Reconciling economic and ecological sustainability: Can non-intensive hunting of red-legged partridges be economically profitable?

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Abstract The red-legged partridge (*Alectoris rufa*) is the most important gamebird in Spain. Due to population declines in recent decades, management approaches increasingly include the release of farm-reared partridges, and the establishment of so-called intensive estates, where hunting is based on put-and-take partridges. The release of farm-reared partridges is controversial because these birds negatively affect wild populations. However, according to managers, releases are necessary to maintain commercial hunting. We analysed economic parameters using data provided by 20 red-legged partridge hunting estates with different management and economic aims in central Spain. We calculated total revenues, total expenses, benefits and profitability of these estates, and simulated results under two different scenarios (prices for buying farm-reared partridges being 15% higher, and prices for hunting in estates not using releases being 15% higher) attempting to mimic the internalization of some ecological costs of farm-reared birds or possible rewards from using wild populations sustainably. Non-commercial estates (n = 5), as expected, just broke even, with almost no benefits. Benefits of intensive estates, where massive releases throughout the hunting season allow a much higher harvest, were on average an order of magnitude higher (20404 ± 24413 euro/km², n = 8) than those of other commercial estates (1713 ± 1280 euro/km², n = 7). Benefits of non-intensive commercial estates using releases were on average lower than those of commercial estates without releases. In fact, profitability of non-intensive commercial estates not using releases was similar to that of intensive estates. Any of the two price scenarios considered led to non-intensive commercial estates not using releases being the most profitable on average. Thus, efforts should be made to identify ways of improving economic profitability of non-intensive estates, which may be important for promoting hunting management styles that are ecologically more beneficial.

Keywords: *Alectoris rufa*; Game management; Interview survey; Profitability; Spain; Sustainable harvest

Introduction

Hunting is a popular activity practiced traditionally over wide areas either for recreation or subsistence (Reboussin 1991; Rose 2001; Mileson 2009). Hunting interacts with local biodiversity both through the hunting itself and through game management practices. Therefore, hunting has both ecological functions and effects (Fischer et al. 2013). Additionally, this activity includes an important economic dimension (Bernabéu 2002; Chardonnet et al. 2002; Rao et al. 2010; Martínez-Jauregui et al. 2014), which is particularly relevant in rural areas (Fischer et al. 2013). Economic benefits from hunting may in turn be invested in managing habitats and species, and thus economically profitable hunting estates may be in better ecological condition than unmanaged areas (Robertson et al. 2001; Arroyo et al. 2012). However, economic interests may also lead to intensive management potentially associated with negative ecological effects, such as the maintenance of unsustainable high densities of game through fencing (e.g. Gortázar et al. 2006; Perea et al. 2014) or using farm-reared game, which spreads parasites and diseases into the wild (Tompkins et al. 2000; Díaz-Sánchez et al. 2012). The relationship between profitability and ecological significance of managed hunting systems is insufficiently assessed, as there is no clear and homogeneous market information for game species (Martínez-Jauregui et al. 2014). Overall, very few studies have evaluated in detail the economic returns of hunting (Sotherton et al. 2009, Martínez-Jauregui et al. 2014).

This lack of information is particularly glaring in southern European countries, where hunting plays a very important role, both socioeconomically and ecologically (Fontoura 1992; Beja et al. 2009). In Spain, for example, hunting is widespread with about one million hunters (Garrido 2012) and is practiced in approximately 85% of the country (MAGRAMA 2015). Around 95% of the hunting area is organised into private estates (MAGRAMA 2015), where the owners of the hunting rights are legally responsible for making decisions on hunting management (Gálvez Cano 2006), and may charge money for allowing other people to hunt there (Bernabéu 2002). The profitability of hunting as a business in this country has been scarcely evaluated. The only published studies on this issue include one that evaluated big game hunting in nine case study estates in five European countries, including one in northern Spain (Martínez-Jauregui et al. 2014), and more recently a study assessing the economic value of hunting versus

other activities in forest estates, where big game is also predominant, in Andalucía, southern Spain (Herruzo et al. 2016). In contrast, information about economic margins for small game hunting is absent.

The red-legged partridge (*Alectoris rufa*) is an extremely important gamebird in Spain: it is highly appreciated by many hunters and accounts for almost half of the income related to small-game hunting. It is a species of conservation concern and is the prey of protected predators. It is associated with widespread management, which may in turn have ecological consequences beyond the target species (Blanco-Aguilar et al. 2004; Garrido 2012; Delibes-Mateos et al. 2014; Estrada et al. 2015). Most of the world's wild red-legged partridge population is found in Spain (Blanco-Aguilar et al. 2003). In the second half of the 20th century, intensification of agriculture, together with an increase in hunting demand, led to a decline of this gamebird (Blanco-Aguilar 2007). As a response, management has increasingly shifted toward more intensive systems, which include the release of farm-reared partridges (Blanco-Aguilar et al. 2008; Caro et al. 2014), among other practices. The existence of partridge farms has allowed the establishment of the so-called intensive hunting estates, where hunting is mainly based on put-and-take partridges (Díaz-Fernández et al. 2012). This management style is regarded with contrasting views by both hunters and managers (Fischer et al. 2013; Sokos et al., 2014; Delibes-Mateos et al. 2015).

The release of farm-reared partridges into the wild implies problems for the viability of wild stocks, as it is associated with anthropogenic hybridization, the spread of parasites and diseases and reduced productivity of wild populations (Villanúa et al. 2008; Blanco-Aguilar et al. 2008; Casas et al. 2012; Díaz-Sánchez et al. 2012; Díaz-Fernández et al. 2013a). However, these effects may not be apparent within a hunting season for an individual estate, and it is currently not mandatory to internalize (*sensu* Hennart 1986) the costs of the ecological risks of this practice. Additionally, many managers (even some of those who are against the use of releases) believe that the use of farm-reared birds is necessary to maintain economic activities in hunting estates (Delibes-Mateos et al. 2015). A detailed analysis of the economic consequences of management styles and, more specifically, of whether hunting of wild stocks of red-legged partridge is economically profitable, is currently lacking. Such an analysis would help inform the debate about the consequences and sustainability of using farm-reared

partridges as a hunting management tool, and thus in defining strategies to preserve wild partridge populations (Delibes-Mateos et al. 2015).

In this study, our goal was to analyse economic parameters of hunting estates with different management and economic aims in central Spain (one of the main regions for small game hunting in the Iberian Peninsula; Ríos-Saldaña 2010). We used detailed information provided by 20 partridge estates (representing the largest available data set for small game estates in Mediterranean areas) as a case study for hunting estates for the area. Specifically, we calculated total revenues, total expenses, benefits and profitability of these estates, and simulated results under different price scenarios. Overall, we aimed to increase our understanding of the economic functioning of small game estates with different management styles, which may help in identifying hunting options that are economically sustainable and do not negatively impact biodiversity conservation.

Materials and methods

Study area and study system

The economics associated with hunting in Spain are not well understood, as official statistics about many of the necessary parameters do not exist. Qualitatively, income generated by red-legged partridge hunting has been estimated at more than 1000 million €/per year (Garrido 2012). In general, partridges amount to a quarter of all small game animals harvested annually in the country, with official estimates of about 3 million birds shot every year (MAGRAMA 2015).

The Spanish government started programs in the 1960s based on artificial incubation facilities with the aim of halting the partridge population decline whilst meeting the hunting demand (González-Redondo 2004). These programs were quickly followed by private promotion of red-legged partridge industrial production for release in hunting estates. The number of farms and farm-reared partridges produced increased exponentially during the 1990s, attaining the current numbers of millions released yearly (Blanco-Aguilar et al. 2008; González-Redondo et al. 2010; Caro et al. 2014).

As stated above, most hunting estates in Spain are privately managed (MAGRAMA 2015). The aim of private hunting estates ranges from providing access to game to a group of local hunters that pay an annual fee for this right (henceforth called ‘social’ or ‘non-commercial’ estates), to making economic profit from hunting activities (henceforth called ‘commercial’ estates) (Arroyo et al. 2012). Farm-reared partridges can be released outside the hunting season in both social and commercial estates that have requested authorisation for this management activity. Additionally, Spanish hunting laws allow since the end of the 20th century the existence of ‘intensive’ estates, which are defined as those “where hunting is carried out through the regular release of game raised in game farms” (typically known as ‘put-and-take’; Farfán 2010; Díaz-Fernández et al. 2012). Thus, intensive estates (which must pay an additional fee for the lable) do not have legal temporal or numerical limits to release farm-reared animals throughout the hunting season. Intensive hunting estates are almost always commercial. The intensity of releases in these estates is an order of magnitude higher than in commercial non-intensive or in non-commercial estates (Arroyo et al. 2012), allowing the increase of the annual harvest to levels much over what would be possible from wild stocks (Díaz-Fernández et al. 2012). The intensity of other management tools, such as predator control or the use of feeders, and the number of gamekeepers employed, is also higher in commercial (particularly in intensive) estates than in non-commercial estates (Arroyo et al. 2012).

The methods typically used for hunting partridges in Spain include the following (Buenestado et al. 2009; Arroyo et al. 2012): i) driven-shooting, where assistants beat the ground to flush partridges and drive them towards a strategically arranged line of hunters; ii) walked-up hunting, where hunters (with or without dogs) shoot the birds as they encounter them; and iii) “*reclamo*” hunting, where a live male partridge is used as a decoy to attract wild partridges with calls. There is no quantitative information about which hunting method provides higher satisfaction to Spanish hunters. All three are in accordance with the hunting traditions in Spain, although walked-up hunting is more frequently practiced than driven-shooting (Rios-Saldaña 2010), except in intensive estates (Arroyo et al. 2012), as partridge densities that allow for driven-shooting are not very frequently attained in non-intensive estates. Nevertheless, a recent study showed that Spanish hunters, on walked-up hunting days, prefer hunting wild partridges than

farm-reared ones, and are willing to pay much more for additional wild partridges than for additional farm-reared ones (Delibes-Mateos et al., 2014).

We worked with hunting estates mainly devoted to the hunting of red-legged partridges (i.e., in which red-legged partridge hunting was the most important in relation to other species harvested) located in central Spain. This area contains the highest red-legged partridge abundances within the country (Blanco et al. 2003). There also exists a deep tradition for red-legged partridge hunting in central Spain, where commercialization of this activity is common. At the same time, a broad range of management intensities (including release intensity) is found among estates in this area (Ríos-Saldaña 2010; Arroyo et al. 2012; Díaz-Fernández et al. 2012).

Revenues and expenses in red-legged partridge hunting estates

As part of a wider project that assessed different aspects regarding game management in central Spain (Arroyo et al. 2012; Díaz-Fernandez et al. 2012; Delibes-Mateos et al. 2013; 2015; Caro et al. 2015), we interviewed a sample of 59 managers of different partridge hunting estates. We refer to ‘*game managers*’ as those people in charge of game management decisions in each hunting estate (i.e., landowners, gamekeepers or presidents of hunting associations). Collaborators in previous projects with the Research Institute on Game Resources (IREC) provided contact details of potential future interviewees (see for more details Delibes-Mateos et al. 2013; 2015). Overall, studied estates were representative of the types of small-game estates in the area (Ríos-Saldaña 2010). Interviews were face-to-face and were conducted by the same person (S. Díaz-Fernández) in 2005, 2008 and 2009 (more information on this survey can be found in the supplementary material, and Arroyo et al. 2012). We asked for qualitative and quantitative data on management for a specific hunting season and prices, costs and incomes. Quantitative information on variables needed to construct reliable economic balances was provided for 20 of the interviewed managers, and this is the sample we use for this work. These 20 estates included examples of the whole range of commercial situations observed in the 59 estates: there were eight intensive estates, seven non-intensive commercial estates and five non-commercial estates (see Table 1 for details on the characteristics of each estate). Revenues and expenses were similar between study

years (at least in as much as we could evaluate). The interviewees for the three study years used a similar range of partridge prices per day (see Table 1), and a similar number of hunting days offered per year.

Information from the interviews was used to define the main items (revenues and expenses) of a generic hunting estate necessary to detect economic differences among estates varying in management (see more details in electronic supplementary material). We found 17 expense and five revenue items (Table S1 in electronic supplementary material) attributable to red-legged partridge hunting estates. Expense items referred to management costs (releases, supplementation of water and/or food, predator control), staff, costs associated with land (i.e.. rent to owners or opportunity costs when managers were also land owners), and taxes. Revenue items were mainly related to income from selling hunts for different hunting modalities. In general, there are two different ways to sell hunts in Spain (Bernabéu 2002): i) selling the hunting rights for the estate for the whole hunting season to a group of hunters; in this case, the revenue from hunting is a single payment at the beginning of the season, independent of the number of the animals bagged. This is the case for some commercial estates, and also for all non-commercial estates, which charge an annual fee to the hunters that use them; ii) selling independent hunting days; in this case, the hunting revenue of the estate is the sum of all the payments made at different times throughout the hunting season. Individual hunting days may be sold for driven-shooting, for walked-up hunting, or for decoy hunting, and payments may be per day, per partridge shot, or a combination of both. Furthermore, partridges shot may stay in the estate and be subsequently sold as meat, which represents an additional revenue from hunting; this is usually paid per partridge.

In estates where red-legged partridges are hunted alongside other species, practices or investment may be directed jointly to different species, so expenses may not belong specifically to red-legged partridges. Similarly, income (particularly when hunting rights are sold for the whole season, or for walked-up hunting days when more species may be hunted) may not belong exclusively to partridges. However, as the main aim of the studied estates was red-legged partridge hunting, and we were interested in the profitability of the estate as a whole (and not specifically profitability of partridges solely with respect to other small game hunting), we considered all incomes and

expenses for the estate as related to partridge hunting (see electronic supplementary material for more details).

We define the formulas to calculate the main items of red-legged partridge hunting in individual estates per unit surface in Table S2. We used these generic functions to calculate each main item for the 20 study estates, and calculated for each estate the following parameters: i) total expenses per square km (the sum of expenses divided by the estate area); ii) total income per square km (sum of revenues divided by the estate area); iii) total benefits per square kilometre (total income minus total expenses, divided by the estate area); iv) profitability, equal to the total revenues divided by the total expenses in absolute value. We compared these variables among estates with different characteristics (among non-commercial, commercial or intensive; and among estates with and without releases). Given the small sample size, we did not perform statistical comparisons.

Quantities for variables related to management decisions were used as recorded in each interview. These variables were: number of animals harvested, number of partridges released, number of partridges sold as meat, hunters taking part in a hunting day, number of hunting days sold in the season, the amount of times that food supplementation devices were refilled, number of vehicles in the estate, area cultivated for game crops, number of gamekeepers, number of day's wages paid to supplementary staff, number of cage-traps or supplementation devices, and area of the hunting estate. Prices for certain items were also used as recorded in each interview. These were: price per farm-reared partridge bought, price paid per partridge shot, gamekeepers' salary, or price for renting the hunting rights to land owners (Table 1). Other variables (e.g., average amortization periods of different materials, rate of interest and characteristics of materials, opportunity cost for land owners) were considered equal for all the estates, and estimates of their values were based on expert information or consulting technical specifications on commercial catalogues (Table S3).

In addition to calculating economic parameters using real data, we also calculated benefits and profitability for each studied estate under two different price scenarios: i) Scenario 1, if the price for hunting partridges in estates without releases was higher than the current one, something that has been supported by hunters (Delibes-Mateos et al. 2014), we arbitrarily set the price at 15% higher for this simulation; ii)

Scenario 2, if, in addition, prices for buying partridges in farms were higher than the current ones, simulating an additional cost internalizing some of the environmental costs of releasing partridges, we also set the price at 15% higher for simulations.

Results

There was large variation among the studied estates in overall expenses (Table 1). In absolute terms, intensive estates had much higher expenses (mean $\pm$ SD, 26863 ± 20704 €/km², n = 8) than commercial non-intensive estates (2864 ± 1050 €/km², n = 7) or non-commercial estates (364 ± 210 €/km², n = 5). On average, staff salaries represented a large proportion of expenses in all of our studied hunting estates, but the purchase of farm-reared partridges for releases was also a large proportion of expenses in those estates that used this management tool (Fig. 1). Taxes represented in our sample an average of 7.7 ± 5.4 % of estate expenses.

In relation to revenues, there was also large variation among studied estates (Table 1) and, on average, intensive estates also had much higher revenues (47267 ± 42568 €/km²) than commercial non-intensive (4557 ± 2023 €/km²) or non-commercial estates (417 ± 182 €/km²). Driven-shooting days accounted for most (93.6 ± 4.4 %) of the revenues in intensive estates.

On average, intensive estates had benefits an order of magnitude higher than other types of estates (Fig. 2), although values were highly variable among estates and one of the eight studied estates within this category even had economic losses in the year of study (Table 1). Non-commercial estates, as expected, broke even with almost no benefits (Fig. 2). Commercial non-intensive estates in our sample all had positive benefits (Table 1), but these were lower in estates with releases than in estates without releases (Fig. 2). In fact, profitability of commercial estates not using releases was similar to (or slightly higher than) that of intensive estates (Fig. 3). Non-intensive commercial estates not using releases were the most profitable on average, under both of the price scenarios considered (Fig. 3).

Discussion

Our results showed that intensive estates had much higher benefits than other commercial estates, but that hunting of wild red-legged partridges in estates not using releases may also yield economic benefits. In fact, profitability of non-intensive commercial estates not using releases was similar to that of intensive estates, and could be higher if market prices rewarded estates using wild populations sustainably or internalized some of the ecological costs of releases. Non-commercial estates, as expected, broke even, with almost no economic benefits. We discuss these results below.

One limitation of this study is the small sample size and the variability of management and commercialization styles in our study estates. Nonetheless, this is the largest sample available of economic data for small game estates in the European Mediterranean region, as managers do not readily provide this information. Additionally, as surveys were done between 2005 and 2009, different results could have been obtained if the study had been conducted more recently, under the economic crisis. However, our results provide a reliable reference to compare hunting management strategies for a given economic situation.

According to our results, the main indirect beneficiaries of estate expenses related to red-legged partridge hunting were the local labour force, the farm-rearing partridge industry and the wheat sellers. The value of hunting activities as a provider of rural jobs has been highlighted in other studies (Fischer et al. 2013; Arnett and Southwick 2015), including some in Spain (Garrido 2012). Additionally, the purchase of farm-reared partridges in the estates that used this management tool represented an important proportion of expenses, higher than the investment in other management techniques, and higher than expenses related to taxes. Indeed, expenses that are paid to the government (taxes associated with hunting rights) represented on average only 8% of estate expenses in our sample. Nevertheless, taxes paid for hunting rights in 1996 for all small game hunting were around two million euros in the main region of our study area (Castilla-La Mancha). In this study, taxes associated with revenues were not considered. However, it is widely accepted within the hunting sector that a significant part of the income obtained by commercial estates in the study area is not declared, and therefore not taxed (Garrido 2012).

Our results also showed that benefits of intensive estates, where releases throughout the hunting season allow a much higher harvest overall (Díaz-Fernández et al. 2012 and Table 1), were on average an order of magnitude higher than those of other commercial estates. Their much greater commercial margin is probably related to the fact that they have no limitation in the number of partridge hunts they can offer; this limitation exists in non-intensive estates, particularly for driven-shooting days, because the offer is limited to the partridges available in the area at the beginning of the hunting season. Thus, commercializing driven-shooting days is much more limited in estates based on wild stock (Arroyo et al. 2012), and estates selling driven-shooting days through advertisements in hunting magazines and websites rarely claim to use wild partridges (Díaz-Fernández et al. 2013b). Prices for driven-shooting are also much higher than those for walked-up hunting (Díaz-Fernández et al. 2013b), which contributes to higher benefits of estates offering more driven-shooting days. Sotherton et al. (2009), looking at economics of red grouse (*Lagopus lagopus scoticus*) hunting in the United Kingdom, concluded that moving from driven-shooting to walked-up hunting would decrease the estates' profitability, because total expenses would decrease less than proportionally to the decrease in revenues. However, their results are not directly comparable, as grouse hunting is based on wild stock, so expenses are indeed related to estate surface rather than to grouse abundance. In the case of intensive partridge estates, a large part of estate expenses (partridges bought and wheat for supplementary food devices) are indeed proportional to harvest, so reducing harvest would not necessarily reduce profitability. In fact, overall expenses necessary to maintain this type of hunting estate were also an order of magnitude higher than other non-commercial estates, and this may explain why they only represent a small fraction of all hunting estates (Ríos Saldaña 2010).

Our results also indicate that the use of farm-reared partridges in non-intensive red-legged partridge estates is not necessarily associated with any economic benefits. Releases in low numbers before the hunting season do not imply any additional harvest (Díaz-Fernández et al. 2012). The obligation to release outside the hunting season in non-intensive areas reduces the likelihood of released birds contributing to hunted birds, as farm-reared birds have very high and quick post-release mortality (Gortázar et al. 2000; Sánchez-García et al. 2011). Encouragement to annually reinforce populations with farm-reared birds in these estates may come from the lack of information on the

efficacy of low intensity restocking, a perceived benefit of deferring investment (as investments to establish an adequate environment for high partridge densities must be made long before the hunting season starts, and are usually long-term), or simply the observation of population declines. The perception that exploited natural populations do not produce the expected outputs often leads to the stocking of new species or genetic lineages. For example, in Spain the introduction of American crayfish species (*Procambarus clarkii* and *Pacifastacus leniusculus*) was seen as an urgently needed response to the collapse of white-clawed crayfish (*Austropotamobius italicus*) in the 1970s, as the latter was an abundant and appreciated species for fishing and consumption (Clavero 2016). In the case of partridges, the decline of wild populations led to the release of farm-reared birds to supplement stocks, and this may have been encouraged through positive feedback from some managers, at least until the negative consequences of releases were more widely known. Currently, Spanish partridge hunters and game managers often have negative opinions towards the release of farm-reared partridges, although they also frequently mention that they are necessary to maintain commercial activities (Delibes-Mateos et al. 2015; Caro et al. submitted). Sustainable management of wild partridge populations includes stopping hunting in years of low partridge productivity so as not to overhunt the breeding stock (Lucio 1991). Managers with economic interests may be tempted to use releases in these years. Given that releases can be detrimental to wild populations (Díaz-Fernández et al. 2013a, Casas et al. 2016), this may lead to perpetuating the need for subsequent use of releases on those estates to maintain hunting activity.

Importantly, our results also indicate that non-intensive hunting of wild red-legged partridges in estates not using releases may be a profitable business, even if benefits are not comparable to those of intensive estates. Bernabéu (2002) noted that in many commercial hunting estates only a fraction of the annual income was associated with hunting, from which he concluded that in these cases hunting merely provides the opportunity to bring in additional revenues to those from agriculture. In accordance with this, the gross margin per hectare in 5 of 9 studied hunting estates in four European mountain areas (including one in Spain) was negative (Martínez-Jauregui et al. 2014), suggesting that factors like cultural heritage or self-consumption associated with hunting also play a crucial role in these systems (see also Fischer et al. 2013). In our study, the low benefits of some of the non-intensive commercial estates could be

indicative of these other factors being important in these estates, or that efficiency may not be taken into account in management decisions when hunting is a secondary economic activity. Indeed, a recent study showed that decisions about annual harvests are usually taken based on qualitative rather than systematic criteria, which may lead to over or under-harvesting in many instances (Caro et al. 2015). Whatever the cause, this suggests that efforts may be made to find ways to improve economic profitability of non-intensive estates aiming to obtain economic revenues from hunting. This may be important in trying to promote non-intensive hunting management styles that are ecologically beneficial, or at least not ecologically detrimental, such as those based on wild stocks in well-preserved habitats. Additionally, and as mentioned above, releases of farm-reared partridges have ecologically negative consequences (Villanúa et al. 2008, Díaz-Sánchez et al. 2012), and current market prices do not internalize any of these ecological costs. If they did, competitiveness of estates using releases would be further reduced in relation to estates that manage wild partridges with sustainability criteria. Our price scenarios, in an attempt to simulate a small part of that cost, or possible rewards to those using wild populations sustainably, support this idea.

In this context, a debate arises: should we consider social costs for releases of red-legged partridges (Cross 1989), and should the government force the internalization of that cost (Hennart 1986)? This would theoretically be more fair, but the precise valuation of ecological consequences and other effects of releases is always difficult to assess. If achieved, a differential fiscal pressure on estates that contribute differentially to preservation of natural heritage (e.g. due to releases) would be a possible way to internalize ecological costs. As the general fiscal pressure of hunting is relatively low (hunting together with agriculture are considered protected and disfavoured activities), this possibility could be considered. Another way to encourage more sustainable behaviour would be to help clearly discern in the hunting market between these two kinds of management. A mandatory system of marking released birds that allows hunters to distinguish the product they are buying could be established (Díaz-Fernández et al. 2013b). Another, more elaborate approach may be the use of eco-labels (e.g. Shen 2012). Both approaches would give the consumer the power to choose, and research suggests that they would be prepared to pay more for hunting in such ecologically-valuable estates (Delibes-Mateos et al. 2014).

Finally, the impact that restocking may have on wild red-legged partridge should be better quantified, to determine its social cost more precisely. This is necessary to establish control mechanisms to change behaviour in this business sector, as has been done in other contexts (Minton and Rose 1997). With this information and knowledge on the economic implications of management decisions in hunting estates, we would be in a better position to promote red-legged partridge hunting strategies that are both economically profitable and ecologically sustainable.

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Table 1. Characteristics and management values for the studied red-legged partridge hunting estates. AREA: area of the hunting estate, in km²; %: percentage of the land belonging to the owner of the hunting rights; Type: I-intensive estate, C-commercial non-intensive estate, SC- estate for self consumption, NC- non commercial estate; SMALL: other small game species hunted in the estate: R-rabbits, H-hares, P-pigeons; SELL: how hunts are sold in the estate, per individual day ('Day') or jointly per season ('Seas'); PPP: price per partridge shot (estates selling per individual days), in Euros; PPS: price per season paid for hunting in the estate (where selling jointly for the season), in Euros; PShot: partridges shot per season; SEASON: hunting season for which data were provided in the interview; FARM: number of farm-reared partridges released; PR: price paid per farm-reared partridge, in Euros; PLO: payment as rent to land owners, in Euros; FEED: number of devices for supplementary food in the estate; REFILL: number of times a year each device is refilled; KEEP: number of gamekeepers employed; SALARY: annual salary of each gamekeeper, in Euro; ADWDAY: additional work days paid; REVENUES: total annual income in the estate, in €/km²; COSTS: total annual expenses in the estate, in €/km²; BENEFITS: total benefits for the year, in €/km²; PROFIT: profitability (revenues/costs in absolute value).

ID	AREA	%	TYPE	SMALL	SELL	PPP	PPS	PSHOT	SEASON	FARM	PR	PLO	FEED	REFILL	KEEP	SALARY	ADWDAY	REVENUES	COSTS	BENEFITS	PROFIT
1	60.0	0	I		Day	30		34500	08-09	45000	7.5	8820	2000	24	3	20300	2425	18198.4	15243.4	2955.0	1.19
2	40.0	100	I		Day	20		15000	07-08	20000	6.6	0	400	24	3	20406	750	7766.7	8042.8	-276.2	0.97
3	30.0	80	I		Day	40		98800	07-08	180000	8.0	1205	900	25	7	27143	6500	137248.8	72009.4	65239.3	1.91
4	20.0	50	I	R, H	Day	35		11500	08-09	12000	7.2	1500	120	25	3	18000	1500	21534.3	12931.4	8602.9	1.67
5	17.0	100	I		Day	30		23000	07-08	33000	7.5	0	1900	24	2	16320	65	42068.9	37409.8	4677.9	1.13
6	54.1	30	I		Day	50		70800	07-08	110000	7.8	5676	1000	24	5	24000	100	66831.4	22356.7	44474.7	2.99
7	21.5	0	I		Day	31		43713	08-09	85000	6.1	3218	650	12	2	25000	0	65263.9	31343.4	33920.5	2.08
8	36.0	5	I		Day	30		23000	07-08	40000	7.3	54072	250	24	2	25000	1800	19212.0	15571.4	3640.6	1.23
9	12.2	100	C	R, P	Day	50		1500	08-09	0		0	200	12	1	24330	250	8774.7	5136.8	3637.9	1.71
10	66.1	0	C		Day	49		5593	08-09	0		9912	0	0	3	24096	600	4374.6	2200.7	2173.8	1.99
11	4.9	0	C	R, HP	Seas		17000	98	08-09	0		738	30	6	0.2*	18000*	0	3550.3	2463.4	1086.9	1.44
12	35.8	10	NC	H	Seas		10500	950	08-09	0		0	0	0	1	5580	10	301.6	272.1	29.5	1.11
13	100.0	90	NC	R	Seas		36000	800	08-09	0		0	0	0	1	10800	0	369.9	307.8	62.1	1.20
14	2.3	100	C	R, P	Seas		12000	200	04-05	0		0	16	6	0.2*	18000*	0	5480.0	2495	2985.4	2.20
15	280.0	0	NC	R, H P	Seas		90000	5500	08-09	0		0	0	0	2	19600	0	330.3	261	68.8	1.26
16	4.0	100	C	R, H	Seas		13200	150	04-05	100	7.8	0	20	9	0.4	11000	0	3390.8	2607.8	783.0	1.30
17	7.8	100	C	R, H	Seas		25575	200	04-05	200	7.8	0	30	12	0.6	11000	0	3390.8	2081.1	1309.6	1.63
18	8.0	0	C	R, H	Seas		24000	300	04-05	500	6.00	0	60	12	1	10000	0	3082.5	3063.6	18.9	1.01
19	8.0	0	NC	H, P	Seas		5760	46	08-09	50	7.50	4792	0	0	0	0	0	739.8	737.8	2.0	1.00
20	50.0	0	NC	R, H	Seas		16800	400	08-09	1143	8.50	0	0	0	0	0	0	345.2	241.2	104.0	1.43

* estates that employed no game keepers but where the manager performed some game-keeping activities himself. We estimated this as 20% and used average salary in other estates

Figure 1. Proportion of expenses related to different items in relation to type of red-legged partridge hunting estate. Sample sizes (number of estates) above the bars.

Figure 2. Total benefits (€/km²) in red-legged partridge hunting estates in central Spain in relation to management type. Depicted are results based on accrual data, as well as two price scenarios (Scenario 1: prices 15% higher for hunting in estates without releases; Scenario 2: as Scenario 1, as well as prices for buying farm-reared partridges being 15% higher).

Figure 3. Profitability (revenues/expenses) of red-legged partridge hunting estates in central Spain in relation to management type. Depicted are results based on accrual data, as well as two price scenarios (Scenario 1: prices 15% higher for hunting in estates without releases; Scenario 2: as Scenario 1, as well as prices for buying farm-reared partridges being 15% higher).

Figure 1.

Figure 2.

Figure 3.