LIFE SAFE FOR VULTURES

REPORT - YEAR 2021

ACTION A.2 Assess the current and potential food availability for vultures in Sardinia

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Livestock data provided by Osservatorio Epidemiologico Veterinario Regionale della Sardegna (https://www.izs-sardegna.it/CdSE-OEVR.cfm)
Wild ungulates data provided by Apollonio M. et al. Aggiornamento della Carta delle Vocazioni Faunistiche della Sardegna - Sezione Ungulati, 2012[3].
Pictures of Mauro Sanna

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

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Action description

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

Avian scavengers are part of the detrital food web of ecosystems and they provide the important ecological service of recycling carrion biomass, thereby contributing to waste removal, disease regulation, nutrient cycling (DeVault *et al.* 2003, Moleón *et al.* 2014). Replacing some of these services has not only conservation costs but also unnecessary environmental and economic costs associated with carcass transport and processing (Morales-Reyes *et al.* 2015). The Griffon Vulture is a typical scavenger, feeding mainly on carcasses of medium and large-sized animals (Campbell, 2015). One of the main limiting factors for vulture conservation in Europe is the availability of safe food, due to changes in its geographic occurrence, quality and unavailability as a result of changes in European sanitary policies (Margalida and Colomer, 2012) and repeated poisoning events (Margalida and Mateo, 2019). Several official ongoing conservation programs in different European countries are tackling these threats with anti-poisoning activities and by providing safe food at feeding stations. As a result, the population in Europe is significantly increasing and it is estimated at 32,400-34,400 pairs, with Spain alone accounting for an estimated 25,000 pairs (BirdLifeInternational 2018). Its range has also expanded thanks to reintroduction projects in France, the Italian peninsula and the Balkans (Deinet *et al.* 2013). However, in Italy the Griffon Vulture is still included on the Red List as 'Near Threatened' (Gustin *et al.* 2019), with the last natural population persisting on the island of Sardinia.

Distributed over the whole island up to the late 1940s with an estimated population of 800-1200 individuals (Aresu and 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 and Schenk 2006). Moreover, the other large vulture species present on the island (*Aegypius monachus, Gypaetus barbatus*) had become extinct by the second half of the last century. The long-term conservation of the Sardinian population of Griffon Vultures is therefore 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.

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The project LIFE Under Griffon Wings (LIFE14 NAT/IT/000484) has mitigated food shortage for the population of Griffon Vultures in Sardinia by implementing a network of feeding stations in their core area. At the moment, 2 centralized feeding stations and 37 farm feeding stations are being provisioned. However, this sustainable solution was designed to meet the requirements of ≈ 250 Griffon Vultures, according to the carrying capacity of the area, and it limits the geographic range of Griffon Vultures to north-western Sardinia. Therefore, to enlarge the area of occupancy of Griffon vultures and increase its carrying capacity, the project LIFE Safe for Vultures will activate 1 more centralized feeding station in south-eastern Sardinia and 31 more farm feeding stations in north, centre and south Sardinia. The activation of the centralized feeding station in south-eastern Sardinia will be functional to the creation of a second nucleus of Griffon Vultures and hence to the enlargement of their area of occupancy. In this context, assessing current and potential food availability for vultures in the island is crucial not only to estimate the carrying capacity and to guide future conservation actions but also to assess the actual feasibility of restoring the vulture guild.
Carcass availability for vultures depends on the presence and density of both reared and wild animals. We estimated the kilos of biomass that can be generated from reared animals from data on livestock farms located in the Nature 2000 sites included in the project area. The data gathered included: location of the farms and number of animals bred. From these numbers we estimated the actual (feeding stations already activated within LIFE14/NAT/IT/000484 plus new ones to be activated within this project) and potential livestock carcass availability for vultures. We also considered wild ungulates as a potential food source of carcasses for vultures, since in eastern and southern Sardinia there are high numbers of wild boar (*Sus scrofa meridionalis*), European mouflon (*Ovis gmelini musimon*), Sardinian deer (*Cervus elaphus corsicanus*) and fallow deer (*Dama dama*).

Current food availability for Griffon Vultures

Due to its evolutionary strategy, the Griffon Vulture is a “K-selected” species, since its density or numerical consistency is mainly regulated by the “carrying capacity” of its specific habitat. In Sardinia the food resources of the species consist mostly of carcasses of reared animals provided by extensive and semi-extensive farms, in particular sheep and goats represent over 80% of its diet (Schenk et al., 1987; Aresu&Schenk, 2004; 2006). Considering that daily food requirements of an adult

Figure 1

Location of the farm feeding stations activated during the LIFE Under Griffon Wings project

GV are estimated at 0.5 kg/day (Donázar and Fernandez, 1990) and that the total population size is evaluated at 242-272 individuals, approximately 45,000 kg of biomass are annually required to feed the actual population. To reduce the impact of food shortage, the project LIFE Under Griffon Wings LIFE14/NAT/IT/000484 established a network of 37 farm feeding stations and two centralized feeding stations in Porto Conte and Monte Minerva to guarantee the availability of sufficient food for the population of vultures. Natura 2000 sites where feeding stations have been activated occupy an area of 51,163 ha and include: SCI ITB020041 entroterra e zona costiera tra Bosa, Capo Marargiu e Porto Tangone; SPA ITB023037 costa e entroterra di Bosa, Suni e Montresta; SCI ITB020040 Valle del Temo; SPA ITB023050 Piana di Semestene, Bonorva, Macomer e Bortigali; SCI ITB021101 Altopiano di Campeda; SCI ITB011155 Lago di Baratz - Porto Ferro; SCI ITB010042 Capo Caccia (con le Isole Foradada e Piana) e Punta del Giglio; SPA ITB013044 Capo Caccia.

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The network of feeding stations activated during the LIFE14 project provided a total of 102,995 kilos of biomass from 2017 to 2020. To date, the number of animals present in the 37 farm feeding stations activated amounts to 2,897 cattle and 13,368 sheep and goats. Figure 1 shows the location of the feeding stations currently active in Sardinia.
The data of biomass provided are shown in Table 1. The number of cattle carcasses annually disposed in the farm feeding stations ranged from a minimum of 0.3 to a maximum of 16.9 and consequently the number of Griffon Vultures annually fed ranged from 0.6 to 38 individuals1. The number of sheep carcasses annually disposed in the farm feeding stations ranged from a minimum of 0.5 to a maximum of 20.3 and consequently the number of Griffon Vultures annually fed range from 0.1 to 16.5 individuals. The variability in the number of carcasses disposed for sheep farms could be partly explained with the number of present animals. In cattle farms, the correlation between animals reared and disposed is poor1. The centralized feeding stations activated include those of the Regional Park of Porto Conte (Marina di Lioneddu) and of Monte Minerva (Villanova Monteleone). The first was authorized in December 2016 and that one of Monte Minerva in September 2017. Their provisioning is guaranteed by 70 livestock farms located mostly in the Alghero area, authorized by the ASL – Veterinary Services.

Table 1

Kg of biomass provisioned by the feeding stations activated within the LIFE Under Griffon Wings project during their actual activity period

Feeding stations	Location	Number	Activity period	Biomass Kg	Meeting the requirements of n. Griffon Vultures * Farm
Farm	Central Western	12	Jan 2017 – Ago 2020	58,378	92
	Central Eastern	18	Jul 2017 – Ago 2020	17,983	31
	North Western	7	Jul 2018 – Ago 2020	4,940	13
Centralized	Porto Conte	1	Dic 2016 – Jun 2017 Jan 2018 – Ago 2020	9,464	14
	Monte Minerva	1	Jun 2018 – Ago 2020	12,230	30
Total				102,995	180

* Calculated over the period of activity

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Periods of significant provisioning have been recorded (December 2017, January 2018) in which the biomass provided was equal to 3.5-5 times the requirements of the population. These significant changes in the provisioning index appear mostly related to stochastic events of mortality in cattle, while the supply index of small ruminants does not show significant seasonal variations. The stochastic events of cattle mortality linked mainly to environmental problems (such as droughts in the autumn of 2017) or pathologies. Cattle farms, on the other hand, are capable of meet the nutritional needs of significantly more Griffon Vultures than sheep while showing significant variations with periods of abundance alterning with periods of scarcity of trophic. Sheep farms, on the other hand, ensure a more limited provisioning but less subject to significant seasonal variations. The seasonal shortage of carcasses can be overcome by carcasses provided, for example, by previously created stocks (Monsarrat et al., 2013) or, as in our case, by the centralized feeding stations. The food supplementation provided within the project LIFE Under Griffon Wings allowed to ensure the maintenance and/or restoration of the natural feeding habitat of the Griffon Vultures and helped to reach a consistency of 242-272 Griffon Vultures with 60 territorial pairs in 2020. The increase in the population size was linked with an increase in productivity (+ 0.18) and reproductive success (+0.11).

Potential food availability for Griffon Vultures

Thanks to the conservation actions carried out during the project LIFE Under Griffon Wings (LIFE14/NAT/IT/000484), the Griffon Vulture population increased from 95-100 individuals in 2015 to 242-272 in 2020. The number of territorial pairs increased from 36 in 2015 to 60 in 2020, breeding pairs increased from 27 in 2015 to 51 in 2020 with a concomitant increase in the number of fledglings (20 in 2015 against 37 in 2020). Furthermore, the average colony productivity is in an optimal range (0.62). The increase in reproductive indices shows the positive response of the local population to the conservation actions implemented. The restocking program led to a release of 63 Griffon Vultures with a survival rate of 84% one year after release (53/63).
The project LIFE Safe for Vultures aims to fix the results achieved and to ensure the long-term survival of Griffon Vultures in Sardinia by the expansion of the area of occupancy, the increase of the carrying capacity of the vulture feeding area and the mitigation of the main threats to its survival. The data obtained with the GPS/GSM transmitters showed that vulture locations are concentrated in the north-west of the island (Figure 2) where the feeding stations have been activated.
The improvement of the habitat will allow a rapid increase in the population which, concentrating where food resources are available, will overcome the carrying capacity of the area and limit the normal dispersal of the population. Population

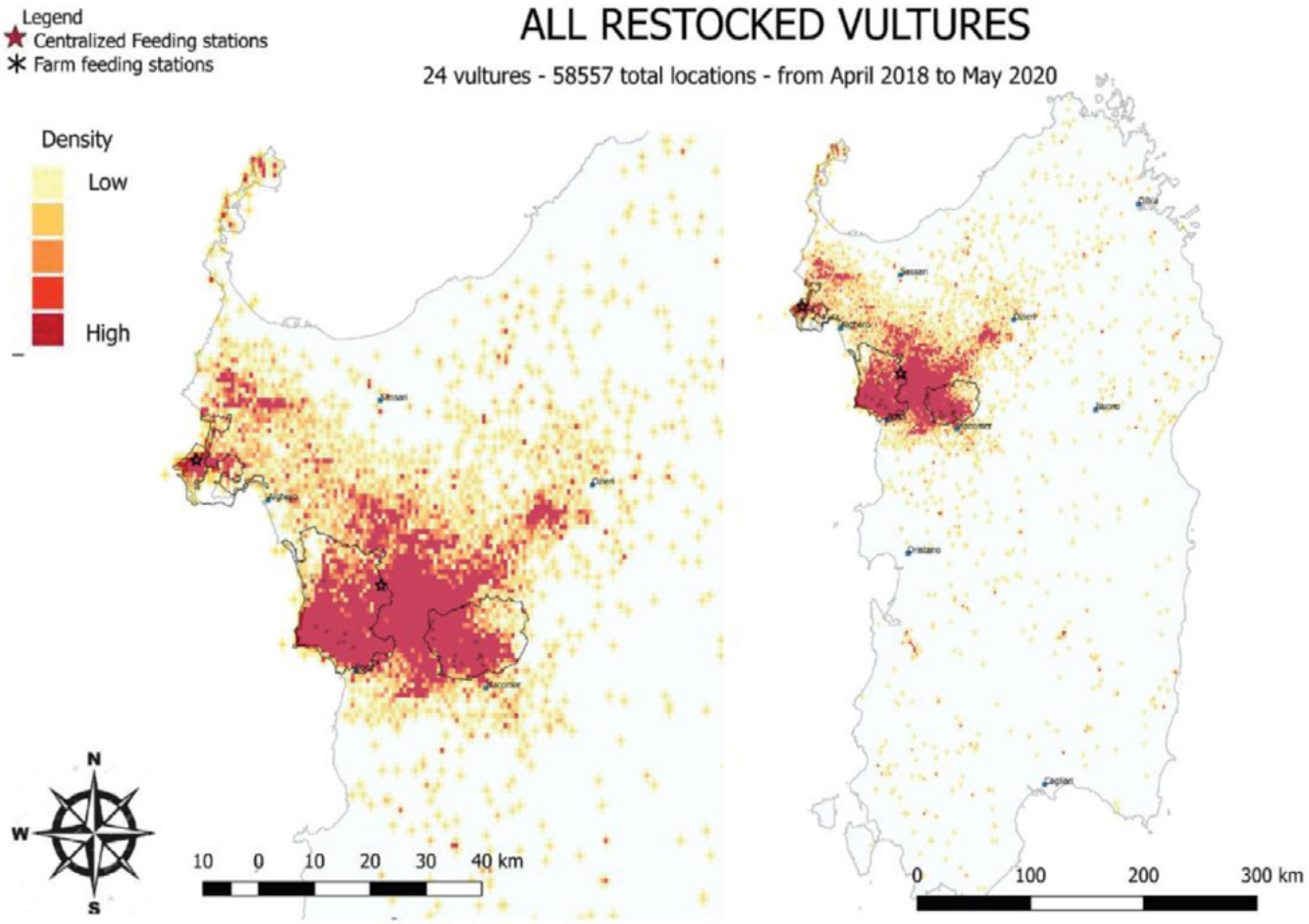

Figure 2

Heat map of Griffon Vultures locations

projections obtained after a population viability analysis using the Vortex simulation software as previously described (Aresu et al., 2020) show that population will grow rapidly, and it is estimated at 341 individuals by 2026 (see Annex 1).
To extend the occupation area of the Griffon Vultures and its carrying capacity, the project LIFE Safe for Vultures has foreseen 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 (table 2). In these areas, inside the Nature 2000 network, a minimum of 31 farm feeding stations and one centralized feeding station will be activated (Figure 3). The cen-

Table 2

Activation plan of farm feeding stations

	2021				2022				2023				2024				2025				2026			
	Tri1	Tri2	Tri3	Tri4	Tri1	Tri2	Tri3	Tri4	Tri1	Tri2	Tri3	Tri4	Tri1	Tri2	Tri3	Tri4	Tri1	Tri2	Tri3	Tri4	Tri1	Tri2	Tri3	Tri4
Farm feeding station set up centralnorthen Sardinia (n=15)						■	■	■	■															
Farm feeding station set up in southerneastern Sardinia (n=5)								■	■	①														
Farm feeding station set up in centraleastern Sardinia (n=5)										■	■	■												
Farm feeding station set up in southernwestern Sardinia (n=5)													■	②	■			③						

①②③ Indicate the three releases within the restocking action C.5

tralized feeding station will be realized in south-eastern Sardinia, to integrate the network of feeding stations and to contribute to fix the restocked Griffon Vultures (n = 40-50) on the territory. The releases, scheduled between 2023 and 2025, will aim to create a new nucleus in the south-eastern of Sardinia to increase the conservation status of the Griffon vultures in the Island. An acclimatization will be built inside the centralized feeding station.The activation plan of the farm feeding stations is planned to ensure meeting feeding requirements during the natural expansion of the vulture colony and will be completed between the second quarter of 2022 and the third quarter of 2024 (Table 2).

Data on carrying capacity of the vulture feeding zone have been calculated considering data on number and consistency of farms located in the proposed area provided by the Regional Veterinary Epidemiological Observatory (figure 4) compared with the expected increase in the Griffon Vulture population as described in Annex 1. Daily food requirements of an adult GV is estimated at 0.5 kg/day (Donázar and Fernandez 1990). Average biomass of adult sheep and goats has been estimated at 55 kg for previous food availability studies (Parra and Telleria 2004; Van Beest *et al.* 2008) and of cattle at 500 kg. GVs eat only soft tissues (meat, organs and intestines) meaning that 27% of the total carcass biomass is available for their consumption (Donázar and Fernandez 1990). According to data collected during the project LIFE Under Griffon Wings, mortality rates have been estimated at 8%

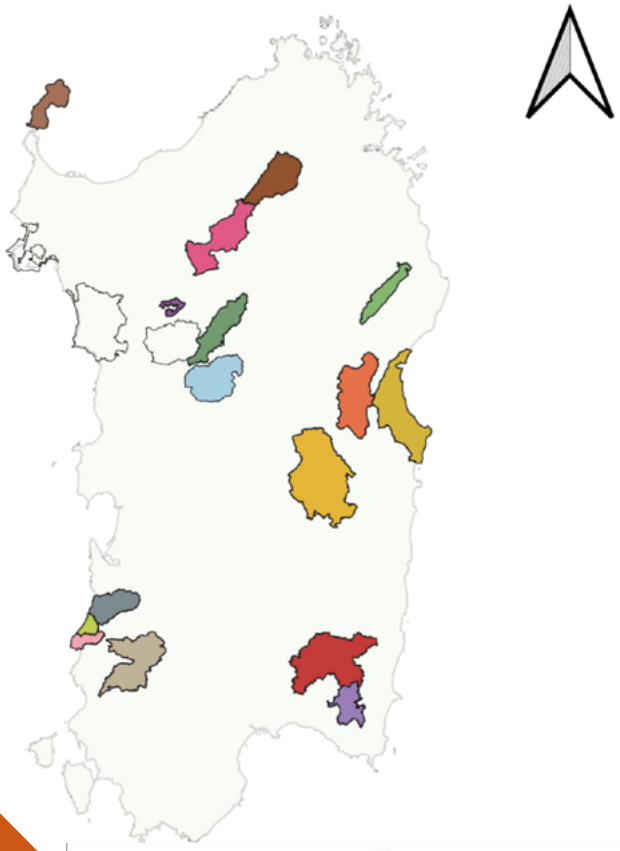

Figure 3

Vulture feeding zone in Sardinia as approved by the Region of Sardinia[2]

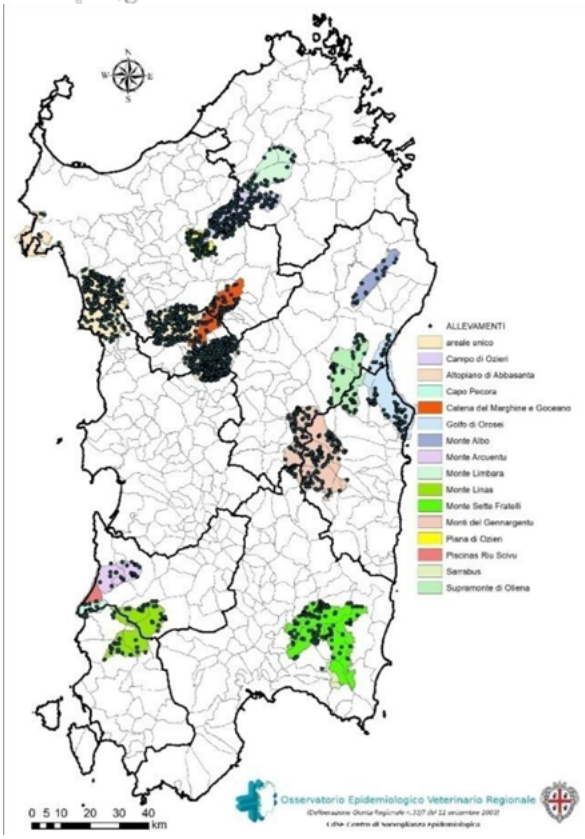

Figure 4

Farms located in the vulture feeding zone.

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for sheep-goats farms and at 3% for cattle farms. Biomass Kg/year were calculated according to the formula: heads reared x average weight x mortality rate x 27%. The total Griffon Vultures fed per year were calculated by dividing the biomass per year by daily feed intake of Griffon Vultures (0.5 kg/day, Donázar and Fernandez, 1990).

Based upon these values, the biomass production in the vulture feeding zone is presented in Table 3.

If all of these carcasses were made available to Griffon Vultures a total biomass of 418,128.84 Kg/year would be provided, this would meet the requirements of 2,291 individuals. From these data it appears that biomass production largely exceeds vulture requirements. Herders have showed a high interest in this practice, and there is good attitude towards the activation of on-farm feeding sites for vultures. The activation of the farm feeding station represents an opportunity for farmers both from an economic and organizational point of view. Based on these estimates, livestock carrion biomass availability is not supposed to be a limiting factor for population growth thanks to the high number of livestock farms located within the vulture feeding zone in Sardinia.

Table 3

Biomass production by the livestock farms located in the new areas of the vulture feeding zone in Sardinia

SPA/SCI	SITE CODE	SITE NAME	Small ruminants farms	Cattle farms	Total n. of farms	Small ruminants reared (n. head)	Estimated kg of biomass produced by small ruminants	Cattle reared	Estimated kg of biomass produced by cattle	Equine reared	Estimated kg of biomass produced by equine	Estimated total kg of biomass produced	Estimated n. of Griffon Vultures fed
SPA	ITB023051	Altopiano di Abbasanta	441	212	653	99786	107768.88	4961	20092.05			127860.93	700.61
SCI	ITB011113	Campo di Ozieri e Pianure comprese fra Tula e Oschiri	192	89	281	55607	60055.56	3062	12401.10			72456.66	397.02
SCI	ITB040030	Capo Pecora	19	0	19	3110	3358.80	0	0.00			3358.80	18.40
SCI	ITB011102	Catena del Marghine e del Goceano	68	59	127	10174	10987.92	1632	6609.60			17597.52	96.42
SCI	ITB040071	Da Piscinas a Rio Scivu	2	1	3	834	900.72	57	230.85			1131.57	6.20
SPA	ITB020014	Golfo di Orosei	101	38	139	6704	7240.32	884	3580.20			10820.52	59.29
SCI	ITB021107	Monte Albo	15	13	28	1405	1517.40	476	1927.80			3445.20	18.88
SCI	ITB040031	Monte Arcuentu e Rio Piscinas	42	6	48	5046	5449.68	157	635.85			6085.53	33.35
SPA	ITB043055	Monte dei Sette Fratelli	119	79	198	15382	16612.56	3302	13373.10			29985.66	164.30
SCI	ITB041106	Monte dei Sette Fratelli e Sarrabus	2	0	2	284	306.72	0	0.00			306.72	1.68
SCI	ITB011109	Monte Limbara	21	39	60	3959	4275.72	953	3859.65			8135.37	44.58
SCI	ITB041111	Monte Linas-Marganai	73	8	81	7886	8516.88	80	324.00			8840.88	48.44
SPA	ITB021103	Monti del Gennargentu	209	166	375	33557	36241.56	10373	42010.65			78252.21	428.78
SPA	ITB010001	Parco Nazionale dell'Asinara				1900	2052.00	0	0.00	520.00	2520.00	4572.00	25.05
SPA	ITB013048	Piana di Ozieri, Mores, Ardara, Tula e Oschiri	75	51	126	19165	20698.20	2250	9112.50			29810.70	163.35
SPA	ITB022212	Supramonte di Oliena, Orgosolo e Urzulei - Su Sercone	69	46	115	7059	7623.72	1937	7844.85			15468.57	84.76
Total			1448	807	2255	271858	293606.64	30124	122002.20			418128.84	2291.12

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We considered population growth as estimated in a population viability analysis (see Annex 1) to evaluate the fulfilment of vulture feeding requirements in the following years by the network of feeding stations (Table 4). At the current population size, ≈ 45,000 Kg of biomass are required per year. By 2026, population size is estimated at 341 individuals, which will require ≈ 62,000 Kg of biomass. From our estimates, the network of feeding stations to be established will be able to fully cover vulture requirements and thus allow their growth and establishment in the new areas.

Table 4

Food requirements of the growing Sardinian Griffon Vulture population.

Year	Population size	Feeding stations (farm + centralized)	Kg Biomass available	Kg Biomass needed
2021	264	37 + 2	45,613.4	48,180.00
2022	278	53 + 2	58,929.4	50,735.00
2023	293	63 + 3	68,873.4	53,472.50
2024	309	68 + 3	74,729.4	56,392.50
2025	324	68 + 3	81,531.4	59,130.00
2026	341	68 + 3	81,531.4	62,232.50

Wild ungulates distribution in Sardinia

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[3], 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 5).
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[4].
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 daily feed intake of Griffon Vultures (0.5 kg/day, Donázar and Fernandez, 1990).

Table 5

Population size and distribution of wild ungulates in Sardinia[3]

Area	Cervus elaphus	Dama dama	Ovis gmelini musimon	Sus scrofa
North	406	300	655	Medium-high (5-10 heads/100 ha)
Center Eastern Sardinia	100	50	5999	Medium-low density (5 heads/100 ha)
Centrer Western Sardinia		193	341	High density (10-15 3 e >1 heads/100 ha)
South Eastern Sardinia	1913		90	Medium-low density (5 heads/100 ha) except for Gerrei
South Western Sardinia	4417	217		Medium-low density (5capi/100 ha) except for Sulcis
Other areas	150			
Total	6986	760	7085	18750

Data provided by Carta delle Vocazioni Faunistiche della Sardegna 2012

Based upon these values, the biomass available for vultures from wild ungulates in Sardinia is presented in Table 6. 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.

Table 6

Biomass/year provided by wild ungulates in Sardinia

SARDINIAN WILD UNGULATE	HEADS NUMBER	BIOMASS KG/YEAR	GRIFFONS FED/YEAR
SARDINIAN DEER (Cervus elaphus)	6986	5587.93	30.62
FALLOW DEER (Dama dama)	760	369.36	2.02
MUFLON (Ovis orientalis musimon)	7085	2080.33	11.40
WILD BOAR (Sus scrofa)	18750	6834.38	37.45
Total		14871.99	81.49

Data provided by Carta delle Vocazioni Faunistiche della Sardegna 2012

Data provided by Schede Fauna di Sardegna

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Conclusions

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Primo passo verso il ripristino della gilda dei vulturidi in Sardegna

Data presented in this study have highlighted that, thanks to the implementation of the farm feeding stations, carrion 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 a 330 ha and it includes more than 50% of the total Nature 2000 sites in the island. Within this area, mostly characterized by grassland and pastures, are located a total of 2,255 livestock farms, rearing 301,982 cattle and small ruminants. The growth of vulture population can thus be sustainably followed by a proportionate increase in the number of feeding stations. Under this scenario, if the main threats will be successfully mitigated, the restoration of the vulture guild in Sardinia can be regarded as an achievable aim in the following years.

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