The forest road density evolution at the island of Skiathos, Greece

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Abstract

Ecosystems of island regions change at great speed and, in most cases, they are environmentally degraded. Changes in forest landscapes resulting from road construction have increased remarkably in recent years. Roads are essential structures to provide access to the forest from the establishment phase to the harvesting stage. Thus, it is important that roads are properly planned in order to ensure the transportation of forest products as well as the safety, comfort and economy of vehicle operations. The sustainable management of forest resources can only be achieved through a well-organized road network which is crucial for the sustainable management of forest resources regardless of the forest use such as wood production, ecotourism, water supply, or soil conservation. The aim of this paper is to present the progress of the existing forest road network at the island of Skiathos for the last decades. With the contribution of Geographic Information Systems (GIS) and the orthophotomaps, the spatial planning of the forest road network can be evaluated for all these years and the road density can also be calculated. Thematic maps of the forest roads, for each year separately, will also be presented. The current study explores the application of spatial planning in forest roads in order to achieve sustainable development with respect to nature assets and the landscape, in combination with viable forest exploitation.

Keywords: Forest Road Density, Spatial planning, Forest Roads, GIS

1. Introduction

Forest roads are conspicuous components of landscapes that play a substantial role in the definition of the landscape pattern. The forest landscapes and ecosystems are defined by the interaction among anthropogenic and natural interferences, land ownership, land use-cover and landforms (Forman and Godron 1986; Forman and Alexander 1998). One of the most important anthropogenic interferences to the natural environment is the road construction. Also, physical and ecological characteristics of landscapes constrain the land use and landscape pattern. Land-use changes are influenced by political, social, and economic parameters.

Forest roads provide access and allow the exploitation of natural assets, but also change the land use and create new transportation needs (Dale *et al*. 1993; Turner *et al*. 1996; Ewing and Cervero 2001; Hess *et al*. 2001; Noland 2001; Tampekis *et al*. 2009).

The evolution of the existing forest road network at the island of Skiathos, in the last decades, as well as the variation in forest road density are important factors affecting forest landscapes. The heterogeneous landscape of Skiathos Island allows the examination of a wide range of factors that affect the road density.

Our results are important for understanding the impacts of roads on ecosystems in the frame of sustainable development.

2. Methodology

2.1 Study area

The study area is the island of Skiathos. It is a small Greek island in the northwest Aegean Sea. It is the most western island in the Northern Sporades group, east of the Pelion peninsula in Magnesia on the mainland, and west of the island of Skopelos. Specifically, the study area is situated at 23° 37′ 33′′ until 23° 51′ 41′′ Western Longitude and 39° 11′ 92′′ and 39° 21′ 45′′ Northern Latitude from the base of the National Observatory of Athens.

Skiathos' vegetation consists mainly of *Quercus coccifera*, *Quercus ilex*, *Arbutus unedo*, *Juniperus phoenicea*, Aleppo pine forests (*Pinus halepensis*) and brushwood (*Sarcopoterium spinosum*). Previously dominated forests of oak where gradually replaced by pine forests. The prevalence of pine trees was helped by this replacement, as the wood was used in the construction of ships' skeletons.

The population of the island, during 2011, was 6.088 and the density was 122 people/km^2.

2.2 Method

For the needs of the research, digital orthophotomaps of the area were used. We also used the forest management plan of Skiathos Island for the last decades and we utilized factors such as forest, urban, rural road network length etc. Thus, the road networks were digitized and finally, we extracted measurements that regard the length of the road networks. We digitized the roads, visible in digital orthophotos and in the map of the management plan. The digital orthophotos and the management plan's map regard the period between the years 1945 and 2010.

The density of forest roads (D_F) is expressed by the ratio of the length of main forest roads (in meters) to the area (in hectares).

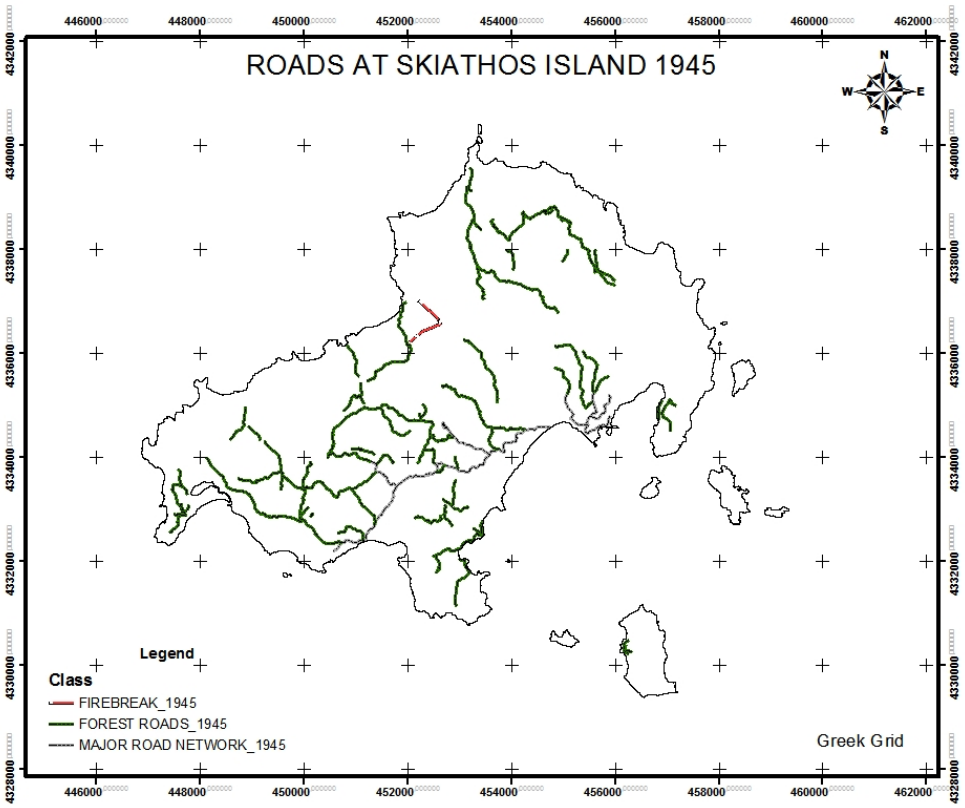
$$D_F=\frac{L}{F}$$

D_F : Forest road density (m/ha), L: Length of forest roads (m),F: Surface (ha).

3. Results and discussion

For the year 1945 we calculated approximately 68807,6368 (m) of roads. In Figure 1 the road network is presented.

Figure 1. Roads at Skiathos Island for the year 1945.



Also, the length of the road network is presented in Table 1.

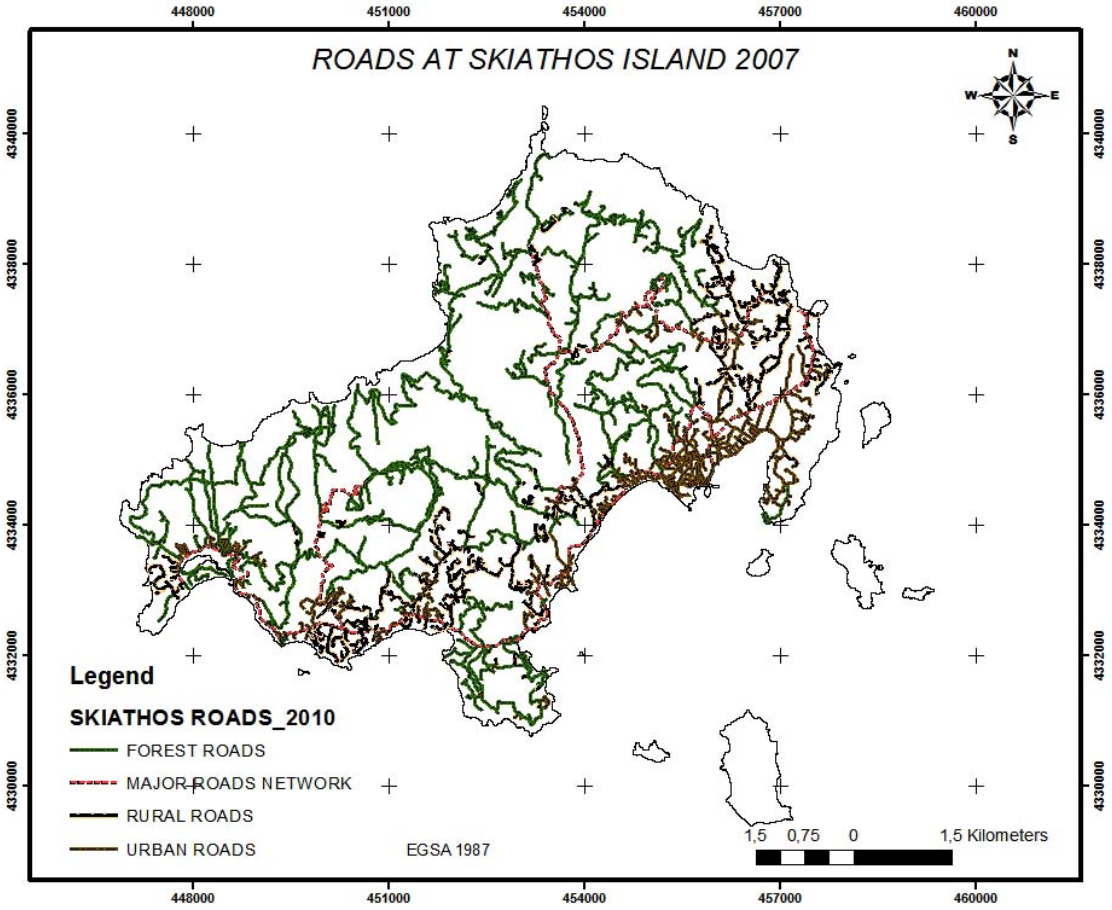
Table1. Road network length (m) for the year 1945.

a/a	Name	Sum_Length (m)
0	FIREBREAK	1314,1783
1	MAJOR ROADS NETWORK	11483,9157
2	FOREST ROADS_1945	56009,5427
SUM		68807,6368

The forest road density is calculated by the equation $D_F = \frac{L}{F} = \frac{56009,5427}{4925,7866} = 11,3707 m/ha.$

For the year 2010 we calculated approximately 146904,1085 (m) of forest roads. In Figure 2, the road network is presented.

Figure 2. Roads at Skiathos Island for the year 2010.



Also, the length of road network is presented in Table 2.

Table 2. Road network length (m) for the year 2010.

OID	Layer	Sum_Length (m)
0	FOREST ROADS	146904,1085
1	MAJOR ROADS NETWORK	31258,4435
2	RURAL ROADS	59814,5813
3	URBAN ROADS	59181,6312
SUM		297158,7645

The forest road density is calculated by the equation $D_F = \frac{L}{F} = \frac{146904,1085}{4925,7866} = 29,8235 m/ha$.

4. Conclusion

Roads are prevalent features of landscapes that have a wide range of ecological effects. A greater understanding of factors affecting road networks is needed. Between the years 1945 and 2010, an increase of the forest road density has been noted. In the year 1945 the length of the forest road network was 56009,5427 m (total road network length 68807,6368 m) and in the year 2010 the length was 146904,1085 (total road network length 297.158,7645 m). This happened due to an increase of the population in the island and also, due to a diversification of land uses which appeared in recent years.

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