Wildfires impact on the economic susceptibility of recreation activities: application in a Mediterranean protected area

Abstract

Development of many rural forestry areas depends strongly on tourism activities; therefore, it is critical to incorporate these activities in the decision-making process for the management and conservation efforts. Different from other market resources provided by forests, recreation activities provide benefits not only to forest owners but to all surrounding communities. Economic valuation of recreation activities requires using indirect valuation approaches like the travel cost method. Annual welfare estimates for the "Aracena y Picos de Aroche Natural Park" in southern Spain ranged from 25.30 € per recreationist for driving and travel time costs to 72.69 € per recreationist for these former costs plus associated incidental (food, lodging, etc.) costs. The annual value of this natural protected area was estimated at 3,656,609 € for the driving and travel time costs approach; and it was increased to 10,505,885.7 € for the total costs approach. Distributing the recreation welfare estimate proportionally is not reasonable as the visitation rate to different areas is different. Therefore, we use the individual recreational activities demand to distribute the estimated recreation value. Finally, we integrate the consumer surplus, the vegetation resilience and the potential fire behavior to estimate the fire recreation susceptibility. The fire susceptibility was increased by 58.25 million € from driving and travel time costs to total costs including incidental costs. Development of a socio-economic susceptibility framework using Geographic Information Systems provides an objective tool for budget allocation and prioritization of prevention activities and suppression actions during wildfires.

Key-words: economic impacts, recreation demand, travel cost method, fire behaviour, fire management

1. Introduction

Nowadays, the concept of forest is associated to the concept of multifunctionality (Constanza et al., 1997) creating the need to value not only the market (tangibles) resources, but also the environmental services (Johst et al., 2002) and the forest landscapes as a leisure and recreation resource (Kerkviet and Novell, 2000). Although it is important to recognize the difficulty in assigning monetary values to these resources (Christie et al. 2006), the indirect valuation methods gives us a good idea of its importance (Farber et al., 2002), and in some cases providing a large proportion of the ecosystem total value (Van Beukering 2003; Molina et al., 2016).

World population growth, and as a consequence, the need of new agriculture, industrial and municipal activities, has become a crucial problem because of the creation of environmental issues in different forms such as water pollution owing agricultural activities and rural life and industrial wastes o residues (Mo et al., 2018). Although a lot of rural regions have paid great efforts to the development of renewable energy, it is still needed to increase the reduction of CO_2 emission (Zhang et al., 2018). Therefore, forests in rural areas are globally undervalued and many of their benefits are not captured by marked values. Forests can help meet the growing demands for food and energy products as the world population increase. In the developed countries, the forests have become primarily supplies of wood and providers of numerous benefits as recreation areas for the urban population (FAO, 2016). About 20% of the European forests is protected for biodiversity and/or landscape. While the Nordic and Baltic countries focus on protection, central, north-western and southern European countries stress active management for biodiversity (European Commission, 2017). In these former rural areas, natural protected areas provide a wide range of benefits to the community, such as tangible assets, environmental services and landscape goods (Flemming and Cook, 2008). Landscape goods are associated with the increasing demand as holiday destinations which have acquired greater economic relevance (Riera, 2000; Ruiz et al., 2001; Navarrete and González, 2003; Molina et al., 2017).

Four standard methods could be used to value the potential recreation value of a natural area: the contingent valuation method (CVM) (Schläpfer et al., 2004; Fernández et al., 2014), the travel cost method (TCM) (Hesseln et al., 2003; Fleming and Cook, 2008; Zhang et al., 2015), the hedonic price method (HPM) (Hunt et al., 2005, Mueller et al., 2009), and stated choice experiment method (CE) (Louviere et al., 2000). There are concerns with of these methods, particularly the CVM, which according to critics does not measure the value of the good or service in itself but the feeling good sense of contributing to a good or just cause (Azqueta and Pérez, 1996, Hanley et al., 1998). A concern with the TCM is its impossibility to value the non-use value, e.g., knowing that an area exists even though it would never be visited (Azqueta and Pérez, 1996). TCM can only estimate use value of an environmental good and service, and as a consequence, it mainly provides estimates of value of natural protected areas and recreational facilities. In regard to use value, TCM has an advantage in respect to the other indirect methods due to the use of actual consumers in real visits (Ward and Beal, 2000). Although we have also used CVM to assess landscape resource (Molina et al., 2017), TCM could be a more objective method to explore the real value of tourism industry, and as a consequence, fires impacts across different sectors in the rural economy (hotel, restaurants, gas stations, nature activities companies, souvenir shops,...). In this approach, TCM has been used to estimate an economic value of a change or deterioration in environmental quality by asking the same tourists how many trips they would make in the case of fire occurrence.

The travel cost method (TCM) is one of the most frequently used approaches to estimating the use values of recreational sites. TCM is based on the assumption that the number of visits to a site decreases as the cost of visit increases. Under this assumption, the demand function could be estimated using the number of annual visits as long as it is possible to observe different costs per visit (Ward and Beal, 2000). TCM shows the willingness to pay based on consumption behavior of visitors. Recreation demand models evaluate welfares provided by a natural resource by combining information on respondent´s characteristics, visitation length, visitation frequency and travel costs, which include driving costs, the opportunity cost of travel time and incidental costs (Riera, 2000). The value of time can vary up to a factor of three depending on the approach used to calculate (Fezzi et al., 2014; Wolff, 2014). This paper contributes to the debate by including incidental costs for estimating consumer surplus and annual recreation value.

Geographic Information Systems (GIS) are potentially useful tools for public land managers. Some researchers have developed spatially-explicit representation of landscape values because the traditional analysis does not attempt to ascertain the specific value of each patch of the landscape (Baerenklau et al., 2010; Termansen et al., 2013). Spatially allocating the recreation value to the whole landscape plays an important role of benefit-cost analysis (Bateman et al., 1996). Furthermore, its use is ideal to manage spatial economic information of natural resources facilitating land planning optimization and budget allocation (Lant et al., 2005; Molina et al., 2016). One important application, which utilizes GIS-based economic modeling, is the evaluation of the efficiency of disturbance prevention investments and the effects of some treatments on disturbance susceptibility (Rodríguez y Silva and González-Cabán 2010).

Large wildfires are a societal problem affecting millions of hectares around the world, and causing huge economic impacts (Rodríguez y Silva and González-Cabán 2010). The impact of fire on natural resources and the associated consequences is difficult to estimate and arises on non-market values provides by forests (Constanza et al., 1997). Some studies (Hesseln et al., 2003; Sánchez et al., 2016) suggested that visitors´ demand is influenced by fire intensity and the location of burned area. This paper uses stated social preferences to investigate relationships between fire intensity and net value change on recreation value. The research uses a survey to collect stated preference data from visitors who answered about hypothetical wildfire scenarios (Molina et al., 2017, 2018). Losses or depreciation rates could be derived from stated choice data using a fire intensity levels classification (Zamora et al., 2010; Rodríguez y Silva et al., 2012).

The concept of economic susceptibility does not include burn probability as in the case of economic vulnerability (Molina et al., 2017). While this vulnerability assessment only considered landscape resource in use value, our susceptibility approach has included all tourism industry activities, such as pickniking, hiking, camping and scenery or landscape resource.

Although landscape attraction has played a keystone role in social preferences, it is not the sole determinant of holiday destinations. The aim of this research was to develop an objective tool to assess the recreation susceptibility of protected natural areas to fire by integrating economic valuation, vegetation resilience and potential fire behavior. We used TCM to estimate consumer surplus using two approaches: driving costs and travel time costs, and total costs. Stated social preferences and GIS allow us to carry out the spatial allocation of recreation value based on the visitors demand for each recreation activity and not only for landscape assessment. Incorporation of the vegetation resilience and fire behavior increases the capabilities of the method presented here moving it from being just an economic evaluation method to be able to estimate the economic impacts of wildfires.

2. Material and methods

Study area

The study area consists of 186,827 ha within the "Sierra de Aracena y Picos de Aroche Natural Park" in the Huelva province, southern Spain (Figure 1). The area is mainly characterized by a high landscape diversity highlighted by the scenic contrast between the *Quercus* and *Castanea* forests and the *Quercus* dehesas[1]. These former zones are exploited by traditional agroforestry systems with cereal cultivation and swine farming. In addition, natural park is an area of high socioeconomic value because they are home to the production of the highest quality of Iberian ham. Tourism is an important community benefit because of its landscape variety and many gastronomical, historical, floristic and geological attractive attributes. For example, the natural cave *Cuevas de Maravillas* receives over 140,000 visitors a year. These types of value added activities have sensitized rural communities to the benefits of tourism creating a source of wealth for the municipalities within the natural park boundaries.

Figure 1 around here

[1] Dehesa is a multifunctional and anthropogenic system and cultural landscape of southern and central Spain and Portugal. Used primarily for grazing they produce a variety of products including non-timber forest products such as swine production, mushrooms, cork, firewood and game resources.

The dominant climate has an Atlantic influence despite the warm summers induced by the Mediterranean climate. Annual precipitation in the study area ranges between 750 and 1,100 mm, and rarely occurring during the summer months. It is characterized by a continental Mediterranean climate with daytime summer temperature above 35ºC conductive to fire ignition and propagation. Province fire statistics show an average of 165.43 forest fires per year (2002-2017), which burn 2,090.04 ha of woodlands.

Study design

The fundamental premise of this TCM is that even though there might not be entrance fee to the recreation site in question, the driving costs, the travel time, and other associated or incidental costs (food, lodging, souvenirs, etc.) represent an implicit price of access to the site. In this sense, willingness to pay to visit the site could be estimated based on the number of visits that they make at different travel costs from the onsite questionnaire surveys. Furthermore, the sum of all or some of these costs (driving, travel time and incidental costs) is then used to estimate a demand function for the site, and ultimately, users' willingness to pay for visiting the site. Including all costs or only travel time and travel costs have a significant impact on the total demand curve for the site and consequently, in the user's willingness to pay or welfare derived by the user for visiting the site. Therefore, the decision to which costs include is an important consideration when using this methodology (Riera, 2000; Navarrete and González, 2003; Gürlük and Rehber, 2008). To err on the side of cautions, we estimated two consumer surplus, and as a consequence, two demand functions; one with only travel costs and travel time costs and the other with travel costs and travel time costs plus incidental expenses by each travel zone.

Driving costs can be estimated based on gasoline cost plus the costs (depreciation, insurance and maintenance) of using your personal vehicle of 0.19 €/km (Spanish Law Nº 462/2002 updated by public agencies). However, a lot of visitors usually go to the site using a public transport, and as a consequence, its average cost would increase to 1.33 €/km for bus and 1.08 €/km for minibus (Viajeros, 2016). Driving costs must be divided among the adult passengers per vehicle according to questionnaire responses. Although there are different approaches of the "value of time" (VOT) (Fezzi et al., 2014; Wolff, 2014), VOT is usually computed as one third of the average hourly salary of workers (15.7 €/h according to Eurostat official information to Spain). In Spain, some studies suggested a VOT between 4.90 €/h (updated by Ruíz et al., 2001) and 8 €/h (Gutiérrez, 2008). This study suggested a VOT of 6.45 €/h according to the average value of the previous Spanish studies and the 41.5% of the hourly salary of workers. The driving and time costs should be considered as per round-trip; those are the distance and time to and from the origin to the recreation site.

The demand function to estimate the value of the study area can be developed by estimating individual's demand functions per visitors or zonal demand functions (Fleming and Cook, 2008; Zhang et al., 2015). The zonal travel cost method is applied by collecting information on the number of visits from different distances identifying a set of zones surrounding the site (Ward and Beal, 2000). In this work, these zones were defined by concentric zones around the natural park. The number of zones is variable, but it is recommended to have at least 4 for development of the demand function. In this sense, we define four travel zones according to the previous experiences in Mediterranean protected areas (Ruiz et al., 2001; Navarrete and González, 2003): less than 75 km, 75-150 km, 150-250 km and more than 250 km. Once the visit length and visit frequency made from each zone was collected, it is necessary to calculate the visitation rates per 1,000 inhabitants in each zone. We could calculate the average round-trip distance and travel time to the site for each zone. Finally, demand function for visits was constructed using statistical analyst and calculating the consumer surplus, or the area under the curve.

Survey instrument

The onsite questionnaire surveys consisted of three parts. The first collected information on basic costs, for example, trip origin and destination, main reason for trip, transportation mode (car, bus, etc.), number of passengers and other socioeconomic characteristic (gender, age and income). We used the information on distance and mode of travel to calculate travel costs and travel time. The second part addresses information on incidental expenses on the trip such as food, lodging, souvenirs, etc., the length of the trip, if they intend to overnight and where, number of visits to the site in the past year. Some questions, such as transportation mode and car brand or where they would stay or eat were used to ascertain the validity of the income information provided. The last part is concerned with information on what type of recreation activities attracted them and how the presence of wildfires would affect their future visits to the site.

Once a draft questionnaire was developed, we conducted 3 focus groups to ensure understanding and comprehension of the material presented, language clarity and time it took to complete the survey. Prior to implementation, we also conducted a survey instrument pre-test with a total of 18 participants in the area. Results of this exercise showed no problems with understanding of the material or fatigue while completing the questionnaire. For economic and time reasons the sample was not completely random and the interviewer went to strategic sites like the natural cave "Gruta de Las Maravillas" or the natural park visitor´s center able to attract more recreationists. Random sampling in these areas was used to initially contact 706 visitors or questionnaire surveys. Implementation was done through an in-person interview process to facilitate survey comprehension and reduce loss of data (Mitchell and Carson, 1989) during the months of March and April (tourism peaks due to the mushroom harvesting and holy week).

Allocation of the recreation value

Knowing the consumer surplus (area under the demand function) and the proportion of visitors by concentric zones, we can derive the annual recreation value for the study site. The proportional allocation of the recreation value for the whole natural park could not be a good approach because the recreation value usually is increased by landscape quality (Zhang et al., 2015) and the presence of trails and picnic areas (Kaval and Loomis 2008; Baerenklau et al. 2010). In this sense, our approach provides a spatial allocation of forest recreation value using GIS in a similar way than for these former papers.

GIS permits identification of strategic places or areas in the natural park such as hiking trails, picnic areas, landscape lookouts, activity and recreation centers, climbing areas and hotels; and also game reserves, public woodlands, roads, 4 x 4 routes and villages. This fact allows us to estimate their added contribution to total value. The buffer zone of each recreational place is identified with the Viewshed Analysis tool using GIS. This tool scans the area surrounding each point using a Digital Elevation Model (pixel size of 10 m) at 1.7 m offset value without consideration to weather conditions (Baerenklau et al., 2010). The offset value is set at 1.7 m which is in relation to the average height of adult. However, wildfires are discernible at short-distance causing trail closures and welfare losses (Sánchez et al., 2016), but one can only observe the color contrast at long-distance. The landscape could be divided into four landscape bands: immediate foreground (< 50 m), foreground (50-200 m), middle ground (200-5,000 m) and background (> 5,000 m) according to the average tree height of the study area. Each pixel is characterized by its landscape band (immediate foreground, foreground, middle ground and background) using GIS. Delphi method (Molina, 2008) gives us social importance of these landscape bands around different observation points (photographs). Based on these results, we try to adjust an equation to relate forest fire impact and viewshed distance.

Finally, we must assign the number of people using each recreational place. The last section of the questionnaire asked visitors of "Aracena and Picos de Aroche Natural Park" to identify the main recreational reason for their visits (hunting, camping, scenery & natural attraction, mountain biking, horseback riding, clean air, fishing, picnicking, hiking, trekking, wildlife viewing, etc.), thus helping us determine the social preferences or recreational activity´s demand (0-100%). Recreational places where visitors can enjoy practicing the different recreational activities were identified using GIS. Viewshed analysis allowed us to identify the potential visual impact based on its location from each interesting point and recreational place. In this sense, the value of the potential visual impact for each pixel ranged from 0 (background band) to 1 (immediate foreground band). The recreation value was calculated for each pixel by the product between the potential visual impact and the percentage of total users that practices the activity (survey results). If there are more than one activity on a pixel, recreational activities demand was estimated as the sum of all activities from which each pixel can be seen. The recreation value was between 0 (not visible pixel) and 100 (pixel located in the immediate foreground and visible for all recreational activities). Statistical analysis allowed us to classify range value on different qualitative categories. We selected natural breaks classification method (Jenks method) in relation to other clustering methods due to the reduction of the variance within classes and the maximization of the variance among qualitative categories. Finally, a qualitative category was associated with each pixel, and as a consequence, total are for each qualitative category was known. Therefore, each category was converted to form of monetary units through proportional assignment of the annual economic assessment of “Aracena and Picos de Aroche Natural Park” according to its extend and important rating.

Socioeconomic susceptibility due to wildfires

Although low-intensity fires and sites partially affected could have positive effects on grasslands and fire-prone ecosystems (Sánchez et al., 2016), fire impacts on a landscape level in the study area were viewed as negative changes according to the experiences of the last severe wildfires and their economic impacts (Molina et al., 2017). As an exception of this consideration, we do not believe that very low-intensity fires have negative effects in recreational visit frequency. The valuation of economic impacts is computed as the interaction between the annual recreation value for each site (from the GIS allocation of TCM based on social preferences) and the vegetation resilience or recovery time to return to its original recreation activity as shown in Equation 1.

$$L = V\frac{(1+r)^n - 1}{r(1+r)^n} \qquad (1)$$

where "L" is the recreational impacts caused by the forest fires (€/ha), "V" is the annual recreation value (€/ha), "r" is the interest rate, and "n" is the vegetation resilience in years.

The vegetation resilience (number of years needed to restore pre-fire conditions) showed great spatial-temporal variability according to the dominant species and site conditions, such as topographical aspect and site quality (Román et al., 2013); however we could assign mean recovery periods from vegetation similar to burned one. These periods are estimated using historical wildfires restoration reports, field inventories and scientific studies (Gallegos et al., 2003; Molina, 2008; Román et al., 2013; Chuvieco et al., 2014). Total losses were based in the maximum Fire Intensity Level (FIL) despite it is not homogeneous in the fire-affected area.

After the maximum fire economic impact is calculated, the recreation depreciation or net value change (NVC) is computed based on the potential fire behavior. A set of informative layers was required by software that used to aid in fire behavior simulation. Fire simulators, such as Farsite (Finney, 2004) and Visual Cardin (Rodríguez y Silva et al., 2010) could be used to estimate fire-line intensity using weather information from local weather stations and GIS information to physiographic and fuel model characterization. Differences in fire intensity are closely related to the impact caused by the amount of heat emitted. Statistical analysis allowed us to classify fire intensity on different categories. Similar to the allocation of recreation value, we used Jenks classification method. Jenks optimization method seeks to reduce the variance within classes and maximize the variance between fire intensity classes.

NVC is determined by fire intensity, which is directly related to flame length (Alexander and Cruz, 2012). FILs are related to flame length intervals using a percentage depreciation or resource NVC ratio to estimate the economic vulnerability of each resource, similar to other studies (Zamora et al., 2010; Rodríguez y Silva et al., 2012; Molina et al., 2017). However, NVC of the recreation activities cannot be measured directly (visual observation or simple sampling inventories), having to resort to indirect measurements like that collected in the third section of the questionnaire. In this section, participants were asked about panoramic photos of different wildfire intensities (low, moderate, severe and very severe) that occurred in similar landscapes. Participants, based on pre-fire visit frequency, gave its opinion according to the new trip frequency they would take under the occurrence of different types of wildfires.

Results

Demand study

The sample size was representative at 95% confidence level and an error margin of ±5%. A total of 584 interviews were completed out of 706 that were scheduled for a completion rate of

82.72%. However, 91 questionnaires (15.58%) were discarded because the natural park was not the main focus of the trip causing consumer surplus bias (Maille and Mendelsohn, 1993; Gürlük and Rehber, 2008). The final sample size was 493 questionnaires based on single-destination trips. Despite the interviewer was instructed to maintain gender proportion, the sample had a larger proportion of males (57.36% male). In the age equilibrium, there was less than a 15% difference between the main visitor age group (< 35 years) and the second one (35-50 years). The zonal visitation rate was regressed against average zonal travel cost and the social variables (gender, age and income level).

There were significant differences in consumer surplus according to the consideration of incidental costs (Table 1). The most important factor in the total consumer surplus was incidental costs (Figure 2). In this sense, incidental costs ranged from 48.18% ("zone 3") to 74.91% ("zone 1") of the total costs. When we only used driving and travel time costs, the consumer surplus was highest at the "zone 4" (49.44 €). The maximum consumer surplus was also obtained for "zone 4" (213.2 €) although closely followed by "zone 3" (188.87 €), when we included incidental costs (Figure 2).

Figure 2 around here

The demand function was calculated using the mean consumer surplus ("x") and the prospective visitation rate ("y") to the Natural Park which was expressed as the number of visitors per 1,000 people in each travel zone (Table 1). The visitation rates per 1,000 inhabitants in each zone (ratio between the number of visitors and population per travel zone) were estimated using 2015 Spanish census (www.juntadeandalucia.es/institutodeestadisticaycartografia/sima/htm/sm21001.htm, consulted in 2016). These rates were increased in the closest zone (2.15 E-04 visitors/1000 inhabitants) in relation to the far-zone (2.47 E-07 visitors/1000 inhabitants). The results provided by different functional forms (linear, logarithmic, polynomial, power and exponential) are reported in Table 2. Observation of the R^2 value and significance level was considered in choosing the best functional form. Against these criteria, logarithmic form showed more reliable adjust than the rest of functional forms for both assumptions using only driving and travel time costs and using travel, time and incidental costs (R^2=0.97 and R^2=0.78, respectively).

Table 1 around here

Table 2 around here

The "Aracena y Picos de Aroche Natural Park" aggregated consumer surplus was computed as the area under the demand curve ranging between 25.30€ (±10.37€) for the driving and travel time costs assumption and 72.69€ (±56.39€) for the total costs assumption. Inserting the aggregated consumer surplus and multiplying by the number of annual visitors, we estimated the total economic value of the study area. Several regional and local organizations provided estimates between 100,000 and 170,000 annual visitors to the study area. We used an average number of annual visitors of 144,530 based on "Cueva de las Maravillas" dataset. The annual value of "Aracena y Picos de Aroche Natural Park" was estimated at 3,656,609 € for the driving and travel time costs approach; and it was increased to 10,505,885.7 € for the total costs approach.

Allocation of the recreation value

Once each interesting place was located, individual landscape bands for each viewshed were identified using GIS. It is estimated that about 82% of the total pixels are visible from some recreational places, such as picnic areas, roads, villages and public lands, showing a maximum search radius to 30 km. However, visible area on public domain lands covered only 56.37% of this former area. Forest fires were recognized at short distance, but they were visible as outline or shade contrast at middle-distance. At background band, questionnaire participants could not observe negative effects of forest fires. According to analytical results, we calculated the following approach to determine the weight of visual impact:

$$VI = 0.9971 * e^{-0.0001x} \quad (2)$$

where "VI" is the visual impact ranging from 0 (background) to 1 (immediate foreground), and "x" is the distance from interesting place (m)

The recreation value was allocated using the social preferences of the 493 valid questionnaires. Scenery & natural attraction (27.4%), picnicking (27.39%) and hiking (25.11%) were the highest value activities (Figure 3). Wildlife viewing (6.16%) and camping (3.88%) reached high values by social preferences. Hunting (2.97%) and horseback riding values (2.51%) were higher than other important recreational activities, such as trekking (1.6%) and mountain biking (1.37%). Lookouts, castles and other recreational places with more expansive viewsheds tend to have larger visual impacts, and thus contribute more to the total value of the natural park.

Figure 3 around here

From the qualitative recreation valuation (Jenks optimization method), we proceeded to assign economic recreational values for both the driving and travel time costs and the total costs approaches. For the first approach, annual recreational values ranged from 3.47 €/ha to 55.6 €/ha (Table 3) and mean value reached at 19.57 €/ha. For the total costs approach, values ranged from 9.98 €/ha to 159.72 €/ha and mean reached a maximum value of 56.23 €/ha (Table 3).

Table 3 around here

Socioeconomic susceptibility due to wildfires

In the study area, vegetation resilience varied from 1 year (grasslands without trees) to 60 years (mixed forests). As an example of Mediterranean shrublands resilience, a first group of colonizer species regenerates naturally after a fire (2-3 years); a second group can regenerate from sprouts and/or seeds present in mature plants (3-10 years); a third group could survive for long periods on the forest floor (5-10 years).

Fire simulator allowed us to characterize each terrain pixel according to its flame length and fire-line intensity. In this sense, fire behavior was represented by four fire intensity levels according to Jenks optimization method (Table 4): low-intensity (< 259.88 kW/m covering 0.1% of the total area), moderate intensity (454.3-6,037.95 kW/m covering 32.10% of the total area), high intensity (3,873.33-23,197.27 kW/m covering 65.55% of the total area) and very high intensity (> 17,1916.34 kW/m covering 2.35% of the total area). Mean depreciation rate was associated to each fire-line intensity based on the reduction of trip frequency obtained in the social preferences from the last part of the questionnaire. Depreciation rate was significantly increased in relation to fire-line intensity (Table 4). In this sense, recreation impact was significant reduced in moderate fire intensity in relation to high and very high fires. The rate was very huge in "very high intensity" level (almost 92% of the recreation value), although distantly followed by "high intensity" level (almost 66.5% of the recreation value).

We calculated the losses caused by a potential fire based on the interaction between the annual recreation value (using GIS and social preferences) and the vegetation resilience (Equation 1). Then, considering the relationship between potential fire-line intensity and depreciation rate (Table 4), the economic susceptibility of the "Aracena y Picos de Aroche Natural Park" was estimated at 31,210,807 € for the driving and travel time costs approach and at 89,460,204 € for the total costs.

Table 4 around here

Discussion

The application of the travel cost method (TCM) has produced a range of estimates for "Aracena y Picos de Aroche Natural Park". Although the sampling was not completely random, the interviews procedure in strategic places is rigorous. The sampling frame is representative at 95% confidence level and a ±5% of error similar to other studies valuating natural resources (Ruíz et al., 2001; Navarrete and González, 2003; Fleming and Cook, 2008). The completion rate (82.72%) is higher in our research than in other studies (Loomis and González-Cabán, 1998). The multi-destination or multipurpose visits and high visitation congestion days are not included in the consumer surplus estimation because they could cause biased values (Loomis, 2006; Timmins and Murdock, 2007). Although gender ($t = -0.807$, $p > 0.05$) was no found be significant, similar to other studies (Kerkviet and Novell, 2000; Fleming and Cook, 2008), significant differences were found based on age intervals and income levels (Figure 4). While the maximum consumer surplus was identified by visitors with 45-50 years, the income level was directly related to higher consumer surplus (Figure 4). The most influential social variable in consumer surplus of the "Sierra de Aracena y Picos de Aroche Natural Park" was income level.

Figure 4 around here

This study used four concentric travel zones (zonal travel cost method) around the Natural Park to derive the recreation demand function in order to handle visitors heterogeneity to the site (Riera, 2000; Fleming and Cook, 2008; Hilger and Englin, 2009). The use of GIS to characterized the visitor by zones of origin according to road network increases information reliability (Bateman et al., 1996; Brainard, 1999). The majority of the Mediterranean TCM studies have demonstrated that there is an inverse relationship between consumer surplus and the visitation rates (Riera, 2000; Ruiz et al., 2001; Navarrete and González, 2003). In our case, it is interesting to note that for the total costs (including additional costs, such as food and lodging) the consumer surplus estimates for visitors from fourth zone (> 250 km) is only slightly larger than that from third zone (150-250 km). This could be explained by the fact that visitors coming from these travel zones use tour agencies to organize their foods and lodgings resulting in a consumer surplus lower than those coming from zone three. As an example, some travel agencies offer cheap weekend packages for 187 € per person from Madrid (506 km to study area) and 90 € per person from Málaga (294 km to study area). Therefore, the visitation length did not obtain significant differences according to the two most remote areas (3.6 and 3.85 days, respectively). We tested several functional forms obtained for the driving and time costs demand rather than for the total costs demand showing the correlation coefficient and significance level. In our study, logarithmic form provided the most reliable predictor of consumer surplus similar to other recreation demand studies (Riera, 2000; Ruíz et al., 2001; Fleming and Cook, 2008), although closely followed by second degree polynomial form, mainly in driving and travel time costs approach.

We try to build a consumer surplus dataset with the most objective conditions as possible. Our first step is the calculation of driving costs with some technical limitations. This approach only works with traffic and road information at times of perfect sky conditions without precipitation, fog and minimum temperature considerations (Wolff, 2014). Then, we assume that visitors have a feel for the efficient distribution of the travel time and driving costs required by each possible route. Some recent studies have indicated that 3/4 of the wage rate provide a reliable approximation of the value of travel time (VOT) for recreation trips, and as a consequence, the commonly implemented assumption of 1/3 of the wage rate obtains biased results (Fezzi et al., 2014; Wolff, 2014). According to this new point of view, regional and national TCM applications would have generated a significantly lower consumer surplus. On the other hand, the assumption of 3/4 of the wage rate could inflate VOT values according to the specific conditions of Spain, such as the high proportion of partial jobs and unemployed respondents. In this sense, we believe that the best approach of the true VOT is provided by adopting a mean value of the previous Spanish studies (Ruíz et al., 2001; Gutiérrez, 2008) and a conservative assumption of the wage rate (41.5%) according to Eurostat official information to Spain.

The Mediterranean landscape is characterized for the relevance of the forestry system externalities, mainly in protected natural areas (Molina et al., 2016). However, welfare estimates derived via recreation demand models are highly sensitive to the assumed costs. The debate on whether to use only the driving and travel time costs versus total costs is still open (Azqueta, 1996). In this sense, we have estimated demand models employing different cost assumptions and compared them. The average consumer surplus of our sample is between 25.30 € and 72.69 €. As expected, the total costs approach generates a significantly higher consumer surplus, increasing the average amount of a factor of almost three. The recreation value of the "Aracena y Picos de Aroche Natural Park" was increased by 6,849,276.7 €, which corresponds to rough 65.19% of the economic valuation. It is believed that if a significant decrease in visitation occurred to the "Aracena y Picos de Aroche Natural Park", this fact would translate to an important negative effect on the local economy (incidental costs), which depends on the area´s 2,500 hotel rooms, multiple restaurants, food stores and many souvenir shops. This drawback was shown on "Cazorla, Segura y Las Villas Natural Park" by two large fires in 2001 and 2005 (Molina et al., 2017). Nevertheless, fire intensity and fire size would have a significant influence in visitation decrease and recreational losses (Molina et al., 2018).

Incorporation of forest externalities in the decision-making process requires the implementation of an efficient allocation tool. In this sense, fires in remote areas should not have the same recreational impacts than fires at short distance from trails (Baerenklau et al., 2010). The economic allocation of use values in terms of the stated preference activities itself rather than a proportional allocation seems more appropriate (Kaval and Loomis, 2008). Scenery & natural attraction (27.4%) and picnicking (27.39%) were the most demanded activities similar to other natural parks in the south of Spain (Ruíz et al., 2001). The viewshed and observation distance integration using GIS produces a steady spatially-landscape representation of recreation value (Baerenklau et al., 2010). Generally, a recent foreground fire would have a declining effect on visitation (Sánchez et al., 2016). Our findings are in relation to other previous studies (Englin et al., 2001; Hilger and Englin, 2009) that estimate increases in visitation after recent fires, but a declining effect on visitation over time. In this sense, Mediterranean protected areas required numerous advertising campaigns during a period between 3 and 7 years to recover a similar tourism status. Further studies should provide additional information of fire impacts on recreational behavior over time. Expressing the recreational susceptibility in terms of the deterioration rate or visit frequency decrease responds to a needed simplicity required by the questionnaire respondents (Zamora et al., 2010; Rodríguez y Silva et al., 2012).

Our findings identify that there is a growing rural importance on landscape goods. Specifically, the recreation susceptibility ranged from 31,210,807 € for the driving and travel time costs approach to 89,460,204 € for the total costs. In both cases, the high susceptibility is in relation to vegetation flammability and spread fire conditions. A large difference (58,249,397 €) was obtained by using driving and travel time costs approach or total costs. We obtained economic recreation impact values ranging from 167.06 € to 478.84 €. This aggregative contribution might encourage the use of incidental costs because of the elevated dependency of study area on ecotourism.

The final step in the process, once recreation value, vegetation resilience and potential fire intensity were determined, was the preparation of a GIS-based data layer providing an improvement to territorial planning as a consequence of wildfires.

We argue that the proposed methodology can be replicated to other regions and countries, although travel cost method is required for the inclusion of recreational value in the economic assessment. For easier managerial decision-making, recreation susceptibility can be represented in qualitative categories such as "low", "medium", "moderate", "high" and "very high" (Figure 5). Economic impacts increased according to qualitative categories. "High" and "very high" areas needed some prevention and/or suppression activities to reduce the impacts on welfare resources. As observed previously (Baerenklau et al., 2010), "very high" values were concentrated in a relatively small area, and the broad expanse of low values across the most of the landscape. This fact appears that the benefit of preserving recreation opportunities is significantly only in a limited area of the natural protected areas.

Figure 5 around here

Fuel management in prioritize areas can be implemented using fuel-breaks and area-wide fuel modification in strategic locations (Moreira et al., 2011). Our susceptibility model promotes an integral and innovative methodology for the analysis of economic fire impacts on recreation activities that could identify and justify landscape preservation efforts. There is a need to define prevention strategies in areas where fire susceptibility identified as "high" and "very high" sites for fuel reduction. The pattern of fuel treatments in "high" and "very high" sites would create a landscape mosaic that could be justified in any virulent fire behavior are regardless of its value to preserve nearby recreation opportunities. Pastoral activities, mainly in *Quercus* dehesas, and the promotion of sustainable tourism industry, mainly in steeper slopes, may contribute to reducing fire hazard, while job opportunities to rural populations. In prioritize areas where no possibilities of promoting pastoral and/or recreational and leisure activities, one other alternative to manage shrublands is to carry out prescribed or control burning undertaken by fire professionals. In forests, efforts should be given to *Castanea* forests and immature pine stands, often more vulnerable landscape in relation to post-fire regeneration ability.

One of the most important applications of our georefenciated susceptibility model is in the definition of landscape-scale fuel breaks. In this sense, the proposed landscape-wildfire interaction can be improved by further studies associated with the integration of land-use, biomass accumulation and afforestation into the model framework (Carmo et al., 2011; Fernandes et al., 2014; Guiomar et al., 2015), with the use of remote sensing techniques to enhance risk model assessment (Chuvieco et al., 2010) and with the incorporation of fire behavior following landscape metric pattern (Fernandes et al., 2016).

Conclusions

Development of an integral valuation is not possible without considering landscape goods, mainly in natural protected areas. This research demonstrates that the travel cost method is a promising approach to include recreation value into spatial planning of the territory. However, welfare estimates from recreational demand functions are highly sensitive to the travel cost scenario (driving costs, travel time costs and/or incidental costs). We introduce a novel fire susceptibility approach to estimate recreation impacts based on travel cost method, vegetation resilience and fire intensity. In this sense, this approach provides decision makers a tool to evaluate where to invest the limited fire protection resources available. It could also help them analyze the potential economic consequences of fire policy changes based on dynamic cost-benefit framework.

Inclusion of monetary units for recreation resource is in response not only to economic criteria but also to rural development and social criteria. From a economic perspective, a model capable of evaluation the fire susceptibility is of great importance for the comprehensive management of the territory, mainly in fire prevention effectiveness. While the recreation value was not completely depreciated by low and moderate fires, we estimated potentially significant economic impacts associated with intense wildfires at short distance of the recreational infrastructures. Welfare susceptibility using GIS increases the flexibility of this methodology enabling an extrapolation to other territories. However, as this study uses a particularly natural park observations only, future research should evaluate the validity of depreciation rates in other territories.

Acknowledgments

The authors of this work express special gratitude to the VIS4FIRE (RTA2017-00042-C05-01) and GEPRIF (RTA2014-00011-C06-03) projects of the Ministry of Science and Innovation. We also thank two anonymous reviewers and the Associate Editor for their help in improving presentation of this paper.

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Figure captions

Figure 1. Study area location

Figure 2. Representativeness of driving, travel and incidental costs for each travel zone

Figure 3. Allocation of recreation value based on social activity preferences

Figure 4. Box-plot or whisker diagram for age interval (< 25 years, 25-35 years, 35-45 years, 45-50 years and > 50 years) and income level (< 12,500 €/year, 12,500-20,000 €/year, 20,000-35,000 €/year and > 35,000 €/year)

Figure 5. Spatial distribution of recreation susceptibility on "Aracena y Picos de Aroche Natural Park"

Figure 1
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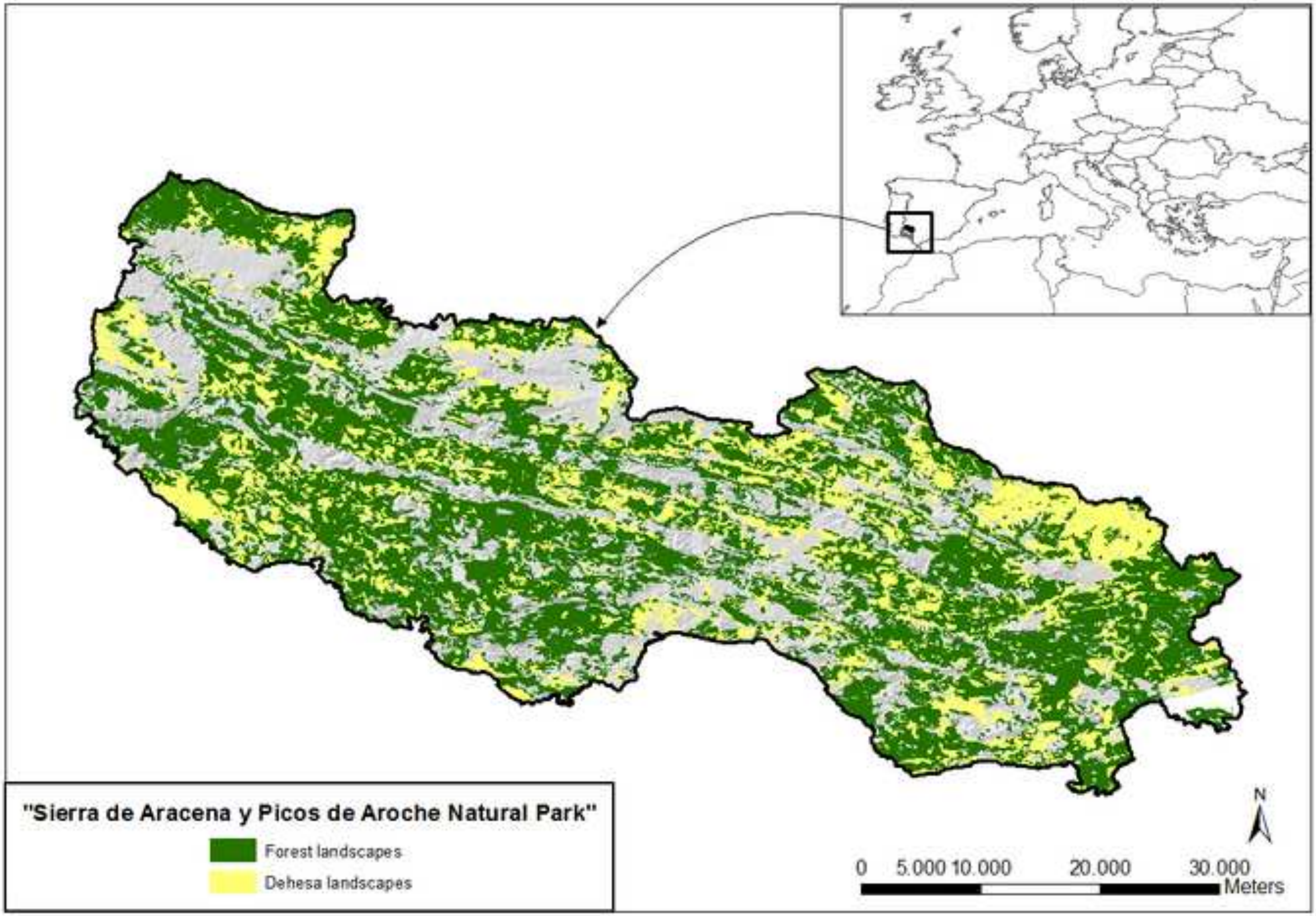

Figure 2
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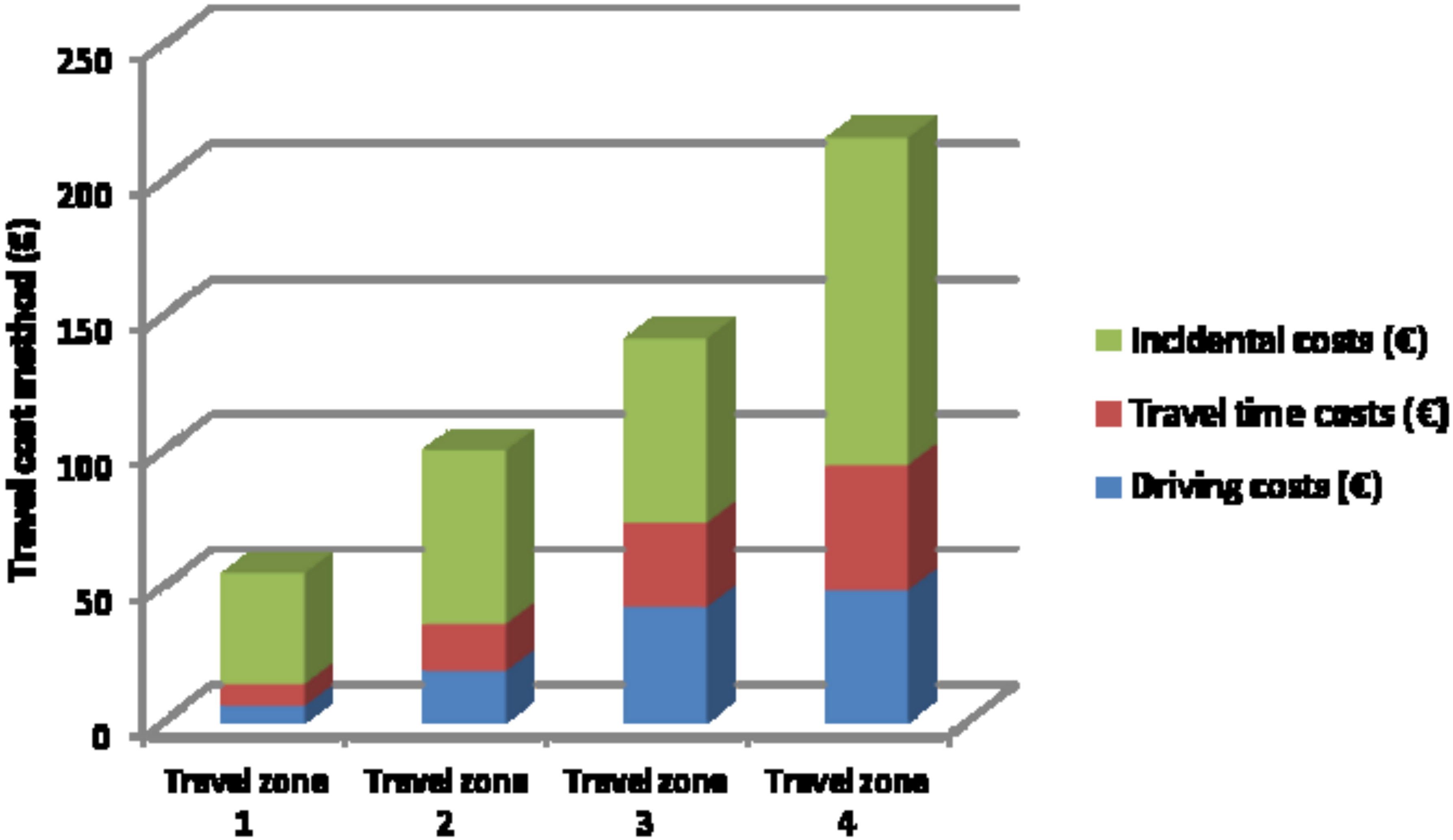

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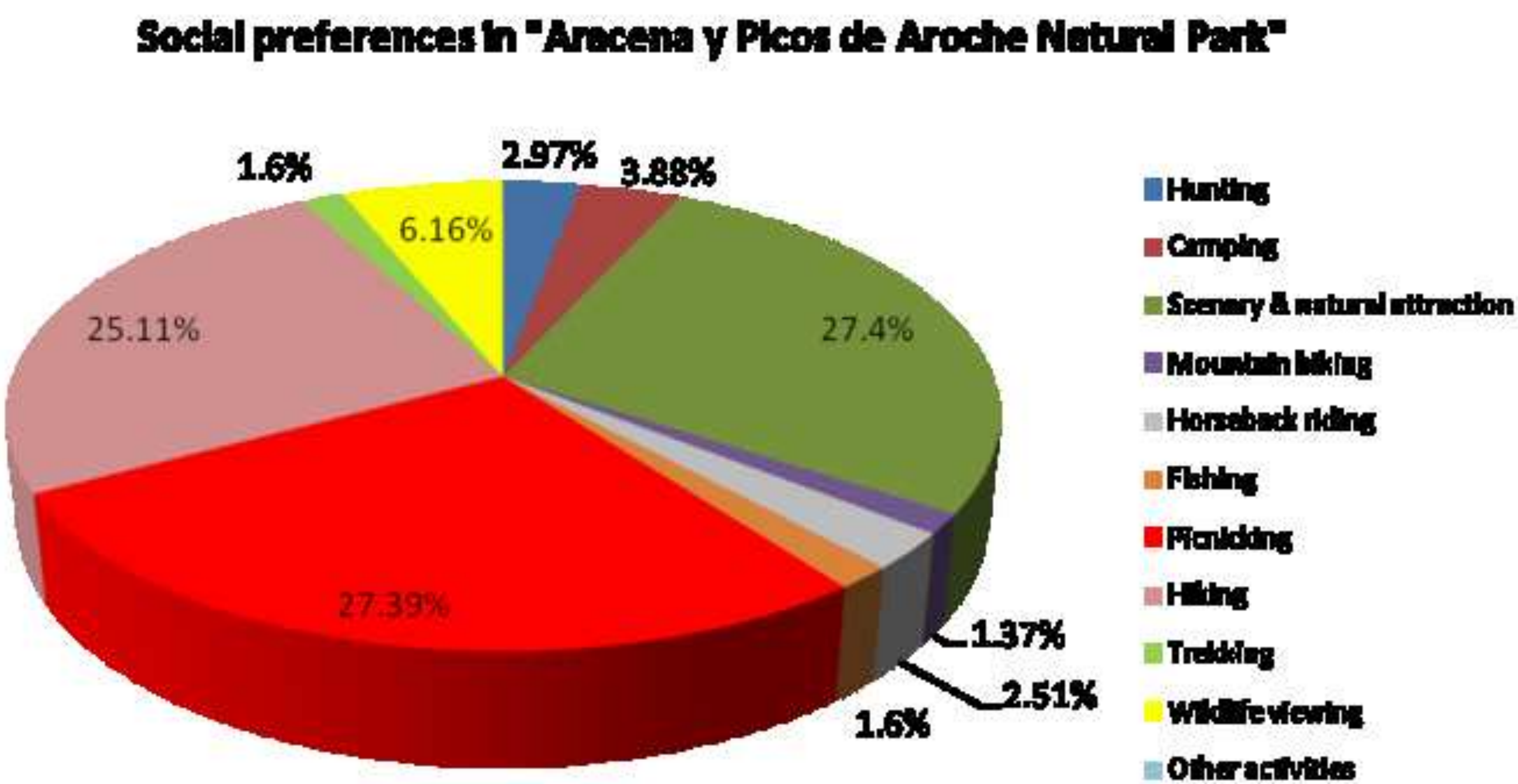

Figure 4a
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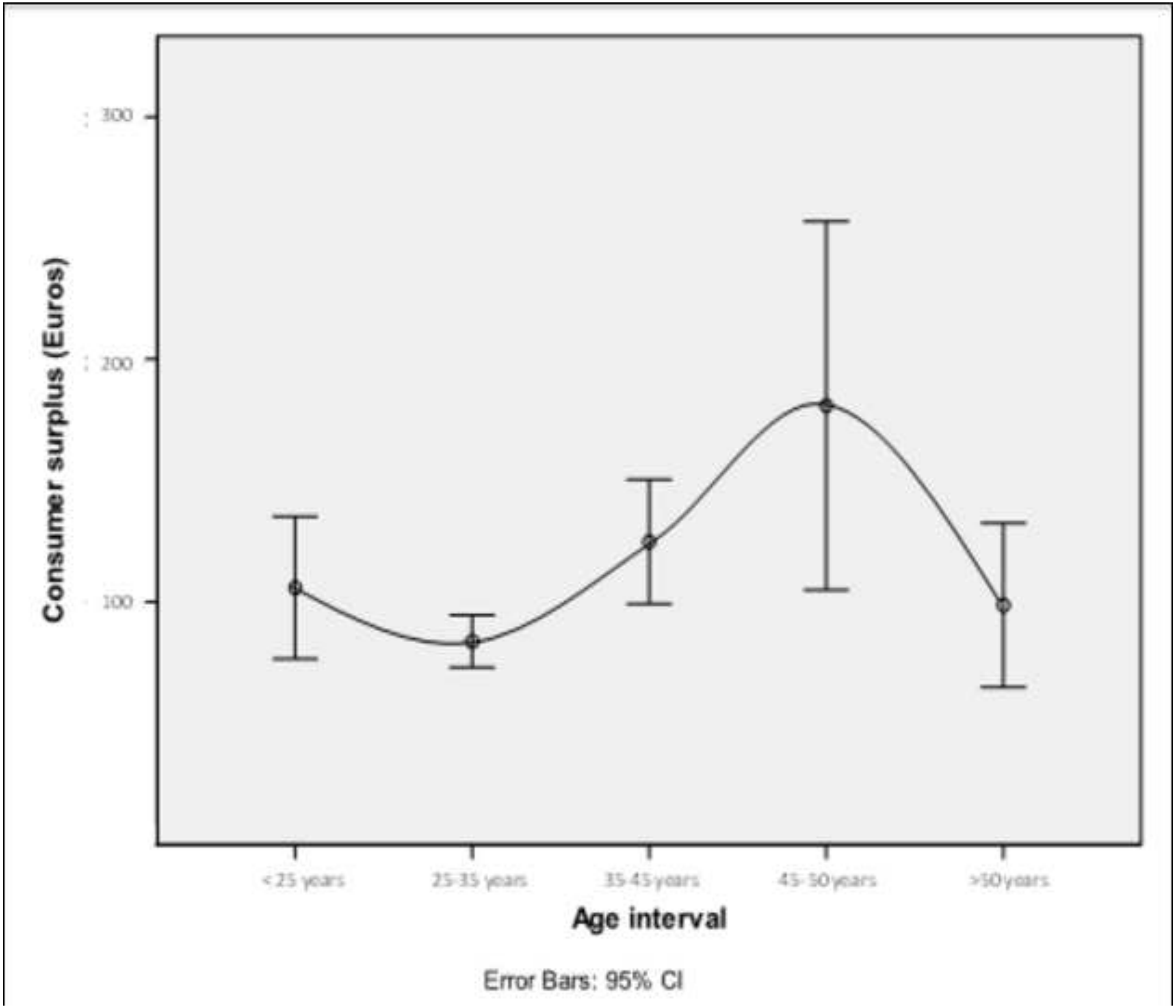

Figure 4b

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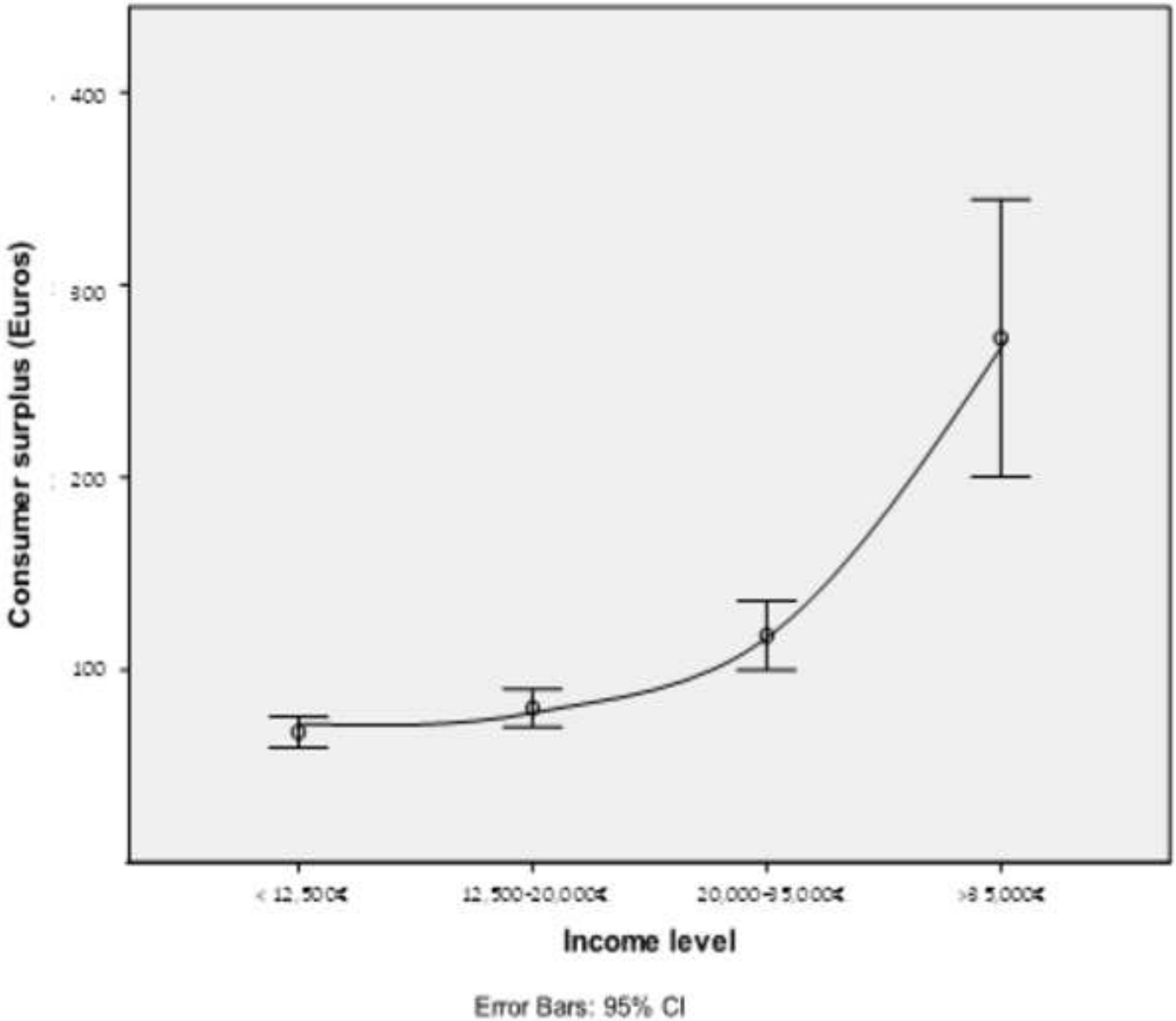

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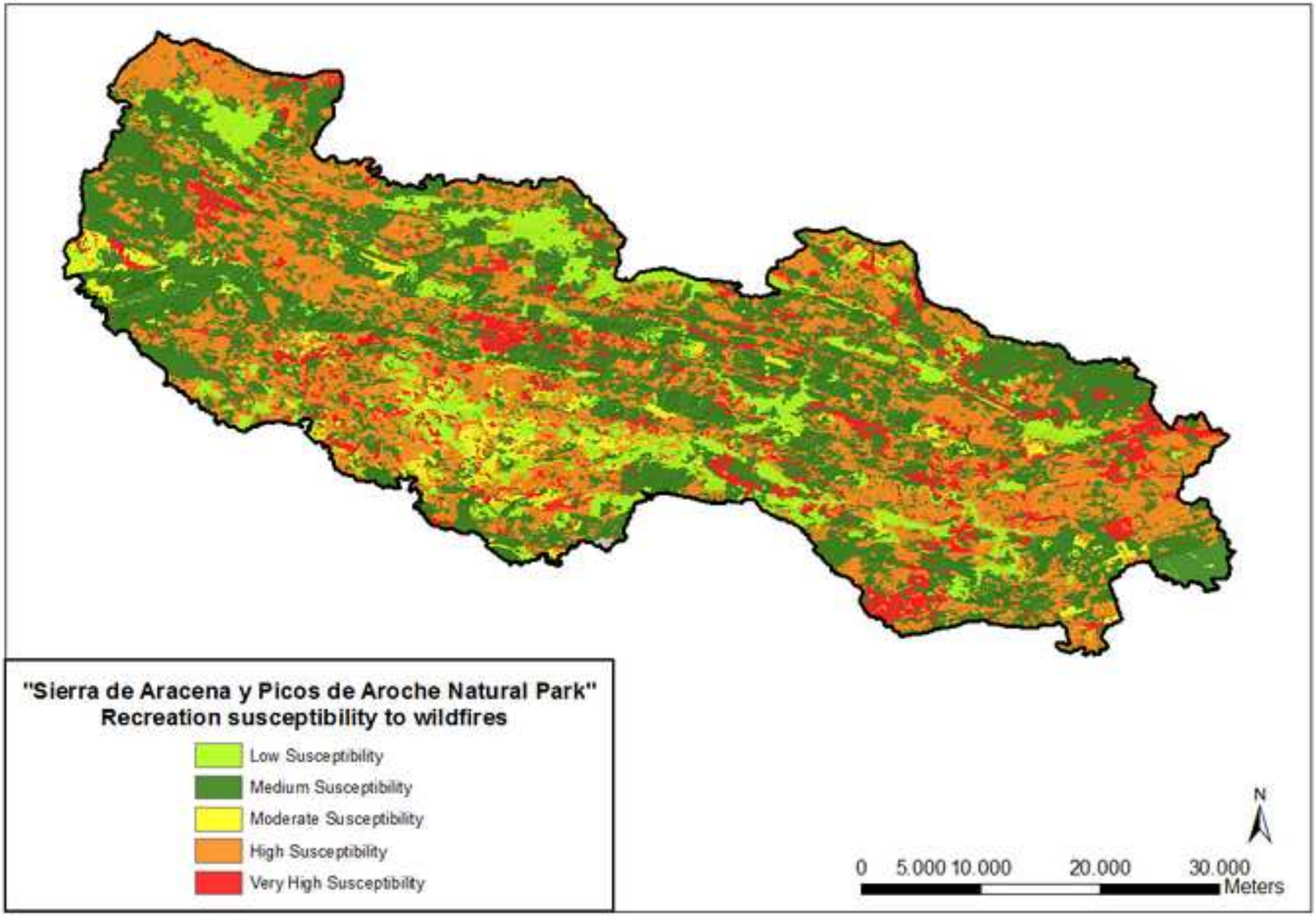

Table 1. Estimation of consumer surplus according to driving and travel time costs and total costs approaches

Travel zones	Consumer surplus (€). Driving and travel time costs	Consumer surplus (€). Total costs	Visitors/1000 inhabitants
1 (< 75 km)	11.83(±8.43)[a]	56.48(±49.94)[a]	0.00021593
2 (75-150 km)	22.66(±5.29)[b]	66.01(±57.96)[a]	9.0737E-05
3 (150-250 km)	34.00(±9.89)[b]	188.87(±135.54)[b]	3.5051E-05
4 (> 250 km)	49.44(±8.99)[c]	213.20(±53.21)[b]	2.4723E-07

Standard deviation in brackets
Mean values in a column followed by the same letter are not significantly different ($p < 0.05$)

Table 2. Demand functions for both methodological approaches

Demand function	Driving costs + travel time costs	R^2	Total costs	R^2
Lineal	$y = -5E^{-06} x + 0.0002$	0.87^{*}	$y = -2E^{-06} x + 0.0003$	0.74
Logarithmic	$y = -0.0002 Ln(x) + 0.001$	0.97^{**}	$y = -0.00001 Ln(x) + 0.001$	0.78^{**}
Polynomial	$y = 1E^{-07} x^2 - 1E^{-05} x + 0.0004$	0.99^{*}	$y = 9E^{-09} x^2 - 3E^{-05} x + 0.0001$	0.77
Power	$y = 19.328 x^{-4.2299}$	0.73	$Y = 237.57 x^{-3.458}$	0.62
Exponential	$y = 0.0037E^{-0.1769x}$	0.88^{*}	$y = 0.001E^{-0.03x}$	0.67

Significance level: ** $p < 0.05$ and * $p < 0.1$

Table 3. Economic valuation per unit area according to the different approaches

Qualitative valuation*	Area (%)**	Annual value according to approach 1*** (€/ha)	Annual value according to approach 2*** (€/ha)
Low (1-14.7)	17.47	3.47	9.98
Medium (14.71-25.73)	13.31	6.95	19.96
Moderate (25.74-51.46)	24.73	13.9	39.93
High (51.47-77)	36.42	27.8	79.86
Very High (> 77.01)	8.06	55.6	159.72

* Qualitative categories based on Jenks optimization method
** This percentage is in relation to the total area (forest and non-forest lands)
*** Approach 1: driving and travel time costs
Approach 2: driving and travel time costs and incidental costs

Table 4. Mean recreational depreciation rates (social preferences) by Fire Intensity Level

Flame length (m)	Fire intensity range (kW/m)	Fire intensity mean (kW/m)	Depreciation rate (%)
< 1	18.6-259.88	171.80(±98.75)[a]	-*
1-4	454.3-6,037.95	4,901.17(±1,748.72)[b]	12.52(±6.09)[a]
4-9	3,873.33-23,197.27	17,352.31(±5,170.88)[c]	66.47(±27.36)[b]
>9	17,916.34-64,970.70	28,659.66(±9,360.09)[d]	91.89(±17.36)[c]

*For this Fire Intensity Level, it is not considered any negative depreciation
Standard deviation in brackets
Mean values in a column followed by the same letter are not significantly different ($p < 0.05$)