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# Invisible barriers: Differential sanitary regulations constrain vulture movements across country borders

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ABSTRACT

Political boundaries may represent ecological barriers due to differences in wildlife management policies. In the European Union, it might be expected that these differences should be highly diluted, because all countries have to comply with common directives issued by the European Commission. However, the subsidiarity principle may lead to the uneven uptake of European Union regulations, which can impact on biodiversity conservation due to unequal legislation in neighboring countries, particularly in the case of highly mobile organisms. Here we address this issue, by analyzing how EU regulations issued in response to the Bovine Spongiform Encephalopathy (BSE) crisis differentially affected vulture conservation in Portugal and Spain. Taking advantage of the intensive GPS-tracking of 60 griffon (*Gyps fulvus*) and 11 cinereous vultures (*Aegypius monachus*) from Spain, we found that the Spanish-Portuguese border acts as a quasi-impermeable barrier. In fact, there was an abrupt decline in the number of vulture locations across the Spanish-Portuguese border, with modelling showing that this was unlikely to be related to differences in land cover or topography. Instead, the pattern found was likely due to differences in trophic resource availability, namely carcasses from extensive livestock husbandry, resulting from the differential application of European sanitary legislation regarding the mandatory removal of dead livestock from the field. Overall, our results should be seen as a warning signal to policy makers and conservation managers, highlighting the need for a stronger integration of sanitary and environmental policies at the European level.

## 1. Introduction

Human frontiers are based on political and socio-economic criteria, and seldom have an ecological foundation (López-Hoffman et al., 2010; Dallimer and Strange, 2015). As a consequence, wildlife, especially highly mobile organisms, may encounter different degrees of human impact, disparate conservation regulations, and contrasting environmental policies within otherwise homogeneous ecological regions (Bolger et al., 2008; Perz et al., 2013; Lambertucci et al., 2014; Gervasi et al., 2015). Addressing these differences has been the goal of a range of conservation initiatives, such as international conventions and regulations (e.g., the Bern Convention and the European Habitats and Species Directive). However, undesirable transboundary effects on biodiversity are still common in natural systems and deserve more scientific and management attention.

Transboundary conservation challenges are likely to occur when different countries implement different environmental policies (Gervasi et al., 2015), or when hard borders are planned or implemented, such as the infamous US-Mexico border wall (Cohn, 2007; Lasky et al., 2011). To solve these problems, a number of initiatives have been developed, often based on the creation of transboundary protected areas (Sandwith et al., 2001), or through ambitious projects involving transboundary natural resource management initiatives with wider benefits for conservation and sustainable development (e.g. Wolmer, 2003). It is

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possible; however, that even simple coordination of environmental policies in neighboring countries might achieve significant conservation benefits, thereby avoiding abrupt changes in regulations and practices across borders (Gervasi et al., 2015). In Europe, it might be expected that a high degree of policy integration across countries would achieve such biodiversity conservation benefits, as there are general directives emanating from the European Commission that regulate key issues such agriculture, water management, environmental pollution, and biodiversity conservation itself, among other aspects (Hodge et al., 2015). However, the subsidiarity principle adopted by the European Commission implies that countries, and even regions within countries, have a wide flexibility on how the directives are applied in practice, depending on local policy, socioeconomic and ecological contexts (Kukkala et al., 2016). This may have significant implications for conservation, particularly for migratory or otherwise wide-ranging species, though to the best of our knowledge this idea has never been tested explicitly. However, addressing this issue would be important, because it may help guiding efforts for a better integration across Europe of policies that impact on biodiversity conservation (Sánchez-Fernández et al., 2017).

The bovine spongiform encephalopathy (BSE) crisis provides a unique case study to examine the conservation consequences of the differential uptake across countries of regulations emanating from the European Commission regulations. In 2001, after the BSE crisis, the EU prohibited the abandonment of livestock carcasses in the field (EC 1774/2002; Donázar et al., 2009). The subsequent change in carrion availability resulted in disturbances at different ecological levels, including changes in scavenger communities, disruption of intra-guild relationships, and an increment in $CO_2$ emissions associated with the transport of carcasses to transformation and incineration plants (Morales-Reyes et al., 2015; Cortés-Avizanda et al., 2016). Fortunately, the consensus among scientists and conservation managers led to improved EU legislations (CE 322/2003, CE 830/2005 CE 142/2011; Margalida et al., 2012), which partially reconciled sanitary requirements with biodiversity conservation concerns (Morales-Reyes et al., 2017). Nevertheless, the new legal framework did not establish mandatory guidelines for member states, which are allowed to develop their own regulations concerning livestock carcass disposal. This has resulted in a paradoxical situation where neighboring countries in a continuous ecological region may apply different criteria, as occurs in the Iberian Peninsula. In Spain, home to c. 95% of European vultures (Margalida et al., 2010), the CE 830/2005 made the requirements to dispose carcasses for feeding vultures at authorized feeding points more flexible, and the prohibition on carcass disposal was unofficially lifted. More recently, new European regulations led to the designation of a network of "Protection areas for the feeding of necrophagous species of European interest" (Royal Decree 1632/2011; Morales-Reyes et al., 2017) as an attempt to mitigate food shortage for scavengers and associated environmental costs (Margalida et al., 2010; Morales-Reyes et al., 2015). In contrast, the Portuguese governmental authorities still require livestock breeders to remove dead animals from the field (Decreto-lei 38/2012), with the exception of a few scavenger feeding stations (all located close to the Spanish border) that may be supplied with livestock carcasses under very restrictive licensing conditions (Monteiro et al., 2009).

Here, our main objective was to show that differences in the uptake of EU regulations across countries can impact on biodiversity, using vulture conservation in Portugal and Spain as a case study. Specifically, we wanted to determine how foraging individuals of the two most common Iberian vulture species respond to the asymmetric implementation of EU sanitary regulations, while controlling for potentially confounding factors associated with differences in topography, land cover and livestock density. We took advantage of three GPS-tracking projects, involving two populations of griffon vulture (*Gyps fulvus*) and one of cinereous vulture (*Aegypius monachus*), which provided detailed information on individuals space use in 50-km buffers on each side of the border. Our main prediction is that vultures will avoid the Portuguese territory, where livestock removal from the field has been more rigorous and is still mandatory, thereby resulting in lower food availability.

## 2. Methods

### 2.1. Study area

We focused our analyses on vulture foraging around the Spanish-Portuguese border, which is largely defined by river valleys and is not associated with any abrupt or systematic change in terms of climate, topography or land cover (Clark Labs, 2000; AEMET I., 2011; CEC, 2012). We defined our study area in two steps. First, we established the lateral limits by generating a grid of 10 × 10 km cells over a 50 km buffer on both sides of the border. All cells completely or partially included in the 50 km buffer were considered. Second, we selected 90% of locations inside the buffer strips to exclude accidental non informative locations. This established the northern limit at latitudes 40°30′51″ north and the southern limit at 37°43′06″ north. The result is a study area composed by 445 10 × 10 km cells (Fig. A1), being 22,541.55 $km^2$ (50.7% of the whole study area) in Portugal and 21,958.45 $km^2$ in Spain. Most of the study area is covered by pastures and crops with scattered native trees (mainly *Quercus ilex* and *Q. suber*), a savanna-like landscape called "dehesa" in Spain and "montado" in Portugal. This habitat has been historically managed for livestock (mainly sheep and pig) and agricultural (mainly cereals) purposes (Acácio et al., 2016; Garrido et al., 2017). This combination of human traditional uses with natural vegetation creates a semi-open habitat, which is very favorable for a range of wildlife species (Moreno et al., 2016), particularly for large scavengers (Carrete and Donázar, 2005). In addition, the study area includes vast expanses of shrubland dominated by *Cistus ladanifer* and *Cytisus scoparius*, and commercial plantations of *Eucalyptus* spp., *Pinus pinaster* and *P. pinea*. Extensive livestock husbandry is widespread on both sides of the border, with animals grazing in dehesa/montado woodlands or in more open pastures (Sales-Baptista et al., 2016). There are also wild ungulates on both sides of the border, mainly red deer *Cervus elaphus* and wild boar *Sus scrofa* (Apollonio et al., 2010), which may provide an additional source of carrion to vultures, but there is no information on spatial variation in their abundance.

### 2.2. Vulture GPS tracking

Griffon and cinereous vultures, which are considered as Least Concern and Near Threatened respectively (BirdLife International, 2016, 2017), are the main obligate scavenger species of Europe. Iberian Peninsula hold 90% of European population of both species being much abundant griffon vulture (Margalida et al., 2010) which population is estimated in 24,609 breeding pairs (del Moral, 2009) in Spain and 500–1000 breeding pairs in Portugal (ICNB, 2017). Breeding colonies are widely distributed along the Iberian Peninsula (MAPAMA, 2017; Fig. A2). On the other hand, cinereous vulture colonies are mostly distributed in the western-central sector of the peninsula (Fig. A2) and the population estimate is 1845 breeding pairs in Spain (de la Puente et al., 2007) and 11 breeding pairs in Portugal (ICNB, 2017).

We captured and tagged 30 adult griffon vultures in the Guadalquivir Valley, southern Spain (Fig. A2). These birds were monitored between December 2014 and December 2016 (see Table A1). Another 30 adult griffon vultures were tagged in the Ebro Valley, northern Spain (Fig. A2), and monitored between December 2015 and December 2016 (see Table A1). All birds were captured by cannon nets at baits and equipped with 90 g GPS/GPRS-GSM devices from e-obs digital telemetry (http://www.e-obs.de). Cinereous vultures, 9 fledglings captured at the nest and 2 sub adults trapped by folding net (García-Matarranz, 2011), were tagged in Cabañeros National Park,