabilities of extinctions of uncharismatic and poorly known species (Woolaston & Akhtar-Khavari, 2020). Respondents to our survey made the choice that would have resulted in extinction of a native plant species at a level similar to their prioritization for the snail species, suggesting that conservation unconcern is not a problem restricted to invertebrates.

Our wallaby example was less preferred than the koala but more preferred than the more imperiled snail or plant. This rating is consistent with the wallaby likely being perceived as more charismatic than the snail and plant but less charismatic than the koala; there was some support for trying to avoid its further imperilment. The relatively high rating for protecting the wallaby is consistent with previous choice studies that indicate that, along with koalas, kangaroos are highly prioritized for conservation efforts by Australian respondents (Pearson et al., 2022).

The potential loss of Indigenous cultural values was not rated highly by most survey respondents. This may be due in part to reporting of the Black Summer wildfires giving few examples of such loss, relative to the publicity focused on losses of wildlife, infrastructure, and people (van Leeuwen & Miller-Sabbioni, 2023), or it may reflect that appreciation of the value and significance of such cultural assets is underdeveloped. Possibly, respondents also considered our rock art example may have been unlikely to be destroyed. There have been some examples of such loss, but they have not attracted wide media interest (van Leeuwen & Miller-Sabbioni, 2023).

Although some features of our sample showed a high degree of consistency among respondents (e.g., the overwhelming preference to prioritize the protection of human life), there was also variation among respondents in their preferences: societal values were not uniform (Table 3; Appendix S5). Some of this variation appears self-explanatory. For example, Indigenous respondents rated the 2 assets of Indigenous cultural value higher than did non-Indigenous respondents. However, significant differences in preferences toward assets for some of the other considered survey respondent parameters (e.g., gender, age) reflected more nuanced attitudinal variation.

One view might consider that our results provide little comfort for imperiled but uncharismatic species. On this reading of the results, it is sobering that the community so overwhelming chose to protect a single human life (even when the person ignored safety advice) rather than preventing a species extinction. The apparent disregard for extinctions of poorly known and noniconic species is consistent with the limited response by the community to several recent extinctions in Australia (Marsh et al., 2022; Woinarski, 2018). As such, this could be considered an uncomfortable result for conservation biologists—an example of the moral conflict that is almost inevitably involved in tragic trade-offs (Mandel & Vartanian, 2008; Tetlock, 2003). Taking this view, more effort could, and perhaps needs to, be made to strengthen the case made to the community for trying to prevent any extinction. This conclusion is comparable to those based on previous studies that illustrate the challenge of shifting community unconcern for uncharismatic biodiversity, such as most invertebrates, even if threatened. For example, Pearson et al. (2022) noted that "… limited recognition of, and knowledge about, endangered Australian wildlife may be a significant barrier to increased conservation support and success—especially for Australia's highly endangered but lesser known species" and that conservation efforts for such species may hinge on the ability to change public perceptions. This may be a formidable challenge, and it may be inconsistent with the principle countenanced here that prioritization of what to protect in wildfires should reflect community attitudes.

The preference of our respondents for saving a single human life ahead of extinction may also reflect current systems of legal accountability. Potentially, any manager who knowingly chose not to save a person, whatever the circumstances, could potentially face legal repercussions, such as being charged with manslaughter. In contrast, there is generally no comparable accountability for actions that lead to extinctions, especially when it is *not* taking an action that ensured that outcome (Woinarski et al., 2017). The descriptions and context we provided to respondents did not portray the legal environment in which the fire manager was working, leaving the respondents to make their own assumptions. The high priority accorded by our respondents to saving a warned person (who it can be assumed has taken responsibility for their action) may indicate a need for further legal refinements (i.e., the fire control agencies should not be legally responsible for deaths of people who have ignored advice to leave).

Whether one views our results as dispiriting or encouraging, they strongly support the supposition of the NSW Commission that there needs to be far more discussion in the community about just what to protect during wildfires and comparable events. In particular, our results suggest that policy and practice should be changed to prioritize the protection of nature over the protection of at least some forms of human property—a reversal of at least part of the current hierarchy of priorities. Any such change would also benefit from enhancing the legal context to provide for more accountability for the loss of important natural assets (and especially those resulting in extinctions) in wildfires, even where such loss is the result of actions not taken. Another potential improvement would be for mandatory reparation after a fire to repair or restore biodiversity losses that have occurred as a consequence of management authorities privileging other asset types. However, no reparation will recover species rendered extinct.

Our results complement a previous study that demonstrated that society wants many disparate values protected during wildfires (Williams et al., 2018). However, in contrast to the

pluralism of that study, our methodology forced participants to make explicit choices about what to and what not to protect. Emergencies force people to make choices, and choices made in such settings can test the strength or weakness of general commitments, such as to protect biodiversity and prevent extinctions. Our results offer critical insight into such commitments: when tested, biodiversity values are subordinated to human life in general.

Like any social survey relying on people's honest responses, no matter if obtained through in-person, telephone, or online surveys, our results should be treated with caution. Responses from online surveys, as used here, may be subject to various biases, such as self-selection and sampling bias (Dillman et al., 2014). Self-selection means that people who have strong opinion about a topic are more likely to participate in a survey, potentially distorting the results (Ferri-García & Rueda, 2020). We minimized this bias because respondents were invited using an anonymous link that did not reveal what the survey was about. Moreover, respondents were paid to complete the survey, so those not interested in the topic and without strong opinions might have had an incentive to complete it. A sampling bias occurs when the sample may not accurately represent the entire population—here, the Australian adult society. Online surveys indeed tend to attract younger and well-educated respondents (Duffy et al. Bremer, 2005; Szolnoki & Hoffmann, 2013). Our analyses of variation in scoring associated with differing characteristics of respondents provided some insight into the potential effects of such biases, for example, indicating that respondent age had some nuanced impact on prioritization (Appendix S5).

Another study limitation relates to the design and the chosen BWS approach. We used a simple hypothetical setting in our survey, but in reality, many other factors may affect the prioritization of protecting one asset rather than another in an emergency setting, such as the likelihood of achieving that protection, the potential risks to fire fighters, and potential collateral benefits and costs. In many wildfires of high severity, any ambition to protect a given asset may be impossible to achieve: the fires may be uncontrollable and operating at great speed.

Our results can inform policy and practice to ensure it better reflects community expectations, and our results clearly suggest that such change is needed. In particular, this should include according higher priority to protecting biodiversity relative to protecting infrastructure, with such recognition built into the application of fire management and response (Otero et al., 2018; Williams et al., 2021). We recommend a process for expanding and elaborating on this study, in Australia and other countries comparably affected by wildfire, such as through a series of regional stakeholder consultations in which prioritization and its rationale are carefully teased out, including across a broader menu of infrastructure, biodiversity, and other assets.

There are increasing global commitments to halting and reversing biodiversity loss and preventing extinctions (CBD, 2022). However, if such commitments are to be achieved in a world exposed to an increasing incidence of severe wildfire and other extreme disturbance events, then managers—reflecting society as a whole—will need to increase the prioritization accorded to biodiversity protection in the management of such events (and in the plans and policies developed in anticipation of such events) (Otero et al., 2018; Williams et al., 2021). Our results indicate some support in Australian society for such biodiversity protection but that this support also reflects some pervasive biases in the way different components of biodiversity are valued.

Given that the current policy and legal settings accord low priority to biodiversity protection in wildfire, that our survey indicated relatively little societal support for prioritizing actions that would prevent the extinction of uncharismatic species in such wildfires, and the high rates of biodiversity loss in wildfires, there is a fundamental need to try to reduce the incidence of such wildfires and other comparable disasters (e.g., through early detection of ignitions and more effective control capability and, of course, greater efforts to constrain global climate change). This is a formidable challenge. But other preparatory actions may be more readily achievable, for example, proactive management of biodiversity assets that can be predicted to be susceptible in wildfires, such as translocations of narrowly endemic species and establishment of insurance populations to reduce risk of total loss in wildfires (Woinarski et al., 2023).

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SUPPORTING INFORMATION

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

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