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Decision biases and environmental attitudes among conservation professionals

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Abstract

The importance of human behavior in biodiversity conservation is widely recognized, but there is little published evidence about how conservation professionals make decisions when conservation values are at stake. We take a behavioral economics approach, administering simplified decision problems ("choice experiments"), questions about choice-relevant preferences and views ("elicitation questions"), and a psychometric scale (the New Ecological Paradigm scale) to a difficult-to-recruit sample ($n = 100$) of Canadian professionals involved in managing *Rangifer tarandus caribou* (Woodland Caribou). Our choice experiments reveal the importance of several decision biases (risk aversion, commission bias, and a bias towards fairness) in this influential group of conservation stakeholders. We then examine in-sample differences between categories of professional affiliation (e.g., resource industry, environmental nongovernmental organization, or federal/provincial government), finding significant variation in responses to one elicitation question (reference points) and in psychometric scores. We discuss the implications of our findings for choice in conservation practice and for multistakeholder conservation policy. Comparing our findings to prior work on choice under uncertainty in nonconservation contexts suggests a possible replication problem in applying behavioral science insights to conservation problems, pointing to the need for a systematic research program. Results from development testing with a convenience sample of university students are presented for comparison throughout the study.

KEYWORDS

behavioral economics, behavioral science, biodiversity conservation, decision-making, fairness bias, new ecological paradigm (NEP), omission bias, Prospect Theory, risk aversion

1 | INTRODUCTION

An estimated US$78–91 billion per year is spent on the conservation, sustainable use, and restoration of biodiversity (OECD, 2020), yet relatively little is known about how the individuals in charge of conservation efforts make decisions. Understanding the "decision behavior" of conservation practitioners is important, because such behavior (e.g., how options are framed or trade-offs are evaluated) determines which conservation actions are

taken and how. Several lines of evidence suggest that decision behavior is important. First, prior work has suggested that avoiding risks negatively impacts outcomes in conservation and resource management (Canessa et al., 2020; Maguire & Albright, 2005; Tulloch et al., 2015), and that government funding decisions overweight costly-yet-futile projects (Gerber, 2016). Second, the broad uptake of decision support frameworks and tools in conservation (Schwartz et al., 2018) suggests the importance of "correcting" choices by imposing structure on conservation decisions. Third, many structural features of choice in conservation (e.g., uncertain options, low probability/high consequence outcomes) have been shown to produce "bad" choices in other contexts (Kahneman, 2011). If choice in conservation is subject to decision behavior that produces similar outcomes, identifying such tendencies may improve decision-making.

Studying decision behavior requires a benchmark model for evaluating choice (Baron, 2004). We take a behavioral economics approach and employ expected value,[1] referring to systematic deviations from choices which maximize expected value as biases. We recognize that choice in conservation is complex and multifaceted, and that maximizing expected value within a given conservation choice situation is not necessarily optimal (see, e.g., criticisms of conservation "triage", e.g., Jachowski & Kesler, 2009; Wiedenfeld et al., 2021). Identifying deviations from a benchmark model allows behavioral scientists to understand why people choose the way they do, and if these deviations are associated with preferences about outcomes identifying them may lead to better choices. For example, identifying biases underlies current efforts to improve policy design and program delivery in a wide variety of choice situations via "nudging" (Thaler & Sunstein, 2009), that is, manipulating choice structure to bias toward preferred outcomes while preserving free choice. However, efforts to inform environmental policy design and program delivery by cataloguing biases (Bujold et al., 2020; Iftekhar & Pannell, 2015; OECD, 2017) are limited by the unknown reproducibility of a particular bias in a novel choice context (e.g., in conservation vs. healthcare). Despite sustained enthusiasm for a behavioral approach to biodiversity conservation (Cowling, 2014; Croson & Treich, 2014; Nielsen et al., 2021; Reddy et al., 2017), behavioral factors in conservation science and practice have received little attention (Kiik, 2019; Root-Bernstein, 2020). We know of no experimental studies assessing bias among conservation professionals themselves.

Ideally, empirical decision studies will lead to a predictive theory of decision behavior in conservation. In behavioral economics this role is played by Prospect Theory (PT)[2] (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), which arguably remains the preeminent description of choice under uncertainty in experimental settings (Barberis, 2013). PT is robust to replication (Ruggeri et al., 2020) and consistent with economic evidence (List, 2004) but is empirically supported by decision studies that overwhelmingly involve choices over monetary (or at least money-fungible) outcomes. Some aspects of choice captured by PT may be domain-contingent (e.g., risk attitudes; Riddel, 2012) and it is not clear whether the predictions of PT replicate when conservation values are at stake, or whether other theories of choice are more appropriate (e.g., norms about actions; Baron & Spranca, 1997). Since PT remains highly influential in both behavioral economics and behavioral science more generally, testing its validity in a conservation context is an important step for applying behavioral insights to conservation problems.

This paper aims to advance understanding of decision behavior among conservation professionals by attempting to experimentally replicate several important decision biases in a nonrandom sample ($n = 100$) of Canadian conservation professionals. We focus on reference-dependent risk aversion (the "reflection effect"), omission bias, and a bias toward fairness. We select these biases due to their theoretical and practical importance: the reflection effect is a core feature of PT, while omission bias and a bias towards fairness have direct implications for conservation management (we describe these biases alongside our choice experiments below). Obtaining responses from conservation professionals themselves is important because results from more convenient samples (e.g., university students) may not generalize, a phenomenon borne out here by results from development testing, but experimental work with professionals is complicated by small sample sizes and the lack of a meaningful sample frame. We address these issues (small n, nonrandom recruitment) by applying randomization-based statistics and avoiding out-of-sample assertions, noting that foundational advances in behavioral economics have commonly relied on similar sample sizes ($n < 100$).

Conservation professionals are not a homogenous group (Kiik, 2019). We therefore examine differences in choice behavior by professional affiliation, using categories of affiliation that are widely recognized in our study context (i.e., the Canadian caribou conservation discourse; see following section). A central insight of PT is that humans typically evaluate options in terms of changes from some reference state (the "reference point"), which may be a realized state of the world or an expectation about how things should be (Kahneman, 2011). Changes are typically seen as either gains or losses, altering both the perceived value of options and the risk tolerance of the decision maker. Many behavioral biases can be explained using reference points (e.g., Baron & Ritov, 1994).

Whether reference points vary across conservation professionals is therefore an important empirical question; for example, where conservation policy is negotiated among multiple stakeholder groups, differences in reference points between groups may block compromises (McDermott, 2009). These considerations, alongside the importance of heterogeneity for replication in behavioral science more generally (Bryan et al., 2021), argue strongly for incorporating heterogeneity in experimental work on behavioral conservation. To this end, we test for differences in choice experiment responses between categories of professional affiliation and complement our findings with simple elicitation questions about reference points and risk tolerance. We also apply a widely used psychometric measure of environmental attitudes (Dunlap et al., 2000) to explore the potential role of underlying differences in worldview. We find significant differences between groups on several of these items, suggesting a complex set of behavioral challenges to multistakeholder conservation decision-making.

2 | DESCRIPTION OF STUDY

Governments around the world are increasingly bringing stakeholders together in pursuit of mutually acceptable solutions for natural resource management challenges (e.g., Ratner et al., 2022). This is exemplified in Canada in the management of Woodland Caribou (*Rangifer tarandus caribou*), a high-profile and threatened species characterized by large ranges, low population densities, aversion to disturbance, and reliance on late seral stage forest (Superbie et al., 2022). Of 37 woodland caribou subpopulations with trend data (51 total), 30 are in decline (Environment and Climate Change Canada, 2020), likely due to apparent competition and habitat loss associated with oil and gas extraction and logging in the Boreal forest (Environment and Climate Change Canada, 2020; Hebblewhite, 2017). Canada's federal government is committed to an ambitious recovery plan under the 2002 *Species at Risk Act* but the costly trade-offs involved in protecting critical habitat (i.e., foregoing resource development), have created an intractable—and contentious (Boan et al., 2018)—conservation challenge.

Early multistakeholder efforts for Caribou conservation (e.g., the Canadian Boreal Forest Agreement) sought negotiated compromises between conservation-oriented environmental nongovernmental organizations (eNGOs) and the forestry and oil and gas industries; following criticism (e.g., Smith, 2015) and setbacks, engagement from Indigenous Nations is now prioritized. While most decision-making authority is ultimately in the hands of federal and provincial governments, eNGO and resource industry staff, academic researchers, and representatives of impacted communities provide input to shape conservation policy, engage in management processes, and implement conservation actions. These activities require all stakeholders to make decisions under uncertain information and subject to constraints that require tradeoffs, with direct and indirect impacts on caribou conservation outcomes.

To study decision behavior in this context, we administered choice experiments (i.e., simplified decision problems), elicitation questions (i.e., questions designed to draw out decision-relevant information), and a psychometric scale to professional respondents self-identifying as affiliated with academia, eNGOs, federal or provincial government, resource industries, or local communities. Our research protocol (#14760, lead author is P.I.) was approved by the University of Toronto's Research Ethics Boards. Data collected during pre-testing with a sample of graduate and undergraduate students in forestry at the University of Toronto is presented for unchanged questions. We designed three versions of the survey instrument to allow between-subject tests and to randomize item order for some questions (item order was identical for all versions, and does not match the order in which items are presented here; see Appendix A, Supporting Information). Subjects were randomly assigned to versions using the JavaScript function `Math.random`. Two Attention Control Questions (ACQs) modeled on Peer et al. (2014) were used as quality controls, with responses passing one or more ACQs retained for analysis. Our final sample consists of 100 professional respondents (and 61 student responses). The professional sample was gender balanced (50 female/48 male/2 other), predominantly urban (65 out of 100) and overwhelmingly nonindigenous (95 out of 99). Since items could be skipped, sample size per item varies.

We used "snowball" sampling (i.e., peer recruitment through social networks) to recruit professional respondents, with a token participation incentive (see Appendix A, Supporting Information, for recruitment criteria). This approach is necessary because there is no clearly defined population of conservation professionals that can be randomly sampled (note that this sampling method precludes the calculation of a response rate). Prior efforts to study the decision behavior of actual decision makers (e.g., Wehrung, 1989) have taken similar, nonrandom, approaches.

Our statistical analysis treats responses as independent but nonrandom, implying that standard parametric tools for statistical inference are inappropriate (Handcock & Gile, 2011; Heckathorn, 2011). We consequently avoid out-of-sample inference and rely on randomization (sensu Ernst, 2004) to assess between-group

differences (i.e., we randomly reassign group labels to responses to evaluate significance, calculating all possible permutations to obtain an exact test where computationally feasible and otherwise drawing 10,000 realizations, which we distinguish by the subscript $p_{\text{simulated}}$). We conducted our analysis in R (v3.6.0) using the packages `stats` and `coin` (Hothorn et al., 2008); for clarity, we also report results from conventional parametric tests. Our sample size per group is small (see Table 1, row 2), and while randomization accommodates the consequently low expected values in some contingency tables (Kroonenberg & Verbeek, 2018) we caution that the overall significance of between-group tests is likely to be determined by mean values in the professional categories with the most responses. Because the null hypotheses we test do not have clear a priori dependence and recruitment challenges in our context increase the risk of Type II error, we do not adjust p values for multiple hypothesis testing.

To assess between-group differences in environmental worldview, we used the New Ecological Paradigm (NEP) psychometric scale (Dunlap et al., 2000). The NEP scale attempts to measure five "facets" (i.e., latent dimensions) of an environmental worldview, using three five-point Likert items per facet. Since the latent dimensionality of the NEP scale is debated (Hawcroft & Milfont, 2010) we assessed dimensionality via factor analysis using the R package psych (Revelle, 2021). Further details, along with a breakdown of responses by subscale, are given in Appendix B, Supporting Information.

3 | METHODS AND RESULTS

We used choice experiments to test for the reflection effect, omission bias, and a bias towards fairness, and three elicitation questions and the New Ecological Paradigm (NEP) scale to study between-group differences in worldview, risk attitudes, and reference points. We do not report results from two additional sets of choice experiments in the main text (items and justification are given in Appendix C, Supporting Information).

3.1 | Reflection effect

Human decision makers are typically not risk-neutral. Conventional economic theory holds that most decision-makers are risk-averse (e.g., Varian, 1992), in this context defined as preferring the expected value of a lottery to playing the lottery itself. PT holds that decision-makers are risk-averse for changes seen as gains, and risk-seeking for changes seen as losses. The classic demonstration of this phenomenon (Kahneman & Tversky, 1979: Q3) employs a choice experiment of the form:

> **Experiment 1.** Imagine that you face the following pair of concurrent decisions. First examine both decisions, then indicate the options you prefer.
>
> *Decision 1*. Choose between:
>
> A. A sure gain of $250
> B. 25% chance to gain $1000 and 75% chance to gain nothing
>
> *Decision 2*. Choose between:
>
> A. A sure loss of $250
> B. 25% chance to lose $1000 and 75% chance to lose nothing.

Since the expected value of option B is $250 ($\mathbb{E}[B] = 0.25 \times 1000 + 0.75 \times 0$) decision makers choosing according to expected value should be indifferent between A and B and between C and D. Choosing A and D demonstrates the reflection effect (i.e., a preference for the expected value of a lottery when framed as a gain, and for the lottery itself when framed as a loss). We employed this format with money-valued outcomes (as above; all survey versions) as well as with three conservation-valued outcomes (one per survey version). For the conservation-valued case, the values in Experiment 1 were replaced with 25 or 100 of: breeding pairs of an imaginary animal ("Harrison's Blackbacks"; using imaginary animals is intended to prevent prior information from influencing responses), Caribou, or Amur Tigers. For the Amur Tiger framing only, a reference point indicating scarcity was introduced in the question text (the world population of Amur Tigers: 540).

Because risk seeking over losses may depend upon the degree to which a risky option can restore a loss (Kahneman, 2011), we posed a second experiment in which respondents were asked to choose between a certain and risky option gain following an initial loss. The magnitude of the initial loss was varied between survey versions. In one case only (version 1) the initial loss was relatively small and could be fully restored by the risky option: these are the conditions under which risk-seeking over losses is thought to be most replicable (Kahneman, 2011). We framed this experiment in terms of habitat for an imaginary animal:

> **Experiment 2.** The King Snapper is a gamefish that normally occurs in a 2000 km^2 area surrounding French Polynesia, where it is culturally and commercially important. Overfishing has caused a decline in abundance, and the species

TABLE 1 Results of reflection effect tests (professional sample).

Unit of valuation	Money ($n = 99$)	Imaginary animal ($n = 24$)	Caribou ($n = 43$)	Amur tigers ($n = 32$)	km² of gamefish range (initial loss) (−20%) ($n = 24$)	(−50%) ($n = 44$)	(−90%) ($n = 31$)
Sure gain	76 (76.8%)	22 (91.7%)	33 (76.7%)	21 (65.6%)	*Experiment did not include choices over gains*		
Uncertain gain	23 (23.2%)	2 (8.3%)	10 (23.3%)	11 (34.4%)			
Sure loss	36 (36.4%)	7 (29.2%)	14 (32.6%)	25 (78.1%)	21 (87.5%)	32 (72.7%)	28 (90.3%)
Uncertain loss	63 (63.6%)	17 (70.8%)	29 (67.4%)	7 (21.9%)	3 (12.5%)	12 (27.3%)	3 (9.7%)

range is now (v1) 1600/(v2) 1000/(v3) 200 km². Imagine you are an islander, and you must choose one of the following policies to implement to restore the species:

A. Under policy A, the range will expand from (v1) 1600–1800 km²/(v2) 1000–1200 km²/(v3) 200–400 km² with certainty.
B. Under policy B, there is a 50% chance that the range will expand from (v1) 1600–2000 km²/(v2) 1000–1400 km²/(v3) 200–600 km², and a 50% chance that nothing changes.

Table 1 collects results. Respondents exhibited the reflection effect when outcomes were valued in money, an imaginary animal, or caribou. By contrast, respondents were strongly risk averse over losses when outcomes were valued in Amur Tigers and in all versions of Experiment 2—including when the initial loss was relatively small and could be fully restored by the risky policy. Note that for the versions framed using imaginary animals or caribou changes are small relative to plausible a priori expectations about total population size (e.g., best available data indicate >30,000 woodland caribou in Canada).

3.2 | Omission bias

Omission bias is a "preference for harm caused by omissions [inaction] over equal or lesser harm caused by acts" (Baron & Ritov, 2004: 74), and has been hypothesized to explain apparently irrational decisions in a variety of circumstances (e.g. refusals to vaccinate). We used an established test for omission bias (Ritov & Baron, 1992: Experiment 1), changing the framing to a Caribou management problem:

> **Experiment 3.** Anne manages a forest in which a group of 20 caribou is overwintering. The winter is severe, and it looks like many of the animals will die. A conservation expert suggests a strategy that could save the animals at essentially no cost. Anne considers the strategy, but decides not to try it. Over the winter 10 animals die, and in the spring Anne learns that if she had implemented the strategy none would have died.
>
> Mary manages a different forest in which a group of 20 caribou is overwintering. The winter is severe, and it looks like many of the animals will die. A conservation expert suggests a strategy that could save the animals at essentially no cost, and she decides to try it. Over the winter 10 animals die, and in the spring Mary learns that if she had not implemented the strategy none would have died.
>
> Who feels worse, Anne or Mary?

Since outcomes are the same in either scenario, respondents indicating that "Mary feels worse" display a preference toward harm caused by inaction (i.e., omission bias). This focus on feelings about action has been widely used to assess omission bias; in Ritov and Baron (1992) applying the above structure with a variety of framings (personal injury, job loss, etc.) produced repeated evidence of a bias towards omission. Our experiment instead showed a bias toward harm caused by action, with 69% of professional respondents ($n = 98$) and 73% of student respondents ($n = 41$) indicating that a conservation manager losing Caribou through inaction would feel worse than one who caused identical harm through action. This result did not vary significantly by professional affiliation (Fisher's Exact Test, $p = .4047$; Pearson's $\chi^2 = 4.503$, $p = .3422$).

3.3 | Fairness bias

The final bias we examined was a bias towards fairness. We hypothesized that conservation professionals may be

influenced by fairness norms when making management decision, and tested for such bias using a prioritization problem in which respondents divided a fixed budget between two caribou herds:

> **Experiment 4.** Imagine you are a conservation manager who is responsible for two caribou herds. You have a budget of $10 million that you must allocate entirely. The two herds are identical, except that it is known with certainty that if no action is taken Herd A has a 50% chance of survival and Herd B has a 10% chance of survival. Choose one of the following options:
>
> A. Allocate the entire $10 million to conservation programs for Herd A, raising its chance of survival from 50% to 90%.
> B. Allocate $5 million to conservation programs for Herd A, raising its chance of survival from 50% to 60%, and $5 million to conservation programs for Herd B, raising its chance of survival from 10% to 20%.
> C. Allocate the entire $10 million to conservation programs for Herd B, raising its chance of survival from 10% to 40%.

The ranking of these options by expected value is A > C > B; this ranking is preserved if options are evaluated either as outcome values or as changes from initial conditions. In other words, splitting resources evenly (or fairly, i.e., option B) is the worst choice (by expected value) and allocating all resources to the best-off herd (option A) is the optimal or "rational" choice. Professional respondents ($n = 100$) chose option A in most cases (67%), but a sizable minority (27%) preferred the even split. No significant differences between professional affiliations were observed using a 5% threshold (Fisher's Exact Test, $p_{\text{simulated}} = .05223$; Pearson's $\chi^2 = 14.799$, $p = .0632$). Student responses ($n = 61$) showed a markedly different pattern, with 44% of respondents preferring the even split and 31% preferring to prioritize the best-off herd. A minority of both groups (6% of professionals, 25% of students) preferred to allocate all resources to the worst-off herd, raising the possibility that most respondents may have viewed low survival probabilities as effectively zero.

3.4 | Environmental attitudes, risk tolerance, reference points, and legitimacy

We used the NEP scale and two elicitation questions to explore differences between respondent groups that may influence multistakeholder decision-making (e.g., negotiation). We do not use these exploratory results (or our demographic variables, such as gender) to model individual choice behavior (i.e., choice experiment responses) because the existence and direction of a causal relationship between results and observed choices is unclear (e.g., some untested factor could cause both high NEP scores and a preference for a particular choice).

The NEP scale measures agreement with pro-ecological attitudes, beliefs, and values thought to correlate with environmental beliefs and actions on a wide range of issues (Dunlap et al., 2000); due to its wide use, it provides a useful point of comparison across multiple studies. In our sample, exploratory factor analysis (Appendix B, Supporting Information) suggests that NEP responses can be treated as measuring a single latent dimension of an environmental worldview. We therefore sum responses across NEP Likert-scaled items and report a single score ranging from 15 to 75 (Table 2; higher values indicate a more pro-ecological worldview). A Brown-Mood median test of complete student and professional responses ($n = 58$ and $n = 94$, respectively) indicated significant differences between groups ($\chi^2 = 14.924$, $p_{\text{simulated}} = .00726$; Kruskal-Wallis $\chi^2 = 15.774$, $p = .0075$); *post-hoc* testing using Bonferroni-corrected General Independence tests found that NEP scores for Industry respondents were significantly lower than those of eNGO, government, and student respondents ($p_{\text{simulated}} = .02820$, .01800, and .01815, respectively). We also asked respondents to self-assess their general willingness to take risks on a scale of 1 (least risky) to 10 (most risky; the behavioral validity of this simple approach was demonstrated by Dohmen & Falk, 2011). We observed no significant differences in risk score between professional groups (Brown-Mood $\chi^2 = 6.801$, $p_{\text{simulated}} = .3389$; Kruskal-Wallis $\chi^2 = 9.0371$, $p = .1715$).

Prior work (McDermott, 2009) has hypothesized that differences in reference point may block negotiated compromise if stakeholders view a change differently (i.e., as a gain or a loss). To substantiate this possibility, we used a simple elicitation question (Table 2: E1) to assess reference point heterogeneity by exploiting the equivalence between goals and reference points (Kahneman, 2011). Respondents were asked to choose one of three stylized options, selected to represent two commonly expressed perspectives on caribou conservation (*rewilding* and *persistence*) plus a third option (*status quo*) that expresses a lack of any specific goal. Responses showed significant differences between stakeholder groups (Fisher's Exact test, $p = .04695$; Pearson's $\chi^2 = 17.955$, $p = .02156$). eNGO respondents were the only group for which *rewilding* was the modal choice, with very few government (17.4%) and industry (11.1%) respondents selecting this option; most industry respondents (66.6%) indicated a *persistence* reference point.

TABLE 2 Elicitation question and New Ecological Paradigm (NEP) responses.

Professional affiliation	Academia	Community representative	Environmental nongovernmental organization (ENGO)	Federal or provincial government	Resource industry	Student
n	6	6	15	46	27	61
Mean NEP score	60.0	57.3	61.9	59.6	52.8	58.2
(SD)	(10.9)	(13.2)	(7.3)	(8.3)	(8.1)	(6.6)
Mean risk score	5.2	4.8	5.3	4.7	6.1	5.0
(SD)	(1.8)	(2.1)	(2.1)	(2.1)	(1.5)	(1.98)
E1 (*Italics added*) Which of the following best describes your feelings? (*status quo*) I want the current situation for caribou to improve. (*rewilding*) I want caribou herds to return to their natural population levels and ranges (as they would be without human disturbance). (*persistence*) I want caribou to survive into the future.						
(*status quo*)	3	0	3	15	6	
(*rewilding*)	0	0	7	8	3	NA
(*persistence*	3	6	5	23	18	
E2 I think putting a dollar value on changes in the status of an endangered species is legitimate. The value of a gain or a loss in the numbers of an endangered species can be meaningfully represented in monetary terms.						
Strongly disagree	1	1	4	10	1	
Disagree	1	3	6	12	6	
Neither agree nor disagree	1	1	2	10	1	NA
Agree	2	0	3	12	16	
Strongly agree	1	1	0	2	3	

Our final elicitation question (E2) addressed the potential nonfungibility of conservation values. We hypothesized that for some conservation stakeholders, conservation values cannot be meaningfully expressed in monetary terms and may be subject to distinct decision processes. Baron and Spranca theorize such values as "protected," noting that human decision-makers resist making tradeoffs when protected values are at stake. To test the possibility that conservation values are not viewed as fungible with economic values, we asked respondents to rate their agreement with the monetary representation of endangered species status on a five-point Likert scale. Results showed significant differences between groups (Cochrane-Armitage test, $p_{\text{simulated}} = .00812$; Pearson's $\chi^2 = 23.269$, $p = .1067$), with industry respondents skewing toward agreement and eNGO respondents skewing toward disagreement.

4 | DISCUSSION

Our study provides experimental evidence about how conservation professionals make decisions, demonstrating several decision biases as well as between-group heterogeneity in decision relevant characteristics. Understanding how conservation decision-makers choose may lead to better choices, thus better conservation outcomes, but what exactly constitutes "good" choice in conservation is up for debate (and may not require concepts of optimality; see Gigerenzer, 2008). Our use of expected value as a benchmark allows us to identify some elements of choice behavior that matter for complex real-world decisions, but is not intended as a normative position. If maximizing expected value is desired, training decision-makers to recognize and avoid biases may help (Catalano et al., 2018)—but it is not yet clear whether such interventions produce lasting changes in decision behavior (Hans et al., 2021). Decision support tools offer an alternative way forward, which can accommodate the formal inclusion of some biases (Tulloch et al., 2015) as well as other important objectives (e.g., decision transparency, accountability).

Our results substantiate the notion that risk aversion on the part of conservation managers may be partly responsible for choices that do not maximize the expected value of outcomes, a tendency previously documented in conservation funding decisions by Gerber (2016). Respondents in our sample showed marked risk aversion when scarcity or realistic conservation framing were introduced, including when confronted with a small loss that could be fully restored by choosing a risky option (the conditions when risk-seeking behavior is most expected). Prior work has shown that risk aversion can hinder

species recovery efforts (Canessa et al., 2020) and landscape management goals (Maguire & Albright, 2005); on the other hand, risk aversion may have an (adaptive) evolutionary basis (Chen et al., 2006). For example, consolidating incremental gains may be an effective conservation strategy when the parameters of the decision problem (e.g., budget constraints) can change.

Respondents in our sample also showed a general bias towards errors of commission (69% of professional respondents, 73% of student respondents), and sometimes a bias toward fairness (27% and 44%, respectively). Commission bias implies that respondents feel that action is more suitable than inaction when conservation values are at stake. Action in our decision problem was costless, but in real life situations a bias towards errors of commission could lead to inefficient management decisions (e.g., wasted resources). Since multiple biases can overlap at one time, decision behavior among conservation professionals may ultimately be biased toward nonrisky action (while risk aversion and commission bias were common in our professional sample, a bias towards fairness was not). Interestingly, 67% of professional respondents chose to maximize expected value in our fairness bias experiment, compared to only 31% of students, raising the possibility that professionals in our sample had learned to suppress bias and choose according to expected value.

The results of our choice experiments provide (to our knowledge) the first evidence that "biases matter" in conservation decision-making, and show *how* risk aversion, omission bias, and fairness influence decision-making in a specific sample of Canadian conservation professionals. The implication for practitioners is that they should consider whether and how biases might influence their own management decisions, and take mitigating actions if desired (e.g., choosing to maximize some objective criterion). The response frequencies we observed (e.g. the relative importance of commission vs fairness bias) are not unbiased estimates of out-of-sample conservation professionals, but in our opinion provide useful prior information about which biases may be important in a novel conservation context.

For policy makers (and researchers), our results point to a potentially important replication problem in applying behavioral insights derived from nonconservation contexts. PT is a widely used model of choice under uncertainty, but our reflection effect experiments revealed PT-consistent behavior only for choices over monetary values or relatively small changes in conservation values (numbers of an imaginary animal, caribou). With scarcity or richer conservation framing, respondents contradicted the predictions of PT by choosing risk averse options framed as losses. Likewise, omission bias is a relatively robust phenomenon (Jamison et al., 2020), but respondents in our sample instead showed a bias toward harm caused by action (Tanner and Medin (2004) also failed to replicate omission bias with environmental values). Our results imply that choice behavior observed in other contexts cannot be assumed to apply when conservation values are at stake—and therefore, that a behavioral approach to conservation can only advance via careful experimental validation (e.g., Reddy et al., 2020).

Our between-group analyses (Table 2) found significant differences between respondent groups in NEP scores, reference points, and the legitimacy of representing conservation values monetarily. These results are driven by differences in both mean responses and sample sizes per group, and suggest complex challenges for negotiating multistakeholder conservation policy. The motivating context for our study (Caribou conservation in Canada) is characterized by conflicting objectives, contested narratives, and persistent failures to reach multistakeholder agreement (Boan et al., 2018; Festa-Bianchet et al., 2011; Smith, 2015). Unsurprisingly, our reference point elicitation question (E1) showed significant between-group differences (e.g., a return to "natural" populations and levels [*rewilding*] was the modal choice for eNGO respondents; most [67%] industry respondents preferred species survival [*persistence*]). Such differences have implications beyond working towards different objectives, because framing a change as a gain or a loss relative to a reference point can impact its perceived value (with losses typically felt more strongly than gains). This can block negotiated compromises when reference points differ (McDermott, 2009), because what is given up (or lost) is felt more strongly than what is gained.

Developing shared framing around conservation problems is an important step in multistakeholder decision making (e.g., negotiating consensus policy), but our NEP results and legitimacy elicitation question (E2) results point to deep-seated challenges. Resource industry respondents in our sample had significantly lower mean NEP scores (i.e., less pro-environmental attitudes) than eNGO, government, and student respondents (mean scores between the latter groups did not differ). Likert-scaled agreement with monetary representation of conservation values skewed strongly toward agreement for resource industry respondents only. These results raise the possibility of underlying psychological differences in how stakeholder groups evaluate conservation options. For example, different environmental worldviews could place constraints on which categories of solution are deemed acceptable, while viewing the monetary representation of conservation values as illegitimate suggests that solutions that make explicit tradeoffs between conservation and economic outcomes may be rejected (Baron & Spranca, 1997). To substantiate the idea that

the between-group differences we observe matter for choice in conservation we tested for an association between NEP scores and choice in our fairness bias experiment, finding that respondents choosing to maximize expected value rather than fairness had significantly lower scores (Brown-Mood $\chi^2 = 6.289$, $p_{\text{simulated}} = .0375$; Kruskal-Wallis $\chi^2 = 10.261$, $p = .0059$). While not causal, this association does suggest that differences in worldview matter for conservation choice.

Our work provides a first assessment of the importance of behavioral considerations in understanding how conservation professionals make key management decisions, including in multistakeholder decision-making processes. We suggest three priorities to build on these results. First, empirical analyses of conservation choices in practice could help reveal when and how such behavioral factors adversely impact conservation outcomes, leading (if necessary) to opportunities for outcome-improving interventions. Second, efforts to apply a behavioral approach to conservation program delivery (e.g., by nudging participation) should prioritize and coordinate efforts to replicate biases best known from other choice settings, thereby accelerating the impact of behavioral insights in this important choice context. Third, a deeper understanding of how shared problem framing is developed could help conservationists engaged in multistakeholder decision processes identify (and perhaps overcome) persistent obstacles to consensus.

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DATA AVAILABILITY STATEMENT

A copy of the data collection instrument along with raw data files has been archived at openCPSR (identifier: openicpsr-176,201).

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ENDNOTES

[1] Behavioral economists typically employ expected *utility* as the benchmark model, which is equivalent to (the utility of) expected value only for a risk-neutral decision-maker (see e.g., Varian, 1992). However, expected value is a sufficient benchmark to identify biases in decision behavior (e.g., Kahneman & Tversky, 1979).

[2] Our study addresses only some features of decision behavior described by Prospect Theory ("reference points" and the "reflection effect"), which we describe below. For a complete introduction, we recommend either the review by Barberis (2013) or Kahneman's (2011) popular book.

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