The impacts of a wildfire on hunting demand: a case study of a Mediterranean ecosystem

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The present study aimed at estimating the socioeconomic impacts on hunting demand caused by a large wildfire occurred in 2006 in a typical Mediterranean ecosystem Kassandra peninsula (north-eastern Greece). The starting hypothesis was that the wildfire, and the consequent hunting ban over the burnt area, had a significant impact on local hunting demand, in terms of licenses and hunting trips. A survey was carried out by structured interviews conducted by telephone over a sample of local hunters. Statistical analysis revealed a decrease in the number of hunting licence issued at the local hunting club after the wildfire. The impact of the post-fire hunting ban on local economy have been assessed by estimating the income elasticity of demand and the expenses for hunting excursions before and after wildfire. The results show that after the wildfire hunters attempted to preserve their activity despite the local restrictions by increasing the number of excursions and the traveling distance towards other hunting areas. Implications for hunting management and policy decision making were also examined.

Keywords: Elasticity of Demand, Hunters, Hunting Management, Wildfires, Greece

Introduction

An increasing interest in the socio-economic aspects related to wildfires is attested by Cortner et al. (2004), Brunson & Tanaka (2011) and reviewed by Stokowski (2007). According to Moreira et al. (2011) "socio-economic drivers have favored land cover changes contributing to increase fire hazard in the last decades". The widespread abandonment of traditional land uses during the 20th century has led to the growth of extensive forests, woodlands and scrubs vegetation prone to wildfires, especially in the Mediterranean regions (Blondel & Aronson 1999), contributing also to significant economic losses for the agricultural and livestock production (Molina-Martinez et al. 2011).

Wildfires are considered as a major disturbance factor to Mediterranean ecosystems, affecting both biodiversity and human activities on forest land (Thonicke et al. 2008), impacting forest structure and landscape (Hong et al. 2002), causing changes in the taxonomic composition of insect communities (Mateos et al. 2011), increasing or reducing populations of some bird and mammal species (Rollan & Real 2010, Rost et al. 2012), and provoking major impacts on soil gastropods (Bros et al. 2011). Quinn (1994) discusses the direct and indirect impacts of wildfire to the wildlife. Barlow & Peres (2006) found a decline in the fruit production and the abundance of species due to wildfires in a central Amazonian forest. On the other hand, Keith & Surrendi (1971) found more snowshoe hares (*Lepus americanus*) in burned areas one year after a wildfire. Similarly, an increase in lagomorphs populations after wild or prescribed fires has been reported (Rollan & Real 2010, Amacher et al. 2011). Moreira et al. (2001) suggest that in Mediterranean ecosystems wildfires can positively affect bird populations, or have little impact on winter visitors like woodcock.

Wildfires also influence human outdoor activities, such as hunting (Zamora et al. 2010), which represents an important socio-economic practice in the Mediterranean area (Molina-Martinez et al. 2002, Sokos et al. 2003, 2009a, 2009b). About 2.5 million hunters live in areas affected by wildfires in the Mediterranean Europe (FACE 2010). Although in Mediterranean ecosystems hunting is reckoned as an important activity, little information exists in the scientific literature on the impact of wildfires on hunting. In general, researches in recreational economics have focused on the effects of wildfires on the recreation demand (Englin et al. 1996, 2001, Boxall & Englin 2008), in particular hiking and biking (Loomis et al. 2001, Hesseln et al. 2003, 2004).

In Greece hunting has a strong recreational character, and is usually practiced at a local level. However, post-wildfires hunting bans (2-5 years) issued by the Forest Service for wildlife protection may push hunters to move up to 300-500 km in order to find game species (Papaspyropoulos et al. 2012a, 2012b). In Spain, post-wildfires hunting bans last from one to ten years according to Spanish law (Zamora et al. 2010).

The goal of the present study is to estimate the impacts of a large wildfire occurred in 2006 in the Kassandra peninsula (north-western Greece) on local hunting activities. Our hypothesis was that hunting activity was negatively affected by the hunting ban issued after the aforementioned wildfire. We investigated the impact of the hunting ban on hunting demand using a socio-economical approach by comparing the following parameters before and after the wildfire: (a) the outdoor activities of hunters in the area; (b) the reduction of hunting licenses after the wildfire; (c) the number of hunting excursions; and (d) the traveling distance of hunters.

Methods

Study area

The study was carried out on the Kassandra peninsula of Chalkidiki's Prefecture, Macedonia (Greece). Kassandra is a touristic and densely populated peninsula and numerous villages or small towns were threatened by the wildfire of August 2006. Total area is 374 km^2 and the wildlife refuges where hunting is prohibited cover an area of 57.1 km^2.

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Tab. 1 - List of variables used in the survey.

Variable	Type	Levels
Age (in years)	Scale	-
Activities before wildfire	Nominal, multiple response	(i) Hunting; (ii) Training of hunting dogs; (iii) Plant collection; (iv) Outdoor training, walking; (v) Picnic; (vi) Others; (vii) Nothing
Activities after wildfire	Nominal, multiple response	(i) Hunting; (ii) Training of hunting dogs; (iii) Plant collection; (iv) Outdoor training, walking; (v) Picnic; (vi) Others; (vii) Nothing
Quarry species	Nominal, multiple response	(i) Hare; (ii) Wild boar; (iii) Birds with pointer dogs; (iv) Arboreal birds; (v) Waterfowl birds
Hunting license (HL) 2005-2006	Nominal	(i) No HL; (ii) Local; (iii) Regional; (iv) General
Hunting license (HL) 2006-2007	Nominal	(i) No HL; (ii) Local; (iii) Regional; (iv) General
Hunting license (HL) 2007-2008	Nominal	(i) No HL; (ii) Local; (iii) Regional; (iv) General
Hunting license (HL) 2008-2009	Nominal	(i) No HL; (ii) Local; (iii) Regional; (iv) General
Excursions (days/week) 2005-2006	Scale	-
Excursions (days/week) 2006-2007	Scale	-
Excursions (days/week) 2007-2008	Scale	-
Travelling distance 2005-2006 (km/excursion)	Scale	-
Travelling distance 2006-2007 (km/excursion)	Scale	-
Travelling distance 2007-2008 (km/excursion)	Scale	-
Type of vehicle	Nominal	(i) Automobile; (ii) Pickup/Van/Light Truck (PVLT)
Reason for not issuing a hunting license after the forest wildfire	Nominal	(i) Because of the forest wildfire; (ii) Other reasons; (iii) Not an adult yet
Distance from burnt area	Nominal	(i) Closer; (ii) Farther
Direction of residency (with regard to the burnt area)	Nominal	(i) North; (ii) South; (iii) Sidelong

The study area was a typical Mediterranean landscape with Aleppo pine forests (*Pinus halepensis*), maquis and cultivated areas (mainly with cereals, legumes and olive groves - Tsitsoni 1997). The area was affected by a wildfire on August 21st, 2006, just one day after the opening of the hunting period (Aug 20 - Feb 28). The wildfire burnt an area of 68.7 km^2 in the center of the peninsula. Hunting was banned initially on the whole peninsula, then it was restricted to the burned area on Nov 25th, 2006. From the season 2008-2009, the ban was removed and hunting was allowed on the burnt area again.

The main quarry species in the area were hare (*Lepus europaeus*) and migratory birds: woodcock (*Scolopax rusticola*), quail (*Coturnix coturnix*), turtle dove (*Streptopelia turtur*), woodpigeon (*Columba palumbus*) and thrushes (*Turdus* spp.). The hunting period for the hare lasts from September 15 to January 10. Hunting system is "*res publica*", *i.e.*, the game become property of the hunter upon payment of an annual license. Furthermore, hunting in the area is allowed to visitors from other hunting clubs with a suitable license (regional or general).

Data collection

Data were collected through structured interviews conducted by telephone on October 2008. This survey methodology is commonly applied in socio-economic researches with the aim of examining citizens' behavior (Maughan 2004, Petrosillo et al. 2007, Røskaft et al. 2007, Ross-Davis & Broussard 2007).

Licensed hunters of the Kassandra region were in total 512 on October 2008. Only local hunters were interviewed, since they constitute the majority in the region (few non-local hunters usually visit the area). A sample of 56 persons (10.94% of the total) was drawn from the alphabetic catalog of licensed hunters for the period 2008-2009, as provided by the Hunting Club of the Kassandra region. After choosing randomly the first hunter, every fifth person was called next (Garson 2012). If the hunter was not available, the previous or the next one (alternately) in the catalog was called. To avoid biases, consanguinity relations were avoided (*e.g.*, father-son). Similarly to previous researches (Sokos et al. 2009b), the response rate was 100%.

After a preliminary exploration of the collected data, eleven questionnaires were discarded as respondents were used to practice hunting out of the study area. This resulted in a total of 45 valid questionnaires, a number similar to that reported for analogous studies in the scientific literature (Selin & Myers 1998, Zhang et al. 2009). Variables used for the statistical analysis are reported in Tab. 1.

Statistical analysis

Data were initially explored by means of descriptive statistics (Bradley 2007) in order to obtain some basic information about the sample. Departure from normal distribution of scale variables was verified by the non-parametric Kolmogorov-Smirnov test (α = 0.05). Multiple response analysis (Jann 2005) was used for the analysis of the multiple response variables (see Tab. 1), while for the analysis of hunters' activities before and after the wildfire, McNemar's test for paired nominal dichotomous data (Gray & Kinnear 2012) was applied.

Hunters' behavior before and after the wildfire with regard of their license type was examined through the Marginal Homogeneity test, which is recommended for detecting response changes in categorical variables due to experimental interventions in before-and-after designs (Norusis 2007). Furthermore, a two-factor mixed factorial analysis of variance (ANOVA) with repeated measurements was applied (Gray & Kinnear 2012), followed by the post-hoc Bonferroni's comparison test, in order to reveal possible differences in the number of hunting excursions and in the overall traveling distance before and after the wildfire. Although a non-parametric analysis is more suitable in the case of small sample size, no analogous non-parametric method does exist for the parametric ANOVA mentioned above. Thus, data were prior checked for homogeneity of covariance by the Mauchly's sphericity test: when such assumption was violated, the Greenhouse-Geisser correction was applied (Gray & Kinnear 2012). All the statistical analyses were performed using the software package IBM SPSS® v.19.0 (Norusis 2007) with α = 0.05.

Economic analysis

The economic impact of the wildfire on hunting activities was assessed in two ways. Firstly, according to other environmental economical studies (Branch 1993, Lopez & Thirlwall 2006), the income elasticity of demand for hunting licenses was estimated

(Wilkie & Godoy 2001, McConnell et al. 2011) in order to test whether other reasons different from the wildfire (*e.g.*, possible hunters' income decreases) may have contributed to a possible post-fire decrease in the hunting demand.

Secondly, hunters' expenditures before the wildfire and for the two subsequent years were compared. As most respondents were local hunters, we expected that the main costs influenced by the post-fire hunting ban were attributable to transportation (Sokos et al. 2003), therefore only the vehicle operating costs were considered. Vehicles were divided in two large categories (1: Automobiles; 2: Pickup/Van/Light Trucks - Tab. 2) and their operating costs (in 2007 eurocents km^{-1}) for fuel consumption, maintenance/repairs, tires and depreciation were calculated. Moreover, since the length of the hunting period is different depending on the game species (15 weeks for hares, 25 weeks for birds), the comparison was carried out independently on the following two categories: (i) exclusive hare hunters; (ii) other hunters (including those hunting on hare and other species). The above cost-analysis approach is fairly common in the recreational economics literature (Loomis & Keske 2012).

Tab. 2 - Vehicle operating costs (2007 eurocents km^{-1} per vehicle). Source: adapted from Barnes & Langworthy (2004).

Cost category	Automobile	% of total cost	Pickup/Van/ Light Truck	% of total cost
Fuel	5.21	47.1	7.9	60.3
Maintenace/Repairs	1.9	17.2	1.59	12.1
Tires	0.5	4.5	0.45	3.4
Depreciation	3.44	31.1	3.17	24.2
Total	10.42	-	13.74	-

Tab. 3 - Outdoor activities of the respondents in the burnt area before and after wildfire (in %). (a): refers to the beginning of 2008-2009 period, when hunting was permitted in burnt area. (*): $p<0.05$; (ns): not significant.

Outdoor Activities	Wildfire		McNemar test p-value	Observed MH statistic		
	Before (%)	After (%)		2005-06 *vs.* 2006-07	2005-06 *vs.* 2006-07	2005-06 *vs.* 2006-07
Hunting	44.4	24.4 [(a)]	0.022*	-	-	-
Training of hunting dogs	17.8	11.1	0.453[ns]	-	-	-
Plant collection	8.9	2.2	0.25 [ns]	-	-	-
Outdoor training, walking	15.6	8.9	0.25 [ns]	-	-	-
Picnic	4.4	0	0.5 [ns]	-	-	-
Other	4.4	4.4	1 [ns]	-	-	-
Nothing	48.9	64.4	0.065[ns]	-	-	-
Hunting licenses	-	-	-	13.0	10.0	9.0
	-	-	-	0.827[ns]	0.739[ns]	0.739[ns]

Results and discussion

Mean age of respondents was 51.7 years (standard deviation = 15.5, min = 21, max = 79, median = 49), with no significant departure from normality (Kolmogorov-Smirnov 2-tailed test: D = 0.102, p = 0.69). The most preferred quarry species were hare (64.4%), followed by birds, mainly woodcock (42.2 %) and arboreal birds (15.6 %).

Results of the survey carried out in this study are reported in Tab. 3. A significant difference in hunting activity within the burnt area before and after the wildfire was detected (McNemar test for paired nominal data: $p<0.05$). Indeed, only 6.1% of the respondents went on with hunting after the wildfire of August 2006, while 55% just gave up. Most of the other outdoor activities showed a consistent though non-significant reduction, and some completely disappeared in the post-fire period (*e.g.*, picnicking). Hasanagas et al. (2010) showed that most human activities on the burnt area were restored two years after the wildfire.

Hunting licenses

The mean number of hunting licenses in three hunting periods before the wildfire was 543, and decreased to 470, 495 and 523 for the 2006-2007, 2007-2008 and 2008-2009 hunting seasons, respectively. No statistically significant differences were found between the hunting periods analyzed after the marginal homogeneity (MH) test (Tab. 3). Some 13.6% of the respondents did not renew their hunting license for the 2006-2007 hunting season, and 11.1% acknowledged it as due to the hunting ban. On the other hand, the percentage of respondents with a new hunting license issued for the first time after the wildfire was 4.5%. The fairly low reduction of the number of licenses in the burnt area may be partly explained by the fact that the wildfire occurred one day after the opening of the hunting period, when many respondents had already renewed their license.

Hunting excursions

The total number of excursions before wildfire was estimated at 20 675 per hunting period; after wildfire it decreased to 6 590 for the 2006-2007 hunting season and to 16 697 for the 2007-2008 season. Such reduction was due by: (i) the decrease of the number of hunters; (ii) the shortening of the 2006-2007 hunting period; and (iii) the decrease of the number of excursions per week. Significant differences within-subjects in the variable "excursions per week" were detected after Greenhouse-Geisser test ($F_{[1.7, 59.9]} = 4.97$, $p = 0.014$). The interaction between the variable "mean number of excursions" and the factor "direction of residency" was also significant (Greenhouse-Geisser: $F_{[3.4, 59.9]} = 3.05$, $p = 0.03$). Significant differences in the mean number of excursions were detected between the 2005-2006 and 2007-2008 hunting periods (mean difference = 0.9, $p = 0.007$) after Bonferroni tests. Unexpectedly, such difference was not significant for the first period after wildfire (2005-2006 *vs.* 2006-2007, $p = 0.135$). This might be due to the shortened hunting period in 2006-2007; thus apparently hunters took more excursions per week to compensate the shortened duration.

Tab. 4 - Main characteristics of the hunting activity before and after the occurrence of the wildfire in the studied area. (a): Mean average of hunting licenses of the last three years before the wildfire. (HH): hare hunters; (OH): other hunters.

Year	Number of hunters (licenses)			Traveling distance (km excursion^{-1} per hunter)		Excursions week^{-1} per hunter		Hunting period (weeks)	
	Total	HH	OH	HH	OH	HH	OH	HH	OH
before wildfire[(a)]	543	217	326	44.25	28.05	1.97	1.75	15	25
2006-2007 (after wildfire)	470	188	282	87.75	15.25	1.78	1.25	6	13
2007-2008 (after wildfire)	495	198	307	76.25	25.34	2.03	1.39	15	25

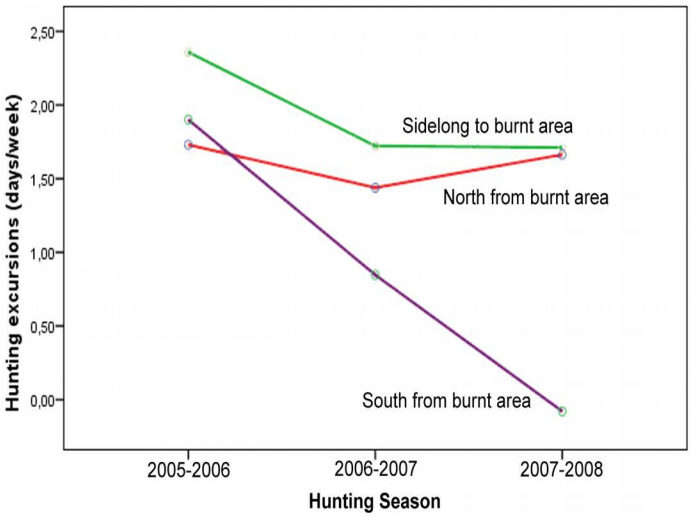

Fig. 1 - Trend of mean hunting excursions per hunter before and after the wildfire (2006) with regard to the direction of residency from the burnt area.

Tab. 5 - Total traveling distances in km. (PVLT): Pickup/Van/Light Truck; (A): automobile.

Year	Total	Hare hunters		Other hunters	
		PVLT	A	PVLT	A
before wildfire	683 809	230 402	53 344	316 850	83 213
2006-07 (after wildfire)	246 069	143 064	33 123	55 347	14 535
2007-08 (after wildfire)	730 051	373 291	86 427	214 104	56 229

The analysis of the interactions among the variables analyzed revealed a significant interaction between the number of excursions and the location (direction) of residency for respondents living south from the burnt area ($F = 5.98$, $p = 0.004$ - Fig. 1), likely due to the longer distance from suitable hunting areas.

Travelling distance

The application of the ANOVA to the dependent variable "travelling distance" (TD) did not reveal any significant differences, neither within subjects nor between distance and direction from the burnt area (Mauhly's $W = 0.87$, $p = 0.18$; $F_{distance\ [2,\ 52]} = 0.068$, $p = 0.93$). However, an increase in the traveling distances after the wildfire was observed ($TD_{2005\text{-}2006} = 25.4 \pm 35.5$ km; $TD_{2006\text{-}2007} = 40.5 \pm 76.8$ km; $TD_{2007\text{-}2008} = 32.0 \pm 49.8$ km).

Analysis of income elasticity

Tab. 4 summarizes the main characteristics of the hunting activity for hare and other hunters before the wildfire and in the two subsequent years. From 2005 to 2006 the decrease of hunting licenses was equal to 13.5 %. Considering the Gross Domestic Product *per capita* for the same period in Greece (17 400 € in 2005, 18 700 € in 2006, and 19 900 € in 2007), the income elasticity of demand (IED) for hunting licenses was calculated. It was reasonably assumed here that hunters (200 000 people, about 2% of the total) are a representative sample of the total Greek population, and that local GDP does not differ from the national one (no GDP data were available for local administrations).

In 2005 and 2006 the IED is below zero for all the categories of hunters ($IED_{05\text{-}06 \rightarrow 06\text{-}07} = -1.8$). This means that, contrary to the expectations, the number of hunting licenses issued in the year after the wildfire was lower even though the respondents' income was higher. Such evidence suggests the hypothesis that the reduction of hunting licenses issued for the burnt area in 2006 was only due the wildfire.

Analysis of car expenses

Tab. 5 shows the total traveling distances of the two categories of hunters with the two class of vehicles considered for the three hunting periods analyzed. Some 81.2% of hare hunters of Kassandra used pick up/van/light trucks and 18.8% used automobiles, while for the category "other hunters" such percentages were 79.2% and 20.8%, respectively.

A reduction in the total expenditures (-35 %) was also observed for the first hunting period after the wildfire (Tab. 6) and this is thought to be related to the hunting ban. However, in the second year after the wildfire a large increase in total expenditures (+90.23 %) was observed, which appears to be due to the greater traveling distances as compared with the previous year. The increase of expenditures was lower for hare hunters than for other hunters, as hare hunters are used to hunt closer to their home places (Sokos et al. 2003, Papaspyropoulos et al. 2012a).

Conclusions

All outdoor activities in the Kassandra peninsula showed a reduction after the large wildfire occurred in the August 2006 (Boxall & Englin 2008); however, hunting was found the only activity to be significantly reduced. After the wildfire, a hunting ban was initially issued over the whole Kassandra's peninsula, then it was limited to the actual burnt area for the subsequent two years. Nonetheless, one year after the wildfire the hare population was higher in burnt area than in nearby non-burnt areas and vegetation regeneration was adequate to provide cover and food to game species (Sokos 2008).

The aforementioned hunting restrictions in the studied area had several important socio-economic consequences. First, a reduction of the number of licenses at the local hunting

Tab. 6 - Total vehicle operating costs per hunter type and per vehicle type (in €). (PVLT): Pickup/Van/Light Truck; (A): automobile.

Cost category	2005-2006 (before fire)				2006-2007 (after fire)				2007-2008 (after fire)			
	Hare hunters		Other hunters		Hare hunters		Other hunters		Hare hunters		Other hunters	
	PVLT	A	PVLT	A	PVLT	A	PVLT	A	PVLT	A	PVLT	A
Fuel	18201.77	2779.24	2503.12	4335.40	11302.10	1725.73	4372.45	757.31	29490.04	4502.85	16914.22	2929.55
Maintenace/ Repairs	4377.64	848.18	602.02	1323.09	2718.23	526.66	1051.60	231.12	7092.54	1374.19	4067.98	894.05
Tires	1152.01	240.05	158.43	374.46	715.32	149.06	276.74	65.41	1866.46	388.92	1070.52	253.03
Depreciation	7925.83	1691.02	1089.96	2637.86	4921.42	1050.01	1903.95	460.78	12841.23	2739.74	7365.18	1782.47
Totals	31657.25	5558.48	4353.52	8670.81	19657.08	3451.45	7604.74	1514.62	51290.28	9005.71	29417.90	5859.10
	37215.73		13024.33		23108.53		9119.36		60295.99		35277.00	
	50240.06				32227.89				95572.99			

club was recorded (13.5% and 8.8% for the first and second hunting periods, respectively), even though hunters' income increased in the same period. The second consequence was the reduction of hunting excursions, especially for hunters living south of burnt area for whom it was difficult to travel out of the banned areas. The third consequence for local hunters was the increase in the traveling distance, mainly in the second hunting period after the wildfire, leading to a strong increase in the vehicle operating costs in the same period (+90.23%). As a result, the lack of hunting areas available in the Kassandra peninsula for the period studied had several impacts like: (i) a higher hunting pressure in allowed areas close to the area interested by the ban; (ii) higher carbon emissions related to the increased distance traveled by hunters (Papaspyropoulos et al. 2012a); (iii) relevant economic losses for hunters and local economy. As for the latter point, we calculated that the hunting ban for the period 2007-2008 (one year after wildfire) implied approximately 45 332 € of additional expenses for hunters, mainly due to the operating costs of vehicles. As an alternative, such money could have been recovered (at least in part) through a special license issued for hunting in the burnt areas, and used as a financial support of post-fire management of forest ecosystems and wildlife conservation, such as habitat improvements with proper plantings and wildlife warding.

Our results highlights the lack of integrated managing strategies for areas affected by wildfires in Mediterranean ecosystems. Indeed, the assessments of impacts of wildfires and their consequences (including hunting bans) on local economy should be conducted using an integrated environmental and socio-economic approach and supported by multi-disciplinary experts, advisory information and monitoring.

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