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Differential values associated with outdoor recreational access among the wildlife management area permit holders

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ABSTRACT

Wildlife management areas (WMAs) are important part of the public land system for forest-based recreation in the United States. Despite the growing literature on the economics of outdoor recreation, information about the economic benefit of visitors' access to WMAs, common to 35 states nationally, is lacking. WMAs differ from other public areas because of their unique focus on promoting conservation as well as consumptive and non-consumptive uses. With the data collected from a mixed-mode survey of WMA permit holders, this study estimated a travel cost model of WMA visitation with price interactions to quantify the economic value of WMA access and evaluate whether and how the value of access varies among recreation activities. The results indicate heterogeneity in the per trip value of access among activities, ranging annually from $95 for hunting to $37 for angling and $32 for other non-consumptive activities. When aggregated across the statewide system, the total net benefit that WMA permit holders enjoy from having access to WMAs was as high as $219 million annually, a $138 per acre in an annual net benefit to permit holders. In addition, personal characteristics, including party size and hunting as the primary purpose of visiting, as well as WMA characteristics, including camping, boat access, and wheelchair accessible blinds, had positive effects on WMA access demand. These findings offer new insights into understanding the public value of conservation areas and help justify investing public funds in establishing and maintaining WMAs.

1. Introduction

The supply of private forestlands for outdoor recreation is declining in the United States because of land-use change, landowners' concern for privacy, liability issues, etc. (Mozumder et al., 2007). As a result, the provision of recreation opportunities to a growing population will require understanding the demand for and value of recreation access at public lands. In the United States, wildlife management areas (WMAs) are one such type of public land that is managed by state wildlife agencies for conservation and recreational use. These areas differ from other public lands, such as state or national parks because of their unique focus on wildlife, location in rural areas, and the types of activities available to visitors. Moreover, in nearly all cases, access to WMAs requires the purchase of a permit, most often as an add-on to one's hunting or fishing license. Unlike other conservation areas that are primarily focused on non-consumptive activities, WMAs are purposely designed for promoting conservation of wildlife while allowing consumptive recreation activities (e.g., hunting, trapping, fishing) and high-impact activities (e.g., ATV riding). In the United States, state wildlife agencies in at least 35 states currently maintain thousands of WMAs, which are visited by millions of outdoor recreationists every year. As the majority of people do not own forestland, WMAs provide the public with an opportunity for hunting, trapping and other outdoor activities. Maintaining visitation at WMAs is critical for state wildlife agencies to continue their conservation efforts, offer forest-based recreation opportunities on publicly accessible areas – at rates often far below hunting leases, and help generate enough license revenue to fund conservation projects.

Demonstrating the public benefit of managing such areas requires understanding the economic value of benefits these areas provide to the user community. Considering that WMAs draw users that visit the site for a variety of consumptive and non-consumptive activities, it is also important to understand whether and how the value of access differs among recreation use types. This information allows managers to

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understand the anticipated burden or benefits (i.e., welfare impact) of any change in access among various user groups. Understanding the significance of various aspects of public land use can help managers in an efficient allocation of funds for the maintenance of facilities (Lorber et al., 2021). In many states, wildlife agencies manage wildlife management areas under a variety of landowner ownership. For example, in Tennessee, USA, about 54% of WMA acres are under federal ownership, 38% under state government ownership, and the other remaining under private or other types of ownership. This complexity in ownership of the WMA system across the state adds a significant challenge in estimating the use and economic benefit of these lands to the visitor community.

The literature on recreational use of public land has analyzed visitation demand and economic assessment in the context of national forests and national and state parks (Loomis et al., 2001; Heberling and Templeton, 2009; Sardana et al., 2016; Chapagain et al., 2021). However, because of the unique nature of WMAs discussed above, the conclusions drawn from empirical studies of other public lands do not help characterize WMAs' economic importance to their user community. Nonetheless, these studies provide a theoretical basis and methodological framework that can be applied in the context of WMAs. In addition, as WMAs offer a variety of consumptive (e.g., hunting, fishing) and non-consumptive (e.g., bird watching, hiking) activities, it is reasonable to expect heterogeneity in the value of recreation benefits. For example, Loomis et al. (2001) found that hikers obtained more benefits than bikers in the years following a forest fire in national forests in Colorado. Similarly, Englin and Moeltner (2004) compared the economic value of winter sports trips to skiers and snowboarders and found that skiers had a higher value per trip than snowboarders. Knoche and Lupi (2012) also compared user groups in their estimation of the economic value of public hunting lands and found that user groups differ in their demand for, and valuation of, their recreation trips. Mingie et al. (2019) compared the economic benefit of access to forestland for big game hunting in Georgia over land ownership types and found that leased and self-owned forestlands have a higher value to hunters than non-leased private lands and public forestlands.

Hussain et al. (2016) conducted one of the few studies on the economic value of WMAs, but their assessment was limited to hunting only. The per-trip value of WMA access for hunters may not apply to other types of visitors (e.g., anglers or ATV riders). Understanding the way different user groups value access to WMAs allows for a more accurate valuation of aggregate benefits. In addition, because site characteristics can affect different natural areas' outdoor recreation potential (De Valck et al., 2017), promoting public use and appreciation of WMAs as conservation areas requires an understanding of the factors that influence the demand for visitation to those areas. Accordingly, the objectives of this study were to assess and compare the economic value of access to recreation in WMAs among permitted user groups (i.e., hunters, anglers, and non-consumptive users) and evaluate whether and how visitors' demographics and WMA characteristics influence demand for WMA visitation. We hypothesize that the net benefit of WMA access to permit holders is significant, and varies among recreation user types. We also expect that the demand for WMA use and visitation is influenced by the characteristics of WMAs and their amenities available.

2. Methodology

2.1. Study area

This study was conducted in Tennessee, USA where the Tennessee Wildlife Resources Agency (TWRA) manages over 150 WMAs for public use and wildlife habitat protection. These WMAs vary in size from 53 to 625,000 acres. All WMAs in the state are available to the public for hunting, fishing, and trapping, but are also used for many other purposes, such as hiking, biking, boating, ATV/OHV riding, and more. The most popular activities include hunting, fishing, hiking, and ATV riding, but visitors use WMAs for many other activities, including camping, biking, attending special events such as bird festivals, wildflower festivals, etc. (Poudyal and Watkins, 2019). Recreation amenities and opportunities available at WMAs vary and include campsites, boat access, shooting ranges, festivals, and wheelchair-accessible hunting blinds. A recent survey of WMA permit holders found that visitors annually spend 3.44 million days for recreation at WMAs and hunting is the most popular activity with 63% of the visitors participating in big or small game hunting, followed by fishing (16%) (Poudyal and Watkins, 2019). The most popular non-consumptive activities were hiking (7%), ATV/OHV riding (5%), and wildlife watching (4%). This estimation was based on a probability-based survey of resident and non-resident permit holders through a stratified random sample representative of all types of licenses that included WMA user privilege.

While the total cost of establishment and maintenance of these WMAs are difficult to quantify and therefore currently unknown, TWRA annually spends $10.58 million in operation and maintenance of the WMAs across the state. While there are no widely known conflicts among the stakeholders about the management of WMAs in Tennessee to date, declining license revenue due to decreasing hunting participation (Tack et al., 2018) may eventually lead to budgetary constraints for the wildlife agency to effectively manage WMAs. In addition, as WMAs often take a substantial acreage of land from local tax rolls, local political resistance may gradually develop against future proposals of land acquisitions for new WMAs or expansions of existing WMAs. Even though studies have shown that the non-market benefit of access to public lands is generally much larger than their best alternative use (Joshi et al., 2017), the benefits these WMAs provide to the user population are still unknown. Hence, demonstrating the net economic benefit that WMA permit holders receive for accessing to WMA system is an important factor to inform economic and political decisions affecting the future support for WMAs.

2.2. Non-market valuation of recreation sites

Because recreational access to conservation areas possesses the characteristics of a non-market good (Kaffashi et al., 2015), estimating its value requires a non-market valuation approach. Economists have developed a variety of methods to characterize non-market goods and services' economic value. The travel cost method (TCM) is such a practice (Parsons, 2017) and has been used widely to quantify the economic value of access to public recreation areas (Loomis et al., 2001; Knoche and Lupi, 2012; Knoche and Lupi, 2013; Hussain et al., 2016; Joshi et al., 2017; Mingie et al., 2019). In the TCM, trip profile data (i.e., annual trips, distance traveled) collected from visitors are used to derive a "demand curve" relating to the number of visits and price of visits (i.e., cost per visit). From that demand curve, a measure of the value of access per trip, also known as consumer surplus (CS), is estimated. Here, CS represents the monetary value that the average visitor is willing to pay above and beyond their current expenditure to be able to access the

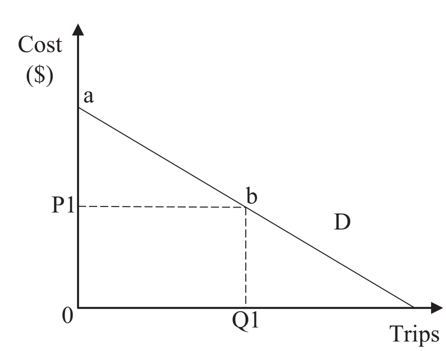

Fig. 1. Demand curve illustrating the relation between travel cost, trips to a recreation site, and per-trip value (i.e., consumer surplus) derived from site access.

WMA for their primary recreation use.

Fig. 1 illustrates the demand for trips, with the number of trips taken to a site shown on the abscissa and the cost per trip (travel cost) on the ordinate. Line D represents an individual's demand curve. At a cost of P_1 per trip, the individual would take Q_1 trips. The individual's total expenditure for Q_1 trips at cost P_1 is illustrated by the rectangular area P_1, b, Q_1, 0, and the willingness to pay (WTP) above cost, or CS is illustrated by the triangular area P_1, a, b. Once the average CS per trip is estimated, it can be combined with an estimate of total annual WMA trips to derive the total economic value of access to WMAs statewide.

A demand model developed with pooled data of recreation users can also be used to derive the CS relevant to specific segments of the sample. Doing so involves testing for differences in price response among alternative segments of the sample. Vaughan and Russell (1982) proposed a varying parameter travel cost with slope interaction terms allowing differential price response for alternative types of anglers. This model has been subsequently adapted for use by others to assess recreation demand by racial grouping (Bowker and Leeworthy, 1998), activity grouping (Hesseln et al., 2003), and site ownership grouping (Mingie et al., 2019).

2.3. Model specification

A conceptual model of WMA visitation demand (Parsons, 2017), was developed as shown in Eq. (1):

$$\text{Trips} = f(\text{C}, \text{S}, \text{A}, \text{D}) \tag{1}$$

in which C is the round-trip travel cost to a WMA, S is a vector of variables that capture the nature of the primary recreation activity at the WMA visited and considers substitute WMAs, A is a vector of variables related to characteristics of the WMA visited, and D is a vector of variables related to visitor demographic characteristics. Visitors' demographics are correlated with their tastes and preferences, which are expected to influence the demand and should be accounted for in a demand model. A complete list of the independent variables and their descriptions is presented in Table 1.

Data from several sites visited were pooled – a common practice in similar studies (e.g., Blaine et al., 2015; Mingie et al., 2019; Chapagain et al., 2021) to estimate a model of demand for visits to WMAs in Tennessee. Variables that distinguish the primary purpose for a site visit the respondents reported were created for hunting, fishing, and non-consumptive uses. Non-consumptive uses included target shooting, hiking, biking, bird/wildlife watching, camping, boating, ATV and horseback riding, picnicking, and other uses. Hunting as the primary purpose for a visit was the reference category and with each other use represented by a binary variable. These binary variables were in turn used with travel cost to create a travel cost interaction term, which if significant, allows estimation of separate price responses for each of the three activities.

Parsons (2017) suggested that to estimate travel costs fully, one must include the costs of time and money invested in taking the trip. AAA's 2019 Your Driving Costs publication (American Automobile Association, 2019) was used to estimate round-trip transportation costs of a four-wheel-drive crew cab pickup, the type of vehicle hunters and other outdoor recreationists use most commonly (Mingie et al., 2019). The operating cost for this category was \$0.24 per mile (American Automobile Association, 2019). The distance reported between the respondent's residence and the WMA visited was doubled to estimate round-trip travel distance. This distance was then multiplied by the \$0.24 per mile operating cost to compute the travel cost in the absence of time cost related to the wage rate.

To estimate travel time and costs, a speed of 45 miles per hour was used, which is an approximation of the average travel speed in Tennessee and is similar to approximations for previous travel cost studies in other states (Knoche and Lupi, 2012; Mingie et al., 2019). Given the sensitivity of income in surveys, many respondents tend to drop out of the survey, which yields a low response rate, and income data were not collected for this reason. Thus, we followed the common practice in travel cost modeling to use the median income data for the respondent's zip code as a reliable proxy of income (Heberling and Templeton, 2009; Knoche and Lupi, 2012; Blaine et al., 2015; Sardana et al., 2016). Two wage rates were used: no opportunity cost of time, and one-third of the wage rate (Knoche and Lupi, 2013; Hussain et al., 2016). The basic premise of assuming a fraction of the wage rate as the opportunity cost is that time involved in traveling also has some value. The rationale for assuming no opportunity cost of time is that people who travel for recreation purposes also derive benefits while traveling and therefore, do not necessarily incur an opportunity cost. It has also been argued that wage earners may not be able to easily substitute work and leisure time (Bowker and Leeworthy, 1998) and thus the wage rate, or some fraction thereof, is arbitrary and heterogeneous within a sample. Wage estimates were calculated by dividing the median household income for the respondent's zip code by a 2000-h work year (Sardana et al., 2016).

Other covariates considered in the model included traveling party size, substitute WMA, and a West Region dummy variable. Party size was the number of adults and children that usually accompanied the respondent on a typical WMA trip, plus the respondent him/herself (Sardana et al., 2016; Mingie et al., 2019). Substitute WMA accounted

Table 1
Definitions and descriptive statistics used in modeling demand for visiting Tennessee WMAs in 2018 ($n = 3526$).

Variable	Definition	Mean	SD
Trips	Number of trips taken in 2018 to a Tennessee WMA	7.14	11.25
Travel costs (\$) – no wage	Travel costs (\$) assuming no opportunity travel cost time	31.27	45.23
Travel costs (\$) – 0.33 wage	Travel costs (\$) assuming one-third of wage rate in opportunity travel cost time	58.11	85.67
Fishing	1 = primary purpose for WMA visit was fishing, 0 = otherwise	0.16	0.37
Non-consumptive	1 = primary purpose of WMA visit was a non-consumptive use, 0 = otherwise	0.21	0.41
Substitute WMA	1 = Respondents indicated that they would visit another WMA for their purpose had the WMA they visited been closed or unavailable, 0 = otherwise	0.27	0.44
Income	Median household income of respondent's home zip code	54,403.74	18,431.63
Age	Age of respondent	49.99	15.33
Party size	Number of people who usually accompany respondent on a trip to a WMA, plus the respondent	3.98	3.06
Education	Education level of respondent (1 = Some high school, 2 = high school diploma, GED, 3 = some college, 4 = associate degree, 5 = bachelor's degree, 6 = post-graduate degree)	3.40	1.45
Acres	Size of WMA in thousands of acres	42.26	76.35
Camping	1 = WMA allows camping, 0 = otherwise	0.21	0.41
ATV	1 = WMA allows ATV and OHV riding, 0 = otherwise	0.17	0.38
Boat access	1 = boating allowed in WMA, 0 = otherwise	0.48	0.50
Wheelchair access blind	1 = WMA offers wheelchair-accessible hunting blinds, 0 = otherwise	0.11	0.31
Shooting range	1 = WMA operates a public shooting range, 0 = otherwise	0.26	0.44
West Regions dummy	1 = WMA is located in TWRA management regions 1 or 2, 0 = otherwise	0.32	0.47
Miles to metro	Distance in miles from WMA to nearest Tennessee metro area	35.89	16.83

for whether the respondents indicated that they would have visited another WMA to participate in the same activity had the WMA they visited been unavailable. As Mingie et al. (2019) discussed, the use of substitute variables in travel cost modeling varies because of data and travel cost estimate limitations, and many studies have failed to account for substitutes at all. Because of WMAs' unique offerings, the binary variable served as an estimate of substitute site availability. The West Region dummy variable accounted for the fact that Western Tennessee offers more opportunities for migratory bird hunting and community fishing lakes. Although the income is also used to estimate travel costs, it should be considered independently in a travel cost model to control for income's effect on demand (Blaine et al., 2015).

The sociodemographic variables of age and education level were included to account for the respondents' varied individual tastes and preferences (Zawacki et al., 2000; Hesseln et al., 2003). The distance to one of eight metro regions in Tennessee was also included to capture the WMAs' proximity to population centers, which has been included in previous studies (Hussain et al., 2016; Mingie et al., 2019). This variable can help account for sites that may see more visitation and a higher demand because more potential visitors live in proximity to the WMA.

Count data models are used typically to model travel costs because the dependent variable, trips, is a non-negative integer. Poisson and negative binomial are two common modeling distributions used for the maximum likelihood estimation of TCM parameters. However, because of the variance in trip frequency, trip data did not meet the Poisson distribution assumption of equal mean and variance. The data were limited, to those who had taken at least one trip to a Tennessee WMA in 2018, i.e., zero truncated, because specific WMA visitation was unavailable for those permit holders reporting zero visits. Thus, a zero-truncated negative binomial model (TNB) was used to account for this limitation and the overdispersion in the data Englin and Moeltner, 2004; Hussain et al., 2016).

2.4. Economic estimation

CS per trip was estimated by taking the negative reciprocal of the travel cost coefficient (Creel and Loomis, 1990) using the following equation:

$$CS = \frac{1}{-(\beta_{tc})} \tag{2}$$

When the objective is to estimate the CS for participants in a particular activity, this equation can be combined with the slope interaction of the relevant segment (Loomis et al., 2001). Following the standard practice in travel cost modeling (Englin and Moeltner, 2004; Mingie et al., 2019), when travel cost interaction terms are used, per-trip CS associated with a particular user group (e.g., anglers) is estimated using the following formula:

$$CS = \frac{1}{-(\beta_{tc} + \beta_{tcXhunt})} \tag{3}$$

In which is the coefficient associated with the respective travel cost interaction term. This equation can be modified to estimate the CS associated with non-consumptive and other recreation use types. Confidence intervals around the CS point estimates were calculated using the Delta method (Englin and Moeltner, 2004). These equations provided a CS estimate for the group that visited the WMA. Per-person, per-trip CS estimates were then derived from these CS values by dividing the group surplus by the mean party size for each primary use type.

In addition, price elasticity measurements are a method used to determine the stability of demand as price changes. This is helpful when adjusting the fees for a permit to consume resources or examining the sensitivity of demand in relation to travel cost or any other cost associated with accessing the site (e.g., access fee) (De Frutos et al., 2019). Price elasticity estimates for count data models can be derived using the following formula (Bowker et al., 2007):

$$\text{Price elasticity} = \beta_{tc} \times TC \tag{4}$$

Price elasticity of demand estimates for a travel cost interaction term can be derived using the following formula (Bowker and Leeworthy, 1998):

$$\text{Price elasticity of user group} = (\beta_{tc} + \beta_{tcXangler}) \times TC \tag{5}$$

2.5. Data collection

Data for this study were collected through a mixed-mode survey of resident and non-resident WMA permit holders in Tennessee. We adopted WMA permit holders as our study population because participating in all consumptive (e.g., hunting, fishing, trapping) and high-impact activities (e.g. ATV riding, camping, boating) in WMAs requires users to have a WMA permit. Although it does not include some users who may access WMAs without a permit for allowed activities (e.g., hiking), this database of permit holders constitutes the best available population of potential WMA visitors. A sample of 10,000 sportspersons with privileges to access WMAs in Tennessee in 2018 was chosen from the pool of all WMA permit holders (166,010) using stratified random sampling to ensure representation of all license types (annual sportsman, lifetime, and annual licenses, WMA specific permits, and high impact conservation permits). The sample distribution across license categories and geographic regions was determined based upon the categories' size (Mingie et al., 2019).

Of the 10,000 individuals sampled, 4 questionnaires were returned because the recipient was deceased and 2 were deemed ineligible because the recipient was a TWRA employee who worked directly with WMAs in administration. This resulted in a final sample size of 9994, all of whom received a mail questionnaire using a modified Tailored Design Method (Dillman, 2009). Individuals who did not return the mail version and had an email address on file were contacted with a follow-up email with a link that allowed them to complete the survey online. Administration of the email survey followed the Dillman method with three subsequent reminder emails. A total of 3037 questionnaires (2272 from mail survey, 757 from online survey) was returned for a response rate of 30.4%, comparable to recent surveys of license holders in the region (Watkins et al., 2018; Meeks et al., 2021; Joshi et al., 2021).

3. Results

3.1. Characteristics of survey respondents

On average, the respondents were 50 years old and approximately 96% were male. The mean number of annual trips taken to WMAs was 7.14 (8.34 for hunters, 6.31 for anglers, 4.18 for nonconsumptive users) and the mean size of the travel party was 3.98 14 (3.66 for hunters, 3.71 for anglers, 5.13 for nonconsumptive users). Approximately 63% of the survey respondents reported that hunting was their primary purpose for visiting a WMA, 16% reported fishing as their primary purpose, and 21% reported a non-consumptive purpose. Following Englin and Moeltner, 2004 and Mingie et al., 2019, multiple WMA visits on an individual respondent's part were treated as individual responses. Even though the resulting dataset of WMA visitation had 3876 observations, 3526 were used for estimation due to independent variable item non-response.

3.2. Travel cost model results

Regression estimates for TCM models with and without an assumed opportunity cost of time are presented in Table 2. The fact that the log of the alpha value is greater than zero confirms the presence of over-dispersion in the data and justifies the use of the truncated negative binomial model over the Poisson. As expected, the coefficients on travel cost variables in both models (*Travel Costs – no wage, Travel Costs – 0.33*

Table 2
Results from zero-truncated negative binomial regression of WMA-trip demand based on alternative wage rate assumptions in opportunity travel cost time (n = 3526).

	None		One-third of the wage rate	
	Coeff.	*p*-value	Coeff.	*p*-value
Travel costs ($) – no wage	−0.006	<0.001	–	–
Travel costs ($) – 0.33 wage	–	–	−0.003	<0.001
Fishing	−0.183	0.040	−0.172	0.053
Fishing x TC	−0.007	<0.001	−0.004	<0.001
Non-consumptive	−0.763	<0.001	−0.744	<0.001
Non-consumptive x TC	−0.005	<0.001	−0.003	<0.001
Substitute WMA	−0.280	<0.001	−0.283	<0.001
Income	0.000	0.614	0.000	0.137
Age	−0.004	0.008	−0.005	0.007
Party size	0.035	<0.001	0.035	<0.001
Education	−0.073	<0.001	−0.078	<0.001
Acres	0.003	<0.001	0.003	<0.001
Camping	−0.264	0.016	−0.262	0.018
ATV	−0.033	0.697	−0.029	0.738
Boat access	0.211	<0.001	0.218	<0.001
Wheelchair access blind	0.166	0.070	0.159	0.084
Shooting range	−0.034	0.632	−0.048	0.512
West Regions dummy	−0.052	0.422	−0.048	0.458
Miles to metro	−0.002	0.114	−0.002	0.122

wage) were negative and significant. This indicates that the demand for Tennessee WMA visitation decreases as the travel cost from the respondent's residence to a WMA increases. A negative and significant coefficient on dummy variables that indicate that fishing or non-consumptive use (*Non-consumptive*) is the primary purpose of visits suggests that those who visited a WMA with the primary purpose of fishing or a non-consumptive use took fewer trips than those who visited to hunt. The interaction of these dummy variables with travel cost (*Non-consumptive x TC 0 and 0.33 wage)* were also negative and significant, suggesting that both the demand for, and the value of, visits differ significantly between the user groups. Similarly, those respondents who would consider visiting another WMA if the site they visit typically did not exist, or was closed, were likely to report fewer visits to this WMA (*Substitute WMA*) than their counterparts. Among personal demographic characteristics, while income had no significant effect on the annual number of trips to WMAs, age[1] and education had negative effects. Further, respondents with a larger party size reported more visits to WMAs. Among the characteristics of the WMAs, a larger WMA (*Acres*) was likely to be visited more compared to one with less acreage. Demand for WMAs with amenities for boat access and those with wheelchair-accessible blinds were higher than those without these amenities, and when camping was allowed in a WMA, that site was visited less. Of note, considering a small portion of WMAs with wheelchair-accessible blinds in our analysis, we believe that this variable may have captured some additional quality of site such as the presence of public duck blinds, quality of waterfowl hunting opportunity, which may have warranted the provision of such structures in those WMAs. In contrast to our expectation, the availability of other amenities, including the opportunity for ATV riding and a shooting range had no significant effect on the demand for visits to WMAs.

3.3. The economic value of access

Per-trip per-person CS estimates for the models based upon varying wage rate assumptions are presented in Table 3. CS estimates were higher when a fraction of the wage rate was assumed for the opportunity cost of time. The CS associated with hunting as the primary purpose of a WMA visit was highest. It was $43.40 per trip when no opportunity cost of time was assumed and $94.53 per trip when 0.33 of the wage rate was assumed in travel cost. The CSs associated with fishing or a non-consumptive use was lower, where CS values for angling were $19.11 per trip with no wage rate and $36.97 per trip with a wage rate, and non-consumptive activities had a CS of $16.75 per trip with no wage assumption and $31.56 per trip with a wage rate.

Aggregate[2] CS estimates were calculated for the statewide system of WMAs by multiplying the activity-specific individual CS per trip by the estimated total person-trips for the activity and then summing across the three activities. The aggregate CS for the activities with and without time cost were, respectively: hunting, $189.86 million and $87.17 million; fishing, $14.63 million and $7.57 million; and non-consumptive, $14.85 million and $7.88 million. Across activities these results indicate that WMA permit holders receive a total CS between $219.34 million and $102.62 million, depending on time cost assumptions.

The price elasticity of demand for WMA visitation is presented in Table 4. This measure indicates the extent to which the demand is responsive to the price or the cost of access. The elasticity value varied among the activity groups from −0.47 to −0.18 for no wage rate and −0.48 to −0.15 for the 0.33 wage rate assumption.

4. Discussion

The negative effect of the travel cost on trip demand is consistent with findings reported in previous studies related to public land visitation (Englin and Moeltner, 2004; Sardana et al., 2016; Mingie et al., 2019) and suggests that the demand for WMA visits decreases as the travel cost increases. The results of this study suggest that WMA permit holders in Tennessee enjoy a significant net benefit from visiting WMAs for recreation activities. Moreover, this value varies among user groups. The individual per-trip value of the recreation benefit from WMA access was highest for primary purpose hunters at $94.53 and $43.40, respectively, with and without time costs. This is consistent with Michigan public land hunters for whom Knoche and Lupi (2012) estimated individual consumer surplus for firearms and archery hunters of $82.92 and $88.71, respectively (included one-third of the wage rate). Other estimates of hunting value in the literature show a substantial variation. For example, a review of 177 estimates reported in 35 different studies across the United States found that the CS value for big game hunting per day ranged from $5 to $209 (Rosenberger and Loomis, 2001).

Table 3
Per-trip per-person consumer surplus estimates ($) from travel cost modeling results based upon alternative wage-rate assumption in opportunity travel cost time (95% confidence intervals).

Wage rate	Hunting	Fishing	Non-consumptive
None	$43.40	$19.11	$16.75
	($36.10, $53.82)	($14.19, $28.85)	($12.43, $25.26)
One-third	$94.53	$36.97	$31.56
	($75.89, $118.56)	($27.17, $53.79)	($23.25, $46.07)

[1] When a quadratic for age was added in the model, a positive coefficient on the age variable and a negative coefficient on the square of age variable were found, suggesting a non-linear effect of age on demand for visitation. However, the square term was removed from the model because 1- it was highly collinear with the age (VIF = 38) and the parameter estimate on travel coefficient and subsequent estimate of CS value was robust regardless of model specification.

[2] *Aggregate CS* = $\sum_{i=1,2,3} P.V.T_i.D_i.U_i.CS_i$ *where P is the total number of WMA permit holders in the year, V is the proportion that took at least one visit in the year,* T_i *is the proportion that reported participating in the ith activity (i = hunting, fishing, nonconsuptive),* D_i *is the average size of traveling party for the ith activity,* U_i *refers to the annual trip reported for the ith activity, and* CS_i *is the CS per-person per-trip estimated for the ith activity.*

Table 4
Price elasticity estimates from the travel cost model based upon alternative wage-rate assumptions in opportunity travel cost time.

Wage rates	Hunting	Fishing	Non-consumptive
None	−0.18	−0.43	−0.47
One-third	−0.16	−0.43	−0.48

For anglers, the CS per person per trip ranged from $19.11 with no wage rate assumption to $36.97 with the 0.33 wage rate. This is lower than that in Hwang et al. (2021), who found a CS of $56.68 for black crappie fishing trips in Florida with a one-third wage rate model. Our estimates are more similar to Rosenberger and Loomis (2001), who reported an average CS of $35.89 in a meta-analysis of US recreation fishing valuation studies.

Non-consumptive WMA users in the model yielded a CS of $16.75 for no wage rate and $31.56 for the 0.33 wage rate. This result is similar to estimates reported in previous studies. For example, Joshi et al. (2017) found a CS of $24.71 for general recreation trips to Georgia state parks at a 0.25 wage rate and Sardana et al. (2016) found that CS values at US national forests were between $49.73 and $85.76 at a 0.33 wage rate depending upon the site use type. The mean CS for general recreation trips was near the average value ($24.26) reported in Rosenberger and Loomis (2001) meta-analysis.

The aggregation of the individual-level benefits to the statewide population of WMA users shows that the total annual economic value of WMA access to visitors is $102.62 million when no opportunity cost of time is considered in travel cost and $219.34 million when one-third of the wage is considered as the opportunity cost of time involved in travel cost. Given the limitation (i.e., not accounting for those who access WMA without a license) of the study that estimated the total visitation to WMAs (Poudyal and Watkins, 2019), the aggregated value of the benefits presented here may be conservative estimates of the economic value of recreation benefits to WMA users in Tennessee. The TWRA manages over 1.59 million acres of WMAs and public hunting areas, which suggests that the approximate annual value of recreation access to WMA users on average is $65 per acre assuming no opportunity cost of time and $138 per acre assuming 0.33 of the wage rate as the opportunity cost of time. The respondents who used these areas for hunting accounted for a majority of the annual economic value, with an annual CS of $87.17 million and $189.86 million for no wage rate and the 0.33 wage rate, respectively. These values are comparatively higher than the benefit of access anglers and non-consumptive users enjoy, with an annual CS for anglers of $7.57 million and $14.63 million and a similar annual CS for non-consumptive users of $7.88 million and $14.85 million for no wage opportunity cost and the 0.33 wage rate, respectively. It should be noted that the economic value of access estimated in this study represents the benefit to the recreational users only, and does not include the existence value or option value that the general public, regardless of visitation, place on the resources in wildlife management areas. Moreover, the initial spending attributable to the WMA visitors can have secondary and induced effects on the local economy. That aspect of the economic impact WMAs provide to the local communities is quantified elsewhere (Poudyal et al., 2020). It should be noted that the net economic benefit of access as estimated in this study (i.e., benefit to WMA visitors) and the economic impacts of expenditures by visitors (e.g., contribution to the local economy) are rather two different metrics to characterize economic importance of WMAs and should not be added. The selection of appropriate metrics depends on the context of the decision or policymaking.

The results also indicated that the price responsiveness for WMA access differed among user groups. It is important to note that the hunters in both wage assumptions were the most price inelastic. Under the 0.33 wage rate, hunters had a price elasticity of −0.16, indicating that a 10% increase in travel cost for this group would result in a 1.6% decrease in visitation. The elasticity values estimated for hunters are similar to that Mingie et al. (2019) found for a one-fourth wage rate assumption of Georgia public land big game hunters (−0.24).

Respondents whose primary purpose was fishing had a price elasticity of −0.43, which would result in a 4.3% decrease in visits for the same 10% travel cost increase. These observations suggest that different user groups may respond differently to a change in the travel cost or other fee increase. The hunter group had more inelastic demand than the fishing and non-consumptive user groups for both wage rate assumptions. For example, a $10 increase in travel costs under the 0.33 wage rate assumption hunters implies the mean number of annual trips would decrease by only 0.2, from 8.3 days to 8.1 days. The more price-elastic anglers would reduce their average visits by 0.5, from 6.3 to 5.8 days, for the same $10 travel cost increase. This shows that the hunter user group may be less sensitive to a change in price or the travel cost to a WMA site. This relative insensitivity to price could be because hunters have fewer substitutes for land, both spatially and due to shorter seasons than other user groups. While most public lands allow hiking and wildlife watching, and most rivers and public lakes allow fishing, few public areas other than WMAs are large enough to be viable for hunting. This is particularly relevant for hunters who do not own land, cannot afford to lease, or want particular hunting experiences (e.g., duck blinds in WMAs). WMAs are one of the few places these hunters have available to use, and thus, even as the price increases, they are less likely to reduce their visits. As well, with price decreases, they are less likely to increase their visits than the other groups.

In addition to travel cost, the demographics of WMA users and characteristics of WMAs appear to autonomously affect the demand for WMA visits. The positive effect of WMA acreage suggests that a larger WMA may be more desirable than smaller ones. This is consistent with other findings in the literature indicating that public land users prefer larger areas (Hussain et al., 2016; Birdsong, 2019). Preference for larger areas may be attributable to the nature of outdoor recreation activities at WMAs. For example, larger areas can support bigger game populations for hunters and wildlife watchers. Moreover, both hunters and non-consumptive visitors generally prefer less crowding and more solitude and isolation in nature, something often rare in smaller WMAs with frequent encounters and resulting in inter and intra-group conflicts (Watkins and Poudyal, 2021).

A similar observation on boating access suggests that WMAs that provide boating opportunities may have a higher demand for visitation, indicating that this is a desirable amenity for respondents. The observed positive effect of party size on trip demand suggests that respondents who traveled in larger groups tended to visit more often. This differs from the results of previous studies that have found that larger party sizes have a negative influence on the number of annual trips (Bowker et al., 2007; Sardana et al., 2016; Chapagain et al., 2021). The effect of party size on the number of trips may depend upon the nature of the recreation activity. For example, compared to non-consumptive activities, such as picnicking, camping, etc., hunting may be more suitable for smaller party sizes.

The negative effects of education and age suggested that sportspersons who are more educated and older tend to make fewer trips to WMAs. This is consistent with previous findings of Bowker et al. (2007) and Mingie et al. (2019), who reported that older individuals and those with higher incomes made fewer recreation trips to hiking trails and big game hunting sites respectively, as well as Chapagain et al. (2021), who found similar results concerning age and wildlife viewing trips. Hussain et al. (2016) reported conflicting results, in which older WMA users visited more often in Alabama, although those with a higher income still reported fewer trips.

The proxy substitute variable, i.e., whether WMA users would visit another WMA should the one they visited not be available, had a negative influence on the model. Consistent with economic theory, this suggests that respondents who have no substitute WMA or are unwilling to readily substitute another site, have a higher demand for a given WMA. As it is important to control for substitutes in a typical demand model, this variable was included to account for whether a visitor would consider visiting other similar sites (Parsons, 2017). While public lands like WMAs may not be similar to private lands, it is possible that those who choose to recreate in WMAs may find that the recreation experience between WMA sites constitutes a reasonable substitute.

A few limitations of this study should be noted. The aggregate economic benefits estimated in this study apply only to those who hold Tennessee WMA permits. Moreover, as calculated, they apply only to those permit holders who visited at least one WMA over the course of a year. Sample proportions indicate about 63% of the 166 thousand holder population visited. Thus, the benefits we estimate are likely a lower bound, albeit a significant one. To fully capture the economic benefits of WMA access, an extensive on-site survey effort would be necessary, something well beyond the scope of this study. We also note that there is likely a segment of users who do not possess WMA permits. This can be divided into two groups, i.e., those who do not comply with WMA rules, either through choice or ignorance; and those who access areas and participate in activities not requiring a permit. Future studies could focus on developing methods and quantifying the benefit to the non-permit holders' portion of the WMA user population, but this would require some form of intercept sampling. We also note that this study does not attempt to estimate any passive or nonuse values attributable to the Tennessee WMA system.

The second limitation is that while the demand model of WMA visitation captured some characteristics of WMAs, other factors including expectations regarding recreation success (i.e. catch, harvest, or view) may also be important predictors of demand and choice of WMA. Future studies can expand our regression model by incorporating such data, which may be available through harvest surveys of big or small game hunters and creel surveys of anglers at the WMA level.

Although the estimates presented in this paper are based upon data collected in Tennessee, wildlife agencies and institutions (e.g., NGOs, conservation groups) elsewhere may use these estimates in a "benefit transfer" approach to approximate the economic value of the WMA system in their respective regions, particularly in the Southeastern US.

5. Conclusion

Quantifying the demand for, and economic value of, public land for outdoor recreation can inform and provide support for management and policy decisions. This study can help us understand better the economics of a particular type of public land (i.e., wildlife management areas), which have a unique mission both to promote conservation and consumptive outdoor recreation for the public. The findings from this research have several important implications. First, this study confirmed that WMA users place significant value on access to wildlife management areas for recreation. The access values presented in this study represent the potential welfare loss WMA user communities may experience if the WMAs are no longer available for recreational access. Further, the estimates of the net benefit of access can be used to characterize the public value of wildlife management areas and in benefit-cost analyses of new investments in wildlife management areas. As the new acquisition of land for conservation purposes may face political resistance at the local level, showing the economic benefit of recreational access may help demonstrate its significance to local user communities and secure support for WMA management.

Second, evidence from this study of WMA permit holders suggests that the economic value of WMA use differs among use types, as those who visit to participate in consumptive activities (hunting, fishing) place higher per trip value on access than those who visit for non-consumptive activities (hiking, biking, etc.). This implies that the welfare derived by the users of WMA depends on the type of activity they participated in. Accordingly, the welfare burden of the potential closure of WMAs may be relatively higher on consumptive recreationists such as hunters and anglers. This also implies that any attempt to characterize the economic importance of outdoor recreation should not rely on generic estimates of value for an average visitor. Because different visitors enjoy different amenities available at WMAs, activity-specific estimates of the per trip economic value of access will be useful to managers and practitioners interested in precise estimates of the value of ecosystem services public lands provide.

Third, as revealed by the price elasticity of demand estimated in this study, WMA visitation may be sensitive to the visitors' travel cost. A seemingly small increase (e.g., \$10) in travel cost, which could potentially be attributable to an increase in license, entrance, or parking fees, could have a significant effect. Across all user groups, this hypothetical \$10 increase in travel costs would result in a \$46.79–\$54.35 million annual loss in economic welfare for Tennessee WMA users. Policymakers should keep this potential reduction in visitor welfare in mind when considering changes in users' costs and fees. After all, equity, not economic efficiency, is the backbone of wildlife policies, and therefore, any fee-related decisions that may have implications on citizens' ability to access these areas should be considered carefully (Cothran et al., 2020).

Fourth, management agencies will benefit from understanding whether and how WMAs' varied characteristics and amenities can help maintain or increase their public value. For instance, adding acreage to existing WMAs may be considered when establishing new units, maintaining boating access and wheelchair access facilities, and providing opportunities for larger visitor groups (e.g., camping, picnicking facilities) are are likely to attract visitors.

Declaration of Competing Interest

The authors declare no conflict of interest regarding their work in this study.

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