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Promoting grazing or rewilding initiatives against rural exodus? The return of the wolf and other large carnivores must be considered

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Research Paper

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Summary

The human abandonment of rural areas facilitates rewilding, which is also supported by European projects and initiatives. Rewilding often implies the return of iconic predators such as the wolf (*Canis lupus*), leading to human–wildlife conflicts. To reverse human depopulation, initiatives such as the European Union's Common Agricultural Policy (CAP) subsidize extensive grazing of areas unsuitable for intensive agriculture. Therefore, rewilding and reversing depopulation initiatives seem to be mutually incompatible, and further insight into controversial aspects of the return of apex predators is needed when considering the reform of the CAP for post-2020. To develop understanding of these different objectives in the context of large carnivore recolonizations, we analysed wolf attacks on livestock in central Spain, where livestock is managed differently between the plateau and the mountains. As with other European regions, this area is undergoing rural abandonment and is subsidized by the CAP. Free-roaming cattle at higher elevations were subject to increased attacks irrespective of the abundance of wild prey. Efforts to subsidize human repopulation of areas experiencing recolonization by large carnivores require consideration of a model of cohabitation with these predators assisted by mitigation and compensation measures. Rewilding could bring alternative sustainable income based on the values brought by the presence of large carnivores and associated ecosystem services.

Introduction

Socioeconomic trends have motivated rural-to-city migrations of people and the abandonment of rural areas (MacDonald et al. 2000, Hobbs & Cramer 2007). To reverse this depopulation, agri-environmental strategies such as the European Union's (EU) Common Agricultural Policy 2014–2020 (CAP) promote and subsidize the rural repopulation through farming and extensive grazing of marginal less favoured areas (LFA), which include mountain regions mostly unsuitable for intensive agriculture (Merckx & Pereira 2015). These actions aim to preserve the development of the countryside while enhancing ecosystems and promoting biodiversity (Nègre 2020). However, recent studies claim that biodiversity could be more effectively promoted by rewilding approaches (Merckx 2015, Dantas de Miranda et al. 2019, Martins et al. 2020). The concept of rewilding has been widely discussed in the literature since early interpretations mostly based on large carnivore restoration (Soulé & Noss 1998, but see also Lorimer et al. 2015, Jørgensen 2015, Prior & Ward 2016, Gammon 2018). Currently, rewilding is mostly considered as the recovery of natural processes, species and ecological functioning such as trophic-related processes (trophic rewilding; Boitani & Linnell 2015) while reducing the impact of human activities (Navarro & Pereira 2015). A reduction of the human impact in the countryside often results from decreasing land exploitation following rural migration of people to cities (Navarro & Pereira 2015). Currently, rewilding is supported by initiatives and projects like Rewilding Europe (https://rewildingeurope.com), which consider the depopulation of rural areas as an opportunity for new business and employment sustained on the re-establishment and dominance of natural ecological processes and wilderness.

Despite the captivating 'narrative of hope' of the rewilding concept (Bakker & Svenning 2018), livestock grazing continues to be an important economic activity in the European countryside. A critical area where rewilding and farming come into conflict is the increased prevalence of charismatic wildlife species that cause human–wildlife conflict, such as recolonizing large carnivores (Henle et al. 2008, Chapron et al. 2014, Boitani & Linnell 2015). The return of wild species is fundamental for rewilding initiatives to reverse defaunation, increase biodiversity and restore natural function to the ecosystem, including trophic processes (Fernández et al. 2017). In this sense, initiatives promoting farming or rewilding can be seen as mutually incompatible ideals for the future of rural Europe. Analyses of institutional (e.g., CAP) and non-governmental organization (e.g., European Rewilding Network) initiatives help to inform the complexities of supporting livestock husbandry as claimed by farmers, while promoting the rewilding claimed mostly by conservationists in favour of the recovery of wild predators. Ongoing reform of the CAP for the post-2020 period is considered to favour Member States to choose low-ambition implementation pathways for environmental conservation, and it is claimed that scientific evidence should be incorporated into its design as a necessity to address future environmental challenges (Pe'er et al. 2020).

Among large carnivores, the grey wolf (*Canis lupus*) is an iconic but highly controversial species for economic and cultural reasons. The wolf was extirpated in parts of its distribution range due to direct persecution and decline of prey abundance (Ripple et al. 2014). However, the species is currently recolonizing areas of its historical range in Europe (Kaczensky et al. 2012, Chapron et al. 2014), facilitated by conservation strategies of the European Commission (e.g., the European LIFE program; European Commission 2020), including a strict protection status in Council Directive 92/43/EEC (Habitats Directive) of the EU, and by habitat restoration strategies at country and continental scales (Chapron et al. 2014, Ripple et al. 2014). Although the recolonization of the wolf and other large carnivores could be enthusiastically interpreted as a relevant milestone of the rewilding process (Boitani & Linnell 2015), this process conflicts with farming initiatives (Mech 2017) because of predation of game species, livestock and other domesticated animals (Meriggi & Lovari 1996, Gazzola et al. 2008, Chapron et al. 2014). These conflicts could be intensified after the adoption of relaxed husbandry practices that have abandoned protection against predators that were eradicated, thus facilitating conflict when these predators return (Gazzola et al. 2008, Chapron et al. 2014, Torres et al. 2015). Under these conditions, it is crucial to assess objectively how the wolf's return can fit into the efforts to improve the coexistence of large carnivores and agriculture (LIFE COEX 2005–2011 for Southern Europe; Boitani & Linnell 2015).

Here, we focus on the Iberian wolf (*Canis lupus signatus*) recolonization of the central Mediterranean region of Spain where livestock grazing is a predominant economic activity among those still in the area. This expansion challenges the adaptability of the species to recolonize landscapes that, due to the proximity of the city of Madrid, contain a gradient of human-dominated and wild habitats in one of the top-ranked countries for rural depopulation in Europe (Delgado Urrecho & Martínez Fernández 2017, Pinilla & Sáez 2017). We investigated the anthropogenic and ecological factors influencing the frequency of wolf attacks on livestock (WALs) in this region in order to understand how rewilding objectives can fit into these landscapes where livestock husbandry and grazing are promoted. Particularly, we tested how WALs were associated with elevation, livestock density, human presence and densities of wild prey for wolves (i.e., wild ungulates; Torres et al. 2015). These factors and the landscape heterogeneity of Central Spain provided an ideal opportunity to investigate the challenges of rewilding and the CAP. Wolf recolonization of areas defined by gradients of human population density also occurs in other European countries such as Germany (Reinhardt et al. 2012), Sweden and Norway (Recio et al. 2018). Therefore, considering the ongoing reform of the CAP by the European Commission for the post-2020 period, our research aims to offer insights into the feasibility of promoting farming alongside wolf conservation and rewilding objectives across Europe towards the paradigm of coexistence proposed by Boitani and Linnell (2015) and the EU-promoted LIFE COEX.

Methods

Study area

Our research focused on the northern Central System range (Central Iberian Peninsula), in the province of Segovia, Autonomous Community of Castilla y León. This is one of the regions of Europe most impacted by rural depopulation (colloquially known as the 'Southern Lapland'), with people mostly concentrated in urban and suburban areas (26 inhabitants km^{-2} in total, but 7 inhabitants km^{-2} in 80% of its territory) (Delgado Urrecho & Martínez Fernández 2017, Pinilla & Sáez 2017). In the municipalities near the border with Madrid Province to the south (Fig. 1), human population densities range from very low (<10 inhabitants km^{-2}) to moderate (>25 inhabitants km^{-2}). Considering the relative proximity to the city of Madrid, the urban development of recreational houses as second residencies is common in the area.

The elevation ranges between 700 and 2428 m and encompasses two bioclimatic zones: the Castile plateau and the northwest slope of the Central System range (Fig. 1). The plateau is a mosaic of crops and forest patches of cluster pine (*Pinus pinaster*), stone pine (*Pinus pinea*) and evergreen oak (*Quercus ilex*). The vegetation in the mountains is scots pine (*Pinus sylvestris*) alternating with Pyrenean oak (*Quercus pyrenaica*) and dense shrubs (e.g., dog rose, *Rosa canina*). Most of the mountains are composed of natural grasslands and pastures for livestock (Fig. 2). The climate is continental Mediterranean.

The last census in the area identified 10 wolf territories (Sáez de Buruaga et al. 2015). The southern face of the Central System range belongs to the Autonomous Community of Madrid, where the wolf is currently expanding (Silva et al. 2018). This is the southernmost front of the current wolf recolonization in Europe and the last barrier for the expansion of the species into the southern half of the Iberian Peninsula. The wolf is protected in Castilla y León and is the only large carnivore in our study area, where it returned in 1998 (Blanco & Cortés 2001). Roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) are the most abundant wolf prey in the plateau and mountains. Livestock consist of cattle ($n = 54\,325$), sheep ($n = 152\,771$) and goats ($n = 1394$) (Regional Administration Livestock and Agriculture Section, unpublished data). Cattle are the most abundant livestock, typically grazing unattended and freely in the mountains with few confinement measures or protection. This practice is common over the central mountain range of Spain, where cattle are only semi-confined to villages during the coldest months (Álvares et al. 2014), while all livestock are usually enclosed in paddocks on the plateau. Herds of sheep and goats are commonly accompanied by shepherds and dogs and enclosed at night.

Data collection

We collected anthropogenic and ecological variables previously related to WALs (Meriggi & Lovari 1996, Treves et al. 2004, Gazzola et al. 2008, Eggermann et al. 2011) and data on the level of either ancient or restored wilderness (i.e., rewilding). Anthropogenic variables included human density, livestock density (cattle, sheep and goats separately) and the percentage of urban and crop land cover. Ecological variables included altitude, wild prey density and the proportions of natural land-cover classes.

We identified five levels of WAL intensity (no attacks and the quartiles of the data reporting attacks) based on the number of attacks between 2007 and 2012 in 80 municipalities distributed over the mountains (24.7%) and the plateau (75.3%) (public data from the Regional Administration): no attacks (0 records), low (1–30),

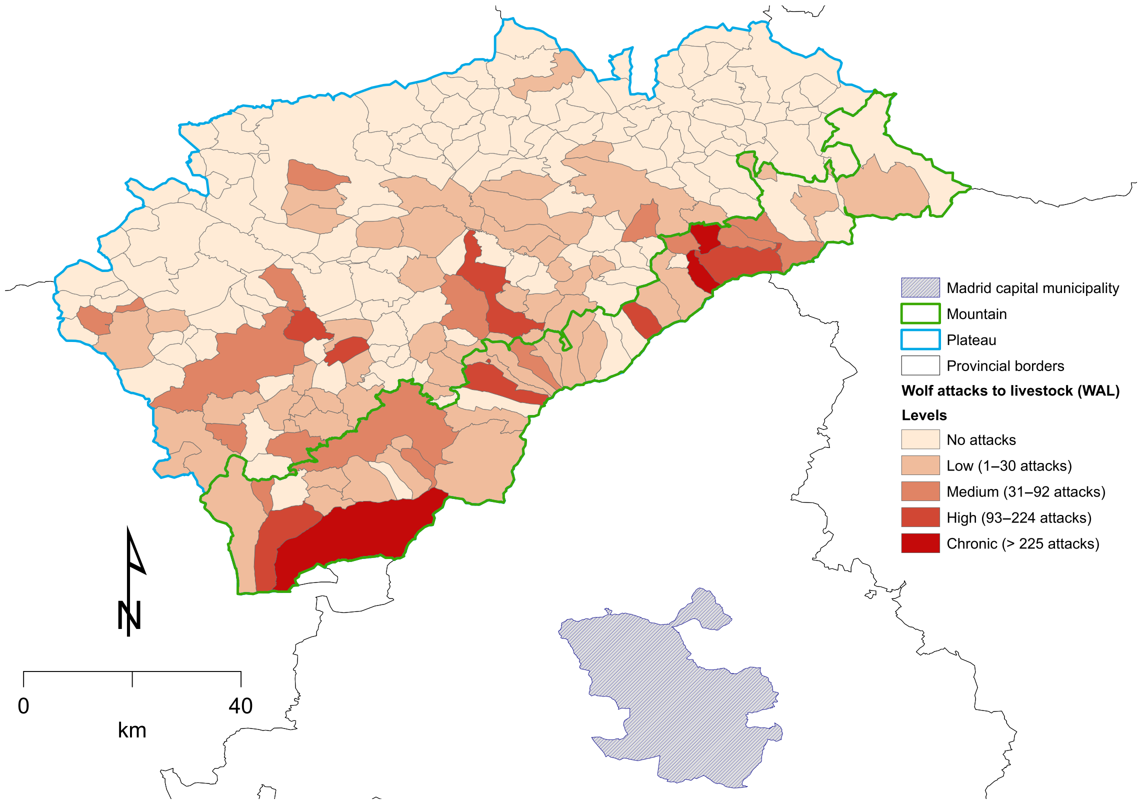

Fig. 1. Wolf attacks on livestock in central Spain by municipality in the province of Segovia, Central Range Mountains of Spain.

medium (31–92), high (93–224) and chronic levels (225–521) (Fig. 1). For each municipality, we collected the density of human population (humans ha^{-1}), area (ha) and elevation (National Geographic Institute, www.ign.es/web/ign/portal). Remote elevated habitats are commonly used by free-grazing livestock and are the main determinant of space use and refuge for wolves in the north of Spain (Llaneza et al. 2012). For livestock, we calculated the density of sheep, goats and cattle (individuals ha^{-1}) independently from the regional census of agriculture.

Historically, overhunting and deforestation have reduced the abundance of wild ungulates and caused livestock to become an alternative prey for wolves (Torres et al. 2015). However, the recovery of natural habitats also increases the abundance of wild ungulates (Arrondo et al. 2019), and a high availability of these prey for wolves could lead to a reduction in the number of WALs (Meriggi & Lovari 1996, Sidorovich et al. 2003). Thus, we calculated the relative density (individuals ha^{-1}) of roe deer and wild boar from hunting bags (Territorial Service of Environment of Segovia), which were only available in 57 of the total of 80 municipalities for roe deer and in 44 municipalities for wild boar. Hunting bags are considered to be a surrogate of ungulate population density (Nowak et al. 2005, Gazzola et al. 2008), so for each municipality, we selected hunting grounds randomly up to a total area equal to 30% of the whole municipality area. We quantified the weighted average of wild ungulate density for each municipality based on the area of hunting grounds that it contained. This method is analogous to the sampling protocol used by the provincial forest rangers, which combines indirect evidence and hunting bags to estimate wild boar population size (Sáez-Royuela & Tellería 1988); it is also similar to Kelker's estimator for direct observation of roe deer (Buckland et al. 2001).

The land-cover variables of importance for the wolf ecology and WALs included urban areas, agricultural land (crops), grasslands, scrub transitions, scrubs, forests, open areas and water (Meriggi & Lovari 1996, Eggermann et al. 2011). We extracted these variables from CORINE 2006 in ArcGIS 10.1 software (Esri, Redlands, CA, USA) to quantify the percentage of each land-cover category per municipality.

Statistical analyses

We conducted preliminary Spearman correlation test analyses to avoid multicollinearity in the independent variables and considered only uncorrelated variables ($|r| \geq 0.7$) for modelling procedures (Hosmer & Lemeshow 2000). To accommodate our data set containing different sample sizes for the ungulate variables, we conducted parallel modelling procedures based on a multimodel inference using the Akaike information criterion with a correction for small sample sizes (AICc) (Burnham & Anderson 2002). We used the full data set including all municipalities ($n = 80$) to test the impact of elevation, livestock abundance (cattle, sheep and goats, independently), land cover and anthropogenic variables on the level of WALs. Elevation was included to identify WAL levels occurring across the altitude range between the plains and the mountains. Variables on livestock density discriminated between different trends of predation on cattle, sheep and goats.

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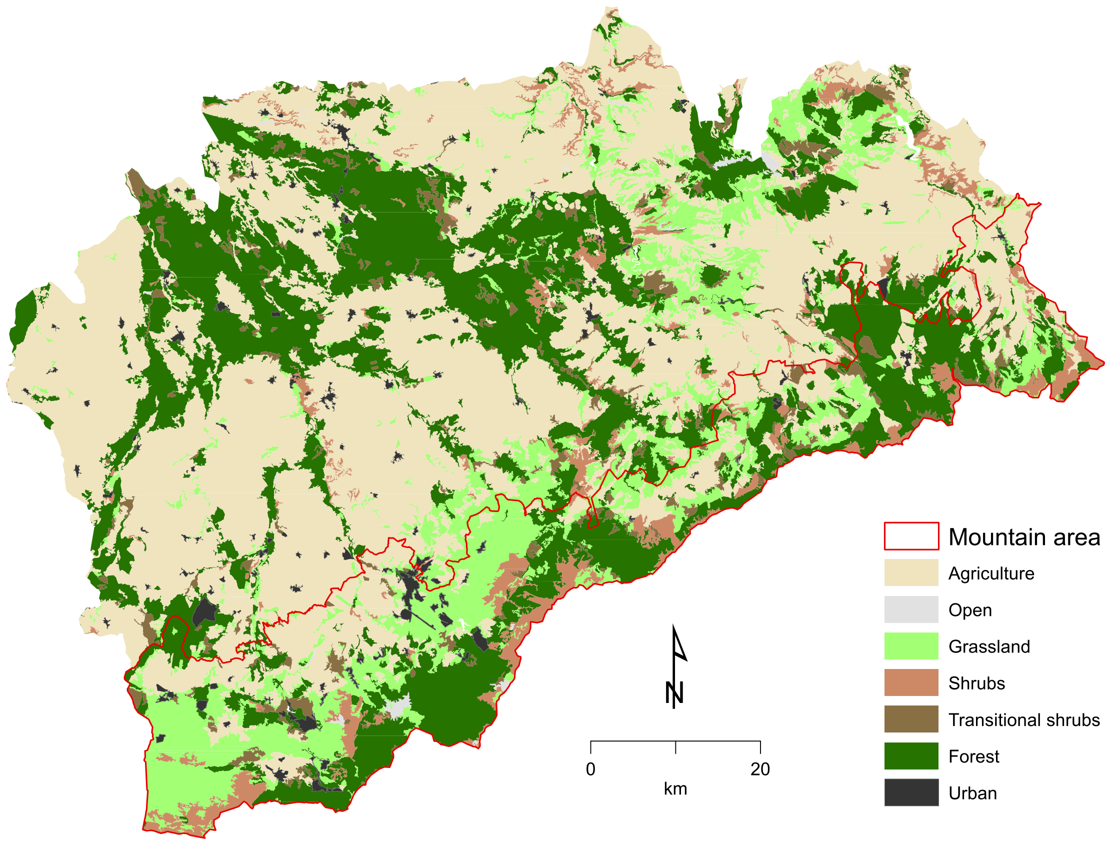

Fig. 2. Land cover and topography of the province of Segovia in the Central Range Mountains of Spain.

Land-cover variables enabled the identification of landscapes where WALs would predominantly occur. Anthropogenic variables identified the influence of humans on the occurrence of WALs. We combined the scaled variables in a set of equations to test alternative ecological hypotheses in accordance with patterns described in the literature and our research objectives. We used ordinal logistic models in the package 'ordinal' (Christensen 2019) of R software (R Core Team 2014) with the WAL levels as the dependent variable.

We then conducted two independent analyses with the subsets of the data sets containing the information on roe deer and wild boar abundance, respectively. For each ungulate species, we ran multi-model inferences of models including the best model(s) selected in the previous step plus roe deer or wild boar independently. We added to the model set a univariate model with only the ungulate variable and models containing livestock and ungulate abundance variables to test for the exclusive importance of prey type (domestic and wild) available in the habitat. This subsequent model inference helped to identify significant patterns of WALs due to the presence of one of these ungulate species exclusively in synergy with livestock or with the variables identified in the best model of the first modelling procedure run with the whole data set. The AIC of identical models tested using different data sets cannot be compared. Therefore, we ensured that the predictive capacity of the best model(s) selected from the whole data set also held for the subset data, equivalent to testing models using an ungulate density variable. We tested the predictive capacity using a Hosmer–Lemeshow test of goodness of fit for categorical logistic models in the package 'generalhoslem' (Jay 2019).

Results

The multi-model selection for the whole data set without the ungulate variables resulted in two plausible models on the frequency of WALs (AICc weights < 2) (Table 1). The averaged model from these two models included elevation, the variables related to livestock and human impact. This model showed a positive relationship of WALs with elevation ($\beta_{altitude} = 0.58 \pm 0.24$ SE) and densities of livestock species ($\beta_{sheep} = 0.05 \pm 0.24$, $\beta_{goat} = 0.02 \pm 0.18$, $\beta_{cattle} = 0.74 \pm 0.23$) and urban features ($\beta_{urban} = 0.82 \pm 0.28$), and negative relationships with human population density ($\beta_{hpop} = -0.78 \pm 0.31$) and agricultural coverage ($\beta_{agri} = -0.11 \pm 0.27$). These relationships were significant ($p < 0.05$) for cattle, elevation, urban features and human population density (Table 2).

A Hosmer–Lemeshow test of the best models indicated non-significant differences between observed and expected values ($p = 0.17$ and $p = 0.21$ for Models 1 and 2, respectively), demonstrating a good fit of the models. The same test was applied on Models 1 and 2, but with the data set including roe deer ($p = 0.63$ and $p = 0.66$ for Models 1 and 2, respectively) and wild boar ($p = 0.41$ and $p = 0.48$ for Models 1 and 2, respectively), which also showed a good fit. Therefore, we considered these two best models as suitable for the multi-model inferences that included roe deer and wild boar data.

The average of the two best models (ΔAICc < 2; Supplementary Table S1, available online) resulting from the model selection using the roe deer subset of the data set included elevation ($\beta_{altitude} = 0.50 \pm 0.24$ SE), livestock species ($\beta_{sheep} = -0.11 \pm 0.26$,

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Table 1. Model selection output for wolf attacks on livestock in central Spain considering the full data set ($n = 80$ municipalities). 'Livestock' depicts the variables on density of cattle, goats and sheep (i.e., cattle + goats + sheep). 'Humans' contains the variables on urban and agricultural land cover (lc) independently and human population density (i.e., urban lc + agricultural lc + human density). 'Natural land cover' groups the lc variables forest, grassland, open natural areas, shrubs and transitional shrubs (i.e., forest + grassland + open + shrubs + transitional). The global model contains all of the variables tested (cattle + goats + sheep + elevation + elevation:cattle + urban lc + agricultural lc + human density + forest + grassland + open + shrubs + transitional).

Rank	Model	AICc	ΔAICc	wAICc
1	Livestock + Elevation + Humans	219.01	0.00	0.49
2	Livestock + Elevation	220.79	1.78	0.20
3	Livestock + Elevation + Humans + Elevation:cattle	221.65	2.64	0.13
4	Elevation	222.74	3.74	0.08
5	Livestock + Elevation:cattle	223.20	4.19	0.06
6	Livestock	225.51	6.50	0.02
7	Null model	227.12	8.11	0.01
8	Humans	227.93	8.92	0.01
9	Livestock + Elevation + Natural land cover	232.64	13.63	0.00
10	Natural land cover	232.96	13.95	0.00
11	Livestock + Elevation:cattle + Natural land cover	235.02	16.02	0.00
12	Global	236.02	17.02	0.00

AICc = Akaike information criterion for small sample sizes; wAICc = AICc weights.

Table 2. Description of the output from the model averaging the most plausible models (ΔAICc < 2) on wolf attacks on livestock in central Spain considering the full data set ($n = 80$ municipalities) (Table 1).

Variable	β	SE	p-value
Cattle	0.740	0.234	<0.001*
Goats	0.023	0.185	0.903
Sheep	0.054	0.254	0.826
Elevation	0.587	0.244	0.016*
Urban land cover	0.822	0.280	0.004*
Agriculture land cover	−0.116	0.271	0.667
Human population density	−0.788	0.318	0.014*

*$p < 0.05$.

$\beta_{goat} = 0.01 \pm 0.18$, $\beta_{cattle} = 0.72 \pm 0.23$) and roe deer density ($\beta_{roe\_deer} = 0.13 \pm 0.26$), with only cattle and elevation showing significance ($p < 0.05$) (Table 3). Elevation and abundance of cattle were the only significant variables associated with WALs. The results from the multi-model inference using the wild boar data set yielded one unique best model (ΔAICc < 2; Table S1) that contained only the variable wild boar, which was positively ($\beta_{wild\_boar} = 0.34 \pm 0.25$) but not significantly associated with WALs (Table 3).

Discussion

Rural abandonment can be viewed as an opportunity for a new paradigm of rural development based on the return of nature and wildlife. Considering the ongoing reform of the CAP for post-2020 and the claimed need to accommodate scientific findings together with human requirements (Pe'er et al. 2019), our results contribute relevant timely information about the recolonization of iconic large carnivores. The Central Iberian Peninsula is an example of a naturally recolonizing wolf population; however, within this region, livestock husbandry is promoted and subsidized

Table 3. Outputs from the most plausible models of wolf attacks on livestock in central Spain considering the partial data sets related to roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) ($n = 57$ and 44 municipalities, respectively).

Model	Variable	β	SE	p-value
Roe deer first model	Cattle	0.746	0.237	0.001*
	Goats	0.008	0.183	0.960
	Sheep	−0.108	0.263	0.670
	Elevation	0.501	0.248	0.044*
	Roe deer	0.088	0.257	0.326
Roe deer second model	Cattle	0.675	0.236	0.004*
	Goats	−0.001	0.180	0.995
	Sheep	−0.122	0.265	0.645
	Roe deer	0.249	0.247	0.312
Wild boar first model	Wild boar	0.343	0.257	0.182

*$p < 0.05$.

by initiatives like the CAP to sustain or increase the rural human population in the face of progressive rural abandonment. Our results show that WALs are not random (see also Blanco et al. 1990) and occur more frequently with increased cattle densities and at higher elevation (Blanco et al. 1990, Meriggi & Lovari 1996, Treves et al. 2004, Gazzola et al. 2008), which are areas of very low human density due to rural abandonment. Conversely, the low frequency of WALs on the plateau was most likely due to the practice of enclosing livestock in stables. Consequently, accessibility to livestock is a key factor in WALs, and more protection and different practices for free-ranging livestock are required in the mountains if this activity should continue to be promoted in the presence of increasing wolf populations. Importantly, we found that the existing abundances of wild ungulates (the same in the plateau and the mountains) did not reduce WALs. Therefore, this factor cannot explain the differences found in the frequency of WALs, and the promotion of livestock farming at high elevations is likely to clash with rewilding initiatives and with the return of large carnivores like the wolf.

Increased urban land cover in elevated areas and a low human population density were also significant drivers of WALs, which could be explained by the reduction of the human population in these areas due to rural abandonment, although the proximity of Madrid promotes the acquisition and use of rural homes as second residences. However, the CAP subsidizes the permanent establishment of rural populations in these areas based on a livestock husbandry economy. Thus, this positive association between WALs and urban land cover is also likely a consequence of the attractiveness of mountains to people and the sustainability of the rural population through traditional activities. Livestock becomes an alternative food resource to wolves due to the scarcity of wild ungulates (Sidorovich et al. 2003, Torres et al. 2015), and a dietary review from 27 countries suggests that, overall, wild prey was selected over abundant livestock (Janeiro-Otero et al. 2020). However, our results showed no association between an increased abundance of wild ungulates and a reduction in WALs (see also Hosseini-Zavarei et al. 2013), suggesting that livestock are not simply targeted in a compensatory manner, and might instead be predated more opportunistically. This highlights the complexity of the system and the need to avoid simplified assumptions about the drivers of WALs. A relevant question would be whether a shift from livestock to wild prey would occur at increased abundance and diversity of the latter, which could facilitate coexistence with wolves (Sidorovich et al. 2003, Llaneza & López-Bao 2015).

The increased WALs in elevated areas may be related to the absence of suitable preventative measures in areas of recolonizing

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wolves where abundant free-grazing livestock are undefended from wolves. There, farmers are likely not prepared to protect livestock after the long absence of wolves and are reluctant to change free-grazing practices (Gazzola et al. 2008, Álvares et al. 2014). Non-existent or unsuitable protection combined with high cattle densities likely result in a higher relative availability of livestock to wolves than wild prey (Blanco et al. 1990, Gazzola et al. 2008, Llaneza & López-Bao 2015). From an optimal foraging perspective, a high WAL incidence could be expected, as livestock are often more profitable and easier to kill than wild prey (Meriggi & Lovari 1996). Because the wolf is a large, opportunistic carnivore that easily adapts to variable local contexts and prey availability (Mech & Boitani 2003), it is capable of trading off potential energy gains with the risk of injury while hunting prey (Meriggi & Lovari 1996, Mech & Boitani 2003). In this sense, the size of the wolf pack is also important because consolidated packs can hunt larger prey, while smaller packs tend to capture easier and smaller prey (Sidorovich et al. 2003, MacNulty et al. 2014). Therefore, even in the presence of suitable wild prey, attacks on livestock might be more beneficial for wolves considering the effort needed to kill and the risk of injury.

Investment in suitable protection measures of domestic animals is essential to decrease wolf attacks under programmes such as the CAP promoting livestock activities. It has been demonstrated that WAL reduction is possible with the implementation of preventative measures, as occurred in Segovia (LIFE COEX 2005–2011). However, these preventative measures are still insufficient and/or inadequate. Improvements in protection should be of particular importance in isolated farms and during periods of particular vulnerability of livestock, such as lambing and calving seasons (Meriggi & Lovari 1996, Álvares et al. 2014). Protecting livestock in enclosures (stabled) or herding with shepherds and dogs is likely to result in a significant reduction of WAL incidents, although these measures that are already applied for sheep in the mountains are cumbersome to implement there for cattle. Livestock often move in pastures away from lowland crops, which might also explain why attacks were more frequent in areas of increased presence of pastures but away from lowland crops (Eggermann et al. 2011). Nowak et al. (2005) identified the efficiency of using trained dogs to protect herds. Other studies suggested preventative measures like night confinement, protective fences (Meriggi & Lovari 1996, Treves et al. 2004), decoy carcasses away from the grazing areas (Hosseini-Zavarei et al. 2013) or avoiding unguarded offspring and grazing in pastures near cowsheds (Álvares et al. 2014).

Our research provides key information for management decision-making to reduce conflicts under different local conditions, which is particularly useful in the early stages of wolf recolonization. This information will guide the development of suitable initiatives to combine long-term conservation of the species with reduced conflicts with humans. Because ecological rewilding is rooted in historical and ecological knowledge (Navarro & Pereira 2015), as conflicting management objectives are pursued (such as those of the CAP and Rewilding Europe), unpredictable conditions will likely arise. Identifying and strengthening common targets between the CAP and rewilding initiatives is required in order to allocate subsidies to shared objectives while avoiding opposing goals. Aichi Target 3 of the agreement in Nagoya adopted by the Convention on Biological Diversity (CBD) states that subsidies harmful to biodiversity should terminate or be reformed. The return of iconic species like the wolf requires promoting a coexistence paradigm that is also supported by an increasing network of protected areas and improving legal protections (Helmer et al. 2015). For a shift towards a coexistence paradigm in the context of rewilding, reforms of the CAP subsidies supported by scientific evidence are required in order to promote alternative management strategies that are able to incorporate farming strategies and opportunities for rewilding, such as the model suggested by Merckx and Pereira (2015) on marginal farming to large-scale rewilding. For our study case, subsidies could focus on sustainable farming of fertile land in the plateau while also promoting rewilding of less productive land to new sustainable economic activities. Meanwhile, farmers of the remaining livestock in mountain areas should implement protection measures such as guard dogs and/or fences (see LIFE COEX), while subsidies should only be granted to farms that guarantee the application of these measures. The reform of the CAP for the post-2020 period could be a new opportunity to shift towards supporting the involvement of rural people in new economic opportunities brought about by rewilding values, including the presence of large carnivores. Activities such as wildlife tourism could be of high value in ensuring the continued presence and protection of recovered populations of large carnivores and their prey (Cerqueira et al. 2015, but see also Wilson & Heberlein 1996, Wolf et al. 2019). In addition to ensuring improved measures of livestock protection, subsidies and the conditions to receive them should also focus on educational schemes, control of feral dogs and incentivizing farmers to accept the presence of large carnivores while also being compensated for damages.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S0376892920000284

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