Conservation Biology

Special Section Contributed Paper

Addressing social attitudes toward lethal control of wildlife in national parks

María Martínez-Jauregui [1,2]*, Miguel Delibes-Mateos,[3] Beatriz Arroyo,[4] and Mario Soliño [5]

[1]National Institute for Agriculture and Food Research and Technology (INIA), Forest Research Centre (CIFOR), Ctra. de La Coruña km. 7.5, 28040 Madrid, Spain
[2]Sustainable Forest Management Research Institute, University of Valladolid & INIA, Avda. de Madrid 57, 34004 Palencia, Spain
[3]Instituto de Estudios Sociales Avanzados (IESA-CSIC), Campo Santo de los Mártires 7, 14004 Córdoba, Spain
[4]Instituto de Investigación en Recursos Cinegéticos (IREC), CSIC-UCLM-JCCM, Ronda de Toledo 12, 13005 Ciudad Real, Spain
[5]Department of Economic Analysis & ICEI, Complutense University of Madrid, Campus de Somosaguas, 28223 Pozuelo de Alarcón, Spain

Abstract: The extraordinary population growth of certain ungulate species is increasingly a concern in agroforestry areas because overabundance may negatively affect natural environments and human livelihoods. However, society may have negative perceptions of killing wildlife to reduce their numbers and mitigate damage. We used an online survey that included a choice experiment to determine Spanish citizens' (n = 190) preferences toward wildlife population control measures related to negative effects of ungulate overabundance (negative impacts on vegetation and other wildlife species and disease transmission to livestock) in 2 agroforestry national parks in Spain. We used latent-class and willingness-to-pay in space models to analyze survey results. Two percent of respondents thought a national park should have no human intervention even if lack of management may cause environmental degradation, whereas 95% of respondents favored efforts to reduce damage caused by overabundant ungulate species. We estimated human well-being losses of survey respondents when sustainable effects of deer overabundance on the environment became unsustainable effects and well-being gains when sustainable effects transitioned to no visible effects. We found that the type of wildlife-control program was a very relevant issue for the respondents; indirect control in which killing was avoided was the preferred action. Sixty-six percent of respondents agreed with the option of hunters paying for culling animals to reduce ungulate impacts rather than management cost coming out of taxes, whereas 19% of respondents were against this option and willing to pay for other solutions in national parks. Our results suggest that killing wildlife in national parks could be a socially acceptable tool to manage overabundance problems in certain contexts, but it could also generate social conflicts.

Keywords: choice experiment, conflict, hunting, overabundance, rewilding, ungulate

Soluciones para las Actitudes Sociales hacia el Control Letal de la Fauna en Parques Nacionales

Resumen: El extraordinario crecimiento de ciertas poblaciones de ungulados es cada vez más preocupante en las áreas agroforestales ya que la sobreabundancia puede afectar negativamente al ambiente natural y el sustento humano. Sin embargo, la sociedad puede percibir negativamente el exterminio de fauna para reducir sus números y mitigar el daño. Usamos una encuesta en línea que incluía un experimento de elección para determinar las preferencias de los ciudadanos españoles (n = 190) por las medidas de control poblacional relacionadas con los efectos negativos de la sobreabundancia de ungulados (impactos negativos sobre la vegetación y otras especies silvestres y el contagio de enfermedades al ganado) en dos parques nacionales agroforestales de España. Usamos la clase latente y la disposición para pagar dentro modelos espaciales para analizar los resultados de la encuesta. El 2% de los respondientes creyó que un parque nacional no debería tener intervención humana, incluso si la falta de manejo pudiera causar una degradación ambiental. Mientras tanto, el 95% de los respondientes estuvieron a favor

*Address correspondence to M. Martínez-Jauregui, email martinezmari@gmail.com
***Article Impact Statement**: The selection of tools to reduce wildlife impacts in parks is relevant when avoiding conflicts in environmental-agenda planning.*
Paper submitted April 10, 2018; revised manuscript accepted September 22, 2018.

Conservation Biology, Volume 00, No. 0, 1–11

DOI: 10.1111/cobi.13468

de los esfuerzos para reducir el daño causado por la sobreabundancia de ungulados. Cuando los efectos sustentables sobre el ambiente de la sobreabundancia de venados se convertían en efectos insostenibles, los estimamos como pérdidas de bienestar humano para los respondientes de la encuesta; cuando los efectos sustentables transitaron hacia la nula visibilidad de efectos, los estimamos como ganancias de bienestar. Descubrimos que el tipo de programa de control de fauna era un tema muy relevante para los respondientes; el control indirecto, en el que se evita el exterminio, fue la acción preferida por los respondientes. El 66% de los respondientes estuvo de acuerdo con la opción de que los cazadores paguen por sacrificar animales para reducir el impacto de los ungulados en lugar de que el costo del manejo provenga de los impuestos, mientras que el 19% de los respondientes estuvo en contra de esta opción y dispuesto a pagar por otras soluciones en los parques nacionales. Nuestros resultados sugieren que el exterminio de vida silvestre en los parques nacionales podría ser una herramienta socialmente aceptable para manejar problemas de sobreabundancia en ciertos contextos, pero también podría generar algunos conflictos sociales.

Palabras Clave: cacería, conflicto, experimento de elección, sobreabundancia, retorno a la vida silvestre, ungulados

摘要: 一些有蹄类动物种群数量的飞速增长在农林业领域日益受到关注, 因为其种群数量过多可能会对自然环境和人类生计产生负面影响。然而, 社会公众对于猎杀野生动物以减少数量来减轻其影响的做法可能存在负面看法。我们通过选择实验在线调查, 确定了西班牙公民 ($n = 190$) 对西班牙两个农林复合经营的国家公园中与有蹄类数量过多负面影响 (对植被及其它野生动物的负面作用、向家畜传播疾病) 有关的野生动物种群控制措施的偏好性。我们在空间模型中使用潜在类别和支付意愿分析了调查结果, 结果显示, 百分之二的受访者认为, 即便缺少管理可能导致环境退化, 国家公园中也不应进行人为干预; 而百分之九十五的受访者则赞成采取措施来减少因有蹄类动物数量过多造成的破坏。我们估计, 当鹿群数量过多造成的环境可持续影响转变为不可持续影响时, 受访者的人类福祉会有所损失, 而当可持续影响转变为不明显的影响时, 人类福祉则会有所提升。我们还发现, 受访者认为野生动物控制计划的类型十分重要, 应优先选择避免猎杀的间接控制方法。百分之六十六的受访者赞同由猎人为选择性猎杀有蹄类动物以减少影响而付费的做法, 而不是从税收中支付管理成本; 而百分之十九的受访者反对这一做法, 并愿意为国家公园的其它解决方案付费。我们的结果表明, 在某些情况下国家公园猎杀野生动物以应对动物数量过多的问题或能得到社会认可, 但也可能引发社会冲突。
【 翻译: 胡怡思; 审校: 聂永刚 】

关键词: 狩猎, 冲突, 数量过多, 选择实验, 有蹄类, 野化

Introduction

In most developed countries there is a growing demand for natural landscapes and a desire to let areas undergo natural succession (i.e., rewilding [Corlett 2016]). However, nonintervention could produce environmental degradation in certain cases (Delibes-Mateos et al. 2019). For example, seminatural habitats traditionally maintained by anthropogenic activities, such as grazing or extensive agriculture, harbor a high diversity of animals and plants (San Miguel et al. 2010), and a lack of active management may be ecologically less favorable for some species (Delibes-Mateos et al. 2019). This has led to an increasing scientific debate between conservation scientists who believe natural processes should be allowed to take their course without human intervention (Deary & Warren 2017) and those who advocate for managing nature actively (Linnell et al. 2015). Some of the general public also thinks there should be no intervention, and the debate about when and where to carry out interventions to maintain, reduce, or enhance wildlife populations has been heated at times (Nelson et al. 2016).

This debate may be particularly contentious in relation to national parks. These areas are meant to be a reflection of wilderness, but management of certain ecological situations may be needed, particularly when habitat protected by national parks is already created or maintained through human activities or when national parks are relatively small and thus largely influenced by activities outside them, as happens frequently in Europe. Management objectives of protected areas are usually based on scientific information about the ecology of the system and the efficiency of different management tools. However, there is a need to assess how people perceive management of protected areas because social preferences may influence the management tools chosen to attain certain objectives and their success (Treves et al. 2006; Mace 2014). An extreme case of valuable ecosystems that could be compromised by a nonintervention model is national parks in agroforestry systems.

In many agroforestry systems in Europe and North America, the expansion of forests as a consequence of land abandonment (e.g., Lasanta et al. 2015), intensification of certain hunting management practices (supplementary feeding, fencing, etc.), and a lack of large predators has resulted in a tremendous increase in ungulate numbers (e.g., Côté et al. 2004; Apollonio et al. 2010; Herruzo & Martínez-Jauregui 2013). These increases are related to a number of negative impacts on ecosystems and human livelihoods, including detrimental effects on

vegetation (e.g., Gerhardt et al. 2013) and other fauna (e.g., Gill & Fuller 2007), disease transmission to livestock (e.g., Gortázar et al. 2007), traffic accidents (e.g., Bruinderink & Hazebroek 1996), and damage to crops (e.g., Bobek et al. 2017). Models predict that the number and extent of favorable areas for ungulates will increase in the next decades (Acevedo et al. 2011), suggesting that their distribution and abundance and the damage they cause could increase. There is growing concern about overabundant (i.e., beyond carrying capacity) ungulate populations in Europe and North America (Côté et al. 2004).

Reducing ungulate numbers and mitigating their damage can be done multiple ways, such as culling (Nugent et al. 2011), translocation (Massei et al. 2010), contraception (Boulanger et al. 2012), introduction of large carnivores (Ritchie et al. 2012), fencing to prevent vegetation browsing (VerCauteren et al. 2006), vaccination to prevent disease transmission (Gortázar et al. 2011), management of food and water points to prevent contact between wild and domestic animals (Putman & Staines 2004), etc. The application and success of different management tools depend on many ecological and human factors (Simard et al. 2013; Nelson et al. 2016). Among other things, acceptance of the techniques employed and collaboration between stakeholders involved are important (Treves et al. 2006). Several societies have a negative perception of different wildlife population management tools (e.g., Liordos et al. 2017). Lethal control may be one of the most effective tools to mitigate wildlife damage (Van Eeden et al. 2018), although consequences are not always certain (Simard et al. 2013). Nowadays, there is a growing repudiation of it (Dandy et al. 2011; Liordos et al. 2017), which may be influenced by mass media campaigns against it (Gore & Knuth 2009). Acceptance may depend on damage or threat levels, on the species involved, and on the goal of the intervention (e.g., Jacobs et al. 2014; Sponarski et al. 2015; Liordos et al. 2017), which all in turn have ethical and emotional underpinnings (Nelson et al. 2016).

Most knowledge about people's attitudes toward wildlife management that takes into account the perceived level of damage has been generated in studies that considered direct impacts on human livelihoods or safety (e.g., Jacobs et al. 2014; Sponarski et al. 2015; Liordos et al. 2017). Much less information is available on attitudes toward wildlife management linked to ecosystem effects (Jacobs et al. 2014; Johnson & Horowitz 2014). It is essential to assess not only people's acceptance of different management methods, but also how this relates to the economic costs associated with the use of alternative management tools. However, the use of environmental economics to quantify societal preferences is rarely considered (Austin et al. 2011; Brock 2015). It is particularly interesting to address these points in relation to national parks because societal acceptance of human interventions in these areas may differ from acceptance of interventions in other areas less valued from a conservation perspective. Assessing the balance between sensitivities related to nonintervention, nonlethal control, and lethal control used to minimize ungulate damage in agroforestry protected areas may inform and contribute to rethinking the concept of pristineness and wilderness management dilemmas in these areas of high conservation value (Kalamandeen & Gillson 2007; Hobbs et al. 2010). It might also contribute to the debate around the use of recreational hunting to provide funding for conservation (Nelson et al. 2016).

We sought to improve knowledge of the societal acceptance of different management tools to control overabundant populations of ungulates in national parks in southern Europe. We used environmental economics tools based on individual stated preferences to analyze the trade-offs between environmental and human costs of overabundance and management tools. This approach allowed us to estimate the change in well-being associated with different scenarios and to consider societal preferences related to lethal and nonlethal wildlife control.

Methods

Study Area

The Spanish Cabañeros and Monfragüe National Parks (Fig. 1), established in 1995 and 2007, respectively, are representative of Mediterranean agroforestry areas. These parks are 408 and 184 km^2, respectively. The main objectives of Spanish national parks are to ensure the conservation of their natural and cultural values. According to the Spanish legislation, national parks are places where natural processes are a priority, although proactive management may become necessary to preserve ecological equilibrium.

The red deer (*Cervus elaphus*) is a hallmark of these parks. Large predators that may prey on ungulates do not occur in the study area. Red deer densities in both parks are >15–30 individuals/km^2 (similar to densities in surrounding areas) (Acevedo et al. 2008). Such high deer numbers are associated with significant damage to vegetation (Perea et al. 2014), high disease prevalence (Gortázar et al. 2006), and the displacement of other wildlife species (Lozano et al. 2007) in similar ecosystems. Also, large densities of ungulates lead to increased physical contact between wildlife and livestock, resulting in increased disease transmission risk (Gortázar et al. 2007). Traffic accidents and crop damage are also cited among the effects of overabundant ungulate populations, although there are fewer such problems in the study areas because crops inside the parks do not have a production aim and traffic is limited. Further description of the effects

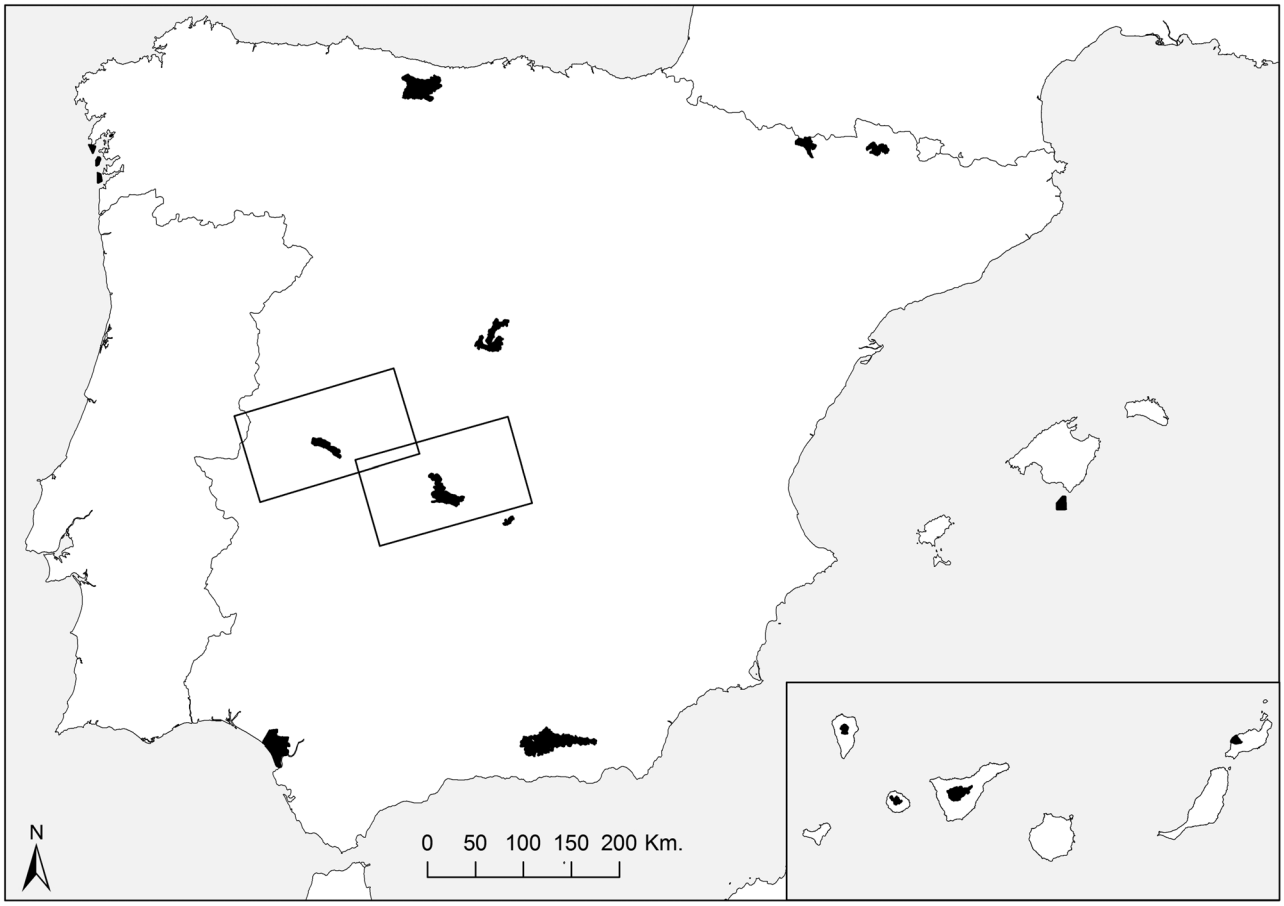


Figure 1. National parks and location of the Monfragüe National and Cabañeros National Parks in Spain.

of deer overabundance in the study areas is in Supporting Information.

In the studied national parks, deer densities and their impacts are considered sufficiently high by park managers to warrant regular ungulate management to reduce damage. Actions are usually live trapping of deer (carried out by park rangers) and subsequent transportation of trapped animals to a private hunting ground (trap and relocate) or a slaughterhouse (trap and kill). Culling and other indirect measures to mitigate ungulate impacts, such as fences for the protection of vegetation and ungulate vaccination, are also used. Recreational hunting is not allowed in Spanish National Parks.

Data

An online survey was conducted in February 2018 on the web platform www.tickstat.com. We used a stratified consumer panel and identified 190 people representative of Spanish society relative to rural and urban populations, age, and gender. Respondents had to be ≥18 years old. The online questionnaire included several initial questions on knowledge of and experience with Spanish national parks (questionnaire in Supporting Information). The questionnaire also dealt with respondents' a priori perceptions of the effects of overabundant ungulates on ecosystems and human livelihoods and current ungulate management tools in Spanish National Parks.

The questionnaire included 12 choice cards (details in "Choice Modeling" below). After responding to the choice cards, respondents chose their preferred deer-management program taking into account that the cost of the program varied depending on the chosen level of management. The costs reflected the average marginal willingness to pay (WTP) estimated in a pilot phase (see below) of the questionnaire. Once they selected their preferred management program, respondents were referred to a scenario in which recreational hunters cover the cost of the preferred program, rather than the cost being covered by tax payments.

Choice Modeling

Choice modeling (CM) includes a set of economic valuation methods based on stated individual preferences. Respondents choose or rank several scenarios (Louviere et al. 2000) that present different combinations of

levels of the attributes related to the subject matter. These combinations are the result of an experimental design based on D-efficient criteria (Rose et al. 2008) and were produced with Ngene software. Several pretests of the questionnaire were performed, including 2 pilot surveys with 39 and 35 individuals, respectively. Pilot surveys were conducted to get the priors for the experimental design.

We examined the social preferences of respondents for different management tools employed in relation to the level of effects of red deer overabundance on vegetation and other wildlife species and the level of risk of infection to livestock (an indirect measure of the effect on human activities). Effects were categorized as damage not visible (no damage); damage visible but the system is sustainable (sustainable); and damage visible and the system is unsustainable (unsustainable). In the cards presented to the respondents, the terms *sustainable* and *unsustainable* were not used. Rather, we used specific terms to describe each category. For *sustainable*, we mentioned only that damage was visible; for *unsustainable*, we used, for example, "there are problems with the growth of some plants and some species are missing from the park" (definitions of terms are in Supporting Information). A no-management alternative was presented as a "no program" scenario (i.e., no management in national parks). In this context, lack of a program to control deer overabundance would have negative effects on these 2 national parks. A detailed description of selected attributes and their respective levels are disaggregated in Fig. 2.

Individuals chose their most preferred and least preferred programs, and a full ranking was obtained. Figure 3 shows an example of choice cards. A respondent's choice among the scenarios presented on each card represented their idea of trade-offs among management tools, environmental impacts, and the price attribute. This let us estimate their WTP for each of the management tools relative to the different levels of environmental impacts. We used the most preferred choices (Caparrós et al. 2008) in a WTP-in-space model to estimate respondents' preferences. The model was run with the software NLOGIT version 6.0. We assumed normally distributed random parameters (Train & Weeks 2005). We also used a latent class model (LCM) with random parameters (Soliño & Farizo 2014; Soliño et al. 2018) to analyze heterogeneity among respondents (Varela et al. 2014) with Latent GOLD version 5.1 software (Vermunt & Magidson 2016) (details in Supporting Information).

Results

Respondents included 95 men and 95 women, and their average age was 47 years (range 18–85 years). Most (>80%) had visited a national park in Spain at least once. Monfragüe (15% of respondents) and Cabañeros (13% of respondents) were in the tenth and twelfth visitation positions, respectively, among the 15 Spanish national parks. Seventy percent of the respondents were willing to visit a national park in the following year. Monfragüe and Cabañeros were chosen for a visit <12% of the time.

More than 90% of respondents expressed their a priori opinion about the effects of overabundant ungulates on ecosystems and livelihoods, whereas few selected the not-sure option. On a scale of 1–5 (1, most negative; 5, most positive), respondents thought that the more negative impacts of ungulate overabundance were road accidents (2.1 score on average), crop damage (2.4), and vegetation damage (2.5). The rest of the analyzed attributes were perceived as being less affected by an overabundance of deer (Table 1). Among the set of management tools to deal with deer overabundance in national parks, respondents were only in a priori agreement (1, strong disagreement; 5, strong agreement) with use of indirect measures (3.8) to mitigate ungulate damage. Respondents were indifferent to other management options (Table 1). Approximately one-third of the participants (32%) were a priori against the use of lethal control of deer in National Parks, and 52% of them did not change their position in extreme cases, such as overabundant deer increasing the risk of lethal traffic accidents, damaging protected animals and plant species, or threatening the red deer population.

Choice modeling showed that most respondents (95%) had positive preferences toward managing deer overabundance. All the attributes' coefficients (WTP) were statistically significant at the 95% level, and the signs of the effects were as expected (Table 2). Human well-being was subject to losses as sustainable effects transitioned to unsustainable effects and to gains as effects transitioned to no visible effects (no damage). Coefficients were higher for unsustainable effects than for sustainable effects, indicating stronger well-being losses in the former case. Respondents thought the unsustainable impact of deer overabundance on livestock was the most important effect to avoid (WTP €137), followed by unsustainable effects of overabundant deer on wildlife (€80) and on vegetation (€75). However, comparisons of WTP for the no-damage options showed that the largest gain in well-being was on no damage to vegetation (€37), followed by no damage to wildlife (€23) and no damage to livestock (€22), precisely the opposite order of effects. Indirect measures were on average the preferred management tool (€201), followed by live trapping (€141).

Only 2% of respondents always chose no intervention in the choice experiment and thus thought a national park should follow its course without human intervention. These respondents explicitly expressed their reasoning in answers to a follow-up question and were willing to accept the environmental degradation of

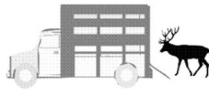
Attribute	Level of attribute	Image used in the experiment
How the overabundance of red deer is managed (HOW): overabundance of red deer and their effects can be controlled in various ways	culling: park rangers shoot some red deer	
	live trapping: some red deer are captured alive and are carried to a private hunting ground (trap and relocate) or a slaughterhouse (trap and kill).	
	indirect measures, such as installing fences to protect vegetation, deer vaccinations to limit disease transmission, etc.	
Effects on vegetation (VEG): overabundance of red deer can cause damage to vegetation because the leaves, branches, flowers, and fruits are eaten	damage not visible in vegetation (VEG_nodamage)	
	damage to the vegetation can be observed (VEG_sust)	
	damage to the vegetation can be observed; there are difficulties for the growth of new plants; and some species are missing in the park (VEG_unsust)	
Effects on other wildlife (WILD): overabundance of red deer can displace other wildlife species that compete for the same food, shelter, water, habitat, or the use of space.	damage to other wildlife species not visible (WILD_nodamage)	
	damage to other wildlife can be observed (WILD_sust)	
	damage to other wildlife can be observed; some animals have difficulty reproducing and are missing in the park (WILD_unsust)	
Effects on livestock (LIV): overabundance of red deer increases probability of contact with livestock and thus favors the transmission of diseases to livestock.	low probability of infection (LIV_nodamage)	
	moderate probability of infection (LIV_sust)	
	high probability of infection (LIV_unsust)	
Cost: annual payment for selected program via increase of taxes (€/year)	10, 20, 30, 40, 50, 60	

Figure 2. In the choice experiment, attributes and levels of damage and interventions to mitigate damage from overabundance of red deer.

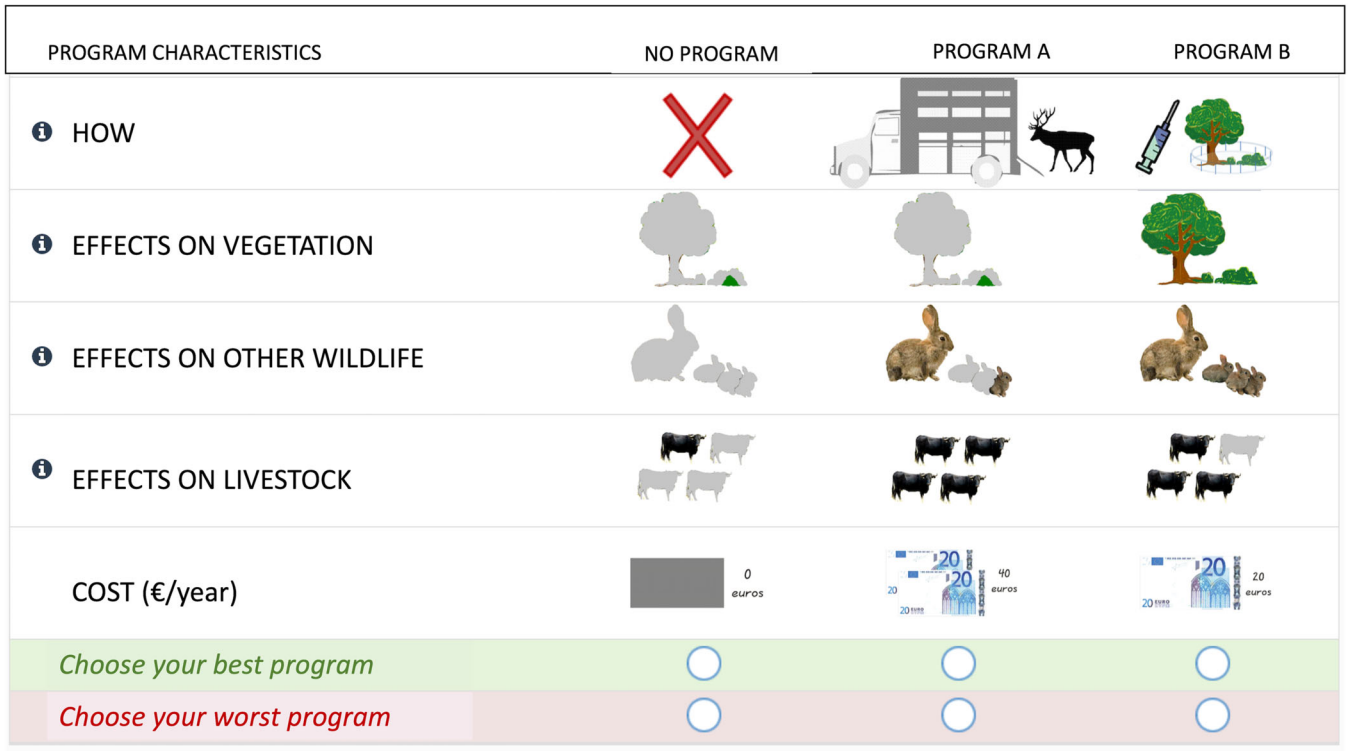


Figure 3. Example of a card used in the choice experiment.

Table 1. Perception of the impacts caused by deer overabundance and of management tools available to mitigate such damage in 2 Spanish national parks.

	n	*Average*[a]	*SD*
Factors deer overabundance affects			
traffic accidents	176	2.1	0.80
agricultural crops	184	24	0.90
plants	183	2.5	1.03
water	177	2.7	0.91
soil	171	2.8	0.84
other wildlife species	176	2.8	0.92
cattle	178	2.9	0.88
own deer population	176	2.9	1.06
landscape	176	3.3	1.09
Management tools in Spanish national parks[b]			
recreational hunting	190	3.1	1.24
trap and relocate or trap and kill	190	2.7	1.35
culling	190	2.7	1.40
indirect measures	190	3.8	1.01

[a]*Perception score: 1, very negative perception or strong disagreement; 2, negative perception or slightly disagreement; 3, indifferent; 4, positive perception or slight agreement; 5, very positive perception or strong agreement.*
[b]*Recreational hunting, hunters pay a fee to hunt red deer; trap, animals trapped live and removed from the park; cull, rangers kill red deer; indirect, fencing, vaccination, etc.*

these biodiversity-rich areas that would result from no intervention.

Results of the WTP in space model showed high heterogeneity among respondents, and the LCM identified 3 different classes of behavior (Table 3). We found that 44.5% of respondents (class 1, general interventionists) attached more importance to unsustainable effects than to management tools. The vegetation interventionists (class 2, 41.9% of respondents) were significantly influenced by the tools to be employed, impacts of overabundant deer on vegetation, and unsustainable livestock damage. Wildlife interventionists (class 3) were 13.7% of the sample, and their WTP was mainly explained by management tools to be employed, wildlife effects of deer overabundance, and unsustainable livestock damage. A comparison of WTP values in the WTP in space and LCMs is in Supporting Information.

Sixty-six percent of respondents agreed to selling permits to hunters to cull deer so they could avoid paying additional costs to control overabundant deer. In this way, additional funds would be raised without additional monetary efforts for the citizens. Nineteen percent of respondents were willing to implement a management program to mitigate the impact of overabundant species, but were absolutely against this being done by recreational hunters in national parks.

Discussion

Perception of Lack of Management

In most developed countries, the vision of management and conservation of natural resources has shifted from a

Table 2. Results of space model of willingness to pay for deer overabundance management.[a]

	Random parameters in utility functions		*Random parameters standard deviations*	
Variable[b]	*coefficient*[c]	*SE*	*coefficient*[c]	*SE*
Indirect	200.747***	37.27988	212.128***	49.78373
Live trapping	140.940***	22.52546	107.978***	28.46600
VEG no damage	36.8666***	12.53544	74.4039***	19.67712
VEG unsust.	−74.8153***	20.96372	84.1081***	19.06269
WILD no damage	23.0348**	9.85882	33.3317***	11.72456
WILD unsust.	−80.4895***	19.55504	119.174***	28.20470
LIV no damage	21.5094**	10.07549	58.6264***	15.82540
LIV un sust.	−136.501***	25.91556	112.443***	25.60314
Cost (in preference-space form)	−0.006**	0.00305	0.009**	0.00416

[a]*Panel data with 190 individuals and 12 choices per individual. Replications for simulated probabilities = 500. Halton sequences used in simulations. McFadden pseudo $R^2 = 0.386$. Log-likelihood function = −1536.748. Restricted log likelihood = −2504.836.*
[b]*Attributes, their levels, and abbreviated measures defined are shown in Fig. 2*
[c]*Significance: ***, 1% level; **, 5% level.*

Table 3. Results of latent class model of respondents' preferences for tools to manage overabundance of red deer.[a]

	Class 1		*Class 2*		*Class 3*		
	General interventionist		*Vegetation interventionist*		*Wildlife interventionist*		*Classes 1–3*
Variable[b]	β	θ	β	θ	β	θ	θ_i
Intercept	0.41***		0.35***		−0.77***		
Live trapping	0.83**	−0.46	2.44***	−0.94**	2.55**	−3.86**	−0.26
Indirect control measures	0.91**	0.68	3.96***	0.54	2.97**	−8.09***	1.48***
VEG_nodamage	0.41**	0.59*	0.43**	−0.36	0.25	−1.41	0.39**
VEG_unsust.	−1.04***	0.71***	−0.75***	1.18***	−0.84	4.42***	−0.18
WILD_nodamage	0.03	−0.23	0.09	0.44	1.96**	−4.81***	0.04
WILD_unsust.	−1.881***	0.91***	−0.35	0.82***	−2.04***	4.61***	−0.73***
LIV_nodamage	0.62***	0.46	−0,05	−0.07	−0.46	4.35***	0.40**
LIV_unsust.	−1.79***	−0.18		0.59**	−2.88**	8.61***	−0.05
			−0,86***				
Cost	−0.02***	0.01**	−0.01*	−0.02***	−0.15***	0.17***	0.00
Class size (%)	44.47	41.86	13.67				
R^2	0.47	0.55	0.79				

[a]*Panel data with 190 individuals and 12 choices per individual. Overall $R^2 = 0.6405$. The β is mean coefficient and θ is SD of random parameters. Significance: ***, 1% level; **, 5% level; *, 10% level.*
[b]*Abbreviated variables defined in Fig. 2.*

utilitarian view to a more mutualistic vision, where nature and society affect each other (Mace 2014). In this context, it is important to investigate societal attitudes toward natural and human disturbance in protected areas such as national parks (i.e., gather information about possible risks in biodiversity hotspots derived from society's attitudes and behaviors that could deteriorate their conservation value) (e.g., Corlett 2016; Deary & Warren 2017). The majority of our respondents agreed with the implementation of a program to manage overabundance of deer in Spanish national parks, rather than holding a view of parks as pristine landscapes where no management actions should be taken. This contributes to the unsettled dilemma about human intervention versus letting nature take its course in protected areas (Linnell et al. 2015; Corlett 2016) and indicates a general perception that human activities are an essential component of agroforestry habitats and their maintenance. In other words, Spanish society seems to believe these 2 biodiversity hotspots are the result of long-term human activities and that preserving the ecological equilibrium there may require proactive management.

Trade-offs Between Environmental Costs of Overabundance and Management Tools

Our results showed that, in general, management tools used in the overabundance-management program affected respondents' social well-being more than the environmental impacts of overabundant deer (vegetation, wildlife, and livestock), indicating that the way to manage

deer numbers in these 2 national parks is the main source of potential conflict to be considered by policy makers. However, decisions of individuals from class 1 (45% of respondents) were more influenced by whether environmental costs of deer overabundance were unsustainable than by the management tools employed.

Our results illustrate the sensitivities of society to ungulate lethal and nonlethal management in protected areas, where recreational shooting is usually much maligned (e.g., Castilho et al. 2018). Nonlethal management of overabundant deer impacts was the preferred action. The second-most preferred action was live trapping of deer (i.e., indirect lethal management). Direct culling was the least preferred method to control deer overabundance. These results are consistent with current management in these 2 national parks and previous findings in the scientific literature (Dandy et al. 2011; Jacobs et al. 2014; Liordos et al. 2017) and are explained by moral and philosophical considerations discussed by Manfredo et al. (2009), Fischer et al. (2013), and Brock (2015). Respondents perceived that the consequences of the management tool mattered (because high levels of damage are to be avoided), but they also often viewed killing animals as something to be avoided (indirect measures are preferred) and perceived that the context of the killing was relevant (recreational hunting as a tool to control overabundant deer was rejected by part of the respondents). In any case, a large part of the respondents did not reject use of lethal control of wildlife when it causes severe detrimental environmental and social impacts. Similarly, most people interviewed by Garrido et al. (2017) in southern Spain agreed with the use of hunting to control wild animals when they present a risk to the health of other animals, but not when wildlife control was done for other objectives, such as to improve game populations.

When taking into account the different levels of deer impact, avoiding unsustainable damage was most valued, regardless of the management method. This is consistent with results of previous studies that show lethal and more invasive wildlife management options become more acceptable as the threat level by wildlife increases (Jacobs et al. 2014; Johnson & Horowitz 2014; Sponarski et al. 2015; Liordos et al. 2017). Other factors, such as the species, motivations for the management action, and stakeholders involved also explain variations in tolerance to damage (Kansky et al. 2014; Garrido et al. 2017).

Recreational Hunting in National Parks

We incorporated in the exercise societal attitudes toward recreational hunting as a tool to address overabundance of ungulates because of the difficulties of financing protected areas (McCarthy et al. 2012; Watson et al. 2014) and the current debate on hunting in national parks. We are, however, aware of the potential downgrading effect that could arise due to the increase in human activities authorized in protected areas (Mascia & Pailler 2011). Our results showed that a majority of respondents favored control via recreational hunters (accompanied by park rangers) paying to shoot deer in these parks because this would reduce the cost to the taxpayer of managing overabundance. Nevertheless, some people (19%) were not in favor of this option, despite the cost implications. The best solution is not obvious because no solution satisfies everyone, as in many human–wildlife conflicts (Redpath et al. 2013). In a hypothetical scenario where policy changed, our results suggest recreational hunting could be a socially acceptable tool to manage overabundance problems in national parks, provided some requisites were met (e.g., supervision by park rangers). However, selection of this management tool is not easy for policy makers. For example, recreational hunting would not be an optimal solution if the manager follows the Pareto principle (i.e., people against recreational hunting have a loss of well-being).

Limitations and Future Research

We focused on deer, but this species is only an example of a common ungulate that negatively affects ecosystems and human livelihoods over vast agroforestry areas in Spain and other European and North American regions. Societal preferences are context specific and vary in space and time, and we highlight the usefulness of environmental economics valuation methods to quantify the perceived welfare changes induced by wildlife control.

Our method may therefore be extended to other ecosystems and species, for example elk (*Cervus elaphus*) in North America (Walter et al. 2011), wild boar (*Sus scrofa*) in Europe (Barrios-Garcia & Ballari 2012), and feral horses (*Equus caballus*) in Australian Alps (Dawson & Hone 2012). However, further considerations may be important when extrapolating methods or results to flagship species, such as elephants (*Loxodonta* spp.), giraffes (*Giraffa* spp.), and lions (*Panthera leo*) because biases associated with charismatics species may come up (Kontoleon & Swanson 2003; Christie et al. 2006; Delibes-Mateos et al. 2015), or when considering irreversible damage and very large territories such as the megaparks in Africa and the United States, where natural control of wildlife species that reach very high numbers and nonintervention policies can be more successful (Van Aarde et al. 2006). Furthermore, future research considering uncertainty in the results of the management programs seems relevant. In any case, information on how society understands the preservation of ecosystems and how they perceive the relationship between humans and nature is essential because it will inform the integration of society in management decisions, which is needed to develop sustainable conservation strategies to mitigate human-wildlife conflicts and to reconcile social concerns with conservation goals in protected areas.

Acknowledgments

This study is framed within the project Social and Ecological Insights for the Sustainable Management of Game Species in Agroforestry Landscapes: from Overabundant to Declining Species" (ref. RTI 2018-096348-R-C21) funded by the Spanish Ministry of Science, Innovation, and Universities. We are grateful to the reviewers for their comments and suggestions.

Supporting Information

Effects of deer overabundance in the study areas (Appendix S1), the survey on perception of the overabundance of ungulates in national parks (Appendix S2), analysis specifications (Appendix S3), and a comparison of WTP values with the WTP in space and latent class models (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials.

Literature Cited

Acevedo P, Farfán MA, Márquez AL, Delibes-Mateos M, Real R, Vargas JM. 2011. Past, present and future of wild ungulates in relation to changes in land use. Landscape Ecology **26:**19–31.

Acevedo P, Ruiz-Fons F, Vicente J, Reyes-García A, Alzaga V, Gortázar C. 2008. Estimating red deer abundance in a wide range of management situations in Mediterranean habitats. Journal of Zoology **276:**37–47.

Apollonio M, Andersen R, Putman R. 2010. European ungulates and their management in the 21st century. Cambridge University Press, London, UK.

Austin Z, Smart JC, Yearley S, Irvine RJ, White PC. 2011. Identifying conflicts and opportunities for collaboration in the management of a wildlife resource: a mixed-methods approach. Wildlife Research **37:**647–657.

Barrios-Garcia MN, Ballari SA. 2012. Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review. Biological Invasions **14:**2283–2300.

Bobek B, Furtek J, Bobek J, Merta D, Wojciuch-Ploskonka M. 2017. Spatio-temporal characteristics of crop damage caused by wild boar in north-eastern Poland. Crop Protection **93:**106–112.

Boulanger JR, Curtis PD, Cooch EG, DeNicola AJ. 2012. Sterilization as an alternative deer control technique: a review. Human–Wildlife Interactions **6:**9.

Brock M. 2015. Putting bambi in the firing line: applying moral philosophy to environmental and economic attitudes to deer culling. School of Economics, University of East Anglia, Norwich, United Kingdom.

Bruinderink GG, Hazebroek E. 1996. Ungulate traffic collisions in Europe. Conservation Biology **10:**1059–1067.

Caparrós A, Oviedo JL, Campos P. 2008. Would you choose your preferred option? Comparing choice and recoded ranking experiments. American Journal of Agricultural Economics **90:**843–855.

Castilho LC, De Vleeschouwer KM, Milner-Gulland E, Schiavetti A. 2018. Attitudes and behaviors of rural residents toward different motivations for hunting and deforestation in protected areas of the northeastern Atlantic Forest, Brazil. Tropical Conservation Science **11:**1940082917753507.

Christie M, Hanley N, Warren J, Murphy K, Wright R, Hyde T. 2006. Valuing the diversity of biodiversity. Ecological Economics **58:**304–317.

Corlett RT. 2016. Restoration, reintroduction, and rewilding in a changing world. Trends in Ecology & Evolution **31:**453–462.

Côté SD, Rooney TP, Tremblay J-P, Dussault C, Waller DM. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution and Systematics **35:**113–147.

Dandy N, Ballantyne S, Moseley D, Gill R, Peace A, Quine C. 2011. Preferences for wildlife management methods among the peri-urban public in Scotland. European Journal of Wildlife Research **57:**1213–1221.

Dawson M, Hone J. 2012. Demography and dynamics of three wild horse populations in the Australian Alps. Austral Ecology **37:**97–109.

Deary H, Warren CR. 2017. Divergent visions of wildness and naturalness in a storied landscape: practices and discourses of rewilding in Scotland's wild places. Journal of Rural Studies **54:**211–222.

Delibes-Mateos M, Barrio IC, Barbosa AM, Martinez-Solano I, Fa JE, Ferreira CC. 2019. Rewilding and the risk of creating new, unwanted ecological interactions. Pages 355–374 in Pettorelli N, Durant S & DuToit J, editors. Rewilding. Cambridge University Press, London.

Delibes-Mateos M, Mougeot F, Arroyo B, Lambin X. 2015. Hunted predators: charisma confounds. Science **349:**1294–1294.

Fischer A, Kereži V, Arroyo B, Mateos-Delibes M, Tadie D, Lowassa A, Krange O, Skogen K. 2013. (De) legitimising hunting–discourses over the morality of hunting in Europe and eastern Africa. Land Use Policy **32:**261–270.

Garrido FE, Castro F, Villafuerte R. 2017. Control hunting of wild animals: Health, money, or pleasure? European Journal of Wildlife Research **63:**95.

Gerhardt P, Arnold JM, Hackländer K, Hochbichler E. 2013. Determinants of deer impact in European forests—a systematic literature analysis. Forest Ecology and Management **310:**173–186.

Gill RM, Fuller RJ. 2007. The effects of deer browsing on woodland structure and songbirds in lowland Britain. Ibis **149:**119–127.

Gore ML, Knuth BA. 2009. Mass media effect on the operating environment of a wildlife-related risk-communication campaign. The Journal of Wildlife Management **73:**1407–1413.

Gortázar C, Acevedo P, Ruiz-Fons F, Vicente J. 2006. Disease risks and overabundance of game species. European Journal of Wildlife Research **52:**81–87.

Gortázar C, Ferroglio E, Höfle U, Frölich K, Vicente J. 2007. Diseases shared between wildlife and livestock: a European perspective. European Journal of Wildlife Research **53:**241.

Gortázar C, Vicente J, Boadella M, Ballesteros C, Galindo RC, Garrido J, Aranaz A, De La Fuente J. 2011. Progress in the control of bovine tuberculosis in Spanish wildlife. Veterinary Microbiology **151:**170–178.

Herruzo A, Martínez-Jauregui M. 2013. Trends in hunters, hunting grounds and big game harvest in Spain. Forest Systems **22:**114–122.

Hobbs RJ, Cole DN, Yung L, Zavaleta ES, Aplet GH, Chapin III FS, Landres PB, Parsons DJ, Stephenson NL, White PS. 2010. Guiding concepts for park and wilderness stewardship in an era of global environmental change. Frontiers in Ecology and the Environment **8:**483–490.

Jacobs MH, Vaske JJ, Sijtsma MT. 2014. Predictive potential of wildlife value orientations for acceptability of management interventions. Journal for Nature Conservation **22:**377–383.

Johnson BB, Horowitz LS. 2014. Beliefs about ecological impacts predict deer acceptance capacity and hunting support. Society & Natural Resources **27:**915–930.

Kalamandeen M, Gillson L. 2007. Demything "wilderness": implications for protected area designation and management. Biodiversity and Conservation **16:**165–182.

Kansky R, Kidd M, Knight AT. 2014. Meta-analysis of attitudes toward damage-causing mammalian wildlife. Conservation Biology **28:**924–938.

Kontoleon A, Swanson T. 2003. The willingness to pay for property rights for the giant panda: Can a charismatic species be an instrument for nature conservation? Land Economics **79:**483–499.

Lasanta T, Nadal-Romero E, Arnáez J. 2015. Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe. Environmental Science & Policy **52:**99–109.

Linnell JD, Kaczensky P, Wotschikowsky U, Lescureux N, Boitani L. 2015. Framing the relationship between people and nature in the context of European conservation. Conservation Biology **29:**978–985.

Liordos V, Kontsiotis VJ, Georgari M, Baltzi K, Baltzi I. 2017. Public acceptance of management methods under different human–wildlife conflict scenarios. Science of the Total Environment **579:**685–693.

Louviere JJ, Hensher DA, Swait JD. 2000. Stated choice methods: analysis and applications. Cambridge University Press, London.

Lozano J, Virgos E, Cabezas-Díaz S, Mangas JG. 2007. Increase of large game species in Mediterranean areas: Is the European wildcat (*Felis silvestris*) facing a new threat? Biological Conservation **138:**321–329.

Mace GM. 2014. Whose conservation? Science **345:**1558–1560.

Manfredo MJ, Teel TL, Zinn H. 2009. Understanding global values toward wildlife. Manfredo MJ, Vaske JJ, Brown PJ, Decker DJ, Duke EA, editors. Wildlife and Society: the science of human dimension. Island Press, Washington, D.C.

Mascia MB, Pailler S. 2011. Protected area downgrading, downsizing, and degazettement (PADDD) and its conservation implications. Conservation Letters **4:**9–20.

Massei G, Quy RJ, Gurney J, Cowan DP. 2010. Can translocations be used to mitigate human–wildlife conflicts? Wildlife Research **37:**428–439.

McCarthy DP, Donald PF, Scharlemann JP, Buchanan GM, Balmford A, Green JM, Bennun LA, Burgess ND, Fishpool LD, Garnett ST. 2012. Financial costs of meeting global biodiversity conservation targets: current spending and unmet needs. Science:1229803.

Nelson MP, Bruskotter JT, Vucetich JA, Chapron G. 2016. Emotions and the ethics of consequence in conservation decisions: lessons from Cecil the Lion. Conservation Letters **9:**302–306.

Nugent G, McShea W, Parkes J, Woodley S, Waithaka J, Moro J, Gutierrez R, Azorit C, Guerrero FM, Flueck W. 2011. Policies and management of overabundant deer (native or exotic) in protected areas. Animal Production Science **51:**384–389.

Perea R, Girardello M, San Miguel A. 2014. Big game or big loss? High deer densities are threatening woody plant diversity and vegetation dynamics. Biodiversity and Conservation **23:**1303–1318.

Putman R, Staines B. 2004. Supplementary winter feeding of wild red deer *Cervus elaphus* in Europe and North America: justifications, feeding practice and effectiveness. Mammal Review **34:**285–306.

Redpath SM, Young J, Evely A, Adams WM, Sutherland WJ, Whitehouse A, Amar A, Lambert RA, Linnell JD, Watt A. 2013. Understanding and managing conservation conflicts. Trends in Ecology & Evolution **28:**100–109.

Ritchie EG, Elmhagen B, Glen AS, Letnic M, Ludwig G, McDonald RA. 2012. Ecosystem restoration with teeth: What role for predators? Trends in Ecology & Evolution **27:**265–271.

Rose JM, Bliemer MC, Hensher DA, Collins AT. 2008. Designing efficient stated choice experiments in the presence of reference alternatives. Transportation Research Part B: Methodological **42:**395–406.

San Miguel A, Perea R, Fernández-Olalla, M. 2010. Wild ungulates vs extensive livestock. Looking back to face the future. Options Méditerraneenes A, **92:**27–34.

Simard MA, Dussault C, Huot J, Côté SD. 2013. Is hunting an effective tool to control overabundant deer? A test using an experimental approach. The Journal of Wildlife Management **77:**254–269.

Soliño M, Farizo BA. 2014. Personal traits underlying environmental preferences: A discrete choice experiment. PLOS ONE **9** (e89603) https://doi.org/10.1371/journal.pone.0089603.

Soliño M, Oviedo JL, Caparrós A. 2018. Are forest landowners ready for woody energy crops? Preferences for afforestation programs in Southern Spain. Energy Economics **73:**239–247.

Sponarski CC, Vaske JJ, Bath AJ. 2015. Differences in management action acceptability for coyotes in a National Park. Wildlife Society Bulletin **39:**239–247.

Train K, Weeks M. 2005. Discrete choice models in preference space and willingness-to-pay space. Pages 1–16. in Scarpa R, Alberini A, editors. Applications of simulation methods in environmental and resource economics. Springer, Dordrecht.

Treves A, Wallace RB, Naughton-Treves L, Morales A. 2006. Co-managing human–wildlife conflicts: a review. Human Dimensions of Wildlife **11:**383–396.

Van Aarde R, Jackson T, Ferreira S. 2006. Conservation science and elephant management in southern Africa: elephant conservation. South African Journal of Science **102:**385–388.

Van Eeden LM, Crowther MS, Dickman CR, Macdonald DW, Ripple WJ, Ritchie EG, Newsome TM. 2018. Managing conflict between large carnivores and livestock. Conservation Biology **32:**26–34.

Varela E, Jacobsen JB, Soliño M. 2014. Understanding the heterogeneity of social preferences for fire prevention management. Ecological Economics **106:**91–104.

VerCauteren KC, Lavelle MJ, Hygnstrom S. 2006. From the field: fences and deer-damage management: a review of designs and efficacy. Wildlife Society Bulletin **34:**191–200.

Vermunt JK, Magidson J. 2016. Upgrade manual for Latent Gold Choice 5.1: Basic, advanced, and syntax. Statistical Innovations. Belmont, Massachusetts.

Walter WD, Lavelle MJ, Fischer JW, Johnson TL, Hygnstrom SE, VerCauteren KC. 2011. Management of damage by elk (*Cervus elaphus*) in North America: a review. Wildlife Research **37:**630–646.

Watson JE, Dudley N, Segan DB, Hockings M. 2014. The performance and potential of protected areas. Nature **515:**67.