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FERAL UNGULATES IN THE MEDITERRANEAN AND MACARONESIAN ISLANDS

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FERAL UNGULATES IN THE MEDITERRANEAN AND MACARONESIAN ISLANDS

- *IMPACTS ON NATIVE FLORA AND FAUNA AND RESTORATIVE ACTIONS* -

Credit: Sandra Hervias Parejo

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SUMMARY

No less than ten species of introduced or feral ungulates are recorded on some 112 islands or islets in the Mediterranean and Macaronesia. Absence of predators other than man very often renders these animals invasive and dangerous to flora, plant cover generally (forest in particular) and the soils of these fragile ecosystems. Certain introductions are very old and date from the Bronze Age; some have led to the constitution of ungulate "populations" of historical interest (Cretan goat, Corsican mouflon, Rhodes deer). The recent changes in archaic pastoral practice and certain introductions for hunting purposes have multiplied these cases and brought new problems. The most widespread and worrying ungulate is the goat, which poses major conservation problems for the endemic plant species and flora generally. Nor is the degradation of the natural environment without effect on wildlife species, notably certain seabirds and insular reptiles; the pasture fires linked with herbivore husbandry can sometimes also have virtually irreversible effects. Thus in many cases herbivores are the major problem for preservation of island biodiversity.

Experience of eradicating herbivores is very plentiful: over 127 islands worldwide have been cleared of goats, pigs, sheep and other ungulates. The methods are now perfected and the results are spectacular. In fact eradication of species introduced to the islands has become one of the most effective means of preserving island biodiversity.

Eradication of ungulates is to be recommended first and foremost in the protected areas of oceanic islands, nature parks and reserves, apart from the cases where their presence is of historical or cultural interest and where it is preferable to resort to plain regulation of stocks. While the presence of herbivores sometimes proves necessary from the biodiversity conservation standpoint, reliance on domestic ungulates – whose management in space and time and general handling are easier – is preferable in every case.

INTRODUCTION

1.1 Procedure for drafting the report

I was assigned the preparation of this report by the Council of Europe Directorate of Democratic Governance (contract 236/14) on 19 June 2014. A hundred or so technical studies and publications on eradication or control operations were examined in this connection. The analysis also covered personal and professional files and records; it benefited from exchanges, direct or by correspondence, with colleagues throughout the Mediterranean region and Macaronesia.

The aim was to make the best use of the available information on a complex subject raising numerous problems in specific insular settings from the historical, biological and socio-ecological standpoints.

As a convention, the term "island" is used in this report for any insular setting populated by man at some period of its history, whether permanently or temporarily, and having hosted an economic activity (agriculture, fishing). The term "islet" is reserved for insular spaces of negligible area and uninhabited except by lighthouse keepers or military personnel.

The islands of the area studied will also be designated by the acronym "MacMed" (Macaronesia and Mediterranean) to disencumber the text of the report.

1.2 Schematic description of insularity in the Mediterranean and Macaronesia

The insular settings of the area studied are many and varied: few islands of medium extent in Macaronesia, some large islands and their retinues of islets in the western Mediterranean, a profusion of scattered islands and islets in the eastern Mediterranean.

Macaronesia comprises the groups of the Azores, Madeira and its Savage Islands, the Canary Islands and the Cape Verde Islands. They are all islands of volcanic origin, more or less ancient, which were never joined to the mainland.

Group	Latitude.	Longitude	No. islands	Inhabited islands	Human density
AZORES	39º41'N 36º54'N	31º16'W 25º01'W	9	9	104
MADEIRA	33º07'N 32º23'N	17º16'W 16º16'W	4	2	334
SAVAGE IS.	30º08N	15º52'W	3	0	0
CANARY IS.	29º25'N 27º38'N	18º09'W 13º25'W	10	8	284
CAPE VERDE	17º13'N 14º47'N	25º21'W 22º39'W	15	9	101

Most of the largest Mediterranean islands lie in the western part : Sicily, Sardinia and Corsica, their attendant islets, and the island groups of the Balearics, Tuscan Archipelago, Aeolian Islands and Malta. Only a few islands of lesser importance and islets lie along the shores of Africa (some tens in Tunisia, Algeria and Morocco) and Europe (Spain, France and Italy).

The coasts of Libya, eastern Italy, Egypt and the Middle East are deficient in islands and islets (about five per sector). Albania has fewer than about ten of them, only one being large. The islands and islets of Croatia (over 1 200 islands, 50 inhabited) and above all those of the Aegean Sea, Greece (some 2 000 islands and islets, of which about 100 are inhabited) and Turkey (60 islands, most being islets) chiefly constitute the bulk of the Mediterranean island space, with Cyprus (9 250 km2) and Crete (8 335 km2).

Most Mediterranean islands are of continental origin, separated from the coast as a result of erosion processes or changes in sea level although several (Alborán, Columbretes, Aeolians, Santorini...) are of volcanic origin and "oceanic" from the bio-geographical standpoint. The differences between the continental islands are sometimes significant: many of them in fact communicated with the mainland during the recent Würm glaciation when the level of the Mediterranean fell by some 200 m. The map of the Mediterranean as it was ten thousand years ago is very different from today's: Corsica and Sardinia were then joined, and Sicily was an extension of the Italian peninsula. Majorca, Minorca and Ibiza-Formentera were two large islands. All the Adriatic islands were joined to the mainland, as were the Turkish islands and Cyprus; of the Greek islands, most including Crete were joined to the mainland.

1.3 The biological and sociological contexts

The bionomic characteristics of the islands and the peculiarities of their animal and human populations need to be considered to understand the topic of this study clearly.

Geography, physical geography in particular, is instructive regarding the biomes (flora + fauna) which differ according to the MacMed islands and groups: in the Atlantic, the effects of the quaternary glaciations were more limited, and there is greater wealth of vegetation especially, which has more kinship than Mediterranean vegetation to that of the Tertiary era, with rain forest as the most typical manifestation. Conversely, in the Mediterranean fewer species have survived the climatic upheavals of the Pleistocene, although these upheavals were more pronounced. Macaronesia enjoys a higher level of endemism, and the strict oceanic character of the islands gives them maximum biological originality.

Another major factor should be taken into account to understand the insular biological communities properly: the presence of man, which has varied through time, as evidenced by the following table which provides some examples of the earliest human settlements in the islands.

Island/group	Human settlement	Reference
Crete	50 000 + 12 000 BC	Martini, F. & Ulzega, A. 1992
Corsica-Sardinia	Middle Pleistocene	

Balearic Islands	2400 BC	Alcover c.p.
Canary Islands	400-500 BC	Navarro Mederos 2012
Madeira	1424 AD	Wikipedia
Azores	1452 AD	Wikipedia

Thus there can be over 55 000 years' difference in human presence depending on the islands considered. These large deviations, however, are not reflected in fundamentally different states of biological conservation. For example, the comparative levels of degradation of Corsica and the Azores, marked by tens of thousands of years of human presence for the former and only a few centuries for the Atlantic group, are not appreciably different. It may even be the opposite! One is thus led to believe that (1) ecological changes of human origin do not occur regularly and constantly, and are linked more with immediate episodes of human settlement; (2) the differences in insular biological communities apparently have a primordial role; and (3) other variables are presumed to operate, such as topography, human density and economic context: grazing and farming lead to more significant major changes of local vegetation and landscape than fishing or trade, for instance.

Nor is population of the islands an episode affecting a single species; not only man occupies the environment, but an entire ecological community made up of numerous animals and plants: man and his retinue of livestock and cultivated species so aptly described by Crosby in 1988. It is established that goats, cattle and sheep populated the islands very early on with man and accompanied him in his settlement through the centuries: it is known from his own notes that Captain Cook introduced sheep into New Zealand as early as March 1773, well before the arrival of the first European settlers! Navigators and ungulates have constantly travelled together through the ages.

In modern history, changes in land use, the rise of protected nature areas and the decline of certain predators have led to the development of ungulates all over Europe, and islands are no exception to this trend. Thus the risks to biodiversity are irrefutable.

1.4 The imprecise borderline between archaic pastoralism and herding of animals gone wild

The presence of ungulates whether farmed or domesticated which have gone wild has developed considerably on the MacMed islands. In fact the absence of carnivores has made it possible to develop in an insular environment a mode of pastoralism rare on the mainland: animals permanently on the loose without surveillance or penning. The smaller an island, the commoner this archaic practice, particularly in the absence of agriculture. The difference between domestic and feral animals is therefore imprecise, and their impact on ecosystems is entirely similar today in either case.

In the past a form of temporary inter-island transhumance was practiced, where livestock was confined there in certain months, at certain times of year, the islands serving as natural corrals and allowing the animals to be separated according to sex and/or age band, at the convenience of the herdsmen.

In the Canary Islands even today, a distinction is drawn between domestic animals, animals known as "*de costa*", which spend long periods on the loose but have owners and are watched from time to time, and feral "*guaniles*".

This insular practice of open range grazing and transhumance has undergone significant changes linked with 20th century socio-economic trends: it has dwindled, together with control over the animals, and vanished from many islands. While in the Balearic Islands the presence of goats and other ungulates was known to Archduke Ludwig Salvator on some 30 islets[i] at the end of the 19th century, it survives today on a single islet (Vedrà). This author published a detailed count of the ungulates on the Lipari Islands[ii], although in this case they were domestic animals. Pliny the Elder already reported an insular transhumance in this archipelago at his period, and a temporary confinement of herds on Filicudi. The comparison between the 19th century figures and current data is surprising:

Head	**1895**	**Present**[iii]
Cattle	747	98
Sheep	3 635	715
Goats	906	
TOTAL	5 288	813

Note: Salina, not part of the Lipari municipality, is left out of the figures in the absence of available current data.

Plainly the development of tourism and rural decline have contributed to this rapid and intense evolution of island grazing.

Another factor to be mentioned is the progressive decrease in control of the animals. Traditionally, goats, sheep and pigs were confined on the islets in strictly limited numbers, often over well-defined periods in the year, according to practices favourable to the livestock and indirectly to the conservation of the island grazing resources. Unfortunately, today these good practices are forgotten and while it is true that there are fewer herbivores, there is also much less control over the remaining livestock, more or less left to itself as witness the cases of Vedrà and the Majorcan goats.

2. SPECIES

Not all aliens are equal, but some are worse than others… (Ferreti & Lovari, in Putman, R. and Apollonio, M. 2014)

2.1 The great success of goats as a species intrinsically adapted to extreme conditions

The goat is recognised as the feral ungulate which has the heaviest impact on vegetation and soil[iv]. According to IUCN, it is the principal factor imperilling threatened island plant species, held responsible for the extinction of one-third (31%) and for the critical situation of a quarter (26%) of the planet's threatened plant species[v]. The assessments of its impact on flora, vegetation generally, soils and even fauna of the MacMed islands are appalling, as summed up in the following table.

Type of impact	***Examples***
Preying on endemic and threatened plant species	Canary & Balearic Islands
Diminution of plant cover	Vedrà
Impairment of the structure of the vegetation	Woods in Majorca
Erosion phenomena	Vedrà
Expansion of introduced plant species	Montecristo
Impact on island reptiles	Greek islands
Impact on seabirds (impairment of nesting habitat)	Madeira
Setting of pasture fires	Majorca, Croatia

The goat has characteristics selected during domestication (early fertility, frequency of kidding, withstanding poor pasture and water shortage) making it a very "effective" invasive species. It can easily double its numbers in under two years and create population explosions in the absence of predators, as is the case in insular environments.

Appendix 1 summarises the position of the MacMed islands with reference to the current or recent presence of goats and other ungulates.

What accounts for this animal's expansion on the MacMed islands, as in virtually all of the world's insular environments, is the intention to form reserves of meat for future navigators and visitors to the islands. This practice probably dates from the Neolithic period and has survived through the centuries.

All goats present on the MacMed islands were introduced; even the Cretan "Cri-cri" – the phenotype closest to the species' wild ancestor *Capra aegagrus* – is of domestic origin. Hunting interests subsequently complicated the management of these herds. Like many other farm animals, the goat embodies a blend of genetically well-defined domestic breeds, of interest in terms of animal husbandry; thus they are part of the domestic heritage to be preserved, provided nonetheless that their rearing is planned, controlled and managed under conditions possibly compatible with hunting interests and carried on without detracting from conservation of the natural heritage.

Nomenclature: the literature abounds in diversity of nomenclature; it generally distinguishes two species of goat, *Capra hircus,* normally confined to domestic goats, and *C. aegagrus,* a wild ancestor of Asiatic origin, the designation used by some authors, particularly for the Crete and Montecristo phenotypes[vi]. Several trinomial combinations are also employed: *Capra aegagrus cretica, C. ae. pictus, C., ae. dorcas, C. hircus dorcas, C. ae. hircus*, etc. This report will make reference to the recommendation of the Caprinae Specialist Group of the IUCN Species Survival Commission (IUCN/SSC) for the area studied; it will refer to *Capra aegagrus* for the Cretan form and for the introductions originating from this stock, and to *Capra hircus* in the other cases.

2.2 Sheep, a future problem?

While the process of adaptation of goats to a feral state is very old, that of sheep is generally more recent. Sheep have gone wild in other islands of the world, but this phenomenon has been observed only recently in the Canary Islands and the Balearic Islands. The European subsidies of the CAP have encouraged maintenance of animals whose husbandry thus becomes economically viable, in addition to the production of wool, meat and milk, and does not require standing control of the animals! There are more and more half-wild animals which are no longer exploited for wool in the mountains of Majorca and the Canary Islands.

The impacts of sheep on vegetation are not as great as those made by goats whose behaviour inclines more to consumption of ligneous plants; while sheep browse less than goats and behave less invasively, their grazing behaviour still needs to be watched. In that sense, controlled farming schemes for the flocks of sheep are in hand in the Canary Islands and other islands throughout the world.

The sheep's semi-domestic ancestor, the Corsican mouflon, present on the islands and on the mainland too, is a special case. The interest of this species for hunting has led to its considerable expansion on at least 25 islands of the area studied, according to the available information.

Nomenclature: have the domestic sheep and the mouflon the same origin or not, do they or do they not belong to the same specific lineage? This is a question analogous to the one concerning the goat: *Ovis orientalis, Ovis orientalis ohion, Ovis orientalis musimon, Ovis aries*… The IUCN group of specialists consider that the designation *Ovis gmelinii* should be used for the wild specimens, and *Ovis aries* for the domestic specimens.

2.3 Other species of feral domestic ungulates

Pigs: This is once again a domestic animal often bred in the insular context under fairly lax conditions. Cases of seasonal introduction are reported on the islands of Ibiza in the context of exploiting *Arisarum vulgare* rhizomes. The same applies on Cabrera and Dragonera, where the pigs were left foraging for long periods and ate gulls' eggs and chicks as well as the vegetation. On Dragonera, this practice persisted up to the 1980s. Pigs were introduced on occasion to insular environments, in the Columbretes Islands for example in the 19th century, to eradicate the snakes there. The Croatian islands provide a dramatic instance of this predator's potency (cf. paragraph on these environments); the case of the wild boar will be commented on later.

Equids: asses and horses are also part of the micro-insular fauna; these animals' working stamina has made them necessary not only to agriculture but also to lighthouse keepers and military personnel for example. The case of Asinara, which inherited its actual name from this, shows the importance of these animals in the past! In the author's own experience, a mule lived absolutely free on Cabrera in the 1970s. On Dragonera, an ass nicknamed "Mayor" of the island also lived in complete freedom; it is related that he hunted and fed on rabbits and rats to avoid starvation[vii], which may be an exaggeration. In the 17th century when Formentera was depopulated after the regular raiding by the North African communities seeking slaves, wild asses became adapted to it; that also happened in the Cape Verde Islands and probably others.

An archaic breed of horse lives on Skyros; others evidently close to it genetically live in Sardinia, Cephalonia, Lesbos and Samos[viii]; however, there is no recent mention of equids living in a truly wild state within the range of study, nor data on the significant impacts of equids introduced to the MacMed islands.

Cattle: some are reported to be present on Piperi and Tilos; uncontrolled animals have existed at Bonifacio, some still exist on Molara. Their impacts are similar to those of animals living wild; they subsist in the scrub without any real extra supply of fodder.

2.4 Game species: escalation of a dangerous practice

Rural decline, particularly in grazing – which if well managed can constitute a practice favourable to biodiversity – leaves broad expanses unoccupied and unused economically. The human population of many of the MacMed islands lives on the tertiary sector today and the dereliction of land brings about a very dangerous situation linked with domestic herbivores supplanting large game; this trend means the introduction to the insular environment of originally mainland species, without effective control. This is not simply a recreational practice which could be dispensed with but a genuinely economic activity subjected to strong lobbying pressure which complicates its control.

Although this practice is not new, the pace at which it is developing today is most alarming. Mouflons and wild boars are the animals most used, but not the only ones.

The species of ungulates introduced into the zone studied during the 20th century appear in the following table, according to the available data.

Species	Archipelagos, islands
Red deer (*Cervus elaphus)*	Majorca (+)
Fallow deer (*Dama dama)*	12 islands of Croatia, Majorca.
Chital or axis deer (*Axis axis)*	Rab (Croatia)
White-tailed deer (*Odocoileus virginianus)*	Brač (Croatia)
Roe deer (*Capreolus capreolus)*	Cres, Krk, Hvar and Brač (Croatia)
Barbary sheep (*Ammotragus lervia)*	La Palma (Canary Islands), Hvar, Tijat, Plavnik and Mrcara (Croatia)
Mouflon (*Ovis musimon)*	17 islands of Croatia, Tenerife (Canary Islands), Elba, Zanonne, Zembra.
Wild boar (*Sus scrofa)*	15 islands of Croatia. Elba. Majorca (+)
"Wild" goat[1] (*Capra hircus)*	Majorca, Mljet, Hvar, Prezba, Mrcara and Kopiste (Croatia)

[1] Not only the cases with a known hunting-related purpose are counted.

More detailed information specific to each island is appended.

Historical and older cases are also reported: an indeterminate species of gazelle lived on Majorca for several centuries in the Middle Ages; it had probably been introduced at the Muslim period, and its meat was sold in markets; gazelles are also represented in a painting of the classical era at Akrotiri (Thera)[ix].

The current rate of these introductions generally is nevertheless higher than ever.

3. IMPACTS

3.1 Herbivorism and flora conservation

The situation may differ according to the islands, oceanic or continental.

Consumption of plants, when excessive as well as when totally absent, can be equally unfavourable to Mediterranean flora and by extension to the biological communities in general. An experimental study conducted in an enclosure – albeit in a non-insular environment – in Israel[x] concludes for example that small plant species sparsely distributed or radially structured are moderately appetising to herbivores; in the absence of any pressure from them, the large-sized permanent plant species become dominant and their development leads to a reduction of aggregate diversity.

In fact similar conclusions are found in differing contexts: the action of herbivores, browsing, grazing and trampling, is known for diversifying the conditions of survival of plants, encouraging the best-adapted species and reducing or eradicating the other flora species. In Majorca for example it has been observed that in the absence of goats, the threatened micro-endemic species *Naufraga balearica* vanished beneath the competing species, while conversely stands of it can also be destroyed by over-grazing; it is all a matter of proportion.

The position is very different on the oceanic islands where historically there have never been ungulates; nor is abundance always a good indicator: its level may often increase in the presence of common species with a wide geographical distribution, without major conservation issues.

It seems well-established that mountain flora is more sensitive to the adverse effects of herbivores than low-altitude flora, and often the species severely threatened by herbivores are mountain endemics; cases have been reported both in Majorca and in the Canary Islands. Certain invasive exotic species and ruderal plants, generally nitrophytes, are sometimes encouraged by the introduction of ungulates[xi], although in some cases the eradication of an ungulate can also encourage spread of exotic plants.

The impact may furthermore affect the total vegetable biomass, the plant cover and the structure of the vegetation. Biomass decreases, even considerably in some cases whereas in others the plant cover on the ground partly or completely disappears to the advantage of species that withstand herbivores better and possess adaptive mechanisms: toxicity, thorny or highly fibrous structure, high regenerative capability… These are often mainland or exotic species fostered by herbivores; finally there may be cascade effects.

Impacts differ according to the ungulates' sex ratio and age structure; for example, the selection of fodder plants or the damage done to trees by the males with their antlers vary with the circumstances.

Finally, damage to crops (olive groves) and in gardens, together with the health hazards of livestock contamination, have also been repeatedly mentioned.

3.2 Ungulates and threatened and heritage fauna

The impact of ungulates on vegetation plainly has implications for the local fauna owing to transformation of habitats, changes along the food chain, competition for resources, etc. Several studies demonstrate that impairment and depletion of plant cover in an insular environment and, in certain cases mentioned, degradation of soils and erosion, have adverse effects on abundance of insular reptiles (cases studied in Greece and the Lavezzi islands) and seabirds (Madeira, Azores). A case is reported in Minorca in which destruction by the goats of the plants providing shelter to endemic lizards of an islet has made

them more vulnerable to predation by common kestrel. Stabilisation of the soils by ungulates was also a significant factor in the preservation of the Zino's petrel (*Pterodroma madeira)*. Besides the cases mentioned, and in the absence of other pieces of information, it is nevertheless difficult to take stock of the question.

Introduced ungulates may pass on diseases or pathogens to local or old-established species: tuberculosis, bluetongue …, even sometimes to man.

3.3 Case study: the Balearic Islands

The goat is the sole seriously problematic ungulate today in Majorca, Minorca and Es Vedrà. Fallow deer, red deer and mouflons have been introduced illegally into Majorca of late, but have not proliferated and are controlled in such a way that their presence remains virtually anecdotal[2]. The presence of wild boars has long been documented in the islands, as from the Middle Ages when their introduction is mentioned, but their extinction was also early and though undated, before the 17th century). Two cases of proliferation of domestic or hybrid feral pigs have been verified in the last few years.

The goat is to blame for the poor state of conservation of most of Majorca's threatened endemic species (mountain flora), together with decline of undergrowth vegetation, deficient regeneration of burnt-off zones, and even soil erosion in some places. A tentative count made in 2000 estimates the numbers of goats present on the island in a feral condition at some 22 000 specimens. According to the estimates, 7 000 head are eliminated yearly (3 500 kids for meat; 1 500 animals controlled by the administration and the remainder culled by private individuals); however, the number of animals needing to be eliminated to guard against all problems is estimated at 12 000. Damage to agriculture is significant in the highlands of Majorca, and even road accidents are reported every year.

The situation has been complicated by the existence in the island of an ancient phenotype purportedly of Neolithic origin (!). Yet no comparative study has been made between the existing zoo-archaeological remnants and the present-day animals for one thing, and genetic studies conducted in Cordoba confirm that the domestic breed known as "Majorcan goat"[xii] and the form called "wild" are absolutely identical. Direct testimonies reveal that forty years ago goats were managed as sheep are today, caught and marked every year, and that the "wild" goats were actually goats released contrary to the express terms of the leasehold contracts. These contracts normally forbade releases of this type of livestock for its impact on the forest vegetation[xiii]. The income from forests was not leased but reserved for the owner. Today the "wild goat" is protected by hunting bodies, with the exception of four private hunting grounds which continue to pursue touristic hunting for this domestic (!) trophy.

The economic recession has also had effects on prevalence of feral animals. Over the last ten years, a service dedicated to catching strays in Majorca has permitted the elimination of 399 horses, 400 goats and sheep, 129 pigs and 11 cattle.[xiv] The risk of further introductions is therefore high.

3.4 Case study: introduced herbivores in the protected areas of the Canary Islands

The problem in these territories centres on four species: domestic goats and sheep, whose breeding is controlled and whose numbers are down; Barbary sheep in La Palma and mouflon in Tenerife and La Palma[xv]. These introduced ungulates together consume 130 of the 330 endemic plant species of the Canary Islands.

Grazing is an archaic activity in the Canary Islands, already existing in 313 BC. The *guanches,* a pre-European population, raised and were closely dependent on livestock. Today the cheeses of the Canary Islands are highly regarded. Generally, as is the case wherever milk is a major yield of pastoral activity, the livestock is well controlled, supervised, and there is little damage to the natural environment. Once European agricultural subsidies become a significant income, the need to manage the animals decreases and control of livestock is often confined to marking and, at the appropriate time, annual screening for

[2] For the time being! One never knows with invasive species...

disease and cutting out the young animals. Over the last ten years, the numbers of goats have reportedly increased and total 100 000[xvi]. Thus the risk of damage to vegetation becomes very high! Feral goats are reported on all the islands; they were eradicated recently from the Chinijo group northeast of Lanzarote. Controls are carried out in La Palma, Gomera and Tenerife. A dispute between hunting and animal protection circles has caught the attention of the media: the hunters would like to take over the controls, which is not accepted by the animal protectionists. Apparently this dispute may be connected with local politics.

The best known case concerns the wild ungulates introduced into two national parks: Barbary sheep (*Ammotragus lervia)* in the Caldera de Taburiente National Park (La Palma) where 16 specimens were released in 1972; the species is also present in the Las Nieves Nature Park, the Pinar de Garafia Reserve and in several Natura 2000 classified sites. The total numbers could be in the region of 200-250 animals[xvii]. This species threatens no fewer than 10 endemic plant species, which it eats and tramples at the same time. Mouflon (*Ovis aries musimon)* were introduced into the Teide park in 1971; their stocks, currently present over an area of some 370 km2, may total about 400 individuals. Their impacts on threatened plant species are proven and are particularly worrying for 4 plant species threatened with extinction.[xviii] Recent observations of animals were made in La Palma.

Endemic plants threatened by introduced herbivores are numerous. The following box summarises the data consulted in connection with this study.

Examples of species threatened by direct consumption in the Canary Islands	
Stands of *Pinus canariensis*	Nogales et al. 2006
24 phanerogams, 20 of them endemic	Nogales 92
Helianthemum bystropogophyllum	idem
Endemic cedar and juniper woods, and mocanera heaths	Gesplan 2014
Helianthemum bramwelliorum and *H. gonzalez ferreri*	Leon Guerra, L. 2010
Chamaecytisus proliferus, Teline stenopetala, Spartocytisus filipes and Cicer canariense.	Garzon-Machado, 2010
Stemmacantha cynarioides, Lotus berthelotii and H. cirae	Garzon Machado 2011
26 endemic plants on Gran Canaria, 21 Tenerife, 16 La Gomera and Fuerteventura, 13 Lanzarote, 10 La Palma, 8 Hierro	Rando 2014
Probable extinction of *Helianthemum agariae*	Rando 2014
4 birds, 3 endemic lizards, 8 snails and 1 insect	Rando 2014

In his fine 2014 report, Rando supplies data on the birds of Fuerteventura in relation to the intensity of grazing; the author gives interesting results, correlating the number of species and of individuals present with the intensity of grazing, assessed by sampling; the results are as follow.

	Present situation	**Over-grazing**	**Intensive over-grazing**
Number of species	28	19	13
Number of individuals	2123	1519	1447

It is worth noting that certain bird species such as the Egyptian vulture (*Neophron percnopterus)* or the common raven (*Corvus corax*) depend on domestic herbivores and that a species of great interest in terms of conservation, such as the Canary Islands bustard, is all the more plentiful and in a good state of conservation as the territory is grazed and thus open!

3.5 Case study: Montecristo

Montecristo, the largest Tuscan island, deserted and never under cultivation, has long harboured goats considered feral and even descended from the wild ancestor of the domestic goat. Although the island is classified as a nature reserve, the reserve manager has ascertained the need to ensure ongoing control of their numbers and to carry out selective culls.

The specialists concur today that these animals are domestic goats, *Capra hircus,* of quite an old phenotype. Goats of Corsican origin may even have been introduced during the second half of the 20th century to give the Montecristo goats new blood. These goats have proven impacts on the vegetation and affect the regeneration of the evergreen oak (*Quercus ilex);* they have aided the proliferation of the species *Aylantus altisima* on the island, creating one of the conservation problems which are the most involved and expensive to handle throughout the reserve.

The goat is regarded as one of the most emblematic components of Italian fauna[xix]. Its introduced quality is countered by its historical and cultural value, and the isolation of a "population" of imperfectly known origin. After the island's classification as a reserve, its numbers increased and reached a known maximum of 770 animals in 1992; numbers are now limited to a few hundred in the interests of the diversity of the island vegetation which can regenerate thanks to enclosures installed, protecting it from the pressure of the goats. The results are under permanent review and provide directions for the management of the reserve, particularly by determining the admissible density of animals which should be adjusted to climate change and specifically the trend of rainfall.

3.6 Case study: the islands of Croatia

The Croatian islands, after those of the Aegean Sea, form the Mediterranean archipelago comprising the largest number of islands; they offer great variety including landscape variety. Before the development of tourism, intensive sheep farming was the main activity on many of them. This form of use determined the vegetation of the islands and even brought about their wildlife diversity, as witness one of the most remarkable Mediterranean colonies of griffon vultures (*Gyps fulvus*) on the island of Crc. The introduction of European and exotic ungulates is uncontrolled here today, helping to create a critical situation for nature in this archipelago.

A summary of the writings of Dr Goran Susic (e.p.) who studied the case appears below. No less than 24 islands of over one km2 are occupied by introduced ungulates (although wild boar may have colonised these islands of its own accord and in certain cases by swimming). This massive introduction began after the Second Wold War, with the introduction of wild boars and fallow deer on Veliki Brijuni, an occasional residence of President Tito. The species introduced and the number of islands concerned are shown in the following table:

Introduced species		Number of islands concerned
English name	*Latin name*	
Wild boar	*Sus scrofa*	15
Fallow deer	*Dama dama*	12
Mouflon	*Ovis musimon*	17
Roe deer	*Capreolus capreolus*	4
Barbary sheep	*Ammotragus lervia*	4
Axis deer or chital	*Axis axis*	1
White-tailed deer	*Odocoileus virginianus*	1
Feral goat	*Capra hircus*	>5

The case of Brijuni, classified as a national park in 1983, is the most serious; over 1 000 exogenous animals have reportedly been counted on this territory with an area of only 5.55 km2. They have to be fed as the island's natural vegetation is insufficient. In fact, the island has been used as an acclimatisation park for herbivores since 1901 and a safari park hosting elephants, zebras, lamas and zebus has been created there!

3.7 A brief overview of other islands and archipelagos

The Azores. Goats and sheep have been present in a domestic state on all islands of the group, since man's arrival in the 15th century. Up to a recent period, these animals were controlled but over the last few decades, and owing to decrease in the price of wool, some sheep have gone wild, together with goats inhabiting cliffs particularly and other inaccessible sectors on all islands of the group. Flora and the habitats of nesting seabirds are the hardest hit. Eradication schemes have been devised for some islands[xx], but the political will to implement them seems to be lacking. There are data also recording the presence of feral cattle in the natural woods of Terceira, Flores and Pico, where they are thought to cause damage to soil and vegetation[xxi].

Madeira. Goats, of purportedly very early origin, occupy Deserta Grande and Bugio; a current Life project aims at their eradication: 200 of them have been eliminated, a hundred or so may still remain. Feral herds have undergone controls in Madeira and Porto Santo in order to preserve endemic species of seabirds whose breeding grounds have been damaged by these ungulates[xxii].

Cape Verde Islands. Goats of Portuguese origin are the sole non-domestic ungulate present here. In fact Portuguese navigators were in the habit of abandoning goats and asses on the islands to have meat in future. A trial modern-day introduction of goats from the Canary Islands producing more milk failed after the animals fell ill. Some now remain on Sao Vicente, Boa Vista, Santo Antonio, Brava and Santa Lucia. Eradication schemes have been devised but not implemented on the last of these islands. Probably there were also pigs on Santa Lucia where bones have been found. Vegetation in this arid archipelago has suffered very severely indeed, and impacts on the endemic reptilian fauna are presumed (Mateo). About halfway through the 20th century it was reported that semi-wild goats, pigs and asses had bitten down the vegetation so far as to lay bare the soil, to a still greater degree than the Sahara[xxiii]. Similar observations have been made on islands considered to have been covered with trees at their discovery in the 15th century, and where two centuries later half or two-thirds of the human population was to disappear through water shortage after the original natural vegetation had been devastated by these ungulates. This is one of the most dramatic known cases of destruction of island ecosystems.

Corsica and Sardinia. The Corsican red deer (*Cervus elaphus corsicanus)*, introduced to these islands at a very early period, is the most interesting reported case. This ungulate became extinct in Corsica in 1970 and at the time numbered only about a hundred head in Sardinia. It has been reintroduced into Corsica and specimens have also been released in other Sardinian localities over the period 2003-2010. The state of conservation of this species is developing favourably today.

Albania. Goats were introduced in the communist era on the island of Sazani, where the military forces had a base. They have now vanished; only a few horses may remain, though without significant impact. However, rabbits were introduced during Italian occupation (1914-1947) and affect the vegetation[xxiv].

The islands of the Aegean Sea. Overgrazing is unfortunately the rule here and many islands have lost much of their plant cover and soil. The "*frigana"*, a sparse scrub of thorny plants, is only a relic of the original island flora, and the teeth of goats and sheep caused its appearance.

Many herds of supposedly wild goats of Cretan origin or mingled with other more domestic forms exist or have existed on the Greek islands, in a more or less wild state, and are poorly controlled. Damage to flora, vegetation generally, and fauna through loss of habitat or of food chain resources are well documented in scientific literature.

4. INVASIONS AND EXPERIENCES WITH CONTROL

4.1 Ungulates as invasive species

The literature devoted to invasive ungulates in insular environments is extremely plentiful. Their effects are better known in the islands of the Pacific and Indian Oceans owing to the recent date of their introduction, and makes for easier comparison of former and present conditions. The situation is obviously similar in the MacMed islands even in the absence of equivalent documentary references.

In insular environments ungulates have man as their sole significant predator, and he is usually interested more in the development than in the regulation of these animals. Domestic species, selected according to criteria such as early and rapid breeding, are particularly dangerous when pastoral control tends to disappear.

The Balearic Islands are an interesting case in relation to the goat. Archduke Ludwig Salvator has left an account of the rapid and severe reduction of goats in Ibiza: towards the mid-19th century, owners understood that the damage caused by goats exceeded the yield from their presence, and in fact the domestic or feral herds quickly diminished. Today only strictly domestic and well managed goats remain on the island. In Ibiza and Majorca the threatened plant species include three scrub species as against 17 cliff species. Pine and juniper woods cover more than 80% of Ibiza's forest environments, far less in Majorca where scrub and growths of *Ampelodesma mauretanicus* are better represented. It is also observed that pasture fires, fires generally, held favourable to livestock, are of course more frequent on islands where there are ungulates.

By their effects on flora, ecosystems and economic activities (agriculture, animal husbandry, forestry), goats and wild boars/pigs are animals whose impact is significant, as much as that of cervids in certain cases. The impact of mouflons/sheep also varies according to context.

4.2 Means of control

Control or eradication of ungulates in insular environments is a very widely used mode of conservation throughout the world. Shooting animals is the most effective basic method, although the use of toxic substances has been tried in certain cases. Shooting on the ground or from a helicopter, with dogs, and by using goats equipped with radio transmitters ("Judas goat technique"), are techniques employed depending on the context. Catching with the help of enclosures, with lassos or nets has also been used with varying results too, depending on the circumstances. Archery on the other hand is said to achieve only poor results and cannot be recommended. In all circumstances, the support, possibly commitment, of the local population is valuable and remains a major factor of success.

Fencing off stands of great botanical interest has also shown its effectiveness in certain insular environments; long-term maintenance of these structures is always awkward and expensive, however.

In the writer's opinion, shooting by specialist teams, well-trained, familiar with the ground and provided with dogs, is effective and to be recommended as a general rule in the case of MacMed. Prior examination of the animals' behaviour and of the structure of the groups to be controlled is recommended.

In certain rare cases, the animals can be captured alive if they have a possible use (domestic livestock for instance). As a rule, destruction of animals is the sole reasonable solution.

Sterilising the animals is not of much avail either; they continue having an impact on the environment and it is impossible to achieve a satisfactory result, with few exceptions, when their capture and recapture can be contemplated; such methods also carry risks of injuring the animals and/or of unsuitable responses. Putman & Apollonio made a review of the results of this method in 2014.

Conflicts may arise with animal protection groups (cf. case of the Olympic national park studied by Scheffer in 1993, where an association opposed the eradication of introduced specimens of *Oreamus americanus* of Canadian origin on the ground of its historical presence). This type of conflict is becoming more and more frequent nowadays and may become a key factor in future. Eradication schemes of this

kind should seek to keep the animals' suffering to a minimum and use alternative methods to their elimination, the most rational and "humanitarian". In the West, public opposition to lethal methods diminishes in affected localities as the level of damage increases.

4.3 Hunting for sport, an unsatisfactory technique

Despite frequent availability for such operations, volunteers are not very effective most of the time. It is exceptional for a sportsman to agree to wipe out his resource. Collaborations are nevertheless sometimes possible as an adjunct to the intervention of professional groups, preferably made up of local people.

Formation of working groups associating the local communities, as has been done in Australia and the Galápagos, is a conceivable avenue. Local support is most important for the success of operations and in order to discourage fresh introductions, as has happened on many past occasions.

4.4 Control of ungulates worldwide

There are very many experiences of ungulate eradication worldwide.

Species concerned	**Number of islands**	Data from DIISE (Database of Islands Invasive Species Eradications) http://diise.islandconservation.org/ (Consulted in Dec. 2014)
Capra hircus	181	
Sus scrofa	67	
Ovis sps	43	
Bos taurus	20	
Equus sps	18	
Cervus sps	12	
Others	5	

One of the first goat control trials was carried out on Raoul Island [xxv] (NZ) in 1937. Since 1972 annual hunting drives have been organised and have almost achieved their aim. On the other hand, the productivity of the remaining goats has increased by 77%, showing that control of numbers also must keep abreast of these developments if the objective is to maintain a low density of animals.

Today 16% of New Zealand's area is occupied by feral goats, distributed among 150 herds. The government has stipulated four possibilities for intervention depending on the localities: 1) no action. 2) preferably eradication. 3) sustained annual control established on the basis of a standing compromise with civil society or 4) intermittent sustained control with more uncertain results[xxvi].

In Australia, according to the assessment of the 2008 plan made by the government in 2013[xxvii], feral goat numbers rose from 1.4 million in 1997 to 3.3 million in 2010. Industrial exploitation of the culled animals is an important economic and social activity; efforts focus on reducing the spread of the animals and eliminating them in sectors of major interest for conservation. Use is made of corralling but also of more expeditious methods such as selective poisoning of goats without risk to other herbivores[xxviii]. Biological and fertility control procedures are not deemed suitable. In the driest sectors, creation of pens near waterholes proves effective for eliminating the goats in the sector. The government plan also makes it a priority to eliminate the goats on sea islands or in isolated habitats where the risk of animals immigrating is slight or non-existent. Three islands have undergone eradication schemes since 2008, one being Kangaroo Island; the unit cost of elimination ranged from 71.71 to 237.75 USD for animals killed by shooters on the ground, and 363,00 USD for those shot from helicopters. The scheme was completed in 10 months.

In Hawaii, Yocom proposed the eradication of goats from the national parks as early as 1967 (the first were released by Cook in 1778), because of their impact on vegetation and soils. Such operations are conducted permanently in the Volcanoes National Park where pens were created; however, corrosive fumes from eruptions reduce the life cycle of these infrastructures and the objective of eradication has not been achieved to date. An interesting case was studied by Cabit et al. in 2000: a dry tropical forest, free of ungulates for 70 years, suffered a decline in the regeneration of shrubs following invasion of the environment by the species *Pennisetum setaceum*[3]*;* in general, the vegetation nevertheless makes a prompt and positive response. That was so, for example, in Hawaii where the natural forest successfully regenerated after the eradication of goats by means of experimental enclosures[xxix].

The experiments with eradication carried out in the Galápagos are the most extensive in the world; 9 islands have been "cleaned up" and over 152 000 animals eliminated[xxx]. Pinta, Santiago and Isabella, the most extensive island where goats were eradicated, are the three most important. The description of the methods, problems and solutions chosen was well documented and published by Campbell et al. in 2007. This project is where the "Judas goat" technique was perfected; it was thereby demonstrated that females, sterilised and with induced *oestrus* after hormone treatment, were the most effective: this technique was called "*Mata Hari goat"* because of its effectiveness.

In sum, the techniques employed today combine shooting on the ground or by helicopter, use of dogs or otherwise, and corralling. Judas goats and Mata Hari goats facilitate location of the animals all the better, the lower their density. Detailed planning of operations, use of GPS and GIS, and the participation of the local population are key factors in the success of these operations.

Appendix 2 contains a translation of the outline drawn up by Zavaleta in 2002, proposing a logical sequence of decision to (or not to) eradicate; this outline gives the most suitable answers to the difficulties and the risks inherent in this kind of operation.

5 CONCLUSIONS

Eradication of introduced or feral ungulates in an insular environment is a powerful tool for preserving and rehabilitating ecosystems, as well as for preventing extinction of native plant and animal species[xxxi]. That is the paradox whereby a conservation problem, if soluble, becomes a possible instrument of success and improvement to the state of preservation of nature areas, and of habitats and threatened species.

5.1 Recommendations for the Mediterranean and Macaronesia

On the basis of the foregoing elements, the following recommendations are made. They are considered the most reasonable in the case of the MacMed islands:

- Eradicate introduced or feral ungulates located in **protected nature areas, particularly Reserves and National Parks, on oceanic islands**; their presence is incompatible with the primary role of these areas which concerns conservation of local biodiversity first and foremost;
- Also eradicate feral or introduced ungulates located in **protected nature areas (National Parks and Reserves) on continental islands**; with the exception of well-established "populations" of cultural or historical interest and to be controlled nonetheless; these are notably the Cretan goat, the mouflon in Corsica and Sardinia, perhaps also the Rhodes deer and the Montecristo goat. In all cases, detailed monitoring of the trend in numbers should be carried out, and a maximum density of animals will be stipulated, determined on the basis of specific prior ecological studies;
- Eradicate ungulates introduced to a protected or natural island **in breach of the legislation** of the state concerned;

[3] A grass, also problematic in the Canary Islands and the Balearic Islands.

- Where vegetation management so requires – after the extinction of a native herbivore, as with *Myotragus* in the Balearic Islands – have recourse to domestic livestock whose density, pressure or seasonal cycle of husbandry are easy to manage, unlike wild or feral species liable to become invasive.

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APPENDICES

1. – List of species according to islands
2. – Outline for planning eradications (De Zavaleta 2002)

ONGULÉS INTRODUITS OU SAUVAGES SUR LES ÎLES DE MACARONESIE ET MÉDITÉRRANNÉE (Voir bibliographie)

Population disparue

Espéce	*île*	*Arxipel*	*Pays*	*Observations*
Dama dama	Majorque	Baleares	Espagne	Introduit a plusieures réprises. Presque eradiqué
	Tenerife	Canaries	Espagne	Introduit et eteint 1970
	Corse	Corse	France	Présent depuis l'année 100
	Sardeigne	Sardeigne	Italie	Intro. VIII-VII a de C. Bien établit
	Sicile	Sicile	Italie	Intro. Neolitique. Eteint ± 1850. Réintroduit et établi.
	Hvar		Croacie	
	Brac		Croacie	
	Cres		Croacie	Intro. 1986, de 500 a 1000 captures annuelles
	Losinj		Croacie	
	Mljet		Croacie	
	Scedro		Croacie	
	Plavnic		Croacie	Intro. 1995, de 170 a 200 têtes
	Sv.Grgur		Croacie	Intro. 1953. Quelques 50 têtes
	Mrcara		Croacie	
	Prezba		Croacie	
	Brijun		Croacie	
	Krk		Croacie	Intro. 1978
	Xipre		Xipre	Intro. - 6.000 éteint XVIème
	Rodes		Grèce	Intro. ± 1400, (contre les serpents!). Certains auteurs le considèrent éteint sous la dominatiuon turque, reintroduit par les italiens debut du Xxème, mais Massetti considère que sont descendents de l'introduction neolitique.
	Lemnos		Grèce	Introduit recemment de Rodes
	Kos		Grèce	Introduit recemment de Rodes. En enclos
	Tilos		Grèce	Introduit recemment de Rodes. En enclos
	Crete		Grèce	Intro. Puis éteint. Reintro. recente de Rodes.

	Corfú		Grèce	Fosil pleistoceniques.
	îles de l'Egée		Grèce	Des restes archeologiques a maintes îles de l'Egée
Espéce	*île*	*Arxipel*	*Pays*	*Observations*
Cervus elaphus	La Gomera	Canaries	Espagne	Intro. ? Éteint XIXème
	Majorque	Baleares	Espagne	Intro. XIII éteint XVIII, essai de reintro. XXème, no reussi.
	Corse		France	Intro. Romains. Èteint 1960. Reintro. En cours depuis 1985
	Sardeigne		Italie	Intro.- 6000. Bien établit.
	Euboea		Grece	Présent jusque à 1940, introduit (ou nage?)
	Skorpios		Grece	En enclos le XXème, pas de données recentes.
	Youra		Grece	Sur de nombreuses îles grèques, il y a des restes qui temoignent nombreuses introductions prehistoriques et historiques, les prèmières du Neolitique. Au Moyen Age, diverses îles ont dévénus territorire de chasses privilegiés pour les nobles. A Naxos, jusqu'à le XVIIIème.
	Kephala		Grece	
	Thera		Grece	
	Kea		Grece	
	Milos		Grece	
	Tinos		Grece	
	Naxos		Grece	
	Chipre		Chipre	D'aprés Pinius, l'espèce il y aurrai arrivé a la nage, ce qui est impossible (>100 km). Absente aujourd'hui
Capreolus capreolus	Krk	Adriatic	Croacie	Intro. 1975
	Cres	Adriatic	Croacie	Intro. 1987
	Hvar	Adriatic	Croacie	
	Brac	Adriatic	Croacie	intro.1920
	Euboea	Adriatic	Croacie	Connu a l'êtat subfosile, reintroduit recemment.
	Corfu		Grece	Restes subfosiles
	Thasos		Grece	Restes subfosiles
Odocoileus virginianus	Brac	Adriatic	Croacie	
Axis axis	Rab	Adriatic	Croacie	Quelques 50 têtes
Espéce	*île*	*Arxipel*	*Pays*	*Observations*

Ovis gmelinii	Tenerife	Canaries	Espagne	11 libérés au Parc N. El Teide 1971. 370 km2. Quelques 400 ex.
	Corse	Corse	France	Quelques 1200 têtes
	Elba	Toscana	Italie	
	Sardeigne	sardeigne	Italie	Quelques 2000 têtes
	Marettimo	Sicilie	Italie	
	Zanonne		Italie	
	Zembra	Zembra	Tunis	
	Brijuni		Croacie	Intro. Années 50
	Hvar		Croacie	Intro. Années 60
	Dujiotok		Croacie	Intro. 1978
	Brac		Croacie	
	Cres		Croacie	Intro 1986. 50 têtes
	Losinj		Croacie	
	Rab		Croacie	120-150
	Mljet		Croacie	
	Ugljan		Croacie	> 100
	Solta		Croacie	
	Scedro		Croacie	
	Tijat		Croacie	> 1.000
	Zlarin		Croacie	
	Zmajan		Croacie	
	Mrcara		Croacie	
	Prezba		Croacie	
	Vir		Croacie	
	Chipre		Chipre	Bois de Paphos. Intro. Moyen Age ou XIXème?
	Atalandi		Grèce	Intro. 2ème moitié Xxème
	Sapienza		Grèce	Intro. 2ème moitié Xxème

Espéce	*île*	*Arxipel*	*Pays*	*Observations*
Ammotragus laevia	La Palma	Canaries	Espagne	16 ex. Libérés a Taburiente NP en 1972. 200-300 têtes
	Hvar		Croacie	
	Tijat		Croacie	
	Plavnik		Croacie	Intro. Trés recente, ilegale.
	Mrcara		Croacie	
Capra hircus cf ***aegagrus***	Créte		Gréce	Intro.neolitique. Semidomestiques, ancienne gestion.
	Antimilos		Gréce	Des nombreuses introductions cynegétiques ont été faites sur des îles et îlots grecques, a partir de la Créte. Certaines de cettes populations peuvent être *C.hircus* ou hibrides *hircus x aegagrus*.
	Youra		Gréce	
	Samotracie		Gréce	
	Theodoru		Gréce	
	Aghii Pantes		Gréce	
	Dhia		Gréce	
	Sapientza		Gréce	
	Moni		Gréce	
	Atalandi		Gréce	
	Skopelos		Gréce	
	Euboea		Gréce	
	Dragonada		Gréce	
	Rodes		Gréce	Intro XIXème, exemplaires d'Anatolie au Xxème
	Erimomilos		Gréce	Controles depuis 1963
Capra hircus vars domestiques	Corvo	Açores	Portugal	Une centaine d'individus sur les falaises orientales.
	Flores	Açores	Portugal	
	Faial	Açores	Portugal	

	Pico	Açores	Portugal	
	S.Jorge	Açores	Portugal	
	Graciosa	Açores	Portugal	
	Terceira	Açores	Portugal	
	S.Miguel	Açores	Portugal	
	Santa Mara	Açores	Portugal	
	Madère	Madère	Portugal	élévage libre éliminé en 2003
Capra hircus vars domestiques	Porto Santo	Madère	Portugal	élévage libre éliminé en 1995
continuation	Deserta grande	Madère	Portugal	Eradiqué annés 90
	Buio	Madère	Portugal	
	Tenerife	Canaries	Espagne	
	Gran Canaria	Canaries	Espagne	
	La Palma	Canaries	Espagne	
	La Gomera	Canaries	Espagne	
	El Hierro	Canaries	Espagne	
	Fuerteventura	Canaries	Espagne	
	Lanzarote	Canaries	Espagne	
	Sao Vicente,	Cap Vert	Cap Vert	
	Boan Vista	Cap Vert	Cap Vert	
	Santo Antonio	Cap Vert	Cap Vert	
	Brava	Cap Vert	Cap Vert	
	Santa Lucia	Cap Vert	Cap Vert	
	Majorque	Baleares	Espagne	Quelques disaines de miliers.
	Minorque	Baleares	Espagne	Quelques centaines
	Vedrà	Baleares	Espagne	Quelques 80 sur l'îlot. Degradation intense.
	San Pietro	Sardeigne	Italie	
	Tavolara	Sardeigne	Italie	

	Asinara	Sardeigne	Italie	
	Montecristo	Toscane	Italie	Intro.ancienne, chèvres corses au Xxème.
	Lampedusa	Sicile	Italie	
	La Gallitte	La Gallitte	Tunisie	
	Mljet		Croacie	Plus de 1000
	Hvar		Croacie	Population dense
	Prezba		Croacie	
	Mrcara		Croacie	
	Kopiste		Croacie	
	Cres			localement trés abondante
	Alonissos			
	Tilos			

Et beaucoup d'autres îles et îlots grecques et turques.

Espéce	*île*	*Arxipel*	*Pays*	*Observations*
Sus scrofa var. Sauvage (Sanglier)	Majorque	Baléares	Espagne	Intro. + 700 éteint 1400. Sporadique de nôs jours
	Corse	Corse	France	Intro. - 5600
	Elba	Toscane	Italie	
	Sardeigne	Sardeigne	Italie	
	Sicile	Sicile	Italie	Intro - 7000
	Marettimo	Sicile	Italie	Intro. Datte inconue (moderne?)
	Cres	Adriatic	Croacie	Intro. Années 80. 500 à 1000 cap. annuelles
	Krk	Adriatic	Croacie	Intro. Années 80. 500 à 1000 cap. annuelles
	Lošinj	Adriatic	Croacie	Intro. Années 80
	Rab	Adriatic	Croacie	Intro. Années 80
	Hvar	Adriatic	Croacie	Intro. Années 80. 100 à 200 cap. annuelles
	Mljet	Adriatic	Croacie	Intro. Années 80
	Šćedro	Adriatic	Croacie	Intro. Années 90
	Brac	Adriatic	Croacie	Intro. Années 90
	Solca	Adriatic	Croacie	Intro. Années 90
	Zeka	Adriatic	Croacie	Intro. Années 90

	Plavnik	Adriatic	Croacie	Intro. Années 90
	Prvić	Adriatic	Croacie	Intro. Années 2000
	Vis	Adriatic	Croacie	Intro. Années 2000
	Korcula	Adriatic	Croacie	Intro. Années 2000
	Murter	Adriatic	Croacie	Intro. Années 2000
	Crete		Grèce	Intro de - 1200 à - 500. Établi
	Lefkade		Grèce	Presence occasionelle, peut y arriver a la nage.
	Corfu		Grèce	Presence recente, soit disant arrivés a la nage. Fossils.
	Rodas		Grèce	Introduit par les Templiers, eteint. Il y en a en enclos.
	Samos		Grèce	Indices de presence depuis les années 90. Soit disant a la nage
	Youra		Grèce	Fossil
	Chipre	Chipre	Chipre	Intro. - 5000 ou 11.700 BP. Réclus a Troodos mont., fuites.
	Sehir Adari		Turquie	Masseti le raporte de cettes îles, petites et prôches du continent, ou il peut arriver en nageant. Certains auteurs considererent que l'espècue peut traverser detroits de 20 ou 25 km.
	Dehirmen Bükü		Turquie	
	Yediadalar		Turquie	
	Gemile		Turquie	
	Geykova		Turquie	

Espéce	*île*	*Arxipel*	*Pays*	*Observations*
Sus scrofa var. domestique (Porc)	Majorque	Baléares	Espagne	Population hibride avec sanglier, eradiqué recement
(Cas d'assauvagement)	Corse		France	
	Amaphi		Gréce	
	Samotracia		Gréce	
	Fourni		Gréce	
	Rhodas		Gréce	
	Tilos		Gréce	

Bos taurus (libres)	Piperi		Gréce
	Tilos		Gréce
	Lavezzu		France
	Molara		Italie

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Basse de données DAISIE
Genovesi et al. 2012
IUCN. Caprine specialists group
Lucchesi 2007
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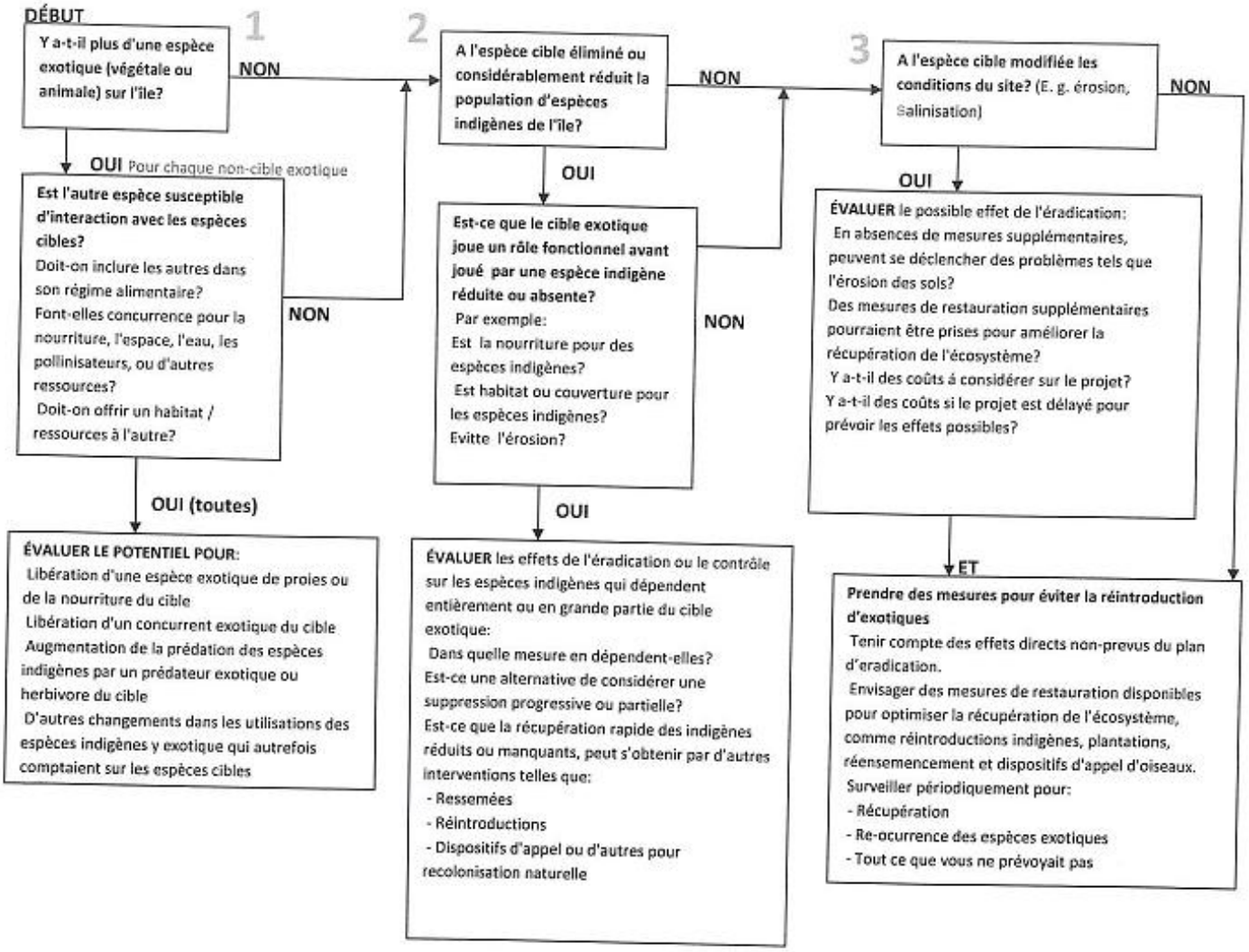
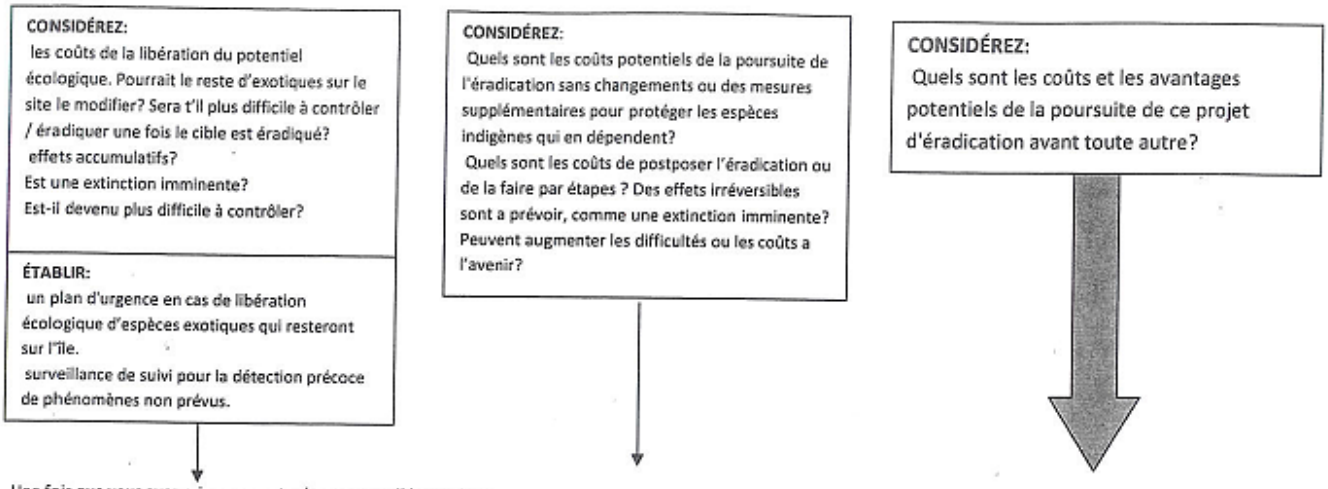
Données personelles

Novembre, 2014

Joan Mayol

Schéma pour la planification d'éradication (De Zavaleta 2002)





Schema de guide de planification d'éradication. (De Zavaleta, 2002)

[i] Salvator, L. 1865
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[iii] http://dati-censimentoagricoltura.istat.it/
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[xiv] Mas, T. c.p.
[xv] Rando 2014
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[xviii] Palomares Martínez 1999
[xix] Gotti 2010
[xx] Hervías, S. et al. 2012 Invasive mammal species on Corvo Island: is their eradication technically feasible? *Airo,* 22: 12-28
[xxi] P.A. Vieiria Borges, c.p.
[xxii] ZINO, F. & Biscoito, M., 1994
[xxiii] Chevalier, Aug. 1937 cf.
[xxiv] Dr Ferdinand Bago, p.c.
[xxv] Parkes 1984
[xxvi] Parkes 1990
[xxvii] Anon. 2013
[xxviii] Hunt 2012
[xxix] Scowcroft 1987
[xxx] Lavoie el al. 2007
[xxxi] Campbell et al. 2005