

GOOD PRACTICE GUIDE

for the adaptation of

the
eleonora's falcon
to climate change



FOREWORD

This guide aims to summarize and present the conservation actions that were implemented for the Eleonora's Falcon within the framework of the LIFE13 NAT/GR/000909 "Conservation measures to assist the adaptation of *Falco eleonora** to climate change" (LIFE EIClimA). The project partnership included specialized actors with long experience in the species' research and conservation, namely the Department of Biology at the University of Patras, the Hellenic Ornithological Society and the consultancy Nature Conservation Consultants (NCC).

It is the outcome of 5 years efforts to deal with the threats that this emblematic species faces. Even though the population status of Eleonora's Falcon in Greece and other Mediterranean countries is considered to be stable, the fact that Greece hosts over 85% of its world population during the breeding season makes necessary the implementation of conservation actions that will ensure a favourable status, in a planet where climatic change and biodiversity loss are here and now.

Current threats for the species include: deterioration of breeding habitat conditions due to climate change, increased pressure from invasive species at its breeding colonies, climate imposed shift in the timing and distribution of passerine autumn migration, affecting prey availability during the critical brood rearing period for the species, and impact of land uses in the species' foraging grounds.

LIFE EIClimA addressed those threats in order to facilitate Eleonora's Falcon adaptation to the ongoing and future climate change by the implementation of a series of conservation actions. These actions included (a) improvement of nesting habitat quality and species breeding success through rat eradication operations in selected breeding colonies (b) creation of artificial, well-sheltered nests in selected breeding colonies in order to increase nest quality and availability at optimal nesting sites, and (c) plantation of fruit trees and bushes in important passerine stopover areas in the vicinity of the target species' breeding colonies in order to improve body condition and availability of target species prey.

All these actions proved to be quite successful and we hope that will serve as good and useful examples for future conservation actions for that and other species facing similar threats. With the support of the European Union LIFE Instrument and of Green Fund, we believe that we managed to improve the prospective of Eleonora's Falcon in a changing world. However, these efforts should not stop here. It must live and after LIFE.

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good practice guide

ABOUT THE GUIDE

The purpose of this guide is to provide useful information concerning the application of specific conservation measures for the adaptation of Eleonora's Falcons to climate change, with emphasis on the measures applied by the LIFE EIClimA project. The guide aims to provide practical guidelines and know-how, which are essential for improved species response and adaption to climate change.

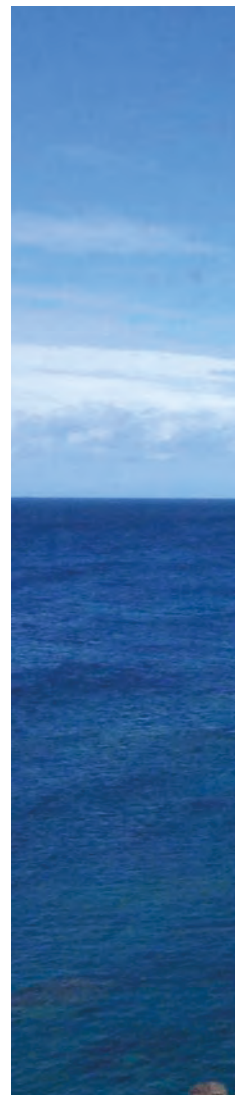
The guide addresses the following topics:

- Which are the predicted effects of climate change in the region of the Mediterranean Sea and Eastern Africa, especially Madagascar?
- What are the main characteristics of the Eleonora's Falcon?
- How vulnerable the species is to the predicted effects of climate change?
- Which are the potential mitigation measures at the sites where the species currently breeds and feeds?
- How can these mitigation measures be applied and under which circumstances?

Case studies on the proposed mitigation measures are provided, as well as practical know-how information.

It should be noted that the guide does not provide an exhaustive list of measures and it is based on the experience gained in the framework of the LIFE EIClimA project.

The guide is primarily aimed at **Natura 2000** site managers and policy makers, including Management Bodies of protected areas, forestry services, as well as non-governmental organizations undertaking conservation measures for Eleonora's Falcon.





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leonora's falcon

ELEONORA'S FALCON

2.1 Identity

Eleonora's Falcon (*Falco eleonorae*; Gén  , 1839) was named after the princess of Sardinia Eleonora d'Arborea (1347-1404), who in 1392 issued the first known law against bird poaching. However to most people in the Cyclades, the Dodecanese and Crete where the vast majority of the world population breeds it is commonly known as "Varvaki".

Eleonora's Falcon is a medium-sized migratory raptor, which belongs to the family of falcons with characteristic long, narrow pointed wings, long tail and slim body. Its body length is 36-42cm, wingspan 87-104cm and mass 350-450g with females being larger in size. It is quite unique among falcons as it occurs in two colour morphs, a dark and a light one. While both morphs have black back, the appearance from below is quite different. The light morph has rusty-brown chest with black strips and white throat and cheeks, but the dark morph is black also below, making it completely black. The juveniles have light brown chest with light brown tips of feathers on the back and wings,



creating a scaly appearance from above. Only a very small proportion of juveniles is completely dark.

Eleonora's Falcon is very agile in flight. Most of the time it has a relaxed, energy-saving, seemingly effortless flight with soft wing beats utilizing air currents and thermals for soaring



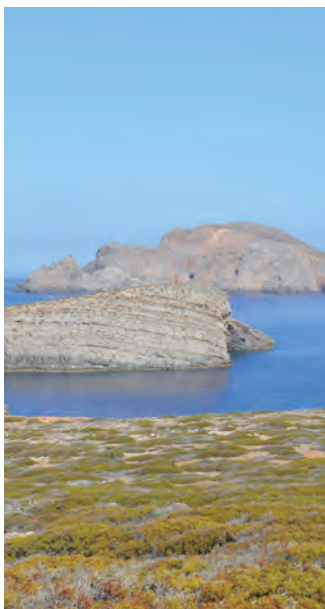
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Conservation measures to assist
the adaptation of *Falco eleonorae**
to climate change (LIFE13 NAT/GR/000909)



ΠΑΝΕΠΙΣΤΗΜΙΟ
ΠΑΤΡΩΝ
UNIVERSITY OF PATRAS





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princess of Gardinia

and gliding, but changes to quick dynamic flight with fast wing beats when pursuing or hunting.

The global population of this migratory, colonial breeding species is estimated at 29,200-29,600 mature individuals. It breeds on the islands of the Mediterranean Sea and West Africa. In October and November Eleonora's Falcons migrate to Madagascar, East Africa and the Mascarene Islands to winter, from where they return in April and May. Greece hosts more than 85% of its global breeding population.

Threat and conservation status

IUCN, Greek Red Data Book:

Least Concern

Birds Directive:

Annex I

Bonn & Bern Conventions, CITES:

Annex II

The annual cycle of Eleonora's Falcon comprises of five, partially overlapping, stages: the breeding period, extending from late July until October, the autumn migratory period, from October until December, the wintering period, from November until April, the spring migratory period, from March until May and the pre-breeding period, from April until July. Although the mature individuals return to their breeding areas in spring to secure their nesting territory and breeding partner, they postpone their breeding until late summer in order to coincide with the autumn migration of passerines that comprise the main food source for feeding falcons' chicks. Eleonora's Falcon exhibits high marital fidelity, as well as, fidelity to its natal and breeding colony. Before late summer the food availability around the colonies is limited, therefore the falcons move large distances far from their colonies to feed over larger islands or the mainland. Egg-laying period starts in late July. One to three, exceptionally four eggs are laid in nests, which are located in caves, rock crevices or under vegetation cover mainly on uninhabited islets or inaccessible cliffs on larger islands. Chicks



hatch after approximately 35 days, namely during the second half of August. During the period of egg incubation and the first two weeks after hatching the males provide food for the chicks but afterwards both parents contribute to food provision. After about a month, in late September, the chicks make their first flights and by mid-October they are ready for migration.

Although Eleonora's Falcons are notorious for hunting autumn migrants to raise their chicks, most of the year they depend on a more "common" type of food, insects. Therefore, despite their fame as passerine hunters, they

are essentially insectivores, feeding on larger insects, such as cicadas, beetles, locusts and butterflies or flying ants which they catch with their claws and consume in the air.

In late October the falcons start migrating towards their wintering quarters in Southeast Africa. On Madagascar, their main wintering area, they use open areas with cultivations, tree plantations and degraded forests for foraging and at least some large trees for roosting.

2.2 *Breeding colonies*

Eleonora's Falcon breeds on small islets and rocky island coasts in the Mediterranean, from Cyprus to the Balearics and the coasts of Algeria, with a few colonies lying along the Atlantic coast, in Morocco and the Canaries.

According to the global population survey carried out in the past decade through a devoted LIFE project, over 12,000 pairs of the species nest in Greece and up to 3,500 in the other countries. The second largest species breeding concentration is in Spain (900 pairs), followed by Italy (650 pairs). The easternmost colony of the species is located in Cyprus, the northernmost in Croatia, and the southern- and westernmost in the Canaries.

The centre of the species colony distribution in Greece covers the Aegean archipelago including the Kythira area and the islets north of Crete. The species is very scarce in the Ionian Sea (Eptanisa). The bulk of Eleonora's Falcon population is located in six regions, i.e., northeast Aegean, south Sporades, east

Cyclades, Antikythera, southwest Dodecanese and the islets neighbouring eastern Crete. The largest colonies occur in regions where summer winds ("meltemia") prevail (>6 Beaufort scale) creating favourable tail winds for the autumn passerine migrants.

During the last four decades the major colony sites remained the same. However, with the exception of Crete, concrete figures regarding the species' population trend for most of the Aegean islands were lacking since the previous decade. For the case of Crete, a population decline at a rate of 15% per year during the period 1997–2000 has been reported for certain colonies, which have been closely monitored since 1965. This negative trend was attributed to incidences of secondary poisoning in the foraging areas over Crete. But climate change may also have played a role in the decline of this population, as this specific region includes some of the southernmost species colonies.



Top

*Areas of breeding colonies
of Eleonora's Falcon*

Right

Eleonora's Falcon nestling

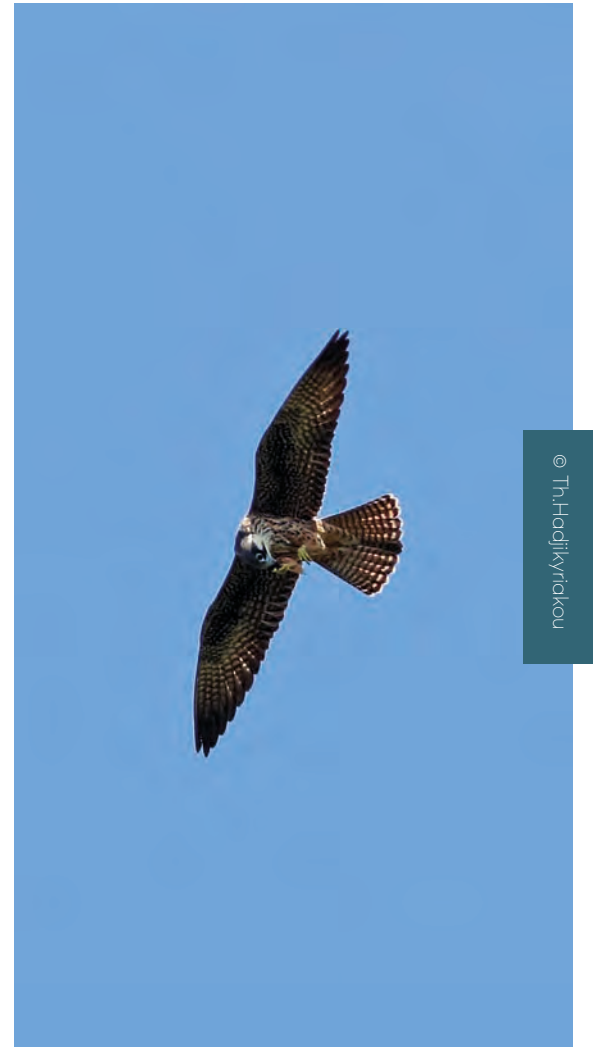


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2.3 Foraging grounds

The assessment of the status of the frequently used habitats for each species, including current pressures and potential threats, is considered a key component, yet daunting task, for the successful and efficient conservation of protected species, like Eleonora's Falcon. Migratory birds rely on a variety of habitats located in distant geographic areas during different stages of their annual cycle. The information presented below is derived mainly from tracking data pertaining to Eleonora's Falcons from colonies in the Central and South Aegean Sea, but also field surveys and ecotoxicological assays, conducted during the course of the LIFE EIclimA project, as well as during past conservation projects.

The species has fine-tuned its breeding period with the peak of autumn migration of birds, upon which it feeds during this period of the year and raises its chicks. However, throughout the rest of its annual cycle Eleonora's Falcon diet is mainly insectivorous. The availability of these two food sources, namely insects and migratory birds, in space and time results in two distinct foraging patterns: one comprising of short trips in the vicinity of the breeding colonies during the breeding period to hunt birds, and another one encompassing a wide area, comprising longer trips, during the pre-breeding and wintering period to catch insects.



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Pre-breeding period

Following the completion of the spring migration and until the onset of the breeding period Eleonora's Falcons prefer relatively productive and insect-rich areas that are particularly heterogeneous in terms of landscape composition. They may wander several hundred kilometers away from their breeding colonies in search of food in forested, herbaceous and cultivated areas, but also lakes and rivers, equally in mountainous and lowland areas. Some falcons may spend a considerable amount of time at their breeding colonies and forage in the nearby area depending on the

local food availability. Foraging areas where Eleonora's Falcons typically occur during the pre-breeding period are located in the continental mainland as well as on large islands of the Aegean Sea. Tracking data, although from a limited number of falcons, suggest substantial foraging site fidelity between years. These regions are considered areas of high biodiversity value and many of them have been designated as protected areas at the national and international level (e.g. Natura 2000 areas, Important Bird Areas, Wildlife refuges, Ramsar sites).

Left

*Eleonora's Falcon feeding
on insect*

Right

Forests and lakes in Greece



© C.Kassara/UpP

However, land use changes related to the abandonment or intensification of farming practices, habitat degradation and infrastructure installation, e.g. wind farms or power lines, could impact habitat quality. Climate change is also expected to perpetuate habitat degradation by means of increased desertification and incidence of forest fires within these areas. Although heavy metals burden in Eleonora's Falcons' tissues is relatively low, past incidents of poisoned falcons at their breeding grounds raise the alarm for uncontrolled use of pesticides in Europe.

A.

Known distribution of Eleonora's Falcon during the pre-breeding period, based on Natura 2000 database, on non-systematically collected field observations (ebird database and personal observations), and in a lesser extent, on tracking data.

B.

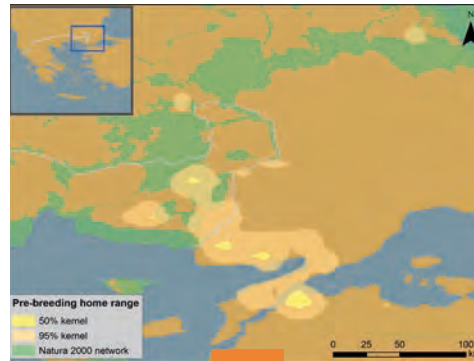
The home range of an Eleonora's Falcon derived from tracking data during the pre-breeding period extended over a large area lying in the borders of Greece, Bulgaria and Turkey.

C.

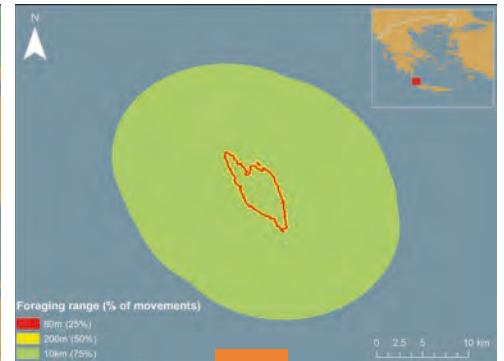
The range of foraging movements of tracked Eleonora's Falcons from the island of Antikythera during the breeding period.



A



B



C

Breeding period

The degree of knowledge regarding the location of the species' breeding colonies is considered very good, while data on its foraging range during the breeding period are accumulating. Breeders may hunt as far as 100km away from their colony over the open sea, but most hunting excursions occur no greater than 10km away. Under unfavourable weather conditions, such as windless days during which the flow of the autumn migratory birds is limited, Eleonora's Falcons may also hunt insects in nearby mainland areas to complement their diet. Rather regularly Eleonora's Falcons may also occur in the interior of the island hosting their breeding colony or of nearby islands in search of ponds or streams, either temporary or permanent, for drinking and bathing and probably thermoregulation.

The anticipated increased drought conditions during the summer period as a result of climate change could limit water availability and thus challenge the physiological tolerance of the species. Considering the high wind potential

in the Aegean Sea, where the majority of the global breeding population of the species is concentrated, future plans for wind energy development, particularly at or in the vicinity of the breeding grounds could constitute a significant threat to Eleonora's Falcon conservation status globally due to direct breeding habitat loss and collision mortality risk.



Eleonora's Falcon feeding on bird.

Wintering period

As the breeding season of Eleonora's Falcon comes to an end, and autumn migration of passerines ceases, the lack of food availability urges Eleonora's Falcons to depart from their breeding colonies and head to their wintering grounds in Southeastern Africa. Madagascar is considered the main wintering area, where Eleonora's Falcons, regardless of their breeding origin, congregate to spend the austral summer. Information on the species' distribution during this time of the year is mostly derived from tracking data. Eleonora's Falcons mainly occur in rainforests in the north and eastern highlands of Madagascar, as well as in cultivated areas and grasslands in the central plateau of the country.

However, pristine areas of rainforests have shrunk by logging and other land-use changes, including intensively managed tree plantations and cultivations. Human disturbance is expected to increase in the future, as according to climate change scenarios, Eleonora's falcons will occur more frequently in the southern part of the country, in areas that are currently heavily exploited by local populations. The future foraging grounds of the species are thus of doubtful quality, mainly as a consequence of the use of pesticides for pest control and the expansion of intensively cultivated areas at the expense of rainforests and other natural habitats, both affecting the food (i.e. insect) abundance and the risk of secondary poisoning.



Migration period

Lastly, the trans-equatorial journey of ca 10,000km between their breeding and wintering grounds undertaken twice each year represents a physiologically demanding endeavor for Eleonora's Falcons. Based on information derived from tracking data, this long trip is typically completed approximately within a month without well-defined stopover periods; instead the falcons rather adopt a fly-and-forage strategy over suitable habitats. During their southbound journey, mostly inexperienced falcons and

occasionally some elder ones may reduce their pace after the crossing of the Sahara Desert and wander in the savannah in central Africa to replenish their fat reserves, taking advantage of the "short rains" period. On the contrary, the timing of their return journey to their breeding grounds coincides with the "long rains" period; given the increased local availability of insects and with no rush to reach their breeding grounds as opposed to other migratory birds, both immature and adult falcons wander for some days in the highlands in the Horn of Africa before resuming their northbound journey. Over the past decades, while the Sahel region seems to recover from the drought conditions in the 1970s and 1980s, East Africa has experienced extreme weather anomalies, including long and intense droughts even during the rainy season, as well as strong floods. Climate change, which puts an additional pressure on the investment in energy resources including wind energy, could prove a significant stressor for Eleonora's falcons occurring in these diffuse staging areas.



Left

Wooded grasslands on Madagascar

Right

Dragonfly on islet

CLIMATE CHANGE, BIODIVERSITY AND THE ELEONORA'S FALCON

EUROPE

Today: According to the latest IPCC report for Europe, an increase in the average temperature is observed, showing regional and seasonal differentiations. Since 1950, the frequency of high-temperature extremes has increased, while annual precipitation has decreased in Southern Europe.

In the future: According to projections, even for the moderate scenarios, the temperature in Europe is expected to increase, mainly during summer in Southern Europe, while further decrease of precipitation is expected. A marked increase in extreme weather phenomena is expected in Europe, in particular in droughts, heat waves and heavy precipitation events.

AFRICA

The existing records for Africa are limited and thus the knowledge about the current situation incomplete.

Today: Africa is, due to high exposure and low adaptive capacity, one of the most vulnerable continents. An increase of 0.5°C or more of the near surface temperature has been observed during the last 50-100 years over most parts of Africa. The equatorial and southern parts of Eastern Africa have experienced a significant increase in temperature since the beginning of the early 1980s, while precipitation has increased in areas of Eastern and Southern Africa. Over Eastern Africa, including Madagascar, extreme precipitation changes have been observed, with droughts and heavy

rainfalls being more frequently experienced during the last 30-60 years.

In the future: According to projections the temperature is expected to rise faster in Africa than the global average increase during the 21st century. By the end of the 21th century Eastern Africa is expected to experience a wetter climate, with more intense wet seasons and less severe droughts during October-December and March-May. Furthermore, increase of heavy rainfalls is expected.

Species response to climate change

Species respond to climate change through genotypic adaptation and phenotypic plasticity. Thus, they move out of unfavourable and into more favourable climates, or get locally or globally extinct.

Today: In Europe climate change has altered to date the breeding periods, timing of spring migration, breeding habitats, latitudinal distribution and migratory behaviour of birds. Thus, spring arrival dates have advanced for many migratory bird species.



© M.Tzoli/NCC

In the future: The Mediterranean ecosystems have been identified as being among the most likely to be impacted by climate change, due to precipitation decrease and increase of temperature, drought and wildfire frequency. Model projections show further species range contractions under all climate change scenarios for the Mediterranean ecosystems, which will lead to biodiversity loss. Specifically for birds, the suitable habitats for Europe's breeding birds are expected to shift nearly 550km northeast by the end of the 21st century.

It should be noted that it is estimated that in the scenario of the highest rates of climate change (RCP8.5) the rates of displacement will be so high that many species will be unable to do so, moderate rates (RCP4.5 & RCP6.0) would allow more species to respond, but will still exceed the capacity of many species, while the lowest rate (RCP2.6) would allow most species to track climate.



Vulnerability of Eleonora's Falcon to climate change and expected impacts

The species vulnerability to climate change is related to three main factors, namely exposure to it, species sensitivity to change and adaptive capacity. According to Sajwaj et al. (2009), the Eleonora's Falcon faces **high vulnerability** for the period 2070-2099 in the case of a moderate climatic scenario comparable to RCP6.0.

Furthermore, the overlap of the observed and simulated breeding range is expected to be 35.8% for a moderate scenario comparable to RCP6.0 and 37.0% for an adverse scenario comparable to RCP8.2, while the range extent is expected to be 474% and 293.8%, respectively. This indicates that the species will lose the greatest part of its current breeding range and theoretically would have to distribute and occupy significantly larger areas northwards, mainly at mainland Europe. As the species is specialized in terms of habitat and diet the displacement is expected to lead to the reduction of its distribution and potential population size, rather than colonization of new areas.

Accordingly, the simulated suitable species' wintering sites at Madagascar are expected to overlap with the observed by just 59.54% and the current distribution is expected to change substantially and shift southwards.



Climate change scenarios:

A Representative Concentration Pathway (RCP) is a greenhouse gas concentration trajectory. Four pathways have been selected and studied by the IPCC, which describe different climate futures, all of which are considered possible. The pathways are labeled after a possible range of radiative forcing values in the year 2100 compared to those of the pre-industrial level (+2.6, +4.5, +6.0, +8.5 W/m²)

The parameters that affect its ability to adapt to climate change are various and include the following.

- Its breeding sites are expected to experience increase of temperature, as well as frequency and intensity of extreme events, such as droughts and heat waves. As a result (a) the vegetation on the islets, which provides protection from weather conditions, may also be affected and reduced, leading to further degradation of abiotic conditions for eggs and chicks and (b) the fresh water sources the species uses for drinking, bathing and hunting of large insects may be impacted and reduced or extinct, affecting the birds' fitness and vulnerability to parasites and diseases.

- Climate change is also expected to shift the migration period of passerines, on which the species directly depends. Although no shift of the autumn migration has been yet observed, this possibility may lead to loss of the synchronization between the egg hatching and the migratory flow and subsequently to reduction of the breeding success. The same applies in the case the flow of migrating

passerines is reduced, either due to reduction of passerine population or due to more birds wintering in Europe.

- In case Eleonora's Falcons are forced to abandon breeding sites on islets, they will also lose the benefits they provide, including (a) shelter from predation, with the species being ground-breeder and lacking terrestrial predation-defense mechanisms, (b) increased availability of prey and especially migratory birds, as the islets act as stopover sites for passerines that migrate otherwise in a wide-front, thus providing increased food availability compared to the mainland.

- At the wintering sites the distribution shift is expected to be into cultivated areas in the central part of Madagascar, leading to increased exposure to anthropogenic habitats and to biocides used in agriculture, leading to reduction of prey availability and increase of secondary poisoning risk.

- Its pre-breeding sites are expected to experience increased desertification and incidence of forest fires.

- It should also be noted that as a long-distance migrant with a distance between breeding and non-breeding ranges being over 7,000km, it is expected to have difficulty in adjusting to phenological changes and it will be less flexible than species that do not migrate or are short-distance migrants. Furthermore, a barrier for adaptation is the fact that the species has high site fidelity and individuals remain faithful to their breeding locations and return every year, frequently to the same territory.



MANAGEMENT

"The optimal management of protected areas is likely to assist those species declining in a region because of climate change by delaying their disappearance and thus providing a continuing source of propagules/offspring for dispersal to areas with more favourable climate."
Huntley et al., 2008

"The protection of the Natura 2000 sites that currently provide suitable habitat for such species [species of Community interest, that are habitat specialists and are already contained by habitat availability and/or condition], should be a priority. However, [...] it will be equally important to improve the resilience of existing populations by improved management of habitats, and where necessary expansion and reconnection of habitats to create a functionally coherent network." Sajwaj et al., 2009

4.1 Adaptive management

Management for the protection of the Eleonora's Falcon against climate change requires being adaptive, in order to allow monitoring of the species response to conservation measures, as well as the adaptation of the management according to the modifications due to climate change.

Adaptive management is a structured, iterative process of optimal management decision-making in the face of uncertainty,

based on system monitoring (EU, 2013). Through management implementation the lessons learned are utilized through continuous adapting of approaches, actions and measures in order to improve management outcomes. Finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge constitutes its main challenge.

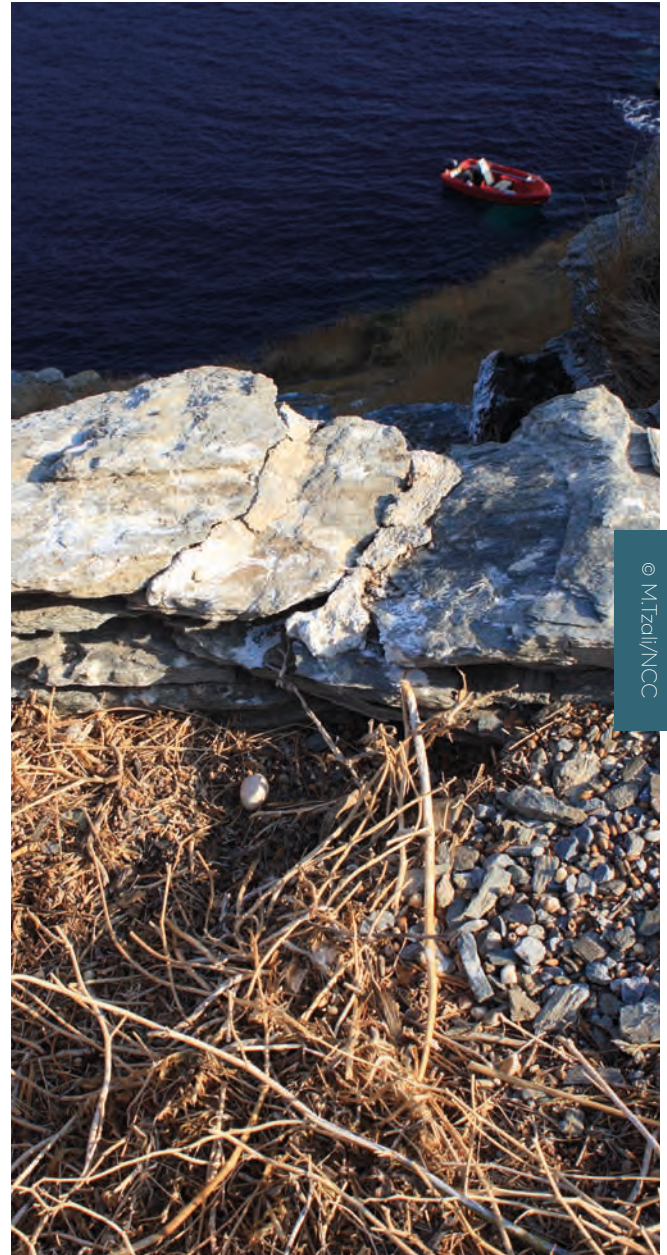
Its main steps include:

- Determination of conservation objectives and assessment of existing problems
- Designing of solutions
- Implementation of measures
- Monitoring
- Evaluation of measures effectiveness
- Adaptation of solutions and measures

The main measures that have been identified that may be applied for the adaptation of species and habitats in Natura 2000 sites to climate change concern the mitigation of the impacts caused by the changes due to climate change and the increase of the ecosystem and species adaptation capacity to climate change.

The main categories include:

- Reduction of existing pressures
- Ensuring ecosystem heterogeneity
- Connectivity increase
- Ensuring abiotic conditions
- Management of impacts due to extreme events
- Other measures





4.2 Proposed management measures

The proposed management measures focus on the measures applied in the LIFE ElClimA project, in order to transfer know-how and experience gained through their implementation.

The management measures involve the reduction of existing pressures for the species breeding colonies, through rat eradication, improvement of abiotic conditions for nesting

birds, through provision of artificial nests, as well as the increase of prey availability, through the creation of refueling oases for passerines. Furthermore, measures concerning the improvement of knowledge of feeding grounds and their use by the species, as well as the threats it faces due to human activities through sensitivity mapping and estimation of contamination load due to chemical substances.



4.2.1 Breeding colonies

4.2.1.1 Rat eradication

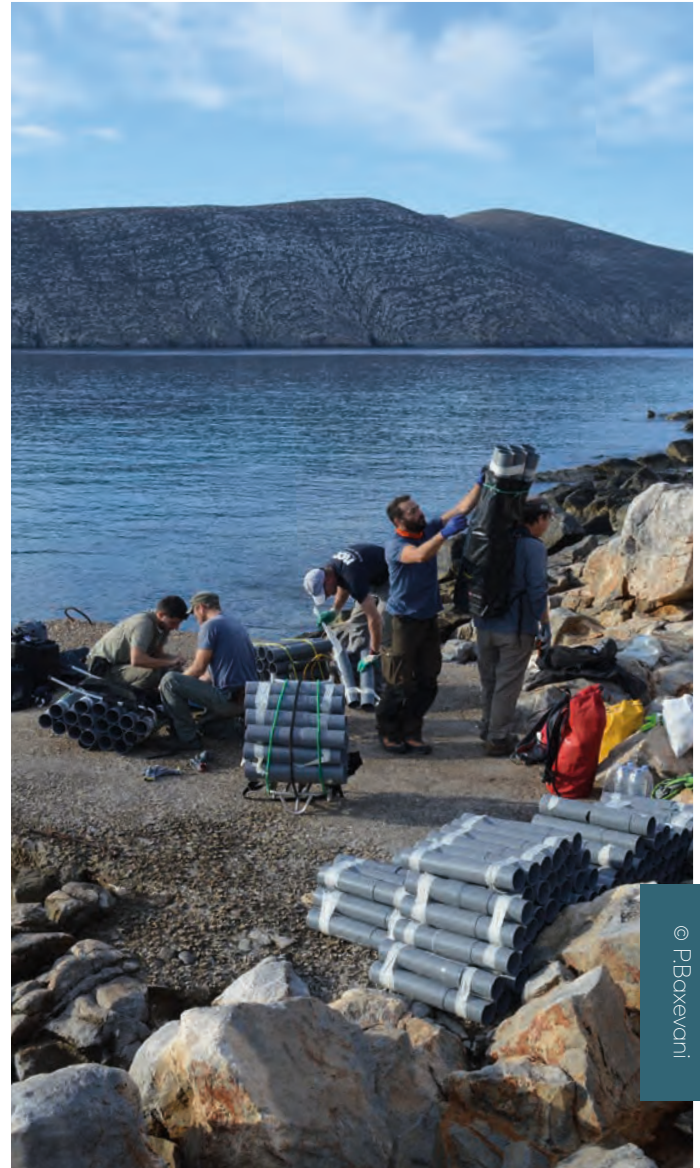
Mediterranean islands are unique ecosystems hosting numerous endemic, rare and threatened flora and fauna species. These ecosystems are particularly vulnerable to anthropogenic stresses, including the introduction of alien invasive species which disturb the original ecological equilibrium by additional competition for food and habitat, as well as predation of introduced species on native fauna and flora. Among all alien invasive species of plants and animals, mammalian alien species are responsible for the greatest impact on the biodiversity.

Among mammalian alien species introduced to the Mediterranean islands, the black or ship rat (*Rattus rattus*) is one of the most damaging and has been recognized as one of the 100 worst invasive species globally. Rats are omnivores and in their search for food they compete, suppress and control numerous populations of bird, animal and plant species. Globally and particularly on

islands, this species has caused or contributed to extinctions of numerous species of birds, small mammals, reptiles, invertebrates and plants. It has been introduced unintentionally to the Mediterranean along human trade and traveling routes more than 2,000 years ago and is currently present on the majority of the Mediterranean islands, including uninhabited ones. On the Mediterranean islands the black rats are known to prey on the terrestrial birds and seabirds, reptiles, invertebrates, plants and their seeds. Although the vast majority of rat diet on uninhabited islands consists of plants, their seeds and fruits, their impact on nesting birds by preying on eggs, chick or even adult individuals is particularly significant, especially for those species which have evolved to breed on islands where terrestrial predators do not exist, including the Eleonora's Falcon. Eleonora's Falcons do not prey on ground animals therefore their unattended eggs and chicks are exposed to rat predation which can destroy up to 20-29% of falcons'

eggs. Apart from the direct predation there is also evidence that when rats invade an island the number of active falcon nests is reduced, thereby additionally reducing the productivity of the falcons' colonies.

Tackling with invasive alien species such as rats is a complex task, because it includes scientific, technical and socio-economic aspects which require a hierarchical approach that has been agreed internationally: (a) *Prevention of introduction*, (b) *Early detection of the presence of alien invasive species and rapid eradication* to prevent their establishment, (c) *Management of already established alien invasive species* to prevent them from spreading and to minimize their impacts and (d) *Restoration of the native biodiversity*. This approach has been successfully applied in hundreds of cases worldwide for the prevention of rat introduction or reintroduction to islands as well as to manage the established rat populations which are causing harm to biodiversity.



Prevention

Like dealing with any problem, prevention of its occurrence is more environmentally desirable and cost-effective than dealing with the invasive alien species once it has been introduced and established. In the case of rats, measures must be taken to prevent spontaneous or accidental introductions of rats to islands without rats or islands that have been cleared of rats. For this purpose, the major potential invasion routes need to be identified, which usually include boats transporting people, animals or materials to islands. Whether invasion of rats is due to natural expansion or due to anthropogenic

factors, the prevention measures must include informing and educating the public, as well as taking active measures of containment and prevention of spreading of rats, such as preventing rats from entering the boats at ports and keeping boats clear of rats. Public may play a major role in the prevention campaign. In considering prevention actions, the risk of a possible rat invasion and its consequences should be considered. The effort of prevention of invasions in certain areas might not be viable due to low ecological benefits or high costs.

Early detection and rapid eradication

The counterpart to prevention at source is prompt detection and intervention on invaded uninhabited islands. Early detection is essential for taking rapid eradication actions to prevent establishment of significant rat populations. The early detection is based on the surveillance, which identifies the presence of rats and may include monitoring of rat presence signs, such as rat droppings, signs of

rat predation on invertebrates, birds and their eggs or plants and their fruits or seeds, signs of rat runways, burrows or footprints. It may also involve the use of rat traps, trail cameras, gnawing material or tracking tunnels to directly record the presence of rats or their gnawing or footprint signs. Following the early detection of invading rats, a rapid rat eradication should be carried out.

Management

On the majority of Mediterranean islands rats have been established in the past therefore management of their populations may be the only option. Management may include the following actions:

1. *Rat eradication*: a complete and permanent removal of all invading individuals using optimal lethal or non-lethal means.
2. *Control measures*:
 - a. *Containment of rats*: restriction of rats to limited geographical area.
 - b. *Population control*: reduction of the density and abundance of rats below an agreed threshold to lower their impacts to an acceptable extent.
 - c. *Mitigation of rat impacts*: reducing and maintaining rat impacts at a tolerable level.
3. *No action*



The decision on the appropriate management action should be based on the feasibility and usefulness of the method. However, in general, from the conservation of biodiversity point of view, eradication is the first to be considered. Eradication is considered the most effective action, because it allows a complete recovery of the ecosystem. However, rat eradications are usually very costly and need full commitment until completion; therefore the feasibility of eradication has to be carefully and realistically assessed. If a scientifically-based assessment shows that eradication, containment, control or mitigation are not feasible or resources are not available they should not be implemented. Studies of the success of eradication operations suggest that they are more effective, cheaper and more ethical than other methods of control or containment. The results have also shown that rat eradication is much more beneficial to the ecology of an island than rat control operations. In the long term, control operations are much more expensive and cause more disturbance to the environment than eradication operations, because the islands are repeatedly disturbed.



However, there are several issues which need to be considered for a successful design of rat eradication:

- A scientifically based research should be used to determine the ecological, economical and social feasibility of an eradication operation. The research includes monitoring of the known populations and their effects on the ecosystem, feasibility of prevention further invasions, research of the impact of eradication on the target and non-target species and



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the assessment of efforts required to achieve desired benefits (cost-benefit analysis). Political, social, physical, technical and biological constraints must be considered in planning eradication. Used techniques must be target-species-selective and environmentally, socially and ethically acceptable.

- A method of eradication must be selected to ensure that all individuals of the target population are susceptible to the eradication technique being used to ensure that the entire

target rat population is eradicated and that the possibility of rat reinvasion is minimal. The main purpose of rat eradication is not to just remove rats, but creating long-term ecological benefits for the entire island. Different methods may be used to ensure that entire target population is eradicated.

- Eradication projects must have sufficient economic resources to be completed. In case all rats are not eradicated, the removal of the last remaining individuals may unpredictably increase required time, effort and cost or may lead to the reestablishment of rat populations. Insufficient resources for completing rat eradication particularly with lethal means may have adverse impacts on the entire ecosystem.

- Only well-tested eradication methods applied by well-trained and experienced teams can be applied to reduce the risk of failure.

- Careful planning and preparations demand most of the time and effort of an eradication operation, but the benefits of thorough and robust planning can be truly appreciated only when confronted with obstacles. It should be always assumed that if something can go wrong

it will. If an operation is planned correctly, even unexpected changes and challenges can be avoided or compensated and will not obstruct the eradication implementation.

- A clear chain of authority and absolute commitment of all personnel to the project is vital for achieving eradication success. The eradication team must be well equipped and looked after.

- Success or failure of an eradication operation must be evaluated by monitoring any changes or effects of an eradication attempt on the entire ecosystem during and after the eradication. Simultaneous monitoring of the impact of an eradication operation allows constant overview of its progress and will identify its negative unexpected results, allowing the operation to adapt and to change according to new perceptions and situations. Eradication should be immediately stopped if the risks to non-target species are high.

Rat eradication or control methods may induce pain, distress, fear or other forms of suffering to the animals, even when using the best available technical means. Therefore necessary

measures should be taken to spare avoidable pain, distress and suffering of animals during eradication, control or containment. Non-lethal methods should be considered and any action taken should minimise the impact on non-targeted species.



Case study: Rat eradications in Greece

Rat eradications on uninhabited islands and islets in the Aegean Sea have been implemented since 2005 with rats being removed from 42 islands and islets until the end of 2018 for the improvement of the breeding performance of Eleonora's Falcon and seabirds. These islets, with the total surface area of 1,075ha, are located in 16 islet groups throughout Aegean Sea and range in size between 0.1ha and 298ha. In all cases rat eradications were carried out using Brodifacoum-based baits in bait stations covering the entire surface area of the target islets, which provided optimal control of the eradication process, minimal bait exposure to the non-target species and minimal bait release into the natural environment. The above rat eradication operations have been carried out at colonies hosting 10% of the national population of Eleonora's Falcon.

Despite increased effort required for the operation of bait stations compared to other rat eradication methods, this method is considered to be the safest for the environment and non-target species.



4.2.1.2 Construction of artificial nests

The Eleonora's Falcons do not build nests but instead find a suitable site on the ground to which they may make minor improvements. In general nests are located under bushes or boulders, on ground without overhead cover, in caves, rock crevices or potholes, as well as on ledges and in small caves of high cliffs and on cliff tops. The nests aim to provide shelter from the weather elements, such as wind and sun exposure during the day, as well as protection against predators or competitors (i.e. other falcons). The ground temperature during egg incubation period can reach up to 55°C, therefore the incubating female is cooling down eggs by its body temperature during the hottest time of the day. In case female is forced to leave the nest, the excessive heat to which egg embryos may be exposed can be fatal. It was observed that well-sheltered nests, e.g. under boulders or in rock crevices, have higher breeding success than those under bushes.

The availability of suitable nesting sites may be limited particularly in cases of small uninhabited islets with high density of falcon nests. The

availability of protected nesting sites may be further reduced during periods of heat waves, which reduce vegetation cover of plants under which falcons nest, e.g. capers. In these cases some pairs are forced to nest in more exposed and less suitable sites, which may lead to lower breeding success. Therefore the construction of artificial nests can be an effective means to increase the availability of suitable and well-protected nesting sites, as well as to reduce the potential degradation of the nest quality due to heat waves or higher summer temperatures.



The construction of artificial nests for the Eleonora's falcon aims at (a) provision of shade during the hottest parts of the day to protect the nest from excessive heat, while at the same time provide sun exposure during early morning hours to reduce humidity in the nest, and (b) protection against prevailing summer, mainly northern, winds. Listed below are suggested artificial nest characteristics:

- Which colonies: Colony sites with reduced breeding success due to limited available

nesting sites or with significant proportion of nests being under vegetation.

- Where in the colony: With the aim of improving existing breeding nesting areas the artificial nests are suggested to be constructed within existing nesting territories. Cliffs or steep slopes should be avoided for the safety of field workers.

- When: From late autumn to early spring to avoid disturbing breeding birds.

Left

*Installation of
wooden artificial
nests*

Right

*Nestlings in
artificial nest*



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- How many: Depending on the availability of nesting sites and nest densities, the distance between nesting territories should be between few meters up to 30-50m. Within each territory there are several optional nesting sites among which the falcons every year choose where to breed. Three alternative natural or artificial nesting sites are sufficient for each territory.

- Nest material: It is suggested that artificial nests are constructed from stone material available at the colony to reduce introduction of foreign materials and to reduce costs and effort. Optionally laminated wood can be used when natural materials are insufficient.

- Nest characteristics: The entrance of the artificial nests is suggested to face southeast. The nest diameter should be 40-50cm and its height 35cm. Any loose or sharp stones should be removed or trimmed. About 10 small up to 9mm stones may be left in the nest for digestion. A flat, palm-sized stone at the edge of the nest will assist female in plucking prey and feeding the chicks.

- Maintenance: Due to weathering artificial nest need to be annually checked and maintained, if necessary.



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Left

*Artificial stone
nest monitoring*

Right

*Stone artificial
nest*

Case study: Artificial nests in Greece

During the last decade more than 1,300 stone and wooden artificial nests have been constructed in Eleonora's Falcon colonies in the Central and Southern Aegean Sea. Their occupancy was particularly high on small uninhabited islets with high nest densities, where more than 25% of all active nests were artificial, usually from the first or second year of their construction. The breeding success in the artificial nests was similar or higher in comparison with the natural nests.



4.2.2 Foraging grounds

4.2.2.1 Creation of refueling oases

Passerines stop to rest and refuel during their migration trip in order to carry on and reach their final destination either in their wintering or their breeding grounds. The existence of suitable sites to rest and refuel will have a positive effect on the abundance of passerines on the island, resulting in an increase in the availability of prey for breeding Eleonora's Falcons. In addition, suitable and rich refueling sites also means heavier and fatter passerines, meaning better food quality for adult Eleonora's Falcons and their chicks. These two factors are expected to have a positive effect on the population's breeding success counteracting the negative effect of harsher weather conditions caused by climate change.

The following proposals aim to assist in the design, creation and maintenance of refueling oases for migratory passerines on islands and coastal areas where the climate is characterized by low precipitation, high

temperatures and strong winds. The main goals that should be achieved when creating a refueling oasis are:

1. *Habitat improvement* (enhancement of environmental quality for the birds)
2. *Efficient use of natural resources* (minimize agricultural inputs and employ natural methods of agricultural practice)
3. *Resilience and Viability* (ensure high tolerance to adverse climatic conditions, natural enemies and lack of resources)

Presented below are some basic guidelines for the achievement of the aforementioned goals.

Habitat improvement

- Food availability

Foraging opportunities for migrating passerines are crucial during stopover. High quality and quantity of food has a direct effect on both stopover time and survivorship of the

individuals. In order to create optimal foraging opportunities, an oasis should be designed to provide spatial and seasonal variation of food resources such as seeds, grasses, insects and other invertebrates, reptiles and mammals.

In plantations, plants native of the region and tolerant to the climatic conditions should be preferred. A variety of trees and bushes should be incorporated in the planting design of the oasis. Variety of plant species aims at enhancing biodiversity and extending the fruit and nut bearing and flowering periods at the widest seasonal range possible. Planting design must also take into consideration (a) the preferred density of the trees and bushes, (b) favor the creation of a patchy habitat, interspersed with crops, wild grass and biodiversity enhancement features and (c) ensure facilitation of agricultural practices and maintenance works.

Crops should include cereals, legumes and oil seeds, cultivated in combination crops or separately. In order to increase the abundance of insects and especially bees, it is suggested that flowering perennials, herbs

and shrubs are planted in various sites of the oasis. Lastly, it is advisable that plants which are not considered beneficial for the purposes of the oasis and may cover greater areas than required or are alien and/or intrusive, should be permanently removed from the oasis by mechanical (non-chemical) means.

Apart from the vegetated areas, the design should also incorporate biodiversity enhancing features such as hedgerows, water bodies, stonewalls, invertebrate habitats (beetle banks, insect boxes, habitat walls), rock and/or log piles for reptile hibernacula and bat boxes.

- Water provision

Water provision has been proven to be of high importance for both migrating passerines and the Eleonora's Falcons for drinking and bathing. Ponds with fresh water or tank-supplied watering sites should be available within the oasis. Furthermore, certain prey items such as mammals and invertebrates are expected to benefit from the presence of water as well, thus enhancing biodiversity in the oasis and increasing food availability for birds. Special attention must be paid to ensure

water safety and quality, in order to avoid eutrophication and mortality by bacterial pathogens, especially during the warmest months of the year. Lastly, pools and watering sites should be properly constructed and equipped, as to prevent drowning incidents of animals or birds and accumulation of waste.

- Sites to roost and cover

During stopover, migrating passerines that are replenishing fat stores and/or waiting for

favourable weather conditions are in need of rest and cover. Therefore, providing safe sites is crucial for their survival. Cover/roost site type preferences depend on the species concerned, so designers must try to provide adequate coverage for the majority of them. Roosting sites in an oasis could include (a) stands of high trees with continuous, dense canopy and absence of disturbance, (b) patches of thick vegetation, unreachable to ground predators such as thick bushes covered with climbing plants, and (c) reeds.



© P.Petrou

Left

*Bathing Eleonora's Falcons
on Antikythera*

Right

*Newly planted and existing
trees, on terraced land,
alongside cereal crops
and local flora*

Efficient use of natural resources

- Soil

Soil is the foundation of agriculture and the basic element where many biological processes take place. As a result, soil quality affects directly the surrounding ecosystem in terms of plant growth and biodiversity enhancement. Soil conservation should aim at preventing soil loss by erosion and reduced fertility caused by excessive usage, acidification, salinization or other types of chemical soil contamination.

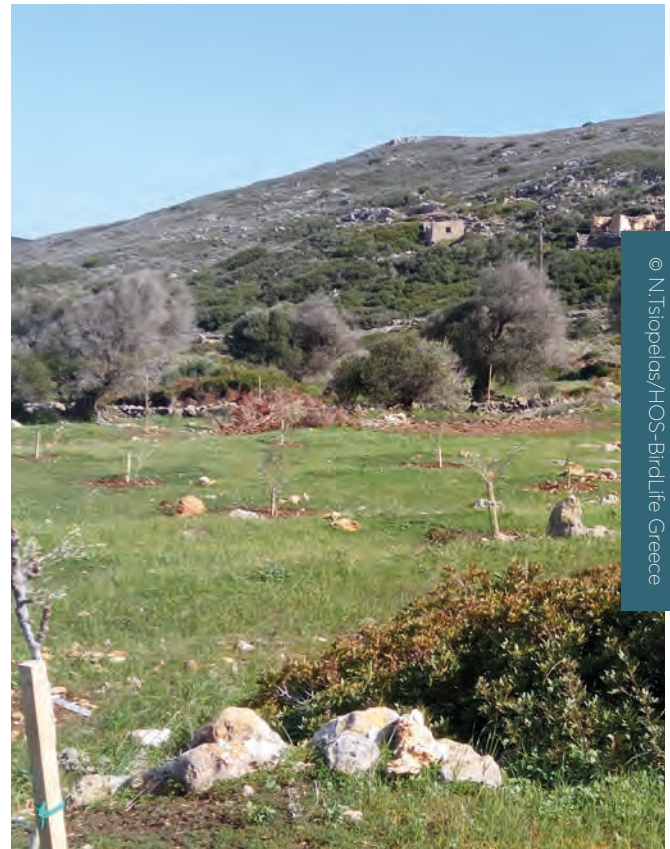
Erosion control measures aim at reducing removal of the topsoil layer, which is usually caused by wind, precipitation and tillage. Methods for achieving these include contour farming and terracing, cover crops, matting and conservation tillage.

Improvement of soil fertility is achieved by combining inputs of organic matter and soil elements (in the form of manure, compost and organic fertilizers), mulching, and good agricultural practice such as crop rotation and cultivation of legumes. In any case soil analyses should be conducted regularly in

order to monitor the characteristics of the oasis' soil.

- Water

Water in arid areas is probably the most restricting factor related to agriculture. When creating an oasis, the designers must provide solutions for efficient water storage and water use.



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Efficient water storage starts from the soil. Plant Available Water Capacity is the amount of water stored in the soil that can be used by the plants. It can be improved by increasing soil organic matter levels, avoiding soil compaction, providing surface cover, creating raised beds and gullies, increasing rooting

depth of the plants and by planting species low water requirements. In addition, excess water from precipitation or other sources should be stored for the dry season. For this reason construction of wells, cisterns, ponds, tanks and other water harvesting facilities is highly recommended.



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byneck

Water use should be carefully planned, avoiding any losses. Best water-use practices include drop irrigation systems and underground irrigation. Finally, recycling water from domestic use can provide an extra resource for an oasis.

Resilience and Viability

When designing a refueling oasis, the long-term viability of the project with the minimum assistance possible should be considered. This means that the oasis is expected to withstand harsh climatic conditions or minimal maintenance for a significant amount of time. Therefore, the following guidelines should be taken into consideration.

- Choose the proper types of plants and crops.

Drought tolerant trees, legumes and cereals should be planted. Best solutions are varieties native to the insular areas, thus tolerant to heat/drought stress and strong winds.

- Ensure sustainability.

All practices in the oasis should follow sustainable agricultural practices. Crop

rotation, plant diversity, integrated pest-management, sustainable management of resources and exclusion of non-native species, are some of the main practices.

- Protect the oasis from domestic animals and other potential threats.

Oasis design should incorporate structure that aim in avoiding the infliction of damage by domestic animals (grazing, soil compaction, pollution by animal waste, wildlife predation), human visitors or natural elements.

Fencing is required in most of the areas, where unattended domestic animals occur. In some regions, protection measures against natural disasters, such as floods and wildfires may be needed as well. Finally, regulation of human activities is suggested to take place in order to avoid both damage to the oasis and disturbance to the wildlife. This can be achieved by creating paths for visitors, establishing no-go zones and scheduling maintenance activities accordingly.



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*Olive tree
plantation in the
refueling oasis on
Antikythera*

Case study: Refueling oasis on Antikythera

Antikythera hosts one of the most important colonies of Eleonora's Falcon in Greece and is also an important stopover site for migrating passerines. Through the LIFE EIClimA project 1.13ha land plot was purchased, being the second purchase of land for nature conservation through the LIFE Financing Instrument in the country.

The area was fenced with electrical wire while its drystones, traditional path and cistern were restored. A total of 105 fruit bearing trees and shrubs were planted, namely olives, carobs, figs, almond trees, pomegranates and mulberries, while cereals and legumes were cultivated including barley, split peas and broad beans.

4.2.2.2 Identification of feeding grounds and sensitivity mapping

In recent years, telemetry studies have shed more light into the foraging ecology of Eleonora's Falcon year round. Tracking data of high spatiotemporal resolution have allowed the identification of foraging areas and the investigation of the daily activity pattern during the pre-breeding, breeding and wintering period. Even though these data pertain to just a few falcons, they have provided a substantial amount of information regarding unknown aspects of Eleonora's Falcon ecology, which showcased the potential of telemetry in bird conservation, pinpointed gaps of knowledge where further research is required in order to gain more insight into the stressors affecting Eleonora's Falcon year round and highlighted eminent threats.

Regarding the pre-breeding period additional detailed distribution data are still required to identify critical habitats for the species, which, with the use of freely available remotely sensed data, will enable the production of a species distribution map during this period of the year.

Considering the species' extended distribution pattern during the pre-breeding period, tracking data and distribution maps can guide targeted field surveys, providing detailed information on the location of areas used intensively by falcons either for foraging or roosting.

In the framework of the LIFE EIClimA project such tracking data have revealed habitat preferences patterns of a handful of falcons and have also highlighted the need for cross-country cooperation regarding the species' conservation at its breeding grounds. At a larger scale this methodology has been already applied successfully at the Eleonora's Falcon's main wintering grounds, where fine-scale tracking data and field surveys have contributed to the exploration of the species' ecological requirements and the identification and assessment of the pressures and threats it faces there. Additional tracking data pertaining to a larger sample of falcons could provide vital information for the compilation of sensitivity maps of critical areas used by Eleonora's Falcon

during pre-breeding and breeding period, which in time could be used for development spatial planning, e.g. for wind energy developments in order to minimize impacts in the species' critical habitats.

A variety of tracking devices are currently available, differing in their technical specifications, such as dimensions, spatial accuracy and temporal resolution of retrieved data, method of data retrieval, energy requirements and so on. The choice of the tracking device should suit the needs of the research design and the study organism. To gain further insight into Eleonora's Falcons' foraging grounds, habitat requirements and threats, currently available GPS, solar-powered devices offer to date the best solution, providing frequently retrieved locations of high spatial accuracy.

Prior to the onset of the field surveys all necessary, legal documents, i.e. fieldwork permits, should be issued by the competent authority. Trapping surveys should be carried out by experienced field researchers to ensure minimal disturbance to the birds, especially if they are carried out

during the breeding season. A team of 2-3 people is required for the trapping and handling of the birds. Conventional trapping methods, such as mist nets, can be applied but need to be customized depending on the behaviour of the birds and the geomorphology of the study area. The attachment of the tracking devices must only be performed by an experienced, licensed ringer. A hood should be placed on the birds' head in order to remain calm during handling. Prior to the attachment of the device, the trapped falcons should be first examined to ensure that they do not show any signs of injury or weakness. Following standard international protocols for bird surveys, biometric measurements, such as weight and wing chord length, as well as the traits of the birds, such as sex, age and morph, should be taken and noted down in field protocols. A metal ring should be also placed in the birds' tarsus to allow future identification in the field. As a rule of thumb the total mass of the device and attachment system must not exceed 3-5% of the bird's body mass, particularly if the device remains attached for longer period of time. Tracking devices are typically affixed on the birds' back

with Teflon tape. The attachment procedure must last the minimum time possible with the birds remaining in a shaded place during the entire process to avoid heat stress.

The retrieval of the collected locations is most frequently performed remotely, i.e. via a user friendly, web-based platform or via sms/email; either service is provided by the device manufacturer. Data filtering may be required to identify and remove duplicate records and then geospatial analyses are commonly

applied to estimate path metrics (i.e. distance travelled, travel speed), home range, as well as to associate the birds' location to habitat characteristics in order to explore their habitat requirements. Currently, the free, online database of animal tracking data hosted by the Max Planck Institute for Ornithology, Movebank, offers an automatic method for management, archiving and analysis of animal tracking data, thus alleviating the need for very technical expertise on data management and geospatial analyses.



© C.Kassara /UoP

*Tagged
Eleonora's Falcon*

4.2.2.3 Sampling for toxicological analysis

So far, injured, sick or dead Eleonora's Falcons admitted in wildlife hospital and rescue centers or pertaining to museum collections have been used for assessing their cause of death or sickness, providing information on the contaminant load. However, the use of stress indices or biomarkers in tissues of apparently healthy falcons can serve as an early-warning tool for assessing the quality of their habitat,

as well as their effect on the falcons' health, thus providing baseline reference values for future studies. Furthermore, due to its wide distribution and its dependency on two food sources, i.e. insects and migratory birds, biomonitoring studies on Eleonora's Falcon may serve as an umbrella for the conservation of a variety of habitats and species.



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The feasibility of biomarkers on healthy falcons was tested in the framework of the LIFE EIClimA project and stemmed with great success. Measurement of enzyme activity (i.e. AChE, BChE) and cellular abnormalities in erythrocytes of falcons constitute reliable and cost-effective tools for determining the exposure of birds to chemical substances (i.e., heavy metals, pesticides, etc.). Although the obtained results imply low exposure of sampled Eleonora's Falcons to genotoxic factors, further monitoring studies are highly recommended for the identification of critical contamination levels over time. More samples pertaining to falcons of different breeding origin, age, sex and morph, as well as to falcons sampled during different periods of the year, will also allow the exploration of any trait-related or seasonal patterns in the birds' exposure to chemical substances. Furthermore,

Left

Blood sampling

depending on the availability of expert personnel and resources, the aforementioned biomarkers could be cross-referenced to direct measurements of pesticide residues and heavy metal concentrations to assess the genotoxic potential of specific contaminants. They could also be examined in combination with other indices assessing the birds' body condition, such as immuno-competence indices, to gain a deeper insight into the impact of chemical substances to the birds' health status.

The experimental procedure and analysis of biomarkers is based on laboratory assays performed by expert personnel using a small amount of blood. Following the capture of a falcon in the field, blood samples can be retrieved by experienced ornithologists and veterinaries. Specialized equipment may be required if the samples are not to be transferred immediately to the laboratory for subsequent analyses; in this case the appropriate storage conditions must be ensured to preserve the blood samples. All field surveys and laboratory analyses must be approved by the competent authority.

CONCLUSIONS

The Eleonora's Falcon is one of the most magnificent birds of the Western Palearctic, with a unique life history and traits that still remain to be uncovered.

It is an emblematic species for Greece and the Mediterranean Sea and for the past 50 years has become one of the best studied birds in the region, with systematic research that started from Dr. Dietrich Ristow at the colony on Dionysades islets in the mid 1960s.

The implementation of two LIFE projects in Greece, devoted to the species conservation, based on the work of many researches, conservationists and trained volunteers, has resulted in considerable experience and know how related to the species conservation at the Aegean colonies.

The first project ("Conservation Measures of the *Falco eleonora* in Greece", LIFE03 NAT/GR/000091), had the active support of Leventis Foundation and the participation of the RSPB, resulting in a significant accumulation of ecological and conservation

knowledge for the species, across its breeding range.

The present project (LIFE EIClimA), focused mainly in the species conservation in relation to the implications of climate change on the species breeding and wintering grounds. It has been a practical conservation project with significant conservation achievements.

Through research and conservation actions these two projects have provided a concrete basis for understanding the species life history, ecological requirements and conservation implications, in relation to current pressures and future threats, such as climate change.

Simple but effective conservation measures, such as the creation of artificial nests using local materials to provide shadow and shelter from extreme heat waves and sun radiation, or re-establishment of abandoned terrace cultivations on Aegean islands, to revitalize the island landscape and provide critical food resources for migratory passerines over the Aegean Sea, aim to alleviate the impacts

of climate change and other human induced pressures to the island ecosystems of the species breeding range.

More demanding management measures, such as eradication of invasive rats from important species colonies, have been successfully implemented in the past 15 years, at a scale that was beyond any imagination in 2003, when relevant planning started by the Hellenic Ornithological Society with the valuable assistance of world - known RSPB experts. Selective eradication methods have been applied in over 40 islands with excellent results so far.

The technological advances over the past decades have enabled the species satellite tracking, providing valuable information for the habitat and spatial use throughout the year, raising conservation issues on a much wider spatial scale than the Aegean Sea.

Meanwhile, new technologies for tracking insect migration over the last 15 years, provide the basis for exciting theories related to

insect migration flows over the Mediterranean Sea, that may coincide with bird migration corridors and the Eleonora's Falcon colonies, supporting thus a more comprehensive explanation related to the species distribution, similar to the one of the Amur Falcon, which migrates from Asia to east Africa following the migrating swarms of dragonflies.

Fascinating challenges for scientists and conservation experts of the region that need to assess and deal with the impacts of climate change on the species prey (migratory birds and insects), all over its distribution range, arise.

Let's hope that the conservation adventure of the Eleonora's Falcon will continue for the following years, uncovering all these new aspects of the ecology of this unique species. We hope that until then, this Good Practice Guide will become a useful starting point for spreading knowledge and experience gained during the project, to the site managers throughout the species breeding range.

THE LIFE ELCLIMA PROJECT

The LIFE project "Conservation measures to assist the adaptation of *Falco eleonorae* to climate change" (LIFE EIClimA, LIFE13 NAT/GR/000909) aimed to facilitate the species' adaptation to the ongoing and future climate change by the implementation of a series of conservation actions.

Specifically, the objectives of the program were related to:

- the improvement of breeding performance of the species, by (a) reducing egg losses and mortality rates of nestlings, (b) improving the quality and increasing the availability of nesting sites and (c) improving prey availability and quality.
- the improvement of the species' conservation status at its foraging areas both within its breeding and wintering range by (a) identifying foraging areas utilized by the species, (b) assessing the quality and impact of land use in these areas, (c) networking among experts and (d) organizing workshops to help design and promote efficient mitigation measures.

The project was implemented by the University of Patras, in collaboration with the Hellenic Ornithological Society and the Nature Conservation Consultants (NCC), on 7 insular sites of the Aegean Sea, with the financial support of the European Union LIFE Instrument and the Green Fund.

www.lifefalcoeleonorae.gr

LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.



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