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# Processes and patterns of landscape change on a small Aegean island: The case of Sifnos, Greece

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ABSTRACT

The Mediterranean island landscape is a mosaic of land-cover types that manifest the historical interaction between physical and anthropogenic processes that have affected significantly landscape composition and spatial configuration. The aim of this study is to investigate the processes and patterns of landscape changes in small Mediterranean islands as exemplified by the Aegean island of Sifnos, Greece. Satellite imagery was used to measure land-cover changes from 1987 to 1999. A suite of landscape metrics was employed to quantify changes in landscape structure. The results show that cropland suffered the highest area loss through conversions to semi-natural vegetation or settlements. The maquis vegetation of *Juniperus phoenicea* expanded over time with hotspots of expansion mainly located away from settlements. Overall, Sifnos' landscape became less fragmented and more homogeneous. The main drivers of landscape change were agricultural decline and tourism. These processes have resulted in semi-natural vegetation expansion and landscape closure. Landscape polarization of land-use intensity has increased with anthropogenic processes operating only on certain locations close to settlements and large parts of the island loosing their productivist profile. However, tourism should not be considered as the primary cause of land-use polarization but rather as an aggravating factor; agriculture and tourism do not represent competing economic sectors and land-use polarization is mainly the outcome of spatially co-occurring rather than spatially competing processes. Aegean island landscapes' management needs to be pragmatic and as such adaptable to future emerging priorities.



## 1. Introduction

Small islands are natural laboratories for the study of natural and cultural processes (Blondel, 2008; Patton, 1996; Whittaker and Fernandez-Palacios, 2006). Although small islands and continental areas are often subject to similar socio-economic and physical processes, the effects are more profound on islands due to their limited size, resources, and their remoteness (Royle, 2001).

The typical Mediterranean island landscape is a mosaic of land-cover types that manifest the historical interaction of physical and anthropogenic processes (Vogiatzakis et al., 2008a), which over the last 50 years have produced significant physical and cultural changes (Terkenli, 2005). The main activities that have shaped these landscapes are mining, wood-cutting, agriculture and tourism, exploiting often-limited natural resources. Mining plays an important role in modifying the landscape of some small Mediterranean islands by directly affecting the character of the landscape (Evangelinos and Oku, 2006). Wood-cutting, to supply both fuel and timber, has been historically one of the most significant human resource exploitation activities (Thirgood, 1981) but the intensity of at which this takes place has decreased considerably during the last century (Margaris et al., 1996; Grove and Rackham, 2001).

Exogenous drivers, such as the European Union Common Agricultural Policy (CAP) (Tzanopoulos et al., 2007; Vogiatzakis et al., 2008b) and tourism (Ioannides et al., 2001) have also considerably impacted the composition and dynamics of many of the Mediterranean island landscapes. Since the second world war the main priority of European agricultural policy has been the maximization of food production and modernization of the agricultural sector (Evans and Morris, 1997; Hadjimichalis, 2003). The productivist ideology of CAP prior to 1992 led to increasing polarization between intensively farmed areas (such as the productive lowlands and plains) and extensively managed areas (such as the less productive uplands and islands) (Antrop, 2005; Zomeni et al., 2008). This pattern has been observed across the islands of the Mediterranean. As a result, on larger islands such as Sicily, Sardinia, Crete, investments in irrigation were made and intensive agriculture is now present (Vogiatzakis et al., 2008a). On the smaller islands however, agricultural decline is widespread (Petanidou et al., 2008). Both of these processes of agricultural change have resulted in the grad-

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ual decline of low intensity crop production and the abandonment of the terraced fields (Kizos and Koulouri, 2006; Kizos et al., 2009; Tzanopoulos et al., 2007). In addition, over the past 50 years, most of the Mediterranean islands have experienced significant tourism development, of variable type and intensity between and within islands. The contemporaneous agricultural decline and "leisuring" (a term coined by Bunce, 2008) of these island landscapes can be viewed as part of the wider process of change from a productivist to a consumption countryside taking place in many places in the Mediterranean (Antrop, 2005; Pinto-Correia, 2000).

The diverse impacts of the above drivers of change on the physical elements of these Mediterranean island landscapes have been reported in numerous studies. Kizos and Koulouri (2006) note that changes in the agricultural sector have often been associated with abandonment of terrace cultivation and the subsequent grazing has led to vegetation degradation (see also Petanidou et al., 2008; Tzanopoulos et al., 2007). Papanastasis et al. (2009) observe that some agro-silvopastoral practices on the islands in the past have resulted in forest degradation, however Grove and Rackham (2001) point out that this has also contributed to the fine-grained structural heterogeneity of Mediterranean landscapes. Cartagena and Galante (2002) point out that the rapid growth of urban and tourism development has resulted in significant loss of biodiversity and habitats of high ecological value, as well as the homogenization of island landscapes (see also Morey and Ruiz-Pérez, 2008; Otto et al., 2007; Tzatzanis et al., 2003). These land-use changes have also been associated with land degradation and desertification, something that is still high on the research and political agenda in the Mediterranean region (Geeson et al., 2002). Although the changes reported above are strongly supported by observational evidence, there is also a significant body of literature that contests these visions of change (Grove and Rackham, 2001; Mazzoleni et al., 2004). This lack of consensus regarding the impacts of current anthropogenic processes on Mediterranean landscapes is due to the fact that, with few exceptions, the impact of particular land-use changes on landscapes have so far been treated separately and at a very coarse scale (Ioannides et al., 2001; Mazzoleni et al., 2004).

The overall aim of this paper is to investigate, in more holistic fashion, the processes and patterns of landscape change on small Mediterranean islands, using as an exemplar the island of Sifnos. The specific objectives of the study are: (a) to examine the role of the main drivers that shape the landscape of Sifnos; and (b) to describe and assess the impacts of these drivers on the composition and spatial configuration of the island's landscape. The results are discussed within the broader context of managing landscape change, in order to generate judgments on whether current landscape changes on the such islands should be perceived as negative and requiring policy interventions.

## 2. Materials and methods

### 2.1. The study area

The island of Sifnos is situated in the south-west chain of the Cyclades island group (Fig. 1). Sifnos was selected as the study area because: (a) it is a typical example of small Mediterranean islands in terms of land-use history, environmental conditions, topography and vegetation; and (b) published material is available on vegetation structure and succession; and (c) part of the island is included in the EU network of protected sites for Greece, i.e. the Natura 2000 network (Dafis et al., 1996). Characterized by a xerothermo-mediterranean type climate, Sifnos is a small mountainous island of some 81.1 $km^2$, a maximum altitude of 681 m, with steep slopes and relatively few flat areas. The landscape is a mixture of semi-natural vegetation, cultivated or abandoned terraces and picturesque Cycladic-style villages. The semi-natural vegetation of the island is a mixture of maquis (community of *Juniperus phoenicea*) and phrygana (community of *Sarcopoterium spinosum–Coridothymus capitatus*) (Tzanopoulos et al., 2005, 2007). Historically, the main land-uses have been mining, wood-cutting, agriculture and tourism. In antiquity, Sifnos was famous for its gold and silver mines, which were productive until around 400 B.C. (Ashton, 1991). Iron and lead mines operated on the island from the 16th until the beginning of the 20th century (Davis, 1966).

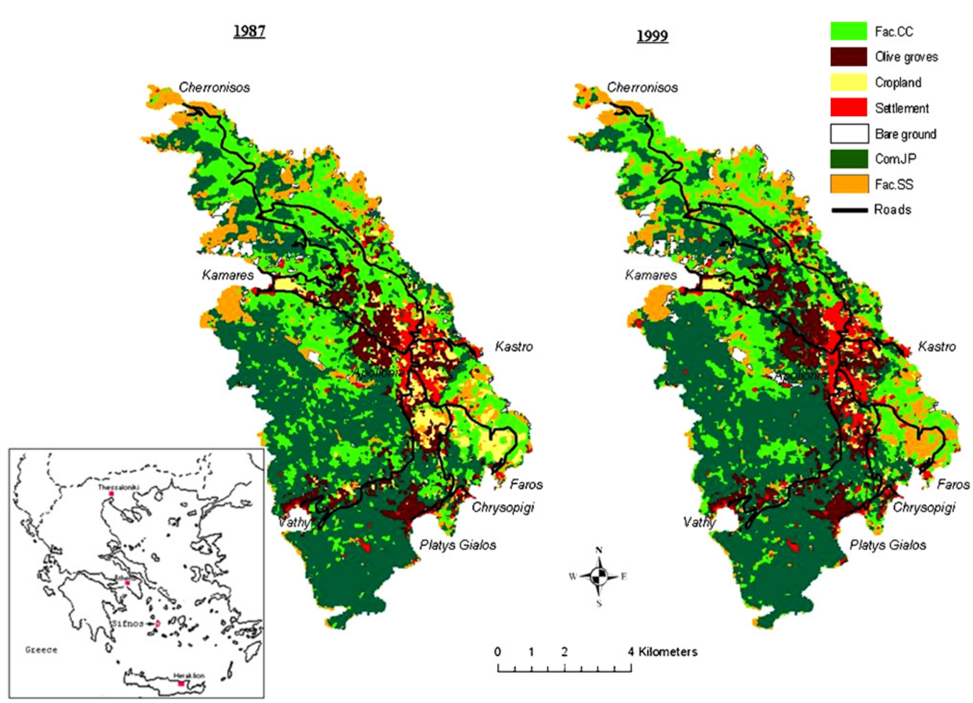


**Fig. 1.** Location of Sifnos in Greece and the generated land-cover maps in 1987 and 1999. The names of some important location are also provided. Apollonia is the capital of Sifnos, Kamares is the main port of the island and Vathy, Platys Gialos, Chrysopigi, Faros and Cherronisos are the sandy beaches accessible to tourists.

**Table 1**
Area (hectares) and percentage area (in italics) of land converted from one land-cover type to the next between 1987 and 1999. *Abbreviations*: Com.JP = community of *Juniperus phoenicea*, Fac.CC = facies of *Coridothymus capitatus–Calicotome villosa–Pistacia lentiscus*, Fac.SS = facies of *Sarcopoterium spinosum*, Built-up = Built-up area, %TA = percentage of total area of the island.

| 1987\1999 | Com.JP | Fac.CC | Fac.SS | Cropland | Built-up | Sum 1987 | %TA |
|---|---|---|---|---|---|---|---|
| Com.JP | 2581 | 379 | 105 | 23 | 16 | 3116 | 41.5 |
| | *82.8* | *12.2* | *3.4* | *0.7* | *0.5* | | |
| Fac.CC | 571 | 1215 | 226 | 29 | 27 | 2090 | 27.8 |
| | *27.3* | *58.2* | *10.8* | *1.4* | *1.3* | | |
| Fac.SS | 103 | 169 | 454 | 10 | 24 | 809 | 10.8 |
| | *12.7* | *20.9* | *56.1* | *1.2* | *2.9* | | |
| Cropland | 91 | 59 | 107 | 90 | 48 | 397 | 5.3 |
| | *22.8* | *14.9* | *26.9* | *22.7* | *12.2* | | |
| Built-up | 0 | 0 | 0 | 0 | 333 | 333 | 4.4 |
| | *0* | *0* | *0* | *0* | *100* | | |
| Sum 1999 | 3364 | 1837 | 912 | 152 | 451 | | |
| %TA | 44.8 | 24.4 | 12.1 | 2 | 6 | | |

Widespread cutting of trees and shrubs have taken place in the past in order to provide fuel for the operation of numerous pottery kilns; however, in the last 30 years this practice has almost entirely ceased (Tzanopoulos et al., 2005). Local timber was once used for boat-making and house-building, but since WWII this activity has also ceased completely. Agriculture has been responsible for the transformation of the hills into small stepped terraces that have been cultivated with crops typical of Aegean island landscapes, such as cereals, vegetables, olive trees and vineyards (Kizos and Koulouri, 2006; Petanidou et al., 2008; Vernicos, 1990). During the past four decades many of these terraces (especially those formerly cultivated) have been abandoned. Some of the abandoned terraces, as well as the infertile mountainous areas of the island have always been used as pastures for sheep and goats (Tzanopoulos et al., 2007). The last 10–20 years has witnessed major development associated with the growth of the tourist industry, resulting in a significant urbanisation and the construction of new roads (Tzanopoulos, 2002). The main period of tourism expansion on Sifnos was during the 1990s, during which time two major road improvements took place connecting the capital of Sifnos (Apollonia) with the towns of Vathy and Cherronisos (pers. Comm., Tourism Development Board of Sifnos – TDBS) (see Fig. 1).

The whole island has been designated as a Special Beauty Landscape (national designation) while the central-west part of Sifnos has been designated as a Natura2000 site (code GR4220008) because of the presence of important *J. phoenicea* maquis vegetation.

### 2.2. Data analysis

Two land-cover maps were generated using supervised maximum likelihood classification, in ERDAS, of two geo-rectified Landsat TM5 images taken in July 1987 and August 1999. The selection of training sites used for the classification was informed by an earlier vegetation survey carried out on the island in 1995–1996 (Tzanopoulos, 2002). The images were acquired from the Global Landcover Facility at the University of Maryland and were selected on the basis of archive availability and cloud cover. Both images used were cloud free. The following seven land-cover classes were identified: maquis, phrygana, mixed (or transitional) maquis–phryganic vegetation, built-up area, cropland, olive groves and bare ground. The first three classes represent the semi-natural vegetation of the island and correspond to three vegetation types identified by Tzanopoulos et al. (2005): (a) maquis community of *J. phoenicea*; (b) facies of *S. spinosum* and (c) facies of *C. capitatus–Calicotome villosa–Pistacia lentiscus*. Both facies belong to the community of *S. spinosum–C. capitatus*. The classification accuracy assessment of the 1999 image was assessed by comparison with the field survey undertaken in June 1999. This consisted of comparison of 1000 points systematically spaced across the island. The overall accuracy of the 1999 image classification was 79%, with a Kappa statistic of 0.7.

In addition, the island was divided into urban and non-urban "zones", where 100 m buffer zones around all roads and built-up areas were classified as urban. Once the classification process was complete a transition matrix was generated which identified the predominant land-cover changes that had taken place between 1987 and 1999, within and outside of the urban zones and across the whole island.

In order to describe how the landscape has changed, particularly in terms of heterogeneity and fragmentation, as a result of land-cover changes between 1987 and 1999, commonly used landscape metrics were estimated using the software V-Late (Lang and Tiede, 2003). These landscape level metrics included: Number of Patches (NP); Edge Density (ED); Shannonǐs Diversity Index (SHDI); Shannonǐs Evenness Index (SHEI); and Mean Proximity. Metrics at land class level included Number of Patches (NP); Class Area (CA); Total Edge (TE); Core Area Index (CAI); and DIVISION.

In order to investigate the spatial pattern of changes in the *J. phoenicea* community, the dominant vegetation type in the Natura 2000 site on the island, the total area of expansion/loss was calculated within a 100 m × 100 m square grid. The ArcGIS Average Nearest Neighbor Distance Spatial Statistics tool was then used to examine whether the *J. phoenicea* community expansion/loss occurs in clusters, or whether it is dispersed across the island. Finally, the ArcGIS Hot Spot Analysis Getis-Ord Gi* Spatial Statistics tool was used to identify the hotspots of expansion/loss across the whole island.

## 3. Results

### 3.1. Changes in the composition of the landscape

The land-cover transitions that took place between 1987 and 1999 are presented in Table 1. As the table shows, cropland suffered the largest area loss (62% of its 1987 extent) mainly through conversions to semi-natural vegetation and in particular to the community *J. phoenicea* (23%) and to facies *S. spinosum* (27%). The built-up area also expanded over this period on former cropland (+35%). Significant changes are also seen to have taken place in the extent of semi-natural vegetation types. The community *J. phoenicea* was the dominant land-cover class in 1987 (occupying 77% of Sifnos' total land area) and over the period of review it further expanded, mainly replacing areas of facies *C. capitatus–C. villosa–P. lentiscus*. Facies *S. spinosum* occupied only 3% of the island's area in 1987, but this expanded by 12%, mainly replacing other semi-natural vegetation types. Facies *C. capitatus–C. villosa–P. lentiscus* suffered considerable area loss mainly through conversion to community *J. phoenicea* and facies *S. spinosum*. As demonstrated in Table 2, land-cover changes have been more prominent inside than out-

**Table 2**
Percentage of overall land-cover change and percentage of land-cover change related to semi-natural vegetation only (i.e. community of *Juniperus phoenicea*, facies of *Coridothymus capitatus–Calicotome villosa–Pistacia lentiscus* and facies of *Sarcopoterium spinosum*) across the whole island, inside and outside the urban zone (as defined in Section 2).

| | Whole island | Non-urban | Urban |
|---|---|---|---|
| % area of land-cover change | 28 | 25 | 34 |
| % area of vegetation change | 7 | 4 | 13 |

side the urban zones; the same applies for observed changes in the semi-natural vegetation across the island.

### 3.2. Changes in the configuration of the landscape

Table 3 shows the changes in the spatial patterns of the landscape metrics between 1987 and 1999. The Number of Patches has increased across the whole island with the highest percentage increase observed in the urban zones. The change in Edge Density showed a similar pattern in urban zones, but not in non-urban. While Number of Patches and Edge Density are two of the metrics most commonly used to describe landscape changes, they may lead to erroneous conclusions if they are used as the sole metrics to describe changes in fragmentation and heterogeneity. The increase in Number of Patches and Edge Density suggests that in specific locations the level of heterogeneity and fragmentation has increased. However, the same cannot be inferred for the landscape of the island overall. This is because both metrics are scale dependant and do not take into account the "overall area" of a habitat. Thus, in order to obtain a more accurate picture of the change in landscape heterogeneity, the Shannon Diversity Index and the Shannon Evenness Index were used. Both of these are measures of diversity, referring to compositional and structural components of diversity, respectively. Using these additional indicators it was observed that between 1987 and 1999 the island became both less diverse and with a more uneven distribution of the patches of the different land-cover types. The % change in SHDI and SHEI was higher in the non-urban zones than the urban, suggesting that the semi-natural vegetation became more homogeneous. Finally, in order to obtain more accurate information on changes in landscape fragmentation, the "Mean Proximity" index was used this is often used to describe overall habitat fragmentation. Analysis showed that the Mean proximity increased considerably (more than 400%) between 1987 and 1999, suggesting that the overall landscape has become less fragmented.

The class level metrics presented in Table 4 provide further information on change in the patterns of semi-natural vegetation. The table shows that the *J. phoenicea* community became more homogeneous over the study period, with increased core area and less interspersed. The increase in the extent of facies *S. spinosum* was accompanied by an increase in its fragmentation (more numerous smaller patches, higher total edge and fewer core areas). Facies *C. capitatus–C. villosa–P. lentiscus* decreased in extent and became more fragmented and interspersed. The cropland changes followed these same general patterns.

Average Nearest Neighbor Distance analysis showed that the spatial pattern of *J. phoenicea* community expansion and loss was clustered and there was less than 1% likelihood that this clustered pattern could be the result of random chance. Although both type of change hotspots (expansion and loss) can be seen across the whole island, most of the hotspots of expansion are located outside the urban zones, while hotspots of loss are located inside, suggesting a polarization pattern for community *J. phoenicea* spatial change (Fig. 2).

**Table 4**
Landscape metrics for selected land-cover types (class level) for the 'non-urban' zones in 1987 and in 1999 land-cover maps. *Abbreviations*: Com.JP = community of *Juniperus phoenicea*, Fac.CC = facies of *Coridothymus capitatus–Calicotome villosa–Pistacia lentiscus*, Fac.SS = facies of *Sarcopoterium spinosum*, NP = Number of Patches, CA = Class Area, TE = Total Edge, CAI = Core Area Index.

| | Year | NP | CA (ha) | TE (km) | CAI | DIVISION |
|---|---|---|---|---|---|---|
| Com.JP | 1987 | 218 | 2674 | 354.4 | 25.41 | 44.7 |
| | 1999 | 235 | 2804 | 353.8 | 31.72 | 41.51 |
| Fac.CC | 1987 | 320 | 1396 | 341.4 | 4.68 | 87.38 |
| | 1999 | 369 | 1277 | 322.5 | 4.87 | 90.38 |
| Fac.SS | 1987 | 240 | 572 | 168.3 | 7.39 | 95.6 |
| | 1999 | 298 | 635 | 191 | 5.54 | 95.57 |
| Cropland | 1987 | 111 | 125 | 48.1 | 1.12 | 88.88 |
| | 1999 | 99 | 34 | 22.7 | 0 | 89.53 |

## 4. Discussion

### 4.1. Anthropogenic drivers that affect landscape changes

The landscape changes observed between 1987 and1999 on Sifnos are manifestations of the combined effect of anthropogenic and natural processes. Anthropogenic processes in particular are complex and reflect temporal and spatial shifts in systems of land-use.

Some past human activities that used to shape the landscape of small Mediterranean islands like Sifnos, such as mining and wood-cutting have decreased in extent over the last century (Evangelinos and Oku, 2006; Margaris et al., 1996). Agriculture and tourism, now represent the main economic sectors currently operating in most small Mediterranean islands (Vogiatzakis et al., 2008a). However, accelerated rural depopulation since the 1940s (Kizos et al., 2009) and changes in agricultural policy and technology, have made island farming increasingly uncompetitive compared with mainland agriculture (Vernicos, 1990; Margaris, 1992; Petanidou et al., 2008). This has led to a decline in crop production and a consequent expansion of livestock production (supported by CAP subsidies, particularly in the form of headage payments). On Sifnos, abandonment of terrace cultivation has taken place for more than three decades, while over the study period alone the area of cropland decreased by 62% (Table 1). The abandoned cropped terraces were subsequently used as rangeland for extensive livestock grazing, or left to secondary succession, leading to the establishment of maquis

**Table 3**
Landscape metrics at landscape level estimated from the two land-cover maps (1987, 1999) for the whole island, the non-urban zone and the urban zone. *Abbreviations*: % ch. = percentage change, NP = Number of Patches, ED = Edge Density, SHDI = Shannon Diversity Index, SHEI = Shannon Evenness Index, Mean Prox = Mean Proximity.

| | Whole island | | | Non-urban | | | Urban | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1987 | 1999 | % ch. | 1987 | 1999 | % ch | 1987 | 1999 | % ch. |
| NP | 1845 | 2213 | 19.9 | 1108 | 1202 | 8.5 | 1559 | 1946 | 24.8 |
| ED | 206.1 | 214.2 | 3.9 | 202.1 | 197.8 | −2.1 | 364.8 | 400.2 | 9.7 |
| SHDI | 1.53 | 1.49 | −2.6 | 1.27 | 1.22 | −3.9 | 1.77 | 1.77 | 0 |
| SHEI | 0.78 | 0.77 | −1.3 | 0.7 | 0.68 | −2.8 | 0.91 | 0.9 | −1.0 |
| Mean Prox. | 2081 | 10592 | 409 | – | – | – | – | – | – |

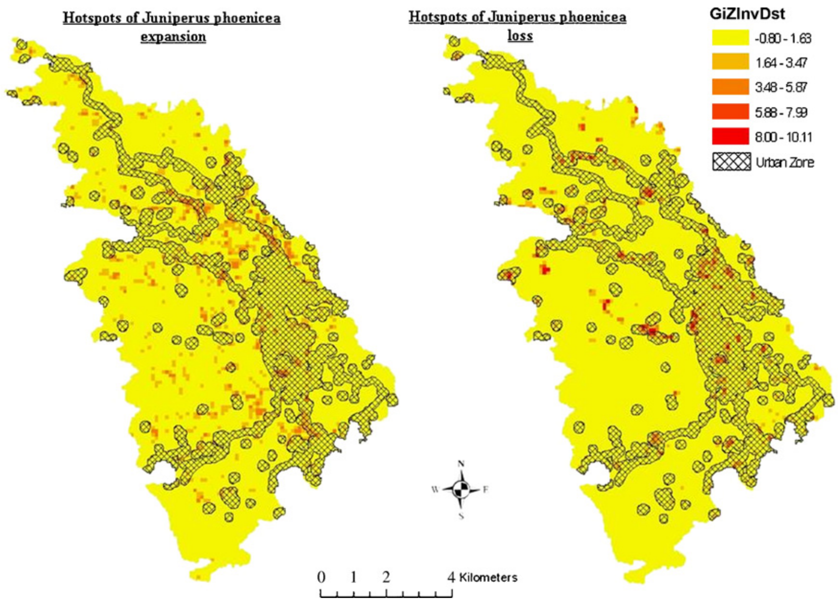


**Fig. 2.** Hotspots of community *Juniperus phoenicea* expansion and loss from 1987 to1999. The GiZInvDst values are the *Z* scores for each pixel. The *Z* scores are measures of standard deviation and they represent the statistical significance of clustering for a specified distance (here the Inverse Distance is used). The gridded area represents the urban zones.

vegetation (Tzanopoulos et al., 2007). During the study period livestock production was based mainly on mixed flocks of goats and sheep. With up to 11,000 animals grazing the island, some areas have been subjected to overgrazing, while others have been undergrazed (pers. comm. the president of the agricultural cooperative of Sifnos). This variation of grazing intensity has acted as a spatially differentiating disturbance factor, affecting the competition between maquis and phryganic species (see Tzanopoulos et al., 2005).

Over the study period, while the agricultural sector was declining, the tourism sector boomed, so altering the economy and the character of the island. Coccossis and Constantoglou (2005) reported a fast growth of tourism on Sifnos between 1991 and 2001 including an increase in the number of both second, or holiday, homes, and other tourist establishments. Data on the number of arrivals to the port of Sifnos (Table 5) shows a similar upward trend. Table 6 shows that tourism activity is characterized by strong seasonality, with more than 75% of arrivals occurring during the months between July and August; a pattern common to many small Greek islands (Leontidou, 1994). Marked seasonality restricts large investments (Getz and Nilsson, 2004) and as a result of the seasonality seen on Sifnos, no major tourist establishments have been constructed. However, tourism expansion has provided new sources of income for the local people, as well as investment prospects for newcomers and expatriates, who have reversed the depopulation trend that has been observed on Sifnos, in common with most Greek islands during last century (Briassoulis, 1993). According to the National Census, between 1981 and 1991 the population of Sifnos decreased from 2087 to 1960 while over the study period, while tourism boomed, the population increased by 25%. Moreover, the increase in tourist numbers strengthened the pottery manufacturing tradition of the island, which occurred without exerting pressure on the semi-natural vegetation of the island (i.e. especially woodlands) due to the modernization of the sector and the use of fossil-fuel-based energy sources.

**Table 5**
Number of arrivals (people disembarking) at the ports of Sifnos over the period 1995–2001.

| Year | No. of people |
|---|---|
| 1995 | 79,331 |
| 1996 | 68,131 |
| 1997 | 80,959 |
| 1998 | 96,252 |
| 1999 | 101,064 |
| 2000 | 106,118 |
| 2001 | 110,667 |

On many small Mediterranean islands tourism activities may complement farming, allowing additional income generation for farm families (Buhalis, 1998) especially through agri-tourism (see Galani-Moutafi, 2004), and this may promote sustainable development. However, on Sifnos the uptake of agri-tourism has been limited.

Although wild-fire has always been part of the ecosystem evolutional history of Mediterranean islands (Grove and Rackham, 2001), the impact of fire on Sifnos has been minimal, since no major fire incidents have occurred on the island in the last 50 years according to data obtained by the Forest Office of Cyclades.

### 4.2. Impact of anthropogenic drivers on landscape composition

Changes in the economic sectors of Sifnos over the study period have affected the composition of islands landscape. In 1987 cropland used was scattered across the island but by 1999, not only had it decreased by 62% as reported above, but it was now confined in just few locations, mainly close to urban zones (Fig. 1).

Over the study period the built-up area increased by 35% and this increase was spatially constrained close to existing villages or along the main sandy beaches of the island. The increase in built-up area are likely attributable to either the expansion of the permanent population (urbanisation), or to the construction of second/holiday homes and tourist establishments (tourism). Unfortunately, the lack of availability of suitable demographic data do not permit the quantification of these two trends. However, the increase in the number of tourist arrivals on the island (Table 5) between 1995 and 2001 suggests that a significant part of the built expansion is driven by tourism development.

Although the overall extent of semi-natural vegetation remained almost constant (occupying 80% of the island in 1987 and 81% in 1999), important shifts have occurred among the veg-

**Table 6**
Number of people arriving at all tourist establishments on Sifnos (excluding camping) over the period 1996–2001.

| Year | Check-in | January–April | May | June | July | August | September | October–December | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1996 | Greeks | 0 | 89 | 702 | 889 | 1620 | 222 | 0 | 4848 |
| | Non-Greeks | 0 | 15 | 312 | 222 | 727 | 50 | 0 | |
| 1997 | Greeks | 0 | 140 | 418 | 1083 | 1538 | 281 | 0 | 4435 |
| | Non-Greeks | 0 | 1 | 172 | 288 | 316 | 198 | 0 | |
| 1998 | Greeks | 0 | 96 | 674 | 1631 | 2422 | 281 | 0 | 6814 |
| | Non-Greeks | 0 | 114 | 390 | 536 | 509 | 161 | 0 | |
| 1999 | Greeks | 0 | 0 | 61 | 1187 | 1921 | 385 | 0 | 5341 |
| | Non-Greeks | 0 | 0 | 856 | 141 | 491 | 299 | 0 | |
| 2000 | Greeks | 0 | 222 | 0 | 1337 | 2359 | 282 | 0 | 5517 |
| | Non-Greeks | 0 | 122 | 0 | 437 | 583 | 175 | 0 | |
| 2001 | Greeks | 0 | 0 | 440 | 961 | 1725 | 227 | 0 | 4388 |
| | Non-Greeks | 0 | 0 | 127 | 370 | 425 | 113 | 0 | |
| | Monthly Average | 0 | 133 | 692 | 1513 | 2439 | 445 | 0 | |

etation classes, mainly due to secondary succession and grazing disturbance. Degradation of semi-natural vegetation and desertification are perceived to be major threats to the integrity of the Mediterranean landscape (Brandt and Thornes, 1996; Geeson et al., 2002; Khaznadar et al., 2009). However, a trend that is increasingly reported, particularly in the north of the Mediterranean Basin, is the expansion of semi-natural vegetation (Grove and Rackham, 2001; Mazzoleni et al., 2004). The transition of land to woodland and forest, following abandonment and fire, has been discussed in the literature in the context of the Mediterranean area in general (Mazzoleni et al., 2004) and island landscapes in particular (Di Pasquale et al., 2004; Mouillot et al., 2005; Rackham and Moody, 1996). The results from Sifnos clearly support the findings of Grove and Rackham (2001), indicating that *J. phoenicea* community, the most important element of the island's NATURA 2000 site, is generally expanding.

### 4.3. Impact of anthropogenic drivers on landscape configuration

Over the study period a loss of landscape heterogeneity has been observed on Sifnos, mainly due to the homogenization of the "non-urban zones", where secondary succession has led to the expansion of core areas of maquis vegetation. In contrast, the Number of Patches and Edge Density have increased within the "urban zones" showing an opposite trend of increased heterogeneity. The existence of these two opposing trends indicates an ongoing spatial polarization of land-use intensity, with anthropogenic processes operating to increase land-use intensity only in certain locations, inside the "urban zones", while large parts of the island appear to have lost their productivist profile, with natural processes taking over. This is consistent with the trend observed by Antrop (2005) and Jongman (2002) that land-use polarization is one of the common manifestations of a constantly modified landscape in developed countries.

In order to understand the operation of drivers of land-use change on Sifnos, it is important to examine the temporal dimension of the land-use polarization process. The agricultural decline, and the consequent loss of land-use intensity in many parts of the island, had already begun prior to the booming of the island's tourism sector (Tzanopoulos et al., 2007). However, the tourism development of the period 1987–1999 resulted in an increase in land-use intensity in the urban zones, deepening the existing spatial variation, and trends of change, in land-use intensity across the island. Thus, tourism should not be considered as the primary cause of land-use polarization, but rather an extenuating factor. The analysis also suggests that agriculture and tourism do not necessarily represent competing economic sectors in terms of land use (at least at local level) while land-use polarization is mainly the outcome of spatially co-occurring rather than spatially competing processes..

### 4.4. Concluding remarks on managing island landscapes

The dynamic landscapes of Mediterranean islands have evolved as the result of pressures generated by socio-economic and political factors, which have acted upon and often magnified the challenge of landscape management. The imposition of external agricultural policies, such as the CAP, not sensitive to the nature of these landscapes, and the economic and social conditions in which agriculture in these areas exist, are likely to have far deeper repercussions on small islands than on mainlands or larger islands. Recent population in-migration, by pensioners/holidaymakers, as currently taking place on Crete, Cyprus and Sardinia, might emerge as an important regulatory factor of the changes to come (Paquette and Domon, 2003). Historically, cultural processes have played a big part in the evolution of island landscapes, resulting in agricultural landscapes of high natural, cultural and aesthetic value. However, the ongoing loss of agricultural lands may undermine the cultural and aesthetic quality of island landscapes, crucial for the tourist industry (Loumou et al., 2000; Makhzoumi and Pungetti, 2008). In recognition of this, the preservation of Mediterranean landscapes has been at the forefront of initiatives for the sustainable future development of the islands (Naveh, 1993). However, the concept of landscape preservation carries an intrinsic contradiction; preserving the landscape in its holistic and integrating nature, inevitably demands the preservation of the processes and the "meanings" that define it. Therefore, their management, in the context of inevitable change, needs to be pragmatic and as such adaptable to newly emerging priorities and as such cannot be driven by popular nostalgia for an unchanging past. Landscape change should not therefore be universally perceived negative.

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