LIFE SAFE FOR VULTURES

# Quantifying the regulation and cultural ecosystem services associated to Griffon Vultures in Sardinia, Italy

2024


*Autors:*
**Andrea Santangeli**[1]
**Ilaria Fozzi**[2]
**Davide De Rosa**[2]
**Mauro Aresu**[3]
**Alfonso Campus**[2]
**Marco Muzzeddu**[4]
**Dionigi Secci**[4]
**Jacopo Cerri**[2]
**Fiammetta Berlinguer**[2]



Data presented in the report are published in the original article "Quantifying the regulation and cultural ecosystem services associated with Griffon Vultures Gyps fulvus in Sardinia, Italy" Andrea Santangeli, Ilaria Fozzi, Davide De Rosa, Mauro Aresu, Alfonso Campus, Marco Muzzeddu, Dionigi Secci, Jacopo Cerri and Fiammetta Berlinguer. Published in Bird Conservation International on 20 November 2024. Doi http://dx.doi.org/10.1016/j.biocon.2024.110870


**Associated BeneficiariesCommunity**


**LIFE19/NAT/IT/000732 Life Safe for Vultures**
First step to the restoration of the vulture guild in Sardinia

**www.lifesafeforvultures.eu**
With the contribution of the LIFE financial instrument of the European Community



**Coordinating Beneficiary** Università degli Studi di Sassari | Via Vienna 2 | 07100, Sassari | mail: lifeforvultures@uniss.it | tel: +39 079 229904

# Summary

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

In the Anthropocene, recognizing nature's role in human well-being is pivotal for biodiversity conservation. Despite their significance, knowledge gaps persist regarding ecosystem services, even for well-studied species like vultures. Our study focuses on the Griffon Vulture (*Gyps fulvus)* in Sardinia, Italy, exploring their cultural and regulating services, including carcass disposaland resulting greenhouse gas mitigation. Through surveys of natural reserve visitors and data on carcass provision and greenhouse gas emissions, we assess public perception, economic value, and environmental impacts associated to vultures. The public perception of Griffon Vultures is predominantly positive, with a strong acknowledgment of their role in disease prevention and carcass disposal, highlighting their contribution to regulation services. Furthermore, vultures are widely recognized as key element characterizing agropastoral landscapes of Sardinia, underscoring their cultural importance. The economic evaluation, through willingness to pay for vulture-watching and photography opportunities indicates a significant appreciation of these birds, with almost three quarters of respondents willing to pay an entrance fee for vulture observation sites. We also show that supplanting the disposal role of vultures at studied feeding sites (during 2017-2022) would result in the emission of 96 tons of $CO_2$ equivalent, highlights the critical role of vultures in climate mitigation. This study not only sheds light on the ecological and cultural significance of Griffon Vultures in Sardinia but also underscores the economic and environmental benefits of their conservation. It emphasizes the need for continued efforts in vulture conservation, integrating ecological, cultural, and economic perspectives to foster sustainable coexistence between humans and wildlife.

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

# Abstract

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

**Nell'Antropocene riconoscere il ruolo della natura nel benessere umano è fondamentale per tutelare la biodiversità. Nonostante la loro importanza, persistono lacune nella conoscenza dei servizi ecosistemici, anche per specie ben studiate come gli avvoltoi. Il presente studio si concentra sul grifone (*Gyps fulvus*) in Sardegna, Italia, ed esplora i suoi servizi culturali e di contributo all'equilibrio dell'ambiente, tra cui lo smaltimento delle carcasse e la conseguente mitigazione dei gas serra. Attraverso indagini condotte sui visitatori delle riserve naturali e la raccolta di dati sulla fornitura di carcasse e sulle emissioni di gas serra, lo studio ha valutato la percezione pubblica, il valore economico e l'impatto ambientale associato agli avvoltoi. La percezione pubblica dei grifoni è risultata prevalentemente positiva, con un forte riconoscimento del loro ruolo nella prevenzione delle malattie e nello smaltimento delle carcasse e una consapevolezza del loro contributo ai servizi ecosistemici. Inoltre, gli avvoltoi sono ampiamente riconosciuti come elemento caratteristico dei paesaggi agropastorali della Sardegna, sottolineando la loro importanza culturale. La valutazione economica, effettuata attraverso la propensione al pagamento per poter osservare e fotografare gli avvoltoi, indica un significativo apprezzamento di questi volatili, con quasi tre quarti degli intervistati disposti a pagare un biglietto d'ingresso per i siti di osservazione degli avvoltoi.**

**È stato inoltre dimostrato che l'assenza del ruolo di smaltimento effettuato dagli avvoltoi nei siti di alimentazione studiati (nel periodo 2017-2022) comporterebbe l'emissione di 96 tonnellate di $CO_2$, evidenziando il loro ruolo cruciale nella mitigazione del clima. Questo studio non solo mette in luce l'importanza ecosistemica e culturale dei grifoni in Sardegna, ma sottolinea anche i benefici economici e ambientali della loro conservazione. Tutto ciò evidenzia la necessità di continuare a impegnarsi nella conservazione degli avvoltoi, integrando prospettive ecologiche, culturali ed economiche per favorire una coesistenza sostenibile tra l'uomo e la fauna selvatica.**

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

# Introduction

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

Nature's contribution to people (i.e. ecosystem services) is nowadays recognised as a main pillar for biodiversity conservation, because of their profound implications for environmental management and policy (Daily and Matson 2008, Geijzendorffer et al. 2017, IPBES 2019). Typically, ecosystem services refer to the various benefits that humans obtain from ecosystems, which can be categorized into three main groups: provisioning, regulation/maintenance, and cultural (Haines-Young and Potschin-Young 2018). Provisioning services are direct products obtained from ecosystems, such as food, water, raw materials, and medicinal plants, which fulfil human needs for sustenance and economic activities. Regulation and maintenance services involve the ecological processes that contribute to the overall balance and stability of ecosystems. These services include climate regulation, water purification, pollination, and disease control, which ensure the health and resilience of ecosystems. Cultural services encompass the non-material benefits that ecosystems provide to humans, including aesthetic, spiritual, educational, and recreational values. These services contribute to the cultural identity, inspiration, and overall well-being of humans.

Birds play a vital role in maintaining ecological balance, conserving biodiversity, and enhancing human well-being (Sekercioglu et al. 2016). As such, birds are often associated with key ecosystem services, including pollination for plant reproduction, natural pest control by feeding on insects, and seed dispersal that supports biodiversity and ecosystem regeneration. Birds also hold a cultural value, symbolizing freedom, beauty, and connection to nature, contributing to recreational opportunities and ecotourism (Becker et al. 2005, Moleón et al. 2014, Gupta et al. 2020, García-Jiménez et al. 2022). Their role in controlling insect-borne diseases, such as mosquitoes, benefits both wildlife and humans (Sekercioglu et al. 2016). Additionally, the presence of birds in the environment enriches the cultural heritage through folklore, art, and traditional practices.

Old and New World vultures play a crucial role in maintaining the ecosystem's health (Gangoso et al. 2013, Mateo-Tomás et al. 2017, Craig et al. 2018, Morales-Reyes et al. 2018, Grilli et al. 2019, Plaza et al. 2020, Berlinguer et al. 2021). Being the only obligate scavengers among vertebrate, they efficiently remove carrion, curbing disease spread and reducing the potential for pathogen proliferation, impacting both wildlife and domestic animals (Plaza et al. 2020, Berlinguer et al. 2021). Beyond disease control, vultures contribute to waste reduction by consuming animal remains, and therefore prevent the release of greenhouse gases and aid nutrient cycling (Morales-Reyes et al. 2015). In addition to their ecological contributions, vultures hold cultural significance, associated with death and rebirth in

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

some cultures, enriching the spiritual identity of communities (Van Dooren 2012). These birds are also central to ecotourism in several regions, providing economic benefits to local communities and raising awareness about vulture conservation and their broader ecological services (Becker et al. 2005, Aguilera-Alcalá et al. 2020, García-Jiménez et al. 2022). Finally, by being apex scavengers, vultures regulate population dynamics across the food chain, influencing the structure of ecological communities and contributing to ecosystem stability (Ogada et al. 2012, Morales-Reyes et al. 2017). Understanding and conserving these species is essential for maintaining the ecological balance and functioning of their habitats.

Research on vultures and their associated ecosystem services has witnessed a substantial growth, with numerous studies shedding light on their vital roles in disease control, waste reduction, and cultural significance (van den Heever et al. 2021, Carucci et al. 2022, Plaza and Lambertucci 2022). However, despite this progress, significant gaps still persist in our understanding of ecosystem services associated to these species. For example, there are no studies, to the best of our knowledge, on how vultures mitigate GHG emissions on Mediterranean islands. The complex and context-dependent nature of the ecosystem services provided by vultures underscores the importance of studying them at the local to regional scale. Such studies are essential for comprehensively assessing the specific contributions of vultures in diverse ecosystems, enabling targeted conservation strategies, and ensuring the sustained provision of these critical services. Closing these knowledge gaps is crucial for the effective conservation and management of vulture populations and to leverage the potential of vultures in providing key services that are so fundamental for modern societies. This also applies to the agropastoral communities of Sardinia, and the rest of Europe, that live on marginal landscapes, such as steppes, whose conservation is often neglected but are crucial for sustainable development and biodiversity conservation. Therefore, in this study we aim to fill the above knowledge gap in the ecosystem service provision by vultures in Sardinia. Specifically, we here aim to:

1. Quantify key cultural services associated to Griffon Vultures in Sardinia, specifically focused on the perceptions of ecotourists towards vultures and their interest and willingness to pay for watching vultures and for their conservation.
2. Quantify key regulation services associated to Griffon Vultures in Sardinia, specifically focused on the waste decomposition and associated climate regulation and opportunity cost services. Essentially, how much animal waste they dispose of, and what are the net savings in GHG emissions and money due to the natural waste disposal by vultures as compared to carcass transport and incineration.

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

# Methods

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

## Perceptions on vultures and associated ecosystem services

Between August 2022 and October 2023, we quantified how visitors at eight protected areas in Sardinia (n = 116) perceived Griffon Vultures (*Gyps fulvus*) and its associated ecosystem services, by means of a structured questionnaire survey. Questionnaires see SM appendix and some broad details below) were completed on-site (n = 100) or was filled online (n = 16). The questionnaire was divided into specific sections asking questions related to: the frequency of visits to Sardinia and its natural reserves, the willingness to pay for observing, photographing or conserving griffons (using pre-defined numerical amounts), the ecosystem services that were perceived as being delivered by vultures (using a five-point bipolar scale from strongly disagree to strongly agree), and the demographic attributes of respondents (see SM appendix). The informed consent was collected at the beginning of the questionnaire.

## Regulation services

We calculated the amount of GHG emissions, in $CO_2$ equivalent, resulting from the artificial disposal of all of carcasses that have been disposed and consumed by vultures at supplementary feeding stationsin North-Western Sardinia during 2017-2022. That is, what would have been the GHG emissions of those carcasses, absent their consumption by vultures. To address this question, we tracked down the artificial carcass disposal process from the moment when the animal dies at the farm, to the point when it is incinerated, by following the framework of Morales-Reyes et al. (2015). Namely, we separated the process into three steps: 1) carcass transport to an intermediate accumulation plant, 2) transport from the accumulation to the incineration plant, 3) incineration at the end of the process **(Figure 1)**.
In step 1, we assumed that one small truck (7.5 tons) would collect a carcass at each farm which has a supplementary feeding station and assumed that if multiple carcasses become available in the same day at the same farm, these are jointly collected within a single trip. We calculated the distance, in km, from each farm to the intermediate plant, located in the municipality of Bitti (Central Sardinia). This distance was calculated using Google Maps. We assumed the consumption of the truck to be at 0.21 l/km on a diesel engine, with 2.7 kg of $CO_2$ emitted per litre of diesel fuel consumed (Morales-Reyes et al. 2015). Then we used historical data about daily carcass provisions for each supplementary feeding station to obtain the total mileage of all trips, and we used the conversion factors mentioned above

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

to estimate the total $CO_2$ emissions associated with carcass collection. Indeed, the total mileage was doubled, as we assumed the truck to always make a return trip on each collection travel.

In step 2, based on available evidence about carrion disposal, we estimated $CO_2$ emissions by assuming that biomass is moved from Sardinia to peninsular Italy via trucks (approx. 538 km) and ferry transport (approx. 313 km). In Sardinia, we assumed that carrion is moved on the road network from the intermediate centre in Bitti to the harbour of Olbia. Then the truck is shipped across the Tyrrhenian Sea, from Olbia to Livorno, on a ferry. Finally, the truck would deliver the biomass from the harbour of Livorno to the incineration plant in Bologna. For this task, usually large trucks (24 tons), operating at a full load, are used. Considered that carrion disposed at supplementary feeding stations in 2017-2022 amounted to 95.7 tons, we estimated that 4 trips would have been required to deliver the biomass from Bitti to the incinerating plant. In terms of emissions, following Morales-Reyes et al. (2015), we also assumed that a large truck would consume 0.26 l/km on a diesel engine, with 2.7 kg of $CO_2$ emitted per litre of diesel fuel consumed and for the ferry an average emission factor of 25 g $CO_2$ per tons-kilometre. Emissions were doubled, to account for the return trip of the truck to Sardinia.

We calculated $CO_2$ emissions from step 3, the artificial carcass disposal process, by assuming a rendering procedure, high-temperature incineration is used, which has a conversion factor of 200 kg of $CO_2$ equivalent per each ton of carcass burned (Plaza and Lambertucci 2022).

By summing up the emissions from each of the three steps we quantified the total $CO_2$ emissions equivalent related to the artificial disposal of the carcasses in a scenario where vultures would be absent from Sardinia to consume this biomass.

Next, we calculated the total amount of potential $CO_2$ emissions mitigated by the whole Griffon Vulture population in Sardinia, per year. We used the total population estimate from the year 2022 (316 – 338 individuals, (Berlinguer et al. 2022), each consuming 208 to 305 kg of biomass per year (Plaza and Lambertucci 2022), amounting to a total annual biomass consumed by the entire population as 65.6 to 103.1 tons. We then converted the biomass to potential $CO_2$ emissions in the case that all that material would be disposed artificially, by using the ratio of emissions from the tonnes of carcass as calculated in the above steps (which is very close to one, that is, 1 ton of biomass would emit 1 ton of $CO_2$ equivalent).

Finally, we calculated the economic opportunity costs (in euros) for all carcasses consumed by vultures at supplementary feeding stations in North-Western Sardinia during 2017-2022. Essentially, how much would have cost if the above carcasses where to be disposed of artificially, as in **Figure 1**? For this, we used the total sum of kg of biomass disposed of at the supplementary feeding stations as above, separated by three livestock categories: cattle, horses/donkeys, sheep/goat. We obtained the maximum cost (in €/kg of biomass) of collection, transport, and in-

cineration of carcasses by each of the three livestock categories from the Official Bulletin of the Italian Republic (series n. 123, date: 27/5/2023) for the Sardinia Region in 2023 (as an average across the region). Total maximum disposal costs are reported as: 0.97 €/kg for cattle, 1.07 €/kg for horses/donkeys, 3.08 €/kg for sheep/goat. We then multiplied the total biomass in kg for the cost of disposal per each livestock category, and then summed the three to yield the total opportunity cost for disposing of those carcasses.


**Figure 1.** Schematic representation of the natural versus artificial disposal process for livestock carcasses in Central-Western Sardinia. Top left figure represents the landscape where livestock dies (farm locations depicted as green circles in the map) and requires disposing, either via the natural scavenger decomposition (the Griffon Vultures role; green area in the figure) or through artificial disposal (grey area). The latter process involves three different steps (locations marked as red circles in the map). The carcass, as it becomes available, is collected from the farm and transported to an intermediate plant (step 1). At this intermediate plant, carcasses are stored and piled up to fill a large truck that then brings them to mainland Italy (step 2), where they are incinerated at a specific plant (step 3).

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

## Perceptions on vultures and associated ecosystem services

***Socio-demographics of respondents***

Overall, 116 respondents filled the questionnaire about the perception of vultures and their associated ecosystem services. This sample was balanced across genders, with 58 male and 57 female respondents, and across various age classes: 28 respondents of age 18-30 years old, 30 of age 31-40, 25 of age 41-50 and 29 of age >51. Moreover, the majority of the respondents had a high level of education, with 45 having at least high school degree, 42 having some basic university degree, and 23 with a higher than basic university degree (e.g. MSc or PhD). As expected, most respondents (n = 91, 79% of the total sample) were Italian, while the remaining ones came from Germany and France (7 for each), Czech Republic (4) and Netherlands, Austria, and Poland (2 for each). Moreover, 57 respondents (50% of the 114 that replied to this question) are resident in Sardinia, while the others were visiting the island for the first time (24) or had already visited Sardinia on two (10), three or more previous occasions (6), or visited the island every year (17). Only 8 respondents stated that they have a profession somewhat related to nature (including e.g. biologist, nature guide, veterinarian, naturalist), while other have different private social or government employment jobs, likely unrelated to nature and its conservation. The sample of respondents was rather balanced among those that enjoy photography (51, amounting to 45% of the total; they are not necessarily nature related) and those that do not practice this activity (63, 55% of the total). Among all respondents who replied to the question about the frequency in which they visit a protected area, 30 did it for the first time, 44 visit it once a year, 8 once a month and 9 once a week.

***Perceptions on vultures' ecosystem services***

With regards to the respondents' perceptions towards vultures and their associated ecosystem services, the results are rather clear that respondents have a broadly positive perception of vultures and are also well aware of some of their main ecosystem services **(Figure 1)**. Specifically, most respondents (almost two out of three) believe that vultures can counteract the spread of diseases, and reduce costs associated with carcass disposal, e.g. due to carcass transport and incineration (regulation services). Moreover, most respondents agree that vultures belong to the agropastoral traditional ecological landscape of Sardinia (Cultural service). Even more clear is the respondents' perception towards vultures, whereby most (71%) of respondents do not agree that vultures are dirty, and an even higher percentage (78%) of respondents do not agree with the statement affirmingthat they do not like to have vultures around, i.e. they like to have vultures in the surrounding landscape.

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

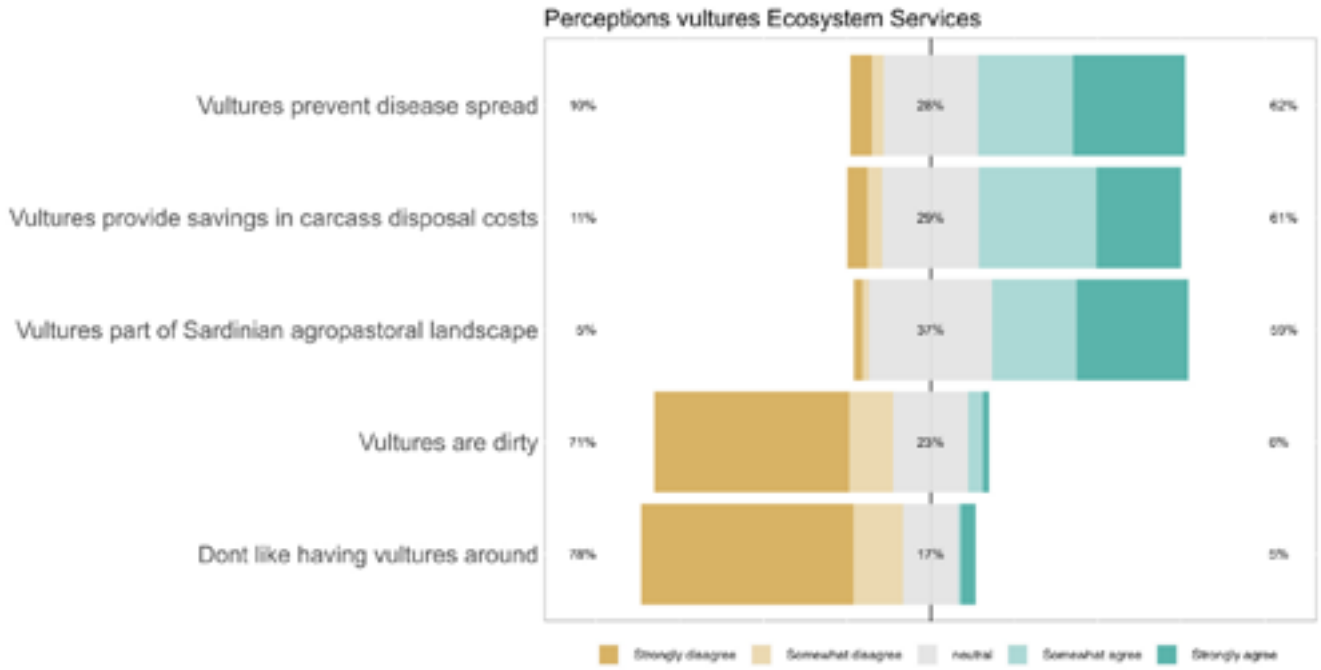


**Figure 2.** Perceptions of visitors to natural reserves on vultures and their associated ecosystem services.

***Cultural ecosystem services***

We also attempted to quantify the willingness to pay for observing and photographing vultures, as a monetary quantification of their potential cultural ecosystem service. Specifically, to the question whether respondents would be willing to visit an observation hide for watching and photographing vultures, 92 (79%) responded positively, 10 negatively and 14 don´t know. Similarly, 85 (73%) would be willing to pay an entrance fee to access such a hide. Among the latter, the average they would pay is 13€ each. However, there was a large variation in the amount respondents would be willing to pay, with 54 respondents willing to pay only 10€ or less, and the rest a larger sum. The results are similar with regards to willingness to join a guided visit to such a vulture observation place (92, 80% of respondents), while 89 (79%) are willing to pay an entrance fee for such a place. Among the latter, the average they would pay is 15€ each, with 46 respondents willing to pay only 10€ or less, 23 respondents willing to pay 20€, and 9 willing to pay 30€ or more. Over half (55) of the respondents stated that they would visit the vultures observation hide only as part of an entire trip to the island, whereby 34 respondents would visit it on purpose. In more general terms, about half of the respondents (58 of 114 who replied) are willing to make a donation for the conservation of the Griffon Vulture in Sardinia, amounting to an average of 21€. Specifically, 29 the 51 willing to support the vulture conservation would donate 10€ or less, 6 would donate 20€ and the remaining 16 would donate more 30€ or more.

***Regulation services***

During the period 2017 – 2022 a total of 30 supplementary feeding stations in North-Central Sardinia provisioned 95.7 tons of livestock (mainly sheep, goat, and cattle) carcasses during 609 provisioning events (each event could include from 1 to 7 animal carcasses). These carcasses were almost entirely consumed by the local Griffon Vulture population **(Figure 2)**. The $CO_2$ equivalent that would have been emitted into the atmosphere from the artificial disposal of such total amount of biomass amounts to 96.07 tons, according to the calculations and related assumptions as detailed in the methods. Out of the total $CO_2$ emissions from the full process of artificial disposal of the above biomass, almost three quarters (77%) of the emissions are due to local carcass transport (from the farm to the intermediate plant), only 3% due to long haul carcass transport (from intermediate plant in Sardinia to the final incineration plant in mainland Italy), and one fifth (20%) of the total $CO_2$ are emitted during the incineration phase.

Extrapolating the above $CO_2$ emissions to the total annual potential biomass consumed by the entire population of Griffon Vultures in Sardinia would amount to 65.9 to 103.5 tons of $CO_2$ equivalent per year (minimum and maximum estimates based on minimum and maximum vulture food intake and population estimate).

The economic opportunity costs that are saved by the disposal service of the vultures at the supplementary feeding stations are also substantial, and equate to 134,016 € for the period 2017 – 2022 at the 30 supplementary feeding stations in North-Central Sardinia.

# Discussion

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

To the best of our knowledge, this study is the first one exploring the public perception, magnitude and economic value of ecosystem services delivered by Griffon Vultures on a Mediterranean island.

Our study reveals a broadly positive public perception of the ecosystem services associated to Griffon Vultures in Sardinia. Most respondents acknowledged the role played by vultures in preventing disease and save costs associated with carcass disposal. Economic aspects are highlighted by the willingness of 73% of respondents to pay for vulture-watching, with an average proposed fee of 13€, indicating the potential cultural value of these birds, also in economic terms. Additionally, about half of the respondents are willing to donate money for conserving vultures, averaging 21€. Moreover, from an ecological perspective, vultures play a role in GHG mitigation. Between 2017-2022, vultures contributed to prevent 96 tons of $CO_2$ equivalent that would have been emitted from artificial carcass disposal, and a potential annual $CO_2$ mitigation of 66 to 103 tons for the whole vulture population in Sardinia. During the same period, the economic savings from carcass disposal by vultures at supplementary feeding stations was substantial, reaching well over 100,000 €.

The positive perception of Griffon Vultures among resident and foreign visitors of natural sites in Sardinia is encouraging and aligns with recent studies on the positive cultural value associated to vultures among modern society (Santangeli et al. 2016, Craig et al. 2018, Carucci et al. 2022, García-Jiménez et al. 2022). These findings underscore the deep integration of vultures into the cultural and ecological landscape of Sardinia. The acceptance and appreciation of vultures are crucial for conservation efforts, as public perception often drives policy and funding support.

In turn, the positive perception of vultures is reflected in the visitor's willingness to pay for observing and photographing these animals. This underscores a great ecotourism potential especially related to those local livestock farms interested in managing a supplementary feeding station that would bring a financial revenue, e.g. through entrance fees for visiting the site. Indeed such cultural services related to vultures bringing local financial revenues have been quantified, at least for a few sites (Becker et al. 2005). These activities not only contribute to local economies but also foster a deeper appreciation for wildlife. The monetary valuation of these services is important for conservation strategies, demonstrating that protecting vultures aligns with local economic interests. Moreover, the variation in the willingness to pay suggests a diverse range of values and interests among different visitor demographics, which could be targeted by future tourism and conservation

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

strategies. We believe that future studies should also explore how local livestock farm owners would be available to develop activities associated with ecotourism. This would allow to better understand under which conditions the demand and offer for observing and photographing vultures would align. In turn, this could also allow to develop vulture sighting activities that would maximize the value of this cultural service for both tourists and farmers, while minimizing the potential disturbance to vultures (Donázar et al., 2023).

Aside from the above cultural services, we also show that the local population of Griffon Vultures in Sardinia can contribute to important regulation/mitigation services through the carcass disposal that, if artificially performed, would result in GHG emissions and also economic costs. To place this finding in context, the net annual savings in $CO_2$ emissions resulting from the total population of Griffon Vultures in Sardinia equate to the annual $CO_2$ emissions of 16 to 34 households in Sardinia. Previous studies have quantified the role of vultures in preventing GHG emissions via their scavenging role, at a global as well as national level (Morales-Reyes et al. 2015, Plaza and Lambertucci 2022). By quantifying the $CO_2$ equivalent emissions prevented by vulture scavenging, we contribute another compelling case for the conservation of these birds, whose ecological role spans across broad contexts of global environmental challenges. Moreover, we believe that translating reductions of GHG emissions into tangible examples, such as household $CO_2$ emissions, could be useful for communication initiatives targeting both residents and visitors in Sardinia, with the goal of increasing the overall awareness about the important ecosystem services associated with vultures. To this end, future studies should use approaches from the social sciencesto test for the effectiveness of similar messaging, through for example informative panels at protected areas (Abrams et al., 2020).

Interestingly, we show that, in the context of Sardinia, over three quarters of the emissions of the full artificial disposal process are related to the local carcass collection and transport, while only one fifth of emissions are related to the incineration process. This finding is relevant, as it indicates that local carcass transport plays a key role in $CO_2$ emission mitigation scenarios related to vultures. For example, a recent study quantified the global emission mitigation relative to the incineration of all biomass that is currently consumed by all vulture populations in the world as 3 to 61 Tg $CO_2$ eq. (Plaza and Lambertucci 2022). That value did not consider the emissions related to carcass transport. Our findings indicate that global values could be up to five times higher, underscoring the importance of considering the full carcass collection, transport and incineration process when estimating emission and cost mitigation.

Overall, the findings on perception and economic valuation of vultures' ecosystem services have important implications for conservation efforts. They underscore the potential benefits these birds could bring to local peoples and their economies.

They also highlight the need for continued education and awareness programs to maintain and enhance public support for vulture conservation. This study adds important insights into our understanding of the Griffon Vulture's role for the ecosystems of Sardinia, with far reaching implications across other Mediterranean islands and beyond where vulture populations occur. It provides a compelling case for their conservation, not only for their ecological benefits but also for their cultural and economic contributions. This holistic understanding is vital for developing effective bottom-up conservation strategies that are supported by the public and aligned with sustainable development goals.

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

# Acknowledgements

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

We thank all those who helped us with monitoring and management activities within the LIFE ''Under Griffon Wings'' project. The study was founded by the European Commission through the Life Under Griffon Wings project (LIFE14/NAT/IT/000484) and the Life Safe for Vultures project (LIFE19 NAT/IT/000732). The present research was carried out within the framework of the activities of the Spanish Government through the "Maria de Maeztu Centre of Excellence" accreditation to IMEDEA (CSIC-UIB) (CEX2021-001198). AS acknowledges support from the European Commission through the Horizon 2020 Marie Skłodowska-Curie Actions individual fellowships (Grant no. 101027534).

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

# Reference list

**Progetto LIFE19NAT/IT/000732**
LIFE SAFE for VULTURES
First step to the restoration of the vulture guild in Sardinia
Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

Abrams, K. M., K. Leong, S. Melena, and T. Teel. 2020. Encouraging Safe Wildlife Viewing in National Parks: Effects of a Communication Campaign on Visitors' Behavior. Environmental Communication **14**:255-270.

Aguilera-Alcalá, N., Z. Morales-Reyes, B. Martín-López, M. Moleón, and J. A. Sánchez-Zapata. 2020. Role of scavengers in providing non-material contributions to people. Ecological Indicators **117**:106643.

Becker, N., M. Inbar, O. Bahat, Y. Choresh, G. Ben-Noon, and O. Yaffe. 2005. Estimating the economic value of viewing griffon vultures Gyps fulvus: a Travel Cost Model Study at Gamla Nature Reserve, Israel. Oryx **39**:429-434.

Berlinguer, F., F. Ahmed, C. Tamponi, S. Carta, A. Scala, M. G. Cappai, and A. Varcasia. 2021. Help from the sky: Can vultures contribute to Cystic Echinococcosis control in endemic areas? PLOS Neglected Tropical Diseases **15**:e0009615.

Berlinguer, F., A. Campus, D. De Rosa, and M. Aresu. 2022. AZIONE D.5 – Censimento annuale del Grifone (Gyps fulvus) in Sardegna. Terzo Report - Anno2022.

Carucci, T., K. Whitehouse-Tedd, R. W. Yarnell, A. Collins, F. Fitzpatrick, A. Botha, and A. Santangeli. 2022. Ecosystem services and disservices associated with vultures: A systematic review and evidence assessment. Ecosystem Services **56**:101447.

Craig, C. A., R. L. Thomson, and A. Santangeli. 2018. Communal farmers of Namibia appreciate vultures and the ecosystem services they provide. Ostrich:1-10.

Daily, G. C., and P. A. Matson. 2008. Ecosystem services: from theory to implementation. Proceedings of the National Academy of Sciences of the United States of America **105**:9455-9456.

Donázar, J. A., A. Cortés-Avizanda, E. Arrondo, A. Delgado-González, and O. Ceballos. 2023. Hidden effects of high numbers of tourists in protected areas: displacement of foraging top scavengers. Ibis **165**:305-311.

Gangoso, L., R. Agudo, J. D. Anadón, M. de la Riva, A. S. Suleyman, R. Porter, and J. A. Donázar. 2013. Reinventing mutualism between humans and wild fauna: insights from vultures as ecosystem services providers. Conservation Letters **6**:172-179.

García-Jiménez, R., J. M. Pérez-García, A. Margalida, and Z. Morales-Reyes. 2022. Avian scavengers' contributions to people: The cultural dimension of wildlife-based tourism. Science of the Total Environment **806**:150419.

Geijzendorffer, I. R., E. Cohen-Shacham, A. F. Cord, W. Cramer, C. Guerra, and B. Martín-López. 2017. Ecosystem services in global sustainability policies. Environmental Science & Policy **74**:40-48.

**Coordinating Beneficiary**
Università degli Studi di Sassari
Via Vienna 2 | 07100, Sassari
mail: lifeforvultures@uniss.it | tel: +39 079 229904
**www.lifesafeforvultures.eu**

**Associated Beneficiaries**
Agenzia Regionale Forestas
Corpo Forestale e di Vigilanza Ambientale RAS
E-distribuzione | Vulture Conservation Foundation
With the contribution of the LIFE financialinstrument of the European Community

Grilli, M. G., K. L. Bildstein, and S. A. Lambertucci. 2019. Nature's clean-up crew: Quantifying ecosystem services offered by a migratory avian scavenger on a continental scale. Ecosystem Services **39**:100990.

Gupta, U., Q. Qureshi, and N. Kumar. 2020. Folk perceptions for avian scavengers in a tropical megacity: implications for biocultural conservation.

Haines-Young, R., and M. Potschin-Young. 2018. Revision of the Common International Classification for Ecosystem Services (CICES V5.1): A Policy Brief. One Ecosystem **3**:e27108.

IPBES. 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany.

Mateo-Tomás, P., P. P. Olea, M. Moleón, N. Selva, and J. A. Sánchez-Zapata. 2017. Both rare and common species support ecosystem services in scavenger communities. Global Ecology and Biogeography **26**:1459-1470.

Moleón, M., J. A. Sánchez-Zapata, A. Margalida, M. Carrete, N. Owen-Smith, and J. A. Donázar. 2014. Humans and Scavengers: The Evolution of Interactions and Ecosystem Services. Bioscience **64**:394–403.

Morales-Reyes, Z., J. M. Pérez-García, M. Moleón, F. Botella, M. Carrete, C. Lazcano, R. Moreno-Opo, A. Margalida, J. A. Donázar, and J. A. Sánchez-Zapata. 2015. Supplanting ecosystem services provided by scavengers raises greenhouse gas emissions. Scientific Reports **5**:7811.

Morales-Reyes, Z., J. A. Sánchez-Zapata, E. Sebastián-González, F. Botella, M. Carrete, and M. Moleón. 2017. Scavenging efficiency and red fox abundance in Mediterranean mountains with and without vultures. Acta Oecologica **79**:81-88.

Morales-Reyes, Z., B. Martín-López, M. Moleón, P. Mateo-Tomás, F. Botella, A. Margalida, J. A. Donázar, G. Blanco, I. Pérez, and J. A. Sánchez-Zapata. 2018. Farmer Perceptions of the Ecosystem Services Provided by Scavengers: What, Who, and to Whom. Conservation Letters **11**:e12392.

Ogada, D. L., M. E. Torchin, M. F. Kinnaird, and V. O. Ezenwa. 2012. Effects of Vulture Declines on Facultative Scavengers and Potential Implications for Mammalian Disease Transmission. Conservation Biology **26**:453-460.

Plaza, P. I., G. Blanco, and S. A. Lambertucci. 2020. Implications of bacterial, viral and mycotic microorganisms in vultures for wildlife conservation, ecosystem services and public health. Ibis **162**:1109-1124.

Plaza, P. I., and S. A. Lambertucci. 2022. Mitigating GHG emissions: A global ecosystem service provided by obligate scavenging birds. Ecosystem Services **56**:101455.

Santangeli, A., V. Arkumarev, N. Rust, and M. Girardello. 2016. Understanding, quantifying and mapping the use of poison by commercial farmers in Namibia – Implications for scavengers' conservation and ecosystem health. Biological Conservation **204**:205-211.

Sekercioglu, Ç. H., D. G. Wenny, and C. J. Whelan. 2016. Why birds matter: avian ecological function and ecosystem services. University of Chicago Press.

Van den Heever, L., L. J. Thompson, W. W. Bowerman, H. Smit-Robinson, L. J. Shaffer, R. M. Harrell, and M. A. Ottinger. 2021. Reviewing the Role Of Vultures At the Human–Wildlife–Livestock Disease Interface: An African Perspective. Journal of Raptor Research.

Van Dooren, T. 2012. Vulture. Reaktion Books.

LIFE SAFE FOR VULTURES

NATURA 2000

**Associated BeneficiariesCommunity**

Forestas

e-distribuzione

VCF

**LIFE19/NAT/IT/000732 Life Safe for Vultures**
First step to the restoration of the vulture guild in Sardinia

**www.lifesafeforvultures.eu**
With the contribution of the LIFE financial instrument of the European Community

**Coordinating Beneficiary** Università degli Studi di Sassari | Via Vienna 2 | 07100, Sassari | mail: lifeforvultures@uniss.it | tel: +39 079 229904