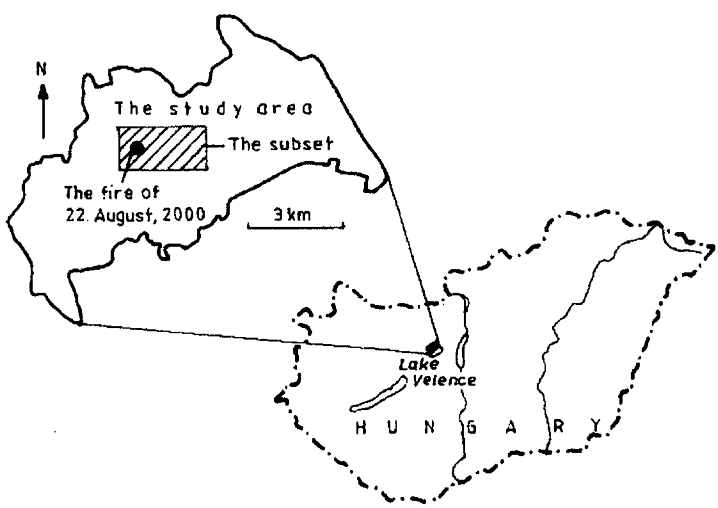
ACTA Geographica Szegediensis Tomus XXXVII. 2000. pp. 19-28.

FOREST FIRE IN THE VELENCE MOUNTAINS

Dormány, Gábor

Introduction

On 22[nd] August 2000, a very quick and devastating fire happened in our test area, the Southern slopes of the Velence Mountains, which is the Northern first order watershed of Lake Velence (*Map 1*). A 25-year-old blank spruce forest burned down seriously in 22 hectares by supposed human irresponsibility. The loss is in millions of forints, not to mention other damage, which is impossible to evaluate.



Map 1 The location of study area

Although Hungary does not belong to the Mediterranean area where 2-3% of total wood area burns down annually (*PIUSSI, 1992*), the phenomena is not unknown owing to the events happening in the last years. The judgement of forest fires is not as obvious as it seems: although it is loss for foresters and menace for firemen to prevent, it helps to renew the ecosystem. The problem with fires is that the damage occurs during a relatively short period of time and causes severe losses in many cases (*SMITH, 1996*) (*Picture 1*).

Forest fire can be interpreted as a geographical problem due to spatial connections of influential factors like weather, topographical or demographical conditions of occurrence, spread and postfire status. It is an important event in the landscape evolution, it can be a cause and a consequence of changes in the land use system, it is a process that connects different entities in time and space. This paper intends to introduce the reader to this issue through references, statistics and analysis of various types of data and facts and tries to draw conclusions.

Picture 1 Landscape after the fire

Method

The risk of forest fire is a combination of structural and dynamic factors. The first branch includes among others the quality and quantity of combustible material, the topography or the cause of fire, which is mainly human and impossible to forecast. The second one contains mainly the meteorological variables like temperature, humidity and others, or the socio-economic factors or the changes in population. Furthermore, the land use, seasonal activities like the combustion of stubble, life around the forest or the power agriculture can become potential causes, sources of fire belonging to both groups.

In the following, I choose some typical factors and try to show how they work in this concept. The different factors demanded different approaches to investigate from analyses in GIS to statistics, as they are members of an existing fire risk mapping and modelling method (*NATURAL HAZARDS PROJECT, 1999*).

What is risk?

First of all, it is important to clarify some expressions. Forest fire or wildfire or wildland fire – different words can be used in parallel – is a *hazard*, as normal as other processes in nature like landslides, earthquakes or tsunamis. The probability of its occurring, the loss caused by it and the vulnerability of the objects create its *risk*, and make fire risky on different rates. To put it simply:

$$\textbf{risk} = \textbf{probability} \times \textbf{vulnerability} \times \textbf{loss.}$$

This definition of risk is only one of many but I consider it the best approach and find it detailed enough. For a general and theoretical instance, standing under a chestnut tree in autumn is highly risky due to the frequent fall of chestnuts and the possible wound on the head, which can cause a two-week-long sick-leave after the hit. On the other hand, running in a flowery meadow and wearing a helmet in springtime is an effective way of mitigating this risk.

Researches on forest fire

Fires in general and moreover fires in wood are in the focus of various researches from different approaches. PERRY's article is a detailed overview of the modelling and the ways of methods (*1998*). The remote sensing started to be used in researches on fires decades ago, and nowadays it is also current for studying. The classification of the vegetation for mapping fire hazard is successful (*ANTONINETTI ET AL, 1993, EL GHAZZAWI, 2000*), the evaluation of damage after events is also easier using remote sensed data (*GUTMAN ET AL, 1995*). To handle effectively the data of this complex process and analyse it precisely would be too much time-consuming without information systems. CHOU's work is also persuasive in management (1992), and although GIS is a versatile instrument, it can be completed with special modules like the PRINCE (*BACHMANN, 1998*). Using remote sensed data and GIS together is the most fruitful considering accuracy and its multifaceted character (it is widely used from prevention to modelling) (*CHUVIECO ET AL, 1989, KUNTZ ET AL, 1993*).

On the other hand, effects on the ecosystem (*KNIGHT, 1987*), the sensitivity of a landscape to this threat (*VAZQUEZ, 1993*) or the postfire mechanisms (*REGO, 1992*) and forest responses (*GILLON ET AL, 1992*) were also studied in details.

Of course, in this chapter I only tried to pick some of the millions of studies, it would be worth introducing all in another paper.

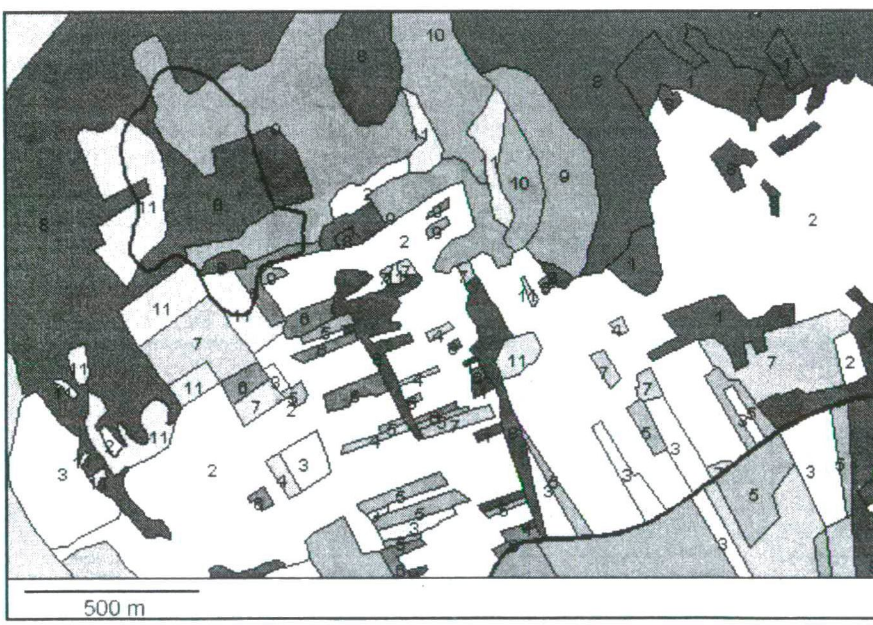
Land use changes in the Velence Mountains

The land use is spatial projection of human activity in a given moment. It appears as patches and covers totally the surface with different types of categories. Our maps of three years - 1968, 1986 and 1999 - representing the changes of the last 32 years were derived from topographical maps in the scale of 1:10000 and partly from field mapping. The southern slope of Velence Mountains covering 48 km^2 is the northern first order watershed of Lake

Velence, and different land use types occupy it: settlements and built-up areas, vineyards and orchards, forest, arable lands and pastures are the main ones. The maps were digitized, overlapped and analysed using GIS like ARC/INFO and ArcView, and the following facts were found:

- the area of the arable land area has decreased which is similar to the national economic changes,
- most of the changes were from arable land and pastures to forests, so the afforestation is significant (more than 1000 hectares only between 1968 and 1999),
- the area of vineyard has increased in the 90's after severe decreasing in the 70's and 80's (*BÓDIS ET AL, 2000*).

In our case, the readable change is the growth of forested area that is understandable regarding the geological and pedological conditions; thin and highly erodable soil layer covers the acidic granite and schist rock formation.



Map 2 The land use map of the study area, 1999 (the map is only a subset of the whole study area)
The numbers represent the following: **1**: settlements, built-up areas, **2**: vineyards and orchards, **3-5**: arable lands, **6:** abandoned areas, 7: meadows and pastures, **8-12**: forests

Parallel to this growth, the area of the possible burning has also increased. The source of ignition and the combusting fuel are linked to the land use too. In our case, most of the forest are contiguous to settlements which is a constant risk of human cause in ignition due to tourism, children's play or arson. Neighbouring arable lands are a threat too; permanent working in 9 months with machines or burning of stubble in autumn can cause fire in forests. Human activity is the main cause of ignition as fire history proves. Fuel type is a structural factor, it depends on the type of the timber and the undergrowth and the activities of forestry like plantation and cutting, etc.

The most threatened forests are the blank spruces in Hungary, partway owing to the dry pine needles and mostly the high resin content, and they represent nearly half of the about 1800-hectare-big forest in our study area (*Map 2*). Proximity to roads has a two-folded importance: their intensive use increases the risk of ignition by letting everyone reach the woods and on the other hand, they can hinder the spread of fire and help to approach the burning parts (*MEZŐSI ET AL, 1998*).

Meteorological variables

The meteorological variables are dynamic factors and easily usable to tell anything about the fire risk rate. The temperature, the precipitation and humidity are as important in the origin as wind speed and directions are in the spread of fire. One of the methods to estimate the possibility of fire due to weather conditions is computing fire risk indices like the Angström Fire Risk Index from Sweden that is precise and calculable enough to apply. The Index can be calculated from the following formula:

$$B = 3{,}3 - 5f + \frac{T}{10}$$

where f is the relative humidity at 2 p.m. and T is the temperature at the same time (*BUSSAY, 1995*). The results can be divided into five different categories:

≥1.5: ***Negligible*** **1.5-2.5:** ***Little*** **2.5-3.5:** ***Average*** **3.5-4.5:** ***High*** **4.5≤:** ***Extreme***

Using the meteorological database of the Plant Health and Soil Conservation Station in Fejér County, Velence, I could count this index for the period between 1st April and 20th September. The period was extremely dry: the amount of precipitation was only 201 mm during the 29 rainy days, which is less than the half of the normal. The values of temperature broke records most of the days, the mean temperature was over 25°C, the maximum values were permanently over 30°C and in the middle of the summer over 40°C! Owing to these extremities, not only the forest, but the whole area dried out, the water of Lake Velence decreased to a scary low level.

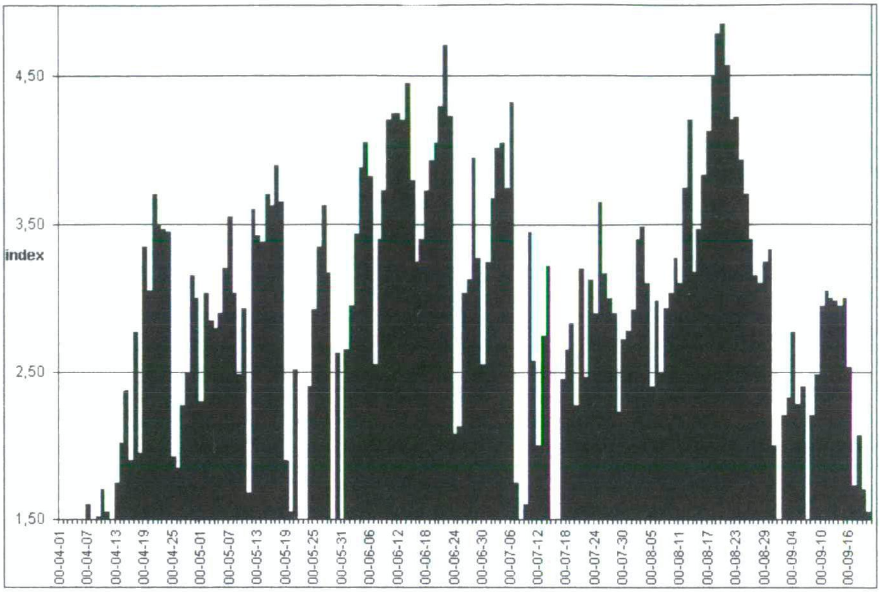


Figure 1 The Angström Fire Risk Index between 1st April and 20th September

The value of the Angström Fire Risk Index reached the 3.5 of high category on 38 days (of 174) and the 4.5 of extreme on 5 days which means that the quarter of this period was fire risky. June was particularly risky: almost the whole month proceeded in this condition, similarly until the middle of August (*Fig. 1*). As it is seen, three days before the fire the value went over the lower limit of extreme category after staying 3 more days in the high category. Unfortunately, there is no space here to deal with the wind that can strengthen the spread of fire and partly depends on topography.

Fire history

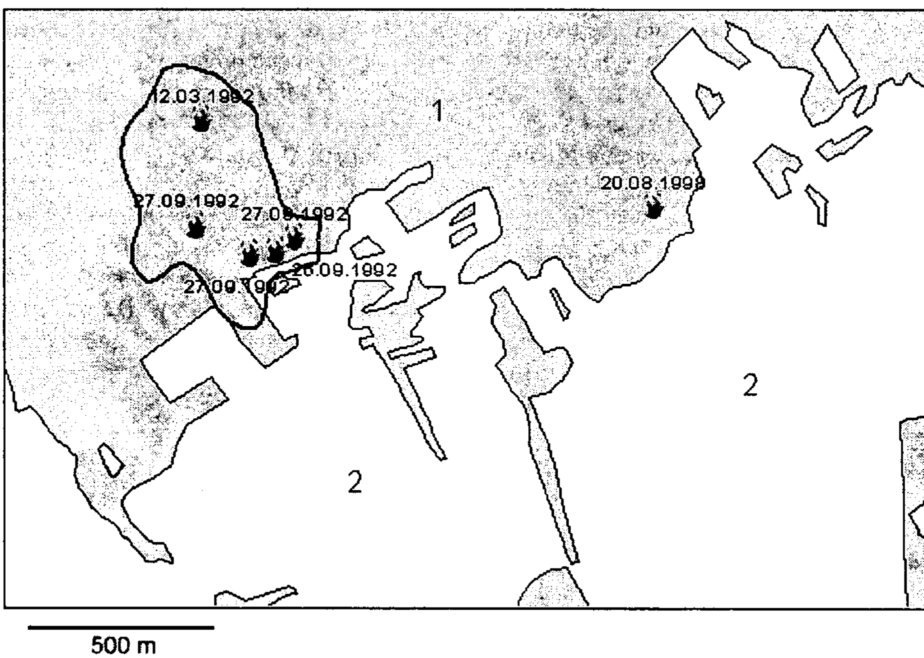
Setting up the fire history is a very useful statistical method to help to evaluate the combustion risk of a given geographical unit with the proper data of former events (*VAZQUEZ ET AL, 1993*). It is possible to map applying GIS if we have the coverage of the single events (*CHOU, 1992*). It makes possible to establish risky periods of time, dangerous places and the most usual causes which are mainly human: accidental or intentional. It is an enormous help in preventing fires and preparing for further actions or managing fighting in dangerous situations.

Using the database of the local Fejér County's Department of Fire, we have a proper image of the area's fire history. The table includes parameters of fire-events in the last 10 years like date, place, area, cause of fire, etc. (*Table 1*).

Date	Location	Cause	Occupation (m^2)
91.04.02	Pákozd - 37/A forest scene	unknown	100-1,000
93.05.30	Velence - around the waste deposit	open fire	> 100,000

Table 1 Example from the used database

I have put the single events on the map of land use and found that the patch of the fire of 22nd August suffered many times earlier (*Map 3*). This fact increases the probability of ignition due to the tendency. On the other hand, it may decrease the loss because of the burned down fuel.



Map 3 The map of fire history (a subset of our study area)

The thick black line shows the shape of the forest which burned down on 22nd August 2000. The dates represent the earlier events, the numbers stand for: **1:** forests, **2:** other than forests

Effects of fire

The fire causes huge loss as the price of the combusted wood can easily reach millions of Hungarian forints. Disappearing of timber is a problem itself in a country where less than 20% of the area is forested. The ecosystem's damage, taken from the passing away of plants in macro- and micro-scale to the appearance of new and strange, mainly weed species and wattle, causes severe degradation. In our case and from the tourism's point of view, fire events do not raise the visitors' sense of safety, and this fact might lead to the drop of income in a region where it is a strong source of livelihood. The disappearing of one capital appeal, the value of nature beside clean air and silence could worsen this fall.

A special and many times modelled problem is soil erosion after fire due to the loss of foliage and leaves that has long-term effects. Field measurements and observations have shown that the annual soil erosion after a severe fire can be fifty times more than before (*GIOVANNINI ET AL, 1992*). Even if the weather conditions are unfavourable regarding soil erosion, the precipitation slowly affects the upper layer and starts to transport it away, and this process is hardly stoppable. It is definitely true in our case too, owing to the geological and pedological situation, since the granite pluton is covered with its weathered small particles and it is highly denuded at some places opening up the rocks forming boxes and the so called "wool sacks". The layer of soil is shallow, less than 10cm in average, so it is not accidental to meet forests on the severe part of the pluton. They were deliberately planted and it is similar to the country trend; the half of the 770.000 hectares of skeleton soils is covered by wood (*SZODFRIDT, 1996*). It is enough for the trees to live on and protect the soils until the forest is cut or burned down. In the latter case, advantageous things happen for instance the possible increase in global P by deposition of ashes (*FERRAN ET AL, 1992*), but this ash-layer can be washed off easily especially by the first rainfall event (*FERREIRA ET AL, 2000*). It is absolutely sure that the following facts are disadvantageous like the 90% of humus layer can be burned up in a severe fire according to PIETIKÄINEN and HANNU (*1992*) and the loss of N could be extremely high a year after the event (*SERRASOLSAS ET AL, 1992*). In cases like in the Arbucies basin, the sediment loss after fire could be 13 times higher than in pre-fire conditions (*ROVIRA ET AL, 2000*), the loss of the total nutrients can be 3-4 time more than before the fire (*THOMAS ET AL, 1999*). Besides, it is not so simple to answer the question how the area's heat and radiation, and of course, the water balance change.

Conclusions

The soil loss in our test area is being evaluated by different investigations from the application and validation of the EUROSEM model to field measurements. To state more precise parameters of this process, we started to measure the amount of the eroded sediment and its qualities. It is based on the collection of soil in modified Gerlach-type sediment traps on three slopes that have the same length of 10 meters and gradient of 5-6° (10-12%). One of them is under trees untouched by the fire, the second is under a partly, the third one is under a totally burned timber. We suppose that the eroded soils' quality increases to a several-times-higher level and the amount of different nutrients in the upper layer will change. Considering that the whole study area is the first order watershed of the environmentally very sensitive Lake Velence, the changes in the watershed will indicate changes in the lake, from the quality and quantity of water to the ecosystem in and around the lake.

As it was mentioned above, many approaches exist to model fires and some of them are worth trying. In the future, I want to try out some of them and compare their efficiency, accuracy, suitability to manage this risk. By this investigation, I will try to find proofs for the theory that the land use has influence on natural hazards' risk and risks affect the use of the land. At last, I will try to create a model to involve this theory and I would try to use it in distinct cases and study areas.

References

ANTONINETTI, M., BINAGHI, E., RAMPINI, A., D'ANGELO, M. (1993) The integrated use of satellite and topographic data for forest fire hazard mapping, In: Winkler, P. (ed.) *Remote Sensing for Monitoring the Changing Environment of Europe*, Balkema, Rotterdam

BACHMANN, A. (1998) Coupling of PRINCE with the GIS ARC/INFO - Final Report for MINERVE 2, Department of Geography, Division of Spatial Data Handling, University of Zurich, Switzerland

BÓDIS, K., DORMÁNY, G., TILLMANN, A. (2000) Land Use Changes and Their Effects Between 1968-1999 in the Northern Watershed of Lake Velence, Hungary (poster), 15th ESRI European User Conference – ESRI European, Middle-Eastern and African User Conference, Istanbul, Turkey

BUSSAY, A. (1995) Az erdőtűz és a meteorológiai tényezők közötti kapcsolatok, In: Erdészeti Lapok, CXXX./5.

CHOU, Y.H. (1992) Management of Wildfires with GIS, In: International Journal of GIS VI./2.

CHUVIECO, E., CONGALTON, R.G. (1989) Application of Remote Sensing and GIS to Forest Fire Hazard Mapping, In: Remote Sensing of the Environment, vol. 29.

EL GHAZZAWI, I. (2000) Forest and Fire Monitoring with NOAA AVHRR Imagery in the Central African Republic, In: Casanova, J.L. (ed.) *Remote Sensing in the 21st Century: Economic and Environmental Applications*, Balkema, Rotterdam

FERRAN, A., SERRASOLSAS, I., VALLEJO, V.R. (1992): Soil Evolution After Fire in Quercus ilex and Pinus halpensis forests, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of forest ecosystems to environmental changes*, Elsevier Applied Science, London-New York

FERREIRA, A.D., COELHO, C. Hydrological Constrains in Forest Ecosystem in a Transitional Atlantic/Mediterranean Climate Region, In: *International Proceedings of the International Seminar and Field Trip on Land Degradation and Desertification*, Portugal, 24-30 August 2000

GILLON, D., REGO, F. (1992) Forest response to Fires and Implications in Ecosystem Functioning and Management, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of Forest Ecosystems to Environmental Changes*, Elsevier Applied Science, London-New York

GIOVANNINI, G., LUCCHESI, S. (1992) Effects of Experimental Fires on Soil and Vegetation, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of forest ecosystems to environmental changes*, Elsevier Applied Science, London-New York

GUTMAN, G., BARTALEV, S., KOROVIN, G. (1995) Delineation of Large Fire Damage Areas in Boreal Forests Using NOAA AVHRR Measurements, In: Advanced Space Researches XV./11.

KNIGHT, D.H. (1987) Parasites, Lightning and the Vegetation Mosaic in Wilderness Landscapes, In: Turner, M.G. (ed.) *Landscape Heterogenity and Disturbance*, Ecological studies 64., Springer-Verlag, New York

KUNTZ, S., KARTERIS, M. (1993) Fire Risk Modeling Based on Satellite Remote Sensing and GIS (presentation), International Workshop of Satellite Technology and GIS for Mediterranean Forest Mapping and Fire Management, Thessaloniki, Greece

MEZŐSI, G., DORMÁNY, G. (1998) Regional Differences of Forest Fire Hazard in the Test Area of the Mátra Mountains, In: Bassa, L., Kertész, Á. (eds.) *Windows on Hungarian Geography - Studies in Geography in Hungary, vol. 28.*, Geographical Research Institute of MTA, Budapest

NATURAL HAZARDS PROJECT – FOREST FIRE RISK MAPPING (1999), Space Application Institute, http://natural-hazards.aris.sai.jrc.it/fires/risk/

PERRY, G.L.W. (1998) Current Approaches to Modelling the Spread of Wildland Fire: a Review, In: Progress in Physical Geography XXII./2.

PIETIKÄINEN, J., HANNU, F. (1992) Influence of Fire on Forest Soil Microflora, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of forest ecosystems to environmental changes*, Elsevier Applied Science, London-New York

PIUSSI, P. (1992) Environmental Changes in Forests - Examples from the South of Europe, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of Forest Ecosystems to Environmental Changes*, Elsevier Applied Science, London-New York

REGO C. (1992) Land Use Changes and Wildfires, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of Forest Ecosystems to Environmental Changes*, Elsevier Applied Science, London-New York

ROVIRA, A., GARCIA, C., BATALLA, R.J.: Land Use and Forest Fire Hazards in the Suspended Sediment Load of a Mediterranean Basin, In: *International Proceedings of the International Seminar and Field Trip on Land Degradation and Desertification*, Portugal, 24-30 August 2000

SERRASOLSAS, I., ALCANIZ, J.M., ARIAS, X., JOSA, R., SOLE, A., VALLEJO, V.R. (1992) The Effects of Burning and Clearcutting in Forest Floor Layers of Holm Oak Forest, In: Teller, A., Mathy, P., Jeffers, J.N.R. (eds.) *Responses of forest ecosystems to environmental changes*, Elsevier Applied Science, London-New York

SMITH, K (1996) *Environmental Hazards*, Routledge, London-New York

SZODFRIDT, I.(1996) Az erdő és talaja (*Forest soils*), In: Mátyás, Cs. (ed.) Erdészeti ökológia (*Forest ecology*), Mezőgazda Kiadó, Budapest

THOMAS, A.D., WALSH, R.P.D., SHAKESBY, R.A. (1999) Nutrient Losses in Eroded Sediment After Fire in Eucalyptus and Pine Forests in the Wet Mediterranean Environment of Northern Portugal, In: Catena, vol. 36.

VAZQUEZ, A., MORENO, J.M. (1993) Sensitivity of Fire Occurrence to Meteorological Variables, In Mediterranean and Atlantic Areas of Spain, Landscape and Urban Planning, vol. 24.

Dormány, Gábor
Department of Physical Geography, University of Szeged,
Egyetem u. 2.-6., H-6701 Szeged, POB 653, Hungary, *dg@earth.geo.u-szeged.hu*