When to go to a forest?

An analysis of the seasonal demand for forest visitation in Poland

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Abstract

While the demand for forest recreation has been a topic of interest in many studies, little attention has been paid to seasonal demand. The seasonal analysis is particularly interesting in this context since the temporal variation in visitation is driven in large part by nature. As is well known trip taking behavior varies across winter, spring, summer and fall. Each season brings different aspects of the forest into prominence. The model of seasonal demand developed in this analysis for forest recreation helps provide a richer understanding of the role seasonal weather patterns have on forest recreation demand.

Keywords: forest visitation, seasonal demand, travel cost method, Poisson distribution, exponential distribution

1. Introduction

Forests are an important natural environment and are often under the management of public agencies that seek to maximize multiple uses. Recreation benefits constitute a substantial part of the total economic value of forests. The valuation of forest recreation, either based on the state preference approach or on the reveled one, has a rich literature (see e.g. Brainard et al. (2001), Croitoru (2007), Lindhjem (2007), Scarpa et al. (2000), and Zandersen and Tol (2009)). While the demand for forest recreation and outdoor recreation benefits has been examined in many studies, little attention has been paid to the seasonal recreation demand so far.

Seasonal fluctuations in recreation and potential substitution between forest activities across seasons can clearly be important for developing multi-functional forest policies. Each forest environment provides some aspects that remain constant across seasons while also providing a rich change in attributes throughout the year. The mix of coniferous and deciduous forest, the species of deciduous trees and shrubs as well as the changes in wildlife all bring a rich texture to a forest. While the aggregate annual demand for a forest is well studied the way in which individuals allocate their demand across the year is not understood. This is becoming a more important consideration as forces such as climate change affect a broader spectrum of social benefits. Seasonal analysis of the recreational demand can play a prominent role in long term analyses of the impact of climate change on forest use evolve.

The primary focus of this paper is to examine the recreational forest demand by seasons using the travel cost approach (TC). The analysis is based on the data obtained from the on-site survey conducted in four Polish forests. Poland is a country where four distinct seasons can be observed. These seasons are characterized by significant differences in temperature and the rainfall levels[1]. The seasonal fluctuation has a strong influence on vegetation processes and therefore, for the visual aspect of forests and types of possible recreation activities.

[11]Temperatures in Poland vary widely according to seasons (approximately: in the spring 8C, in the summer 18C, in the autumn 8C, in the winter -2C). Average annual temperature in Poland ranges from 6C in the north-east to 8C in the south-west. The average annual rainfalls equal 600mm. 2/3 of them are usually in the summer time.

The remainder of the paper proceeds in the following way. The next section presents the survey design and data. The third section develops the theoretical models and econometric distributions used in the paper while in the fourth section the estimation results are discussed. The last section provides a summary of key findings, a discussion of limitations of the analysis and suggestions for future research.

2. Modeling Seasonal Forest Demand – Theoretical Considerations

The travel cost method is one of a few revealed preference methods applied to the non-market goods and services valuation. This method has been mainly employed for measuring benefits from outdoor recreation. It relies on the assumption that an individual who wants to visit a site and enjoy its service must incur the cost of overcoming the distance. The demand function for the recreation can be used to estimate benefits per a single visit or a recreation day derived by visitors.

The demand for recreation sites being modeled as a demand system was first done by Burt and Brewer in 1971. They developed the restrictions that would be consistent with a linear system approach. Some years later, Shaw began the empirical analysis of linear exponential demand for recreation sites. The linear exponential demand system is the form utilized by count models. For the purpose of our analysis we develop the recreational demand system, taking into account the differences in the quantity of trips between seasons.

The linear seasonal exponential demand system can be written as:

$$\ln(y_{is}) = \alpha_s - \sum_{j=s}^{4} \beta_s TC_{is} + \gamma_s m_i + \kappa_s x_i , \tag{1}$$

where y_{is} is quantity of trips by individual i in season s, α_s is the intercept associated with season s, TC_{is} are travel costs faced by individual i for trips to the site in season s, m_i is individual i's income, x_i is a vector of other shift parameters related to a set of visitor-specific variables. β_s, γ_s , and κ_s are parameters to be estimated.

These are four important constraints that the system of demands must obey:

- the intercepts must be positive,
- the demand curves must be downward sloping,
- there must be a single income effect in the system,
- the Marshalian cross price terms must be zero.

Although, the uncompensated cross-price effects are restricted to zero, the compensated cross-price effects can be calculated from the Slutsky equation (Englin et. al, 1998). For the semi-logarithmic demand functional form the Hicksian cross-price formula is as follows:

$$e_{ijk} = y_{ij} \frac{\partial y_{ik}}{\partial m_i} = \gamma \, y_{ik} \, y_{ij} \tag{2}$$

where s_{ijk} is the compensated substitution effect between season *j* and *k* for individual *i*, and the *y's* are quantities of the trips by season in the system by individual *i*. As Englin et al. (1998) point out the cross price effects will be symmetric (i.e. $s_{jk} = s_{kj}$) for individual *i*, but will not be identical across individuals who may have different seasonal visitation patterns. The estimation of compensated cross-price effects between seasons are going to be used to check if visits in different parts of a year can be treated as complementary or substitute goods.

3. Survey design and data

The empirical database used in this paper derives from a study founded by the Norwegian Financial Mechanism and the Polish Ministry of Science and Higher Education. The data were collected in an on-site survey conducted in fall 2009 by a professional polling agency. Interviews were carried out at four forest sites selected to be in close proximity (less than 30 km) to large urban areas and to have on average similar household incomes (see Table 1). The number of residents in these cities varies from 118,000 to 408,000. Additionally, the survey sites were chosen to represent different geographical regions of Poland with various forest covers ranging from 14% to 49% (on the national level the average forest cover is 29%). All four sites are public forests managed by the State Forests National Forest Holding which owns around 80% of Polish forests.

Forest visitors were polled along main paths, picnic areas and parking places randomly during day time and all days of the week. The target group was limited to people over the age of 18 who came to the forest only for recreation purposes. In all selected sites, interviewers approached 1345 people, among whom around 10% opted out and 1% resigned during the course of the survey. This resulted in 1128 interviews from all four sites. The main survey was preceded by a pilot study comprising 50 interviews and was evaluated by experts in the field of forestry.

The questionnaire consisted of two main components with the first one directed at revealing forest visits – the travel cost part and the second part directed at recording peoples' willingness to pay for two forest management programs – the contingent valuation part. The TC part aimed at estimating the recreational value per visit as well as to reveal forest visitation patterns. The CV part focused on valuing biodiversity and aesthetical aspects of the forest. In this study we are using data only from the TC part, since we want to investigate differences in forest visit demands depending on seasons. To avoid the problem of multi-destination trips, the data set was constrained to observations where respondents had stated that visiting the forest was the only or the most important reason for leaving their home that day. Additionally, we reduced our sample only to the one day trips. This provided 743 observations.

Information about the frequency of visits to the study sites was obtained from a two stage question format. Firstly, respondents were asked how often they visited the forest in the last 12 months. They could choose answers from the following options: "I am here for the first time", "A few times a year or more often", "Once a year" or "Once every few years". Secondly, those who responded "a few times a year or more often" were subsequently asked about the frequency of their trips in each season.

In the analyzed sample respondents stated that on average they have visited three forest sites in the last 12 months. For 60 % of them, the forest site at which they were interviewed was the most frequently visited forest[2]. Table 2 shows the results of visit frequency to this site.

Almost 68% of respondents stated they visited particular forests a few times per year or more often. In each season but winter, the highest share of recreationists claimed that on average they

[2] For particular forests this share varied from 47% to 74%. Respondents could choose the option "I do not know".

went to the forest once a month. 41% of respondents said they did not visit the forest during winter. Table 3 presents information about the trip and visit to the forest during which respondents were interviewed.

At all study sites, most respondents were visiting the forest accompanied by other people. The most popular transport mode for getting to the forest was a car. It was chosen by more than half of all respondents. One third of all respondents stated that they walked to the forest. Table 4 includes same socio-demographic characteristics of the interviewed samples.

4. Econometric Considerations

In this paper, we developed single-site travel cost models to estimate the seasonal forest recreation demand. For our analysis, we chose the count data model with a Poisson distribution and the model with a continuous distribution – the exponential one. On the one hand, count data models have recently become the standard approach to model recreational demands, because a TCM response variable concerning frequency of visits is discrete with a distribution that places probability mass at only nonnegative integer value. On the other hand, count distributions, by nature, are not developed for data collections that encompass the large number of trips per person to a site. Count models are especially useful if the response variable takes relatively few values and the counts are small (Cameron and Trivedi, 1998). If the visitation pattern is characterized by the high average number of trips models with non-negative continuous distributions can perform better (Englin and Nalle, 2005).

We decided to apply models with right-truncated distributions due to an answer format to the question concerning the forest frequency of trips applied in our survey. In both cases, those models were right-truncated for the number of trips set at 24. This was the highest number of trips we could assign to respondents' answers without the assumptions about their distribution of trips per each season[3].

[3] The choice set of answers to the question concerning the seasonal trips frequency is presented in the Table 2. The number 24 was assigned to the answer about seasonal visit frequency "on average twice per week".

Since the data set came from an on-site survey, in which interviews were carried out in the fall, for the recreational demand for this season, we applied models additionally adjusted for both left truncation at zero and endogenous stratification. The parameters of travel cost models were estimated using maximum likelihood. The seasonal demand function was used to estimate recreationalists' benefits from forest visits expressed in terms of consumer surplus. CS per trip was calculated as $1/\beta_1$, where β_1 is the parameter on the travel cost variable of the demand slope coefficient. The variance of CS per trip estimates can be calculated using the following formula (Englin and Shonkwiler, 1995):

$$\mathrm{Var}\left(\frac{1}{\beta_1}\right) = \frac{S^2}{\beta_1^4} + 2\frac{S^4}{\beta_1^6} \qquad (3)$$

Poisson and exponential distributions

The joint estimation method sum up all likelihood functions from the models to be estimated, treating all variables and all parameters jointly. The results are efficient among all estimators with normally distributed disturbances (Greene, 2003).

The Poisson model, adjusted for right-truncation at *a* (used to estimate the summer, the winter, and the spring recreational demand) can be written as:

$$P(Y_i \mid Y_i \le a) = \frac{\lambda^y}{y!}\left(\sum_{j=0}^{a}\frac{\lambda^j}{j!}\right)^{-1}, \quad y_i = 0,1,2,... \qquad (4)$$

where *Y* is the number of trips, the subscript *i* represents the individual, λ is the latent quantity demanded for a given season.

The Poisson model, adjusted for zero-truncation, endogenous stratification and right-truncated at *a* (used for the estimation the fall demand) can be represented as:

$$P(Y_i \mid 1 \le Y_i \le a) = \frac{\lambda_i^{\,y_i-1}}{(y_i-1)!}\left(\sum_{j=0}^{a}\frac{\lambda_i^{\,j}}{j!}\right)^{-1}, \quad y_i = 1,2,3,... \qquad (5)$$

For our Poisson models, the joint estimation likelihood function is:

$$L_P = \sum_{s=1}^{3}\sum_{i=1}^{n}\left[y_{si}\ln(\lambda_{si}) - \ln(y_{si}!) - \ln(\sum_{j=0}^{a}\frac{\lambda_{si}^{j}}{j!})\right] + \sum_{i=1}^{n}\left[(y_i - 1)\ln(\lambda_i) - \ln((y_i - 1)!) - \ln(\sum_{j=0}^{a}\frac{\lambda_i^{j}}{j!})\right] \quad (8)$$

The first part of the likelihood function for the *i*th observation refers to the right-truncated Poisson model for three seasons *s*: summer, winter and spring. The second part of the likelihood function is the zero-truncated, endogenous stratification and right-truncated Poisson for the fall.

The exponential model, corrected for right-truncation at *a*, can be expressed as:

$$P(Y_i \mid Y_i \le a) = \frac{\dfrac{e^{-\frac{y_i}{\lambda_i}}}{\lambda_i}}{(a + \lambda_i)(-e^{-\frac{a}{\lambda_i}}) + \lambda_i} \quad (6)$$

The exponential model, corrected for zero-truncation, endogenous stratification and right-truncation at *a*, can be represented as:

$$P(Y_i \mid 1 \le Y_i \le a) = \frac{\dfrac{\dfrac{y_i}{\lambda_i^{2}} e^{-\frac{y_i}{\lambda_i}}}{(\dfrac{1}{\lambda_i} + 1)e^{-\frac{1}{\lambda_i}}}}{(a + \lambda_i)(-e^{-\frac{a}{\lambda_i}}) + \lambda_i} \quad (7)$$

The joint estimation likelihood function for the exponential case is presented by:

$$L_E = \sum_{s=1}^{3}\sum_{i=1}^{n}\left[-y_{si}\cdot\frac{1}{\lambda_{si}} - \ln(\frac{1}{\lambda_{si}}) - \ln\left((a + \lambda_{si})(-e^{-\frac{a}{\lambda_i}}) + \lambda_{si}\right)\right] +$$

$$\sum_{i=1}^{n}\left[\ln(y_i) - 2\cdot\ln(\lambda_i) - y_i\ln(\frac{1}{\lambda_i}) - \ln(\frac{1}{\lambda_i} + 1) + \frac{1}{\lambda_i} - \ln\left((a + \lambda_i)(-e^{-\frac{a}{\lambda_i}}) + \lambda_i\right)\right] \quad (9)$$

Like in the previous case, the first part of the likelihood function is related to the right-truncated exponential model for summer, winter and spring and the next part of the likelihood function is the zero-truncated, endogenous stratification and right-truncated exponential for the fall.

5. Results

The dependent variable in our models was *y* defined as a person-trip. The explanatory variables were: a round-trip traveled distance (a proxy for travel cost), gender, age, education measured in years, net individual income in 1,000 PLN, and a dummy for analyzed forest sites. We estimated both models where a constraint of the same constant and distance for four seasons are imposed (the annual forest recreational demand) and models where this constraint is released (i.e. each season has its own demand). Apart from that, since the influence of income is often found to be weak in travel cost studies, we examined models with and without this explanatory variable. Additionally, in these models, we constrained the number of the site dummy variables only to two forests: Puszcza Bukowa and Lasy Zielonogorskie.

The selected models were labeled in the following manner: RTP I – the right-truncated Poisson model without a division per season, RTP II – the seasonal model including income among socio-demographics explanatory variables, RTP III – the seasonal model, without income and two dummies for forest sites. RTE refers to the right-truncated exponential model, with the same numbers notification as in RTP. Since the data collection was done onsite, in fall, for this season distributions were additionally truncated at zero.

Table 5 displays estimation results for analyzed models. For all six models, the constant terms are positive. They are significantly different from zero (at the 1% level) for all Poisson models except for winter. In the case of exponential models an intercept is significant only for summer. In all models, the round-trip distance coefficients are negative and significant at the 1% level, showing the downward sloping forest recreational demand curves as was expected. While we tried several socioeconomic variables in our analysis, only respondents' age appeared to be significant in all models with a positive sign suggesting that older people visit forests more often. Apart from that, there are no sign changes observed across models with different distributions, apart from the income parameter and the parameter for the Puszcza Koziencka. However, in all analyzed models these parameters were highly insignificant.

In two of three analyzed exponential models, the Puszcza Bukowa dummy variable was significant as well, suggesting that this forest is more visited than other investigated sites. This site is a part of a landscape park and a promotional forest complex. Compared to the other sites, Puszcza Bukowa has a very dense network of walking and biking paths and it is located on a hilly area with a few panoramic viewpoints of the city. Additionally, in this case, interviews were carried out near an arboretum. These factors could stand behind the significantly higher number of trips to Puszcza Bukowa than to the other analyzed forests.

The conducted likelihood ratio tests showed that the econometric specification that best fits the data among models with the Poisson distributions is the model III. Among exponential models, the likelihood ratio test did not resolve if the model II fits significantly better than the model III. The results of the likelihood ratio test are displayed in Table 6.

To compare the econometric specification between models with different distributions RTP II vs RTE II and RTP III vs RTE III) the Vuong non-nested selection test was used. This is a two-step procedure. In the first step, the sample variance of log likelihood ratio is compared to the critical value from a multivariate chi-squared distribution. If the calculated value of sample variance exceeds the multivariate chi-squared value, the null hypothesis that two conditional models are distinguishable is rejected. For the rejection case, Vuong developed a second step, a directional test, to indicate either that one model dominates the other or that neither model is preferred. For our data we found that both exponential models have a better fit than count models. The results of two pair-wise comparisons of model selections indicated a strong preference for the RTE II and the RTE III ($p<0.01$).

Consumer surplus estimates per season are reported in Table 7. Obtained estimation results from seasonal demand models indicate that respondents valued a single trip taken in the fall the most. In both the RTE II and the RTE III, CS counted in km equaled 44. Assuming that, the cost of traveled kilometer was 0.36 PLN[4], the consumer surplus per trip in monetary terms equaled 10.4 PLN, 15.8 PLN, 12.2 PLN, and 11.2 PLN respectively for summer, fall, winter and spring. The results of the CS in monetary terms are presented in Table 8.

Although the likelihood ratio test did not resolve if the RTR III model has a better fit than RTE II, for simplicity, in our further analysis we will concentrate only on parameters obtained from the exponential model without the income effect and a dummy for the Puszcza Kozienicka site. In both models estimated parameters are almost identical.

In Table 9 the results from the model RTE III are expanded to show an entire compensated demand system. The reported results include intercepts for all seasons, the own-price parameters, age and the Puszcza Bukowa shift parameters. Since the income effect for the chosen RTE III model was zero, the cross-priced effects between seasons equaled zero as well[5]. This result suggests that the number of trips to forests in different seasons is independent from each other.

7. Conclusions

Quantifying the seasonal demand and the associated welfare measures for forest recreation provides insight into the rhythm of the benefits that flow from forests. Understanding the rhythm grows in importance in at least two settings. One includes situations where changes in climate are anticipated. The long run implications of seasonal change cannot be effectively understood unless the components of annual demand are broken down into the effects of each season. A second setting where the seasonal demands are important to understand is when forests are intensively utilized year-round. In contrast to North America, European countries are densely populated leading to year-round utilization of forests at greater levels of intensity.
It is difficult to think about effective management in the absence of seasonal welfare and use projects.

[4] The assumed average consumption of fuel was 8 l/100km. The price of 95 octane unleaded petrol in the fall 2009 equaled around 4.3 PLN per liter.
[5] In the case of the RTE model II, the income parameter was close to zero and insignificant.

One of the key findings of the analysis was that there is considerable seasonal variation in the value of a trip to a forest. The most valuable trips are those taken in the fall. In this sample of Polish recreational visitors the fall trips include a wide range of foliage in fall colors (the Polish golden autumn) as well a favorite recreational activity; mushroom picking. Trips are least valued in the summer. This finding is in contrast to the conventional assumptions about North American forests which most valued in the summer. Winter and spring trips are about equally valued.

An interesting finding was that seasonal trips are separable. This result is driven by the econometric result that there were not any income effects in the seasonal demand system. This finding suggests that one can usefully investigate trips within any season without regard for potential Hicksian cross-price effects. An interesting avenue for future work is to investigate the robustness of this result. If it is a robust finding it would simplify many future empirical analyses, especially of European forests which exhibit rather different use patterns that are not well suited to the traditional North American based modeling approaches.

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Table 1. Selected forest sites

Name of the site	Conservation regime	Type of forest	Dominant species	Adjacent city	Forest cover in region	Location
Lasy Kozlowieckie	LP[6]	mixed, broadleaved	pine, sessile oak	Lublin (352,000)	14%	SE
Puszcza Kozienicka	LP, PA[7]	mixed	pine, sessile oak, oak	Radom (225,000)	25%	C
Puszcza Bukowa	LP, PA	broadleaved	beech, alder, hornbeam	Szczecin (408,000)	32%	NW
Lasy Zielonogorskie	None	coniferous, broadleaved	pine, ash, alder	Zielona Gora (118,000)	49%	SW

Note: The number of inhabitants is given in parentheses.. SE, C, NW, and SW refer to southeast, central, northwest, and southwest respectively.

[6] A landscape park is a protected area due to its unique environmental, historical, and cultural or landscape values in order to protect and popularize them in terms of sustainable development. They are established by local Polish governments. In 2008, there were 121 of these parks with an approximate area of 2.5 million hectares representing 8% of the Polish territory. Forests account for half of this area (GUS, 2009).

[7] Promotional areas (PA) are large compact forest areas characteristic for a given region, where a pro-ecological forest policy has been implemented.

Table 2. Stated frequency of visits to the forests where respondents were interviewed.

Answers concerning frequency of the forest visits	Shares (%)			
"I am here for the first time"	11.77			
"A few times a year or more often"	67.79			
	Summer	Fall	Winter	Spring
- "I do not go to the forest during this season at all"	4.80	0.00	**41.40**	15.00
- "Once at this season"	14.80	16.20	19.60	19.00
- "Once a month"	**24.80**	**30.20**	16.80	**23.20**
- "Once per two weeks"	17.80	18.40	8.20	14.20
- "Once per week"	17.60	17.60	7.60	13.00
- "On average twice per week",	8.00	9.80	3.20	6.40
- "Every day or almost every day"	11.20	6.80	2.20	6.20
- "I do not know/it is difficult to say"	1.00	1.00	1.00	3.00
"Once a year"	13.53			
"Once every a few years"	6.90			

Table 3. Summary statistics for the trip and visit to the selected sites in the day of an interview.

Forest	Lasy Kozlowieckie	Puszcza Kozienicka	Puszcza Bukowa	Lasy Zielonogorskie	All forests
Variable	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)
One-way distance traveled (km)	18 (12)	7 (10)	18 (18)	13 (19)	14 (15)
One-way travel time (min)	27 (14)	17 (16)	31 (26)	29 (27)	25 (22)
Time spend on site (min)	112 (57)	105 (67)	115 (81)	94 (50)	108 (67)
Purpose of the trip ("yes"=1):					
- Walking	0.48	0.61	0.63	0.59	0.58
- Watching nature	0.14	0.19	0.28	0.29	0.22
- Picking berries or mushrooms	0.69	0.44	0.31	0.40	0.46
- Doing sport activities	0.08	0.12	0.13	0.09	0.11
- Other	0.09	0.04	0.09	0.06	0.07

Table 4. Descriptive statistics of the respondents.

Forest	Lasy Kozlowieckie	Puszcza Kozienicka	Puszcza Bukowa	Lasy Zielonogorskie	All forests
Variable	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)
Sex (female=0; male=1)	0.54 (0.50)	0.46 (0.50)	0.39 (0.49)	0.36 (0.48)	0.45 (0.50)
Age	37.84 (12.85)	40.69 (17.56)	39.48 (15.42)	41.71 (17.60)	39.80 (15.93)
Education (in years)	13.10 (2.37)	11.75 (2.56)	12.75 (2.54)	13.26 (3.00)	12.62 (2.62)
Number of household members	3.00 (1.22)	3.49 (1.42)	2.91 (1.29)	2.71 (1.20)	3.08 (1.33)
Net household income	2965.47 (1482.25)	3002.63 (2160.09)	3915.32 (2358.26)	2788.89 (1818.64)	3224.88 (2054.94)
Net individual income	1652.24 (698.27)	1154.82 (981.08)	1514.95 (1242.79)	1445.06 (890.38)	1433.95 (1003.48)

Note: Household and individual income was calculated based on the middle points of picked income intervals by respondents.

Table 5. Estimation results

Variable	RTP			RTE		
	I	II	III	I	II	III
Constant	1.9252*** (0.5700)			1.0093* (0.5608)		
Round-way distance	-0.0418*** (0.0077)			-0.0263*** (0.0038)		
Summer						
Constant		2.3580*** (0.5968)	2.3070*** (0.4688)		1.8893*** (0.7132)	1.9220*** (0.5774)
Round-way distance		-0.0483*** (0.0106)	-0.0477*** (0.0098)		-0.0339*** (0.0044)	-0.0340*** (0.0044)
Autumn						
Constant		1.9083*** (0.6088)	1.8598*** (0.4767)		0.7286 (0.6871)	0.7558 (0.5488)
Round-way distance		-0.0340*** (0.0081)	-0.0335*** (0.0071)		-0.0227*** (0.0041)	-0.0229*** (0.0040)
Winter						
Constant		1.0328 (0.6445)	0.9840* (0.5074)		0.0992 (0.7036)	0.1228 (0.5730)
Round-way distance		-0.0424*** (0.0106)	-0.0418*** (0.0094)		-0.0292*** (0.0060)	-0.0292*** (0.0060)
Spring						
Constant		1.8787*** (0.6185)	1.8284*** (0.4836)		1.0684 (0.7081)	1.0972 (0.5541)
Round-way distance		-0.0497*** (0.0091)	-0.0490*** (0.0078)		-0.0322*** (0.0043)	-0.0323*** (0.0041)
Demographics						
Sex (male=1)	0.0784 (0.1453)	0.0818 (0.1591)	0.1045 (0.1623)	0.1445 (0.1649)	0.2013 (0.1630)	0.1965 (0.1636)
Age	0.0092* (0.0048)	0.0103* (0.0056)	0.0106* (0.0056)	0.0107** (0.0053)	0.0106* (0.0057)	0.0106* (0.0056)
Ne individual income (in 1000 PLN)	0.0447 (0.0586)	0.0490 (0.0690)		-0.0156 (0.0476)	-0.0088 (0.0537)	
Education (years)	0.0318 (0.0254)	0.0347 (0.0294)	0.0412 (0.0284)	0.0140 (0.0307)	0.0201 (0.0421)	0.0179 (0.0294)
Number of household members	-0.0645 (0.0576)	-0.0720 (0.0652)	-0.0771 (0.0659)	-0.0587 (0.0575)	-0.0385 (0.0523)	-0.0357 (0.0634)
Forests						
Puszcza Kozienicka	-0.0308 (0.3228)	-0.0283 (0.2730)		0.2185 (0.2157)	0.0321 (0.2207)	
Puszcza Bukowa	0.2391 (0.2714)	0.2656 (0.2516)	0.2989 (0.1834)	0.5120** (0.2164)	0.4934** (0.2141)	0.4731*** (0.1844)
Lasy Zielonogorskie	0.0740 (0.3063)	0.0855 (0.3033)	0.0982 (0.2573)	0.4703 (0.3546)	0.6268 (0.4157)	0.6223 (0.3983)
Log likelihood	-13729.7387	-12591.6663	-12605.7456	-7447.4463	-7077.0256	-7077.2969

Note: ***, **, * indicates significance at 1%, 5%, and 10% level, respectively. Heteroskedasticity-consistent (robust) standard errors are reported in parentheses.

Table 6. Likelihood ratio test results

Comparison	Test statistic	Significance
RTP I vs RTP II	2276.1442	Prob> $\chi^2_{0.1}(4)=7.779$
RTP III vs RTP II	28.1586	Prob> $\chi^2_{0.1}(1)=2.706$
RTE I vs RTE II	740.8414	Prob> $\chi^2_{0.1}(4)=7.779$
RTE III vs RTE II	0.5426	Prob> $\chi^2_{0.1}(1)=2.706$

Table 7. Consumer surplus [in km] for forest recreation

	RTP			RTE		
	I	II	III	I	II	III
CS per person per visit						
- Summer	23.93 (0.37)	20.70 (0.38)	20.97 (0.36)	38.00 (0.45)	**29.48** **(0.32)**	**29.39** **(0.31)**
- Fall	23.93 (0.37)	29.40 (0.59)	29.88 (0.54)	38.00 (0.45)	**43.97** **(0.67)**	**43.70** **(0.64)**
- Winter	23.93 (0.37)	23.58 (0.51)	23.93 (0.46)	38.00 (0.45)	**34.26** **(0.59)**	**34.27** **(0.59)**
- Spring	23.93 (0.37)	20.11 (0.31)	20.41 (0.27)	38.00 (0.45)	**31.04** **(0.34)**	**30.97** **(0.33)**

Standard errors are reported in parenthesis.

Table 8. Consumer surplus for forest recreation in monetary terms

CS per person per visit	PLN	Euro	USD
- Summer	10.44	2.43	3.73
- Fall	15.84	3.68	5.66
- Winter	12.24	2.85	4.37
- Spring	11.16	2.60	3.99

Note: Nominal exchange rate from the November 2009: 1 Euro=4.3 PLN, 1 USD=2.8 PLN

Table 9. Implied compensated demand parameters for the seasonal demand system (from the RTE III model)

Variable	Summer	Fall	Winter	Spring
Constant	1.9920	0.7558	0.1228	1.0972
Price coefficient				
Summer	-0.0340	0	0	0
Fall	0	-0.0229	0	0
Winter	0	0	-0.0292	0
Spring	0	0	0	-0.0323
Demand shifter				
Age	0.0106	0.0106	0.0106	0.0106
Puszcza Bukowa	0.4731	0.4731	0.4731	0.4731

Appendix

The derivation of distributions

The derivation of (2)

$$P(Y_i \mid Y_i \le a) = \frac{\dfrac{e^{-\lambda}\lambda^{y}}{y!}}{\Pr ob(Y_i \le a)}$$

$$= \frac{\dfrac{e^{-\lambda}\lambda^{y}}{y!}}{\dfrac{e^{-\lambda}\lambda^{0}}{0!} + \dfrac{e^{-\lambda}\lambda^{1}}{1!} + \dfrac{e^{-\lambda}\lambda^{2}}{2!} + \cdots + \dfrac{e^{-\lambda}\lambda^{a}}{a!}}$$

$$= \frac{\dfrac{e^{-\lambda}\lambda^{y}}{y!}}{e^{-\lambda}(1 + \lambda + \dfrac{\lambda^{2}}{2!} + \cdots + \dfrac{\lambda^{a}}{a!})}$$

$$= \frac{\lambda^{y}}{y!}\left(\sum_{j=0}^{a}\frac{\lambda^{j}}{j!}\right)^{-1}$$

The derivation of (3)

1) Correcting Poisson distribution for zero-truncation and endogenous stratification

$$P(Y_i | Y_i \ge 1) = \frac{e^{-\lambda}\lambda^{y}}{y!} * \frac{y}{\lambda} = \frac{e^{-\lambda}\lambda^{y-1}}{(y-1)!}$$

2) Correcting equation for right-truncation at a

$$P(Y_i \mid 1 \le Y_i \le a) = \frac{\dfrac{e^{-\lambda}\lambda^{y-1}}{(y-1)!}}{\Pr ob(Y_i \le a)} = \frac{\lambda^{y-1}}{(y-1)!}\left(\sum_{j=0}^{a}\frac{\lambda^{j}}{j!}\right)^{-1}$$

The derivation of (4)

$$P(Y_i \mid Y_i \le a) = \frac{\frac{e^{-\frac{y}{\lambda}}}{\lambda}}{\Pr ob(Y_i \le a)}$$

$$= \frac{\frac{e^{-\frac{y}{\lambda}}}{\lambda}}{\int_0^a \frac{e^{-\frac{y}{\lambda}}}{\lambda} dy}$$

The denominator of the above equation: $\int_0^a \frac{e^{-\frac{y}{\lambda}}}{\lambda} dy$

Where u=y du=dy

$$dv = \frac{1}{\lambda} e^{-\frac{y}{\lambda}} dy \qquad v = -e^{-\frac{y}{\lambda}}$$

$$\int_0^a \frac{e^{-\frac{y}{\lambda}}}{\lambda} dy = y(-e^{-\frac{y}{\lambda}})\Big]_0^a - \int_0^a (-e^{-\frac{y}{\lambda}})dy$$

$$= a(-e^{-\frac{a}{\lambda}}) - 0 - (\lambda \cdot e^{-\frac{y}{\lambda}})\Big]_0^a$$

$$= a(-e^{-\frac{a}{\lambda}}) - 0 - (\lambda \cdot e^{-\frac{a}{\lambda}} - \lambda)$$

$$= \quad (a + \lambda)(-e^{-\frac{a}{\lambda}}) + \lambda$$

Thus, $P(Y_i \mid Y_i \le a) = \dfrac{\frac{e^{-\frac{y}{\lambda}}}{\lambda}}{(a + \lambda)(-e^{-\frac{a}{\lambda}}) + \lambda}$

The derivation of (5)

1) Correcting Exponential distribution for zero-truncation and endogenous stratification

$$P(Y_i | Y_i \geq 1) = \frac{\frac{y}{\lambda^2} e^{-\frac{y}{\lambda}}}{(\frac{1}{\lambda} + 1) e^{-\frac{1}{\lambda}}}$$

2) Correcting above equation for right-truncation at *a*

$$P(Y_i \mid 1 \leq Y_i \leq a) = \frac{\frac{\frac{y}{\lambda^2} e^{-\frac{y}{\lambda}}}{(\frac{1}{\lambda} + 1) e^{-\frac{1}{\lambda}}}}{\Pr ob(Y_i \leq a)} = \frac{\frac{\frac{y}{\lambda^2} e^{-\frac{y}{\lambda}}}{(\frac{1}{\lambda} + 1) e^{-\frac{1}{\lambda}}}}{(a + \lambda)(-e^{-\frac{a}{\lambda}}) + \lambda}$$