FORESTRY IDEAS, 2013, vol. 19, No 1 (45): 59–68

ENVIRONMENTAL IMPACT ASSESSMENT OF THE A CATEGORY ASPHALTED FOREST ROAD "PHILLIPION – XILIA DENDRA – EXOCHI"

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Received: 05 October 2012 Accepted: 23 May 2013

Abstracts

As results of forest roads construction, a large number of impacts on the social and natural environment are identified, both at construction and operation phases. In this work an Environmental Impact Assessment for the asphalted forest road, of A category "Philippion – Xillia Dendra – Exochi" was conducted. Initially, we analyzed the concept of environmental impact assessments and recorded all the information about the location of the road. Then the information was collected necessary for the preparation work, such as related measurements, graded on the basis of the criteria forestry absorption and intensity. These criteria evaluate forestry, topographic and social factors that are indicators for the adaptability of the road environment and the capacity of the area to overcome the construction and to restore the balance of the forest ecosystem with minimum negative impact on the forest and the social surroundings. The intensity criteria by which the layout and the construction of a forest road is evaluated measures adaptation of the natural environment to the road construction. Finally, the investigation concludes that the specific forest road needs several interventions to improve and restore the environment after its construction.

Key words: environmental impacts, forests, pavements, roads.

Introduction

The first human beings used forests as a source of fuel, food, accommodation, water etc. Over the years, stone tools were replaced by metal ones and thus the industrial revolution began and with it the construction of forest roads and forestry activities, which resulted in a rise of productivity both in land cultivation and timber harvesting. Despite the beneficial use of modern digging machines, they also caused problems in the balance of the forest habitat.

The paper deals broadly with the issue of environmental impact assessments and specifically with the Environmental Impact Assessment of the A category asphalt road "Philippion – Xilia Dendra – Exochi".

Viewed from an economical perspective, the construction of a forest road must not be considered to be a negative undertaking. Although it can be a source of severe environmental impact it also has many positive aspects. In order to assess the degree of opening of a road forest analytical and empirical methods are mainly used. The analytical methods rely on theoretical models and take into account quantitative opening criteria (expressed in monetary units) in relation to road density (Kroth 1973, Abegg 1983). Empirical methods are based on knowledge of economic theory. Such are the dynamic methods (Stamou 1985, Karagiannis 1991) as well as the method of cost-benefit analysis (Stamou 1985, Doukas 1989, Karagiannis 1991) which takes into account only quantitative criteria irrespective of whether these are related to road density. Additionally, the assay value – benefit analysis is used to empirically assess quantitative as well as qualitative criteria (that can not be expressed in monetary units) and has been widely applied in the fields of engineering and forestry science.

The economic evaluation of environmental impacts is difficult because they cannot be assessed economically with accuracy since the individual factors are often qualitative and in many cases the situations that arise can be permanent or temporary, may have different influences on construction, restoration, maintenance and during operation (Tsochos 1997). In areas that have economic criteria, both quantitative and qualitative (environmental), we can apply the value-benefit analysis.

Materials and Methods

Research area

The forest that surrounds the city of Thessaloniki in Greece (Seix-Sou) is located to the northeast of the city at a relatively small distance from the city-centre. It occupies the southern and southwestern slopes of Mount Chortiatis, up to the Eptapyrgio – Asvestochori Road (Figure 1). The forest has a total area of 30.2 million m^2 (3,000 ha). The longitude of the forest is between 22°57´ and 23°04´ and its latitude – between 40°35´30´´ and 40°39´30´´. The maximum altitude is 400 m. The main tree species in this area are: *Quercus coccifera* Kit., *Pinus bruttia* Ten. and *Cupressus sempervirens* L. The forest road in question is 5.5 km long. It is

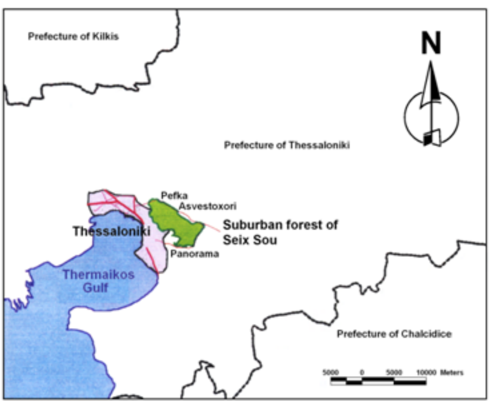

Fig. 1. Region of Seix – Sou.

to be a permanent road and its usage is for transportation but also for forest recreation. The direction is west – east and the exposure is western.

Methodology

The method, which would be applied, should be practical, effective and easy to use prior to road construction. If a forest road is a new construction, the intensity of the impacts and its ecosystem absorbency should be evaluated against certain criteria (Drosos 2009). These criteria are divided into 2 categories: the criteria of the absorbency capacity of the ecosystem and the criteria of the intensity effect of the forest road construction. Additionally for each criterion a weight coefficient is introduced. These coefficients resulted from a research based on specific questionnaires filled by specialized scientists on forestry and environmental issues.

The grading of these criteria depends on the following principle: We accept a situation as ideal (=100 %) with respect to forest protection against road construction. The percentage of deviation from this ideal situation will be subtracted from 100 %. The result will be the grading of the criteria.

A. As far as absorbency is concerned

These criteria are based on the opinions of experts (special scientists) and relevant literature (Warner 1973, Kotoulas 1987, Stergiadis et al. 1984, Ntafis 1990, Trzesniowski 1993, Drosos et al. 2006). The absorbency criteria are divided into 3 categories: 1st forestry criteria, 2nd topographic criteria and 3rd social criteria.

The weights of the criteria are: three (3) for the forestry criteria, two (2) for the topographic criteria and one (1) for the social criteria.

The forestry criteria are the following:

1. The kind of coverage, i.e. the percentage attributed to road coverage on the basis of the type of area that the road crosses: if it goes through a forest it is graded with excellent 100 %, if it goes through a wooded area it is graded with 25–50 % depending on its density, and if the road crosses a woodless area it is assessed with 15 %.

2. The forest species, i.e. the length percentage of the part of the road under study that crosses a mixed forest is graded with excellent 100 %; that of the part crossing a coniferous forest – with 70 %; and that of the part that crosses a broadleaf forest – with 50–80 % depending on the season when measurements are performed, that is if trees have leaves or not.

3. The management form, i.e. the length percentage of the part of the road under study that crosses a seedling (high) forest is graded with excellent 100 %; that of the part crossing a coppice forest is graded with 50 % and that of the part that crosses a composite or middle forest is graded with 75 % to 100 % depending on the seedling-coppice forest rate.

4. Age (forestry form), i.e. the length percentage of the part of the road under study that crosses a group-selective forest is graded with excellent 100 %; that of the part crossing a selection forest with 75 % and that of the part that crosses an even-aged forest – with 50 %.

5. The height of the trees, i.e. the length percentage attributed to the road under study on the basis of the height of the trees present in the area: if the road goes among large trees >20 m it is graded with excellent 100 %; among medium size trees 10–20 m – with 75 % and if the road

goes among small trees <10 m – with 25–50 % depending on their height.

6. The site quality. Good (first and second site quality), medium (third and forth site quality) and poor (fifth and sixth site quality). The percentage of the road crossing: good site quality is graded with excellent 100 %, medium – with 50 % and poor – with 25 %.

7. The productivity of the forest:

Category I (productivity over 3 $m^3 \cdot year^{-1} \cdot ha^{-1}$).

Category II (productivity 1–3 $m^3 \cdot year^{-1} \cdot ha^{-1}$).

Category III (productivity less than 1 $m^3 \cdot year^{-1} \cdot ha^{-1}$).

The percentage of the road crossing forest of category I productivity is graded with excellent 100 %, forest of category II productivity – with 50 % and forest of category III productivity – with 25 %.

The topographic criteria are the following:

1. The cross slope of the land. The percentage of the road passing along small slopes <8 % is graded with excellent 100 %, along medium slopes 8–20 % – with 50 and high slopes >20 % – with 25 to 5, depending on the slope.

2. The aspect. The percentage of the road passing at an altitude less than 1000 m with northern exposition is graded with excellent 100 %, southern – with 50 % and eastern-western – with 75 %.

The percentage of the road passing at an altitude over 1000 m, with eastern or western exposition is graded with excellent 100 %, and with northern or southern ones – with 70 %.

3. The terrain relief. The percentage of the road passing through a mild relief is graded with excellent 100 %, through a multifarious relief – with 15 % and through a varied relief with 50 %.

Social criteria depend on the number of humans affected by the road. Distance plays a major role in impact e.g.

1. Distance from a tourist resort (Since tourism is seasonal and is culminated during the peak season, each kilometer of the distance from the resort increases grading e.g. distance 0–1 km is graded with 0, 1–2 km with 10 %, 2–3 km with 30 % etc.).

2. Distance from the national and country road network (the same as with the resort).

3. Distance from a railway (it has no direct impact but if one sees the road from the train, he/she might want to visit the forest by car. However, it has impact due to noise).

4. Distance from an archaeological site (the same as with the resort).

5. Distance from an adjacent big city (the same as with the resort).

6. Distance from an adjacent village (the same as with the resort).

7. Distance from a European path every time the road crosses the path, its grading is reduced (e.g. if it crosses the path once it is graded with 80 %, if twice with 60 %, 3 times with 40 % etc.).

8. Distance from a natural or artificial lake or river (the same as with the resort).

B. As far as intensity is concerned

The criteria of intensity have been determined on the basis of the relevant literature and a specific questionnaire (Kotoulas 1985, Ntafis 1986, Mader 1990, Zundel 1990, Sedlak 1993, Becker 1995, Doukas 2004). The intensity criteria were divided in layout criteria and construction criteria. The layout criteria are the following:

1. The curve radius (the more it exceeds 25 meters the lower the grading).

2. The layout of the gradient (the higher than 0.5 m the height discrepancy be-

tween the ground and the gradient, the lower the grading).

3. The cross section (the larger than 0.5 m the distance of the centre line and the section point of the road with the ground, the lower the grading depending on the discrepancy in meters).

4. The road gradient (the percentage of the road where the road gradient is not 3–12 %, reduces the grading on a scale of 100).

5. The width of the road (the percentage of the road where the road width is different than 3.5 m with widening every 250 m, reduces the grading on a scale of 100).

6. The distance of serpentines (the less than 500 m the distance between serpentines, the lower the grading).

7. The distance of the forest road from a stream, from the forest boundaries and from dangerous sites.

● The percentage of the forest road that is located on a valley less than 10 m away from a stream bank reduces the grading on a scale of 100.

● The percentage of the forest road that is located less than 10 m outside the forest boundaries or less than 20 m inside the forest borders, for aesthetic reasons, reduces the grading on a scale of 100.

● The percentage of the road passing by a clay ground, large opening streams, unstable grounds, reduces the grading on a scale of 100.

8. The view of the forest road to morphological formations, vegetation, space projection, compatible constructions, and water areas.

● The percentage of the road where there are no morphological formations (no need to prevail), reduces the grading on a scale of 100.

● The percentage of the road, where the visual field is not consisted of vegetation forms providing even a limited variety; uniform cultivation in the form of geographical shapes reduces the grading on a scale of 100.

● The percentage of the road, where the visual view does not focus on the forest and the assiduous forestry interventions, is graded with a lower percentage on a scale of 100.

● The compatible constructions should be constructed of wood and stone and are graded with excellent 100 %; the construction of concrete – with 50 %; and the construction with the combination of the above materials – with 75 %.

● The percentage of the road, where the visual field include no water flows and streams, even with limited visual interest and clarity (provided that they exist), is graded with a lower percentage on a scale of 100.

9. The adaptation of the forest road in the environment.

The percentage of the road, which is not visually concealed when observed from the opposite slope from a spot of the same altitude, is graded with a lower percentage on a scale of 100.

The construction criteria are the following: construction machinery, construction materials, the seeding and mulching of side slopes, technical operations, drainage and supply.

1. Machinery for excavation works.

● The percentage of the road, where a hydraulic excavator has not been used on earthy grounds with ground slope over 60 %, is graded with a lower percentage on a scale of 100.

● The percentage of the road, where a hydraulic excavator has not been used on rocky grounds for fragment management, is graded with a lower percentage on a scale of 100.

2. Construction materials.

● The percentage of the road that has not been stabilized on a road gradient >10 %, is graded with a lower percentage on a scale of 100.

● The percentage of the road where the material of **road surfacing** is not taken from the site or does not consist of environmental-friendly recycled materials is graded with a lower percentage on a scale of 100.

● Depending on the construction materials, if the road is gravel-paved, it is graded with a lower percentage on a scale of 100. If it is asphalted or if it bears other construction materials, it is graded with 50 %.

3. Seeding and mulching of side slopes.

The percentage of the road's side slopes, where on the embankments with slope near the corner of the natural side slope and ground slope of about 60–70 %, natural or technical seeding and mulching has not been carried out, is graded with a lower percentage on a scale of 100.

4. Technical operations, drainage, supply.

● The percentage of road culverts that are not: a) Slab-roof culverts in openings 3–4 meters wide; b) Drain boxes on soil of poor bearing, 3–4 meter wide; c) Concrete pipes with embankment twice as large as the pipe's diameter, depending on the type and corner of bearing; d) Stabilized stream beds with concrete (passages), is graded with a lower percentage on a scale of 100.

● The percentage of the road retaining walls exceeding 3 m in height is graded with a lower percentage on a scale of 100.

● The percentage of exceeding the bridge's opening over 8 m is graded with a lower percentage on a scale of 100.

● The lack of drain dips (rills) across the surface at road gradient >10 % and length >100 m., is graded with a lower percentage on a scale of 100.

● The percentage of the main forest road where ditches on the road surface and the necessary sloping for its drainage lack is graded with a lower percentage on a scale of 100.

The evaluation of all these criteria of absorbency and intensity will be difficult and therefore the description of an E.I.A. in a profile form will be a necessary addition (Figures 2 and 3).

Final grading – Compatibility coefficient

The grading is carried out as follows:

1. To calculate the mean intensity value, we multiply the grade of each criterion by its weight and at the end; we divide the sum of the products by the total sum of the weights. This value is the mean intensity value (C_I) on a scale of 100 %. The same applies for mean absorbency (C_A). These figures, C_I and C_A, provided that weight coefficients are not subjective, indicate the approximate protection degree of the natural environment from the construction of the forest road.

2. To calculate the forest road's compatibility coefficient (C_C) we multiply the mean absorbency value by the mean impact intensity value.

When the compatibility coefficient is more than 60 % or 0.60 the construction is accepted under no special conditions. If the compatibility coefficient is 0.50–0.60 the construction is accepted under conditions. If the compatibility coefficient is less than 0.50, the impacts will be too big and there is a need to change the layout or to design activities for restoring the natural environment.

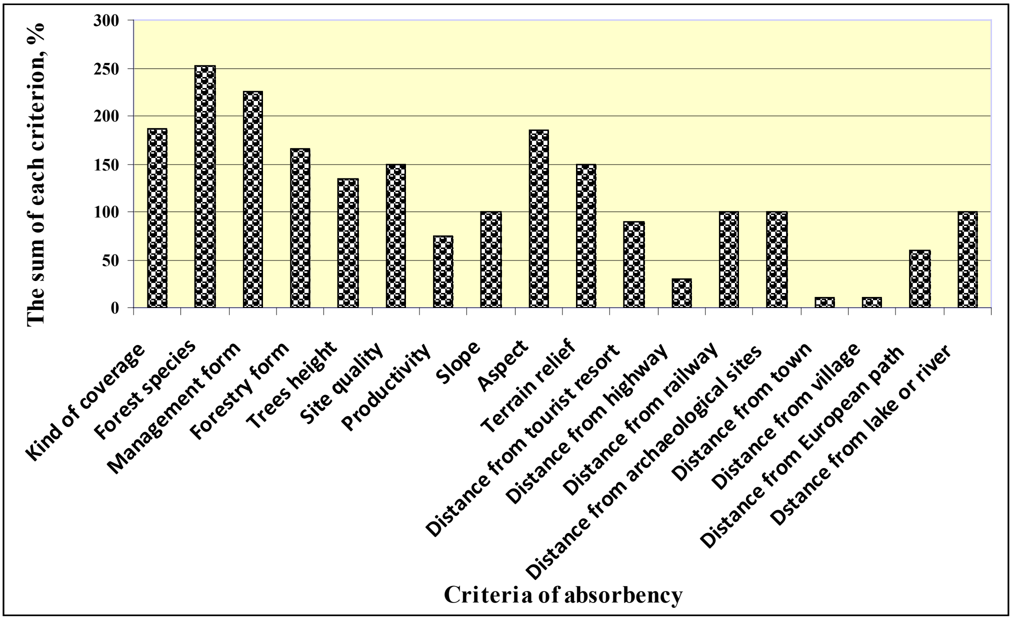

Fig. 2. The profile form of absorbency criteria.

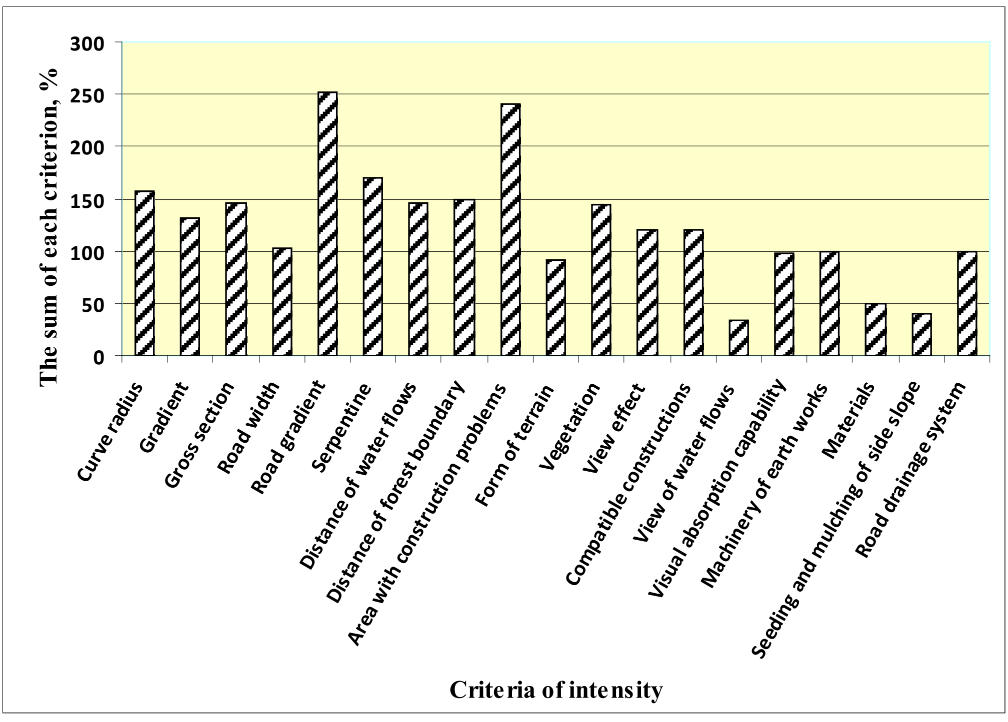

Fig. 3. The profile form of intensity criteria.

Results

The evaluation of the forest road intensity and ecosystem's absorbency resulted in Table 1.

To calculate the forest road's compatibility coefficient we multiply the mean absorbency value by the mean impact intensity value (Formula 1).

$C_C=C_I \cdot C_A=60.66\% \cdot 72.68\%=44.09\%$ (1)

It seems that the forest road in question has mean absorbency value of 60.66 % and mean intensity value of 72.68 %. The forest road's compatibility coefficient with natural environment is 44.09 % or 0.4409.

Conclusions and Suggestions

Because the compatibility coefficient is below 0.50 (*Cc*=44 %) the impacts are very large and there is a need either to change the layout or to design activities for restoring the natural environment. Generally, the low rate (<50 %) indicates that there have been (or will be) significant impacts on the forest because of the construction of forest road. In this case, the compatibility coefficient, although quite low (44 %) can be improved with additional new activities which will help the restoration of the natural environment, such as slope protection technical operations, seeding and mulching of side slopes etc.

In order to be acceptable the road needs to be improved substantially. Based on the results we see that problems emerge on absorbency because of: 1) the site quality is medium to poor so the density and the height of the trees are extremely low; and 2) it is inside a suburban forest and there is no wood production The main role that a suburban forest is called to fulfill is the protective one, secondly – the recreation role and then the healthy one.

Regarding the intensity, the forest road in question was not constructed as it should be according to the criteria of mixed section. Furthermore, the width of the road surface is well above the required width (3.5 m). There was no proper roadway and the road surface was stabilized through the process of embankment using healthy aggregates. Also the visual absorption capability is too low as well as the landscape especially in the form of terrain and in parts where water flows are extremely low.

On several locations the road is well above the grade line set out on the ground so that it can be constructed in a filling and in some cases even small trapezoidal cross sections were created.

The method used here for the characterization of the road network can also be used in the case of road construction assessments or of alternative road alignment projects so that we can choose the best methodology in terms of the smallest degree of environmental impact in order to improve certain aspects of road construction. The evaluation of the construction in a forest road depends on three parameters:

1. The cost of construction and rehabilitation of the natural environment;
2. The intensity of the effect that is not negative; and
3. The absorption of forest ecosystem.

Construction or maintenance of a road network that is compatible with the natural environment is also dependable on the availability of sufficient governmental funds.

In the assessment of environmental impacts, failings are identified, due to:

- the means or methods used for the assessment of all the direct consequences;

- the expected or unexpected future impacts;
- non-objective estimation of the magnitude of the direct consequences.

Interventions by scientists (such as forest engineers etc.) to restore the environment from the effects should be proportional to the absorbency of the natural environment, i.e. must not exceed the capacity of the environment to absorb the consequences of the construction of developmental infrastructures or works.

This method of calculating the compatibility coefficient for a proposed forest road should be applied to the primary route and all proposed alternative routes so that the optimal route for minimized environmental impact can be selected.

Table 1. Evaluation of forest road.

Criteria	Weights	Grade, %	Sum
a. Criteria of absorbency (*A*)			
1. Terrain conditions			
1.1. Forest	3	62	186
1.2. Broadleaved forest	3	84	252
1.3. High forest	3	75	225
1.4. Selection forest	3	55	165
1.5. Mean height	3	45	135
1.6. Site quality	3	50	150
1.7. Productivity	3	25	75
1.8. Slope	2	50	100
1.9. Aspect	2	92.5	185
1.10. Relief	2	75	150
2. Distance from			
2.1 Tourist resort	1	90	90
2.2. National and country road network	1	30	30
2.3. Railway	1	100	100
2.4. Archaeological site	1	100	100
2.5. Adjacent big city	1	10	10
2.6. Adjacent village	1	10	10
2.7. European path	1	60	60
2.8. Lake or river	1	100	100
b. Criteria of intensity (*I*)			
Layout			
1. Earthwork allocation			
1.1. Curve radius	2.10	75	157
1.2. Gradient	2.01	65	131
1.3. Cross section	2.25	65	146.25
2. Road width	2.04	50	102
3. Road gradient	2.52	100	252
4. Serpentine	2.13	80	170.40
5. Position of road			
5.1. Distance of water flows	1.83	80	146.4
5.2. Distance of forest boundary	1.65	90	148.5
5.3. Area with construction problems	2.40	100	240
6. Picture of landscape			
6.1. Form of terrain	1.83	50	91
6.2. Vegetation	1.80	80	144
6.3. View effect	1.70	70	119.7
6.4. Compatible constructions	1.60	75	120
6.5. View of water flows	1.65	20	33
7. Visual absorption capability	1.77	55	97.35
Construction			
8. Construction of forest road (only for existing road)			
8.1. Machinery for excavation works	2.16	2,16	100
8.2. Materials	2.08	2,08	50
8.3. Seeding and mulching of side slope	1.38	1,38	40
8.4. Road drainage system	2.31	2,31	100

References

Abegg B. 1983. Einfluss der Wegedichte auf Rückeverfühlen und Rückedistanzen im Bergwald. Zürich. Schweizerische Zeitschrift für Forstwesen 134(8): 621–628.

Becker G. 1995. Walderschließung auf dem Prüfstand. Deutschland Allgemeine Forstzeitung 9: 482–483.

Doukas K. 1993. Walderschließung in Griechenland. Allgemeine Forstzeitung 19: 1056–1057.

Doukas K. 2004. Forest Constructions and Natural Environment. Giaxoudis Publishing. Thessaloniki, 408 p.

Drosos V.C. 2009. Environmental improvement of forest road. In: Proceedings of the second Pan-Hellenic Conference of Urban Planning and Regional Development: "Management and Protection of the Environment", Volos: 1025–1032.

Drosos V.C., Giannoulas V., Doukas K. 2006. General forest opening up works by the use of modern technologies: An evaluation of the intensity and absorbent capacity. In: Proceedings of the International Conference: "Sustainable Management and Development of Mountainous and Island Areas", Naxos, vol. 2: 219–228.

Kotoulas D. 1985. Management and control of torrent streams. Part I. Aristotle University of Thessaloniki. University Studio Press, 293 p.

Kotoulas D. 1987. Management and control of torrent streams. Part II. Aristotle University of Thessaloniki. University Studio Press, 400 p.

Kroth W. 1973. Entscheidungsgrundlagen bei Walderschließungsinvestitionen. Hamburg. Forstwissenschaftliches Centralblatt 87(4): 237–248.

Mader H.-J. 1990. Ökologische Aspekte des Waldwegebaues. Allgemeine Forstzeitung 46/47: 1184–1187.

Ntafis S. 1986. Forest Ecology. Giachoudis – Giapoulis Publishing. Thessaloniki, 443 p.

Ntafis S. 1990. Applied Silviculture. Giachoudis – Giapoulis Publishing. Thessaloniki, 258 p.

Sedlak O. 1993. Walderschließung und Naturschutz. Österreich, Wien. Österreichische Forstzeitung 104(7): 23–25.

Stergiadis Ch.G, Kotoulas D, Papastaurou A. 1984: Forest and mountainous regions – protection, development and exploitation. Scientific Annals of Department of Forestry and Natural Environment, Volume K KST-KZ. Thessaloniki: Aristotle University of Thessaloniki 1: 17–50.

Trzesniowski A. 1993. Wozu Walderschließung in Österreich? Österreich, Wien. Österreichische Forstzeitung 104(7): 5–7.

Tsoxos G. 1997. Environmental Road Construction. Aristotle University Press, Thessaloniki, 167 p.

Warner M.L. 1973. Environmental Impact Analysis: An Examination of three Methodologies. PhD-thesis. Wisconsin: University of Madison, 248 p.

Zundel R. 1990. Rechtliche Aspekte des Waldwegebaus. Deutschland, München. Allgemeine Forstzeitung 45(46–47): 1182–1184.