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Raptor conservation experts' viewpoints about raptors' contribution to people: a "broken phone game"?

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Research Article

Keywords: Birds of prey, Ecosystem disservices, Ecosystem services, Experts' viewpoints, Human-human conflict, Human-wildlife conflict

Posted Date: August 4th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1922356/v1

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Version of Record: A version of this preprint was published at Frontiers in Bird Science on August 18th, 2026. See the published version at https://doi.org/10.3389/fbirs.2026.1819176.

Abstract

Conservation of predators and scavengers should take advantage of the application of interdisciplinary approaches that connect both ecosystem processes/services and conflicts/disservices. Despite this, there is an overall lack of interdisciplinary research on ecosystem processes/services and conflicts/disservices provided by aerial predators and scavengers like raptors. Our specific goals here are: *i*) to assess the experts' viewpoints on ecosystem processes/services and conflicts/disservices provided by raptors to people and *ii*) to know the main intervention strategies that experts consider effective for managing raptor populations. Through an online survey we obtained 87 surveys for four raptor groups: *hawks and eagles* (40%), *vultures* (29%), *owls* (16%), and *falcons* (15%). Experts agreed that many ecosystem processes/services and only a few conflicts/disservices are provided by raptors to society. Experts indicated that four ecosystem processes/services were provided by all raptor groups (i.e., *vultures*, *falcons*, *hawks and eagles*, and *owls*), and another one was provided by all the predator groups (i.e., all but *vultures*). In contrast, no conflict/disservice was considered to be produced by all groups of raptors. According to experts, *hawks and eagles* were involved in only three conflicts/disservices, *vultures* and *owls* in one, and *falcons* in none. Experts agreed that five strategies are effective for raptor management. Raptor conservation experts' viewpoints were mismatched with evidence from raptor literature and, as we expected, this mismatch was higher when considering conflicts/disservices produced than ecosystem processes/services provided by raptors to people. To successfully promote policies and practices for raptors conservation, experts need to base their viewpoints on raptor literature.

Introduction

Predators and scavengers are connected in contradictory ways to society since on one hand, they providing provide key ecosystem processes/services, and on the other, they cause some unwanted conflicts/disservices (Gilbert et al., 2021). While services may be provided if these species support socially valued activities (e.g., wildlife-related tourism or removal of organic waste), conflicts can arise from social-ecological interactions when socially valued activities interfere with predator and scavenger conservation (e.g., damage to livestock) (Lozano et al., 2019). Ecosystem processes/services and conflicts/disservices have most often been studied either from an ecological or from a social sciences perspective (Dickman, 2010; MEA, 2005). However, today, there are new interdisciplinary approaches which allow a social and ecological integration, which reduce possible disciplinary biases and, thus, improve the management of these species in the wild (Ceauşu et al., 2019; Díaz et al., 2018).

In the last two decades, with the increase of interdisciplinarity in research of human-wildlife relationships, several approaches proposed to integrate ecosystem processes/services and conflicts/disservices provided by wildlife have shown how research on this topic has some disciplinary biases. For instance, several studies with groups of ungulates and terrestrial carnivorous mammals showed that interdisciplinary scientific evidence generated for these species was biased towards conflicts/prejudices studied from a social science approach, while ecological studies focused on the

ecosystem processes/services provided by these groups were much scarcer (Expósito-Granados et al., 2019; Lozano et al., 2019; Pascual-Rico et al., 2021, 2020). This bias, therefore, influences the management measures that are being taken for the conservation of these species in ecosystems shared with humans, therefore, to be awareness of this bias is very important for improving our management of these species in the wild (Pascual-Rico et al., 2021).

Other wildlife groups of predators and scavengers that also provide key ecosystem processes/services and conflicts/disservices to humans are large reptiles and raptors (Donázar et al., 2016; Miranda, 2017; Miranda et al., 2016). Nevertheless, interdisciplinary biases in the management of the contribution to people of these species have not been evaluated yet. The lack of interdisciplinary studies for those groups limits our ability to provide adequate answers and management options in cases where, for instance, species that may cause some particular conflicts/disservices also provide key contributions to humans and, at the same time, are severely threatened by human-wildlife conflicts (e.g., some vutures and endangered eagles; Donázar et al., 2016; McClure et al., 2018).

Historically, raptor researchers have investigated the ecosystem processes/services and conflicts/disservices that raptors provide to humans based primarily from an ecological approach (without considering social or cultural factors; Canney et al., 2021). An ecological approach is useful to rigorously establish the existence of most ecosystem processes/services. But this approach is usually not useful for establishing conflicts/disservices, which must be rigorously assessed from a social approach as well, given the implication of those conflicts for stakeholders with different social, cultural and educational backgrounds. This situation thus involves different perspectives on the problems that may also involve non-tangible social effects that are hard or impossible to measure from a merely ecological view (see Kansky et al., 2016; Redpath et al., 2013). Probably, as a consequence of this historic disciplinary bias towards ecology, in recently published synthesis studies there is the prevailing idea that raptors provide many ecosystem processes/services and few conflicts/disservices to humans (see Carucci et al., 2022; Lambertucci et al., 2021; Michel et al., 2020). Although new social evidence is showing that the number of conflicts/disservices caused by raptors as well as conflicts between people over how to manage raptors in the wild could be also significant (e.g., Hodgson et al., 2019, 2018; Kumar et al., 2019; Redpath et al., 2015; Young et al., 2016; Zuluaga et al., 2022b), it is possible that some raptor conservation experts could still be unaware of such conflicts/disservices or dismiss them as negligible and thus ignore the perspective of other stakeholders (e.g., Carucci et al., 2022; Lambertucci et al., 2021; Michel et al., 2020). The fact that the conflicts/disservices side of human-raptor interactions has rarely been studied from an interdisciplinary focus is relevant, because many of the key ecosystem services that raptors provide to humans today (O'Bryan et al., 2018; Sekercioglu, 2006; Zuluaga et al., 2022a) are threatened by human-raptor conflicts that are difficult to manage from a single-discipline point of view, particularly, when solving those conflicts requires a change in human behaviors and involves several stakeholders (Redpath et al., 2013).

Given the complexity of Anthropocene's problems and of their possible solutions, interdisciplinary expert knowledge is needed to build the highest possible consensus among stakeholders around potential

solutions to the conflicts (Sutherland et al., 2020). Thus, having good scientific knowledge on the ecosystem processes/services and conflicts/disservices associated with raptors is important to experts and managers because the management strategies applied in the field for raptor conservation depends to a large extent on that knowledge. Additionality, it is very important that experts' knowledge about ecosystem processes/services and conflicts/disservices associated with raptors be objective rather than biased (Lozano et al., 2019; Pascual-Rico et al., 2021, 2020). Nowadays, there is an increasing number of interdisciplinary studies that are starting to include social evidence on raptor conservation studies (Hodgson et al., 2019, 2018; Miranda et al., 2021; Redpath et al., 2015; Salom et al., 2021; Young et al., 2016; Zuluaga et al., 2022b). However, likely as a consequence of a historic disciplinary bias towards ecology in the study of human-raptor conflicts, there may be a mismatch between the new social evidence on human-raptor conflicts in literature and the raptor conservation experts' knowledge. Determining whether this mismatch exists could be critical to strengthening interdisciplinarity in raptor conservation (i.e., to improve interdisciplinary raptor conservation practices) because conservation practices must be based on all available scientific knowledge of species. Therefore, our specific goals here are: i) to assess the experts' viewpoints on ecosystem processes/services and conflicts/disservices provide by raptors to people from evidence in literature and ii) to know the main intervention strategies that experts consider effective for managing raptor populations in the long-term.

By considering the different habits and ecological roles of raptor species in ecosystems (Ferguson-Lees and Christie, 2001; McClure et al., 2018), we expect that experts' opinions will support the existence of differences among ecosystem processes/services and conflicts/disservices produced by the different raptor groups (i.e., vultures, hawks & eagles, owls, and falcons). Additionally, considering that conflicts/disservices provided by wildlife to humans are highly influenced by particular socio-ecological contexts and, thus, can occur in limited geographical areas involving different actors and species of raptors (see Arroyo et al., 2004; Donázar et al., 2016; Santangeli et al., 2019; Zuluaga et al., 2022b) we expect to find different viewpoints among experts on two specific widespread conflicts/disservices of raptors regarding their place of residence (e.g., Europe vs. North America or Global North vs. Global South). In addition, we will test the following hypothesis/prediction:

Raptor conservation experts' viewpoints on the conflicts/disservices provided by raptors are mismatched with the current evidence in literature. Ecological science is useful to rigorously establish the existence of most ecosystem processes/services (Díaz et al., 2018; MEA, 2005) but not to identify conflicts/disservices which must be rigorously assessed from a social sciences perspective (Kansky et al., 2016; Redpath et al., 2013). As a consequence of a historic disciplinary bias towards ecology and a delay for most experts in updating their knowledge on the current conflicts/disservices provided by raptors, we predict that raptor conservation experts' viewpoints will be prone to accept more ecosystem processes/services than conflicts/disservices provided by raptors.

Material And Methods

Study species

Raptors are considered a paraphyletic group of 557 extant bird species in the orders Accipitriformes, Falconiformes, Cathartiformes, and Strigiformes which share several morphological and ecological traits (Ferguson-Lees and Christie, 2001; McClure et al., 2018). There are at least four groups of raptors: *vultures*, *hawks & eagles*, *owls*, and *falcons* (McClure et al., 2018). *Vultures* of the old- and new-world (Accipitriformes and Cathartiformes, respectively) are specialized scavengers and, thus, are involved in the removal of organic waste (Grilli et al., 2019). However, *vultures* can occasionally depart from their scavenging habits to injure or kill young livestock and thus generate human-raptor conflicts and subsequently human-human conflicts (Duriez et al., 2019; Manzano-García et al., 2017; Salom et al., 2021; Zuluaga et al., 2020a, 2020b). *Hawks & eagles* and *falcons* (Accipitriformes and Falconiformes, respectively) are specialized predators that hunt live prey at daylight and, thus, can reduce species that cause agricultural damages and species that cause human injury, disease or death (Kross et al., 2018) although some of them (especially some *hawks & eagles*) can be facultative scavengers. Some *hawks & eagles* and *falcons* can also feed on pets, livestock, or game species, thus generating human-raptor conflicts (Miranda et al., 2021; Restrepo-Cardona et al., 2019; Valkama et al., 2005) and subsequent human-human conflicts (Hodgson et al., 2019, 2018; Redpath et al., 2013; Thirgood et al., 2000). *Owls* (Strigiformes) are specialized predators that capture live prey predominantly at night and, thus, can also increase agricultural output and reduce the abundance of species that cause human injury, disease or death (O'Bryan et al., 2018). However, in some areas they are also considered as vermin species and consequently persecuted, even when protected (e.g., Martínez et al., 2006). Also in some societies, *owls* are considered messengers of ill tidings as an omen of death and disaster (Enriquez and Mikkola, 1997; Rashid et al., 2021). Therefore, owls can also generate human-wildlife and human-human conflicts. Raptors can inhabit many habitats, from wild forests to urban ecosystems and migrate, even crossing large tracts of sea between continents, maintaining active links between ecosystems around the earth (Lundberg and Moberg, 2003). For instance, connecting areas to one another through long distance secondary seed dispersal and transference of nutrients (Dean and Milton, 1988; López-Darias and Nogales, 2016; Pérez-Méndez and Rodríguez, 2018; Sekercioglu, 2006).

Data collection

Between 30th September 2019 and 30th January 2020, we led a web-based expert survey including questions on ecosystem processes/services (Table 1), conflicts/disservices (Table 2), strategies for managing raptors in the wild, and socio-demographic and professional development (Table 3). The survey was hosted in Google forms (https://docs.google.com/forms). Our emphasis on ecosystem processes/services (Díaz et al., 2018; MEA, 2005) and conflicts/disservices (Peterson et al., 2010) is because they represent the core areas of interdisciplinarity (see Lozano et al., 2019). We created the survey in English to allow accessibility of the survey to the maximum number of raptor conservation experts around the world. Because we wanted to know the differences among different groups of raptors, we made four separate surveys, one for each one of the main groups of species. Then, following McClure et al., (2018) the considered groups were: *hawks and eagles*, *vultures*, *owls*, and *falcons*. Each survey had roughly the same questions, with the change in the name of the group of raptors and some very specific details for each group to ensure these questions would be clear to participants. On 30th

September 2019, we sent the surveys to the email discussion group of the World Working Group on Birds of Prey and Owls (WWGBP) ‘Raptor Conservation’. This Group includes approximately 1300 subscribers, of around 3000 members around the world (http://www.raptors-international.org/) and promotes communication among professionals working on raptor ecology, biology, medicine, and raptor conservation. The call was also circulated in the Board of the Raptor Research Foundation, in the Asian Raptor Research & Conservation Network and in several raptor Facebook groups. Our target group included people working specifically on raptor conservation. Therefore, using a convenience sampling (see Lute et al., 2018), we asked participants to pass the survey along to their colleagues and regional networks of raptor conservation around the world. In all cases, ethical standards of social surveys were met by informing respondents that their participation was voluntary and that we would ensure their anonymity.

Table 1
Categories of ecosystem processes/services provided by raptors. Classification based on Díaz et al., (2018).

Category of processes/ services	Subcategory	Assessed item	References
Material	Materials, companionship and labor	Provide materials for craft or traditional cultural activities	(Bochenski et al., 2016; Williams et al., 2012)
Non-material	Physical and psychological experience	Ecotourism	(Becker et al., 2005)
	Supporting identities	Intellectual, spiritual, and aesthetic inspiration	(Morelli et al., 2015)
Regulating	Habitat creation and maintenance	Positive effect on other groups of biodiversity	(Sergio et al., 2008, 2005)
	Pollination and dispersal of seeds and other propagules	Primary and secondary seed dispersal	(López-Darias and Nogales, 2016; Pérez-Méndez and Rodríguez, 2018)
		Relevant links among ecosystems	(Lundberg and Moberg, 2003)
	Regulation of detrimental organisms and biological processes	Controlling food webs	(Morales-Reyes et al., 2017)
		Reduce species that cause human injury and death	(O'Bryan et al., 2018)
		Reduce disease risk	(Markandya et al., 2008)
		Remove organic waste	(Grilli et al., 2019)
		Increase agricultural output	(Kross et al., 2018; O'Bryan et al., 2018)

Table 2
Categories of conflicts/disservices provided by raptors. The classification is based on Peterson et al., (2010).

Category of conflict/ disservice	Subcategory	Assessed item	References
Human-raptor	Damage to livestock	Predation on domestic livestock	(Amador-Alcalá et al., 2013; Li et al., 2015)
	Damage to game	Competition with hunters for wild prey	(Valkama et al., 2005)
	Human safety	Risks to human safety	(Curti and Valdez, 2009; Kumar et al., 2019)
	Fear	Fear of raptors	(Enríquez and Rangel-Salazar, 2004)
Human-human	Human disagreements over raptor management	Lack of transparency in decision processes	(Hodgson et al., 2019)
		Mistrust between decision-makers and locals	(Hodgson et al., 2018)
		Misunderstanding among stakeholders	(Redpath et al., 2015)
		Unequal power among stakeholders	(Young et al., 2016)

Table 3
Groups of variables included in the survey of experts with possible answers or type of variable.

Variable groups	Specific item	Possible answers or type of variable
Socio-demographics	Age	Continuous
	Gender	Male / Female / Non binary
	Formal education	Doctor / Master / Bachelor / Bachelor unfinished / High school / Basic school / None
	Country	Nominal
	Continent	South America /North and Central America / Antarctic / Africa / Asia / Europe / Oceania
Experience working with raptor conservation	Years	Continuous
	Continents	South America /North and Central America / Antarctic / Africa / Asia / Europe / Oceania
Ecosystem processes/services	Provide materials for craft or traditional cultural activities	Yes / No
	Ecotourism	
	Intellectual, spiritual, and aesthetic inspiration	
	Positive effect on other groups of biodiversity	
	Primary and secondary seed dispersal	
	Relevant links among ecosystems	
	Controlling Food Webs	
	Reduce species that cause human injury and death	
	Reduce disease risk	
	Remove organic waste	
	Increase agricultural output	
Conflicts/disservices	Predation on livestock and domestic birds	Yes / No

Variable groups	Specific item	Possible answers or type of variable
	Competition with hunters for wild prey	
	Risks to human safety	
	Fear of raptors	
	Lack of transparency in decision processes	
	Mistrust between decision-makers and locals	
	Misunderstanding among stakeholders	
	Unequal power among stakeholders	
Management strategies	Targeted removal of problematic raptors	0 = Not effective 1 = Somewhat effective 2 = Very effective 3 = Not sure.
	Spatial separation of humans and raptors	
	Relocation of people out of raptor habitats	
	Reducing costs associated with raptors through financial tools	
	Legal hunting of raptors	
	Establishing wilderness protected areas	
	Deterring raptors with non-lethal methods	
	Avoiding situations that put people at risk	
	Adopting livestock husbandry that prevents depredation	
	Education programs about raptors	
	Restoration of wild prey populations	
	Involving stakeholders in decision-making	

Variable groups	Specific item	Possible answers or type of variable
	Community-based management	

Questionnaire

The questionnaire consisted of 61 questions, 22 of which were included in this study (Appendix A). To assess characteristics of our sample, we included some questions related to socio-demographic and professional development (i.e., age, gender, education, country of residence, and years of experience). Categories and subcategories on ecosystem processes/services were defined a priori from Díaz et al., (2018), while assessed items were taken from three literature reviews studies on this regard (Donázar et al., 2016; O'Bryan et al., 2018; Sekercioglu, 2006) and reviewing the cited bibliography of these papers. We also reviewed recent papers citing those three literature reviews studies to add additional subcategories on ecosystem processes/services not found in our initial searches. This search was made in Google Scholar (www.scholar.google.com). In this rapid evidence assessment, we found bibliographic references supporting eleven ecosystem processes/services (Table 1). The categories on conflicts/disservices were defined a priori from Peterson et al., (2010), while the subcategories and assessed items were taken from an assessment of terrestrial carnivores by Lute et al., (2018). We used this already established list of conflicts/disservices in order to have a more standardized number of items to assess given that currently there are no review studies covering all the conflicts/disservices involving raptors. Considering those categories and subcategories on conflicts/disservices from Peterson et al., (2010), we performed a scientific bibliographic search of articles published on raptors between 2000 and 2020, in Google Scholar (www.scholar.google.com) using different combination of the words: "conflict", "disservice", and "persecution" with "raptor", "birds of prey", "vulture" "owl", and "human-raptor". We reviewed the first 1000 outcomes of the search in Google Scholar, but when the number of outcomes were less than this value, we reviewed all outcomes obtained. We also reviewed the cited bibliography of the papers to add additional items not found in our initial searches. We considered all subcategories with evidence to at least a raptor species (e.g., in the case of some human-human conflicts currently associated with only a species). In this search, we found evidence of conflicts/disservices provided by raptors within all the eight subcategories assessed by Lute et al., (2018) for carnivores (Tables 2). Questions related to the efficacy of strategies for managing raptors in the wild (Table 3) were adapted to raptors from a similar assessment done previously by Lute et al., (2018) also for terrestrial carnivores.

Before sending the survey to the WWGBP e-mail list, we conducted a pilot survey among colleagues working in conservation with several raptor groups to check for potential problems with the survey and to get feedback from them regarding any potential necessary adjustments or unclear details. The dataset used in this study is provided in the Supporting Material (Appendix A).

Statistical analyses

Descriptive statistics were calculated using R 3.6.3 (R Development Core Team, 2014). To examine consensus among experts on the ecosystem processes/services and conflicts/disservices provided by raptors we estimated the percentage of experts (and standard error; *hereafter* SE) who agreed with each statement. Potential for Conflict Index$_2$ (PCI$_2$; https://sites.warnercnr.colostate.edu/jerryv/) was used to examine consensus in the efficacy of strategies for governing trade-offs in ecosystem processes/services and conflicts/disservices (Lute et al., 2018). The PCI$_2$ assesses the degree of consensus or disagreement, in multinomial variables, with a response scale that ranges between 0 and 1 (where complete consensus is 0, when all respondents provide the exact same response on a response scale [e.g., 100% strongly agree], and the least amount of consensus is 1, when responses are equally divided between the two extreme values on a response scale [e.g., 50% strongly disagree and strongly agree, respectively]) (Vaske et al., 2010). Finally, we assessed differences in respect to the percentage of agreement between experts on two conflicts/disservices generated by raptors such as *competition with hunters for wild prey* and *predation on domestic livestock.* Then, we first compared the agreement between experts on two conflicts/disservices: *i*) between the Global North (i.e., Europe, Canada and United States of America) vs. the Global South (i.e., the remaining countries) and second *ii*) within the Global North (i.e., Europe vs. Canada and United States of America).

Results

Participants

We obtained 87 completed surveys (from 76 participants): *hawks & eagles* (40%, 35 of 87), *vultures* (29%, 25 of 87), *owls* (16%, 14 of 87), and *falcons* (15%, 13 of 87). The 76 participants were from 31 different countries and 6 continents (38.2% of North and Central America, 30.3% of Europe, 17% of South America, 6.6%Africa, 5.3% of Asia, and 2.6% of Oceania; Fig. 1). Some of the participants (26%; 20 of 76) had worked on raptor conservation on at least two continents. Of these 20 participants, 15% had worked in raptor conservation on three continents and 5% on four continents. Of the 76 participants, 91% completed a survey for a single raptor group, 6.4% completed surveys for two groups, and 1.3% completed them for three and four raptor groups, respectively.

The majority of participants were males (70%, 53 of 76) followed by females (29%, 22 of 76) and one non-binary sex person. The mean age was 46 years (range 23–77). Half of 76 participants had a Ph.D., 26% had a Master’s degree, 17% had a Bachelor's degree, and the remaining 7% was between middle school and unfinished college education. The majority of participants (55%) had more than 10 years of experience working on raptor conservation, 25% (19 of 76) had between 5 and 10 years, and the rest (20%, 15 of 76) had between 1 and 5 years.

Points of view of experts on raptor´s contribution to people

Ecosystem processes/services. Four ecosystem processes/services were attributed to all raptor groups (experts agreement’s range): *ecotourism* (57–86%); *intellectual, spiritual, and aesthetic inspiration* (56–

79%); *positive effect on other groups of biodiversity* (68–86%); and *relevant links among ecosystems* (60–85%). Most experts considered that all raptor groups, except *vultures*, contribute to *controlling food webs* (range = 69–80% without *vultures*). *Reduce disease risk* was considered an ecosystem processes/services provided by *vultures* (96%, SE = 4) and *owls* (64%, SE = 13). R*emove organic waste* was an exclusive ecosystem processes/services attributed to *vultures* (92%, SE = 5.5). *Reduce species that cause human injury and death* (57%, SE = 13.7) as well as *increase agricultural output* (64%, SE = 13) were exclusively attributed to *owls*. Most raptor experts disagreed that any group of raptors could p*rovide materials for craft or traditional cultural activities* (range = 21.4–40%) and that they may play a role in *primary and secondary seed dispersal* (range = 7–17%). For most experts, *owls* were the group of raptors that provided more ecosystem processes/services (73%, 8 of 11), followed by *vultures* (55%, 6 of 11), and finally *falcons* and *hawk & eagles* (45%, 5 of 11 in both cases) (Fig. 2a).

Conflicts/disservices. None of the conflicts/disservices assessed was considered to be generated by more than one raptor group. *Hawk & eagles* were involved in three conflicts/disservices: *predation on domestic livestock* (63%, SE = 8), *competition with hunters by wild prey* (54%, SE = 8.5), and *mistrust between decision-makers and locals* (51%, SE = 8.6). According to experts, *Vultures and owls* were involved in one conflict/disservice each: *misunderstanding among stakeholders* over *vultures'* management (56%, SE = 10) and *fear of owls* (71%, SE = 12.5). Experts thought that *Falcons* were not involved in any conflict/disservice (range = 15–46%). Most experts agreed that no raptor group was involved in three of the conflicts/disservices categories, these were: u*nequal power among stakeholders* (range = 21–38.5%), *lack of transparency in decision processes* (range = 7–40%), and r*isks to human safety* (range = 8–31%). Experts identified *hawk & eagles* as the group of raptors that provided more conflicts/disservices (37.5%, 3 of 8), followed by *vultures* and *owls* (12.5%, 1 of 8 in both cases) and finally by *falcons* (0%, 0 of 8) (Fig. 2b).

Effects of experts' geographical origin. We found differences in expert agreement between the Global North and the Global South and within the Global North. While most experts of the Global South (64%; 7 of 11) agreed that *vultures* were involved in *livestock damage*, only a minority of experts of the Global North agreed (36%; 5 of 14). Raptor experts from Europe agreed that falcons (83.3%; 5 of 6) and *owls* (66.7%; 2 of 3) are involved in *competition with hunters for wild prey*, but no experts from North America agreed with that (0%; 0 of 6 for *falcons* and *owls*).

Efficacy of strategies for managing raptors in the wild

Experts agreed (mean PCI_2 = 0.37, range = 0.17–0.55) that five strategies are effective for governing trade-offs in ecosystem processes/services and conflicts/disservices produced by raptor groups (Fig. 3). These were: *restoration of wild prey populations, involving stakeholders in decision-making, establishing wilderness protected areas, education programs about raptors*, and *community-based management.* Experts agreed that *adopting livestock husbandry that prevents depredation* is an effective strategy for most raptor groups except *owls* (mean PCI_2 = 0.46, range = 0.35–0.60). In the case of *hawks & eagles*, r*educing costs associated with raptors through financial tools* was to be an effective way of

reducing conflicts (PCI_2 = 0.53). Almost half of the proposed strategies (46%, 6 of 13) were considered ineffective for managing raptors in the wild, these were: *targeted removal of problematic raptors, spatial separation of humans and raptors, relocation of people out of raptor habitats, legal hunting of raptors, deterring raptors with non-lethal methods, and avoiding situations that put people at risk* (mean PCI_2 = 0.34, range = 0—0.56).

Discussion

Our results showed that most experts agreed that raptors provide many ecosystem processes/services and cause only a few conflicts/disservices to society. According to the experts, four ecosystem processes/services were common for all raptor groups (i.e., vultures, falcons, hawks & eagles, and owls), and another one was provided by all the predator groups (i.e., all but vultures). In contrast, from the experts' viewpoints, no conflict/disservice was common to two groups of raptors. *Hawks & eagles* were involved in only three conflicts/disservices, *vultures* and *owls* in another and *falcons* in none. There was a consensus among experts that five of the 13 strategies assessed were effective for managing raptor populations in the wild long-term.

As we predicted, raptor conservation experts' viewpoints were more prone to accept ecosystem processes/services than conflicts/disservices provided by raptors to people. This is probably the result of the long-term reliance of raptor researchers on the study of ecosystem processes/services and conflicts/disservices of raptors from an ecological science perspective, which is a good tool to rigorously establish most ecosystem processes/services but not the conflicts/disservices. In order to rigorously establish the conflicts/disservices, both ecological and social sciences must be considered when assessing the tangible as well as the non-tangible costs of these human-raptor interactions, and their implications for stakeholders (see Kansky et al., 2016; Redpath et al., 2013). Further, considering that conflicts/disservices usually have a restricted geographical occurrence determined by particular socio-ecological contexts, they can be very difficult to quantify and solve from a strictly ecological approach, while ignoring social approaches (IUCN, 2020; Redpath et al., 2013). Thus, experts working on raptor conservation need to adjust their viewpoints taking into account the social evidence available in the literature that shows that conflicts over raptor management as *unequal power among stakeholders* (Young et al., 2016) and *lack of transparency in decision processes* (Hodgson et al., 2019) or disservices generated by raptors as *risks to human safety* (Curti and Valdez, 2009; Kumar et al., 2019) exist and could be more important than previously thought. Acknowledging this can help experts better manage raptors in the wild, in the sense that they could find answers, and possible solutions, to conservation problems that may not make sense from the ecological science's lens (Lischka et al., 2018).

Despite availability of empirical evidence in the published literature related to some ecosystem processes/services that raptors provide to humans, most experts considered that two of these were not associated with any group of raptors. The ecosystem processes/services being unnoticed by most experts were: *provide materials for craft or traditional cultural activities* and *primary and secondary seed dispersal.* Probably, because raptors are more associated by experts with their ecological role as

predators and scavengers, the *provision of materials for craft or traditional cultural activities* or the raptor's capacity for primary and secondary dispersal of seeds could have been overlooked. In the case of *providing materials for craft or traditional cultural activities*, it is an ecosystem service in the material category, which also has a strong social component which experts could have failed to recognize. In the case of *primary and secondary seed dispersal*, it is very curious that despite the historic and current ecological evidence on this ecosystem process/service provided by raptors (see Dean and Milton, 1988; Fitzsimons and Leighton, 2021; Galetti and Guimarães, 2004), it was the least accepted by the experts for all group of raptors (i.e., only among 7–17% of experts accepted that some of the raptor groups were involved in this service). Thus, there is probably a "broken phone" between the empirical evidence in the published literature and the raptor conservation experts' viewpoints at least with respect to the latter ecological issue and some of the above mentioned conflict/disservices.

When human-raptor conflicts are wrongly managed, they can transcend to more difficult-to-manage human-human conflicts over raptor management and thus the effective management of raptors in the wild might be jeopardize (Redpath et al., 2015). Although our results show that experts marginally disagree that vultures are involved in predation on livestock (i.e., slightly less than half of experts agreed; 48% SD = 10.2) at the global level, they agree that there is *misunderstanding among stakeholders* over *vulture* management. Because it is very probable that there is a link between the two conflicts, we consider that overlooking the conflicts/disservices that *vulture* species provide can exacerbate human-vulture conflicts (e.g., *predation on domestic livestock*) triggering human-human conflicts (e.g., *misunderstanding among stakeholder*; Cailly-Arnulphi et al., 2017; Grande et al., 2018; Manzano-García et al., 2017; Salom et al., 2021; Zuluaga et al., 2020b). Thus, as suggested before, we highlight the importance of recognizing the existence specific human-vulture conflict, although this may be rare and not always easy to quantify or understand from an ecological approach. It also may be geographically more limited than the key ecosystem processes/services that *vultures* provide. This could be the first step to better address human-vulture conflicts and avoid the subsequent human-human conflicts (Zuluaga et al., 2020a, 2020b). The minimization, omission or denial of the existence of a human-vulture conflict (Ballejo et al., 2020; Estrada-Pacheco et al., 2020) in areas where local communities have historically expressed its existence (Cailly-Arnulphi et al., 2017; Manzano-García et al., 2017; Salom et al., 2021) would make *in situ* management even more difficult to raptors conservation experts (Zuluaga et al., 2020a, 2020b).

Effective raptor management would help maintain key ecosystem processes, while avoiding cascading ecological effects that could have very negative implications for humanity (e.g., rise in disease transmission), while ineffective management could accelerate the loss of raptor populations and species and the key processes/services in which they are involved (Markandya et al., 2008). As a prerequisite to effective management, we should involve all local stakeholder groups and consider all the processes/services and conflicts/prejudices that raptors provide (Ceauşu et al., 2019). Our results showed that the toolbox of effective strategies for managing raptors is wide and experts highly agreed (i.e., low values of PCI_2) that strategies such as *involving stakeholders in decision-making* and *community-based management* are effective for all groups of raptors. Although these strategies require

interdisciplinary teams in contrast with other government-based strategies (e.g., *restoration of wild prey populations, establishing wilderness protected areas, education programs about raptors, adopting livestock husbandry that prevents depredation*, and *reducing costs associated with raptors through financial tools*). Those could also have better results in the mid- to long-term by involving all stakeholder groups, as has been demonstrated for some terrestrial predators (e.g., Salvatori et al., 2021; Young et al., 2021). However, these strategies also should be systematically evaluated with raptors in order to be sure they can have good conservation results in different socio-ecological contexts.

In order to effectively plan and manage the conflicts/disservices in which raptors are involved worldwide, spatial variability also should be considered and assessed. Our results showed that where the experts live has an influence on their viewpoints regarding some conflicts/disservices in the category of human-raptor conflict. In agreement with the literature, none of the North American experts considers that *hawks and eagles* or *owls* are involved in *competition with hunters for wild prey*, while most of the European experts agreed that they are indeed involved in this conflict/disservice. In the case of *predation of livestock and domestic birds*, experts agree that only *hawks and eagles* are involved in this conflict/disservice at a global level, however, based on the literature, there is evidence that *vultures*, *owls* and *hawks and eagles* may be involved in these conflicts/disservices as well, at least on some continents (Amador-Alcalá et al., 2013; Li et al., 2015; Manzano-García et al., 2017; Nyirenda et al., 2017). In support of this, we find that most experts from the Global South consider *vultures* to be involved in this conflict/disservice, while most experts from the Global North did not consider it. In the case of the conflicts/disservices in the category of human-human conflicts, although these have been mainly assessed and associated to only a few species and socio-ecological contexts in the Global North, this does not mean that these are so limited but rather that they have not been assessed rigorously in the contexts of the Global South. For instance, in a current study, we found that human disagreements over environmental management is an important driver of conflict with the Black-and-chestnut eagle (*Spizaetus isidori*) in at least two countries of the Tropical Andean Montane Forest in South America (Zuluaga et al., 2022b). Therefore, experts should be cautious when generalizing the idea that raptors are not involved in a certain human-raptor or human-human conflict or that human-raptor conflicts are negligible (e.g., these involving new world vultures) without rigorous social and ecological evidence on larger spatial scales.

Our results suggest that raptor conservation experts need to adjust their viewpoints based on the current evidence in literature on conflicts/disservices but also on ecosystem processes/services that raptors provide to people since conservation practices must be based on all available social and ecological scientific knowledge of species. If most experts do not make this adjustment, but rather keep their single-discipline focus, attempts to implement strategies to increase human tolerance towards raptors (i.e., to turn human-raptor conflict into coexistence) will be jeopardized. When experts minimize the social importance of conflicts/disservices of raptors, they lose objectivity and raise barriers to raptor conservation, such as in the cases where human-raptor conflicts transcend to human-human conflicts that are certainly more difficult to manage. Interdisciplinary frameworks such as the unified Social-Ecological framework of Ecosystem Disservices and Services (SEEDS) could be a very useful tool to

guide raptor conservation experts to this purpose. With the application of the SEEDS, for example, raptor conservation experts could rigorously establish the existence of all ecosystem processes/services and conflicts/disservices involving raptors as well the stakeholders in each socio-ecological context and thus improve their management (Ceauşu et al., 2019).

Conclusion

The results of this study make the first significant contribution to understanding how the viewpoints of raptor conservation experts on the ecosystem processes/services and conflicts/disservices that raptors provide to humans omit social but also ecological evidence from the literature. Nowadays, experts tend to accept to a lesser extent the existence of conflicts/disservices caused by raptors than the ecosystem processes/services they provide to people. However, to successfully save raptors in the wild, experts need to adjust this mismatch of knowledge in their viewpoints with the social and ecological evidence in literature. Through interdisciplinary approaches, experts could integrate both ecosystem processes/services and conflicts/disservices of raptors in a more objective way while involving stakeholders in social and environmental decision-making to save raptors in the wild.

Declarations

Consent: Authors got participant consent of all interviewers by informing them that their participation in the study was voluntary and that we would ensure their anonymity if they want to participate in it.

Acknowledgments

We want to specially thank each one of the 76 expert interviewees for their kind participation that made this study possible. I.M. Luque Romero, A.S. Costan and M.S. Liébana kindly helped us test the online survey. Thanks to Marta Curti for English proofreading and Markus Jais for voluntarily sharing our online questionnaire on his website “European Raptors: Biology and Conservation”. Santiago Zuluaga wrote this paper while funded by doctoral grants from CONICET, The Peregrine Fund, and Fundación Proyecto Águila Crestada-Colombia.

Conflict of Interest

The authors have no financial or non-financial competing interests to declare.

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Appendix A

Appendix A is not available with this version.

Figures

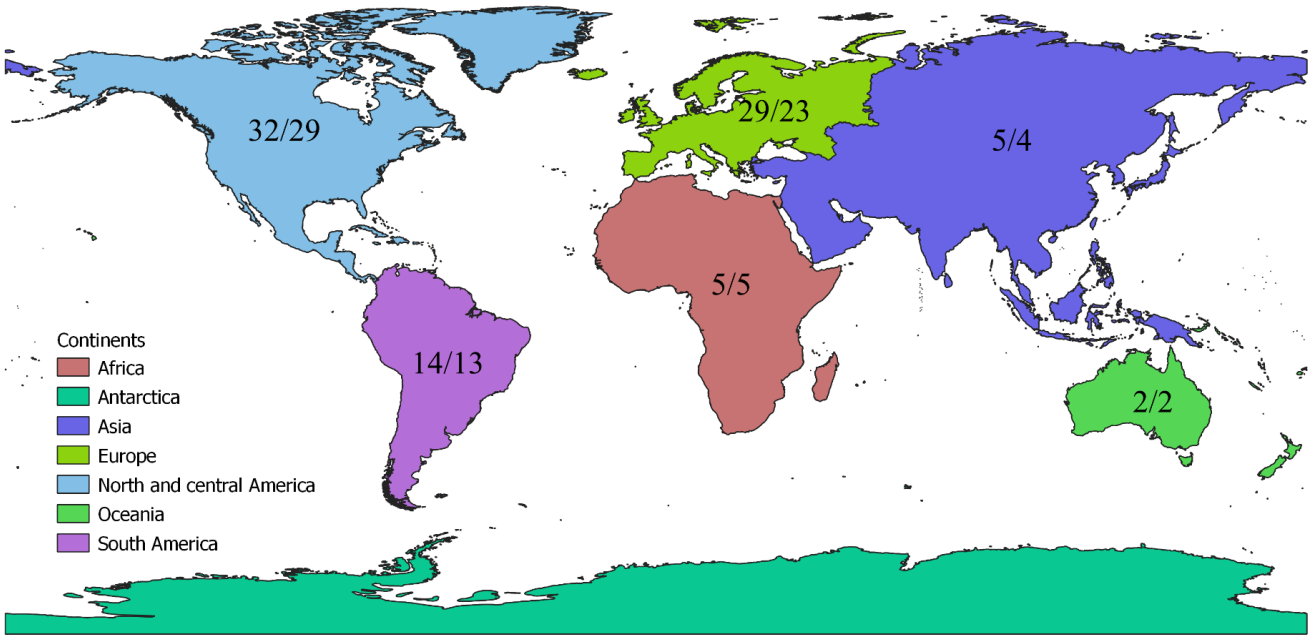


Figure 1

Map showing raptor conservation experts by continent of residence. Number of surveys/number experts are shown.

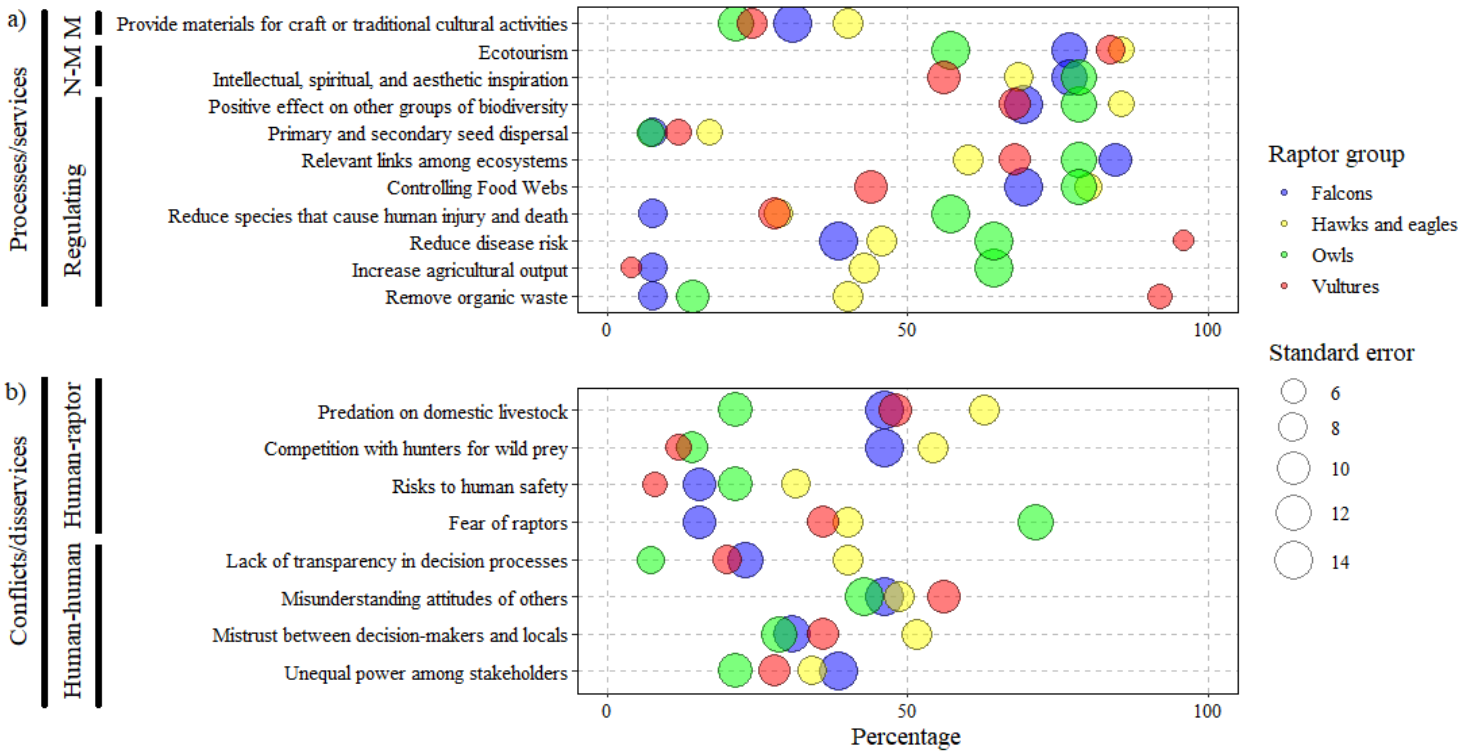


Figure 2

Percentage of participants that agreed with the questions for three topics: (a) Ecosystem processes/services and (b) Conflicts/disservices. Percentages above 50% indicate overall agreement whereas values below 50% indicate overall disagreement. Because responses were binary, standard errors are shown to illustrate variation in responses. **M**: Material **N-M**: Non-Material

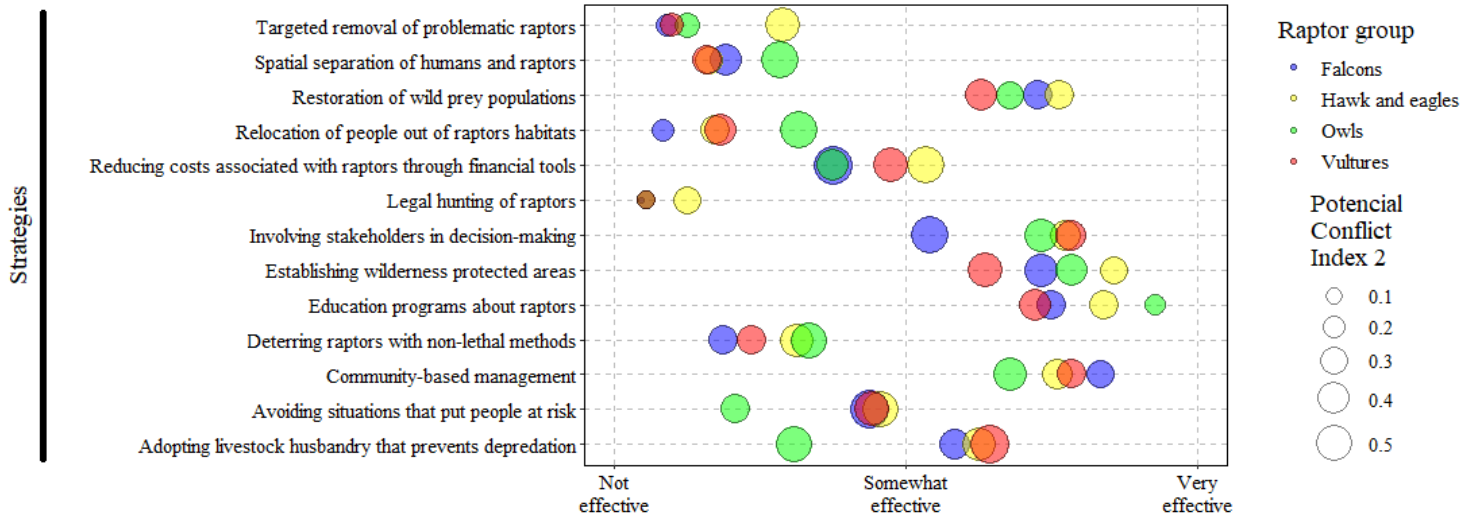


Figure 3

Strategy efficacy for reducing detrimental Nature's Contribution to People (NCP). Effectiveness values calculated from 87 participants for various strategies. Responses to these questions were: not effective (0), somewhat effective (1), or very effective (2). The response 'not sure' was omitted from the analysis.

Effectiveness values over 1 indicate that participants overall believed a strategy to be effective whereas values below 1 indicate an overall belief that a strategy is not effective. Bubble size illustrates the relative magnitude in PCI2 values, ranging from 0 (complete consensus) to 1 (no consensus), among the survey items of this block.