LIFE SAFE FOR VULTURES

ACTION E.6

LIFE 19 NAT/IT/000732

"LIFE SAFE FOR VULTURES - FIRST STEP TO THE RESTORATION OF THE VULTURE GUILD IN SARDINIA"

FEASIBILITY STUDY FOR THE REINTRODUCTION OF THE CINEREOUS VULTURE (Aegypius monachus) AND THE BEARDED VULTURE (Gypaetus barbatus) IN SARDINIA

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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

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Foreword

The reintroduction of species that have become locally extinct represents one of the most complex and ambitious challenges in modern conservation. Within this context lies the present feasibility study for the reintroduction of the Cinereous Vulture (*Aegypius monachus*) and the Bearded Vulture (*Gypaetus barbatus*) in Sardinia, two species that were historically present on the island but have since disappeared due to direct persecution and other human-induced factors.

The study was developed through a multidisciplinary approach that integrated historical, ecological, spatial, and management data, and involved a range of expertise, including the analysis of current and potential threats. The assessment of environmental suitability, food availability, interactions with human activities, and synergies with ongoing conservation actions for the Griffon Vulture (*Gyps fulvus*) under the LIFE Safe for Vultures project formed the technical foundation for the development of realistic reintroduction scenarios.

The feasibility study was shared with European experts and critically reviewed during an international technical meeting entitled *"The reintroduction of the Bearded and Cinereous Vultures species in Sardinia and 10 years vulture species conservation plan LIFE"*, held in Alghero from 7 to 9 May 2025. The meeting represented a crucial opportunity for discussion among international experts, researchers, technicians, institutional representatives, and project partners, who contributed their experience to validate the results achieved and to identify priority actions for the next decade.

The event included technical sessions, thematic workshops, and field visits to key sites involved in the proposed reintroduction, such as the Monte Minerva area, the Bosa sites, and other potentially suitable territories. Participants had the opportunity to engage in in-depth discussions on issues related to food availability, the risks of electrocution and collision, the use of poison, and the regulatory framework, comparing approaches and strategies already implemented in other European contexts.

In addition, the workshop contributed to the joint development of a multi-species Action Plan for the conservation of vultures in Sardinia, aimed at ensuring a long-term, sustainable vision based on the best available scientific evidence.

The high level of participation and the quality of both scientific and operational discussions confirm the importance of events like this, which strengthen international cooperation and provide a solid foundation for strategic decision-making in biodiversity conservation.

Below is the list of experts who took part in the technical meeting held in Alghero, as well as those who contributed to the evaluation of the feasibility study through their comments and suggestions. We would like to express our sincere gratitude for the valuable scientific and operational input provided, both during the in-person discussions and through the shared review process. Their contributions have been essential to refining the study and shaping future conservation actions.

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1. The Strategic Reintroduction of Bearded and Cinereous Vultures in Sardinia

1.1 Introduction: The strategic imperative of vulture reintroduction in Sardinia

This chapter aims to articulate a comprehensive, evidence-based justification for the reintroduction of the Bearded Vulture (*Gypaetus barbatus*) and the Cinereous Vulture (*Aegypius monachus*) in Sardinia. It will detail the multifaceted ecological, conservation, and strategic imperatives driving these initiatives, emphasizing how the island's unique suitability and the successes of existing conservation infrastructure provide a robust foundation for their return.

1.1.1 Ecological Significance of Vultures

Vultures represent a distinctive, iconic, and spectacular component of terrestrial biodiversity, valued not only for their imposing appearance but, more critically, for their indispensable ecological function. These avian scavengers provide vital ecosystem services, primarily through the rapid removal of carcasses and other organic waste (Berlinguer et al., 2021). This swift disposal is crucial as it mitigates serious environmental and sanitary risks that would otherwise arise from decaying organic matter. A key physiological adaptation, their highly acidic stomach fluids, enables vultures to neutralize harmful bacteria, viruses, and other pathogens, allowing them to digest substances toxic to most other species. This unique ability effectively limits the spread of disease and reduces pathogen transmission (Berlinguer et al., 2021).

Studies have demonstrated that in areas lacking vultures, carcass decomposition can take up to five times longer, significantly escalating disease risks for both wild and domestic animals, as well as for human populations (Santangeli, et al., 2024). Beyond these profound ecological and public health benefits, vultures also offer a tangible economic advantage in livestock farming by serving as a free and natural means of carcass disposal (Santangeli, et al., 2024).

From a broader perspective, vultures have long held significant historical and cultural value across various civilizations. They have been regarded as natural purifiers and sacred animals, with their unique role in consuming decaying flesh often associated with the transformation of death into vital energy, symbolizing renewal and balance. Ecologically, the consistent presence of vultures within a landscape serves as a robust indicator of overall environmental health (Moleón et al., 2014). The reintroduction of these species is therefore not merely an effort to increase avian populations, but a strategic intervention aimed at restoring fundamental ecosystem processes and enhancing the monitoring of overall environmental quality. The absence of these birds can lead to a cascade of negative effects, including increased disease transmission and delayed decomposition, while their return signals a restoration of ecological integrity.

1.1.2 Historical Context of Vulture Decline in Sardinia

Until the mid-20th century, specifically the 1950s, Sardinia was a critical habitat for three of Europe's four necrophagous raptor species: the Griffon Vulture (*Gyps fulvus*), the Cinereous Vulture and the Bearded Vulture (Schenk, 1976). However, the island experienced a significant ecological collapse decades before similar crises emerged in Asia and Africa. Between the 1940s and 1970s, the widespread introduction of toxic substances, coupled with direct persecution, led to the local extinction of both the Bearded Vulture and the Cinereous Vulture from Sardinia (Schenk, 1976). Today, the historical presence of these once-abundant scavengers is largely confined to a few photographs and taxidermized specimens held in ornithological collections (Schenk, 1976).

This historical decline in Sardinia mirrors the more recent "African Vulture Crisis" of the 1990s, where catastrophic collapses of vulture populations were primarily attributed to poisoning, particularly from veterinary drugs like diclofenac (Ogada et al., 2016). The threats that caused vultures to disappear from most European countries in the past, such as poisoning, electrocution, collisions with power lines, habitat loss, and reduced food availability, remain present across much of their range. Drawing this direct parallel between Sardinia's past and ongoing global vulture crises underscores a recurring, systemic threat that necessitates sustained, coordinated international efforts. Sardinia's reintroduction initiatives, therefore, offer a valuable case study for effectively overcoming deeply entrenched anthropogenic pressures, providing lessons applicable to current global vulture conservation challenges.

1.2. Sardinia: A Resilient Hub for Vulture Restoration

1.2.1 Sardinia as an Island Refugia and Reintroduction Hub

The geographical distribution of European vultures inherently involves populations dispersed across continental mainland and their associated islands. In the Mediterranean, indeed, several islands like Corsica, Crete (S. M. Xirouchakis et al., 2019), Cres (Dobrev et al., 2022), Mallorca (Cortés-Avizanda & Tavecchia, 2021), Cyprus (Phipps & Vogiatzakis, 2020), Sicily and Sardinia host vulture populations (Table 1). This fragmented distribution creates a complex interplay of challenges and opportunities for population persistence.

Islands, including Sardinia, have historically served as crucial "refugia," providing sanctuary for species during periods of significant environmental upheaval, such as the glacial maxima of the Pleistocene (Hewitt, 2000). These areas allowed species to persist when conditions in broader Europe were inhospitable, subsequently acting as sources for recolonization during interglacial periods (Hewitt, 2000). In contemporary conservation, islands continue to function as refugia, offering reduced human disturbance or unique ecological conditions that enable populations to persist and even thrive, even when their mainland counterparts face intense pressures or extirpation (Whittaker & Fernández-Palacios, 2007). This resilience is partly attributable to geographical isolation from widespread threats like large-scale poisoning campaigns or extensive habitat destruction. In the case of vultures Mallorca is the only island in the world with a stable breeding population of Cinereous Vultures. Corsica harbours a small, geographically isolated, and critically endangered population of Bearded Vultures. The last autochthonous Griffon Vulture population in Italy persisted solely on Sardinia, which now, thanks to targeted conservation efforts, holds the largest island population of

Griffon Vultures globally, together with Crete. This rapid rebound demonstrates that island populations, while initially vulnerable, possess significant resilience and can be highly responsive to intensive, well-managed conservation efforts.

The relatively contained nature of islands also renders them highly suitable for closely monitored reintroduction projects (Armstrong & Seddon, 2008). The lower risk of wide dispersal behaviour in newly released birds allows for close tracking to assess their adaptation and implement rapid interventions if needed (Armstrong & Seddon, 2008). For these reasons, islands like Sardinia are increasingly recognized not merely as passive sanctuaries but as active "reintroduction hubs" and "critical nodes" within conservation networks (IUCN/SSC, 2013). This represents a strategic shift from simply protecting existing island populations to actively utilizing islands as launchpads for broader continental recovery, a proactive approach validated by the documented success of Griffon Vulture reintroduction in Sardinia (LIFE Under Griffon Wings, 2015–2020; LIFE Safe for Vultures, 2021–2026).

Table 1.1 *Overview of insular vulture populations in the Mediterranean region. The table reports the islands where vulture species are currently present, their estimated population size, ongoing conservation actions, and key references supporting the data.*

Island	Species present	Population size	Ongoing conservation efforts	References
Sardinia (Italy)	Griffon Vulture	424-470 individuals (2024), with 105 territorial pairs, 86 breeding pairs and 71 fledglings.	Long-term conservation initiatives including restocking with individuals, anti-poisoning actions, supplementary feeding stations, public awareness campaigns, and habitat protection under LIFE projects (LIFE Under Griffon Wings, LIFE Safe for Vultures).	http://www.lifeundergriffonwings.eu/it/index.html https://www.lifesafeforvultures.eu/
Sardinia (Italy)	Egyptian Vulture	Historically the first established breeding pair in Sardinia, with successful nesting recorded since 2019 and chicks fledging in 2019, 2020, 2023, and 2024	Recent natural colonisation possibly supported by vulture-friendly infrastructures and anti-poisoning measures implemented for Griffon Vultures; conservation actions targeting the Griffon are indirectly benefiting this species.	(De Rosa et al., 2024) http://www.lifeundergriffonwings.eu/it/index.html https://www.lifesafeforvultures.eu/
Corsica (France)	Bearded Vulture	~20 individuals estimated in 2020, with 4	The LIFE GYPRESCUE project (2021–2025) aims to prevent the extinction of the Bearded Vulture in	https://4vultures.org/blog/highlights-from-the-

		territorial pairs; recently increased to 4–6, indicating a positive trend	Corsica by reinforcing the small, isolated population through the release of captive-bred individuals, artificial incubation of wild eggs, and habitat management. Key actions include supplementary feeding stations, restocking of wild ungulates (e.g., mouflon), mitigation of poisoning and power line risks, and community engagement to promote vulture-friendly practices. These measures are coordinated by the Parc Naturel Régional de Corse with the support of national and international partners.	life-gyprescue-seminar-protecting-the-bearded-vulture-in-corsica/
Crete (Greece)	Griffon Vulture	341–417 individuals (as of 1990s data, the largest island population in the world). In the mid-1990s, there were 84-92 breeding pairs across 15 colonies.	The island has played a crucial role in supporting Griffon Vulture populations in other regions. For example, between 2011 and 2014, within the framework of the GYPAS project, 25 Griffon Vultures were translocated from Crete to Cyprus to reinforce the local population.	https://birdlifecyprus.org/projects/project-gypas/ (S. M. Xirouchakis & Mylonas, 2005)
Crete (Greece)	Bearded Vulture	10 breeding pairs (2022)	Between 1998 and 2006, the Natural History Museum of Crete coordinated two LIFE projects focused on the conservation of the Bearded Vulture: LIFE98 NAT/GR/005276 and LIFE02 NAT/GR/008492These projects addressed key threats such as the use of poisoned baits, food shortage, and direct persecution. Actions included nest monitoring, awareness campaigns, the creation of information centres, and the promotion of sustainable farming practices.	https://4vultures.org/wp-content/uploads/2022/09/Report-Vulture-Population-Estimates-Europe-VCF-September-2022.pdf
Cyprus	Griffon Vulture	Approximately 37 individuals as of early 2025, with 22 estimated at the end of 2022 (5-6 likely mature	The GYPAS project (2011–2014) involved the translocation of 25 Griffon Vultures from Crete to reinforce the small and declining local population. The LIFE with Vultures project (2019–2023) introduced an additional 28 vultures from Spain, established anti-poison dog units, and implemented	https://birdlifecyprus.org/projects/project-gypas/ https://lifewithvultures.eu/

		individuals).	GPS tracking to monitor movements and threats. The long-term goal is to reach a self-sustaining population of at least 200 individuals to secure the species' future on the island.	
Balearic Islands (Spain)	Cinereous Vulture	~ 350 individuals, with 45 breeding pairs (as of February 2023). This is a significant increase from just 19 individuals and one breeding pair in 1986.	The conservation of the Cinereous Vulture has involved protecting nesting sites, tackling illegal poisoning, providing safe feeding stations, releasing individuals from other populations, GPS monitoring, and public awareness campaigns. Thanks to these efforts, the population has grown from around 20 individuals in the 1980s to a much more stable number today.	https://4vultures.org/our-work/reintroduction-and-restocking/cinereous-vulture-mallorca/
Balearic Islands (Spain)	Griffon Vulture	15 breeding pairs, population which arrived in Mallorca during a storm-derailed migration from Africa in 2008.	Although no specific conservation projects have been implemented for Griffon Vultures, their presence is being monitored to assess interactions with the Cinereous Vulture and the local ecosystem. Ongoing studies aim to better understand the dynamics between the two species and the potential impact of the Griffon Vulture's colonisation on the resident Cinereous Vulture population.	https://4vultures.org/blog/griffon-vultures-colonised-mallorca-and-joined-the-resident-cinereous-vultures-a-novel-project-now-studies-the-consequences-of-this-phenomenon/?utm
Sicily (Italy)	Griffon Vulture	Currently home to 315 Griffon Vultures, with the main colony in the Nebrodi mountains and a smaller group in the Madonie region (as of April 2024).	The "Reintroduction of Vultures in Madonie, Sicily" (ongoing) initiative is working to bring back Griffon Vultures in the Madonie Regional Natural Park in north-central Sicily. Membership of the European Rewilding Network will enhance its rewilding efforts. The project has led to the successful return and growth of the Griffon Vulture population in the Madonie area, and the initiative is now part of the European Rewilding Network.	https://rewildingeurope.com/news/sicilian-griffon-vulture-initiative-joins-the-european-rewilding-network/
Sicily (Italy)	Egyptian	10-12 breeding	The LIFE Egyptian Vulture and LIFE ConRaSi projects have supported the	https://www.lifegyptianvulture.it

	Vulture	pairs	conservation by releasing captive-bred individuals, tracking them with GPS, providing safe feeding stations, and securing power lines. They also tackled illegal poisoning and protected nesting sites.	/ https://www.lifeconrasi.eu/home

1.2.2 Role in Broader Metapopulation Dynamics

Islands are not merely isolated sanctuaries; instead, they function as crucial links within larger migratory and dispersal networks, as evidenced by the historical distribution range of European vultures (Brichetti & Fracasso, 2018; Grussu & Seguin, 2015). A healthy, growing island population, such as the one envisioned in Sardinia, can effectively act as a "stepping stone" or "reservoir" from which dispersing young birds can naturally cross to nearby mainland areas (Cerri, et al., 2024). This process facilitates the natural recolonization of areas where vultures were previously extinct and contributes significantly to genetic exchange between different populations (Cerri, et al., 2024).

Observational evidence unequivocally confirms natural dispersal movements among Mediterranean vulture populations, demonstrating existing and potential connectivity across the region. For instance, a colour-ringed Cinereous Vulture released in France was observed in Corsica and then Sardinia in 2005-2006 (Brichetti & Fracasso, 2018). Similarly, an immature Griffon Vulture from Northern Italy was re-observed in Corsica in 2015 (LIFE GYPRESCUE, 2021–2026).

Historical records from 1980-2012 also suggest Bearded Vultures in Sardinia likely originated from Corsica (Brichetti & Fracasso, 2018; Grussu & Seguin, 2015). More recent tracking studies further confirm exploratory flights by young vultures, including short sea crossings (e.g., from Corsica to Capraia Isola, Sardinia to Corsica) and even extraordinary sea crossing movements (e.g., Sardinia to Sicily[1]). Human intervention in re-establishing viable populations on islands can thus catalyse or restore these natural dispersal patterns, thereby strengthening the broader metapopulation dynamics between islands and nearby mainland (Cerri, et al., 2024).

1.2.3 Robust Food Availability and Established Conservation Infrastructure

Sardinia's long-standing tradition of extensive livestock farming inherently provides a significant and ecologically fitting potential food source for vultures (LIFE Under Griffon Wings, 2015–2020, LIFE Safe for Vultures, 2021–2026). This consistent natural food supply is further bolstered by a robust network of centralized (n=3) and farm feeding stations (n=48), established and managed under ongoing conservation projects. These stations have provided substantial quantities of carcasses, ensured adequate food availability and improved the island's carrying capacity for vultures.

[1] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.lifesafeforvultures.eu/comunicati-stampa/24.04.24%20LIFE%20Safe%20for%20Vultures%20-%20Registrato%20il%20primo%20spostamento%20di%20un%20grifone%20dalla%20Sardegna%20alla%20Sicilia.pdf

The strategic rationale for vulture reintroduction in Sardinia is deeply intertwined with the successful outcomes and legacy of two major conservation initiatives: the LIFE Under Griffon Wings and the ongoing LIFE SAFE for VULTURES projects. These projects, financed by the European Commission's LIFE program, primarily focused on Griffon Vulture conservation but implemented multiple, comprehensive threat mitigation strategies applicable to all vulture species, as shown in Table 2.

Table 1.2 *Threats to vulture conservation in Sardinia and mitigation strategies under LIFE Under Griffon wings and LIFE Safe for Vultures.*

Threat Category	**Specific Threat Examples**	**Mitigation Strategies Implemented in Sardinia**	**Observed Impact/Status in Sardinia**
Direct Mortality	Illegal Poisoning (e.g., poisoned baits targeting predators)	Establishment of 4 anti-poison dog units; 178 inspections conducted; prosecution of offenders	Significant progress in reducing poisoning
	Electrocution and Collision with Energy Infrastructure	Securing 20 km of power lines with insulation and dissuasion devices – energy provider committed to secure power lines in case of confirmed mortality events involving large raptors within vulture's core area	Currently identified as the main threat for raptors in Sardinia; ongoing mitigation efforts
Food Availability	Decreased availability of wild and domestic ungulate carcasses due to agricultural changes and disposal regulations	Establishment of 48 farm and 3 centralized feeding stations; provision of over 14720 kg of carcasses per year; expansion of feeding network to southern Sardinia	Adequate food availability guaranteed; improved population growth and carrying capacity
Habitat & Disturbance	Habitat loss and human disturbance at nesting sites	Reduction of human disturbance in reproductive sites thought	Improved reproductive success for Griffon Vultures

		communication campaigns and awareness raising	
Emerging Threats	Dangerous veterinary drugs (e.g., diclofenac)	Continuous monitoring and proactive measures	Vet drug residues monitored in carcasses from feeding stations

These concerted efforts have demonstrably contributed to the demographic recovery of the Griffon Vulture in north-western Sardinia, with the population showing steady growth since 2015 (LIFE Under Griffon Wings, 2015–2020; LIFE Safe for Vultures 2021–2026). Currently, Sardinia hosts approximately 450 Griffon Vultures (105 territorial pairs in 2024), representing a considerable share of the Italian population. Crucially, key conservation actions, such as the management of centralized feeding stations by FoReSTAS, provisioning of farm feeding stations by local herders, and anti-poisoning measures by CFVA, are committed to continue beyond the projects' conclusion, ensuring long-term support.

The successful Griffon Vulture recovery has effectively prepared the ground for the reintroduction of the Cinereous and Bearded Vultures. This demonstrates a sophisticated, multi-species conservation approach where the recovery of one species creates a positive cascading effect, improving overall ecosystem health and attractiveness for other scavengers and raptors. The presence of the Griffon Vulture facilitates the potential return of the Cinereous and Bearded Vultures, with which it naturally interacts in carrion detection and landscape use (Cortés-Avizanda et al., 2012). The ongoing LIFE SAFE for VULTURES project explicitly aims to lay the groundwork for the return of these two extinct necrophagous species. Furthermore, the institutions involved in these projects have acquired extensive experience and competence over the past decade, building a robust network of European experts and scientists. This ensures that the reintroduction of the Bearded Vulture and Cinereous Vulture will be carried out using state-of-the-art solutions and techniques, adhering to shared methodologies and best practices developed over 30 years of European vulture conservation (Botha et al., 2017).

1.3 Summary of Key Reasons for Bearded and Cinereous Vulture Reintroduction in Sardinia

The proposed reintroduction of the Bearded Vulture and Cinereous Vulture in Sardinia is supported by a comprehensive array of ecological, conservation, strategic, and practical justifications. These factors, ranging from the restoration of vital ecosystem services to the island's unique role in broader European conservation networks, collectively underscore the imperative and feasibility of these initiatives. The table below provides a concise summary of these key reasons, categorized by their overarching principles and detailing their specific relevance to each species. This structured presentation highlights how local conservation successes and conditions serve as foundational elements for achieving broader regional and international conservation objectives, illustrating a scalable and replicable model for species recovery.

Table 1.3 *Summary of the main ecological, conservation, and strategic arguments supporting the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. The table outlines general justifications and species-specific benefits.*

Category of Reason	**General Justification (Overarching Principles/Conditions)**	**Specific Justification for Bearded Vulture**	**Specific Justification for Cinereous Vulture**
Ecological Benefits	Restoration of crucial ecosystem services (carcass removal, disease control, nutrient recycling); enhancement of ecological stability and functionality; strong indicator of environmental health	Contributes to complete carcass removal (specialized in bones)	Contributes to complete carcass removal (specialized in skin, tendons, cartilage)
Conservation Imperative	Restoration of locally extinct taxa; preservation of biodiversity; recovery of threatened species	Supports Critically Endangered Corsican population (last surviving genetic pool of former meta-population); addresses decline factors (low genetic variability, inbreeding, human mortality, food scarcity).	Restores original geographic range in central-western Mediterranean; aligns with European goals to halt declines and achieve favourable conservation status.
Strategic Importance (Sardinia's Role)	Sardinia as an "island refugia" and "reintroduction hub"; crucial link in migratory/dispersal networks; "stepping stone" or "reservoir" for broader recolonization; enhances metapopulation dynamics and connectivity across Europe; aligns with Vulture MsAP and European Action Plans.	Provides essential ecological space for Corsican population, strengthening regional metapopulation.	Establishes new population node, expands species' range, enhances overall European metapopulation resilience.

Practical Feasibility	Robust food availability (extensive livestock farming, established network of 3 centralized and 48 farm feeding stations); strong existing conservation infrastructure (successful LIFE projects, threat mitigation efforts for poisoning, electrocution, habitat disturbance, vet drugs); proven expertise and state-of-the-art methodologies from Griffon Vulture recovery; positive cascading effects on other scavengers.	Limited inter-species competition (distinct trophic niche – bones); distinct nesting sites (rock niches, far apart); individuals available from EEP captive breeding network.	Limited inter-species competition (distinct trophic niche – skin, tendons, cartilage); distinct nesting sites (almost exclusively in trees); individuals available from captive breeding and Spanish Recovery Centres.

1.4 Reasons for Reintroducing the Bearded Vulture in Sardinia

1.4.1 Critical Support for the Critically Endangered Corsican Population

The reintroduction of the Bearded Vulture in Sardinia is strategically vital, primarily due to its direct role in supporting the critically endangered population in Corsica. The Corsican Bearded Vulture population is alarmingly small, consisting of only 4-6 pairs and an estimated 25-30 individuals, leading to its classification as Critically Endangered (CR) on the IUCN regional red list. This population faces severe threats including geographical isolation, critically low numbers, low genetic variability, inbreeding, and significant mortality from human activities such as shooting and poisoning. A substantial decrease in natural food sources and susceptibility to random demographic events further exacerbate its precarious status.

Crucially, the Corsican population represents the last surviving genetic pool of a former meta-population that historically spanned Sicily, Sardinia, Corsica, and the Alps. The reintroduction in Sardinia is explicitly designed to complement existing conservation efforts in Corsica, notably the LIFE GYPRESCUE project, by providing essential ecological space for this small, ancient, and genetically unique population. The long-term viability and sustainability of the Bearded Vulture in the Mediterranean region are considered closely linked to the success of its reintroduction in Sardinia (BirdLife International, 2015–2018). The emphasis on the Corsican Bearded Vulture being the "last surviving genetic pool" highlights the critical importance of Sardinia's reintroduction for genetic rescue. This moves beyond simple species reintroduction to a sophisticated understanding of population genetics and metapopulation viability as central to long-term conservation success. Without the Sardinia reintroduction, the Corsican population faces a high risk of extinction due to genetic factors, making the Sardinia effort a direct and urgent intervention for regional genetic preservation.

1.4.2 Preserving Genetic Diversity and Enhancing Metapopulation Resilience

By re-establishing Bearded Vultures in Sardinia, there is a significant opportunity to safeguard the unique genetic lineage of the autochthonous Corsican population (Bretagnolle et al., 2004). This reintroduction is expected to foster potential dispersal and genetic exchange between the islands, thereby enhancing the overall genetic viability and resilience of the broader European metapopulation. Sardinia, once a part of the historical range, can act as a new source area or stepping stone, strengthening metapopulation dynamics and facilitating the recolonization of former territories, contributing to the species' long-term persistence across its European range (BirdLife International, 2015–2018).

1.4.3 Practical Feasibility and Absence of Significant Competition

The practical feasibility of Bearded Vulture reintroduction is high due to the availability of suitable individuals. These birds belong to the subspecies *Gypaetus barbatus barbatus* and are sourced from the robust EEP (European Endangered Species Programme) captive breeding network (BirdLife International, 2015–2018; LIFE GYPRESCUE, 2021–2026). This network comprises 44 institutions, including zoos, private partners, rehabilitation centres, and specialized breeding facilities, collectively ensuring the annual production of over twenty chicks specifically to support various reintroduction projects across Europe (e.g., Spain, France, Austria, Switzerland, Italy, and the Balkans). The reliance on this extensive captive breeding network for sourcing Bearded Vulture individuals demonstrates the sophisticated, coordinated international effort required for successful species reintroduction. This highlights a critical shift from purely *in situ* conservation to integrated *ex situ* and *in situ* strategies, showcasing advanced methodologies for population management and recovery. This highly organized, long-term, and collaborative approach to sourcing individuals ensures genetic health and viability for reintroduction programs across the continent.

Furthermore, potential inter-species competition among Bearded Vultures, Griffon Vultures, and Cinereous Vultures is limited (Cortés-Avizanda et al., 2012). The Bearded Vulture occupies a distinct trophic niche, primarily feeding on bones, which minimizes overlap with the other species (Cortés-Avizanda et al., 2012). Reintroduction experiences in France and Spain have consistently shown no negative interactions between these species; on the contrary, they often benefit from each other in locating food and ensuring the rapid and complete elimination of carcasses (Moleón et al., 2014). Competition for nesting sites is also not a limiting factor, as Bearded Vultures typically occupy solitary rock niches that are far apart between pairs, distinct from the colonial cliff-nesting Griffon Vultures and tree-nesting Cinereous Vultures (Cortés-Avizanda et al., 2012; Moleón et al., 2014).

1.5 Reasons for Reintroducing the Cinereous Vulture in Sardinia

1.5.1 Restoring Historical Range Continuity and Enhancing European Connectivity

The reintroduction of the Cinereous Vulture in Sardinia represents a significant opportunity for the species' conservation, primarily by restoring historical range continuity in the central-western Mediterranean. Historically, Cinereous Vultures were widespread and common breeding birds across central and southern Europe, with Sardinia alone harbouring an estimated 150 pairs at the turn of the 20th century (Schenk, 1976). The overarching European conservation goal for the Cinereous Vulture is clearly defined: to halt current population declines and restore the species to its original geographic range, ensuring all populations achieve a favourable conservation status (Botha et al., 2017). This includes fostering recolonization of former territories, systematically reducing threats across all relevant range states, and establishing safe corridors and ecological links between populations to enhance connectivity and genetic flow (Botha et al., 2017). This aligns directly with the European Species Action Plan for the Conservation of the Cinereous Vulture (Andevski et al., 2017).

The reintroduction in Sardinia directly advances these goals by re-establishing a population in a region where the species was previously extinct (Andevski, & Tavares, 2018; Botha et al., 2017). Establishing new colonies in Sardinia would significantly enhance metapopulation dynamics and connectivity across Europe. Sardinia's reintroduction of Cinereous Vultures thus holds strategic importance as it expands the species' range, establishes a new population node, and potentially serves as a stepping stone or "ecological space" for dispersal, thereby enhancing the overall resilience and genetic viability of the European metapopulation (Andevski et al., 2017; Botha et al., 2017).

1.5.2 Leveraging Successful Models and Practical Feasibility

The remarkable conservation success story of the Cinereous Vulture population in Mallorca, which grew from near extinction to over 300 individuals, serves as a compelling model and demonstrates the feasibility and potential for similar success in Sardinia This success reinforces the ultimate aim of moving beyond mere species survival to the establishment of robust, self-sustaining populations that fully contribute to ecosystem health and resilience, with the added benefit of potentially attracting nature-based economies and benefiting local communities (Cortés-Avizanda & Tavecchia, 2021; Dobrev et al., 2022; Santangeli et al., 2024). The explicit mention of Mallorca's success as a model for Sardinia underscores the importance of learning from and replicating proven conservation methodologies across different geographical contexts. This suggests a mature field of conservation where best practices are shared, adapted, and applied to maximize the likelihood of success in new reintroduction efforts. This also highlights a broader, holistic conservation approach that integrates ecological goals with socio-economic development, demonstrating the multi-faceted return on investment beyond pure environmental gains. The project is seen as a tool for sustainable regional development through ecotourism and increased public awareness, fostering stronger local buy-in and enhancing the long-term viability of the conservation effort by linking it to tangible human well-being benefits.

Practical considerations further support the reintroduction. Competition between Cinereous Vultures and other vulture species (Griffon, Bearded) is limited due to distinct trophic niches; Cinereous Vultures feed on parts of the carcass (skin, tendons, and cartilage) not typically utilized by Griffon Vultures Reintroduction experiences in France and Spain have consistently shown no negative interactions between these species; instead, they mutually benefit from each other in locating food and ensuring the rapid and complete elimination of carcasses (Cortés-Avizanda et al., 2012). Competition for nesting sites is also not a limiting factor, as Cinereous Vultures nest almost exclusively in trees, which is distinct from the rock-nesting habits of Griffon and Bearded Vultures. Individuals for reintroduction, belonging to the monotypic species *Aegypius monachus*, are available from pairs that breed in captivity and individuals successfully recovered from Spanish Recovery Centres, ensuring a viable source population (LIFE GYPRESCUE, 2021–2026).

1.6 Alignment with European and International Conservation Strategies

1.6.1 Integration into Overarching Conservation Frameworks

Vulture conservation is not a collection of disparate projects but a highly networked endeavour, demanding coordinated efforts across Europe and internationally (Botha et al., 2017). This approach recognizes shared threats and necessitates a unified commitment to conservation. Sardinia's central geographical position in the Mediterranean grants it a strategic role in the recovery of vulture populations across the entire region (Botha et al., 2017; LIFE Safe for Vultures, 2021–2026). Consequently, the reintroduction efforts for both the Bearded Vulture and the Cinereous Vulture in Sardinia are highly desirable and directly align with several key international and European conservation frameworks:

- **Multi-species Action Plan to Conserve African-Eurasian Vultures (Vulture MsAP):** Adopted under the Convention on the Conservation of Migratory Species of Wild Animals (CMS), this plan outlines coordinated conservation actions at a continental scale to reverse population trends. Sardinia's efforts are a direct contribution to this overarching strategy.
- **European Species Action Plan for the Conservation of the Cinereous Vulture (***Aegypius monachus***) - Vulture Conservation Foundation (2018–2028):** This plan aims to halt declines and restore the species' original geographic range, emphasizing the enhancement of connectivity and genetic flow. Sardinia's reintroduction directly supports these goals.
- **European Union single species recovery plan for the Western Palearctic population of Bearded Vulture (***Gypaetus barbatus barbatus***) LIFE EuroSAP Project:** This recovery plan specifically focuses on strengthening the Western Palearctic population of the Bearded Vulture, a goal directly advanced by the Sardinian reintroduction.

1.6.2 Leveraging Interconnectedness and Shared Methodologies

Effective European vulture conservation relies on strategies that explicitly acknowledge and leverage the interconnectedness of mainland and island populations. This approach moves beyond isolated protection efforts to foster a more resilient, metapopulation-level persistence (Andevski et al., 2017; Botha et al., 2017). Islands, like Sardinia, serve as critical refugia, safeguarding unique genetic lineages and providing demographic stability amidst pressures faced by mainland populations (LIFE Safe for Vultures, 2021–2026). Conversely, robust mainland populations, particularly established source areas, are indispensable for providing demographic and genetic rescue to struggling island and regional populations through natural dispersal and human-mediated translocations (Botha et al., 2017) (LIFE GYPRESCUE, 2021–2026). Reintroduction programs are thus fundamental tools for enhancing population persistence, especially in fragmented landscapes or where local extirpations have occurred (Botha et al., 2017) (LIFE Safe for Vultures, 2021–2026). The consistent framing of the Sardinia reintroduction within a broader "metapopulation" context, emphasizing connectivity, genetic exchange, and the strategic role of islands as "critical nodes," indicates a sophisticated, modern conservation paradigm. This approach moves beyond isolated species protection to managing dynamic, interconnected populations across vast geographical areas, highlighting the interconnectedness of conservation efforts at a continental scale.

The reintroduction of the Bearded Vulture and Cinereous Vulture in Sardinia will be carried out using state-of-the-art solutions and techniques, adhering to shared methodologies and best practices developed and refined over 30 years of extensive vulture conservation efforts across Europe (LIFE GYPRESCUE, 2021–2026; Andevski et al., 2017). This commitment to established, scientifically proven methods ensure high standards and maximizes the potential for long-term success.

1.7 Conclusion: Sardinia's Pivotal Role in European Vulture Conservation

1.7.1 Synergistic Benefits and Long-Term Vision

The successful recovery of the Griffon Vulture in Sardinia stands as a compelling testament to the effectiveness of targeted, science-driven interventions in significantly reducing extinction risk and improving conservation status (LIFE Under Griffon Wings, 2015–2020; Aresu et al., 2022). These efforts have demonstrably prepared the ecological and social ground for the restoration of the entire vulture guild on the island. Sardinia's enduring tradition of extensive livestock farming provides a significant and consistent food source, making the reintroduction of additional vulture species ecologically fitting and sustainable. The strategic investment in reintroducing the Bearded Vulture and the Cinereous Vulture in Sardinia is projected to yield substantial returns, not only for the island's unique ecosystem but also by establishing a robust source population for broader regional recovery efforts (Andevski et al., 2017; LIFE Safe for Vultures, 2021–2026). The re-establishment of these extirpated island populations is a strategic imperative for regional persistence, as it will complete the restoration of vital ecosystem services in Sardinia and concurrently contribute to the broader European metapopulation by creating new source areas or steppingstones for dispersal (Botha et al., 2017; LIFE Safe for Vultures, 2021–2026).

1.7.2 Sardinia as a Model for Integrated Vulture Conservation

Sardinia's remarkable progress in mitigating threats and fostering population growth, exemplified by the successful recovery of Griffon Vultures, positions the island as a significant model for integrated vulture conservation (LIFE Under Griffon Wings, 2015–2020; Aresu et al., 2022). The Sardinian experience clearly demonstrates how localized successes can contribute powerfully to a larger, interconnected ecological network across Europe, providing a valuable blueprint that can inform and inspire similar initiatives in other regions facing comparable conservation challenges (LIFE Safe for Vultures, 2021–2026; Botha et al., 2017). The successful Griffon Vulture recovery in Sardinia serves as empirical evidence that the island is now suitable and that the methodologies employed are effective. This acts as a powerful validation for the proposed reintroduction of the other two species, significantly reducing perceived risk and bolstering confidence in future, more ambitious efforts. Indeed, Europe, through its extensive knowledge base and unwavering commitment to vulture conservation, has emerged as the only vulture stronghold in the Old World (Andevski et al., 2017; Botha et al., 2017). The integrated approach and success in Sardinia can inform and inspire similar initiatives elsewhere, elevating Sardinia's role from a local conservation site to a global exemplar. This highlights the potential for knowledge transfer and replication of successful models worldwide, particularly regarding threat mitigation, community engagement, and fostering inter-island connectivity.

2. Legal framework for translocations

2.1 Introduction

Conservation translocation refers to the deliberate movement and release of living organisms with the primary goal of achieving a conservation benefit. This typically involves enhancing the conservation status of the target species—either locally or globally—and/or contributing to the restoration of natural ecosystem functions and processes (IUCN/SSC, 2013).

Conservation translocations involve releasing animals either within or outside their native range. A species' native range is based on historical records or physical evidence of past presence. When such evidence is lacking, suitable nearby habitat may suggest prior occupancy.

There are two main types of conservation translocation:

1. Population restoration (within native range):
    - Reinforcement: the intentional movement and release of an organism into an existing population of conspecifics; it aims to enhance population viability.
    - Reintroduction: the intentional movement and release of an organism inside its indigenous range from which it has disappeared; it aims to re-establish a viable population of the focal species within its indigenous range.

2. Conservation introduction (outside native range):
    - Assisted colonisation: the intentional movement and release of an organism outside its indigenous range to avoid extinction of populations of the focal species.
    - Ecological replacement: the intentional movement and release of an organism outside its indigenous range to perform a specific ecological function.

Wildlife translocation is a commonly employed strategy in the management of threatened species and ecological keystone species.

2.2 National Regulations

In Italy, the legal framework for wildlife is established by Law No. 157 of 1992 (*Norme per protezione della fauna selvatica omeoterma e per il prelievo venatorio*), which recognises wildlife as a national asset under the protection of the State. This law aims to safeguard wildlife in the interest of both the national and international community. In particular, Article 20 of Law No. 157/1992—updated by Law No. 96 of 4 June 2010 (Community Law 2009)—regulates the introduction of wild fauna from abroad, specifically:

1. The introduction of live wild fauna from abroad, provided they belong to native species, may be carried out solely for restocking or genetic improvement purposes.
2. Import permits may be granted only to companies or entities equipped with appropriate facilities and equipment for each individual wild species, to ensure proper monitoring, potential quarantines, and relevant health checks.
3. Authorisations for the activities referred to in paragraph 1 are issued by the Ministry of Agriculture, Food and Forestry Policies, based on the opinion of ISPRA, and in compliance with international conventions.

In the case of bird species that do not naturally occur in the wild within the territory of the European Union Member States, the Minister of Agriculture, Food and Forestry Policies must also consult the European Commission in advance.

2.3 International Regulations

The international legal framework regarding the translocation of wild species is established by the Washington Convention (CITES).

CITES is an international agreement on the trade of endangered species of wild fauna and flora, signed in 1975. The main purpose of the Convention is to ensure that, where international commercial exploitation of a wild species is permitted, it is sustainable for the species and compatible with the ecological role that the species plays in its habitat.

More than 35,000 species of animals and plants are listed in the CITES Appendices, with varying levels of protection. The provisions of the Convention apply to both live and dead specimens, parts (such as ivory and skin), and derivative products (such as medicines obtained from animals or plants). CITES Parties work together to regulate trade in the listed species by issuing permits and certificates.

CITES has been adopted throughout the European Union via regulations that are directly applicable to Member States. The current regulations in force in the European Union for the implementation of CITES are:

- Council Regulation (EC) No. 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by regulating trade therein, including the Annexes to the regulation listing the species subject to controlled trade.

- Commission Regulation (EC) No. 865/2006 of 4 May 2006 laying down detailed rules concerning the implementation of Council Regulation (EC) No. 338/97 on the protection of species of wild fauna and flora by regulating trade therein.

- Commission Implementing Regulation (EU) No. 792/2012 of 23 August 2012 laying down rules for the design of permits, certificates, and other documents provided for under Council Regulation (EC) No. 338/97 on the protection of species of wild fauna and flora by regulating trade therein and amending Commission Regulation (EC) No. 865/2006.

- Commission Implementing Regulation (EU) No. 1587/2019 of 24 September 2019 prohibiting the introduction into the Union of specimens of certain species of wild fauna and flora.

These regulations constitute the legal framework for governing the international and domestic trade of wild animals and plants for all EU Member States. The EU regulations include four Annexes (A, B, C, and D); Annexes A, B, and C broadly correspond to CITES Appendices I, II, and III, but also include some species not listed by CITES that are protected under EU domestic legislation. Annex D, which has no equivalent in CITES, includes certain species not listed in Annexes A to C but for which the volume of imports into the EU justifies monitoring.

To comply with other EU instruments on the protection of native species, such as the Habitats Directive and the Birds Directive, some indigenous species listed in CITES Appendices II and III are included in Annex A. Member States may adopt stricter national measures, for example concerning the possession or trade of species listed in the Annexes.

Italy ratified the Washington Convention through Law No. 874 of 19 December 1975. Pursuant to Legislative Decree No. 300 of 30 July 1999, the main Management Authority in Italy is the Ministry of the Environment and Energy Security, which is responsible for political, administrative, and coordination functions. The authority responsible for issuing certificates is the Ministry of Agriculture, Food and Forestry, which operates through the Command of Forestry, Environmental and Agri-food Units (CUFA) of the Carabinieri Corps. The authority in charge of issuing import and export licences is the Ministry of Foreign Affairs and International Cooperation. The enforcement of compliance with the Convention, EU regulations, and national legislation is entrusted to the CITES Carabinieri Unit throughout the national territory and to the Guardia di Finanza at customs checkpoints.

Italy has regulated offences related to the implementation of the Convention and EU regulations through Law No. 150 of 7 February 1992. This law also introduces certain stricter measures compared to those provided by the Convention and EU regulations, such as the prohibition of keeping live specimens of mammals and reptiles that may pose a danger to public health and safety, and the requirement to maintain a register for commercial activities that hold live or dead specimens, parts, or derivatives of species listed in Annexes A and B of Regulation 338/97.

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of 15 May 2023

amending Council Regulation (EC) No. 338/97 to take account of the amendments adopted at the 19th meeting of the Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Annex (partial)
(covering only falconiform species listed in Appendix II)

Annex A	Annex B	Annex C	Common Name
			FALCONIFORMES
			Diurnal birds of prey (eagles, falcons, hawks, vultures)
			FALCONIFORMES spp. (II)
			(except for species listed in Annex A and one species from the family Cathartidae listed in Annex C; other species from this family are not included in this regulation; Caracara lutosa is also excluded)
			Diurnal birds of prey
			Accipitridae
			Hawks, eagles
	Accipiter brevipes (II)		Levant Sparrowhawk
	Accipiter gentilis (II)		Northern Goshawk
	Accipiter nisus (II)		Eurasian Sparrowhawk
	Aegypius monachus (II)		Cinereous Vulture
	Aquila adalberti (I)		Spanish Imperial Eagle
	Aquila chrysaetos (II)		Golden Eagle
	Aquila clanga (II)		Greater Spotted Eagle
	Aquila heliaca (I)		Eastern Imperial Eagle
	Aquila pomarina (II)		Lesser Spotted Eagle
	Buteo buteo (II)		Common Buzzard

	Buteo lagopus (II)		Rough-legged Buzzard
	Buteo rufinus (II)		Long-legged Buzzard
	Chondrohierax wilsonii (I)		Wilson's Hawk or Cuban Black Hawk
	Circaetus gallicus (II)		Short-toed Snake Eagle
	Circus aeruginosus (II)		Western Marsh Harrier
	Circus cyaneus (II)		Hen Harrier
	Circus hudsonius (II)		Northern Harrier
	Circus macrourus (II)		Pallid Harrier
	Circus pygargus (II)		Montagu's Harrier
	Elanus caeruleus (II)		Black-winged Kite
	Eutriorchis astur (II)		Madagascar Serpent Eagle
	Gypaetus barbatus (II)		Bearded Vulture
	Gyps fulvus (II)		Griffon Vulture
	*Haliaeetus spp. (*I/II)		Sea Eagles (White-tailed Eagle in Annex I; others in Annex II)
	Harpia harpyja (I)		Harpy Eagle
	Hieraaetus fasciatus (II)		Bonelli's Eagle
	Hieraaetus pennatus (II)		Booted Eagle
	Leucopternis occidentalis (II)		Grey-backed Hawk
	Milvus migrans (II) (except *M. migrans lineatus* listed in Annex B)		Black Kite
	Milvus milvus (II)		Red Kite
	Neophron percnopterus (II)		Egyptian Vulture
	Pernis apivorus (II)		European Honey Buzzard

2.4 Conclusions

In cases of wildlife reintroduction projects, the translocation of specimens of species listed in Annex A of the regulation and the related authorizations involve several entities at the national, regional, and provincial levels.

The main management authority in Italy is the Ministry of Environment and Energy Security; the issuance of certificates is handled by the Ministry of Agricultural, Food and Forestry Policies. The authority responsible for issuing import and export licenses is the Ministry of Foreign Affairs and International Cooperation.

The Ministry relies on the Command of Forestry, Environmental and Agri-food Units (CUFA) of the Carabinieri Corps, which carry out inspections also through the CITES Carabinieri Group. The Higher Institute for Environmental Protection and Research (ISPRA), as the competent national authority, after the necessary verifications, supports the project with a Declaration of Support. The Regional Department for Environmental Protection in the area concerned by the project authorizes restocking or reintroduction operations through specific determinations. Finally, the Environment, Planning and Wildlife Management Service of the relevant Province authorizes the project, requiring monitoring through annual reports on the operations carried out and to be carried out, including communications of the dates and locations planned for the release of individuals into the wild.

3. Funding the Return: Strategic Perspectives and Opportunities for Bearded and Cinereous Vulture Reintroduction in Sardinia

3.1 Current Funding Landscape and Key Contributors

Securing the financial resources for the reintroduction of Bearded and Cinereous Vultures in Sardinia requires a comprehensive understanding of the existing funding landscape, encompassing European Union programs, national and regional public funding.

3.1.1 European Union Funding

The European Union is a cornerstone of biodiversity conservation funding, with several programs directly relevant to species reintroduction efforts. The LIFE Programme is the EU's flagship funding instrument for environment and climate action, with a substantial budget of €5.432 billion for the 2021-2027 period. Since its inception in 1992, it has co-financed thousands of projects across the EU.5 The program is structured into four sub-programmes, with the Nature and Biodiversity sub-programme being directly pertinent to vulture reintroduction. This sub-programme, with an indicative budget of €153.4 million for 2025, is specifically dedicated to protecting and restoring Europe's nature and halting and reversing biodiversity loss. It provides financial support for projects that contribute to the implementation of the EU Birds and Habitats Directives, as well as the objectives of the EU Biodiversity Strategy for 2030, which is a key part of the European Green Deal. Any legal person registered in the EU, including public and private organizations, non-governmental organizations (NGOs), universities, and community groups, is eligible to apply (*LIFE | Cluster 6 | Horizon Europe NCP Portal*). Applications can be submitted by a single organization or by several entities working in collaboration with other European partners (*LIFE Calls for Proposals 2025 | ERRIN Website*). For Standard Action Projects (SAPs), the maximum EU co-funding rate is generally 60%, but can increase to 75% for projects under Nature and Biodiversity that fulfil specific conditions (*LIFE | Cluster 6 | Horizon Europe NCP Portal*). Strategic Nature Projects (SNAPs) and Strategic Integrated Projects (SIPs) also have a maximum co-funding rate of 60%. Calls for proposals are launched annually, with the 2025 calls published on April 24, 2025. Deadlines for single-stage SAPs are September 23, 2025, while two-stage projects require a concept note by September 4, 2025, and a full proposal by March 5, 2026.

The prior success with Griffon Vultures through the LIFE Under Griffon Wings and LIFE SAFE for VULTURES projects means the project team has demonstrated capacity, built relationships with EU funding bodies, and understands the application process. This history of successful project delivery under the LIFE program makes future proposals from Sardinia highly competitive and credible, signalling low risk and high potential for impact to the European Commission. For this reason, the project team in Sardinia committed in presenting a proposal to the LIFE call 2025 for the restoration of the vulture guild in Sardinia and Corsica. The proposal will be submitted under the topic Nature and Biodiversity - type of action Standard Action Projects (SAPs), – intervention area “Safeguarding our species". If approved, the starting date will be fixed in late 2026 – early 2027 and it will last 7 years.

At the moment (May 2025), the following bodies have confirmed their commitment in being part of the LIFE proposal partnership:

- University of Sassari https://www.uniss.it/it
- Fo.re.s.t.a.s. Regional Agency https://www.sardegnaforeste.it/
- Forest and Environmental Surveillance Corps of the Sardinia Region https://www.sardegnaambiente.it/corpoforestale/
- e-distribuzione S.p.A. https://www.e-distribuzione.it/
- Vulture Conservation Foundation https://4vultures.org/
- Parc Régional de Corse https://www.pnr.corsica/
- Sardinia Regional Department for the Environment
- Sardinia Regional Department for Tourism
- GREFA https://www.grefa.org/
- Gutturu Mannu Regional Park https://www.parcogutturumannu.it/

Beside the reintroduction of the two species in Sardinia and the reinforcement of the Bearded Vulture population in Corsica, main actions will include:

1) Mitigate threats to reduce mortality

a) Mitigate the risk of mortality related to energy infrastructures

b) Ensure prevention, detection and persecution of any crime against nature such as illegal use of poisons, poaching, persecution

c) Ensure prompt rescue and recovery of translocated individuals and diagnosis of the causes of death

d) Raise awareness to reduce potential conflicts with human activities

2) Improve habitat around potential colonies through:

a) Reduce human disturbance related to outdoor activities

b) Prevent fires in old forest areas and improve surveillance to ensure habitat resilience to climate change

c) Construct artificial nesting platforms in areas with high breeding potential for the CV

d) Improve food availability from livestock carcasses by enlarging the network of feeding stations and by the touristic exploitation of the farm feeding stations

e) Create new SPAs.

The analysis of the prioritization for funding under the LIFE program confirmed that the proposal would be granted the following priorities:

First level prioritization: target species covered by the EU Birds Directive and listed as priority species by the Ornis Committee

Priorities stemming from EU nature and biodiversity legislation:

- The project will implement objectives and measures outlined in the Vulture Multi-Species Action Plan to Conserve African-Eurasian Vultures (Botha et al., 2017) endorsed by the Convention on the Conservation of Migratory Species of Wild Animals (resolution n. UNEP/CMS/Resolution 12.10), of the "Action Plan to prevent illegal poisoning of wildlife of the European Network against Environmental Crime", the "International species action plan for the Bearded Vulture", the French Action plan for the Bearded Vulture (Plan national d'actions en faveur du gypaète barbu *Gypaetus barbatus* 2010-2020), and in the Conservation Plan for vultures in Sardinia (under drafting and approval);
- Project activities focus on the implementation of conservation objectives for existing Natura 2000 sites;
- Project activities focus on reducing the deliberate or accidental killing of the targeted species (e.g., poisoning), improving acceptance and promoting co-existence with protected species (farm feeding stations, communication actions to be specifically designed at this aim).

Priorities stemming from the EU Biodiversity Strategy for 2030:

1. Establishing a coherent network of protected areas – a) Proposals contributing to the target of legally protecting a minimum of 30% of the EU's land area and 30% of the EU sea area, and on integrating ecological corridors, as part of a true Trans-European Nature Network; b) Proposals contributing to the target of strictly protecting at least a third of the EU's protected areas, including all remaining EU primary and old-growth forests.

2. Implementing EU nature restoration targets for species and habitats - a) Proposals that are focused on implementing national commitments or pledges, for improving the status of species and habitats covered by the EU nature directives, including through trans-national or trans-boundary approaches.

3. Bringing nature back to agricultural land: Project proposals that demonstrate innovative approaches to restoring high-biodiversity landscape features in agroecosystems that also bring benefits for farmers and communities (favouring the exploitation of vulture ecosystem services) and communicate such approaches.

Securing the LIFE funding will allow the development of all preparatory, conservation, monitoring, communication and management actions needed to sustain the success of this ambitious reintroduction programme. It will hence represent the first step towards its full implementation.

3.1.2 The Autonomous Region of Sardinia Funding

The Autonomous Region of Sardinia has a demonstrated history of funding conservation projects within its territory. This indicates a precedent for regional financial commitment to biodiversity initiatives. The Region of Sardinia regularly issues calls for expressions of interest for the management of Natura 2000 sites, targeting municipalities, provinces, and managing bodies of protected areas. These calls explicitly aim to "strengthen the protection and preservation of nature, biodiversity and green infrastructure". Additionally, Sardinia has allocated funds for mountain communities, with declared goals including environmental protection and sustainable development. There are also ongoing calls related to agricultural biodiversity, which could indirectly support habitat quality for vultures.

A significant enabling policy at the regional level is Sardinia's pioneering authorization for the use of carcasses from domestic animals raised in extensive and semi-extensive systems for feeding necrophagous birds. This policy, unique in Italy, includes a detailed procedure for managing farm feeding stations, which are crucial for supporting viable vulture populations. This regional policy demonstrates a strong commitment to facilitating vulture conservation.

The Region of Sardinia, besides being a partner of the new project with two different Departments, further confirmed its commitment in vulture conservation allocating a budget for the year 2025 – 2027 to specific preparatory actions for the reintroduction of the two species to be carried on by Agenzia Forestas. The total amount of budget allocated sum to 400.000,00 euros, and it will allow to build the new aviary for Cinereous Vulture acclimatisation (develop the executive project, acquisition of the permits, implementation of the works), renew the facilities of the wildlife rescue centres managed by the Agenzia Forestas to adapt them for the hospitalization of large vultures, keep on tagging and releasing Griffon Vultures (in the south area of Sardinia) to monitor the threats and acquire information on the habitat use.

The strategic commitment of the Region of Sardinia will be pivotal also in ensuring the long-term sustainability of these efforts. The regional government is indeed responsible for implementing specific calls for proposals under European Union Funds (channelled through Italy), tailoring them to local needs and priorities:

1) European Agricultural Fund for Rural Development (FEASR) under the CAP Strategic Plan: FEASR serves as a consistent and vital funding source for rural development initiatives across Italy, including various agro-environmental schemes that directly benefit biodiversity. This fund supports "non-productive agricultural investments" with clear environmental objectives. These include initiatives aimed at arresting biodiversity loss, preserving traditional rural landscapes, and improving the coexistence between agricultural practices, livestock, and wild fauna. Specific targets include managing ungulates (such as wild boars and cervids) and protecting species of community interest. FEASR also provides strong incentives for the adoption and expansion of organic farming and other agroecological practices.

2) European Regional Development Fund (FESR): FESR is a significant and recurring funding source that supports a wide array of regional development initiatives across multiple intervention areas. It frequently co-finances regional biodiversity and nature protection projects.

These programmes will ensure other funding opportunities for the long-term implementation and management of the reintroduction project.

3.2 Strategic Funding Opportunities for Long-Term Sustainability

Given the long-term commitment needed to establish viable populations of Bearded Vulture and Cinereous Vulture in Sardinia, other funding opportunities must be searched to ensure the sustainability of the project. Beyond traditional grants and public funding, a robust financial strategy for vulture reintroduction in Sardinia must explore innovative and sustainable mechanisms that integrate conservation with economic development.

3.2.1 Ecotourism and Nature-Based Economies

The reintroduction of iconic species like the Bearded and Cinereous Vultures can significantly enhance Sardinia's ecotourism appeal, transforming these birds into powerful "ecotourism anchors" and economic multipliers. The presence of Griffon Vultures in Sardinia's natural reserves already attracts ecotourists and nature enthusiasts from across Europe. Studies conducted in Sardinia reveal substantial interest: 73% of nature reserve visitors would be willing to pay to visit hides for vulture observation, and 80% would join guided tours (Santangeli et al., 2024). This quantifiable interest underscores the significant ecotourism potential that can be further capitalized upon with the return of additional vulture species.

Ecotourism, when managed responsibly, serves as a powerful tool for funding conservation efforts. It generates revenue through park fees, accommodations, guide services, and local purchases, a portion of which can be directly allocated to conservation initiatives such as wildlife monitoring, anti-poaching efforts, and habitat restoration. This sustainable funding model creates a direct incentive for local communities to protect their natural resources, as they directly benefit from the economic opportunities provided by ecotourism. Furthermore, ecotourism supports local economies, reducing the need for communities to resort to activities that degrade habitats, such as unsustainable agriculture or logging (Samal & Dash, 2023). It also raises awareness about the importance of conservation among visitors, who often become advocates and donors for wildlife protection (Brightsmith et al., 2008).

The new project will indeed specifically foresee actions for the creation and promotion of ecotourism in Sardinia taking advantages of the presence of farm feeding stations and of vulture iconic species.

3.2.2 Private Sector Engagement and Corporate Social Responsibility (CSR)

There is a growing global and European trend towards increased corporate interest in biodiversity conservation and environmental sustainability. Companies and investors are increasingly aware of the "double threat" of biodiversity loss and climate change, leading to a growing focus on maintaining and improving biodiversity (*CSR, Corporate Social Responsibility*, 2024). Financial institutions are stepping up their biodiversity due diligence and integrating biodiversity risk into investment decisions (United Nations Environment Programme, 2023).

This shift is reflected in the rise of Environmental, Social, and Governance (ESG) investments, with European financial institutions, insurance companies, asset managers, and family offices committing to biodiversity-focused funds (EFAMA - European Fund and Asset Management Association, 2023). The European Investment Bank, for instance, has established its own Environmental and Social Standards, which include an assessment of biodiversity impact to inform decision-making (European Investment Bank, 2022). In the Italian context, companies are increasingly integrating environmental policy into their business operations, with dedicated investments in Corporate Social Responsibility (CSR) growing significantly (*CSR, Corporate Social Responsibility*, 2024). Environmental sustainability is recognized as a key factor in their growth strategies.

Several models for private sector engagement can be leveraged for vulture reintroduction:

- **Direct Corporate Partnerships/Sponsorships:** Companies can directly fund or sponsor conservation projects. Notable examples include the partnership between the World Wildlife Fund (WWF) and The Coca-Cola Company, which supported polar bear conservation (*WWF and COCA-COLA Join Forces to Help Protect the Arctic, Home of Polar Bears*, 2013), and Rolex's collaboration with the National Geographic Society (*One Year of the Rolex and National Geographic Perpetual Planet Amazon Expeditions*). Such partnerships can involve direct financial contributions, in-kind support, or joint initiatives that leverage corporate resources and reach.
- **ESG Reporting and Impact Investing:** Global frameworks like the Science-Based Targets Network (SBTN) and the Taskforce on Nature-related Financial Disclosures (TNFD) are increasingly used by companies to report on their biodiversity impacts, driving investment into mitigation and restoration efforts (United Nations Environment Programme, 2023).[40] Biodiversity impact funds are emerging, such as Goldman Sachs' Biodiversity Bond fund, which invests in bonds whose proceeds support biodiversity conservation and remediation projects (*Biodiversity, Bond, Goldman Sachs, SFDR, Article 9, Mutual Fund*).
- **Supply Chain Financing:** Projects like "Revenues for Nature" aim to unlock private sector investment through scalable, replicable revenue models, including commodity supply chain financing, for nature restoration (*Revenues for Nature Community of Practice*).[43] If vulture conservation can be linked to sustainable agricultural or livestock practices in Sardinia, this model could provide a unique funding stream.

3.2.3 Innovative Finance Mechanisms

Innovative finance mechanisms offer promising avenues for securing long-term, diversified funding for conservation projects, moving beyond traditional grant reliance.

- Biodiversity Credits: Biodiversity credits are emerging mechanisms that allow private sector organizations to compensate for the biodiversity loss caused by their activities by investing in conservation or restoration efforts elsewhere (Manez & Clifton, 2025). This market-based approach is gaining traction in Europe. The Italian government plans to launch biodiversity credit pilot projects across the country, indicating a national commitment to exploring this mechanism (*BRIEFING: Italy to Pilot Biodiversity Credits amid Unresolved Market, Ecosystem*

Challenges « Carbon Pulse). A public-private consortium in Italy is already exploring biodiversity credits to mobilize financing for wetland restoration (*Italian Cohort Weighs Biodiversity Credits for Wetland Restoration Plan « Carbon Pulse*). European precedents exist, with France having launched a national scheme for voluntary biodiversity credits and Germany utilizing an "Ökokonto" system where municipalities generate credits through habitat or species conservation (Rayment et al., 2014). The nascent biodiversity credit market in Italy offers a novel and significant funding opportunity for the long-term sustainment of the vulture reintroduction programme, which can be framed as a "biodiversity gain" generator. By quantifying the ecological uplift provided by the returning vultures (e.g., tons of carcasses consumed, reduction in disease vectors, increase in scavenger biomass, restoration of ecosystem functionality), these benefits could be packaged as biodiversity credits. These credits could then be sold to companies seeking to offset their environmental impacts or meet ESG targets, creating a market-based mechanism for long-term project funding that moves beyond traditional grants to a more self-sustaining, private-sector-driven financial model.

- Payments for Ecosystem Services (PES): Payments for Ecosystem Services (PES) schemes involve compensating individuals or communities for managing their land or resources in a way that generates specific ecosystem services, such as conserving biodiversity or protecting watersheds (*Markets and Payments for Environmental Services*). Vultures provide crucial ecosystem services by rapidly removing carcasses, controlling disease, and recycling nutrients. These services have quantifiable economic value, including cost savings from carcass disposal and reductions in greenhouse gas emissions associated with alternative disposal methods. The economic value of the ecosystem services provided by vultures, particularly carcass disposal, can be formalized into a PES scheme. Instead of viewing carcass disposal as a "free" service, it can be monetized. For instance, local livestock farmers or regional authorities could receive direct payments or subsidies for managing their land in a way that actively supports vulture foraging (e.g., maintaining feeding stations, ensuring carcasses are accessible). A precedent exists in the United States, where the Florida Fish and Wildlife Conservation Commission provides annual per-acre payments to landowners for maintaining high-quality Florida panther habitat, with additional payments for evidence of panther use (*Panther - Payment for Ecosystem Services*).[47] In Italy, a LIFE project in the Veneto region involved payments to landowners for creating biodiverse forested areas that provided ecosystem services like water management (*Parco Fiume Brenta - LIFE Brenta 2030 Project*, 2025). This approach creates a direct financial incentive for land managers to become active partners in vulture conservation, transforming a cost-saving into a revenue stream for the local community, thereby embedding conservation directly into the local economy.

- Conservation Trust Funds and Blended Finance: Conservation Trust Funds are an innovative financing mechanism that provides long-term, stable funding for biodiversity conservation (GEF Secretariat, 2024). These funds are typically established as private, legally independent grant-making institutions that mobilize and invest resources from diverse sources, including governments, multilateral agencies, foundations, corporations, and individuals. They promote financial sustainability and local ownership of conservation efforts by involving local stakeholders in decision-making processes and strengthening the capacity of local organizations. Blended Finance involves combining public and private capital to fund projects, often de-risking private investment through public grants or guarantees. The European Investment Bank (EIB) is actively involved in setting up financial agreements for nature restoration (*Unlocking Finance and Investments in Nature*, 2023), and Rewilding Europe Capital specifically finances nature-based businesses working to restore wild areas (*Rewilding Europe Capital*). Establishing a dedicated conservation trust fund for Sardinian vulture reintroduction could provide long-term financial security. Blended finance models, combining public grants (e.g., EU LIFE) with private investment (e.g., impact funds, corporate contributions), could significantly scale up funding for the project, allowing for more ambitious and sustained efforts.

The following table synthesizes the ecological and socio-economic benefits of vulture reintroduction, providing a comprehensive value proposition for potential funders:

Table 3.1 *Ecological and Socio-Economic Benefits of Vulture Reintroduction in Sardinia*

Benefit Category	**Specific Benefit**	**Quantifiable Impact/Evidence**
Ecological	Rapid carcass removal	Carcasses may take up to five times longer to decompose in vulture absence
	Disease control	Highly acidic stomach fluids neutralize pathogens; disrupts transmission cycle of endemic zoonoses like Cystic Echinococcosis
	Nutrient recycling	Direct contribution to nutrient cycling; prevents accumulation of decaying biomass
	Reduction of greenhouse gas emissions	Prevents CO_2 emissions from carcass incineration; Sardinian Griffon Vultures consumed 65.5-103.1 tons of biomass in 2022, preventing equivalent CO_2 emissions of 16-34 households/year
	Broader ecosystem recovery	Acts as a catalyst for other scavenger birds and raptors; favoured spontaneous colonization of Egyptian Vulture; increasing wintering Red Kite population
Public Health	Reduced pathogen transmission	Limits spread of disease for wild/domestic animals and humans

Economic	Cost savings from carcass disposal	Free and natural means of carcass disposal for livestock farming
	Ecotourism revenue generation	Griffon Vultures attract ecotourists; 73% willing to pay for observation, 80% for guided tours
	Local job creation	Ecotourism supports local economies and jobs (e.g., guides, accommodation)
Cultural/Social	Enhancement of human well-being	Aesthetic and cultural values; symbol of renewal and balance
	Public awareness and engagement	Promotes awareness of biodiversity conservation issues; visitors become advocates
Regional Resilience	Metapopulation resilience & genetic viability	Establishes new population node; serves as stepping stone for dispersal; enhances connectivity across Europe

3.3 Recommendations for a Robust Funding Strategy

To ensure the long-term success and sustainability of the Bearded and Cinereous Vulture reintroduction in Sardinia, a robust and multi-faceted funding strategy is imperative. The key approaches are outlines as follows:

- Starting preparatory actions:

The Region of Sardinia funding specifically allocated for the restoration of the vulture guild to the Agenzia Forestas Agency annual budget for the years 2025-2027 will allow the implementation of key preparatory actions, such as the construction of the acclimatisation aviary for the Cinereous Vulture, the renewal of the facilities of the wildlife rescue centres managed by the Agenzia and the continuous monitoring of the threats thanks to the release of satellite tagged Griffon Vultures

- Developing a proposal under the EU LIFE programme:

It will emphasize nature conservation and adherence to EU Birds and Habitats Directives, leveraging Sardinia's proven track record with Griffon Vulture projects. The partnership built will actively work for the preparation of the proposal to be submitted to the 2025 call. Securing the LIFE funding will allow the development of all actions needed to sustain the success of this ambitious reintroduction programme.

- Actively promote subsequent long-term funding opportunities

The regional government is responsible for implementing specific calls for proposals under European Union Funds, tailoring them to local needs and priorities: European Agricultural Fund for Rural Development (FEASR) under the CAP and Strategic Plan European Regional Development Fund (FESR). Both programs can co-finance regional biodiversity and nature protection projects. The direct engagement of the Regional Departments for the Environment and for Tourism in the new LIFE proposal confirms the interest of the regional government in vulture conservation. This will increase the chance for future funding opportunities.

- Highlight the Socio-Economic Returns on Investment

The economic benefits derived from vulture presence must be clearly quantified and communicated. This includes calculating the cost savings for livestock farmers and public authorities due to natural carcass disposal, and the reduction in greenhouse gas emissions compared to alternative disposal methods. Detailed projections for ecotourism revenue generation, including direct income from guided tours and indirect benefits to local businesses, should be developed. Framing the project as a strategic investment in natural capital and ecosystem resilience will resonate with private sector entities and impact investors increasingly focused on ESG (Environmental, Social, and Governance) goals and sustainable development.

- Foster Strong Public-Private Partnerships

Leveraging existing successful collaborations, such as those established through the LIFE projects involving the University of Sassari, FoReSTAS, CFVA, e-distribuzione, and the Vulture Conservation Foundation, is paramount. Actively seeking new partnerships with Italian and European companies that have strong environmental CSR commitments, are interested in biodiversity offsets, or are exploring nature-based solutions is also crucial (*CSR, Corporate Social Responsibility*, 2024). Engaging local businesses and communities directly in ecotourism development will create shared economic incentives for conservation, fostering a sense of ownership and collective responsibility (Rahman & Baddam, 2021).[36] Collaboration with regional authorities (Regione Sardegna) should be intensified to explore and implement innovative finance mechanisms such as biodiversity credits and Payments for Ecosystem Services (PES) schemes, capitalizing on Sardinia's pioneering policies.

- Enhance Communication and Public Awareness to Attract Support

Developing compelling communication strategies is essential to garner broad support. This involves highlighting the unique story of the vultures' return to Sardinia, emphasizing their vital ecological role, historical and cultural significance, and the tangible economic benefits they bring. The island's established status as a "reintroduction hub" and the demonstrated success of Griffon Vulture recovery should be prominently featured to build public and investor confidence. Continuous engagement with local communities is critical to foster stewardship and demonstrate the direct benefits of vulture presence, thereby creating a supportive social environment for the reintroduction efforts.

3.4 Conclusion: Realizing Sardinia's Potential as a Vulture Stronghold

The analysis underscores Sardinia's exceptional suitability and strategic importance for the reintroduction of the Bearded and Cinereous Vultures. The island's abundant natural food sources, coupled with a sophisticated and proven conservation infrastructure developed through successful Griffon Vulture recovery projects, provides a robust foundation for these ambitious reintroduction efforts. The established network of institutional partners, coupled with a proactive regional policy environment, further de-risks future investments and enhances the likelihood of success.

The reintroduction of these iconic species transcends a singular conservation objective. It represents a multi-faceted investment that promises substantial returns across ecological, public health, economic, and cultural domains. By restoring the full vulture guild, Sardinia will not only reclaim a vital ecological function but also enhance its natural capital, mitigate environmental risks, and unlock new avenues for sustainable economic development through ecotourism and nature-based economies. Furthermore, Sardinia's role as a critical node in the broader Mediterranean metapopulation network means that local successes will contribute significantly to the genetic viability and long-term persistence of vulture populations across Europe.

To realize Sardinia's full potential as a vulture stronghold, a strategic, multi-faceted funding approach is essential. This approach must skilfully combine traditional public grants from the European Union and national/regional sources with innovative finance mechanisms, including the burgeoning biodiversity credit market and tailored Payments for Ecosystem Services schemes. Crucially, fostering strong public-private partnerships and effectively communicating the compelling socio-economic returns on investment will be paramount. By embracing these strategic funding opportunities, Sardinia can secure the long-term sustainability of its Bearded and Cinereous Vulture populations, cementing its legacy as a leading model for integrated conservation and a beacon of hope for Europe's endangered scavengers.

4. Past distribution and causes of extinction of Bearded Vulture and Cinereous Vulture

Sardinia's historically pastoral economy has profoundly shaped the island's landscapes and wildlife for centuries. Within this socio-economic framework, vultures were once a prominent and characteristic presence across the region, persisting until the relatively recent past.
Evidence of their historical abundance can still be found in the many toponyms scattered throughout Sardinia's mountainous areas, as well as in the various dialectal names used by locals to refer to these scavenging birds *Anturzu, Gutturzu, Entulzu, Enturzu, Bentulzu, Entruxi,* and others. Further confirmation comes from increasingly rare oral accounts from the island's elders and, most significantly, from the writings of scientists and travellers of earlier times.
When examining the rapid decline of these species across much of the island—particularly the complete extinction of the Bearded Vulture and the Cinereous Vulture, these historical testimonies are especially revealing.
In certain areas of Sardinia, especially the Supramonte-Gennargentu region in the central-eastern part of the island, local herders interviewed in recent decades (n.d.a.) recalled that during the 1930s and 1940s, vultures were so numerous that their sudden disappearance seemed inconceivable.
To fully understand the causes behind this swift extinction, it is essential to explore the evolving relationship between humans and the environment, beginning in the early 19th century. Widespread environmental transformations during this period, well-documented in historical sources, offer critical insight into the decline of these emblematic species.

4.1 Bearded Vulture

The Bearded Vulture is a massive and behaviourally distinct, mountain dwelling species, with a highly disarticulated range of 62 million km^2 in mountainous southern Europe, Africa, Indian subcontinent and the Tibetan plateau. The Bearded Vulture has a fully feathered head with a small black beard protruding from the base of its bill and mainly blackish wings, back, tails and facial masks. Its body is covered in rust-coloured or creamy-white feathers, often stained reddish-orange from iron-rich soil, which the bird uses intentionally to dye its plumage (Bildstein, 2022).
During their juvenile stage and until around their fourth year, Bearded Vultures have predominantly dark brown plumage. After one or two moults, their head, neck, chest, and much of their body gradually lighten, becoming increasingly pale or white (Cramp & Simmons, 1980).
Adults can reach a length of 110–115 cm (with the wedge-shaped tail alone measuring 42–44 cm), a wingspan of 266–282 cm, and a weight of 5–7 kg. These measurements apply to both sexes, as the female is only slightly larger than the male, a difference that is not visually noticeable. There is also no seasonal or sexual dimorphism in plumage (Cramp & Simmons, 1980).
The species is known for its unique behaviour of bathing in iron-rich mud puddles, which gives its feathers a reddish or rust-coloured hue. The purpose of this behaviour remains uncertain. Some theories suggest it may serve a decorative or social function, while others propose a hygienic or antimicrobial role, such as protecting eggs from infection, but none of these hypotheses have been definitively confirmed.

Unique in being the only bird that has an adult diet consisting largely of bones including those as big as a sheep's vertebra. Thanks to a wide gape, a keratin-hardened esophageal wall, and the absence of a crop, they can ingest bones measuring up to 25–35 cm. Their highly acidic stomach juices allow them to break down the mineral content of the bones. When bones are too large to swallow, the vulture carries them to heights of up to 100 meters and drops them onto rocks to shatter them—an advanced skill that takes years to master (Cramp & Simmons, 1980).
Bearded Vultures are long-lived birds, living up to 30-35 years in the wild and over 45 years in captivity. They have a slow and extended reproductive cycle. Breeding spans most of the year, beginning in autumn with nest preparation and concluding when the fledglings leave the territory, just as the adults begin courtship rituals for the next season (Cramp & Simmons, 1980).
Unlike the Cinereous and Griffon Vultures, Bearded Vultures are territorial, often occupying territories as large as 300 km^2. A pair may maintain multiple nests, which they use alternately, likely as a strategy to prevent nest failure due to collapse or occupation. In autumn, after courtship displays, the pair begins frequenting the nest site, typically a large cavity or rocky ledge, built with dry branches and wool. Egg laying usually occurs between January and February. The pair typically lays two cream-colored, speckled eggs, 4–7 days apart. Reproduction is a slow and demanding process. Birds reach sexual maturity at 5–7 years but breeding often begins only around the age of 8. Bearded Vultures are monogamous and maintain lifelong partnerships unless one partner dies. Though two eggs may be laid, only one chick survives due to kainism, a natural phenomenon where the stronger chick prevents the weaker one from feeding, leading to its death. Therefore, each pair (or occasionally a breeding trio) raises only one chick per year. Both parents take turns incubating the eggs, which hatch after 54–60 days.
From fledgling to the first winter, both captive-bred and wild-born Bearded Vultures behaved overall as a resident, with movements remaining restricted within their fledging area (<100 km). Such resident behaviours could be explained by the need for young birds to learn soaring-gliding techniques in their first summer (Harel et al., 2016) or reflect harsh climatic conditions that limit soaring-gliding flight during winter as documented in Eurasian Griffon Vultures and California Condors, *Gymnogyps californianus* (Rivers et al., 2014). On the other hand, in the spring of their second calendar year, Bearded Vultures increased their movement activities, with a peak of exploration departures concentrated between March and June and displayed larger home ranges. After 1 year, more than half of the Bearded Vultures have displayed long-distance explorations, usually characterized by short but intensive traveling periods (~10 days), and about 20% of birds have exhibited medium-distance explorations over longer time periods (~40 days) and more progressive displacement from their fledging site. Eventually, less than a third of the birds remained resident after 1 year (Tréhin et al., 2024).

Bearded Vultures translocated in regions with low elevation, small area, and that were the most distant from established populations display exploration behaviours in much higher proportion, moving farther and in more scattered directions than wild-born and translocated individuals released closest to established populations (Tréhin et al., 2024).
For instance, the vast majority of birds translocated in the most isolated site (70% in Causses) were either medium- or long-distance explorers moving up to 1000 km or more, whereas wild-born birds from Corsica were all resident and travelled relatively short distances (<200 km) (Tréhin et al., 2024).

Exploration movements in Corsica could be limited because large raptors may be reluctant to cross large marine areas (Bildstein et al., 2009). However, observations of Bearded Vultures reaching Sardinia and even crossing the Mediterranean have been documented (Grussu & Seguin, 2015). The wider exploration behaviour of birds fledged on the mainland continent may have been enhanced by the terrestrial geographical continuum, with some adjustments depending on the environmental habitat characteristics and the social environment (e.g., presence of conspecifics) (Tréhin et al., 2024).

4.1.1 Current Distribution of the Bearded Vulture in Europe

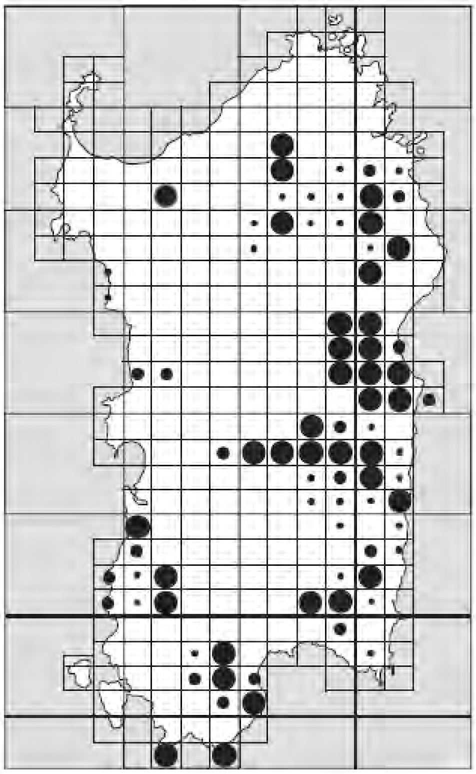
Thanks to extensive conservation and reintroduction efforts, the Bearded Vulture is now present in several mountainous regions across Europe:

- **Alps**: Reintroduced successfully after extinction in the 20th century. As of 2023, the Alpine population numbers between 316 and 419 individuals, with strongholds in areas like the Stelvio National Park in Italy.
- **Pyrenees**: One of the strongest populations, with around 77 breeding pairs.
- **French Pre-Alps and Massif Central**: Part of the project LIFE GYPCONNECT (2015-2022) LIFE14 NAT/FR/000050, where over 40 birds have been released to create connectivity between the Alps and Pyrenees.
- **Andalusia and Maestrazgo (Spain)**: Stable populations, with 39–54 individuals in Andalusia and 4–5 in Maestrazgo, where reintroduction is ongoing to connect populations.
- **Corsica**: A small, isolated population of 4 breeding pairs is being supported by a reinforcement program in the period 2021-2025. LIFE GYPRESCUE LIFE20 NAT/FR/001553
- **Crete**: Home to the world's largest island population, with 9–10 breeding pairs. It's the only viable population in Greece and the Balkans.
- **Bulgaria**: The species has been extinct since 1972, but reintroduction projects are currently underway with LIFE22-NAT-BG-Bearded-Vulture-LIFE/101113869 started in 2023 until 2030.

According to VCF, there are 465 breeding pairs in Europe (Terraube et al., 2022).

4.1.2 Past distribution of Bearded Vulture in Sardinia

The distribution of the Bearded Vulture in Sardinia has been reconstructed for the 1875-1967 period by Schenk et al. (2004), based on bibliography, an inquiry (1969/70) in 40 Sardinian municipalities concerning the distribution of five large birds of prey: Griffon, Black and Bearded Vulture, Sea Eagle, Golden Eagle. Systematic research among rural populations (shepherds, hunters) and an inquiry addressed to Italian, European and North American natural museums and private collections containing skins, mounted specimens, skeletons and eggs of Bearded Vulture from Sardinia (Schenk et al., 2004).



Number of 10 km squares in which recorded	Breeding		
	Possible	Probable	Confirmed
= 81 (27,4%) breeding confirmed, probable and possible	= 29	= 17	= 35
	35,8%	21,0%	43,2%

Figure 4.1 *Bearded Vulture historical distribution (10 km squares) in Sardinia, 1875 – 1945. (Schenk et al., 2004)*

In 1875-1945 period, the Bearded Vulture was present in Monte Limbara in the north, Monti di Alà, Monte Nieddu, Monte Albo, Supramonte, Gennargentu, Ogliastra mountains and the south-eastern massifs of the Sarrabus-Gerrei district. Separated by the Campidano Plain there was an isolated range in the south-western part of the island including the Sulcis-Iglesiente mountains, but also the sea cliffs of Teulada. Smaller isolated nucleus was found in the north-western part of Sardinia, near Sassari (Bunnari). Breeding has been evaluated as possible, probable or confirmed in eighty-one 10 km squares (27.4% of the Sardinian's 296 squares). Confirmed breeding has been proofed at least once in 35 squares (43.2% of the 81 squares where the species has been recorded); probable breeding in 17 squares (21.0%) and possible breeding in 29 squares (35.8%). It is highly probable that at the beginning of the 20th century the BV was a breeding species also in other parts of the island where unfortunately the collection of oral testimonies was difficult because the direct witnesses (shepherds, hunters) were no longer alive (Schenk et al., 2004).

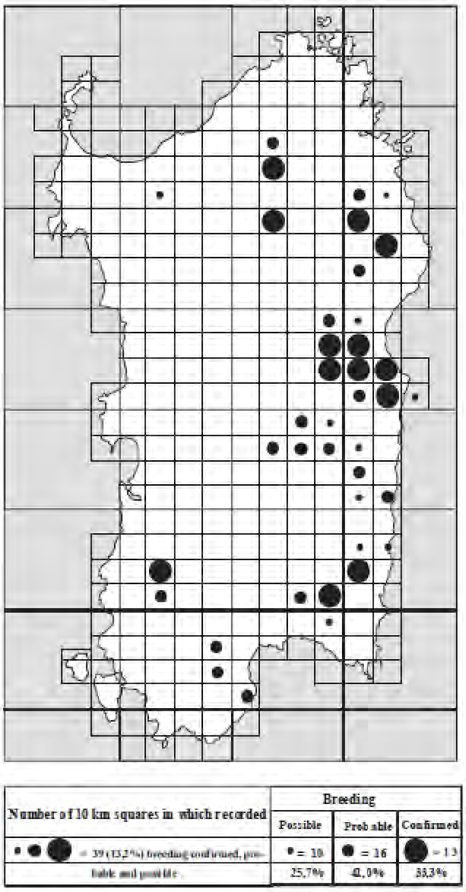
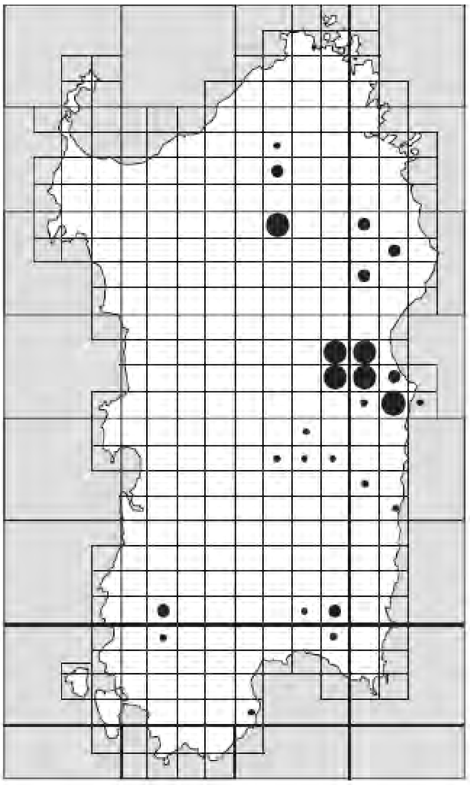


Figure 4.2 *Historical distribution (10 km squares) of the Bearded Vulture in Sardinia, 1946 – 1955 (Schenk et al., 2004).*

For the 1946-55 period breeding has been evaluated as confirmed, probable or possible in 39 squares (13.2% of the total of 296) with an estimated total of 10-4 breeding pairs concentrated in the central-eastern part of the island and single pairs in the north-east, in the south-east and in the Iglesiente mountains. Confirmed breeding has been proofed in 13 squares (33.3%) at least in one of the 10 years considered (Schenk et al., 2004).

In recent years, new reliable accounts have been collected over the past 20 years regarding the historical presence of the Bearded Vulture also in the Bosano and Villanovese areas (Aresu ex verbis; Campus ex verbis).



Number of 10 km squares in which recorded	Breeding		
	Possible	Probable	Confirmed
= 26 (8,8%) breeding confirmed, probable and possible	= 13	= 7	= 6
	50,0%	26,9%	23,1%

Figure 4.3 *Historical distribution (10 km squares) of the* Bearded *Vulture in Sardinia, 1956 -1967 (Schenk et al., 2004).*

For the 1956-67 period breeding has been considered confirmed, probable or possible in 26 squares (8.8% of the total number of 296). Reproduction was certain in 6 squares (23.1% of the total of 26 positive squares) and 5 of them (83.3%) were situated in the calcareous mountains of Supra- monte and one in the northern part of the island (cf. Figure 4.3). The breeding pairs were 3 or 4 (Supramonte and Monti di Alà), dropping to one in 1967, the last year with successful breeding in central-eastern Sardinia (Schenk, 1974, 1976; Muscau, *ex verbis*; Sanciu, *in litt.*). The last Supramonte pair from Fruncu sos Cuzzos/ Orgosolo was present in the area up to 1969 (Muscau, *ex verbis*; Schenk, 1974, 1976). The last breeding attempts of the Monte Lerno pair/Buddusò/Monti di Alà are to be collocated in the 1965-67 period (Sanciu, *in litt.*; Schenk, 1976).

Table 4.1 *Estimated numbers of Bearded Vultures in Sardinia, 1870 – 2002 (Schenk et al., 2004).*

Period	Breeding Pairs	Individuals	Specimens (Eggs) Collected	Source
1870-1900	40-35	150-125	>15 (3)	Brooke, 1873; Giglioli, 1886; Schenk et al., 2004
1901-1920	35-20	65-125	>41 (7)	Arrigoni Degli Oddi, 1929; Arrigoni degli Oddi, 1931; Martorelli, 1960; Schenk et al., 2004
1921-1945	10-20	35-65	>21 (3)	Foschi, 1984; Schenk et al., 2004; Stemmler, 1932; Moltoni, 1949
1946-1966	2-10	5-35	>10; >10 killed by poisoned baits?	Bezzel, 1957; Schenk, 1974, 1976, 1977; Schenk et al., 2004; Ruiu,1981; Schenk & Genero, 1996
1967	1 (last breeding attempt 1969?)	5?	?	Schenk, 1974; 1976; 1977; Ruiu, 1981; Schenk & Genero, 1996; Schenk, et al., 2004
1968-2002	0	1-2?	?	Individuals From Corsica and/or the Alps?

The most recent documented evidence of its presence on the island is a photograph from 1977 (Domenico Ruiu in *Supramonte*). Between 1986 and 2012, Grussu & Seguin (2015) reported 12 observations of the species on the island, but only one is confirmed: an individual sighted on 10 October 1996 in Capo Caccia (Sanna M.). The last confirmed observation outside of this publication dates to 26 June 2002, north of Bosa (Schenk et al., 2004).

4.1.3 Accounts from the past

We know with certainty that it was once a common inhabitant of the island, nesting in the rocky ravines of cliffs and, along with other vulture species, playing a key role in consuming animal carcasses—feeding primarily on the bones.
Its name in the Sardinian dialects, in fact, consistently reflects this dietary habit—for example, *Guttuzu Ossarju* or simply *Ossarju*, both referring to its association with bones (Casu *et al*., 1989).
Francesco Cetti, in his 1776 treatise "Gli Uccelli di Sardegna" (The Birds of Sardinia), wrote: **"***Qui* (Sardegna ndr) *il barbato esiste in bastevole quantità; più volte ne ho avuto da diversissime parti dell'isola, e dopo l'avoltor nero con più frequenza ho veduto il barbato***"** ("Here in Sardinia, the Bearded Vulture exists in fair abundance; I have had it several times in different parts of the island and after the Cinereous vulture, it is the vulture I have seen most frequently…")
He therefore asserted not only that the species was relatively common on the island, but that it was second in abundance only to the Cinereous Vulture, implying it was more frequently encountered than even the Griffon Vulture.
Gaetano Cara in his 1842 book "Elenco degli uccelli che trovansi nell'isola di Sardegna" (List of birds found on the island of Sardinia) also described the Bearded Vulture as resident (*stazionario*), although he added: "*It is rarely seen, perhaps due to the great difficulty in hunting it, as it lives in the highest and steepest mountains*."

Tommaso Salvadori in his 1864 "Catalogo degli Uccelli di Sardegna" (Catalogue of Sardinian Birds), despite his very brief stay in Sardinia, remarked: "*It is not very rare; I saw two individuals on the same day in the mountains near Gennargentu*.".
Toward the end of the 19th century, the ornithologist Enrico Hillyer Giglioli in his "Avifauna Italica" (1889), quoting Bonomi, described *Gypaetus barbatus* as both common and resident (*comune e stazionario*), noting that numerous young individuals were observed at the "Passo di Correboi" in 1886.
Similarly, Pasquale Cugia, in his *Nuovo Itinerario dell'Isola di Sardegna* (1892), referred to the Bearded Vulture as "*…the largest bird found in Sardinia, nesting at Perdaliana*."
Arrigoni degli Oddi in his 1902 Atlante Ornitologico (Ornithological Atlas), speaking about the Bearded Vulture in Sardinia, writes: "*For Italy it is a fairly common species in Sardinia, it was found in Corsica and in the Madonie in Sicily, where it is very rare"*.

4.2 Cinereous Vulture

The Cinereous Vulture is the largest vulture species in Europe. Adults weigh between 9 and 11 kg and have a wingspan of 2.85 to 3 meters. There is little visible sexual dimorphism, although females are typically slightly larger than males. Sex determination is usually done through genetic analysis.
These vultures are notably long-lived, with life spans ranging from 30 to 40 years in the wild.
It is a semi colonial species, with pairs, nesting far from each other but still in visual sight. Colonies are often loosely spaced, with nests separated by tens to hundreds of meters. In some cases, even two nests may be found in the same tree. Nesting density tends to be higher in Mediterranean scrub habitats, such as those in Extremadura, where the average distance between nests is around 600 meters.
Each colony maintains feeding buffer zones that may exceed 50 km in radius. As colony populations grow, competition for food can increase, potentially reducing productivity.
Cinereous Vultures are considered monogamous, typically forming lifelong pair bonds. However, studies conducted between 2000 and 2004 in the Alto Lozoya colony (Madrid) revealed that pair changes can occur within the same colony.
Pairs remain attached to their nest site year-round, often using it as a perch. Nesting activity intensifies from December to January, continuing until the chick is fully fledged.
Each pair typically maintains between 1 and 5 nests, built in tall trees or large shrubs. These nests are large platforms made of branches, measuring 140–250 cm in diameter and 70–130 cm in height. Over time, the nest grows larger as more material is added each year. Nests are usually located in the highest and most exposed parts of the tree canopy to facilitate easy access for flight.
Preferred nesting trees in the Mediterranean region include pines (*Pinus spp*.), holm oaks (*Quercus ilex*), and cork oaks (*Quercus suber*), although nests have also been found in juniper (Juniperus spp.), strawberry trees (*Arbutus unedo*), and mastic trees (*Pistacia lentiscus*). Very rarely, nests may be found on rocky ledges, but these are typically less successful.
Courtship involves synchronised flight displays, including aerial manoeuvres and mutual grasping of talons in flight.
A single egg is usually laid between late February and early March, with both parents sharing incubation duties over 50 to 62 days. Hatching occurs between early April and early May. During the

first two months after hatching, one adult typically stays at the nest to protect the chick from predators and weather.

The chick fledges at 100–120 days of age (about four months), but full independence comes only after 206 to 280 days, about three to five months after its first flight.

During their first four years, juveniles undergo wide-ranging dispersal movements, sometimes traveling far from their native colony. Post-release movements of reintroduced Cinereous Vultures have shown considerable variability across different European conservation projects, influenced by factors such as age at release, release technique, landscape features, and conspecific presence. In France, survival rates were high across origins and methods, but movement patterns differed: wild-born juveniles in the Grands Causses dispersed more erratically than those from the Alps, while reintroduced individuals showed more restricted movements during their first year. Despite these differences, most individuals developed strong site fidelity over time (Rousteau et al., 2022). Similarly, vultures released in Spain exhibited extensive exploratory movements during their first months post-release, with some dispersing across regions and even crossing international borders before returning to breeding or foraging sites (Margalida et al., 2017). In Bulgaria, where the species was reintroduced more recently, GPS tracking revealed that vultures explored large territories, often visiting known breeding colonies of conspecifics in the Balkans and occasionally roosting with Griffon Vultures (*Gyps fulvus*), which may facilitate social integration (Stoynov et al., 2019).

Like most vultures, the Cinereous Vulture is a scavenger that primarily feeds on carrion from medium to large mammals. Its diet also occasionally includes snakes and insects. At carcasses, it tends to feed on what is left by Griffon Vultures—particularly tougher tissues like skin, tendons, and cartilage.

Sheep carcasses are a key food source, especially in open pastures or at supplementary feeding stations. The vultures often consume the remains of newborn lambs and placentas. As wild rabbit populations decline (particularly in Spain), sheep remains increasingly serve as an important substitute.

Cinereous Vultures are adept at foraging in wooded and scrub-covered areas, flying relatively low and either alone or in small groups. This allows them to find small and concealed carcasses, unlike Griffon Vultures, which prefer open areas and often miss these food sources. Cinereous Vultures can also occasionally feed on living small mammals.

4.2.1 Current Distribution of the Cinereous Vulture in Europe

The Cinereous Vulture was extinct in several European countries, including Portugal, France, Italy, Austria, Poland, Slovakia, and Romania but various reintroduction projects are currently underway. Thanks to targeted conservation efforts, such as the protection of breeding sites, measures to combat poisoning, and reintroduction programs, the population is slowly increasing.

Spain hosts the largest and most stable population, currently exceeding 2,000 breeding pairs. In France, successful reintroduction programs have led to the return of the species, with over 25 breeding pairs now established. In Greece, conservation efforts have helped preserve the only remaining colony in the Balkans, which includes about 28 breeding pairs.

Across Europe, including Turkey and Russia, the current total population is estimated at approximately 2,800 breeding pairs (Terraube et al., 2022).

4.2.2 Past distribution of Cinereous Vulture in Sardinia

Based on an indirect survey (Schenk, 1976) and a feasibility study for the reintroduction of the Cinereous Vulture in Sardinia conducted by Schenk and Genero (1996), the two authors reconstructed the historical distribution and population dynamics of the species on the island between 1940 and 1975.

Until 1945, the species bred in small colonies and isolated pairs in various parts of the island: the Supramonte, Silva Manna/Montresta Forest, Bosano, the Monteferru area near Cuglieri, and the slopes of the Gennargentu mountains. It was also present, and likely breeding, in Salto di Quirra (Sarrabus), Monte Albo, Monte Senes (Siniscola), as well as forested areas between Olbia, Bitti, and Siniscola, and in Ogliastra. The estimated population at the time was around 40 to 60 individuals, with approximately 10 to 12 breeding pairs.

By around 1955, the species was still breeding, though only in very small numbers, 2 to 3 pairs in the Supramonte, possibly 1 to 2 pairs in the Silva Manna Forest, and 1 to 2 pairs in the Montiferru area. Lone individuals were occasionally observed in the Gennargentu, the southeastern mountain ranges, and the area south of Olbia. The overall population had dropped to about 20 individuals.

The last nesting attempts are believed to have occurred in the 1960s (Schenk & Genero, 1996), with the last confirmed breeding case recorded in 1961, when a young vulture was taken from a nest on June 25th by a shepherd from Urzulei (Foschi, 1984). By that time, the total population had declined to fewer than 10 individuals.

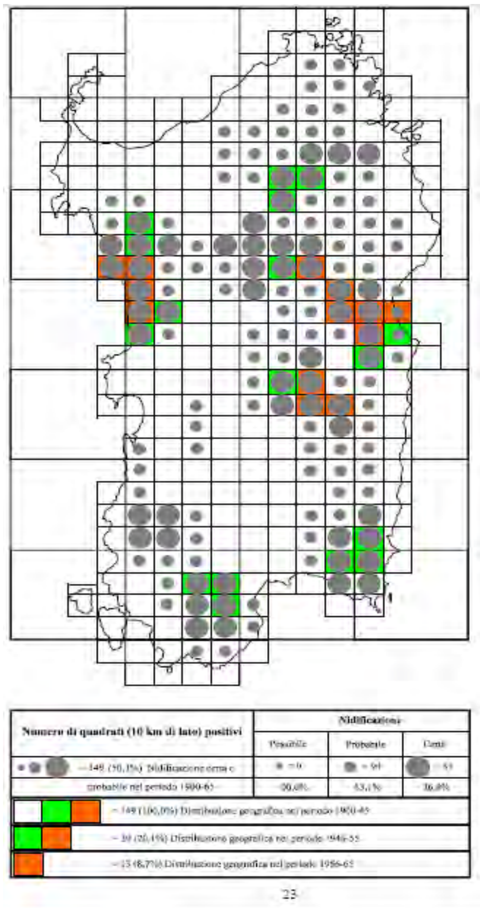


Figure 4.4 *Historical nesting areas (10 km squares) of the Cinereous Vulture in Sardinia, 1946 – 1960 (*Schenk & Genero, 1996*).*

By the early 1970s, the Cinereous Vulture population in Sardinia had declined to a maximum of 3 to 5 individuals, concentrated in the central-eastern part of the island. For the period between 1970 and 1994, there are fewer than 10 reliable sightings, almost all of which originated from the Supramonte and Gennargentu areas (Schenk, 1976; Ruiu, 1981; Schenk & Genero, 1996).

Table 4.2 *Estimated Breeding Pairs of Cinereous Vulture in Sardinia, 1900–1965 (Schenk & Genero, 1996).*

Years	Estimated breeding pairs
1900-1935	150 - 70/50
1936-1945	70/50 - 35/25
1946-1955	35/25 - 10
1956-1965	0-1

In 1981, two Cinereous Vultures were released in the Bosano area, Sardinia's main Griffon Vulture stronghold, after being bred in a private Italian aviary. One of the birds was found dead six weeks after its release, while the second disappeared and was never seen again after approximately nine months (Aresu, 1981 and unpublished data).
The last confirmed sighting of a Cinereous Vulture in Sardinia dates back to 2005–2006, when "Kora," a vulture released in the Baronnies region of France, was observed multiple times in the Bosano area. The bird was seen from November 2005 until April 2, 2006 (*Associazione Kalarighes, personal communication*).

4.2.3 Accounts from the past

The ornithologist Francesco Cetti, in his 1776 treatise "Gli Uccelli di Sardegna" (The Birds of Sardinia), describes the species Black Vulture (Cinereous Vulture, ed.), distinguishing it decisively from the Griffon Vulture. Speaking of this species this is what he says in the text:
"*...l'Avoltor nero menzionato da Bellonio non é altro, che l'avoltor nostro; poiché l'avoltor di Bellonio è un avoltore, che si incontra al meriggio, e nelle isole del mediterraneo; un avoltor frequente, un avoltor maggiore degli altri; e tale è il nostro onninamente; esso è un avoltor del meriggio e del mediterraneo per la situazione della Sardegna; è altresì un avoltor frequente, poiché di questa spezie ne ho avuto più abbondantemente di ogni altra; quattro ne ebbi in pochissimo intervallo di tempo; lo ho ancora trovato costantemente maggiore non solo del grifone, ma egualmente degli altri avoltoi...*" "*...The "black vulture" mentioned by Bellonio is none other than our own vulture; for Bellonio's vulture is a species found in the south and on the Mediterranean islands— a common vulture, a vulture larger than the others; and ours fits this description entirely. It is a southern and Mediterranean vulture, given Sardinia's geographical position; it is also a common vulture, as I have found this species more abundantly than any other— I obtained four in a very short span of time. I have also consistently found it to be larger not only than the griffon vulture, but also than all other vultures.…"*

From what Cetti reported in the second half of the 18th century, the Cinereous vulture is said to be the most common species in Sardinia, as subsequently confirmed by other authors.

In 1842, in the book “Elenco degli uccelli che trovansi nell'isola di Sardegna” (“List of birds found on the island of Sardinia”), Gaetano Cara wrote about the *A. monachus*: “*Comune, stazionario, abita in tutte le nostre montagne, se ne fa preda in ogni stagione e con diverse livree...*". “*Common, stationary, living in all our mountains, it preys on them in every season and in different liveries*”. Tommaso Salvadori too, in his 1864 “Catalogo degli Uccelli di Sardegna” (Catalogue of Sardinian Birds), mentions: “*This vulture* (Cinereous vulture ed.) *seemed to me the most common of all in Sardinia. It inhabits mountainous places. Several times, while I was lurking near some corpse, I saw them arrive from great distances, and up to five of them settled simultaneously on the rocks surrounding me*”.

Later on, the ornithologist Enrico Hillyer Giglioli in his “Avifauna Italica” of 1889, quoting Bonomi, for the Avvoltoio Monaco in Sardinia “*Common and sedentary*” but already identifies the griffon vulture as “*Sedentary and more abundant than the previous species*”.

Arrigoni degli Oddi, in his *"Atlante ornitologico"* (1902), reports that the species "In Italy is fairly common in Sardinia... It nests in February in trees, rarely on rocks..."

Although we cannot state with certainty what the above-mentioned authors report on the actual extent and numerical ratio of these species on the island, it is nevertheless clear that massive deforestation works began in the first half of the 19th century, with a consequent impact on the island's fauna, particularly on a species such as the Cinereous Vulture, whose reproductive habitat is precisely the woods and large plants.

These deforestation works are documented by many authors, among them the texts by Enea Beccu ‘*Tra cronaca e storia le vicende del patrimonio boschivo della Sardegna*’ (2000) and Fiorenzo Caterini ‘*Colpi di scure e sensi di colpa*’ (2013), which testify unequivocal witness to this process.

Enea Beccu, in his book, speaks of a Sardinia of the second half of the 18th century:

“*with a forest cover that still covered the mountains of Sulcis, Iglesiente and Sarrabus to the south; that saw the forests of Goceano in the centre of the island pushing southwest, without interruption, through the heights of Bolotana and Silanus and the mountains of Macomer, up to the woods of the Commenda di S. Leonardo and Scano Montiferro and Seneghe, and joining, through the forests of Pattada, Buddusò, Alà dei Sardi and Monti, the forests of Gallura north of the island, the forests of Pattada, Buddusò, Alà dei Sardi and Monti, the forests of Gallura north of the island of Sardinia, the forests of Buddusò and Alà dei Sardi and the forests of Alghero and the forests of Alghero. Leonardo and Scano Montiferro and to Seneghe, and joining, through the forests of Pattada, Buddusò, Alà dei Sardi and Monti, to the forests of Gallura to the north, and finally joining, to the east, the forests of Barbagia, Ogliastra and Gerrei. Still partly wooded at the time was the Nurra, and the mountains above Bosa were covered with a single forest cover as far as Montresta and Villanova, a cover that extended northwards towards Putifigari and northeast towards Uri. Coppice woods, some of which were rich in woody stock or dense, centuries-old holm oak and downy oak forests; stands of holm oak mixed with ancient wild olive trees or oak groves interspersed with majestic yews and thousand-year-old junipers*”.

However, already in 1794, as Fiorenzo Caterini tells us:

"*3331 trees of exceptional quality were felled in the San Leonardo Forest for use by the Navy [Beccu, 2000, p. 88]. Only 500 of these plants were reserved for the State, the rest constituted the compensation for the company that had taken care of the felling; a disproportionate compensation, even considering the difficulties in extracting the wood. This fact can be considered the forerunner of a whole series of speculative agreements between private individuals and the state. Legislation was circumvented by this simple ruse: it was enough to pass off the majority of the cut as contract costs; the state obtained its share without disbursement, the complacency of important constituents and financiers, some infrastructure works left behind and, probably, some under-the-table subsidies for diligent politicians and officials. There was in those years a singular coincidence of interests between the private and the public; the feudal lords ended up becoming private individuals themselves, investing their own landed incomes in the nascent and very profitable business. The forest of Sardinia was entering the Europe of the market economy, with a system of rights of use that until then had sufficiently protected the patrimony, which was beginning to show its first cracks*".
Afterwards, logging operations at the hands of various actors continued throughout the 19th century:
"*The charring of Sardinian woods was carried out not only by large Italian and foreign forestry companies, which had become the owners of vast expanses of woodland, but also by a multitude of small local entrepreneurs*" (Beccu, 2000).
This is how an anonymous person quoted it in 1800:
"*Forests and woodlands are burnt all day long, as well as afforested estates, and not infrequently even untilled woods, trees are cut out of order and out of time, and trees are never replaced, uprooted and uprooted at whim, and without any restraint, caring only for the present and not thinking of posterity and future needs*" (Discorso istorico politico legale, Anonymous, 1800. Page 31 by Beccu).
Forest fires were another important phenomenon that, in addition to logging, contributed to the devastation of the island's forests.
To understand the gravity of the fires that afflicted Sardinian forests (and still afflict today), it is enough to read a figure reported by Beccu referring to the five-year period 1879-1883:
"*In relation to the phenomenon on a national scale, the surface area affected by fire in Sardinia represented 73.65% of the total, with a damage equal to 64.40% of the damage suffered by the entire country*' and again '*For the Cagliari district alone, in the period 1891/95, a total of no. 422 fires occurred, 178 of which involved tall-trunk forests, with a total area affected of over 19,805 hectares".*
There have been exceptional cases of wildfires that lasted for weeks and were never brought under control, eventually burning themselves out after affecting vast areas of land.
Examples are the Nurra-Argentiera fire in July 1839, which lasted 15 days and affected three million large holm oaks and one million large wild olive trees; or the Carvacone-Supramonte fire in 1931, which, over the course of a week, affected 8,000 hectares of tall holm oaks, downy oaks and Mediterranean scrub.
In addition to destroying the breeding habitat of the Cinereous Vulture, the fires occur in the summer season, a time when the chicks are rearing inside the nests.
The contribution of the fires to the extinction of the species on the island was therefore not only indirect, but also direct, causing the death of the youngest specimens.
Considering that *A. monachus* begins its reproductive activity at 5-6 years of age and lays only one egg per year, the damage caused by fire on the generational turnover of the species was probably considerable.

On the basis of an indirect survey, Schenk (1976) attempted to reconstruct the population dynamics for the period between about 1940 and 1975.

4.3 Causes of extinction of Bearded Vulture and Cinereous Vulture

The direct human-induced causes of decline and extinction of the Bearded Vulture an Cinereous Vulture in Sardinia are principally harvesting (collection of skins, eggs, trophies), followed by hunting, poaching, occasional killing and plundering of eyries; among indirect human induced causes of extinction the use of poisoned baits (strychnine; arsenic compounds; DDT) for pest control (*Vulpes vulpes*, feral dogs; locusts; *Anopheles labranchiae* - the malaria vector) probably played a major role during the 1950s. These principal causes have been accompanied by a general decline in livestock mortality, a progressive increase in the human population and roads, which together augmented human pressure on the last wilderness areas of the island (Schenk, 1976; Schenk & Genero, 1996)

4.3.1 Oology and taxidermy collecting

Specimen collection appears to have been the primary cause of the sharp decline in the Sardinian Bearded Vulture population between 1870 and 1934. During this period, 93 individuals were killed (including 5 nestlings) and 15 eggs were collected, all legally, amounting to a total of 108 specimens, or 84.4% of the 128 dated records by Schenk et al. (2004).

Table 4.3 *Bearded Vultures from Sardinia in natural museum and private collections (Sardinia, Italy, Europe, North America), 1821 – 1962 (Schenk et al., 2004).*

Period	Number of specimens		
	Skins, skeletons and mounted	Eggs	Total
1821 - 1900	29	5	34
1901 - 1910	41	6	47
1911 - 1920	13	3	16
1921 - 1930	14	-	14
1931 – 1940	7	3	10
1941 – 1950	1	-	1
1951 - 1962	6	-	6
undated	11	-	11
1821 - 1962	122	17	139

The decade from 1901 to 1910 was particularly "productive," accounting for 47 specimens (41 individuals and 6 eggs), which represents 36.7% of all dated samples (see also Hiraldo et al., 1979). In contrast, the 8 specimens (6.3%) dated between 1939 and 1962 were collected illegally, as the Bearded Vulture had been granted legal protection in Italy starting in 1939 (Conder, 1977).

A document dating from the early 20th century is a price list compiled by Sardinian taxidermist Riccardo Meloni. In it, the Cinereous Vulture and Bearded Vulture are listed among the most

expensive birds, surpassed only by a few exceptionally rare species such as the Audouin's Gull (*Larus audouinii*), for which the price had to be negotiated privately.
At the time, the Cinereous Vulture was valued at 250₤, while the Bearded Vulture ranged from 400₤ to 250₤, depending on age and plumage. These figures far exceeded those for the more common Griffon Vulture, which was listed at 150₤. This pricing reflects the fact that both the Cinereous and Bearded Vultures were already rare on the island, much harder to find than Griffon Vulture, highlighting their declining status even then.

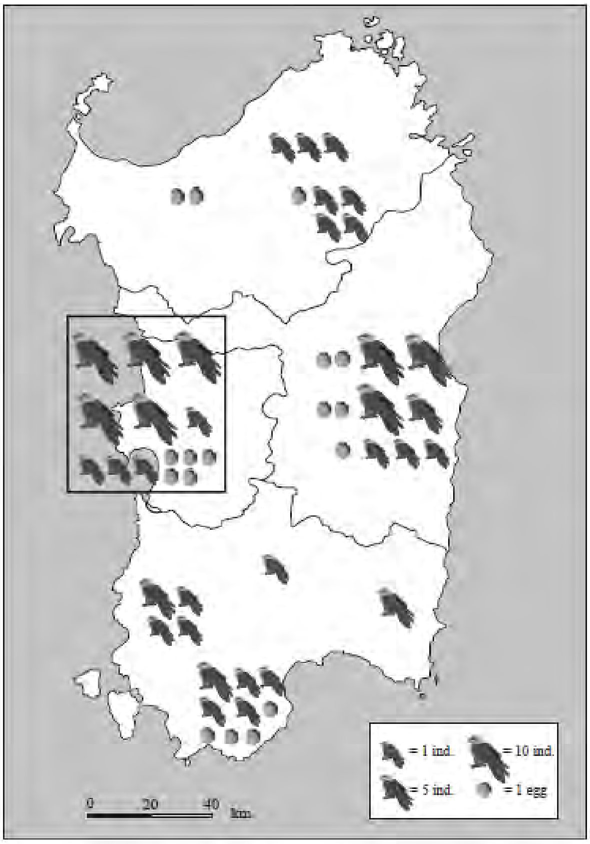


Figure 4.5 *Distribution of 139 specimens (skins, mounted, skeletons, eggs) of Bearded Vultures collected in Sardinia, 1821 - 1962 (the box refers generally to Sardinia).*

Also for the Cinereous Vulture a prominent place is occupied by the collection of eggs, skins and trophies, particularly intense in central-western Sardinia in the period 1945-55/60 and, at the beginning of the century, also in the south of the island (see Schenk & Genero, 1996; Foschi, 1996).

4.3.2 The use of poisons in Sardinia

Among the contributing factors to the decline of vultures, it is important to highlight the widespread use of new toxic substances and chemical agents. These included sodium arsenite, which was employed during locust control campaigns in the late 1930s and 1940s (notably in 1946), as well as para-dichlorodiphenyltrichloroethane (DDT), extensively used during anti-malaria campaigns linked to wetland reclamation efforts in the late 1940s and early 20th century.

Sodium arsenite

As early as 1928, the use of arsenic was considered by leading academics of the time to be an outdated and harmful practice—both to humans (arsenic is toxic to all animal species and classified as a carcinogen) and to domestic animals. For this reason, it had already been abandoned in many parts of the world.

In 1927, Alghero's veterinarian, Dr. Taccaliti, openly criticized the use of arsenic, pointing out the risks to livestock and the damage caused by its application. During the 1931 campaign, more than 500 livestock deaths were recorded in the province of Nuoro alone due to arsenic poisoning. It is reasonable to assume that many of these contaminated carcasses were consumed by scavenging birds, leading to widespread secondary poisoning. The grasshopper species targeted in these campaigns—commonly known in Italy as the *"Grillastro crociato"* or *"Locusta del Marocco"*—has found, and continues to find, a highly favorable reproductive environment in Sardinia. The species thrives in semi-arid steppes, which are often of anthropogenic origin, formed by deforestation or overgrazing. Heavily grazed land becomes compacted from excessive trampling, creating ideal conditions for egg-laying, as females deposit their oothecae only in uncultivated, compact soil. Each female lays two to three oothecae per year, each containing around thirty eggs, meaning that in heavily infested areas, thousands of eggs may be present in just a single square meter. Since this grasshopper species feeds on a wide range of plants, it poses a serious threat to agriculture. As a result, throughout the first half of the 20th century, it was subject to extensive control measures, including the use of chemicals that caused significant environmental damage, also impacting vulture populations.

According to a study by Molinu and collaborators, whose estimates they themselves consider conservative, 27,114 quintals of sodium arsenite were distributed across Sardinia during the first half of the 20th century. Following a brief hiatus during World War II, the use of sodium arsenite resumed on a massive scale due to increased infestations driven by favourable climatic conditions and reduced soil tilling. In 1946 alone, an amount of arsenite equivalent to nearly half of the total used in Sardinia up to 1950 was distributed across the island.

Today, arsenic tops the U.S. National Priorities List for hazardous substances, surpassing even lead, which previously held this grim distinction. It is now recognized that arsenic can persist for decades in both soil and the food chain, posing long-term ecological risks.

DDT

Before the introduction of DDT, between the 1920s and 1930s, Sardinia saw the use of an even more toxic substance: copper arsenite acetate, commonly known in Italy as *Verde di Parigi*. This compound was employed to combat malaria by eliminating mosquito larvae in marshes and as an insecticide for adult mosquitoes. Although its application was limited to smaller areas and used in significantly lower quantities than DDT, it was introduced at the behest of local authorities.

The fight against malaria in Sardinia is most notably associated with the infamous 'Sardinia Project', an experimental program spearheaded by the Rockefeller Foundation with the aim of eradicating malaria and its local vector, *Anopheles labranchiae*, from the island. The campaign was conducted between 1946 and 1957 by ERLAAS (*Ente Regionale per la Lotta Anti Anofelica*) and was financed by the UNRRA (United Nations Relief and Rehabilitation Administration), the ECA, the Italian government, and the Rockefeller Foundation.

As part of this large-scale field experiment, a staggering 11 million litres of DDT were dispersed across Sardinian territory. This chemical was later banned in Italy in 1978 due to its proven hazards to human health. Subsequent research revealed that far smaller quantities of DDT would have been sufficient to achieve comparable results, results which, in any case, fell short of completely eradicating the vector. DDT is a lipophilic compound that accumulates in fat tissues and persists in the bodies of animals, especially top predators and scavengers like vultures. This bioaccumulation contributes significantly to population declines due to reproductive issues already observed in other ecological contexts. Specifically, DDT has been shown to interfere with calcium metabolism in birds, resulting in thinner, more fragile eggshells and consequently lower hatching success rates. The species most affected by this substance include insects, fish, and birds (Hall, 2004).
In her groundbreaking 1962 book *Silent Spring*, Rachel Carson documented how DDT severely affected fish-eating birds, such as ospreys, cormorants, and pelicans, that ingested the chemical by feeding on contaminated fish. In Chapter VIII of the same volume, Carson also warned of the rapid disappearance of many bird species due to DDT and other synthetic chemicals.
Later studies confirmed not only the impact on wildlife but also the long-term health risks to humans, including neurodegenerative diseases, hormonal disruption affecting reproductive health and lactation, and carcinogenicity. At the time, however, DDT was widely and incorrectly reported as being harmless to humans and warm-blooded animals.
Despite growing concerns, in 1947, during the height of the anti-malaria campaign, the World Health Organization issued warnings about the disruptive effects of DDT on ecosystems, including its impact on fauna, crops, and trees. Nevertheless, even in the face of documented poisonings of fish, bees, and livestock, the *Sardinia Project* continued unabated until the objective of malaria eradication was officially declared achieved.

Strychnine

Strychnine and other poisons, once legally used until just a few decades ago to control so-called “vermin” (particularly foxes and feral dogs), played a significant role in the disappearance of necrophagous species from the island. Both direct and indirect poisoning, often resulting from scavenging on the carcasses of poisoned foxes or other carnivores, were major contributing factors to the vultures' decline.
These direct poisonings were carried out under the regulations of the "pest control" policies, which allowed for the eradication of such animals by any means necessary.

4.3.3 Hunting

Until the early 1970s, all birds of prey were considered "harmful" and undesirable competitors to hunting activities—or, in the case of scavenger species, even potential spreaders of disease. An exception was the Bearded Vulture, which was protected under Royal Decree No. 1016/1939 (Art. 38). However, the same decree still classified most major avian and terrestrial predators as game species, allowing their capture at any time of day or night using any means, including snares, traps, steel-jaw leghold traps, and poisoned bait (Articles 25 and 26 of Royal Decree 1016/1939).

Starting in 1973, vultures in Sardinia were no longer considered huntable according to the region’s annual hunting calendars (see also Schenk, 1976b), leading up to the implementation of the national Framework Law No. 968/1977. This law, adopted by the Sardinia Region through Regional Law No.

32/1978, established legal protection not only for vultures but also for all other birds of prey and non-game species. It marked the first major hunting reform in Italy, redefining the legal status of wildlife from *res nullius* (belonging to no one) to *res publica* (public property), and introduced a system of "controlled hunting."

Currently, hunting is regulated by the new national Framework Law No. 157/1992, adopted in Sardinia through Regional Law No. 23/1998. This legislation reaffirms the legal protection of vultures and transitions from the concept of "controlled hunting" to "planned hunting" within Territorial Hunting Areas (*Ambiti Territoriali di Caccia*, or ATCs). The goal is to ensure hunters remain tied to their local territory, with a predetermined number of participants and harvests based on actual wildlife population data. However, these principles have inexplicably yet to be fully implemented in Sardinia.

Hunting tourism also played a role in the persecution of vultures on the island. The Guida d'Italia del Touring Club Italiano – Sardegna (1918) provided visitors with information on where to hunt and, concerning these species, noted:

"*In the mountainous regions of the interior, vulture hunting is not difficult. It is generally practiced by leaving the carcass of a donkey, horse or sheep in a valley and hiding in a concealed spot nearby. It doesn't take long before crows and vultures descend from the surrounding mountains and pounce on the carrion. It is also customary to hide strong hooks within the flesh, tied to ropes, so that the vultures, in their greed, swallow them and become ensnared*."

4.3.4 Powerlines

Recent historical research, conducted at various times and for different purposes, including the feasibility study for the reintroduction of the Griffon Vulture in southeastern Sardinia (Secci et al., 2021), has revealed that the electrification of Sardinia played a significant role in the rapid decline of vulture populations on the island.

Although often overlooked in assessments of local and regional extinction causes, there is a striking correlation between the development of the island's electrical grid and the sudden disappearance of vultures and other bird species. The presence of high-voltage (HV), medium-voltage (MV), and low-voltage (LV) power distribution networks continues to pose a serious threat to avian wildlife. In the past, this threat was even greater, as the earliest power lines, composed entirely of bare wires, including LV lines, lacked any safety mechanisms. As a result, the incidence of bird electrocutions was likely higher than it is today.

While some raptors die by electrocution when perching on pylons, vultures are particularly vulnerable to collisions with overhead wires, which can be fatal or severely injurious. Adult Griffon and Cinereous Vultures tend to follow consistent flight paths across their territories. When power lines are installed along these habitual aerial routes, they can cause significant population declines.

This issue also emerged in eyewitness accounts collected for the Griffon Vulture reintroduction feasibility study in the historical Gerrei region. For example, Mr. Italo Tronci, a resident of Villasalto (SU), independently recalled how the construction of the power line between Ballao and San Vito was believed to be one of the main causes of the disappearance of many birds of prey.

Additional insights into the arrival of electricity in Sardinia can be found in History of the Electrification of Sardinia by Fabrizio Benincasa, a 2015 paper published by the CNR–Institute of

Biometeorology. The study provides a chronological overview of the island's electrification, describing how both public and residential access to electricity expanded between the early and mid-20th century.

Some key dates include:

- Ozieri: the first urban centre electrified, in 1907
- Cagliari: 1911
- Carloforte, Nuoro, Macomer: 1914
- Tempio Pausania: 1915
- Sassari: 1919

Initially, towns were not part of a unified grid; instead, they were powered by nearby thermal or hydroelectric plants operated by local entities. By the mid-20th century, approximately forty small municipalities, mostly in central-eastern Sardinia with populations under 2,000, still lacked access to electricity.

During this period, Sardinia was crisscrossed by an uneven and fragmented electrical network, where electricity was transmitted via 15 kV high-voltage lines made with bare cables. The spacing between these wires was much narrower than current standards, making the lines significantly more hazardous to birdlife.

The electrification process culminated in 1962 with the nationalization of energy services and the founding of ENEL (Ente Nazionale dell'Energia Elettrica), through Law No. 1643. By then, 97.6% of Sardinians had access to electricity, slightly higher than the national average of 96.8%. Figure 1 shows the power grid operated by Sardinia's main energy company, Società Elettrica Sarda, in 1961, just before unification.

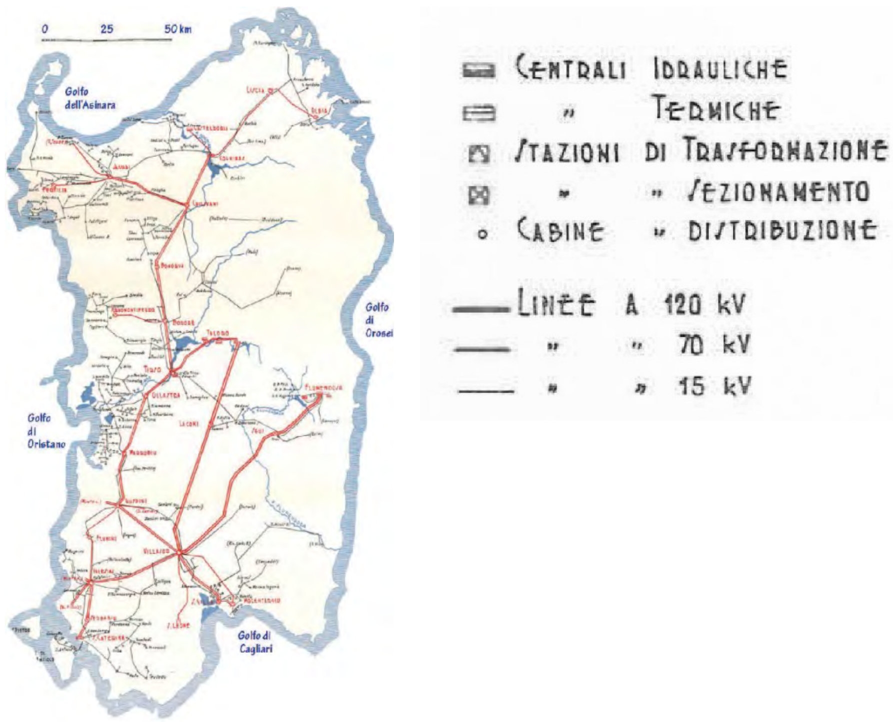


***Figure 4.6** The grid of the Sardinian Electric Company in 1961* (*Benincasa, 2015*).

5. Status of Egyptian Vulture and Griffon Vulture population in Sardinia

5.1 Egyptian Vulture

The Egyptian Vulture (*Neophron percnopterus*) is the most threatened bird species in Italy, with only 8–13 breeding pairs recorded in 2023, distributed across three regions in Southern Italy. In 2019, for the first time, a pair successfully bred in Sardinia (De Rosa et al., 2024).
Starting in early April 2019, following the first sightings of the two individuals at a supplementary feeding station, focused observations of the breeding pair were conducted. Direct observations were carried out every 3–7 days between 6:30 AM and 6:00 PM, from a vantage point located approximately 700 meters from the nesting cliff. Equipment used included a 10×60 mm spotting scope, 8×42 mm binoculars, and a camera equipped with a 100–600 mm telephoto lens.
The pair's use of the supplementary feeding station was monitored using a Scubla 904 camera trap, programmed to capture three photos and a 30-second video per activation. The feeding station, managed by FoReSTAS, the regional forestry agency, was stocked 1–2 times per week with 2–3 livestock carcasses, primarily sheep.
The supplementary feeding station played a crucial role during the first two years. Later, the adult vultures began foraging independently, often following Griffon Vultures in the Nurra area.
Since 2021, nest monitoring has been conducted through direct observation both from land and from a rubber boat.
In 2019, the chick hatched around July 5th and fledged around September 21st. In 2020, fledging occurred on July 14th. Breeding attempts in 2021 and 2022 were unsuccessful. In 2023, the chick fledged around July 20th, and in 2024, fledging occurred around August 15th.
The two adults are present in the area for most of the year. They typically remain near the nest for 10–15 days after fledging and return again in Porto Conte Regional Park around mid-October.

5.2 Griffon Vulture

Distributed over the whole island up to the late 1940s with an estimated population of 800–1,200 individuals (Aresu & Schenk, 2006), the population of Griffon Vultures in Sardinia dropped very rapidly after the second half of 20th century, mainly due to the use of poisoned baits. In central-eastern Sardinia the Griffon Vulture was present up to the 1980s, after which the population survived only in the north-western part of the island (Schenk et al., 2008). By 2005 the number of territorial pairs was estimated at only 31–32, and the population was distributed in the territories of Alghero and Bosa (Aresu & Schenk, 2006). The long-term conservation of the Sardinian population of Griffon Vultures is pivotal not only to preserve its role in the ecosystem but also to allow the development of a wider conservation plan to restore the vulture guild on the island. At his aim, starting from 2015, two consecutive LIFE project specifically targeting this species have been implemented: LIFE Under Griffon Wings (2015-2020; LIFE14/NAT/IT/000484) and LIFE Safe for Vultures (2021–2026; LIFE19/NAT/IT/000732).

The Sardinian population of Griffon Vultures has been closely monitored since 1986, and a large dataset on breeding records is available. The population was managed by restocking and supplementary feeding between 1987 and 1995. However, poisoning episodes in 1997, 1998 and 2006 hampered the conservation actions implemented. Thereafter, LIFE project continued targeting the main threats, providing supplementary feeding (see chapter 7), managing a restocking program, and monitoring population trend to evaluate the effectiveness of the conservation actions implemented.
Currently, the nesting area of the Griffon Vulture is located within Natura 2000 Network sites, including:

- SPA ITB023037 and SCI ITB020041, which host the most important natural nesting colony of Griffon Vultures in Italy.
- SPA ITB013044 and SCI ITB010042, among the most significant Griffon Vulture breeding areas in the Mediterranean region.

These are the only areas in both Sardinia and Italy where the Griffon Vulture has maintained a continuous breeding presence and never disappeared.

Over the past 10 years, reproductive parameters of the species significantly increased, and the population grew tripling its numbers.
In 2015, 35 territorial pairs, 27 clutches, and 20 fledglings were recorded. By 2020, these numbers had increased to 60 territorial pairs, 51 clutches, and 37 fledglings, with the total population estimated between 242 and 272 individuals.
The positive trend of the Griffon Vulture population in Sardinia has continued in the following years, with improvements recorded both in reproductive success and in overall population size. In 2023 a total of 93 territorial pairs were recorded, along with 69 clutches and 54 fledglings, corresponding to a reproductive success rate of 0.79 and a productivity rate of 0.66.
In 2024, a record number of territorial pairs and fledglings was recorded in both subpopulations of the Alghero and Bosa areas. The overall increase in territorial pairs was 26.5%, accompanied by a 29.1% rise in the number of fledglings. The most significant growth occurred in the Alghero area, where the number of territorial pairs and fledglings increased by 71.4% and 66.7%, respectively. In the Bosa area, although the absolute numbers were higher, the growth was more moderate but still noteworthy, with a 22.4% increase in territorial pairs and a 24.5% increase in fledglings (Figure 5.1; see also chapter 7 for more details).

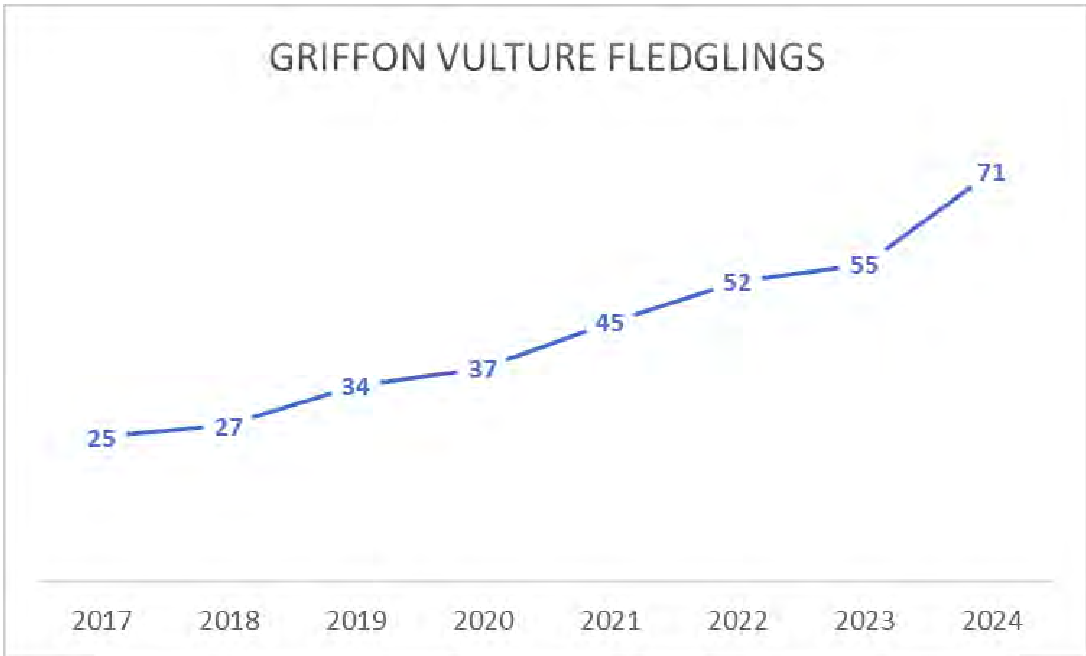


Figure 5.1 *Number of Griffon Vulture fledglings recorded from 2017 to 2024.*

Despite this generally positive situation and ongoing population growth, an analysis of individual colonies and isolated nesting sites reveals a fluctuating trend in reproductive parameters. In 2024 a total of 11 breeding failures were recorded, including 11 lost clutches, although fewer than in 2023, and the death of 4 fledglings before they were able to leave the nest. These losses, particularly in the Bosa area, which hosts about 90% of the breeding pairs, appear to be partly due to adverse weather conditions affecting the most exposed nests. They are also linked to increased human disturbance caused by recreational activities during the breeding season, such as rock climbing, paragliding, and hiking near nesting sites. Some of these activities are still not regulated within the SPA (Special Protection Area) "Costa e Entroterra di Bosa, Suni e Montresta," as stipulated by its Management Plan.

From 2017 yearly censuses have also started (Tab. 5.1). During this period, the estimated population of Griffon Vultures has shown a steady and significant increase. In 2017, the population was estimated between 144 and 160 individuals. Over the following years, the population continued to grow, with the most notable increases occurring in:

- **2018**, with a **26.0%** growth,
- **2019**, with a **25.3%** growth, and
- **2024**, showing a substantial **25.9%** rise.

Despite slower growth in 2020 (**7.1%**) and 2023 (**8.6%**), the overall trend is clearly positive. By 2024, the estimated population reached between **424** and **470** individuals, nearly tripling the numbers from 2017.

Table 5.1 *Minimum and maximum estimated population during the annual census and corresponding percentage increase compared to the previous year.*

	ESTIMATED POPULATION		
YEAR	**MIN**	**MAX**	**INCREASE**
2017	144	160	
2018	180	203	26,0%
2019	230	250	25,3%
2020	242	272	7,1%
2021	272	296	10,5%
2022	316	338	15,1%
2023	332	378	8,6%
2024	424	470	25,9%

5.3 Restocking actions in Sardinia (2018 - ongoing) and survival rates

Since 2018, a total of 105 Griffon Vultures has been released in Sardinia as part of the restocking efforts carried out under the LIFE projects *Under Griffon Wings* and *Safe for Vultures*.

The LIFE project *Under Griffon Wings* restocking action aimed at increasing population size and took place near the colonies of Alghero and Bosa. A total of 63 individuals were released. Of these, 58 individuals came from wildlife rehabilitation centres in Spain (Hospital de Fauna Salvaje de AMUS and the Wildlife Recovery and Environmental Education Centre "Los Hornos" in Extremadura), while 5 were provided by the captive breeding program managed by ARTIS Amsterdam Royal Zoo.

The restocking action was implemented through five distinct release events between 2018 and 2019 with a soft release strategy with different acclimatization periods, 15 months for the first group and 3-6 months for the others.

The first release took place on 14 April 2018, involving 13 individuals from Spain and 2 from the ARTIS zoo. The second release occurred on 13 September 2018, involving 12 individuals from Spain. A third release was carried out on 10 December 2018, comprising 11 individuals from Spain.

On 25 June 2019, a fourth group of 13 individuals was released, 10 from Spain and 3 from the ARTIS Zoo. The final release of this LIFE project occurred on 22 October 2019, with 12 individuals from Spain.

Furthermore, between 2016 and 2021, 12 Sardinian individuals—rescued locally due to different causes—were released following recovery at wildlife rescue centres. These individuals were all released with the hard-release strategy, without an acclimatization period, in the area of the Bosa colony.

To estimate survival rates, we used a comprehensive dataset combining multiple sources of information. Individuals were monitored through camera traps placed at feeding stations, direct observations conducted by project staff and trained volunteers, and records from a network of wildlife photographers. Additional data were obtained from GPS tags fitted to some individuals. Griffon Vultures were individually recognisable thanks to the coloured PVC rings applied to their legs, each bearing a unique alphanumeric code. All observations were compiled into a central database, which allowed us to track the last confirmed sighting date for each individual. Survival was assessed at two time points—6 months and 1 year after release (Tab. 5.2 and Fig. 5.2 for the individuals of the restocking, Tab. 5.3 and Fig. 5.3 for the Sardinian individuals) —under a conservative scenario, where individuals not observed after the threshold date were considered dead.

Table 5.2 *Number of individuals released per group, number of individuals survived after 6 months and 1 year, and survival rates*

GROUP	TOTAL RELEASED	SURVIVED AFTER 6 MONTHS	SURVIVAL RATE (6 MO)	SURVIVED AFTER 1 YEAR	SURVIVAL RATE (1 YR)
April 2018	15	14	93.3%	14	93.3%
September 2018	12	6	50.0%	6	50.0%
December 2018	11	10	90.9%	9	81.8%
June 2019	13	10	76.9%	9	69.2%
October 2019	12	11	91.7%	9	75.0%
	63	51	**80.95%**	47	**74.60%**

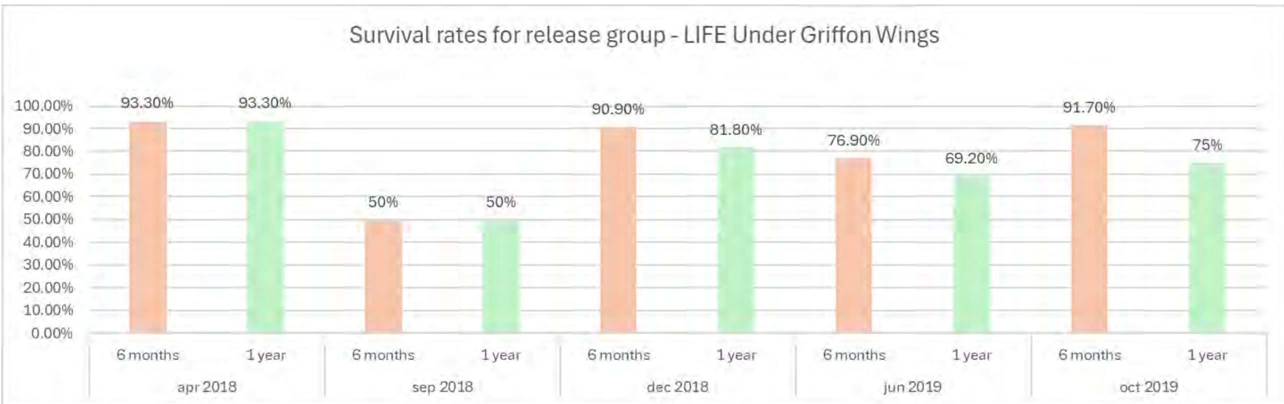


Figure 5.2 *Survival rates of restocked individuals released within the LIFE Under Griffon Wings.*

Table 5.3 *Number of Sardinian individuals released, number of individuals survived after 6 months and 1 year, and survival rates*

TOTAL RELEASED	SURVIVED AFTER 6 MONTHS	SURVIVAL RATE (6 MO)	SURVIVED AFTER 1 YEAR	SURVIVAL RATE (1 YR)
12	10	**83.30%**	8	**66.60%**

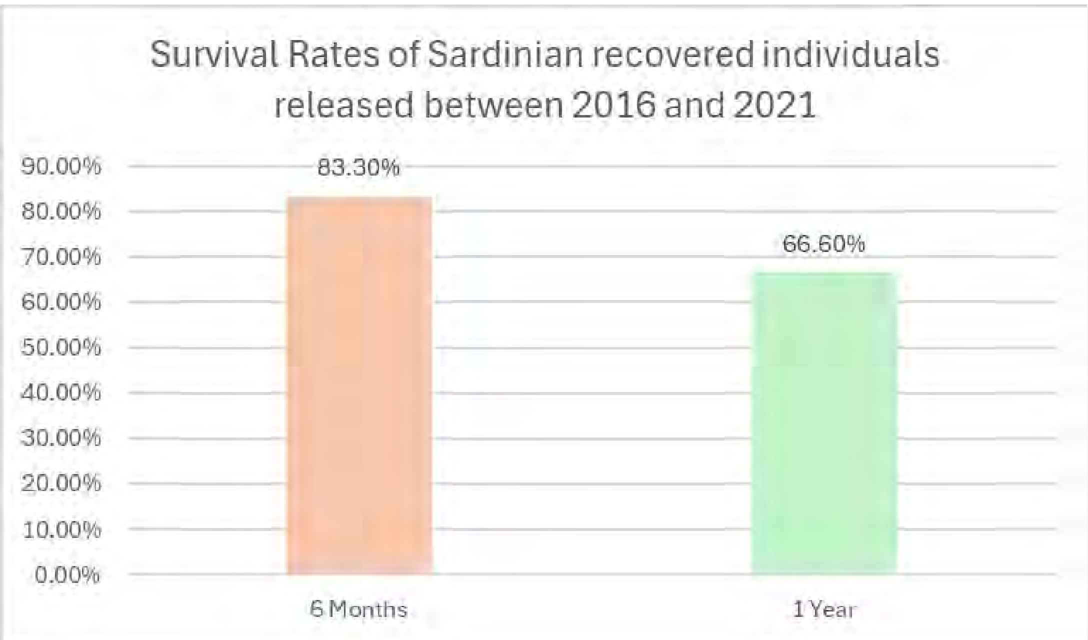


Figure 5.3 *Survival rates of Sardinian individuals released between 2016 and 2021.*

The LIFE Safe for Vultures project aims to establish a new breeding nucleus in south-eastern Sardinia to enlarge the area of occupancy of the species. To achieve this, four releases have been planned, involving a total of at least 60 Griffon Vultures.
To date, two releases have been carried out in 2024, involving a total of 37 Griffon Vultures (Tab. 4), and two more releases are scheduled in May 2025 (n=30) and in the spring of 2026.

Table 5.4 *Status of Griffon Vultures released in April and October 2024, assessed in mid-April 2025. The table includes the number of individuals resighted, found dead, never resighted, or in recovery centres.*

		SITUATION IN MID-APRIL 2025			
RELEASE DATE	N. IND.	RESIGHTED IN 2025	DEAD	NEVER RESIGHTED	RECOVERY CENTRE
09/04/2024	15	10	4	1	0
09/10/2024	22	16	2	0	4

As of mid-April 2025, the first group, consisting of 15 individuals, had 10 animals resighted, 4 confirmed dead, and 1 that was never resighted. None of the individuals from this group are currently in a rehabilitation centre. In contrast, the second group, made up of 22 individuals, showed 16 resighted, 2 dead, while 4 individuals were housed in a rehabilitation centre.
Regarding their origin, the majority of the animals came from Spain or zoos, with 11 in the first group and 22 in the second.

The survival of released Griffon Vultures was evaluated also for this project over two time intervals, 6 months for both release groups, and 1 year for the first release group only (Tab. 5.5 and Fig. 5.4).

Table 5.5 *Number of individuals released per group, number of individuals survived after 6 months, and survival rates*

GROUP	TOTAL RELEASED	SURVIVED AFTER 6 MONTHS	SURVIVAL RATE (6 MO)	SURVIVED AFTER 1 YEAR	SURVIVAL RATE (1 YR)
April 2024	15	11	**66.70%**	10	**60%**
October 2024	22	19	**86.40%**	NA	NA

Figure 5.4 *Survival rates of restocked individuals released within the LIFE Safe For Vultures*

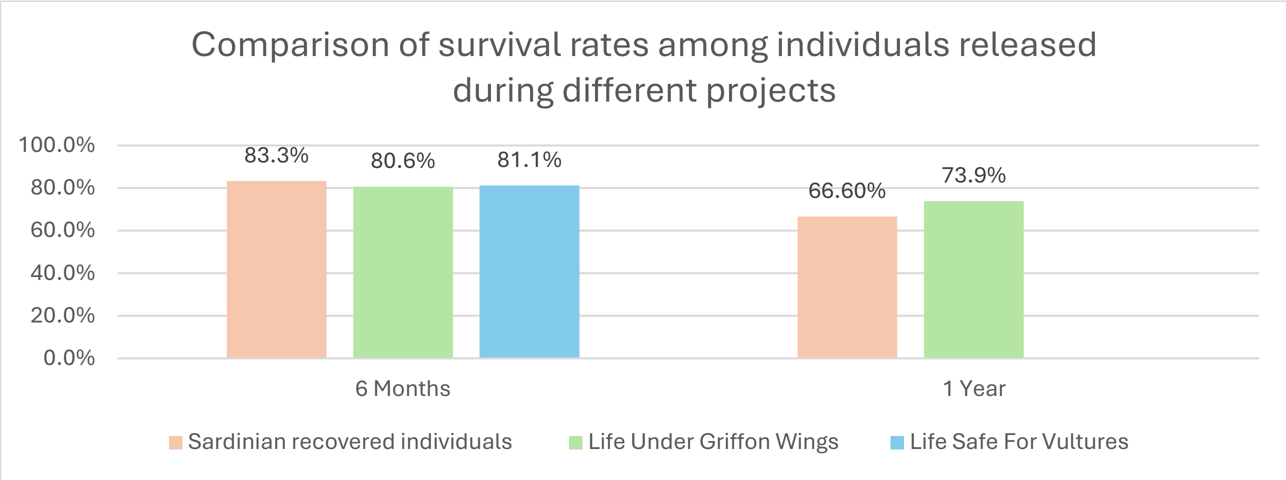


Figure 5.5 *Comparison of survival rates among different projects*

5.4 Breeding of restocked Griffon Vultures

From 2021 to 2024 mixed Griffon Vulture pairs were observed in Sardinia. These pairs consisted of one local and one released individual as part of the LIFE *Under Griffon Wings* restocking program (identified by orange PVC rings). The number of mixed pairs increased over time: at least 4 in 2021, 7 in 2022, 9 in 2023, and 12 in 2024 (Fig. 5.6). Several mixed pairs successfully completed their breeding cycle each year.

Due to the geomorphology of certain sites and the considerable observation distance, not all rings were readable.

Starting in 2022, fully reintroduced pairs were also recorded with successful breeding outcomes, both in the Alghero area and, for the first time in 2024, also in the Bosa area.

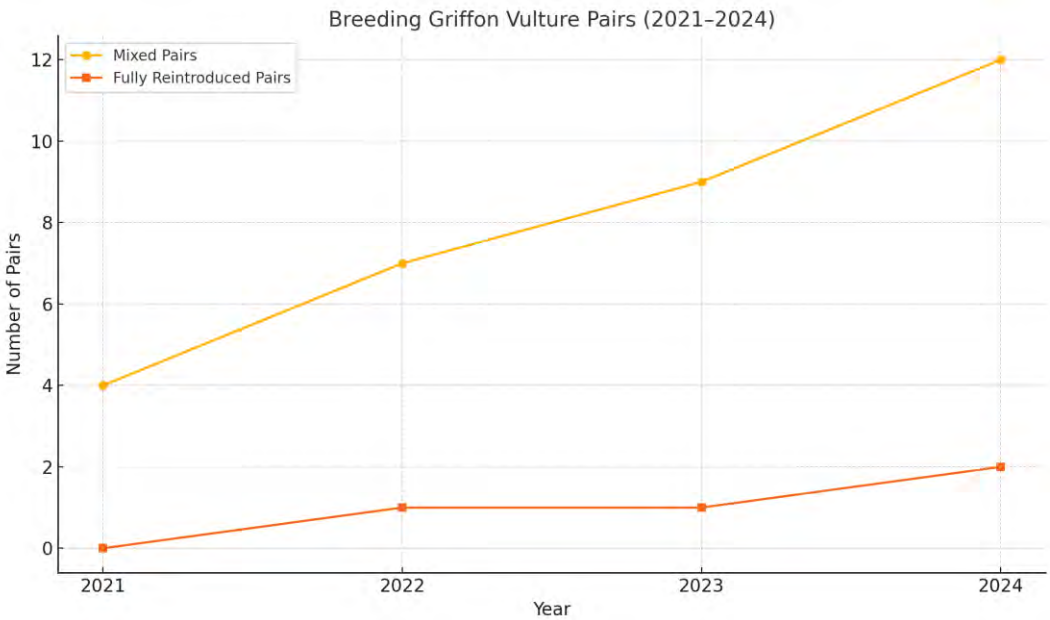


Figure 5.6 *Number of mixed and fully reintroduced Griffon Vulture pairs observed annually from 2021 to 2024.*

5.6 Conclusions

The consolidation and increase of the Griffon Vulture population in Sardinia over the past decade represent a significant conservation success, attributable to the implementation of targeted measures including restocking, supplementary feeding, mitigation of main threats as poisoning and collision/electrocution against power lines, and systematic population monitoring under successive LIFE projects. The steady increase in territorial pairs, fledging success, and overall population size—culminating in record breeding numbers in 2024—demonstrates the effectiveness of these interventions in enhancing demographic parameters and restoring a viable insular population.

In parallel, the natural colonisation and sustained presence of a breeding pair of Egyptian Vultures since 2019 further supports the notion that Sardinia currently possesses the ecological conditions necessary to support additional scavenger species. The pair's breeding success and year-round presence highlight the island's suitability for obligate scavengers with specific ecological requirements.

Taken together, these outcomes provide a robust scientific basis for pursuing the reintroduction of the Cinereous and Bearded Vulture in Sardinia, capitalising on the conservation strategies and operational frameworks successfully applied to Griffon Vultures.

6. Main threats to vultures

Bearded and Cinereous Vulture populations, and vulture species in general, face numerous threats, mostly deriving from anthropogenic causes. The main threats include energy infrastructures, such as power lines and wind farms, poisoning, intentional killing and persecution, habitat loss and degradation, human disturbance, and food shortage. The latter is often driven by changes in livestock practices. In West Africa, Southeast Asia, and Europe, such changes have contributed to vulture declines (Ogada et al., 2012). In Europe, sanitation regulations introduced after a bovine spongiform encephalopathy outbreak mandated the collection and destruction of livestock carcasses (Heever et al., 2021), reducing food availability for vultures and leading to lower breeding success and higher juvenile mortality (Ogada et al., 2012). Supplementary feeding is a key conservation measure to address this threat. Chapter 7 explores this topic in detail.

The following sections will delve into each threat in detail, examining their causes, impacts, and potential mitigation strategies.

6.1 Risks related to energy infrastructure

Energy infrastructure, including power lines and wind farms, is a major factor contributing to the decline and mortality of many vulture species.

In recent decades, wind energy has experienced exponential growth, establishing itself as a primary source of renewable energy globally. In 2019, global wind power capacity reached 651 GW, underlining the crucial role of this technology in the global energy transition (Leung & Yang, 2012). However, despite their role in green energy transition, wind farms and power lines are among the main threats to large raptors such as the Cinereous and Bearded Vultures, potentially impacting their survival and reintroduction success both directly and indirectly.

Among avian species, those that use soaring flight, such as raptors, are particularly vulnerable to the impacts of wind farms. The latter, in fact, cause high mortality among them due to collisions with turbine blades, recorded in various areas (Barrios & Rodriguez, 2004; Davis, 2002; De Lucas et al., 2008).Their vulnerability can be attributed to three principal factors: low reproductive rates and delayed sexual maturity, which make populations incapable to compensate for additional mortality (Duriez et al., 2023); limited visual capacity in the direction of movement, impairing their ability to detect vertical obstacles such as turbine blades (Martin et al., 2012); and the overlap between wind farm locations and geomorphological features, such as ridges and updrafts, which are attractive for raptor activities (Katzner et al., 2012; Poessel et al., 2018; Rushworth & Krüger, 2014). Other factors may also influence collision risk. For example, species with high wing loading and weak-powered flight, like Griffon Vultures, rely on uplift winds to stay aloft. In poor uplift conditions, they are forced to fly lower, increasing their risk of collision with turbine blades (De Lucas et al., 2008; Janss & Ferrer, 1998; Pennycuick et al., 1975; 1998).

6.1.1 Risks associated with wind energy

Although the environmental benefits of reducing greenhouse gas emissions, wind turbines can negatively impact wildlife, particularly flying vertebrates such as birds and bats (Jonasson et al., 2024; Marques et al., 2014).

Impacts include direct mortality from collisions with rotor blades and power lines (Garvin et al., 2011; Huso et al., 2016; Rydell et al., 2010) and indirect impacts such as habitat loss and disturbance, which can lead to species displacement and reduced population viability (Arnett & May, 2016; Drewitt & Langston, 2006; Frick et al., 2017; Madders & Whitfield, 2006; Zimmerling et al., 2013).

Moreover, wind-power plants may act as barriers to movement, with the severity of these effects varying depending on site-specific and species-specific factors. However, birds can exhibit behavioural adaptations to mitigate these impacts, such as fleeing, shifting activity patterns, or modifying habitat utilization responses collectively termed avoidance (May, 2015).

6.1.2 Status of the threat in Sardinia

In Sardinia, the expansion of wind energy is particularly evident, with a steady increase in installed capacity in recent years (Costantino et al. *in prep*). At the same time, the island is home to species of high conservation value, such as the Griffon Vulture, which is currently the focus of the LIFE Safe for Vultures project and for which four collision events with wind turbines were recorded between 2017 and 2019. The overlap between wind energy expansion and the presence of vulnerable species makes Sardinia a key area for balancing the development of renewable energy and biodiversity conservation. Following concerns raised regarding both landscape and biodiversity impacts, in 2024 the Regional Government adopted an 18-month moratorium (https://delibere.regione.sardegna.it/protected/70085/0/def/ref/DBR70069/), which was later followed by the approval of Regional Law No. 20/2024, titled *"Urgent measures for the identification of suitable and unsuitable areas and surfaces for the installation and promotion of renewable energy (RES) plants, and for the simplification of authorization procedures"* (https://leggiregionali.regione.sardegna.it/legge-regionale?data=05-12-2024&numero=20).

This regional law, to which the UNISS group contributed significantly during its development (as outlined in the following section), introduces strict criteria to regulate the development of renewables. It classifies energy installations based on their capacity and type, and clearly defines unsuitable areas, including parks, forests, protected areas, Natura 2000 sites, and zones of high sensitivity for birds and bats.

Suitable areas, on the other hand, mainly include degraded sites such as former industrial areas, landfills, and extractive sites undergoing restoration. The legislation drastically limits the territorial expansion of energy installations, allocating only 1% of the regional territory for this purpose. Among its objectives, the regulation aims to ensure sustainable energy development that respects biodiversity, creating a balance between energy needs and ecosystem protection.

6.1.3 Ongoing mitigation measures

In the context of the Sardinia region, the research group from the University of Sassari (UNISS) has worked on two main fronts to mitigate the impacts of renewable energy sources on biodiversity, with a particular focus on birds and bats. One of the main obstacles to informed renewable energy planning in Sardinia was the lack of updated and reliable databases mapping existing wind energy infrastructure in the region. In this context, the PhD project titled *"Integrated territorial planning aimed at maximizing compatibility between renewable energy development and wildlife communities in the Sardinia Region"*, funded by the PNRR and the Public Administration, was launched in 2023 and is expected to conclude in 2026.

The main goal of the project is to develop innovative strategies and tools to minimize the negative impacts of renewable energy installations on Sardinia's natural ecosystems. This has involved adopting a multidisciplinary approach that integrates landscape analysis, ecological data, and species distribution models to identify the most suitable areas for plant installation, while avoiding zones sensitive to wildlife. To ensure effective management of environmental impacts, it is essential to have reliable data on the distribution of operational wind turbines.

As part of this project, an analysis conducted in Sardinia by the UNISS group compared three publicly available datasets with direct observations based on high-resolution satellite imagery. The datasets examined include the following sources:

- Smeraldo et al. (2020), a database based on integrated data validated through satellite imagery up to 2020.

- OpenStreetMap (https://www.openstreetmap.org/#map=18/40.743230/8.957970), a collaborative platform where users map the presence of infrastructures, including wind power plants.

- Atlaimpianti (https://www.gse.it/dati-e-scenari/atlaimpianti), the only official public map of wind turbines in Italy, based on government data.

The analysis identified the location and number of operational turbines, comparing them with the information available in the datasets to assess their accuracy and level of update.

The satellite analysis revealed that there are 1,155 operational wind turbines in Sardinia, a number significantly higher than that reported by the examined datasets (Fig. 1) and the results of this study were published in the scientific journal *Biological Conservation* (Cerri, et al., 2024a).

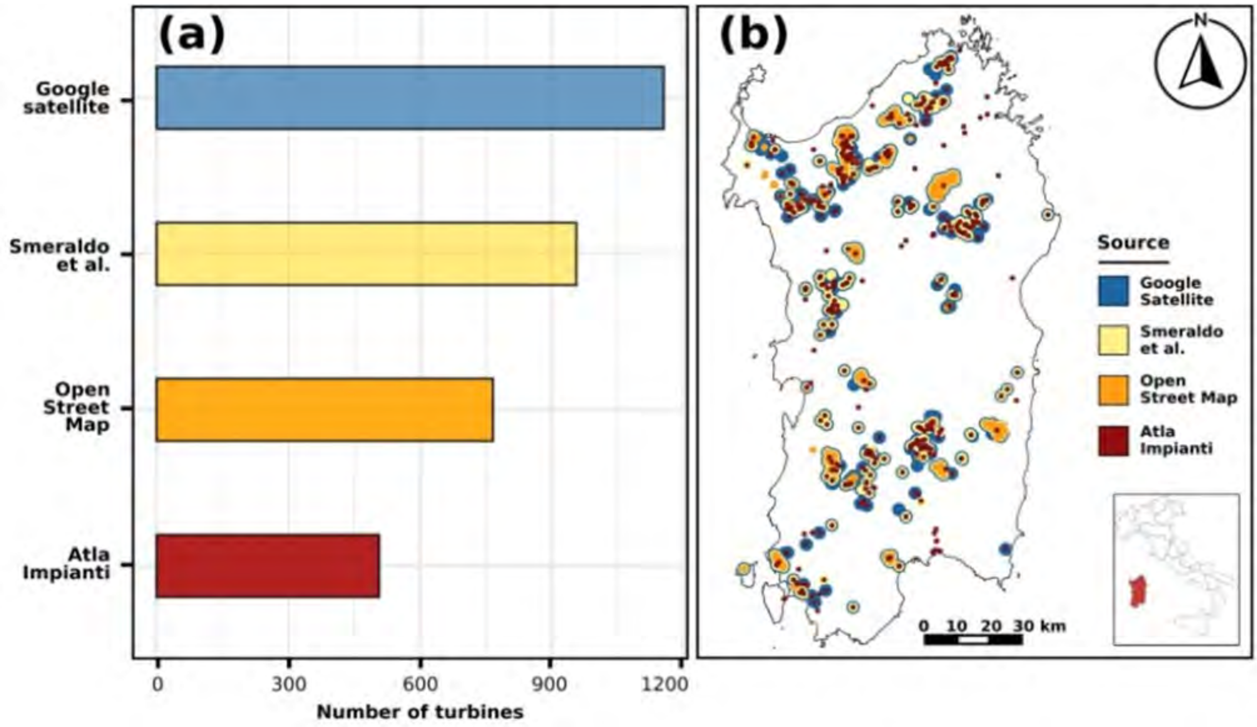


Figure 6.1. *Comparison of wind turbine data sources for Sardinia. Panel (a) shows the total number of turbines identified by four different datasets: our satellite-based survey (Cerri et al. 2024), Smeraldo et al., OpenStreetMap, and AtlaImpianti. Panel (b) displays the spatial distribution of turbine locations across the island, highlighting discrepancies among sources and areas of overlap.*

Considering these findings, a subsequent study was conducted to assess how the use of different wind turbine data sources can significantly influence estimates of high-risk areas for Griffon Vultures in Sardinia (Cerri, et al., 2024b).

To quantify collision risk, GPS and accelerometer data from six Griffon Vultures monitored in Sardinia were used. The risk was estimated by comparing three different wind turbine data sources derived from the study by Cerri et al., 2024a. The results show that the different turbine data sources significantly influence the estimation of high-risk areas (Fig. 6.2):

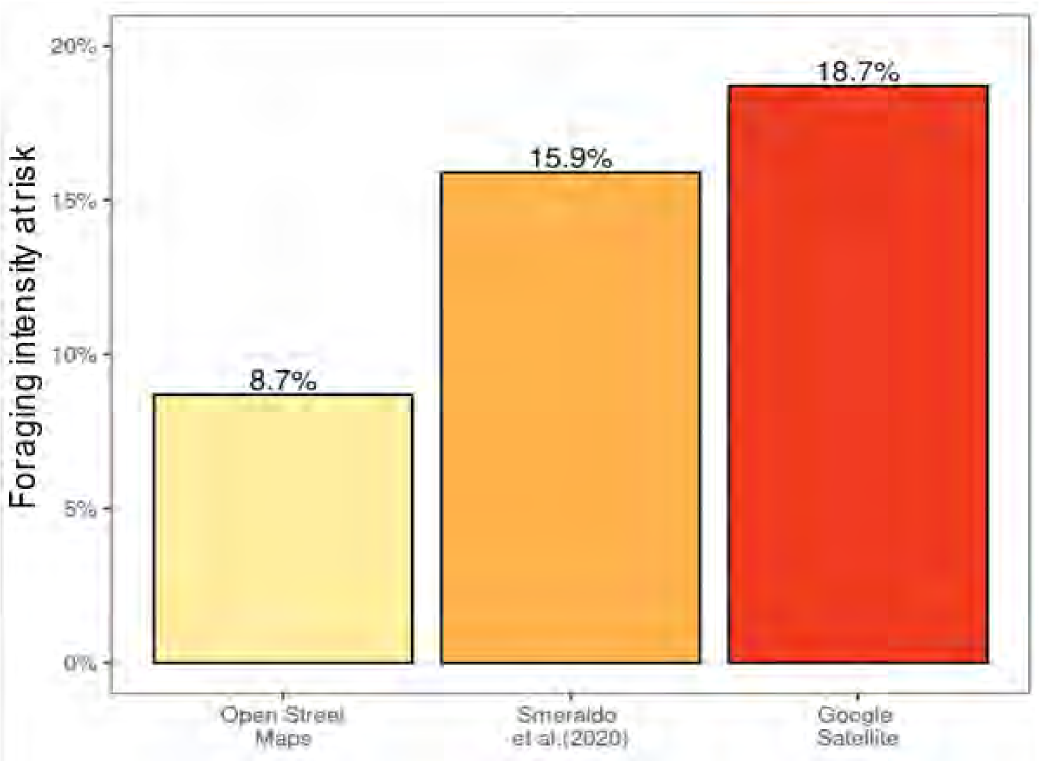


Figure 6.2. *Differences in collision risk for Griffon Vulture based on the wind energy datasets used. The bar chart shows the proportion of foraging intensity estimated to be at risk when using wind turbine locations from OpenStreetMap, Smeraldo et al. (2020), and our satellite-based survey (Cerri et al. 2024). The higher value associated with the satellite dataset highlights the importance of accurate and up-to-date turbine mapping in assessing species vulnerability.*

The turbines mapped using aerial imagery (Cerri et al., 2024a) overlap with 18.7% of the Griffon Vultures' foraging intensity, while Smeraldo et al. (2020) report an overlap of 15.3%. Using OpenStreetMap data, the overlap is lower, at 8.7%.

The results of this study highlight how differences in wind turbine datasets can lead to significant underestimations of collision risk for Griffon Vultures. Given the current expansion of wind energy in the Mediterranean, improving the quality and availability of data is a priority to support evidence-based decision-making and minimize the impact of energy infrastructure on vulnerable species. Only through transparent and up-to-date data management will it be possible to balance the need for renewable energy with the protection of biodiversity.

As part of the PNRR project, and in collaboration with the Department for Environmental Protection of the Sardinia Region, the University of Sassari (UNISS) provided essential data for the management and planning of wind energy development within the region. In particular, the dataset published by Cerri et al. (2024a) was made available, offering detailed information on existing wind infrastructure and enabling a clear understanding of the current situation and the impact of already installed wind energy.

In addition, the research group developed a new dataset on potential wind energy installations, based on the analysis of wind project proposals submitted to the Ministry of the Environment and subsequently forwarded to the Region for the required assessments (Fig. 6.3). This dataset, updated as of July 2024, not only provides a detailed overview of possible new installations but also integrates key information to support strategic decision-making in territorial planning and environmental impact mitigation.

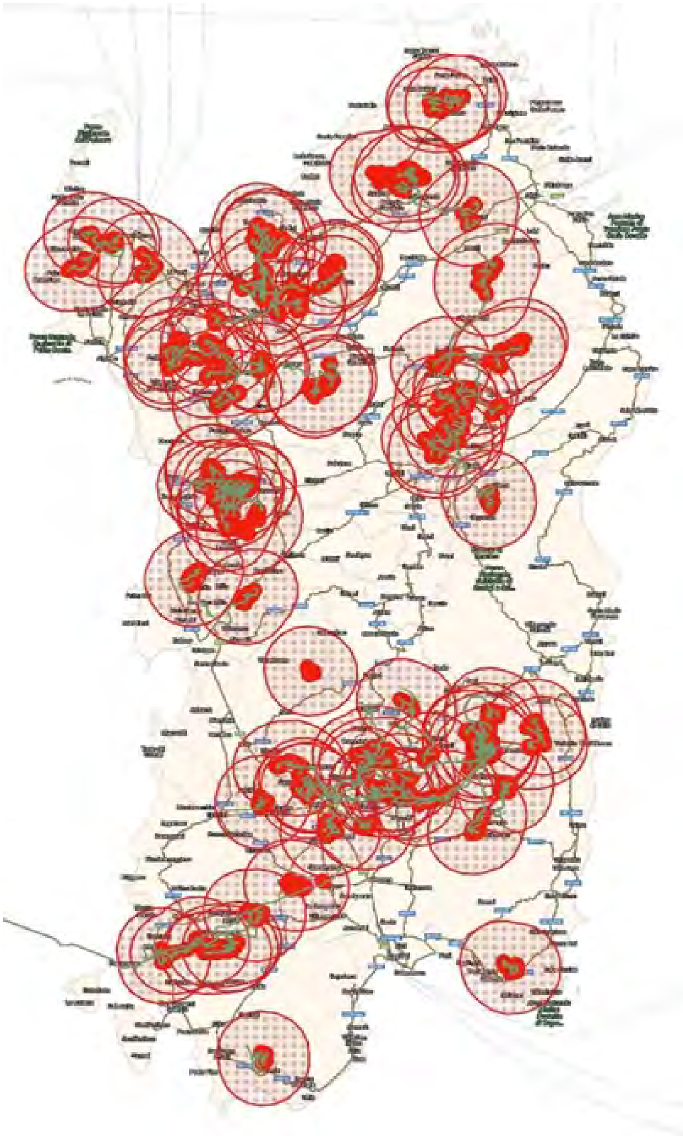


Figure 6.3 *Map of wind energy potential and associated infrastructure in Sardinia. Red dots indicate the locations of proposed wind farms, while red circular buffers represent the estimated turbine sweep areas. Green lines show the potential power line network associated with future wind energy development.*

Among these is the georeferencing of essential data for land management. The UNISS group has accurately mapped existing power lines, wind turbine sweeps areas, and all project-specific information related to potential installations, thereby providing a comprehensive and reliable information base. This approach improves the analysis of how new infrastructure integrates with the landscape and sensitive areas, supporting the Department in environmental assessments and in energy planning decisions for the future of Sardinia.

In parallel, the UNISS group coordinated the development of sensitivity maps for renewable energy installations with respect to birds and bats. These maps were included as annexes to Regional Law No. 20/2024, titled *"Urgent measures for the identification of suitable and unsuitable areas and surfaces for the installation and promotion of renewable energy (RES) plants, and for the simplification of authorization procedures"* (https://leggiregionali.regione.sardegna.it/legge-regionale?data=05-12-2024&numero=20, Fig. 6.4). This work was carried out in collaboration with the Environmental Impact and Assessment Service (VIA) of the Autonomous Region of Sardinia.

The identification of these areas was based on the analysis of the distribution of 39 bird species and 10 bat species, selected based on their sensitivity to the impacts of wind and solar energy. For most of the bird species considered in the study, potential occurrence areas were estimated using Species Distribution Models (SDMs), from which an environmental suitability index was derived. Final areas were obtained by selecting values above a defined cutoff threshold. For other species, such as the Griffon Vulture, the Egyptian Vulture, Bonelli's Eagle, and Eleonora's Falcon, suitable areas were defined using specific approaches described in dedicated studies, referenced later in the document.

The data used in this study come from reliable and diverse sources, depending on the species considered. Presence data for most species were obtained from the Ornitho database (https://www.ornitho.it/), which collects field observations through a wide network of contributors. For certain species, such as the Little Bustard (*Tetrax tetrax*), data were sourced both from Ornitho and from observations kindly provided by Dr. Davide De Rosa.

The environmental variables selected for this study were chosen from a broader initial set, based on their ecological relevance and statistical significance. After an analysis using the Variance Inflation Factor (VIF, Naimi, 2023) to reduce multicollinearity, 11 environmental variables were identified. The first phase of the analysis involved applying the spatial thinning method (SP Thin, (Aiello-Lammens et al., 2015) to the species presence data. This process was essential for reducing spatial bias by selecting presence points in a way that ensured a more uniform spatial distribution and minimised the effect of oversampling in specific areas.

Subsequently, a Random Forest (RF) algorithm was used to test and evaluate different configurations of pseudo-absences, to determine the optimal number to include in the final dataset for modeling each species.
Then, Species Distribution Models (SDMs) were built using an Ensemble Modeling approach via the "biomod2" package (Thuiller et al., 2012) in R. This method combines multiple modeling algorithms to improve prediction accuracy and reduce the uncertainty associated with individual models. Specifically, the following algorithms were used:

• GAM (Generalized Additive Models): A flexible model that captures non-linear relationships between predictor variables and species presence.

• GBM (Generalized Boosted Models): A boosting model that combines the power of multiple simple models to improve predictive performance.

• GLM (Generalized Linear Models): A generalized linear model that allows for both linear and non-linear relationships between variables.

• RF (Random Forest): An algorithm based on an ensemble of decision trees, robust to noise in the data and highly effective for accurate predictions.

• MARS (Multivariate Adaptive Regression Splines): A model that captures interactions between variables and non-linear relationships using a piecewise approach.

Subsequently, the following metrics were used to evaluate model performance:

1. ROC (Receiver Operating Characteristic): Measures the model's ability to discriminate between presences and absences. The AUC (Area Under the Curve) value was used to quantify this ability. Good AUC values are above 0.7.
2. KAPPA: An index that measures the agreement between predicted and observed occurrences.
3. TSS (True Skill Statistic): Assesses model accuracy by considering both sensitivity and specificity, with values ranging from -1 to 1 (where 1 indicates perfect accuracy).

After model construction, response curves were extracted for each environmental variable within the best-performing models, analysing how each variable influences the probability of species presence. This allowed for a visual representation of the effect of each variable and a better understanding of the environmental conditions that favour the species' occurrence. In addition, the importance of variables within the best-performing models was assessed. This process made it possible to identify which variables have the greatest impact in determining environmental suitability for the species under consideration.

The Ensemble Modeling approach allowed for robust and reliable predictions of potential species distributions. Moreover, the combined use of multiple algorithms and the careful evaluation of model performance helped reduce uncertainty and provided high-quality environmental suitability maps, which can serve as decision-support tools for species conservation. Subsequently, for each species, presence areas were defined as the 1 km² cells with a potential suitability value from the SDMs greater than or equal to 0.5.

For the analysis of potentially suitable areas for the Griffon Vulture (*Gyps fulvus*), GPS telemetry data from 32 individuals released as part of the Life Under Griffon Wings project (LIFE14/NAT/IT/000484) were used. These data were recorded between 2016 and 2023. The GPS sensors recorded the animals' positions approximately every 60 minutes, from 06:00 UTC to 18:00 UTC, resulting in a total of about 237,000 GPS locations.

To estimate the area covered by the vultures over the long term, the so-called home range, the weighted Autocorrelated Kernel Density Estimate (wAKDE, Silva et al., 2022) method was used. The Griffon Vulture presence map was then generated using the following method:

First, all individual space-use distributions around the Bosa and Punta Cristallo colonies, obtained using wAKDE, were overlaid. Then, the median value of spatial use was calculated, from which the 95% isopleth was extracted to identify the boundaries of the areas regularly used by Griffon Vultures in the northwestern part of Sardinia (Cerri et al., 2023; Fozzi et al., 2023).

Additionally, based on the surface area of all 32 home ranges of the various individuals, a median home range was calculated for the vultures released in the Villasalto area. This represents the area expected to be visited by the vultures over the long term, once their movements have stabilized in southeastern Sardinia.

Assuming that the vultures move multidirectionally around the Villasalto release site, a buffer of the same size (with a radius of 21 km) was calculated around this area. This second boundary corresponds to the zone where the animals released as part of the Life Safe for Vultures project (LIFE19/NAT/IT/000732) are expected to move regularly.

Finally, in line with the recommendations of the directive issued by the Regional Directorate of the Department of Health of the Autonomous Region of Sardinia No. 1199 of 19/10/2016—concerning procedures for derogation authorizations for the use of animal by-products to feed scavenging birds at on-farm feeding stations—which recommends the construction of feeding stations at least 4,000 meters away from power lines and wind turbines, a 5 km buffer was created around the on-farm feeding stations activated under the Under Griffon Wings project, located outside the boundaries of areas regularly used by Griffon Vultures in northwestern Sardinia (n = 29), and around those activated under the Life Safe for Vultures project (n = 16). These three boundaries were combined to define the full extent of current and potential Griffon Vulture presence areas in Sardinia.

For the Egyptian Vulture (*Neophron percnopterus*), the identification of presence areas was based on a combination of two types of data:

1. The presence of a breeding pair on the cliff of Punta Cristallo, recorded since 2019 (De Rosa et al., 2024), has occasionally been observed moving within a radius of approximately 30 km from the nesting site.
2. The identification of Griffon Vulture feeding areas, which were also observed being used by Egyptian Vultures during foraging activities. These areas were identified using accelerometer data collected from 6 Griffon Vultures.

Accelerometer data from the Griffon Vultures recorded acceleration along three axes at a frequency of 20 Hz, in 10-second sampling intervals every minute. This allowed for the identification of all instances in which individuals were feeding in the wild, using a Random Forest algorithm trained on video footage of vultures feeding both in captivity and in nature.

Subsequently, analysis of the GPS coordinates associated with feeding activities enabled the identification of the locations of feeding events. To identify the most frequently used areas for foraging, the Kernel Density Estimate method was applied to calculate the spatial distribution of feeding density. The most frequently used areas by Egyptian Vultures were therefore identified by combining a 30 km buffer around the Punta Cristallo nest with the 95% isopleth of Griffon Vulture foraging areas, which are also used by this second vulture species.

To identify the potential presence areas for Bonelli's Eagle (*Aquila fasciata*), data provided by ISPRA were used, derived from the LIFE "Aquila a-Life" project (2017–2022) and the "Back to Sardinia. Supporting the return of Bonelli's eagle in Sardinia" project (European Wildlife Come Back Fund – Rewilding Europe). These data include GPS telemetry positions of the animals (23 females and 20 males) collected up to August 28, 2024.

To identify the potential presence areas for Eleonora's Falcon (*Falco eleonorae*), a buffer was created around the two known colonies in the region, with a size corresponding to the maximum distance covered by the species during movements around the colonies (Mellone et al., 2012). For the identification of areas most suitable for bat presence, data on the main colonies in the region were obtained from the Center for the Study and Protection of Bats in Sardinia. The provided dataset included 52 aggregation sites across the region, hosting the following 10 species: *Miniopterus schreibersii*, *Myotis capaccinii*, *Myotis emarginatus*, *Myotis punicus*, *Plecotus auritus*, *Plecotus sardus*, *Rhinolophus euryale*, *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, and *Rhinolophus mehelyi*.

In accordance with the EUROBATS guidelines (Rodrigues et al., 2015), an area subject to systematic bat presence was identified around the main aggregation sites, using a 5 km radius buffer. This area was then assigned to the 1 km grid cells of the raster used to calculate the presence of sensitive species.
To produce the summary map identifying areas of high sensitivity to renewable energy installations based on the presence of the considered bird species—and in line with the *EU Guidance Document on Wind Energy Developments and EU Nature Legislation*—a vulnerability score to wind or solar development was calculated for each species.

This score measures how much a given species may be affected by the construction of wind or solar energy infrastructure within its range in Sardinia, and combines this with the species' conservation value at both the Italian and European levels to obtain an overall score: species with higher values are therefore expected to experience greater and more likely impacts, and also have higher conservation importance. The vulnerability score to wind energy development was assessed by six different experts for each bird species, and by one expert for each bat species.

With respect to wind energy:

1. The following impacts were considered:
   i) reduction and alteration of key habitats,
   ii) increased disturbance levels in activity areas,
   iii) increased disturbance at breeding or roosting sites,
   iv) collision or barotrauma with turbine blades,
   v) collision with the power grid, and
   vi) barrier effect.

2. For each impact, its potential severity for a given species was evaluated, specifically in relation to the species' situation in Sardinia. Severity was assessed using a unipolar scale ranging from *"Negligible"*, when the impact has no consequences at the population level—to *"Irreversible"*, when the impact could cause regional extinction.

3. For each impact, the probability of occurrence was assessed using the probability scale adopted by the Intergovernmental Panel on Climate Change (IPCC) (https://www.ipcc.ch/site/assets/uploads/2018/05/uncertainty-guidance-note.pdf).

The central value of each probability range was used.

4. The severity of each impact was weighted by its probability.

5. The weighted severities were aggregated across experts using the arithmetic mean.
6. The average weighted severities for each impact were then summed to obtain an overall severity score of impacts.
7. For each species, a value was assigned to represent the importance of the Sardinian population for the conservation of the species at both national and European levels. The conservation importance score ranged from 1 (*"No importance"*) to 5 (*"Extreme importance"*), and the two values were averaged.
8. In line with the *EU Guidance Document on Wind Energy Developments and EU Nature Legislation*, the overall severity score was added to the conservation score (doubled) to obtain the final vulnerability score.

The same analyses were replicated for bird species potentially susceptible to the development of photovoltaic installations. The only difference was that, for these species, a general impact assessment was carried out by categorizing them as having *"Low"*, *"Medium"*, or *"High"* impact. These values were then aggregated and added to the conservation score following the same procedure used for wind energy. Due to gaps in the available literature, bats were not included in the assessment of unsuitable areas for photovoltaic development. Once the vulnerability scores for the various bird and bat species were calculated for each 1 km resolution cell across the region, they were summed to obtain three overall scores: a total vulnerability score for i) birds and ii) bats with respect to wind energy development, and iii) a total vulnerability score for birds with respect to photovoltaic development.

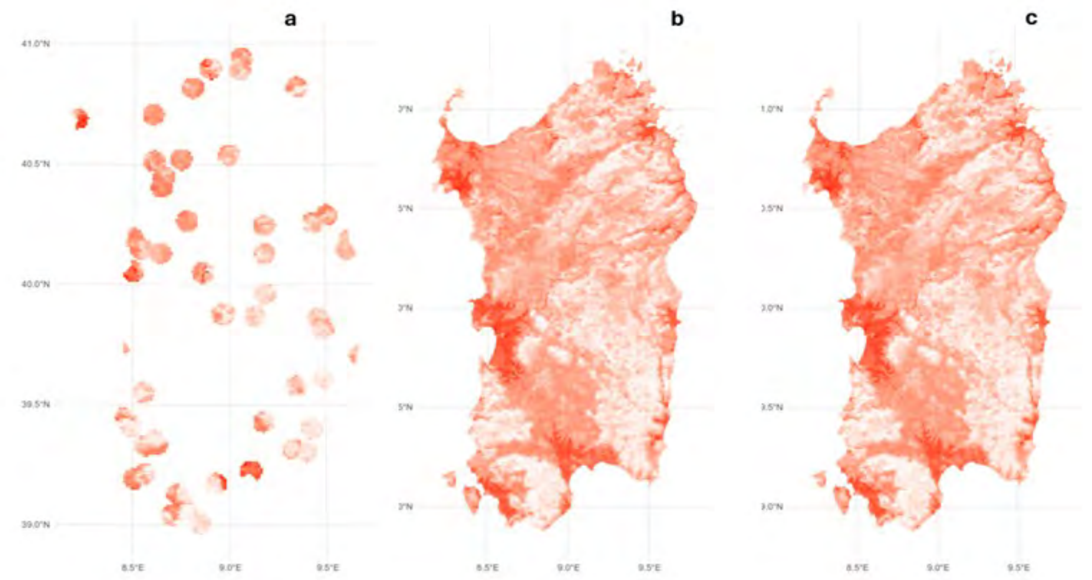


Figure 6.4 *Sensitivity maps to the presence of renewable energy installations. (a) Bat sensitivity to wind energy installations; (b) Bird sensitivity to wind energy installations; (c) Bird sensitivity to photovoltaic installations. The areas are shown using a colour scale from white (low sensitivity) to red (high sensitivity).*

The activities related to the creation of the sensitivity map for identifying areas of high vulnerability to renewable energy installations, due to the presence of bird and bat species, were carried out in accordance with a formal agreement between the Environmental Impact Assessment (VIA) Service and the research group coordinated by Prof. Fiammetta Berlinguer from the Department of Veterinary Medicine at the University of Sassari. This work was part of the process for identifying suitable areas for renewable energy (RES) installations, as outlined by Ministerial Decree No. 236 of June 21, 2024, Regional Law No. 5 of July 3, 2024, and the Regional Government Resolution No. 25/8 of July 17, 2024.

Specifically, for data processing and sensitivity map creation, the Department of Veterinary Medicine at the University of Sassari made available both permanent staff and contract researchers funded through the LIFE Safe for Vultures project – LIFE19/NAT/IT/000732, as well as through PNRR Public Administration doctoral fellowships at the University of Sassari. These maps represent a significant advancement in the planning of renewable energy in Sardinia, ensuring a more informed and sustainable approach to land management.

In addition, a study was conducted on the changes in wind energy development in Sardinia over the past 13 years. This study, too, was made possible through PNRR-funded research. Figure 6.5 shows wind energy development from 2011 to 2023. This type of analysis introduces a new approach for monitoring changes in wind infrastructure over time, made possible through the analysis of historical satellite imagery.

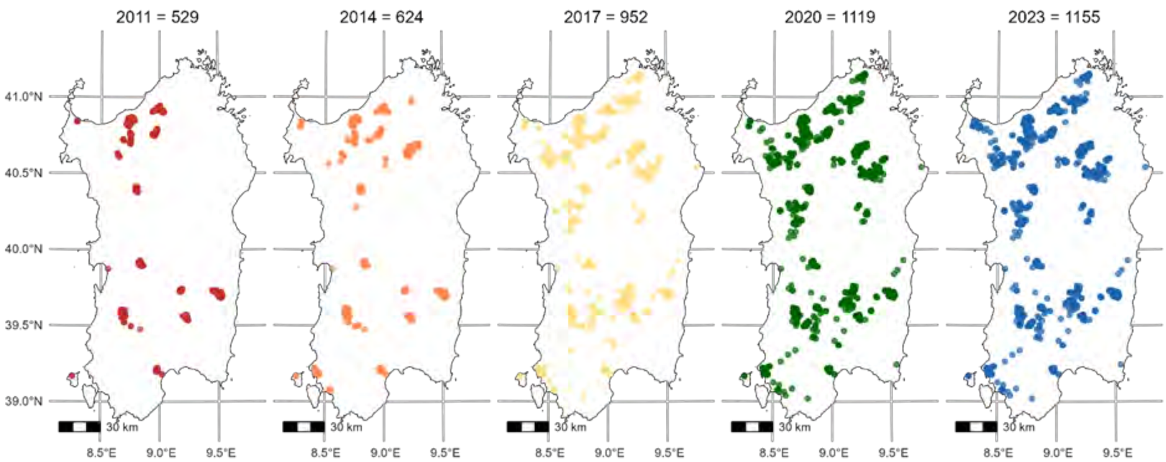


Figure 6.5 *Spatial distribution of wind turbines installed in Sardinia between 2011 and 2023, grouped by year of installation. Each panel shows the cumulative number and geographic spread of turbines for a given year, highlighting the progressive expansion of wind energy infrastructure over time.*

Subsequently, using data on the longitudinal development of wind energy, Species Distribution Models (SDMs, described in Figure 6.6), and the Dynamic Brownian Bridge Movement Model (dBBMM, described in Figure 6.7), precise overlap areas between wind turbines and suitable habitats were identified. Among the most notable results is the case of the Griffon Vulture, which experienced a significant increase in the number of turbines within the territory of the northwestern Bosa colony, rising from 25 to 90 turbines over the same period, as shown in Figure 6.7.

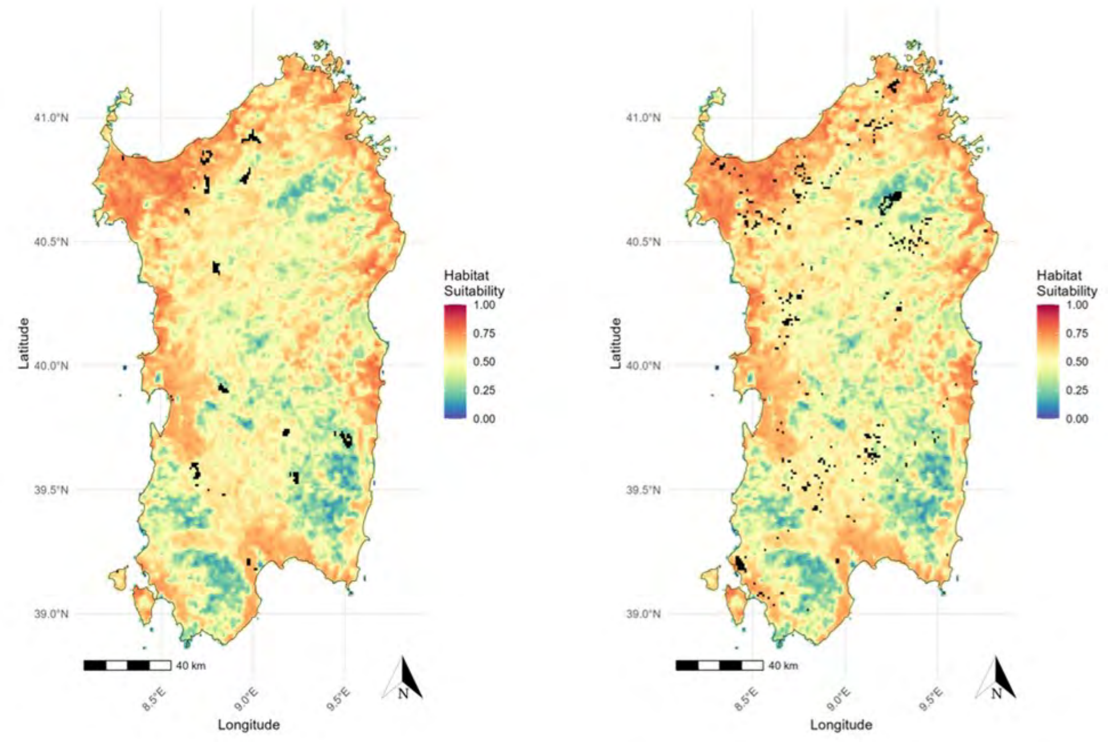


Figure 6.6 *Cumulative suitability maps for seven raptor species (Aquila chrysaetos, Athene noctua, Circus aeruginosus, Falco peregrinus, Falco tinnunculus, Milvus milvus, and Buteo buteo). On the left, historically active areas represent cells where wind energy activity was already present in 2011 and remained active through 2023. On the right, Expansion zones highlight cells where wind energy activity was absent in 2011 but present in 2023, indicating new wind farm developments established in the last decade.*

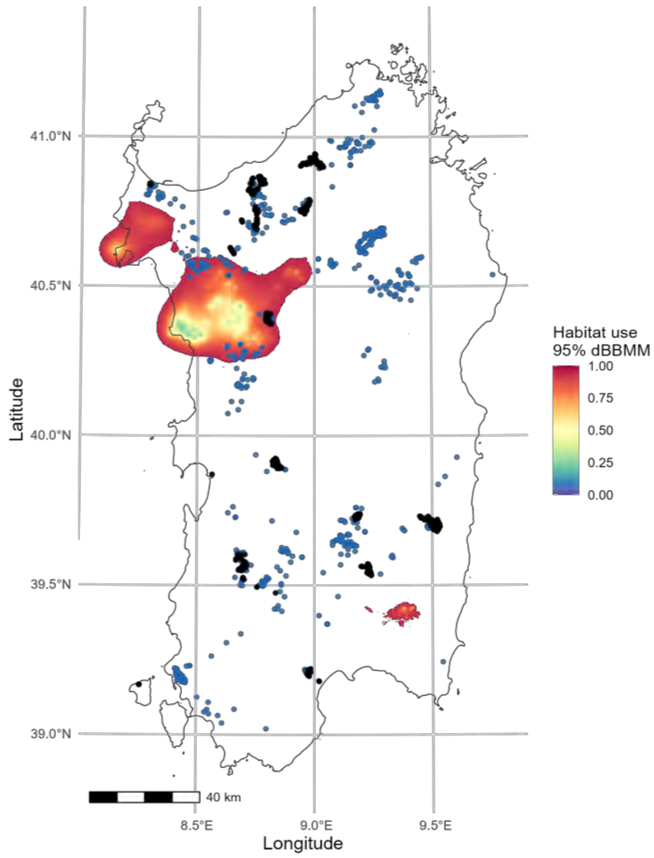


Figure 6.7 *Distribution of Griffon Vulture movement estimated using a Dynamic Brownian Bridge Movement Model (dBBMM), applied to identify suitable areas for the species. The gradient scale represents the cumulative probability distribution of movement: Wind turbines operational in 2011 are shown in black, while those installed by 2023 are in blue.*

The mitigation measures described above are of crucial importance in relation to the feasibility of reintroducing the Bearded Vulture and the Cinereous Vulture in Sardinia, especially considering that collisions with energy infrastructure represent an increasing threat to these species. In addition, specific analyses have already been conducted in view of the reintroduction of the Cinereous Vulture and particularly the Bearded Vulture. Specifically, historical nesting sites of the Bearded Vulture were georeferenced (Schenk et al., 2004), and a 10 km buffer was applied around them, allowing for the analysis of spatial overlap with existing and planned wind farms, as well as with Natura 2000 network areas (Fig. 6.8). This analysis revealed that 43% of existing wind turbines and 41% of planned wind farms fall partially or entirely within these critical areas.

Therefore, the strict implementation of zoning strategies, restrictions on development in sensitive areas (especially within Natura 2000 sites), and the adoption of specific measures, such as supplementary feeding stations, are essential to ensure the success of reintroduction efforts and the long-term survival of both species.

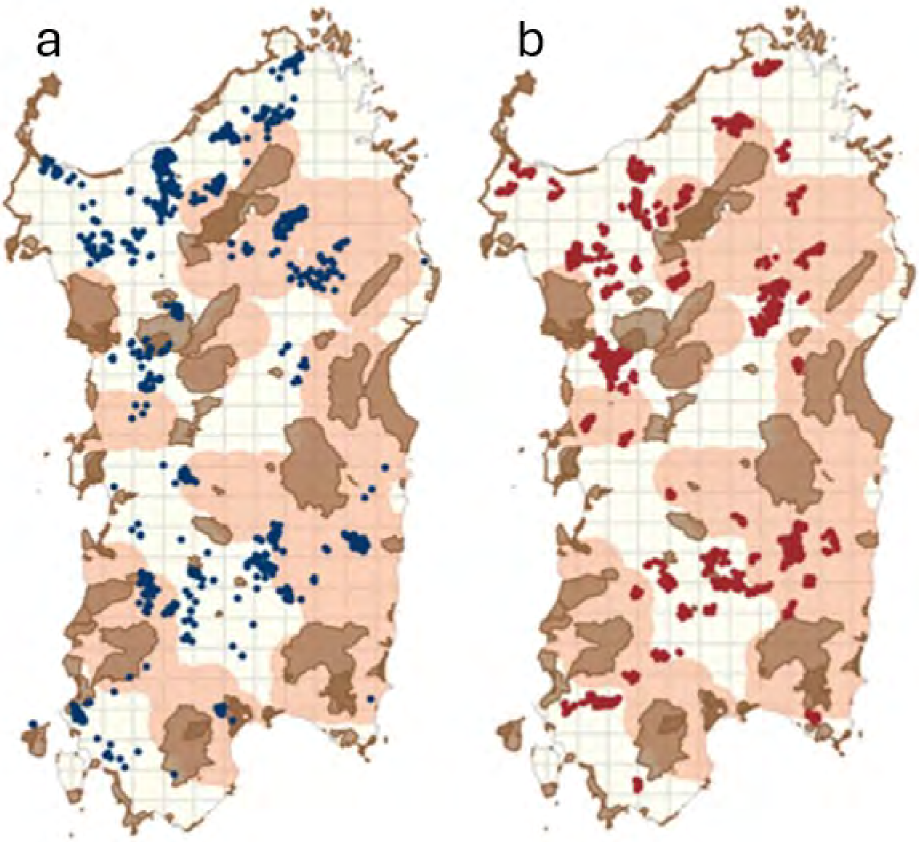


Figure 6.8 *Overlap between historical Bearded Vulture nesting areas (10 km buffers; pink) and Natura 2000 protected sites (brown) in Sardinia, with existing (a, blue points) and planned (b, red points) wind farms. The maps highlight potential conflicts between wind energy development and areas of high conservation value.*

In conclusion, the work carried out by the research group at the University of Sassari (UNISS), thanks to funding received from the PNRR in collaboration with the Public Administration, represents a fundamental step toward promoting the sustainable management of renewable energy in Sardinia, especially in view of the reintroduction of the Cinereous Vulture and the Bearded Vulture. To ensure the success of conservation and reintroduction initiatives for these two important vulture species, it will be essential to continue integrating scientific research with informed territorial planning and concrete conservation measures, thereby ensuring a lasting balance between energy development and biodiversity protection.

6.2 Risks associated with power lines

The direct contact with non-insulated electrical components can result in the immediate death of birds of prey. This risk is particularly high for large species that use poles as perches or observation points. Studies conducted in Mediterranean areas have shown that the probability of electrocution is correlated with several factors, including the configuration of the masts, their position in the landscape and the density of available prey (Tintó et al., 2010).

However, electrocution can alter the population dynamics and structure of the most affected species. Tucker and Heath (1994) showed that at least 7% of threatened species in Europe suffer significant losses due to interaction with electrical conductors, either by collision or electrocution.

Griffon Vultures, as well as Egyptian Vultures (*Neophron percnopterus*) and Cape Vultures (*Gyps coprotheres*), are also affected by this threat (Boshoff et al., 2011; García-Alfonso et al., 2021). In the province of L'Aquila, six Griffon Vultures fell victim to electrocution between 2000 and 2018, equating to an average of one fatality every 3.1 years (Posillico et al., 2023).

In addition, power lines represent physical obstacles that may not be easily detected by birds in flight, increasing the risk of collision.

6.2.1 Status of the threat in Sardinia

Power lines represent one of the main threats to the conservation of large raptors, particularly the Griffon Vulture (*Gyps fulvus*), whose restocking in Sardinia is currently underway. As previously mentioned, collision and electrocution risks are well-documented for this species, providing a crucial reference point for evaluating potential impacts on the recently reintroduced population.

In the 1940s, the destruction of some Griffon Vulture colonies in the Sarrabus area, in the lower Flumendosa valley, was mainly due to the construction of a power line (Schenk et al., 1987). Between 1987 and 1998, at least seven cases of Griffon Vulture deaths and/or injuries caused by collision or electrocution on power lines were recorded, most of them in north-western Sardinia (Schenk et al., 2004).

In 2004, a survey in the environmentally sensitive Bosa area, home to Italy’s largest Griffon Vulture colony, highlighted risks posed by overhead power lines near the colony, including collisions and electrocutions of raptors. To mitigate impacts and ensure energy supply without harming endangered species, the study recommended undergrounding cables in critical zones (Aresu & Schenk, 2004).

The analysis of data on electrocuted animals up to 2024, provided by the CFVA (Forestry and Environmental Surveillance Corps) and Forestas agency and shown in Figure 6.9, highlights the extent of this threat. Between 1999 and 2023, over 100 electrocution events were recorded (see Figure 6.9), 39 of which involved the Griffon Vulture, confirming the significant risk that power lines pose to large raptors.

To mitigate this impact and ensure the safety of the reintroduced species, the project partner e-Distribuzione, within the framework of the LIFE Safe for Vultures project, is already working to secure power lines. This aspect will be discussed further in the next section.

Figure 6.9 *The map displays electrocution events recorded by the CFVA, represented by star symbols, indicating locations where bird electrocution incidents have been reported. Additionally, the pink polygon highlights the area where power lines have been secured to mitigate electrocution risks in the Pozzomaggiore area. However, the details of these secured power lines will be further explored in Figure 6.8.*

6.2.2 Ongoing conservation measures

In recent years, numerous actions have been initiated to mitigate the impact of electrical infrastructures on birdlife, with particular emphasis on large-sized species.

To address the risks posed by power lines, the University of Sassari (UNISS) and e-Distribuzione, within the framework of the LIFE Safe for Vultures project, have developed a conflict map aimed at identifying critical areas for the Griffon Vulture and prioritising intervention measures. This map was created by integrating various information sources, including movement data from Griffon Vultures equipped with satellite transmitters and released under the LIFE Under Griffon Wings project (LIFE14/NAT/IT/000484), collision and electrocution incident records provided by the CFVA, and information regarding the type and location of electrical infrastructures.

Within the scope of this work, e-Distribuzione has carried out interventions in the Pozzomaggiore area to secure power lines in zones identified as critical (Fig. 6.10). Specifically, interventions targeted branches 1, 8, 9, 10, 11, and 12, where deterrent devices were installed to reduce the risk of collision and electrocution. Additionally, insulating sheaths were applied to structures equipped with suspended fittings, ensuring enhanced protection for birdlife in the area.

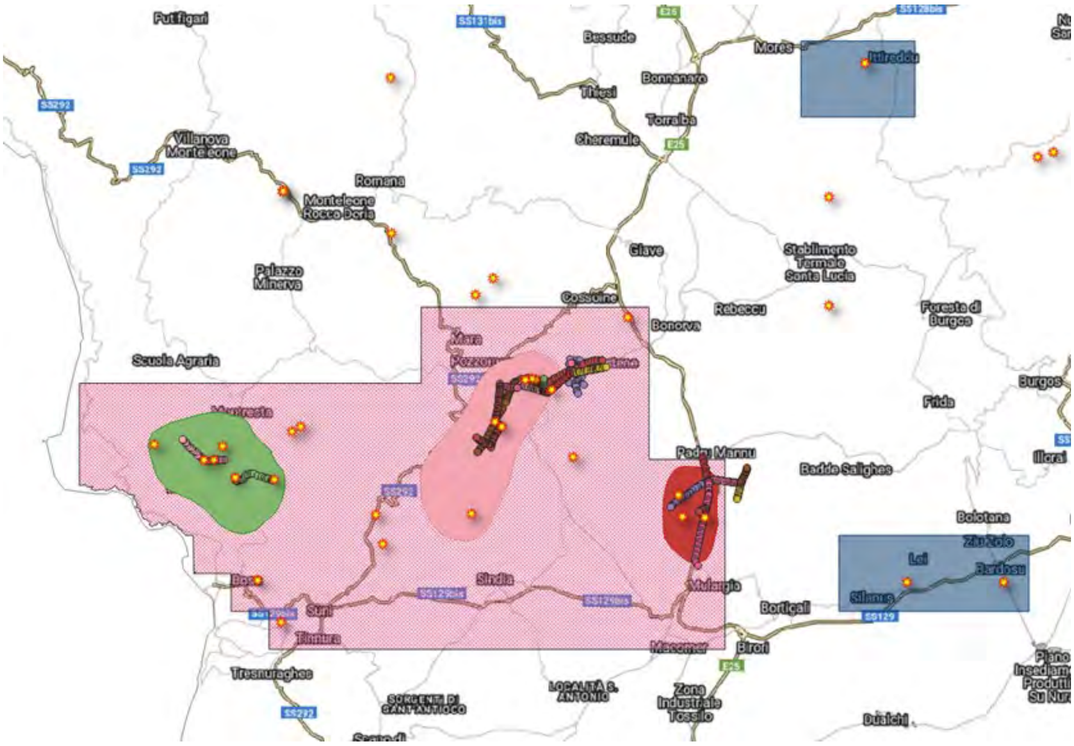


Figure 6.10 *Priority areas for power line mitigation, where interventions have been carried out to reduce the risk of electrocution. The areas shaded in pink, green, and red represent zones where power lines have been secured. The outlined polygons (Area 1, Area 2, and Area 3) indicate the highest-priority zones for future mitigation efforts. Yellow star symbols mark recorded bird electrocution events, as reported by the CFVA, while the highlighted line segments show sections of the power grid that have already been secured. This map provides a detailed overview of the most critical areas for conservation actions, expanding upon the context presented in Figure 6.7.*

Furthermore, beyond the interventions foreseen by the project, e-Distribuzione has committed to securing pylons located within the Griffon Vulture's core area should electrocution incidents involving large raptors occur. In line with this commitment, following the electrocution deaths of three Griffon Vultures, a total of 3 pylons were secured through the installation of deterrent devices (Fig. 6.11). These devices are specifically designed to discourage birds from landing or nesting on sensitive infrastructure components, thereby reducing the risk of electrocution, short circuits, and service interruptions.

Among these deterrent devices are those designed for grounded components, which protect pylons and metallic structures of installations by preventing birds, particularly large-sized species, from landing and nesting.

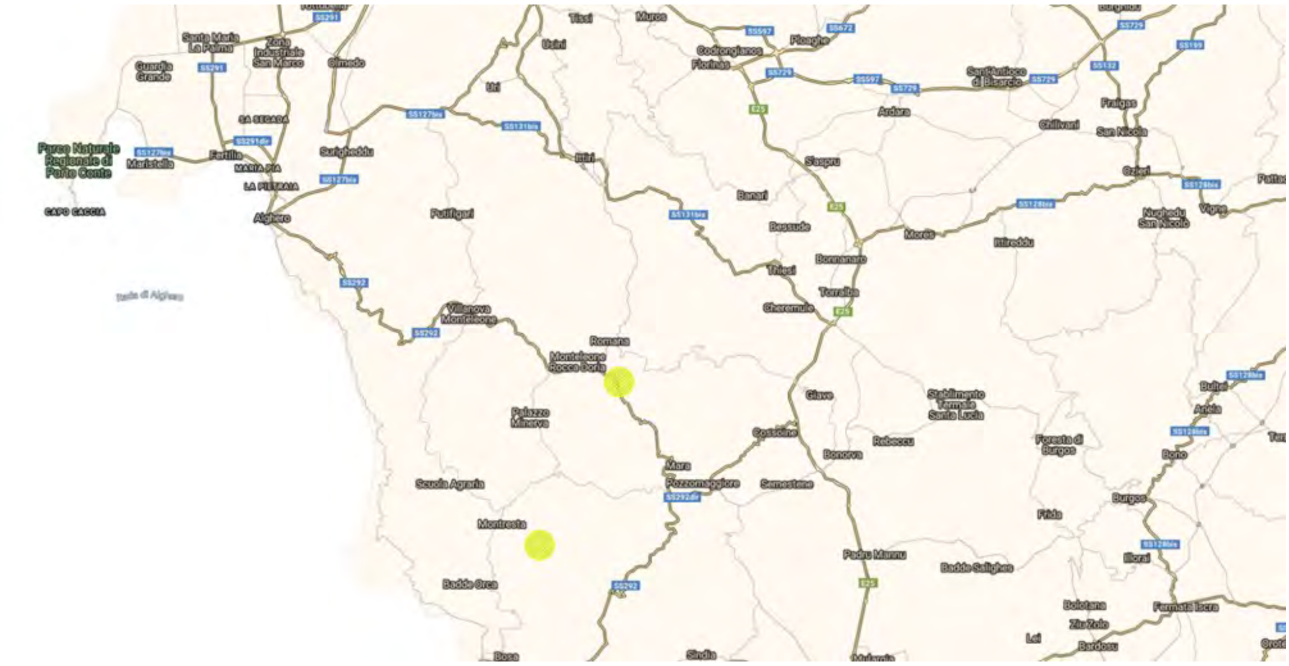


Figure 6.11 *The yellow markers on the map indicate intervention areas for the securing of power lines in the Bosa area. These zones were identified by applying a 1 km buffer around locations where electrocution events had occurred.*

Additionally, deterrents for active components have been installed, designed to prevent accidental contact between conductors and branches carried by birds. These also help to limit the accumulation of bird droppings on insulators and prevent network failures. Specifically, one of the deterrents used by e-Distribuzione in this context is the BPS-C Star deterrent (Fig. 6.12), a device engineered to prevent birds from perching on power line structures, particularly poles, insulators, and critical parts of pylons, thereby reducing the risks of electrocution, collision, and unwanted nesting.

Figure 6.12 *BPS-C Star deterrent model, Hubix Safety in Power.*

Finally, to evaluate the effectiveness of the mitigation measures, a Before-After Control Impact (B.A.C.I.) approach was applied, comparing data collected before and after the interventions.

Monitoring activities were carried out through systematic field inspections along the power lines, conducted by RAS-CFVA agents following predefined routes and thoroughly examining an area extending 25 metres on each side of the line. The search effort was further enhanced by employing anti-poison dog units and high-resolution drones (Table 6.1), thus improving carcass detection effectiveness. During the monitoring period, a total of 32 surveys were conducted, covering 4,377 km by vehicle and 154 km on foot.

Throughout this period, branches 1, 8, 10, 11, and 12 of the power lines were inspected and secured. No carcasses were detected during the 32 surveys performed.

Table 6.1 *Monitoring activities carried out along power lines following the B.A.C.I. protocol, Report on the Impact of Mitigation Measures on the Power Lines 01/2024 (https://www.lifesafeforvultures.eu/report/d4-the%20impact%20of%20mitigation%20measures%20on%20the%20power%20lines-01-2024.pdf).*

Monitoring date	Inspected power line branch	Notes
5/11/2021	1	Detection dog Mia – presence
16/11/2021	1	
16/11/2021	8+10	
19/11/2021	1	
30/11/2021	8+10	
3/12/2021	8+10	
14/12/2021	1	DJI Mavic Mini 2 drone flight
17/12/2021	8+10	Detection dog Mia – presence
21/12/2021	1	
28/12/2021	1	
3/1/2022	1	
7/1/2022	11+12	
11/1/2022	8+10	
12/1/2022	1	
25/1/2022	8+10	
28/1/2022	11+12	Detection dog Mia – presence
2/2/2022	1	
4/2/2022	8+10	
2/3/2022	8	

4/3/2022	10	
18/3/2022	10	
24/3/2022	10	
25/3/2022	11+12	
7/4/2022	1	
8/4/2022	10	
13/4/2022	11+12	
22/4/2022	10	
29/4/2022	11+12	
4/5/2022	8	
23/5/2022	11+12	
30/5/2022	10	
9/11/2022	10	

Another highly significant intervention was carried out on the Island of Asinara, a protected area of exceptional natural importance, located in north-western Sardinia. This island is included in the vulture feeding area and a feeding station was activated in May 2024. In this area, e-Distribuzione initiated the undergrounding of medium-voltage overhead power lines with bare conductors, thereby eliminating the risk of electrocution for birdlife (Fig. 6.13).

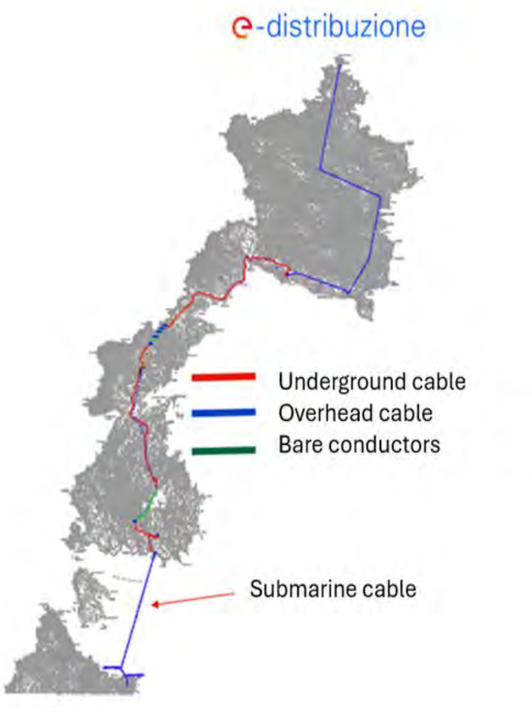


Figure 6.13 *Progress of power line securing works on the Island of Asinara. The map shows different types of infrastructure interventions carried out by e-distribuzione, including underground cables (red), overhead cables (blue), bare conductors (green), and the submarine cable connecting the island to the mainland grid.*

Recently, the Region of Sardinia funded a project to the Regional Park of Port Conte which included conservation and monitoring actions for the population of griffon vulture and Egyptian vultures. The action included retrofitting 5 km of power lines in the area, after having drafted a conflict map for these two species.

Similar interventions to secure power lines have been implemented in other projects, particularly for the conservation of the Bonelli's Eagle (*Aquila fasciata*), a target species of the LIFE *AQUILA a-LIFE* project. Among these, the ElectroRevolution project, funded by the Segrè Foundation, contributed to the securing of power lines in the Azzanì area (north-eastern Sardinia), as shown in Fig. 6.14. These measures also benefit other threatened species, such as the Bearded Vulture (*Gypaetus barbatus*) and the Cinereous Vulture (*Aegypius monachus*), in the event of future reintroduction initiatives on the island.

Figure 6.14 *Power line mitigation measures implemented in the Azzanì area (north-eastern Sardinia) as part of the ElectroRevolution project, benefiting Bonelli's Eagle (Aquila fasciata) and other threatened species.*

The ongoing mitigation actions represent a key element in ensuring the safe reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. The installation of deterrent devices on power lines and pylons, the application of insulating sheaths, and the undergrounding of overhead lines in the most sensitive areas are essential interventions to reduce the risks of electrocution and collision, two of the main threats to large soaring vultures.

In particular, the conflict-mapping approach, which integrates bird movement data, documented incidents, and the characteristics of electrical infrastructures, enables the concentration of efforts in the most critical areas. The experience gained with the Griffon Vulture demonstrates that such strategies are both effective and replicable, offering a model for future interventions involving other scavenging species.

The commitment of e-Distribuzione and other partners of the LIFE Safe for Vultures project to the continuous optimisation of mitigation measures is essential to ensure a safe environment for the return of the Bearded and Cinereous Vultures. Continuous monitoring of the measures already implemented, and the expansion of safeguarding actions are vital steps for the success of the reintroduction process, ensuring that electrical infrastructures do not pose a barrier to the long-term survival of these species.

6.3 Poisoning

Poisoning, in its various forms, is the most severe threat to vulture species. Broadly, vulture poisoning falls into two categories: unintentional (secondary) poisoning, where vultures are not the intended target, and intentional poisoning, where they are deliberately killed (Botha et al., 2017).

Poisoning is a major driver of vulture population declines, often resulting from consuming contaminated carcasses. As obligate scavengers, they are highly exposed to poisons in carrion, and their social feeding behaviour means multiple individuals can be poisoned in a single event. Additionally, their long lifespan and position at a high trophic level also make them susceptible to toxin bioaccumulation (D. L. Ogada et al., 2012). Poisoning can originate from at least three sources: the illegal use of poison, veterinary drugs, and contamination with heavy metals.

6.3.1 Illegal use of poison

Illegal poisoning is often related to human-wildlife conflict. In Europe, vultures are rarely the direct targets of poisoning; instead, they are usually unintended victims of poison used against wild predators, primarily carnivorous mammals such as wolves and foxes, which are perceived as threats to human activities like livestock farming and hunting. Although this practice is illegal across all European countries, it persists in some areas where local communities see it as a quick solution to conflicts with predators. The main motivation behind its use is the concern of livestock breeders over predator attacks and the efforts of hunters to protect small game populations (Botha et al., 2017).

Poisoning remains widespread in many countries where toxic baits are used to target predators like wolves, foxes, and feral dogs (Hernández & Margalida, 2008, 2009). Consequently, it is a leading cause of vulture mortality across Europe. In Bearded Vultures, for instance, intentional poisoning ranks as the second most common cause of death, while unintentional poisoning is the fourth (Margalida et al., 2008).

The scale of the problem is evident in multiple studies. In the French Pyrenees, poisoning has been identified as the primary cause of mortality among avian scavengers, including Bearded, Griffon, and Egyptian Vultures, as well as the Red Kite. Illicit use of banned pesticides accounted for 53% of poisoning cases (Berny et al., 2015). Similarly, a study examining pesticide poisoning incidents in Cinereous Vultures in Spain found that out of 241 cases involving 464 vultures, only 1.3% were due to legal pesticide use, while 98% were intentional poisonings, primarily linked to illegal predator control (Hernández & Margalida, 2008).

Further evidence comes from the southern Balkan Peninsula, where a study investigating illegal vulture poisoning in the southern Balkan Peninsula analysed 38 cases affecting 224 Griffon, Egyptian, Cinereous, and Bearded Vultures. Nine toxic compounds were identified, with strychnine, carbamates, and organophosphates most commonly used. Poison baits targeting grey wolves caused the most collateral damage, accounting for 60% of vulture poisoning incidents over 36 years (Parvanov et al., 2018).

In Italy, poisoning has also had severe consequences for vulture populations. A study of the reintroduced Griffon Vulture population in the central Apennines, covering mortalities from 1994 to 2020, found that poisoning, mainly from carbamates, accounted for 53% of recorded deaths (Posillico et al., 2023).

Addressing intentional poisoning requires a multifaceted approach. Effective mitigation measures include banning harmful pesticides, regulating their sale and distribution, and implementing educational programmes (D. L. Ogada, 2014). Additionally, enhancing enforcement efforts, allocating more economic resources, and improving the speed and accuracy of poisoning diagnostics are critical steps in tackling this ongoing threat.

6.3.2 Status of the threat in Sardinia

In Sardinia, the use of poisoned baits poses a significant threat to vulture populations, mirroring the patterns observed in other parts of Europe.

Poisoned baits intended for mammalian predators have caused the death of over 40 Griffon Vultures in Sardinia over the past 30 years, with two peaks: one between 1995 and 1998 (11 deaths) and another between 2006 and 2007 (35 deaths, Secci, 2022). Poisoning has also led to the death of three Bearded Vultures, ultimately halting their reintroduction project.

The use of poison is widespread on the island. Mortality events can go undetected without targeted monitoring efforts. In Sardinia, most reported poisoning events occur within urban areas, which are generally not frequented by vultures for their feeding activities. Between 2019 and 2024, only 1 out of 265 reported poisoning cases involved wild animals (Tab. 6.2).

Table 6.2 *Number of poisoning cases and detected toxic compounds by species and year. The table presents the total number of poisoned samples (n. sample), and the number of toxic compounds identified (n. toxic comp.) for different species from 2019 to 2024.*

Species/Year	**n. sample**	**n° toxic compounds**
BAIT	**85**	**99**
2020	22	29
2021	32	34
2022	9	12
2023	12	13
2024	10	11
DOG	**100**	**110**
2019	1	1
2020	11	15
2021	37	41
2022	31	33
2023	14	14
2024	6	6
DOMESTIC CAT	**129**	**137**
2019	1	1
2020	23	29
2021	32	33
2022	16	16
2023	52	51
2024	5	7
GOAT	**1**	**1**
2021	1	1
WILD BOAR	**1**	**2**
2020	1	2
FERAL CAT	**4**	**6**
2020	1	2
2022	1	1
2023	2	3
Total	**320**	**355**

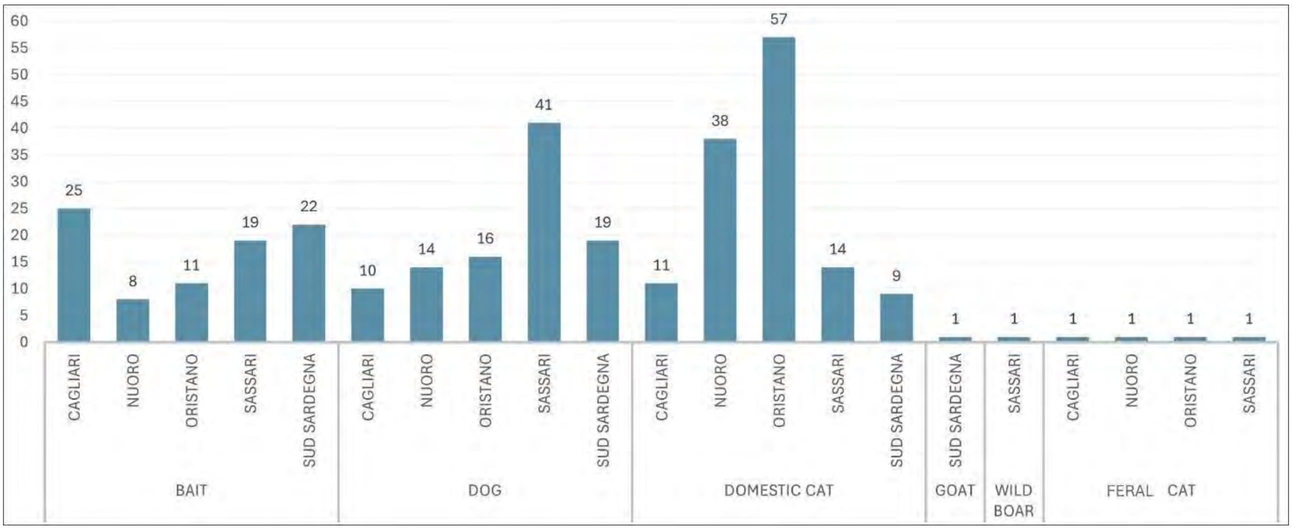


Figure 6.15 *Number of poisoning cases by species and province in Sardinia from 2019 to 2024. The graph shows the distribution of poisoned baits and poisoned animal samples across different provinces.*

Figure 6.16 shows the map of reported poisoning events in Sardinia. To assess whether these events could pose a risk to Griffon Vultures, we examined whether they occurred within or near urban centres. As an indicator of urban areas, we used the human density variable and additionally traced a 1 km buffer around anthropized zones. Out of a total of 265 reported poisoning cases, 190 occurred within urban centres, 64 in areas within 1 km of urban centres, and only 11 outside the municipalities.

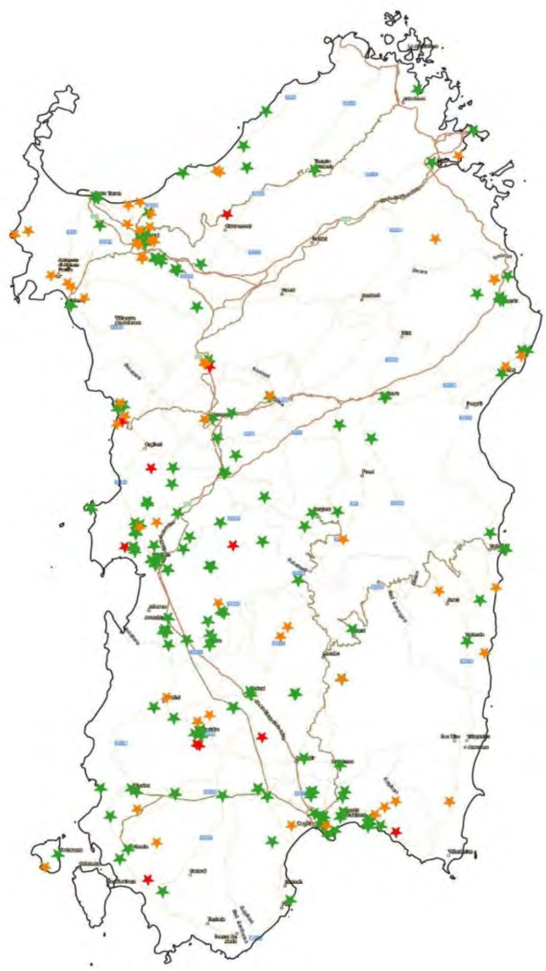


Figure 6.16 *Map of reported poisoning events in Sardinia between 2019 and 2024. The data show the distribution of poisoning incidents, with most occurring within urban centres (green dots), followed by areas within a 1 km radius of urban centres (orange dots), and a smaller number outside urban area (red dots). Source: Portale Nazionale degli Avvelenamenti Dolosi degli Animali https://avvelenamenti.izslt.it/ Ministero della Salute Istituto Zooprofilattico Sperimentale del Lazio e della Toscana "M. Aleandri"*

6.3.3 Ongoing mitigation measures

In Sardinia, the Anti-Poison Dog Unit of the *Corpo Forestale e di Vigilanza Ambientale* (CFVA) was established in early 2016 as part of the LIFE Under Griffon Wings project to prevent and combat crimes related to poison use. Under the LIFE Safe for Vultures project, the CFVA has expanded this initiative by creating four Anti-Poison Dog Units, composed of specially trained CFVA agents, to mitigate poisoning incidents and enforce laws against the illegal use of poison. These teams operate with the support of dogs and handlers provided by the Faculty of Veterinary Medicine of the University of Sassari.

The Anti-Poison Dog Units were established to operate across a wider area than the previous LIFE Under Griffon Wings project. Under that initiative, a single anti-poison dog unit was created in 2016, primarily covering the coastal territories between Bosa and Alghero. In contrast, the new Anti-Poison

Dog Units have been set up within the *Servizi Ripartimentali* of Nuoro, Cagliari, Sassari, and Oristano. Each unit operates within its respective jurisdiction, facilitating the organisation of inspections across different project areas in the search for poison. The *Servizio ispettorato Ripartimentale* of Sassari identified 20 personnel members (officers and non-commissioned officers) to be assigned to the new Anti-Poison Dog Units. The selected officers and agents underwent a training course between September and October 2021 to prepare for their duties. The training was coordinated and led by an officer from the *Servizio ispettorato Ripartimentale* of Sassari.

In all Natura 2000 sites included in the project area, the Anti-Poison Dog Units, supported by specially trained anti-poison dogs and a dog handler provided by the University of Sassari, are required to carry out a minimum of eight preventive inspections per month for five years, amounting to a total of 480 inspections. The area covered each month is approximately 40 km, reaching an estimated 2,400 km by the end of the project. Each Anti-Poison Dog Unit may also be called upon to conduct emergency inspections in response to reports from *Stazioni Forestali* or other authorities (such as mayors, local veterinary services, or other law enforcement agencies) to remove poisoned baits or carcasses and collect material that may have come into contact with poison, aiding investigative efforts. Their work is complemented by the *Istituto Zooprofilattico Sperimentale della Sardegna*, which conducts necropsies and laboratory analyses to confirm poisoning cases and identify the toxic substances used.

From January 2022 to 31 January 2025, the Anti-Poison Dog Units of Sassari, Nuoro, Oristano, and Cagliari carried out a total of 178 inspections, covering more than 800 km of territory. Additionally, in response to specific intervention requests following the discovery of poisoned baits and dead animals suspected to have been poisoned, the Anti-Poison Dog Units intervened in 20 reported cases between 2022 and 2024 across various municipalities on the island. These interventions, conducted with the support of UNISS dogs, aimed to clear contaminated sites and initiate investigations.

Alongside preventive inspections to detect poisoned baits—often used to deter livestock predators but more frequently to eliminate unwanted domestic or stray animals—the Anti-Poison Dog Unit agents have also carried out thorough investigations. In every confirmed case of animal poisoning, they worked to identify those responsible. In 2022, the Anti-Poison Dog Units of the *Corpo Forestale* intervened to launch investigations following five reports of poisoned animal carcasses found in the municipalities of Norbello, Bonorva, Capoterra, Ploaghe, and Villaspeciosa. In 2023, investigative activities continued, and further inquiries were initiated into nine new cases of animals found dead after ingesting poisoned baits in the municipalities of Terralba, Sassari, Nurachi, Bonarcado, Villanova Monteleone, Allai, Villacidro, and Sinnai. With the valuable support of trained dogs and handlers from the University of Sassari, all affected sites were cleared to remove poisoned baits and carcasses, as well as to collect any materials that had come into contact with the poison, which could be useful for investigations. Guided by the alerts provided by the dogs during the clearing operations, investigations were launched, further supported by the collection of witness statements, which helped gather crucial elements for evidence building.

In Villaspeciosa, an investigation was initiated by the Anti-Poison Dog Unit of the Cagliari Inspectorate in November 2022 and continued into 2023 after the discovery of a domestic cat displaying clear signs of poisoning (extended front and hind limbs, frothing at the mouth, traces of diarrhoea, wide-open eyes, and muscle retention in the mouth). Similarly, in Terralba, the Anti-Poison Dog Unit of the Oristano Inspectorate intervened following the discovery of several domestic animals exhibiting symptoms consistent with suspected poisoning. As part of the investigation, court-authorised house searches were conducted in both locations, leading to the seizure of evidence, including the poison used, and the subsequent formal reporting of the alleged perpetrators to the Public Prosecutor's Offices of Cagliari and Oristano. The individuals were charged under Articles 544-bis and 674 of the Italian Penal Code, which carry prison sentences ranging from four months to two years. The legal proceedings before the Cagliari Prosecutor's Office resulted in a criminal conviction by penalty decree, whereas the outcome of the Oristano case is still pending.

The collaboration between the agents of the Anti-Poison Dog Units of the CFVA, the trained dogs, and the handlers provided by UNISS has strengthened over the years of the project. This synergy has led to the progressive refinement of procedures to be carried out after each discovery of poisoned baits or animals suspected of poisoning and has proven crucial for the success of investigations. The CFVA's goal is to continuously improve investigative techniques to identify those responsible in an increasing number of cases, aiming to deter the dangerous practice of using poisoned baits. By demonstrating that poisoning an animal is not only despicable but also a criminal offence, the CFVA seeks to discourage this illegal activity.

To enhance knowledge of wildlife crimes, particularly poisoning offences, the agents of the Anti-Poison Dog Units attended a specialised training course provided by the Spanish foundation Wildlife Crime Academy. The course focused primarily on investigative procedures, covering all stages from the initial identification of the cause of death of the wildlife to the final formalisation of the crime report.

Throughout the project, the agents of the Anti-Poison Dog Units have consistently carried out outreach and awareness campaigns aimed at the rural community. Given the need to inform local areas about the programme for introducing new Griffon Vultures, and to raise awareness about the agro-pastoral realities across the territory, the Anti-Poison Dog Units agents have focused on promoting the project's primary goal: expanding and consolidating the Griffon Vulture's range in Sardinia. As part of this effort, they have conducted important communication activities targeting those working in the countryside, particularly farmers and shepherds.

In particular, the Anti-Poison Dog Unit of the Cagliari Inspectorate Service, especially from the second half of 2023, has engaged with farmers from various farms near the centralized feeding station set up within the Cea Romana - M. Arrubiu forestry site (Municipality of Villasalto), managed by the Fo.Re.S.T.A.S. Agency. This area is now frequented by the released Griffon Vultures, thanks to the centralised feeding station. These vultures are unfamiliar to the younger local population, as they have been absent from the area for quite some time. To prevent these 'new guests' from being viewed as threats, the CFVA has launched an outreach campaign to prepare the rural inhabitants for their arrival, explaining the vultures' characteristics, feeding habits, and ethology.

During preventive inspections for poison detection, the dog handlers visit all the livestock farms in the selected inspection area. They explain to the farmers the reasons for their presence, the purpose of the inspections, and the objectives of the project, aiming to increase understanding and facilitate the acceptance of the Griffon Vulture.

To enhance prevention efforts against the use of poisoned baits, the Anti-Poison Dog Units, based on information from the *Stazioni Forestali*, have identified areas where poisoned baits or animals suspected of poisoning were previously found. The goal is to intensify checks in these areas, as such crimes often recur in the same locations. The survey found that most reports were from urban areas or their immediate surroundings, indicating the use of poisoned baits, primarily to remove unwanted domestic animals (especially dogs and cats). This is further confirmed by the cleanup operations at sites where poisoned baits or animals dead from suspected poisoning were found. Of the 20 sites where agents intervened, half were in urban centres.

6.4 Veterinary drugs

Another serious threat comes from the ingestion of nonsteroidal anti-inflammatory drugs (NSAIDs) used in livestock farming, which cause lethal renal failure in vultures. These drugs were responsible for a 95% decline in *Gyps* vultures in South Asia before being banned in 2006 (Moreno-Opo et al., 2021).

Diclofenac-based veterinary medicines were first authorised in several European countries, including Italy, Estonia, Latvia, and the Czech Republic, in 1993. Spain approved two diclofenac-based veterinary drugs in 2013 for use in pigs, cattle, and horses not intended for human consumption (Moreno-Opo et al., 2021). In 2020, NSAIDs were linked to vulture mortality in Spain when a Cinereous Vulture fledgling was found dead in its nest. Diclofenac was detected in its liver and kidney, confirming fatal gout due to intoxication—the first documented case of diclofenac poisoning in Spain, Europe, and the species (Herrero-Villar et al., 2021). In the Pyrenees, four out of 24 dead Bearded Vultures tested positive for topical antiparasitic used in livestock veterinary treatments (Mateo et al., 2015).

6.4.1 Status of the threat in Sardinia

In Sardinia, various medicines are used to treat cattle, sheep/goats, pigs, and horses, including antibiotics, anti-inflammatory drugs, and antiparasitic. These treatments are specific to each of the four main categories of livestock raised in the region.

As a result, there is a risk of poisoning for vultures in Sardinia from the ingestion of livestock carcasses that contain drugs toxic to them, especially when these carcasses are consumed before the required withdrawal period for each active ingredient has passed.

A list of the active ingredients toxic to vultures, including the commercial names of the drugs, the target species, and their withdrawal times, is presented in Tab. 6.3. However, at present, the Griffon Vulture population in Sardinia appears stable and even increasing, with no recent mortality events that can be directly linked to the ingestion of toxic veterinary drugs.

This situation could change, though, as the ongoing bluetongue outbreak places additional pressure on livestock farming. Bluetongue, a viral disease affecting ruminants, poses a significant threat to Sardinian livestock. In 2024, the infection affected approximately 25% of the island’s 13,000 sheep farms, resulting in the deaths of 40,000 sheep and lambs—an alarming increase compared to the 5,000 fatalities recorded in 2023. While bluetongue outbreaks have been reported in several parts of Europe in recent months, Sardinia has experienced an exceptionally severe impact.

The disease, caused by the *Bluetongue virus* (BTV), is not transmissible to humans and does not compromise the safety of meat or dairy products. BTV is transmitted by biting midges of the *Culicoides* genus, small insects measuring 1–3 mm in length. Rising temperatures in the Mediterranean region, driven by climate change, have contributed to an extended period of vector activity. While *Culicoides* midges traditionally thrive in summer, warming conditions now enable their survival well into autumn, increasing the risk of prolonged virus transmission.

As the outbreak continues, the widespread mortality of livestock could lead to an increase in the availability of carcasses, some of which may contain residues of toxic veterinary drugs. This could heighten the risk of secondary poisoning for scavengers, including the Griffon Vulture, potentially reversing the positive population trend observed in recent years. Monitoring both the use of veterinary pharmaceuticals and their potential impacts on scavenger species remains essential in mitigating this risk.

Table 6.3 *List of active ingredients toxic to vultures, commercial drug names sold in Italy containing them, target species, and withdrawal times (from Berlinguer et al., 2016).*

Pharmacological Class	Active Ingredient	Commercial Name	Target Species	Withdrawal Time
Antibiotics	Enrofloxacin	Baytril® 5% and Baytril® 10%	Cattle, Goats, Sheep, Pigs, Rabbits	Cattle: 7 days IV; 9 days SC; Sheep: 4 days; Goat: 14 days; Pig: 10 days
		BaytrilMax®	Cattle	Cattle (meat): 14 days
		Valemas®	Cattle, Goats, Sheep, Pigs	Cattle: 7 days IV, 9 days SC; Goat: 14 days; Sheep: 4 days; Pigs: 10 days
		FloxatrilMax®	Cattle	Meat: 14 days
		Gelliflox®	Cattle, Pigs	Cattle: 14 days; Pigs: 10 days
	Marbofloxacin	Marbokem®	Cattle	3 days
		Marbocyl®	Cattle, Pigs	Cattle: 6 days; Sows: 4 days
		MarbocylBolus®	Calves	6 days
		Marbox®	Cattle, Pigs	Cattle: 3 days IM; 6 days SC; Sows: 4 days IM
		Aristos®	Cattle, Pigs	Cattle: 6 days; Sows: 4 days
Non-Steroidal Anti-Inflammatories	Diclofenac	Reuflogin®	Cattle, Pigs, Horses	Cattle: 15 days; Sows: 12 days; Horses: 180 days
	Ketoprofen	Rifen®	Cattle, Pigs, Horses	Cattle, Pigs, Horses: 4 days

		Dinalgen Bovini®	Cattle	2 days
		Dinalgen Suini®	Pigs	1 day
		Dolovet OS powder®	Cattle	1 day
		Fin-dol 10%®	Cattle, Pigs, Horses	Cattle: 4 days; Pigs and Horses: 4 days
		Vet-Ketofen® 10%	Cattle, Pigs, Horses	4 days
	Flunixin meglumine	Finadyne®		Cattle: 7 days; Sows: 7 days; Horses: 18 days
		Alvios®	Cattle, Pigs, Horses	Cattle: 7 days; Pigs: 18 days; Horses: 7 days
		Flogend®	Cattle, Horses, Pigs	Cattle: 7 days; Pigs: 18 days; Horses: 14 days
		Flunamine®	Cattle, Horses	Cattle: 10 days; Horses: 28 days
		Flunifen®	Cattle, Pigs, Horses	Cattle, Horses: 7 days; Pigs: 18 days
		Flunixin®	Cattle, Horses	Cattle: 14 days; Horses: 28 days
		Meflosyl®	Pigs, Horses, Cattle	Cattle: 3 days IV, 19 days IM; Horses: 14 days; Pigs: 16 days
		Niglumine®	Pigs, Horses, Cattle	Cattle: 4 days; Horses, Pigs: 28 days
	Carprofen	Rymadil® INIET FL 50ML®	Cattle	Cattle: 21 days
	Phenylbutazone	BUTE® BUTE GEL® FENILBUT. FL20%®	Horses (sport use)	180 days
	Meloxicam	Metacam® 15mg/dl		Horses: 3 days
		Metacam® 20mg/dl	Cattle, Pigs, Horses	Cattle: 15 days; Pigs, Horses: 5 days
		Melovem®	Cattle, Pigs	Cattle: 15 days; Pigs: 5 days

		Meloxidyl®	Cattle, Pigs, Horses	Cattle: 15 days; Pigs, Horses: 5 days

6.4.2 Ongoing mitigation measures

Within the LIFE Under Griffon Wings project, 40 livestock feeding stations were activated to support the Griffon Vulture population. In addition to the absolute prohibition of disposing carcasses of animals that were euthanized or died during surgery; to prevent the vultures from ingesting potentially lethal molecules and residues, measures were also implemented to mitigate the risk of feeding stations being supplied with animal carcasses treated with antibiotics and anti-inflammatory drugs before the withdrawal period for meat and offal had expired. To achieve this, awareness-raising actions were developed targeting farmers and veterinarians, as well as monitoring actions in collaboration with ASL veterinarians regarding the management of livestock feeding stations.

Specifically, as part of the procedures for authorising the use of whole animals or animal body parts containing category 1 material as feed for scavenger birds in livestock feeding areas, the farmer was required to sign a commitment, including a pledge not to provide carcasses of animals recently treated with antibiotics and anti-inflammatory drugs, as these could contain residues in the meat and offal. In turn, the ASL veterinary service, as part of its pharmacovigilance activities, conducted targeted document checks on the use of certain pharmacological molecules toxic to scavenger birds, such as diclofenac, flunixin meglumine, ketoprofen, and enrofloxacin.

To support these activities, within the LIFE Under Griffon Wings project, and in conjunction with checks at farms following reports of animal deaths, random sampling was carried out, ensuring at least three samples per farm, of carcasses to determine the presence of pharmacological residues of the aforementioned harmful drugs. Furthermore, the same analyses were performed on the blood of Griffon Vultures housed at the Bonassai Wildlife Rescue Centre and on the meat of any vultures found dead during the project (action D4).

The analytical work was carried out by the *Istituto Zooprofilattico Sperimentale della Sardegna "G. Pegreffi"* which had a laboratory equipped for this purpose as part of its pharmacovigilance measures included among its institutional tasks. The *Istituto Zooprofilattico Sperimentale della Sardegna* has been accredited since 1999 (formerly by SINAL, currently by ACCREDIA). ACCREDIA accreditation is granted to laboratories that meet the requirements of the UNI CEI EN ISO/IEC 17025:2005 standard.

The accreditation certifies the technical competence of the laboratories to conduct specific tests and implement a Quality Management System. The tests for which accreditation has been obtained cover both the food safety sector and the animal health sector, which are crucial for certifying the health status of farms. The lists of accredited tests are available on the ACCREDIA website (www.accredia.it). All samples subjected to testing are appropriately stored until the required tests are performed, and, except for those subject to specific regulations, are disposed of in accordance with current waste management regulations (D.Lgs 152/2006). Test reports are kept in the institute's archives for 10 years, while the records supporting the test results are kept for 48 months.

In addition to gathering information that may later support future campaigns to ban the sale of veterinary drugs containing active ingredients toxic to vultures in Europe, this action served to minimize the likelihood that farmers would not comply with the proper livestock feeding station supply regulations. If post-mortem checks on carcasses revealed the presence of pharmacological residues toxic to vultures, the feeding station authorization would be withdrawn in agreement with the ASL veterinarians.

Table 6.4 outlines the tests that were performed, the sample storage methods, their types, and the average response times. In addition to quinolone antibiotics and non-steroidal anti-inflammatory drugs, the analyses also included screening for the presence of benzimidazole and avermectin-based antiparasitics, given their widespread use in sheep, which represent a significant food source for Griffon Vultures. To further broaden the scope and collect as much information as possible on the health of the carcasses used to supply livestock feeding stations, an additional screening was carried out to expand the range of antibiotics tested, including beta-lactams (penicillins and cephalosporins) and tetracyclines.

Table 6.4 *Tests carried out at the Istituto Zooprofilattico Sperimentale della Sardegna on samples taken from carcasses used to supply feeding stations on farms, sample storage conditions, sample type, and average response times.*

Test	Result Expression	Storage Conditions	Sample Type	Average Response Time
Determination of Antibiotics (beta-lactams, tetracyclines, quinolones) by LC-MS (MI 6RF/95)	µg/kg	Room temperature or refrigerated	Muscle, liver	30 days
Determination of Non-Steroidal Anti-Inflammatory Drugs by HPLC (MI 6RF/85)	µg/kg	Refrigerated or frozen	Serum, plasma, muscle	30 days
Determination of Benzimidazole and Avermectin Antiparasitics by LC/MS (Interpretative reference Reg. 37/2010) (MI 6RF/51)	µg/kg	Refrigerated or frozen	Liver	30 days

A total of 65 analyses were carried out, of which 28 were on samples collected from Griffon Vultures, 19 on muscle samples taken from carcasses provided at the farm feeding stations, 16 on muscle samples taken from carcasses provided at centralised feeding stations, and 2 from carcasses abandoned in the field. The results are shown in Table 6.5.

In total, 6 positives were detected (9.2%), 5 for antibiotics (oxytetracycline, tilmicosin, sulfadimethoxine/trimethoprim) and 1 for the antiparasitic ivermectin. Oxytetracycline is a broad-spectrum veterinary antibiotic used for treating numerous infectious diseases caused by Gram-positive and Gram-negative microorganisms, spirochetes, rickettsiae, chlamydia, mycoplasmas, and protozoal diseases such as amoebae, anaplasma, and toxoplasma.

After injection, it is rapidly absorbed and easily distributed to all tissues, establishing therapeutic and effective levels in a short time. It is eliminated through the urine in a partially active form. However, it can accumulate in bone tissue, skin, adipose tissue, tendons, muscles, liver, and the gastrointestinal tract (Agwuh & MacGowan, 2006). To date, there are no indications about its toxicity to vultures, and the Griffon Vulture in which oxytetracycline positivity was detected did not show any clinical symptoms and was successfully reintroduced into the wild.

Table 6.5 *Determination of veterinary drug residues in carcasses disposed of at feeding stations and in Griffon Vulture admitted to the FoReSTAS Recovery Centre or found dead.*

Origin	**Species (n)**	**No. of Positives**	**Drug Residues**
Farm Feeding Stations	Cattle (8)	3	Ivermectin (67.4 μg/kg), Tilmicosin (11 μg/kg), Sulfadimethoxine/trimethoprim (5414.8/38.7 μg/kg)
	Sheep (9)	1	Oxytetracycline (907.4 μg/kg)
	Donkey (1)	0	
	Pig (1)	0	
Centralised Feeding Stations	Sheep (16)	1	Oxytetracycline (870 μg/kg)
Carcasses Found in the Field	Cattle (1)	0	
	Pig (1)	0	
	Organs (4)	0	

Griffon Vultures	Blood (24)	1	Oxytetracycline (101 µg/kg)
Total (65)		6 (9.2%)	

A recent study evaluated the presence of antibiotics in the feeding stations for the Cinereous Vulture in the southeast of Portugal (Gómez-Ramírez et al., 2018). 87 samples of liver, muscle, and kidney were analysed from 7 goats and 25 sheep disposed of at the feeding stations. Although the farmers stated that the animals had not been treated with pharmaceuticals, 29% of the analysed samples tested positive for antibiotics. Among them, oxytetracycline was the most frequently detected antibiotic.

Ivermectin is a broad-spectrum anthelmintic drug effective in controlling internal and external parasites. There is no evidence regarding its toxicity to vultures, but one study showed a correlation between its use in livestock farming and the decline of several species of dung beetles in Spain and Portugal (Verdú et al., 2015). Therefore, its use poses environmental risks that are not commonly considered.

Tilmicosin is a macrolide antibiotic synthesized from tylosin, with an antibacterial spectrum similar to tylosin, and strong activity against respiratory infections caused by *Pasteurella multocida* and *Mannheimia haemolytica*. The doses found in the bovine muscle sample are very low, and there is no literature on its toxicity to vultures. However, it is worth noting that the injection of tilmicosin can be lethal to humans, dogs, and pigs. The combination of the two antibiotics sulfadimethoxine/trimethoprim is widely used in veterinary medicine.

Sulfadimethoxine is a sulfonamide antibiotic, which, when combined with a new synthetic chemotherapeutic agent, trimethoprim, ensures a broad-spectrum bactericidal action that reaches microorganisms resistant or less sensitive to either of the two components. Sulfadimethoxine has the advantage of being rapidly absorbed and providing therapeutically effective and persistent blood levels at relatively low dosages.

Although there is no information regarding the toxic doses for vultures of the drugs found in the samples we analysed, considering the active ingredients and therapeutic doses for other bird species, the concentration of antibiotics in the carcasses does not pose an acute poisoning risk to Griffon Vultures in the project area. However, the impact on the health of Griffon Vultures should still be evaluated, considering that chronic exposure to these drugs could have negative consequences for vultures. In Spain, other authors have observed, for example, an increase in the incidence of opportunistic mycoses in the Cinereous Vulture following chronic and episodic exposure to veterinary-origin antibiotics in the carcasses they feed on (Gómez-Ramírez et al., 2018).

The project LIFE Safe for Vultures foresees a continuation of the presence of vet drug residues in the carcasses provisioned within the network of feeding stations. A total of 150 random analyses are foreseen in carcasses sampled in the farm feeding stations and a total of 90 analyses are foreseen in carcasses sampled in the centralized feeding station. The random sampling is intended to have a deterrent effect, which, together with the formation of the herder and the banning of the harmful drugs from the farm foreseen by the regional legislation, will contribute to mitigating the risk of provisioning harmful carcasses.

In case of finding high levels of harmful veterinary drug residues, the regional legislation foresees the revocation of the sanitary authorization. In the same way, biological samples will be collected from each Griffon vulture brought to the WRC (estimated at 18-20 in 6 years) and from the restocked vultures during the acclimatization period (50). These vultures are fed with carcasses provisioned by the same herders provisioning the centralized feeding station. This way we will also double check the quality of the carcasses fed to the wild population.

At the moment (May, 2025) 88 samples have been collected, of which 29 from carcasses provisioned to the centralised feeding station, 22 to the farm feeding stations and 37 from Griffon Vultures. The analytical work is ongoing, and the first results should be obtained by 2025.

6.5 Lead poisoning

Lead contamination is a widely recognised conservation problem for raptors worldwide (Monclús et al., 2020). Lead is a chemical element that is not metabolised by living organisms and accumulates in tissues, leading to dose-dependent toxicity. Although the main sources of lead pollution have been gradually eliminated and strictly regulated over the last 50 years, lead is still used in ammunition for hunting and shooting sports and in fishing equipment. Hunting waste is often contaminated with lead fragments and poses a threat to vultures, as confirmed by the relation between high lead blood levels and the hunting season in southern European countries (Monclús et al., 2020).

An estimated 2.3 million birds die each year in Europe due to ingestion of lead, frequently from hunting ammunition. Mudge (1983) estimates that 8,000 birds died in England because of ingesting lead shot, while Wobeser (1997) estimates that 2,400,000 died across the globe. Despite the ban on the use of lead ammunition in the EU's wetlands, around 14,000 tonnes of lead are still released into the environment each year because of their use in hunting. Wild animals can ingest lead fragments, either directly or indirectly, resulting in intoxication. Wild ungulates, constituting a food source for vultures, are a possible cause of intoxication risk causing acute and chronic toxic effects, including death.

Hunting waste is frequently contaminated with lead fragments, posing a threat to several species of large birds of prey, such as vultures and eagles (Bassi et al., 2021; Mateo-Tomás et al., 2016) also due to the habit of actively following hunters in search of the viscera left on the ground (Bedrosian et al., 2012; Mateo-Tomás & Olea, 2010).

A study carried out in the Italian Alps showed that necrophagous scavengers feeding on small carcasses are at high risk in hunting areas due to the large number of unrecovered wounded individuals that may incorporate whole or fragmented lead ammunition (Bassi et al., 2021; Donázar, Palacios, et al., 2002).

Bullets containing lead very frequently fragment upon impact and this increases the chances of ingestion with food and makes it more easily eroded by digestive juices, facilitating its absorption (Bassi et al., 2021).

Lead in the European Union

In Europe, lead poisoning is a significant problem affecting both humans and wildlife. Lead is an almost ubiquitous chemical element used in a wide variety of products (Ensley, 2003); it is not metabolised by living organisms but accumulates in tissues causing dose-dependent toxicity. Awareness of its negative impact on the environment, animals and humans has led to the progressive elimination, or strict regulation, of the main sources of lead pollution over the past 50 years. Today, this metal is still used in ammunition for hunting and sport shooting and in fishing equipment. An estimated 44,000 tonnes of lead are released into the EU environment each year as a result of these practices (57% sport shooting, 32% hunting, 11% fishing). Its use in lead shot is a reason for accumulation in areas open to hunting, and in wetlands. It results in high saturnism mortality, which may extend to predators feeding on intoxicated animals (Eisler, 1988-b; Merendi et al., 2006).

According to ISTAT (National Institute of Statistics) data, licensed hunters in Italy currently represent 1.2% of the population (equal to about 760 thousand individuals). Sardinia is one of the regions with the highest hunting vocation (about 46 thousand hunters), in particular towards lagomorphs (hare, rabbit), game birds and, above all, ungulates (wild boar and in the future, probably also fallow and deer due to the significant increase in the size of their populations). Wild ungulates, constituting one of the food sources of griffon vultures, represent a possible risk of lead poisoning following the escape and later death of affected individuals and the hunting practice of evisceration releasing the viscera on site.

This situation has led the European Chemicals Agency (ECHA) to formulate a proposal to restrict the use of lead in ammunition for both recreational and commercial hunting and fishing, to limit the risks to human health and the environment, and to ban its sale and use.

The main points of the request concern:

- A ban on the sale combined with a ban on the use of lead ammunition or fishing equipment, where its use would inevitably lead to releases into the environment, irrespective of the conditions of use, and where suitable alternatives are available.

- Obligation for retailers to inform consumers about the timing of lead disposal in ammunition and fishing equipment, as well as the presence, toxicity and risk of lead to human health and the environment. Retailers will also be required to inform customers about alternatives to lead-containing items (fishing equipment, ammunition, bullets).

European Regulation on Lead Use

The use of lead in Europe is subject to stringent regulation due to the significant health and environmental risks associated with this metal. The use of lead-based ammunition for hunting has been regulated in 23 European countries, with some countries adopting total (e.g., The Netherlands and Denmark) and others partial bans (Monclús et al., 2020). Current regulations aim to ensure the safe handling of lead and its compounds, reducing human exposure and limiting environmental pollution.

1. REACH (Regulation (EC) No 1907/2006): The REACH Regulation (Registration, Evaluation, Authorisation, and Restriction of Chemicals) requires the registration, evaluation and authorisation of chemicals placed on the European market. Lead and its compounds are subject to specific restrictions:

- Restrictions: The use of lead is restricted in several products, including paints, toys and children's articles.

- Authorisations: Some uses of lead require specific authorisation, for which industry must demonstrate that the risks are adequately controlled or that the socio-economic benefits outweigh the risks.

2. Batteries Directive (Directive 2006/66/EC, as amended by Regulation (EU) 2023/1542): this directive regulates the management of batteries and accumulators, including those containing lead.

3. Industrial Emissions Directive (Directive 2010/75/EU): this directive lays down rules to prevent and reduce pollution from industrial activities.

4. RoHS (Directive 2011/65/EU, updated by Directive (EU) 2017/2102): the RoHS (Restriction of Hazardous Substances) Directive restricts the use of hazardous substances, including lead, in electrical and electronic equipment.

5. Drinking Water Directive (Directive (EU) 2020/2184): this directive sets requirements for the quality of water intended for human consumption.

6. EU Regulation 2021/57 of 15 February 2023: prohibits the use and transport of lead ammunition in wetlands in order to protect the health of waterfowl and reduce the risk of environmental contamination.

7. Regulation (EU) 923/2023: entering into effect on 29 November 2024, introduces new restrictions on the use of lead in polyvinyl chloride (PVC).

8. New Restriction Proposals (2024 and beyond): the European Commission is considering further restrictions to reduce the use of lead in several sectors:

<u>- Construction sector:</u> Stricter restrictions on the use of lead in building materials.

<u>- Automotive sector:</u> Progressive phase-out of lead-acid batteries in favour of more sustainable alternatives.

<u>- Hunting and fishing sector:</u> Expansion of the ban on ammunition and fishing tackle containing lead.

Italian regulations on lead use

1. Law No 157 of 1992: this law, one of the first significant hunting regulations in Italy, did not explicitly deal with lead in ammunition but established general guidelines for the protection of wildlife and the use of hunting weapons. Since this law, hunting regulations have evolved to include criteria of environmental sustainability.

2. Directive 2003/33/EC: this European directive concerns the management of waste containing lead, including industrial waste and batteries. It has influenced Italian legislation on hazardous waste management and disposal, creating obligations to reduce pollution from heavy metals such as lead.

3. Legislative Decree No 152 of 2006 ('Environmental Code'): this legislative decree transposes European directives on environmental management and establishes rules for the control and reduction of pollution by heavy metals such as lead, including criteria for the cleaning up and management of waste containing lead. The Legislative Decree introduced measures to prevent the risk of soil and water contamination, including provisions on the use of lead in several industrial and commercial settings.

4. Legislative Decree No 205 of 2010: this decree transposes further European directives on waste management and includes specific measures for the treatment of lead-containing waste, such as batteries and electronic waste. The decree also strengthened provisions for the safe management of hazardous waste and introduced preventive measures to limit the use of substances harmful to health and the environment.

5. REACH Regulation (EC No 1907/2006): Although it is EU-wide, REACH directly impacts Italian legislation by imposing restrictions on the use of lead and its compounds in a number of sectors, including consumer products and industrial chemicals. Italy has been called upon to comply with the provisions of the regulation, which requires the registration, evaluation, authorisation and restriction of hazardous chemicals.

6. Law No. 136 of 9 October 2023: this law amends Law 157/92 and establishes a ban on the use and transport of lead ammunition in wetlands. In particular, the ban covers areas defined by the Ramsar Convention, nature reserves, protection oases, as well as Sites of Community Interest (SCI) and Special Protection Areas (SPAs).

7. EU Regulation 2021/57: this regulation, transposed by Italy, prohibits the use of lead cartridges during hunting and shooting activities in wetlands or areas within 100 metres of them. The ban also covers the transport of such ammunition in transit through these areas. Penalties are provided for anyone found with lead ammunition in prohibited areas, unless they can prove that the ammunition is intended for use elsewhere. Sport shooting is exempted from the prohibition, provided that the facilities take measures for the collection and treatment of lead in accordance with the regulations in force.

8. Infringement by the European Commission (February 2024): on 7 February 2024, the European Commission sent a letter of formal notice to Italy regarding the use of lead in ammunition for hunting. The object of the infringement concerns changes introduced by Italian regulations that would not fully comply with the Birds Directive and the REACH Regulation. In particular, Italy is accused of failing to take sufficient measures to reduce the use of lead in hunting ammunition, despite European environmental and public health obligations.

Italy has undertaken a regulatory update regarding the use of lead, with particular regard to hunting ammunition in wetlands and the management of lead-containing waste, to align with European regulations. The recent infringement by the European Commission suggests the need for further updating of Italian regulations to ensure greater protection of the environment and public health.

Lead poisoning is a significant risk for vultures, as they might ingest fragments of lead-based ammunition from hunter-killed carcasses, leading to acute poisoning or chronic exposure that affects reproduction, behaviour, immunity, and physiology (Carneiro et al., 2016; Gangoso et al., 2009).

In the French Pyrenees, poisoning is the leading cause of death among avian scavengers, including Bearded, Griffon, and Egyptian Vultures, with lead poisoning accounting for 17% of cases (Berny et al., 2015).

6.5.1 Status of the threat in Sardinia and ongoing mitigation measures

To maximise the effectiveness of mitigation actions and to know the extent of the risk of lead poisoning in Sardinia, the LIFE Safe for Vultures project has dedicated parts of its actions to mitigate this threat:

- Action A.6 - Risk factors for lead poisoning: the project distributed and analysed questionnaires on hunting practices (type and number of ammunitions used, species hunted, disposal of viscera, percentage of animals not recovered after shooting, etc.)
- Action C.7 - Pilot test with lead-free ammunition: thanks to collaboration with hunters, lead-free ammunition was tested in hunting ungulates, specifically wild boar, over two hunting seasons, and evaluations on its effectiveness were collected. The aim of the test was to facilitate the transition to the use of lead-free ammunition on the market, thanks also to a communication and awareness-raising campaign, and to assess the level of satisfaction with this ammunition
- Action D.3 - Assessing lead concentrations in biological matrix: to acquire knowledge on the extension of the issue in Sardinia and on the risk of exposure for griffon vultures, lead concentrations are determined in vultures and sentinel species through the collection of organic samples to be analysed in the laboratory to test the lead concentrations in tissues. Raptors can be valuable indicators of environmental pollution as well as warning system of potential hazards to human health (Monclús et al., 2020)
- Action D.1 - Monitoring the functioning of feeding stations: the project is monitoring concentration of lead in carcasses provisioned to the supplementary feeding stations for griffon vultures.

Action A.6 - Risk factors for lead poisoning

The ‘LIFE Safe for Vultures’ (LIFE19/NAT/IT/000732) project in Action A.6 - Risk factors for lead poisoning, collected 82 cognitive questionnaires on the perception of lead-free ammunition and the risk of lead poisoning for humans and animals. At the same time, it distributed the lead-free ammunition test application form to select volunteers throughout the region to test the ammunition.

This action was carried out in cooperation with the Sardinian Region's Forestry and Environmental Surveillance Corps (RAS-CFVA), which recruited and selected hunters, with valid identity documents and gun permit, throughout the region. Volunteers were contacted by direct knowledge or through the cooperation of hunting associations, particularly the Federcaccia of Sassari.

The RAS-CFVA staff contacted all the test applicants by telephone for assistance in filling out the application forms and questionnaires, at the same time carrying out an information activity to make hunters aware of the problem of saturnism in vultures and other raptors, which can result from ingesting leaded ammunition.

The information obtained was published in a report on the institutional website of the LIFE Safe for Vultures project (https://www.lifesafeforvultures.eu/report/life-safe-for-vultures-report-2021-action-a6.pdf).

Results showed that the most frequently hunted species is wild boar (91.1% of interviewees), and this appears of great relevance as wild boar is a food source for Griffon Vultures and, therefore, a possible risk factor for lead poisoning, especially in relation to wounded animals that escape capture and may subsequently die (Bassi et al., 2021).

23.2% of the hunters in the analysed sample stated to perform evisceration on the site (Fig. 6.17) and of these, 64.4% admitted to leaving the viscera in an exposed or buried environment (Fig. 6.18).

However, since for some species this practice is prohibited by Determination 14 of 18.06.2019 as part of the measures to implement the African Swine Fever Eradication Programme, it is rational to expect that both data may be underestimated.

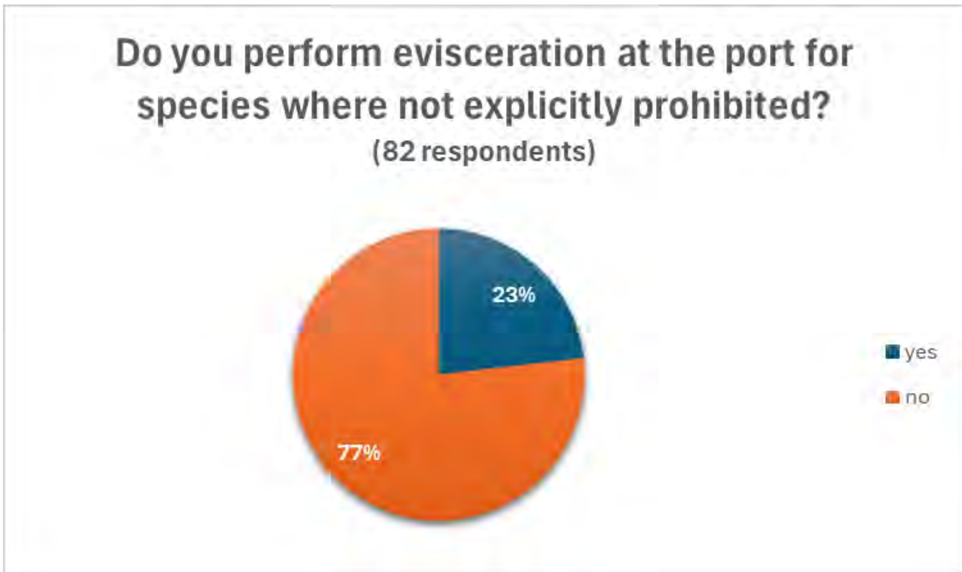


Figure 6.17 *Survey results on the question: 'Do you perform evisceration at the port for species where not explicitly prohibited?' 76.8% of respondents answered 'No,' while 23.2% answered 'Yes'.*

Figure 6.18 *Survey results on the question: 'If evisceration is performed, what happens to the viscera?' 65.4% of respondents indicated that the viscera are left on site, 34.6% reported they are removed, and 0% stated they are used for dog food.*

In relation to the number of ammunitions used per season for hunting ungulates, 43.4% of the respondents stated that they used between 26 and 40 rounds of ammunition and 23.7% claimed to use more than 40 rounds. Some of these do not reach the prey and are deposited in the environment, contributing to environmental pollution.

From the results, an awareness and sensitivity to environmental problems emerged, in fact 88.5% of the sample were informed about the toxicity of lead for the environment and public health and 89% would be willing to use lead-free ammunition and, of these, 92.4% stated that they would be willing to use it exclusively to protect the environment.

Action C.7 - Pilot test with lead-free ammunition

To encourage the transition to lead-free ammunition in Sardinia, the LIFE Safe for Vultures project conducted a pilot study with the collaboration of hunters to test lead-free ammunition during two hunting seasons. Results are published in a report on the project website (https://www.lifesafeforvultures.eu/report/report-azione-c7-2024.pdf).

For the test, 3844 pieces of lead-free ammunition of 12, 20, 308 and 30.06 calibres were purchased.

The RAS-CFVA collaborated in this step by offering hunters support on technical aspects and on how to collect ammunition.

At the end of each hunting season, feedback on the overall perception of bullet performance was collected.

The test with lead-free ammunition took place during the 2022/23 and 2023/24 hunting seasons with the total participation of 73 volunteers. At the end of the two seasons, the participants were interviewed by telephone and 54 opinions were collected on the performance perception of the lead-free ammunition used.

All participants were satisfied with their participation in the LIFE Safe for Vultures project and in the test with lead-free ammunition. Regarding overall satisfaction with the performance of lead-free ammunition, results are shown in Fig. 19.

Figure 6.19 *The survey results on hunter satisfaction with lead-free ammunition show that 83.4% of respondents were satisfied, with 59.3% being very satisfied and 24.1% fairly satisfied.*

When asked which the main problems encountered with lead-free versus leaded ammunition were, the respondents answered:

- A higher risk to people and animals due to the greater hardness of the alloy resulting in less deformability and greater rebound power, especially in rocky areas (55.6%)

- Lower impact effectiveness in the sense of reduced stopping power (18.5%)

- 29.6% found no problems.

94.4% of the respondents stated that they would continue to use unleaded ammunition in their usual hunting practice, 48.1% exclusively and 46.3% together with leaded ammunition (see Fig. 20).

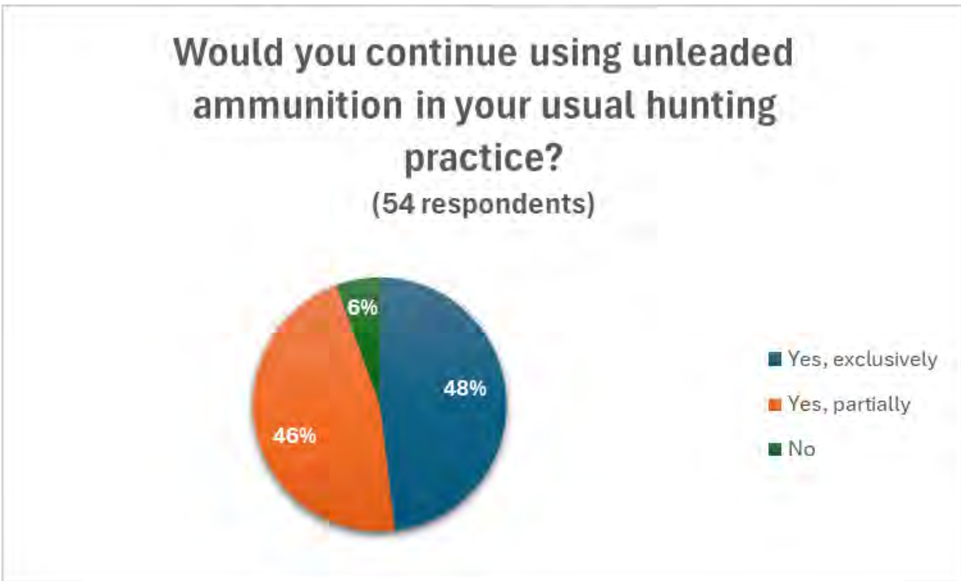


Figure 6.20 *The survey results show that 94.4% of respondents stated they would continue using unleaded ammunition in their usual hunting practice, with 48.1% using it exclusively and 46.3% combining it with leaded ammunition.*

On the question of what could be done to improve the performance of unleaded ammunition to encourage its use as replacement for leaded ammunition, the most common suggestions were

- Use of a softer alloy, more similar in consistency to lead ammunition

- Reducing prices, considered too high compared to those of lead ammunition

- Increasing information campaigns with the involvement of gunsmiths and hunting leaders, who have great power to influence the type of ammunition purchased and used.

Action D.3 - Assessment of lead concentrations in Griffon Vultures and sentinel species

Action D.3 - Assessing lead concentrations in biological matrices aims to detect lead concentrations in griffon vultures and in several sentinel species. Results are published in a report on the project website available at this link[3].

Lead is not normally present inside cells and tissues but, following its penetration into the body by inhalation, skin contact or ingestion, it can cross cell membranes. Once penetrated cells, this metal causes metabolic disorders with effects on various systems (nervous, respiratory, excretory, digestive, circulatory, endocrine, Pain et al., 2019). Through the bloodstream, absorbed lead penetrates various tissues and organs, especially the liver, kidneys and bones. It is detectable in the blood and soft tissues (kidneys, bone marrow, nervous system, etc.) for a relatively short period of time (from a few weeks to a few months, depending on the quantities absorbed, Pain, 1996); in the days following exposure, the highest concentrations are recorded in the kidneys. Over time, lead from the various districts concentrates mainly in the bones, where, in chronic intoxication, it accumulates over a lifetime (bioaccumulation).

High levels in the blood and liver and, to a lesser extent, in the kidneys are indicative of recent exposure to high doses (acute exposure), while high levels in the bones are indicative of not recent and prolonged intake (chronic exposure).

From July 2021 to January 2025, 89 samples of sentinel species, including 37 Griffon Vultures, were submitted to the Experimental Zooprophylactic Institute of Sardinia for analysis of heavy metal concentrations.

The results provided by the IZS laboratory concern lead levels in 23 blood samples from the following species: Griffon Vulture (n=14), Golden Eagle (n=7), Common Buzzard (n=1) and Greater Flamingo (n=1). Levels were compared in the first two species, whose numerical consistency allowed for a comparative statistical analysis. As can be seen from Figure 18, the Griffon Vulture has significantly higher levels than the Golden Eagle. It has been argued that necrophagous animals run a greater risk than active hunters of ingesting lead particles from spent ammunition while feeding on the unrecovered carcasses of hunted animals (Krone, 2018). Our results are consistent with this concept as, within the studies investigated in a recent literature review on lead intoxication in European avifauna (Monclús et al., 2020), obligate and facultative necrophagous species generally had the highest concentrations of lead in liver, kidney, blood and bone.

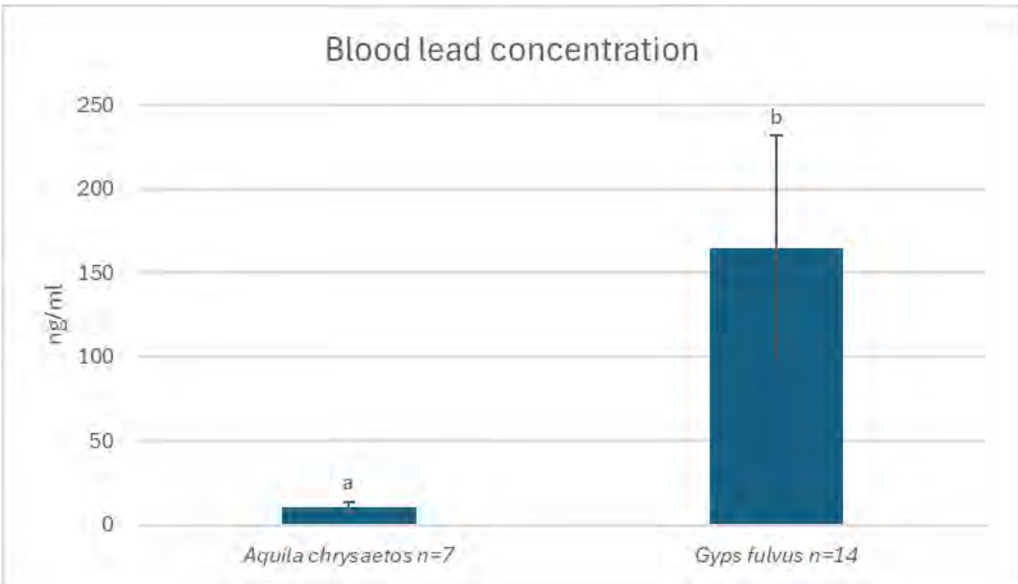


Figure 6.21 *Circulating levels of lead in Griffon Vulture and Golden Eagle (median ± S.E.). Letters indicate statistically significant difference: Mann-Whitney Rank Sum Test p<0.05.*

Lead levels were also assayed in autopsy samples (n=16) of muscle taken from the species shown in Figure 6.15. Studies analysing lead concentrations in birds have used a variety of different matrices, and some studies have analysed multiple matrices. A recent literature review (Monclús et al., 2020) found that the most commonly analysed matrix was liver (n = 53 studies), followed by blood (n = 36), kidney (n = 34), bone (n = 26); other organs and sample types included lung, stomach, brain, intestine and heart (n = 34), feathers (n = 24), pellets (n = 9) and eggs (n = 7). A significant positive correlation was found between lead concentrations in liver and kidney in all species combined while no other significant correlations were found in lead concentrations between matrices (Monclús et al., 2020). As we do not have specific references in the bibliography on the lead concentrations in the muscle of the species studied, we can therefore only conclude that the levels appear higher in the griffon vulture than in the other species for which we have enough samples for comparison (>1). This confirms what has already been represented above regarding the higher risk of lead poisoning for necrophagous animals. In addition, the concentrations in the samples examined are always below the threshold value of 0.2 mg/kg (Andreotti & Borghesi, 2012), above which a subclinical intoxication picture would be set for other matrices.

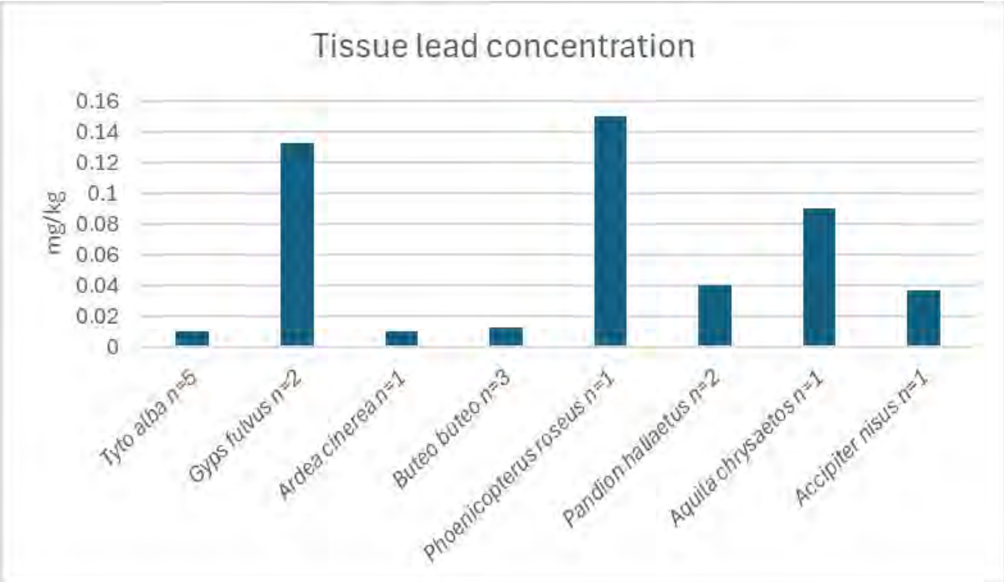


Figure 6.22 *Lead levels (median ± S.E.) in autopsy samples of muscle in different sentinel species.*

Lead levels in Griffon Vultures

Among the actions of the LIFE Safe for Vultures project aimed at promoting the conservation of the griffon vulture in Sardinia is a restocking activity involving the translocation of three groups of Griffon Vultures totalling about 50 individuals from European, in particular Spanish, recovery centres for subsequent release in south-eastern Sardinia.

Before being transported to Sardinia, the griffon vultures undergo a one-month quarantine period at the Forestas Agency's CRAS. During this period, they undergo rigorous health checks that include the detection of infectious diseases and the measurement of lead concentrations.

The Griffon Vultures in the first and second restocking groups (n=33), which arrived in Sardinia, underwent the following checks for the measurement of lead concentrations:

- An initial check is carried out upon arrival at the AMUS Centre in Villafranca de los Barros (Badajoz province) and at the Los Hornos Centre in Sierra de Fuentes (Cáceres province), both located in the autonomous community of Extremadura, Spain.

- A second check upon their arrival in Sardinia at the Bonassai-Olmedo wildlife recovery centre (CARFS)

- A third check before release on 9 April 2024.

The controls (Figure 6.20) showed that the mean concentrations did not differ significantly (One-way Anova p=0.089) at the three times.

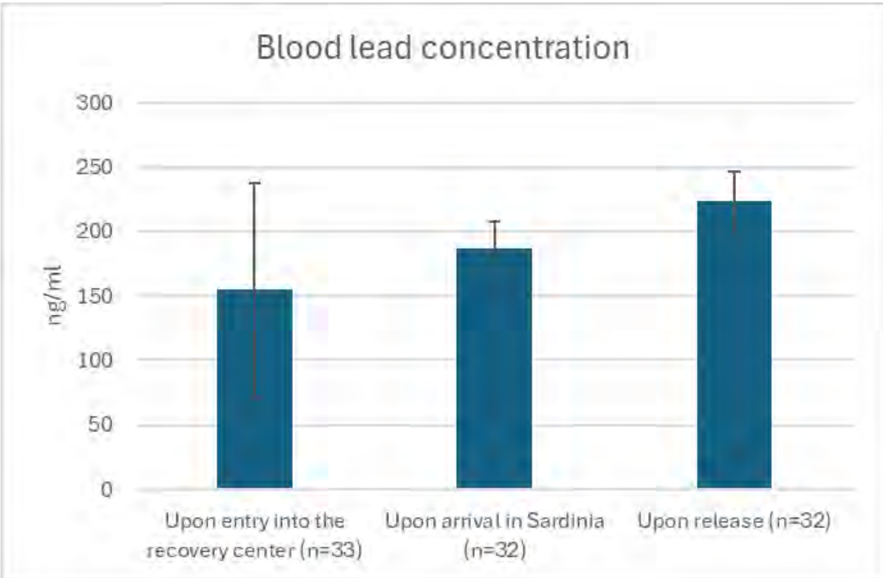


Figure 6.23 *Blood lead concentrations (median ± S.E.) in Griffon Vultures released in Sardinia in the restocking action.*

Similarly, as shown in Figure 6.21, no significant differences (one-way ANOVA p=0.625) were found between the mean lead levels detected in subjects from the two populations at the time of recovery.

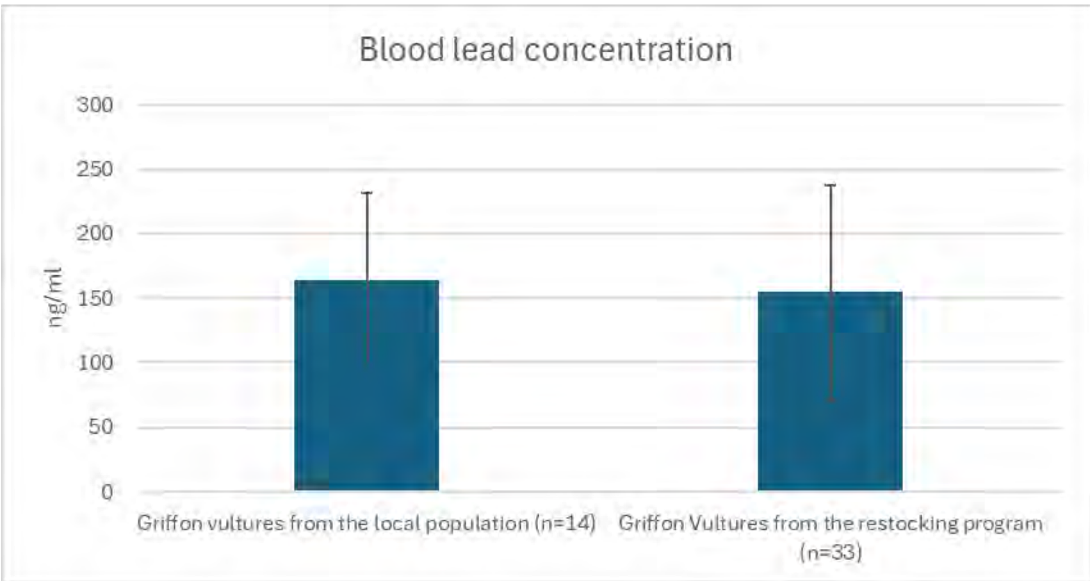


Figure 6.24 *Blood lead concentrations (median ± S.E.) in Griffon vultures in the two populations.*

Overall, the results show detectable levels of lead but below the (200 - 500 ng/ml; Descalzo et al., 2021; Naidoo et al., 2017; Pain et al., 2019) recognised as the threshold above which clinical symptoms related to organic lead accumulation may begin to manifest. Repeated analyses over time show variation in lead concentrations within the same subject but remaining below the threshold.

One individual from Spain showed particularly high concentrations on arrival at the recovery centre prior to transfer to Sardinia (2695.53 ng/ml), which, however, declined strongly on detection near release (619 ng/ml). No individuals showed clinical signs of acute or chronic lead intoxication.

Action D.1 - Monitoring the functioning of feeding stations

The LIFE Safe for Vultures project envisages the creation of a network of supplementary feeding stations aimed at favouring the expansion of the griffon vulture population towards the central south of the island, facilitating the creation of a new nucleus in the south-eastern area of Sardinia. The network of feeding stations aims to support any temporal and spatial shortages of food resources while respecting the ethological characteristics of the species. The functioning of the feeding stations is monitored in terms of carcass supply, carcass quality and number of Griffon Vultures and other species of interest using them. The safety of carcasses is assessed through random monitoring in the activated feeding stations of concentrations of heavy metals and residual drugs potentially toxic to Griffon Vultures.

From September 2023 to January 2025, 26 samples were sent to the Istituto Zooprofilattico Sperimentale della Sardegna for monitoring heavy metal concentrations in carcasses destined for Griffon Vulture feeding.

As of 20 January 2025, the IZS provided the results of 14 of the 26 samples sent.

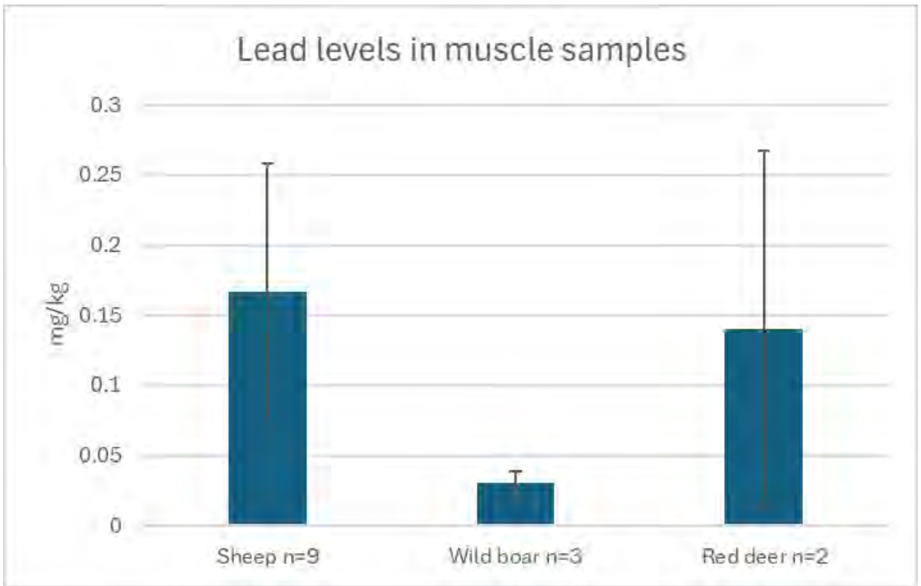


Figure 6.25 *Lead levels (median ± S.E.) in muscle samples from carcasses supplied at feeding stations.*

The samples analysed were collected from carcasses delivered to FoReSTAS central feeding station Cea Romana (Figure 6.26). The graph shows the lead concentrations in muscle samples from sheep (9), deer (2) and wild boar (3). Again, the concentrations in the samples tested were always below the tissue threshold value of 0.2 mg/kg ((Andreotti & Borghesi, 2012).

To make a preliminary comparison of tissue lead levels, the levels found in the muscle, kidney and liver of deer carcasses are shown in Figure 6.24. Muscle levels appear higher than those in internal organs. However, it is necessary to increase the number of samples analysed to draw conclusions about the correlation between lead levels in the different matrices analysed.

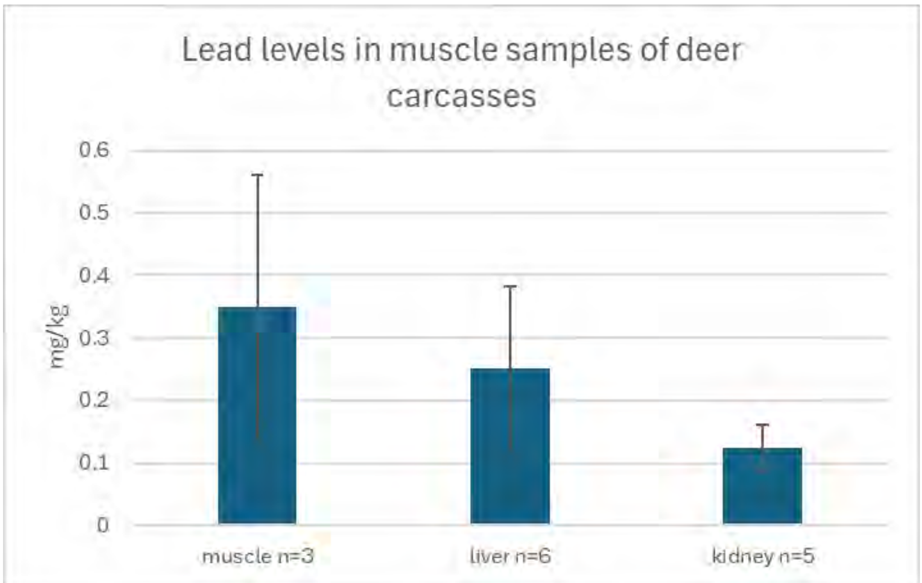


Figure 6.26 *Lead concentrations (median ± S.E.) in samples of muscle tissue, liver and kidney from deer carcasses used to supply the Villasalto centralised feeding station.*

The results obtained within the LIFE Safe for Vultures project show that, despite the presence of detectable concentrations of lead in Griffon Vultures and sentinel species analysed, the values are generally below the threshold levels recognised as toxic to animal health. This result is indicative of a relatively low risk of lead poisoning in the study population, although critical thresholds may be species-specific as it has been shown that some raptor species are more sensitive to lead than others (Ecke et al., 2017; Pain et al., 2019), it underlines the need to continue monitoring the situation.

The Griffon Vulture, which is the most abundant vulture in south Europe (BirdLife International, 2017), has been the only species in which lead contamination has been studied extensively. Other obligate scavengers in Europe include the Bearded Vulture and the Cinereous Vulture, which have not yet been well studied, so it could be very informative to increase studies on these species.

Analyses conducted on the carcasses used to supply the centralised feeding station confirmed that the concentrations of lead in the tissues are well below the toxicity threshold values, ensuring a safe food source for Griffon Vultures.

Awareness-raising actions, continuous monitoring and experimentation with lead-free ammunition are key steps to further reduce the risks of lead exposure for Griffon Vultures, sentinel species in Sardinia and the environment. The integration of these data with environmental monitoring and carcass analysis will continue to provide a sound scientific basis for the long-term conservation of this species.

Given the successful conservation of Griffon Vultures in Sardinia and the effective efforts to reduce the risks of lead exposure, conditions are increasingly favourable for the reintroduction of the Bearded Vulture and the Cinereous Vulture. However, it should be considered that Bearded Vultures can be more exposed to lead intoxication due to their higher sensitivity to lead compared to other vulture species and to their osteophagous diet. Indeed, they produce pellets less frequently and ingested lead ammunition particles are longer exposed to gastric acids. This means that lead can remain longer in the stomach and, because of both the longer permanence time and the low pH, can be higher dissolved and absorbed in greater quantities.

Therefore, key considerations for a successful reintroduction strategy include:

- Continued lead reduction efforts: expanding the use of lead-free ammunition.
- Supplementary feeding programs: ensuring safe food availability.
- Public awareness campaigns: enhancing hunter and community cooperation.
- Habitat restoration and monitoring: maintaining ecosystem health to support vulture populations.

6.6 Habitat loss and degradation

Other threats to vultures include habitat loss, degradation, and fragmentation (Safford et al., 2019). The impact of habitat changes on vulture populations is complex, though it is frequently identified as a factor in their decline. These changes may involve large-scale modifications that affect food availability or other ecological conditions. Both cliff-nesting and tree-nesting vultures have specific breeding site requirements that can be easily disrupted by human activities, such as quarrying, the construction of tourism or leisure infrastructure near nesting cliffs, road and highway expansion, logging, deforestation, and the removal of large trees in agricultural landscapes (Botha et al., 2017).

Habitat loss and degradation are considered key factors in the decline of the Bearded Vulture population in Greece, where the species was once widespread across mainland mountain ranges and Crete (S. Xirouchakis et al., 2001). In South Africa, adult Bearded Vultures avoid areas with dense infrastructure, favouring less-developed habitats, indicating their sensitivity to land-use changes (Sheik Abbass, 2021). Additionally, infrastructure expansion in mountain regions, such as roads, dams and ski resorts, has contributed to irreversible habitat loss and increased disturbance for the species (Tavares, 2013).

Habitat loss can also occur through afforestation and forest fires. Afforestation reduces the grazing areas vultures rely on for foraging, while forest fires pose a threat to Cinereous Vultures by destroying their tree nesting sites (Tewes et al., 2004).

To address this threat, habitat conservation should focus on establishing a network of protected areas and developing management plans for both public and private lands that consider Bearded and Cinereous vulture habitat needs.

The legal protection of over 90% of Cinereous Vulture breeding areas in Spain has safeguarded vast territories by preventing irreversible habitat alterations. Since the 1980s, and especially the 1990s, numerous protected areas and Special Protection Areas have been established, alongside official conservation plans. These measures have helped reduce human disturbance during breeding and limit habitat loss, though challenges remain in balancing conservation with economic use (Moreno-Opo & Margalida, 2014).

Other conservation measures to safeguard Cinereous Vulture populations include preserving mature trees, maintaining strictly protected areas as vulture sanctuaries, safeguarding unused but suitable habitats from disturbance and logging, and monitoring habitat changes to assess their impact on vulture nesting (Poirazidis et al., 2004).

6.6.1 Status of the threat in Sardinia and ongoing mitigation measures

Accurately quantifying habitat loss is challenging, and while habitat fragmentation is less immediately apparent, it remains a pervasive threat to many species. Since the early 20th century, Sardinia has undergone extensive environmental changes that have degraded habitat quality for wildlife. These include the expansion of road networks, agricultural reforms, the construction of power lines, dams, industrial sites, and tourism infrastructure, particularly along the coastline. These developments are closely linked to population growth and human expansion, leading to progressive habitat loss and fragmentation (Schenk et al., 2004).

Wildfires represent a potential threat to vulture conservation in Sardinia, primarily due to their potential to cause large-scale habitat degradation. As shown in the Figure 27, vast areas of the island are subject to varying degrees of fire risk, with particularly high vulnerability in the southern, eastern and central regions. Fires can destroy nesting and foraging habitats, reduce food availability, and trigger landscape changes that may affect the long-term suitability of key areas for vultures. In a Mediterranean context increasingly affected by climate change, where extreme heat and drought conditions are becoming more frequent, wildfire prevention and response strategies must be considered an integral part of conservation planning for species such as the Griffon Vulture, the Bearded Vulture and the Cinereous Vulture.

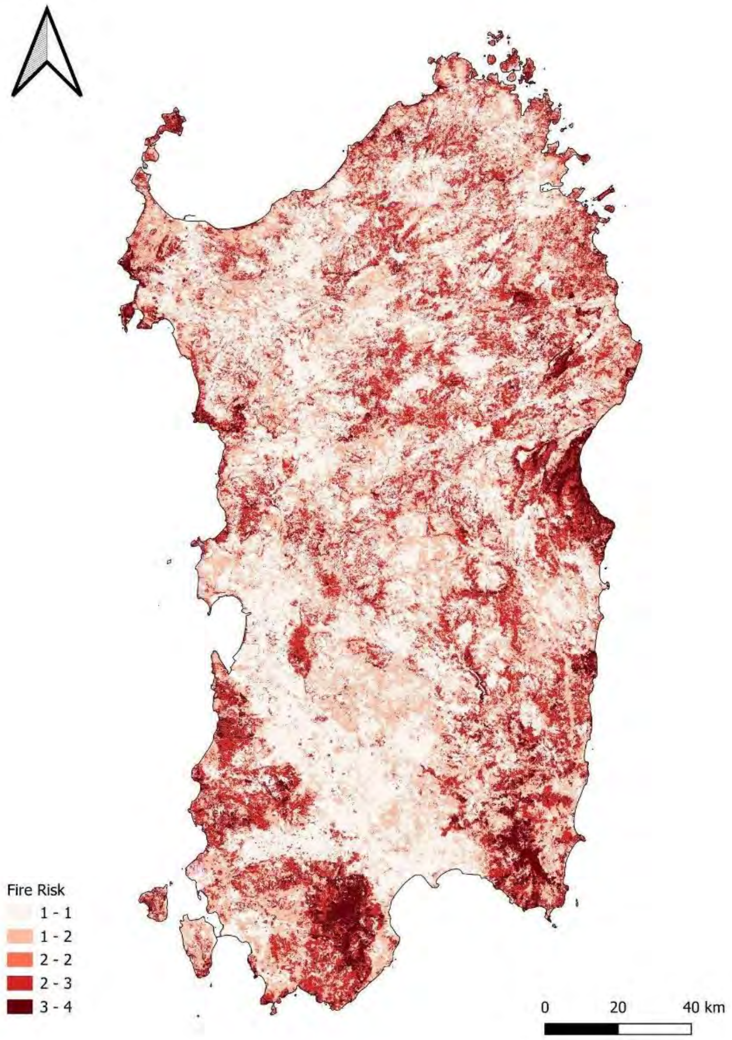


Figure 6.27 *Map of wildfire risk (year 2017 – source: https://www.sardegnageoportale.it/). The risk values are represented using a color gradient legend ranging from 1 (low risk) to 4 (high risk), indicating the varying levels of wildfire risk across the region.*

The Bearded Vulture is attracted to long, steep escarpments and ridges, as well as warm valleys and plains that generate strong thermals. These thermals allow it to glide efficiently across vast foraging areas, often located far from its nesting site. It typically nests in small caves or on cliff ledges sheltered by overhangs. This solitary species maintains territories with up to five alternative nesting sites, spaced between 30 and 1,000 metres apart. Nests are either reused in consecutive years or alternated within the territory (Cramp et al., 1982).

Fortunately, Sardinia continues to provide suitable habitat for the Bearded Vulture, with its extensive rugged landscapes, steep cliffs, and remote areas that meet the bird's nesting requirements. The island’s varied topography, with significant elevation changes and rough terrain, offers ideal conditions for thermal generation and undisturbed breeding sites. Figure 6.28 illustrates the distribution of terrain roughness across Sardinia.

Figure 6.28 *The map shows terrain roughness at a 250-meter resolution, with areas of higher roughness indicating more uneven or rugged terrain, while smoother areas exhibit minimal elevation variation.*

The Cinereous Vulture, on the other hand, typically selects arboreal nesting sites, often on crags or steep slopes, often in mature trees in mature woodland even if not necessarily in tall trees. It can tolerate substantial forest cover within its foraging range, favouring coniferous species like pines (*Pinus*) or junipers (*Juniperus*), as well as various southern oaks (*Quercus*). However, in certain parts of its range, such as Mallorca, it shows a preference for rocky nesting sites. The nest is usually located at the top of a tree, occasionally on a sturdy branch, and may also be built on a cliff ledge, even when trees are available. Nests are typically positioned 10–20 metres above the ground but can be as low as 5 metres. The species nests either solitarily or in loosely structured colonies (Cramp et al., 1982).

Sardinia still provides suitable habitat for the Cinereous Vulture as well, with a mosaic of forested areas, craggy slopes, and open landscapes that align with its nesting and foraging needs. The availability of tree cover, particularly in the form of conifers, junipers, and oaks, offers potential nesting sites. In Figure 6.29 is shown the distribution of tree cover across Sardinia.

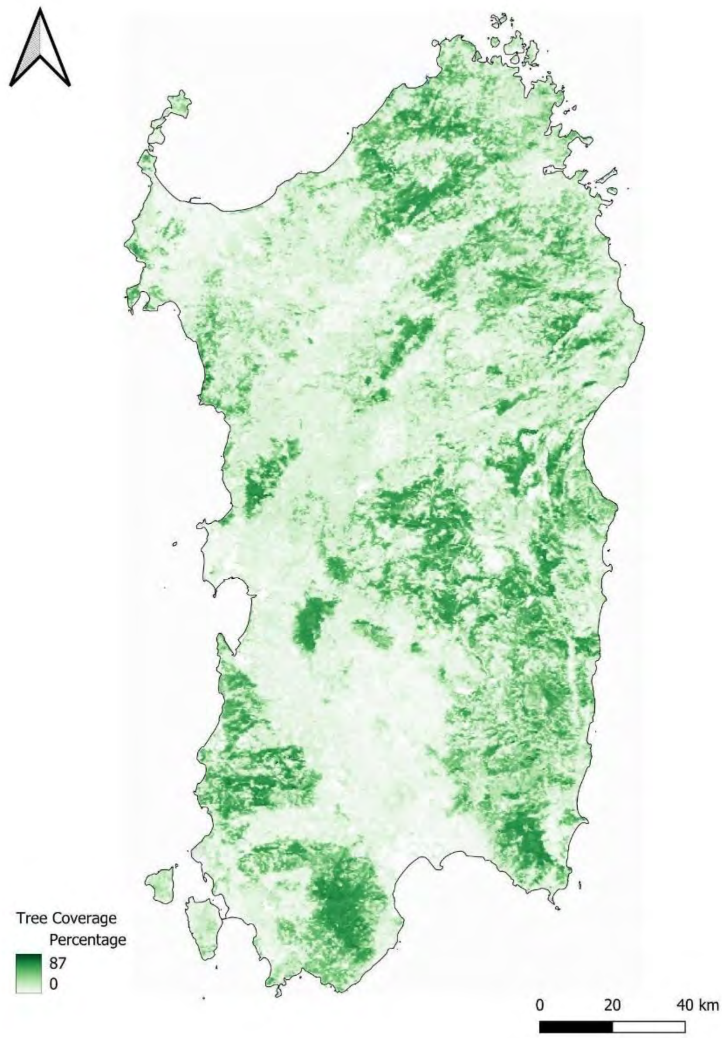


Figure 6.29 *The map represents the percentage of tree coverage in 2019, highlighting areas with varying levels of vegetation density across Sardinia.*

Protected areas are essential for biodiversity conservation, providing crucial habitats for numerous species and helping to mitigate threats from human activities. In Sardinia, the Natura 2000 network comprises 92 Sites of Community Importance (SCIs) and 37 Special Protection Areas (SPAs), collectively covering nearly 19% of the island's total land area (Lai & Zoppi, 2017). The total area of these sites is approximately 864,000 hectares (Figure 6.30).

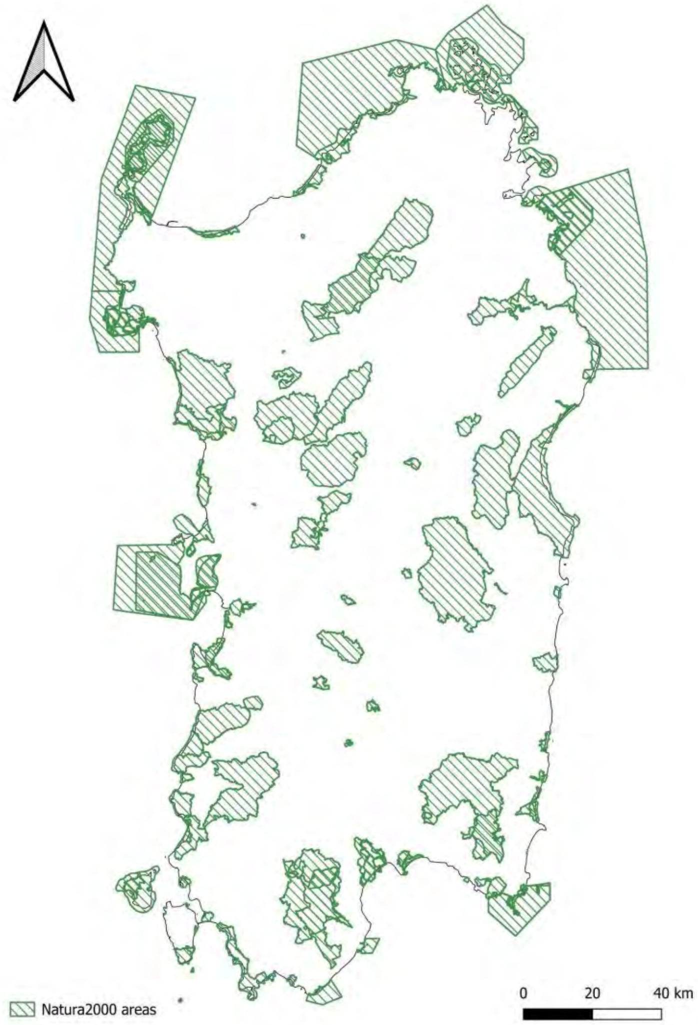


Figure 6.30 *The map displays Natura 2000 protected areas in Sardinia, highlighting regions designated for conservation to protect biodiversity and maintain valuable habitats.*

This network plays a vital role in safeguarding Sardinia's diverse wildlife, including species such as the Griffon Vulture. Given the extent and ecological value of these protected areas, they could also provide suitable habitat conditions to support the reintroduction of the Bearded and Cinereous Vultures, contributing to the long-term restoration of the island's vulture community.

The LIFE Safe for Vultures project includes, among its key actions, the expansion of the Griffon Vulture's distribution range and an increase in carrying capacity by broadening its feeding area. This is being achieved through the establishment of a network of farm feeding stations across livestock farms, extending from eastern to southern Sardinia. These feeding stations were authorised by the Sardinia Region under Determination No. 351 of 24 May 2021, which defines the Griffon Vulture feeding areas in Sardinia and integrates Determination No. 422 (Protocol No. 10330) of 13 May 2014 (See Chapter 7 for further details).

Analyses of GPS tracking data and field observations conducted by ornithologists from the Department of Veterinary Medicine of the University of Sassari have revealed that an important area frequented by 100–120 Griffon Vultures lies outside the Natura 2000 network. This area, which serves both as a foraging ground and as a roosting site, is located near the Special Protection Area (SPA) ITB023050 Piana di Semestene, Bonorva, Macomer e Bortigali, already included in Determination No. 422 (Protocol No. 10330) of 13 May 2014. LIFE Safe for Vultures aims to facilitate the Griffon Vulture’s recolonisation of its historical range, extending the achievements of the LIFE Under Griffon Wings project from northwestern Sardinia to the central-eastern and southern parts of the island.

In addition to Griffon Vultures, this area is of great importance for the breeding and wintering of the Red Kite (*Milvus milvus*), a species classified as Vulnerable (VU) on the Italian Red List of Breeding Birds (Gustin et al., 2021) and as Critically Endangered (CR) on the Red List of Vertebrates Breeding in Sardinia (Schenk, 2015).

The proposed area (Fig. 6.31), spanning the municipalities of Mara and Padria (Sassari province), will be connected to the Natura 2000 sites ITB023037 “Costa e Entroterra di Bosa, Suni e Montresta” to the west and ITB023050 Piana di Semestene, Bonorva, Macomer e Bortigali to the east. It will also link with Sites of Community Importance (SCIs) ITB020040 Valle del Temo, ITB020041 Entroterra e zona costiera tra Bosa, Capo Marargiu e Porto Tangone, and ITB021101 Altopiano di Campeda.

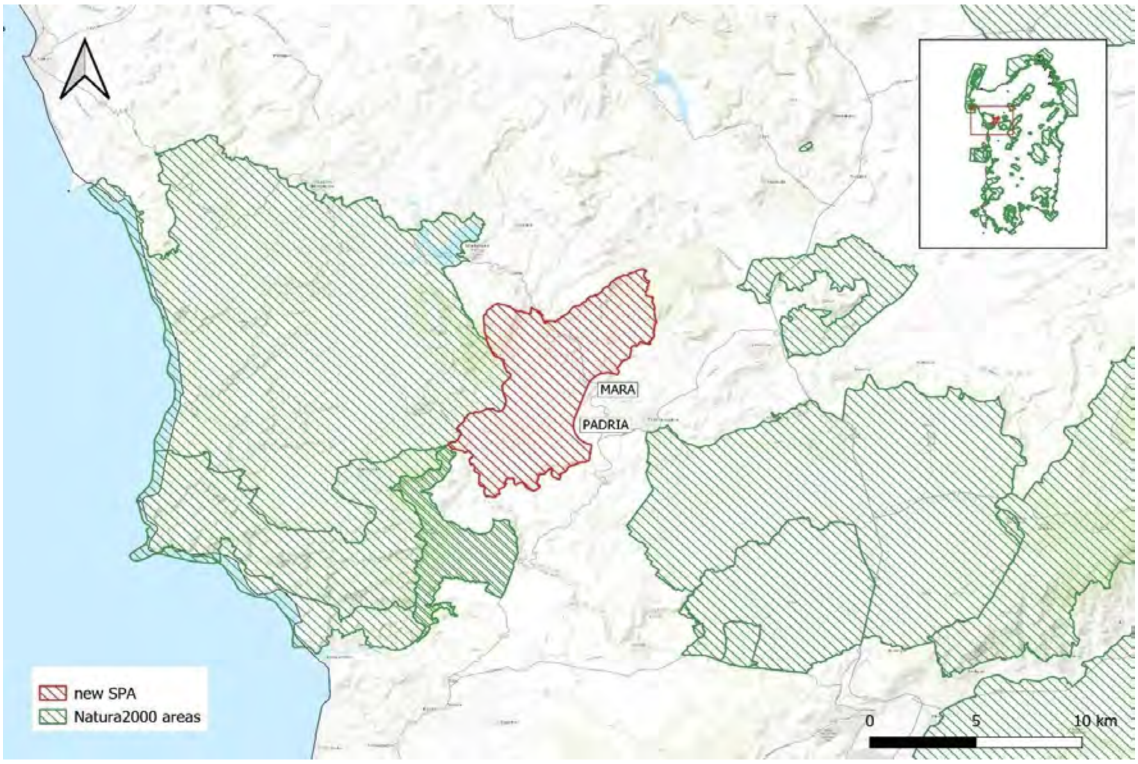


Figure 6.31 *Existing Natura2000 protected areas (green) and proposed new SPA in the municipalities of Mara and Padria (red).*

The creation of a new SPA in the municipalities of Mara and Padria would establish an ecological corridor connecting the Natura 2000 sites:

- SPA ITB023050 Piana di Semestene, Bonorva, Macomer and Bortigali;
- SPA ITB023037 Costa e Entroterra di Bosa, Suni and Montresta;
- SCI ITB020040 Valle del Temo;
- SCI ITB020041 Entroterra e zona costiera tra Bosa, Capo Marargiu and Porto Tangone;
- SCI ITB021101 Altopiano di Campeda.

This proposal for a new SPA also offers livestock farms in the area the opportunity to request the installation of farm feeding stations, benefiting both the Griffon Vulture (and other scavengers) and farmers. It would reduce carcass disposal costs and lower CO_2 emissions. Based on the experience of the previous project, Griffon Vultures processed 81,361 kg of biomass, saving farmers approximately €90,000 in incineration costs and around €1,000 in greenhouse gas emissions.

6.7 Intentional killing, persecution and human disturbance

Intentional killing and persecution of vultures remain significant threats across many regions, often driven by ignorance, superstition, or specific human interests. Vultures have been shot or deliberately poisoned in the United States, Europe, and North Africa, mistakenly blamed for killing livestock, targeted to conceal poaching activities, or exploited in traditional medicine (Ogada et al., 2012).

For the Bearded Vulture, such persecution led to dramatic population declines or local extinctions across Europe by the early 20th century. Margalida et al. (2008) reported that direct persecution, especially shooting, accounted for 31% of 106 recorded deaths between 1955 and 2006 in key regions such as the Pyrenees, Alps, Corsica, and Crete. The Cinereous Vulture faces similar threats, particularly in the Balkans, where human-related mortality remains high, for instance, two released individuals in Bulgaria were shot within a few years of reintroduction (Terraube et al., 2022). Beyond mortality, human activities also disrupt breeding: disturbance reduces nest attendance and breeding success (Arroyo & Razin, 2006; Zuberogoitia et al., 2008) often prompting the implementation of spatial and temporal restrictions during sensitive periods (Richardson & Miller, 1997). In Bearded Vultures, increased human access to mountain nesting sites has led to higher breeding failure, especially outside protected areas, with disturbed pairs less likely to breed in subsequent years (Arroyo et al., 2021; Izquierdo, 2018). Similarly, in Cinereous Vultures, breeding success is negatively affected by human disturbance and rainfall during the nesting season, with forestry activities having long-lasting effects (Donázar, Blanco, et al., 2002). Raising public awareness through environmental education campaigns and involving local communities in wildlife monitoring can help reduce persecution, build trust, and support the long-term conservation of these threatened scavengers (Badia-Boher et al., 2019).

6.7.1 Status of the threat in Sardinia

In Sardinia, at least 12 cases of Griffon Vulture mortality caused by gunshot wounds have been reported: six between 1970 and 1974, one in 1988, two in 1989, one in 2001, one in 2007 (Schenk et al., 2008; Secci, 2022), and one in 2025.

Direct persecution was one of the main causes of extinction for the Bearded Vulture in Sardinia, primarily through activities such as hunting, poaching, incidental killings, plundering of eyries, and the harvesting of skins, eggs, and trophies. Collection of specimens was a major factor contributing to the significant decline in the Sardinian population between 1870 and 1934. During this period 93 Bearded Vultures were killed and 15 eggs collected legally, accounting for 84.4% of the 128 dated samples, with the 1901-1910 period being the most destructive. Despite legal protection in 1939, 8 specimens were still collected illegally between 1939 and 1962 (Schenk et al., 2004).

Between 1974 and 1984, human disturbance caused, directly or indirectly, at least 15 breeding failures in Sardinia (17.2% of 87 breeding attempts). These figures were also confirmed for the periods 1986–1989 and 1994–2003, with 42 losses among clutches and chicks (16.2% of 259 nesting attempts). Out of a total of 96 failed breeding attempts (including both chicks and clutches), human disturbance accounted for 43.8% (Schenk et al., 2008). These impacts occurred in a time of growing human activity in vulture habitats – including unregulated birdwatching, recreational activities near nests, and forest management – and before the implementation of consistent awareness campaigns and protection measures for breeding sites.

Direct or indirect human disturbances near nesting sites, including photographic hunting, birdwatching, hiking, paragliding, trekking to observe Griffon Vultures on their nests, boat tourism, noise from wild boar hunting, and woodcutting between January and April, often encouraged by publications revealing the exact locations of nests, have been largely responsible for the low breeding success and high pre- and post-breeding mortality rates of Sardinia's small Griffon Vulture population (Schenk et al., 2008).

In the last two decades (2005–2024), the situation has significantly improved, also thanks to awareness and communication activities carried out or underway as part of the LIFE Under Griffon Wings and LIFE Safe for Vultures projects, as well as to the increased presence in the field of the *Corpo Forestale e di Vigilanza Ambientale* of Sardinia Region. During this most recent period, 30 losses among clutches and chicks (4.4% of 675 nesting attempts) have been recorded due to direct or indirect human disturbance, representing less than 20% of the total 175 breeding failures (Aresu, unpublished). These losses, especially in the Special Protection Area (SPA) "Costa e Entroterra di Bosa, Suni e Montresta", where about 90% of the breeding pairs are concentrated, appear to be largely related to adverse weather events affecting the most exposed nests and to intraspecific competition. However, they are also linked to an increase in human disturbances caused by certain sports and recreational activities, unsustainable during the breeding season near nesting sites (e.g. climbing, paragliding, hiking, etc.). The development of outdoor rock-based activities represents a potentially increasing source of disturbance. Targeted monitoring is needed to quantify the impacts and identify the sites where these activities overlap with nesting areas. This is also necessary to support the regulation of such activities. Some of these activities are still not regulated as required by the "Minimum Uniform Criteria for the Definition of Conservation Measures for Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)", as per the Decree of 17 October 2007 by the Ministry of the Environment and Protection of Land and Sea (now the Ministry of the Environment and Energy Security), published in the Official Gazette No. 258 of 6 November 2007

6.7.2 Ongoing mitigation measures

Addressing direct persecution and human disturbance requires a strong communication strategy aimed at raising awareness and fostering support for vulture conservation. In Sardinia, significant efforts have been made to engage the public, institutions, and media in promoting the protection of Griffon Vulture.

In Sardinia, the protection of birdlife during the breeding season is reinforced by Regional Law 23/1998, which establishes strict regulations to minimise human disturbance.

Specifically, *Article 5* states that "during the nesting period of birdlife, any form of disturbance is prohibited," ensuring that breeding birds are not disrupted in this critical phase. *Article 62* further strengthens this protection by prohibiting unauthorised photography and filming of wild birds listed in Annex II of the Bern Convention during incubation and chick-rearing.

These legal measures highlight the importance of safeguarding sensitive species, including the Griffon Vulture, whose conservation has been actively supported through the LIFE project *Under Griffon Wings*. As part of this initiative, several actions have been implemented to reduce human disturbance in key areas, redirecting tourists in the territories of Porto Conte and Monte Minerva. In these areas, the Forestas Agency has created the conditions to allow the observation of vultures without causing disturb to the breeding couples.

Trail maintenance efforts have focused on clearing obstructive vegetation, restoring the soil, installing fences, and placing directional arrows and informational signage to emphasise the ecological significance of these sites and their key species. Additionally, new trails have been created to improve access to vital conservation infrastructures, such as feeding stations and acclimatisation aviaries, with 2 km of paths established in Porto Conte and 3 km in Monte Minerva.

To further limit human impact, birdwatching stations have been strategically positioned in both areas, allowing visitors to observe vultures while maintaining a safe distance from sensitive sites. These stations are equipped with seating and information boards that provide insights into the project, Griffon Vulture ecology, and the importance of the LIFE Programme and Natura 2000 sites.

Moreover, an ethical code for nature photographers and eco-tourists has been introduced (http://www.lifeundergriffonwings.eu/en/scientific-data/scientific-reports/), promoting low-impact behavioural guidelines and specifically discouraging the use of drones, which can be particularly disruptive near nesting sites (Zink et al., 2023). While not legally binding, this code, endorsed by the Municipality of Bosa and other partners, serves as a valuable tool for raising awareness and encouraging responsible wildlife observation practices.

Within the LIFE project *Safe for Vultures*, several actions are being carried out to inform the general public and raise awareness, such as community meetings to engage local residents in vulture conservation efforts, as well as environmental education programmes in schools to foster awareness among younger generations. Additionally, conferences and public events are being organised to share scientific knowledge and highlight the importance of safeguarding Griffon Vultures. One of the most impactful initiatives is the release of rehabilitated vultures in the presence of the public, providing a unique opportunity for people to witness conservation efforts firsthand and deepen their connection with these majestic birds.

In the early stages of the Life Under Griffon Wings project, an analysis was also conducted on the knowledge of the griffon vulture in Sardinia, and on the communication, actions related to the conservation of the species conducted in previous decades.

Before the project was launched, communication on the Griffon in Sardinia was developed in three directions:

1. the narration of some protection and reintroduction experiences carried out mainly by environmental associations. Among these were the WWF/IUCN's 'Birds of Prey in Sardinia' projects (1974-77) and the 'Griffon Vulture Project LIPU & Region of Sardinia' (1986-89) and 'Large Vultures Project - LIPU, Region of Sardinia' (1994/95), which included not only monitoring, surveillance and the establishment of karsts, but also information campaigns reported in newspapers. Part of this narrative was linked to the prominence of key figures such as the ornithologist Helmar Schenk and the nature photographer Domenico Ruiu, who were the two main disseminators on this subject. The main events narrated concerned the launch of projects and the release of animals recovered and sheltered in the Bonassai Wildlife Rescue Centre
2. individual incidents, such as poisoning incidents or the rescue of griffon vultures, mainly young, found on the coast of Bosa
3. Some sites of environmental associations, such as the Gruppo d'Intervento Giuridico (GrIG), have fulfilled the function of aggregating news on the subject, sometimes relaunching articles from the local press.

Main recurring themes in the communication prior to the Life Under Griffon Wings project therefore included aspects of the inherent vulnerability of the species, the need to intensify conservation efforts, the need to counter lethal practices for the species such as the use of poisons, and individual stories of rescue. It is therefore a fluctuating coverage, linked to the presence of individual projects or news items

This was the basis for the Communication Plan drawn up in 2016 as part of Life Under Griffon Wings. Its basic philosophy, in line with the spirit of the LIFE Programme, focused not only on the need to “inform” or “advertise”, but on the use of communication as an essential tool to promote those changes in behaviour that are fundamental for the preservation of endangered species such as the Griffon Vulture. The final objective of the Plan was to “reactivate that relationship between man and the vulture that has governed life in the Sardinian countryside for millennia”, with the intention of making the community an active protagonist of the intervention and not just an informed spectator.

The general communication objectives defined by the Plan included the need to create, in stakeholders (internal and external) and in the local community, the necessary motivational framework to share the project's objectives and contents, and to foster the participation and empowerment of the local community.

To achieve these objectives, the Plan punctually identified the recipients of the communication actions, set a series of general requirements that all communication actions and products had to meet, and began to outline a series of contents of the main messages to be conveyed. Specific actions, pure information actions aimed mainly at the traditional media, communication actions essential to foster participation and stimulate dialogue, actions functional to achieving specific conservation objectives, dissemination actions aimed at transferring results and good practices, and internal communication actions.

The Communications Management Plan therefore envisaged a structured, multi-channel approach, with a strong emphasis on active involvement of the local community and stakeholders. The main results of the communication actions achieved at the end of the project, with reference to the key developments recorded from 2015 to 2020, are as follows:

Media Coverage

During the project, a total of 35 press releases, 1 press conference and 11 newsletters were produced. The total number of press reports on the project reached 216, with a significant presence in regional newspapers (such as *La Nuova Sardegna* and *L'Unione Sarda*) and in national and international newspapers and programmes (*Tg1*, *Tg3*, *Rai News24, GEO, La Repubblica*, *Ocean Treks with Jeff Corwin* on the US network ABC, *Il Venerdì di Repubblica*).

Online Presence

The pages on social networks (Facebook, Twitter, YouTube, Instagram) were active and managed on a weekly basis, with 467 posts published in 2016-2020. The Facebook page reached 5,460 followers and generated significant interactions, with individual posts reaching around 60,000 people. The website recorded almost one million total hits in 2019 alone (15,000 unique users), with a monthly average of 42,000 hits throughout the duration of the project

Production of printed materials

During the project, five issues of the institutional magazine, 6 different leaflets, three editions of the school diary for primary and secondary school students, and other material for the info points set up in Bosa and Porto Conte such as banners, roll-ups and maps of the project area were produced.

Photo and video material

57 videos were produced for social media and local and national television.

Public events

Two conferences were organised (project opening and closing), 4 meetings with environmental associations, 4 meetings with breeders, 5 events dedicated to the illegal use of poisons, 6 events as part of the project format 'Griffon Vulture Days', 6 events for students, 4 events to promote the Code of Ethics for Nature Photography, and some public releases of griffon vultures. The project also participated with interventions or gazebos in 20 events organised by other organisations.

Citizen Science

Citizen Science' actions, which generally refer to the involvement of the non-scientific public in scientific data collection, observation or other stages of the research process. This happened on the following occasions:

i. Monitoring and population censuses: One of the most direct forms of citizen involvement was participation in the monitoring and annual censuses of the griffon vulture population. Data on the reproductive success and annual censuses of the population were collected by different groups of surveyors composed of historical members of environmental associations together with simple enthusiasts, who followed the protocol drawn up by the Project.

ii. Involvement of breeders in the network of farm feeding stations: the activation of farm feeding stations represented a significant form of involvement of the local community (breeders) in a key conservation action. In addition, the farm feeding stations were identified as potential locations for eco-tourism activities, attracting photographers and birdwatchers, creating further interaction between the local community (breeders) and the public interested in nature.

iii. Development of the Code of Ethics for Nature Photography: The project promoted the development of a Ethical Code for Nature Photographers and Hikers to reduce human disturbance, particularly at nesting sites. This process actively involved nature photographers, photographers' associations, environmental associations and communication professionals.

iv. Awareness-raising and school involvement: The first communication action was the idea competition for schools to create the project logo. This was a way of actively involving the students at an early and visible stage of the project.

The communication actions favoured the active collaboration of several environmental associations (such as LIPU, Legambiente, L'Altra Bosa, AFNI Sardegna), their volunteers and, in general, citizens passionate about the issue.

The associations, with a long history of commitment in Sardinia, provided fundamental support to the project, participating in field monitoring activities, in particular for estimating reproductive success and annual population censuses. The monitoring conducted also thanks to the support of these groups of 'citizen scientists' provided essential data to assess population trends, reproductive success and the effectiveness of the mitigation actions undertaken. Internal communication and the promotion of collaboration allowed for the timely sharing of data collected by the different monitoring groups, enabling cross-checks and a more accurate picture of the status of the population and nests.

The activation of farm feeding stations was one of the most innovative actions of the project and the first of its kind in Italy. Communication and dissemination actions played a role in promoting the 'expression of interest' among breeders and encouraging their adhesion to this network. Communication also contributed to putting the value of the mutualistic relationship between breeder and griffon vulture back at the centre of conservation actions, showing how the griffon vulture performs important ecosystem services, not only for nutrient recycling and carcass disposal, but also potentially for the eco-touristic enhancement of farms.

Communication was a component of the action against poisoning, considered the main threat to Griffons. The Anti-poison Dog Unit carried out prevention activities that included information actions in the countryside and villages, meeting farmers and explaining the ethology of the Griffon Vulture and the effects of poisoning. The project launched an awareness-raising campaign to inform students about the risks of using poisoned baits, seeking to involve all institutional actors in a common strategy. Dedicated events such as "#VELENO" were promoted to raise awareness among schools and institutions. The aim was for students to become the first testimonials against this illegal and dangerous practice. A process that led, during the project, to the first investigation of poisoning cases in the countryside, which was widely reported in the local media.

The project also addressed human disturbance at breeding sites through the promotion of conscious behaviour. This was done, as mentioned, through the development and dissemination of Codes of Ethics for Nature Photography and Hiking. This process actively involved photographers, associations and other practitioners to define guidelines based on input from interested citizens. Communication actions aimed at reducing disturbance have been carried out, including raising awareness of the use of drones in nesting areas and launching specific campaigns in the holiday periods when excursions or trips are normally made to sites affected by the presence of nests or roosts in the Bosa area.

Subsequently, between 2021 and 2024, several press releases, media features, and public outreach initiatives have been conducted to highlight conservation actions and counter misconceptions about vultures (see Tab. 6.6). These communications focused on key aspects, such as:

- Mitigating electrocution risks through collaborations with energy providers.
- Reinforcing vulture populations by releasing captive-bred individuals and rehabilitated birds.
- Combating wildlife poisoning by supporting anti-poisoning canine units.
- Strengthening scientific research and monitoring, including population censuses and tracking movements.

Table 6.6 *Summary of communication and awareness-raising activities (2021–2024) supporting mitigation measures for vulture conservation in Sardinia. The table highlights the number of press releases issued each year, key topics covered, and major media coverage, which contributed to public engagement and stakeholder involvement in the project.*

Year	Press Releases	Key Topics	Media Coverage
2021	**6**	Power line mitigation, vulture restocking, anti-poison dog unit, monitoring and census	*Repubblica* (April), *Tg1* (27 Sep), *Sardegna Verde* (*Videolina*, 16 May)

2022	**10**	Breeding season, demographic trends, release of captive-bred vultures, regulatory updates on feeding stations	*Tg1 Speciale* (3 April), *Dalla parte degli animali* (*Rete4*, 20 Nov), *Close-Up: A caccia di parassiti* (SKY, 19 Dec), *Sardegna Azzurra* (*Videolina*)
2023	**11**	Electrocution risk mitigation, international conference (Cagliari, May), Griffon Vultures from Spain, local community engagement, Egyptian Vulture chick born in Sardinia, vulture rescues	*Geo* (*Rai1*, 24 Feb), *Buongiorno Regione* (*Rai Sassari*, 31 May), *Itinerari di Sardegna* (*Videolina*, 7 June)
2024	**21**	Electrocution mitigation, conservation & rural development meetings, fully rehabilitated Griffon release, first farm feeding station in a National Park (Asinara), 50 years of Griffon Vulture conservation (Molentargius)	*Tg1* exclusive (9 April), Villasalto release documentary, German documentary on October release

In 2021, six press releases were issued. Of these, two were dedicated to the activities carried out by e-Distribuzione in the Pozzomaggiore area on medium-voltage power lines, two to the actions taken by Forestas for restocking through the release of vultures born in Sardinia and rehabilitated at Bonassai or sourced from abroad, one to the implementation of the Anti-poison Dog Unit of the CFVA, and one to monitoring and census activities led by the University of Sassari.

During the same year, additional communication activities were initiated by various media outlets. Notably, journalist Cristina Nadotti produced a report for *Repubblica* in April, featuring the University of Sassari, the Forestas Agency, and the Forest and Environmental Protection Corps in the areas of Bosa and Villanova Monteleone.

Similarly, a report by journalist Giuseppe Lavenia for *Tg1* aired on Monday, 27 September, during the highly watched 8 PM edition, with the journalist and crew visiting the project and its sites. Additionally, *Videolina* dedicated a segment within the *Sardegna Verde* programme on 16 May, with contributions from Forestas, the University of Sassari, and the Porto Conte Regional Natural Park.

In 2022, ten press releases were issued. Topics included the breeding season (in collaboration with the University and the Vulture Conservation Foundation - VCF), actions involving all partners, demographic trends, and the release of captive-bred individuals from the Netherlands. Other releases covered an international conference organised in Alghero by VCF and regulatory updates related to feeding stations.

In the same year, several media-led initiatives took place. *Tg1 Speciale* aired the documentary *Il richiamo della Foresta* by journalist Alessandro Marini on 3 April, involving all project partners in Bosa and Villanova Monteleone. The *Rete4* programme *Dalla parte degli animali*, which aired on 20 November, showcased the project describing the work of all partners. Furthermore, the *Close-Up: A caccia di parassiti* documentary, aired on SKY channel 235 on 19 December, highlighted the Griffon

Vulture's ecological role. *Videolina*'s *Sardegna Azzurra* also covered the project, featuring an interview with journalist Virginia Devoto.

In 2023, eleven press releases were issued. This addressed electrocution risk mitigation, an international conference in Cagliari, the arrival of 12 Griffon Vultures from Spain and their transfer to Villasalto, a Griffon's unprecedented movement from Sardinia to Corsica, and local community engagement initiatives. Other releases covered vulture rescues by Forestas and the CFVA, along with outreach events such as the Tree Festival in Villasalto.

Media coverage in 2023 included a feature on *Geo* (Rai1) on 24 February, with project coordinator in the studio. On 31 May, *Buongiorno Regione* (Rai Sassari), also provided an overview of the project's progress. On 7 June, *Videolina*'s *Itinerari di Sardegna* included a segment on the project.

In 2024, twenty-one press releases were issued. These covered various topics, including electrocution risk mitigation, meetings on conservation and rural development, the release of a fully rehabilitated Griffon Vulture in Sardinia, annual population census results, new vulture arrivals from Spain, the species' return to southern Sardinia, and the establishment of the first-ever farm-based feeding station within a national park in the Asinara island. Special attention was given to international events, such as the 50th anniversary of Griffon Vulture conservation in Sardinia, celebrated in Molentargius.

During the same year, media outreach intensified. On 9 April, to mark the first release of Griffon Vultures in Villasalto, bringing the species back to southern Sardinia after more than 60 years, a documentary was produced and premiered at a public event hosted by the local municipality. *Tg1* journalist Giuseppe La Venia was granted exclusive coverage for a segment aired during the 8 PM edition. A second documentary, created by a German production team during the October release, was widely shared on social media and at the Molentargius event.

These communication efforts have been essential in raising awareness and informing and educating the public about the crucial role of vultures in the ecosystem. Highlighting their ecological importance is paramount to ensuring their conservation and mitigating the threats they face. By collaborating with the media, institutions, and local stakeholders, the project has effectively promoted understanding and support for vulture protection in Sardinia.

The outgoing communication flow produced through the dissemination of the press releases was the basis for the creation of over 230 articles and journalistic reports published by major regional print, television, and online media outlets, as well as in-depth reports from leading national print, television, and online outlets and some publications by the international press. Considering the daily circulation data of the media that published articles related to the project, its activities, and the results produced, along with the data on unique site visits (about 5,523 recorded in 2024, compared to 638 in 2021, the first year of the project, with a peak of 6,375 unique visits in 2023) and followers on Instagram (984) and Facebook (7,952), it is estimated that the total number of people reached exceeded 600,000.

In addition to media dissemination, the *Life Safe for Vultures* project carried out a wide range of communication and awareness-raising activities, reaching a total of 4,935 individuals at local, regional, and international levels. These included public presentations of the project (shown it detail in Table 7), and the actions implemented to support the Griffon Vulture population in Sardinia, often combined with guided visits to the Cea Romana infrastructures (nature trail, birdwatching station, and aviary) and meetings with local communities, students, and environmental guides.

Several sessions were held in primary and secondary schools, where students were introduced to the ecological role of the Griffon Vulture, the main threats affecting the species, and the work carried out by the anti-poison dog unit. Environmental awareness days and classroom workshops were also organised, promoting biodiversity knowledge and the importance of vulture conservation.

Numerous meetings were conducted with livestock farmers, veterinarians, technicians, and local administrators to encourage the activation of Farm Feeding Stations (FFS) and to highlight the ecosystem services provided by the Griffon Vulture in the context of extensive livestock farming. Hunters involved in lead-free ammunition testing were engaged in dedicated meetings to share project objectives and explain the testing procedures.

Further outreach included events linked to the annual Griffon Vulture census in Sardinia, involving volunteers, stakeholders, and institutional representatives in sharing field experiences and results achieved. On a broader scale, the project organised international and technical conferences, such as a European meeting on the role of feeding stations within Natura 2000 sites and a symposium on best practices to mitigate the risks of electrocution and collision with power lines. These events welcomed experts from across Europe and promoted dialogue between conservation professionals, infrastructure managers, and decision-makers.

Table 6.7 *Summary of outreach, awareness, and technical meetings carried out within the LIFE Safe for Vultures project, with details on location, audience, and main topics addressed.*

Stakeholder	Brief description	Geographical dimension	Participants	Year
Students (from primary schools to university level)	Presentation of the LIFE Safe for Vultures project and activities supporting the Griffon Vulture in Sardinia, including a demonstration with the anti-poison dog unit.	Local	3582	2021, 2022, 2023, 2024, 2025
Local herders	Meeting with local herders to present the Farm Feeding Station opportunity and the ecological role of the Griffon Vulture	Local	135	2022, 2023, 2024 2025
Institutional stakeholders	Meetings with institutional stakeholders to discuss Farm Feeding Station activation and raise awareness of the Griffon Vulture's ecological role	Local	28	2023, 2024
Local guides	Presentation of project goals and actions for Griffon Vulture conservation, emphasizing the importance of local community support and the key role of local guides	Regional	70	2022

Hunters	Meeting with hunters involved in lead-free ammunition tests to share project objectives and explain test procedures.	Regional	24	2022, 2023
Engaged citizens	Census and lunch with stakeholders supporting the annual Griffon Vulture census in Sardinia	Regional	282	2021, 2022, 2023, 2024
Energy sector, NGOs, public authorities, researchers, and bird conservation groups	European conference on regulatory frameworks and best practices for Griffon Vulture conservation through feeding stations on farms in Natura 2000 sites, with experts from across Europe	International	296	2022
Energy sector, NGOs, public authorities, researchers, and bird conservation groups	International conference on best practices for electrocution and collision risk mitigation, promoting dialogue among stakeholders in power infrastructure, mitigation measures, and bird conservation	International	470	2023
Energy sector, NGOs, public authorities, researchers, and bird conservation groups	Technical meeting with European experts to plan vulture reintroduction in Sardinia and define a 10-year multi-species conservation strategy	European	48	2025
			Total participants 4,935	

In addition to the activities directly organised within the LIFE Safe for Vultures project, the partners Forestas, CFVA, and UNISS took part in several events promoted by other organisations. These occasions were used to present the project and raise public awareness on Griffon Vulture conservation. The main events are listed in the Table 8.

Table 6.8 *Main events promoted by external organisations in which Forestas, CFVA, and UNISS participated to raise awareness on Griffon Vulture conservation and present the LIFE Safe for Vultures project.*

Stakeholder	Brief description	Geographical dimension	Participants	Year
Meetings with schools	Several environmental education initiatives were carried out in collaboration with schools, including awareness days, classroom sessions,	Local, International	2617	2023, 2024

	and sustainability projects. These activities focused on the ecological role of the Griffon Vulture and the importance of biodiversity conservation.			
Meetings with the local population	Forestas, CFVA and UNISS took part in numerous public events, fairs, and local festivals to present the LIFE projects and raise awareness on Griffon Vulture conservation in Sardinia. These occasions allowed for direct engagement with schools, citizens, and local institutions, highlighting the role of environmental protection actions.	Local, International	47570	2021, 2022, 2023, 2024
University students	Presentation of the LIFE Safe for Vultures project with the activities carried out to support the Griffon Vulture population in Sardinia and the activity of the anti-poisoning dog unit.	Regional	1000	2025

These events played a key role in enhancing the visibility of the LIFE projects and strengthening community engagement in vulture conservation. By actively participating in a wide range of public initiatives, Forestas, CFVA, and UNISS successfully contributed to promoting a conservation culture, fostering collaboration with local stakeholders, and raising awareness on the ecological value of the Griffon Vulture in Sardinia.

6.8 General conclusion

The LIFE Safe for Vultures project has marked a crucial step forward in the conservation of the Griffon Vulture in Sardinia, building upon and expanding the achievements of the LIFE Under Griffon Wings initiative. Through a multidisciplinary approach, firmly rooted in the local territory, the project has addressed the main threats to the species' survival in an integrated and coordinated manner. The establishment and strengthening of the CFVA Anti-Poison Dog Units, the monitoring of lead contamination in tissues and feeding sites, and the promotion of lead-free ammunition through cooperation with hunters have all contributed to reducing risks for vultures and other scavenger species.

Communication and public awareness have also played a central role. Public events, school education activities, meetings with rural communities, and targeted outreach campaigns have not only informed citizens but actively engaged them in conservation efforts, strengthening the perception of the Griffon Vulture as an ecological, cultural, and even economic asset for the island.

Among emerging threats, power lines remain one of the leading causes of vulture mortality. However, this risk is now being mitigated thanks to a fruitful collaboration with *e-distribuzione*, which has enabled the installation of deterrents and insulation systems in the most critical areas. On the other hand, although wind energy currently does not show significant evidence of impact on the Griffon Vulture population in Sardinia, it represents a potential threat that requires continuous monitoring. Future wind developments must be subject to rigorous environmental assessments, and whenever collisions or disturbances are identified, effective mitigation measures should be promptly implemented.

The creation of a network of farm-based feeding stations and the progressive expansion of the vulture's range towards central and southern Sardinia, including areas outside the Natura 2000 network but of high ecological value, demonstrate how conservation can translate into concrete actions for ecological rebalancing and active community involvement.

Overall, LIFE Safe for Vultures stands as a model of integrated conservation, successfully combining scientific research, territorial management, and local stakeholder participation, laying the foundations for a sustainable future for the Griffon Vulture and Sardinia's wider natural heritage, while also preparing the ground for the reintroduction of the Bearded Vulture and the Cinereous Vulture.

Table 6.9 *Overview of the threats to Bearded and Cinereous Vulture and ongoing mitigation measures in Sardinia.*

Threat		Ongoing Mitigation Measures
Energy infrastructure	Collision with power lines	Retrofitting, power line insulation and marking, power line undergrounding
	Collision with wind farms	Creation of maps identifying unsuitable areas for wind energy development
Poisoning	Illegal use of poison	Activation of anti-poison dog units in every province
	Veterinary drugs	Analysis of carcass samples to detect harmful veterinary drugs, supplementary feeding stations
	Lead poisoning	Promotion and testing of lead-free ammunition among hunters
Habitat loss and degradation		Network of protected areas
Direct persecution		Communications actions through newspaper, social media, meeting with general public and schools, conferences
Human disturbance		
Food shortage		Supplementary feeding station

7. Food availability, food needs and food management - carrying capacity

7.1 Supplementary feeding as a conservation measure for vultures

Supplementary feeding is a widely used conservation strategy aimed at increasing food availability for wildlife within a given area. It is often employed in the early stages of restocking or reintroduction projects to enhance site fidelity among translocated individuals. Additionally, it can help booster survival and reproductive success in populations affected by food shortage. As mentioned in chapter 6, supplementary feeding is particularly crucial for vulture conservation in Europe, given sanitary regulations that limit livestock carcass availability in the wild. It can also help mitigate ecological traps near human infrastructure and facilitate the inspection of carcasses to prevent accidental poisoning from veterinary drugs or lead contamination (Cortés-Avizanda et al., 2016).

Evidence suggests that supplementary feeding has long-term positive effects on vulture demographics (Donázar et al., 2009; Pfeiffer et al., 2015). There are two main models of supplementary feeding: centralized feeding stations and diffuse, or light, feeding stations. Centralized stations provide food at a single or limited number of locations, whereas light feeding stations are dispersed across multiple sites, often within livestock farms. While centralized stations are easier to manage, despite requiring dedicated resources for their provisioning and maintenance, they can lead to unintended ecological consequences. When food sources are predictable in space and time, vultures reduce their dispersal and foraging movements, leading to large aggregations that may be affected by density-dependent dynamics (van Overveld et al., 2020).

Conversely, light feeding stations, managed by farmers, mimic natural carrion availability by introducing unpredictability in time and space. This approach encourages vultures to forage over larger areas (Alarcón & Lambertucci, 2018) and promotes niche segregation among different species (Arrondo et al., 2015; Moreno-Opo et al., 2015). Moreover, engaging farmers in vulture conservation, beside being sustainable in the long-term, enhances local awareness of the ecosystem services these birds provide. However, a key drawback of light feeding stations, especially if too few are established, is the potential fluctuation in their provisioning. While adult vultures can endure food scarcity by lowering their metabolism, insufficient carrion can negatively impact reproduction and the establishment of reintroduced individuals.

7.1.1 Legal framework in Europe

Following the first outbreak of Bovine Spongiform Encephalopathy (BSE), commonly known as "mad cow disease," between 1986 and 1996, the European Commission introduced Regulation No. 2000/148/CE to curb the spread of Transmissible Spongiform Encephalopathies (TSEs). These diseases are caused by misfolded proteins known as prions, which accumulate in specific tissues such as the central nervous system, cranium, and ileum of cattle, sheep, and goats. Although the epidemiology of TSEs remains unclear, the Regulation mandated the removal and incineration of carcasses containing tissues susceptible to prion contamination.

In practical terms, the implementation of this Regulation through national decrees prevented farmers from leaving livestock carcasses in the environment, a practice historically common in the Mediterranean region (Olea & Mateo-Tomás, 2009). This decision had significant consequences for vulture populations in the European Union. While some vulture species adapted by shifting to wildlife carcasses (Donázar et al., 2010), many populations faced a drastic reduction in food resources. This led to decreased reproductive success, as vultures struggled to feed their chicks and accumulate adequate body reserves for egg-laying (Almaraz et al., 2022; Donázar et al., 2020).
In response, conservation practitioners and researchers gathered scientific evidence advocating for a revision of Regulation No. 2000/148, which was subsequently amended seven times within a decade. The initial updates, introduced through Regulation No. 1774/2002 and Decision No. 322/2003, allowed the use of livestock carcasses at fenced feeding stations, restricting access to large carnivores. Further amendments, such as Regulation No. 1069/2009, extended the use of livestock carcasses beyond the conservation of endangered scavengers to include the management and preservation of large carnivores listed in Annex II of the Habitat Directive (No. 92/43/CE), particularly those inhabiting extensive pasture ecosystems. Regulation No. 142/2011, addressing animal byproducts, clearly defined the terms for provisioning livestock carcasses in conservation projects for scavengers. Despite this evolving legal framework, implementation varied across the EU, with some regions lacking concrete enforcement (Arrondo et al., 2018; Fernández-Gómez et al., 2022; Margalida et al., 2010; Mateo-Tomás et al., 2022). Nonetheless, these regulations set the parameters for vulture conservation through supplementary feeding. Regulation No. 142/2011 (Article 3, Paragraph III) permits the disposal of livestock carcasses on the ground, but only in specific, pre-identified areas deemed important for scavenger conservation. The quantity of carcasses that can be left in these areas is determined based on assessments of the daily food requirements of the targeted scavenger populations.
According to Section 2 of Annex IV of Regulation No. 142/2011, in Italy, livestock carcasses may be left in the field for the conservation of following species:

1. Bearded Vulture (*Gypaetus barbatus*)
2. Cinereous Vulture (*Aegypius monachus*)
3. Egyptian Vulture (*Neophron percnopterus*)
4. Griffon Vulture (*Gyps fulvus*)
5. Golden Eagle (*Aquila chrysaetos*)
6. Black Kite (*Milvus migrans*)
7. Red Kite (*Milvus milvus*)

An official note published on July 10, 2013 (DGISAN No. 29562) by the General Directorate for Food Hygiene, Safety, and Nutrition of the Italian Ministry of Health provided operational guidelines for local authorities regarding the authorization of fenced feeding stations for scavenging birds. It foresees those regional authorities, along with the autonomous provinces of Trento and Bolzano, should seek an assessment from the National Institute for Environmental Protection and Research (ISPRA) regarding the role of supplementary feeding in conserving specific scavengers. This aligns with the provisions outlined in Annex IV, Section II, Paragraph II, Point 1, Letter d) of Regulation No. 142/2011. The note also designates local health units (ASL) as the primary authorities responsible for issuing permits and developing specific authorization forms for supplementary feeding stations. Furthermore, it outlines site requirements, including distance from human settlements and fence height, as well as the process for carcass disposal. However, the note does not provide specific guidance on the provisioning of carcasses outside fenced feeding stations. Apart from the obligations set forth in Annex VI of Regulation No. 142/2011, no additional technical or operational criteria are specified at the national level for authorizing farmers to leave animal byproducts in the field for scavengers in Italy.

7.1.2 Legal framework in Sardinia

In 2014 the Regional Department for Environmental Protection of Sardinia, having accepted the *Preliminary proposal for the feeding of Griffon Vultures outside of feeding stations* submitted by a group of experts (Aresu *et al*., unpublished), as well as the positive opinion expressed by ISPRA regarding the same proposal (note no. 48507 dated December 3, 2013), established—through Determination no. 422 of May 13, 2014—the geographical area in which Griffon Vulture feeding is permitted. This area includes nearly all Natura 2000 sites and Wildlife Protection Oases located in central-northern and northwestern Sardinia.
Afterwards the Veterinary Public Health and Food Safety Service of the Sardinia Region established a working group to develop an experimental feeding project for the Griffon Vulture through the creation of farm feeding stations. The group subsequently defined the procedure for issuing authorizations to farm feeding stations for necrophagous birds following the derogation from European regulations (Regulation No. 142/2011) and prepared the necessary forms for farmers.
The procedure's objectives were to standardize at the regional level:
a) the operational methods for submitting applications for authorization to use category 1 materials for feeding Griffon Vultures
b) the processes for issuing authorizations by the local health authorities (Azienda Sanitaria Locale; ASLs) responsible for each territory
c) the list of duties and responsibilities for both applicants and the competent authorities;
d) the registration of the farm feeding station in the national SINTESI system in accordance with Article 23 of Regulation (EC) 1069/2009.

As detailed in the procedure, in the activities related to the issuance of authorizations and the monitoring of the proper functioning of the feeding stations, the ASL Veterinary Service will be supported by technicians from the Department of Veterinary Medicine of the University of Sassari, the lead institution of the LIFE Under Griffon Wings – Implementation of Best Practices to Rescue Griffon Vultures in Sardinia project (LIFE14/NAT/IT/00484). Specifically, farmers will receive assistance from the project group throughout the authorization process and, upon receiving the health authorization, will be provided with an electric enclosure free of charge to demarcate the identified trophic area.
Over the subsequent five years, the project group will monitor the feeding stations by tracking the number of carcasses supplied, the frequency of vulture visits and the sanitary condition of the carcasses. This monitoring will verify whether the carcasses are effectively utilized by the Griffon Vultures, whether their state of preservation improves with increased food availability, and whether farmers comply with sanitary requirements by refraining from supplying carcasses from animals previously treated with veterinary drugs harmful to necrophagous birds. To ensure compliance, inspections will be conducted on the carcasses in collaboration with the Experimental

Zooprophylactic Institute of Sardinia, which will test for residues of various drug classes, including antibiotics (beta-lactams, tetracyclines, quinolones), non-steroidal anti-inflammatory drugs, benzimidazole antiparasitic, and ivermectin's. For further information http://www.lifeundergriffonwings.eu/export/sites/default/.galleries/doc-notizie/Farm-feeding-station-set-up-plan.pdf

Regional Determination no. 422 of May 13, 2014 was subsequently updated by Determination no. 1199 (RAS Protocol no. 27062 of October 19, 2016) and further revised by Determination no. 351 of May 23, 2021. The latter document lists the Natura 2000 sites where on-farm feeding stations may be authorized, encompassing the majority of the Natura 2000 sites designated in Sardinia (Figure 1). This update was made in response to requests from the coordinators of the Life *Safe for Vultures* project and is aligned with the Griffon Vulture reintroduction program planned for the southeastern part of the island.

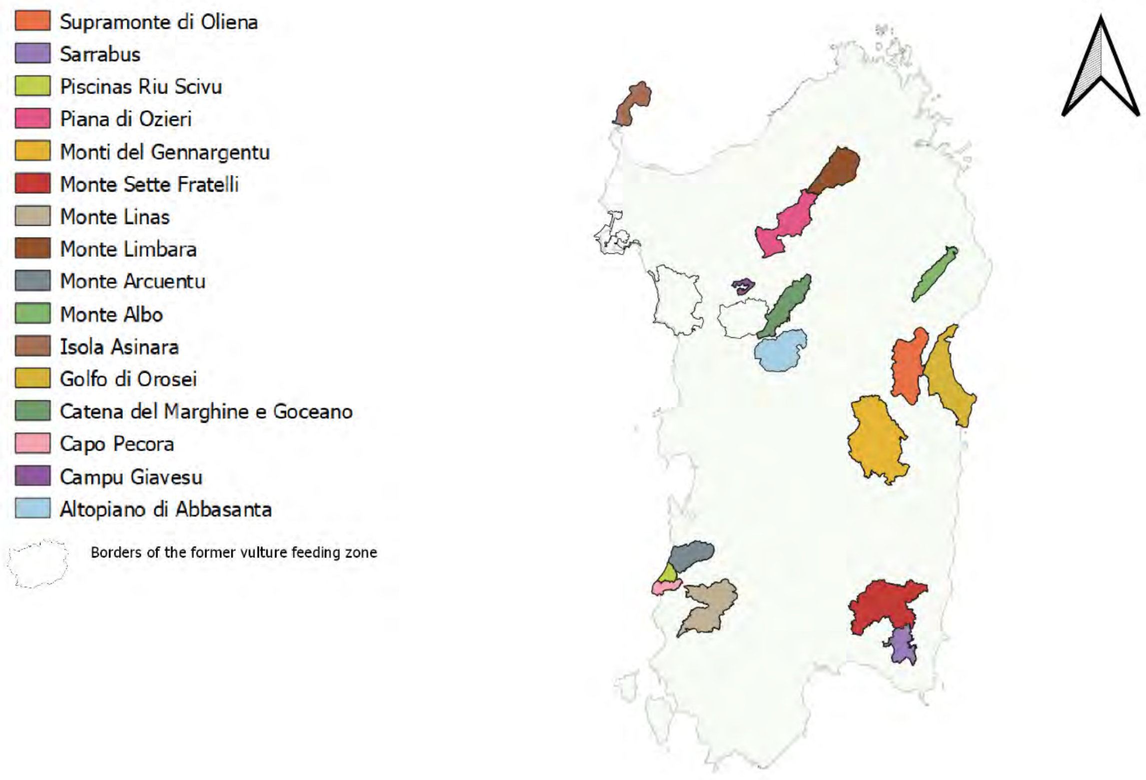


Figure 7.1 *List and location of the Natura 2000 sites comprising the vulture feeding area in Sardinia.*

7.2 Supplementary feeding in Sardinia

The first feeding stations for vultures in Sardinia were established as part of a conservation program primarily targeting scavenger species. This initiative, promoted by WWF/IUCN between 1974 and 1977, aimed mainly to reduce the risk of Griffon Vultures feeding on poisoned carcasses—commonly used at the time in pest control campaigns (poison bait was legally permitted until 1977). A secondary objective was to limit food competition from predators such as foxes, stray dogs, and wild boars, and

to ensure food availability during periods of scarcity, particularly immediately after fledging of the year's young (Schenk, 1976; 1978).
Two fenced feeding stations of approximately 1 hectare each were established in northwestern Sardinia (Bosa and Alghero), along with an unfenced site in the Supramonte area of Oliena (Nuoro Province). A fourth fenced feeding station, attached to an acclimatization aviary, was later created by AFDRS/LIPU in the Montiferru massif (Cuglieri, Oristano Province) as part of a restocking program, with the aim of encouraging site fidelity among released Griffon Vultures (Schenk & Aresu, 1988).
The first three feeding stations operated until the early 1980s, while the Montiferru site remained intermittently active until the late 1990s. Its discontinuation was largely due to the introduction of new European regulations (Directive 2000/148/EC), which imposed a general ban on the use of animal carcasses, effectively outlawing traditional vulture feeding practices.
These early conservation efforts had already highlighted the need for a network of feeding stations in northwestern Sardinia, given the persistent risk of poisoning due to the illegal reintroduction of poison bait. Significant population losses in the 1990s (Aresu & Schenk, 2003) and again during 2006–2007—likely caused by poisoning and/or intoxication—reaffirmed the urgency of reactivating existing feeding stations and developing a functional network of "carnai" (vulture feeding sites). This network was envisioned as being managed preferably by local livestock farmers (on-farm feeding stations), particularly in northwestern Sardinia, home to the only remaining native population of Griffon Vultures in Italy (Schenk et al., 2008).
As a result, the Maria Pilu feeding station (Bosa, Oristano Province) was reactivated and officially authorized on August 11, 2007, under EC Regulation No. 1774/2002. Authorization was granted by the Italian Ministry of Health in collaboration with the Regional Departments of Hygiene, Health, and Social Welfare (Prevention Service), and the ASL No. 5 of Oristano (Veterinary Service for Livestock Hygiene and Animal Production). Between 2007 and 2010, Maria Pilu operated as the only authorized "collection center for category 1 and 2 materials" in Sardinia (Aresu et al., 2010; 2011). Its activity was later suspended following the implementation of the new European Regulation No. 142/2011.
Nowadays the strategy designed in Sardinia combines light feeding stations with a few centralized feeding stations managed by local authorities. This model has been successfully implemented through the LIFE Under Griffon Wings (LIFE14/NAT/IT/000484) and LIFE Safe for Vultures (LIFE19 NAT/IT/000732) projects. As part of these initiatives, the regional agency Fo.Re.S.T.A.S. established three centralized feeding stations at sites hosting Griffon Vulture acclimatization aviaries used for translocations, while the University of Sassari, in collaboration with the local public veterinary services, activated 47 farm feeding stations.
Centralized feeding stations are primarily located in the northwest and southeast of the island, near the release sites of the Porto Conte Regional Park (SS), Monte Minerva (SS) and Villasalto (SU). These stations have been established as part of the LIFE Under Griffon Wings (LIFE14/NAT/IT/000484) and LIFE Safe for Vultures (LIFE19 NAT/IT/000732) projects (Fig. 2).

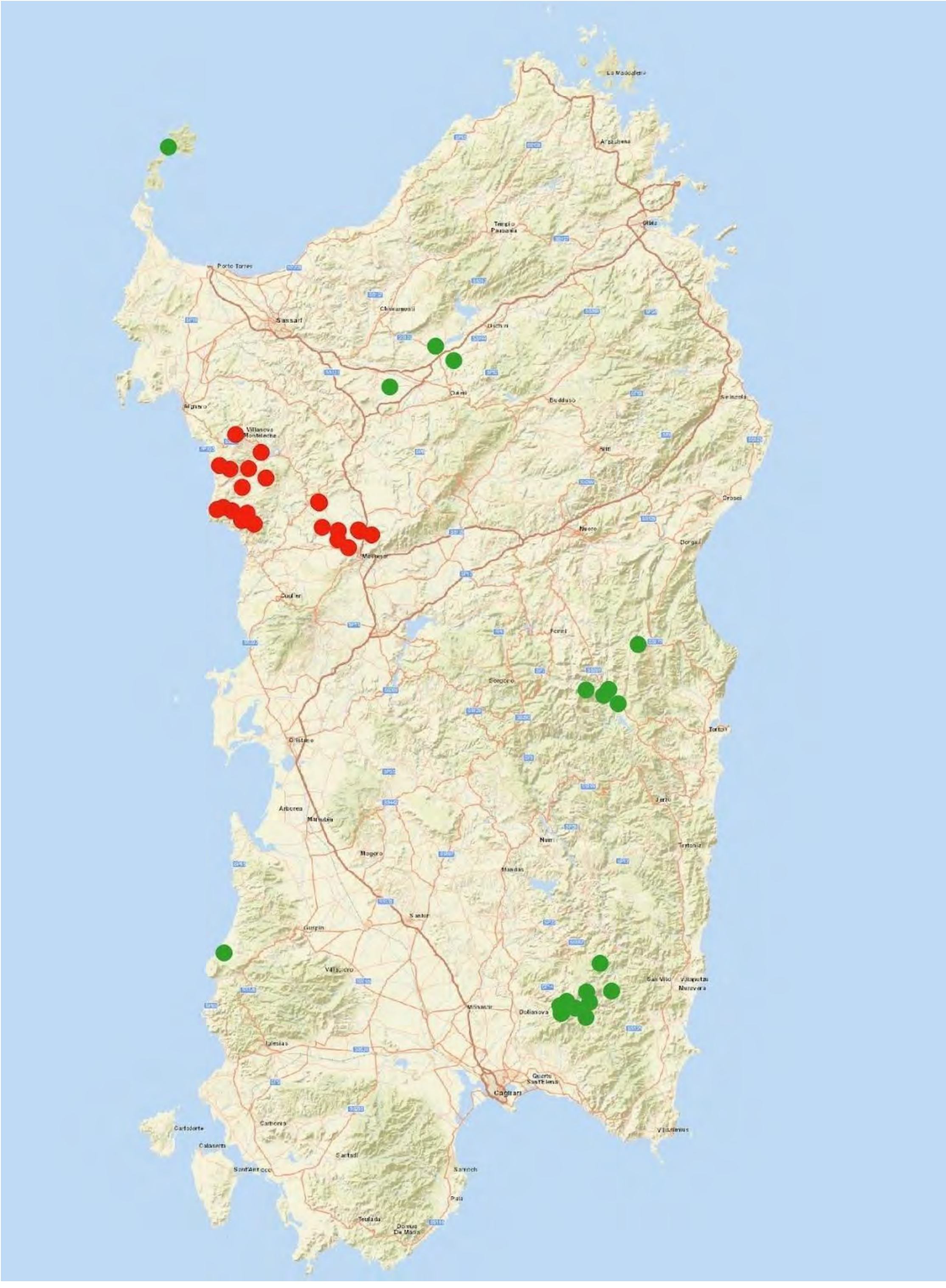


Figure 7.2 *Locations of activated farm feeding stations in Sardinia. Red dots indicate feeding stations established during the LIFE Under Griffon Wings project, while green dots represent those installed under the LIFE Safe for Vultures project.*

Farm feeding stations are distributed in the nesting and foraging area identified for Griffon Vultures in north-west Sardinia and in the release area for the establishment of the new nucleus of vultures in south-east Sardinia. To engage breeders interested in installing a farm feeding station on their properties, initial contact is made through local mayors and the veterinarians responsible at the relevant veterinary public service. This sector oversees health surveillance, compliance with animal welfare regulations, and the control of animal feed, by-products of animal origin, veterinary drugs, residues, milk, and dairy products. In addition, collaboration is established with local veterinarians who have direct knowledge of breeders and farms in the area.

Following the initial contact, informational meetings are organised to explain the process, timeline, and requirements for setting up a farm feeding station. Upon submission of applications, on-site inspections are carried out by researchers from the Veterinary Department of the University of Sassari, in collaboration with the local public veterinary service. These inspections evaluate the suitability of the proposed location and identify potential risks, such as the presence of power lines or other obstacles. Once a suitable site is identified, the farm feeding station is installed with the support of the shepherd, the *Corpo Forestale e di Vigilanza Ambientale* (CFVA), students, and volunteers involved in the project.

The farm feeding station consists of a lightweight, easily removable structure, including PVC poles measuring 160 cm in height, two wooden poles, and a spring gate. Around the perimeter, a plastic and iron wire cable is installed to conduct electric current from an energiser powered by a solar panel. Detailed descriptions of the installed farm feeding stations and an analysis of the deposited biomass can be found in the report *Technical Description of the Installed Farm Feeding Stations*:

Read the full report

Additional reports on the functioning and biomass deposition in farm feeding stations:

2018 Report

2019 Report

2020 Report

2024 Report

By implementing farm feeding stations, carcasses that would otherwise be classified as special waste are repurposed into a valuable food source for Griffon vultures. Additionally, these sites have the potential to become attractions for photographers and birdwatchers. A dedicated Business Plan has been developed, demonstrating that with minimal investment farmers could generate revenue by adapting these feeding stations for ecotourism activities such as wildlife photography and birdwatching.

Read the Business Plan http://www.lifeundergriffonwings.eu/export/sites/default/.galleries/doc-notizie/Business-Plan-Carnai-Aziendali-per-sito-web.pdf

7.3 Griffon vulture population viability analysis

To estimate the biomass needed to sustain the population of the 3 species of vultures, first we needed to estimate the growth rate of the Griffon Vulture population to predict population size in the next years. At this aim we conducted a population viability analysis (PVA) using Vortex simulation software (R. Lacy & Pollak, 2014), which is one of the most commonly used tools for PVAs. The program uses vital rate estimates (survival, reproduction, dispersal), along with population characteristics (e.g. initial population size, age distribution, carrying capacity, and harvest or restocking), to simulate population dynamics over time by creating a representation of each individual in the population, and following their fate through a time series of stochastic demographic and environmental events (R. C. Lacy, 1993, 2000).

Baseline model inputs

Demographic parameters were introduced into Vortex simulation software (Version 10.2.6; Lacy et al., 2017) in order to build a PVA. We developed a baseline model using demographic input parameters from a variety of sources, including original data, previously published information (Aresu et al., 2020), and discussions with experts on the species (Table 7.1). The parameters used in the baseline method are those of unmanaged populations. We parameterized the baseline model as a three-population projection (Alghero, Bosa and Villasalto population, with different reproductive rates and located at a distance of >40 km from each other) with 1,000 iterations to provide reliable estimates of risk. We scaled extinction risks to generations (O'Grady et al., 2008; Reed & McCoy, 2014) and extended the time frame to five generations (55 years). Estimated generation time was approximately 11 years as calculated in Vortex using the Euler equation (Lacy et al., 2017). We defined extinction as occurring when only one sex remained. Because little is known about the effects or impacts of inbreeding depression on Griffon Vultures, and because starting from 1987 several restocking programs were carried out in Sardinia, we developed models without including inbreeding depression. Estimates for age at first reproduction, lifespan and brood size were set as fixed variables in our PVA, whereas stochasticity was built into models through environmental variation in the proportion of females breeding successfully in a year and age-specific annual survival (Table 7.1). The potential effects of harvesting and genetic management were not included in the simulations.

Table 7.1 *Vortex parameter inputs for the baseline Griffon Vulture population model. EV: environmental variation*

Parameter	Value	Source
Species description		Assumed
Inbreeding Depression	No	
EV Correlation of Reproduction and Survival?	Yes	
Dispersal among population		Assumed
Dispersing classes	Age range: Youngest 1 yr, Oldest 3 yr - Dispersing sexes: males and females	
Survival of dispersers	72%	
% of individuals that disperse	Bosa: 0%; Alghero to Bosa 15%, Villasalto to Bosa 40%	
Reproductive System		Campbell, 2015, García-Ripollés and López-López, 2011, Pavoković and Sušić, 2006
Reproductive System	Long-term monogamy	
Age of 1st Offspring Females	6	
Age of 1st Offspring Males	6	

Maximum lifespan	20	
Max Age of Reproduction	20	
Max # Broods/Year	1	
Max # Progeny/Brood	1	
Sex Ratio at birth in % Males	50	
Reproductive Rates		Original data
Productivity	Alghero: 80; Bosa: 63.8, Villasalto 63.8	
EV (SD) in productivity	Alghero: 29.6; Bosa: 5.1, Villasalto 5.1	
Distribution of Broods each Year	0- Alghero 0, Bosa 26.6, Villasalto 26.7; 1-Alghero 100, Bosa 73.3, Villasalto 73.3	
Mortality rates (equal values for male and females and for the two populations)		García-Ripollés and López-López, 2011
from 0 to 1 (SD)	14.2 (3.9)	
from 1 to 2 (SD)	14.2 (3.9)	
from 2 to 3 (SD)	14.2 (3.9)	
from 3 to 4 (SD)	3.3 (3.7)	
from 4 to 5 (SD)	3.3 (3.7)	
Annual mortality after age 5 (SD)	3.3 (3.7)	
Catastrophes		Original data
One type	Poisoning	
Frequency (Alghero and Bosa populations)	10%	
Severity: reproduction	Alghero: 0.592; Bosa: 0.787	
Severity: survival	Alghero: 0.625; Bosa: 0.796	
Mate Monopolization		
% Males in Breeding Pool	100%	
Initial Population Size		
Stable Age Distribution?	Yes	Assumed
Initial Population Size	Alghero: 50; Bosa: 336, Villasalto: 38	Aresu and Schenk, 2006
Age ratios (% of population)	Specified age distribution	García-Ripollés and López-López, 2011, Pavoković and Sušić, 2006
Carrying Capacity (K)	Alghero: 200; Bosa: 900; Villasalto: 200	Aresu and Schenk, 2006

Dispersal

As a three-population projection, we had to define in our scenario the dispersal rates among populations. Over the years, dispersal of immature vultures from the Alghero area to Bosa has been observed by ornithologists, while no record exists of the dispersal of individuals from the Bosa area to Alghero. As previously assumed (Aresu et al., 2020), we foresaw that 15% of vultures aged 1–3 years disperse from Alghero to Bosa and that both sexes disperse. We also assumed that the survival of dispersers did not differ from non-dispersers, given the low distance between the two populations. As for the Villasalto population, we foresaw that 40% of individuals aged 1–3 years would disperse to Bosa and that both sexes disperse. This percentage was estimated from the actual number of individuals released in Villasalto in 2024 that joined the Bosa colony (15/38).

Reproductive system

Griffon Vultures are long-term monogamous, and individuals of both sexes can breed at six years old. They lay one egg per clutch. Maximum age of reproduction is estimated at 20 years (García-Ripollés & López-López, 2011; Pavokovic & Susic, 2005). Griffon Vultures are sexually monomorphic, and the sex ratio cannot be estimated from field observations. Therefore, we assumed an equal sex ratio for the population, and that the sex ratio at birth was equal.

Reproductive rates

Reproductive rates used in the model were obtained by calculating the median and SD of breeding propensity (number of breeding pairs/territorial pairs) and reproductive success (number of fledglings/breeding pairs) from field data recorded from 2014 to 2024 in the Alghero and Bosa populations. This was a subset of a larger dataset of reproductive records collected from 1986 to 2024 (Figure 7.3). Reproductive rates for the Villasalto population were assumed to be the same as those of the Bosa one, as at the moment, being the restocked individuals all immature (fledged in 2022 and 2023), no data are available.

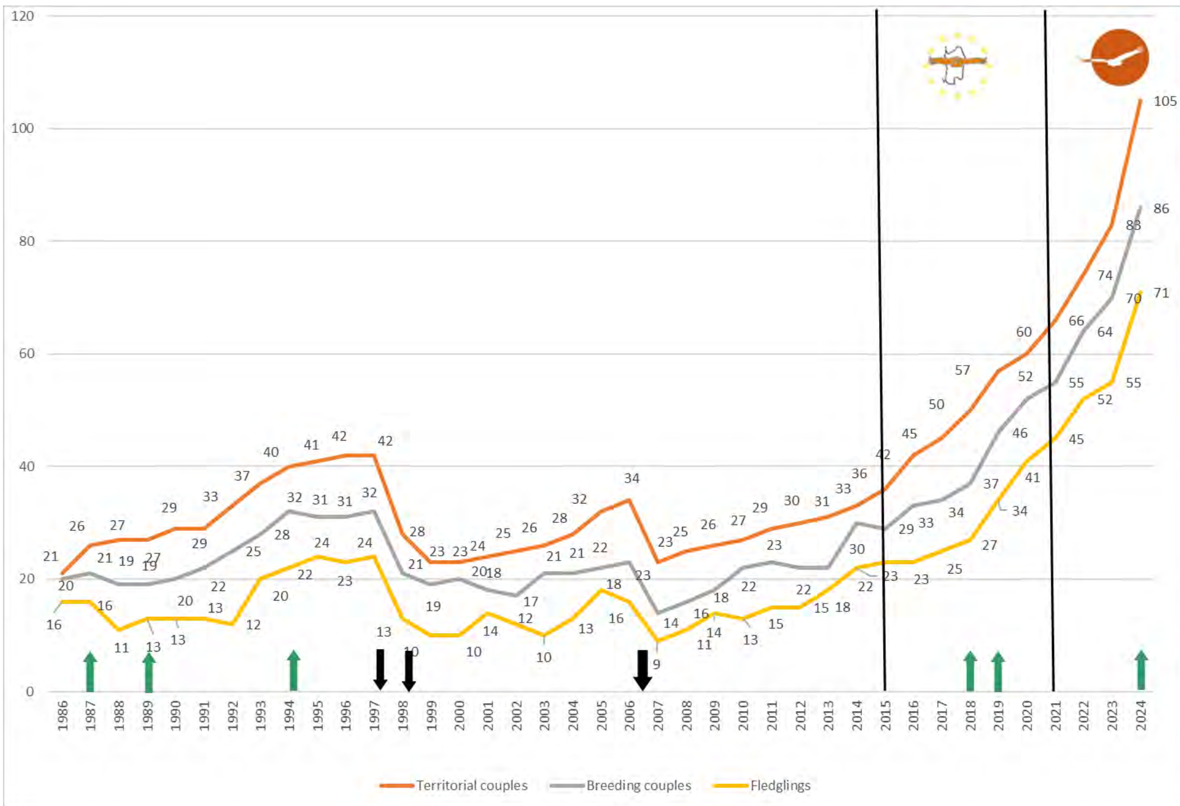


Figure 7.3 *Number of territorial pairs, breeding pairs and fledglings in the population of Griffon Vultures in Sardinia from 1986 to 2024. Grey arrows indicate restocking while black arrows indicate*

poisoning events. The vertical lines delimitate the years under LIFE project management (from 2015 to 2020 LIFE Under Griffon Wings -LIFE14/NAT/IT/000484; from 2021 to 2026 LIFE Safe for Vultures – LIFE19/NAT/IT/000732).

Field work in each breeding season was carried out between December and August to observe the entire breeding period of the species (courtship flights, building nest, deposition, brooding, hatching, breeding of the chicks and the first flight of juveniles). Observations were carried out from vantage points or by rubber dinghy at 300–600 m from the breeding sites with binoculars (8x42, 10x50) and scopes (20–60 x 80). Each colony was visited 6–10 times during each year. Parameters recorded during the breeding period were: i) number of territorial pairs: pairs observed in mating behaviour (display flights, nest repair, mating); ii) number of breeding pairs: pairs incubating the egg; iii) number of fledglings.

Mortality rates

Age-specific mortality rates were taken from our previous report (Aresu et al., 2020) and from the literature (García-Ripollés & López-López, 2011; Gouar et al., 2008) (Table 7.1). Due to the absence of site-specific mortality rates available in the literature, they were considered the same for all populations without sex differences (García-Ripollés & López-López, 2011).

Catastrophes

From 1986 to 2024, three main poisoning events occurred in the Sardinian populations of Griffon Vultures (1997, 1998 and 2006). The episodes resulted in a loss of a significant number of individuals (approximately 40–60). As a result, in our baseline model we included poisoning as a local catastrophic event that can occur in Sardinia. The frequency was set at 8% (3 episodes in 38 years, 7.89%). The effect of catastrophic events on survival and/or reproduction was modelled including a severity factor ranging from 0 to 1 (Lacy et al., 2017). The severity factor with respect to reproduction was modelled as previously reported (Aresu et al., 2020) at 0.592 and 0.787 for the Alghero and Bosa populations, respectively. This means that, in the period of the catastrophe, reproductive rates decreased by 40.8% and 21.3% in the Alghero and Bosa/Villasalto populations, respectively. Survival severity factor was set at 0.625 and 0.796 for the Alghero and Bosa/Villasalto populations, which means that survival rates decreased by 37.5% and 20.4% in the Alghero and Bosa/Villasalto populations, respectively. For example, in a poisoning event in the Alghero population, survival rates of birds aged 0 to 3 years were changed from 85.8 % (considering that mortality rates were set at 14.2 for both sexes and populations) to 53.6% [85.8 - (85.8*0.375)]. For birds aged more than 3 yrs, survival rates were changed from 97.3% to 60.8%. For reproduction we considered for each population the mean decrease in productivity from the year before the catastrophe to the year in which it occurred. For survival, we calculated for each population the decrease in territorial pairs from the year before the catastrophe to the year in which the catastrophe occurred, after subtracting the annual mortality rate of 0.033. We applied this value for the whole population, on the assumption that poisoning would have the same possibility of occurring in all age classes.

Initial population size and age structure
To verify if the baseline model inputs gave realistic projections, we used as a starting point the population size in 2014 (5 and 94 individuals, for the Alghero and Bosa population, respectively) (Aresu & Schenk, 2006) and a simulation time of 10 years (from 2014 to 2024). Figure 7.4 shows how our projection matched the most recent observation data of 2024.

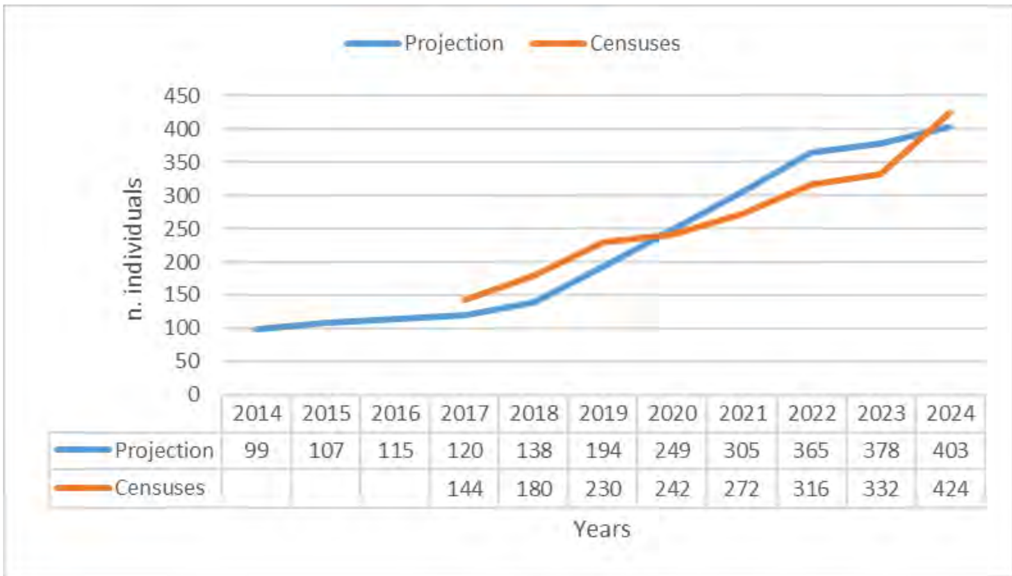


Figure 7.4 *Matching between our projection and the most recent observation data collected from 2017 to 2024.*

Thereafter, we updated the initial population size to 2024 estimates (50 and 336 individuals, for the Alghero and Bosa populations, respectively; project LIFE/19/NAT/IT/000732) and included the Villasalto population to develop our baseline scenario (n = 38; Table 7.1). Precise age-class distribution for each species and each population was not available. Therefore, for the Bosa and Alghero populations age ratios were calculated following ((García-Ripollés & López-López, 2011; Pavokovic & Susic, 2005; Table 7.1). For the Villasalto population, we included the actual data on restocked individuals in 2024.

Carrying capacity (K)
VORTEX implements carrying capacity as a probabilistic truncation across all age classes when K is exceeded. If the population size exceeds K at the end of a particular time cycle, additional mortality is imposed across all age classes in order to reduce the population back to this upper limit (Lacy et al., 2017). Based on historical data on Griffon Vulture population size and distribution in Sardinia (Aresu & Schenk, 2006), we set K as 200 in the Alghero and Villasalto populations and as 900 in that of Bosa.

Sensitivity analysis
Sensitivity analysis is a crucial methodology used to evaluate how variations in the input parameters of a model affect its outputs, such as the projected population growth rate or the estimated risk of extinction. Essentially, it helps to determine which parameters have the most significant "leverage" on the outcomes predicted by the PVA model. Our primary purpose of employing sensitivity analysis

in PVA was to identify the key parameters that exert the greatest influence on population growth rates and overall viability, primarily of the newly established Villasalto population. This nucleus was established in 2024 and hence we do not have long-term monitoring data as for the Bosa and Alghero population. This information is invaluable for guiding management decisions by identifying which factors, if altered through conservation interventions – such as restocking, would yield the most substantial positive impact on decreasing extinction risk. Secondly, we also needed to understand the degree of uncertainty associated with model predictions that arises from uncertainty in the estimates given for mortality rates, especially juvenile. By varying parameter values within a plausible range, we assessed how robust the model's conclusions are to potential errors or natural variability in the input data.

We followed the perturbation approach which involves systematically changing a single parameter to see how much a parameter value can be changed until a population either declines to extinction or persists throughout the study period (if it is going extinct under baseline conditions). We used the sensitivity analysis tool in Vortex. The parameters examined were (Table 7.2): dispersal of the Villasalto population to Bosa, reproductive rates of the Villasalto population, juvenile (< 3 yrs) mortality rates of all populations. We also tested the effect of continuing supplementation to the Villasalto population by increasing the duration of the intervention from 2 to 3, 5, 7 and 10 years and the numbers of individuals to be supplemented from 25 (13 females and 12 males) to 85 (43 females and 42 males). The numbers of individuals to be supplemented were randomly chosen for females and males from across the range specified. Simulation number was set at 100 and each scenario was run for 1,000 iterations and 55 years.

Table 7.2 *Sensitivity testing input table*

Description	Base value	Minimum	Maximum	Choice of parameters
Dispersal – Villasalto pop.	40%	15%	60%	Single factor
Productivity - Villasalto pop.	0.64	0.4	0.8	Single factor
Reproductive success – Villasalto pop.	0.73	0	1	Single factor
Mortality rates (< 3 yrs) – all populations	14%	5%	30%	Single factor
Supplementation – female	13	13	43	Sampled
Supplementation – male	12	12	42	Sampled

Results

Baseline model

Stochastic results for the baseline scenario are shown in Table 7.3. Population growth rates are negative for Villasalto population (-0.0479), and positive for the Alghero (0.0492) and Bosa (0.0581) ones.

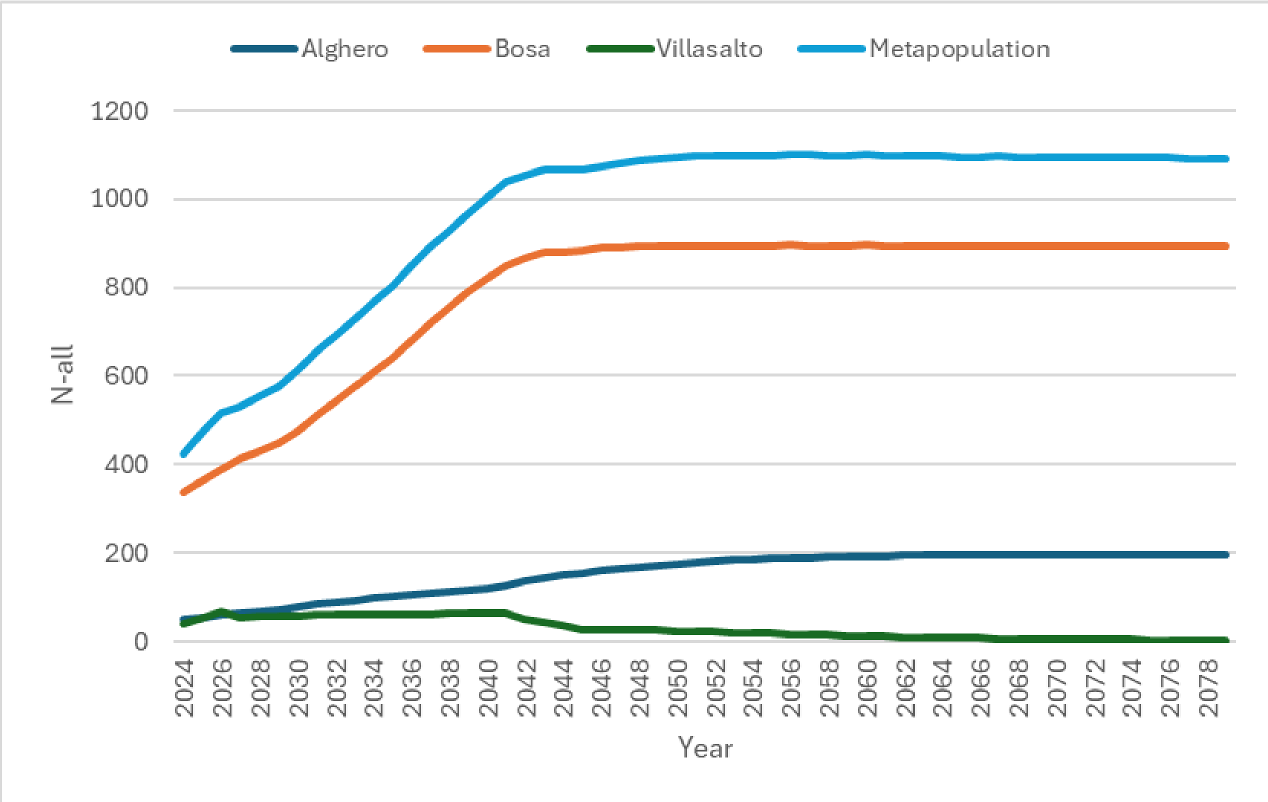
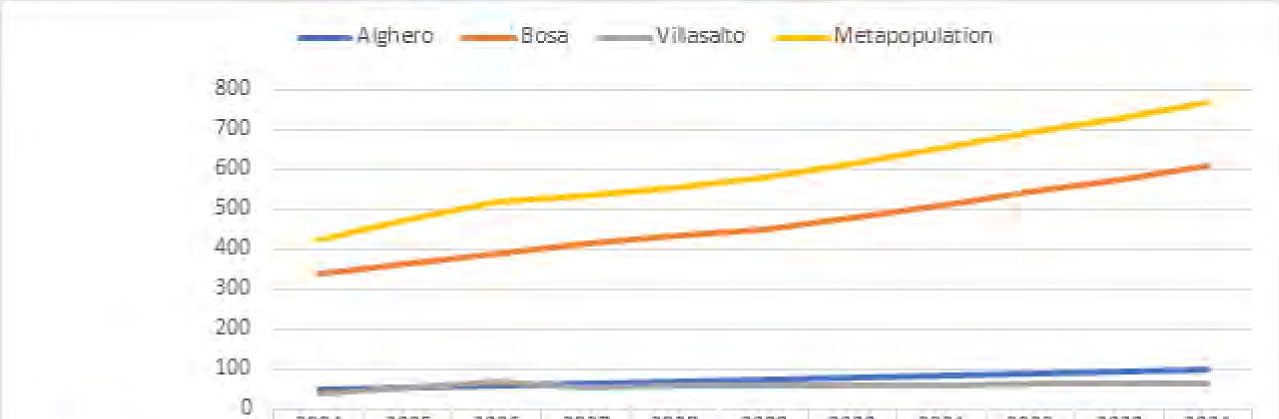


***Figure** 7.5 Probability of extinction for the metapopulation (light blue), for the Alghero population (dark blue), the Bosa population (orange), and the Villasalto population (green).*

The model estimated the probability of extinction as 0 for the metapopulation and as 67% for the Villasalto population, the mean time to first extinction being 46.5 years, corresponding to approx. 4 generations. The mean final metapopulation size was 1092.43 (23.94 SD; Fig. 7.5).

Table 7.3 *Stochastic results for the baseline scenario. PE = probability of extinction; TE: time to extinction.*

Population	det-r	stoch-r	SD(r)	PE	N-extant	SD (N-ext)	N-all	SD (N-all)	Median TE	Mean TE
Alghero	2.0401	0.0492	0.0777	0	195.25	10.09	195.25	10.09	0	0
Bosa	2.2266	0.0581	0.0553	0	895.14	17.27	895.14	17.27	0	0
Villasalto	2.2266	-0.0479	0.1552	0.67	4.64	2.27	2.04	2.38	51	46.5
Meta	2.1979	0.0547	0.0533	0	1092.43	23.94	1092.43	23.94	0	0



	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Alghero	50	55	60	64	68	72	77	83	88	93	98
Bosa	336	363	389	414	431	448	477	511	542	574	608
Villasalto	38	55	67	54	56	57	59	61	61	61	62
Metapopulation	424	474	516	532	555	577	613	655	691	728	767

Figure 7.6 *A closer representation of projected N-individuals from 2024 to 2034.*

Sensitivity analyses

Sensitivity analyses showed that the probability of extinction of the Villasalto population increases steadily when dispersal to Bosa exceeds 30% of the juveniles (<3 years). The other parameters, such as productivity and reproductive success, were less effective in changing the probability of extinction. With 100% reproductive success, the probability of extinction was still at 20%, while keeping dispersal lower than 30% would guarantee the persistence of the population in the projected time frame (Figure 7.7).

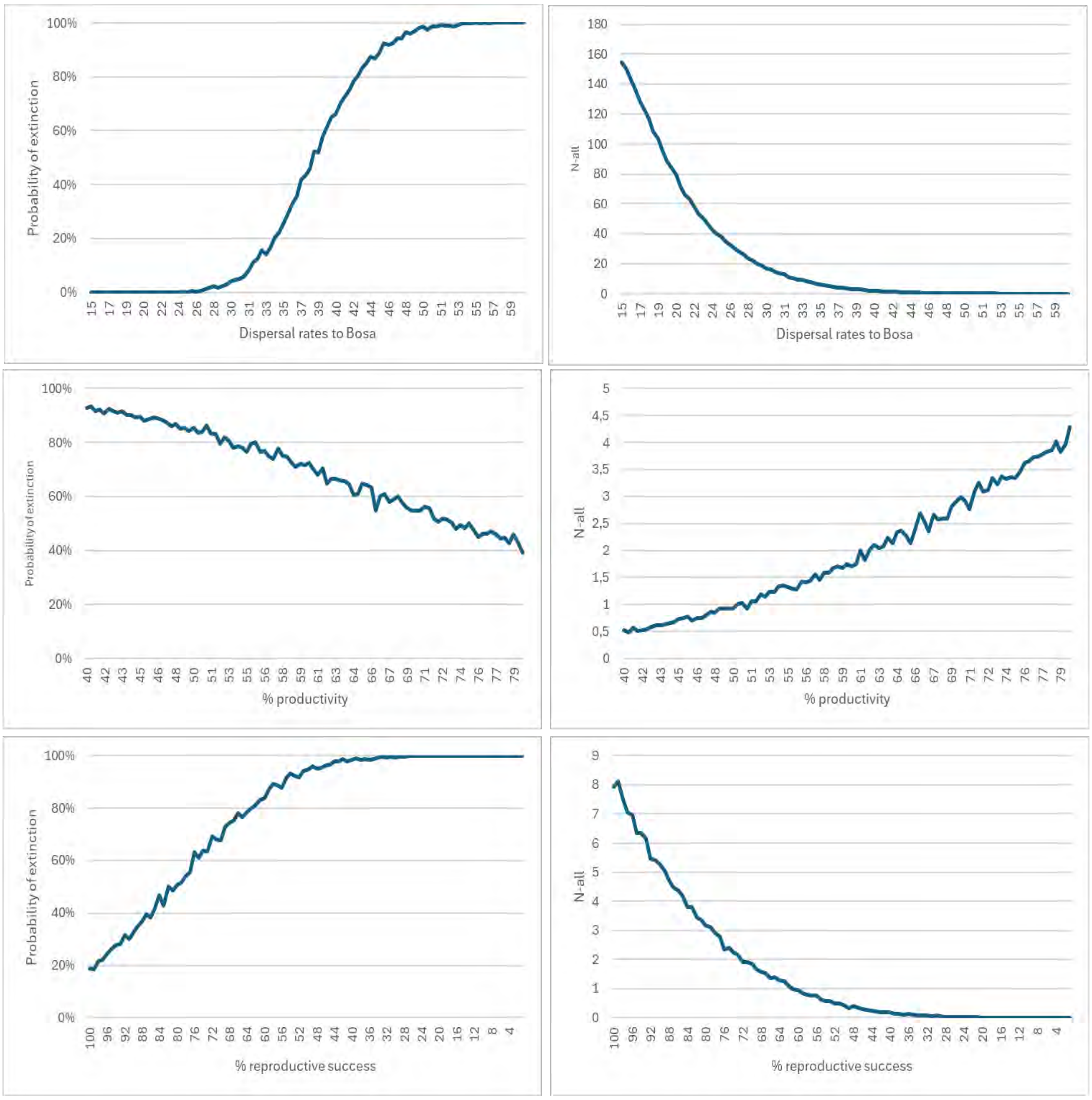


Figure 7.7 *Sensitivity analyses show the effect of perturbation in dispersal and reproductive rates on the probability of extinction and projected individuals after 55 years in the Villasalto population.*

Variations in juvenile (<3 years) mortality rates did not change the probability of extinction of the Alghero and Bosa populations (Figure 7.8). As for the Villasalto population, with mortality rates lower than 5%, the probability of extinction was still at 20%.

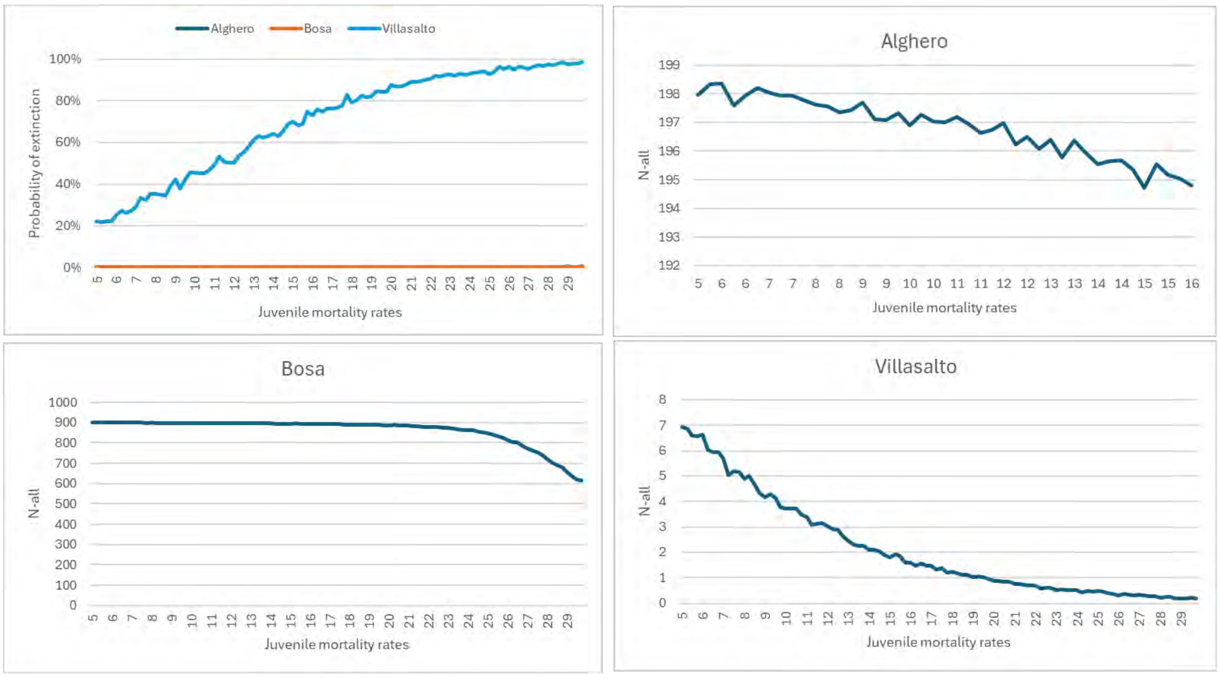


Figure 7.8 *Sensitivity analyses show the effect of perturbation in juvenile mortality rates on the probability of extinction and on individuals after 55 years in the Alghero, Bosa and Villasalto populations.*

Continuing supplementation to the Villasalto population also proved to be effective in decreasing the probability of extinction of this population (Figure 7.9), with the most cost-effective scenario being represented by the supplementation of 19 individuals/year (7 males and 12 females) over 5 additional years (3 additional years compared to the base scenario).

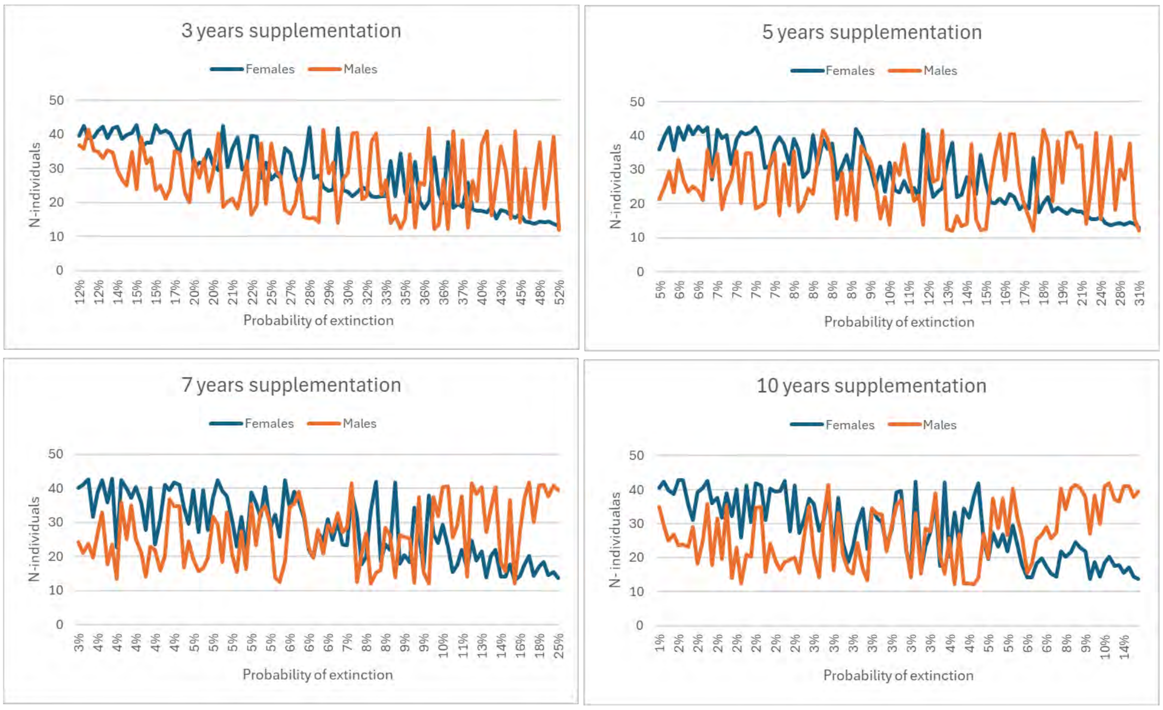


Figure 7.9 *Sensitivity analyses show the effect of supplementation on the probability of extinction of the Villasalto population.*

7.4 Vulture food requirements

In Sardinia food resources for Griffon Vulture mainly consist of carcasses from livestock raised in extensive and semi-extensive farming systems, with sheep and goats accounting for over 80% of their diet (Aresu & Schenk, 2004, 2006; Schenk et al., 1987).

The food requirement in terms of average annual biomass for the Griffon Vulture and Cinereous Vulture is comparable, probably due to the similarities regarding the body mass and trophic habits of the two species. The Bearded Vulture, on the other hand, requires a lower quantity of biomass (70% bone, 25% soft tissue and 5% skin), probably due to its lower body mass and because the species' diet (Houston & Copsey, 1994) is mainly made up of bones. The food requirement of the three vulture species was calculated by Bretagnolle et al. (2004); Donázar et al. (1993); Stoynov et al. (2019) (Table 7.4).

Table 7.4 *Vulture's food requirement (Stoynov et al., 2019).*

	Soft tissue /individual/day in kg	Bones/individual/day in kg	Annual/individual in kg
Gyps fulvus	0,55	0,00	200,89
Aegypius monachus	0,57	0,00	208,19
Gypaetus barbatus	0,08	0,33	149,75

To calculate annual biomass requirements for vultures, we estimated population size of the three species up to 2034. For the Griffon vulture, we used Vortex projections (see previous section, Figure 7.5). For the Cinereous vulture we assumed 15 individuals/years to be reintroduced starting from 2026, with 20% mortality rates after release. For the Bearded vulture we assumed 3 individuals/years to be reintroduced starting from 2026, with 20% mortality rates after release. In both cases, we acknowledge that those are highly optimistic estimates (Figure 7.10).

Figure 7.10 *Estimation of population size of the three vulture species up to 2034.*

Thereafter, we could easily estimate biomass requirements for vultures during this time period (Table 7.5).

Table 7.5 *Estimation of biomass requirements for vultures (GV: Griffon Vulture; CV: Cinereous Vulture; BV: Bearded Vulture).*

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Soft tissues GV (tons)	85	95	104	107	111	116	123	131	139	146	154
Soft tissues CV (tons)	0	0	3	6	8	9	10	12	12	13	14
Soft tissues BV (tons)	0	0	0.09	0.16	0.22	0.27	0.30	0.33	0.36	0.37	0.39
Total (tons)	85	95	107	113	119	125	134	143	152	160	168
% for GV	100%	100%	97%	95%	93%	92%	92%	92%	92%	92%	92%
Bones BV (tons)	0	0	0.36	0.65	0.88	1.06	1.21	1.33	1.42	1.49	1.56

7.5 Current, potential, and future food availability for Vultures in Sardinia

7.5.1 Current food availability for Vultures

Vultures primarily feed on the carcasses of domestic animals (Arrondo et al., 2023). However, not all the available biomass is utilized. Considering food habits of the three species, from the composition of Sarda sheep, goats and cattle raised extensively for meat production, we estimated the kilos of biomass consumed by GV, CV and BV (Table 7.6).

Table 7.6 *Estimated biomass (kg) consumed by Griffon Vultures (GV), Cinereous Vultures (CV), and Bearded Vultures (BV) based on the composition of extensively raised Sardinian sheep, goats, and cattle used for meat production.*

Composition of an adult Sarda sheep/goat (45 kg)	Estimated kg	Griffon Vulture	Cinerous Vulture	Bearded vulture
Muscle	13	☑ Yes	☑ Yes	☑ Yes (limited quantity ≈ 25% of food requirements)
Viscera	9	☑ Yes (preferred)	☑ Yes (preferred)	✗ No
Blood	3	☑ Yes	☑ Yes	✗ No
Bones	8	✗ No	✗ No (but they can strip the flesh off)	☑ Yes (bone marrow ≈ 10-15% of bone weight)
Skin and fat tissues	6	✗ No	✗ No (difficult to strip off)	☑ Yes (limited quantity ≈ 5% of food requirements)
Biomass available for consumption (kg)		25	25	32.2
		Consumed by		
Composition of an adult cattle (700 kg)	**Estimated kg**	**Griffon Vulture**	**Cinerous Vulture**	**Bearded vulture**
Muscle	270	☑ Yes	☑ Yes	☑ Yes (limited quantity ≈ 30 kg indv/year)
Viscera	140	☑ Yes (preferred)	☑ Yes (preferred)	✗ No
Blood	15	☑ Yes	☑ Yes	✗ No
Bones	140	✗ No	✗ No (but they can strip the flesh off)	✗ No (they cannot break them)
Skin and fat tissues	105	✗ No	✗ No (difficult to strip off)	☑ Yes (limited quantity ≈ 5% of food requirements)
Biomass available for consumption (kg)		425	425	530

According to data collected during the LIFE Under Griffon Wings project, mortality rates have been estimated at 8% for sheep/goat and 3% for cattle. The annual biomass generated for vultures has been calculated using the following formula: number of heads reared x mortality rate x kg of biomass actually consumed by the three vulture species.

Currently, in Sardinia, there are 47 active farm feeding stations and 3 centralized feeding sites. Unfortunately, over the years, 11 farm feeding stations have been closed by the competent local health authorities (ASL).

Table 7.7 shows the number of carcasses in farm (potentially available on the basis of reared livestock mortality rates) and centralized feeding stations (actual provisioned) in 2024.

Table 7.7 *Number of carcasses in farm (potentially available on the basis of reared livestock mortality rates) and in centralized feeding stations (actual provisioned) in 2024 and biomass made available to vultures. The estimation of quintals of soft tissues and bones generated from livestock carcasses for vultures is based on figures given in Table 6. For wild ungulates, we used same figures as for sheep/goat.*

		Cattle	**Sheep**	**Goat**	**Wild ungulates**	**Total**
Farm feeding stations - FFS	Life Under Griffon Wings (n. heads in 26 FFS)	3660	7218	14		10892
	Life Safe for Vultures (n. heads in 21 FFS)	797	5005	4891		10693
	Total (n. heads raised)	**4457**	**12223**	**4905**		21585
	Mortality rates	3%	8%	8%		
	Soft tissues available for	**56.8**	**24.4**	**9.8**		**91.1**

	vultures/year (tons)					
	Bones available for vultures/year (tons)		**1.2**	**0.5**		**1.6**
Centralized feeding stations	Porto Conte (n. carcasses)		39			39
	Monte Minerva (n. carcasses)		5			5
	Villasalto (n. carcasses)		37		7	44
	Total (n. carcasses)		**81**		**7**	**88**
	Soft tissues available for vultures/year (tons)		**2.0**		**0.2**	**2.2**
	Bones available for vultures/year (tons)		**0.1**		**0.0**	**0.1**
Total	Soft tissues available for vultures/year (tons)	**56.8**	**26.5**	**9.8**	**0.2**	**93.3**
	Bones available for vultures/year (tons)		**1.3**	**0.5**	**0.0**	**1.7**

From this estimation 93.3 tons of biomass was available in 2024 from farm and centralized feeding stations for vultures. This covers vulture requirements for 2024 and 2025 (85 and 95 tons, respectively; Table 7.5). Moreover, the 1.7 tons of bones produced would already cover for the requirements of the 13 Bearded Vultures potentially present in Sardinia by 2034.

7.5.2 Potential food availability for Vultures in Sardinia

Domestic livestock

The project LIFE Safe for Vultures has favoured, in collaboration with the Regional Departments for the Environment and for the health, the extension of the feeding area of the Griffon Vulture from approximately 51,163 ha to 330,109.69 ha (278,946.69 ha more) in the Nature 2000 sites in the central, eastern and southern Sardinia. In these areas (Fig. 7.1), inside the Nature 2000 network, a minimum of 30 farm feeding stations will be activated by 2026.

Data on carrying capacity of the vulture feeding zone have been calculated considering the number and consistency of farms located in the proposed area provided by the Regional Veterinary Epidemiological Observatory. From these data we estimated the potential availability of biomass – both soft tissues and bones - for vultures (Table 7.8).

Table 7.8 *Estimated quintals of biomass available for vultures in SPA and SCIs comprised within the vulture feeding area in Sardinia. Biomass q/year were calculated according to formula: n. heads x mortality rate x kg soft tissues/bones consumed by vultures (see Table 7.6).*

SITE NAME	N. farms	SMALL RUMINANTS			CATTLE			TOTAL	
		N. heads	Soft tissues (tons)	Bones (tons)	N. heads	Soft tissues (tons)	Bones (tons)	Soft tissues (tons)	Bones (tons)
Altopiano di Abbasanta	653	99786	200	10	4961	63,25	3,13	262,82	12,70
Campo di Ozieri e Pinaure comprese fra Tula e Oschiri	281	55607	111	5	3062	39,04	1,93	150,25	7,27
Capo Pecora	19	3110	6	0	0	0,00	0,00	6,22	0,30
Catena del Marghine e del Goceano	127	10174	20	1	1632	20,81	1,03	41,16	2,00
Da Piscinas a Rio Scivu	3	834	2	0	57	0,73	0,04	2,39	0,12
Golfo di Orosei	139	6704	13	1	884	11,27	0,56	24,68	1,20
Monte Albo	28	1405	3	0	476	6,07	0,30	8,88	0,43
Monte Arcuentu e Rio Piscinas	48	5046	10	0	157	2,00	0,10	12,09	0,58
Monte dei Sette Fratelli	198	15382	31	1	3302	42,10	2,08	72,86	3,56
Monte dei Sette Fratelli e Sarrabus	2	284	1	0	0	0,00	0,00	0,57	0,03
Monte Limbara	60	3959	8	0	953	12,15	0,60	20,07	0,98
Monte Linas-Marganai	81	7886	16	1	80	1,02	0,05	16,79	0,81
Monti del Gennargentu	375	33557	67	3	10373	132,26	6,53	199,37	9,76
Parco Nazionale dell'Asinara		1900	4	0	0	0,00	0,00	3,80	0,18
Piana di Ozieri, Mores, Ardara,Tula e Oschiri	126	19165	38	2	2250	28,69	1,42	67,02	3,26
Supramonte di Oliena, Orgosolo e	115	7059	14	1	1937	24,70	1,22	38,81	1,90

Urzulei - Su Sercone									
Entroterra e zona costiera tra Bosa, Capo Marargiu e Porto Tangone	28	10920	22	1	1017	12,97	0,64	34,81	1,69
Valle del Temo									
Costa e Entroterra di Bosa, Suni e Montresta									
Piana di Semestene, Bonorva, Macomer e Bortigali	67	26597	53	3	3728	47,53	2,35	100,73	4,90
Altopiano di Campeda									
Total	**2350**	**309375**	**619**	**30**	**34869**	**445**	**22**	**1063**	**52**

Considering the requirements of the 3 vulture species up to 2034, the availability in soft tissues and bones exceeds by approx. 10 and 26 times the tons needed, respectively (Table 7.5).

Wild ungulates

Wild ungulates could represent a potential additional food source of carcasses for vultures. This population is mainly represented by Wild boars (*Sus scrofa meridionalis*), European mouflons (*Ovis gmelini musimon*), Sardinian deer (*Cervus elaphus corsicanus*) and fallow deer (*Dama dama*), of these species in Sardinia only the wild boar is huntable, so data are provided by Carta delle Vocazioni Faunistiche della Sardegna in 2012, obtained by roaring counts for Sardinian deer, by visual counts for both fallow deer and European mouflon and by territorial institutions and hunting associations for wild boar (Table 7.9).

Table 7.9 *Population size and distribution of wild ungulates in Sardinia. Data are provided by Carta delle Vocazioni Faunistiche della Sardegna in 2012, obtained by roaring counts for Sardinian Deer, by visual counts for both fallow deer and European mouflon and by territorial institutions and hunting associations for Wild Boar, which is the only huntable species.*

Area	***Cervus elaphus***	***Dama dama***	***Ovis gmelini musimon***	***Sus scrofa***
Northern Sardinia	406	300	655	Medium-high (5-10 heads/100ha)
Central - eastern Sardinia	100	50	5999	Medium-low density (5 heads/100 ha)
Central - western Sardinia		193	341	High density (10-15 3 e >1 heads/100ha)
Southern - eastern Sardinia	1913		90	Medium-low density (5 heads/100 ha)
Southern - western Sardinia	4417	217		Medium-low density (5 heads/100 ha)
Other areas	150			
Total	6986	760	7085	18750

An estimation of biomass provided to Griffon Vultures by wild ungulates has been provided. The average weight of wild ungulates present on the island is estimated at 44 Kg for Wild boars, 36.25 Kg for European mouflons, 98.75 Kg for Sardinian deer and 60 Kg for fallow deer. Annually mortality rates have been prudently underestimated at 3%, considering that part of the carcasses could be located in an area not accessible to Griffon Vultures. Biomass Kg/year were calculated according to formula: n. individuals x average weight x mortality rate x 27%. The total Griffon Vultures fed per year were calculated by dividing the biomass by annual feed intake of Griffon Vultures (Stoynov et al., 2019; Table 7.4). Based upon these values, the biomass available for vultures from wild ungulates in Sardinia is presented in Table 7.10.

Table 7.10 *Estimated annual biomass (kg) available for vultures from wild ungulate carcasses in Sardinia and the corresponding number of Griffon Vultures (GV) potentially supported by this resource. Estimates are based on population size and average carcass biomass per species.*

Species	**Estimated population size**	**Estimated kilos of biomass produced per year**	**Estimated number of Griffon Vultures fed**
Sardinian deer (*Cervus elaphus*)	6986	5587.93	27.83

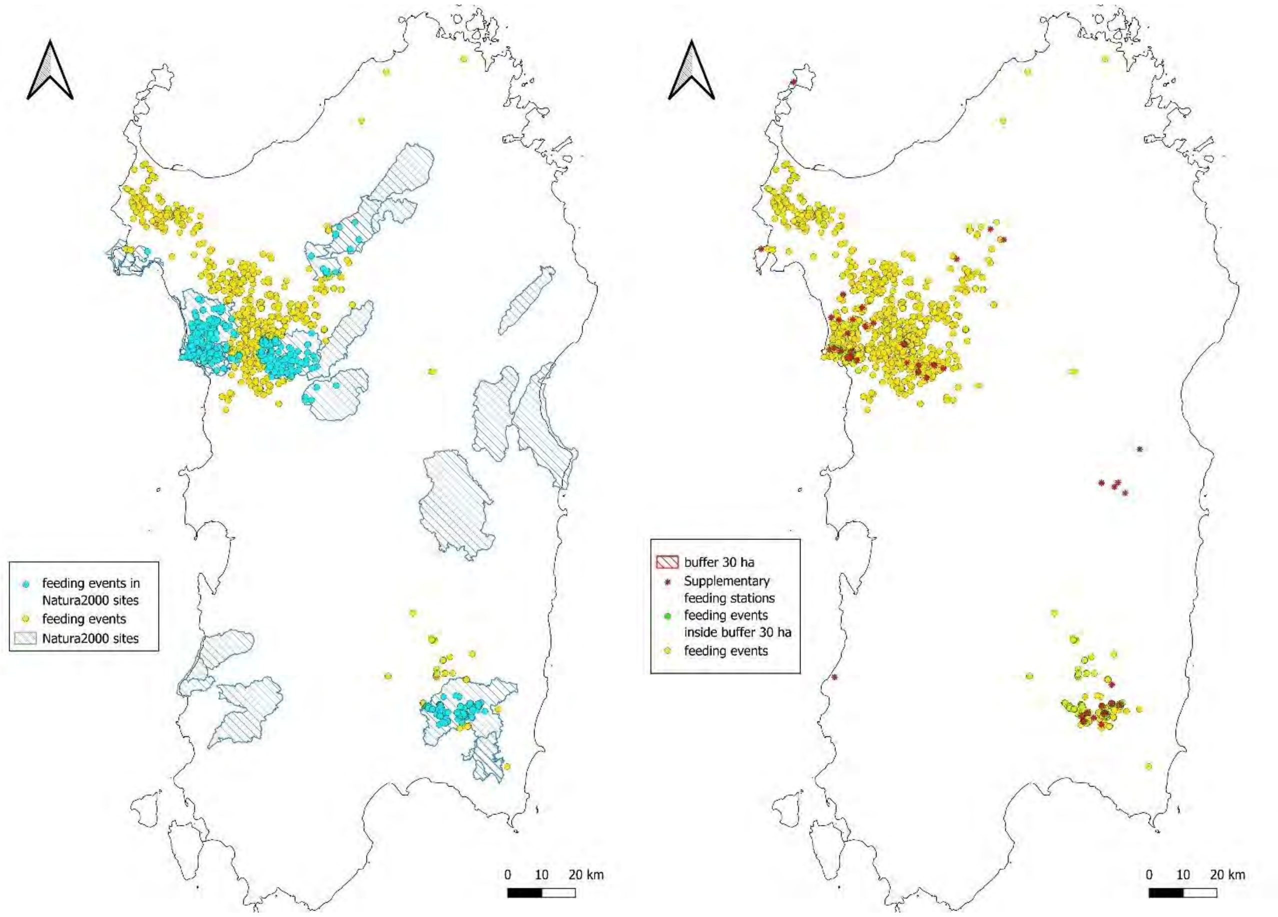
Fallow deer (*Dama dama*)	760	369.36	1.84
European mouflon (*Ovis gmelini musimon*)	7085	2080.33	10.36
Wild boar (*Sus scrofa*)	18750	6682.50	33.28
TOTAL		14720.12	73.31

A study showed that in vultures preferentially used areas with high food resources, namely wild ungulates in winter and a mixture of wild ungulates and livestock in summer (Martin-Díaz et al., 2020) so it is possible that in Sardinia there is a similar condition or that wild ungulates would represent a minor and alternative source of food for vultures, but the actual use of this resources by avian scavengers in Sardinia needs to be evaluated. The rapid growth of the Sardinian deer in south Sardinia may in fact represent an additional resource in the future.

7.5.3 Feeding ground analysis

Some of the individuals released within the LIFE projects were equipped with Ornitela GPS tags with tri-axial accelerometer sensors - 6 within the LIFE Under Griffon Wings and 33 within the LIFE Safe for Vultures. Using a random forest algorithm, we identified feeding events from the acceleration data.

Between May 2020 and February 2025, we detected 6665 feeding events of the 39 individuals pooled together. Of these, 4591 feeding events were inside the Natura 2000 sites of the vulture feeding zone (Fig 7.11), accounting for the 68.88%, while 1357 feeding events were around the supplementary feeding stations, accounting for the 20.22% of the total (Fig. 7.12).



Figures 7.11 and 7.12. *Feeding events inside the Natura 2000 sites and in farm feeding stations.*

For this analysis, we created a buffer area of 30 hectares around each farm feeding station to include carcasses potentially left in the surrounding fields and to accommodate GPS location error. The 30-hectare buffer was chosen based on the average size of farms with meadows and pastures in Sardinia (Regione Autonoma della Sardegna, 2013).

7.5.4 Future food availability for vultures in Sardinia

Given the development of the livestock sector in Sardinia and the widespread distribution of extensive farms, food availability should not be considered a limiting factor for scavenger birds. The collaboration with herders has ensured the provisioning of the centralized feeding stations and the activation of 47 farm feeding stations. As foreseen in the project LIFE Safe for Vultures, this number will be increased to 55 by the end of 2025. Accelerometer data from 2019 to 2024 from 6 Griffon Vultures equipped with Ornitela devices with GPS and accelerometer sensor were analysed to identify feeding events. The density of feeding events peaked in three hotspots. Two of them were in the background of the main colony of Bosa, between Capo Marrargiu and the municipality of Pozzomaggiore, and they significantly overlapped with two Natura2000 sites. A third hotspot was located approx. 30 km northwest, in the Nurra plain, and it fell entirely outside of the Natura2000 network. These hotspots covered an area of approximately 225 km^2. The two hotspots that were closer to the colony of Bosa were approx. at a distance of 15 km (Fozzi et al, accepted for publication in *Ornithological Applications*). From these data, we can conclude that outside the network of feeding

sites, carcasses are also left undisposed in the field and consumed by griffon vultures. Carcasses left in the field, while providing additional carrying capacity, albeit difficult to be estimated, can represent a risk by attracting vultures near to energy infrastructures or by the potential presence of vet drug residues.
The further increase in the number of farm feeding stations should therefore be promoted, as a measure to ensure the safety of the resource and the long-term persistence of vulture populations. The challenge is indeed to sustain the growth of the griffon vulture population, whose requirements up to 2034 stand for the 92% of the quintals of soft tissues needed (Table 7.5). Table 7.9 shows the estimated number of farm feeding stations which should be activated by 2034. Given the annuals resources generated by the already activated farm feeding stations (Table 7.7), we calculated the mean annual quintals of soft tissues (1.94 tons) and bones (0.01 tons) generated by a single farm feeding station.

Table 7.11 *Estimated number of farm feeding stations to be activated up to 2034. The mean annual quintals of soft tissues (19.4 q) and bones (0.94 q) generated by a single farm feeding station was divided by the quintals of biomass needed.*

	Soft tissues (tons)	**FFS**	**Bones (tons)**	**FFS**
2024	85.2	4.4	0.0	0.0
2025	95.2	4.9	0.0	0.0
2026	106.8	5.5	3.6	3.8
2027	112.6	5.8	6.5	6.8
2028	119.3	6.2	8.8	9.3
2029	125.4	6.5	10.6	11.2
2030	134.0	6.9	12.1	12.7
2031	143.3	7.4	13.3	14.0
2032	151.6	7.8	14.2	15.0
2033	159.7	8.2	14.9	15.8
2034	168.0	8.7	15.6	16.4

7.6 Conclusions

Data presented in this study have highlighted that, thanks to the implementation of the farm feeding stations, resource availability would not be a limiting factor for avian scavenger population growth in Sardinia. The area now included in the vulture feeding area, where farm feeding stations can be activated, covers more than 330 ha and it includes more than 50% of the total Natura 2000 sites in the island. Within this area, mostly characterized by grassland and pastures, are located a total of 2,255 livestock farms, rearing 34,869 cattle and 309,375 small ruminants.
The growth of the vulture population can be sustainably supported by a proportionate increase in the number of centralized and farm feeding stations. Their strategic management of feeding stations, alongside the natural availability of biomass, is essential for maintaining and potentially increasing vulture populations in a sustainable manner.

8. Habitat suitability assessment

The selection of suitable areas in Sardinia for the reintroduction of the Bearded and Cinereous Vultures is crucial for the long-term success of their populations. In this study, we combined an expert-based approach with an analysis of potential nesting sites. The experts provided vital insights into the environmental conditions and local threats.
This section will explore the methodologies used to identify the most promising areas to ensure the long-term conservation of both species.

8.1 Expert-opinion habitat suitability assessment

8.1.1 Introduction

Identifying the most suitable areas of Sardinia, which could be used as release sites for the Bearded and the Cinereous Vulture is crucial to ensure the success of their reintroduction. Although the main goal of reintroductions is to achieve the long-term population viability (Beck, 2007; IUCN/SSC, 2013), through the reproduction and/or the immigration/emigration of individuals from the reintroduced population, these two steps cannot be achieved whenever reintroduced individuals die or do not remain at the release site.
As for vultures, available evidence from translocated or reintroduced populations indicates that post-release mortality can be high and that in many cases post-release dispersal can prevent the formation of stable populations (Gouar et al., 2008).
In this study we used an expert-based approach to identify those Natura 2000 sites which could be used as release sites for the Bearded and the Cinereous Vulture. The elicitation of experts, either through quantitative (Burgman, 2015) or qualitative (Sutherland et al., 2018) methods is a valuable approach, as these individuals typically possess long-term experience of a given area. They combine a deep understanding of the environmental conditions derived from their fieldwork with insights into potential threats to species, gained through interactions with local communities (Rival, 2014).

8.1.2 Methods

Between January and February 2025, we asked 14 experts, who worked on the conservation of vultures and large raptors in Sardinia to name and evaluate the 5 most suitable Natura 2000 sites which could be used as release sites for the Bearded and the Cinereous Vultures.
Our 14 experts have a different background and worked on different aspects of vulture and raptor conservation (e.g., population monitoring, GIS analysis and planning, health, surveillance, interaction with herders and local communities). This diversity ensured that they conveyed different perspectives about the different Natura 2000 sites, their environmental characteristics, and the socio-economic attributes of local communities.
We used the Delphi method (Mukherjee et al., 2015) to ask experts to evaluate different Natura2000 sites. Namely, *i*) we initially provided experts with a semi-structured questionnaire to identify Natura 2000 sites, *ii*) we organized a meeting, where we showed questionnaire structure and outputs, and where we invited experts to re-calibrate their initial evaluation, and finally *iii*) we asked our group of experts to complete the questionnaire again. Delphi methods are a well-established method to collect

and structure experts' knowledge, which use collective deliberation to limit the effect of personal judgment.
Semi-structured questionnaire asked each expert to name the five Natura 2000 sites that they deemed to be the most suitable for releasing the Bearded or the Cinereous Vulture in Sardinia. Then for each site experts were asked to:

1. Evaluate its environmental suitability as a release site for the Bearded Vulture, by accounting for all those factors which could result into a high mortality of released individuals, as well as those which could limit their site fidelity (e.g. insufficient food, human disturbance) or which could increase their dispersal to other areas of Sardinia. Environmental suitability was ranked on a unipolar scale ranging from 1 (minimum suitability) to 10 (maximum suitability).
2. Repeat the same operation for the Cinereous Vulture, as this species has a partially different range of limiting factors (e.g., availability of large trees for nesting), compared to the Bearded Vulture.
3. For both the Bearded and the Cinereous Vulture, name the most significant threats which could undermine the reintroduction of the species at that site as well as the most significant environmental characteristics which could make the release successful.
4. Evaluate the extent to which local communities living within, and around, each Natura 2000 site could oppose a reintroduction project for these two species. On a unipolar scale ranging from 1 (totally oppose the project) to 5 (totally endorse the project) and then with an open-ended question to explain the reasoning behind this evaluation.
5. Evaluate the "logistics" of each Natura 2000 sites, in terms of its accessibility, as well as the availability of staff from environmental agencies and the presence of infrastructures which could be used for the reintroduction projects (e.g. acclimatization aviaries for the Cinereous Vulture). From 1 (very limited) to 5 (optimal) and then explain their reasons with an open-ended answer.
6. Evaluate the likelihood that a certain Natura 2000 site, if not used as a release site, could still be used in the future by the Bearded Vulture as a site for roosting and/or breeding.
7. Evaluate the likelihood that a certain Natura 2000 site, if not used as a release site, could still be used in the future by the Cinereous Vulture as a site for roosting and/or breeding.

When analysing the data we did not consider the single Natura 2000 site but rather divided the whole Natura 2000 network in a series of different "macro areas". In fact, Natura 2000 sites include both Special Areas of Conservation and Special Protection Areas designated respectively, under the Habitats Directive and the Birds Directive, and which often overlap.

8.1.3 Results

Our group of experts identified 10 areas of Sardinia which could be used as release sites for the Bearded and the Cinereous Vulture (Fig. 8.1). Most experts indicated the area between the municipalities of Bosa and Pozzomaggiore (A, n = 14), the Gennargentu mountains (B, n = 13), the Supramonte mountains in the municipalities of Oliena, Orgosolo and Urzulei (C, n = 12), the area of Sette Fratelli and Sarrabus-Gerrei (D, n = 10) and the Monte Arcosu area (E, n = 7). Other areas included the Gulf of Orosei (F, n = 3), the Marghine and Goceano mountains (G, n = 2), the Monte

Limbara area (H, n = 2), the Plain of Semestene (I, n = 1), the Media Valle del Tirso area (L, n = 1), the Monte Arcuentu and Piscinas area (M, n = 1) and the Tepilora reserve (N, n = 1, Fig. 8.2).

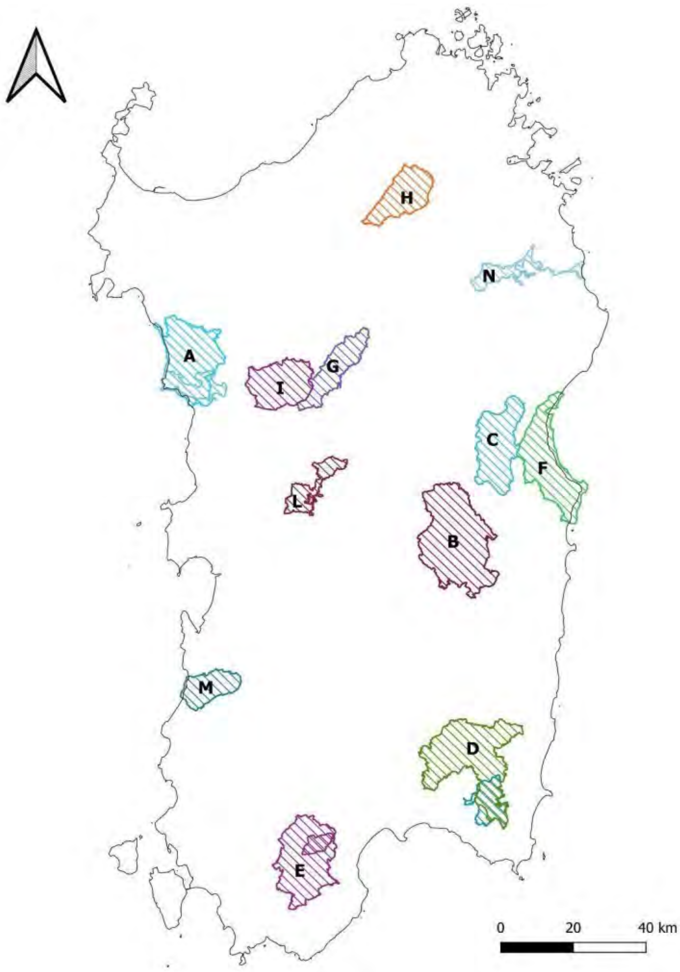


Figure 8.1 *Natura 2000 sites that experts identified as potential release sites for the Bearded and the Cinereous Vulture. A) Entroterra e zona costiera tra Bosa, Capo Marrargiu e Porto Tangone, Costa e Entroterra di Bosa, Suni e Montresta; B) Monti del Gennargentu; C) Supramonte di Oliena, Orgosolo e Urzulei - Su Sercone; D) Monte dei Sette Fratelli, Monte dei Sette Fratelli e Sarrabus; E) Foresta di Monte Arcosu; F) Golfo di Orosei; G) Catena del Marghine e del Goceano; H) Monte Limbara; I) Piana di Semestene, Bonorva, Macomer e Bortigali; L) Media Valle del Tirso e Altopiano di Abbasanta - Rio Siddu; M) Monte Arcuentu e Rio Piscinas; N) Parco Naturale Regionale Di Tepilora.*

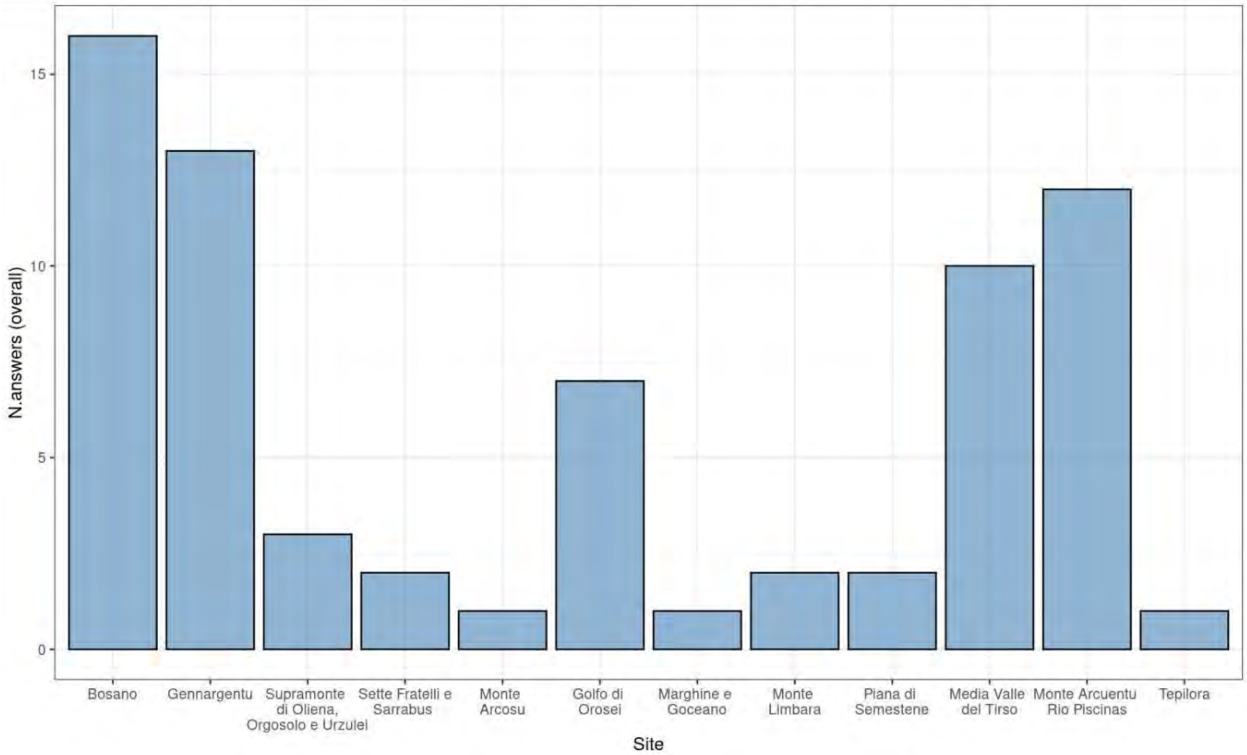


Figure 8.2 *Overall number of answers reported for each Natura 2000 site. The highest number of responses was recorded for Bosano and Gennargentu, with over 12 answers each. Monte Arcuentu – Rio Piscinas and Media Valle del Tirso also received a considerable number of mentions (around 10–12). In contrast, several areas, including Tepilora, Marghine e Goceano, Monte Arcosu, and Piana di Semestene, received very few responses, suggesting a lower perceived relevance or familiarity among respondents.*

When considering the 5 most suitable sites, namely *i*) the area between the municipalities of Bosa and Pozzomaggiore (hereinafter, "Bosa"), *ii*) the Gennargentu mountains (hereinafter "Gennargentu"), iii) the Supramonte mountains in the municipalities of Oliena, Orgosolo and Urzulei (hereinafter "Supramonte"), iv) the area of Sette Fratelli and Sarrabus-Gerrei (hereinafter "Sette Fratelli") and v) the Monte Arcosu, significant differences emerge.

The area around Bosa was, by far, deemed to be the one with the most suitable environmental conditions to be used as a release site for the Cinereous Vulture (Fig. 8.3). This was motivated by the fact that it hosts widespread forested areas with large trees, which could be used by the species, as well as a well-established Griffon Vulture colony, which indicates a stable food supply. Moreover, the area would have a low level of human disturbance, as well as well-implemented initiatives for raising public awareness about vultures and to monitor wildlife poisoning, activated during past LIFE projects. The area also benefits from relatively low poisoning risk.

Furthermore, within the project LIFE Safe for Vultures interventions to retrofit dangerous power lines have been carried on and the energy provider company, e-distribuzione, committed to retrofit any pylon or conductor in which mortality events involving large raptor would be recorded. Nevertheless, more efforts are needed to improve the safety of existing power lines to reduce the risk of collision and electrocution. As for wind energy development, it is scarce or absent, reducing collision risks.

These characteristics make the Bosa area highly suitable also for the reintroduction of the Bearded Vulture (Fig. 8.3). However, some experts have noted that while the area hosts a considerable number of cliffs, they are relatively small and low in height, which could limit the potential for breeding by the Bearded Vulture in the future. Additionally, the area is highly sensitive to wildfires. Other concerns included competition with the Griffon Vulture and the presence of Golden Eagles.

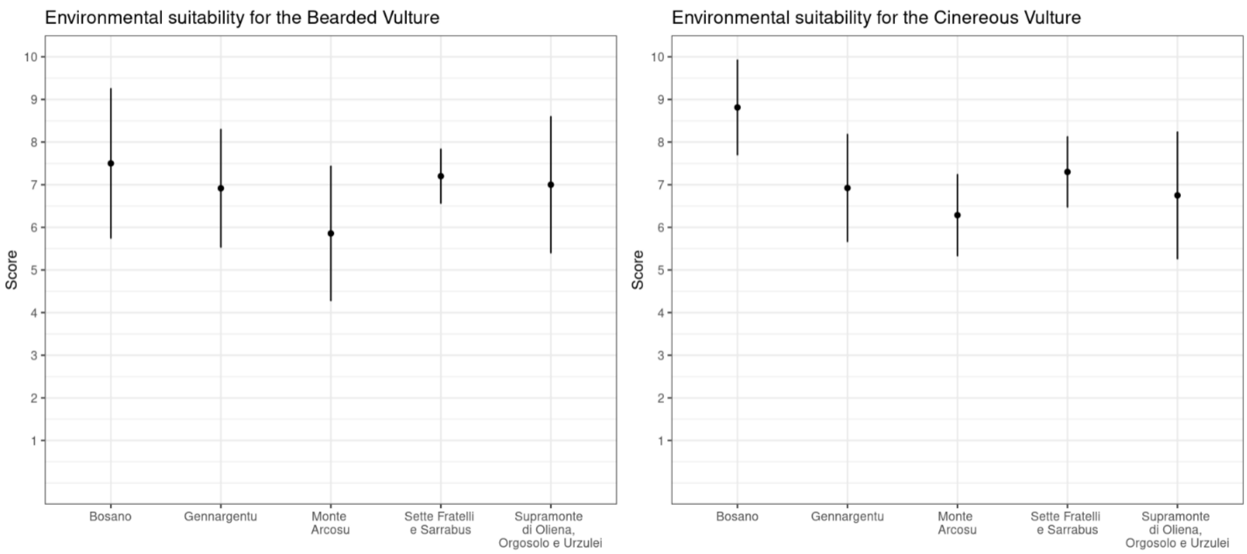


Figure 8.3 *Environmental suitability of the five most cited areas, as release sites for the Bearded and the Cinereous Vultures. Scores range from 1 (not suitable at all) to 10 (extremely suitable). Points are the arithmetic mean of scores, and vertical bars correspond to the standard deviation of scores.*

As for the other areas, Gennargentu offers extensive rocky areas, historical range suitability, and low wind energy development, making it a potentially suitable site. However, for the Bearded Vulture, a major concern is the scarcity of food resources. Experts highlighted the absence of Griffon Vultures, which may indicate insufficient carrion availability. Additionally, high levels of human disturbance, negative local attitudes, and poisoning risk were seen as challenges.

For the Cinereous Vulture, the presence of forested areas was viewed as a positive factor, but experts raised concerns about food scarcity and negative perceptions from local communities. The lack of a Griffon Vulture population could also indicate limited foraging opportunities.

The area of Bosa was also the most suitable one, when considering the potential support of local communities for the reintroduction (Fig. 8.4). Expert assessments indicated a relatively high level of public acceptance compared to other areas, with some engagement in ecotourism and a reduced risk of poisoning, suggesting an awareness of vulture conservation issues. This condition has been favoured by 10 years of communication actions carried on within the project LIFE Under Griffon Wings (2015-2020) and LIFE Safe for Vultures (2021-2026). Experts also anticipated that some stakeholders, such as hunters and shepherds, might express concerns about potential restrictions, although they considered these concerns to be less pronounced than in other regions.

Similarly, the Sette Fratelli area also stood out for its favourable social context, benefiting from prior awareness campaigns related to Griffon Vultures within the project LIFE Safe for Vultures. Although experts noted the possibility of resistance among local livestock breeders and hunters, these challenges were not perceived as more severe than in other regions and could potentially be mitigated through further engagement initiatives.

Overall, both Bosa and Sette Fratelli appear to have a more favourable social environment for vulture reintroduction efforts compared to other regions.
The assessment of Gennargentu and Supramonte is particularly critical from the perspective of local communities, with experts highlighting a possible opposition to conservation-related restrictions. Concerns were raised about a general lack of public awareness and information, particularly among local residents, hikers, and hunters, which could pose significant obstacles to the success of a reintroduction program. In addition to these socio-cultural challenges, experts identified low food availability, potential conflicts with hunters, and the absence of Griffon Vultures, which could hinder the establishment of Bearded and Cinereous Vultures in the area. While some favourable environmental conditions were noted, such as the presence of suitable cliffs and low levels of wind energy development, human dimension remains a major concern.

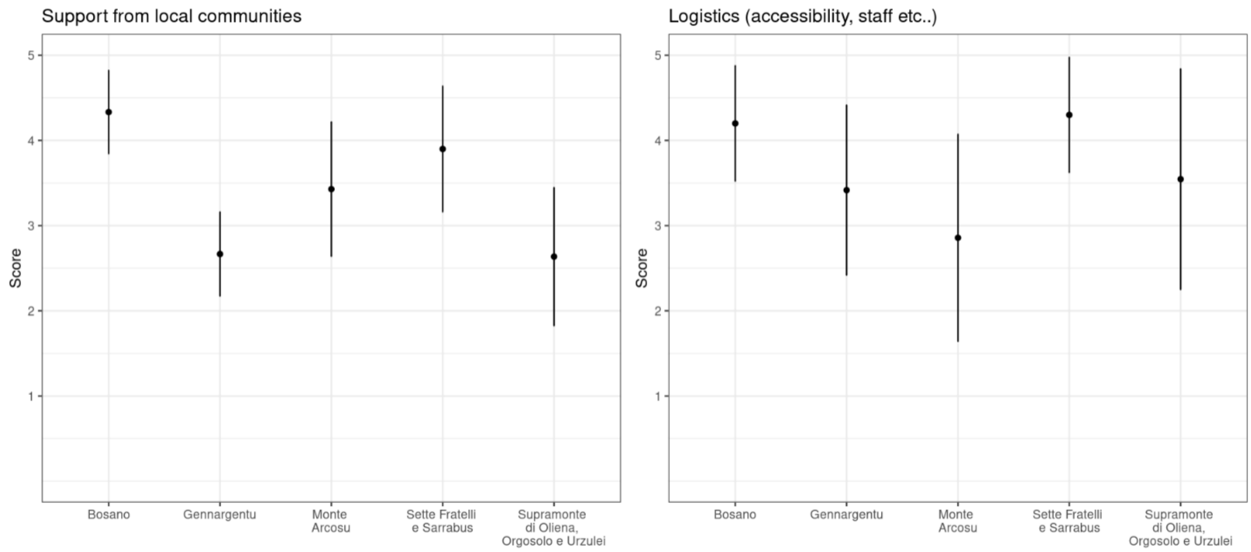


Figure 8.4 *Evaluation of the five most cited areas, in terms of the perceived support by local communities and in terms of their logistics. Scores range from 1 (not suitable at all) to 10 (extremely suitable). Points are the arithmetic mean of scores, and vertical bars correspond to the standard deviation of scores.*

The areas of Bosa, and the Sette Fratelli and Sarrabus mountains are also the most suitable when considering their logistics (Fig. 8.4), or in other terms their accessibility, as well as the presence of dedicated staff from environmental agencies (e.g. CFVA, e.g. Forestas) and the presence of infrastructures (e.g. mountain huts, acclimatization aviaries). In fact, these areas are not as remote as the Supramonte or Gennargentu mountains, nor as the Monte Arcosu area. Moreover, these two areas have already been interested by the Life Under Griffon Wings and the Life Safe for Vultures projects and therefore, they have trained staff available to carry out the post-release monitoring of released individuals.
The expert assessment suggests that areas such as Gennargentu and Supramonte have a high potential for the future dispersal and establishment of Bearded Vultures, even if reintroduction efforts are carried out elsewhere. As indicated in Fig. 8.5, these areas received relatively high scores for potential future establishment, highlighting their ecological suitability. However, given the socio-cultural challenges identified, it is essential to implement awareness-raising initiatives in these regions. Proactive engagement with local communities will be crucial to mitigate potential threats and ensure

a favourable attitude for vulture conservation. Moreover, food availability should be increased through the increase in the number of supplementary feeding sites.

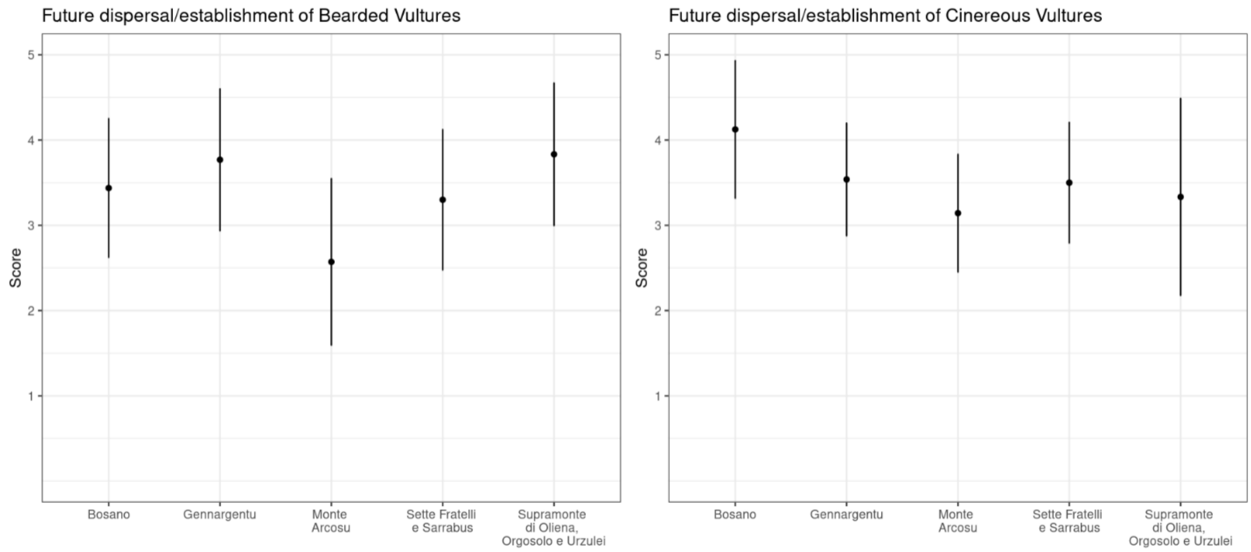


Figure 8.5 *Evaluation of the five most cited areas, in terms of their likelihood to be used in the future by Bearded Vultures or Cinereous Vultures as areas for roosting or breeding, in case these will be released elsewhere.*

8.2 Breeding habitat suitability

8.2.1 Introduction

The selection of suitable nesting sites is of fundamental importance for the reproductive success of species such as the Cinereous Vulture and the Bearded Vulture. Both species require highly specific environments that ensure safety, access to adequate food, and minimal human disturbance. The availability of suitable nesting habitats is hence crucial for the growth and establishment of self-sustaining populations.

For the Bearded Vulture, one of the key aspects in selecting a nesting site is the presence of cliffs or steep rock faces. These environments offer natural protection against predators and external disturbances, as well as a strategic location that allows the monitoring of the surrounding area. Cliffs indeed provide ample surfaces for nesting, where human access is limited. The availability of these habitats, especially in mountainous or inaccessible areas, is therefore essential for the Bearded Vulture's reproduction.

For the Cinereous Vulture, on the other hand, forested areas represent the ideal nesting habitats. These areas provide natural cover that protects the nests from predators and external disturbances. Mature forests, with a good tree density, also offer an environment away from human disturbances, which is vital for reproductive success. Specifically, areas with mixed or broadleaf vegetation are preferred by the Cinereous Vulture, as they provide good visual cover and relative tranquillity, reducing the risk of excessive disturbances during the nesting period.

This section will explore a preliminary survey of the available land in the study area to identify potential nesting areas for these two species. Ecological factors that define the suitability of these environments will be considered, with particular focus on cliffs for the Bearded Vulture and forested areas for the Cinereous Vulture. The aim is to identify the most promising areas for nesting, which possess the necessary ecological characteristics to support the long-term conservation and reproduction of these emblematic species.

8.2.2 Methods

Breeding habitat suitability assessment for Bearded Vulture

To assess the portion of territory suitable for Bearded Vulture nesting, a map was created based on two fundamental rasters: a DEM (Digital Elevation Model) raster and a terrain roughness raster.

- DEM Raster: A DEM raster was used with a minimum altitude of 300 m a.s.l., corresponding to the minimum altitude at which Bearded Vulture nesting sites have historically been observed. This raster was masked to select only areas above 300 m a.s.l., in line with the species' altitudinal preferences.

- Roughness Raster: To identify areas with steep slopes, a terrain roughness raster was used with a threshold set to > 15. This operation allowed the selection of only areas with high slopes, which are typical of Bearded Vulture nesting sites, such as cliffs and rock faces.

The selection and masking operations were carried out using R Studio, with the "*terra*" package for managing and analysing the raster data. The processed rasters were then combined to produce a map that identifies the most suitable areas for nesting, based on topography and the altitudes historically associated with the species' nesting sites.
In addition, an SDM (Species Distribution Model) map for the Golden Eagle was created, as occurrence data was available for this species. Since the Golden Eagle competes with the Bearded Vulture for nesting sites, this map can also serve as a proxy for suitable Bearded Vulture habitat, as the two species share similar ecological preferences in terms of altitude and habitat type, particularly in mountainous areas with cliffs and rock faces.

Breeding habitat suitability assessment for Cinereous Vulture

To develop the nesting suitability map for the Cinereous Vulture (*Aegypius monachus*), the CORINE Land Cover dataset was used to select the most ecologically relevant vegetation categories for the species. Specifically, the following categories were included:

- Broadleaf forests (cat. 311): Mature broadleaf forests represent ideal nesting habitats, providing natural cover that protects nests from predators and reduces human disturbance.

- Sclerophyllous vegetation (cat. 323): This category includes areas with drought-resistant vegetation, such as Mediterranean scrublands, which offer suitable nesting conditions, particularly in mountainous and arid regions.

These categories were extracted from CORINE Land Cover to generate a map identifying potentially suitable nesting areas based on the availability of appropriate forest and scrub habitats known to be associated with the species.

To strengthen the ecological and historical relevance of the analysis, 10 km radius buffers were also created around the centroids of historically confirmed nesting sites. These buffers highlight priority areas for further investigation, as they correspond to regions that have supported breeding in the past and may still retain favourable environmental conditions for nesting.

8.2.3 Results

The results of the Bearded Vulture nesting suitability map, shown in Figure 8.6, identified 949,500 hectares of land characterized by high-gradient areas, such as cliffs and rugged terrain, which are typically preferred by this species. These areas are located at altitudes above 300 meters above sea level, which corresponds to the minimum elevation where the Bearded Vulture has historically been observed nesting in Sardinia. This finding highlights the significant proportion of the landscape that could potentially support the species' nesting requirements, based on its preference for steep, remote environments at higher altitudes (Hirzel et al., 2004; Oliva-Vidal et al., 2024; Simón & Couto, 2007).

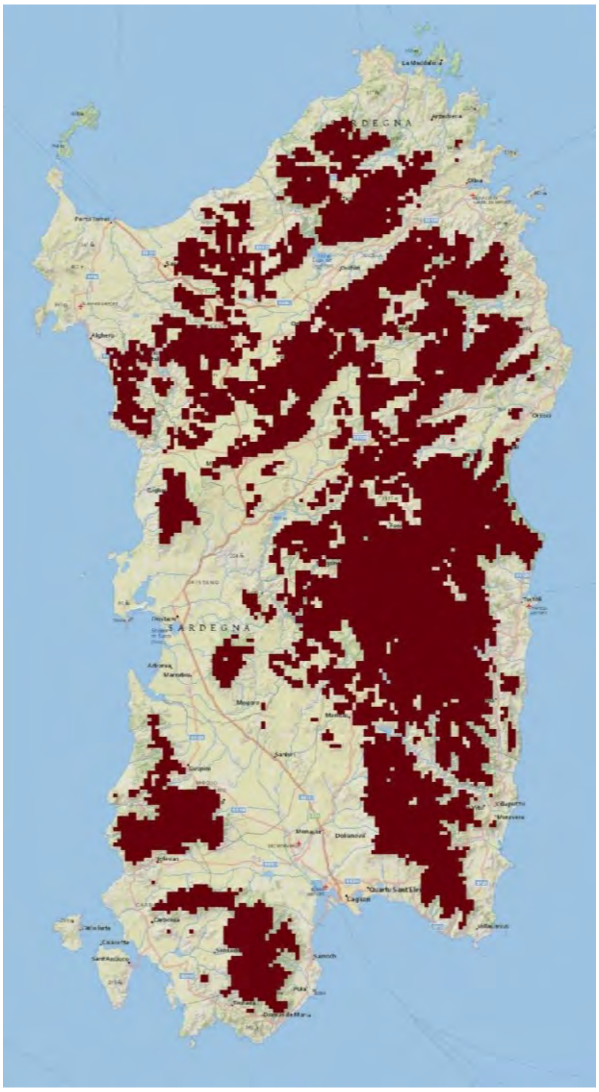


Figure 8.6 *Nesting suitability map for the Bearded Vulture in Sardinia. Suitable areas were identified based on terrain roughness greater than 15 and elevation above 300 metres above sea level, reflecting the species' ecological preference for steep, rugged, and high-altitude environments. The roughness threshold was defined based on ecological studies and topographic criteria commonly associated with nesting behaviour in mountainous regions. Brown areas represent locations that meet these conditions, mainly concentrated in central and eastern Sardinia.*

The results of the Golden Eagle SDM (Species Distribution Model) revealed the most suitable areas for nesting, based on available occurrence data and environmental variables. The model identified regions characterised by steep terrain, high altitudes, and low human disturbance, which align with the Golden Eagle's nesting preferences. Since the Golden Eagle and Bearded Vulture compete for the same nesting sites (Margalida & Bertran, 2005), this map provides valuable insights into where the Bearded Vulture might choose to nest, considering the overlap between the two suitable habitat models.

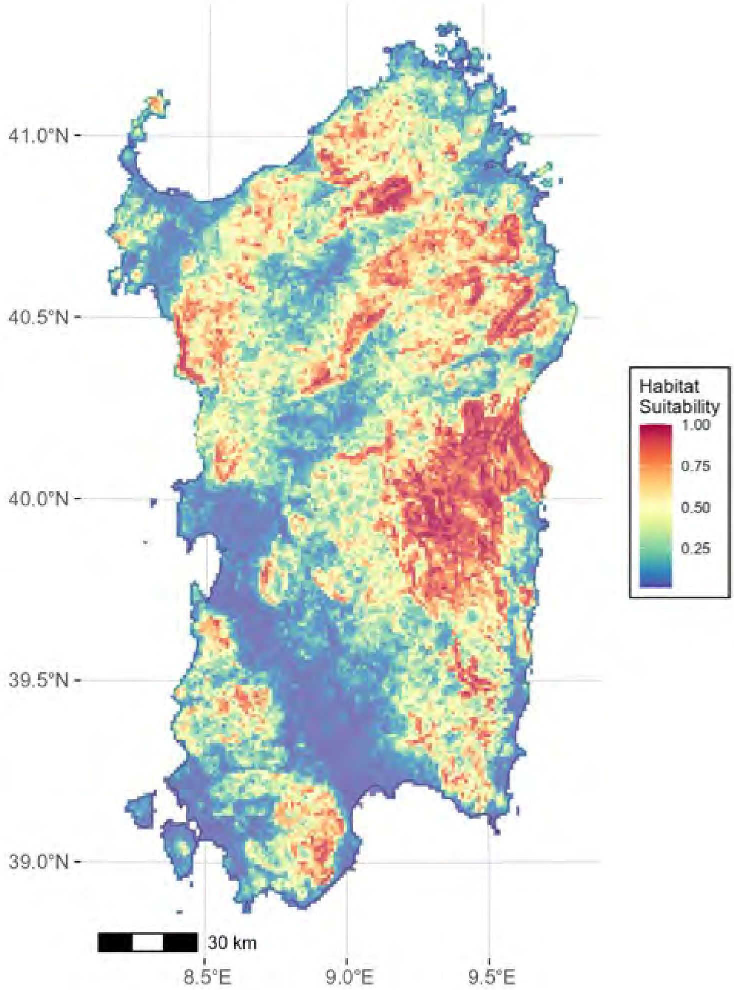


Figure 8.7 *Habitat suitability map for the Golden Eagle in Sardinia. The map shows predicted habitat suitability values ranging from low (blue) to high (red), based on a species distribution model. High-suitability areas are concentrated along the central-eastern mountainous regions, particularly the Gennargentu Massif, as well as in parts of the north and southwest of the island.*

A review of the literature confirms that the Cinereous Vulture typically nests in mature forest environments, showing a preference for tree species such as Cork Oak (*Quercus suber*), Holm Oak (*Quercus ilex*), and occasionally junipers and other broadleaf species with nesting trees have an average diameter of approximately 50 cm and a height ranging from 5 to 25 metres (Guerrero-Casado et al. 2013; Donazar et al. 2002). Furthermore, studies conducted in Spain and other regions have highlighted that nesting success is positively associated with certain structural and landscape features, including tree height, isolation from taller neighbouring trees, low canopy cover, and the presence of shrub vegetation within a 100-metre radius (Fargallo et al. 1998; Moreno-Opo et al. 2013).
Based on these ecological requirements, a preliminary habitat suitability map was developed using CORINE Land Cover (CLC) data. The analysis identified a total of 991,375 hectares as potentially suitable for nesting within the study area.
The map also incorporates historical data on the species' presence, highlighting areas of high conservation relevance. These buffers delineate priority zones for further investigation, as they are likely to retain suitable conditions for nesting and may be strategic for future reintroduction or conservation actions. The intersection of these buffers with the selected CLC habitat categories allows

for the identification of areas that are both ecologically favourable and historically significant for the species.

This map provides a first spatial framework to support targeted field surveys, land-use planning, and the design of effective conservation and reintroduction strategies for this emblematic species.

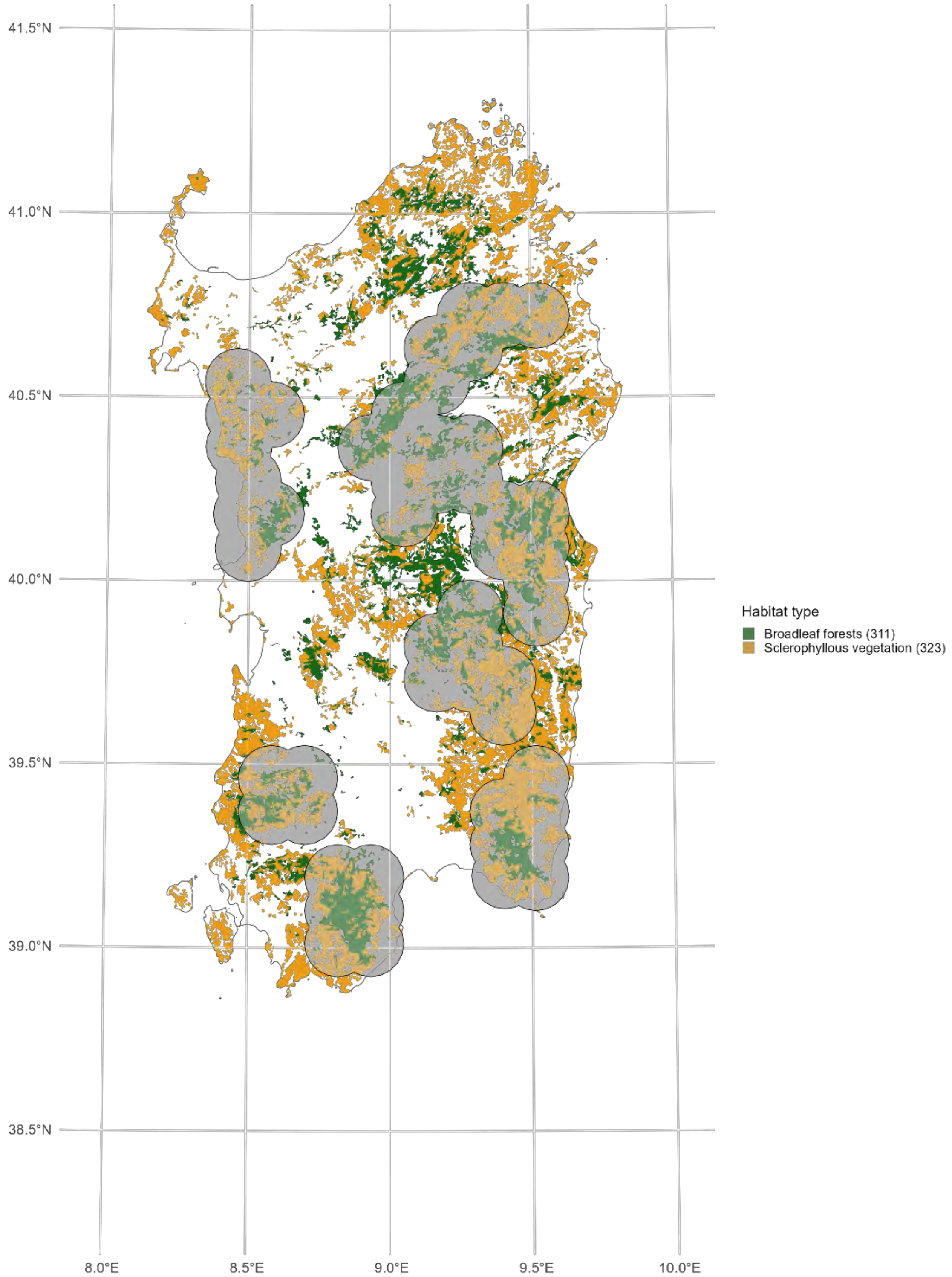


Figure 8.8 *Nesting habitat suitability map for the Cinereous Vulture in Sardinia. The map highlights areas identified as suitable for nesting based on CORINE Land Cover data, specifically broadleaf forests (category*

311) and sclerophyllous vegetation (category 323). Grey buffers (10 km radius) indicate areas surrounding the centroids of historically confirmed nesting sites, highlighting priority zones for future monitoring, conservation, and potential reintroduction efforts.

8.3 Conclusions

The expert-opinion assessment provided valuable insights into the suitability of different sites for vulture reintroduction in Sardinia. Several areas exhibit promising characteristics, such as suitable nesting habitat, food availability, and limited wind energy development. The expert assessments clearly highlight Bosa as the most suitable release site for both the Bearded and Cinereous Vultures, offering suitable environmental conditions and a favourable social context. This area is well-positioned for vulture reintroduction, showing considerable promise due to its forested landscapes, low human disturbance, and a well-established vulture conservation framework. The Sette Fratelli area also offers suitable environmental conditions but, given the ongoing reintroduction program for the Griffon Vultures, more time is needed to verify its potentialities. If the new nucleus of Griffon Vulture recently established will reproduce and grow, this area could be a suitable choice as a second release site.

In contrast, areas such as Gennargentu and Supramonte, despite their ecological suitability, face considerable socio-cultural hurdles. Potential opposition from local communities, compounded by the risks of poisoning and persecution, highlights the need for a proactive, long-term approach to mitigate these challenges with targeted efforts in awareness-raising and stakeholder engagement.

Lastly, the Monte Arcosu area appears less viable for reintroduction due to its limited trophic resources and potential poaching risks.

Regarding breeding habitat suitability, the availability of suitable nesting habitats does not represent a limiting factor for the Bearded Vulture and the Cinereous Vulture in Sardinia. For the Bearded Vulture, cliffs and steep rock faces are abundant, providing ample safe nesting surfaces. Similarly, for the Cinereous Vulture, mature forests with mixed and broadleaf vegetation are widely distributed across the island, offering a protected environment with minimal disturbance. In both cases, Sardinia has vast areas suitable for nesting, and this does not pose a limitation for the conservation of these species.

Considering the results from the expert evaluation and the breeding habitat suitability assessment, Bosa, and potentially the Sette Fratelli areas, emerge as the most promising sites for reintroduction. Given the high dispersal of reintroduced individuals and the potential colonization of other sites, successful long-term establishment of the two species will hinge on addressing food availability, threats mitigation and fostering local support in the whole island to ensure sustainable vulture populations in Sardinia.

9. Social feasibility study

The long-term success of the reintroduction of the Bearded and Cinereous Vultures in Sardinia depends on their acceptance by key stakeholders within local communities. These include livestock herders, recreational hunters, environmental tour guides, and local communities.

9.1 Engagement of livestock herders

The engagement of livestock herders is pivotal. Herders are crucial to provide food to vultures through supplementary feeding stations (Cortés-Avizanda et al., 2016) and they need to be adequately informed about the risks posed by veterinary drugs (Berlinguer et al., 2016). At the same time their engagement is non-trivial. In fact, herders can be subjected to the spread of fake news about vulture predation on livestock, and sometimes they can persecute vultures (Margalida & Donázar, 2020).
As for hunters, their engagement is crucial to avoid illegal shooting of vultures, as well as to encourage their adoption of non-toxic ammunition, a practice that avoids lead poisoning and has already led to regulatory actions in both the USA and the EU (Green et al., 2022). Finally, touristic guides working with outdoor recreationists are a key stakeholder, as they need to be informed on the need to encourage an ethical approach to bird watching to exploit the recreational services vulture provide without disturbing them (Zuberogoitia et al., 2008, 2014). At the same time, their engagement can favour the growth of touristic activities related to vulture observation, increasing their economic value and the perception of their value.
In this study, by using structured questionnaires, we surveyed the knowledge of vultures in a sample livestock herders, hunters and outdoor guides living/working in Sardinia, as well as their attitudes towards a reintroduction project for the Bearded and the Cinereous Vulture.

Methods

Between January and February 2025, we administered a structured questionnaire (Vaske, 2019) to a sample of livestock herders, hunters and outdoor guides. Questionnaire administration and completion differed between the three groups:

- For livestock herders, we focused on those working in the area around Bosa, in the municipalities interested in the Life Safe for Vultures and Life Under Griffon Wings project. We contacted herders that we directly knew through the project, or we interviewed them thanks to the collaboration of the *Corpo Forestale e di Vigilanza Ambientale* (CFVA) agents working in different districts. Questionnaires were completed by an enumerator that read questions and then checked answers according to the response received.
- For hunters, questionnaires aimed to assess social feasibility were distributed by the project partner Corpo Forestale e di Vigilanza Ambientale della Regione Sardegna (CFVA). The CFVA provided the distribution of questionnaires to hunters throughout the island.
- For outdoor guides, we administered an online questionnaire on the Facebook page of outdoor guides working in Sardinia. By doing so we recruited outdoor guides working under the two largest associations in Italy, AIGAE (https://www.aigae.org/) and LAGAP

(https://www.lagap.org/). Moreover, the questionnaire was also sent via email to the official email address of AIGAE and it was snowballed to other guides that we directly know.

Therefore, survey administration resulted in three non-probabilistic samples (Kalton, 2020). Nevertheless, this approach was the only feasible, as no sampling frame was available for the whole Sardinia, about these three groups of stakeholders.
Questionnaires were confidential and took approximately five minutes to complete. For all the three groups of stakeholders we asked:

- Whether they had ever heard about the Griffon Vulture, the Cinereous Vulture, the Bearded Vulture or the Egyptian Vulture
- To check which food were, in their opinion, exploited by vultures, between carrion, bones, garbage and live prey
- If they would have been happy in case that the Bearded and/or Cinereous Vulture were reintroduced in the area where they worked/hunted

For livestock herders we also collected information about the number of goats and sheep, as well as the number of cattle they had in their farm. Moreover, we asked if they had a supplementary feeding station for Griffon Vulture at their farm and then:

- For those herders that already had one, if they would have been happy in case that their station was visited by Bearded and the Cinereous Vulture
- For those herders that did not have any supplementary feeding station yet, if they would have been interested in having one constructed in their farm

For all the three groups of respondents we also collected baseline information about their age and their gender. Before allowing respondents to complete the questionnaire, we collected their informed consent, in line with the General Data Protection Regulation of the European Commission (https://gdpr.eu/). Namely, we emphasized that questionnaire results would have remained confidential and not disclosed to third parties, if not in an aggregated format, and that questionnaire completion was voluntary and that respondents could withdraw at any time, or decide not to answer a certain question, without suffering any consequence.

Results

We collected 186 questionnaires from livestock herders, 159 questionnaires from recreational hunters and 64 questionnaires from outdoor guides.
Almost all hunters (99.4%) and livestock herders (97.8%) were men, while the proportion of men was lower in the case of outdoor guides (56.2%). The distribution of age is show in the table below:

Table 9.1 *Distribution of the age class, between the three groups of respondents.*

	18-24 YEARS	25-34 YEARS	35-49 YEARS	50-64 YEARS	65 YEARS OR MORE
LIVESTOCK HERDERS	1.1%	8.7%	32.6%	42.9%	14.7%

OUTDOOR GUIDES	0%	4.7%	56.2%	37.5%	1.6%
RECREATIONAL HUNTERS	2.5%	5%	26.4%	45.9%	20.1%

As for livestock herders, the distribution of farm size is shown in the table below:

Table 9.2 *Distribution of livestock herders, in terms of the size of their farms. The four categories were identified through the first, second, third quartile of the distribution of farm size, in the study area.*

	0-149 HEADS	**150-249 HEADS**	**250-400 HEADS**	**OVER 400 HEADS**
SHEEP/GOATS	17.5%	35.1%	30.5%	16.9%
	0-5 heads	15-30 heads	5-15 heads	Over 30 heads
CATTLE	14.6%	22.9%	22.9%	39.6%

Only 11 livestock herders in our sample (6.1%) had a supplementary feeding station for Griffon Vultures in their farm.
When considering the knowledge of vultures (Fig. 1), most livestock herders (99.5%), hunters (98.7%) and outdoor guides (100 %) knew the Griffon Vulture. Moreover, when considering outdoor guides, all of them knew the Bearded Vulture and most of them had heard about the Cinereous Vulture (83.9%) and the Egyptian Vulture (85.5%). Also, a significant proportion of hunters declared to know the Bearded (87.3%), Cinereous (75.5%) and Egyptian (69.2%) vultures. However, it is worth noting that only few herders have ever heard about the Bearded Vulture (37.1%), the Cinereous Vulture (42.1%) and the Egyptian Vulture (19.7%).

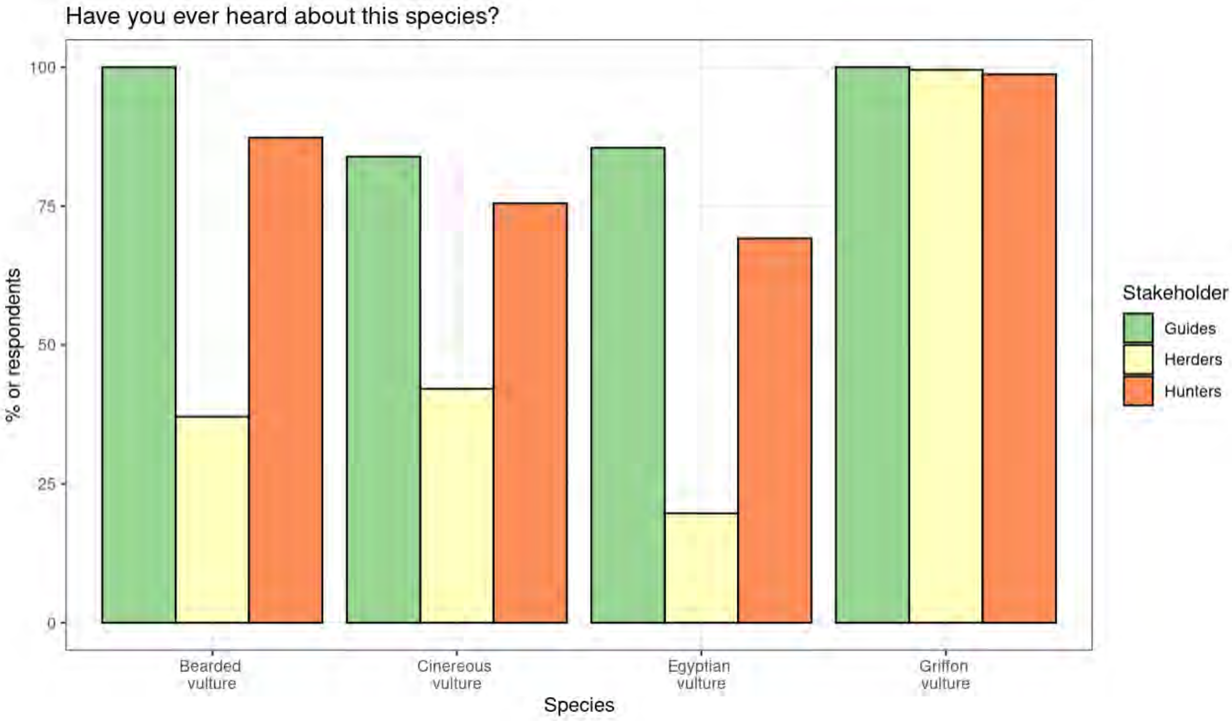


Figure 9.1 *Percentage of outdoor guides, livestock herders and recreational hunters that declared to have heard at least once about the Bearded Vulture, the Cinereous Vulture, the Egyptian Vulture and the Griffon Vulture.*

When considering beliefs about the diet of vultures, almost all livestock herders (98.9%), hunters (98.7%) and outdoor guides (98.4%) believed that vultures feed on carrion (Fig. 2). Moreover, only a minority of respondents believed that vultures could feed on garbage or live animals. However, it is interesting to note that a significant share of outdoor guides (56.2%) and hunters (41.1%), but a much smaller fraction of herders (12.4%) believed that vultures could also feed on bones.

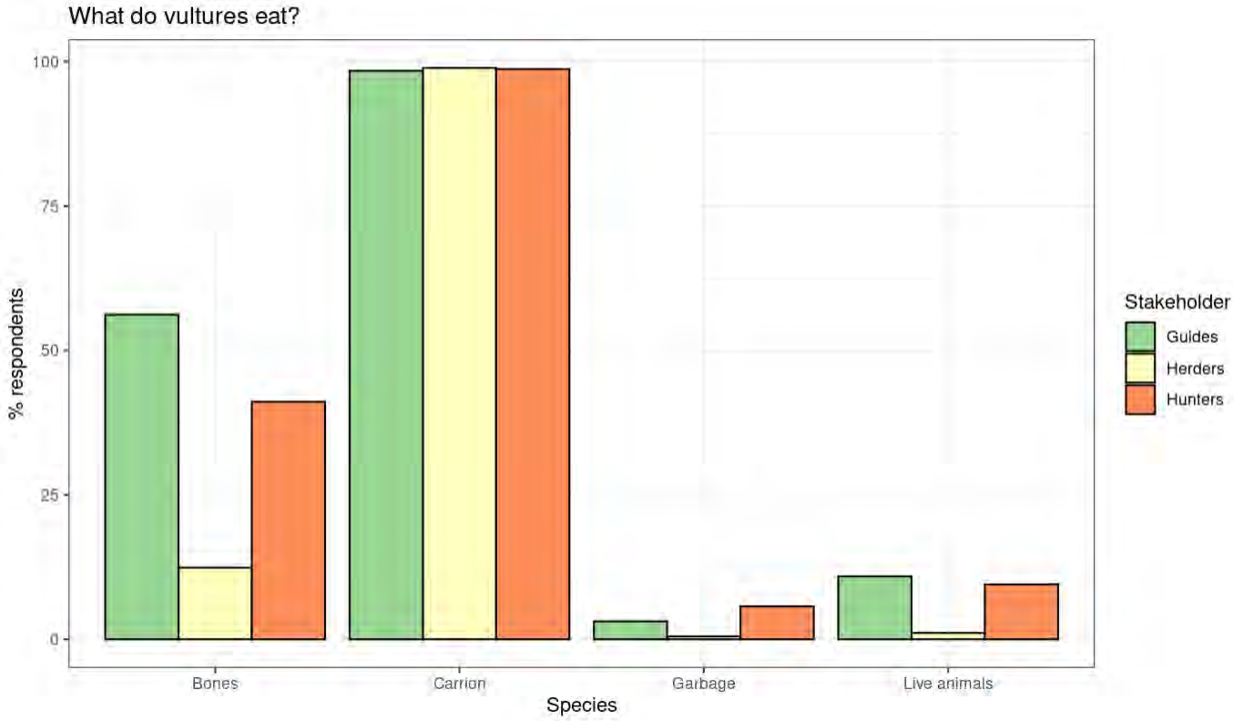


Figure 9.2 *Percentage of outdoor guides, livestock herders and recreational hunters that believed that vultures feed on bones, carrion, garbage and live animals.*

Overall, attitudes towards a reintroduction were quite positive: 77.4% of livestock herders, 70.9% of hunters and 87.5% of outdoor guides in our sample declared that they would have been happy in case of the reintroduction of the Bearded and the Cinereous Vulture in the area where they work/hunt.
As for livestock herders, 9 out 11, among those that have a supplementary feeding station for Griffon Vultures declared that they would be happy in case that this was visited by the Bearded and the Cinereous Vulture. Finally, 98 herders, among the 171 that have not yet built a supplementary feeding station, declared themselves to be potentially interested in having one built on their farm.

Conclusions

The results of this study reveal a solid social foundation for the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. Despite varying levels of knowledge, livestock herders, hunters, and outdoor guides generally expressed a positive attitude toward the project. Notably, many herders showed strong interest in establishing supplementary feeding stations, which are essential for supporting the survival of reintroduced individuals.
Nevertheless, some knowledge gaps persist, particularly among herders, regarding the lesser-known vulture species and the ecological role of bone consumption. Overall, however, perceptions of vulture diets were largely accurate, and awareness of the Griffon Vulture was widespread across all groups.
To ensure the success of the reintroduction effort, it will be crucial to implement tailored engagement strategies aimed at addressing informational gaps, countering misinformation, and enhancing the active participation of each stakeholder group. Strengthening dialogue, building trust, and encouraging informed involvement will be key steps in successfully reintegrating these species into the island's socio-ecological context.

9.2 Engagement in schools for environmental education

The engagement of school communities is crucial in fostering environmental awareness and promoting conservation values from an early age. Schoolchildren are not only future stewards of nature, but they can also act as intermediaries to educate their families and communities about local wildlife, including vultures. As with other stakeholders, the challenge lies in ensuring that their education is grounded in scientifically accurate information while also addressing concerns and misconceptions that may arise from broader societal views on wildlife conservation.

The role of educators is crucial in this process. Teachers request the involvement of the LIFE project team to deliver lessons in schools, in order to provide them with the tools and knowledge necessary to address complex environmental issues in an accessible and engaging manner. This approach ensures that students not only acquire information but are also motivated to take concrete actions.

In this study, we assessed the effectiveness of our environmental education efforts by evaluating and explaining students' knowledge of Griffon Vultures and the importance of poison detection dog units. The primary goal was to help students perceive the Griffon Vulture as a species to protect, so they can also carry this message home. We conducted lectures, showed videos illustrating our conservation actions, administered pre- and post-lesson questionnaires, and distributed educational materials on the Griffon Vulture, the Bearded Vulture, and the Cinereous Vulture. Additionally, we raised awareness about the importance of conservation efforts, including the role of poison detection dog units in protecting these species.

Methods

We administered a structured questionnaire to schoolchildren from primary and secondary schools across Sardinia, focusing on the areas covered by the LIFE Safe for Vultures project (Action E5). The survey was designed to evaluate students' knowledge of vultures, their diet, and their attitudes towards the reintroduction of vultures in the region. The questionnaire was administered in person during school visits.

Both in primary and secondary schools, the same questionnaires were administered by the environmental educator assigned to the LIFE project. The questions asked in the questionnaires and the responses are shown in Fig. 9.3. Each school visit followed the following protocol:

1. General presentation of the project
2. Administration of the pre-lesson questionnaire to assess the students' knowledge before the lesson (a total of 562 questionnaires)
3. A lesson delivered by the LIFE educator on the project, covering various topics such as the role of vultures, the steps in the release of Griffon Vultures, marking methods, etc
4. A lesson from the poison detection dog unit leaders on the role of dogs in the project
5. Distribution of educational sheets to be completed with the LIFE educator
6. Administration of the post-lesson questionnaire to assess the knowledge gained (a total of 564 questionnaires)
7. An outdoor demonstration with the poison detection dogs in the search for poisoned baits
8. Distribution of LIFE project educational material

Results

The questionnaires were administered to the students both before and after the lesson, with the aim of assessing their knowledge about the Griffon Vulture and the importance of anti-poisoning dog units. The responses to the questions showed a significant improvement in the students' knowledge after the lesson (Fig. 9.3).
When asked "What is the Griffon Vulture?", before the lesson, 96.1% of the students knew that the Griffon Vulture was a bird, while the remaining 3.9% thought it was a mammal or a reptile. After the lesson, most of the students correctly identified the Griffon Vulture as a bird.
Regarding the question "What does the Griffon Vulture eat?", before the lesson, 83.7% of the students correctly answered that the Griffon Vulture feeds on dead animals, while the remaining 16.3% had incorrect ideas, including 13.8% who thought that the Griffon Vulture actively hunted live animals. After the lesson, 99.3% of the students confirmed that the Griffon Vulture feeds on carcasses.
When asked "Why is the Griffon Vulture useful for the environment and for humans?", before the lesson, 81.5% of the students knew that the Griffon Vulture plays a beneficial role, while nearly 10% were unsure of its usefulness, and a small percentage considered it dangerous because they thought it preyed on lambs. After the lesson, 96.3% correctly understood that the Griffon Vulture is a "natural scavenger" that eliminates carcasses, along with the parasites and diseases they carry.
When asked "How can properly trained dogs help in the conservation of the Griffon Vulture?", 85% of the students recognized the role of dogs in searching for poisoned baits, while the rest, including 9.1%, believed that dogs were not friends of the Griffon Vulture. After the lesson, 95.9% of the students understood that trained dogs are essential in preventing poisoning of the Griffon Vultures.
Finally, when asked "Have you ever heard of the Griffon Vulture from any of your friends, relatives, or family?", only 24.2% of the students had heard of the Griffon Vulture before the lesson, suggesting that while there was some awareness of the species, it was not yet universal within the local community.

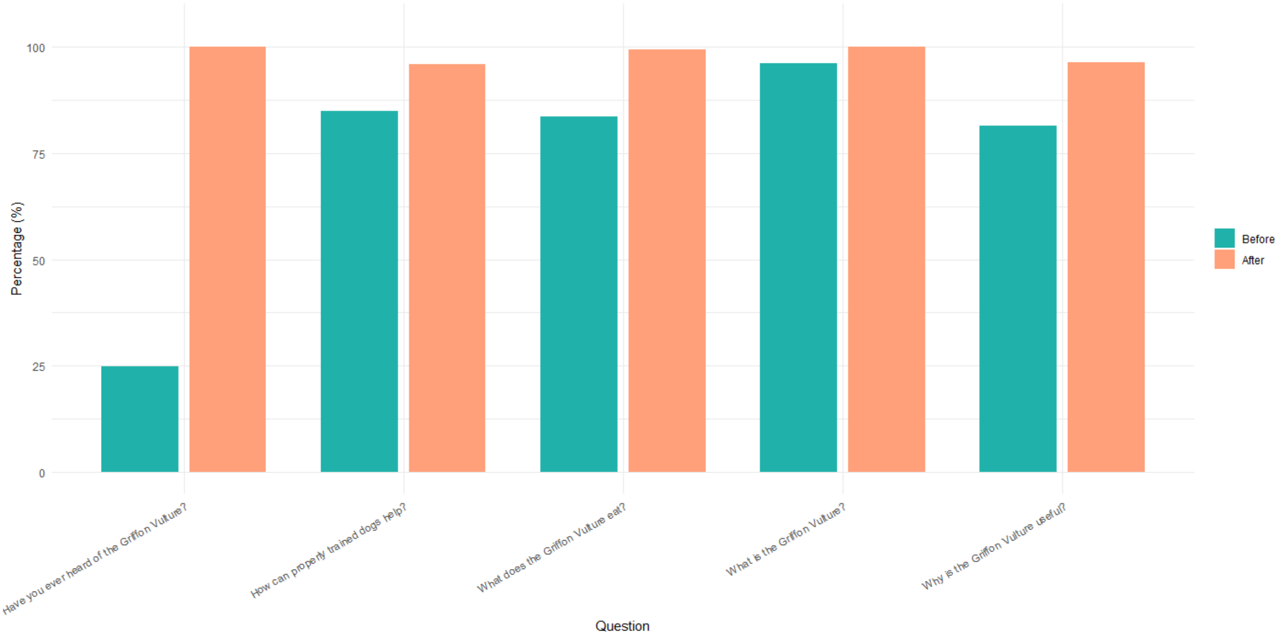


Figure 9.3 *Changes in students' knowledge before and after participating in educational activities about the Griffon Vulture.*

Conclusion

The results obtained highlight a significant improvement in students' knowledge regarding Griffon Vultures and the role of poison detection dog units after participating in the LIFE project lessons. The responses to the questionnaires, administered both before and after the lesson, clearly show that the educational activities had a positive impact, contributing to an increase in environmental awareness among the young participants.

In particular, the identification of the Griffon Vulture as a bird and the understanding of its ecological role as a “natural cleaner” that eliminates carcasses and diseases showed considerable improvement. Additionally, the importance of poison detection dog units was clearly understood by the majority of students, who now recognise the value of these dogs in protecting vultures from the risk of poisoning. The educational activities of the LIFE project have proven effective in conveying scientific information in an accessible and engaging manner, successfully raising students’ awareness about the importance of Griffon Vulture conservation and the species associated with its ecosystem. These results suggest that the approach adopted can be expanded and applied to other schools, contributing to greater awareness and a more sustainable future for vulture species in Sardinia.

In conclusion, the involvement of schools in environmental education activities represents a key step towards the success of conservation projects, creating a generation of young people who are more aware and ready to contribute to the protection of nature.

9.3 Engagement of visitors to protected areas in Sardinia

Social acceptance of vultures and their conservation is a key factor influencing the success of reintroduction programmes and long-term species management. In recent years, the growing recognition of ecosystem services—particularly cultural services—has highlighted the role of public perception and stakeholder engagement in biodiversity conservation (Daily & Matson, 2008; Geijzendorffer et al., 2017; IPBES, 2019). Vultures, as obligate scavengers, not only provide essential regulating services such as carcass removal and disease mitigation (Morales-Reyes et al., 2015; Plaza et al., 2020), but also contribute to cultural ecosystem services through ecotourism, education, and symbolic value (Aguilera-Alcalá et al., 2020; Becker et al., 2005; García-Jiménez et al., 2021). Understanding how these services are perceived by the public is critical for designing effective conservation strategies. To this end, we conducted a study to assess the attitudes of visitors to protected areas in Sardinia toward vultures and their conservation, as part of a broader study that also quantified key regulating services provided by Griffon Vultures in Sardinia, including their contribution to carcass removal, associated reductions in greenhouse gas emissions, and savings in waste management costs through natural decomposition compared to conventional disposal methods (Santangeli et al., 2024). These insights provide a social dimension to the feasibility of reintroducing Cinereous and Bearded Vultures to the island, as social acceptance can substantially influence the success of such conservation interventions.

Methods

Between August 2022 and October 2023, a structured questionnaire survey was conducted to evaluate visitors’ perceptions of Griffon Vultures and the ecosystem services they provide across eight protected areas in Sardinia (n = 116). Data were collected through two modalities: in-person administration on site (n = 100) and an online version of the questionnaire (n = 16), with the latter aimed at increasing the sample size. For the analysis, responses from both formats were combined, as excluding the online responses did not significantly alter the results. The questionnaire was organised into thematic sections covering:

- frequency of visits to Sardinia and its natural areas
- willingness to pay pre-defined amounts for vulture-related activities (e.g. observation, photography, conservation)
- perceived ecosystem services associated with vultures, assessed on a five-point bipolar scale (from strongly disagree to strongly agree)
- respondents' demographic characteristics

The survey protocol ensured that respondents were informed about the purpose of the study, the voluntary nature of participation, and the guarantees of anonymity and confidentiality.

Results

Socio-demographic Profile of Respondents

A total of 116 questionnaires were collected, with a balanced representation across gender (58 males, 57 females) and age groups: 28 respondents were aged 18–30, 30 aged 31–40, 25 aged 41–50, and 29 aged over 51. Educational attainment was generally high; 45 respondents held at least a secondary school diploma, 42 held a basic university degree, and 23 possessed postgraduate qualifications (e.g. MSc or PhD). The majority of participants were Italian nationals (n = 91, 79%), while the remainder were from Germany and France (seven each), the Czech Republic (four), and the Netherlands, Austria, and Poland (two each). Half of the respondents (n = 57) were residents of Sardinia, while the rest were non-residents, including first-time visitors (n = 24), repeat visitors (two visits: n = 10; three or more: n = 6), and frequent visitors who return annually (n = 17). Only eight individuals reported employment in nature-related professions (e.g. biologists, nature guides, veterinarians). Photography was practiced by 51 respondents (45%), while 63 (55%) did not engage in this activity. Regarding protected area visitation frequency, 30 respondents were first-time visitors, 44 visited once annually, 8 once monthly, and 9 once weekly.

Perceptions of Ecosystem Services Provided by Vultures

Respondents demonstrated generally positive attitudes toward vultures and a sound awareness of their ecosystem services (Fig. 9.4). Approximately two-thirds of respondents recognised the role of vultures in mitigating disease transmission and reducing carcass disposal costs (i.e. regulation and maintenance services). Cultural recognition was also notable, with most participants affirming vultures as part of the traditional agropastoral landscape of Sardinia. Negative perceptions were uncommon: 71% disagreed with the statement that vultures are dirty, and 78% disagreed with the notion that they dislike having vultures in the surrounding landscape.

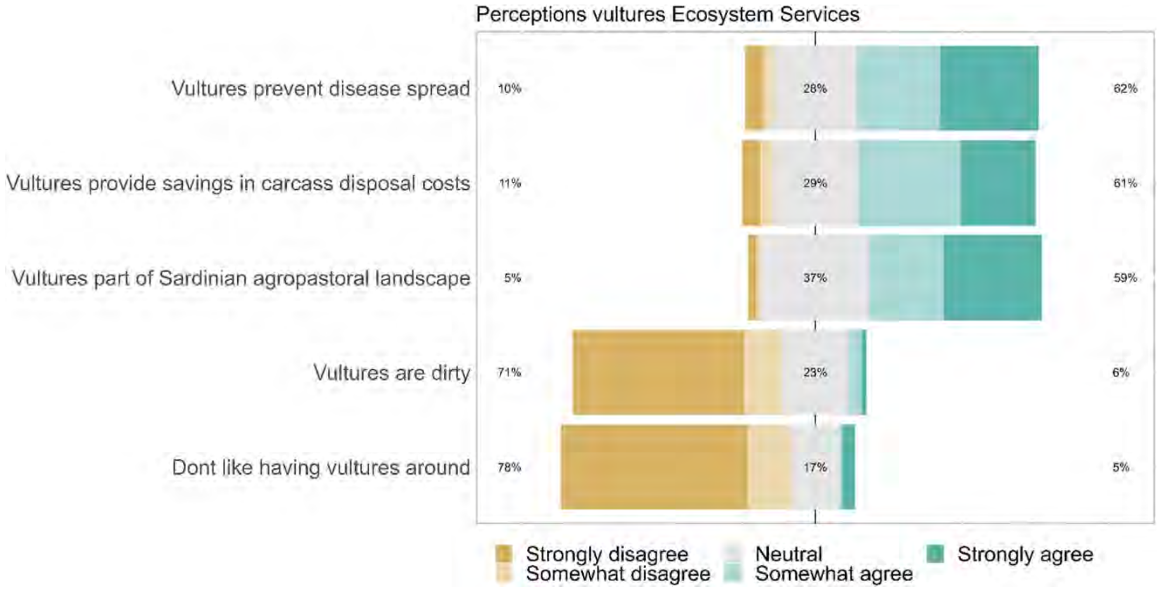


Figure 9.4 *Perceptions of visitors to natural reserves on vultures and their associated ecosystem services (from Santangeli et al., 2024).*

Willingness to Pay for Cultural Ecosystem Services

Cultural ecosystem services were further explored through questions on willingness to pay (WTP) for vulture-related experiences. A large majority (79%, n = 92) expressed interest in visiting an observation hide for vulture watching and photography. Of these, 73% (n = 85) were willing to pay an entrance fee, with a mean WTP of €13, though responses ranged widely: 54 respondents would pay €10 or less, while others indicated higher amounts. A similar proportion (80% of 115 responses) showed interest in joining a guided visit, with 79% (n = 89) willing to pay a fee, averaging €15. Among them, 46 respondents were willing to pay €10 or less, 23 would pay €20, and 9 indicated €30 or more. In terms of motivation, 55 respondents would visit a vulture hide as part of a broader trip to Sardinia, whereas 34 would plan a visit specifically for this purpose. Finally, 58 of 114 respondents expressed willingness to donate to Griffon Vulture conservation efforts, with an average donation of €21. Among them, 29 would donate €10 or less, 6 would donate €20, and 16 would contribute €30 or more.

Conclusion

The results of this study reveal strong public support for Griffon Vultures and an encouraging awareness of the ecosystem services they provide, particularly in terms of disease regulation and cultural value. Visitors to Sardinia's protected areas not only recognised vultures as an integral part of the island's traditional landscape but also demonstrated a tangible willingness to engage with vulture-related ecotourism and conservation initiatives, including financial contributions. These findings suggest that vultures are not only ecologically beneficial but also socially accepted, which reinforces the feasibility of using ecotourism as a conservation tool.

9.4 Conclusions

The results of the questionnaires provide compelling evidence of a robust and multifaceted social foundation for the reintroduction of the Cinereous and Bearded Vultures in Sardinia. Positive attitudes were consistently observed across a range of key stakeholder groups, including livestock herders, hunters, outdoor guides, school students, and visitors to protected areas. Although certain knowledge gaps persist—particularly regarding the less familiar vulture species and their ecological functions such as bone consumption—these deficits may be effectively addressed through targeted educational and outreach initiatives. The demonstrated success of the LIFE project's environmental education programme further highlights the importance of fostering environmental awareness among younger generations to cultivate informed and engaged future stakeholders. Moreover, the pronounced public support and willingness to participate in vulture-related ecotourism underscore the socio-cultural and economic viability of integrating conservation with sustainable development strategies. Ensuring the long-term success of the reintroduction effort will necessitate sustained dialogue, trust-building, and collaborative engagement, tailored to the distinct needs and perspectives of each stakeholder group. Taken together, the strong social acceptance documented herein, alongside ecological considerations, significantly reinforces the feasibility of reestablishing these emblematic scavenger species within the Sardinian socio-ecological landscape.

10. Analysis, evaluation, and application of IUCN translocation criteria

This chapter provides a detailed evaluation of how the criteria outlined in the *IUCN Guidelines for Reintroductions and Other Conservation Translocations* (IUCN/SSC, 2013) have been met in the framework of the reintroduction programme for the Bearded Vulture (*Gypaetus barbatus*) and the Cinereous Vulture (*Aegypius monachus*) in Sardinia. The analysis addresses all mandatory conditions required to ensure the feasibility, sustainability, and effectiveness of the initiative, including ecological, sanitary, socio-economic, and governance considerations.

10.1 Mandatory conditions for species conservation translocations

General justification: The IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013) will be followed at all levels of the reintroduction program. As such, the program's actions cover the required phases of reintroduction/translocation planning and feasibility analyses; risk assessment; monitoring, including of socio-economic and political factors; and dissemination of information to secure long-term support for the reintroduction.
In the table below we provide brief description of how each of the IUCN criteria have been fulfilled:

CONDITION	**HOW IT IS MET**
(i) the actions are justified, expected to yield quantitative conservation benefit based on a cost/benefit analysis, and have a high chance of success based on a thorough risk and feasibility analysis	The aim of the reintroduction programme is to establish new viable nuclei of Cinereous Vulture (*Aegypius monachus*) and Bearded Vulture (*Gypaetus barbatus*) in Sardinia, where both species became extinct as breeding populations during the 20th century. The reintroduction will contribute to restoring the ecological guild of avian scavengers on the island and to improving the conservation status of both species at regional and EU level. The feasibility analysis has been carried out through preparatory action, following IUCN guidelines to assess the costs, benefits, and risks associated with the reintroduction and release of Cinereous and Bearded Vultures in the selected project areas. All preparatory actions, together with the experience gained from previous projects (under Griffon Wings and LIFE Safe for Vultures), have contributed to this analysis. The expected quantitative conservation benefits (e.g. establishment of new viable nuclei of the two species in the island) are based on a cost/benefit analysis and have a high chance of success.

(ii) the reintroduced/translocated organisms are likely to be able to cope with new pathogen and stresses encountered at the destination site and the risk of reintroducing new pathogens in the destination area are minimised	The pre-transport activities for the reintroduction of Cinereous and Bearded Vultures will follow a strict sanitary protocol (clinical examination, biometry, haematological, biochemical, and microbiological analyses) to confirm the birds' health status and to prevent any potential spread of infectious diseases.
(iii) alternatives to reintroduction/translocation have been assessed as less effective or infeasible as a means to reach the specific and clearly defined conservation objectives of the reintroduction/translocation	Without a reintroduction programme, the return of Cinereous and Bearded Vultures as breeding species in Sardinia would be extremely unlikely, due to their extinction as breeding populations on the island and the geographic distance from the nearest continental populations. Natural recolonization therefore cannot be considered an effective strategy to achieve the project's conservation goals. Reintroduction is the most effective approach to foster the stable settlement of these species, strengthen their regional presence, and restore the ecological interactions linked to the scavenger guild. The feasibility and appropriateness of this strategy has been assessed in detail, building also on lessons learned from similar efforts in other parts of Europe.
(iv) the actions target areas where the causes of extinction of the species have been eliminated	In this study we provided a detailed assessment of any remaining threats in the areas selected for the reintroduction of Cinereous and Bearded Vultures. The main threats that historically led to the extinction of both species in Sardinia, especially poisoning, persecution, and food shortage, have been successfully mitigated, thanks to the outcomes of the LIFE *Under Griffon Wings* and *Safe for Vultures* projects. Although both species are currently absent as breeding populations on the island, the ecological, social, and regulatory context is now favourable for reintroduction, which will be accompanied by continuous monitoring and adaptive mitigation throughout the project duration.
(v) the removal of individuals from their present habitat for reintroduction is only considered if it does not endanger the captive or wild source populations	The Cinereous and Bearded Vultures to be reintroduced will come from the captive-breeding programme within the European Endangered Species Programme (EEP). The EEP is the most intensive type of population management for a species kept in the European Association of Zoos and Aquaria (EAZA) zoos. It aims to conserve sustainable back-up populations of animals in captivity while safeguarding the genetic diversity up to 90%. Animals born in captivity can then be used to boost populations in the wild, which is the case for the Cinereous Vulture and the Bearded Vulture.

	In the case of Cinereous vultures recovered from the wild (typically juveniles weakened due to malnutrition, dehydration, or migratory stress), will also be selected, if they are fully recoverable from a veterinary perspective and not affected by major injuries or diseases. Without rehabilitation, these birds would have had a low chance of survival in the wild. Therefore, their removal will have no significant impact on the wild source populations. Moreover, the total number of individuals to be reintroduced will be limited and carefully evaluated in collaboration with national authorities and the partners managing the existing breeding and recovery programmes at the European level, ensuring the full sustainability of the intervention.
(vi) the actions target areas whose habitats and climate meet, the foreseeable future, the conditions necessary for the survival of a viable population of the species	A full assessment of habitat and climatic suitability is presented in the present study. Suitable habitats and climatic conditions occur at the proposed release sites and are appropriate for Bearded and Cinereous Vulture breeding based on historical records. The climatic conditions in the project area and Sardinia as a whole are expected to remain suitable for Bearded and Cinereous Vultures for the foreseeable future, as their widespread distribution suggests that they have a wide climatic tolerance. As a result, there is as yet no published evidence that Bearded and Cinereous Vultures will be adversely affected by the changing climate. Furthermore, under LIFE 14/NAT/IT/000484 and LIFE19 NAT/IT/000732 a total of 95 Griffon Vultures coming from Spain have been restocked with a survival rate of 87.4% after 6 months.
(vii) a prior agreement between all parties involved (e.g. between the competent authority for the donor population and the manager of the area of reintroduction) has been concluded and documented	The Vulture Conservation Foundation (VCF) has established collaboration protocols with different authorities and Captive Breeding Programmes that provide the birds. The competent authorities in Sardinia (Region of Sardinia) expressed their commitment in providing all the necessary authorizations for the reintroduction program.
(viii) the actions target only areas where the attitude of the local population towards the planned reintroduction is favourable or where there is a reasonable expectation that local acceptance can be achieved during the project	Socio-economic factors, including perceptions of vultures and their translocation to the project area will be fully assessed as part of the feasibility study under preliminary actions, and further monitoring under monitoring actions. Preliminary scoping work has secured/confirmed the support of local stakeholders for the proposed releases, and the previous projects elsewhere in Sardinia have been widely supported and received warmly by the full

	range of stakeholders. Thus, there is a reasonable expectation that local acceptance can be further increased during the project.
(ix) organisms are only reintroduced in areas where they previously occurred	The proposed translocation meets the condition of the first bullet point, "*organisms are only reintroduced in areas where they previously occurred*", because the whole of Sardinia is included in the Bearded and Cinereous Vulture's historical distribution and breeding colonies previously existed (up to the early 20th century) in the proposed project implementation areas.
(x) the proposal must include a preparatory phase, a re-introduction phase and a follow-up phase, as well as an exit strategy, in case the translocation/reintroduction does not proceed according to plan.	In addition to the foundations for this project being prepared during previous projects, the reintroduction programs foresee a preparatory phase; a re-introduction phase and a follow-up phase through a well-structured monitoring programme, which will allow rapid and effective adaptive management in response to any challenges. The monitoring actions provide the rationale for how they will facilitate an effective follow-up phase during the project period.

*(xi) and (xii) – Not applicable as all translocation actions are within Natura 2000 sites.

10.2 Conclusion

The in-depth analysis of the IUCN criteria for conservation translocations confirms that the reintroduction programme for the Bearded Vulture (*Gypaetus barbatus*) and the Cinereous Vulture (*Aegypius monachus*) in Sardinia is built upon a strong scientific and operational foundation. All mandatory conditions set out by the IUCN have been thoroughly addressed and met, including feasibility and risk assessments, the implementation of strict sanitary protocols, and the selection of ecologically and socially suitable release sites.

The programme benefits from the legacy of previous LIFE projects, which have already contributed to the mitigation of the threats that once led to the extinction of these species on the island—particularly poisoning, persecution, and food scarcity. As such, the reintroduction is not only feasible but timely, aligning with both regional and European conservation goals aimed at restoring ecological functions and enhancing biodiversity in key areas.

Institutional support is robust, with formal agreements in place between donor and recipient authorities, as well as cooperation with captive breeding centres and wildlife recovery facilities. Crucially, the project also involves and engages local communities and stakeholders, whose support and participation are essential to achieving lasting conservation success.

Overall, the reintroduction of the Bearded and Cinereous Vultures to Sardinia represents a forward-thinking and well-structured conservation initiative. It marks a strategic step toward restoring the island's historical guild of avian scavengers and stands as a model for future translocation efforts in Europe. This case illustrates how science-based planning, international collaboration, and strong local engagement can come together to produce tangible, long-term benefits for biodiversity conservation.

11. Description of the release area

The study area for the reintroduction of the two necrophagous species, the Cinereous Vulture and the Bearded Vulture in Sardinia, follows the current area of presence of Italy's only natural breeding population of the Griffon Vulture.

This latter Sardinian necrophagous species is currently the subject of an important LIFE project (LIFE19 NAT/IT/000732 - Safe for Vultures) which, following what was already started in the previous LIFE14 NAT/IT/000484 “Under Griffon Wings”, foresees important measures for the consolidation of the conservation status, the expansion of the nesting range and its return as a breeding species in the south-eastern sector of the island, as well as preparatory measures for the return of the other necrophagous species.

The north-western sector of the island, the only area of uninterrupted presence of one of the three necrophagous species that nested in Sardinia until the mid-20th century, had hosted the two target species of the study until the recent past. This area represents a ‘safe’ place from a trophic point of view, due to the presence of a consistent network of authorised feeding stations, as well as from the point of view of the healthiness of the carcasses (reduced episodes of poison or drug intoxication).

The choice of the historical regions of Marghine, Planargia, Meilogu and Nurra represents a relatively safe choice, following the IUCN guidelines (Guidelines for Reintroductions and Other Conservation Translocations) and ISPRA's ‘Guidelines for the introduction of wildlife species.

Therefore, the area subject to the feasibility study, falls on a surface of about 220,000 ha, included in the territories of the Municipalities of:

Alghero, Banari, Bessude, Bonorva, Borore, Bosa, Cargeghe, Cheremule, Cossoine, Cuglieri, Florinas, Flussio, Giave, Ittiri, Macomer, Magomadas, Mara, Modolo, Monteleone Rocca Doria, Montresta, Muros, Olmedo, Ossi, Padria, Pozzomaggiore, Putifigari, Romana, Sagama, Santulussurgiu, Scano Montiferro, Semestene, Sennariolo, Sindia, Suni, Thiesi, Tinnura, Tissi, Tresnuraghes, Uri, Usini, Villanova Monteleone.

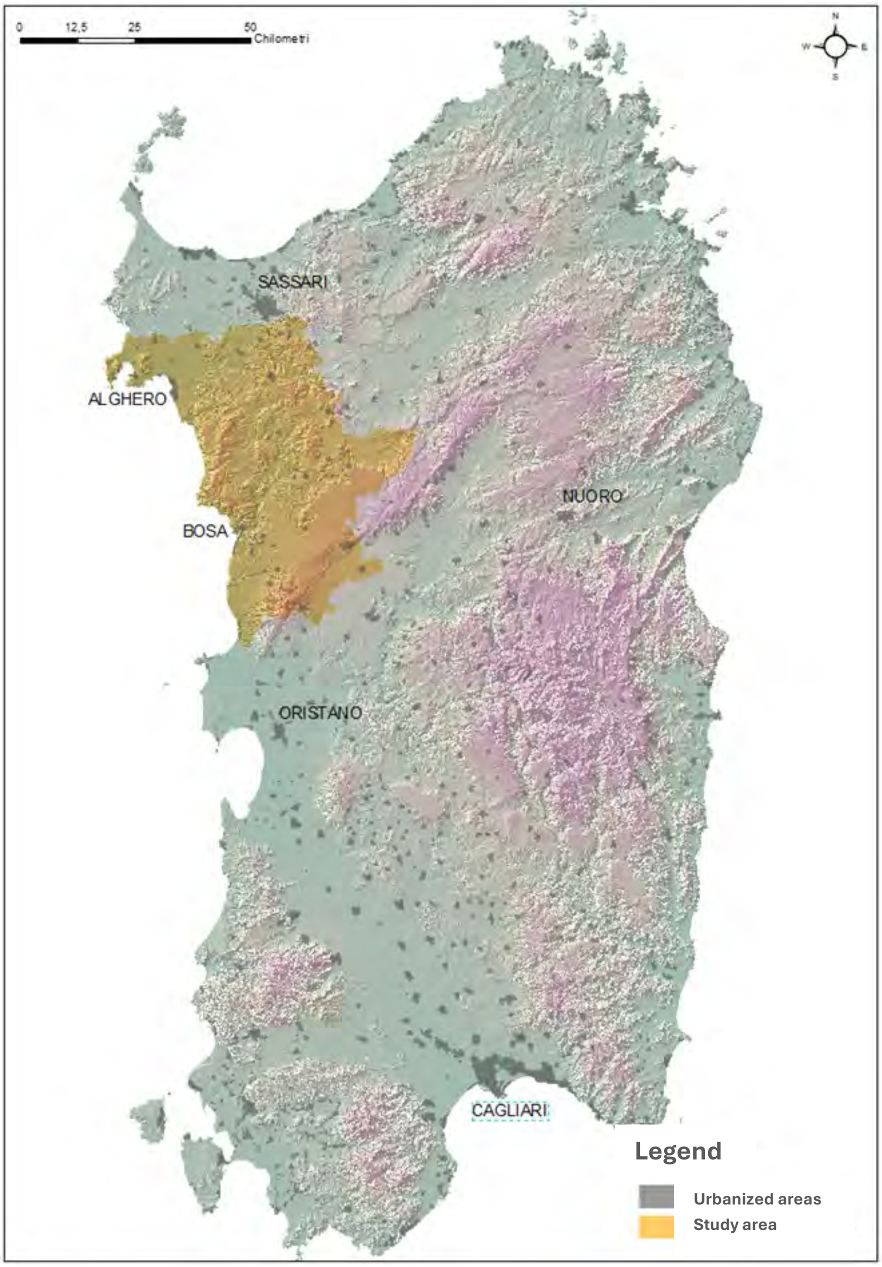


Figure 11.1 *Feasibility study area for the reintroduction of the Cinereous Vulture and the Bearded Vulture in Sardinia (highlighted in orange), corresponding to the current range of Italy's only natural breeding population of the Griffon Vulture. Located in the north-western part of the island, the area offers favourable trophic and sanitary conditions and historically hosted both target species.*

11.1 Demographic and Socio-Economic Characteristics of the Release Area

The release area encompasses 43 municipalities distributed across the historical regions of Marghine, Planargia, Meilogu, and Nurra, in north-western Sardinia. This territory is characterized by a generally low population density (Table 11.1), averaging fewer than 50 inhabitants per square kilometer, with a marked contrast between coastal and inland areas.

Table 11.1 *Demographic characteristics and tourism indicators of the 43 municipalities within the release area. Data include resident population, density, tourist presence, and percentage of increase (annual impact of tourism on resident population, calculated as ((Tourist presence/365)/resident population) x 100).*

Municipality	Population (2024)	Density (inh/km²)	Tourist presence (2024)	Increase (%)
Alghero	42,281	187.6	1,589,756	10.30%
Banari	508	23.8	281	0.20%
Bessude	375	14	N/A	—
Bonorva	3,126	20.8	640	0.10%
Borore	1,930	45	16	<0.01%
Bosa	7,398	57.8	101,768	3.80%
Cargeghe	585	48.8	N/A	—
Cheremule	393	15.8	615	0.40%
Cossoine	753	19	500	0.20%
Cuglieri	2,446	20.2	140,867	15.80%
Florinas	1,445	39.7	233	0.04%
Flussio	398	57.7	1,135	0.80%
Giave	477	10.2	N/A	—
Ittiri	7,937	71.6	876	0.03%
Macomer	9,166	75.2	11,548	0.30%
Magomadas	604	67.1	12,161	5.50%
Mara	528	28.7	67	0.03%
Modolo	175	60.3	1,688	2.60%
Monteleone Rocca Doria	103	7.7	N/A	—
Montresta	443	14.1	N/A	—
Muros	814	74	N/A	—
Olmedo	4,208	124.9	8,729	0.60%
Ossi	5,438	178.8	689	0.03%
Padria	585	12.1	121	0.10%
Pozzomaggiore	2,339	29.6	1,207	0.10%
Putifigari	665	12.6	695	0.30%
Romana	476	22.7	N/A	—
Sagama	188	15.9	75	0.10%
Santu Lussurgiu	2,197	22.1	8,265	1.00%
Scano	1,370	22.7	3,032	0.60%

Montiferro				
Semestene	125	3.2	N/A	—
Sennariolo	153	9.8	1,461	2.60%
Sindia	1,593	27	N/A	—
Suni	983	20.7	796	0.20%
Thiesi	2,715	42.3	2,161	0.20%
Tinnura	248	68.9	117	0.10%
Tissi	2,342	221.9	395	0.05%
Tresnuraghes	1,011	31.9	30,546	8.30%
Uri	2,842	50.2	2,297	0.20%
Usini	4,187	136.8	327	0.02%
Villanova Monteleone	2,074	10.2	2,655	0.40%
Total	**75,343**		**1,925,719**	

Inland municipalities such as Banari (508 residents in 2024), Semestene (375), Modolo (175), and Tinnura (153) are among the smallest by population and show clear signs of demographic decline. These patterns reflect a broader trend of rural depopulation common across the Sardinian interior, driven by low birth rates, ageing populations, and youth outmigration.

In contrast, coastal and more touristic municipalities—such as Alghero, Bosa, and Cuglieri—support larger resident populations and experience substantial seasonal increases due to tourism. Alghero stands out in this respect: in 2024, the city recorded over 1.5 million overnight stays, marking a 16% increase compared to the previous year. With a resident population of just over 42,000 inhabitants, this translates into a temporary seasonal increase of more than 10% in terms of daily human presence. Occupancy rates in Alghero can reach up to 93% during the summer peak, placing considerable pressure on local infrastructures and natural resources. Bosa and Cuglieri, although smaller in scale, also register noticeable seasonal fluctuations, driven by their coastal location, cultural heritage, and appeal to nature-based tourism.

While full tourism figures for smaller inland municipalities are not publicly available — reflecting minimal tourism activity — the disparity between high-visitor coastal towns and sparsely populated inland villages is starkly evident.

Economically, the area continues to be shaped by a mix of traditional and emerging sectors. Extensive livestock farming, particularly sheep and goats, along with agriculture and artisanal crafts, remain central to rural livelihoods. These land-use practices play an important ecological role, providing carcasses and sustaining open landscapes beneficial to scavenger species.

In recent decades, agrifood tourism, rural hospitality, and outdoor - tourism have expanded, especially in municipalities with stronger tourism infrastructure. Coastal towns such as Alghero and Bosa lead in cultural and gastronomic tourism and are emerging as potential gateways for vulture-oriented ecotourism initiatives. The overlap between traditional pastoral economies and wildlife-related tourism offers conservation-linked economic opportunities that align with reintroduction objectives.

11.2 Protected areas and Natura 2000 Network sites

The total number of Natura 2000 Network sites (SAC of Directive 92/43/EU and SPA of Directive 2009/147/EU) included totally or only partially in the area under review is 13, as shown in Figure 11.2 and listed below:

1. ZSC ITB020041 “Entroterra e zona costiera tra Bosa, Capo Marargiu e Porto Tangone”;
2. ZSC ITB011155 “Lago di Baratz – Porto Ferro”;
3. ZSC ITB020040 “Valle del Temo”;
4. ZSC ITB010042 “Capo Caccia (con le isole Foradada e Piana) e Punta del Giglio”;
5. ZSC ITB021101 “Altopiano di Campeda”;
6. ZSC ITB032228 “Is Arenas”;
7. ZSC ITB032201 “Riu Sos Mulinos - Sos Lavros - M. Urtigu”;
8. ZPS ITB013044 “Capo Caccia”;
9. ZPS ITB023037 “Costa e Entroterra di Bosa, Suni e Montresta”;
10. ZPS IT033036 “Costa di Cuglieri”;
11. ZPS ITB013049 “Campu Giavesu”;
12. ZPS ITB230050 “Piana di Semestene, Bonorva, Macomer e Bortigali”;
13. ZPS ITB023051 “Altopiano di Abbasanta”.

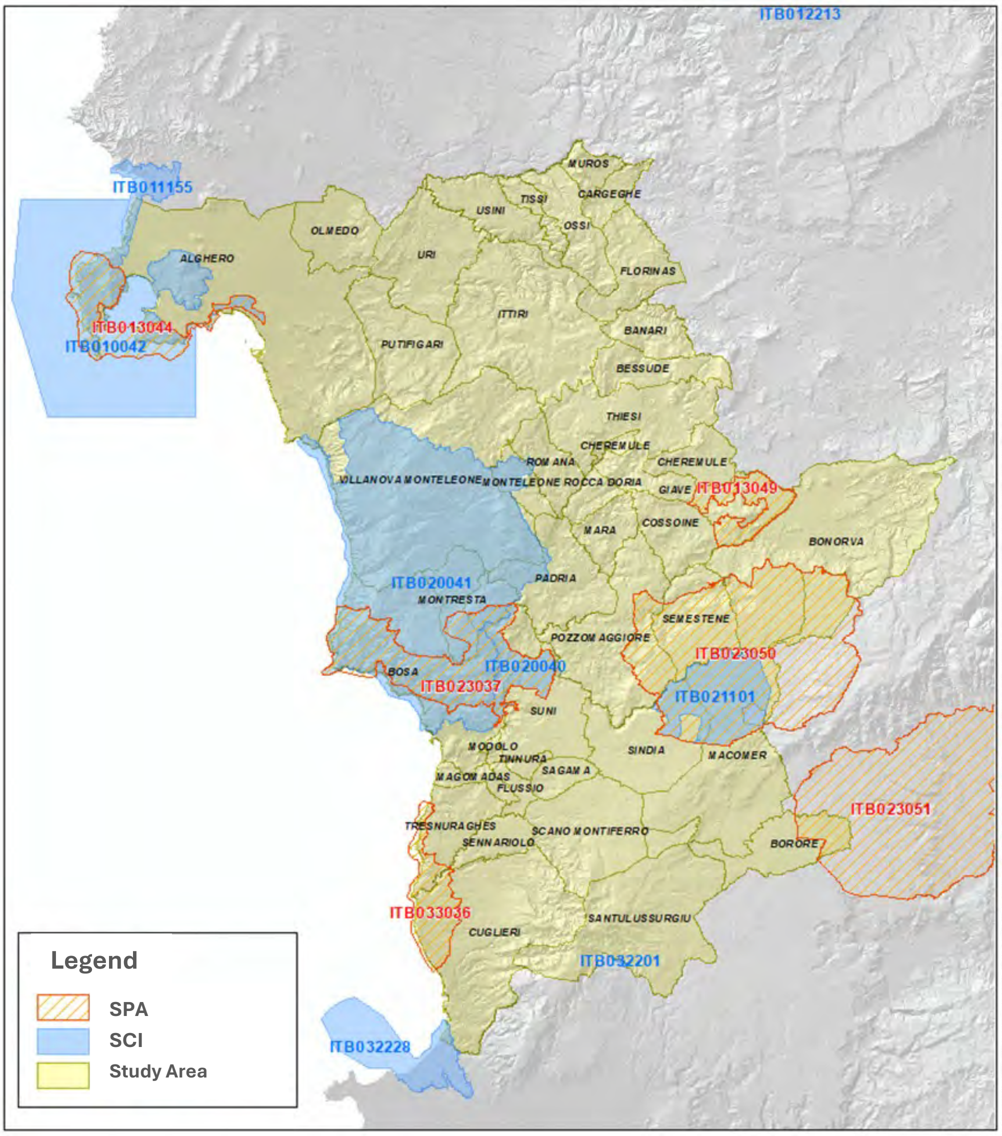


Figure 11.2 *Map of the feasibility study area for the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia (in yellow), overlaid with the Natura 2000 network. Sites of Community Importance (SCI – shown in blue) and Special Protection Areas (SPA – shown in orange hatching) are highlighted within the municipalities included in the study area.*

Of these, the ZSC ITB020041 "Entroterra e zona costiera tra Bosa, Capo Marargiu e Porto Tangone" (29,625 ha), the ZSC ITB020040 'Valle del Temo' (1,934 ha) and the ZPS ITB023037 "Costa e Entroterra di Bosa, Suni e Montresta" (8,222 ha, entirely included in the first two), are barycentric respect to the area under examination and fall within the Municipalities of Monteleone Rocca Doria, Padria, Villanova Monteleone, Bosa, Montresta and Suni.

These areas are extremely important as they were previously selected for the construction of the second Griffon Vulture release aviary, as part of the restocking operations of the first LIFE Project 'Under Griffon Wings' for the conservation of this species on the Island.

Throughout the study area there are also 12 Fauna Protection Oases, four of which (with a total extension of about 1,840 ha) are entirely included in the Natura 2000 areas and fall within the area directly affected by the project activities in the municipalities of Bosa and Villanova Monteleone: the Capo Marragiu Oasis, the Monte Minerva Oasis, the Colonia Agraria Oasis and the Scuola Agraria Oasis (Figure 11.3).

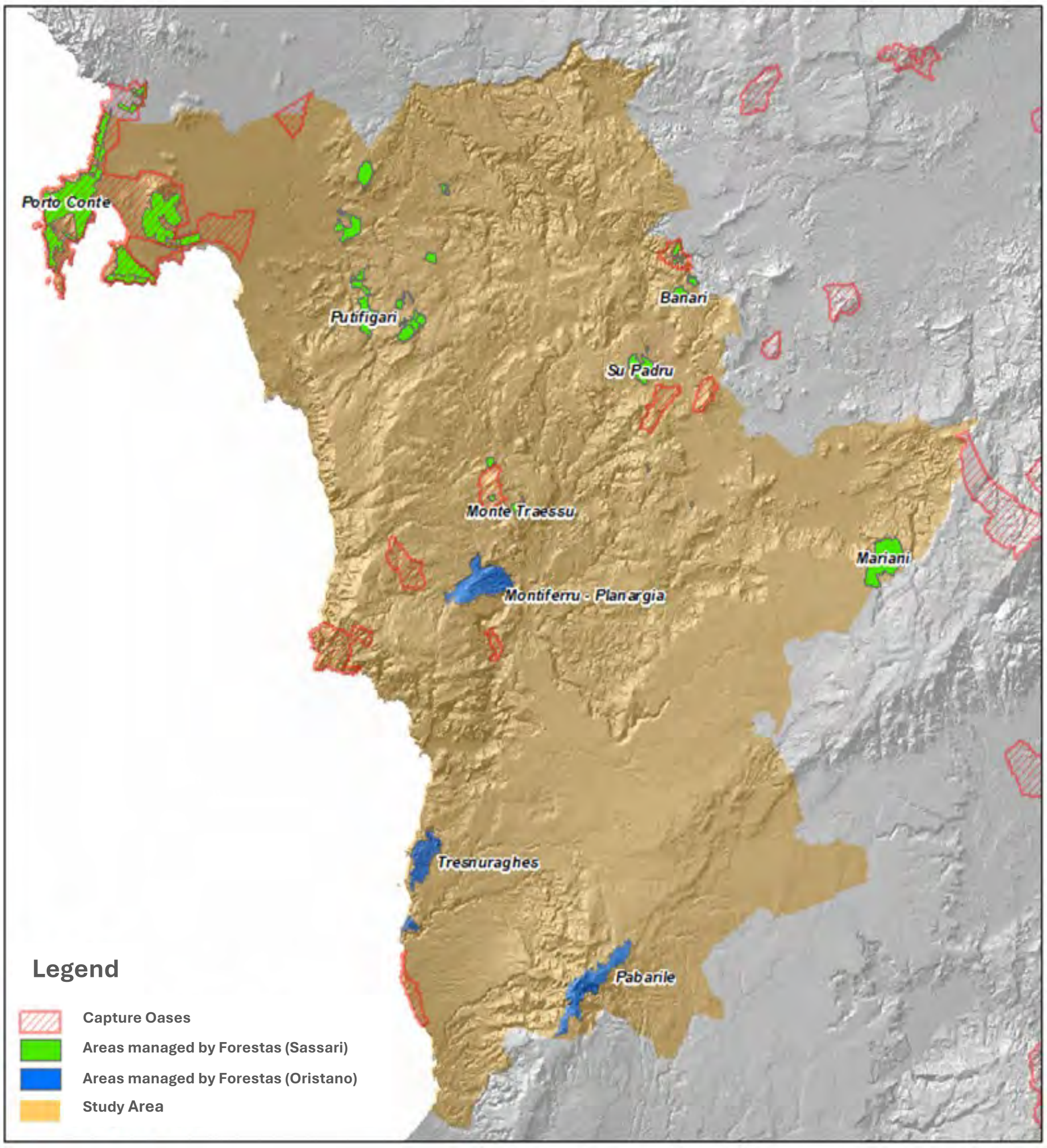


Figure 11.3 *Map of the feasibility study area for the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia (in brown), showing Wildlife Protection and Capture Oases (red hatching) and forest areas managed by the FORESTAS Agency, distinguished by the Sassari Territorial Service (green) and the Oristano Territorial Service (blue).*

Lastly, in the north-western part of the area lies the Porto Conte Regional Natural Park, whose perimeter essentially coincides with Alghero's SAC and SPA.

11.3 Forestry areas managed by Agenzia FoReSTAS

Within the territory under examination, there are several areas directly managed by Oristano and Sassari Territorial Services of the Fo.Re.S.T.A.S. Agency.

Overall, the territorial extension in the area under study, under the direct administration of the Agency, is around 6,878.7 ha (Table 11.2).

Table 11.2 *Table of forest areas within the study area managed by the Fo.Re.S.T.A.S. Agency, divided by Territorial Service (Sassari and Oristano), with approximate surface area in hectares and corresponding municipalities. The total managed surface covers approximately 6,879 hectares.*

Fo.Re.S.T.A.S. Managed areas	Surface ha (circa)	Municipalities
Banari (Serv. Terr. SS)	231.5	Banari
Monte Traessu (Serv. Terr. SS)	127.3	Villanova Monteleone, Cossoine
Mariani (Serv. Terr. SS)	580.8	Bonorva
Porto Conte (Serv. Terr. SS)	2716.2	Alghero
Putifigari (Serv. Terr. SS)	938.1	Putifigari, Uri
Su Padru (Serv. Terr. SS)	207.6	Thiesi
Montiferru–Planargia (Serv. Terr. OR)	779.3	Montresta, Bosa
Pabarile (Serv. Terr. OR)	778.0	Cuglieri, Santu Lussurgiu
Tresnuraghes (Serv. Terr. OR)	519.9	Tresnuraghes
Total managed surface (ha)	**6,878.7**	

11.4 Geomorphology Hydrology and Geology

From a physical and environmental point of view, the area presents multiple forms and different interesting landscapes. In fact, the current geomorphological conformation is the result of past extensive geological and erosive processes that are still ongoing.

The coastline develops (except for the Capo Caccia promontory) in a north-south direction for about 105 km, going from the escarpment edges of the coastal cliffs of Porto Conte in the north with frequent breaks in the slope, to the low rocky coastline and rare beaches in its development towards the south.

The morphologies change from the intensely cultivated plains of the alluvial deposits around the Alghero and Olmedo airport area, to the medium hills of Ittiri and Villanova Monteleone (200–600 m a.s.l.), to the basaltic plateaus (about 300–600 m a.s.l.), and up to the 1050 m a.s.l. of Monte Urtigu (Santu Lussurgiu). A general overview of elevation across the study area is provided in Figure 11.4.

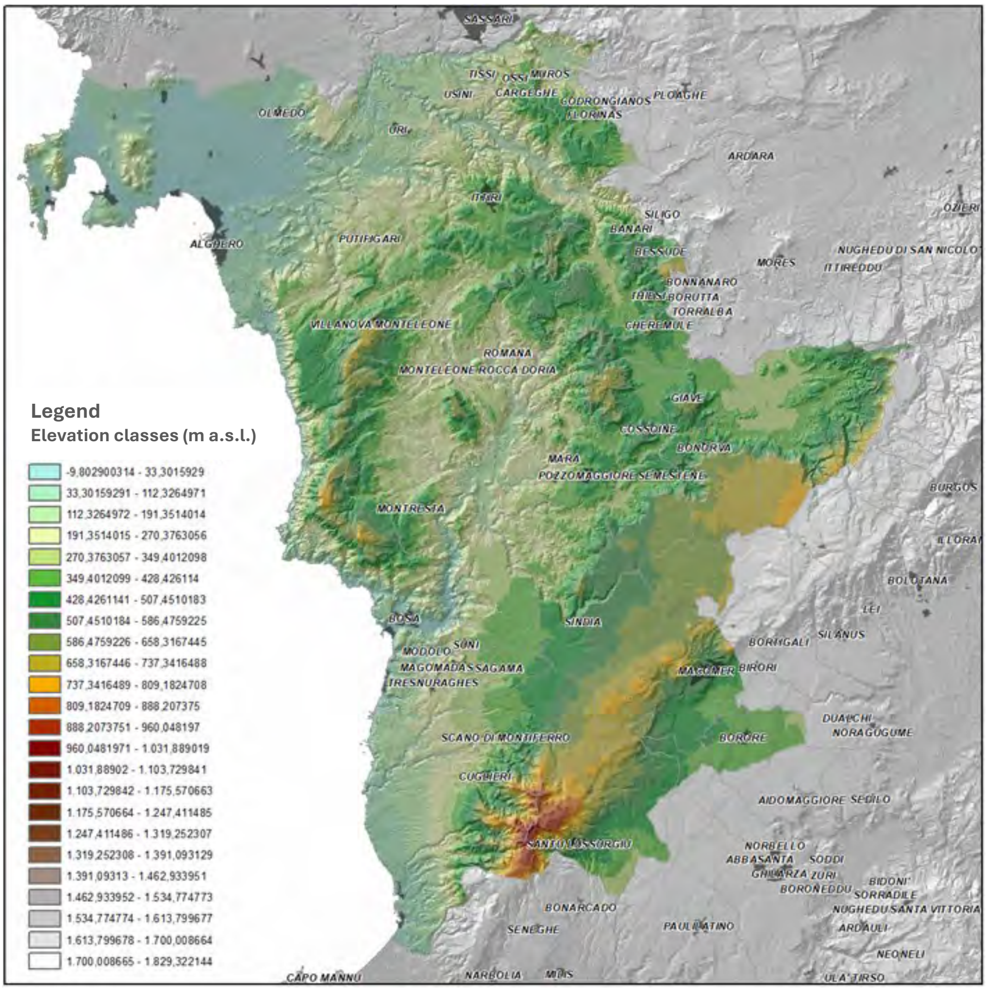


Figure 11.4 *Elevation classes across the study area for the feasibility assessment of the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. The territory displays marked morphological variation, ranging from the alluvial plains around Alghero to the mountainous reliefs of the Montiferru and Marghine regions, exceeding 1000 m a.s.l. near Santu Lussurgiu.*

The clivometry is therefore variable, going from gentler to medium slopes to more marked ones, as shown is Figure 11.5.

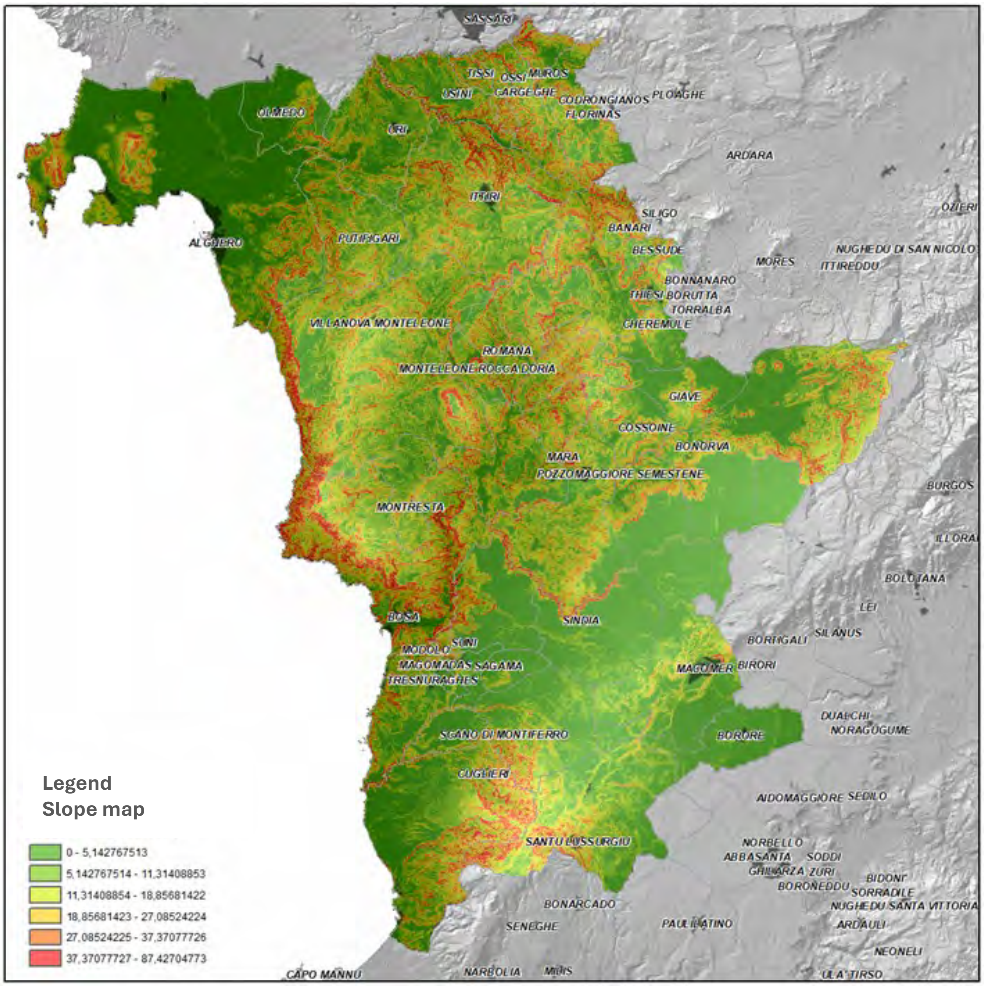


Figure 11.5 *Slope map of the study area for the feasibility assessment of the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. Slope gradients are shown in percentage classes, ranging from flat areas (in green) to steep and rugged slopes (in red), highlighting the geomorphological heterogeneity of the region.*

Hydrographically, the area is in river basin 03: 'Coghinas-Mannu-Temo'. Since the rainfall regime is Mediterranean (with maximum rainfall in winter and minimum rainfall in summer), most of the watercourses are torrential, with dry riverbeds during the warmer months. An exception is the area's main watercourse, the river Temo, which originates from the lake of the same name and flows eastwards, near Bosa marina, collecting the waters of the Su Lacheddu, Ponte Enas and Su Entale streams.

The Rio Mannu flows in a south-east-north-west direction, passing between the villages of Usini and Uri, flowing north into the coast of Porto Torres. Structurally, the main fault system has a south-west-northeast (Putifigari, Villanova Monteleone, Montresta) and south-east-north-west direction.

The lithology of much of the central-northern territory is characterised by landscapes on volcanites: Oligo-Miocene pyroclastic flow deposits at Villanova Monteleone and Chilivani (Villanova Monteleone and Chilivani Units).

In the central zone outcrops of 'Plateau Basalts' consisting of basaltic andesites, weakly alkaline basalts and Plio-Pleistocene trachybasalts in Sindia, Abbasanta, Paulilatino. On the south-west coast, the same outcrops in the Capo Nieddu Unit.

In the northern part, however, the Capo Caccia promontory consists of sands, aeolian sandstones and alluvial deposits from the Upper Pleistocene (Portovesme Synthema), from which the Mesozoic sedimentary succession of northern Sardinia emerges, consisting of dolomite and dolomitic limestone, bioclastic limestone, flintstone, marly limestone and marlstone.

In addition, sandstones, conglomerates, calcarenites, fossiliferous bioclastic limestones, arenaceous marls and marly limestones of the Oligo-Miocene sedimentary succession of the Lugudoro-Sassarese area outcrop in the north-east and in the central part, interspersed with volcanites.

11.5 Soil use

As shown by the land use map (Figure 6), the landscape of the area under review is mainly occupied by agricultural crops and arboriculture (about 70,000 ha, 30%) and by pastures and meadows (30%).

Forests and cork oaks occupy about 30,000 ha (15%), as do shrub formations and garrigue (about 15%). Mediterranean scrub represents the 8% of the remaining area with an extension of about 17,000 ha.

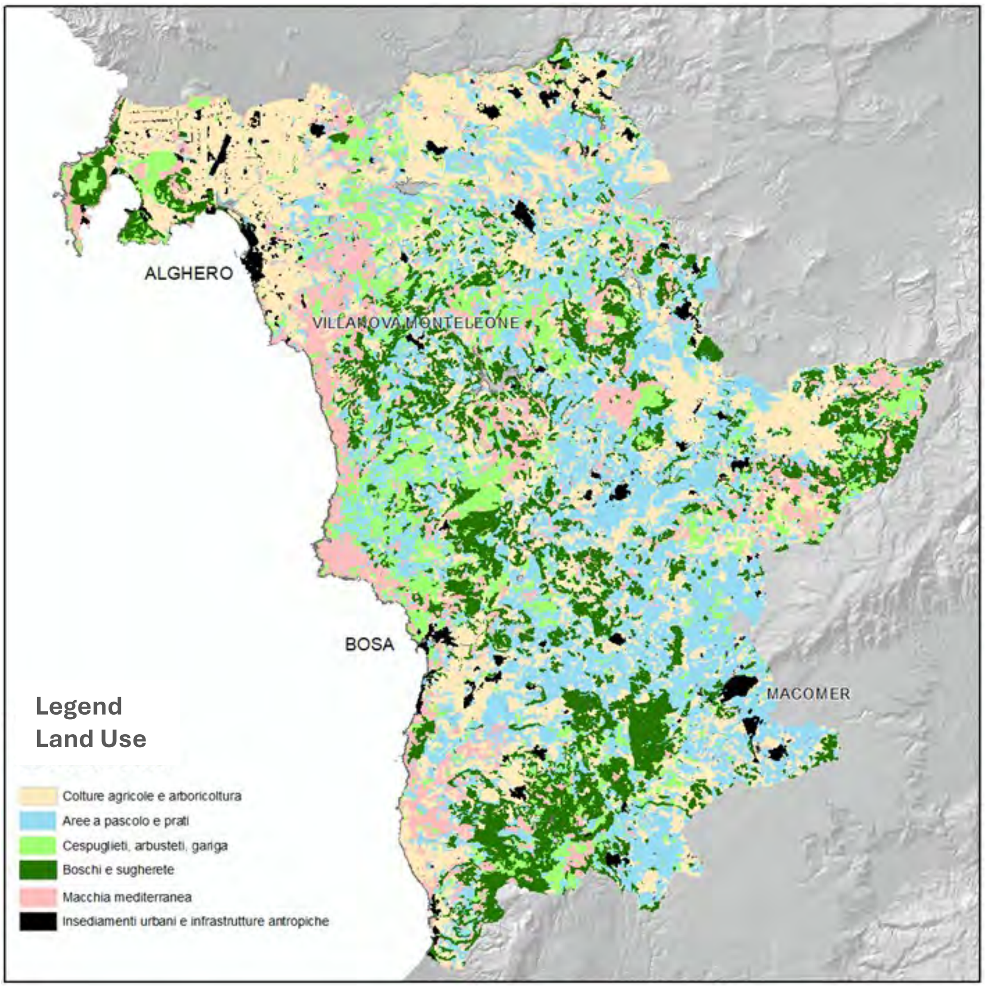


Figure 11.6 *Land use map of the study area for the feasibility assessment of the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. The map shows a heterogeneous landscape composed of agricultural lands and tree crops (light pink), pastures and grasslands (light blue), shrublands and garrigue (light green), forests and cork oak woodlands (dark green), Mediterranean scrub (pink), and urban areas or man-made infrastructure (black). This land cover diversity reflects the typical mosaic character of the north-western Sardinian countryside, offering a suitable environment for necrophagous species.*

11.6 Climate, Bioclimate and Vegetation Series

An analysis of some of the area's meteorological stations reveals peculiar characteristics that identify two climatic areas: the coastal area and the mountainous area:

- the coastal strip has the lowest rainfall in the entire area, with an average index ranging from 285.30 mm. in the months between January and April, and 292.75 mm. in the months between October and December
- the mountainous band, on the other hand, is characterised by high rainfall, but poorly distributed throughout the year, with rainfall concentrated in the two periods October-December and January-April; the average rainfall recorded is 780.5 mm.

The climate of this sector of Sardinia completely mirrors that of the entire island, marked by hot summers, with temperatures exceeding 35°, and mild winters, in which the thermometer rarely and only in very few areas, falls below 0°. In Table 11.3 the average rainfall data measured by the following stations.

Table 11.3 *Monthly and annual rainfall data (in mm) recorded at six meteorological stations within or near the study area for the reintroduction of the Bearded Vulture and the Cinereous Vulture in Sardinia. The table includes the altitude of each station and the average monthly precipitation from January (G) to December (D), highlighting the spatial variability in total annual rainfall, which ranges from 688.3 mm in the coastal station of Bosa (13 m a.s.l.) to 1087.2 mm in Sindia (510 m a.s.l.).*

Station	**Altitude**	**G mm**	**F mm**	**M mm**	**A mm**	**M mm**	**G mm**	**L mm**	**A mm**	**S mm**	**O mm**	**N mm**	**D mm**	**Year mm**
Bosa	13	75,4	74,0	59,2	47,7	35,4	17,5	3,3	9,1	49,5	83,0	105,3	107,2	688,3
Sindia	510	115,5	113,3	100,4	95,8	65,8	24,5	6,5	14,4	62,4	124,4	162,5	178,6	1087,2
V. Monteleo	567	119,5	116,8	90,6	72,6	58,4	23,8	5,8	12,3	59,3	109,6	150,7	159,0	978,5

ne													
Bonorva	479	99,7	94,7	82,5	75,4	57,2	24,0	8,7	17,1	57,5	96,6	128,3	135,0	836,6
Campeda	651	104,5	108,9	98,0	77,5	62,4	23,8	10,0	13,6	52,5	103,1	131,9	149,6	947,2
Reinamare	300	98,1	90,9	75,3	55,0	42,2	17,0	3,0	10,2	45,1	84,5	118,1	120,6	763,1

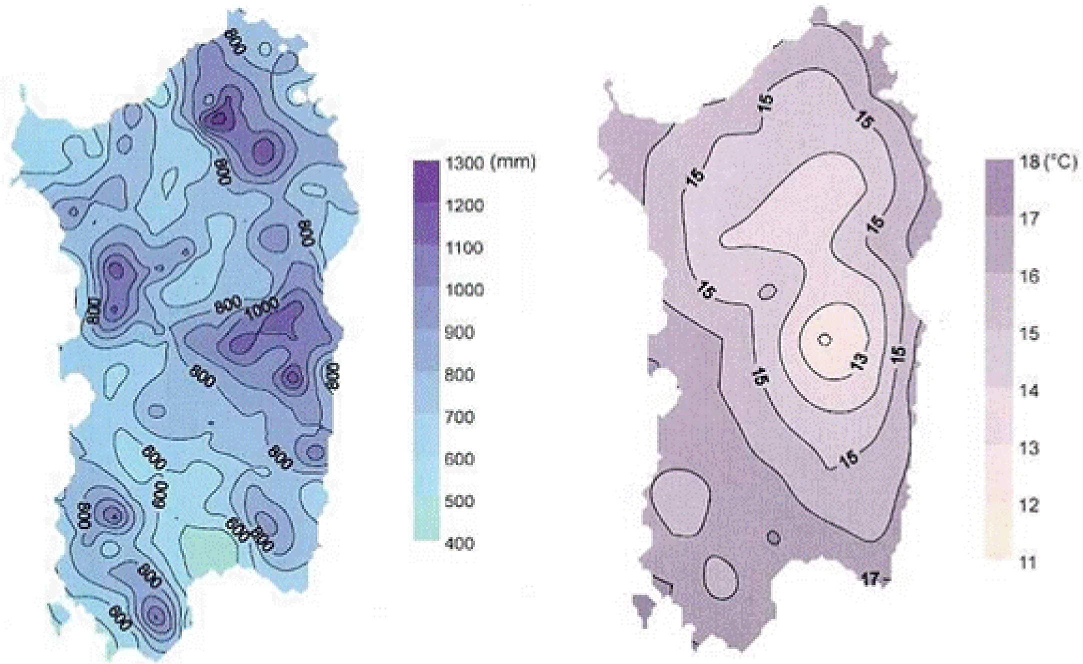


Figure 11.7 *Spatial distribution of average annual precipitation in Sardinia (left) and average annual temperature (right). Rainfall is highest in the central and north-western mountainous areas, exceeding 1000 mm per year. Average annual temperatures are lowest in the elevated inland regions (around 12–13 °C) and highest along the coasts, reaching up to 17–18 °C.*

According to the bioclimatic model 'Worldwide Bioclimatic Classification System' (WBCS, Rivas-Martínez et al., 2002), the study area is included in the Mediterranean macrobioclimate, oceanic pluiscal bioclimate (MEPO) and (referring to the Villanova Monteleone station) with thermotype 'Mmei - lower mesomediterranean' and ombrotype 'Sus - upper subhumid' (Bacchetta et al., 2009).

The flora of the study area presents a great richness and diversity, related to the heterogeneity of the territory's geo-pedological and edaphic characteristics (Figure 11.8).

Figure 11.8 *Forest vegetation map and vegetation series of north-western Sardinia. The map shows the distribution of different forest types, shrublands, and other vegetation units across the region, based on geomorphological and climatic gradients. The area includes a variety of habitats from coastal Mediterranean shrublands to inland forests and agricultural mosaics. Source: Bacchetta et al. 2009.*

The vegetation series represented in the study area are:

- 18 - Sardinian, central, calcifugous, mesomediterranean cork oak series (*Violo dehnhardtii-Quercetum suberis*)
- 20 - Sardinian, central, calcifugous, meso-supratemperate series of the Sardinian oak (*Loncomelo pyrenaici- Quercetum ichnusae*)
- 13 - Sardinian, calciferous, mesomediterranean Holm oak series (*Prasio majoris - Quercetum ilicis quercetosum virgilianae*)
- 24 - Mediterranean, edaphic and lowland, thermo-mesomediterranean geosystem (*Populenion albae, Fraxino angustifoliae - Ulmenion minoris, Salicion albae*).

In the Capo Caccia promontory and along the coast:

- 3 - West Sardinian, calcicolous, thermo-Mediterranean series of Turbinate Juniper (*Chamaeropo humilis -Juniperetum turbinatae*)
- 12 - West Sardinian, calcicolous, thermo-Mediterranean series of holm oak (*Prasio majoris - Quercetum ilicis chamaeropetosum humilis*)
- 10 - Sardinian, calcifuge, thermo-Mediterranean series of the holm oak (*Pyro spinosae - Quercetum ilicis*)
- 8 - Sardinian, thermo-Mediterranean series of the wild olive (*Asparagus albi - Oleetum sylvestris*).

In the southwest Monte Ferru:

- 11 - Sardinian, thermo-mesomediterranean series of the holm oak (*Prasio majoris - Quercetum ilicis typicum and phillyreetosum angustifoliae*)
- 14 - Sardinian, calcifuge, meso-supramediterranean series of holm oak (*Galio scabri - Quercetum ilicis*)
- 16 - Central-western Sardinian, calcifugous, meso- supratemperate series of holm oak (*Saniculo europaeae -Quercetum ilicis*).

The most widespread forest formations in the area are attributable to the classes *Quercetum suberis*, *Quercetum ichnusae and Quercetum ilicis*.

The flora of the study area presents a great richness and diversity, related to the heterogeneity of the geo-pedological-edaphic characteristics of the territory.

In the vast system of the study area, there is a rich mosaic of vegetation resulting from the millennial interaction between man and the environment with fires, grazing, forest cutting and reforestation, as well as other abiotic and biotic factors of various kinds.

Compared to the potential framework, there is therefore a varied situation of vegetation types and habitats, the most characteristic and relevant elements of which are listed below.

11.6.1 The coastal cliffs and beaches vegetation

Starting from the coastal strip, in the closest areas to the sea, the most widespread formations, in relation to the characteristic littoral morphology, are the halophilous rupicolous ones, directly subjected to the marine aerosol, characterised by the presence of *Crithmum maritimum* and *Limonium sp.pl.* (among these we mention *L. bosanum*). They typically present a sparse and discontinuous structure with a dominance of small chamaephytes, sometimes accompanied by hemicryptophytes and nanophanerophytes. Towards the interior, these coenoses fade towards coastal garigues and thickets.

From the point of view of habitat classification, such vegetation falls under Directive 92/43/EU habitats:

1240 - Cliffs with Mediterranean coastal vegetation with endemic *Limonium spp.*

Not all the coastline of the area under examination presents a rocky and rugged morphology. In fact, sandy shorelines are present, albeit to a much lesser extent, characterised by psammophilous vegetation, adapted to factors such as substrate mobility, salinity and strong winds; factors that show a marked gradient from the coast inland and determine the more or less evident characteristic succession from the aphitic zone to the zones with different vegetation formations, which typically see, the pioneer communities of the *cakileto*, in contact with those of the embryonic dunes of the *agropyreto*, with *Agropyron junceum*, and *Sporobolus pungens*, followed inland by the vegetation of the *ammophileto* characterised by *Ammophila arenaria*.

In the more sheltered backdunes, we find communities characterised by *Crucianella maritima* and *Pancratium maritimum*.

This is sometimes followed by stable dunes with formations of junipers and other Mediterranean sclerophyllous plants.

- 1210 Annual vegetation of marine deposit lines.
- 2110 Mobile embryonic dunes.
- 2120 Mobile dunes of the littoral cordon with the presence of *Ammophila arenaria* (white dunes)'.
- 2210: Fixed littoral dunes (*Crucianellion maritimae*)
- 2250*: Coastal dunes with *Juniperus spp.*

11.7 The main forest formations

The study area is criss-crossed by various watercourses to which characteristic vegetation formations are linked below.

Among these, in the permanently flowing watercourses, of particular note are the gallery forests of black alder*, Alnus glutinosa (L. Gaert.),* often in a mosaic situation with poplar *(Populus spp.)* and willow groves *(Salix spp.),* and also, in the more inland areas, laurel thickets*, Laurus nobilis L.,* and in those close to the coast, oleander and tamarisk thickets, *Nerium oleander L.* and *Tamarix africana Poir., t*he latter being able to tolerate even saline soil conditions.

These formations can be ascribed to the habitats:

- *5230*:* Arboreal Matorral of *Laurus nobilis*
- *91E0*:* Alluvial forests of *Alnus glutinosa* and *Fraxinus excelsior*
- *92A0*: Gallery forests of *Salix alba* and *Populus alba.*
- *92D0:* Southern riparian galleries and forts *(Nerio-Tamaricetea and Securinegion tinctoriae).*

In addition to riparian forests, other forest formations are present in the area, in particular extensive oleaster, holm-oak and cork oak forests dense, ranging from true woods to arboreal pastures (Dehesas).

Less extensive and fragmented areas are affected by the presence of deciduous oak groves in *Quercus congesta C. Presl.,* and in the coastal strip by junipers *Juniperus phoenicea L.*

These formations correspond to habitats of Directive 92/43/EU:

*91AA** Eastern white oak forests

9320: Olea and Ceratonia forests

9330: Quercus suber forests

9340 - Quercus ilex and *Quercus rotundifolia* forests

6310 - Dehesas with *Quercus spp.* Evergreen.

An interesting area from the point of view of forestry and the historical presence of the Cinereous vulture in Sardinia is the *Silva Manna forest (92/43/EC - Habitat 9330 and 9340).* This is a wooded area located in north-western Sardinia, between the municipalities of Montresta and Bosa. The forest component of this area of about 1,000 hectares is represented by a predominantly cork *(Quercus suber)* mixed with holm oak *(Quercus ilex)* and downy oak *(Quercus pubescens).*

11.7.1 Mediterranean scrub and garigues

As previously mentioned, the area contains large areas of secondary formations such as thickets, garrigue and pastures. Regarding thickets, different types can be distinguished in relation to the dominant characteristic species.

Particularly frequent in the area are coenoses dominated by tree spurge *(Euphorbia dendroides),* mastic tree *(Pistacia lentiscus), t*ree heather and strawberry tree *(Erica arborea and Arbutus unedo),* spiny broom *(Calycotome villosa) a*nd, in the wetter areas, common myrtle *(Myrtus communis).*

Of ecological and conservation interest are the coenoses characterised by the dominance of the mediterranean fan palm *(Chamaerops humilis).* The vegetation mosaic is completed with other types of dynamically connected habitats, such as garigues and terophytic grasslands.

In this case several species are present in the vast area considered. These include rock rose beds with *Cistus sp.pl.,* lavender formations with *Genista corsica a*nd those with strawflower *(Helichrysum microphyllum).*

Most of these formations belong to subtypes and variants of HD *92/43/EC*:

- *5320:* Low *Euphorbia* formations near cliffs
- *5330:* Thermo-Mediterranean and pre-desert shrublands
- *1.6.2.* Meadows and pastures

The mosaic pattern is completed by formations dominated by herbaceous perennial and annual vegetation of the xerophilous and discontinuous grass-dominated grasslands, referable to the habitat:

6220:* Sub-steppe of grasses and annuals of the *Thero-Brachypodietea.*

This vegetation frequently occurs in areas of erosion or in any case where the continuity of the soils is interrupted, typically within clearings of perennial vegetation, and usually represents aspects of advanced degradation at the end of regressive processes linked to overgrazing or repeated fire phenomena. In the absence of such perturbations, the communities referable to *Habitat 6220** may be recolonised by woody perennial shrub species that tend to supplant the herbaceous vegetation, determining the succession towards more evolved perennial coenoses such as those of garigues, thickets, mattorral and woodlands.

11.8 Fauna

The fauna of this area includes species of significant international importance, as evidenced by the designation of several Natura 2000 network sites, as well as various Wildlife Protection Oases and protected areas established or partially implemented under Regional Law 31/89. In particular, the terrestrial vertebrate fauna (Aves, Amphibia, Reptilia, Mammalia) consists of 161 breeding species within the study area, including 108 bird species, 5 amphibians, 16 reptiles, and 32 mammals. This represents a substantial portion (67.2%) of all vertebrate species that reproduce in Sardinia.

Birds *(Aves*)
A total of 218 bird species have been recorded within the study area, of which 108 have been confirmed as local breeders. The high number of bird species is primarily due to the presence of a variety of contiguous habitats with a high degree of naturalness. Many bird species are present year-round, while others overwinter or pass through the area during migration.
These 218 species are classified into various categories under the EU Birds Directive 2009/147/EC, which outlines protection levels and management measures, as follows:

Category I: 71 species requiring strict protection
Category II/B: 26 species subject to habitat management
Category II/A: 15 species requiring special conservation measures
Category III/A: 3 species that may be hunted during specific periods
Category III/B: 2 species that may be hunted under specific conditions

Table 11.4 *Bird species recorded in Sardinia with their scientific, Italian, and English names. The table includes information on each species' conservation status according to the EU Birds Directive (2009/147/EC), the IUCN European and Italian Red Lists, and the Sardinian regional Red List.*

N.	Scientific name	Italian name	English name	Birds Directive 2009/147/EC	Iucn European Red List	Iucn Italian Red List	Sardinian Red List

1	*Anser anser*	Oca selvatica	Greylag Goose	II/A	LC	LC	
2	*Tadorna tadorna*	Volpoca	Shelduck		LC	VU	NT
3	*Anas strepera*	Canapiglia	Gadwall	II/A	LC	NT	NT
4	*Anas penelope*	Fischione	Wigeon	II/A	LC		NT
5	*Anas platyrhynchos*	Germano reale*	Mallard	II/A, III/A	LC	LC	LC
6	*Anas clypeata*	Mestolone	Shoveler	II/A	LC	VU	NT
7	*Anas acuta*	Codone	Pintail	II/A	VU		
8	*Anas querquedula*	Marzaiola	Garganey	II/A	LC	VU	DD
9	*Anas crecca*	Alzavola	Teal	II/A	LC	EN	NA
10	*Aythya ferina*	Moriglione	Pochard	II/A	VU	VU	NT
11	*Netta rufina*	Fistione turco	Red-crested Pochard	II/B	LC	VU	NT
12	*Aythya nyroca*	Moretta tabaccata	Ferruginous Duck	I	LC	EN	CR
13	*Aythya fuligula*	Moretta	Tufted Duck	II/A	NT	VU	NA
14	*Alectoris barbara*	Pernice sarda*	Barbary Patridge	I, II/B, III/A	LC	DD	LC
15	*Coturnix coturnix*	Quaglia*	Quail	II/B	NT	DD	NT
16	*Tachybaptu sruficollis*	Tuffetto*	Little Grebe		LC	LC	LC
17	*Podiceps nigricollis*	Svasso piccolo*	Black-necked Grebe		LC		
18	*Podiceps cristatus*	Svasso maggiore	Great Crested Grebe		LC	LC	LC
19	*Calonectris diomedea*	Berta maggiore*	Scopoli's Shearwater	I	LC	LC	VU
20	*Puffinus yelkouan*	Berta minore*	Yelkuan Shearwater	I	VU	DD	VU
21	*Puffinus mauretanicus*	Berta minore balearica	Balearic Shearwater				

22	*Hydrobates pelagicus*	Uccello delle tempeste*	Storm Petrel	I	LC	NT	VU
23	*Phalacrocorax carbo*	Cormorano	Cormorant		LC	LC	EN
24	*Phalacrocorax aristotelis desmaresti*	Marangone dal ciuffo*	Mediterranean Shag	I	LC	LC	NT
25	*Botaurus stellaris*	Tarabuso	Bittern	I	LC	EN	CR
26	*Ixobrychus minutus*	Tarabusino*	Little Bittern	I	LC	VU	NT
27	*Nycticorax nycticorax*	Nitticora	Night Heron	I	LC	LC	NT
28	*Bulbulcus ibis*	Airone guardabuoi	Cattle Egret		LC	LC	LC
29	*Ardeola ralloides*	Sgarza ciuffetto	Squacco Heron	I	LC	NT	VU
30	*Egretta garzetta*	Garzetta	Little Egret	I	LC	LC	NT
31	*Casmerodius albus*	Airone bianco maggiore	Great Egret	I	LC	LC	
32	*Ardea cinerea*	Airone cenerino	Grey Heron		LC	LC	NA
33	*Ardea purpurea*	Airone rosso	Purple Heron	I	LC	LC	NT
34	*Ciconia ciconia*	Cicogna bianca	White Stork	I	LC	LC	DD
35	*Ciconia nigra*	Cicogna nera	Black Stork	I	LC	EN	
36	*Plegadis falcinellus*	Mignattaio	Glossy ibis	I	LC	VU	CR
37	*Platalea leucorodia*	Spatola	Spoonbill	I	LC	NT	
38	*Phoenicopterus roseus*	Fenicottero	Flamingo	I	LC	LC	VU
39	*Gyps fulvus*	Grifone*	Griffon Vulture	I	LC	NT	CR
40	*Neophron percnopterus*	Capovaccaio*	Egyptian Vulture	I	VU	CR	
41	*Pandion haliaetus*	Falco pescatore*	Osprey	I	EN	CR	CR?
42	*Aquila chrysaetos*	Aquila reale*	Golden Eagle	I	LC	NT	VU

43	*Hieraaetus pennatus*	Aquila minore	Booted Eagle	I	LC		
44	*Aquila fasciata*	Aquila di Bonelli	Bonelli's Eagle	I	LC	CR	CR
45	*Milvus milvus*	Nibbio reale*	Red Kite	I	LC	VU	CR
46	*Milvus migrans*	Nibbio bruno	Black Kite	I	LC	LC	NA
47	*Circus aeruginosus*	Falco di palude*	March Harrier	I	LC	VU	NT
48	*Circus cyaneus*	Albanella reale	Hen Harrier	I	LC		
49	*Circus pygargus*	Albanella minore*	Montagu's Harrier	I	VU	VU	VU
50	*Circus macrourus*	Albanella pallida	Pallid Harrier	I	LC		
51	*Buteo buteo arrigonii*	Poiana sarda*	Sardinian Common Buzzard		LC	LC	LC
52	*Pernis apivorus*	Falco pecchiaiolo*	Honey Buzzard	I	LC	LC	
53	*Accipiter nisus wolterstorffi*	Sparviere di Sardegna*	Sardinian Sparrwhawk		LC	LC	LC
54	*Accipiter gentilis arrigoni*	Astore di Sardegna*	Sardinian Goshawk	I	LC	EN	VU
55	*Falco naumanni*	Grillaio*	Lesser Kestrel	I	LC	LC	EN
56	*Falco tinnunculus*	Gheppio*	Kestrel		LC	LC	LC
57	*Falco vespertinus*	Falco cuculo	Red-footed Falcon	I	CR	VU	
58	*Falco eleonorae*	Falco della regina	Eleonora's Falcon	I	LC	VU	NT
59	*Falco subbuteo*	Lodolaio*	Hobby		LC	LC	DD
60	*Falco peregrinus*	Falco pellegrino*	Peregrine Falcon	I	LC	LC	NT
61	*Falco columbarius*	Smeriglio	Merlin	I	LC		
62	*Rallus aquaticus*	Porciglione*	Water Rail	II/B	LC	LC	LC

63	*Zapornia parva*	Schiribilla	Little Crake	I	LC	CR	
64	*Porzana porzana*	Voltolino	Spotted Crake	I	LC	CR	
65	*Gallinula chloropus*	Gallinella d'acqua*	Moorhen	II/B	LC	LC	LC
66	*Fulica atra*	Folaga*	Coot	III/B	NT	LC	LC
67	*Porphyrio porphyrio*	Pollo sultano*	Purple Swaphen	I	LC	NT	NT
68	*Grus grus*	Gru	Crane	I	LC	RE	
69	*Tetrax tetrax*	Gallina prataiola*	Little Bustard	I	VU	EN	EN
70	*Haematopus ostralegus*	Beccaccia di mare	Oystercatcher	II/A	NT	VU	
71	*Recurvirostra avosetta*	Avocetta	Avocet	I	LC	LC	NT
72	*Himantopus himantopus*	Cavaliere d’Italia*	Black-winged Stilt	I	LC	LC	NT
73	*Burhinus oedicnemus*	Occhione*	Stone Curlew	I	LC	LC	NT
74	*Charadrius dubius*	Corriere piccolo	Little Ringed Plover		LC	LC	LC
75	*Charadrius hiaticula*	Corriere grosso	Ringed Plover		LC		
76	*Charadrius alexandrinus*	Fratino*	Kentish Plover	I	LC	EN	NT
77	*Pluvialis squatarola*	Pivieressa	Grey Plover	II/B	LC		
78	*Pluvialis apricaria*	Piviere dorato	Golden Plover	I	LC		
79	*Vanellus vanellus*	Pavoncella	Lapwing	II/B	VU	LC	
80	*Calidris alba*	Piovanello tridattilo	Sanderling		LC		
81	*Arenaria interpres*	Voltapietre	Turnstone		LC		
82	*Calidris canutus*	Piovanello maggiore	Knot	II/B	NT		

83	*Calidris alpina*	Piovanello pancianera	Dunlin		LC		
84	*Calidris ferruginea*	Piovanello comune	Curlew Sandpiper		VU		
85	*Calidris minuta*	Gambecchio comune	Temmink's Stint		LC		
86	*Tringa glareola*	Piro piro boschereccio	Wood Sandpiper	I	LC		
87	*Tringa ochropus*	Piro piro culbianco	Green Sandpiper		LC		
88	*Actitis hypoleucos*	Piro piro piccolo	Common Sandpiper		LC	NT	
89	*Tringa totanus*	Pettegola	Redshank	II/B	VU	LC	VU
90	*Tringa erythropus*	Totano moro	Spotted Redshank	II/B	LC		
91	*Tringa nebularia*	Pantana	GreenShank	II/B	LC		
92	*Tringa stagnatilis*	Albastrello	Marsh Sandpiper		LC		
93	*Limosa limosa*	Pittima reale	Black-tailed Godwit	II/B	NT	EN	
94	*Limosa lapponica*	Pittima minore	Bar-Tailed Godwit	I	LC		
95	*Numenius arquata*	Chiurlo maggiore	Curlew	II/B	NT		
96	*Numenius phaeopus*	Chiurlo piccolo	Whimbrel	II/B	LC		
97	*Scolopax rusticola*	Beccaccia	Woodcock	II/A, III/B	LC	DD	
98	*Lymnocryptes minimus*	Frullino	Jack Snipe	II/A	LC		
99	*Gallinago gallinago*	Beccaccino	Snipe	II/A,III/B	VU		
100	*Calidri xpugnax*	Combattente	Ruff	I	LC		
101	*Larus ridibundus*	Gabbiano comune*	Black-headed Gull	II/B	LC	LC	VU
102	*Chroicocephalus genei*	Gabbiano roseo	Slender-bill Gull	I	VU	NT	VU

103	*Larus michahellis*	Gabbiano reale*	Yellow-legged Gull	II/B	LC	LC	LC
104	*Ichthyaetus audouinii*	Gabbiano corso*	Audouin's Gull	I	VU	LC	VU
105	*Larus fuscus*	Zafferano	Lesser Black-backed Gull	II/B	LC		
106	*Sternula albifrons*	Fraticello	Little Tern	I	LC	NT	VU
107	*Thalasseus sandvicensis*	Beccapesci	Sandwich Tern	I	LC	VU	RE
108	*Gelochelidon nilotica*	Sterna zampenere	Gull-billed Tern	I	LC	NT	EN
109	*Sterna hirundo*	Sterna comune	Common Tern	I	LC	LC	VU
110	*Hydroprogne caspia*	Sterna maggiore	Caspian Tern	I	LC		RE
111	*Chlidonias hybrida*	Mignattino piombato	Whiskered Tern	I	LC	VU	
112	*Chlidonias niger*	Mignattino comune	Black Tern	I	LC	CR	
113	*Chlidonias leucopterus*	Mignattino alibianche	White-winged Tern		LC		
114	*Alca torda*	Gazza marina	Razorbill		LC		
115	*Columba livia*	Piccione selvatico*	Rock Dove	II/A	LC	DD	LC
116	*Columba palumbus*	Colombaccio*	Wood Pigeon	II/A, III/A	LC	LC	LC
117	*Streptopelia turtur*	Tortora selvatica*	Turtle Dove	II/B	VU	LC	NT
118	*Streptopelia decaocto*	Tortora dal collare*	Collared Dove	II/B	LC	LC	LC
119	*Cuculus canorus*	Cuculo*	Cuckoo		LC	NT	LC
120	*Clamator glandarius*	Cuculo dal ciuffo*	Great Spotted Cuckoo		VU	EN	DD

121	*Tyto alba ernestii*	Barbagianni di Sardegna*	Sardinian Barn Owl		LC	LC	NT
122	*Otus scops*	Assiolo*	Scops Owl		LC	LC	LC
123	*Athen enoctua*	Civetta*	Little Owl		LC	LC	LC
124	*Asio otus*	Gufo comune*	Long-eared Owl		LC	LC	DD
125	*Asio flammeus*	Gufo di palude	Short-eared Owl	I	LC		
126	*Caprimulgus europaeus*	Succiacapre*	Nightjar	I	LC	LC	DD
127	*Tachymarptis melba*	Rondone maggiore*	Alpine Swift		LC	LC	LC
128	*Apus apus*	Rondone comune*	Swift		NT	LC	LC
129	*Apus pallidus*	Rondone pallido*	Pallid Swift		LC	LC	LC
130	*Coracias garrulus*	Ghiandaia marina*	Roller	I	LC	LC	VU
131	*Merops apiaster*	Gruccione*	Beeìeater		LC	LC	NT
132	*Upupa epops*	Upupa*	Hoopoe		LC	LC	NT
133	*Jynx torquilla*	Torcicollo*	Wryneck		LC	CR	LC
134	*Dendrocopos major*	Picchio rosso maggiore*	Great Spotted Woodpecker		LC	LC	LC
135	*Alauda arvensis*	Allodola*	Skylark	II/B	LC	VU	NT
136	*Lullula arborea*	Tottavilla*	Woodlark	I	LC	LC	LC
137	*Calandrella brachydacryla*	Calandrella*	Short-toed Lark	I	LC	LC	VU
138	*Melanocorypha calandra*	Calandra*	Calandra Lark	I	LC	VU	NT
139	*Riparia riparia*	Topino	Sand Martin		LC	VU	NA
140	*Ptyonoprogne rupestris*	Rondine montana*	Crag Martin		LC	LC	LC

141	*Hirundo rustica*	Rondine*	Barn Swallow		LC	NT	LC
142	*Cecropis daurica*	Rondine rossiccia*	Red-rumped Swallow		LC	VU	DD
143	*Delichon urbicum*	Balestruccio*	House Martin		LC	NT	LC
144	*Anthus campestris*	Calandro*	Tawny Pipit	I	LC	VU	LC
145	*Anthus pratensis*	Pispola	Meadow Pipit		LC	LC	
146	*Anthus trivialis*	Prispolone	Tree Pipit		LC	LC	
147	*Anthus spinoletta*	Spioncello	Water Pipit		LC	LC	LC
148	*Motacilla alba*	Ballerina bianca*	White Wagtail		LC	LC	
149	*Motacilla cinerea*	Ballerina gialla*	Grey Waigtail		LC	LC	LC
150	*Motacilla flava*	Cutrettola	Yellow Wagtail		LC	NT	NT
151	*Prunella modularis*	Passera scopaiola	Dunnock		LC	NT	
152	*Erithacus rubecula*	Pettirosso*	Robin		LC	LC	LC
153	*Luscinia megarhynchos*	Usignolo*	Nightingale		LC	LC	LC
154	*Luscinia svecica*	Pettazzurro	Bluethroat	I	LC		
155	*Phoenicurus ochruros*	Codirosso spazzacamino	Black redstart		LC	LC	
156	*Phoenicurus phoenicurus*	Codirosso comune	Redstart		LC	LC	
157	*Oenanthe oenanthe*	Culbianco	Wheatear		LC	LC	LC
158	*Saxicola rubetra*	Stiaccino	Whinchat		LC	VU	NA
159	*Saxicola rubicola*	Saltimpalo*	Stonchat		LC	EN	LC
160	*Turdus philomelos*	Tordo bottaccio	Song Thrush	II/B	LC	LC	
161	*Turdus iliacus*	Tordo sassello	Redwing		NT		

162	*Turdus viscivorus*	Tordela*	Mistle Thrush		LC	LC	LC
163	*Turdus pilaris*	Cesena	Filedfare		LC		
164	*Turdus merula*	Merlo*	Blackbird	II/B	LC	LC	LC
165	*Turdus torquatus*	Merlo dal collare	Ring Ouzel		LC	LC	
166	*Monticola solitarius*	Passero solitario*	Blue Rock Thrush		LC	NT	LC
167	*Sylvia atricapilla*	Capinera*	Blackcap		LC	LC	LC
168	*Sylvia borin*	Beccafico	Garden Warbler		LC	EN	NA
169	*Sylvia communis*	Sterpazzola	Whitethroat		LC	LC	NA
170	*Sylvia curruca*	Bigiarella	Lesser Whitethroat		LC	LC	
171	*Sylvia melanocephala*	Occhiocotto*	Sardinian Warbler		LC	LC	LC
172	*Sylvia conspicillata*	Sterpazzola di Sardegna*	Spectacled Warbler		LC	LC	NT
173	*Sylvia subalpina*	Sterpazzolina di Moltoni*	Moltoni's Warbler		LC	LC	LC
174	*Sylvia cantillans*	Sterpazzolina	Subalpine Warbler		LC	LC	
175	*Currucaundata*	Magnanina comune*	Dartford Warbler	I	LC	DD	LC
176	*Curruca sarda*	Magnanina sarda*	Marmora's Warbler	I	LC	DD	LC
177	*Cisticola juncidis*	Beccamoschino*	Zitting Cisticola		LC	LC	LC
178	*Cettia cetti*	Usignolo di fiume*	Cetti's Warbler		LC	LC	LC
179	*Acrocephalus scirpaceus*	Cannaiola*	Reed Warbler		LC	LC	LC
180	*Acrocephalus arundinaceus*	Cannareccione*	Great Reed Warbler		LC	NT	NT
181	*Hippolais icterina*	Canapino maggiore	Icterine Warbler		LC		

18 2	*Phylloscopus trochilus*	Luì grosso	Willow Warbler		LC	LC	
18 3	*Phylloscopus collybita*	Luì piccolo*	Chiffchaff		LC	LC	DD
18 4	*Phylloscopus sibilatrix*	Luì verde	Wood Warbler		LC	LC	
18 5	*Phylloscopus bonelli*	Luì bianco	Western Bonelli's Warbler		LC	LC	
18 6	*Regulus ignicapilla*	Fiorrancino*	Firecrest		LC	LC	LC
18 7	*Regulus regulus*	Regolo	Goldcrest		LC	LC	
18 8	*Troglodytes troglodytes*	Scricciolo*	Wren		LC	LC	LC
18 9	*Muscicapa striata*	Pigliamosche*	Spotted Flycatcher		LC	LC	LC
19 0	*Ficedula hypoleuca*	Balia nera	Pied Flycatcher		LC		
19 1	*Ficedula albicollis*	Balia dal collare	Collared Flycatcher	I	LC	LC	
19 2	*Parus major ecki*	Cinciallegra sarda*	Sardinian Great Tit		LC	LC	LC
19 3	*Peripatus ater sardus*	Cincia mora sarda*	Sardinian Coal Tit		LC	LC	LC
19 4	*Cyanistes caeruleus ogliastrae*	Cinciarella sarda*	Sardinian Blue Tit		LC	LC	LC
19 5	*Tichodroma muraria*	Picchio muraiolo	Wallcreeper		LC	LC	
19 6	*Laniuscollurio*	Averla piccola*	Red-backed Shrike	I	LC	VU	NT
19 7	*Lanius senator badius*	Averla capirossa baia*	Mediterranean Shrike		NT	EN	VU
19 8	*Garrulus glandarius ichnusae*	Ghiandaia sarda*	Sardinian Jay	II/B	LC	LC	LC
19 9	*Corvus monedula*	Taccola*	Jackdaw	II/B	LC	LC	LC
20 0	*Corvus corone*	Cornacchia grigia*	Hooded Crow	II/B	LC	LC	LC

201	*Corvu scorax*	Corvo imperiale*	Raven		LC	LC	LC
202	*Sturnus vulgaris*	Storno	Satrling	II/B	LC	LC	
203	*Sturnus unicolor*	Storno nero*	Spotless Satring		LC	LC	LC
204	*Oriolus oriolus*	Rigogolo	Golden Oriole		LC	LC	
205	*Passer hispaniolensis*	Passera sarda*	Spanish Sparrow		LC	VU	LC
206	*Passer montanus*	Passera mattugia*	Tree Sparrow		LC	NT	LC
207	*Petronia petronia*	Passera lagia*	Rock Sparrow		LC	LC	LC
208	*Fringilla coelebs sarda*	Fringuello*	Chaffinch		LC	LC	LC
209	*Fringilla montifringilla*	Peppola	Brambling		LC		
210	*Coccothraustes coccothraustes*	Frosone*	Hawfinch		LC	LC	LC
211	*Chloris chloris madaraszi*	Verdone*	Greenfinch		LC	VU	LC
212	*Linaria cannabina mediterranea*	Fanello*	Linnet		LC	NT	LC
213	*Carduelis carduelis tschusii*	Cardellino*	Sardinian Goldfinch		LC	NT	LC
214	*Carduelis corsicana*	Venturone corso*	Corsican Finch		LC	LC	LC
215	*Serinus serinus*	Verzellino*	Serin		LC	LC	LC
216	*Spinus spinus*	Lucherino*	Siskin		LC	LC	NA
217	*Emberiza calandra*	Strillozzo*	Corn Bunting		LC	LC	LC
218	*Emberiza cirlus*	Zigolo nero*	Cirl Bunting		LC	LC	LC

Considering their conservation status according to the IUCN Red Lists, the situation varies depending on the scale, European (IUCN Red List) and national(Rondinini et al., 2022). At the regional level, the conservation status of species is based on the Red List of Sardinia (Schenk, 2015).

At the European level, one species (*Falco vespertinus* – Red-footed Falcon) is classified as **Critically Endangered (CR)**, and one (*Pandion haliaetus* – Osprey) is listed as **Endangered (EN)**. Fourteen species—including *Clamator glandarius* (Great Spotted Cuckoo), *Streptopelia turtur* (European Turtle Dove), *Larus audouinii* (Audouin's Gull), *Larus genei* (Slender-billed Gull), *Gallinago gallinago* (Common Snipe), *Tringa totanus* (Common Redshank), *Calidris alpina* (Dunlin), *Vanellus vanellus* (Northern Lapwing), *Tetrax tetrax* (Little Bustard), *Circus pygargus* (Montagu's Harrier), *Neophron percnopterus* (Egyptian Vulture), *Puffinus Yelkouan* (Yelkuan Shearwater), *Aythya ferina* (Common Pochard), and *Anas acuta* (Northern Pintail)—are considered **Vulnerable (VU)**.

Additionally, ten species, including *Lanius senator* (Woodchat Shrike), *Turdus iliacus* (Redwing), *Apus apus* (Common Swift), *Numenius arquata* (Eurasian Curlew), *Limosa limosa* (Black-tailed Godwit), *Calidris canutus* (Red Knot), *Haematopus ostralegus* (Eurasian Oystercatcher), *Fulica atra* (Eurasian Coot), *Coturnix coturnix* (Common Quail), and *Aythya fuligula* (Tufted Duck), are listed as **Near Threatened (NT)**.

The situation in Italy reflects a higher level of threat, with several species facing significant conservation concerns. According to the most recent national Red List (Rondinini et al., 2022), the following classifications apply:

- **Critically Endangered (CR)**: 7 species, including *Neophron percnopterus* (Egyptian Vulture), *Pandion haliaetus* (Osprey), *Aquila fasciata* (Bonelli's Eagle), *Porzana parva* (Little Crake), *Porzana porzana* (Spotted Crake), *Chlidonias niger* (Black Tern), and *Jynx torquilla* (Eurasian Wryneck).
- **Endangered (EN)**: 12 species, such as *Anas crecca* (Eurasian Teal), *Aythya nyroca* (Ferruginous Duck), *Botaurus stellaris* (Great Bittern), *Ciconia nigra* (Black Stork), *Accipiter nisus sarda* (Sardinian Goshawk), *Tetrax tetrax* (Little Bustard), *Charadrius alexandrinus* (Kentish Plover), *Limosa limosa* (Black-tailed Godwit), *Clamator glandarius* (Great Spotted Cuckoo), *Saxicola rubicola* (European Stonechat), *Sylvia borin* (Garden Warbler), and *Lanius senator* (Woodchat Shrike).
- **Vulnerable (VU)**: 25 species, including *Tadorna tadorna* (Common Shelduck), *Spatula clypeata* (Northern Shoveler), *Spatula querquedula* (Garganey), *Aythya ferina* (Common Pochard), *Netta rufina* (Red-crested Pochard), *Aythya fuligula* (Tufted Duck), *Ixobrychus minutus* (Little Bittern), *Plegadis falcinellus* (Glossy Ibis), *Milvus milvus* (Red Kite), *Circus aeruginosus* (Western Marsh Harrier), *Circus pygargus* (Montagu's Harrier), *Falco vespertinus* (Red-footed Falcon), *Falco eleonorae* (Eleonora's Falcon), *Haematopus ostralegus* (Eurasian Oystercatcher), *Thalasseus sandvicensis* (Sandwich Tern), *Chlidonias hybrida* (Whiskered Tern), *Alauda arvensis* (Eurasian Skylark), *Melanocorypha calandra* (Calandra Lark), *Riparia riparia* (Sand Martin), *Cecropis daurica* (Red-rumped Swallow), *Anthus campestris* (Tawny

Pipit), *Saxicola rubetra* (Whinchat), *Lanius minor* (Lesser Grey Shrike), *Passer hispaniolensis* (Spanish Sparrow), and *Chloris chloris* (European Greenfinch).

- **Near Threatened (NT)**: 21 species, including *Mareca strepera* (Gadwall), *Hydrobates pelagicus* (European Storm Petrel), *Ardeola ralloides* (Squacco Heron), *Platalea leucorodia* (Eurasian Spoonbill), *Gyps fulvus* (Griffon Vulture), *Aquila chrysaetos* (Golden Eagle), *Porphyrio porphyrio* (Purple Swamphen), *Actitis hypoleucos* (Common Sandpiper), *Larus genei* (Slender-billed Gull), *Sternula albifrons* (Little Tern), *Sterna hirundo* (Common Tern), *Cuculus canorus* (Common Cuckoo), *Hirundo rustica* (Barn Swallow), *Delichon urbicum* (House Martin), *Motacilla flava* (Yellow Wagtail), *Prunella modularis* (Dunnock), *Monticola solitarius* (Blue Rock Thrush), *Acrocephalus arundinaceus* (Great Reed Warbler), *Passer montanus* (Eurasian Tree Sparrow), *Linaria cannabina* (Common Linnet), and *Carduelis carduelis* (European Goldfinch).
- For seven species, data are insufficient to assess their risk status and they are classified as **Data Deficient (DD)**.

Focusing specifically on Sardinia, the regional Red List highlights seven species in the **Critically Endangered (CR)** category: *Aythya nyroca* (Ferruginous Duck), *Botaurus stellaris* (Great Bittern), *Plegadis falcinellus* (Glossy Ibis), *Gyps fulvus* (Griffon Vulture), *Pandion haliaetus* (Osprey), *Aquila fasciata* (Bonelli's Eagle), and *Milvus milvus* (Red Kite).
Four species are listed as **Endangered (EN)**: *Phalacrocorax carbo* (Great Cormorant), *Falco naumanni* (Lesser Kestrel), *Tetrax tetrax* (Little Bustard), and *Sterna hirundo* (Common Tern).
Seventeen species are classified as **Vulnerable (VU)**, including *Calonectris diomedea* (Scopoli's Shearwater), *Puffinus puffinus* (Manx Shearwater), *Hydrobates pelagicus* (European Storm Petrel), *Ardeola ralloides* (Squacco Heron), *Phoenicopterus roseus* (Greater Flamingo), *Aquila chrysaetos* (Golden Eagle), *Circus pygargus* (Montagu's Harrier), *Accipiter nisus sarda* (Sardinian Goshawk), *Tringa totanus* (Common Redshank), *Larus ridibundus* (Black-headed Gull), *Larus genei* (Slender-billed Gull), *Larus audouinii* (Audouin's Gull), *Sternula albifrons* (Little Tern), *Sterna hirundo* (Common Tern), *Coracias garrulus* (European Roller), *Calandrella brachydactyla* (Short-toed Lark), and *Lanius senator* (Woodchat Shrike).
Twenty-nine species are listed as **Near Threatened (NT)**, including *Tadorna tadorna* (Common Shelduck), *Mareca strepera* (Gadwall), *Mareca penelope* (Eurasian Wigeon), *Spatula clypeata* (Northern Shoveler), *Aythya ferina* (Common Pochard), *Coturnix coturnix* (Common Quail), *Phalacrocorax aristotelis* (European Shag), *Ixobrychus minutus* (Little Bittern), *Nycticorax nycticorax* (Black-crowned Night Heron), *Egretta garzetta* (Little Egret), *Ardea purpurea* (Purple Heron), *Circus aeruginosus* (Western Marsh Harrier), *Falco eleonorae* (Eleonora's Falcon), *Falco peregrinus* (Peregrine Falcon), *Porphyrio porphyrio* (Purple Swamphen), *Recurvirostra avosetta* (Pied Avocet), *Himantopus himantopus* (Black-winged Stilt), *Burhinus oedicnemus* (Eurasian Stone-curlew), *Charadrius alexandrinus* (Kentish Plover), *Streptopelia turtur* (European Turtle Dove), *Tyto alba sarda* (Sardinian Barn Owl), *Merops apiaster* (European Bee-eater), *Upupa epops* (Eurasian Hoopoe), *Alauda arvensis* (Eurasian Skylark), *Melanocorypha calandra* (Calandra Lark), *Motacilla flava* (Yellow Wagtail), *Sylvia sarda* (Marmora's Warbler), *Acrocephalus arundinaceus* (Great Reed Warbler), and *Lanius minor* (Lesser Grey Shrike).

Additionally, eight species are classified as **Data Deficient (DD)** due to insufficient information to assess their conservation status.
The presence of numerous bird species facing various levels of threat, both nationally and regionally, underscores Sardinia's critical role as a habitat for avian species of significant conservation interest.

Amphibians
Among terrestrial vertebrates, amphibians (*Amphibia*) represent the least numerous taxonomic group in Sardinia, with a total of 11 species, two of which have been introduced recently. Five species are present within the study area (see Table 11.5), accounting for 45.5% of all amphibian species found on the island.

Table 11.5 *Amphibian species recorded in Sardinia with their scientific, Italian, and English names. For each species, the table reports the conservation status under Annexes of the EU Habitats Directive (92/43/EEC), the IUCN European and Italian Red Lists, and the Sardinian regional Red List. Habitat preferences are also considered in the classification.*

N.	Scientific name	Italian name	English name	Habitat Directive 92/43/EC Annex	Iucn European Red List	Iucn Italian Red List	Sardinian Red List
1	*Euproctus platycephalus*	Tritone sardo	Sardinian newt	IV	EN	EN	EN
2	*Discoglossus sardus*	Discoglosso sardo	Tyrrhenian painted frog	II/IV	LC	LC	DD
3	*Bufotes balearicus*	Rospo smeraldino	Balearic Green toads	IV	LC	LC	LC
4	*Hyla sarda*	Raganella tirrenica	Sardinian tree frog	IV	LC	NT	LC
5	*Pelophylax esculentus*	Rana esculenta	Edible frog		LC	LC	LC

The Sardinian Newt (*Euproctus platycephalus*) is a Sardinian endemic species and is globally threatened, currently classified as Endangered (EN). In contrast, the Sardinian Painted Frog (*Discoglossus sardus*) and the Tyrrhenian Tree Frog (*Hyla sarda*) are endemic to the Tyrrhenian region, with a conservation status still considered satisfactory.
The presence of the Sardinian Newt in the study area requires confirmation, whereas the Sardinian Painted Frog, the Green Toad (*Bufotes viridis*), and the Tyrrhenian Tree Frog are widely distributed throughout the study area. These species are primarily associated with humid environments, such as riverine habitats, temporary ponds (*paulis*), natural and artificial reservoirs (including livestock watering points), wooded areas, and tree-dotted pastures.
Except for the Edible Frog (*Pelophylax kl. esculentus*), the other four species are listed in Annex IV of the Habitats Directive 92/43/EEC (species of community interest requiring strict protection). Additionally, the Sardinian Painted Frog is also included in Annex II, which identifies species whose conservation requires the designation of Special Areas of Conservation (SACs).

Reptiles
The reptile group (*Reptilia*) in Sardinia includes 21 species, belonging to a variety of taxonomic families, often highly diverse from one another, such as Lacertidae (lizards), Testudinidae (tortoises), Gekkonidae (geckos), and Colubridae (non-venomous snakes).
Within the study area, 16 species have been recorded, representing 76.2% of all reptile species found on the island (see Table 11.6).

Table 11.6 *Reptile species recorded in Sardinia with their scientific, Italian, and English names. The table reports the conservation status of each species according to the EU Habitats Directive (92/43/EEC), the IUCN European and Italian Red Lists, and the Sardinian regional Red List.*

N	Scientific name	Italian name	English name	Habitat Directive 92/43/EC Annex	Iucn European Red List	Iucn Italian Red List	Sardinian Red List
1	*Emys orbicularis*	Testuggine Palustre Europea	European pond terrapin	II/IV	NT	EN	VU
2	*Testudo graeca*	Testuggine greca	Mediterranean spur-	II/IV	VU	NT	DD

			thighed tortoise				
3	*Testudo hermanni*	Testuggine di Hermann	Hermann's tortoise	II/IV	EN	EN	NT
4	*Testudo marginata*	Testuggine Marginata	Mrginated tortoise	II/IV	LC	NT	DD
5	*Hierophis viridiflavus*	Biacco	Western whip snake	IV	LC	LC	LC
6	*Natrix maura*	Natrice Viperina	Sardinian Grass Snake		LC	LC	LC
7	*Natrix natrix cetti*	Natrice dal Collare	Grass snake	IV	?	EN	EN
8	*Hemidactylus turcicus*	Emidattilo turco	Turkish gecko		LC	LC	LC
9	*Tarentola maurItanica*	Geco comune	Moorish gecko		LC	LC	LC
10	*Euleptes europaea*	Tarantolino	European leaf-toed gecko	II/IV	NT	LC	NT
11	*Algyroide fitzingery*	Algiroide nano	Pygmy algyroides	IV	LC	LC	NT
12	*Archaeolacerta bedriagae*	Lucertola di Bedriaga	Bedriaga's rock lizard	IV	NT	NT	VU
13	*Podarcis siculus*	Lucertola campestre	Italian wall lizard	IV	LC	LC	LC

14	*Podarcis tiliguerta*	Lucertola tirrenica	Tyrrhenian wall lizard	IV	LC	NT	LC
15	*Chalcides chalcides*	Luscengola comune	Three.toed skink		LC	LC	LC
16	*Chalcides ocellatus*	Gongilo ocellato	Ocellated skink	IV	LC	LC	LC

The Sardinian Grass Snake (*Natrix natrix cetti*) is considered endemic to Sardinia and is highly localized within the study area, particularly on the Campeda Plateau. Other Sardinian-Corsican endemics, such as Bedriaga's Rock Lizard (*Archaeolacerta bedriagae*), the Dwarf Algyroides (*Algyroides fitzingeri*), and the Tyrrhenian Wall Lizard (*Podarcis tiliguerta*), are also present, with the latter species being relatively widespread throughout the area.
At the European level, two species are currently considered under threat: the Hermann's Tortoise (*Testudo hermanni*), listed as Endangered (EN), and the Spur-thighed Tortoise (*Testudo graeca*), listed as Vulnerable (VU).
Nationally, three species are listed as Endangered (EN) in the Italian Red List of Vertebrates (Rondinini et al., 2022): the European Pond Turtle (*Emys orbicularis*), Hermann's Tortoise, and the Sardinian Grass Snake (*Natrix natrix cetti*). The Sardinian Red List (Schenk, 2015) also classifies the Viperine snake as Endangered, while the European Pond Turtle and Bedriaga's Rock Lizard are listed as Vulnerable (VU).
Most of the reptile species recorded in the study area are listed in Annex IV of the Habitats Directive 92/43/EEC (species requiring strict protection), and five of these are also included in Annex II, which identifies species whose conservation necessitates the designation of Special Areas of Conservation (SACs).

Mammals

Sardinia is home to a total of 43 species of terrestrial mammals (Mammalia), including 21 species belonging to the order Chiroptera (bats).
Within the study area, 32 mammal species have been recorded (see Table 11.7), representing 74.4% of the island's total mammalian fauna.

Table 11.7 *Mammal species recorded in Sardinia with their scientific, Italian, and English names. The table includes conservation status information according to the EU Habitats Directive (92/43/EEC), the IUCN European and Italian Red Lists, and the Sardinian regional Red List.*

N	Scientific name	Italian name	English name	Habitat Directive 92/43/EC Annex	Iucn European Red List	Iucn Italian Red List	Sardinian Red List
1	*Erinaceus europaeus*	Riccio europeo	Western europaea hedgehog		NT	LC	LC
2	*Crocidura pachyura*	Crocidura mediterranea	Crocidura pachyura		LC	DD	LC
3	*Suncus etruscus*	Mustiolo	Pygmy shrew with white teeth		LC	LC	LC
4	*Rhinolophus mehelyi*	Rinolofo di Mehely	Mehely's Horseshoe Bat	II/IV	VU	EN	VU
5	*Rhinolophus ferrumequinum*	Rinolofo maggiore	Greater Horseshoe Bat	II/IV	NT	VU	NT
6	*Rhinolophus hipposideros*	Rinolofo minore	Lesser Horseshoe Bat	II/IV	LC	EN	VU
7	*Myotis capaccinii*	Vespertilio di Capaccini	Long-fingered bat	II/IV	VU	EN	VU
8	*Myotis daubentonii*	Vespertilio di Daubenton	Daubenton's bat	IV	LC	LC	DD
9	*Myotis emarginatus*	Vespertilio smarginato	Geoffroy's bat	II/IV	LC	NT	VU

10	*Myotis punicus*	Vespertilio maghrebino	Maghrebian Mouse-eared bat	IV	DD	VU	DD
11	*Pipistrellus kuhlii*	Pipistrello albolimbato	Kuhl'sp Pistrelle Bat	IV	LC	LC	LC
12	*Pipistrellus pipistrellus*	Pipistrello nano	Common Pipistrelle bat	IV	LC	LC	LC
13	*Hypsugo savii*	Pipistrello di Savi	Savi's Pipistrelle Bat	IV	LC	LC	DD
14	*Eptesicus serotinus*	Serotino comune	Serotine	IV	LC	NT	DD
15	*Miniopterus schreibersii*	Miniottero	Schreiber's bent-winged bat	II/IV	VU	VU	NT
16	*Tadarida teniotis*	Molosso di Cestoni	European free-tailed bat	IV	LC	LC	NT
17	*Lepus capensis mediterraneus*	Lepre sarda	Sardinian hare		LC	NA	NT
18	*Oryctolagus cuniculus*	Coniglio europeo	European rabbit		NT	NA	LC
19	*Apodemus sylvaticus*	Topo selvatico	Long-tailed field mouse		LC	LC	LC

20	*Mus musculus*	Topo domestico	House mouse		LC	NA	LC
21	*Rattus norvegicus*	Ratto bruno	Brown Rat		NA	NA	LC
22	*Rattus rattus*	Ratto nero	House Rat		LC	NA	LC
23	*Myocastor coypus*	Nutria	Coypu		NA	NA	LC
24	*Eliomys quercinus*	Quercino	Garden Dormouse		LC	NT	NT
25	*Vulpes vulpes*	Volpe	Red Fox		LC	LC	LC
26	*Martes martes*	Martora	Pine Marten		LC	LC	NT
27	*Mustela nivalis*	Donnola	Least Weasel		LC	LC	LC
28	*Felis lybica*	Gatto selvatico	Afro-Asiatic Wildcat	IV	LC	NT	NT
29	*Sus scrofa*	Cinghiale	Wild Boar		LC	LC	LC
30	*Cervus elaphus corsicanus*	Cervo sardo	Sardinian Red Deer	II/IV	LC	LC	NT
31	*Dama dama*	Daino	Common Fallow Deer		LC	NA	LC

3 2	*Ovis aries*	Muflone	Mouflon	II/IV	NA	NA	NT

Among the Sardinian-Corsican endemics, the Sardinian Pine Marten (*Martes martes*), Fox (*Vulpes vulpes*), Wild Boar (*Sus scrofa*), and Sardinian Deer (*Cervus elaphus corsicanus*) are present.
The species that are critically threatened (CR), endangered (EN), or vulnerable (VU) are exclusively found among the Chiroptera (bats). At the European level, three species are classified as Vulnerable (VU): the Mehely's Horseshoe Bat (*Rhinolophus mehelyi*), Capaccini's Pipistrelle (*Pipistrellus capaccinii*), and the Miniopterus (*Miniopterus schreibersii*).
At the national level, six species are listed, three of which are classified as Endangered (EN): the Mehely's Horseshoe Bat, Lesser Horseshoe Bat (*Rhinolophus hipposideros*), and Capaccini's Pipistrelle. The other three species are Vulnerable (VU): the Greater Horseshoe Bat (*Rhinolophus ferrumequinum*), Maghreb Pipistrelle (*Pipistrellus maghrebensis*), and Miniopterus.
At the regional level, the Mehely's Horseshoe Bat, Lesser Horseshoe Bat, Capaccini's Pipistrelle, and Striped Pipistrelle (*Pipistrellus kuhlii*) are also classified as threatened and are listed as Vulnerable (VU).
All bat species present in the study area are included in Annex IV of the Habitats Directive (92/43/EEC), alongside the Wildcat (*Felis silvestris*) and Sardinian Deer. The Mehely's Horseshoe Bat, Lesser Horseshoe Bat, Greater Horseshoe Bat, Capaccini's Pipistrelle, Striped Pipistrelle, Miniopterus, and Sardinian Deer are also listed in Annex II.

11.9 Ecology, anthropogenic pressure and environmental fragility

The environmental value of the area was mapped using the Nature Map produced by RAS and UNISS in 2010.

The following cartographies were developed:

- the Ecological Value Map, which expresses the environmental value of a biotope (Figure 9)
- the Ecological Sensitivity Map, which summarises the intrinsic aptitude of a habitat to undergo change (Figure 11.10)
- the Anthropic Pressure Map, which represents the distribution of disturbance produced by the presence of man (Figure 11.11)
- the Vulnerability Map, obtained by relating human sensitivity and pressure, considers the presence of endangered species and the biodiversity erosion index as determinants (Figure 11.12).

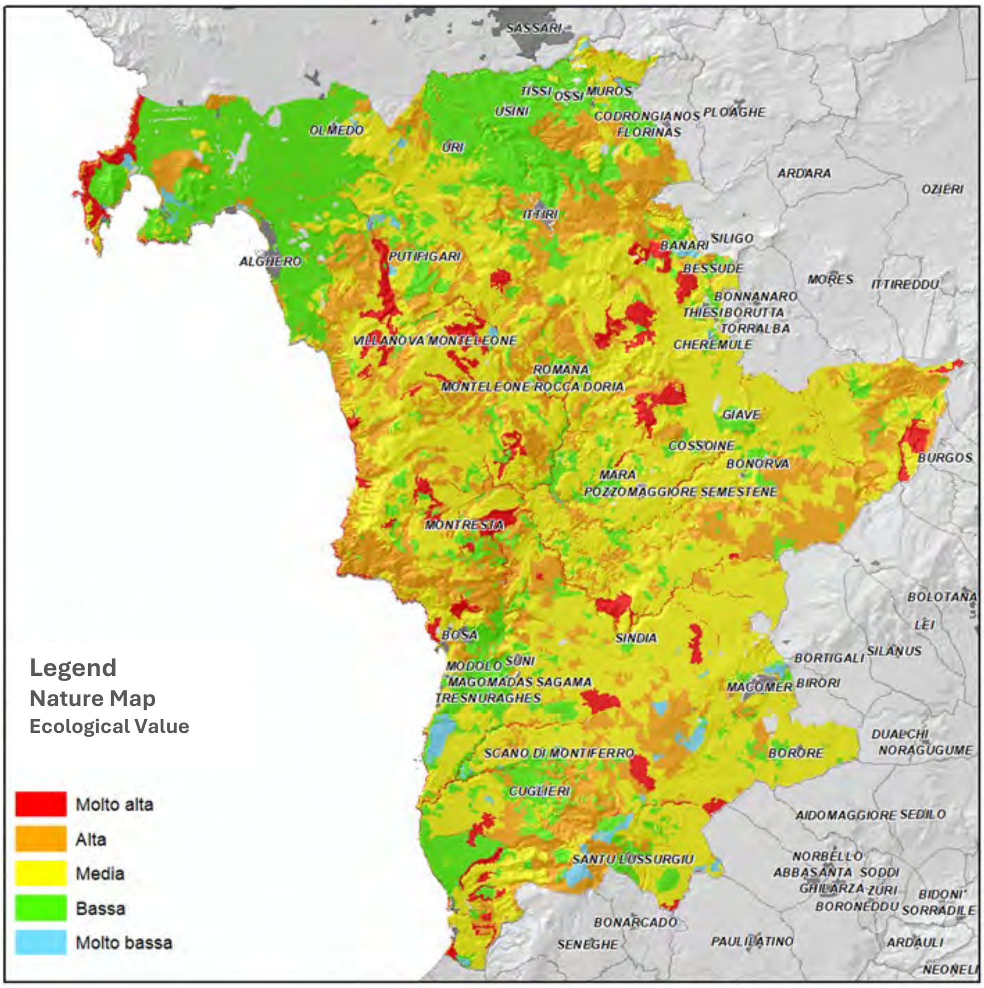


Figure 11.9 *Ecological Value Map – Environmental value of each biotope based on ecological characteristics.*

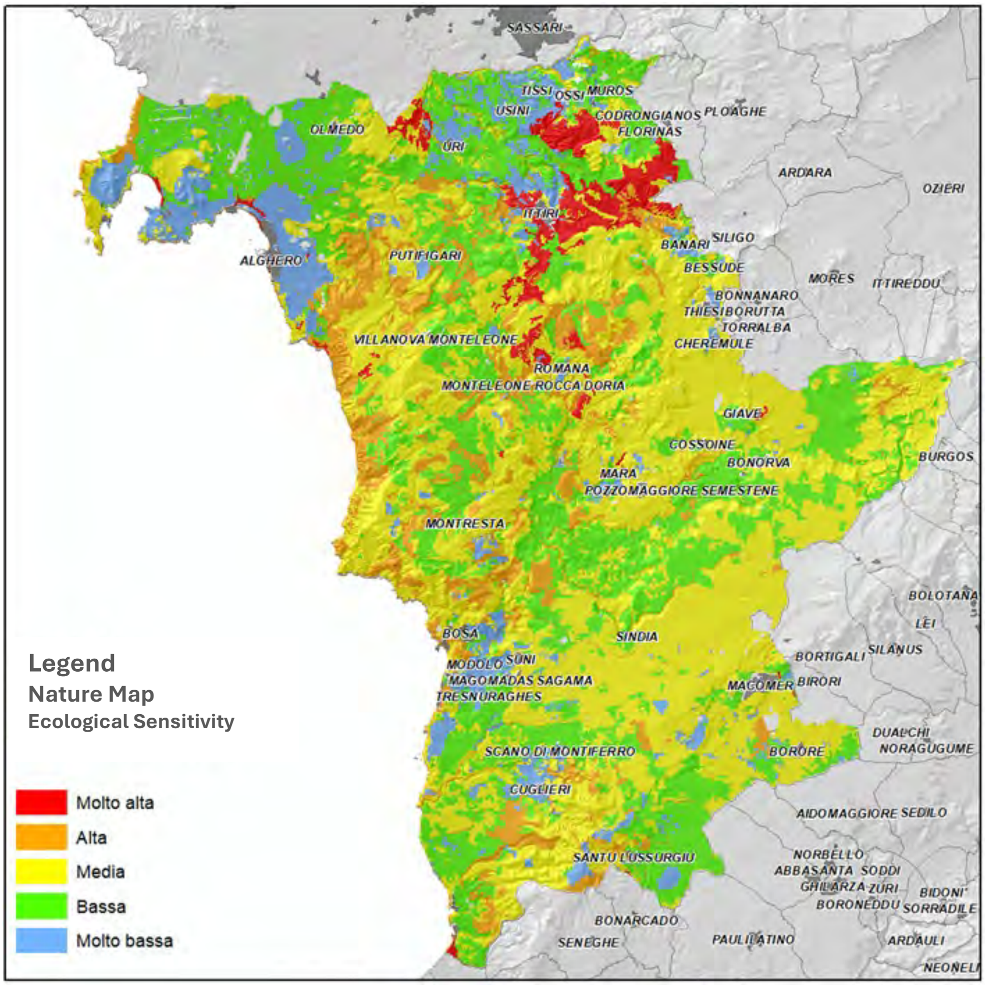


Figure 11.10 *Ecological Sensitivity Map – Intrinsic sensitivity of habitats to environmental changes.*

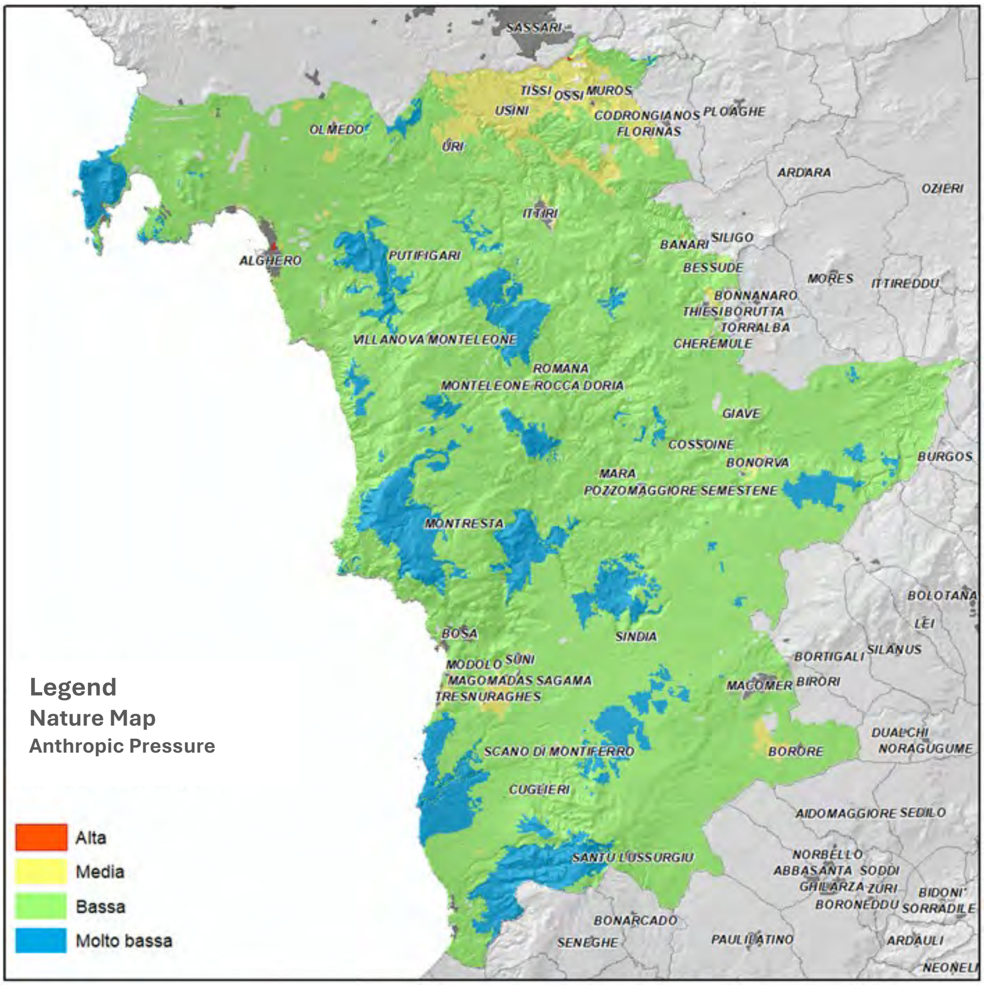


Figure 11.11 *Anthropic Pressure Map – Spatial distribution of human-induced disturbance across the landscape.*

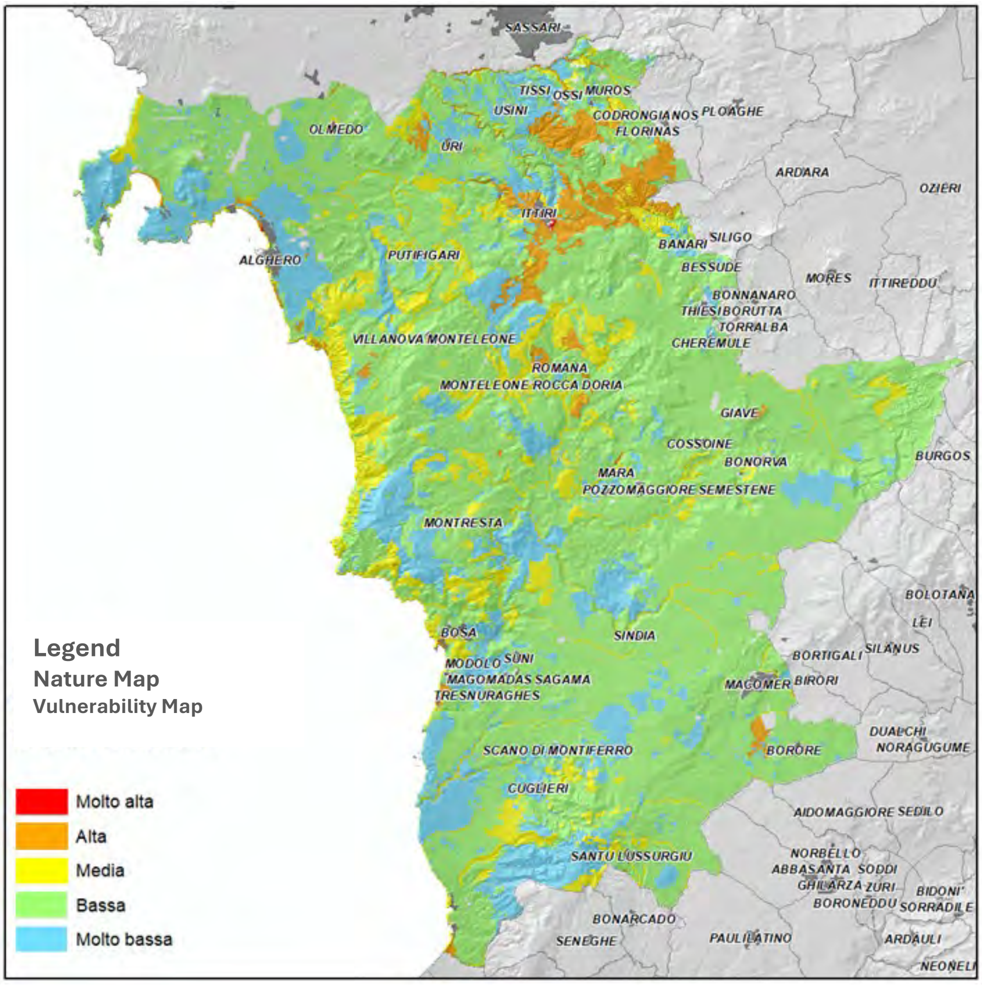


Figure 11.12 *Vulnerability Map – Combined assessment of ecological sensitivity and anthropic pressure, incorporating endangered species presence and biodiversity erosion.*

11.10 Conclusion

The north-western region of Sardinia presents a uniquely favourable context for the reintroduction of the Cinereous Vulture and the Bearded Vulture, combining ecological, historical, and logistical advantages. This area is currently the stronghold of the only natural breeding population of Griffon Vultures in Italy, whose conservation and range expansion are being actively supported through EU LIFE projects. The presence of this established necrophagous species indicates the availability of adequate trophic resources, and an adequate mitigation of the main threats—factors critical to the survival and breeding success of large scavengers.

Historically, both the Cinereous and Bearded Vultures bred in Sardinia until their local extinction in the 20th century, making this reintroduction a restoration of a lost ecological component. The selection of release sites within the historical regions of Marghine, Planargia and Meilogu follows IUCN and ISPRA best practices, ensuring that habitat suitability, risk mitigation, and stakeholder engagement have been fully addressed.

The area spans approximately 220,000 hectares and includes a robust network of Natura 2000 sites, Wildlife Protection Oases, and forest areas managed by the regional forestry agency (FoReSTAS), offering extensive legal protection and opportunities for active habitat management. The region's diverse topography—ranging from rugged cliffs and mountainous plateaus to river valleys and Mediterranean scrublands—ensures the presence of key habitat types necessary for nesting, roosting, and foraging.

Moreover, the socio-economic context of the release area further supports its suitability for a long-term reintroduction initiative. With an average population density below 50 inhabitants per km² and a prevalence of small rural municipalities, the region is characterised by relatively low levels of human disturbance and limited intensive land use. Simultaneously, coastal municipalities such as Alghero and Bosa attract substantial tourist attention, particularly during peak seasons. Tourist activity, particularly overnight stays and visitor numbers, offers avenues to align conservation objectives with local economic interests.

This creates opportunities for integrating vulture conservation with sustainable development strategies, fostering local support through educational, recreational, and economic benefits linked to wildlife observation and traditional livestock practices.

Furthermore, the area supports a rich and diverse avifauna, including numerous species of conservation concern, underscoring its ecological value and potential as a biodiversity hotspot. The presence of favourable climatic conditions, minimal human disturbance in many core areas, and a high degree of habitat heterogeneity further reinforce the site's potential to host reintroduced vulture populations in the long term.

In summary, the north-western sector of Sardinia represents an ecologically coherent, historically appropriate, and technically viable landscape for the re-establishment of both the Cinereous Vulture and the Bearded Vulture, offering the potential to restore functional guilds of scavengers and enhance ecosystem health and resilience.

12. Release strategies

The distinct ethological characteristics of the two species require the adoption of different reintroduction approaches. The Cinereous Vulture is a colonial species which, similarly to the Griffon Vulture, is well suited to release protocols involving large acclimatisation aviaries. These facilities can host multiple individuals, allowing for a gradual adjustment period prior to release (Mihoub et al., 2014). In contrast, the Bearded Vulture is a species that rarely tolerates close proximity to conspecifics within confined spaces. Consequently, for approximately four decades, the preferred reintroduction method has been the hacking technique using artificial nests (Simón & Couto, 2007), as described below.

12.1 Cinereous Vulture

12.1.1 Choice of methodology and release phases

The release strategy for the Cinereous Vulture broadly mirrors that employed for the Griffon Vulture in Sardinia but necessitates a more rigorous approach due to the absence of a pre-existing population. In contrast to Griffon Vulture reintroduction, which benefitted from the presence of a local population, the Cinereous Vulture must be reintroduced into an area where it is currently extinct.

Nevertheless, this reintroduction can build upon the considerable experience of personnel involved in previous projects and on the successful implementation of comparable efforts in regions such as the Cévennes National Park (France) and the Sierra de Guadarrama (Spain). In both contexts, the presence of an established Griffon Vulture population and a network of centralised and farm feeding stations were deemed critical in encouraging released Cinereous Vultures to remain in the area. These conditions, both present in Sardinia, facilitated social interactions and learning, as young Cinereous Vultures followed Griffon Vultures in exploring the territory and locating food resources (Terrasse et al., 1994).

In these earlier projects, released Cinereous Vultures demonstrated rapid adaptation to flight, typically remaining in the proximity of the release site for 4–6 weeks before gradually expanding their foraging range up to a 20 km radius. The Griffon Vulture colony played a key role in this process: Cinereous Vultures displayed a consistent interest in Griffon activities and quickly learned to exploit the same feeding areas through regular association.

Movement data from these reintroduction projects revealed that approximately 80% of Cinereous Vulture flights were associated with Griffon Vultures, often involving high-altitude soaring. However, Cinereous Vultures also showed a distinct behavioural tendency to forage at lower altitudes and to explore forested environments typically avoided by Griffon Vultures, thereby expanding the spatial and ecological range exploited within the landscape.

Two main sources of individuals are used for release:

- Captive-bred juveniles obtained through coordinated breeding programmes in zoos and breeding centres.
- Wild birds (mostly juveniles and immatures) rehabilitated in wildlife recovery centres.

Captive-bred birds are released via the hacking technique, while rehabilitated individuals are housed for several months in large acclimatisation aviaries before the release.

12.1.2 Hacking Technique as a Release Strategy

Hacking is a well-established technique for the release of raptors into the wild (Busse, 1994; Sherrod & Cade, 1978). Among vultures, this method was first successfully applied to the Bearded Vulture and has since become a cornerstone in reintroduction efforts.

For the Cinereous Vulture, the potential of hacking as a release method was initially explored in 1988 as part of the recovery programme for the species on Mallorca. Following its promising results, the technique has been successfully implemented in several projects in France.

Hacking involves the placement of young, pre-fledging vultures into artificial nests situated within suitable release sites. These individuals, typically 80–90 days old, are not yet capable of flight but have sufficiently developed plumage to protect them from environmental conditions such as sunlight and rain. At this stage, they are also capable of feeding autonomously. The presence of at least two chicks in each nest is encouraged to promote social interaction and reduce stress.

Throughout the hacking period, food and water are supplied without direct human contact—either at night or via concealed mechanisms—to minimise habituation. This simulates natural rearing conditions, wherein young vultures would be fed by their parents, while preserving their wariness of humans.

Artificial nests are constructed on rocky outcrops within habitats deemed ecologically suitable for the species, ideally in areas already inhabited by conspecifics or Griffon Vultures, to facilitate social learning and site fidelity. These locations must be secure and inaccessible to terrestrial predators. The design of the site allows for locomotor activity, such as walking, bouncing, and short vertical jumps (up to 2 metres), which are essential for muscular development and flight readiness.

Continuous and intensive monitoring is essential during the entire hacking period, with particular attention given during the post-fledging stage (approximately from day 120 onwards). Observers should maintain surveillance from sunrise to sunset to track movements and intervene in the event of accidents or signs of distress, thereby maximising the chances of successful adaptation and survival in the wild (Stoynov et al., 2017).

12.1.3 Release via Acclimatisation Aviary

The acclimatisation aviary constitutes a controlled method for the reintroduction of individuals originating from the wild, particularly those rehabilitated in wildlife recovery centres. This technique facilitates the reintegration of wild-caught birds into their natural environment following recovery from injury or illness, while minimising post-release stress and disorientation.

The aviary must be established in a remote, ecologically appropriate location, sufficiently isolated from human disturbance and protected from potential threats posed by terrestrial predators. The site must also remain accessible to authorised personnel responsible for provisioning food and water, conducting health checks, and monitoring behavioural development. An open landscape with expansive visibility and terrain conducive to unimpeded take-off is essential to ensure a successful transition to free-ranging behaviour.

Release operations are conducted under favourable meteorological conditions and follow a soft-release protocol, whereby individuals exit the enclosure voluntarily without direct human interference. Post-release support is provided through the continued availability of food and water near the release site, to mitigate early challenges in foraging and territorial establishment.

This method offers several advantages. It allows the birds to become familiar with local environmental conditions and stimuli, including interactions with sympatric species (e.g. corvids, other vulture species), thereby promoting natural behavioural patterns. Moreover, it may also serve as a temporary holding facility for individuals requiring additional support prior to full release.
The release of juvenile individuals from an aviary allows for the containment of at least six Cinereous Vultures per year of project activity. As with the Griffon Vulture programme, individuals will be kept in the aviary for a minimum of six months, during which they will become accustomed to the local environment and establish visual contact with Griffon Vultures feeding at a nearby supplementary feeding station.
To enhance the attractiveness of the surrounding habitat, artificial nest platforms will be installed in trees across approximately 60 hectares managed by the FoReSTAS Agency in Villanova Monteleone. These structures aim to simulate the presence of a small breeding colony, serving both as attractants and as potential nesting sites for future pairs. Breeding attempts are expected to begin from the sixth or seventh year after the start of releases (i.e. by 2033–2034).
The local Griffon Vulture population will play a vital role in facilitating site fidelity and foraging behaviour in the released Cinereous Vultures. The presence of an existing acclimatisation aviary and centralised feeding station—located within the Monte Minerva–Villanova Monteleone area (property of the Sardinian Region, managed by the FoReSTAS Agency) and used for the LIFE projects aimed at the restocking of the Griffon Vultures, enables the immediate start of the release operations, following targeted upgrades to the facility. Planned modifications include increasing aviary height and length, adding visual screens, constructing an observation box, and adjusting perches and access mechanisms.
The release plan foresees the release of at least 40 young individuals over six years of activity (6–7 juveniles per year).

12.1.4 Lessons from Other Projects

Expert assessments of nine Cinereous Vulture reintroduction projects across Spain, France, and Bulgaria have highlighted several factors essential to project success. First, the configuration of release infrastructure must minimise stress and provide adequate privacy. For instance, the use of hacking platforms was found to be unsuitable in certain contexts due to limited space, which contributed to elevated stress levels and insufficient seclusion for the birds. Second, the age of the individuals at the time of release and the duration of their stay in acclimatisation aviaries were shown to influence post-release dispersal: birds released from their second calendar year onward exhibited a stronger tendency to remain in the release area. Third, geographic context plays an important role; while the hacking method proved effective in the island setting of Mallorca, greater success was achieved using acclimatisation aviaries in continental projects. Fourth, the presence of nearby breeding colonies appears to exert a strong attraction effect, facilitating social integration and site fidelity. Finally, settlement success may be further enhanced by releasing groups of more than six individuals, selecting release sites where conspecifics are already present, and ensuring the presence of other vulture species, particularly Griffon Vultures, which may provide important social and environmental cues to support the establishment of newly released birds.

12.1.5 Conclusion

Based on the available evidence and expert assessments from previous reintroduction efforts in Spain, France, and Bulgaria, the acclimatisation aviary has been identified as the most suitable method for the release of Cinereous Vultures in Sardinia. This technique offers several advantages, including reduced stress, improved site fidelity, and the possibility for social learning through visual and acoustic contact with Griffon Vultures already present in the area. The existing facility in Monte Minerva–Villanova Monteleone, with minor modifications, is well positioned to support this approach. The planned release of at least 40 individuals over six years, combined with habitat enhancement measures such as the installation of artificial nest platforms, provides a solid framework for the successful re-establishment of a resident Cinereous Vulture population on the island.

12.2 Bearded Vulture

12.2.1 Choice of methodology and release phases

The Bearded Vulture is a non-colonial species, and it requires a reintroduction strategy that carefully considers its behavioural characteristics to minimise conflict among conspecifics during early development. Accordingly, all major reintroduction projects completed or ongoing across Europe—including those in the Alps, Andalusia, the Grands Causses (France), and the Maestrazgo-Catalonia region (Spain)—have adopted the hacking technique as the preferred method.

This approach involves the release of captive-bred chicks aged between 90 and 100 days, which are transferred from breeding facilities to a secure, easily monitored release niche. The niche is carefully selected to provide protection from predators and human disturbance and is equipped with remote monitoring systems to enable continuous observation.

Each site hosts two to three pre-fledging chicks, housed in artificial nests constructed to simulate natural conditions. To prevent human imprinting, food is delivered via a concealed feeding system—typically using gravity-fed tubes—allowing the birds to be provisioned without direct visual contact with human caretakers.

Chicks remain at the site until they reach approximately 110 to 130 days of age, at which point they initiate their first flights. In the weeks following fledging, they continue to refine their flight skills and progressively begin to forage independently.

Throughout the hacking period and for two to three weeks post-fledging, expert personnel carry out continuous on-site monitoring to enable prompt intervention in the event of any issues.

This method has demonstrated high effectiveness: post-release monitoring indicates that 88% of Bearded Vultures survive their first year, with annual survival rates increasing to approximately 96% in subsequent years—exceptionally high figures for wild-released raptors.

12.2.2 Conclusion

In conclusion, the hacking technique represents a well-established, reliable strategy for the reintroduction of the Bearded Vulture, tailored to the species' solitary nature and behavioural sensitivity. Its consistent success across multiple European regions, combined with high post-release survival rates, provides a strong foundation for adopting this method in any future reintroduction efforts. Careful site selection, rigorous monitoring, and strict protocols to avoid human disturbance remain essential to maximising the effectiveness of this approach.

12.3 Conclusions

The design of effective reintroduction protocols for avian scavengers must be grounded in a thorough understanding of species-specific behavioural ecology, particularly social organisation and territoriality. In this context, the Cinereous Vulture, a gregarious species, is best suited to release strategies involving large acclimatisation aviaries, which facilitate gradual environmental familiarisation, promote social cohesion, and enable visual and acoustic interactions with conspecifics and other vulture species, such as Griffon Vulture. This approach has demonstrated efficacy in fostering site fidelity and post-release survival. Conversely, the Bearded Vulture requires a markedly different methodology. The hacking technique, refined over decades of application in multiple European reintroductions programmes, replicates natural rearing conditions while minimising human imprinting, and has yielded consistently high survival rates post-release. The differential application of these two methodologies, based on robust empirical evidence and inter-regional best practices, provides a scientifically sound framework for the restoration of these keystone scavenger species within the Sardinian ecosystem.

13. Conclusions: Feasibility of Vulture Reintroduction in Sardinia

The comprehensive feasibility study presented in the preceding chapters meticulously evaluates the prospects for reintroducing the Bearded Vulture (*Gypaetus barbatus*) and Cinereous Vulture (*Aegypius monachus*) to Sardinia. This reintroduction is not merely a conservation endeavour, but a strategic ecological imperative aimed at restoring critical ecosystem services, enhancing biodiversity, and rectifying historical anthropogenic impacts on the island's unique natural heritage. Based on a thorough analysis of ecological, social, economic, and governance factors, this chapter synthesizes the risk-benefit assessment and provides a definitive recommendation regarding the project's proceeding.

13.1 Summary of Key Findings

Ecological Justification and Historical Context (Chapters 1, 4): Sardinia historically supported populations of both Bearded and Cinereous Vultures, as evidenced by toponyms, oral accounts, and historical scientific writings. Their extinction was primarily driven by human activities, including poisoning campaigns (e.g., against locusts and malaria vectors), direct persecution, and habitat alterations. The reintroduction aims to re-establish these vital scavengers, recognized for their indispensable role in carcass removal and disease mitigation, thus restoring a crucial component of the island's terrestrial biodiversity.

Current Ecological Suitability (Chapters 5, 8): The island currently exhibits a high degree of ecological suitability for these species. The success of ongoing Griffon Vulture (*Gyps fulvus*) conservation efforts, particularly the thriving population and the natural colonization of Egyptian Vultures (*Neophron percnopterus*), demonstrates the availability of suitable habitat and food resources. The detailed habitat suitability assessment, combining expert opinion and analysis of potential nesting sites, has identified promising areas, particularly within the Natura 2000 network, that can serve as viable release sites.

Threat Mitigation and Food Availability (Chapters 6, 7): Significant progress has been made in mitigating the primary threats that led to the historical decline of vultures. The LIFE Safe for Vultures project has been instrumental in addressing poisoning, reducing collisions with energy infrastructure, and combating persecution. Crucially, the establishment and management of supplementary feeding stations, including the innovative farm feeding station model, demonstrate the capacity to ensure adequate food availability, a critical factor given current sanitary regulations concerning livestock carcasses. The projected increase in farm feeding stations indicates a sustainable and scalable food source for future vulture populations.

Social Feasibility and Stakeholder Engagement (Chapter 9): The social feasibility study highlights the importance of engaging key stakeholders, including livestock herders, recreational hunters, and environmental tour guides. Initial findings suggest a growing acceptance and willingness among these groups to support conservation efforts, provided their concerns are addressed and benefits are clearly communicated. Continued engagement, education, and the promotion of non-toxic ammunition are vital for long-term success.

Funding Landscape and Institutional Framework (Chapters 3, 10): The project benefits from a robust funding landscape, including significant support from EU programs like the LIFE Programme, alongside national and regional public funding. The adherence to IUCN Guidelines for Reintroductions and Other Conservation Translocations ensures a scientifically sound and ethically responsible framework for the reintroduction. Formal agreements between relevant authorities and collaboration with captive breeding centers further strengthen the institutional support for the initiative.

13.2 Risk/Benefit Analysis

13.2.1 Potential Benefits:

1. **Ecological Restoration:** The reintroduction will restore a vital ecological function by re-establishing apex scavengers, thereby enhancing carcass disposal, nutrient cycling, and disease control within the ecosystem. This contributes to a healthier and more resilient Sardinian environment.
2. **Biodiversity Enhancement:** It will enrich Sardinia's biodiversity by reintroducing two charismatic raptor species that were once native, aligning with regional, national, and European biodiversity conservation goals.
3. **Ecosystem Services:** Vultures provide valuable ecosystem services, including waste removal (reducing the need for human intervention), disease control, and potential economic benefits through ecotourism and birdwatching.
4. **Scientific Knowledge:** The project offers a unique opportunity for scientific research on avian reintroduction techniques, population dynamics, and the ecological impacts of top predators/scavengers in island ecosystems.
5. **Conservation Flagship:** The Bearded and Cinereous Vultures can serve as flagship species, raising public awareness and support for broader conservation initiatives in Sardinia and beyond.
6. **Synergy with Existing Efforts:** The reintroduction will build upon the successes and established infrastructure of the Griffon Vulture conservation program, creating synergies and maximizing conservation impact.

13.2.2 Potential Risks and Mitigation Strategies:

1. **Poisoning and Contaminants:** Despite mitigation efforts, poisoning (both intentional and accidental, including lead from ammunition or veterinary drugs) remains a significant threat.
    a. **Mitigation:** Continued monitoring of carcasses, rapid response protocols, education campaigns for hunters and farmers (promoting non-toxic ammunition and responsible drug use), and robust law enforcement against illegal poisoning.

2. **Energy Infrastructure Collisions/Electrocution:** Power lines and wind farms pose collision and electrocution risks.
    a. **Mitigation:** Strategic placement of future energy infrastructure away from identified vulture flight paths and nesting areas, retrofitting existing high-risk power lines, and collaboration with energy companies.
3. **Human Disturbance:** Unregulated tourism or other human activities near nesting sites could disrupt breeding success.
    a. **Mitigation:** Implementation of ethical birdwatching guidelines, designation of buffer zones around sensitive areas, and public education on responsible outdoor behaviour.
4. **Food Shortage:** While supplementary feeding is planned, unexpected shifts in livestock practices or unforeseen events could reduce food availability.
    a. **Mitigation:** Flexible and adaptive management of feeding stations, continued dialogue with livestock herders, and ongoing monitoring of natural food sources.
5. **Post-Release Dispersal and Mortality:** Translocated individuals might disperse away from release sites or experience high post-release mortality.
    a. **Mitigation:** Gradual release methods (e.g., hacking), pre-release acclimatization, careful selection of release sites, and intensive post-release monitoring and intervention.
6. **Social Acceptance Reversal:** Public support, while currently positive, could wane if misconceptions or negative incidents arise (e.g., perceived livestock predation).
    a. **Mitigation:** Continuous community engagement, transparent communication, rapid response to misinformation, and showcasing the tangible benefits of vulture presence.

13.3 Evaluation and Recommendation

The analysis overwhelmingly supports the conclusion that the reintroduction of the Bearded and Cinereous Vultures in Sardinia is not only feasible but highly advisable. The project aligns perfectly with the IUCN's guidelines for conservation translocations, having thoroughly addressed the mandatory conditions related to ecological justification, risk assessment, habitat suitability, threat mitigation, social acceptance, and institutional support.

The potential ecological, conservation, and socio-economic benefits far outweigh the identified risks, especially given the comprehensive and proactive mitigation strategies embedded within the reintroduction program. Sardinia's unique environmental characteristics, coupled with the proven success of existing vulture conservation efforts (e.g., Griffon Vultures), provide a robust foundation for this initiative. The island represents a critical opportunity to restore these magnificent species to a region where they historically thrived and where the conditions for their long-term survival are increasingly favourable.

Therefore, it is the unequivocal recommendation of this feasibility study that the reintroduction program for the Bearded Vulture and Cinereous Vulture in Sardinia should proceed. This ambitious yet well-planned endeavour promises to be a landmark achievement in European biodiversity conservation, contributing significantly to the health and resilience of Sardinia's ecosystems for generations to come.

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