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SOCIAL AND ECONOMIC ASPECTS OF WETLANDS

What waterfowl hunters want: exploring heterogeneity in hunting trip preferences

Katherine A. Sainsbury[1] · Howard W. Harshaw[1] · David C. Fulton[2] · Nicholas W. Cole[3] · Ashley A. Dayer[4] · Jennie N. Duberstein[5] · Andrew H. Raedeke[6] · Rudy M. Schuster[3] · Mark P. Vrtiska[7]

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Abstract
Canadian and American waterfowl hunters were surveyed to identify their hunting trip preferences. Respondents were individuals that were now participating or had participated in waterfowl hunting, and most had hunted the majority of the last five years. We identified four latent classes of waterfowl hunters that varied in their preferences for harvest, access effort, length of travel, quantity of waterfowl seen, and the potential for interference/competition. We found a diminishing return associated with the number of waterfowl harvested, and that 'devoted' and 'local' hunters did not perceive appreciable benefit from harvesting more birds beyond harvesting a single bird. Results highlight the importance of not only considering population size, but also the location of habitat for people and waterfowl. Our results provide waterfowl managers important insights into the heterogeneity of North American waterfowl hunters by highlighting differences in priorities for waterfowl hunting trips. Notably, to address this heterogeneity, managers could consider the balance of objectives, actions and resources designed to satisfy current waterfowl hunters. Managing access to improve the likelihood that hunters will see and have opportunities to harvest some waterfowl has benefit to hunters.

Keywords Waterfowl hunting · Hunting trip preferences · North American Waterfowl Management Plan (NAWMP) · Discrete choice experiment

Introduction

Waterfowl hunters play important roles in the conservation and management of waterfowl populations and wetland habitats in North America (Heffelfinger et al. 2013). Since the early 1900s, waterfowl hunters have responded to declining waterfowl populations through several initiatives, including the purchase of duck stamps (U.S. Federal Migratory Bird Hunting and Conservation Stamp, and Canadian Wildlife Habitat Conservation Stamp); the support of non-governmental organizations (NGOs) working to conserve waterfowl populations and habitats; and through participation in biological and human dimensions research that informs conservation decision making (Anderson and Padding 2015). Duck stamps are part of the permitting required to hunt waterfowl. Funds raised through the sale of duck stamps support waterfowl habitat conservation. In the United States (U.S.), over $1 billion (USD) of duck stamp revenues have enabled the purchase of almost 6 million acres of habitat (U.S. Fish and Wildlife Service 2019). In Canada, duck stamps have raised more than $64 million (CAD), which have contributed to

✉ Howard W. Harshaw
harshaw@ualberta.ca

1 Faculty of Kinesiology Sport, and Recreation, University of Alberta, Edmonton, AB, Canada

2 Minnesota Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, University of Minnesota, St. Paul, MN, USA

3 U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, USA

4 Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA, USA

5 Sonoran Joint Venture, United States Fish and Wildlife Service, Tucson, AZ, USA

6 Missouri Department of Conservation, Columbia, MO, USA

7 School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA

more than 1,600 conservation projects (Government of Canada 2023). The Pittman–Robertson excise tax on ammunition has raised over $16 billion (USD) for wildlife and habitat conservation, including wetlands, since 1937 (The Firearm Industry Trade Association 2023). Established in 1986, the North American Waterfowl Management Plan (NAWMP) is a partnership between the governments of Canada, the United States, and Mexico. NAWMP is supported by funds from the North American Wetlands Conservation Act for the continental conservation and restoration of wetlands and waterfowl; this goal is realized through government-NGO partnerships called Joint Ventures (Anderson and Padding 2015; Devers et al. 2017). Between 1986 and 2022, Joint Ventures in Canada have secured 23.4 million acres of habitat for waterfowl (North American Waterfowl Management Plan Canada 2022). However, based on duck stamp sales, the number of waterfowl hunters has declined since the mid-1970s by 27% in the U.S. and by 55% in Canada (North American Waterfowl Management Plan Committee 2012), which may threaten the future of some of these conservation initiatives (Vrtiska et al. 2013; Humburg et al. 2018; Raftovich et al. 2022).

Connecting the social system dynamics of waterfowl hunting to the ecological systems of wetland and waterfowl conservation and management is a foundational aspect of successful management (Devers et al. 2017). Each system exerts influence over the other at multiple scales. Therefore, it is important to consider the implications of a management action or stressor in both systems. The social ecological systems framework (SES) represents the interaction of social, economic, governance, and ecological processes and structures across spatial, temporal, and organizational scales (Hunt et al. 2013; Lischka et al. 2018). A SES recognizes that the sustainability (i.e., resilience, adaptation) of ecological systems (e.g., wetlands) is influenced by the rules and regulations that govern their use and the behaviors of user groups. These regulations typically reflect societal norms and priorities; however, when they do not, the interaction between social and ecological systems can result in emergent, negative outcomes within one or both systems. Ostrom (2009) has proposed that the nature of these interactions are functions of the socio-economic characteristics of the people using the natural resources (e.g., waterfowl hunters), the importance of the resources (e.g., economic value and ecosystem function), the history of resource use (including hunting and other outdoor recreation activities and tourism), and the location of the resources.

In response to declining numbers of waterfowl hunters, and in an effort to broaden the support of waterfowl and wetland conservation, the NAWMP established the goal of “growing the numbers of waterfowl hunters, other conservationists, and citizens who enjoy and actively support waterfowl and wetlands conservation” (North American Waterfowl Management Plan 2012, p. 2). Understanding what contributes to a quality waterfowl hunting experience may help those involved with waterfowl population management and public engagement better tailor harvest regulations and habitat management to hunter preferences. In addition, this information can help direct hunter recruitment, reactivation, and retention in ways that may sustain waterfowl populations and habitat while also growing the number of waterfowl hunters (Oh and Ditton 2008; Schroeder et al. 2006). Although preferences and satisfaction are often used interchangeably, they are distinct but related concepts. The concept of satisfaction is rooted in expectancy theory: satisfaction is a function of "[t]he congruence between expectations and outcomes" (Manning 2011, p. 13). Determining satisfaction requires understanding whether or not people had experiences that matched the motivations they had for participating in an activity such as hunting (e.g., enjoying nature or experiencing solitude), or experiences that matched their goals or definitions of success (e.g., harvest a limit of ducks). Preferences are expressed evaluations of the individual trip-specific attributes (e.g., distance traveled, condition of the resource, level of crowding, number of ducks seen). The mix of attributes can influence a person’s level of satisfaction, happiness, or well-being associated with a trip (i.e., what economists define as economic utility; McFadden 2001).

Social and economic scientists have employed choice modeling to quantify the relative importance of different biological, physical and socio-economic attributes and determine how preferences among individuals relate to behavior (Adamowicz et al. 1998; Louviere et al. 2000; Boxall and Adamowicz 2002; Hunt et al. 2019). Choice models are a useful tool for decision-makers and regulatory agencies because they describe the relative importance of key attributes that managers may be able to manipulate under alternative management scenarios (Hanley et al. 2001). Choice modeling approaches assume that people will make rational choices to maximize their own happiness and well-being (i.e., utility; McFadden 1973). Discrete choice experiments (DCE) are a stated preference method that offers an effective approach for understanding and characterizing the trade-offs individuals make between different choice scenarios as described by suites of different attributes and levels (Ben-Akiva and Lerman 2018). Discrete choice experiments estimate the relative importance of individual attributes in comparison to all other attributes in the scenario (Hanley et al. 2001). Preference for an attribute in a DCE is measured independent of expectations, and through the use of hypothetical outcomes. When a participant expresses a high preference for an attribute, we assume their satisfaction would be greater if that attribute were present. Latent class analysis of DCE is a powerful statistical technique that describes the heterogeneity of preferences within a population (Train 2009). Latent class analysis hypothesizes an assumed number of classes representing the discrete assumptions about unobserved heterogeneity within a given population

(McFadden 1973). Through latent class analysis of DCE data, it is possible to identify segments with similar characteristics based on latent patterns of preferences (Train 2009).

To help wildlife managers better understand and engage with waterfowl hunters in Canada and the U.S., we conducted a discrete choice experiment (DCE) in both countries to explore preferences for hunting experiences. We explored the relative importance of biological, physical and social trip attributes, including harvest, length of travel, access effort, number of waterfowl seen, and competition with other hunters. We examined heterogeneity in hunting preferences with latent class analysis to identify different segments of active hunters with different priorities and preferences. This information could assist wildlife managers in making habitat and population stewardship decisions that more closely align to the preferences of waterfowl hunters while also supporting ecological objectives. The existing literature about hunting satisfaction indicates that waterfowl hunters prefer seeing and harvesting more ducks, minimizing travel, having easy access, and not having to compete with other hunters (Vaske et al. 1986; Schroeder et al. 2006; Brunke and Hunt 2007). The relative importance of these different aspects of hunting trips, and how waterfowl hunters trade off these different trip features is yet to be explored.

Methods

Sampling and Implementation

We administered the web-based survey to waterfowl hunters in Canada between September 27, 2017 and April 2, 2018 and in the U.S. between November 16, 2016 and March 20, 2017 following a modified Tailored Design Method (Dillman et al. 2014); we made up to four contacts with potential respondents. The questionnaire collected information about respondent socio-demographic characteristics and hunting behaviors, as well as a discrete choice experiment about waterfowl hunting trip preferences (details below). We designed the survey in Sawtooth Lighthouse Studio (software version 9.5). Survey and recruitment materials were reviewed and approved by the University of Alberta Research Ethics Board (Pro 00114170); the Institutional Review Board at the University of Minnesota reviewed and determined that the study did not require additional review for human subjects research.

The Canadian sample frame included residents who had purchased a Canadian Wildlife Habitat Conservation Stamp in 2016 (all waterfowl hunters in Canada are required to purchase a Canadian Wildlife Habitat Conservation Stamp in addition to the necessary hunting permits). Wildlife Habitat Canada provided the sample frame and we used the Postal Code Conversion File (Statistics Canada 2017) to link postal codes with geographic coordinates. Wildlife Habitat Canada sent all the survey materials. The U.S. sample frame included residents that had registered in the 2015 Migratory Harvest Information Program (HIP) database (all waterfowl hunters are required to register within each state they hunt). We limited the sampling frame to hunters who were 18 years or older and reported actively hunting at least once in that year. In total, we contacted 8,000 Canadian waterfowl hunters to complete the survey, of whom 745 did not have valid mail addresses and 27 indicated that they were not waterfowl hunters, leaving a final sample size of 7,228 individuals. We invited a total of 35,101 U.S. waterfowl hunters to participate in the survey with 1,742 undeliverable addresses for an initial sample size of 33,359 (Patton 2018). To be consistent with prior examinations of waterfowl hunters (such as the 2005 National Duck Hunter Survey), we stratified the sample to reflect 17 distinct sub-regions based on flyway and strata (National Flyway Council and Wildlife Management Institute 2006, Patton 2018). Flyways (from east to west: Atlantic, Mississippi, Central, and Pacific) are administrative units based on general north–south travel routes of migratory waterfowl. In North America, the four flyways are used to facilitate cross-jurisdictional management of migratory birds. We designated the strata (from south to north: southern U.S., middle U.S., northern U.S., Canada, and Alaska) based on potential latitudinal differences among waterfowl hunters (National Flyway Council and Wildlife Management Institute 2006; Supplementary Materials Appendix Table S1).

Discrete Choice Experiment

Choice experiments assume that when given a choice, individuals will select the alternative that provides them with the most utility (i.e., random utility theory; McFadden 1973, 2001). By asking respondents to choose between a series of mutually exclusive hypothetical scenarios, each defined by unique combinations of attribute levels, the value of an individual's preferences for different levels of each attribute can be estimated (Hoyos 2010). In general, the utility of an attribute level may be considered a reflection of relative desirability (Orme 2014). In this survey, we presented respondents with ten different choices between pairs of hypothetical hunting trips and asked them to choose between these trips, or whether they would prefer to 'opt out' (i.e., not go hunting if these were the only choices). We included the 'opt-out' alternative to improve the realism of the scenarios, avoid forcing respondents to select undesirable scenarios, and to recognize that hunting is an optional activity (Louviere et al. 2000; Kontoleon 2003).

We designed our choice experiment to estimate the relative preference of waterfowl hunters for different trip-related attributes that may be influenced by waterfowl and wetland managers. Following best practice methodology (Ryan et al. 2008), we defined the attributes and associated levels in consultation with expert stakeholders, the Atlantic, Mississippi, Central, and Pacific Flyway Councils, workshops with waterfowl hunters from across Canada ($n=5$) and the U.S. ($n=12$) between January 2015 and February 2016, as well as a literature review. The final set of salient attributes were harvest, access effort (i.e., ease of getting to hunting locations), length of travel, quantity of waterfowl seen, and potential for interference/competition (Table 1). The final choice experiment design included two attributes with three levels, one attribute with four levels, and two attributes with five levels, which is a full factorial design of 900 possible choice profiles ($3^2 * 4^1 * 5^2$). To minimize the cognitive burden on respondents, while maintaining a balanced design, respondents were randomly allocated one of ten blocks of ten pairs of alternative hunting trips by Sawtooth Software. We used a balanced overlap approach within web-based survey computer software (Sawtooth Lighthouse Studio) in the design of the DCE to ensure that the design was well-balanced and that respondents received almost-orthogonal fractions of the full design (Johnson et al. 2013). We used Bayesian D-efficiency to assess the efficiency of several candidate DCE designs to ensure an efficient design relative to all models (Chrzan and Orme 2000; Kuhfeld et al. 1995). Previous research used designs ranging from 4 to 12 pairs of choices (Louviere et al. 2000). The design we chose (design strength = 2,099) was 19% less efficient than a 12 pair design (design strength = 2,580) but 20% more efficient than an 8 pair design (design strength = 1,687). We explained the attributes and associated levels to respondents at the beginning of the DCE section of the survey and advised respondents to assume all other factors that might influence their trip decisions were equal across the choices presented (example choice card is shown in Fig. 1).

Statistical Models

We specified a conditional logit model (CL) to identify overall preferences for the different levels of each attribute (McFadden 1973, Hensher et al. 2015; see Supplementary Materials Appendix S2). In the CL, we included the flyway and strata variable levels as interaction terms with the harvest attribute levels. We took this approach due to ecological differences in bird abundance and management of bag size limits by geography (i.e., flyway and strata). The full model is presented. We subsequently specified a latent class model (LCM, see Supplementary Materials Appendix S2) to identify segments

Table 1 Descriptions and levels of attributes used to depict the different hunting trip scenarios in waterfowl hunter choice experiment analysis

Variable	Description	Levels
Attributes		
Harvest	The number of waterfowl you are likely to harvest in a day	**1 bird**
		3 birds
		6 birds
Access Effort	How easy or difficult it is to get into, out of and around an area in order to hunt	**Easy access that takes little effort**
		Moderate access that takes some effort
		Difficult access that takes a lot of effort
Length of Travel	The time you have to travel one-way in order to hunt	**30 min**
		1 h
		2 h
		3 h
		4 h
Quantity of Waterfowl	The number of ducks/geese that you see in a day when hunting even if not in shooting range	**25 birds or less**
		50 birds
		250 birds
		500 birds
		1000 birds or more
Potential for Interference/ Competition	Competition from other hunters who might interfere with your hunt in some way such as making you feel crowded or competing for hunting spots or birds	**No competition**
		Low competition from other hunters
		Medium competition from other hunters
		High competition from other hunters
Opt out	The alternative that respondents could choose not to go. Included as the alternative specific constant in modelling	Dummy coded, where 1 = opt out selected, or 0 = a hunting trip selected

Base levels are in bold. All attributes were effects coded unless otherwise stated

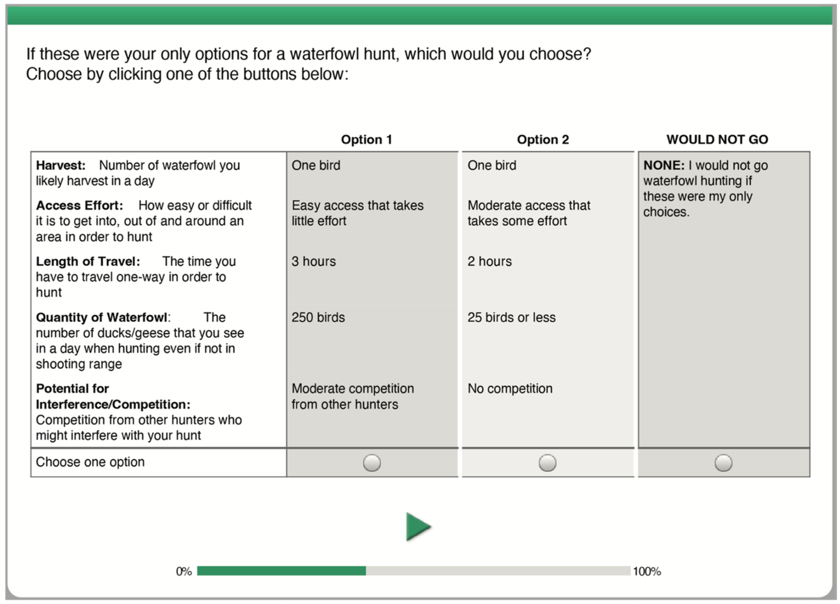

Fig. 1 Example of a choice experiment hunting trip scenario that was presented to waterfowl hunters for evaluation

of active waterfowl hunters with similar preferences for the attributes included in the experiment (Boxall and Adamowicz 2002). To identify the number of latent classes, we used a stepwise exploratory approach of nine LCMs (from 10 latent classes to 2 latent classes) to then determine the best fitting model. We created a unique model for each hypothesized number of classes and compared them within a model selection process. Although there is no consensus on the single best criterion for comparing LCM solutions, best practices encourage considering and reporting multiple criterion statistics (Weller et al. 2020). Here we considered Akaike Information Criterion (AIC, AIC/N), Bayesian Information Criterion (BIC, BIC/N), and model entropy, and the class membership probabilities of each model in turn before settling on our preferred option. BIC is commonly considered more reliable than AIC given its emphasis on parsimony and reduced sample size bias relative to AIC (Weller et al. 2020). Model entropy is not a measure of fit but is instead used to evaluate classification quality based upon the data and measures the discreteness between clusters with higher values equating to better class representation in the data (Weller et al. 2020). Class membership probabilities give an indication of potential class size; models that included classes with very small class membership probabilities were unlikely to be meaningful from a management perspective and so were considered less valid for our purposes.

We effects-coded attributes (Cooper et al. 2012; Hensher et al. 2015) and dummy-coded the opt out variable (i.e., alternative specific constant; see Supplementary Materials S2). Effects-coding is a commonly adopted approach for estimating the average differences in utility for each attribute level, which facilitates comparisons of the relative importance of each attribute (Hensher et al. 2015). Under effects-coding, the base level for an attribute can be estimated by calculating the negative sum of the effects-coded coefficients for the remaining levels of a given attribute (Hensher et al. 2015). We extracted survey data and prepared them for analysis in R Studio (R version 4.2.1, R Core Team 2022), using the tidyverse package (v1.3.0; Wickham et al. 2019). We ran CL and LCMs in econometric and statistical software (NLOGIT 6.0) (Greene 2016).

Assessing LCM validity and implications for management

After model selection, we extracted the class membership probabilities for each individual from the preferred LCM. We assigned individuals to a single class based on the class with their greatest probability of membership, creating a categorical variable for 'Class Membership'. To assess the extent that the latent classes identified meaningful groups, we evaluated convergent validity by comparing classes with survey measures that were theoretically similar and related (Vaske 2008). To help characterize the latent classes, we calculated post hoc chi-square tests and Cohen's w for a number of categorical management variables against Class Membership. The variables included satisfaction with bag limits, number of ducks harvested over the past 5 years, the number of times a bag limit had been shot in the previous season, and identity as a duck hunter. We created mosaic plots, graphical representations of contingency tables (Friendly 1994; Meyer et al. 2006), in the vcd package in R (Version 1.4–10, Meyer et al. 2022) to visualize the data for those variables.

Results

Sample Characteristics

In total, 8,449 hunters from across Canada and the U.S. completed the choice experiment (Canadians represented 15.1% of the sample; Supplementary Materials Appendix Table S2). The majority of respondents were male (male: 91.0%, 7,688 individuals; female: 2.9%, 244 individuals; unknown: 6.1%, 517 individuals). Half of respondents (50.8%, 4,292 individuals) were between the ages of 41 and 65 years old. The youngest age group (18–25 years) had the fewest respondents (7.7%, 654 individuals). Approximately one-quarter of respondents earned $49,000 or less (22.8%, 1,929 individuals). Almost three-quarters of respondents reported hunting both ducks and geese (74.5%, 7,074 individuals); a very small proportion of respondents (2.8%, 269 individuals) reported only hunting geese. Approximately two-thirds of respondents identified strongly or very strongly as a duck hunter (59.7%, 5,048 individuals). When asked how many ducks they had harvested on average over the preceding five years, almost half of respondents had shot 10 birds or fewer (46.3%, 3,908 individuals), approximately one-fifth of respondents had shot 11–20 birds (22.1%, 1,868 individuals) and 21–50 birds (19.2%, 1,619 individuals), and a minority had shot more than 50 birds (9.1%, 772 individuals). The majority of respondents indicated that to have a satisfying hunting season they had to shoot their daily bag limit at least occasionally (90.9%, 7,678 individuals) and a similar majority had only shot their bag limit in the preceding season occasionally or less frequently (88.6%, 7,489 individuals).

Conditional Logit Model

Hunters showed a preference for trips that provided moderate access and an aversion to trips with difficult access (i.e., access that takes a lot of effort; Table 2). Travel time preferences for trips of up to one hour were positive; at two hours and above hunters became increasingly travel averse. There was an increase in preference for trips associated with increasing numbers of waterfowl observable on a hunt day, with the greatest preference for seeing thousands of birds. Hunters were averse to trips where they would see 50 waterfowl or fewer. Hunters preferred trips with lower levels of competition overall and were averse to trips that included high competition. Overall, hunters showed increasing utility when given the option to harvest three ducks compared to one duck, but a smaller gain in utility when given the option of six ducks compared to three ducks. There was some east to west and north to south variation in harvest preferences for six-bird bags, but not three-bird bags. Hunters from the Mississippi and Pacific Flyways showed slightly more preference than average for trips that supported six-bird harvests, whereas hunters from the Central Flyway showed slightly less preference than average for trips with six-bird harvests. There was a north to south gradient of reduced preference for six-bird harvests, with hunters from Canada and Alaska having a below average preference for six-bird harvests, whereas hunters from the middle U.S. strata showing above average preference for six-bird harvests.

Figure 2 illustrates the relative importance of each of the five attributes included in the model in their contribution to overall trip preference. For example, the attribute that contributed the most to respondents' scenario selections was the potential for interference or competition, contributing to 29.4% of the preference for a trip. Length of travel (27.1%) and harvest (21.3%) were the next two attributes contributing to respondent's trip preferences and combined these three attributes contributed to 77.8% of preference. The remaining 22.2% of preferences were composed of quantity of waterfowl seen (13.1%) and access effort (9.2%).

However, the conditional logit model estimation did not reach the adequate threshold of 0.20 for good model fit with an adj. r^2 value of 0.189, indicating that the model was insufficient to explain the amount of variation in the data. As a result, we moved on to a latent class modelling approach to account for the variation in hunter preferences.

Latent Class Model

The LC model selection process indicated that there were a number of candidate models (Table 3). Close inspection of these LC models revealed that the four-class model had the best BIC/N and model entropy of the models with meaningful class membership probabilities (i.e. the two-, three-, and four-class models). The lower entropy values and presence of some very small class membership probabilities in the six- and five- class models meant that these models were not preferred. In the four-class model, hunters had the highest probability of membership (0.370) in latent class 1 (devoted), followed by latent class 3 (harvest-oriented; 0.231), then latent class 2 (local; 0.213) and finally latent class 4 (selective; 0.186) (Table 4). These probabilities do not represent strict percentages within each class.

When comparing the trip attributes between classes (Table 4), the 'devoted' hunters were least likely to opt out of taking a trip. Otherwise, 'devoted' hunters showed similar preferences to the overall model in terms of generally preferring larger harvests, easier access, shorter travel, greater numbers of waterfowl seen and lower competition. The attribute interference/competition contributed the

Table 2 Conditional logit model outputs showing hunter trip preference parameter estimates including geographic variable interactions

Attribute	Coefficient		Std. Error	Odds ratio
Opt out	-0.333	***	0.009	0.72
Harvest – 3 birds	0.205	***	0.018	1.23
Harvest – 6 birds	0.576	***	0.019	1.78
Travel – 1 h	0.549	***	0.011	1.73
Travel – 2 h	-0.044	***	0.012	0.96
Travel – 3 h	-0.415	***	0.012	0.66
Travel – 4 h	-0.812	***	0.013	0.44
Access – moderate	0.150	***	0.008	1.16
Access – difficult	-0.334	***	0.008	0.72
Waterfowl – 50	-0.230	***	0.012	0.79
Waterfowl – 250	0.091	***	0.011	1.10
Waterfowl – 500	0.144	***	0.012	1.15
Waterfowl – 1000 s	0.367	***	0.011	1.44
Competition – low	0.496	***	0.009	1.64
Competition – medium	0.057	***	0.010	1.06
Competition – high	-1.108	***	0.012	0.33
Harvest – 3 birds * Miss. Flyway	-0.008		0.012	0.99
Harvest – 3 birds * Central flyway	0.001		0.013	1.00
Harvest – 3 birds * Pacific flyway	-0.022		0.014	0.98
Harvest – 6 birds * Miss. Flyway	0.050	***	0.012	1.05
Harvest – 6 birds * Central flyway	-0.066	***	0.013	0.94
Harvest – 6 birds * Pacific flyway	0.059	***	0.014	1.06
Harvest – 3 birds * Mid. U.S	-0.009		0.021	0.99
Harvest – 3 birds * North U.S	0.032		0.021	1.03
Harvest – 3 birds * Canada	-0.015		0.023	0.99
Harvest – 3 birds * Alaska	0.006		0.069	1.01
Harvest – 6 birds * Mid. U.S	0.071	***	0.021	1.07
Harvest – 6 birds * North U.S	-0.027		0.022	0.97
Harvest – 6 birds * Canada	-0.064	***	0.023	0.94
Harvest – 6 birds * Alaska	-0.158	**	0.070	0.85
Log-likelihood	-72943.936			
Observations	83908			
Individuals	8449			
Adj. r^2	0.189			
AIC	145947.900			
BIC	146228.000			

All attributes were effects coded. Base levels were 1 bird harvest, 30-min travel, easy access, 25 or fewer waterfowl seen, no competition, Atlantic flyway, and south strata

$^{***} = p < 0.01$, $^{**} = p < 0.05$, $^{*} = p < 0.1$

Odds ratios represent the multiplicative effect of a one unit increase of the attribute over the reference level on hunter preferences for that trip scenario

most to the preference of 'devoted' hunters (40.7%, Fig. 3). 'Local' hunters were second most likely to prefer opting out of taking a trip. This class had a strong aversion to difficult access, the greatest preference for shorter trip times (1 h) and strongest aversion to longer trip times (three and four hours), as well as the greatest preference for lower competition and greatest aversion for higher competition (Table 4). Travel was the most important attribute for the 'local' hunters (40.7%, Fig. 3). 'Harvest-oriented' hunters were the second least likely class to opt out, and this class had the strongest preference for larger bird harvests and least aversion to higher competition (Table 4). In terms of attribute importance, harvest contributed to 43.4% of the preference for 'harvest-orientated' hunters, the greatest contribution of any of the attributes to preferences among all of the classes (Fig. 3). In addition, 'harvest-oriented'

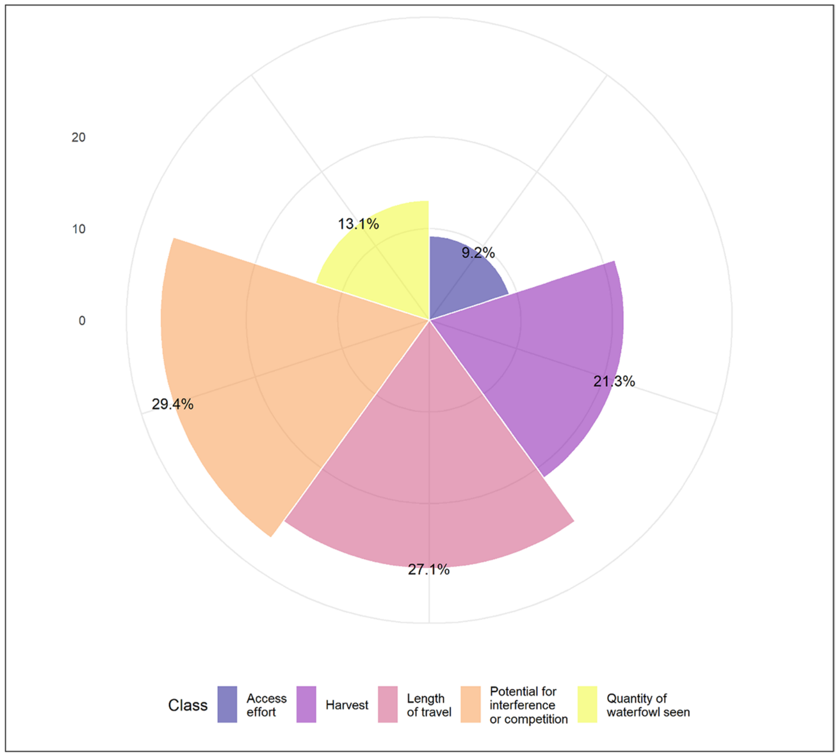

Fig. 2 The relative utility (i.e., importance; as a percent) of each DCE attribute's contribution to Canadian and American waterfowl hunter trip preferences in the conditional logit model

Table 3 Latent class model selection for hunter trip preferences

	6 Class Model	5 Class Model	4 Class Model	3 Class Model	2 Class Model
Log likelihood	-60221.903	-61016.373	**-61031.449**	-62242.525	-63645.951
Adj. r^2	0.347	0.338	**0.338**	0.325	0.310
AIC	120645.800	122,200.700	**122196.900**	124,585.000	127357.900
AIC/N	1.438	1.456	**1.456**	1.485	1.518
BIC	121588.900	122985.100	**122822.500**	125051.900	127666.000
BIC/N	1.449	1.466	**1.464**	1.490	1.522
Entropy	0.210	0.209	**0.242**	0.191	0.136
Class membership probabilities	0.375	0.371	**0.370**	0.484	0.614
	0.163	0.232	**0.213**	0.366	0.386
	0.192	0.187	**0.231**	0.150	
	0.101	0.210	**0.186**		
	0.164	0.001			
	0.006				

Bold indicates the preferred model, based on log likelihood, adjusted r^2, AIC, BIC, entropy and class membership probabilities

hunters were least averse to difficult access, and among the least averse to longer travel times. The ‘harvest-oriented’ hunters also had a strong preference for seeing more birds on trips. The ‘selective’ hunter preferences were a combination of those of the ‘local’ and the ‘harvest-oriented’ hunter classes (Table 4). They were the most likely to opt out and averse to difficult access and longer journeys (similar characteristics to the ‘local’ hunters). They also had among the strongest preferences for bigger harvests, seeing lots of waterfowl and were less averse to higher competition (similar characteristics to ‘harvest-oriented’ hunters). Harvest was the most important attribute for ‘selective’ hunters (33.9%) as well as the ‘harvest-oriented’ (Fig. 3).

Table 4 Latent Class model parameter estimates for hunting trips

Attribute	Devoted hunters			Local hunters			Harvest-oriented hunters			Selective hunters		
	Coefficients		SE	Coefficients		SE	Coefficients		SE	Coefficients		SE
Opt out	-3.055	***	0.077	0.509	***	0.041	-1.010	***	0.070	2.284	***	0.052
Harvest—3 birds	0.143	***	0.014	0.341	***	0.025	0.516	***	0.027	0.326	***	0.038
Harvest—6 birds	0.259	***	0.018	0.489	***	0.031	1.618	***	0.038	1.515	***	0.044
Travel—1 h	0.359	***	0.020	1.421	***	0.046	0.518	***	0.035	0.735	***	0.042
Travel—2 h	-0.038	*	0.021	0.003		0.036	0.020		0.038	-0.098	**	0.049
Travel—3 h	-0.216	***	0.021	-1.196	***	0.052	-0.207	***	0.042	-0.657	***	0.050
Travel—4 h	-0.597	***	0.024	-2.086	***	0.072	-0.859	***	0.044	-1.115	***	0.057
Access—moderate	0.100	***	0.013	0.248	***	0.024	0.209	***	0.025	0.270	***	0.030
Access—difficult	-0.265	***	0.014	-0.684	***	0.029	-0.320	***	0.029	-0.672	***	0.036
Waterfowl—50	-0.195	***	0.020	-0.261	***	0.036	-0.283	***	0.037	-0.386	***	0.046
Waterfowl—250	0.095	***	0.020	0.223	***	0.033	-0.023		0.037	0.151	***	0.041
Waterfowl—500	0.100	***	0.022	0.136	***	0.039	0.231	***	0.039	0.353	***	0.044
Waterfowl—1000 s	0.335	***	0.021	0.411	***	0.036	0.665	***	0.043	0.665	***	0.040
Competition—low	0.514	***	0.016	0.756	***	0.030	0.560	***	0.031	0.544	***	0.036
Competition—medium	-0.014		0.016	0.006		0.031	0.140	***	0.034	0.098	***	0.035
Competition—high	-1.227	***	0.022	-1.571	***	0.044	-1.169	***	0.038	-1.201	***	0.050
Class membership probabilities	0.370	***		0.213	***		0.231	***		0.186	***	
Log-likelihood	-61031.449											
Observations	83,908											
Individuals	8449											
Adj. r^2	0.338											
AIC	122196.900											
BIC	122822.500											
Entropy	0.242											

$^{***} = p = < 0.001$, $^{**} = p < 0.05$, $^{*} = p < 0.1$

Assessing implications for management

We tested four different hunter characteristics against individual latent class membership to help describe the different classes (Table 5). The results of all post hoc tests were significant; Cohen's w values were greater than the threshold for small effects (0.10) but less than the threshold for medium effects (0.30; Cohen 1988). The degree of the overlap between hunters in all classes helps to explain the relatively low effect sizes in the post hoc tests.

The visualizations of the post hoc tests illustrate that more 'harvest-oriented' and 'selective' hunters than expected harvested more than 50 ducks in a season, shot their bag limit on most of their hunts in a season, and had to shoot their bag limit on most of their hunts/every time to be satisfied with their season compared to 'devoted' or 'local' hunters (Fig. 4). In particular, more 'local' and 'devoted' hunters than expected reported to have never needed to shoot their bag limit to have a satisfying season (Fig. 4a). More 'harvest-oriented' hunters than the sample average identified "very strongly" as a duck hunter, and fewer than the sample average identified "not at all", "slightly", or "moderately" as duck hunters (Fig. 4c). These results contrasted with the distribution of 'local' hunters' identification as duck hunters, which largely demonstrated an expected distribution, except that more 'local' hunters than expected identified "not at all" as duck hunters.

Limitations

Our sample frame was current active waterfowl hunters who had hunted in the year prior to their completion of the questionnaire. Although these results are relevant for understanding the preferences of current hunters (and possibly for their continued retention), we are limited in the inferences we can make about the attributes and management actions that would be relevant to lapsed waterfowl hunters, and to recruitment of new waterfowl hunters.

It is important to note that there was not strong differentiation in model selection (i.e., AIC, BIC) among the hypothesized number of classes. We also found the fit statistics (i.e., adj. r^2) and the diagnostic statistics (i.e., entropy) to be poor based on contemporary cut-off

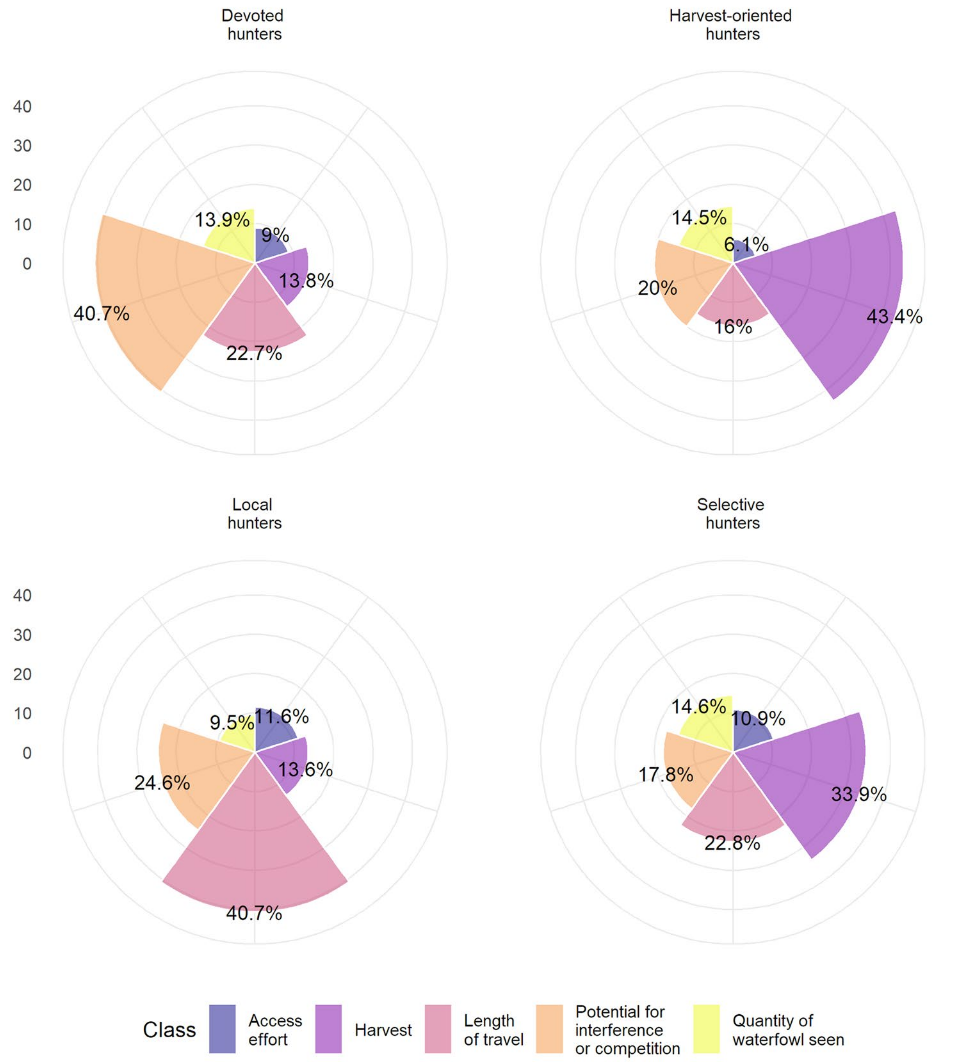

Fig. 3 Percent relative importance of each attribute in its contribution to preference describes the magnitude that each attribute contributes to the preference of each of the four classes of waterfowl hunters. Attributes add to 100% for each plot and describe how each attribute contributes to the total utility of members of that class

Table 5 Post hoc test results for hunter characteristics when compared to latent class membership

Variable	x^2	Df	*P* value	Cohen's w
How many times do you feel the need to shoot a daily bag limit of ducks/geese to have a satisfying season?	357.66	12	< 0.001	0.20
How many ducks have you harvested over the last 5 years on average?	245.59	12	< 0.001	0.17
To what extent do you identify yourself as a duck hunter?	221.12	12	< 0.001	0.17
How many times did you shoot a limit of ducks/geese last year's season?	197.12	12	< 0.001	0.16

thresholds (Weller et al. 2020), but they were improved over the conditional logit model estimate. However, because we examined North American waterfowl hunters trip preferences using attributes that were deemed broadly important by a wide range of waterfowl hunters across the continent, some overlap in the importance of key attributes between hunter classes (e.g., increasing harvest and competition) is expected. For example, all classes receive a similar degree of benefit, or utility, from harvesting a single bird or increasing ease of access. Although the post hoc tests assume that class membership is discrete, the differences between classes are probabilistic; class

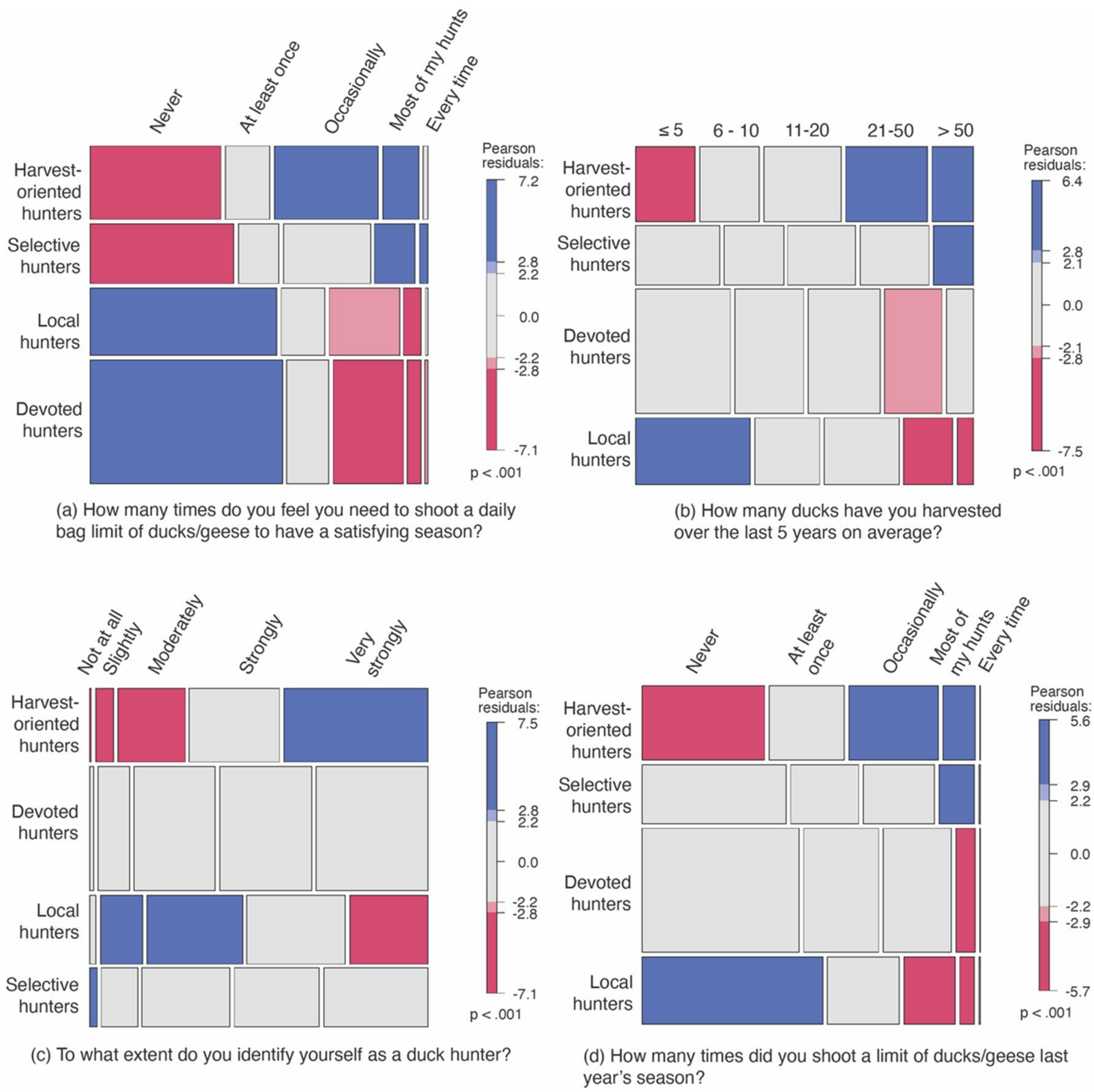

Fig. 4 Mosaic plots showing the latent class membership and additional hunter characteristics. These plots portray the relative sizes of cell counts and standardized residuals (calculated based on the observed and estimated expected frequencies per cell) from underlying contingency tables to visualize the structure of the data (Friendly 1994). Significance at the 95% level are based on the maximum residual value per plot (Meyer et al. 2006). The colors depict the sign and magnitude of standardized Pearson residuals at the 90% and 95% significance levels (Friendly 1994): grey indicates no significant residuals; blue indicates significant positive residuals; and red indicates significant negative residuals

membership is not known definitively but rather an individual has some classes in which they are more likely to be a member, and some that are less likely.

Discussion

Our study results are consistent with previous findings related to waterfowl hunter preferences and build upon past studies by identifying the relative strength of these preferences. Results from the conditional logit model supported our initial assumptions that waterfowl hunter trip preferences are influenced by harvest availability, aversion to difficult access, shorter travel times, and seeing large numbers of waterfowl without competition or interference from other waterfowl hunters. Previous studies have shown that Atlantic Flyway waterfowl hunters' site choices were inversely related to longer distances (Roberts et al. 2017) and that many waterfowl hunters preferred seeing and harvesting more ducks, shorter travel distances, easy on-site access, and low levels of competition from other hunters (Vaske et al. 1986; Schroeder et al. 2006; Brunke and Hunt 2007).

Previous studies have also found that harvesting and seeing waterfowl were important to waterfowl hunter satisfaction (Schroeder et al. 2019; Gruntorad et al. 2020). Although our results seem intuitive, they confirm assumptions about the influence of these attributes and represent an initial effort to compare these attributes with and against each other to examine hunter trip preferences among different types of hunters. While competition was an important attribute in trip preferences in our study, it did not appear to be as influential an attribute as in other studies (e.g., Vrtiska et al. 2010; Gruntorad et al. 2020).

Our identification of four classes of North American waterfowl hunters is similar to those identified through cluster analysis by Schroeder et al. (2006) among Minnesota waterfowl hunters. Although satisfaction among hunters is related to seeing and harvesting game, Schroeder et al. (2006) noted that enhancing waterfowl hunter satisfaction requires identifying different types of hunters and addressing experiential attributes, such as social interaction, and more/different licensing options. We identified four latent classes of waterfowl hunters: 'devoted', ‘local’, ‘harvest-oriented’, and ‘selective’. Our results highlight that increasing harvest is a key element in determining hunter well-being, but it is not the only influence and its importance varies among hunters. Things like on-site access, number of users, travel time, and geographic distribution of hunting opportunities are also important to consider. By taking these factors into account, managers may be able to support different scenarios that appeal to a broader set of users, increasing hunter participation and satisfaction. For example, although the ‘selective’ hunter class was most likely to opt out, without evidence to suggest that they hunt less often, it appears that this class of hunters may be adept at identifying the hunting trip opportunities that meet their specific preferences. Manager awareness of the importance of salient experiential attributes in decision-making may enable them to make the process of identifying suitable trip opportunities easier for all types of waterfowl hunters.

Post hoc tests provided further evidence that the four latent classes of waterfowl hunters engage in hunting differently. Although ‘harvest-oriented’ and ‘selective’ hunters are significantly more likely to need to shoot their daily bag limit to have a satisfying season, the probabilities of membership to these two classes (Table 4) suggest they do not represent the majority of waterfowl hunters in Canada and the U.S. These two classes are also more likely to shoot their bag limits in a season and are more likely to have shot more birds in a season relative to the other classes; this tendency is consistent with the greater importance of the harvest attribute in the latent class models. While the majority of hunters in all classes identify at least moderately as duck hunters, ‘harvest-oriented’ hunters identify disproportionately ‘very strongly’ as duck hunters, which aligns with the greater importance of the bird-related attributes in their trip decision-making.

The preference for experiential attributes is a phenomenon that has been well-studied among recreational anglers (Hunt et al. 2019; Arlinghaus et al. 2017). Studies of recreational angling have consistently shown that for the majority of anglers there is a diminishing marginal return of well-being, or utility, with increasing catch rates but the well-being for key non-harvest related attributes and other harvest-related metrics (e.g., catch size) tended not to diminish, or was more inelastic (Koemle et al. 2022; Beardmore et al. 2015). Our results suggest waterfowl hunting may be similar: we found that ‘devoted’ and ‘local’ hunters did not perceive appreciable benefit from harvesting more birds beyond harvesting a single bird. In both cases, the experiential attribute of decreased competition was more important than it was for hunters who did benefit from harvesting increasing numbers of birds. In contrast, ‘harvest-oriented’ hunters and ‘selective’ hunters benefited more from harvesting a large number of birds (i.e., greater than 3) and were negatively impacted by only harvesting a single bird.

In past studies, hunt quality has often been defined by harvest success (Schroeder et al. 2019; Schummer et al. 2020). Our results suggest the potential for diminishing returns with higher harvests for some classes of waterfowl hunters: there may be thresholds where additional harvest does not equate with increased utility and those thresholds may differ between classes. Future studies could more specifically evaluate this relationship by including more levels on the number of waterfowl harvested in a day attribute within DCEs and focusing on individual species or groups of species relevant for crafting harvest regulations. In addition, future studies could explore more experiential attributes such as hunting in social groups, hunting in aesthetically pleasing locations, or broader definitions of harvesting success that include hunting-associated elements in addition to the number of birds harvested (e.g., harvesting different species).

In response to findings of heterogeneous preferences, recreational angling researchers have begun to connect their results to adaptive social-ecological systems. In doing so, they have recognized the need for landscape-scale management approaches that provide a wide range of attributes levels to meet the varied preferences of recreation anglers (Arlinghaus et al 2017; Van Poorten and Camp 2019). Given the latent heterogeneity among waterfowl hunter trip preferences, it may be beneficial for managers to consider providing a range of waterfowl hunting opportunities, with some focused on key non-harvest attributes, and others focused on increasing harvest quality and opportunity (e.g., sanctuaries, managing hunter densities, limiting time/days afield, and simpler regulations regarding sex- or species restrictions). Within a landscape of opportunity for waterfowl hunting, travel time is a key metric for managers to consider; some waterfowl hunting opportunities may exist within a desired travel time (e.g., 2 h or less), but those opportunities may not provide the key attributes most preferred by specific classes of hunters, or ecological characteristics used to identify priority wetlands for conservation. Planners may satisfy waterfowl hunters' preferences by providing opportunities that represent a variety of settings and experiences within acceptable travel distance thresholds and by considering classes of hunters whose preferences are not being met. Data from this study do not provide enough specificity to make management recommendations for local/regional systems, but point to the need for future down-scaled studies and field experiments at the local, state, and regional levels to better understand the specificity of hunter preferences on these dimensions of the hunting experience. An example of potential approaches includes Missouri's managed waterfowl hunts on its intensively managed wetlands (https://mdc.mo.gov/hunting-trapping/species/waterfowl/managed-hunts-waterfowl). Such an approach targeting dimensions of travel distance, access, crowding, and harvest quality could help tailor opportunities to hunter preferences.

Implications for Management

A central implication of our study is that wetland conservation will be paramount at both continental and local scales to provide the types of experiences waterfowl hunters most desire. For example, conserving high-quality wetland habitats that are well distributed on the breeding grounds of North American ducks will contribute to higher duck populations which in turn will support more liberal seasons, harvest opportunity, and potential to see more ducks. Substantial degradation or loss of waterfowl habitat with subsequent declines in duck populations could have major impacts on all waterfowl.

Additionally, conserving high quality wetland habitats that are well distributed in migration and wintering regions would benefit all waterfowl as habitat availability and conditions of migration and wintering areas affect duck populations (Heitmeyer and Fredrickson 1981; Devries et al. 2008). Given the overall importance of travel time to all classes of waterfowl hunters in our study (Fig. 3), obtaining hunting access to new wetlands in areas desirable to waterfowl hunters could also potentially benefit hunter retention, recruitment and reactivation. Increasing the number of sites accessible to hunters may reduce competition levels in hunting locations, which would benefit the largest class of waterfowl hunters (the 'devoted' hunters) for whom competition was the most important attribute (Fig. 3).

One strategy to conserve wetlands that would provide the greatest benefit to people and waterfowl would be to prioritize wetland restoration efforts closer to urban areas in those scenarios where restoration could be accomplished in ways that benefit both people and waterfowl. The Upper Mississippi River and Great Lakes Joint Venture took this approach when developing a spatial decision support tool to help prioritize locations to target conservation for waterfowl and people (Soulliere & Al-Saffar 2017). In this tool, they applied higher weights to habitats within 50 km of population centers.

We also highlight the importance for waterfowl hunters of seeing as well as harvesting birds while hunting. Wetland managers can influence the distribution of ducks in three different ways. First, wetland managers can regulate the exposure of ducks to human disturbance. Previous research has highlighted the importance of refuges for ducks during hunting seasons (Beatty et al., Guillemain et al. 2008, Blake-Bradshaw et al. 2023, Cox and Afton 1997, Hidden 2016). State and federal wetland managers can manage disturbance by providing spatial refuge. Varying degrees of spatial refuge can be achieved by restricting all public access or certain types of public access (Blake-Bradshaw et al. 2023, Dinges et al. 2015). Second, wetland conservation efforts can focus on conserving wetland complexes that provide a diversity of habitats (Pearse et al. 2012; Beatty et al. 2014; Webb et al. 2010). Third, in those scenarios where wetland managers can manipulate water levels, they can affect food abundance and availability, both of which will influence duck use of wetland habitats (Fredrickson and Reid 1988). Knowing the importance of managing bird visibility and distribution for the overall hunting experience provides managers with the option of, or additional justification for, including these provisions in site management planning.

Our results also have implications for waterfowl population management. A central question of waterfowl population management has been whether greater harvest of waterfowl leads to greater hunter satisfaction. While harvest has been shown to be a factor in hunter satisfaction (e.g., Gruntorad et al. 2020), our results indicate there is a diminishing return associated with the number of waterfowl harvested; while hunter satisfaction is influenced by the opportunity to harvest a certain number of waterfowl, other experiential attributes, like competition and on-site access, are also important considerations. Schummer et al. (2019) also found there were diminishing returns related to hunt quality and the number of mallards (*Anas platyrhynchos*) harvested: although mean hunt quality increased with more mallards harvested, the contribution of additional mallards harvested decreased and there were no increases in mean hunt quality after the third mallard was harvested. Schummer et al. (2020) suggested the assumption of hunter recruitment, retention, and reactivation (R3) programs that increased hunting access and opportunities will lead to increased hunting participation ignores the importance of hunt quality defined by harvest. While we do not disagree with these authors that harvest success is an important element of hunting satisfaction for most waterfowl hunters, our findings indicate that other factors derived from duck populations, like seeing ducks, also contribute to the quality of waterfowl hunting. In particular, our results highlighted that harvest was the most important attribute for only two of four of our hunter classes and that attaining the maximum bag harvest limit was not the only important element in deciding whether to go waterfowl hunting.

The important differences between the four classes describe other key factors that may be important to R3. Churn rates are important descriptors of waterfowl hunter retention and reactivation (Hinrichs et al. 2020; Graham et al. 2021). Our results show that some segments of the waterfowl hunter population (i.e., ‘devoted’ and ‘harvest-oriented’) may be much more likely to be retained from year to year independent of other trip attributes. Inversely, our results suggest that hunter segments who are more likely to opt-out may be more likely to be retained or reactivated with improved harvest opportunity, shorter travel distances, and decreased experiences of competition or interference. Our study only included existing waterfowl hunters so extrapolating our results to recruiting new participants may be challenging, but future research could seek to compare preference for similar attributes between potential recruits and existing participants.

The role of waterfowl hunters in the conservation and restoration of wetland social-ecological systems remains an important one. Although declining numbers of waterfowl hunters does raise concerns about the sustainability of their contributions to wetland conservation, this study identifies the attributes that managers and planners can manipulate to satisfy the desired experiences that waterfowl hunters seek. Overall, our results suggest that improving the likelihood that hunters will see and have opportunities to harvest some waterfowl has benefit to them. High levels of competition are undesirable, especially for ‘devoted’ hunters who are the largest class of waterfowl hunters. In some situations, it may be useful to limit the number of hunters who have access each day, or assign hunters specific locations, to reduce competition while still providing opportunities to see and harvest ducks. Managers should consider offering a diversity of hunting experiences. Those experiences may range from more intensively managed (e.g., easy access, close to home, with good chances of seeing ducks and harvesting a couple of ducks) to less regulated opportunities (e.g., more difficult to access to provide opportunities for hunters to harvest more ducks if they are able to out-compete other hunters). In the future, managers need to more explicitly consider the ways that wildlife, habitat, and people management could be integrated to provide a diversity of experiences while also supporting healthy waterfowl populations.

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Author Contributions David Fulton, Howard Harshaw, Ashley Dayer, Jennie Duberstein, Andrew Raedeke, Rudy Schuster, and Mark Vrtiska contributed to the study conception and survey design. Material preparation and survey instrument design were carried out by David Fulton and Howard Harshaw. Howard Harshaw led data collection in Canada, and Jason Spaeth directed data collection in the U.S. for the University of Minnesota. Katherine Sainsbury and Nicholas Cole wrangled the data and Katherine Sainsbury carried out the data analysis. Manuscript writing was led by Katherine Sainsbury and Howard Harshaw. The first draft of the Methods and Results were written by Katherine Sainsbury and the first draft of the Introduction and Discussion were written by Nicholas Cole. All authors contributed to manuscript drafts and read and approved the final manuscript.

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Data availability The survey data are not available to be shared or disseminated. The informed consent information provided to research participants indicated that “[I]ndividual responses will not be made available to anyone outside the research team.” Dr. Howard Harshaw at the University of Alberta is the point of contact for any questions concerning data availability (harshaw@ualberta.ca).

Declarations

Ethics statement The University of Alberta’s Research Ethics Board approved the Canadian part of this study (Pro00054255). However, the University of Minnesota Institutional Review Board determined that the survey did not meet the definition of human subjects research, and did not require approval.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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