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MANAGEMENT of Natura 2000 habitats
Arborescent matorral with *Juniperus* spp.
5210

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The European Commission (DG ENV B2) commissioned the Management of Natura 2000 habitats. 5210 Arborescent matorral with *Juniperus* spp.

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Juniper matorral in Central Italy. Photo: courtesy Foreste Casentinesi National Park

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EUNIS Classification:

F5.13 Juniper matorral

Summary

The arborescent matorral with *Juniperus* spp. habitat is a scrub vegetation that is found in the countries bordering the Mediterranean Sea. *Juniperus* spp. are evergreen shrubs or small trees with few vital needs that, thanks to their morpho-physiological characteristics, colonise harsh environments such as rocky coasts and dry, incoherent soils. Juniper, with its deep and well-developed root system, is therefore an important species for soil retention and consolidation, preventing soil erosion caused by rain and wind.

It is important as an ecotone, since it is often a transition area between ecosystems. In winter the habitat is a refuge for several mammals and wintering birds due to the protection from predators and warm sheltered conditions offered by the evergreen vegetation, and the presence of insects and of autumn-flowering and fruiting plants, such as *Arbutus unedo* (strawberry tree), *Phyllirea angustifolia* (mock privet) and the juniper itself. Old junipers often are "living monuments" due to their age and tortuous trunks. In France some specimens of juniper despite their small size (1.5 m high, trunk of 8 cm diameter) are 1150 years old. There is a specimen of common juniper aged 2000 years with a trunk of 2.75 m in circumference.

This habitat type can be both an arborescent pre-forestal stage (secondary matorral), or a "permanent plant community' when environmental conditions (aridity, rocky soils, etc.) do not allow the evolution to forest (primary matorral).

Fires, overgrazing, urbanisation and tourist pressure present the main threats to the habitat. Habitat loss is also frequently due to the clearing of areas for stock raising or agriculture. Another threat is linked to transition of the secondary matorrals to forests. This process is frequent in Portugal, France and Italy.

Management activities of matorrals vary, depending on their nature and location. In general we can distinguish two management models, primary matorrals needing natural evolution and secondary matorrals requiring active management. The first model is suitable for matorrals of projecting ledges, cornices or rocky slopes, almost inaccessible and not threatened by human activities, and coastal matorrals, where the main threat is linked to tourism. Here it is necessary to avoid actions that can trigger erosion such as construction of new roads or tracks, overgrazing and climbing.

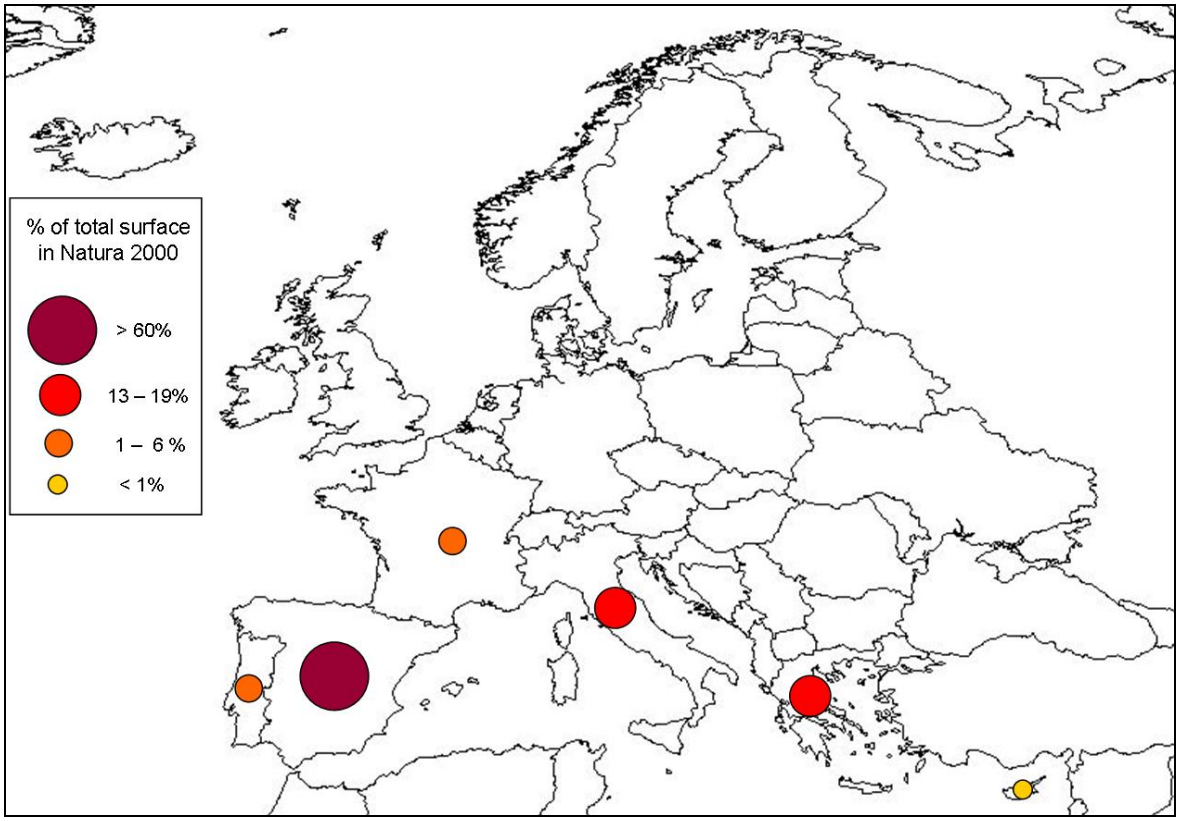
The other model should be applied to secondary matorrals, strictly linked to human related activities, such as stock raising, requiring active management for their conservation. This is the case for small sites, where it is important to block colonisation by competing shrubs or tree species and favour the renovation of juniper plants by keeping the habitat open with moderate grazing and partial scrub clearance. The maintenance of the habitat will result in higher landscape and habitat diversity.

1. Description of habitat and related species

The arborescent matorral with *Juniperus* spp. is a scrub vegetation that consists of evergreen shrubs or small trees, which may include different Juniper species.

Distribution

This habitat is distributed in the countries bordering the Mediterranean Sea. It is found in steep and rocky areas in the whole peninsular and Balearic territory of Spain, in southern and littoral France and Corsica, in central, southern and insular Italy, in northern and southern Greece, Aegean islands included, and in Cyprus. In Portugal it can also be found in the deep valleys of some rivers.



Percentage distribution of the total surface of arborescent matorral with Juniperus in Natura 2000

Arborescent matorral with *Juniperus* in Natura 2000 sites

The following data have been extracted from the Natura 2000 Network database, elaborated by the European Commission with data updated on December 2006. The surface was estimated on the basis of the habitat cover indicated for each protected site and should be considered only as indicative of the habitat surface included in Natura 2000.

Biogeographical region	Nº of sites	Estimated surface in Natura 2000 (ha)	% of total surface in Natura 2000
Mediterranean	538	367,923	98.25
Alpine	15	4,693	1.25
Continental	22	1,813	0.48
Atlantic	1	77	0.02
Countries	**Nº of sites**	**Estimated surface in Natura 2000 (ha)**	**% of total surface in Natura 2000**
Spain	268	226,587	60.50
Greece	70	70,913	18.94
Italy	141	50,397	13.46
France	86	19,522	5.21
Portugal	6	6,524	1.74
Cyprus	5	563	0.15
TOTAL	**576**	**374,506**	**100**

Main habitat features, ecology and variability

The arborescent matorral with *Juniperus* spp. habitat consists of Mediterranean and sub-Mediterranean evergreen sclerophyllous scrub organized around arborescent junipers (EC 2007). It has a pluri-stratified structure, characterized by the arborescent habit of the juniper that dominates or co-dominates the lower bushy or scrubby levels. The maquis height varies considerably according to the *taxon*, but on average the junipers are more than 1.5 metres tall (Goulandris Museum 1996).

The habitat's form varies according to climate conditions and grazing practices, which have an influence in particular on young seedlings. Also the density of the juniper population varies widely from single individuals scattered on grasslands, scrublands or low maquis to the more or less impenetrable dense groups (Bensettiti *et al*. 2005). In Portugal the habitat is characterized by the absence of oak trees (ICN 2007).

In general *J. communis* (common juniper) is found in cooler temperatures, *J. phoenicea* ssp. *phoenicea* (phoenician juniper) and *J. oxycedrus* ssp. *oxycedrus* (prickly juniper) in warmer temperatures, while *J. phoenicea* ssp. *turbinata* is more common in coastal and warm-arid situations. The habitat can host endemism.

This habitat type can be both a vegetation that has replaced different types of natural forests (owing to their degradation), an arborescent pre-forestal stage, or a "permanent plant community" when environmental conditions (aridity, rocky soils, etc.) do not allow the evolution to forest (Bartolomé *et al.* 2005).

Ecological requirements

The habitat can be considered topographically semi-arid, occupying unsheltered, steep biotopes (ICN 2007). It can be found mostly at basal and hilly levels, but in more markedly dry regions, this particular kind of maquis is found in mountain areas (Blasi *et al.* 2005).

In Italy the habitat is present at different altitudes, reaching up to 1800 metres above sea level (GENMEDOC 2007). In Spain it is also frequent at high altitude, up to the tree line. In Greece it is found in low and sub-mountainous areas, up to an altitude of 800 metres, occupying 15% of the total area covered by maquis (Goulandris Museum 1996).

The arborescent matorrals with *Juniperus* spp can tolerate both acid or alkaline soils and are underlain by calcareous, metamorphic and igneous rocks (GENMEDOC 2007). They do however prefer calcareous substrates, characterized by compacted, thin soils. These can be either young soils or eroded older soils with emerging rocks. Maquis usually covers rocky and rough slopes both near the coast and inland.

Main subtypes identified

The habitat is composed of xerophytic communities that include a diversified complex of shrubby formations, linked with junipers of the Mediterranean region (Bensettiti *et al*. 2005). Mixed dominance of different species of junipers indicates a particular sub-type.

Phytosociological differences within and/or between the sub-types are considerable, and depend on the habitat's origin and the evolution (primary or secondary maquis), numerous ecological factors (climatic gradients and local site variation in topography and soils) and human activities.

Juniperus oxycedrus arborescent matorral. The sub-type is found on rocky slopes, mostly on calcareous substrates, sometimes acid, within xeric, warm and sunny biotopes, often with southern exposures. This sub-type varies according to the nature of the substrates, exposure, climatic differences and the use of the land (Bensettiti *et al*. 2005).

Rare on coastal areas, where it is found on slopes descending towards the sea, it is present mostly in inland meso- and supra-Mediterranean areas, where it forms a pre-forest vegetation tall scrub. In southern France it is located mostly between 300 and 600 meters above sea level, even though it ranges from 10 to 800 meters above sea level (Bensettiti *et al*. 2005). In Italy it can reach 1800 meters above sea level (GENMEDOC 2007), in Spain 1200 meters (Bartolomé *et al.* 2005), while in Portugal it is limited to the ravines along the Tejo and Douro rivers and their respective tributaries, where it is abundant (ICN 2007).

Only in rare cases are dense and recognizable populations of prickly matorral found (Bensettiti *et al*. 2005). In Sardinia, for example, it is found in very dense formations between 2 and 5 meters tall, with an average 90% scrub cover (Provincia di Nuoro 2006). They are present in particular in a mosaic with shrubby or scrubby communities, or with individuals spread on ruderal grasslands areas grazed by cows and sheep (Bensettiti *et al*. 2005).

Juniperus phoenicea arborescent matorral. This matorral is found on rocky substrates of different origins (limestone, dolomites, granite, rhyolite, schist), where the biotopes are xeric, warm, sunny, often of southerly aspect, and characterized by harsh situations. These include coastal rocky slopes, rocky scarps, cracks, sites which are permanently exposed to sea spray, sea winds and sometimes severe winter storms followed by drought stress during summer. On the seaward side the trees are often very short and shaped by the wind (Parc National de Port-Cros 2007).

This matorral is present from the thermo-Mediterranean to the supra-Mediterranean level and from sea level to 1200 metres. At higher altitudes the matorral is composed of the subsp. *phoenicea*, while along the coasts subsp. *turbinata* is found. This species is found at 50-80 m in continental France and in Corsica (Bensettiti *et al*. 2005) and below 500-600 m in southern, central and insular Italy while in Sardinia it constitutes the most seaward shrubby species (Minelli 2002).

In Portugal the maquis of *J. phoenicea* (subsp. *turbinata*) is found on coastal cliffs and near the sea or in the rocky slopes of the Guadiana river basin (ICN 2007).

In Greece the Phoenician juniper maquis is found in thermophilous locations on the Aegean islands and in particular on the rocky islets of the south Aegean arc, and in Southern Greece (Goulandris Museum 1996).

In Cyprus it occurs on the lowest elevations near the coast and in the lower slopes of the Troodos, where it is alternates with terraced vineyards (USAID 2006).

J. phoenicea forms open or dense maquis and thickets, between 2-3 m and 6-7 m. tall. They are rich in sclerophillous, rocky thermophilous chasmophytic species. These formations cover slopes, often in mosaic with other formations, such as garrigues with rosemary and *Cistus* or with chasmophytic formations.

The associated flora depends on the exposure, the nature of the substrate, the geomorphology, the geographical situation, anthropogenic impacts and, in the case of coastal maquis, on the prevailing winds. On acid substrates the juniper matorrals are accompanied by *Erica arborea* (tree heath) and by *Olea europaea* var. *silvestris* (wild olive tree) on calcareous substrates. *Chamerops humilis* (Mediterranean

fan palm) is typical on the most arid sites, *Euphorbia dendroides* (tree spurge) on cliffs and in rocky areas and *Helichrysum stoechas* (eternal flower) on the low rocky coasts. In more structured formations it is possible to find *Quercus ilex* (holm-oak), *Q. suber* (cork-oak), *Quercus rotundifolia* or *Q. coccifera* individuals. In these situations matorral is the first succession stage to sclerophyllous oak woodlands (Minelli 2002).

Juniper matorral on cliffs with *J. phoenicea* subsp. *phoenicea* in Provence and Maritime alps are relicts and represent the most northerly communities of the Mediterranean mountains of North Africa and Spain (*Ephedro-Juniperetalia*) (Bensettiti *et al*. 2005).

Juniperus excelsa and *J. foetidissima* arborescent matorral. *J. excelsa* grows mainly on stony or rocky calcareous or non-calcareous slopes in Greece, Cyprus, Anatolia and the Near East (EC 2007). It may grow mixed with J. *foetidissima* or with other conifers such as *Cedrus libani, Cupressus sempervirens* and Pinus *spp*., or it may be part of oak-scrub communities in secondary vegetation, but not in Mediterranean maquis (Farjon 1992).

J. foetidissima occupies largely the same habitats as *J. excelsa* and often grows mixed with it. Like *J. excelsa* it grows on dry, rocky slopes, with shallow, gravely soils. Its altitudinal range is also similar (Earle 2007). In Greece it is found southward to the Peloponnesos, on Mt Athos and on Thásos. In Cyprus it is restricted to a belt of the Troodos Mountains (Farjon 1992) at medium and high elevations. Here, in areas with moderate soil erosion, it is possible to find *J. foetidissima* in scrubs that result largely from man-made activities within *J. foetidissima* woodlands, whose lower limits may in fact in many places be affected by grazing pressures or periodical burning (USAID 2006). *J. foetidissima* seems to be slightly more tolerant to dryness and heat than *J. excelsa* subsp. *excelsa* in at least some of the areas where both taxa are found (Farjon 1992).

Juniperus communis arborescent matorral. The *J. communis* matorral is present in the meso- and supra-Mediterranean levels, mainly between 500 and 1200 m (Bensettiti *et al*. 2005).

It forms primary shrub communities in rocky and sunny sites, normally south-facing, on calcareous substrates (Bensettiti *et al*. 2005). In Sardinia (Italy) common juniper is limited to the Gennargentu mountain slopes at 1500 m of altitude (Ente Foreste Sardegna 2007).

Secondary and pioneer matorrals are more frequent. Single junipers or shrubs on grasslands, garrigues and low matorrals typify them. The biological diversity in these areas depends on the effects of grazing and ongoing dynamic processes (Bensettiti *et al*. 2005). In Italy the habitat is present with different types: shrubs with 5% soil coverage (Ecoservice Consulting 2005); shrubs with junipers with 20 % coverage on intensively grazed grasslands; junipers on recently abandoned pastures or rarely grazed, with a shrub coverage less than 50%; dense shrubs with initial tree coverage (Miozzo 2002).

The floristic diversity is quite low. The association with shrub species of *Prunetalia spinosae* is frequent as well as with *Spartium iunceum* (Spanish broom*)*, in particular in Tuscany (La.M.M.A. 1999). In Northern and Southern Greece subtype with *J. excelsa* and *J. foetidissima* is present. In Spain, this type has the widest altitudinal range, reaching the limit of forests in mountain areas, and often it substitutes at different altitudes for oak woods, beech woods, pinewoods, etc (Bartolomé *et al.* 2005).

Juniperus drupacea arborescent matorral. Formations derived from *J. drupacea* (Syrian juniper) woods of the northern slopes of Mount Parnon and of the Karlik mountain in Thrace, Greece. Part of this wood formation takes the appearance of a *J. drupacea* arborescent matorral. This maquis is limited to the Peloponnese and to Asia Minor (EC 2007).

Within the EU the Syrian juniper occurs only in Greece, where it is now restricted to a single population on the northern slopes of the Parnon Mountains in the Peloponnesos (Conifer Specialist Group 1998). It occurs on calcareous rocky substrates either in small groups or in solitary stands composed of *Cedrus libani, Abies cilicica, Pinus nigra, Juniperus foetidissima* and *Juniperus excelsa*. The optimal elevation for this species is between 600 and 1500 m (Vidakovic 1991), i.e., from the meso- to the supra- Mediterranean vegetation zone (Goulandris Museum 1996).

Juniperus thurifera arborescent matorral. *J. thurifera* matorral is located in the western part of the Mediterranean basin and in Europe its distribution is limited to the Mediterranean parts of Spain, Italy and France. Its presence is rare and relict at medium to high altitudes (between 300 to 1.800 m) on dry, sunny

and warm slopes, mainly on cliffs and steep slopes. It is present in biotopes with extreme climatic conditions without competition from other species (Bensettiti *et al*. 2005).

The *J. thurifera* matorrals are formations derived from the degradation of Spanish juniper (*Juniperion thuriferae*) woods (habitat type *9560) (EC 2007) or the initial aspect of this forest (Bartolomé *et al.* 2005). They are secondary coenosis resulting from the colonisation of abandoned cultivated areas on land previously occupied by juniper forests. This matorral is an open habitat with scattered junipers on lands or scrublands.

Species that depend on the habitat

Numerous species of phytophagous (plant-eating) insects are associated with juniper, including *Lepidoptera, Hymenoptera, Hemiptera, Diptera* and *Acarous* (Bensettiti *et al*. 2005). These feed on different parts of the plant, such as the needles and the seeds. Insects in turn are eaten by numerous bird species that find refuge in this habitat.

Because of its dense cover of prickly needles, juniper provides a good nesting site for birds as the song thrush (*Turdus philomelos)*. The berries are eaten, and the seeds distributed, by birds, in particular *Turdus* spp.

Juniper foliage is eaten by mammals such as red deer (*Cervus elaphus*) and rabbits (*Oryctolagus cuniculus*), and other mammals species, as *Felis sylvestris* (wild cat), *Genetta genetta* (common genet) and the wolf (*Canis lupus*) are associated to the habitat in some locations (MMAMRM, in prep.).

Related habitats

The arborescent matorral with *Juniperus* spp. is dynamically linked to the following habitats with which it is often found "in mosaic":

- thermo-Mediterranean and pre-steppe scrub habitats: 5330 Thermo-Mediterranean and pre-desert scrub (*Rosmarinion officinalis*); 5320 Low formations of *Euphorbia* close to cliffs (*Euphorbion pithyusae*),
- Semi-natural dry grasslands and scrubland facies: 6220 Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* (*Phlomido lychnitidis-Brachypodion retusi*),
- Mediterranean sclerophyllous forests: 9340 *Quercus ilex* and *Quercus rotundifolia* forests (*Quercion ilicis)*; 9320 *Olea* and *Ceratonia* forests (*Oleo sylvestris-Ceratonion siliquae*).

Other associated habitats are:

9560 *Endemic forests with *Juniperus* spp. These forests are medium altitude formations dominated by *Juniperus* spp. (*J. thurifera*, *J. excelsa*, *J. foetidissima* and *J. drupacea*). The arborescent matorrals of *Juniperus* spp are generally associated in the field with this habitat, since they derive from them (EC 2007).

2250 *Coastal dunes with *Juniperus* spp. Arborescent matorrals with juniper on coastal dune systems constitute a different habitat: 2250 *Coastal dunes with *Juniperus* spp. This habitat is treated in a specific Management Model. The populations of *Juniperus phoenicea* subsp. *turbinata* and of *J. oxycedrus* subsp. *macrocarpa* on sandy Mediterranean coasts are therefore part of this habitat. This habitat is made up of primary communities that represent the edaphic substitute on sandy coasts of arborescent matorral on rocky coasts. Both habitats are threatened by analogous pressures related to human activities, such as cutting, fires, grazing and coastal tourist development.

5130 *Juniperus communis* formations on heaths or calcareous grasslands. This habitat includes the Euro-Siberian populations of *J. communis* and differs from 5210 (Bensettiti *et al*. 2005), which includes only Mediterranean populations. When they are of secondary origin, the two habitats are threatened by the same pressures, which can be faced in similar ways.

Ecological services and benefits of the habitat

Soil retention and formation. Juniper is a species with few vital needs that, thanks to its morpho-physiological characteristics, colonises harsh environments such as rocky coasts and dry and incoherent soils (Cervelli 2005). It is therefore a species which is important for soil retention and consolidation and its deep and well-developed root system prevents soil erosion caused by wind and rain (Mugnaini *et al.* 2003). Junipers improve the soil with organic matter, helping the colonisation of other less resistant plants and favouring ecological succession to more evolved vegetation types (Cervelli 2005).

Ecological, biologic and landscape values. This habitat is important as an ecotone (Miozzo 2002; Arpa 2006), forming a transition to other ecosystems such as the Endemic forests with *Juniperus* spp. or the Coastal dunes with *Juniperus* spp.

A range of entomological fauna is associated with junipers, including several phytophagous taxa (*Lepidoptera, Hymenoptera, Hemiptera, Diptera* and *Acarous*) (Bensettiti *et al*. 2005).

Arborescent matorrals host rare species of fungi, such as *Gymnosporangium clavariaeforme,* which lives on the branches of *Juniperus communis* and *J. oxycedrus* (LIFE00 ENV/E/000402).

In winter the habitat is a refuge for several mammals and wintering birds due to the protection from predators and warm sheltered conditions offered by the evergreen vegetation, and the presence of insects and of autumn-flowering and fruiting plants, such as the *Arbutus unedo* (strawberry tree), myrtle, *Phyllirea angustifolia* and juniper itself. Old junipers are often "living monuments" due to their age and tortuous trunks. In France some specimens of juniper despite their small size (1.5 m high, trunk of 8 cm of diameter) are 1150 years old. There is a specimen of common juniper aged 2000 years with a trunk 2.75 m in circumference (Bensettiti *et al*. 2005).

CO_2 sequester. The role carried out by these formations in carbon fixation is often neglected because it is difficult to estimate their biomass increase. They certainly do not accumulate meaningful amounts of biomass in the short term (Bassi and Baratozzi 1998). However, studies do confirm that Mediterranean maquis has a function in climate-change mitigation in the form of carbon storage, if only because of their sheer surface area (Costa and La Mantia 2005). According to a study carried out in an area of Sardinian juniper matorral, there was a biomass increase of 0.25 t/ha/year (Peressotti *et al.* 1999).

Trends

In general the primary juniper matorrals on coasts are rare and in constant regression due to the pressures of tourism and building. Secondary juniper maquis is declining too, due in great part to secondary evolutionary dynamics in areas that were originally cultivated or maintained by pasture, leading to the development of forest formations.

In France the habitat does occur in stable primary formations, but these are rare, while secondary matorrals are more frequent and expanding in areas where agriculture and stock raising have recently been abandoned (Bensettiti *et al*. 2005). The renaturalisation of these areas has progressed: the surface occupied by pre-forestal formations such as matorrals has enlarged. The area affected by this process is also large in other Mediterranean countries (Pasta *et al.* 2005, Rühl *et al.* 2005).

The colonisation of suitable new areas by junipers is quite rapid, since mammals or birds disperse the seeds, but fires often limit it, together with overgrazing (Costa and La Mantia 2005) and other human activities.

In Italy the regression of juniper maquis is due to forest vegetation substituting for open habitats, such as matorral (ARPAV 2004). In Tuscany the habitat is disappearing due to the abandonment of stock raising and the consequent evolution of pastures into woods (Miozzo 2002). An opposite trend can be found in Sardinia where the conservation status of the habitat is low due to overgrazing (Provincia di Nuoro 2006).

In other situations it forms well-preserved environments in low and medium altitude mountains where there is a moderate grazing intensity (ARPAV 2004).

In Portugal the surface of the habitat has decreased due to the spread of vineyards and to livestock raising and afforestation (e.g. artificial plantations of *Pinus* spp. and *Quercus rotundifolia*) (ICN 2007).

Threats

Overgrazing

Mismanagement of pastures and grazing threatens the composition of pastures, damaging the recruitment of junipers and favouring the growth of scattered junipers and/or a low matorral rich in nitrophilous and ruderal species (Bensettiti *et al*. 2005). Young seedlings of juniper are found mostly in un-grazed situations (Vedel 1961). Excessive grazing causes soil compacting with consequent erosion, soil loss and desertification.

In Greece conservation of this habitat depends mainly on the amount of grazing pressure to which they are subject and on their resistance to this pressure (Goulandris Museum 1996).

Succession into woodland

Transition to forests is the main threat to secondary matorrals, which are transition communities characterized by strong dynamism that normally evolve into arboreal communities, with habitat loss as a consequence. In the medium and long term, various forest species re-appear and out-compete the junipers. This process is frequent in Portugal, France and Italy.

Fires

Forest fires are common in the Mediterranean basin and statistics reveal that the fires are increasing. This seems to be due to the abandonment of less favoured lands (hills and mountains) and urban development (mainly tourism development in the coastal zone) (MATT 2003).

Juniper spp. is generally killed or seriously damaged by fire - its resistance to fire is low due to the presence of flammable aromatic substances in the branches (Cervelli 2005). Furthermore post-fire re-establishment is poor, since propagation is by seed, typically produced in abundance but with a relatively long germination period and relatively poor germination rates (Cervelli 2005; Mugnaini *et al*. 2003).

Young junipers are subjected to competition from more rapidly-growing plants such as broom and *Cistus* (ICN 2007). The risk of fires is higher in matorrals dominated by *Cistus*, left un-grazed by cattle and sheep (ICN 2007).

Fire is the main threat in Cyprus, where the climate provides ideal conditions for forest fire development and rapid spread (intense heat, low rainfall, low humidity and strong winds). The National Report to the Fifth Session of the United Nations Forum on Forests (MOA 2005) states that today the two main factors resulting in deforestation and forest degradation are drought and the consequent increase of forest fires (USAID 2006).

Soil erosion

In primary matorrals on steep slopes, erosion is a natural process, but in coastal areas and in secondary matorrals it can be caused by overgrazing, urbanisation, tourist pressure, or the opening of pathways and the consequent trampling, which causes gullies.

Land use changes

Habitat loss is frequently due to the clearing of new areas for agriculture or for the construction of tourist infrastructures, railways or new roads (MATT 2003). These activities increase the human frequentation for the remaining areas with the habitat and the consequent risk of fire.

Juniper cutting

Among the major threats that this maquis faces in Greece, ongoing tree felling must be mentioned: *J. drupacea* is used as a source of wood for carpentry and fuel; *J. foetidissima* for firewood (Goulandris Museum 1996). In Portugal the juniper habitats present in the valley of the Rio Guadiana and its tributaries are threatened mainly by non-selective clearance for fire prevention or "to clean" streams in order to reduce the possibility of winter floods (ICN 2007).

Climate change effects

Model simulations for the Mediterranean region indicate that the recent rise in atmospheric CO_2 may already have had significant impacts on the productivity, structure and water relations of sclerophyllous shrub vegetation, which tend to offset the detrimental effects of climate change in the region (Osborne *et al.* 2000). Total canopy water loss, net primary production and leaf area index have all risen.

Young seedlings are vulnerable to summer drought (Garcia *et al.* 1999; Rosen 1988 and 1995), and some authors speculate that this aspect of climate might have implications for juniper under some global warming scenarios (Ward 2004).

2. Conservation management

General recommendations

We can distinguish two management models, depending on the nature of the matorral (Bensettiti *et al*. 2005).

Primary matorrals needing natural evolution

- Matorrals of projecting ledges, cornices or rocky slopes, almost inaccessible and not threatened by human activities. These communities can be threatened by local natural erosion processes. It is necessary to avoid actions that can trigger erosion such as the laying down of new roads or tracks, overgrazing and climbing (MATT 2003).
- Coastal matorrals: the main threat is linked to tourism: it is necessary to channel the tourist flow so as to avoid creating of new tracks and causing erosion.

Secondary matorrals requiring active management

- Matorrals in expansion: they are expanding on abandoned arable land where grazing favours the expansion of junipers. These populations are not threatened but it is necessary to prevent their colonisation by competing species.
- Matorrals evolving into woods: in this case the main problem for the maintenance of the habitat is natural succession. Although this natural process should be included as part of juniper ecology on large-scale nature reserves, it might be necessary on small sites to extend the reproductive life of the existing juniper bushes. In this case it is important to limit the competition of forest species, leaving open areas for the renovation of junipers. The maintenance of the habitat guarantees a higher landscape and habitat diversity.

Active management

Controlled grazing

Controlled grazing is beneficial to the habitat when aimed at a moderate disturbance, maintaining the habitat in a dynamic equilibrium (MATT 2003). An experiment carried out in France on an area with secondary matorral of *Juniperus thurifera* invaded by *Quercus pubescens,* has shown that goats prefer scrub below two meters in height, except junipers. Goats dedicated most of their time to grazing oaks (29%) and grasses (12,5%) leaving open areas among the clumps of juniper bushes, thus reducing the grass fuel load and thereby diminishing the risk of fire propagation (Bensettiti *et al*. 2005).

Grazing also favours juniper seed dispersal: Rosen (1988) reports that domestic sheep may also serve as dispersal agents since juniper is often associated with sheep drove routes. On the other hand overgrazing can be detrimental to the matorral because it can prevent the regeneration of juniper, whose seeds die before germination due to trampling by the animals (Bensettiti *et al*. 2005).

The first step to controlling grazing activity is the formulation of a "pasturage plan". It should be based on accurate field surveys to determine both the habitat characteristics and needs and the livestock pressure. Then the appropriate stocking levels for matorral should be determined taking into consideration its conservation status, other management practices, such as cutting of the fuel, and the number of wild herbivores present. Grazing by different animal species should also be taken into consideration. It is significant from an ecological point of view due to the different preferential grazing behaviour of the various species. The plan should subdivide the area for grazing into different lots and include their dimensions and location, the timing of grazing in each lot and the grazing rotation (Gusmeroli 2003).

The herbaceous vegetation generally present in the habitat is only of medium quality and quantity but it can be convenient for livestock maintenance. Grazing should preferably be carried out only in winter, when grass is more abundant (Bensettiti *et al*. 2005). The grazing plan should keep cattle to a minimum, as they compact the soil. Extensive sheep/goat grazing after an initial scrub clearance is preferable (MATT

2003). In some cases, fencing to allow different management regimes may be an option. The enclosures should be large enough (from 25 to 50 ha) so that cattle graze any particular area at intervals of a month or two at the very least, or one to three weeks for sheep (Bensettiti *et al*. 2005).

In France, contractual agreements have been made with breeders, which aim to promote extensive stock raising in order to protect the landscape, preserve biodiversity and prevent fires (Bensettiti *et al*. 2005; Parc Naturel de Luberon 2004).

Management of the habitat through livestock grazing should take into account the ecological requirements of the environment and the economic needs of the local inhabitants. It is therefore important to (Provincia di Nuoro 2006):

- involve breeders and technicians when determining the carrying capacity of the habitat for grazing,
- provide technical assistance to breeders, identifying financial incentives for the sustainable management of grazing.

Mowing and periodic cuttings

To preserve matorrals threatened by invasion and competition of other shrubs or trees it is necessary to clear them periodically and to maintain open spaces.

Scrub species such as *Genista hispanica, G. scorpius, Spiraea hypericifolia*, etc. should be cut periodically so as to open up areas where light, heat and water conditions will be more suitable for the growth of the junipers, the production of seeds and their germination. Young seedlings of juniper are most often found in communities with a lot of bare ground or little competition from other vigorous plants, usually due to low nutrient conditions (Vedel 1961).

The initial invasion of other wood plants can be prevented by removal of potential seed sources. An arbitrary distance of 100 m around the junipers has been proposed (Ash 1996). Any woody plants already present and competing with the juniper should best be cut during the earlier years of growth, as once junipers are elongated by competition for light they become unstable when the other plants are removed (Ward 2004). It is necessary to cut the suckers of *Quercus* spp. (LIFE00 ENV/E/000402), which grow rapidly.

In case of common juniper, the alternative of cutting some individuals to create a mixed-age population by favouring young, thriving plants of arboreal form, since fertile seed production is more reliable from young bushes (Bensettiti *et al*. 2005). Clearing to give the young bushes space and light should be carried out manually in small patches. The size and density of the clearings depend on the density of the matorral and on the capacity of the surrounding forest species to colonise it. As a side effect, clearings reduce the availability of fuel and thus the risk of fire (IPLA 2000).

Clearing limited areas only, without intervening in the surrounding area, favours the rapid re-colonisation by the micro-fauna, such as insects and reptiles, and allows an increase in the populations of eliophilous plants, as soon as the cleared areas return to a state suitable for their survival (IPLA 2000; RSPB 1994). The material coming from the clearings should be left on site, chopped up to favour decomposition, assist significantly in limiting soil erosion and to favour the mineralisation of organic material (IPLA 2000).

Fire prevention

Fire prevention is important in high-risk areas, not only to prevent fires from starting in the first place but to limit the propagation of fires which do manage to start. Intervention to mitigate fire damage is also necessary (Thavaud 2006). Below are some suggested actions to achieve this goal:

- fuel elimination: mowing and the selective cutting of scrub reduce the biomass available and break the continuity of the herbaceous and arboreous vegetation, thus preventing the spread of fires;
- controlled grazing (Arpa 2006): it permits an accurate and effective elimination of biomass from the habitat, limiting the cost of clearance;
- improvement and maintenance of roads to facilitate access of fire-fighting vehicles.

On some sites fire prevention measures require the cleaning of the herbaceous vegetation before summer, preventing grazing during summer, with a consequent loss of net income to the farmers. Part of the pastures should be grazed before summer, using semi-mobile enclosures, and the remaining part should be left for grazing in winter (Bensettiti *et al*. 2005).

Other actions to prevent fire risk include:

- the creation of fire breaks free of litter and scrub at least 4 meters wide and at an interval of approximately 40 meters;
- the creation of water pools to be used in case of fire;
- the identification of sighting points and coordination of the personnel involved (Provincia di Nuoro 2006);
- public awareness activities.

Obviously when implementing these recommendations, account must be taken of the conservation priorities of the site - saproxylic fauna depends on dead wood, for example.

Other relevant measures

Recovery management

The recovery of juniper vegetation on potentially suitable areas should be carried out only by favouring the normal succession and not through reforestation, which could have a negative impact on the soil and favour the introduction of allochthonous germplasm (Parco Nazionale dell'Asinara 2005). Before any recovery operation, it is necessary to stop or limit the activities causing the diminution of the habitat, such as:

- change in land use and conversion to forestry and arable land;
- the clearing of scrub in neighbouring woods (ICN 2007);
- tourist impact (by actions to control and channel the tourist flow - the creation of paths; avoiding the use with vehicles; limiting the possibility to detour from the paths, in particular in the coastal areas and the placing of informative panels);
- climbing and rambling activities, which should be regulated so as to preserve the most important cliffs and slopes (Provincia di Nuoro 2006).

Allochthonous plants should be gradually eliminated.

Monitoring

Monitoring programmes should be aimed at evaluating the status of the habitat and at verifying the efficacy of the management actions carried out and should include studies to improve management guidelines (Provincia di Nuoro 2006).

Particular attention should be directed at the following aspects:

- Management activities;
- Tourism impact;
- Bird population dimension and diversity trends.

The monitoring can be carried out on the basis of:

- Aerial photos at a decent scale (1:2000)
- On site surveys
- GIS mapping using a GPS system
- Photo interpretation
- Updating of cartography

The density and structure of the juniper population should be surveyed periodically in permanent plots (Provincia di Nuoro 2006).

Indicators for habitat monitoring should include:

- Number of junipers/hectare;
- Population structure;
- Number of allochthonous species/hectare;
- Number of allochthonous species/total n° of species present;
- Height of the trees;
- Mean diameter at breast height;
- Age and age structure of the juniper population.

Network of reserves and micro reserves

It could be feasible to create a network of reserves and/or micro-reserves so as to reduce fragmentation and recreate ecological continuity (ICN, 2007). This is important since seed dispersion by birds and mammals reduces rapidly with distance from the parent plant – juniper seedlings are rarely found more than a few hundred metres from vigorously fruiting bushes (Ward 2004).

Cost estimates and potential sources of EU financing

Estimate of costs is difficult to provide since there are few experiences of management specifically aimed at the "Arborescent matorral with *Juniperus spp.*". When assessing the costs for active management of this habitat it is however important to take into consideration a number of factors, such as:

- the extension of the habitat;
- the kind of activity: labour and equipment connected with grazing are different from those required by mowing and cutting. Controlled grazing, for instance, needs the presence of the herder to guard livestock or to move mobile fences, etc. Another aspect to take into consideration in this case is the distance of the area of pasture from the farm, which involves different costs for transportation;
- topographic conditions (slope, rocky outcrops, etc): in steep slope conditions, greater costs derive from the use of human labour for a longer period that would be needed if mechanical equipment is used;
- the realization of infrastructures: the construction of small infrastructures, such as drinking troughs and temporary fences, should be considered in estimating costs connected with grazing.
- the altitude, which has an indirect influence on the costs;
- the rate of infestation of other shrubs or trees: the cost of cutting rises with the increase in competitive plants density;
- the type of equipment: mowing and cutting can be carried out by hand or by mechanical means. The latter is generally more expensive because of the costs related to the use of machinery and equipments (purchase, insurance, combustible, lubricants, maintenances, reparations, etc).

Potential sources of EU financing. The cost issue has to be seen in the light of Article 17 of the Charter of Fundamental Rights of the European Union, which sets the principle of compensation for income foregone, and the rules concerning concurrency.

Management measures for Natura 2000 were defined in the annexes of Communication from the Commission on Financing Natura 2000 (COM 2004-0431 and its working documents). Four categories were defined with several types of activities for each of them. The two first ones concern the establishment of the Natura 2000 network and management planning, administration and maintenance of network related infrastructure. They will not be considered within the Management Models Project. The two last ones are more appropriate to this exercise and focused on active management. However the monitoring items as well as the action focusing facilities to encourage visitor access or the action related to land purchase are not relevant here. Only conservation management measures, management schemes and agreements, provisions of services and infrastructure costs will be considered here.

Concerning potential sources of EU financing, a Guidance Handbook presents the EU funding options for Natura 2000 sites in the period 2007-2013 that are, in principle, available at the national and regional level. Furthermore an IT-tool is available on the EC web site (http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm). By developing an IT-tool the Commission wishes to provide easier access to the information of the Guidance Handbook and create the opportunity to use the information in the framework of management planning.

For the period 2007-2013, several structural funds exist (EARDF, EFF, ERDF, and Cohesion fund) with a national/regional programme based on EU and national strategic guidelines. Furthermore several project funds, interconnected or not with structural funds, can be used, such as Interreg, LIFE+, the 7th Research Framework Program (FP7) or Leader+. However some actions are not eligible for certain financial schemes, e.g. with LIFE+ recurring management is not eligible.

Each Member State has identified the issues that are of most concern locally, and has prioritized EU funds in order to address these issues. The integrated use of these resources will allow financing various management actions for areas with habitats listed in the Habitats directive and included in the Natura 2000 network.

The analysis of opportunities presented in the following table is based on the Guidance handbook "Financing Natura 2000", issued by the European Commission (Torkler 2007). It should be noted that the activities listed below often need to be integrated into a broader development context (projects, programmes) and are specific to particular areas. The funds taken into consideration are:

- The Structural Funds (European Social Fund (ESF) and European Regional Development Fund (ERDF));
- The Cohesion Fund (CF);
- The European Agricultural Fund for Rural Development (EAFRD);
- The European Fisheries Fund (EFF);
- The Financial Instrument for the Environment (LIFE+);
- The 7th Research Framework Programme (FP7).

Types of activities	**EU Funding opportunities, references in the Regulation, eventual examples**
Management planning	
Preparation of management plans, strategies and schemes (Elaboration and/or update of management and action plans, land use plans etc.)	EAFRD art. 52 (b)(iii): it could finance Natura 2000 management plans of sites associated to rural areas, and high nature value areas in the context of conservation and upgrading of the rural heritage. Art. 63, Leader, could finance the elaboration of site management plans as an objective of local development strategy encouraging the sustainable management of environmentally sensitive habitats such as matorrals. LIFE+ art. 3 and Annex I, LIFE+ Nature and Biodiversity component: it could finance site and species management and site planning, including the improvement of the ecological coherence of the Natura 2000 network. ERDF art. 4-6 could finance development of management plan, but only where management of the Natura 2000 site is crucial for risk management.
Establishment of management bodies (Start-up funding, feasibility studies, management plans etc.)	ERDF, art. 4-6, could finance establishment of regional/trans-boundary management bodies to promote sustainable use of biodiversity and nature protection.
Consultation – public meetings, liaison with landowners (Including costs incurred for the organisation of meetings and workshops, the publication of consultation outcomes, financial support of stakeholders, etc.)	EAFRD, art. 52 (b)(iii), could support regional networking, sharing of positive experiences to communicate economic benefits of Natura 2000 sites in the context of initiatives to conserve and upgrade the rural heritage, and within, private-public partnership for sustainable rural development (Leader, art.63). FP7, art. 2(2)f, Transnational Cooperation, theme Environment, could finance consultation and networking as part of a research projects including stakeholders involvement. ERDF, art. 4-6, could finance networking and consultations on various socio-economic aspects of Natura 2000 sites on local/regional/transnational level. ESF, art.3 (2), could finance networking between public and private bodies, departments, public administrations and public services etc. in relation to management of Natura 2000 sites, in "objective Convergence" regions.

Types of activities	EU Funding opportunities, references in the Regulation, eventual examples
Management planning	
Review of management plans, strategies and schemes	EAFRD art. 63: Leader, could finance revision of present management schemes to achieve a more sustainable rural development. LIFE+ art. 3 and Annex I: Nature and biodiversity component could finance site planning, including the improvement of the ecological coherence of the Natura 2000 network, the development and implementation of species and habitats conservation action plans. FP7 art. 2(2)f: Transnational Cooperation, theme Environment, could finance plans review as part of a research projects aimed at determining plans efficacy. ERDF art. 4-6: could finance revision of management plans, in the framework of risk management, and in transnational cooperation initiatives to favour ecotourism in areas needing socio-economic diversification.
10 Maintenance of facilities for public access to and use of the sites, interpretation works, observatories and kiosks etc. (Including costs related to guides, maps, related personnel.)	EAFRD art. 52, Art. 63, Leader could finance maintenance, restoration and upgrading of facilities for public access to Natura 2000 sites in the context of the conservation and upgrading of rural heritage and private-public partnership for sustainable rural development strategies. EFF, art. 41(1) could finance maintenance or improvement of public access facilities for use at coastal sites (e.g. coastal matorrals), to facilitate development of eco-tourism with the objective of restructuring and redirecting economic activities. ERDF art. 4-6, could finance development of infrastructure to improve access linked to biodiversity and Natura 2000 contributing to sustainable economic development and diversification of rural areas.
Ongoing habitat management and monitoring	
Conservation management measures – maintenance and improvement of habitats' favourable conservation status (Including restoration work, provision of wildlife passages, management of specific habitats, preparation of management plans.) Implementation of management schemes and agreements with owners and managers of land or water for following certain prescriptions.	EAFRD, art. 63, Leader, could finance management of local habitats to facilitate objectives of the local rural development plan. Art. 36 (b)(i) could finance first afforestation of agricultural lands with typical plants, habitat recovering on matorrals, support and management of traditional activities necessary for the habitat conservation (stock raising). EFF art 41(1)(f) could finance restoration of coastal habitats (e.g. coastal matorrals) so as to protect the environment in fisheries areas to maintain its attractiveness. LIFE+, art. 3 and Annex I, Nature and biodiversity component, could finance pilot conservations projects for site and species management, implementation of species and habitats conservation action plans. FP7, art. 2(2)f, Transnational Cooperation, theme Environment, could finance conservation management measures as part of a research projects on management options of natural habitats. ERDF, art. 4-6, could finance adaptation/improvement of transport infrastructure to mitigate effects on Natura 2000 sites e.g. to reduce habitat fragmentation, and actions to reduce fire risk.
Conservation management measures in relation to invasive alien species (IAS) (Including restoration work, infrastructure, management of specific species, preparation of management plans).	EAFRD, art. 36 (b)(v), could finance removal of invasive plant species that threaten native plants and forest structure in the context of forest-environment payments. EFF, art. 26(1)(c), could finance retraining of fishermen as rangers in habitat restoration work on Natura 2000 sites, including invasive species management. EFF, art 41(1)(f), could finance restoration of coastal habitats e.g. coastal matorrals through removal of invasive plants within initiatives to protect the environment in fisheries areas to maintain its attractiveness. LIFE+, art. 3 and Annex I, Nature and biodiversity component, could finance removal of invasive alien species or elaboration of demonstrative methodologies as part of larger nature conservation projects. ERDF, art. 4-6, various opportunities could be used to fund a one-off eradication or control programme for an IAS with significant negative economic/social/environmental effects. FP7, art. 2(2)f, Transnational Cooperation, theme Environment, could finance control of alien species as part of a research projects on biodiversity threats.

Types of activities	EU Funding opportunities, references in the Regulation, eventual examples
Ongoing habitat management and monitoring	
Monitoring and surveying (Refers mainly to one-off costs related to monitoring and surveying activities, e.g. development of monitoring plans, methods and equipment; training of personnel.)	EAFRD art. 52 (d) could finance base studies aimed at elaborating the local development strategies. Art. 63, Leader, could finance monitoring activities in the framework of rural development projects. LIFE+ art. 3 and Annex I, Nature and biodiversity component, could finance projects aimed at designing and implementing policy approaches and instruments for monitoring and assessing nature and biodiversity and the factors, pressures and responses that impact on them in natural areas. FP7, art. 2(2)f, Transnational Cooperation, theme Environment, could finance biodiversity surveying as part of research projects on new methods to monitor biodiversity. ERDF art. 4-6: could finance habitat monitoring plans or infrastructures, in the framework of environmental risk management programmes, or in a transnational cooperation initiatives. CF art. 2(2): could finance monitoring plans on Natura 2000 sites as part of larger projects on regional sustainable development in "Convergence" regions.
Risk management (fire prevention and control, flooding etc) . Includes the preparation of wardening and fire-control plans, development of relevant infrastructures, and the acquisition of equipment.	FP7 art. 2(2)f: Transnational Cooperation, theme Environment, could finance research projects on new methods to manage risks in Natura 2000 sites. ERDF art. 4-6: could finance plans or infrastructures to avoid risks such as fires, invasive species, in the framework of environmental risk management programmes, at local/regional/transnational level. LIFE+ art. 3 and Annex I: Nature and Biodiversity component: see point above. Information and Communication component: could finance training activities of agents involved in forest fire prevention initiatives.
Provision of information and publicity material (Includes establishing communication networks, production of newsletters and awareness and information materials, setting-up and maintenance of internet pages, etc.)	EAFRD art. 52.: could finance promotion of Natura 2000 sites within environmental awareness actions on rural heritage associated with the development of high natural value sites. art. 63: Leader, could finance information material on the environmental values of the rural areas e.g. on Natura 2000 sites within private-public partnership for sustainable rural development. EFF, art. 41(1): could finance production of informative material on coastal Natura 2000 sites with juniper matorrals in the framework of redirecting fishing activities, facilitating development of coastal eco-tourism. LIFE+ art. 3 and Annex I: Nature and biodiversity component, could finance public awareness activities e.g. in the context of projects for habitat and species management. ERDF art. 4-6: could finance elaboration and spread of informative material, in the framework of programmes to enhance ecotourism, at local/regional/transnational level. ESF art 3(2): could finance elaboration of information for training programmes to strengthen institutional capacity and the efficiency of public administrations.
Training and education Including production of handbooks, seminars, workshops, communication materials.	EAFRD art. 20, 52.: could finance training and networking necessary for realisation of the local development strategy (e.g. regional promotion in relation to Natura 2000), to enhance ecotourism e.g. through promotion of Natura 2000 sites. EFF, art. 41(1): could finance training to fishermen to develop coastal eco-tourism on coastal Natura 2000 sites in the framework of projects to redirect fishing activities. LIFE+ art. 3 and Annex I: Information and Communication component could finance training activities of agents involved in forest fire prevention initiatives. ESF art 3(2): could finance training activities on good management of Natura 2000 coastal sites in the context of training programmes for public administrations to strengthen institutional capacity and the efficiency.

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