VOLUME I|Issue 2|2013|CIEO

Guest Editor: Thomas Panagopoulos
Editor: Teresa de Noronha

Journal of Spatial and Organizational Dynamics

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TECHNICAL INFORMATION

Volume I, Issue 2, 2013

JOURNAL OF SPATIAL AND ORGANIZATIONAL DYNAMICS

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Publisher:
Research Centre for Spatial and Organizational Dynamics - CIEO
Campus de Gambelas, Faculdade de Economia, Edifício 9
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Open Access Policy:
This is a blind peer-reviewed journal.
Articles submitted to this journal should not have been published before in their current or substantially similar form.
The JSOD is diffused by all links related to the Research Center for Spatial and Organizational Dynamics and is continually online (http://www.cieo.pt/discussion_papers_editions.php)
This journal is supported by the Portuguese Foundation for Science and Technology (FCT).

Networking and Indexing:
Silvia Fernandes

Page Layout:
Marlene Fernandes

Design and Cover Concept:
Bloco D, Design e Comunicação

Quarterly Edition
ISSN: 2183-1912
CIEO, Faro, Portugal

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ANALYZING THE IMPACTS OF INFORMATION IN THE PREVENTION OF FOREST FIRES IN GREECE

Paraskevi Karanikola
Stilianos Tampakis
Evangelos Manolas
Georgios Tsantopoulos

ABSTRACT

The forest fires which occurred in the prefecture of Ilia, Greece, in August 2007 resulted in significant losses in forest lands, property and human lives. The citizens behaved as simple spectators of the disaster. Although they could have reacted, they did nothing. The citizens, however, declare that they know what actions they need to take in case of fire. Their information regarding forest fires mainly comes from television and radio, family and friends, newspapers and magazines and education. Indeed, it seems that through interpersonal channels of communication better results are achieved. In confronting forest fires, knowledge alone is not sufficient. In order to effectively confront forest fires, the local population also needs to be trained and organized in a voluntary system of confrontation.

Keywords: Forest Fire, Ilia 2007, View of Citizen, Citizen Participation, Greece

JEL Classification: Q28, Z18, Z13

1. INTRODUCTION

The prefecture of Ilia is among the most fire-struck prefectures of Greece. For the period 2000-2009 it was second in the list of prefectures with the greatest number of agro-forest fires and first in the list of prefectures with the most destructive agro-forest fires (Gourbatsis, 2010). Indeed, in the period 24-28 August 2007 it had the most serious problem of all areas in Greece as a result of extreme weather temperatures which were higher than 40°C and north-eastern winds of a speed of 29 km/h (Xanthopoulos et al., 2008). As a result of these fires, 38.94% of forest land in the prefecture of Ilia was burned (Kaoukis, 2008) while 44 people lost their lives (Riga, 2010).

The synergistic effect of fuel accumulation and weather can explain the large and catastrophic wildfires of 2007 in Peloponnisos (Koutsias et al., 2012). These characteristics did not allow the confrontation of fire in a direct manner, since it was difficult to confront them by ground forces or even by air forces. However, in many cases it was possible, and there was time for clear-cutting in the perimeter of villages during evening or morning hours; however, in many of these cases, the locals did not engage in such activity (Miltiadis and Xanthopoulos, 2009). Indeed, in one case the citizens, in their effort to escape from their village, which eventually did not get burned, were trapped in open space and finally lost their lives. Generally, we can say that the citizens did not have the necessary knowledge and guidance as to how they should react. The above was also confirmed through a research project in which the majority of citizens in Ilia replied there was a lack of education and

provision of information to the citizens regarding how forest fires are confronted (Karanikola et al., 2011). Having an informed public is an important part of the mechanism for the prevention and confrontation of forest fires. The aim of such information is to make the public aware of the causes and handling of forest fires (Baden, 1981). Such information can also contribute greatly to the formation of effective policy at both national and regional levels (Gonzalez-Duque and Panagopoulos, 2010; Noronha, 2011).

The basic aims of the research are to investigate how citizens get their information regarding forest fires, how informed they are regarding actions they need to take in case of forest fires and the evaluation of the causes of the forest fires which took place in the prefecture of Ilia in 2007. The paper also attempts to connect information sources with the actions which citizens need to take in case of forest fires. The investigation of the sources from which citizens get their information is an important tool for the purpose of designing appropriate strategies for the solution of problems (Tsantopoulos and Karamichas, 2009). Real and substantial environmental information becomes practice when citizens, through appropriate methods, equip themselves with adequate information so that they can develop an informed opinion on environmental issues which, in turn, will be the basis for good decisions regarding the necessary actions (Skanavis, 2004; Alberto Pérez, 2012).

2. METHOD OF RESEARCH

The area of this research was the prefecture of Ilia. The research was carried out in 2008, a year after the destructive fires of 2007, so that the citizens of the areas would have ceased being emotionally charged and be able to freely speak about the forest fires which occurred in their area. To investigate the views of the citizens of the prefecture of Ilia, the method used was simple random sampling. This method was chosen because of its simplicity and the fact that, when compared to other methods, it needs less information about the population under study (Freese, 1984; Matis, 1992; Damianos, 1999; Kalamatianou, 2000). The 'population' studied was the total of households of the prefecture of Ilia. As a framework of sampling, we used the catalogues of electricity consumers. The estimation of the proportion of the population and of standard error, sp, is given by the formulas of simple random sampling.

In order to calculate the size of the sample, we needed to conduct pre-sampling, with the size of the sample being 50 people. The size of the sample for each variable was estimated on the basis of the formulas of simple random sampling (for probability (1-a) 100 = 95%, e = 0.05 and without the correction of finite population because n is small in relation to the size of the population N) (Freese, 1984; Matis, 1992; Pagano and Gauvreau, 1996; Kalamatianou, 2000). Thus, the most changing variable is estimated with desirable precision, and the rest with higher precision than originally determined (Matis, 1992). In this case the size of the sample was calculated to be 385 households. For the analysis of the data, the statistical package SPSS was used.

The total of the questions on sources of information constitute a multi-theme variable on which reliability is tested (reliability analysis). In order to find the internal reliability of a questionnaire, we use the alpha co-efficient (or the reliability co-efficient α-Cronbach); that is, we try to find if the data have the tendency to measure the same thing (Howitt and Gramer, 2003). When the alpha coefficient is 0.70 or greater it is regarded as satisfactory (Howitt and Gramer, 2003), and when it is greater than 0.80 it is regarded as very satisfactory. In practice, smaller alpha co-efficients, with values not less than 0.60, may also be accepted (Siardos, 1999).

The testing must be reliable in order to be useful. However, it is not enough to be reliable, it must also be credible, and this can be done through the application of factor analysis

(Siardos, 1999). Factor analysis is a statistical method which aims to find the common factors within a group of variables (Sharma, 1996). It tries to interpret structure rather than the variability (Djoufras and Karlis, 2001). Its goal is to reproduce the correlations between the variables to the highest degree, by using the smallest possible number of factors and thus lead to a solution which is "unique" and easily interpreted (Siardos, 1999).

More specifically, we used the principal components method, which is based on a spectral analysis of the variance table (correlation) (Djoufras and Karlis, 2001). The criterion used for the significance of the principal components is the one proposed by Guttman and Kaiser (Cattell, 1978; Frangos, 2004), according to which, the limit for receiving the appropriate number of principal components is determined by the values of the typical roots which are equal or greater than one. We also resorted to the rotation of the principal components matrix by using the maximum variance rotation method by Kaiser (Harman, 1976). According to Frangos (2004), the variables which "belong" to each factor are those whose burden, on the table indicating the burdens of the factors after rotation, is greater than 0.5 for that factor.

In order to test the pairs of variables which refer to the sources from which the citizens get their information and the pairs of variables which refer to knowledge citizens say they have regarding actions they need to take in case of forest fires, the test of independence was used. The criterion used was X2 (Mendenhall, 1979; Kiohos, 1993; Steel et al., 1997; Makrakis, 1997; Pagano and Gauvreu, 2000; Retiniotis, 2004). In the test of independence of features, the null hypothesis that is tested is "Ho: there is no difference between the variables".

In order for the test of independence to be credible, the expected frequencies should not be less than 1, while those that are less than 5 should not exceed 20% of the total of the frequencies (Koliva-Machaira and Mpora-Senta, 1995; Gnardellis, 2003; Siomkos and Vasilikopoulou, 2005). So, in order to avoid problems with the expected frequencies, we grouped the answers in each of the two groups of variables as follows: a) "very unimportant – mediocre" and "important – very important", b) "none – fairly" and "much – very much". The statistical measure X2 is based on comparing the expected frequencies to the observed frequencies and is done through the Crosstabs procedure of the statistical program SPSS (Apostolakis and Kastania, 1994; Howitt and Gramer, 2003; Frangos, 2004).

However, neither the measurement of intensity nor the specification of the nature of the (probable) relation of the variables can result from the statistical X2 (Tsantas et al., 1999). This is the reason contingency measures were created. In categorical imperatives only the intensity is meaningful, and the measures which rely on the statistical X2 are the phi coefficient, Gramer's V coefficient and the contingency coefficient (Tsantas et al., 1999; Retiniotis, 2004). The phi coefficient examines the direction between the variables (Siomkos and Vsilikopoulou, 2005). For reasons of space, although the above contingency measures were checked, nevertheless, these are not presented in the results. Indeed, for the pairs of variables, the co-efficient phi (Table 4) receives a positive value.

3. RESULTS – DISCUSSION

The dominance of the mass media regarding communication practices has brought several changes in the sector of provision of information to the public. The transmission of large amounts of information very quickly creates a false feeling of directness and active participation in what is happening (Bibi, 2009). During the awareness stage, mass media is the most effective communication channel. However, after the persuasion stage has been completed, interpersonal communication channels, particularly with expert information sources, become the most influential method (Fliegel, 1993). Citizens prefer more interactive

forms of information exchange (Daniels et al., 1996; Parkinson et al., 2003). Such two-way communication is most effective in reducing the inherent uncertainty of adopting a new innovation, as it promotes discussion and clarification. It is no surprise that interpersonal communication is particularly important for complex innovations or ones that require continual monitoring (Fliegel, 1993). People tend to respond better to messages coming from recognized sources, instead of anonymous information that comes from brochures, newspaper articles, written plans, and so forth (Shindler, 2007).

The results regarding the evaluation of the sources on forest fires from which the citizens of Ilia get their information, are presented in Table 1. 38.4% of the citizens of Ilia believe television and radio are very important sources, 26.5% important and 23.6% mediocre. 38.7% of the citizens believe family and friends are very important sources and 24.4% important and 24.4% mediocre. 34.5% of the citizens accept newspapers and magazines as important sources of information, while 23.6% and 22.6% as mediocre and very important respectively. 36.6% of the citizens think education is an important source of information while 26.8% think of it as mediocre. Next in order of importance comes the internet, noting that 21.3% characterizes this source as important and 25.7% as very unimportant, showing that a big percentage of the population (older in age) does not have access to the internet. 27.0% of the citizens think information booklets are a mediocre source of information, 22.3% important, 21.3% unimportant and 21.3% very unimportant. 27.5% of the citizens think books and encyclopedias are a mediocre source of information, 24.9% unimportant and 21.3% important. Finally,27.5% believe voluntary organizations are a very unimportant source of information and 24.7% a mediocre one.

Table 1. Sources of information regarding forest fires

		Very unimportant	Unimportant	Mediocre	Important	Very important
Family and friends	%	2.9	9.6	24.4	38.7	24.4
	s_p	0.0850	0.0150	0.0219	0.0249	0.0219
Education	%	4.4	16.4	26.8	36.4	16.1
	s_p	0.0105	0.0189	0.0226	0.0245	0.0188
Television - radio	%	1.3	7.5	26.2	26.5	38.4
	s_p	0.0058	0.0135	0.0224	0.0225	0.0248
Newspapers and magazines	%	4.7	14.5	23.6	34.5	22.6
	s_p	0.0108	0.0180	0.0217	0.0243	0.0213
Books - encyclopedias	%	18.4	24.9	27.5	21.3	7.8
	s_p	0.0198	0.0221	0.0228	0.0213	0.0137
Internet	%	25.7	17.7	18.7	21.3	16.6
	s_p	0.0223	0.0195	0.0199	0.0209	0.0190
Information booklets	%	21.3	21.3	27.0	22.3	8.1
	s_p	0.0209	0.0209	0.0227	0.0213	0.0139
Voluntary organizations	%	27.5	18.7	24.7	19.7	9.4
	s_p	0.0228	0.0199	0.0220	0.0203	0.0149

The total of the above questions constitutes a multi-theme variable. In order to check the consistency of these equivalent questions (variables), we used reliability analysis. The value of the reliability co-efficient alpha is significantly high (0.801). This constitutes a strong

indication that the degrees of the scale are logically consistent; that is, the data have the tendency to measure the same thing.

Before applying factor analysis, we checked our data in order to ensure that they are appropriate. We also checked if all variables are suitable for use in the model. In table 2, we see the burdens, which are the partial correlation coefficients of the eight variables with each of the three variables that have been extracted from the analysis. The greater the burden of a variable in a factor, the more this factor is responsible for the total variance of degrees in the variable we study. The variables which "belong" to each factor are those for which the burden (columns 1, 2, 3) is greater (than 0.5) in this factor.

Table 2. Table of factor burdens, before and after rotation

Variable	Factor burdens					
	Before rotation			After rotation		
	1	2	3	1	2	3
Family and friends	0.415	-0.269	0.786	0.032	0.088	0.924
Education	0.699	-0.283	0.318	0.499	0.107	0.639
Television and radio	0.500	0.700	0.285	0.067	0.887	0.177
Newspapers and magazines	0.588	0.646	0.001	0.295	0.822	-0.012
Books and encyclopedias	0.707	-0.287	-0.080	0.703	0.032	0.306
Internet	0.731	-0.063	-0.359	0.795	0.187	-0.004
Information leaflets	0.759	-0.141	-0.205	0.765	0.159	0.166
Voluntary organizations	0.721	-0.089	-0.301	0.766	0.171	0.051

According to the above results, the first factor includes the variables "books and encyclopedias", "internet", "information leaflets" and "voluntary organizations". This factor can be named "informing after the activation of the citizens".

The second factor titled "provision of information by the mass media" includes the variables "television and radio" and "newspapers and magazines".

The third factor titled "interpersonal channels of communication" includes the variables "family and friends" and "education". Indeed, we can accept that the variable "education", since the value is marginally less than 0.5, belongs to the first factor and constitutes a bridge between the first and third factors. In other words, the first and third factors are connected to each other. This is logical since the institutions of family and education teach/activate people to collect the information they need.

However, the issue is how today's confusion of knowledge with information is not a simple confusion of ideas but a confusion of mental processes that pushes people towards a more and more shallow evaluation of pieces of information without direction and cohesion (Davou, 2000). Therefore, the citizens of Ilia were asked if they know or if they are aware of the actions they need to take in case of fire; or, in other words, the knowledge they have is indeed deeper. In addition, an effort was made to connect sources of information to this particular knowledge. We should accept that the answers of the citizens are likely a reflection of the numerous formal and informal ways in which people may learn about and understand wildfire mitigation (McCaffrey et al., 2011).

In general, we see that the citizens of Ilia declare that they are knowledgeable as to how they should act in case of forest fire (Table 3). In particular, regarding ways of protecting their lives, 29.6% say they are very knowledgeable, 27.3% sufficiently knowledgeable and 26.5% extremely knowledgeable. Regarding more general measures of forest fire prevention, 33% declare they are very knowledgeable, 27% sufficiently knowledgeable and 20.5% extremely

knowledgeable. In relation to preventive measures regarding protection of houses from forest fires, 38.2% say they are very knowledgeable and 29.4% sufficiently knowledgeable. Regarding ways for protecting houses during forest fires, 30.1% declare they are sufficiently knowledgeable and 27.8% very knowledgeable. The citizens of Ilia seem less knowledgeable regarding ways of putting out forest fires since 29.1% declare they are very knowledgeable, 26.8% sufficiently knowledgeable and 20.3% characterize their knowledge as poor. There is a need for more systematic education – provision of information to the citizens on how forest fires should be confronted (Karanikola et al., 2011).

Table 3. Information regarding actions in case of forest fires

		None	Poor	Fairly	Much	Very much
More general preventive measures regarding forest fires	%	4.9	14.5	27.0	33.0	20.5
	s_p	0.0111	0.0180	0.0227	0.0240	0.0206
Preventive measures regarding protection of houses from forest fires	%	3.1	16.1	29.4	38.2	13.2
	s_p	0.0089	0.0188	0.0232	0.0248	0.0173
Methods for putting out forest fires	%	7.5	20.3	26.8	29.1	16.4
	s_p	0.0135	0.0205	0.0226	0.0232	0.0189
Ways for protecting houses during forest fires	%	4.9	18.7	30.1	27.8	18.4
	s_p	0.0111	0.0199	0.0234	0.0229	0.0198
Ways for protecting your life during forest fires	%	5.2	11.4	27.3	29.6	26.5
	s_p	0.0113	0.0162	0.0227	0.0233	0.0225

Table 4 presents the results of the test of independence on forest sources regarding forest fires, as well as information regarding actions which citizens need to take in case of forest fires. Therefore, we see that better information coming from family and friends and education (that is what we call basic education) leads to better knowledge regarding what to do in case of fire. Also, better knowledge provided by information leaflets leads to better knowledge as to what to do in case of fire with the exception of ways for putting out forest fires. Better information from books and encyclopedias leads to better knowledge regarding ways for putting out forest fires. Better information coming from television and radio leads to better knowledge regarding more general, preventive measures against forest fires. Finally, better information from voluntary organizations leads to better knowledge regarding ways for protecting life during forest fires. For pairs in Table 4 for which no values are mentioned, we cannot reject the null hypothesis (Ho); therefore, we are not certain whether or not the pairs of the variables are independent among them.

Table 4. Results of the test of independence among sources of information and information regarding actions in case of forest fires

		Family and friends	Education	Television-Radio	Newspapers and magazines	Books-encyclopedias	Internet	Information leaflets	Voluntary organizations
More general preventive measures against forest fires	Value	6.436	5.945	8.031				11.701	
	A. Sig.	0.011	0.015	0.005				0.001	
Preventive measures regarding protection of houses against forest fires	Value	7.582	8.306					13.920	
	A. Sig.	0.006	0.004					0.000	
Methods for putting out forest fires	Value	10.875	6.234			4.304			
	A. Sig.	0.001	0.013			0.038			
Ways for protecting houses during forest fires	Value	9.636	14.507					5.875	
	A. Sig.	0.002	0.000					0.015	
Ways for protecting your life during forest fires	Value	12.596	13.204					20.664	5.282
	A. Sig.	0.000	0.000					0.000	0.022

In order to confront forest fires, we should work as much as possible for the eradication of the causes which create them (Kailidis et al., 2004). Through the evaluation of the causes of the forest fires which occurred in 2007 in the prefecture of Ilia, it becomes obvious that the citizens think that the most important causes of forest fires are either from being on purpose (arson) or from negligence, while the causes of random event or natural causes are the least accepted causes (Table 5). 40.5% of the citizens think that setting a fire on purpose for economic reasons is a very important cause of forest fires, 31.7% an important cause and 17.9% a mediocre cause. Urban and tourist areas were developed at the expense of forest lands, and fire was used as a "tool" for making land appear as agricultural land so that such lands could be exploited for commercial purposes (Karanikola and Tampakis, 2003).

Table 5. Evaluation of the causes of forest fires which occurred in 2007 in the prefecture of Ilia

		Very unimportant	Unimportant	Mediocre	Important	Very important
Negligence	%	5.7	10.9	19.7	35.6	28.1
	s_p	0.0118	0.0159	0.0203	0.0244	0.0229
Random event	%	17.7	28.8	26.5	20.0	7.0
	s_p	0.0195	0.0231	0.0225	0.0204	0.0130
Natural cause - thunderstorm	%	30.6	28.8	19.2	9.9	11.4
	s_p	0.0235	0.0231	0.0201	0.0152	0.0162
Economic expediency	%	4.4	5.5	17.9	31.7	40.5
	s_p	0.0105	0.0116	0.0196	0.0237	0.0251
Political expediency - elections	%	6.2	11.9	23.4	25.7	32.7
	s_p	0.0123	0.0166	0.0216	0.0223	0.0239
Absence of forest cadastre	%	12.7	18.7	26.0	22.3	20.3
	s_p	0.0170	0.0199	0.0224	0.0213	0.0205

Thirty-five percent of the citizens think that negligence is an important cause of forest fires and 28.1% a very important cause. Programs for informing the public regarding prevention and control of forest fires should be intensified in Mediterranean countries so that they can contribute to a gradual reduction of forest fires which are caused by negligence (Tampakis et al., 2005).

32.7% of the citizens think that political expediency – elections is a very important cause of forest fires, 25.7% an important cause and 23.4% a mediocre cause. In periods of national disasters, political crises and elections, we generally witness an increase of forest fires in Greece (Kailidis and Karanikola, 2004). 26.0% of the citizens think that the absence of forest cadastre is a mediocre cause of forest fires, 22.3% an important cause and 20.3% a very important cause. Preventing building activities on forest lands essentially constitute an indirect method of protecting these lands, because the easiest way of removal of vegetation is repetitive forest fires. Indeed, the best way for achieving that is the creation of a forest cadastre (Karanikola and Tampakis, 2005).

Finally, 28.8% of the citizens think that random events are an unimportant cause of forest fires and 26.5% a mediocre cause, while 30.6% of the citizens think that natural events – thunderstorms are a very unimportant cause and 28.8% unimportant cause. We see the same in another paper on the views of citizens in Greece as a whole: thunderstorms as natural causes and forest fires caused by random events have small percentages of acceptance as a cause of forest fires (Karanikola and Tampakis, 1998).

4. CONCLUSIONS

The citizens of Ilia say that they get their information regarding forest fires from television and radio, family and friends, newspapers and magazines and education. Through the aid of factor analysis, the variables "television and radio" and "newspapers and magazines" constitute a factor titled "information from the mass media", while the variables "family and friends" and "education" constitute a factor titled "interpersonal channels of communication". Next in order of importance comes the internet – although a large percentage of the population (those older in age) do not have access to it – information leaflets, books and encyclopedias, and voluntary organizations which constitute a factor named "informing after the activation of the citizens".

The citizens also declare that, regarding confrontation of forest fires, they have deeper knowledge; in other words, they know the actions they need to take in case of fire. In particular, they know how to protect their lives during forest fires, about more general preventive measures against forest fires, about preventive measures regarding protection of houses from forest fires and about ways for protecting houses during forest fires. However, on ways of putting out forest fires, they seem to be less knowledgeable.

This research becomes interesting when, via the test of independence, information sources and existing knowledge are connected. This is because the results are fully compatible with everything mentioned above on different forms of communication. Therefore, we see that better information from family and friends and education, i.e. information from interpersonal channels of communication, leads to better knowledge as to what we should do in case of fire. We also see that information leaflets are an important source of information, which in the case of forest fires are published by the Forest Service and the Fire Department, that is, from recognized sources of information. However, information leaflets, due to the large amounts of knowledge involved, cannot cover the subject of putting out forest fires. This seems to be done through information from books and encyclopedias. Regarding more general preventive measures against forest fires, information from television and radio lead to better knowledge.

It is a fact that the messages from the mass media mainly concern the prevention of fire from citizen negligence and immediately contacting the Forest Service when they realize that a fire has started. On the other hand, better information from voluntary organizations leads to better knowledge regarding ways of protecting life during forest fires.

It becomes obvious that education and, indeed, education from recognized sources such as the Forest Service and the Fire Department would constitute a positive development towards better knowledge and training of citizens on issues related to forest fires.

However, it remains a question as to why the majority of citizens did not do what they had to do in case of fire, since they declare that they know what they needed to do. Confronting forest fires is a science (knowledge), but it is also an art. In other words, it is necessary to combine theoretical knowledge with practical (manual) action. Indeed, the activation of citizens should assist fire extinguishing forces and be done under their guidance, e.g. clear-cutting in the perimeter of inhabited areas and when the fire has not yet reached the specific area. Indeed, we do not need theoretical education but practical education and organization of voluntary groups for dealing with natural disasters that will be guided by specialists, e.g. those who trained these groups, when this is necessary.

Finally, in assessing the causes of the forest fires which occurred in 2007 in the prefecture of Ilia, the citizens think that the most important causes of forest fires are expediency (arson) and negligence rather than random events or natural causes.

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EVALUATION OF THE URBAN GREEN INFRASTRUCTURE USING LANDSCAPE MODULES, GIS AND A POPULATION SURVEY: LINKING ENVIRONMENTAL WITH SOCIAL ASPECTS IN STUDYING AND MANAGING URBAN FORESTS

Jose Antonio Gonzalez-Duque
Thomas Panagopoulos

ABSTRACT

Modern cities have to reconcile the needs of the citizens for green areas considering the evolutionary trends of the city, especially in terms of growth and the required transformation in modern times. The present study attempts to analyze and evaluate the amount and distribution of the existing urban green space and the requirements of those green areas by the public. The green infrastructure of the city of Faro was evaluated with three methods: landscape assessment using modules, spatial assessment using GIS and social assessment using an urban population survey. This research provided indicators and thresholds to be included by policy makers in local regulations about green infrastructure of the city of Faro.

Keywords: Cityscape, Urban Green Network, Evaluation of Green Areas, Urban Forestry

JEL Classification: Q28, Z18, Z13

1. INTRODUCTION

In recent times Green Infrastructure (GI) has gained importance as a planning tool for regional and urban sustainability (E.E.A. 2011). Attention is also given to the environmental services provided by GI in the context of city resilience and climate change adaptation and mitigation. As the urban population increases, so do diverse urban problems and concerns including issues of servicing large numbers of people within existing infrastructures, as a result of over-development and over-concentration. Environmental problems, particularly air and water pollution, have become more evident and are now considered central issues for urban planners and decision-makers (Oh et al., 2005). A well-structured urban forest mitigates temperature; absorbs air, soil and water pollutants; and decreases acoustic pollution, water run-off and soil erosion (Jankovska et al., 2010; Ferreira and Panagopoulos, 2012).

It is acknowledged that, alongside environmental services, GI can also provide a number of social benefits or cultural ecosystem services for a range of uses (Goličnik and Ward, 2010). Urban green spaces (UGS) form an integral part of any urban area, and quantity and quality of UGS are of prime concern for planners and city administrators (Gupta et al., 2012). UGS create opportunities for recreational activities which contribute to people's health, well-being and quality of life, particularly in relation to their capacity to provide environments which help to alleviate stress (Gonzalez-Duque and Panagopoulos, 2010). The ameliorating thermal effect induced by green areas inside the warm, urban microclimate of densely populated cities can improve the thermal comfort, as well as the overall health and living conditions of their inhabitants (Papangelis et al., 2012).

The design of urban landscapes strongly influences the well-being and behavior of users and nearby inhabitants (Matsuoka and Kaplan, 2008). The aesthetic qualities they bring to spaces can help improve the sense of place and make the city more appealing to live in (Panagopoulos, 2009). It has also been suggested that GI can have a positive impact on social interaction and inclusion, providing spaces for use by the whole community. Furthermore, UGS are valuable in terms of education and learning, helping people to 're-connect' with nature and educating them about its continued relevance in their lives.

The processes and management in past traditional landscapes and the manifold relations people have towards the perceivable environment, and the symbolic meaning it generates, offer valuable knowledge for more sustainable planning and management for future landscapes (Antrop, 2005). The concept of landscape broadens and differentiates according to the context. Concepts such as natural, human, social or quality of life capital are principally expressions of this broadening. They are attempts to formulate new frameworks adapted to specific visions or conditions of the landscape (Antrop, 2006). The urbanized landscapes are highly dynamic, complex and multifunctional. Therefore, detailed inventories of landscape conditions and monitoring of change are urgently needed in order to obtain reliable data for good decision-making (Antrop, 2004).

Cultural identity is strongly associated with the ways in which people interact with their landscapes. A few special landscapes may have 'universal' or 'outstanding' values, but almost all landscapes will be valued in multiple ways by those people who are closely associated with them (Stephenson, 2008). Since the social values of urban woodlands are not always sufficiently taken into account in decision-making on urban land-use and green space planning, new means of collecting the experienced values of urban green areas and integrating this information into the planning processes are needed (Tyrväinen et al., 2007).

The cities are complex ecosystems affected by social, economic, environmental and cultural factors. The problem of attaining urban, sustainable development is thus an important challenge. The development of evaluation indicators and a method for assessing the status of urban sustainable development will be required to support urban, ecological planning (Li et al., 2009). Rapid urbanization has caused many environmental impacts associated with the reduction of green space. Having realized the important role of green space in urban ecosystems, many local governments in China have set out a series of policies to introduce green elements into urban areas (Zhou and Wang, 2011). Accordingly, the urban landscape is becoming increasingly important for maintaining biodiversity on site, as well as for understanding the concept of biodiversity in general, and its maintenance in urban landscapes (Sandström et al., 2006). The need for suitable planning strategies to reduce landscape fragmentation favoring energy and matter fluxes between ecosystems, while preserving biodiversity, is a key issue of nature conservation and sustainable development (Gobattoni et al., 2011). Making landscape functions explicitly spatial adds an important component to research conducted in the field of quantification of landscape goods and services (Willemen et al. 2008).

Attitudes influence behavior towards urban green spaces, but determining attitudes toward urban green spaces is not operationalized well in urban planning research (Balram and Dragićević, 2005). Human attribution of multiple values to landscapes is not well understood owing to the variability and complexity of both the landscape concept and the human valuation process (Brown and Brabyn, 2012; Panagopoulos, 2012). In China, rapid urbanization has profoundly transformed the spatial pattern of urban land use, including urban green spaces. The government plans to optimize green spaces to integrate with urban development; this requires an understanding of the process of green space change. Quantification of green space patterns is a prerequisite to understanding green space changes,

and it is essential for monitoring and assessing green space functions (Kong and Nakagoshi, 2006).

According to Ryan (2011), landscape planners in the future will need to know as much about the social landscape as they do the physical landscape before embarking on planning actions. Attitudes toward urban green spaces include: an integrating questionnaire survey and collaborative GIS techniques to improve attitude measurements. The citizens are making greater demands for a more active role in the planning and decisions that are made about the green spaces in their communities. These demands are motivated by reasons such as: a desire to improve the quality of community life, environmental protection, participation in decisions that will affect their lives, concern for social conditions and a need for satisfaction with their surroundings (Balram and Dragićević, 2005).

The objective of this research was to evaluate the green infrastructure of the city of Faro and examine if it meets the desires (needs) of the population. In this paper the amount and distribution of the green areas of the city of Faro were assessed with three different methods. In the first method landscape modules were used, as described in Gonzalez-Duque and Panagopoulos (2012); in the second method the green areas based on GIS technology were assessed and linked; and in the third method the relationship regarding green areas and urban population was studied with a survey.

2. METHODOLOGY

1. The study objects of this article are the urban green areas and the opinion of the citizens of Faro (Portugal) by the method of direct survey. This research integrates spatial variables (methods one and two) with social variables (third method). The data collection methods have been taken by direct observation, digital mapping (GIS software), statistical functions and questionnaires. Instruments used for the study and data analysis are: software such as ArcGIS, CAD and statistical software such as SPSS. The following hypotheses were studied: Do the different urban areas have different needs in green area or similar? Does GI affect the existence of green areas and, if so, likewise influences the distribution and size of green areas in appetite (need) of green space for citizens?

2.1. The Study Area. The landscape of Faro city

The Algarve region in Portugal is often considered as one of the most appealing regions for tourism in the country. Its attractive location and moderate climate have brought increasing economic prosperity since the mid-1960s (Noronha Vaz, Eric de, et al., 2012). Those kinds of metrics are highly applicable to the study of urban landscape dynamics and processes. This is especially true for Southern European cities, given the acceleration of their urban growth processes (Aguilera F., et al., 2011). Urban land employs scenarios for a tourist region in Europe. Urban growth arises from the increase in population, particularly due to tourism and economic change. However, the spatial patterns are different due to alternative assumptions about urban development processes/purposes (Petrov, L.O., et al., 2009).

The city of Faro is surrounded to the north, east and west by the countryside of Faro, offering gentle relief and soils with high agricultural capacity (alluvium) which is dominated by intensive agriculture irrigation, horticulture and vineyards with predominantly greenhouse crops and fruit trees. To the south of the city, by the Atlantic Ocean, the Natural Reserve Park of Ria Formosa is located, which has great natural wealth. In the urban area of the city of Faro, there is a multitude of species of both trees and shrubs that make up the different areas of the urban landscape.

An inventory of Faro refers to a variety of public spaces: alignments, plazas, squares, gardens and parks. The highlight for its size is the garden "Alameda João de Deus" located along the Rua da Segurança, the Police Post, and the wooded park located in the Liceo surrounded by the Rua de Berlim; within these two elements, there is a wide variety of plant species of herbaceous, shrub and tree.

2.2. Urban Structure

Current research on sustainability of cities has favored the implementation and conservation of greenery in the urban context. The benefits of plants are not just environmental but recreational, aesthetic and emotional (Ong, B.L., 2003). The term 'landscape' focuses upon the visual properties of the environment, which include natural and man-made elements and physical and biological resources that could be identified visually; it also includes non-visual biological functions, cultural/historical values, wildlife and endangered species, wilderness value, opportunities for recreation activities and a large array of tastes, smells and feelings (Panagopoulos, T., 2009). Green space around settlements is increasingly important for recreation. However, recreation managers have limited spatially explicit data on recreation potential around cities, and representative field data are expensive to gather (Kienast, F., et al., 2012).

Nowadays you can see Faro progress and differentiate into four areas or general areas:

1. Vila-a-Dentro: the old city center with homogeneous architectonic characteristics, harmony in building typologies and irregular borders.
2. Zona de Extramuros: a zone with heterogeneous characteristics, buildings in blocks of low and average density and neighborhood gardens, open spaces and avenues.
3. Periferia Urbana: a zone of high buildings in blocks of high density, with an absence of connection and with disarticulated public space.
4. Area de Expansion: a zone of high buildings in blocks of high density and an absence of public space.
5. For the application of the three methods, it has been divided into seven areas of urban characteristics and similar landscaping (fig. 1).

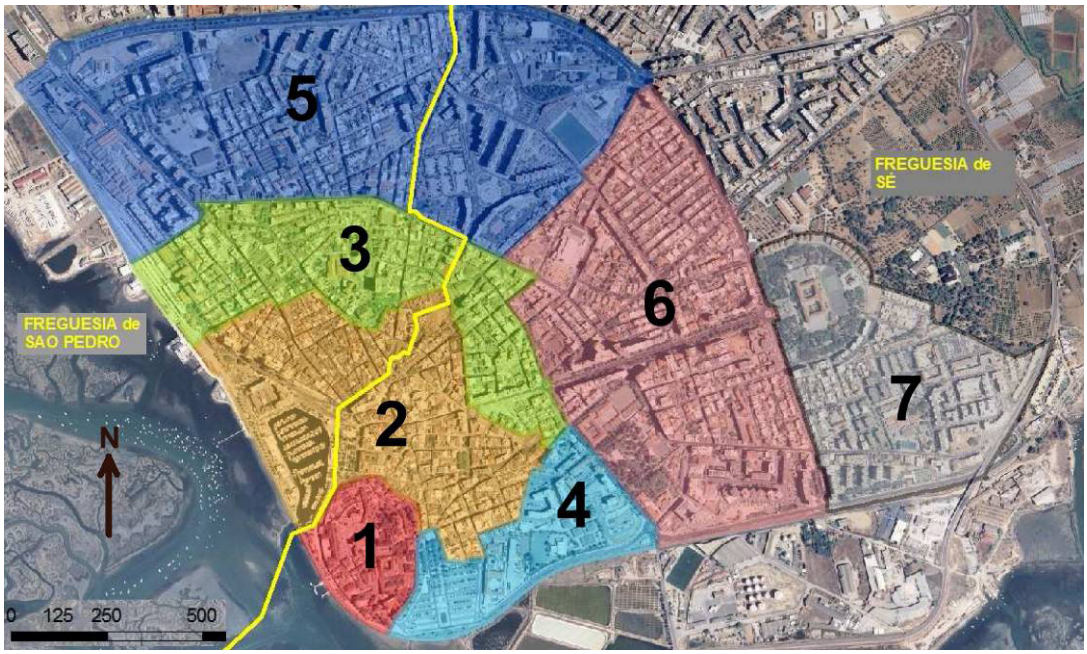


Fig. 1. Faro (Portugal) division into seven zones

2.3. Landscape Modules method

2.3.1. Description of the vegetation modules

The landscapes modules method is based on the doctoral thesis of Gonzalez Duque (2011). A basic element method explained and utilized in this study is the variable upon which the suggested methodology has been developed. The variable in question is the Vegetation Module (VM). The VM evaluates a facet of the quality of urban vegetation based on other objective parameters, depending on the urban environment as well as the feature being studied. The evaluation of the urban landscape is done through the calculation of the VM using the parameters streets, buildings and vegetative elements (Gonzalez-Duque and Panagopoulos, 2012).

There are six basic, analytic VM: three of them refer to constructive or structural elements: non-vegetative elements (Modules I, II, and III - "Evaluation Constructive Elements" - ECE), and another three, which are vegetative elements (Modules IV, V, and VI - "Evaluation Vegetative Element"- EVE).

2.3.2. Indicator pattern method in relation to urban green areas (IPRUGA)

For weight with Green Zones within the cities, a new empirical method has developed, which has not been taken from previous normalizations. The results obtained with this method are quantitative and indicate whether the surface of green areas in a city is adequate or not.

Table 1 shows the "Indicator Pattern in Relation to Urban Green Areas (IPRUGA)". The IPRUGA is defined as: (IPR1 + IPR2 + IPR3) / 6. Where:

IPR1 = Buildings / Green Areas (The objective of this first application is to establish a direct link between buildings and green areas).

IPR2 = (Buildings + Roads-sidewalks) / (Green Areas + Open Space) (The numerator is reflected categories that are not eligible to become a Green space and the denominator is current and possible future Green space).

IPR3 = (Buildings + Roads-sidewalks + Open Spaces) / Green Areas (is based on the worst case that the "vague" will not become part of the green areas).

Table 1: Range of values that can take the method IPRUGA in each application area

TABLES
Indicator Pattern in Relation to Urban Green Areas (IPRUGA)

Abbreviation	Urban space types
GA	Green Areas
OS	Open Space
RS	Roads-sidewalks
B	Buildings

Ipruga elements	Urban elements
IPR1	B / GA
IPR2	(B+RS) / (GA+OS)
IPR3	(B+RS+OS) / GA

IPRUGA	VALUES
Excellent	0 ≤ I ≤ 1
Very Good	1 < I ≤ 1,5
Good	1,5 < I ≤ 2,5
Middle	2,5 < I ≤ 4,5
Middle low	4,5 < I ≤ 6,5
Low	6,5 < I ≤ 8,5
Very low	8,5 < I ≤ 10

IPRUGA: (IPR1 + IPR2 + IPR3)/6

2.4. Method of Citizen Survey

The purpose of conducting a survey of the population of the city of Faro is to know the opinion of the inhabitants of the city of Faro on the use and enjoyment of green spaces and their preferences for them.

The research variables have been specified, focusing on the different types of Landscape (Garden, Park, Plaza, Alignments, scattered plants and/or grass and plants in containers) and their current status (maintenance, accessibility, location , ...).

This questionnaire will provide the different opinions and thoughts of the inhabitants of the city on the green areas that are surrounding them.

3. RESULTS

3.1. Result of the Method Vegetation Modules

After applying the vegetation modules to each study area, ECE and EVE values of each city zone were obtained. The results can be seen in figure 2 showing that most zones present a negative, unbalanced rating.

- Zones 4 and 7 were those that best meet the needs of green areas for the city of Faro according to the ECE and EVE values. The zone 4 was the best and most balanced and zone 7 was good but not as balanced as above.
- Zones 1, 2 and 3 present values that are generally unbalanced and streets with very few green areas.
- Zone 5 follows the same trend as previous areas but is somewhat better (than 1, 2 and 3).
- Zone 6 has enough green areas in relation to the characteristics of the streets.

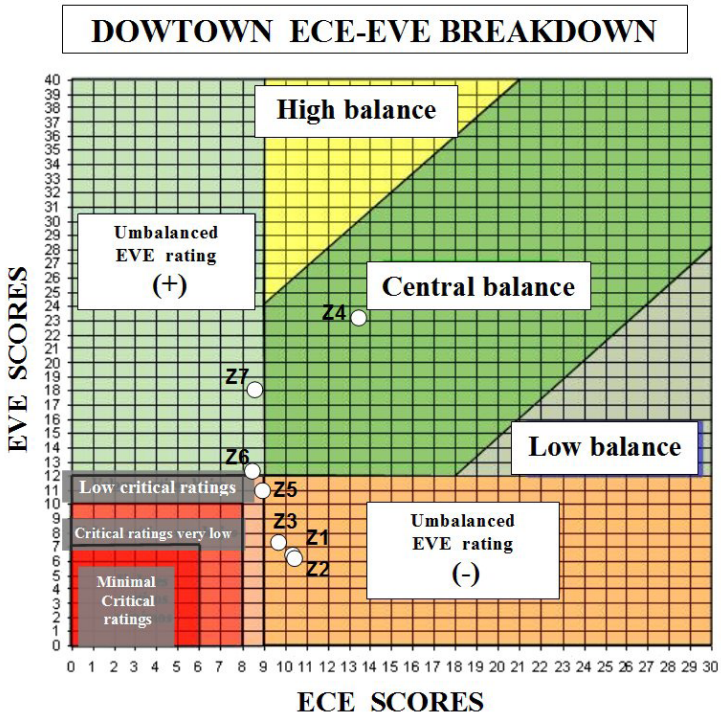


Fig. 2. Relation matrix ECE-EVE study area

3.2. Result of the Method of Indicator Pattern in Relation to Urban Green Areas (IPRUGA)

The estimation of the surface of urban elements (GA, OS, RS, B) for calculating IPRUGA can be seen in table 2 and figure 3. In figure 3 it can be seen as a graphic representation of the IPRUGA assessment for the city of Faro. In figure 4 it can be seen as the surface of urban elements for calculating IPRUGA by zones.

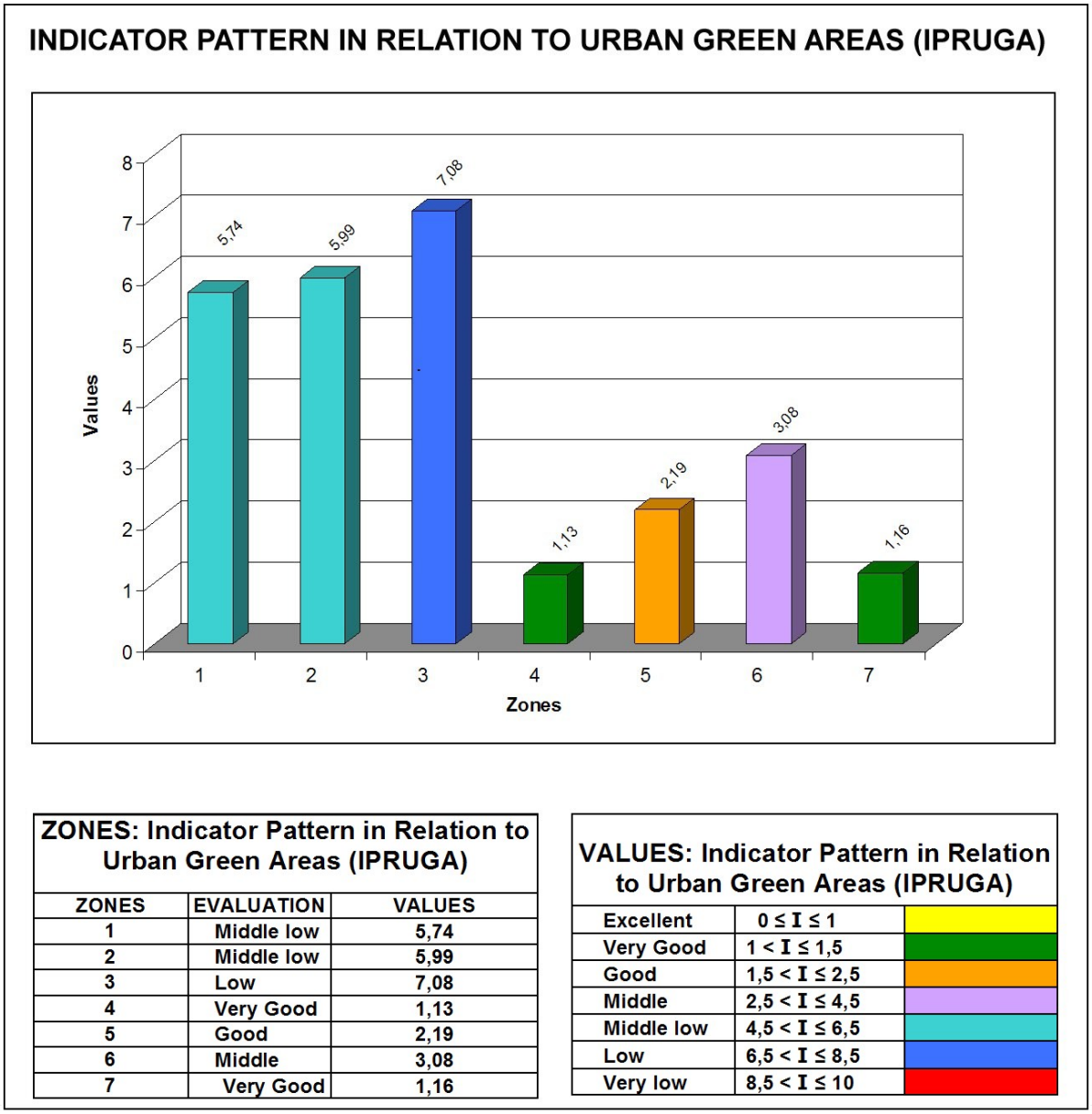
Table 2. Estimation of the surface of urban elements for calculating the Indicator Pattern in Relation to Urban Green Areas (IPRUGA)

Estimation of the surface of urban elements (GA, OS, RS, B) for calculating IPRUGA (Indicator Pattern in Relation to Urban Green Areas)				
Zones	GA(%)	OS (%)	RS (%)	B (%)
1	7,23	0	29,07	63,69
2	6,72	0,51	30,55	62,22
3	5,62	0,36	37,85	56,16
4	24,12	5,47	39,86	30,54
5	14,48	3,92	40,76	40,85
6	12,14	1,22	28,98	57,66
7	26,41	1,98	28,8	42,81

As shown in the graph of figure 3, the results can be classified in three groups:

- A first grouping would consist of a zone 1 with green zone of 7.23%, Zone 2 with 6.72% and zone 3 with 5.62% which would be a significant shortage of green areas.
- A second grouping consists of zones 5 and 6 which had 14.48% and 12.14% of green areas respectively.
- The third group consists of zone 4 with 24.12% of green areas and zone 7 with 26.41%, both having very good assessment areas.

The Indicator Pattern in Relation to Urban Green Areas (IPRUGA) method provided a useful and practical tool to establish a proper classification of green space, referencing the urban fabric. The ranges of the classification can be a clear reference of green areas that should exist in a city. In the study area there are three areas of acute shortage of green areas with high building density and two areas with very good assessment of green areas.



ZONES: Indicator Pattern in Relation to Urban Green Areas (IPRUGA)

ZONES	EVALUATION	VALUES
1	Middle low	5,74
2	Middle low	5,99
3	Low	7,08
4	Very Good	1,13
5	Good	2,19
6	Middle	3,08
7	Very Good	1,16

VALUES: Indicator Pattern in Relation to Urban Green Areas (IPRUGA)

Excellent	$0 \leq I \leq 1$
Very Good	$1 < I \leq 1,5$
Good	$1,5 < I \leq 2,5$
Middle	$2,5 < I \leq 4,5$
Middle low	$4,5 < I \leq 6,5$
Low	$6,5 < I \leq 8,5$
Very low	$8,5 < I \leq 10$

Figure 3. Graphic representation of the IPRUGA valuation

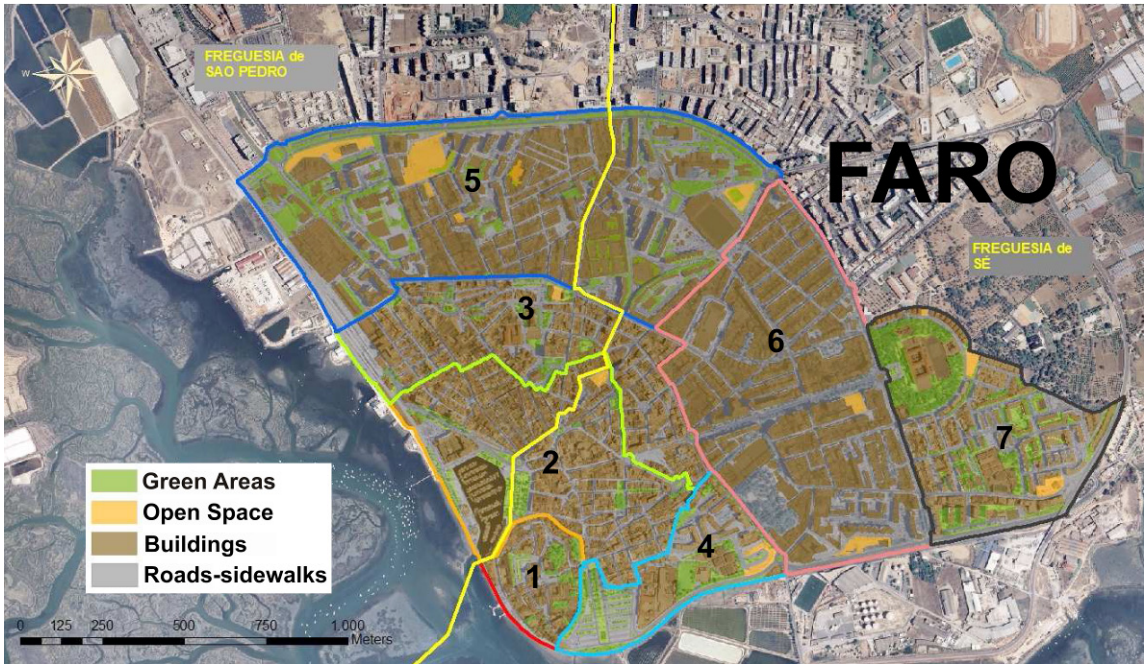


Fig. 4. Surface of urban elements for calculating by zones the Indicator Pattern in Relation to Urban Green Areas

3.3. Overall results of the survey to the citizens

According to the survey method, interesting results were found for each of the city zones that link with the results of the other two methods. In this paper the 7th question of the study is presented as a sample.

Zone 1: public green areas have an intermediate position in relation to other areas.

Zone 2: about 40% of people believe there are enough green areas near their homes.

Zone 3: the views of local residents have been very diverse with 70% of responses in the range between low and fairly close to the green areas of their homes.

Zone 4: about 60% of the population surveyed in Zone 4 think that the proximity of green areas to their homes is quite good (52.6%) or acceptable (10.5%).

Zone 5: most people surveyed believe that the green areas are poorly (23%), fair (29.2%) and significantly (38%) near their homes.

Zone 6: almost 50% of the population surveyed in this area believe that the green areas are fairly close to their homes.

Zone 7: the vast majority of the surveyed population believed that the green areas were fairly close to their homes (42.2%).

Results from the 7th Question of the survey can be seen in the figure 5 in table 3. The survey can be seen in Appendix A (Supplementary data).

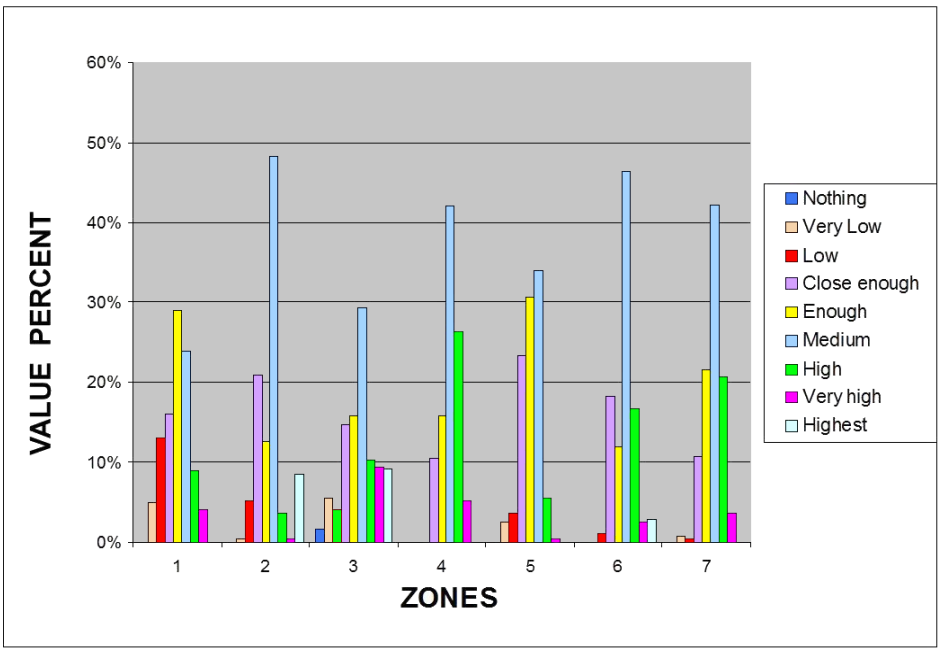


Figure 5. Graphical results of question number 7 of the citizen survey

Table 3. Valuation of the distance of the citizen green areas from home (Results of the 7th question of the survey)

	ITEMS / VALUE	CITIZEN	ZONE NUMBER						
		PERCENT	1	2	3	4	5	6	7
ACCESIBILITY	1: Nothing	CITIZEN - 1	0	0	4	0	0	0	0
		PERCENT - 1	0.00%	0.00%	1.60%	0.00%	0.00%	0.00%	0.00%
	2: Very Low	CITIZEN - 2	5	1	14	0	7	0	2
		PERCENT - 2	5.00%	0.40%	5.60%	0.00%	2.60%	0.00%	0.80%
	3: Low	CITIZEN - 3	13	13	10	0	10	3	1
		PERCENT - 3	13.00%	5.20%	4.00%	0.00%	3.60%	1.10%	0.40%
	4: Close enough	CITIZEN - 4	16	52	37	4	64	50	27
		PERCENT - 4	16.00%	21.00%	14.70%	10.50%	23.40%	18.20%	10.80%
	5: Enough	CITIZEN - 5	29	31	40	6	84	33	54
		PERCENT - 5	29.00%	12.50%	15.90%	15.80%	30.70%	12.00%	21.50%
	6: Medium	CITIZEN - 6	24	120	74	16	93	127	106
		PERCENT - 6	24.00%	48.40%	29.40%	42.10%	33.90%	46.40%	42.20%
	7: High	CITIZEN - 7	9	9	26	10	15	46	52
		PERCENT - 7	9.00%	3.60%	10.30%	26.30%	5.50%	16.80%	20.70%
	8: Very high	CITIZEN - 8	4	1	24	2	1	7	9
		PERCENT - 8	4.00%	0.40%	9.50%	5.30%	0.40%	2.60%	3.60%
	9: Highest	CITIZEN - 9	0	21	23	0	0	8	0
		PERCENT - 9	0.00%	8.50%	9.10%	0.00%	0.00%	2.90%	0.00%
	10: Maximum	CITIZEN - 10	0	0	0	0	0	0	0
		PERCENT - 10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
TOTAL		CITIZENS	100	248	252	38	274	274	251

4. DISCUSSION BETWEEN THE RESULTS OBTAINED IN THE DIFFERENT METHODS OF ASSESSMENT OF LANDSCAPE

The results of the three methods: Landscape Modules method, Indicator pattern in relation to urban green areas (IPRUGA) and Method of citizen survey were analyzed independently and jointly.

We can consider that areas 1, 2 (medium-low valuation) and 3 (low assessment), due to a shortage of green areas and existing ones, are removed. Zones 4 and 7 rated as very good due to the amount of green space and, therefore, the relative proximity to their homes. Zones 5 (good) and 6 (average) actually occupy an intermediate position in both green areas and in the opinion of citizens (opinion good and sufficient in relation to green areas).

Zone 1. According to the population survey method in Zone 1, green areas have an intermediate position. This seems contradictory when compared with the results of the other two methods (method of landscaping modules and methods based on GIS technologies) that obtained data that Zone 1 lacks green areas based on the urban fabric. This apparent contradiction is justified by the small area of Zone 1, which allows residents of this area to take advantage of the green areas of the surrounding areas.

Zone 2. In Zone 2, according to the method of survey population, about 40% of people believe they are close enough to green areas from their homes. For both modules in the method of landscape, as in the method of GIS technology, we have obtained data that the green areas of Zone 2 are limited to the urban fabric that has the zone.

Zone 3. In the method of population survey, the views of local residents have been very diverse. Method 3 found 70% of responses in the range between low and fairly close to the green areas of their homes. This can be justified for the other two methods. In the method of modules landscape, data was obtained that only 40% of streets have enough green spaces in terms of its urban fabric. Furthermore, the application of the GIS technology in this area of study also supports the results that Zone 3 has very few green areas to the urban fabric that it has (only 5.62% of the area are green areas).

Zone 4. About 60% of the population surveyed in Zone 4 think that the proximity of green areas to their homes is enough (52.6%) or acceptable (10.5%). These responses are confirmed by the other two methods applied where Zone 4 perfectly fits the needs of green areas.

Zone 5. Most people surveyed in Zone 5 believe that the green areas are poorly (23%), fair (29.2%) and significantly (38%) near their homes. These responses are justifiable as Zone 5 has 14.48% landscaping. The results obtained in applying the method IPRUGA also support these responses as data obtained in the green areas of Zone 5 are good.

Zone 6. Almost 50% of the population surveyed in this area believe that the green areas are fairly close to their homes. Also, in the method of landscape modules, half the streets of study in this area are in balance. All of this can be justified by how close they are to Zone 4 and Zone 7, which are areas with plenty of green areas that can be enjoyed by people in Zone 6 and other areas of study. The method IPRUGA demonstrates that the average values of this area as a zone agrees with the opinion of the surveyed population in proximity to the satisfaction of the green areas.

Zone 7. The vast majority of the surveyed population in Zone 7 believes that the green areas are fairly close to their homes (42.2%). They also agree with the answers of the other two methods, qualifying Zone 7 as very good in green areas.

Despite the experimental nature of this study, investigative developments have implications for future research and management in the urban environment.

The results also have implications for managers and researchers of urban planning as to the best way to assess the perceptions of citizens and visitors. If the goal is to understand

the perception of green areas, questions should be asked directly about the green areas, proximity, characteristics, scope, requirements, etc. using decimal valued questions for better and more accurate assessment of the various views.

Another research implication relates to the fact that three methods have been applied very differently on any one target "Evaluation of the urban green infrastructure", the only relationship, for a result as close as possible to a target result.

The utility of an integrated approach that uses three methods could help in the creation, distribution and sustainable management of urban green areas and opportunities for outdoor recreation that are needed for citizens (fig. 6).

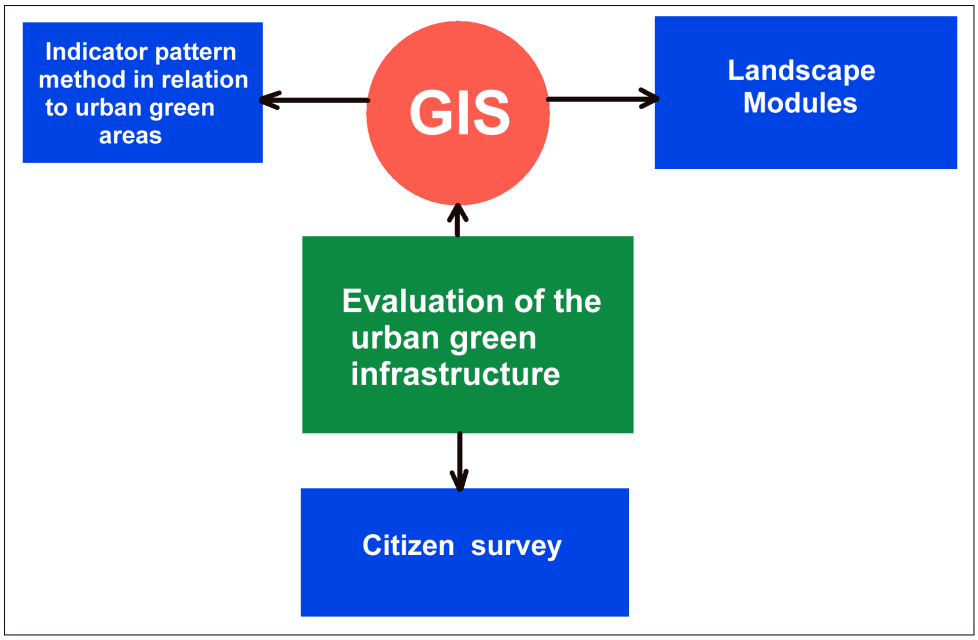


Fig. 6. Three methods of evaluation of the urban green infrastructure

5. CONCLUSIONS

This research created evidence on the distribution of ecosystem services from GI which may help to better design the city GI for the maximization of social and environmental benefits and a more equitable distribution. From the assessment of the GI of Faro by three different methods, the following conclusions were reached:

1. The interest of the population in the green areas is directly proportional to the amount of these that are near their homes.
2. In areas with a good value in the method IPRUGA, the survey population also states a greater interest in green areas (such as Zone 4).
3. The establishment of green areas in cities promotes the public interest in plants and nature in general. The proximity of green areas is encouraged to participate and enjoy more of the same.
4. In all three applied methods, the results have the same tendency for each of the city areas.
5. These evaluation methods are intended to help improve planning of GI to meet the needs of the urban population because the benefits of plants in the cities are not only environmental but also recreational, social and aesthetic.

6. This research provided indicators and thresholds to be included by policy makers in local regulations about GI of the city and may help to develop guidelines for GI planners and managers on how to implement GI approaches with an emphasis on linking the environmental and social services of urban forestry.

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FACTORS OF RECLAMATION SUCCESS AT THE LIGNITE STRIP-MINED LAND IN NORTHERN GREECE

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ABSTRACT

The adverse ecological conditions at the lignite mines of Ptolemaida make the landscape reclamation difficult. The naturally established vegetation and soil properties were studied prior to reclamation. Various forest species were planted to assess the afforestation potential. The natural vegetation was heterogeneous but can be used for the analysis of the site. The soil of the spoil heaps was heterogeneous with unfavourable physicochemical properties. Surface soil temperature was still 24°C higher in bare soil than in soil covered with vegetation. The most successful species of the afforestation trial were *Robinia pseudoacacia* and *Cedrus atlantica*. Covering of fly ash spoils with topsoil presented poor results, while sewage sludge gave a favorable amelioration response in areas with high fly ash content. Topsoil from older stands was the suggested method to establish *Robinia pseudoacacia*. Reclamation success was dependent on appropriate planning; thus, the new landscape had to be designed in harmony with the surrounding landscape before the start of the mining activity.

Keywords: Landscape Reclamation, Mining Industry, Afforestation, Greece

JEL Classification: Q01, Q15, Q26

1. INTRODUCTION

Lignite is the most important energy resource for the electric power production in Greece. However, the different lignite mining activities create peculiar problems. Except the environmental pollution from fly ash, dust, toxic or radioactive substrates and noises, one of the biggest problems that lignite mining creates is the destruction of large productive areas and the change in the landscape aesthetics (Panagopoulos and Hatzistathis, 1995).

The lignite exploitation activities are occupying the area only temporarily. Following the appropriate program in all stages of mining the area can even return it to the society improved and ready for use as agriculture, forestry, recreation, sports, industrial areas etc. (Brenner and Steiner 1987; Gonzalez-Duque and Panagopoulos, 2010). However, every reclamation trial has to fight with peculiar problems caused by the adverse ecological conditions that exist. The Public Electric Company, which is responsible for the reclamation of the area, did not manage to store the surface soil and replace it after the end of the excavation.

The Public Electric Company has already done many trials to establish many different forest species. The trials have not been adequately planned, but trees were planted in areas that probably will not be excavated again in the near future. Some of the species selected for these trials were inappropriate for the climate and soil of the area. Irrigation of the trees for at least two summers fertilisation and additional soil were not provided as it is suggested from McGinnies and Nicolas (1980) for most of the reclaimed lignite mines.

The most important parameters for successful reforestation-revegetation of the lignite spoils are the climate (especially the microclimate), the soil (physical, chemical and biological properties) and the vegetation (natural and artificially established). Ashby and Kolar (1985) have pointed out that climate, type of rooting medium, drainage and herbaceous competition may limit reclamation success with trees. Most of the afforestation trials fail due to faulty treatments during the establishment and because of the extreme ecological conditions in some microenvironments. Another important reason for these failures was the lack of care and cultivation treatments after establishment of trees.

The lignite spoils of Ptolemaida have diverse physical and chemical properties and its colour may be black, white, red, brown or gray, depending on the percentage of marl, lignite, topsoil and fly ash in the soil. Addition of topsoil in some extreme microenvironments improves the physical and chemical properties of the soil and water retention in it (Barth and Martine, 1984), decreases the high surface soil temperatures (Helgerson, 1990), helps in quickly establishing a high diversity of species of natural vegetation and introduces microorganisms. Many researchers have studied the use of natural revegetation and forest establishment on the spoils from some years before those areas to be agricultural lands (Alexander, 1989). The establishment of natural vegetation and reforestation help to cover and stabilise the soil, start microbiological activity and soil genesis (Gonzalez et al., 1991) and generally impose the physical and chemical properties of the spoils soil; thus, agricultural cultivation and grazing can be reestablished to these areas 20-30 years after reclamation (Chambers et al., 1987).

This study examines the ecological conditions at the lignite spoils of Ptolemaida and their influence to landscape reclamation success.

2. DESCRIPTION OF THE STUDY AREA

The lignite mines studied are located in Northwest Greece near the city of Ptolemaida, in a valley with 667.5 meters mean altitude, at latitude 40° 30' North and longitude 22° East of Greenwich (Fig. 1). The climate of the area is continental Mediterranean with very hot and dry summers and mild winters. Average annual precipitation is 551.26mm (Ptolemaida meteorological station, 35 years of record) with a maximum monthly average in November (68mm) and a minimum in August (27mm). Average annual air-temperature is 12.3°C with the coldest month being January (1.8°C) and the warmest month being July (22.5°C). The absolute maximum air temperature during the research period was 41°C and the absolute minimum air temperature was -21°C. Wind direction is principally Northwest (38.7%) and Southeast (24.4%) with slow to medium velocity. Cloudy days were 56% on average. During winter, snow and early and late frosts are common; frost (minimum air temperature <0°C), appears on average 74 days per year and severe frost (maximum air temperature <0°C) appears on average 10 days per year. The average relative air humidity was 62.5%. The dry period starts at the end of June and finishes in September, which is relatively shorter than other regions of Greece and with even more precipitation.

Fig. 1 The study area of lignite mines in Ptolemaida, Greece

Before mining began, the area was an almost plain valley with some small hills and surrounding mountains that rise to an altitude of 1500 meters. The topography now has changed. Strip mining created pits up to 230m deep; huge volumes of overburden have been excavated and transferred to nearby agricultural and forest areas or used to refill old pits. The slope of the new topography varies from 0-70%; steep slopes do not permit a variety of land uses. It is necessary to reduce slopes before rehabilitation and the establishment of vegetation. The topography of the new landscape has to designed to be as much as possible in harmony with the surrounding area and to emphasize on some of the new, peculiar shapes. The target of the design has to be that the new topography, in combination with barrier vegetation, will cover the view of the excavation area.

The hydrology of Ptolemaida valley have been drastically changed. The mining activity change the level of the underground water table, which is 14 meters lower compared with 1968 levels; 35 years after the establishment of the first spoils, the underground water table had not been created yet (Papadopoulos and Nikolaidis, 1992). The lignite of Ptolemaida is a soft brown to black coal with a low fuel value of 10-16Kj/g and a sulfur content generally below 0.6%. The thickness of the lignite layers varies between 12 and 32 meters.

The spoils are generally consisted of the materials that arise after the extraction of lignite. The overburden of the lignite layers is mixed together with bad quality lignite and lignite gasification ashes (fly ash) and surface soil. The new soils that arise from this mixture are heterogeneous, unstable and unconsolidated, with a high pH and low compaction (Panagopoulos, 2012). The transportation of the spoil materials is by tracks and the mixture of them is not programmed or planned. The overburden that covers the lignite layers in the valley consists of marls (forms of soft limestone characterized by high quantities of $CaCO_3$, alkaline and rich in bases), sediments, red-soils, alluvial, peatmould, earthy lignite, fossils, and others. The pH of the fly ash varies between 9 and 12. Soil analyses showed that the new soils are poor in nutrients and contain some toxic elements. The colour of the soil was between light grey (7/1 10YR) and black (2/1 10YR).

Unplanned placement of the spoil materials provokes the instability of the new soils and the high risk of erosion, topsoil in most of the cases buried in high depths and lost, self-igniting fires when unburned lignite is exposed close to the surface of the spoils, soil on the surface with unidentified properties, mineral toxicity and problems with vegetation survival in areas of high fly ash presence.

The vegetation of the Ptolemaida valley corresponds to the submediterranean vegetation zone of *Quercetalia pubescentis* (Athanasiadis, 1986). Chenopodiacae species dominate on newly-established spoils (2 years old) while Compositae species are more common on older spoils; leguminous species are generally on younger and herbaceous species on older spoils (17 years old).

3. MATERIALS AND METHODS

3. 1. Phytosociological study

For the phytosociological study, 48 geographically positioned sampling areas of 1 m^2 were established, permanent for two years on a spoil in which soil preparation for reclamation activities terminated 3 years before and forest species establishment finished 6 months before. Plant samples were collected between 25 of May and 10 of June for both years. For every sampling area, the Braun-Blanquet method was used and soil type, percentage of soil cover by plants and plant vitality were also measured. Species identification was done using Flora Europea of Tutin et al., (1964-1980). Phytosociological units were separated with criteria based on species physiognomy, ecology, flora and evolution (Athanasiadis, 1986). The method based on ecology and flora is assisting better on the target of the study, which was the ecological description of the separated communities that will arise from the plant-table process. In the present research, the systematic determination of phytosociological units was not studied. Specifically, the plant communities were defined with the method of the comparative process and the construction of phytosociological units tables. The separation of the plant communities was done with the help of the indicator plant groups. This method is based on the presence or absence of specific groups.

The method used by the present study was not based on the characteristic or differential species, but on the combination of the indicator groups that were appearing in the phytosociological units. The same group included all the species with the same or similar ecological behaviour. The ecological description of the separated plant communities was done with the help of the ecological properties of the indicator groups. The disadvantage of this method was that the separated communities had value only for the study of the research area, and they cannot be used for larger areas without additional process.

The method of the school Zürich-Montpellier based on Braun-Blanquet was used for the plant table process (Athanasiadis, 1986). The initial table with sampling areas and species was first constructed in the order they were collected. In a second table, sampling areas remain as they were, but species were written with appearance ascending order. In a third table, species remained as they were, but sampling areas were placed depending on their botanical relationship. In a forth table, species were placed in groups with appearance ascending order. After a continuous table process, the indicator plant groups were separated.

3.2. Soil study

Soil is from the most important factors in surface mine reclamation. In the 1.5ha afforestated research area, 16 geographically positioned soil samples were collected. Many soil and water parameters that could explain the cause of spatial variability in revegetation success were analysed. Thus, soil colour, type of soil (lignite, peat, topsoil, fly ash, marl or mixture

of the above) and percentage of vegetation cover were measured. The samples were packed in polyethylene bags and transferred to the laboratory. Soil colour was recognized with the tables of Munsell. Samples for the calculation of the soil moisture were weighed and dried. The mixture of soil and coarse fragments was air-dried, weighed and carefully sieved through a 2mm screen without breaking up fragile fragments. The fine earth fraction was analyzed for the following: texture by sieve and pipette method, particle density, specific weight, available water content by pressure membrane extraction of saturated soil at 0.33 and 15 bar, total porosity, air porosity, organic matter, pH, electrical conductivityin 1:1 slury of soil and distilled water, calcium carbonate ($CaCO_3$), available phosphorus, total nitrogen, and exchangeable calcium, magnesium and potassium by ammonium acetate extraction at pH 9.

3.3. Planting of forest species in pits

Between the 20th and 30th of November, 1992, 680 seedlings from 6 forest species in pits were planted. The area was 1.5ha and prepared for revegetation 3 years ago. The 6 forest species were planted in a split-split plot design with treatments of irrigation and fertilisation. For every treatment there were 4 replications. Seedlings were planted in a 4X3 spacing and they were: 160 *Pinus nigra* (one year old in paper pots), 160 *Pinus brutia* (one year old in paper pots), 160 *Cupressus arizonica* (one year old in paper pots), 160 *Robinia pseudoacacia* (one year old bear-root), 20 *Cedrus atlantica* (two year old in pots) and 20 *Prunus avium* (one year old bear-root). In spring of 1993, 40 more *Cupressus arizonica* seedlings were planted to replace some of the winter losses. Measurements on survival and growth were done at establishment and every 6 months (November and May). Also, data for soil colour and natural vegetation cover around every tree was collected.

3.4. Soil temperature

Soil temperature during summer is a very important factor limiting reclamation success in the lignite mines of Ptolemaida. This is happening mainly due to the black colour of lignite which in many areas is the main element in the surface. For the estimation of the soil temperature mercury thermometers were placed in 17, 11, 2.5 and 0.5cm depths, in three different soil colours: red (5YR 4/3), light grey (10YR 7/1) and black (10YR 3/1). The red coloured soil was mainly surface soil, the grey had a main element of marl and the black lignite. Air temperature was measured under shadow 50cm from the soil. soil and air temperatures of 20 days were measured between the 20th of June and the 20th of August of 1993 and 1994, at 11.00, 13.00, 15.00 and 17.00 hours. It was a completely randomized design with main treatment of the soil colours. Soil surface temperatures (0.5cm) were also measured, under the shadow of the natural vegetation and planted trees in a black coloured soil. The results were compared with the soil surface temperatures of the black coloured bare soil. Soil surface temperature was measured at 0.5cm depth.

3.5. Establishment of a Robinia forest by spreading surface soil from Robinia mother forest

The main methods for establishing Robinia on the spoils of the lignite mines of Ptolemaida is the plantation in pits, plantation by riper or other machines and the establishment by spreading surface soil from the Robinia mother forest. For the first method, bare-root plants or plants in paper pots were used; the success of establishment was high but with much higher cost. For the second method, a bulldozer type “CATERPILLAR D9N” was used with a riper in the back which opens a half meter deep rill while a man is placing the seedlings in it simultaneously. This method has higher success than planting in pits, because roots are covered immediately and the cost is lower. The third method was applied for the first time in February of 1992.

It is known that Robinia can easily become multiplied with small pieces of roots (3-5cm) (Papanastasi, 1991). By spreading surface soil from the Robinia mother forest, a bulldozer type FIAT-ALLIS-21C is used carrying in the back a disk used to cut the roots till 40cm depth. The disk has diameter 130cm and thickness 5cm that finishes in high sharpness. The soil of the Robinia mother forest is ripped many times and then is carried and spread on the reclamation area. There it is ripped again and irrigated. The success of this method is very high and the cost of it is minimal. From 120 tons of mother soil, 1.5ha of spoils can become afforestated, with a seedling density of 1.5/m^2.

This chapter compares the success of the three methods. Forest establishment by spreading surface soil from the Robinia mother forest was studied in the three areas that were planted 32, 20 and 8 months ago. In the last area, planted in February of 1994, an area of 3ha was split in three and mother forest topsoil was mixed with topsoil, sand and lignite respectively. In every research area, three permanent 2X5 sample plots were placed and the number, height, and basal diameter of Robinia seedlings were measured in June and November of 1992 to 1994.

The mixture with light coloured materials was done to alter the success of the method on the dark coloured spoil materials where the success, especially during the first summer, was lower. The number of the emerging Robinia was increasing after the first summer and especially when natural vegetation was covering the soil and with its shadow protecting the Robinia seedlings from high soil temperatures. The main disadvantage of this method is that there are not many available areas from where mother soil can be taken. However, 40cm deep soil can be taken for many years without Robinia losing its ability to multiply.

3.6. Statistical methods

All data was entered into a field-scale GIS (ArcView), and interlayer data analytical tools were utilized to quantify spatially dependent relationships. Two-way analysis of variance (ANOVA) was used to determine differences (P=0.05) in soil temperatures, seedling growth and survival. Comparisons of all means were examined with Fisher's protected LSD's and with Duncan's test. Significant differences at P=0.01 were noted separately. The search of the influence from the parameters soil type and colour, natural vegetation species and cover to the parameters height, diameter, survival and seedling vigour was done with the simple correlation analysis. The above statistics were done based on the methodology mentioned from Snedecor and Cochran (1977) and with the help of the SPSS, EXCEL and MSTAT statistical programs.

4. RESULTS

4.1. Results from the phytosociological research

Determination of the phytosociological units. Phytosociological units were determined with the help of the indicator plant groups. After the plant-table process, 6 indicator plant groups were separated in the 1st year table of species sampling (Table 1) and 5 indicator plant groups in the 2nd year table (Table 2). The ecological description of those groups was done bibliographically, after an "on site" research (Ellenberg et al., 1992).

Group A. Constant in both years with average drought species. Those species appear in infertile, clay soils, with relatively high salinity, pH 8 and in relatively warm environments. The characteristic species of this group were: *Melilotus officinalis, Medicago lupulina, Cichorium endivia, Medicago coronata,* and *Dasypyrum villosum.*

Group B. Constant in both years with higher number of species in the second sampling year. This group had species of average humid areas, indicators of fertile soil with normal

moisture and pH 7-8. The characteristic species of this group were: *Bilderdykia convolvulus, Carduus sp., Centaurea cf. depressa* and *Rumex crispus.*

Group C. Appearing only in the table of the 1st year. Includes drought species, with large ecological adaptation, developing in medium fertile soil with pH 8 and warm environments. The characteristic species of this group were: *Tragopogon dubius* and *Reseda lutea.*

Group D. Constant in both years. Includes species of average drought, with large ecological adaptation, growing in warm environments and average fertile soil with pH 7-8. The characteristic species of this group were: *Sonchus arvensis, Crepis foetida, Lappula squarrosa, Elymus repens* and *Crepis pulchra.*

Group E. Constant in both years. The characteristic species of this group (*Calamagrostis epigejos*) can be seen in humid and cool environments, in soil of average fertility and pH 7-8.

Group F. Appearing only in the table of the 1st year. Includes drought resistant species, growing in warm environments and soils with poor fertility and pH 9. The characteristic species of this group was: *Vaccaria pyramidata.*

Group G. Appearing only in the table of the 2nd year. Includes drought resistant species, expanding in warm environments with fertile soils and pH 7-8. The characteristic species of this group were: *Crepis pulchra, Avena barbata* and *Linaria genistifolia.*

Description of the determined phytosociological units. With the above indicator plant groups, the keys for the determination of the phytosociological units were made. Tables 3 and 4 show the range of the group appearance in the phytosociological units where those groups belong. From the coverage of the group appearance, it can be seen that the drought group A is limited in areas where clay topsoil was spread on the spoil. The average drought group B is decreasing as the soil fertility decreases. The groups C and D were increasing by time, with the first to develop in more infertile areas and the second in fertile soils with a high percentage of lignite. Indicator group E appears as a spot in a small part of the spoil where marl was the dominant element and surface soil temperature was lower due to lighter soil color, while the F appears in small spots all over the spoil in areas where fly ash was the dominant material (fly ash pH was higher than 9). Finally the group G always becomes visible in areas adjacent to group D, but in spots where lignite was significantly higher.

Phytosociological unit E_1 (constant for both years). Indicator plant group (d). This unit appeared in areas affected from topsoil that exists in a depth of more than 30cm and covered with lignite spoils. Soil was fertile and pH varied between 7.5-8. The forest species planted at the specific area had fast growth, while the few dead trees noted in the area were caused from the high soil surface temperatures. Natural vegetation was covering the soil with its shadow between 40% and 50% and assisted in the survival of the newly established forest species. Dominant species of this unit were: *Bromus tectorum*, *Tussilago farfara, Isatis tinctoria* and *Carduus thoermeri*. The indicator value for this community had only the species *Bromus sterilis, Crepis foetida* and *Lappula squarrosa* of group D; but, because its representation in the table was minor, it is recorded with a small letter between parenthesis. This plant community was characterized by the absence of any other indicator groups.

Phytosociological unit E_2 (constant for both years). Indicator plant groups A(c) for 1st and A(d) for 2nd year. This unit appears in areas affected from topsoil. That soil had a clay loam texture, pH 8-8.5 and a high content of Na^+ (0.5-0.6meq/lit). The forest species planted in that area had low growth and survival. The soil was compacted and

waterlogged. Hydraulic conductivity and air porosity were lower than in the other soil types of the spoil. Soil cover by natural vegetation was less than 50%. Dominant species of this unit were: *Tussilago farfara, Bromus tectorum*, *Bromus squarrosus*, *Sonchus asper* and *Artemisia vulgaris*. The indicator value for this community had all the species of group A, *Tragopogon dubius* and *Reseda lutea* of group C and *Elymus repens* of group D. This plant community was characterized from its stability in both sampling years. *Melilotus officinalis* appears in compacted, clay and salty soils and *Sonchus asper* is resistant in high soil salinity as noted by Ellenberg et al. (1992).

Phytosociological unit E_3 (for 1st year). Indicator plant groups (a)B. This unit became visible in areas affected from topsoil mixed with marl, lignite and fly ash. Soil was loamy with pH between 7 and 8. The forest species planted in the area had good growth and survival. Dominant species of this unit were: *Tussilago farfara, Bromus tectorum, Lappula squarrosa, Verbascum speciosum* and *Rumex crispus,* but the indicator value only had the species *Bilderdykia convolvulus* and *Cichorium endivia*. The main characteristic of this plant community was its relationship with group A species, a fact that became more clear in the second year.

Phytosociological unit E_3 (for 2nd year). Indicator plant groups ab(d). Developing in the same area as E_3 of 1st year, with dominant species: *Tussilago farfara, Bromus tectorum, Carduus thoermeri, Isatis tinctoria* and *Centaurea solstitialis.* The indicator value for this plant community had the species *Cichorium endivia* (group A), *Centaurea cf. depressa, Bilderdykia convolvulus* and *Carduus* sp. (group B), *Elymus repens, Lappula squarrosa* and *Crepis foetida* (group D), but with minor representation in the table so they were recorded with a small letter. This plant community was the intermediate stage between E_2 and E_4, and *Cichorium endivia* was increasing its presence over time.

Phytosociological unit E_4 (1st year). Indicator plant groups (a)Cd. The soil of the area where the community was developing had well mixed all of the spoil materials with a higher content of fly ash and marl. Texture was sandy loamy and pH was varying between 7 and 8. Dominant species of this unit were: *Tussilago farfara, Bromus tectorum, Bromus squarrosus, Lappula squarrosa, Cirsium arvense, Carduus thoermeri*, *Isatis tinctoria, Sonchus asper* and *Centaurea solstitialis,* but the indicator value had the species *Cichorium endivia* (group A), *Tragopogon dubius* and *Reseda lutea* (group C) and *Crepis foetida* (group D).

Phytosociological unit E_4 (2nd year). Indicator plant group B. The characteristics of the area where this community was appearing were the same as E_3 of 1st year. Dominant species of this plant community were: *Tussilago farfara, Bromus tectorum, Bromus squarrosus, Cirsium arvense, Carduus thoermeri* and *Isatis tinctoria.*

Phytosociological unit E_5 (1st year). Indicator plant groups (c)D(f). This community was a developing on soil that was a mixture of all spoil materials. Texture was loamy and pH was varying between 7 and 8. The forest species planted in the area had good growth and survival. Dominant species of this unit were: *Tussilago farfara, Bromus tectorum, Bromus squarrosus* and *Lactuca serriola,* but the indicator value for this plant community had the species of group D and *Tragopogon dubius* of group C and *Vaccaria pyramidata* of group F.

Phytosociological unit E_5 (2nd year). Indicator plant group D. This community was developing in soil that was a mixture of all spoil materials. Dominant species of this unit were: *Tussilago farfara, Bromus tectorum* and *Reseda lutea.*

Phytosociological unit E_6 (1st year). Indicator plant group (d)F. This community become visible in soil similar to the E_5 unit, but in spots where fly ash content was high; as a consequence, pH was higher than 9. Dominant species of this plant community were: *Tussilago farfara, Bromus tectorum* and *Cirsium arvense,* but the indicator value only had the species *Crepis foetida* (group C) and *Vaccaria pyramidata* (group F). Kavadas (1956-1964) mentioned that *Vaccaria pyramidata* grows in calcareous soils, while Ellenberg et al. (1992) cited that this species is an indicator of dry and infertile soils with pH 9. Those species may be used as bioindicators of low quality zones, and soil improvement of those areas should be done before reforestation.

Phytosociological unit E_6 (2nd year). Indicator plant group (b)DG. This community appeared in soil similar to E_5, but in spots where lignite and topsoil were higher. The forest species planted in that area had low growth and high survival. Seedling growth was low due to high competition from natural vegetation, but survival rate was high due to a shadowing effect of almost total soil cover that kept low surface soil temperatures during summer. Dominant species of this plant community were: *Bromus squarrosus, Isatis tinctoria, Sonchus asper, Bromus arvensis, Tragopogon dubius* and *Bromus tectorum,* but the indicator value had the species *Carduus sp.* (group B), *Crepis foetida, Lappula squarrosa, Elymus repens* (group D) and *Crepis pulchra, Avena barbata, Linaria genistifolia* (group G). Those species may be used as bioindicators of good quality zones on the lignite spoils, and forest species density could be lower on the establishment.

Phytosociological unit E_7. Indicator plant group E(f) for 1st and E for 2nd year. This unit comes into view in areas of marl soil with loamy clay texture. Soil surface temperatures were lower than in the other sites of the spoil because soil colour was white. The forest species planted in that area had low growth and high survival. Dominant species of this community were: *Tussilago farfara, Lappula squarrosa, Lactuca serriola, Carduus thoermeri* and *Bromus tectorum.* The indicator value had the species *Calamagrostis epigejos* which is increasing its presence with time and *Vaccaria pyramidata* which appears in spots around the area of *Calamagrostis epigejos*. Natural vegetation cover was less than 20%, but the forest species planted in that area had a higher rate of survival because the lighter soil colour did not permit high surface soil temperatures.

Table 1. Phytosociological units and indicator plant groups at the 1st year, resulting from the combination of the sampling areas following the Braun-Blanquet method

Sampling No	12	30	29	18	1	2	3	4	5	6	8	7	13	16	17	10	15	14	23	48	36	24	26	20	21	22	25	27	19	42	40	38	41	44	43	46	37	39	47	28	35	11	9	32	34	33	31
Cover (%)	80	50	50	80	80	80	50	50	50	50	70	50	60	50	60	60	70	40	70	50	50	50	50	60	50	60	80	50	60	30	40	40	60	40	50	80	50	70	40	50	30	50	70	60	10	20	20	20
No of species/sample	7	9	12	9	13	10	11	10	12	12	9	12	11	9	10	14	13	11	11	7	9	7	10	11	13	8	11	8	10	6	7	7	14	9	14	14	9	12	9	9	7	8	11	10	4	5	10	9
1			2				3						4											5												6						7				8		
Medicago coronata					1v	+	1v	+	1				1																							1												
Dactyporum villosum					2	+	+	+	r																																							
Medicago lupulina					r	+	+	+	+																																							
Melilotus officinalis					r	+	r	r	r	+																																						
Cichorium intybus					1	1	1*	+	1	+	1					+	1					1	1							+			1															
Bilderdykia convolvulus											+	1	1	+	1																					1												
Brenda latum									1	+	+					1		+	2	1	1																			1								
Trisetopogon dubius					1v	1										1	1		1					+	2	1	1		1				1	1														
Cynosurus foetidus																		+	+	1	+	+		+				1v	+	+	1	+	2	1	1	2	1		1	2						+		
Elymus repens							+			1																1							2	1				2*	1									
Cynosurus echinatus													r																				+	+		1	+											
Bromus sterilis		+		+											+	+											+								+	+	+		+									+
Sonchus arvensis																r																																
Calamagrostis epigejos																																												1	+	+	1
Vaccaria pyramidata										1	+					+																						1	1	1	1	1	1	r*	r*			
Tussilago farfara	1	+	1	1	1	1		+	1	2	1		3	3		2	1	+	1	+	1	1	2	1	2*	3	4*	1	1*	1		2	1			1*	1	1*		1		1	2	3		+	1	
Bromus inermis	2		3				2	1	+	1		+	1	+			2	1	2		1	1	1	1	r	r	r	1	1	+	+	1	1	1	1				1	2	+	+				+		
Lappula squarrosa		+	+					1	+	+		1*	r	+	r	1	1		+		+				+		r		1				1	r	1	+		+	2								+	+
Bromus squarrosus					1	r	+	+		r	1	+	1				+	+			1		1	1		1		+			r		1	r		r		1	r		+		1					
Cirsium arvense		+		2	1	+			1			1			2	+		1	2	+			1		1		3		1	+	1					1			1	+		2*					
Lactuca serriola		1	+	+	1							+		+	r	r								+	+		1	+				+				1	+	1			+			+		+	+
Papaver rhoeas		+	1*	+			+	r				+	+		+				r						1				+		r		r							1v		+	r		r		r	r
Carduus thoermeri	1											1v		1			2	1	1					1	1			1			2	+							1		+	1				1	1
Isatis tinctoria	1	1							+					1			1	+	1	1	+			2							1			1						1			1					
Sonchus asper		1	1				1					1					1	+		+			1	r	1*									+			+								+			1
Bromus arvensis		1		+			r				1*				+										1			r										+	r		r							
Lactuca virosa		+	1												2	r									1										1	+									1			+
Conyza canadensis			+														+		r										1							r							r	r			
Cynosurus echinatus													+								+	+							r				+			+		+									
Fumaria vaillantii			+										r															+															r*	+		+	
Centaurea solstitialis																		1				2				1						+														1	
Avena barbata	r																						r				r							r			+										
Cirsium ligulare	1						2*				1				1									1																								
Diplotaxis muralis				+																	+			+																	+	+		+			
Taraxacum officinale																	1						1				1														1		+				
Sonchus oleraceus																					+																	+	+				1					
Centaurea cf. diffusa				+								+					1								1																							
Lepidium campestre																1																							1			1						
Bupleurum rotundifolium				r																		r					r																					
Carduus tenuiflorus	1																															+											2					
Carduus sp.																		1								1									2													
Cornopalpus arvensis												1														1																1						
Hypatrum diffusum														r									r																									
Polygonum aviculare													1												1																						1	
Stachys arvensis			1																											+			1		1													
Centaurea solstitialis																								1					2*																			
Rumex crispus				1											2																																	
Arrenatherum elatius									2*							1																																
Cardaria draba														+			+																															
Diplotaxis tenuifolia										1						+																																
Verbascum speciosum												3																					2															
Achillea millefolium																																				+												
Amaranthus blitoides																																						r										
Astragalus glycyphyllos										2																																						
Cynoglossum officinale			1																																													
Chenopodium album																																			r													
Chondrilla juncea			r																																													
Cynosurus echinatus																																			r													
Daucus carota					r																																											
Erodium moschatum																																				r												
Juglans regia																																										1						
Erysimum sylvestre																																																r
Linaria genistifolia																																			r													
Lotus corniculatus									r																																							
Malus sylvestris											1																																					
Populus nigra																																					2											
Robinia pseudacacia																																						2										
Sanguisorba minor					+																																											
Senecio vernalis																																	1															
Setaria viridis																																			2													
Solanum nigrum					1																																											
Stachys recta																																									r							
Vicia villosa																											r																					
Xanthium strumarium						1																																										

Table 2. Phytosociological units and indicator plant groups at the 2nd year, resulting from the combination of the sampling areas following the Braun-Blanquet method

Sampling No	30	29	28	27	26	23	40	20	7	1	2	3	4	5	6	13	23	24	42	21	11	10	8	9	12	14	16	18	17	22	19	15	48	33	39	47	36	37	38	41	46	43	44	45	51	32	35	34
Cover (%)	60	30	40	60	70	90	30	70	90	30	40	30	30	30	30	30	70	60	30	80	60	80	80	90	60	70	70	70	70	60	70	60	70	60	70	60	30	70	80	60	70	90	60	90	20	10	20	20
No of species/sample	9	10	10	9	10	10	8	11	9	12	11	9	9	14	14	13	10	9	7	8	8	15	11	14	8	12	11	13	16	11	9	10	8	9	12	12	12	11	13	13	14	13	14	13	7	6	8	9
1					2								3								4								5						6							7						8	
Dactylorhiza sambucina									r	2*	1		+	+										r																								
Medicago lupulina										1	1	r	r		r																			r														
Medicago coronata														r	r																																	
Melilotus officinalis										1	1			1	1	2																											r						
Cichorium intybus										2*	2	2	2	1*	1	1	2	1		1	r		1		r											1				r								
Carduus sp.																								1	2	2		r	r										1			2							
Centaurea cf. *diffusa*																						r							1								1												
Bilderdykia convolvulus																																																
Rumex crispus																											1	1	3																				
Sonchus arvensis																																			1		1		1										
Crepis foetida							r										r																2		1		1		1	r	1		2	2				
Lappula squarrosa									r					r													r						r	1			1		r		r	2	r	r				
Elymus repens												1								1				1									2			2	1			1	2	1	1	1				
Crepis pulchra																																							2	1	r			2				
Avena barbata																	r	r																				r				r						
Linaria genistifolia																														r												2						
Calamagrostis epigejos																												r	+																1	2	2	1
Tussilago farfara					2*			1	1		1	1		1	2		1	1		1	2	2	r		1			3		2*	1	2		2			1	r							r	r	
Bromus tectorum		2	+	+	2	+		2	1	1	1	1	1	+	+	1	1	1	+	+			1	+		1	1			+	2	1		2		1				+	+		1		r		+	+
Bromus squarrosus				r	1		r			r	+	+	+	+	1	+	+				+		r	+	1	+		+	+	1							+		1	r		+		1	r		r	r
Carduus thoermeri							2	1						2		2*					1	1		1	1	2	1*				1*	2			1		1			r		1						
Sonchus asper	r				+	1		+				+	+	1	2	+										+	r		+		+	r	1	+		1						+	+	1	1				
Salsola tragus	1	1					2	2						+							2			1	2		2*		+		1	1		1	+		1	+			1	2	1					
Papaver rhoeas			r		r		r				r			r		r	r	r		r		+				r		+		+				+	+							+	1					
Cirsium arvense				1	1		2				1					1				2						1				1		1					1					1						
Bromus arvensis	1	r	r	r								r	r		1								r		r				1					1					r		1		+	r	r			r
Lactuca serriola	r	r	r	r																			r					r	r		r	r	r		r	r										r	r	r
Tragopogon dubius					1						1				+	+			1	1		r				+				+											1	2				r	+
Reseda lutea									+					2	2*			1				+	+			r				1			2	1		1		2										
Viscaria pyrenaica			+		+			+	r													+	1											1											+	r*	r*	+
Bromus sterilis	+					+																+						+	+				1							+	1			1				
Centaurea solstitialis			+														+	2		2										1					2													
Centaurea calcitrapa								2																							1		+		1		1		1									
Crepis capillaris		+																r														+								+	r			+				
Lactuca virosa		r		r																									r							r												
Viola arvensis																																								+	r							
Cirsium vulgare																																																
Cichorium intybus																																																
Cornus sanguinea																																																
Polygonum aviculare																																																
Diplotaxis tenuifolia																																																
Centaurea solstitialis																																																
Lolium perenne																																																
Sonchus oleraceus																																																
Diplotaxis muralis																																																
Achillea millefolium																																																
Artemisia vulgaris																																																
Bupleurum rotundifolium																																																
Caralluma diffusa																																																
Cirsium lepidum																																																
Consolida regalis																																																
Erysimum diffusum																																																
Plantago lanceolata																																																
Setaria verticillata																																																
Sisymbrium irio																																																
Verbascum specularum																																																
Antirrhinum majus																																																
Artemisia glycophylloides																																																
Chenopodium album																																																
Chondrilla juncea																																																
Crepis vesicaria																																																
Dianthus gracilis																																																
Erysimum cuneatum																																																
Euphorbia seguierana																																																
Hordeum murinum																																																
Juglans regia																																																
Malus sylvestris																																																
Populus nigra																																																
Robinia pseudacacia																																																
Sanguisorba minor										+																																						
Scorzonera cana																																																
Sinapis alba																								r*																								
Sinapis arvensis																																																
Sinapis vacca																											r																					
Trigonella corniculata																																			r													
Vicia peregrina																												r																				
Vicia villosa						2																																										
Xanthium strumarium											1																																					

Table 3. Appearance of plant indicator groups in the phytosociological units that were separated at the 1st year

Indicator	Phytosociological units						
groups	E_1	E_2	E_3	E_4	E_5	E_6	E_7
A							
B							
C							
D							
E							
F							
	(d)	A(c)	(a)B	(a)Cd	(c)D(f)	(d)F	E(f)

Note: The darker the colour, the stronger the appearance; minor representations in the table were recorded with a small letter and insignificant representations were placed under parentheses

Table 4. Appearance of plant indicator groups in the phytosociological units that were separated at the 2nd year

Indicator	Phytosociological units						
groups	E_1	E_2	E_3	E_4	E_5	E_6	E_7
A							
B							
D							
G							
E							
	(d)	A(d)	ab(d)	B	D	(b)DG	E

Note: The darker the colour, the stronger the appearance; minor representations in the table were recorded with a small letter and insignificant representations were placed under parentheses

4.2. Soil physical properties

The physical properties of a soil govern its suitability for any further use of it. The bearing capacity, drainage, erodibility, moisture storage capacity, plasticity, ease of penetration by roots, aeration and availability of nutrients are related to the physical conditions of the soil. Table 5 shows that particle size composition of the soils on the spoil heaps were varied, primarily because of the composition of the soil mixtures on which soil forms; generally, they are characterized as medium-textured loamy.

Colour is the most obvious and easily determined soil property and is usually one of the first properties to be noted in a field description. Generally, the colour of the spoils in Ptolemaida was light gray to dark black, depending on water content, calcium carbonate, the percentage of unburned lignite and ash mixed with overburden and the presence of organic matter. In the spoils of Ptolemaida, dark coloured sites contain more lignite and, in some of them, well accumulated humus; grey sites contained more fly ash and light grey sites a mixture of marls, sand, limestone and ash. Topsoil usually used in the lignite mines to mix with the other materials generally has a red or brownish red colour.

The topsoil texture varied between clay to sandy clay. The ash sample had a sand-loamy texture. Sand is used to mix with the dark soils to decrease soil surface temperatures and soil moisture losses. Table 6 shows that samples with high lignite content keep larger quantities of water available to plants. Topsoil had a lower capacity of keeping water, because it had less organic matter and a different texture and structure. In soil samples with more lignite, capillary water was up to 50.42%, but because hygroscopic water was also a lot, the availability of water to the plants was up to 21.60%.

Bulk density and particle density were measured to calculate total porosity and air porosity. Particle density varied between 2.41 and 2.62 gr/cm^3, depending on the presence or absence of the organic matter. Bulk density varied between 0.77 and 1.43 gr/cm^3 and depended on soil compaction, texture, structure and organic matter in the soil. Fly ash had a bulk density of 0.79 gr/cm^3 and sewage sludge, 0.48 gr/cm^3. Total porosity was higher than 45% in samples. Air porosity of the fly ash samples were 8.9%, which is not allowing irrigation if the physical properties will not become improved with amelioration means. The other samples have air porosity between 10 and 20%, and irrigation can be applied in small quantities while, for soils with air porosity more than 20%, irrigation can be applied without any precautionary means. Thus, the loamy textured spoils of Ptolemaida keep much of their water as hygroscopic and capillary water, and they have low gravitational water (between 40 and 60%). When the soil was saturated, most of the pore space was filled with capillary or hygroscopic water, so that the aeration may be insufficient in periods with heavy precipitation. The spoils of Ptolemaida were structureless and fine textured, containing large quantities of ash; however, in dry years, soil moisture deficits during summer may be a more important determinant of tree survival and growth than short term winter waterlogging.

Table 5. Texture and soil colour of the afforestated spoil heap

Soil type	Colour (Munsell)	Colour	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Texture
Lignite	2/1 5YR	black	6.95	34.30	45.60	20.10	Loamy
Topsoil	3/4 5YR	dark brownish red	23.76	29.30	54.90	15.80	Silt loamy
Topsoil	5/3 5YR	brownish red	36.54	29.00	55.60	15.40	Silt loamy
Topsoil, fly ash	5/2 5YR	reddish gray	16.41	39.70	48.50	11.80	Loamy
Topsoil, marl	6/2 10YR	light reddish gray	2.48	29.60	48.00	22.40	Loamy
Lignite	7/2 7.5YR	reddish gray	9.54	42.40	29.20	28.40	Clay loamy
Marl	7/1 10YR	light gray	4.69	21.60	41.00	37.40	Clay loamy
Mixture	4/2 2.5YR	dark brownish gray	12.43	31.60	35.10	33.30	Clay loamy
Topsoil, lignite	3/2 10YR	dark brownish gray	14.65	31.90	40.80	27.30	Clay loamy
Mixture	3/1 10YR	dark gray	10.91	32.80	37.20	30.00	Clay loamy
Lignite	2/1 10YR	black	13.12	47.40	33.50	19.10	Loamy
Topsoil	3/4 2.5YR	dark brownish red	28.76	35.10	25.10	35.80	Clay loamy
Mixture	3/2 10YR	dark brownish gray	4.68	30.10	36.40	33.50	Clay loamy
Marl	6/1 10YR	light gray	1.78	13.70	47.90	38.40	Silt clay loamy
Topsoil	3/4 5YR	dark brownish red	33.75	34.10	40.20	25.70	Loamy
Lignite	3/1 10YR	dark gray	8.95	35.90	41.10	23.00	Loamy

Table 6. Available water, total porosity and air-porosity of the afforestated spoil heap

Soil type	Hygroscopic Water (%)	Capillary water (%)	Gravitat. water (%)	Available Water (%)	Bulk density (gr/cm^3)	Particle density (gr/cm^3)	Total Porosity (%)	Air Porosity (%)
Lignite	27.80	49.40	50.60	21.60	0.77	2.52	69.44	20.04
Topsoil	17.60	27.74	72.26	10.14	1.29	2.58	50.00	22.26
Topsoil	16.10	27.20	72.80	11.10	1.43	2.62	45.42	18.22
Topsoil, fly ash	19.52	36.40	63.60	16.88	1.15	2.53	54.55	18.15
Topsoil, marl	21.32	37.36	62.64	16.04	1.08	2.51	56.97	19.61
Lignite	20.89	37.09	62.91	16.20	0.94	2.41	61.00	23.91
Marl	20.10	38.70	61.30	18.60	1.17	2.58	54.65	15.95
Mixture	18.29	35.60	64.40	17.31	1.12	2.41	53.53	17.93
Topsoil, lignite	26.90	43.60	56.40	16.70	0.97	2.52	61.51	17.91
Mixture	20.20	41.50	58.50	21.30	1.02	2.58	60.47	18.97
Lignite	28.14	47.32	52.68	19.18	0.81	2.55	68.24	20.92
Topsoil	17.40	28.90	71.10	11.50	1.32	2.62	49.62	20.72
Mixture	21.70	43.50	56.50	21.80	0.90	2.49	63.86	20.36
Marl	21.92	41.54	58.46	19.62	1.02	2.57	60.31	18.77
Topsoil	16.10	25.30	74.70	9.20	1.41	2.58	45.35	20.05
Lignite	30.20	50.42	49.58	20.22	0.79	2.57	69.26	18.84

4.3. Soil chemical properties

To estimate the soil chemical properties, pH, carbon (C), organic matter, $CaCO_3$, available nitrogen (N), electric conductivity (EC) and the exchangeable cations of calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+) were measured (Table 7). In all of the soil samples, a high pH was caused by the fly ash and marl that were present in all of the soils. $CaCO_3$ content was high in most samples, with higher values in marl (up to 96.8%). Carbon, organic matter and nitrogen were varying. Samples with high lignite content were rich in organic matter and nitrogen, while some topsoil samples were poor.

Nitrogen is a limiting factor in tree growth. Although there are large amounts of inorganic N_2 in the atmosphere and large amounts of organically bound N in soils, they are not available to plants, which can generally take up only nitrate and ammonia. Available N in soil at 0.2% is satisfactory (Wilde, 1958). The average percentage of organically bound N in spoils was 0.18%. The generally high percentage of organic matter was probably due to the presence of peatmould and unburned lignite in the spoils, which usually keep large amounts of carbon, but in a form not available to plants.

The amounts of organic matter and available nitrogen were directly related. The C:N ratio is an important factor, influencing both the rate of decomposition and nutrient cycling, with low ratios favouring more rapid decomposition (Vimmerstedt *et al*, 1989). C:N ratios were high in all samples (>20:1), indicating slow decomposition, so that the availability of nitrogen may have been limited on all sites. Alexander (1989) stated that where the C:N ratio exceeds 15-17:1 then the availability of N in particular may be limiting.

Available phosphorus varied between sites and was generally low (4.23-15.78ppm) in all samples (Table 7). According to Wilde (1958), most forest species need 50ppm available P and frugal species need at least 15ppm to grow well; thus, when the available phosphorus was below 10ppm, fertilisation was necessary. A solution to that problem could be found by

the addition of sewage sludge from the biological treatment of Thessaloniki, which contains 40.000ppm phosphorus.

Palmer and Iverson (1985) note that the effect of phosphate, together with climatic factors, particularly the amount of rainfall and the associated soil moisture, are important factors governing nitrogen fixation, so the success of the nitrogen fixing *Robinia pseudoacacia* in enriching the soil with nitrogen depends on available phosphorus.

Exchangeable Ca was high on all sites, 32.71 meq/100gr average, with coefficient limits ±3.99 meq/100gr. These high values of exchangeable calcium may be caused at the time of analysis because even though CH_3COONH_4 was used at pH9, some quantities of marl $CaCO_3$ may become diluted. However, these high values of calcium are indicator of a possible deficiency in boron and potassium (Wilde, 1958). Potassium is available to plants as K^+, usually present at a concentration of 1-2%, and frugal species such as pines need at least 36ppm K_2O (Wilde, 1958). Potassium in the spoils of Ptolemaida was low (0.71meq/100gr average). Exchangeable Mg must range from 20-33% of the exchangeable Ca (Wilde 1958), but in most of the samples of the lignite spoils of Ptolemaida it was less than 10%, indicating Mg deficiency.

Table 7. Chemical properties of the afforestated spoil heap and of the topsoil and sewage sludge used as amendments at the spoils of Ptolemaida

Soil type	pH	$CaCO_3$ (%)	C (%)	Org. mat. (%)	N (%)	C/N	P (ppm)	Ca^{2+} (meq/100gr)	Mg^{2+}	K^+	EC ds/m	Na meq/lit
Lignite	8.10	46.70	12.82	22.11	0.39	32.88	7.65	44.91	5.45	0.45	2.159	0.261
Topsoil	8.20	34.80	1.94	3.35	0.09	21.57	9.13	28.69	6.48	0.64	0.423	0.586
Topsoil	8.50	33.40	1.29	2.23	0.05	25.88	7.93	28.69	5.65	0.64	0.548	0.434
Topsoil, fly ash	8.30	27.80	2.29	3.96	0.11	20.86	10.03	37.43	3.29	0.83	1.961	0.695
Topsoil, marl	8.40	26.70	3.80	6.55	0.17	22.35	13.34	24.33	3.70	0.54	0.442	0.369
Lignite	7.80	43.50	4.12	7.10	0.20	20.59	14.51	31.81	4.93	0.83	0.903	0.565
Marl	7.80	83.20	1.89	3.26	0.12	15.75	7.43	29.94	3.19	0.51	2.163	0.956
Mixture	8.60	43.40	5.71	9.84	0.28	20.39	6.32	28.69	3.70	0.80	0.789	0.239
Topsoil, lignite	8.20	41.40	3.71	6.39	0.16	23.16	4.23	30.56	3.80	0.77	0.725	0.256
Mixture	7.90	47.10	2.82	4.87	0.12	23.53	10.13	28.07	4.32	0.54	1.278	0.739
Lignite	8.20	46.70	11.18	19.27	0.35	31.93	6.45	44.91	6.37	0.45	1.028	0.231
Topsoil	7.40	41.30	1.65	2.84	0.07	23.53	8.88	28.69	7.20	0.54	0.379	0.608
Mixture	7.70	61.50	8.06	13.89	0.25	32.24	7.63	44.91	4.63	0.74	2.401	1.173
Marl	7.80	96.80	1.50	2.59	0.06	25.00	15.78	20.58	1.95	0.38	2.308	0.956
Topsoil	8.40	3.80	1.94	3.35	0.09	21.57	6.22	26.82	3.50	2.30	0.729	0.565
Lignite	8.00	42.50	10.53	18.15	0.34	30.97	7.89	44.29	5.76	0.54	0.838	0.287

Total soil electric conductivity was low or average in most of the samples (Table 7). Fly ash and one topsoil sample were found to have high electric conductivity (3.85 and 7.68ds/m respectively), resulting in poor plant growth. Soluble Na content was also very high in those two samples (9.95 and 15.65meq/lit respectively), indicating high salinity of those soils.

Topsoil replacement on the fly ash spoils of Akrini-Klitos gave until now very poor results. Sample 3 shows that this topsoil, placed in part of the experimental site, had good physical properties but did not contain nitrogen and was low in organic matter. The result was to become easily eroded from the first year of placement, mainly because natural vegetation was not established even five years after reclamation. The reforestation trials on it had survival of less than 30% and erosion created 40cm deep rills. This area compared with two neighbouring areas (Table 7, sample 1 and sample 2) which became covered with surface soil and had high reclamation success. Reclamation success could be higher if fertilisation with organic fertilisers was applied, like sewage sludge or manure. Root soil from the mother soil forest could also help in the faster and easier establishment of flora and fauna on spoils.

4.4. Growth and survival of forest species planted in pits

From the forest species planted in pits in the lignite spoils of Ptolemaida, only *Cupressus arizonica* had low survival the first winter after the establishment. Table 8 shows the survival of all forest species after May of 1993. Survival of the *Cupressus arizonica* was 47.5% followed by the *Pinus brutia* with 85-93%. The main reason for low survival of the seedlings was the exceptionally low temperatures during the first winter after the establishment.

In the area of Ptolemaida during the first winter, the minimum temperatures were 15 times lower than -9ºC and, in some cases, reached as low as -21ºC, a temperature that had not been noted since February of 1956. During the first winter, the frost days were 81, more than the annual average and the total frost days were 14. In reforestation of the Forest Service in the nearby villages of Mikrobaltos and Rimnio, *Cupressus arizonica* had survival rates of 50% and 60% respectively.

Figure 2 shows the survival of all forest species two years after their establishment and for all treatments. There were no significant differences between the *Cupressus arizonica* and *Prunus avium* survival. *Pinus nigra* with irrigation and *Pinus brutia* with irrigation and fertilisation were not significant. *Robinia pseudoacacia* and *Cedrus atlantica* had very high survival without significant differences between them. Survival of *Pinus nigra* after the first summer started to decrease, especially for the non-irrigated seedlings. The non-irrigated *Pinus nigra* had significantly lower survival than the irrigated. *Pinus brutia* also had low survival after the first summer, but without significant differences between the irrigated and non-irrigated seedlings. Survival of Pinus nigra was higher when it was fertilised without being irrigated. *Cupressus arizonica* planted in spring also had low survival after the end of the summer (70-80%), in contradiction with the *Cupressus arizonica* planted in November. Survival of the other forest species was unchanged until the second year except *Prunus avium* that started to decline and to die after the spring of the second year.

Table 8. Survival of tree species planted in pits on a lignite spoil heap in Ptolemaida

Species	Irrigation 50lit/pl 4/summer	Fertilisation 100g/plt	Survival May '93 (%)	Survival November '93 (%)	Survival May '94 (%)	Survival November '94 (%)
Pinus nigra	yes	yes	100.0b*	97.5c	97.5c	92.5cd
Pinus nigra	yes	no	95.0b	95.0c	95.0c	95.0cd
Pinus nigra	no	yes	97.5b	88.5bc	70.0b	70.0bc
Pinus nigra	no	no	87.5b	70.0b	70.0b	65.0b
Pinus brutia	yes	yes	85.0b	85.0bc	85.0bc	80.0bcd
Pinus brutia	yes	no	87.5b	87.5bc	87.5bc	97.5bcd
Pinus brutia	no	yes	90.0b	80.0bc	80.0bc	80.0bcd
Pinus brutia	no	no	92.5b	77.5bc	77.5bc	77.5bcd
Cupressus arizonica	yes	yes	50.0a	50.0a	45.0a	45.0ab
Cupressus arizonica	yes	no	43.5a	38.5a	33.5a	30.0a
Cupressus arizonica	no	yes	48.5a	40.0a	37.5a	33.5a
Cupressus arizonica	no	no	48.5a	38.5a	35.0a	38.5a
Robinia pseudoacacia	yes	yes	97.5b	97.5c	95.0c	95.0cd
Robinia pseudoacacia	yes	no	100.0b	100.0c	97.5c	95.0cd
Robinia pseudoacacia	no	yes	97.5b	97.5c	97.5c	97.5d
Robinia pseudoacacia	no	no	100.0b	100.0c	100.0c	100.0d
Cedrus atlantica	yes	yes	100.0	100.0	100.0	100.0
Cedrus atlantica	yes	no	100.0	100.0	100.0	100.0
Cedrus atlantica	no	yes	100.0	100.0	100.0	100.0
Cedrus atlantica	no	no	100.0	100.0	100.0	100.0
Prunus avium	yes	yes	100.0	100.0	100.0	80.0
Prunus avium	yes	no	100.0	100.0	80.0	70.0
Prunus avium	no	yes	100.0	100.0	80.0	40.0
Prunus avium	no	no	80.0	80.0	80.0	20.0

* Values in the same column followed by different letters are significantly different by Duncan's multiple range test (a=0.05)

The cause of the *Prunus avium* deaths was probably due to the high percentage of fly ash and marl in the area that was planted. Fly ash and marl had very low air porosity and high hygroscopic water. Savill (1991) mentions that *Prunus avium* needs deep and well aerated soils during the entire year. Thus, while in winter, survival was high, during summer it fell to a 53% average. The low survival of *Prunus avium* can be noted more easily in the non-irrigated areas where it only reached up to 20%.

Other researchers in similar reforestation trials had higher survival rates (Plass, 1975; Asby and Kolar, 1977). This may have happened mainly because the surface soil of the lignite mines of Ptolemaida was not replaced when mining ended, resulting in fewer microorganisms and less natural vegetation on the spoils, higher soil temperatures and fewer nutrients in the soils.

In the lignite mines of Ptolemaida, except for the seedling death, there is the death of higher trees 15-20 years old. When those trees reach a homogenous lignite spot in the spoil and when humidity and pressure are reaching a specific point, then, suddenly, a self ignition of the lignite occurs and the trees die. A solution to that problem can be given if the spoils are deep ploughed and the lignite spoils are mixed very well with the other overburden materials. *Pinus nigra* sometimes is dying because the pH of the spoils is very high due to the fly ash and marl content; thus, it is unfavourable for this species because they prefer and grow better in slightly acid soils.

For the growth of the seedlings planted in pits on the lignite mines of Ptolemaida the following was noted. The height of the seedlings at establishment was not significantly different for the species of cypress, cedar and cherry (fig. 2). At establishment, the height of Pinus nigra with fertilisation was higher than the other treatments, and the height of Pinus brutia with fertilisation was lower than the other treatments. In May of 1993, 6 months after the establishment, the height was recorded again, and the elimination of the above height differences at establishment was recorded.

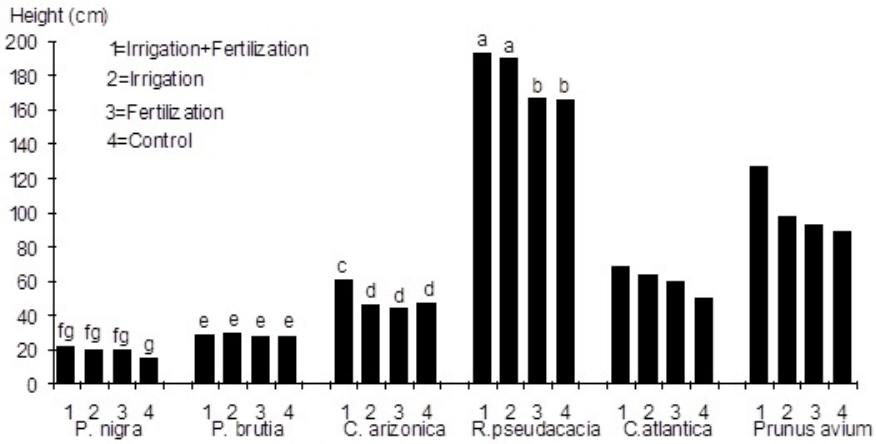

Figure 2. Height of tree species planted in pits, 2 years after the plantation on a lignite spoil heap. Values followed by different letters are significantly different by Duncan's multiple range test (á=0.05)

One year after the establishment, the effect of irrigation on plant growth started to become significant, especially in black Pinus and cherry seedlings. Brutia and cedar did not have significant differences after the first summer irrigation. In May of 1994, the height was recorded 3 months after the fertilisation treatment. Fertilisation positively affected the height of the cherries that were irrigated in comparison with the non-irrigated ones.

Two years after tree establishment, black Pinus and cedar that were not fertilised and irrigated had growth rates lower than the other treatments of the same species (fig. 3). Lastly, one year after the fertilisation and after two years of irrigation (November of 1994), the height of irrigated black Pinus was significantly higher than the initial height. However, statistically significant differences in seedling growth were recorded only in growth difference compared with the establishment height (fig. 3). During the same period, the seedlings of brutia were not affected from the fertilisation and irrigation treatments and at the end of the two years had the same height. Pinus brutia is a drought resistant species and irrigation usually does not affect it, while the higher growth rate of the trees planted in the unfertilised area was probably caused because of the lower competition from natural vegetation.

At the end of the second summer, the height of cypress and cherry trees that were irrigated and fertilised was significantly higher than the other treatments (Figures 2 and 4). The irrigated Robinia was significantly higher than the non-irrigated one; but, as figure 4 shows, there were no significant differences between the treatments of the same species if the comparison is done only for the increment of the second summer. Figure 4 shows that, two years after the establishment of cedar, there were significant differences between the irrigated and fertilised plants and the other treatments.

Basal diameters of the irrigated and fertilised black Pinus and Robinia were significantly higher than the control plants (fig. 3). Basal diameter of the irrigated and fertilised cypress was higher than all other treatments. The basal diameter of brutia, cedar and cherry was not affected by any of the treatments.

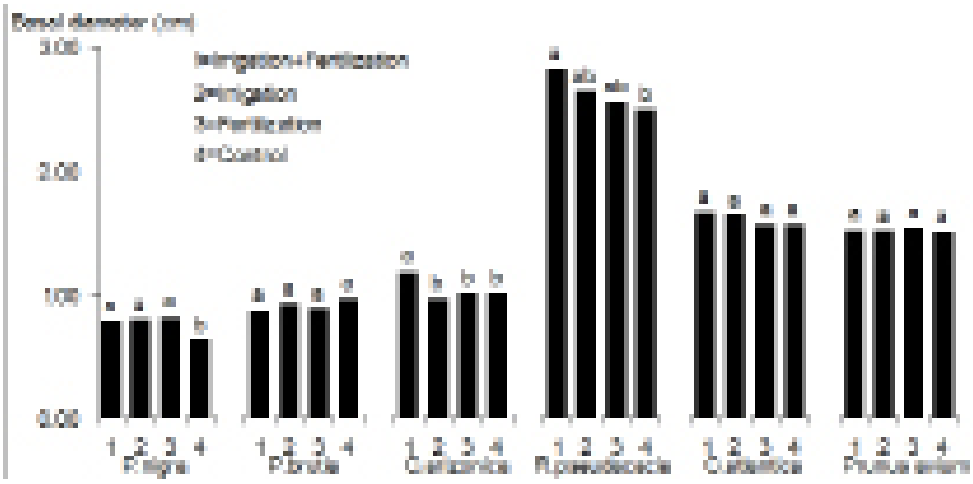

Figure 3. Basal diameter of tree species planted in pits, 2 years after the plantation on a lignite spoil heap. Values for the same species followed by different letters are significantly different by Duncan's multiple range test (a=0.05)

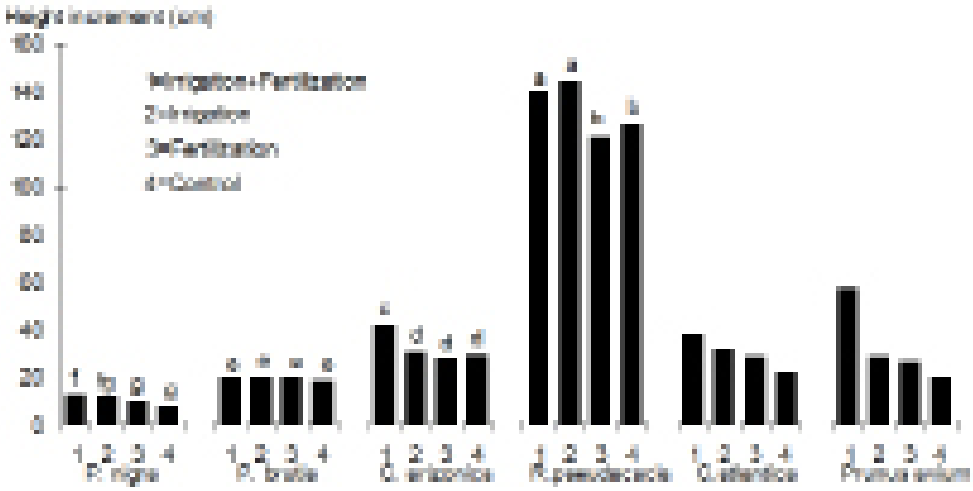

Figure 4. Height increment (cm) of tree species planted in pits, 2 years after the plantation on a lignite spoil heap. Values followed by different letters are significantly different by Duncan's multiple range test (á=0.05)

Figure 4 shows that two years after the establishment of the forest species the height of black Pinus, except control, was not different than brutia, and those species were much lower than all others. The height of cypress can be compared with the cedar which was the immediately higher species of the afforestation, while cherry and Robinia were the highest. It has to be mentioned that the height of Robinia was up to 305cm.

However, if the height comparison is conducted without the initial height, then brutia, cedar and cypress had the same increment as cherries. Additionally, it can be seen that *Pinus brutia* grew much more than *Pinus nigra*. Thus, if the height comparison is shown as growth rate as percentage from the initial height, then Robinia is again first, but two of the treatments are not significantly different with brutia and cypress treatments. Those species are following in tree growth rate, while slower growth rate was noted from *Pinus nigra* and cedar without significant differences between them. Finally, wild cherry was last in growth rate, having a significantly lower growth rate than all other species.

The statistical research of the effect from the parameters of colour and type of soil, natural vegetation and percentage of soil cover at the parameters: height, diameter, vigour and seedling survival led to these findings:

- When seedlings were irrigated and fertilised, there was a weak correlation (r=0.38) between height and soil colour and type. Darker soil (with more lignite content) indicated higher trees, but because r was less than 0.50 this result is only an indicator and not a proof.
- When seedlings were irrigated and fertilised, there was a weak negative correlation (r= -0.29) between survival and soil colour. Darker soil meant decreased survival rates.
- When seedlings were not irrigated and fertilised, there was a weak negative correlation (r= -0.27) between height and soil colour. Thus, in the non-irrigated, fertilised area, when the soil was dark then tree growth was low.
- The correlation between soil colour and soil covered by natural vegetation was very strong (r=0.75 till 0.82). This correlation was strong in all of the treatments.
- There was a weak correlation between soil cover and tree height in the non-irrigated areas (r=0.27), while the correlation was stronger in areas with irrigation (r=0.57).
- All other parameter correlation made with the simple correlation analysis found r close to zero.

4.5. Soil temperature and moisture

A very important parameter limiting tree growth and survival of forest species planted on the lignite spoils of Ptolemaida is the high surface soil temperature during the hot summer days. This is caused due to the black colour of lignite leftovers mixed with overburden on the surface. Soil temperature during the two years of experiment was varying between 35ºC on the surface, when the weather was cloudy, to 62ºC on the very hot days.

The highest values at 0.5cm depth were 62ºC (air temperature 41ºC). Table 9 shows the air temperature in the four areas where the soil temperatures were measured. There were no significant differences between the four areas at any time of the day because all of them have the same aspect and slope. Table 10 shows the average soil temperature at 2.5cm depth. At all mentioned times there were statistically significant differences, as it can be seen in figure 5, with the higher differences during the hot midday hours (fig. 6). The average soil temperature at 3 p.m. in the black coloured soil was 55°C, while the brown coloured soil had a 47.05°C soil temperature and the white marl soil was 42.94°C. Average temperature difference observed between the darkest and lightest spoil materials was approximately 12°C

Table 9. Average air-temperature of a lignite spoil heap, in areas with different soil colour

Air temperature (°C)				
Colour - Time	11 a.m.	1 p.m.	3 p.m.	5 p.m.
Black (10YR 3/1)	29.88[a]*	33.65[a]	35.18[a]	32.00[a]
Light gray (10YR 7/1)	29.64[a]	33.52[a]	34.88[a]	32.05[a]
Brownish red (5YR 4/3)	29.41[a]	33.00[a]	34.82[a]	32.17[a]
Black with vegetation cover	29.82[a]	33.47[a]	34.88[a]	31.94[a]

* Values in the same column followed by different letters are significantly different by Duncan's multiple range test (á=0.05)

Table 10. Average soil-temperature of a lignite spoil heap, in 2.5cm depth

Soil temperature at 2.5cm depth (°C)				
Colour - Time	11 a.m.	1 p.m.	3 p.m.	5 p.m.
Black (10YR 3/1)	30.88[a]*	36.53[a]	38.71[a]	37.17[a]
Light gray (10YR 7/1)	26.70[b]	30.00[c]	32.41[c]	32.47[b]
Brownish red (5YR 4/3)	27.94[b]	34.41[b]	36.94[b]	36.88[a]
Black with vegetation cover	27.05[b]	28.82[c]	29.47[d]	28.76[c]

* Values in the same column followed by different letters are significantly different by Duncan's multiple range test (a=0.05)

The lowest temperature at the soil surface was measured at a black lignite soil under the shadow of the natural vegetation. Specifically, surface soil temperature under shadow at 3 p.m. was 19.49°C lower than the temperature of the same area at bare soil. At the other times of the day that difference was also large and was varying between 12 and 13°C. Under the protection of a four year old Robinia forest stand, it was observed that the highest difference of the temperature between bare and shadowed soil reached 24°C.

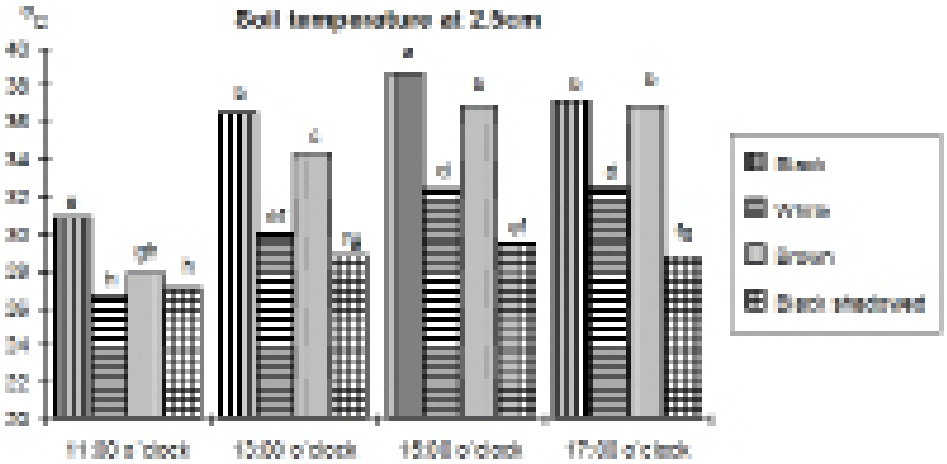

Figure 5. Soil-temperature of a lignite spoil heap, in 2.5cm depth, in areas with different soil colour. Values followed by different letters are significantly different by Duncan's multiple range test (a=0.05)

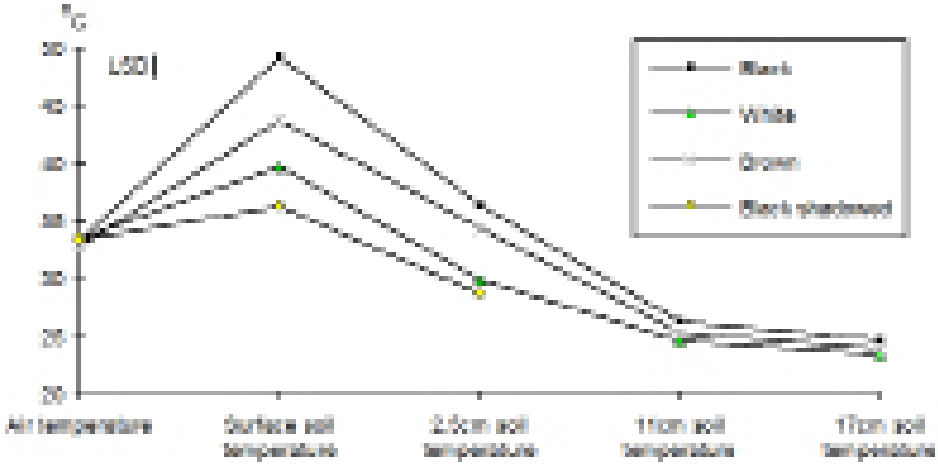

Figure 6. Soil and air temperature at different colour lignite spoils, at 1 p.m.

4.6. Fast establishment of forest by spreading surface soil from a Robinia mother stand

As it has already been mentioned, poor results for the permanent revegetation and reclamation of the area on the fly ash spoils in Akrini and Klitos were reported when a sub-soil that comes from the nearby agricultural lands and from 5 meters depth was transported and spread on the spoils. Revegetation of the spoils was not successful even when the replaced soil layer had 0.5 centimeters depth, and it was planted with herbs and trees.

The establishment of vegetation was much easier and erosion was minimal when the soil that covered the fly ash spoils was coming from a maximum depth of 40cm. Vegetation cover from the first year was almost 80%, and reseeding was not necessary. That surface soil was derived from an area in the mines having all the negative properties of mine soils; but, because it contained a high number of seeds and roots that were already adapted to the adverse ecological conditions of the mines, it rapidly created a vegetation cover that protected the soils from erosion. Nicholas and McGinnies (1982) mention that when the top 25cm of soil is replaced in a mined area then productivity and survival of plants are higher than in undisturbed areas. The contribution of topsoil replacement on reclamation success is also referenced by Cundell (1977), who noticed a high number of microorganisms added in spoils after spreading of topsoil in comparison with undisturbed soil.

In 1992, an area reforestated with Robinia was clear cut because the National Electric Company decided to start mining on it. Those responsible for the revegetation of the mined areas of Ptolemaida decided to transfer the surface soil from that area and spread it on some spoils. The result of that action was to create new stands of Robinia in areas many times larger than previously. In the first year after the spreading of the mother forest topsoil, 800 to 2200 seedlings of Robinia per hectare emerged.

In the old area where Robinia forest topsoil was received and spread on spoils in Ptolemaida, new and greater numbers of Robinia seedlings than before emerged from the remaining roots and seeds. After the successful results of 1992 for rapid revegetation of large areas with the Robinia forest topsoil use, the procedure was repeated in the next few years with the topsoil receiving from the same area and from some other neighbouring areas.

This time the spreading of the topsoil was accomplished by bulldozers which were also used for cutting the roots into smaller pieces (fig. 7). Topsoil was spread on spoils of Kardia, and 300 to 1,200 new seedlings per hectare emerged one year after.

Figure 7. Spreading of topsoil with caterpillar used to cut the Robinia roots into smaller pieces

The lower number of emerged trees was caused because topsoil was spread in the end of spring and the year had a long dry period. Tacey and Glossop (1980) mention that the appropriate season for topsoil spreading on mine soils is immediately after the end of summer, because seeds just fall on soil and microorganisms do not have time to take them away. For the lignite mines of Ptolemaida, the appropriate season for topsoil spreading is the end of the winter before the first spring rain.

Irrigation was applied until the end of the summer in areas where topsoil was placed on spoils later than winter. In those areas, the number of seedlings until summer was low (less than 500 seedlings per hectare), but new seedlings emerged in autumn from seeds and roots that were covered in greater depth. This phenomenon was also repeated in the second year of the experiment.

In February of 1994, Robinia forest topsoil was placed on a 3ha area, and three treatments were applied. Those treatments consisted of an admixture with red subsoil, yellow sand and lignite. The admixtures were made to improve soil moisture relationship and to decrease the high surface soil temperatures during summer. The result of the experiment was to improve soil temperatures during summer in the areas of yellow sand and red subsoil and to increase the available water in the area of lignite admixture. As a consequence, a higher number of Robinia seedlings emerge in the lignite area.

Specifically, soil surface temperature (0.5cm) was 5°C lower on red subsoil and 7°C lower on sand than on the lignite admixture. Soil moisture in summer, at 30cm depth, was 20% in lignite, 15% in red subsoil and 12% in the sand area. From the above, it is concluded that after the subtraction of water at wilting point, the available water on red subsoil was almost zero, on lignite there was no available water and only in the area covered with yellow sand was there enough water available for plants during summer.

However, even though in the lignite area there was a water deficiency, the number of trees grown in that area was higher than the other two areas. Three years after the first trial of establishing Robinia with the use of mother forest topsoil, 2200 seedlings of Robinia per hectare was recorded as an average of the total area (fig. 8). In the second experimental trial, the average number of sprouted Robinia was 1420 seedlings per hectare. In the area with three different soil admixtures, 4700 seedlings of Robinia per hectare were recorded.

Figure 8. Fast establishment of Robinia forest with the use of soil from mother stand

In a similar research conducted by Farmer et al. (1982), it is mentioned that a year after the removal of a 10cm deep topsoil, and by spreading it until the depth was 2-3cm on a coal mine, the following data were recorded: 0.65 *Acer rubrum,* 0.81 *Betula lenta,* 0.07 *Carya* sp., 7.34 *Liriodentron tulipifera,* 0.2 *Platanus occidentalis,* 0.02 *Prunus serotina,* 0.57 *Robinia pseudoacacia,* 0.57 *Sassafras albidum* per square meter. Gene and Samuel (1979) recorded between 1.77 and 4.16 perennial plants per square meter when a 20cm deep surface topsoil was spread on coal mine spoils in Pittsburgh.

Height and basal diameter of Robinia seedlings was measured in the end of November 1994 in all areas where topsoil was spread. In the black coloured area of lignite, the one year old Robinia had an average height of 103.8cm and an average basal diameter of 1.06cm. In the area where red subsoil was added, the average height and diameter were 61.16 and 0.72cm, respectively, and in the area of yellow sand admixture the height and diameter were 81 and 0.77cm, respectively. The height of two years old Robinia varied between 44 and 291cm, while the average height was 170.95cm and the average basal diameter was 1.83cm. The height of the three years old Robinia was between 68 and 430cm, while the average height was 278.38cm and the average basal diameter was 2.24cm.

In the lignite mines of Ptolemaida, the following conclusions are made from the three tree establishment methods. Survival of seedlings planted in pits was around 90%. Survival of seedlings planted with heavy machinery as the riper method was between 60 and 80%. Tree establishment with the method of spreading topsoil of an older forest was 3 to 4 times lower than the cost of planting trees by riper and 10 to 20 times lower than planting trees in pits.

5. CONCLUSIONS

Conclusions that arise from the present research are briefly the following.

- From the phytosociological research of two consecutive years, it was accrued that: 1) Natural vegetation presented a lack of homogeneity and none of the dominant species presented more than 80% stability. 2) With the assistance of indicator plant groups, seven phytosocial units were distinguished which differ between them by vegetation composition and soil type. 3) The average drought species of phytosocial group A, which appear in areas of replaced topsoil, are increasing their population by time. 4) Phytosocial group E, which is represented from *Calamagrostis epigejos,* appears in a compacted marl area and remained constant for both years. 5) Phytosocial group Z, which is represented from *Vaccaria pyramidata,* appears in locations with high fly ash content.
- From the soil analyses at the lignite spoils of Ptolemaida, it was accrued that the soil presented high heterogeneity in both physical and chemical properties. Bulk density was low and varied between 0.77 and 1.43 gr/cm^3. Porosity of fly ash was 8.9%; thus, irrigation of areas with high fly ash content was impossible without prior improvement of the physical properties. pH and $CaCO_3$ content was high in most of the area. Organic matter, carbon and nitrogen content were varying. Available phosphorus, potassium and magnesium were low. Electric conductivity was low in most of the area, and no serious plant growth problems were recorded from it. Fly ash samples had high electric conductivity and soluble sodium content, and vegetation cover was minimal in areas with a high presence of fly ash.
- From the forest species planted in pits, *Cupressus arizonica* and *Pinus brutia* presented low survival rates during winter months due to low temperatures, while *Pinus nigra* and *Prunus avium* presented low survival rates during summer due to drought. Irrigation significantly improved the ability of survival of all species. Fertilisation did not affected tree survival, but it increased plant growth when it was followed by irrigation. Inoculation of *Pinus nigra* with *Pisolithus tinctorius* before the plantation in the lignite mines of Ptolemaida may increase the afforestation success and reduce or replace the use of fertilisers.
- The most successful species of the afforestation trial were *Robinia pseudoacacia* and *Cedrus atlantica*.
- The highest surface soil temperatures were 55°C and recorded at 15.00 hours. Surface soil temperature was up to 24°C higher in bare soil than when covered under natural vegetation.
- Covering of fly ash spoils with soil presented poor results. Subsurface soil had luck of organic matter, microorganisms and seeds of natural vegetation, resulting in low vegetation cover and high erosion (Ferreira and Panagopoulos, 2012). From the present research it has been demonstrated that sewage sludge may give a favourable amelioration response and, in consequence, may improve reclamation success of areas with high fly ash content. The best method to establish *Robinia pseudoacacia* in the lignite mines of Ptolemaida was the use and spreading of topsoil from older stands of Robinia.
- From the present research, it was concluded that afforestation of the lignite mine spoils was possible despite the extreme environmental conditions. However, reclamation success depended on appropriate planning for reclamation, and the new landscape had to be designed in harmony with the surrounding landscape before the start of the mining activity.

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THE MEDITERRANEAN FORESTS: PROBLEMS AND MANAGEMENT MODELS

António Xavier
Maria de Belém Martins

ABSTRACT

The following paper presents a detailed insight about the situation of the forest management in the diversity within the Mediterranean Forests, and their response to different problems, in order to allow the development and application of a forest management model. Therefore, a survey was carried out in several partners' areas of the PROTECT project (An Integrated European Model to Protect MEDiterranean Forests from Fire). The results provided a comparative analysis between different areas located in the Mediterranean Basin, and the analysis shows that there are several management systems that may be improved with experiences from other countries. Also, there are some common problems which need solutions in the different areas, namely forest fires. This general information also provided a good background for carefully applying and adapting different forests' management models, both ecological and economically sustainable, in the PROTECT partners, where the problems and agents to be considered are different, giving conditions for the adaptation and development of a common model.

Keywords: Mediterranean Forests, Forest Management, Fire Prevention, Forest Sustainability

JEL Classification: Q28, Z18, Z13

1. INTRODUCTION

The forests are sensitive and important ecosystems for human life and for human survival: they contribute to carbon fixation and biodiversity preservation, while being essential for the subsistence of different species (Gonzalez-Duque and Panagopoulos, 2010). The role of forests in improving and maintaining the value of landscape has long been recognized, and it is nowadays even more emphasized in the forest laws of many countries. For instance, landscape and microclimate amelioration by forests is especially important in the densely populated urban and suburban areas of the Mediterranean basin (Corona and Mariano, 1992, cited by Scarascia-Mugnozza *et al.*, 2000).

In this context, the Mediterranean area is rich in diversity regarding not only the fauna and flora (Scarascia-Mugnozza *et al.*, 2000) but also the several ways of life activities and culture resulting from the many millenniums of human activity within it. In fact, the history of forests in the Mediterranean area is a history of not only forest degradation and eventual deforestation but also temporary natural expansion (Scarascia-Mugnozza *et al.*, 2000). Therefore, it is rare to find a clear separation between economic activity and the natural environment: the dynamics of a Mediterranean forest have always been intimately linked to the human societies that have grown up around them (IAMF, W.D); and, due to

ancient civilization and continuous human activities, Mediterranean ecosystems are now very different from their origin.

However, Mediterranean regions have received only passing attention by foresters and environmental specialists. It is recognized that, apart from the FAO (Food and Agriculture Organization) initiative of drawing up a Mediterranean forests action program, approved at the March 1992 session of *Silva Mediterranea* in Faro, Portugal, little attention has been given to Mediterranean forests at the international level (Palahi, *et al*., 2008).

Nevertheless, the many strengths and weaknesses of the Mediterranean forest need a specific study for a correct management. The drought-prone environment, the difficult socioeconomic conditions and the history of over-exploitation of the Mediterranean forests are indisputable weaknesses; however, the rich biological diversity, the attractiveness of the environment and the high production potential for specific products are clear strengths that should not be underestimated (Scarascia-Mugnozza *et al.*, 2000).

Besides these general problems, there are some specific forest management problems to be solved, as well as a necessity to protect the forest from some of its most important enemies: floods, droughts and forest fires, which are the traditional triad of natural hazards in the Mediterranean. The ''extremes'' of the hydrological cycle show patterns of occurrence that are still difficult to discern. However, forest fires remain a recurrent threat during the summer season, and their incidence has increased significantly during the last decades (Badia *et al.* 2002). Therefore, forest fires represent a major agent promoting changes at the landscape level and increasing land degradation risk, and it is the most important natural threat to forests and wooded areas under the dry summer conditions of Mediterranean climates (Odeja *et al.* 2001). They cause extensive damage to forested ecosystems (Maheras, 2002), and, over the last years, wild fires have become issues of great importance in the southern European countries and efforts have been made to control their negative effects (Maheras, 2002). Even if in some countries, according to the national burnt area statistics, the problem seems to be under control and of steady or decreasing magnitude, in regions like the western Iberian Peninsula, namely the Portuguese area, the trend is worryingly opposite (Pelizzari *et al.*, 2008). It is also a fact that, according to some research, in contrast to elsewhere where a high percentage of fires are of natural origin, the Mediterranean area is characterized by fire provoked by humans. The natural causes represent only a weak percentage, probably because of the absence of climatic phenomena such as the dry storms (Alexandrian *et al.*1999).

The political and socio-economic interest that Europe is directing to the Mediterranean and the European research policy (Noronha, 2011), aiming to study sound conservation strategies and a locally-tailored sustainable management of the regional forest and landscape resources, renewed the interest in Mediterranean forests (Scarascia-Mugnozza *et al.*, 2000). Also, the measures of the common agriculture policy have led to some intensification of agriculture and to an increase of the forest area, which also led to a higher importance of the forest and forest management within the agro-forestry farms.

In this context, the PROTECT project (An Integrated European Model to Protect MEDiterranean Forests from Fire) has several relevant objectives, as follows: 1) To jointly develop European prevention methods and instruments to efficiently map, assess and monitor risks; 2) To set up a common Action Plan for the strategic and operational management of awareness raising & training activities; 3) To consequently adapt or introduce prevention plans in the different territories; 4) To develop and introduce a sustainable economic and environmental forest maintenance model to prevent/reduce the outburst and deployment of forest fire by appropriate forest cleaning and reuse of biomass; 5) To improve European cooperation among civil protection experts by the creation of a European network consisting of various actors situated in the different territories (PROTECT, 2008).

These tasks are being carried out by 3 Working groups (WP). In WP2 an economic and eco-compatible sustainable model for forest maintenance is a relevant task being developed. This will be an ecological and economically sustainable forest management model, where the valorisation of the biomass is essential to not only promote ecological sustainability but also economic sustainability. This is quite relevant because fragile and unstable ecosystems, like the Mediterranean ones, are often unable to produce large quantities of woody biomass per unit area; consequently, intensive management is often incompatible with the other roles of forests such as soil conservation and landscape improvement (Scarascia-Mugnozza *et al.*, 2000).

This model needed an important amount of data and the detailed knowledge of the forests' situation within the different areas participating in this study: forests' characteristics, management models, forest uses and outputs and fire prevention.

Therefore, and with respect for the PROTECT project's objectives, a survey was developed in the project partners. This allowed the acquisition of general information necessary for the model framework design, but it also permitted us to analyse some of the practices carried out in some countries which may be applied and followed according to the main, positive achievements carried out in other areas.

The remainder of this study is organized as follows. In section two a description of the Mediterranean Forests and the localization of the participants in this study is made; in section three the methodological approach is discussed; in section four the results are presented and some discussion is made regarding the main findings of this study, namely regarding the main improvements of the work for forest management for the different situations. Finally, in section five, the main conclusions of this study are presented.

2. THE MEDITERRANEAN FORESTS AND THE STUDY AREAS

2.1. The Mediterranean Forests

The Mediterranean Floristic Region has a high diversity of species, as recognized by different authors (Scarascia-Mugnozza *et al.*, 2000; Palahi *et al.,* 2008; Boydak *et al.*, 1997). During the last few thousand years most of the original Mediterranean woodland has been eradicated, used for timber or replaced by agriculture. Coastal areas are the most damaged, especially in the last century, because of urban areas' development and tourism. Today, therefore, in the Mediterranean basin the forests are in a unique mosaic of terrestrial, freshwater and marine ecosystems, as a result of a distinct regional climate imprinted on a dynamic topography (Palahi, 2008).

Despite the strong anthropic influence on Mediterranean environment, the Mediterranean area is still home to considerable biodiversity, including thousands of endemic species (Palahi et al., 2008).

The floristic composition is related to the influence of the pedological conditions and other physical factors. For instance, in a siliceous substrate derived from the granite we find Quercus suber. The main formations are the Scrublands, Savannas and grasslands, the Evergreen woodlands and the mixed Forests.

Scrublands occur in the driest areas, especially near the seacoast around the Mediterranean. They are dense evergreen sclerophylle shrubs and small trees, the most common plant community in such areas. In some places scrublands are the mature vegetation type, while in other places they are the result of degradation of a former forest or woodland by logging or overgrazing, or disturbance by major fires. Typical species are Pistacia lentiscus, P. terebinthus, Juniperus Sabina, Rosmarinus officinalis, Arbutus unedo, Rhamnus alaternus.

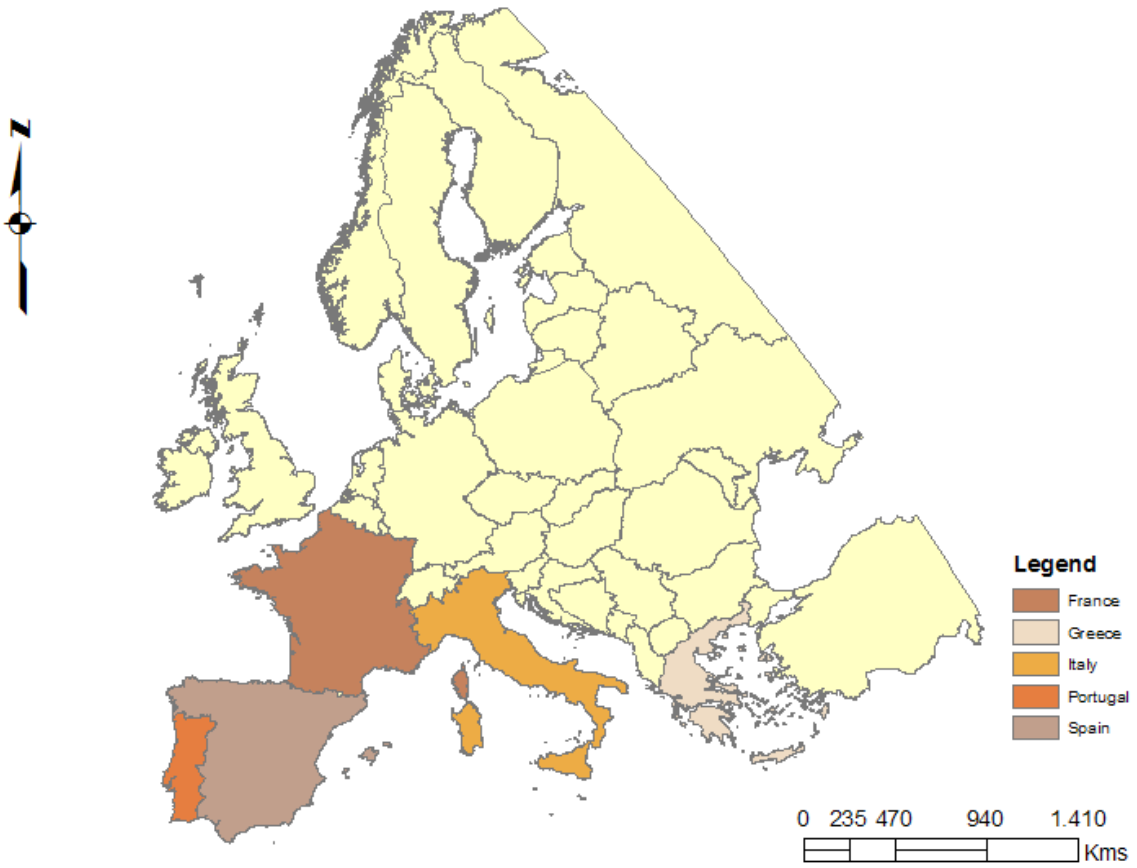
Savannas and grasslands occur around the Mediterranean vegetation, and are usually dominated by annual grasses. The evergreen woodlands are usually dominated by oak (*Quercus ilex, Quercus suber*) and pine (*Pinus pinea, Pinus pinaster* and *Pinus halepensis*). Finally, mixed forests occur in the areas of highest rainfall, in the mountain belt, in riparian zones along rivers and streams where they receive summer water. These kinds of forests are generally composed of deciduous species like *Quercus pubescens, Quercus cerris* or the *Ostria carpinifolia*.

2.2. The study areas

The different study areas correspond to the different PROTECT partners' areas. The partners are the Province of Macerata (Italy), the Provincial Government of Malaga (Spain), the Region of Peloponnese (Greece), the National Forest Authority (Portugal), the Department of Forests-Cyprus (Cyprus), the University of Camerino (Italy), the University of Algarve (Portugal), the University of Provence (France) and the Region of Istria - Department of Sustainable Development (Croatia), who abandoned the project due to funding specific problems.

Since there are countries with more than one partner, focus was placed on each of the managed/ involving the different territorial partners (fig. 1).

Fig. 1- The different countries participating in the project



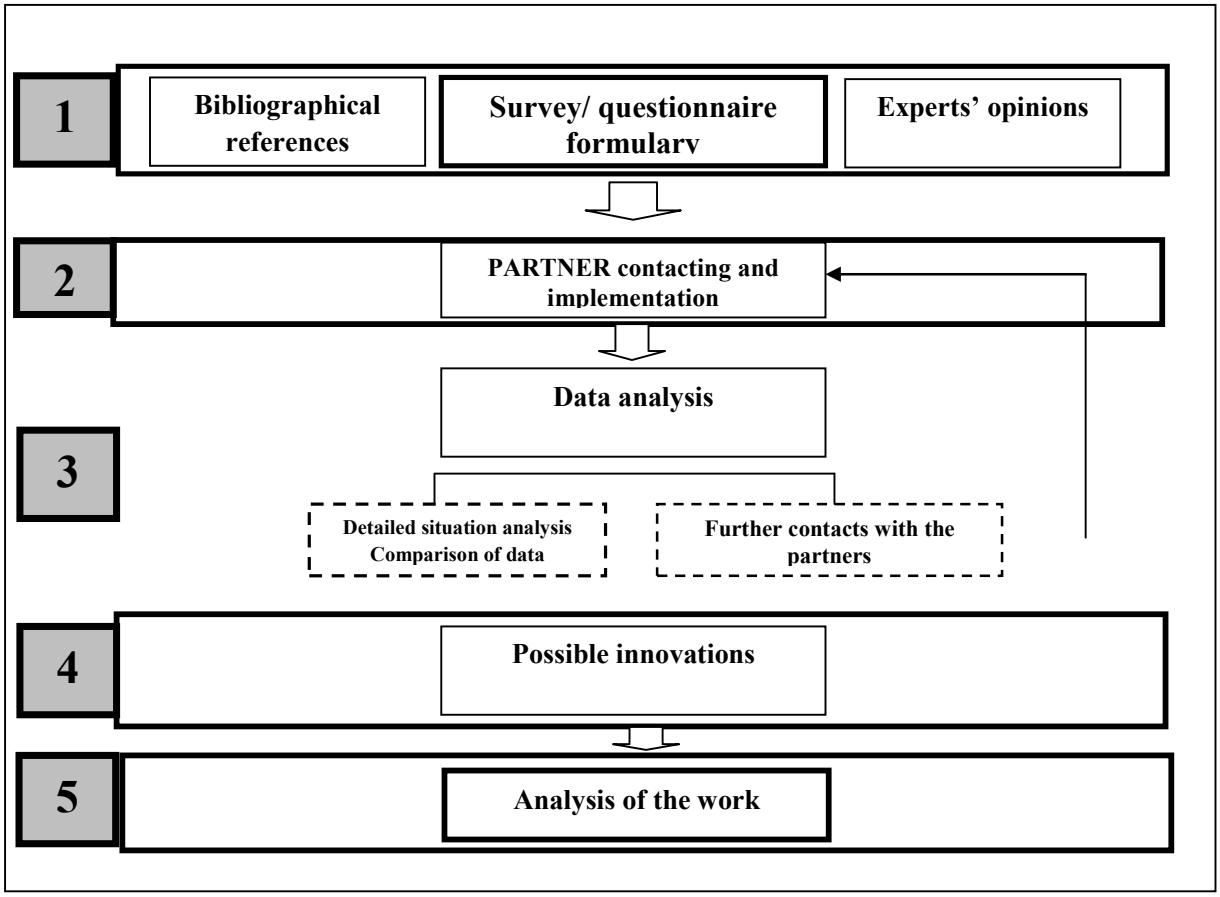
(source: own elaboration)

3. THE METHODOLOGICAL FRAMEWORK

The methodological framework created was intended to promote a detailed information gathering to determine the situation of each partner, but it was also based on the idea that a cooperative approach may be quite useful for solving common problems.

Therefore, the methodological framework used was based on several steps, which are presented in the following figure (fig. 2). These were all carried out during the PROTECT project, and constituted an initial phase of the WP2 work.

Fig. 2- Schematic design of the methodological framework followed



In a **first step**, a general questionnaire was created which followed some of the main guidelines and ideas of different previous projects and studies regarding the main indicators to be considered. Therefore, the main findings regarding the indicators of the MOSEFA project (Guidelines for Establishing Farm Forestry Accountancy Networks) based on EFI (2001) were analysed in a very detailed way. In order to consider a careful design of such formulary, we also used as a reference the questionnaires created in some agricultural studies, namely the Agricultural Census and other related studies.

We also asked for a critical background of some partners in order to have a more clear and detailed insight of those situations. Furthermore, some experts in the field were asked the relevant points to be considered in this kind of formulary, and their opinion was inserted whenever possible, always considering the project's main objectives.

The following structure was defined: 1) Forest physical characteristics 2) Forest uses, 3) Output, 4) Social/ legal issues, 5) Forest management, 6) Forest fires and prevention, 7) Agro-forestry farms. All the items are related to different dimensions of the problem.

Besides the inclusion of the characteristics of the forests which would imply some specific considerations, other main subjects were also considered such as the forest use and the output in terms of productions. Also, the social issues, namely the propriety of the forest, were considered, and the consideration of fire occurrences was another crucial item to be inserted for risk planning reasons. Finally, a point was inserted regarding the situation/existence of farms within the area, namely those which have as land use forests, since in many cases they may have a relevant role in forest management and fire prevention.

In a **second step**, the questionnaires were distributed to all partners who implemented them according to our guidelines. In a **third step**, the questionnaires were analyzed following a critical opinion of different experts regarding their validity and eventual doubts/inefficiencies.

A systematic comparison of the results was also conducted for the purpose of withdrawing results and valorising the study. The data were analyzed with respect for the eventual richness of information that may be retired from them (Alberto Pérez, 2012). Statistical analyses were also implemented. Therefore, a detailed analysis for each variant of the management model, to be developed, was made.

In a **fourth step**, possible innovations were analysed, and new ideas that were present in some of the members studied, following the premises that a cooperative approach may give some good results.

Finally, in a **fifth step**, a critical analysis of the data collected for each of the areas for modelling purposes was performed, but also regarding possible problems of this approach. This allowed an idea of the problems that this approach may present to become apparent and to design guidelines for a posterior application in other areas.

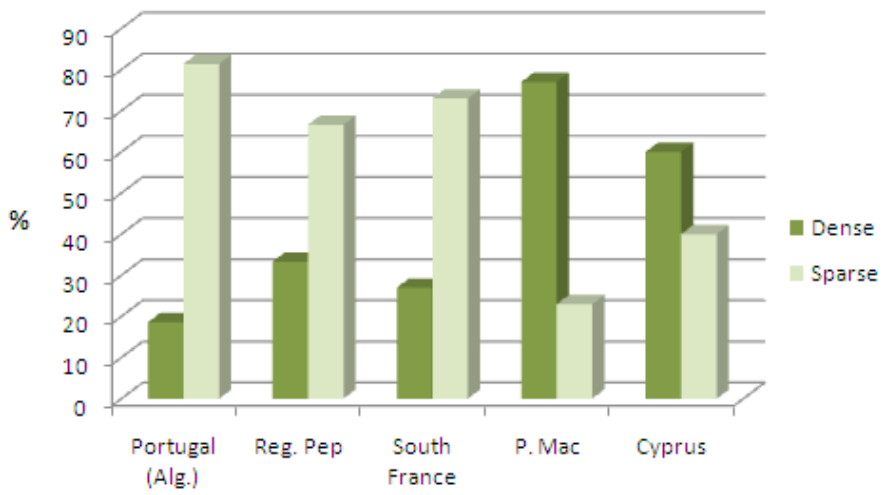
4. RESULTS

The results are presented next and follow the main points of the survey structure. These results refer in some cases to the area that is surrounding the enquired or to the general background, for adaptation purposes to each reality. The Spanish results are not presented.

4.1. Forest physical characteristics

Regarding the physical characteristics of the forests, in spite of all members being in the Mediterranean domain, there are quite different physical characteristics among them. Even so, the forestry area combined does not represent more than 32% of the total area, with the highest value registered in Greece. The forest also has different characteristics regarding density as can be seen in the following figure (Fig. 3) which presents the situation in the different studied PROTECT.

Fig. 3- The forest density in the different PROTECT partners



(source: survey results)

The forest height at maturity age is considered to be around 12 or more meters, except in Portugal and South France, where the average reaches from 5 to 8 meters. It is also considered that there are different predominant forest types in each partner.

Regarding the Province of Macerata, Italy, there is a predominance of broadleaf and deciduous species. It is estimated that about 95.2% of woods are composed of broadleaf forests and 4.8% of reforestations with conifers; at the same time, about 92.4% of woods are composed of deciduous forests and 7.6% of evergreen forests (2.8 holm oak woods, 4.8 reforestations with conifers). Evergreen forests' floristic composition is always composed by a percentage of deciduous trees - 37% individuals and 32% in volume. The most widespread deciduous woods are dominated by Quercus pubescens s.l., Ostrya carpinifolia, Quercus cerris or Fagus sylvatica. Also, the evergreen woods are dominated by Quercus ilex subsp. Ilex.

Regarding Cyprus, there are only permanent leaf trees, and the vegetation composing the forests in Cyprus are mainly trees, including shrub and bush understory, where coniferous species predominate. The dominant specie is Pinus, occupying more than 90% of the forest area.

Specifying the analysis, the main tree species in Cyprus are *Pinus brutia*, Calabrian Pine, which thrives up to 1200 m altitude, and it is the dominant species forming extensive forests on the Troodos and Pentadactylos mountain ranges and in other regions; the *Pinus nigra ssp. pallasiana*, Troodos Pine, which forms thick forests around the central Troodos area, from 1200 up to 1950 m; finally, the *Cedrus brevifolia*, Cyprus Cedar which is restricted around the Tripylos peak (Paphos Forest) from 800 up to 1400 m. Riparian vegetation is mainly composed of broadleaves like *Platanus orientalis*, Plane Tree and *Alnus orientalis, Alder*.

As regards shrubs these are either part of the understorey of the forests or they form extensive maquis and garigues. Under favourable conditions some shrubs attain the dimensions of small trees. The main shrub species found in Cyprus are: *Juniperus phoenicea*, Phoenician Juniper, *Quercus alnifolia*, Golden Oak, *Acer obtusifolium*, Maple, *Arbutus andrachne*, Strawberry Tree, *Pistacia lentiscus*.

In the Region of Peloponnese, Greece, the situation is the same: there are only evergreen forests, and the forest is dominated by coniferous species such as fir, black pine and spruce and there are also chestnuts. The undergrowth consists of broadleaf species such as *P. lentiscus*, *Arbutus*, *Olea europea*.

In France, the South-East forest is a mixture of broadleaved species and conifers with evergreen foliage, maquis scrublands and wooded garrigue scrublands. The general French forest, on the other hand, is mostly a forest of broadleaved trees. Broadleaved stands cover 59% of the forested area. Conifers are more often present in the Landes Forest and in the mountainous regions. Mixed broadleaved/coniferous stands are located at the interface between plain and mountain.

Finally, in Portugal, the predominant type is a permanent leaf forest. The main species present are Cork oaks, Eucalyptus and Holm Oaks. The first one is located preferentially in Serra do Caldeirão (in the center north of the Algarve territory) and Serra do Espinhaço de Cão (in the southeast of the territory). The Eucalyptus plantations are mostly located in Serra de Monchique (in the northeast of the Algarve territory), and they are more recent in the territory. Finally, the holm oaks are mainly concentrated in the northwest part of the territory (Alcoutim county).

The above analysis allows the conclusion that there are differences among the different PROTECT project partners that need different answers. In order to better understanding the composition of such areas, the next table (table 1) presents the different forest species' dominance in each partner, represented by the area dominated by such species.

The analysis of these results shows that, in Cyprus, there are practically only Pinus trees; all the other areas reveal a more reasonable distribution of their forestry species. There are also some species not typical of Mediterranean forests but are linked to particular conditions, such as in the Province of Macerata, where the altitude is high. Moreover, there are quite different variations among all the other areas, revealing not only the diversity within the Mediterranean basin but also the influence of different geographical factors.

Table 1- The predominant species in each of the PROTECT partners

Species/area	**Prov. Mac**	**Cyprus**	**S. France**	**Reg. Pep**	**Port-Alg.**
Pine-trees	4,8	99	31,3	12,9	7,3
Cork oaks			3,1		21,5
Holm-oaks	2,8		27,4		10,6
Oaks	20,3			9,02	0,07
Pubescent Oaks			20,4		
Ostrya carpinifiolia	52,8				
Castanea sativa	0,7				
Fagus sylvatica	11,5				
Cedar trees		0,2			
Riparian vegetation		0,5			
Spruce				10,63	
Chestnut				0,15	
Evergreen				66,7	
Eucalyptus					10,5
Beech			6,4		
Others	7,1		11,4		

Prov. Mac-Province of Macerata; Cyprus-Cyprus forests; S. France-South of France; Reg. Pel.-Region of Peloponnese Port-Alg.-Portugal-Algarve

(source: survey results)

4.2. Forest management

Distinct management models with different organizations are present in these forest areas. In common, all of them argue to promote the participation of different agents and stakeholders.

In the Province of Macerata, Italy, there is a combination of a public, associative and private managing system. Forest management in Italy is subjected to DM June 16, 2005, the so called "Guidelines for forest planning". Regions must draw up their Regional Forest Plan that defines the range of application, conservation strategies and forest sector development. Also, Marche's Regional Law number of 2005 provides guidelines for the Forest Regional Plan, and so the regional plan for this area was approved by Marches Regional Council on February 26, 2009.

These plans provide indications about regional forest heritage, the functions of woods, guidelines for management of public properties (Demanio Forestale Regionale), criteria for a sustainable management of Marches woods, woods to be submitted to management forms and intervention priority, and management models in public properties (Demanio Forestale Regionale).

Management plans are drawn by "Comunità Montane", the authorities which directly manage woods belonging to "Demanio Forestale Regionale" and authorize felling, activities and interventions in all the woods belonging to their territories, except for small cutting areas. Out of territories belonging to "Comunità Montane", cutting down is authorized by the Province of Macerata. Due to the legal framework, only in particular cases the Province of Macerata can authorize forest surface reduction or transformation, which means the forest's conservation is assured.

Despite everything mentioned above, the main objective discussed on our survey is wood production, considering both the production and protection issue, with no other additional objective being considered as relevant.

In Cyprus the management system is based on multiple uses of forest resources and seeks to protect and improve the natural environment for the benefit of all citizens and visitors from abroad. The system is directed to the improvement of forests' condition; conservation of soils and watersheds; protection of the flora, fauna, biodiversity and heritage; the promotion of ecotourism; and the sustainable production of wood and non-wood products, up to the limits of forests' capacity to supply them. This is a public model, which still provides incentives for the participation of different stakeholders, and it does not have profit or other related aspects as an objective. The main forest uses discussed on the survey were three: wood production, wildlife conservation and tourism.

In France, the management system for forests, whatever the type of owner (private or public), is based on a sustainable management. Regeneration is always the case after each harvest. This is realized by plantings or by seedlings coming from the stand itself. Cuts are progressive during the stand's lifetime. The public forest, managed by Office National des Forêts (ONF), is divided between state-owned forest and other public forests that belong to local authorities, mainly townships. Private forests' management is realized by certified forest managers or by the CRPF (Regional Center of Forest Ownership) by the owner itself. Whatever the manager, if the surface is more than 10 ha, the "Serot" French act must be applied, imposing a specific management plan. The FFN (National Forestry Fund) brings financial support for the owners. The FFN is financed by tax payments given by all wood industrials or importers. The main use discussed was wood production.

The Region of Peloponnese has a forest management model based on public laws, and they are managed according to this within the principle of sustainability. For regulation purposes, there have been two main Forest Acts enacted: the forest code of 86 in 1969 and the law of 998 in 1979, which are also supported by additional acts.

In the Region of Algarve, Portugal, the management model can be private, associative and public. The majority of the area is managed by private owners. There are several forest producers' associations who give technical support to these private managers. Since 2005, a new territorial ordinance figure was created - the Forest Intervention Zones (FIZ). A FIZ is a continuous and delimitated area, composed mainly of forest areas, subjected to a forest management plan and to a specific plan of forest intervention and managed by an entity (which may be a forest producers' association). It has a minimum of 750 ha and includes at least 50 owners or forestry producers and 100 rustic proprieties. It is constituted by the initiative of a group of land owners or forestry producers - the creator nucleus. Finally, the public areas are managed at the national level (matas nacionais) or in associations between the national level and the municipalities (forest perimeters).

In these two countries, the main uses discussed on the survey were wood production and wildlife conservation.

Given these results, it seems that society still does not value the multiple uses of forests, which means it is not recognizing its true value – in the end one can argue that the society probably will not be available to pay for its true value.

Besides the main objective, we also wanted to know which products are mostly considered within the main objectives. In the Province of Macerata, the main product is timber, used mainly as firewood; additionally, there is also some unspecified production of truffles and fungi. In Cyprus the main product is pinus timber used mostly in local private sawmills and as fuel wood and for the production of charcoal. In the Region of Peloponnese, Greece, the main product is also timber, mainly for sawn timber and also for firewood. In South France the main product is timber, and in the Algarve, Portugal, the forest gives two main products: timber, for wood and paper pulp, and cork, which has a very high quality in this area. This means that producers are not only centered in some uses, but that they do not value other products, such as non-timber products, which are interesting products for which these areas have potential.

4.3. Social/ legal issues

Concerning the social and legal issues, namely the ownership of the forest area, the situation is also quite different among all the PROTECT partners.

In the Province of Macerata, the forest is mostly privately owned by small owners or small owners associated in "Comunanze Agrarie", which are particular forms of collective ownership. In this case, the lands belong to the inhabitants and each of them can exercise the rights of civic use, for the traditional forms of exploiting the land, namely grazing and wood harvesting.

In Cyprus the forest is mainly public and it is therefore mostly managed by state entities.

In the Region of Peloponnese, Greece, a large percentage of forest land is owned by the state, and the small percentage of non-public forests is either private, municipal, church property or co-owned.

On the contrary, in South France the ownership is mainly private, representing 73% of the total of owners, which is also a value close to the national average. 3/4 of these owners have inherited their forest, 85% of them live in the region where their forest is located, 57% of private owners are retired people and 12% are active farmers.

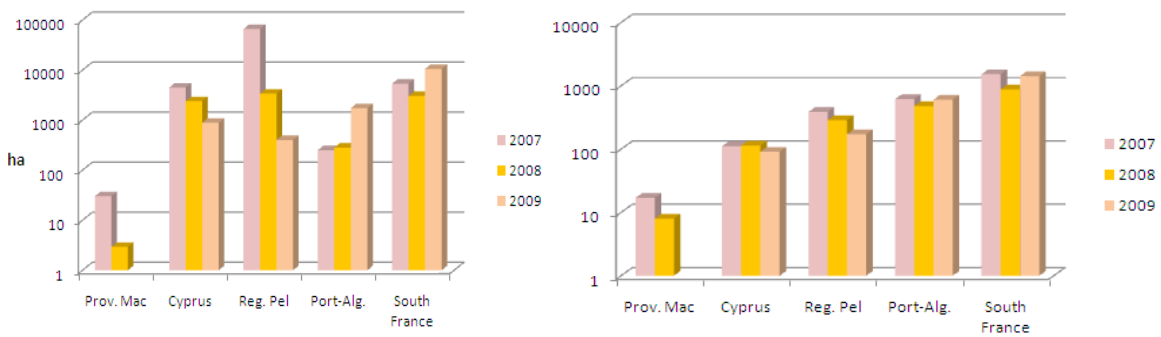
Finally, in Algarve, Portugal, almost all of the forest is owned by privates, individuals and enterprises, mainly with low dimension proprieties.

4.4. Forest fires and prevention

The forest fires are a problem in these areas. The following figure (fig. 3) represents the burnt area (ha) and the number of fires in the different partners' areas.

The most relevant burnt area was registered in the year of 2007 in the Region of Peloponnese, Greece. Concerning the number of fire occurrences, the Algarve and South France registered the largest numbers with a tendency to increase in all the years; the other three regions registered, in these years, a tendency to decrease.

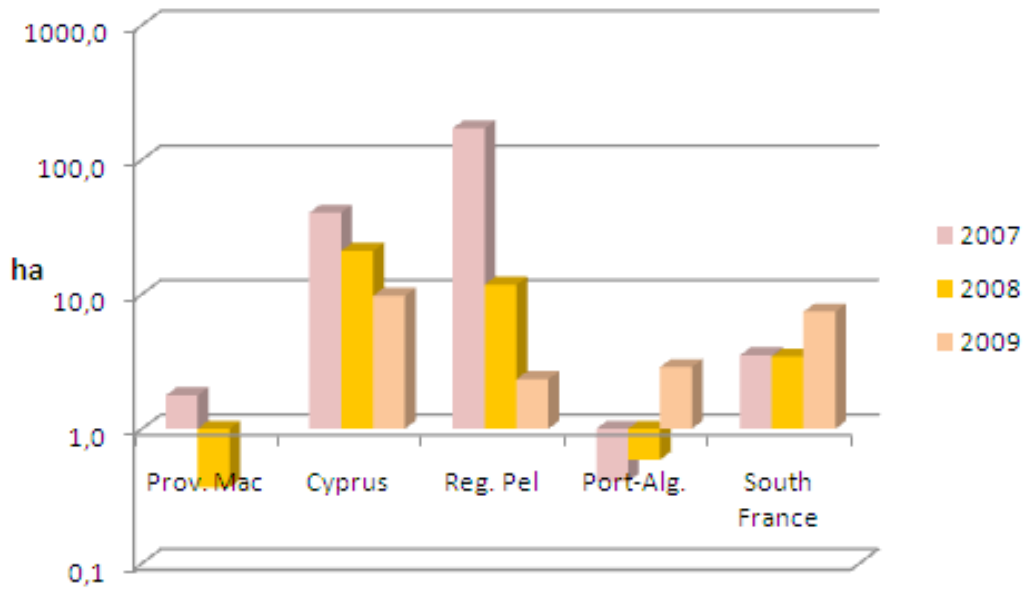
Fig. 4- The forest area burnt and the number of occurrences



(source: survey results)

The burnt area by forest fire is presented as follows. Results show that the higher average values of burnt area by forest fire are found in Cyprus and the Region of Peloponnese, with a decreasing tendency. In South France and Portugal, the value is lower, but the results present an increasing tendency on the analysed years.

Fig. 5- The burnt area by forest fire



(source: survey results)

The causes of fires registered within the different areas seem to be two: arson and negligence (table 2); nevertheless, there are a large number of respondents reporting unknown causes.

Table 2- The main causes of fires in the PROTECT partners

Area/cause	Unknown	Negligence	Accident	Arson	Others
Prov. Mac	■	■		■	
Cyprus	■		■	■	■
Reg. Pel.	■	■			
Port-Alg.	■	■		■	
South France		■		■	

(source: survey results)

4.6. Agro-forestry farms

The agro-forestry farms may be present in different areas of the Mediterranean Basin, and their logic may dictate some important consequences for forest management. Concerning this issue, three partners - the Region of Peloponnese, South France and the Province of Macerata – mention the existence of farms within the forest area. This question, however, must be detailed with data from other sources, such as national statistics. For the partners who gave a positive answer, the French partner had no information on the farms' characteristics; the situation, for the two other partners, is presented below.

In the Province of Macerata, 45.87% of the forests are included in the farms' area. These are mostly private farms, whose key management objectives regarding forest are timber production and conservation. They develop activities regarding extensive cattle production and agriculture.

In the Region of Peloponnese, less than 10% of the forests are included within the farms, and they are mostly private. They mainly develop activities regarding extensive cattle breeding and hunting and use forests mainly for extensive cattle breeding. Their average net income is low and no conservation objectives were referred.

4.7. Discussion

The above results allowed us to better understand the implementation of a forest management model; however, there are some questions to be addressed and discussed.

As was presented before, in the Mediterranean region one can find different forests with different physical characteristics. These physical characteristics are related with different physical and human factors. This diversity represents a net of interactions between agents and physical factors that must be carefully considered in a management model.

Regarding the main uses of forests, it seems to be quite a specialization, with the activities relating to non-timber products and tourism not being particularly valued. Therefore, it seems that an additional gain could come from the valorisation of those products. For a management model purpose, this issue should be carefully discussed within the partnership.

Finally, regarding forest management, it was shown that there are different management models which may easily respond to problems in other areas. In Portugal the recently created FIZs could be an interesting solution to replicate in other areas such as France or the province of Macerata, or the ideals of the "Comunità Montane" could work better and improve the situation in Portugal. This is especially true for those areas whose types of owners are the same.

For forest fires, the aspect that must be underlined is the substantial number of fire occurrences that have, as main causes, unknown – the common feeling of people inquired was that these fires' causes, although not officially classified this way, would be mostly arson,

negligence or accident. A management plan should mainly consider a concerted approach to fight these fire causes.

The management of these areas must often consider the existence of agro-forestry farms. These farms may have different characteristics, but a common characteristic is their scale. A management plan could profit from the ideas presented, for instance, by the Province of Macerata, which may be applied in other areas.

Due to the above exposure, the model to be developed must consider the differences among partners but should also be able to integrate approaches, including some of those presented.

5. CONCLUDING REMARKS

This study provided detailed information about current problems in the Mediterranean area and several management options used to tackle them. It was shown that some of the practices carried out in the different countries may be applied in other areas. It was also shown that the forest fires tend to be a problem in most of them. In spite of the fire being a natural agent in the territory, it is a fact that, many times, it is related to negligence and arson, which are non-natural causes.

The questionnaire administered to the different PROTECT partners also provided a general problem description of the forest management situation in the different partners and their main problems. Therefore, a model for forest management of the territory may be developed.

Finally it is recommended that a posterior application of such methodology should consider a more complete approach concerning forest fires' prevention and occurrences; also, the implementation of such method should be as participatory as possible, since it will allow valorising the results. Social issues should also be accounted in a more detailed way considering both the type of owners and other relevant aspects, such as the importance of the forests to society.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge partial financial support from FCT, program POCTI. The authors gratefully acknowledge the PROTECT partners: Province of Macerata (Italy), Provincial Government of Malaga (Spain), Region of Peloponnese (Greece), National Forest Authority (Portugal), Department of Forests-Cyprus (Cyprus), University of Camerino (Italy) and University of Provence (France).

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ISSN: 2183-1912

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