Hunters' Willingness to Pay and Attribute Ranking for Deer Hunting Sites: The Roles of Sanctuaries, Food Plots, and Canopy Covers

Bijesh Mishra [1, 2, *], Omkar Joshi[2], and Dayton Lambert [3]

[1]Jimmy and Rosalynnn Carter School of Public Policy, Georgia Institute of Technology, Atlanta, GA, 30332

[2]Natural Resource E. and Management, Oklahoma State University, Stillwater, OK, 74078

[3]Agricultural Economics, Oklahoma State University, Stillwater, OK, 74078

[*]Corresponding author: bijesh.mishra@okstate.edu; bmishra36@gatech.edu

Abstract

Food plots, sanctuaries, forest canopy cover, and deer observed per visit are crucial in maintaining quality deer hunting site and improve hunting success. However, deer hunter's valuation and relative preference for these site attributes are less understood. The better understanding of hunter's relative preference and valuation for these attributes helps landowners to make a better land management decision. We used best worst choice to estimate willingness to pay for these hunting site attributes and ranked them based on deer hunter's relative preference. We found a that hunting site with food plots, sanctuaries, and 6-10 deer observed per visit are more valuable for deer hunters compared to forest canopy cover. We further discuss management implication of the findings for hunting site management.

Keywords: Deer Sanctuary, Food Plots, Canopy Cover, Best Worst Choice, Ecosystem Management

Highlights

- We estimated relative preference of deer hunting site attributes and it .
- We used best-worst choice to elicit conditional and unconditional demands for deer hunting.
- Hunters prioritize the quality of the hunting site over the cost while leasing land for deer hunting.
- Landowners benefit by diversifying their land management objectives.
- Outreach programs are essential for long-term conservation and ecosystem sustainability.

1. Introduction

Deer hunting is one the most popular recreational hunting activities with social, cultural, traditional, and historical significance in the U.S. (Arnett & Southwick, 2015; Boehm et al., 2023; Grado et al., 2007; Hanberry & Faison, 2023; Hewitt, 2015; U.S. Department of the Interior, 2023). Managing tree canopy cover, installing food plots, and maintaining deer sanctuary are important management activities to improve deer habitat, increase deer visitation, and improve herd quality (Murphy et al., 2021; Pruitt et al., 2023). Strategic placement of food plots with closed and moderate canopy cover provide food and screening cover for deer. Food plots supply forage with balanced and nutritious food which otherwise become deficit in the hunting site (Fulbright & Ortega-Santos, 2013). Sanctuaries provides safe hiding places for deer to reduce herd losses and increase management success for landowners (Yarrow, 2009). The forage quality, and forage availability, and nutrient content vary with tree canopy cover and thus, the habitat quality (Adhikari, Masters, Adams, et al., 2021; A. Johnson et al., 1995; McKinney et al., 2023). Deer observed per visit and habitat quality have crucial role in providing a high-quality hunting experience. Hunting sites with better habitat quality attract more deer (Fulbright & Ortega-Santos, 2013; Yarrow, 2009), provide better opportunities to observe deer (Miller & Graefe, 2001) increasing probability of hunting success and hunter's satisfaction (Gruntorad et al., 2020; Miller & Graefe, 2001).

The positive benefits of these hunting site attributes in maintaining quality deer habitat are well established in the literature and, to some extent, summarized above. Theoretically, landowners could benefit by managing their land to maintain ideal deer habitat by incorporating all habitat characteristics that adds value to the hunting site. But, the management cost and complexity in decision making process are major barriers (Mishra, Joshi, Masters, et al., 2023; Starr et al., 2019). The cost can be reduced and the decision making process can be simplified by maintaining site characteristics that are relatively better preferred by deer hunters and generate higher willingness to pay, given the site characteristics. A few research in the past have quantified economic value of hunting site attributes such as food plots (Mingie et al., 2019), lease rate for hunting site (Hussain et al., 2010), site quality (Hussain et al., 2004), and forest management activity (Mingie et al., 2017a). Findings from above research suggest these site characteristics have positive influence on the valuation of deer habitat and hunters decision to lease a hunting site. However, these research could not provide a relative importance of the hunting site attributes and their valuation in terms of willingness to pay. This limits landowner's ability to select highly valued site characteristics for their land from the potential list of hunting site attributes. We aim to fulfill this gap.

We ranked hunting site attributes such that landowners can focus on maintaining site characteristics that have relatively better preferred by deer hunters. We further estimated deer hunter's willingness to pay for the site characteristics to lease the hunting site with the given attribute. We used best worst choice method to achieve both objectives (Louviere et al., 2015). Our research enables landowners to compare relative preference of hunting site attributes and their valuation, such that landowners can select site characteristics that yields highest economic benefit from their land by leasing out the land to hunters for deer hunting.

The other novelty of this paper lies on the quantification of deer sanctuary for the first time in the deer hunting valuation study. Deer sanctuary is becoming increasingly important in quality deer management (Ditchkoff et al., 1997; Green & Stowe Jr., 2008) practice. The incorporation of deer sanctuary in the ecosystem valuation will add value to ecosystem management effort. We found that hunting site with food and deer sanctuary are more valuable than managing forest canopy cover in deer hunting hunting site. We will further discuss the implication of our results and make ecosystem management and policy recommendation.

2. Theoretical Foundation

We use Lancaster's consumer theory (Lancaster, 1966) and McFadden's random utility model (RUM) (McFadden, 1974) to model the choice behavior of deer hunters. Lancaster's consumer theory states that a good has multiple characteristics and multiple goods share multiple characteristics. These characteristics generate utility among consumers (Lancaster, 1966; Navrud & Grønvik Bråten, 2007). We designed multiple deer hunting sites using hunting site characteristics and used RUM to model deer hunter's choice behaviors.

Deer hunter willingness to pay (WTP) is the maximum amount of income (m) the hunters, ($i = 1, ..., N$), is willing to relinquish to lease sustainably managed deer hunting site. Let $U_o(x_i, m_i, u_{oi})$ be an initial utility of unmanaged deer hunting site, x_i. The indirect utility of a deer hunter willingness to lease sustainably managed deer hunting site is $U_1(x_i, m_i - t, u_{1i})$, where t is the annual lease fee per acre of sustainably managed deer hunting site. The variables u_{0i} and u_{1i} are random errors in the decision-making process, both, with expected values of zero and constant variances. A hunter is willing to lease the hunting site if the utility of sustainably managed hunting site is greater than the utility of unmanaged hunting site (i.e. $U_0 < U_1$) and unwilling to pay otherwise.

The RUM decomposes the linearly additive indirect utility of an individual i, for selecting site feature j on choice occasion t into systematic and random components. The utility of unmanaged deer hunting site (U_{0ijt}) is

$$U_{0ijt} = \alpha_{0jt} X_{ijt} + \alpha_{im} m_i + u_{0ijt} \tag{1}$$

where, X_{ijt} includes hunting site characteristics and an alternative specific constant, and β_{0jt} are associated parameters, β_{im} is the marginal utility of income, and u_{ijt} is a stochastic error term.

The indirect utility of deer hunters who are willing to pay to lease sustainably managed deer hunting site is

$$U_{1ijt} = \alpha_{1jt} X_{ijt} + \alpha_{im}(m_i - t_i) + u_{1ijt} \tag{2}$$

The latent change in utility (U^*_{ijt}), WTP for sustainably managed ecosystem, is obtained by subtracting Eq. 1 from Eq. 2 (Train, 2009):

$$U^*_{ijt} = \alpha_{jt} X_{ijt} + \alpha_{im} t_i + u^*_{ijt} \tag{3}$$

where $u^*_{ijt} = u_{1ijt} - u_{0ijt}$ and have an expected value of zero and constant variance.

The WTP is the value that differentiates consumers willing to lease sustainably managed land (Eq. 2) and remain at status quo (Eq. 1). Both consumers are indifferent when the latent utility, U^*_{ijt}, is zero at which t_i is equal to WTP_i (Haab & McConnell, 2002). Equating Eq. 3 to zero, replacing t_i with WTP_i, and solving for WTP_i, we get

$$WTP_i = \frac{\alpha_{jt} X_{ijt}}{\alpha_{im}} \tag{4}$$

The marginal contribution of individual deer hunting site characteristics on WTP can be obtained by partially differentiating Eq. 4 with respect to hunting site characteristics. The marginal WTP of hunting site attributes is

$$\frac{\partial WTP_i}{\partial x_{ijt}} = \frac{\alpha_{jt}}{\alpha_{im}} \tag{5}$$

3. Method

3.1 Best Worst Choice Design

We used profile case (Case 2) best worst choice (BWC) method which consists of two components: 1) best-worst scaling (BWS), and 2) a discrete choice experiment (DCE) (Dumbrell et al., 2016; Louviere et al., 2015; Rubino et al., 2018; Soto et al., 2016, 2018). The first BWS part consists of three-column choice set, which asks to select the best and the worst features of the given hunting site. The BWS part of BWC reveals conditional demand of choices conditioned on a given choice profile (Louviere et al., 2015; Potoglou et al., 2011). The second DCE part of BWC consists of deer hunting sites described by a given choice profile and the binary (yes/no) question at the bottom of the choice profile (Louviere et al., 2015). Respondents have the option to reject the profile and choose to remain at status quo by answering "no" to the bottom binary question (Potoglou et al., 2011). The second part facilitate revealing the unconditional demand of respondent which is the same as the traditional DCE with two profiles–hypothetical choice and status quo profiles–at a time (Louviere et al., 2015). We choose the case 2 BWC method to elicit unconditional and conditional demands without additional cost and effort of collecting data (Louviere et al., 2015; Potoglou et al., 2011; Severin et al., 2013) and to reduce cognitive burden by presenting choice profile with one choice set at a time (Flynn et al., 2007; Louviere et al., 2015; Soto et al., 2016). This method provides an additional advantage over traditional DCE by separating attribute impact and level scale values (Flynn et al., 2008; Louviere et al., 2015).

<TABLE 1 HERE>

<FIGURE 1 HERE>

We selected four attributes and three levels of each attribute (Table 1) to develop choice sets representing individual deer hunting sites (Fig 1). Three attributes–deer sanctuary and food plots, forest canopy cover, and the number of deer observed per visit–represent hunting site characteristics that are crucial in maintaining quality deer habitat. The fourth attribute, the hunting site lease fee, was used to estimate the monetary value of site characteristics. Three levels of lease fee were decided carefully after reviewing the annual leasing fee for deer hunting sites offered by commercial hunting clubs and private landowners in 2018 in the study region. We used SAS OPTEX procedure (SAS Institute Inc, 2016) to select 18 out of 81 available hunting sites using orthogonal main effect balanced design method and divided into three blocks of survey. Each level appeared twice in a survey.

3.2 Survey Administration

We mailed an eight-page long paper-based survey designed as a booklet with a thick front and back covers, personalized cover letter, and prepaid return envelope. We printed contact and mailing details on the back page of the survey so respondents can return the survey even if a prepaid envelope is lost. We recruited landowners from 50 Oklahoma counties residing roughly east of I-35 (Mishra, Joshi, Chapagain, et al., 2023) who own at least 160 acres (about 65 hectares) of land such that at least one deer hunting site can be managed sustainably. Two rounds of surveys, each, followed by postcards were sent within two months following Dillman's Tailored survey method (Dillman et al., 2014). A unique numerical code was assigned to each survey to avoid respondent recruitment redundancies. The survey response rate was 20%. We retained landowners who reported they have hunted in the last five years in Oklahoma through the survey. Thus, our respondents are deer hunters and landowners.

Deer hunters from Oklahoma counties east of I-35 were selected because it has a diverse ecosystem composition, structure, and geography. This region includes the Arkansas Valley, cross timbers, central plains, Flint hills, and the Ouachita mountains with post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), shortleaf pine (*Pinus echinata*), and hickory (*Carya spp.*) dominant forests (E. Johnson et al., 2010; Joshi et al., 2019). This ecological region is also well known for cross timbers with savannas, woodlands, and forests. The region's diverse ecosystem composition and structure make it easier for hunters to visualize hunting sites presented in the survey. Recruiting experience hunters and familiar choice scenarios eliminate concern of hypothetical bias and provide WTP estimates that reflect the real market value of the activity (Hensher, 2010).

4. Data Analysis

We maintained two separate datasets for BWS and DEC models because they require two different data management processes which are discussed below. We used random parameter logit models with simulated maximum likelihood estimation method using the *mixlogit* module developed by Hole (2007) in Stata 18 for both models. We used Davis-Fletcher-Powell and Newton-Raphson optimization algorithms with 50 burn-in sequences and 1000 Halton draws for the simulation. A Huber-White covariance estimator was used to calculate standard errors (Huber, 1967; StataCorp, 2023).

4.1 Best Worst Scaling of Best Worst Choice

We maintained the BWS dataset assuming deer hunters choose one best-worst pair among all available best-worst pairs which is consistent with the maxdiff paired model of choice decision-making process (Aizaki & Fogarty, 2019; Flynn et al., 2007; Louviere et al., 2015). The selected pair represents the maximum difference in the utility among the utility derived from all available pairs thus, maximizing the total utility from choices available at the time of decision-making (Flynn et al., 2007, 2008; Louviere et al., 2015; Soto et al., 2016, 2018). The distance between attribute levels on the latent scale is proportional to the relative probability of a choosing a given pair (Flynn et al., 2007; Louviere et al., 2015; Marley & Louviere, 2005). There were $4 \times (4 - 1) = 12$ pairs available in a single choice set (Fig: 1) from which respondent selected a best-worst pair. A binary variable representing the choices is the dependent variable which received 1 for the selected best-worst pair and 0 otherwise (Aizaki & Fogarty, 2019; Louviere et al., 2015).

We included effect-coded attributes and effect-coded attribute levels as random parameter explanatory variables in the model. In the case of BWS, this can be achieved by creating best and worst dummy variables and subtracting the worst from the respective best

dummy variable. Effect coding allows estimation of the effect of all levels in the model; the reference point is internalized in the model, and coefficients are uncorrelated with the intercept (Bech & Gyrd-Hansen, 2005; Lancsar & Savage, 2004). Attributes were coded as 1 or -1 if they appear as best or worst attributes in the best-worst pair and as 0 otherwise. Attribute levels were also coded as 1 or -1 for best and worst levels and 0 otherwise. Following the BWS convention (Aizaki & Fogarty, 2019; Flynn et al., 2007), attribute "deer sanctuary and food plot" was constrained to zero (Lusk & Briggeman, 2009; Soto et al., 2016, 2018). One level from each attribute was eliminated as references in the model. Eliminated levels were "no deer sanctuary no food plots", "open canopy cover", "1 deer observed per visit", and "\$6 lease fee per acre". In the case of attribute levels, the coefficient of the omitted level is the negative sum of non-omitted levels within the attribute (Flynn et al., 2007). The coefficients of attributes are called attribute impact and coefficients of levels are called level scale values (Aizaki & Fogarty, 2019; Flynn et al., 2007). The negative sign of an estimated coefficient signifies its relative position in the linear utility scale to the eliminated attribute (Flynn et al., 2007; Soto et al., 2016). The coefficient of effect-coded variables are interpreted as the mean utility of the variable across the population (Flynn et al., 2007; Soto et al., 2018).
The probability of choosing hunting site characters as best level r and worst level r', $r \neq r'$, in the given BWS profile X_{tk} by an individual i was estimated as

$$
\begin{aligned}
P_{BW}(rr' = 1 \mid \mathbf{X}_{itk}) = \beta_{\text{CAN}} \cdot \text{CAN}_{itk} + \beta_{\text{DR}} \cdot \text{DR}_{itk} + \beta_{\text{LF}} \cdot \text{LF}_{itk} + \\
\lambda_{\text{NSFP}} \cdot \text{NSFP}_{itk} + \lambda_{\text{SFP}} \cdot \text{SFP}_{itk} + \lambda_{\text{MOD}} \cdot \text{MOD}_{itk} + \lambda_{\text{CLS}} \cdot \text{CLS}_{itk} + \\
\lambda_{\text{DR6}} \cdot \text{DR6}_{itk} + \lambda_{\text{DR10}} \cdot \text{DR10}_{itk} + \lambda_{\text{LF10}} \cdot \text{LF10}_{itk} + \lambda_{\text{LF16}} \cdot \text{LF16}_{itk} + \epsilon_{itk}
\end{aligned} \tag{6}
$$

where the βs are attribute coefficients, λs are coefficients for the attribute levels, and ϵ_i is stochastic error term.

4.2 Discrete Choice Experiment of Best Worst Choice

The binary variable at the bottom of the choice set (Fig: 1) was the dependent variable which was coded as 1 if "yes" was selected and 0 otherwise. "No sanctuary and no food plots", "open canopy cover", and "one deer observed per visit" were selected as reference levels within their respective attributes. All independent variables except "lease fee" were effect coded by subtracting the reference level from the other two levels within each attributes. Effect coded variables were entered as random parameter explanatory variables in the model. Lease fee (price) was coded as a continuous variable and entered as fixed effect variable in the model. The standard errors for random parameters were estimated using the delta method. An alternative specific constant (ASC), coded as 1

for status quo and 0 otherwise, was included in the model as a fixed effect parameter to capture the hunter's status quo utility (Meyerhoff & Liebe, 2009) of deer hunting site and unobserved heterogeneity of deer hunters. Attribute levels included in the empirical model were coded as 0 for the status quo alternative.
The probability of leasing a hunting site (y_{jt}) given the site profile X_{tj} by an individual i was estimated as

$$P(y_{itj} = 1 \mid X_{itj}) = \gamma_{\text{NSFP}} \cdot \text{NSFP}_{itj} + \gamma_{\text{SFP}} \cdot \text{SFP}_{itj} + \gamma_{\text{MOD}} \cdot \text{MOD}_{itj} + \gamma_{\text{CLS}} \cdot \text{CLS}_{itj} + \gamma_{\text{DR6}} \cdot \text{DR6}_{itj} + \gamma_{\text{DR10}} \cdot \text{DR10}_{itj} + \gamma_{\text{LF}} \cdot \text{LF}_{itj} + \gamma_{\text{ASC}} \cdot \text{ASC}_{itj} + \nu_{itj} \quad (7)$$

where the γs are coefficients of hunting site attributes, and ν_{ijt} is a stochastic error term.

5. Results and Discussion

5.1 Deer Hunter Demographics

Our respondents have hunted in Oklahoma in the last five years. They have hunted for an average of 46.57 years and 50% of them have 50 to 75 years of hunting experience (Table 2). Deer is the primary game for 74% of hunters. The majority of the hunters were White American (81%) or Native American (13%) male (95%) who travel on an average of 11.85 miles one-way to reach their preferred hunting destination. During a hunting trip, they observed an average of 8.31 deer per visit and 50% of the hunters observed 6 deer or less during their visit. In the absence of currently accessible regular deer hunting sites, hunters should travel an average of 33.79 miles–about three times more than their current travel distance–to reach alternative hunting site of similar quality. Twelve percent of deer hunters leased land for deer hunting. The average and median sizes of leased land for hunting were 1733.21 acres and 320 acres.

<TABLE 2 HERE>

Their median household income was between $50,001 to $75,000 per year before tax. More than 80% of deer hunters had the highest education below a graduate degree. Deer hunters owned on an average of 209.56 acres of forests, 475.01 acres of rangeland, and 196.47 acres of agricultural croplands. Out of all participating deer hunters, 48% were farmers or ranchers, 10% were business owners, 21% were retired, and 13% held other jobs not stated in the survey. Six percent of the deer hunters were either African American, or others, or more than one races who were collectively categorized as "others" in the Table 2.

5.2 Best Worst Scaling of Best Worst Choice

The likelihood-ratio test for joint significance with the null hypothesis stating all standard deviations are jointly equal to zero (Hole, 2007) was rejected with 99% confidence suggesting a good model fit (Table 3). Based on attribute impact results, "deer observed per visit" was ranked as the best and "lease fee" was ranked as the worst attributes among four deer hunting site characteristics (Fig. 2). The preference heterogeneity for "number of deer observed per visit" and "lease fee ($) per acres per year" were significant among hunters. The least preferred attribute was the lease fee, which is consistent with previous studies (Mingie et al., 2017b).

<FIGURE 2 HERE>

<TABLE 3 HERE>

The hunting site characteristics representing better quality hunting sites such as "10 deer observed per visit" and "deer sanctuary with food plot" were ranked as the most valued attributes of hunting sites. Site attributes such as "1 deer observed per visit" and "no sanctuary and no food plots" and $16/acre leasing fee are considered as top three least preferred by deer hunters. The preference heterogeneity among deer hunters for all attribute levels except for "sanctuary without food plots", three canopy covers, and "$10 lease fee" were statistically significant at 99% level. "Sanctuary without food plots", "moderate canopy", and "closed canopy" were statistically significant at 95% level. Preference heterogeneity among deer hunters for "open canopy" and "$10 lease fee" were statistically non-significant at 90% level.

Comparing relative preferences of twelve attribute levels based on level scale values, "ten deer observed per visit" was the most preferred hunting site characteristic followed by "sanctuary with food plots" and "$6 annual lease fee" (Table 3 and Fig: 2). "One deer observed per visit" was the least preferred site characteristic followed by "no deer sanctuary no food plots" and "$16 lease fee". Similarly, "Sanctuary without food plots", "moderate canopy cover", "$10 lease fee", "open canopy", and "closed canopy" were ranked in the descending order of preferences and fall in the middle of linear utility scale.

Canopy cover related site attributes were ranked as mediocrity preferred site characteristics and are indifferent to each other. Our findings are consistent with previous literature as deer hunters placed higher preference for moderate and open canopy covers compared to closed canopy cover (Brinkman et al., 2009; Eliason, 2021; Hammitt et al., 1989). Our result further suggest that hunting site characteristics such as food plots and sanctuaries that visibly improve the hunting site characteristics were relatively more valuable for deer hunters in the hunting site selection decision making process.

5.3 Discrete Choice Experiment of Best Worst Choice

The likelihood ratio test of goodness of fit was statistically significant at 99% level suggesting a good model fit and standard deviations were jointly and significantly different than zero (Table 4). The alternative specific constant (ASC) that capture unobserved heterogeneity and status quo alternative were not statistically significant suggesting that the status quo bias effect where respondents disproportionately choose status quo instead of providing alternatives and protest attitude toward new hunting sites were non-existent among the respondents (Meyerhoff & Liebe, 2009; Samuelson & Zeckhauser, 1988). The non-significant status quo suggests that deer hunters derived higher utility from well-managed deer hunting sites that provide better hunting experience compared to that from currently available status quo hunting sites. The utility of price variable (lease) was negative and the preference heterogeneity of price among deer hunters was statistically significant at 99% confidence level. The statistically significant cost suggests that deer hunters considered the cost of leasing deer hunting site while making land leasing decisions. The negative sign of the cost variable (lease fee) was as expected because the utility of leasing hunting sites and their demand decrease with the increase in cost.

TABLE 4 HERE

Ten deer observed per visit displayed significant preference heterogeneity statistically at 99% confidence level with a positive sign. Six deer observed per visit was also statistically significant at 95% level. One deer observed per visit were significant at 99% level but has negative sign. The result suggest that deer hunters preferred to see larger number of deer during the hunting trip. The magnitude of coefficients also increased with the increase in the number of deer observed per visit. The number of deer observed was also one of the best indicators of quality deer hunting experience (Hammitt et al., 1989). Seeing a game species was considered as the minimum requirement for deer hunters to involve in hunting activities (Gruntorad et al., 2020). The hunting success and the satisfaction with the habitat management were related with number of deer observed during the hunting trips among deer hunters (Knoche & Lupi, 2007; Miller & Graefe, 2001).

The preference heterogeneity of deer hunters for deer habitat with sanctuary and food plots was statistically significant at 95% level and positive. Deer habitat with sanctuary but without food plots and habitat without both were non-significant and negative. The magnitude of the coefficient was stronger but negative when deer sanctuary and food plots were absent. The importance of food plots in maintaining quality deer habitat is well established in the literature (Fulbright & Ortega-Santos, 2013; Yarrow, 2009). Forage produced in food plots often generate greater benefit than food supplements (Pittman, 2019) and was preferred by deer (McQueen, 2020). Food plots were also less expensive to maintain using prescribed fire (Pittman, 2019) and brings additional ecological benefits associated with prescribed burning (Feltrin et al., 2016; Masters et al., 1993; McKinney et al., 2023; Mishra, Joshi, Masters, et al., 2023). Previous research have documented positive effect of food plots in the hunting club dues (Mingie et al., 2017b). Deer sanctuary is relatively a new concept in quality deer management which gaining familiarity among landowners and gradually incorporated in habitat management to improve deer habitat quality (Murphy et al., 2021). Our research made first attempt to quantify the effect of deer sanctuary in deer hunter's decision making for hunting site selection and established its significance in deer hunter's willingness to pay for leasing land for hunting.

The magnitude of coefficients of three forest canopy covers showed that deer hunters prioritized open, moderate, and closed canopy covers in descending order while making hunting site leasing decision. Open canopy has fewer visible obstructions and provides a better opportunity to observe deer (Lebel et al., 2012; Long et al., 2005). The actual shooting to harvest deer happened more often in the sites with good visibility (Lebel et al., 2012) which is provided by open canopy cover compared to moderate and closed canopy covers. Open canopy cover further provides ample space and sunlight for the growth of herbaceous forages (Adhikari, Masters, Mainali, et al., 2021; Long et al., 2005), produce more forbes and browse that are associated with better habitat for deer (Fulbright & Ortega-Santos, 2013). However, the preference heterogeneity for three canopy cover types were non-significant indicting that deer hunters were indifferent of forest canopy cover in their hunting site leasing decision. Even though the chance of harvesting deer is higher in the location with greater forage abundance ($> 50\%$ ground cover), previous research suggest that forage availability was not associated with the harvest success but visibility and accessibility were (Lebel et al., 2012). Deer hunter's familiarity with their preferred hunting site and their hunting experience could play better role in identifying a location with better visibility and accessibility at a familiar site which could explain reason behind non-significance of canopy cover types in hunting site leasing decision.

5.4 Marginal Willingness to Pay from DCE of BWC

Deer hunters were willing to pay a higher lease fee per year per acre for a deer hunting site that has the potential to provide a better quality hunting experience. Deer hunters were willing to pay \$4.69 to observe ten deer per visit and \$2.95 to observe six deer per visit (Table 5). The WTPs for three levels of deer observed per visit were statistically significant at 99% confidence level. Hunter's marginal WTPs per year per acre was \$1.67 for a hunting site with deer sanctuary and food plots, \$0.45 for the site with open canopy cover, and \$0.12 for the site with moderate canopy cover. Deer sanctuaries with a food plot was statistically significant at a 90% significance level. The WTPs for one deer observed per visit was -\$7.64, sanctuaries without food plots was -\$0.71, no sanctuary with no food plots was -\$0.96, and closed canopy cover was -\$0.58 suggesting dis-utility of lower quality hunting site; deer hunters must be compensated by at least the WTP values to motivate them to hunt in sites with given characteristics.

<TABLE 5 HERE>

The WTP values increased with the increase in the perceived quality of deer hunting site. The WTP increased with the increase in the number of deer observed per visit and the dis-utility is very high for one deer observed per visit (Fig: 3). The WTP values were higher for open to moderate canopy covers compared to closed canopy cover. Our findings suggest that landowners benefit by actively managing their land to maintain quality deer habitat in their hunting site by maintaining food plots, deer sanctuary, and increasing deer population so hunters can observe 6 to 10 deer per visit. Landowners can increase their revenue by maintaining food plots and deer sanctuaries to attract more deer which in-turn provides a higher quality hunting experience. Landowners can increase their revenue by introducing other habitat management interventions that increases the number of deer observed per visit in addition to maintaining food plots and deer sanctuaries. The satisfaction with habitat management among deer hunters and the hunting success is associated with the number of deer observed during the hunting trips (Miller & Graefe, 2001). However, the WTPs for three canopy covers, the site lacking deer sanctuary and/or food plots, and one deer observed per visit were not significantly different than zero. The results also suggest that landowners have the flexibility to maintain diverse canopy covers without compromising deer habitat quality.

<FIGURE 3 HERE>

6. Discussion, Management Implications, and Limitations

The BWS results show that deer hunters first consider quality of hunting site followed by the cost of leasing the site in their choice decision to lease land for deer hunting. The highest price (\$16) to lease deer hunting site was not the least preferred characteristic but site characteristics that have may reduce the quality of their hunting experiences were ranked as two least preferred site characteristics. The hunting site characteristics which could provide high quality hunting experiences were chosen as the best two attributes from available choices of hunting site attributes. They further considered costs after the quality in their decision making by ranking "\$6 lease fee" as their third best and "\$16 lease fee" as third worst hunting site characteristics. Previous literature also reported that the number of deer observed and smaller membership dues have a positive impact on the deer hunting experience (Gruntorad et al., 2020; Hammitt et al., 1989; Mingie et al., 2017a) and hunter's satisfaction (Lebel et al., 2012; Miller & Graefe, 2001).

The results support findings of previous research that hunters carefully select site to increase harvest success (Hammitt et al., 1989). Deer hunters also preferred hunting sites that attract more deer and provide quality hunting experiences. Previous research have recommended hunting site managers to increase deer populations to increase hunting experience quality (Hammitt et al., 1989). Adding hunting site characteristics such as food plots and deer sanctuary which provide food and shelter to deer along with other habitat management interventions to attract more deer can increase probability of observing more deer which further provide better hunting experience (Hammitt et al., 1989; Lebel et al., 2012). Providing high quality hunting experience and better opportunities to observe large number of deer per visit might increase number of avid deer hunters who might be willing to pay high price for quality hunting experience. This will generate higher revenue for landowners while remaining competitive in the market by offering high quality hunting experience at low cost and sustainably manage their land by reinvesting revenue generated through leasing fee.

7. Policy Implications

Our findings have a few policy implications. First, deer hunters prioritize quality of deer hunting site over the cost while making leasing decision suggesting that actively managing the land to maintain quality habitat for deer hunting have benefit to landowners. Hunting sites with food plots and deer sanctuary along with other habitat management practices to increase deer population have potential to generate higher revenue which could further motivate landowners to consistently manage their land for a long term ensuring ecosystem sustainability. Actively managing ecosystem for deer hunting, generating continuous revenue stream by leasing hunting site, and reinvesting revenue to actively manage ecosystems could help in building sustainable and resilient ecosystems against changing climate.

Second, deer hunters lack knowledge about the importance of canopy cover in maintaining quality deer habitat because the result suggests that hunters were indifferent to three types of canopy covers. Our respondents were landowners and self-reported deer hunters implying that landowners lack knowledge about the importance of canopy cover in maintaining quality deer habitat. So, we suggest the need for outreach programs to educate deer hunters and landowners about ecological principles of deer habitat management and importance of incorporating habitat management principles to maintain quality deer habitat. Extension programs are important in fulfilling the knowledge and awareness gaps without which landowners who might be interested in managing their land for deer hunting may ignore maintaining suitable canopy covers. Ignoring canopy cover management in the long run may hamper sustainable land management and conservation effort. For example, the encroachment of invasive species and wildfires may increase additional management cost burden and degrade ecosystem benefits if active management is discontinued after actively managing property for a few years (Joshi et al., 2019; Kaur et al., 2020; Sharma Acharya et al., 2018; Starr et al., 2019).

Third, landowners have flexibility in maintaining canopy cover types they desire based on their land management objectives in the short run because deer hunter's WTP and choice preference for three canopy covers were close to zero and were indifferent to each other. This provides opportunity for landowners to diversify their land management objectives such as cattle, timber, biodiversity, and habitat for multiple wildlife to generate additional revenue throughout the year. Landowners leasing land for hunting have incentives to diversify their land to create a better societal values such as biodiversity conservation, landscape aesthetics, and habitat for endangered species (Lund & Jensen, 2017). Landowners who are interested in managing their land specializing in deer hunting may not have enough incentives to maintain canopy cover that provides excellent quality deer habitat based on deer habitat ecological principles (Fulbright & Ortega-Santos, 2013). While active management is essential for ecosystem sustainability, economic incentive could guide the ecosystem management activities. Thus, balancing economic benefit and ecosystem sustainability might be essential for long term ecosystem conservation and to create resilient ecosystem against changing climate.

8. Conclusion

We studied deer hunting as an economic activity to generate revenue for the sustainable management of degraded ecosystems. We ranked deer hunting site characteristics such as sanctuary, food plots, canopy covers, number of deer observed per visit, and lease fee based on hunter's preferential order. We further estimated hunter's WTP to lease a deer hunting site with these characteristics. We found that hunters prioritize quality hunting experience followed by the cost of leasing hunting sites. For example site attributes such as 10 deer observed per visit, sanctuary with food plots were ranked as most preferred characteristics followed by \$6 leasing fee and 6 deer observed per visit. Our finding suggests that deer hunters prefer hunting site characteristics such as food plots, a deer sanctuary, a larger number of deer observed per visit that have the potential to provide a high-quality deer hunting experience at a lower-cost. So, landowners benefit by improving hunting site by actively and sustainably managing their land to attract avid deer hunters who are willing to pay higher leasing fee for better quality hunting experience. Canopy covers were under-valued by deer hunters who may have had a positive effect on landowner's revenue in the short-term as it provides an opportunity to diversity their land management objectives. But it might have a negative impact on the long-term ecosystem management and ecosystem conservation effort because lack of management may result in a degraded ecosystem, increase in fuel load causing wildfire, and encroachment of invasive species. Our result suggests the need for an outreach program to educate landowners about the sustainable management of ecosystem for deer habitat based on ecological principles while addressing the need of diverse deer hunters and landonwers (Lund & Jensen, 2017). Our result further suggests finding a balance between economic benefit and ecosystem sustainability to create resilient ecosystem against changing climate (Browne et al., 2024).

One limitation of this research was combining deer sanctuary and food plot in a single attribute which limited our ability to tease out their independent effects in the hunting site leasing decision choices. However, our results suggest that landowners benefit by maintaining food plot and deer sanctuaries in their hunting site. Impact of food plots in quality deer habitat management is also well known in deer habitat management literature; as an example, the hedonic price had been estimated concerning hunting club dues (Mingie et al., 2017b). Yet, the relative importance of food plots compared to other crucial hunting site attributes in quality deer management and it's WTP was unclear; we fulfill this important knowledge gap. We further studied other hunting sites attributes mentioned above that are becoming increasingly important in QDM in relation to hunter's conditional and unconditional demands for actively and sustainably managed ecosystems. Deer sanctuary is relatively new concept in deer habitat management which was quantified for the first time in our research. Deer sanctuary being new concept, the general unfamiliarity among deer hunters might have contributed to the undervaluation of attribute level "deer sanctuary without food plot" which could be future research question to explore.

9. Bibs

References

Adhikari, A., Masters, R. E., Adams, H., Mainali, K. P., Zou, C. B., Joshi, O., & Will, R. E. (2021). Effects of climate variability and management on shortleaf pine radial growth across a forest-savanna continuum in a 34-year experiment. *Forest Ecology and Management*, *491*, 119125. https://doi.org/10.1016/j.foreco.2021.119125

Adhikari, A., Masters, R. E., Mainali, K. P., Zou, C. B., Joshi, O., & Will, R. E. (2021). Managment and climate vaiability effects on understory productivity of forest and savanna ecosystems in oklahoma, usa. *Ecosphere*, *12*(6), Article e03576. https://doi.org/10.1002/ecs2.3576

Aizaki, H., & Fogarty, J. (2019). An r package and tutorial for case 2 best–worst scaling. *Journal of Choice Modelling*, *32*, Article 100171. https://doi.org/10.1016/j.jocm.2019.100171

Arnett, E. B., & Southwick, R. (2015). Economic and social benefits of hunting in north america. *International Journal of Environmental Studies*, *72*(5), 734–745. https://doi.org/10.1080/00207233.2015.1033944

Bech, M., & Gyrd-Hansen, D. (2005). Effects coding in discrete choice experiments. *Health economics*, *14*(10), 1079–1083. https://doi.org/10.1002/hec.984

Boehm, L., Chakraborti, L., Melstrom, R. T., Piccolo, N., & Reeling, C. (2023). Measuring the economic value of deer hunting: Comparing estimates from survey and harvest check-in data. *Human Dimensions of Wildlife*, 1–17. https://doi.org/10.1080/10871209.2023.2283070

Brinkman, T. J., Chapin, T., Kofinas, G., & Person, D. K. (2009). Linking hunter knowledge with forest change to understand changing deer harvest opportunites in intensively logged landscapes. *Ecology and Society*, *14*(1).

Browne, G. R., Hürlimann, A. C., March, A., Bush, J., Warren-Myers, G., & Moosavi, S. (2024). Better policy to support climate change action in the built environment: A framework to analyse and design a policy portfolio. *Land Use Policy*, *145*, 107268. https://doi.org/10.1016/j.landusepol.2024.107268

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). John Wiley & Sons.

Ditchkoff, S. S., Welch Jr, E. R., Starry, W. R., Dinkines, W. C., Masters, R. E., & Lochmiller, R. L. (1997). Quality deer management at the mcalester army ammunition plant: A unique approach. *Proceedings of the annual conference of the Southeastern Association of Fish and Wildlife Agencies*, *51*(1), 389–399.

Dumbrell, N. P., Kragt, M. E., & Gibson, F. L. (2016). What carbon farming activities are farmers likely to adopt? a best–worst scaling survey. *Land Use Policy*, *54*, 29–37. https://doi.org/10.1016/j.landusepol.2016.02.002

Eliason, S. L. (2021). A place to hunt: Some observations on access to wildlife resources in the western united states. *Human Dimensions of Wildlife*, *26*(5), 461–471. https://doi.org/10.1080/10871209.2020.1839604

Feltrin, R. P., E., W. R., Meek, C. R., Masters, R. E., Waymire, J., & Wilson, D. S. (2016). Relationship between photosynthetically active radiation and understory productivity across a forest-savanna continuum. *Forest Ecology and Management*, *374*, 51–60. https://doi.org/10.1016/j.foreco.2016.04.049

Flynn, T. N., Louviere, J. J., Peters, T. J., & Coast, J. (2007). Best–worst scaling: What it can do for health care research and how to do it. *Journal of Health Economics*, *26*(1), 171–189. https://doi.org/10.1016/j.jhealeco.2006.04.002

Flynn, T. N., Louviere, J. J., Peters, T. J., & Coast, J. (2008). Estimating preferences for a dermatology consultation using best-worst scaling: Comparison of various methods of analysis. *BMC medical research methodology*, *8*, 1–12. https://doi.org/0.1186/1471-2288-8-76

Fulbright, T. E., & Ortega-Santos, J. A. (2013). *White-tailed deer habitat: Ecology and management on rangelands* (2nd ed.). Texas A&M University Press.

Grado, S. C., Hunt, K. M., & Whiteside, M. W. (2007). Economic impacts of white-tailed deer hunting in mississippi. *Proceedings of the Southeastern Association of Fish and Wildlife Agencies*, *61*, 59–67. Retrieved March 31, 2024, from https://www.mdwfp.com/media/3971/economicimpacts.pdf

Green, D., & Stowe Jr., J. P. (2008). Quality deer management: Ethical and social issues. *Human Dimensions of Wildlife*, 62–71. https://doi.org/10.1080/10871200009359195

Gruntorad, M. P., Lusk, J. J., Vrtiska, M. P., & Chizinski, C. J. (2020). Identifying factors influencing hunter satisfaction across hunting activities in nebraska. *Human Dimensions of Wildlife*, *25*(3), 215–231. https://doi.org/10.1080/10871209.2020.1722866

Haab, T. C., & McConnell, K. E. (2002). *Valuing environmental and natural resources: The econometrics of non-market valuation*. Edward Elgar Publishing.

Hammitt, W. E., McDonald, C. D., & P., N. (1989). Wildlife management: Managing the hunt versus the hunting experience. *Environmental Management*, *13*(4), 503–507. https://doi.org/10.1007/BF01867684

Hanberry, B. B., & Faison, E. K. (2023). Re-framing deer herbivory as a natural disturbance regime with ecological and socioeconomic outcomes in the eastern united states. *Science of the Total Environment*, *868*, 161669. https://doi.org/10.1016/j.scitotenv.2023.161669

Hensher, D. A. (2010). Hypothetical bias, choice experiments and willingness to pay. *transportation research part B: methodological*, *44*(6), 735–752. https://doi.org/10.1016/j.trb.2009.12.012

Hewitt, D. G. (2015). Hunters and the conservation and management of white-tailed deer (odocoileus virginianus). *International Journal of Environmental Studies*, *72*(5), 839–849. https://doi.org/10.1080/00207233.2015.1073473

Hole, A. R. (2007). Fitting mixed logit models by using maximum simulated likelihood. *The Stata Journal*, *7*(3), 388–401. https://doi.org/10.1177/1536867X0700700306

Huber, P. J. (1967). The behavior of maximum likelihood estimates under nonstandard conditions. In L. M. Le Cam & J. Neyman (Eds.), *Proceedings of the fifth berkeley symposium on mathematical statistics and probability* (pp. 221–233, Vol. 1). University of California Press.

Hussain, A., Munn, I. A., Hudson, D., & West, B. (2010). Attribute-based analysis of hunters' lease preferences. *Journal of Environmental Management*, *91*(12), 2565–2571. https://doi.org/10.1016/j.jenvman.2010.07.004

Hussain, A., Zhang, D., & Armstrong, J. B. (2004). Willingness to pay for hunting leases in alabama. *Southern Journal of Applied Forestry*, *28*(1), 21–27. https://doi.org/10.1093/sjaf/28.1.21

Johnson, A., Hale, P. E., Ford, W. M., Wentworth, J. M., French, J. R., Anderson, O. F., & Pullen, G. B. (1995). White-tailed deer foraging in relation to successional stage, overstory type and management of southern appalachian forests. *American Midland Naturalist*, *133*, 18–35. https://doi.org/10.2307/2426344

Johnson, E., Geissler, G., & Murray, D. (2010). *Oklahoma forest resource assessment, 2010: A comprehensive analysis of forest-related conditions, trends, threats and opportunities*. U.S. Department of Agriculture, Forest Service. Retrieved March 24, 2024, from https://ag.ok.gov/wp-content/uploads/2022/05/oklahoma_forest_resource_assessment_final_for_web-compressed.pdf

Joshi, O., Will, R. E., Zou, C. B., & Kharel, G. (2019). Sustaining cross-timbers forest resources: Current knowledge and future research needs. *Sustainability*, *11*(17), 4703. https://doi.org/10.3390/su11174703

Kaur, R., Joshi, O., & Will, R. E. (2020). The ecological and economic determinants of eastern redcedar (juniperus virginiana) encroachment in grassland and forested ecosystems: A case study from oklahoma. *Journal of environmental management*, *254*, 109815. https://doi.org/10.1016/j.jenvman.2019.109815

Knoche, S., & Lupi, F. (2007). Valuing deer hunting ecosystem services from farm landscapes. *Ecological economics*, *64*(2), 313–320. https://doi.org/10.1016/j.ecolecon.2007.07.023

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, *117*(5), 132–157.

Lancsar, E., & Savage, E. (2004). Deriving welfare measures from discrete choice experiments: Inconsistency between current methods and random utility and welfare theory. *Health economics*, *13*(9), 901–907. https://doi.org/10.1002/hec.870

Lebel, F., Dussault, C., Massé, A., & Côté, S. D. (2012). Influence of habitat features and hunter behavior on white-tailed deer harvest. *The Journal of wildlife management*, *76*(7), 1431–1440. https://doi.org/10.1002/jwmg.377

Long, E., Diefenbach, D., Rosenberry, C., Wallingford, B., & Grund, M. (2005). Forest cover influences dispersal distance of white-tailed deer. *Journal of Mannalogy*, *86*(3), 623–629. https://doi.org/10.2111/1551-5028(2005)58<128:LGAWDC>2.0.CO;2

Louviere, J. J., Flynn, T. N., & Marley, A. A. J. (2015). *Best-worst scaling: Theory, methods and applications* (1st ed.). Cambride University Press. https://doi.org/10.1017/CBO9781107337855

Lund, J. F., & Jensen, F. S. (2017). Is recreational hunting important for landscape multi-functionality? evidence from denmark. *Land Use Policy*, *61*, 389–397. https://doi.org/10.1016/j.landusepol.2016.10.048

Lusk, J. L., & Briggeman, B. C. (2009). Food values. *American Journal of Agricultural Economics*, *91*(1), 184–196. https://doi.org/10.1111/j.1467-8276.2008.01175.x

Marley, A. A. J., & Louviere, J. J. (2005). Some probabilistic models of best, worst, and best–worst choices. *Journal of Mathematical Psychology*, *49*, 464–480. https://doi.org/j.jmp.2005.05.003

Masters, R. E., Lochmiller, R. L., & Engle, D. M. (1993). Effect of timber harvest and prescribed fire on white-tailed deer forage production. *Wildlife Society Bulletin (1973-2006)*, *21*(4), 401–411. Retrieved January 20, 2023, from https://www.jstor.org/stable/3783411

McFadden, D. (1974). Conditional logit analysis of qualititave choice behavior. In P. Zarembka (Ed.), *Frontiers in econometrics.* (pp. 105–142). Academic Press.

McKinney, C. M., Masters, R. E., Adhikari, A., Mishra, B., Joshi, O., Zou, C. B., & Will, R. E. (2023). Forage quantity and protein concentration changes across a forest-savanna gradient with management implications for white-tailed deer. *Forest Ecology and Management*, *538*, 120987. https://doi.org/10.1016/j.foreco.2023.120987

McQueen, R. W. (2020). *Comparing natural vegetation and food plot preference in captive white-tailed deer* [Doctoral dissertation, Sam Houston State University]. Retrieved March 10, 2024, from https://hdl.handle.net/20.500.11875/2753

Meyerhoff, J., & Liebe, U. (2009). Status quo effect in choice experiments: Empirical evidence on attitudes and choice task complexity. *Land economics*, *85*(3), 515–528.

Miller, C. A., & Graefe, A. R. (2001). Effect of harvest success on hunter attitudes toward white-tailed deer management in pennsylvania. *Human Dimensions of Wildlife*, *6*(3), 189–203. https://doi.org/10.1080/108712001753461284

Mingie, J. C., Poudyal, N. C., Bowker, J., Mengak, M. T., & Siry, J. P. (2017a). Big game hunter preferences for hunting club attributes: A choice experiment. *Forest policy and economics*, *78*, 98–106. https://doi.org/10.1016/j.forpol.2017.01.013

Mingie, J. C., Poudyal, N. C., Bowker, J., Mengak, M. T., & Siry, J. P. (2017b). A hedonic analysis of big game hunting club dues in georgia, usa. *Human dimensions of wildlife*, *22*(2), 110–125. https://doi.org/10.1080/10871209.2017.1263767

Mingie, J. C., Poudyal, N. C., Bowker, J., Mengak, M. T., & Siry, J. P. (2019). Comparing the net benefit of forestland access for big-game hunting across landownership types in georgia, usa. *Forest Science*, *65*(2), 189–200. https://doi.org/10.1093/forsci/fxy045

Mishra, B., Joshi, O., Chapagain, B. P., Lambert, L. H., & Will, R. E. (2023). Intentions of landowners towards active management of ecosystem for deer habitat. *Environmental Management*, *72*(3), 529–539. https://doi.org/10.1007/s00267-023-01810-3

Mishra, B., Joshi, O., Masters, R. E., McKinney, C., Adhikari, A., Zou, C. B., & Will, R. E. (2023). Economic returns and the perceived obstacles to adopting active management in the forest-grassland transition ecoregion in south-central usa. *Journal of Environmental Management*, *343*, 118225. https://doi.org/j.jenvman.2023.118225

Murphy, B., Stewart, D., Demarais, S., & Bales, D. (2021). *Developing successful quality deer management cooperatives* (Report). National Deer Association. GA, USA. Retrieved March 10, 2024, from https://deerassociation.com/wp-content/uploads/2018/09/QDM-Cooperatives-Brochure.pdf

Navrud, S., & Grønvik Bråten, K. (2007). Consumers' preferences for green and brown electricity: A choice modelling approach. *Revue d'économie politique*, *117*(5), 795–811.

Pittman, H. T. (2019). Cost and forage production of food plots, prescribed fire, and roller chopping for northern bobwhite at babcock-webb wildlife management area, florida. *Journal of the Southeastern Association of Fish and Wildlife Agencies*, *6*, 117–122. Retrieved March 10, 2024, from https://seafwa.org/journal/2019/cost-and-forage-production-food-plots-prescribed-fire-and-roller-chopping-northern

Potoglou, D., Burge, P., Flynn, T., Netten, A., Malley, J., Forder, J., & Brazier, J. E. (2011). Best–worst scaling vs. discrete choice experiments: An empirical comparison using social care data. *Social science & medicine*, *72*(10), 1717–1727. https://doi.org/http://dx.doi.org/10.1016/j.socscimed.2011.03.027

Pruitt, H. P., Boley, B. B., D'Angelo, G. J., & McConnell, M. D. (2023). Impact of deer management cooperative implementation on white-tailed deer harvest behaviors. *Wildlife Society Bulletin*, *47*(1), e1409. https://doi.org/10.1002/wsb.1409

Rubino, E. C., Pienaar, E. F., & Soto, J. R. (2018). Structuring legal trade in rhino horn to incentivize the participation of south african private landowners. *Ecological Economics*, *154*, 306–316. https://doi.org/10.1016/j.ecolecon.2018.08.012

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*, 7–59. https://doi.org/10.1016/j.eap.2015.01.003

SAS Institute Inc. (2016). *Sas/qc 14.2 user guide*. SAS Institute Inc. Cary, NC, USA. Retrieved March 10, 2024, from https://documentation.sas.com/doc/en/qccdc/14.2/qcug/titlepage.htm

Severin, F., Schmidtke, J., Mühlbacher, A., & Rogowski, W. H. (2013). Eliciting preferences for priority setting in genetic testing: A pilot study comparing best-worst scaling and discrete-choice experiments. *European Journal of Human Genetics*, *21*(11), 1202–1208. https://doi.org/10.1038/ejhg.2013.36

Sharma Acharya, B., Kharel, G., Zou, C. B., Wilcox, B. P., & Halihan, T. (2018). Woody plant encroachment impacts on groundwater recharge: A review. *Water*, *10*(10), Article 1466. https://doi.org/10.3390/w10101466

Soto, J. R., Adams, D. C., & Escobedo, F. J. (2016). Landowner attitudes and willingness to accept compensation from forest carbon offsets: Application of best–worst choice modeling in florida usa. *Forest Policy and Economics*, *63*, 35–42. https://doi.org/10.1016/j.forpol.2015.12.004

Soto, J. R., Escobedo, F. J., Khachatryan, H., & Adams, D. C. (2018). Consumer demand for urban forest ecosystem services and disservices: Examining trade-offs using choice experiments and best-worst scaling. *Ecosystem services*, *29*, 31–39. https://doi.org/10.1016/j.ecoser.2017.11.009

Starr, M., Joshi, O., Will, R. E., & Zou, C. B. (2019). Perceptions regarding active management of the cross-timbers forest resources of oklahoma, texas, and kansas: A swot-anp analysis. *Land Use Policy*, *81*, 523–530. https://doi.org/10.1016/j.landusepol.2018.11.004

StataCorp. (2023). *Stata 18 user's guide*. StataCorp LLC. College Station, TX, Stata Press. Retrieved March 10, 2024, from https://www.stata.com/manuals/u.pdf

Train, K. (2009). *Discrete choice methods with simulation* (2nd ed.). Cambridge University Press.

U.S. Department of the Interior. (2023). *2022 national survey of fishing, hunting, and wildlife-associated recreation*. US Department of the Interior, Fish; Wildlfe Service. Retrieved March 29, 2024, from https://www.fws.gov/sites/default/files/documents/Final_2022-National-Survey_101223-accessible-single-page.pdf

Yarrow, G. (2009). *White-tailed deer biology and management* (Extension Report). Clemson University. SC, USA, Clemson Extension Service. Retrieved March 10, 2023, from https://deeradvisor.dnr.cornell.edu/sites/default/files/resources/White-tailed%20Deer%20Biology%20%26%20Management.pdf

10. Figures

Q: In your opinion, what are the best attribute and the worst attribute of this hunting site?

Best attribute of site (Check only one box)	Hunting site attributes	Worst attribute of site (Check only one box)
☐	Deer sanctuary with food plots	☐
☐	Closed canopy forest	☐
☐	10 deer observed/visit	☐
☐	$16 hunting lease/acre/year	☐

➔ Would you lease this hunting site? ☐ Yes ☐ No

Figure 1: Example choice set presented to respondents in the survey. Respondents were instructed to select a best-worst pair by selecting the best and the worst choices one at a time. Respondents were further instructed to decide whether they would pay given fee to lease the hunting site described by characteristics in the given choice set. Selecting "no" is an indication of respondent's unwilling to lease new hunting site and remain at "status quo" state. In this example, deer sanctuary with food plots and $16 hunting lease/acre/year is selected as the best-worst pair among 12 such possible pairs and chose to lease the hunting site at $16 lease fee/acre/year.

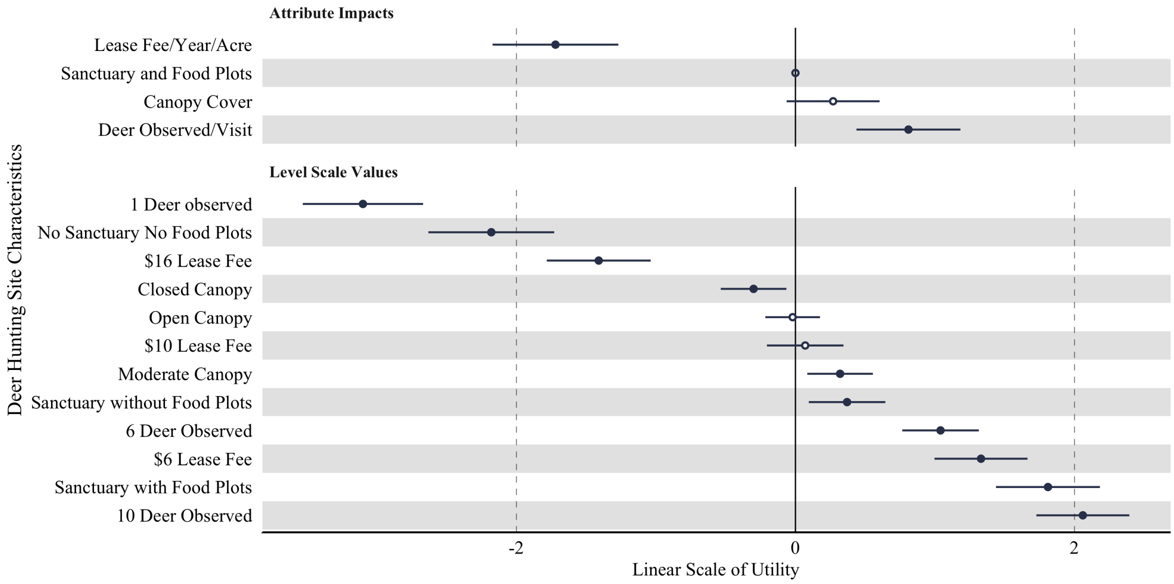

Figure 2: Attribute impacts and level scale values ranking of deer hunting site characteristics based on BWS regression coefficients. This graph shows ascending order of attribute and levels preferences among deer hunters. Statistically significant estimated coefficients for hunting site characteristics at 95% confidence were plotted as solid-filled points and non-significant coefficients were plotted as hollow points.

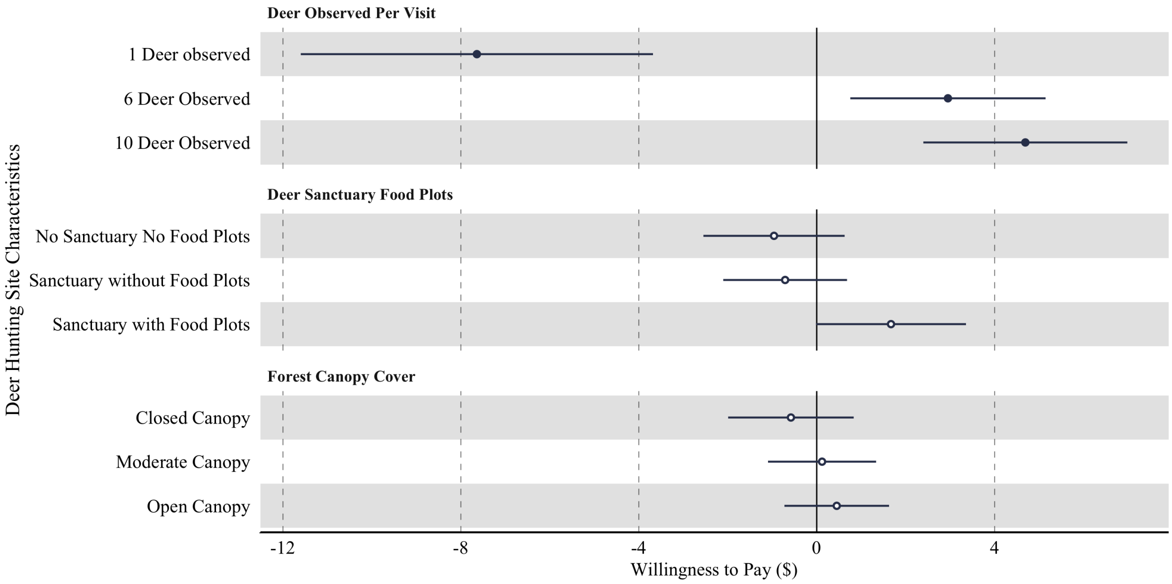

Figure 3: Marginal WTP for deer hunting site characteristics. This chart shows marginal WTP of three levels of all attributes in the increasing order of marginal WTP value. Statistically significant estimated coefficients for hunting site characteristics at 95% confidence were plotted as solid-filled points and non-significant coefficients were plotted as hollow points.

11. Tables

Table 1: Deer habitat characteristics used to design deer hunting sites (choice sets).

Attributes	Descriptions	Levels
Deer Sanctuary and Food Plots (SAFP)	Deer sanctuary is an area within a hunting site designed to attract more deer. This area is secure habitat for deer (Murphy et al., 2021). Food plots are maintained inside deer hunting site to grow forage and attract more deer.	(1) No sanctuary no food plots (NSNFP) (2) Sanctuary without food plots (SNFP) (3) Sanctuary with food plots (SFP)
Canopy Cover (CAN)	How open forest top cover (canopy) is and varies from closed canopy with little understory, moderate, and open canopy with abundant understory and sparse overstory vegetation.	(1) Open (OPEN) (2) Moderate (MOD) (3) Closed (CLS)
Deer (DR)	Total number of deer observed per visit.	(1) 1 Deer (DR1) (2) 6 Deer (DR6) (3) 10 Deer (DR10)
Leasing Fee (LF)	Land leasing fee for hunting deer ($/year/acre)	(1) $ 6 fee (LF6) (2) $10 fee (LF10) (3) $16 fee (LF16)

Table 2: Demographics of Deer Hunters

Demographic Variables	N	Mean	Std. Dev.	Median	Min	Max
Hunting experience (Years)	235	46.57	15.30	50	2	75
Primary game deer (Yes = 1)	233	0.74			0	1
Agricultural Cropland (Acres)	134	196.47	513.36	80	0	5,500
Rangeland (Acres)	224	475.01	529.19	282.50	0	3,000
Forests (Acres)	200	209.56	417.49	100	0	3,500
Land Leased (Yes = 1)[a]	235	0.12		1	0	1
Land Leased (Acres)[b]	38	1,733.21	5,152.33	320	0	30,000
Deer observed per visit	206	8.31	7.83	6	0	50
Travel distance (Miles)[c]	220	11.85	30.43	2	0	300
Alternative site (Miles)[d]	214	33.79	87.33	7.5	0	1,000
Age (Years)	234	63.54	12.07	65	21	92
Race[e]	231	1.49	1.08	1	1	5
White American (1) = 1	231	0.81			0	1
Native American (3) = 1	231	0.13			0	1
Others = 1	231	0.06			0	1
Gender (Female = 1)	227	0.05	0.22	0	0	1
primary job/occupation	228	2.78	2.01	2	1	6
Farmers/ranchers (1) = 1	228	0.48			0	1
Business owners (2) = 1	228	0.10			0	1
Manual labor jobs (3) = 1	228	0.04			0	1
Medical jobs (4) = 1	228	0.04			0	1
Retired (5) = 1	228	0.21			0	1
Other jobs (6) = 1	228	0.13			0	1
Highest education level	233	3.74	1.46		1	6
Less than high school (1) = 1	233	0.01			0	1
High school degree/GED (2) = 1	233	0.25			0	1
Some college education (3) = 1	233	0.21			0	1
Bachelor's degree (4) = 1	233	0.23			0	1
Associate degree (5) = 1	233	0.12			0	1
Graduate degree (6) = 1	233	0.19			0	1
Annual income before tax ($)	228	3.73	2.45	3	0	8
Below $25,000 (1)	228	0.15			0	1
$25,000 to $50,000 (2)	228	0.03			0	1
$50,001 to $75,000 (3)	228	0.13			0	1
$57001 to $100,000 (4)	228	0.21			0	1
$100,001 to $125,000 (5)	228	0.12			0	1

\$125,001 to \$150,000 (6)	228	0.09		0	1
\$150,001 to \$200,000 (7)	228	0.10		0	1
Above \$200,000 (8)	228	0.07		0	1
Prefer not to answer (0)	228	0.10		0	1

Notes:

a and b = Land leased for hunting.

c = One way travel distance to regular deer hunting site.

d = One way travel distance to alternative hunting site with about the same quality.

e = African American (2), others (4), and more than one races (5) were combined.

(#) = Number (#) assigned to each category in a variable. Eg. Annual income has eight levels as defined by numbers 1 to 8 given to eight income categories.

Table 3: Mixed logit model result estimates from BWS of BWC

Site Attributes	Coefficients (Std. Err.)	$p > \|z\|$	95% CI Lower, Upper
Means:			
Attribute Impacts:			
Canopy cover	0.27 (0.17)	0.116	-0.07, 0.61
Deer observed per visit	0.81 (0.19)	0.000	0.43, 1.19
Lease fee	-1.72 (0.23)	0.000	-2.16, -1.27
Deer sanctuary and food plots	0.00 (NA)	NA	NA
Level Scale Values:			
No sanctuary no food plots	-2.18 (0.23)	0.000	-2.62, -1.73
Sanctuary without Food Plots	0.37 (0.14)	0.007	0.10, 0.64
Sanctuary with Food plots	1.81 (0.19)	0.000	1.43, 2.19
Open canopy cover	-0.02 (0.10)	0.844	-0.22, 0.18
Moderate canopy cover	0.32 (0.12)	0.008	0.08, 0.55
Closed canopy cover	-0.30 (0.12)	0.014	-0.53, -0.06
1 deer observed per visit	-3.10 (0.22)	0.000	-3.53, -2.66
6 deer observed per visit	1.04 (0.14)	0.000	0.76, 1.32
10 deer observed per visit	2.06 (0.17)	0.000	1.73, 2.39
$6 lease fee	1.33 (0.17)	0.000	1.00, 1.67
$10 lease fee	0.07 (0.14)	0.600	-0.20, 0.35
$16 lease fee	-1.41 (0.19)	0.000	-1.78, -1.03
Standard Deviations:			
Attribute Impacts:			
Canopy cover	1.49 (0.22)	0.000	1.07, 1.91
Deer observed per visit	2.44 (0.24)	0.000	1.98, 2.90
Lease fee	3.01 (0.40)	0.000	2.23, 3.80
Level Scale Values:			
Sanctuary without food plots	1.31 (0.20)	0.000	0.92, 1.71
Sanctuary with food plots	2.17 (0.21)	0.000	1.76, 2.58
Moderate canopy cover	0.72 (0.18)	0.000	0.37, 1.07
Closed canopy cover	0.82 (0.20)	0.000	0.42, 1.21
6 deer observed per visit	1.01 (0.17)	0.000	0.67, 1.34
10 deer observed per visit	1.68 (0.23)	0.000	1.22, 2.13
$10 lease fee	0.50 (0.26)	0.055	-0.01, 1.02
$16 lease fee	1.84 (0.23)	0.000	1.38, 2.29
Log Likelihood =		-2487.63	
Number of Observations (N) =		16,884	
Wald $\chi^2_{(11)}$ =		356.65	
Prob > χ^2 =		0.000	

Note: Coefficients, Standard error (Std. Err.), and confidence intervals (CIs) for means and standard deviations were rounded to two decimal points.

Table 4: Mixed logit model result estimates from DCE of BWC

Site Attributes	Coefficients (Std. Err.)	$p > \|z\|$	95% CI Lower, Upper
Means:			
No sanctuary no food plots	-0.13 (0.10)	0.217	-0.32, 0.07
Sanctuary without food plots	-0.09 (0.09)	0.308	-0.27, 0.09
Sanctuary with food plots	0.22 (0.10)	0.033	0.02, 0.42
Open canopy cover	0.06 (0.08)	0.445	-0.09, 0.21
Moderate canopy cover	0.02 (0.08)	0.840	-0.14, 0.17
Closed canopy cover	-0.08 (0.09)	0.405	-0.25, 0.10
1 deer observed per visit	-1.00 (0.28)	0.000	-1.55, -0.44
6 deer observed per visit	0.38 (0.16)	0.013	0.08, 0.69
10 deer observed per visit	0.61 (0.16)	0.000	0.29, 0.93
Lease fee	-0.13 (0.02)	0.000	-0.17, -0.09
ASC	0.08 (0.24)	0.738	-0.39, 0.55
Standard Deviations:			
Sanctuary without food plots	0.02 (0.13)	0.872	-0.20, 0.24
Sanctuary with food plots	0.01 (0.04)	0.836	-0.07, 0.09
Moderate canopy cover	0.03 (0.08)	0.712	-0.12, 0.18
Closed canopy cover	0.05 (0.08)	0.521	-0.10, 0.21
6 deer observed per visit	0.47 (0.28)	0.091	-0.08, 1.02
10 deer observed per visit	0.44 (0.25)	0.076	-0.05, 0.93
Log Likelihood =		-515.38	
Number of Obs. (N) =		2,082	
Wald $\chi^2_{(11)}$ =		71.50	
Prob > χ^2 =		0.000	

Note: Coefficients, Std. Err., and CIs for means and standard deviations were rounded to two decimal points.

Table 5: Marginal WTPs from DCE of BWC

Site Attributes	Marginal WTP ($) (Std. Err.)	$p > \|z\|$	95% CI Lower, Upper
No sanctuary no food plots	-0.96 (0.81)	0.235	-2.53, 0.62
Sanctuary without food plots	-0.71 (0.71)	0.317	-2.11, 0.69
Sanctuary with food plots	1.67 (0.86)	0.053	-0.02, 3.36
Open canopy cover	0.45 (0.60)	0.453	-0.73, 1.64
Moderate canopy cover	0.12 (0.62)	0.841	-1.09, 1.34
Closed canopy cover	-0.58 (0.72)	0.421	-1.98, 0.83
1 deer observed per visit	-7.64 (2.02)	0.000	-11.59, -3.69
6 deer observed per visit	2.95 (1.12)	0.009	0.75, 5.14
10 deer observed per visit	4.69 (1.17)	0.000	2.41, 6.98

Note: Marginal WTPs, Std. Err., and CIs were rounded to two decimal points.