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Full Length Research Paper

An evaluation of the ecosystem and administration of the Samaria Gorge, a Greek biosphere reserve

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This paper refers to ecological values of one of the famous Greek national parks. It concerns the White Mountains (2,453 m altitude) including a world biosphere reserve, that situated in western Crete. The area includes extensive cave systems and flat internal upland plains encircled by mountains. The typical landscape consists of deep gorges, steep and imposing vertical rocks forming narrow openings. The steepest, tallest and narrowest opening of the White Mountains is the Samaria Gorge, that was proclaimed as National Park by the Greek Government in 1962 and a Biosphere Reserve by UNESCO in 1981. The Gorge is famous as a mountainous limestone area with steep rocky slopes and canyons up to 600 m deep. The area is characterized by the presence of 16 habitats of the European Habitat Directive, 7 of which are of priority. The vascular flora consists of more than 500 species of trees, shrubs and herbs, 77 of which are endemic species, 37 rare, and 6 vulnerable. The forest ecosystems are broadleaved evergreen woodlands, pines, cypress, maples, wetlands, garrique, maquis, phrygana and chasmophytes. The fauna is very rich in species with 16 mammals (nine are referred to in the Red Book including the endemic *Capra aegagrus cretica*) and 69 birds (12 are included in annex I of the Directive 79/409/E.U. and eight in the Red Book). The special values of the studied area and the impact of human activities to local land-use were clearly described and taken into consideration by the General Management Plant.

Key words: Samaria Gorge, World Biosphere Reserve, Crete, Lefka Ori, general management plan.

INTRODUCTION

Greece is situated in south-eastern Europe (the Balkan peninsula) and it is endowed with splendid scenery, historical and archaeological interest. The country is characterized by many protected areas (320 sites-2,760,000 ha) listed in the European Network “NATURA 2000” as Special Protected Areas (SPAs) aiming to protect wild and vulnerable species of flora and fauna. Natural sites were declared (by Greek Law) as district protected areas (360,000 ha), of which 95,000 ha consist of 10 national parks (34,254 ha are the cores and 68,742 ha are the peripheral zones). Apart from its important landscape and a high diversity of flora and fauna, two national parks (Mount Olympus and the Samaria Gorge) were declared as Biosphere Reserves. Former lies in the eastern part of central Greece and the latter on the island of Crete. Each National Park consists of a core area, of strict conservation importance, which normally should not be less than 1,500 ha, and a peripheral zone, which should be at least as large as the core area (Higgs and Usher, 1980; Trakolis, 2001a). In the core area, the law allows only scientific research and environmental education. Forestry activities, grazing, hunting, and fishing are prohibited. Whereas in the peripheral zone there are no such restrictions but the Forest Service can take any neces-sary measures for the realization of the aims of the park (Malamidis et al., 1996; Trakolis, 2001b).

Crete, the largest of the Greek islands, defines the southern most boundary of Europe. Its unique geographical position is responsible for its being able to boast

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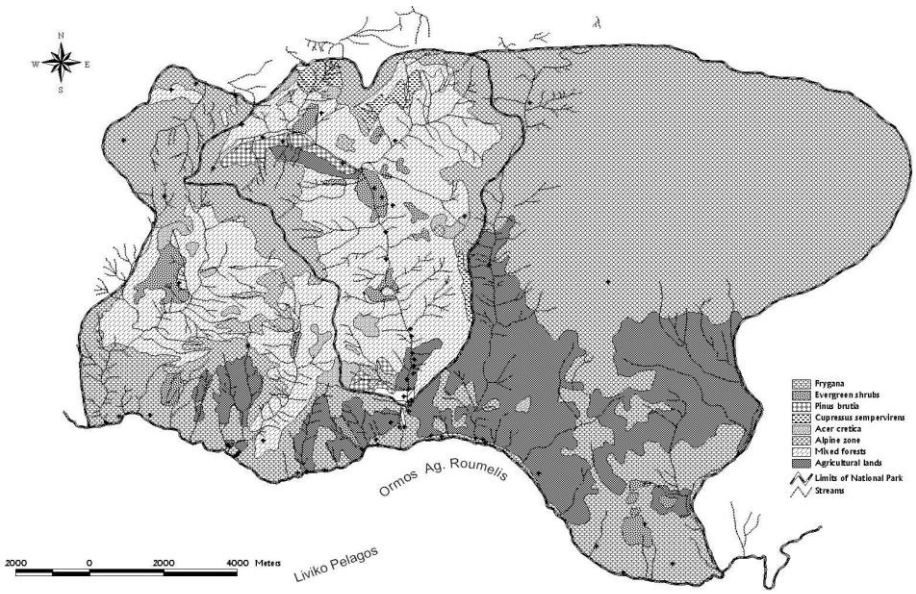

Figure 1. Map showing orientation and vegetation of White Mountains*. *Source: Laboratory of Remote Sensing (Forest Research Institute)

an incredible variety of flora and fauna, many of which are endemic with Asiatic and African relationships. The island of Crete has been inhabited since the Neolithic period (6000 - 2800 BC). The agricultural settlements of that period were transformed into urban communities during the Minoan Civilisation (2800 - 1000 BC) with the influx of new inhabitants (Lyrintzis and Papanastasis, 1995). Herodotos has reported that the Minoan Civilisation (2800 - 1000 BC) was based on shipping, and cypress wood was used in ship manufacturing. Until today several remarkable studies on vegetation and human activities have been made in different regions of Crete (Tutin et al., 1964- 1980; Strid, 1989; Rackham, 1990; Grove et al., 1993; Turland et al., 1993; Lyrintzis and Papanastasis, 1995; Rackham and Moody, 1996; Vogiatzakis et al., 2003). The “Cretan area” is the most south-easterly of the 39 floristic territories defined by *Flora Europaea* and is situated in the south Aegean region covering an area of approximately 8,700 km^2. The first botanical studies in Crete started during the Minoan Civilisation (2800 - 1000 BC). The vascular flora of Crete is the most remarkable in Europe and comprises of about 1,800 native species many of which are widespread Mediterranean and Euro-Siberian plants. Many of these species (up to 180) are endemic, as a result of the geographical isolation and adaptation to human activities such as intensive grazing and wildfires. The most important references to the flora and fauna in the Samaria Gorge are the following: Schultze-Western, 1971; Maurommatis, 1976; Husband, 1977; Nicholson et al., 1994; Husband and Davis, 1984; Husband et al., 1986; Husband and Brown, 1994; Malamidis et al., 1996; Strid, 1989; Strid and Kit, 1991; Turland et al., 1993; Spanos et al., 1998.

The main aim of this study is reviewing the ecological value of Samaria Gorge and evaluate the role of the General Management Plan for future conservation efforts. The evaluation of these values in combination with proposals of the last integrated General Manage-ment Plan (GMP) are discussed in order to conserve this World Biosphere.

METHODS

Site description

Location: Crete island has long been renowned for its agreeable Mediterranean climate that has always been attractive to humankind and allowed the ancient Minoan civilisation to flourish over four thousand years ago. Although mountains run from east to west across the island, the most rugged and handsome is the White Mountains in the west, which rises to 2,453 m. It is called “White Mountains” since it is covered with snow until late in the spring and during the summer the sun is reflected off the limestone summits and makes them appear white as well. The highest summit is Pachnes (2,453 m). The mountain has played a significant historical, economic and cultural role throughout the centuries. It includes extensive cave systems and flat internally upland plains away from the coast encircled by mountains named “Polje”. The typical landscape consists of deep gorges, steep and imposing vertical rocks forming narrow openings, as a result of water action on limestone for thousands of years.

The steepest, tallest and narrowest opening of the White Mountains is the famous Gorge of Samaria, that was proclaimed a National Park in 1962 (Figure 1). The Samaria Gorge covers the core of the National Park (4,850 ha). This gorge is the longest in

Europe (18 km long) and is famous world wide. In 1981, it was declared by UNESCO as a Biosphere Reserve due to the great interest of its natural resources. Classified as a National Park, the gorge is one of the most spectacular natural parks in Europe (IUCN 1993). The gorge is unique for its great importance and for its fascinating geology. It is a mountainous limestone area with steep slopes and canyons up to 600 m deep. The gorge is extremely narrow (minimum 2 m wide) extending to the north in an almost straight line 6 km long and contains an intermittent stream. There are exceptional geological formations of limestone and silica schist. It is an area with important biotic and abiotic natural elements, landscape diversity and exceptional biodiversity concerning its flora and fauna. It is open to visitors during the summer for approximately six months. Hiking down the gorge is permitted form May to the end of October, depending on the weather. Hiking the Samaria Gorge takes about four to five hours.

Climate

The climate can be characterized as typical mild Mediterranean with a long dry period, favourably influenced by the sea (Maurommatis, 1980). The nearest meteorological station is situated to the Gorge in Kantanos at 466 m altitude, and the meteorological data is recorded by the National Meteorological Service of Greece. The mean yearly precipitation is relatively high (depending on the altitude) and it is estimated by the equation P = 600 + 0.55 x h (Roseman, 1965), where P = annual percipitation and h = altitude. Thus, for a period of 35 years (1971 - 2006), the mean annual rainfall at sea level is P = 600 mm and at high altitudes P=1797 mm. The xerothermic period starts at the beginning of May and finishes at the end of September. Most of the rainfall occurs between October and April.

METHODOLOGY

The study was based on the general management plan (GMP) for the national park of the White Mountains with special emphasis on the Samaria Gorge (the core zone). The GMP was created by the National Agricultural Research Foundation (Forest Research Institute of Thes-saloniki) and was funded by the E.U. (LIFE program) and Greece (Ministry of Agriculture and Ministry of Environment and Public Works). Five persons were the core group for the execution of this GMP (the four authors of this paper, and their colleague Mr. G. Malamidis, who unfortunately has died).

The first GMP proposed to extend the area of the Samaria Gorge including a peripheral zone to the White Mountains to reach 22,110 ha (the core of the Samaria Gorge-6,315 ha, plus the peripheral zone-15,795 ha, (Figure 1). The area is characterized by the presence of 16 habitats according to the European Habitat Directive, seven of which are of priority. It is an important area with native forests of calabrian pine, common cypress and maple with high diversity, which many wild animals and plant species inhabit. The avifauna is very rich and 69 birch species have been identified, 20 of which are very important (12 included in annex I of the Directive 79/409/E.E.C. and eight in the Red Book).

Flora analysis was based on field data collections and on previous botanical studies in the area (Mavromatis, 1986; Spanos et al., 1998; Turland et al., 1993; Vogiatzakis et al., 2003). Many plants (herbs particularly) were collected from October 2000 to June 2005 and samples were transferred to Thessaloniki (labora tory of Forest Research Institute) for identification.

The botanical nomenclature of the plant species is taken from “Mountain Flora of Greece” (Strid,1989; Strid and Kit, 1991) and “Flora Europaea” (Tutin et al., 1964-1980).

The distinction of habitat types was made according to the Annex I of the Habitats 92/43 of the European Communities. Fauna analysis was based on field observations and previous studies in the area (Karandinos and Paraschi, 1992; Katsadorakis 1985, 1999, 1994; Phitos et al., 1995). Land use types were classifies via orthophoto maps of the area, while data for visitors and threats were taken from the local Forest Directorate of Chania.

RESULTS

Flora and vegetation

The types of forests are the result of the impact of mankind (grazing, cultivation, cutting of rich forests, hunting, fires for clearance and many wildfires) from pre-historic and historic times, to the Neolithic period (6,000 - 2,800 BC), through to the Minoan Civilisation (2,800 -1,000 BC), Christian, Byzantine, Venetian and Ottoman periods until today, as the result of dominant human activities. Greek flora is unrivalled in richness and diversity by other equivalent Mediterranean countries and possesses many lesser known species, and comprises of 739 ende-mic species (IUCN, 1982).

The vegetation and diversity of plant species in the Samaria Gorge are influenced by the typical Mediterra-nean climate and human activities such as pasture, harvestings and hunting throughout successive historical periods. Much of the vegetation shows obvious adapta-tions to the Mediterranean climate and many plants are scleroplyllous with thick leaves, others are small-leaved, or densely covered with hairs so that they transpire less during the hot dry summers. Three vegetative zones (types) with five subzones (sub- types), according to altitude (Dafis, 1973; Athanasiadis, 1978; Maurommatis, 1980; Spanos et al., 1998) can be distinguished, as illustrated in Table 1. It is remarkable that many shrubs or high trees of *Quercus coccifera* L. and *Phyllirea latifolia* L. are spiny, making them resistant to browsing. Additionally, in the sub-type of *Quercetum cociferae criticum* there are extended plant communities of hemispherical, usually spiny, often aromatic dwarf shrubs, resistant to drought and grazing and rarely growing above 50 cm high named phrygana such as *Calicotome villosa* Link*, Euphorbia acanthothamnos* Heldr.& Sart*., Satureja Juliana* L*., Verbascum spinosum* L*., Berberis cretica* L., *Origanum microphyllum* Bogel and *Sideritis syriaca* L. The forests consist mainly of seven tree species (*Pinus brutia* Ten*., Cupressus sempervirens* ssp. *Horizontalis* L., *Acer sempervirens var. creticum* L*., Quercus coccifera* L*., Quercus ilex* L*., Phylirea latifolia* L. *and Platanus*

Table 1. Vegetation types of white mountains

Vegetative Zone	Sub-Zone	Altitude (m)	Main species
Quercetalia ilicis	*Pistacietum lentisci-Ceratonieto*	0-500	*Pinus brutia, Curpessus sempervirens Pistacia lentiscus Ceratonia siliqua Myrtus communis Sarcopoterium spinosum*
Quercetalia ilicis	*Quercetum cocciferae creticum*	501-1000	*Pinus brutia Cupressus sempervirens Quercus coccifera Quercus ilex Phillyrea latifolia Cistus creticus Sarcopoterium spinosum*
Cupressacea-Aceraceae	*Cupressaceae cretici*	1001-1700	*Cupresus sempervirens Pinus brutia Acer sempervirens Quercus coccifera Berberis cretica Zelkova abelicea*
Cupressacea-Aceraceae	*Aceretea cretici*	1001-1700	*Acer sempervirens Cupressus sempervirens Quercus coccifera Quercus ilex Phyllirea latifolia Erica manipuliflora Berberis cretica*
Sub-alpine zone	*Astragalo-Acanthomonetalia*	1700-2350	*Juniperus oxycendrus Astragalus sp. Berberis cretica Verbascum spinosum*

*Source: Spanos et al 1998.

orientalis L.). Many plants, resistant to hot, dry and infertile conditions (*Achillea cretica* L.*, Adiantum capillus-veneris* L.*, Asperula incana* L.*, Ceterach officinarum* Willd.*, Ebenus cretica* L.*, Coronilla globosa* Lam.*, Linum arboreum* L.*, Onosma erecta* Sibth.&Sm.*, Petromarula pinnata* L.*, Putoria calabrica* Pers.*, Scutellaria globosa* L.*, Symphyandra cretica* L.*, Verbascum arcturus* L.*)* grow on calcareous rocks hung in small openings named Chasmophytes. Also, many endemic plants, such as *Berberis cretica* L.*, Calicotome villosa* Link.*, Euphorbia acanthothamnos* Heldr.& Sart*, Satureja Juliana* L. and*, Verbascum spinosum* L.*,* have developed spines making them resistant to grazing and other human activities.

The medicinal and aromatic plants which flourish on White Mountains and in the gorge are of the greatest interest, consisting mainly of chicory (*Chicorium intybus* L. *and C. spinosum*), marjoram, mallow, sage and thyme. One other plant is dittany (*Origanum dictamus* L. or *Dictamus creticus* L.), a Cretan endemic plant which grows in the ravines of the Cretan mountains. It is an evergreen plant with small heart-shaped fleshy leaves, light green in colour and covered with fine white hairs. It is very difficult to collect because it prefers high places, where it grows in the cracks of tall, steep cliffs. It is known for its therapeutic properties: according to the ancient writers, wild goats eat dittany to heal their wounds.

Table 2. Principal habitat types, listed by the codes of habitats directive annex I*.

Code	Name	%
1210	Annual vegetation of drift lines	0.3
3290	Intermittently flowering Mediterranean rivers	0.3
4090	Endemic oro-Mediterranean healths with gorge	2.2
5212	Juniperus phoenica arborescent matorral	0.2
5332	Diss-dominated garriques	0.2
5420	Aegean phrygana (*Sarcopoterium spinosum*)	4.1
5430	Cretan, Sardinial, Italian and Balearic phrygana formations	8.3
6310	Screrophyllus grazed forests	9.9
8140	Balkan screes	2.2
8230	Pioneer vegetation of rock surface	0.6
8310	Caves not open to the public	1.5
9290	Cypress forests (*Acero-Cupression*)	30.5
9200	Oriental plane woods (*Platanion orientale*)	1.4
9200	Thermo-Mediterranean riparian galleries (*Nerio-Tamarix*)	1.2
9320	*Olea* and *Ceratonia* forests	7.6
9540	Mediterannean pine forests with endemic Mesogean pine	29.5

*Source: Malamidis et al 1996.

Important habitats

According to the Habitats Directive Annex I in the Berne Convention Resolution of 1996, the principal habitat Type on the studied site (the Samaria Gorge and pro-posed peripheral zone of the national park) are listed on Table 2. Sixteen important habitats were recorded, form which approximately 80% are forest habitats. As men-tioned above, the vascular flora of the national park consists of up to 500 species of trees, shrubs and herbs, 77 of which are endemic, 37 rare, and 6 threatened. (Lam.). Endemic, rare and threatened plant species of the Samaria Gorge are listed on the Table 3.

Fauna

The fauna is very rich with many important and threa-tened species (16 mammals, 69 birds, 29 terrestrial malacia, 24 orthoptera, 7 isopoda, 3 trihoptera, 3 amphi-bians and 8 reptiles).

Many mammals (16) inhabit the national park and nine are listed in the Red Book (Katsadorakis, 1985; Niever-gelt and Stocker, 1986; Karadinos and Paraschi, 1992; Katsadorakis, 1994; Malamidis et al., 1996). The most important are; four endemic (*Capra aegagrus cretica*, *Eptesicus serotinus*, *Felis sylvestris cretensis*, *Rhinolo-phus blasii*), four vulnerable (*Glis glis argenteus*, *Meles mels arcalus*, *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros)*, and one rare (*Acomys minous*) . A native mammal of Crete (*Capra aegagrus cretica*) is a relative species to the domestic goat but distinctively wild, that has been isolated in the gorge. It is the emblem of the Samaria Gorge. It is one of the two remaining habitats of the Cretan wild goat or Kri-Kri (*Capra aegagrus cretica*) that lives in secluded hollows on the mountainside. The Kri-Kri are usually seen in the afternoon but their shyness makes it unlikely to glimpse one. Unfortunately, there are only about 2,000 animals remaining on the entire island and they face an insecure future: hunters still seek them for their tender meat, grazing grounds have become more scarce and disease is a harsh reality for these beautiful creatures. The list of mammals are illustrated in Table 4.

The avifauna is very rich with many birch species, since the total area of the mountain Lefka Ori (core and peripheral zone) is extensive and the number of bird species depends on the length of the forest edge (Katsadorakis, 1991; Malamidis et al., 1996). More than 69 birds nested in the national park, 28 of which are very important (20 are included on the annex I of the Directive 79/409/E.U, and eight in the Red Data Book; *Acrocephalus melanopogon*,
Aquila chrysaetos, Gypaetus barbatus, *Gyps fulvus*, *Falco peregrinus*, *fasciatus*, *Neophron percnopterus*, *Pyrrhoco-rax pyrrhocorax*). The most important are the raptor species *A. chrysaetos* which may disappear from the island of Crete as only seven or eight pairs are left. The list of avifauna (birds) is illustrated on the Table 5.

Landscape

The White Mountain region is mountainous with many

Table 3. List of endemic (E), rare (R) and vulnerable (V) plant species growing in Samaria Gorge*

Allium bourgeaui Rech. *ssp.creticum*	E
Allium dilatatum Zahar.	E
Állium rubrovittatum Boiss.& Heldr.	E
Allium tardans Greuter & Zahar.	E
Asplenium creticum Lovis,Reich., Zaffman	R
Anchusa cespitosa Lam.	R
Arabis cretica Boiss.& Heldr.	E
Arum idaeum Coustur.& Gand.	E
Arenaria guicciardii Boiss.	R
Asperula idaea Halacsy	E
Ásperula pubescens (*A. incana*) (Wild.) Ehrend & Schonb.	E
Asperula rigida Sm.	E
Avenula cycladum (Rech.& Scheff.) Greuter	E
Bellis longifolia Boiss.&Heldr.	E
Bolanthus creutzburgii Greuter	R
Brachypodium sylvaticum (Huds.) P.Beauv. *ssp.creticum* Scholz & Greuter	E
Aufonia stricta (Sm.) Gurke *ssp. Stricta*	R
Bupleurum kakiskalae Greuter	E
Campanula aizoides Zaffran	R
Campanula (Symphyandra) cretica (A.DC) Dietr.	R
Campanula jaquinii (Sieber) A.DC	E
Campanula laciniata L.	R
Campanula tubulosa Lam.	E
Carlina corymbosa L. *ssp.curetum* (Heldr.ex Halacsy) Rech.	E
Centaurea argentea L.	E
Centaurea baldaccii Degen ex Halacsy	V
Centaurea idaea Boiss.& Heldr.	E
Centaurea lancifolia Sieber ex Spreng.	V
Centaurea raphanina Sm. *ssp.raphanina*	E
Centaurea redempta Heldr.	R
Cerastium scaposum Boiss.& Heldr.	E
Cirsium morinifolium Boiss.& Heldr.	R
Colchicum cretense Greuter	E
Cotoneaster nummularia Fisch.& C.A.	V
Corydalis uniflora (Sieber) Nyman	E
Crepis auriculifolia Sieber ex Spreng.	E
Crepis cretica Boiss.	E
Crepis sibthorpiana Boiss.&Heldr.	R
Crepis tybakiensis Vierh.	E
Crocus laevigatus Bory & Chaub.	E
Crocus sieberi Gay *ssp.sieberi*	E
Cyclamen creticum (Dorfl.) Hildebr.	E
Cynoglossum sphacioticum Boiss.&Heldr.	R
Datisca cannabina L.	V
Dianthus fruticosus L., *ssp.creticus*(Tausch)	R
Dianthus juniperinus Sm.*ssp.juniperinus*	R

Table 3. Contd.

Draba cretica Boiss.& Heldr.	E
Ebenus cretica L.	E
Eryngium ternatum Poir.	R
Erysimum candicum Snogerup *ssp.candicum*	E
Erysimum mutabile Boiss.&Heldr.	E
Erysimum raulinii Boiss.	E
Euphorbia rechingeri Greuter	R
Euphorbia sultan-hassei, Strid, Bentzer, Bothmer	R
Ferulago thyrsiflora (Sm.) W.D.J.Koch	R
Festuca polita (Halacsy) Tzvelev *var.cretica*	E
Galium fruticosum Willd.	E
Galium incurvum Sm.	E
Galium monachinii Boiss.& Heldr.	E
Galium samothracicum Rech.	E
Gypsophila nana Bory & Chaub.	E
Helianthemum hymettium Boiss.&Heldr.	E
Helichrysum heldreichii Boiss.	R
zHerniaria parnassica Chaudhri *ssp.cretica*	E
Hypericum empetrifolium ssp.oliganthum (Rech.) Hagemann	E
Hypericum kelleri Bald.	R
Hypericum trichocaulon Boiss.& Heldr	E
Hypochoeris tenuiflora Boiss.	E
Inula candida (L.) Cass.	E
Linum tearns s L.(including.L.caespitosum)	R
Lomelosia (Scabiosa) albocincta (Greuter) Burdet	R
Lomelosia sphaciotica (Roem.& Schult.) Greuter	E
Lysimachia serpyllifolia Schreb.	E
Melica rectiflora Boiss.& Heldr.	E
Minuartia wettsteinii Mattf.	R
Muscari spreitzenhoferi (Heldr.ex Osterm.) Vierh	E
Odontites linkii Heldr.& Sart.ex Boiss. *Ssp.cretica* (Boiss.) Greuter	E
Onobrychis sphaciotica Greuter	R
Origanum dictamnus L.	V
Origanum microphyllum (Benth.) Vogel	E
Paeonia clusii Stern & tearns sp.*clusii*	E
Petromarula pinnata (L.) A.DC	E
Petrorhagia dianthoides (Sm.)P.W.Ball	R
Peucedanum alpinum (Sieber ex Schult.) B.L.Burtt & P.H.Davis	R
Phagnalon pygmaeum (Sieber) Greuter	E
Phlomis lanata Willd.	E
Pimpinella cretica Poir.	E
Pimpinella tragium Vill. *Ssp.depressa* (D.C.)Tutin	E
Prunella cretensis Gandoger	E
Ranunculus creticus L.	R

Table 3. Contd.

Ranunculus radinotrichus Greuter & Strid	R
Ranunculus subhomophyllus (Halacsy) Vierh.	R
Ricotia cretica Boiss.& Heldr.	E
Sanquisorba cretica Hayek	R
Saturejia cretica (L.) Briq.	R
Scabiosa alpestris (Gand.)Greuter,Matthas	E
Scilla nana (Schult.) Speta	E
Scutellaria hirta Sm.	E
Scutellaria sieberi Benth.	E
Senecio fruticulosus Sm.	R
Securigera (Coronilla) globosa (Lam.) Lassen	E
Sedum creticum C.Presl	E
Sedum praesidis Runemark & Greuter	E
Sedum tristriatum Boiss.& Heldr.	E
Sesleria doerfleri Hayek	E
Silene pinetorum Boiss.&Heldr.	R
Silene sieberi Fenzl	E
Silene variegata (Desf.)Boiss.&Heldr.	E
Sideritis syriaca L. *ssp.syriaca*	E
Staehelina fruticosa L.	R
Staehelina petiolata (arborea) (L.) Hilliard & B.L.Burtt	E
Symphytum creticum (Willd) Runemark ex Greut. & Rech.	E
Telephium imperati L. *ssp.pauciflorum*	E
Teucrium cuneifolium Sm.	R
Thlaspi creticum (Degen &Jav.) Greuter	E
Thlaspi zaffranii Greuter & Burdet	R
Ôulipa cretica Boiss.& Heldr.	E
Valeriana asarifolia Durf.	E
Verbascum arcturus L.	E
Verbascum spinosum L.	E
Veronica glauca Sm. *ssp.cavusica* (Rech.) M.	E
Veronica thymifolia Sm.	E
Viola fragrans Sieber	E
Zelkova abelicea (Lam.) Boiss.	V

Source: Malamidis et al 1996; Laboratory of Silviculture (Forest Research Institute)

ravines, and steep slopes. The main ravine of the area is, however, the famous “Samaria gorge”. The geology of the park is basically limestones. The lower part of the gorge-consists of Permian-carboniferous platy crystalline limestones, light grey to dark grey with thin phyllitic intercalations The upper part of the valley consists of a Triassic system overlying transgressively, limestone and dolomites dark grey to black. The dark coloured parts of the series are bituminous and often have a cellular texture, especially the dolomites. The whole area is impassable and almost inaccessible. The many peculiar landscapes form a rare totality, one unique picture to

Table 4. List of endemic mammals, according to the list of Red Book**

Mammals	Core zone (Samaria Gorge)	Peripheral zone	Red book
Acomys minous	+	+	R
Apodemus sylvaticus	+	-	-
Apodemus mystacinus	+	-	-
Capra aegagrus cretica	+	-	E
Eptesicus serotinus	+	-	E
Erinaceus concolor	+	+	-
Felis sylvestris cretensis	+	-	E
Glis glis argeneus	+	-	V
Lepus capensis	+	+	-
Martes foina	+	+	-
Meles meles arcalus	+	+	V
Mustela nivalis	+	+	-
Rattus rattus	+	+	-
Rhinolophus blasii	-	+	E
Rhinolophus ferrumequinum	-	+	V
Rhinolophus hipposideros	-	+	V

*: endemic (E), vulnerable (V), rare (R), presence (+), absence (-).
**: Source: Katsadorakis 1985; Nievergelt & Stocker 1986; Malamidis et al 1996.

wilderness.

Land use

According to existing legislation, activities such as forestry, fishing, hunting, grazing, urban and industrial developments are strictly forbidden within the National park. Law implementation is relatively easy because all private land and the small village of Samaria have been expropriated. The only human activity which is allowed, but is not intensive, is recreation, specially hiking.

All the land of the national park belongs to the State, and is administrated by the Forestry Directorate of Chania, a city 44 Km away. The main land uses are forestry and grazing. There is a rapidly increasing tourist traffic (more than 232,000 visitors per year) . The forest cover is high (71.7 % of the core- Samaria Gorge and 45.5% of the peripheral zone). The peripheral zone has suffered from wildfires, destructive human operations, and overgrazing by goats. Overgrazing, particularly by goats, was the primary cause of deforestation in ancient Greece and Rome (Hughes and Trirgood, 1982; Schule, 1993). Since ancient times, Cretans have spent much of their time grazing their animals on the mountain Lefka Ori. Today, more than 50,000 sheep and goats are grazing in the national park. Generally, the productivity of four types of rangelands (grasslands, phrygana, evergreen shrublands, partially forest areas) in the national park (core and peripheral zone) is much lower than the consumption, due to over -grazing, wildfires, land use changes, etc. (Malamidis et al., 1996).

Land use on White Mountains (national park) is illustrated in Table 6. Another interesting land use of Samaria Gorge is tourism. There is rapidly increasing tourist traffic (today about 200,000 people visit and hike in the gorge every year). The monthly number of visitors to the Samaria Gorge for the period 1981-2005 is illustrated on the Table 7. Total visitors for the period 1981-2005 were 5,718,808, mean annual 232,772, maximum annual 297,680 (1993) and minimum annual 132,794 (1981).

Threats

The main threats to the national park are the pressures of many visitors, wildfires and over-grazing. There is illegal hunting and grazing in the remoter areas. The carrying capacity of the park has not exceeded saturation level. Carrying capacity is the basic issue in resources management (Trakolis, 2003; Rackham and Moody, 1996). But, tourism has created some problems in the nearby village of Agia Roumeli, that is situated near the exit of the Samaria Gorge, close to the sea. This village has been expanding rapidly along the coast and has been transformed from a traditional settlement to a modern seaside resort.

Danger from wildfires caused by summer visitors is a constant threat. The possibility of uncontrolled wildfires is

Table 5. List of the birds of White Mountains (and Samaria Gorge)*

Birds	Nest (during the year) (0)	Nest (during the winter) (*)	Migrate (+)	79/409/E.U. (#)	Red data (V,E,R,K)
Acanthis cannabina	0	*	-	-	-
Accipiter nisus	0	-	-	-	-
Acrocephalus melanopogon	-	*	-	#	R
Alectoris chukar	0	*	-	-	-
Aquila chrysaetos	0	-	-	#	V
Anthus campestris	0	-	-	#	-
Anthus spinoletta	-	-	+	-	-
Anthus trivialis	-	-	+	-	-
Apus apus	-	*	-	-	-
Apus melba	0	-	-	-	-
Buteo buteo	0	*	-	-	-
Campimulgus europaeus	0	-	+	#	-
Carduelis chloris	0	-	-	-	-
Carduelis carduelis	0	*	-	-	-
Certhia brachydachyla	0	*	-	-	-
Columpa livia	0	*	-	-	-
Columba palumbus	0	*	-	-	-
Cinclus cinclus	-	*	-	-	-
Cornus corax	0	*	-	-	-
Cornus corone	0	*	-	-	-
Delichon urbica	0	-	-	-	-
Emderiza circus	0	-	-	-	-
Erithacus rubecula	-	*	-	-	-
Falco peregrinus	0	-	-	#	V
Falco subbueto	-	*	-	-	-
Falco tinnunculus	0	*	-	-	-
Ficedula albicollis	-	-	+	#	-
Frignilla coelebs	0	*	-	-	-
Garrulus glandarius	0	*	-	-	-
Gypaetus barbatus	0	*	-	#	E
Gyps fulvus	0	*	-	#	V
Hieraeetus fasciatus	0	-	-	#	V
Hirudo rustica	-	-	+	-	-
Hippolais icterina	-	-	+	-	-
Hippolais pallida	0	-	-	-	-
Loxia curvirostra	0	-	-	-	-
Lullula arborea	0	*	-	#	-
Monticola solitarius	0	*	-	-	-
Motacilla alba	0	*	-	-	-
Motacilla cinerea	-	*	-	-	-
Motacilla flava	0	-	-	-	-
Muscicapa striata	0	-	-	-	-
Neophron perncopterus	-	-	+	#	V
Oeanthe hispanica	0	-	-	-	-
Oeanthe oeanthe	0	-	-	-	-

Table 5. Contd.

Oriulus oriolus	-	-	+	-	-
Otus scops	0	*	-	-	-
Parus caerutus	0	8	-	-	-
Parus major	0	*	-	-	-
Passer domesticus	0	-	-	-	-
Phoenicurus ochruros	-	-	+	-	-
Phoenicurus phoenicurus	-	*	-	-	-
Phylloscopus collybita	-	*	-	-	-
Phylloscopus bonelli	-	*	-	-	-
Phyloscopus sibilatrix	-	-	+	-	-
Prunella collaris	0	-	-	-	-
Ptyonoprogne rupestris	0	-	-	-	-
Pyrrhocorax pyrrhocorax	0	*	-	-	K
Pyrrhocorax graculus	0	-	+	-	-
Regulus sp.	-	*	-	-	-
Saxicola torquata	0	-	-	-	-
Streptopelia turtur	-	-	+	-	-
Stumus vulgaris	-	*	-	-	-
Sylvia atricapilla	-	*	-	-	-
Sylvia communis		-	+	-	-
Sylvia melanocephala	0	*	-	-	-
Sylvia ruepelli	0	-	-	#	-
Troglodytes troglodytes	0	*	-	-	-
Turdus merula	0	*	-	-	-

Source: , Nievergelt & Stocker 1986; Katsadorakis 1991; Malamidis et al 1996.

Table 6. Land use types of white mountains (Samaria Gorge and peripheral zone)*

	Core zone (Samaria Gorge)	**Peripheral zone**	**Total**	**Core zone (Samaria Gorge)**	**Peripheral zone**	**Total**
Land Type	**Area (ha)**	**ha**	**ha**	**%**	**%**	**%**
Forestry land	4,527.85	7,186.72	11,714.57	71,70	45,50	52.98
Grazing land	1,610.33	8,094.94	9,707.27	25,50	51.25	43.90
Rocky habitats and caves	176.82	442.26	619.08	2,80	2,80	2.80
Agricultural land	0.00	71.70	71.70	0,00	0,45	0.32
Total	6,315.00	15,795.62	22,110.62	100.00	100.00	100.00

*Source: Malamidis et al 1996 ; Laboratory of Rangeland Resources (Forest Research Institute).

due to the extremely flammable plant life. Because of vegetation types, their flammability and the warm-dry climate, wildfire threatens the entire park ecosystem. Traditional measures for fire-fighting such as bare-zones, forest-roads, vehicles for fire combating are not suitable because of the existent Park regulations. Also, they do not allow such activities within the park. So, all efforts for fire fighting have been geared to prevention and control of dangerous visitor activities. There exists, also, a satisfactory system for utilizing stream and spring waters when wildfire breaks-out. Additionally, a large number of uncontrolled pastoral fires burn each year (in the peripheral zone and neighbouring areas) and this is the main reason for the degrading of the forest lands to phrygana

Table 7. Monthly number of visitors in Samaria Gorge for the period 1981-2005*.

YEARS	April	May	June	July	August	Sept.	October	Total
1981	0	14,206	16,084	27,397	36,529	25,260	13,318	132,794
1982	0	15,200	17,913	32,967	37,629	20,024	17,063	140,797
1983	0	15,341	24,740	41,306	42,783	40,815	33,988	198,973
1984	0	20,392	25,745	41,123	53,847	34,961	19,344	195,412
1985	0	25,317	29,302	46,302	53,702	40,080	18,743	213,446
1986	0	30,344	30,450	46,977	54,050	40,122	21,324	223,267
1987	0	11,865	32,136	44,575	53,670	41,144	26,020	209,410
1988	0	31,884	35,161	45,014	60,692	44,116	26,365	243,232
1989	0	37,580	30,840	45,768	58,666	45,136	16,843	234,833
1990	17,820	42,724	38,623	50,455	63,115	52,938	32,005	297,680
1991	6,208	34,500	34,453	49,758	64,456	55,057	27,866	272,298
1992	0	37,534	46,393	55,192	65,270	56,795	29,952	291,136
1993	6,735	31,903	44,627	62,447	71,368	50,552	29,737	297,369
1994	2,940	43,560	40,656	55,176	66,792	58,080	23,233	290,402
1995	0	36,061	40,531	49,794	60,012	48,670	35,027	270,095
1996	2,566	39,843	32,627	45,036	56,380	43,745	27,035	247,232
1997	1,461	36,068	35,213	44,362	59,376	47,680	20,424	244,584
1998	0	30,892	36,577	39,520	50,986	46,649	24,346	228,970
1999	2,157	36,448	36,690	43,138	50,949	48,490	30,642	248,514
2000	2,176	34,089	36,747	37,572	52,044	44,112	25,611	232,351
2001	0	31,706	35,555	44,421	53,822	46,152	30,478	242,134
2002	650	30,905	32,512	38,294	45,255	42,694	21,286	211,596
2003	362	18,863	31,043	31,844	41,327	37,941	25,854	187,234
2004	3,773	27,997	26,917	30,524	37,120	35,080	20,074	181,485
2005	2,720	25,347	29,892	30,635	39,700	36,899	18,368	183,561

Source: Forestry Directorate of Chania.

communities.

Grazing within the boundaries of the park (the Samaria Gorge) is strictly forbidden. However, in the vicinity there is over grazing by domestic goats that are descendants of wild goats. They usually browse freely and very often without shepherds thus destroying the natural regeneration of important plant species.

Other threats are genetic intercourse (interbreeding), hunting and poaching. Although hunting is strictly forbidden within the park boundaries, nobody can guarantee that poaching has been completely eradicated. In the recent years, however, the number of full-time and part-time rangers has considerably increased and they greatly contribute to poaching elimination. Genetic intercourse is one of the major problems which concerns the site. It refers to the cross breeding of the mammal *Capra aegagrus cretica* with domestic goats that have turned wild, a process about which little is known (Papageorgiou, 1972; Husband, 1977; Husband and Brown, 1994). Illegal hunting and poaching in the area surrounding the Samaria Gorge (in the proposed peripheral zone and neighbouring areas on the mountain Lefka Ori) is the main reason for the decrease in the population of wild goats (*Capra aegagrus cretica)* and many important mammals and birds.

Another serious threat is the decline of *Cupressus sempervirens* trees due to the fungus *Seiridium cardinale*. Although the presence of the disease in natural populations of this tree species on the White mountains (Lefka Ori in Greek language) has been recorded, there is a complete absence of essential knowledge regarding the state and stage of the disease's spread at present.

There are few studies referring to the ability of ecosystems to rehabilitate themselves after the cessation of destructive human activities (mainly the abandonment of traditional terrace farming). Accompanying the secondary succession process, is the establishment of the pioneer species of conifers (*Pinus brutia* and *C. sempervirens*).

The impacts of these actions on the population's dynamics of the endemic species have not been adequately studied as yet.

New conservation works and actions

In order to conserve the White Mountains (and Samaria Gorge) National Park and its special value, some new works concerning non-recurring and recurring biotope management should be taken, and the most important are the following:

-Providing the appropriate durable equipment, one helicopter for observation (wildfire threat) and ferrying (visitors after an accident, anti-fire equipment, etc).
-Creating adequate infrastructure (hedges, boundary stones, new paths establishment, observation platforms, entrances, rest areas for visitors, signs).
-Recruitment of the appropriate staff (guides, wardens, foresters).
-Creating appropriate new buildings (administration building, park headquarters, station in the centre of the core, rangers' huts, scientific work station)
-Conservation efforts concern ecological and special values of great importance, (conservation and restoration of the traditional and cultural monuments, monitoring, maintenance of infrastructure recurring and non-recurring works).

DISCUSSION

The Samaria Gorge (the core of the White Mountains national park in Crete) is considered a famous Biosphere Reserve of great interest in its natural resources, rich flora and fauna with many endemic, rare and threatened species.

The park contains a number of plant and animal species which are endemic and rare. The White Moun-tains is the only place where free-ranging *Capra aegagrus cretica* ("agrimi" is the local Greek name) as a pure strain still occurs in the wild. Preservation and conservation of species is necessary. The park, also, contains important and significant natural habitats where rare and threatened species of animals and plants exist (Phitos et al., 1995). The forest ecosystems of the studied area are broadleaved evergreen woodlands, pines, cypress and Cretan maple woods, wetlands, garrique and maquis, Cretan phrygana, Chasmophytes. This vegetation's biodiversity with its many endemic species, is very important for the scientific, ecological and socio-economic profitability of the Samaria Gorge. The fauna is very rich with many interesting and vulnerable species (such as the mammal *Capra aegagrus cretici* and the raptor *A. chrysaetos*).

The Greek Authorities must take into consideration the proposal of the General Management Plan (GMP) (Malamidis et al., 1996), that supports the extension of the national park of the Samaria Gorge (4,850 ha) including a peripheral zone (6,315 ha the core and 15,795 ha the peripheral zone, total 22,110 ha). Local societies, tourists, inhabitants of the settlements on the mountain Lefka Ori, land owners, social and scientific groups will be influenced by the application of the GMP.

Management of people (visitors in particular) is effective. They are allowed to use the single trail and are well controlled. Management of forest and plants is restricted only to their protection from wildfires. For this reason water-fountains and a small fire station with necessary equipment have been constructed. Manage-ment of the wild goat is also negative, consisting mainly of fencing around park boundaries. Fencing, however, has not been completed yet and maintenance of what exists is minimal. The result is inter-breeding between domestic and wild goats, and the development of a park population which is not pure.

Tourism originated from the park. Local people have generally understood its value and respect the park and therefore their tourist activities concentrate on areas outside of the park limits but within its vicinity. Country, regional and national planning by agencies or other organisations primarily focuses also, on promoting tourism in the area.

In case the Samaria gorge is included in the World Heritage List, a buffer zone around the park-core must be defined. Implementation of this decision is easy to the north, west and east borders, where lands are mountainous and the main land use activities from local people are grazing and apiculture. It is difficult to the south side near the sea, where tourism is well developed and any kind of control would be unpopular. However, the control of tourist development will assist the park manager in fulfilling his objectives for conservation, pre-servation and landscape protection. The other impacts on the park would be positive. Namely, the World Heritage Convention as an international legal instrument will provide additional legal protection for the park, if included in the List. Scientific, economic and technical assistance from the Convention will contribute, also, to better preservation, conservation and protection of the park.

There is an absolute need for an efficient, strict and concrete management policy as well as the extension of the National Park's limits so as to include other adjacent gorges and mountain tops of the neighbouring "Lefka Ori".

Additionally, an organisation by public and private groups, responsible for the total management of the White Mountains, must be set up to determine and be able to effectively apply the management decisions. This viable organisation is needed to properly provide for the better protection of the resources of the national park and for their appropriate enjoyment, so that as many people as possible (including local people and politicians) will realise and accept its importance. It has to be demonstrated in practice that the proper management in national parks is capable of bringing real advantages to the local people, to the nation itself and to the world's community as a whole. This can only be achieved through a great change of policy and via active positive management. The first priority must be scientific research related to various matters of nature conser-vation. High priority should also be given to education and its specific applications to the national parks reality, while extra care should be taken in attracting, selecting and controlling visitors and improving the social and economic conditions of the local inhabitants.

It is obvious that there is a need for a comprehensive application of the GMP to cover all aspects of the national park's conservation and management according-ly, so as to successfully implement such a great effort. Today, high priority is given to improve the conservation and management conditions of the studied area. Steps which have already have been taken, demonstrate a commitment on the part of the government for better administration of national parks and other protected areas in Greece.

Facilities for the reception of the public are also expanding each year. However, the progress of improving administration and management of the studied national park, strictly depends on the budget available. The central and local authorities responsible for the Samaria Park have been difficulties in expanding their efforts without special extra support. The budget allocation for this national park is exceptionally small. This budget is part of the total one for all the activities of the forest sector and every year it amounts to a more or less stable percentage of the total expenditure for the region of Crete. This means that the budget for this national park cannot exceed the present levels, without extra support, because this would have negative affects on other activities of the forest sector.

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