Fire History of Central Europe: Implications for Prescribed Burning in Landscape Management and Nature Conservation

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1. Introduction

At least during the past 3000 years natural fires have no longer played a significant role in the vegetation history of Central Europe. It was rather human-caused fire that had a major influence on ecosystem dynamics. Some of the traditional methods of swidden agriculture were even practised until the middle of this century. Due to this reason the emphasis of this study concentrates on human-caused fires and fire history. In addition, current challenges, ongoing developments and future opportunities for the use of fire in future landscape management and nature conservation concepts based on fire and land-use history are discussed.

2. Fire History of Central Europe

Wavering concentrations of charcoal in sediment cores bear witness that in Middle Europe fire must have played an significant role in landscape and vegetation dynamics during the Holocene (Schwaar 1989, Clark et al. 1989, Becker 1995, Hölzer and Hölzer 1995,1998, Tinner and Amman 1996). However, it cannot be reconstructed which of the charcoal depositions have are evidence of lightning fires or human-caused fires. From recent studies it is known that continental (warm and dry) climatic circumstances create good conditions for the development and expansion of vegetation fires (Baumgartner et al. 1967, Granström 1993). It is possible that during the warm and dry periods of the post-glacial climate history natural fires caused by lightning could have played a more significant role than nowadays. With the beginning of the sub-atlantic climate period, about 3000 years ago, the climatic conditions in Middle Europe became colder and wetter. Since that time fires caused by lightning were playing a decreasing and less important role in comparison with many regions of the Nordic and Baltic countries. Fires set by humans began to overrule lightning fires.

With the help of fire humans began to shape landscapes of high ecological and cultural diversity, e.g. heath lands, open grasslands used as grazing grounds, and swidden (shifting) agriculture systems. These ecosystems are all parts of historical cultural landscapes in Central Europe formed by the needs and demands of humans. One of the

oldest and the most efficient tool in land-use history is fire. It is evident that already in the early to mid stone age, long before the onset of the agricultural period, humans in Europe had used fire for hunting wildlife and to attract wildlife to fire-improve grazing grounds (Schwaar 1989, Steensberg 1993, Gouldsblom 1995, Page and Goldammer 1997, Pyne 1993, 1998, Boyd 1999). At a later stage fire became an important element in forestry, agriculture and pastoralism. However, with the beginning of the development of modern farming systems in the 19th century dramatic changes took place within traditional land-use systems and landscape patterns. One reason was the decrease of traditional burning practises. The rapid socio-economic changes in post- World War II Europe enforced this development. New air quality standards and the generally prevailing opinion by government administrations, traditional nature conservation philosophies and the general public that fire would damage ecosystem stability and biodiversity led to fire bans in most European countries.

On the First Baltic Conference of Forest Fires Goldammer (1998b) provided a detailed analysis of the use of fire in different land-use systems in Europe. Based on this information the following remarks concentrate on the consequences of the European fire history for modern land-management and nature-conservation strategies. Concepts for modern fire management systems based on historical land-use and fire regimes are presented in the following.

3. Prescribed Burning in Landscape Management and Nature Conservation in Central Europe

In Central Europe three broad areas of application of operational use of fire in landscape management and nature conservation are recognized.

3.1. Nature Reserves and National Parks

The aim of the World Nature Conservation (IUCN) national park declaration is to protect large areas from human interference in order to give space for natural development and processes. If this idea is taken seriously into consideration natural-caused fires should not be extinguished. In atlantic or subatlantic climate regions the probability of fires caused by lightning is very rare. However, in continental regions of Central Europe, e.g. in the Brandenburg and Mecklenburg-Vorpommern regions of Eastern Germany, the probability of lightning ignition increases. Therefore, it is especially necessary and important to develop strategies how to respond to lightning fires in nature reserves or national-parks in these regions. It must be taken into consideration that nature reserves and national parks generally are isolated islands embedded in a landscapes characterized by intensive land use. Letting burn a prescribed natural fire in relatively small nature reserves potentially causes public and political conflicts.

3.2 Maintenance of Historically Important Landscapes

Most of the nature reserves in Germany are no natural ecosystems but parts of old cultural landscapes to be maintained for biodiversity and landscape esthetical purposes. If it is the aim of the protection to keep these parts of the landscape in their historically grown structure, it is also necessary to maintain the processes which were essential for their generation. If fire played an important role in the ecosystem dynamics it would be indispensable to integrate it a place in the protection strategies.

A famous example where a combination of fire, pastoralism and removal of organic layers (*Plaggen*) led to the formation of very unique ecosystems, are most of the sub-atlantic *Calluna* heathlands in Germany, the Netherlands, Denmark, United Kingdom, Norway and Sweden. The concept of restoration of traditional disturbances, including fire, to maintain these heathland ecosystems receives increasing acceptance in modern management strategies (Lütgepol and Stubbe 1997, Diemont et al. 1997, Webb 1997).

Also in other regions the combination of pastoralism and fire was very common to maintain suitable grazing grounds. A major field for fire application was on those lands where permanent agriculture systems were not possible due to climatic and edaphic limitations. Here extensive grazing and shifting cultivation was often the only possibility for people to survive. For example in the alps and highlands of Central Europe fire was used to prepare grazing grounds and to prolong the grazing season, for example in the *Juniperus* heathlands of the Suebian mountains or the "Reutweiden" (*Sarothamnus scroparius* and *Genista saggitalis* heathlands) in the Black Forest (Gatter 1996, Wilmanns et al. 1979, Feucht 1907, Bartsch and Bartsch 1940; cf. also Schneiter 1970, Goldammer and Page 1997, Goldammer et al. 1997a-c). Many of these areas are abandoned today, open vegetation structures decrease and forest takes over due to the secondary succession, which is judged negatively from a nature conservation point of view. An interesting, relatively extensive and cheap management strategy could be a combination of pastoralism and fire to maintain the open vegetation structures in these regions.

Another example where fire played an important role over centuries were the different shifting cultivation systems which existed all over Europe. However, a restoration of these ecosystems at a large scale is economically prohibitive. The maintenance of selected sites for historic documentation purposes in the form of a landscape museum, however, is advisable to preserve impressions of historical farming methods.

3.3 Fire as a Substitutive Disturbance Process

The majority of protected areas in Central Europe is not of pristine nature. They are embedded in landscapes that have been shaped by land-use systems over centuries. These systems historically involved processes such as burning, grazing, mowing and cutting which transformed natural landscapes to unique ecosystems. These ecosystems provide habitats for many plant and animal species which are under protection today, including many endangered (red list) species. The recent socio-economic developments,

however, resulted in structural changes of the rural space. Many agricultural sites are treated less intensively or are abandoned because farming is no longer profitable. As a result human-made open ecosystems are lost. Without disturbance secondary succession leads to a tree- and shrub-dominated vegetation form which is the potential natural vegetation type in most parts of Central Europe. As a result, many plant and animal species adapted to or were found in these ecosystems will face the threat of extinction.

If the maintenance of these abandoned ecosystems is desired, it is necessary to introduce substitute-disturbance processes into these areas to maintain the dynamics of processes which have shaped these landscapes historically.

To ameliorate the problem, several options can be taken into consideration. These options include traditional mowing, grazing, cutting practices, and the use of fire as a vegetation management tool. Mowing, grazing and cutting are already practised in nature conservation in Germany. But the lack of financial and personnel resources, including the loss of skill and expertise, limits the use of these practices. Thus, alternative approaches are needed. Prescribed burning could offer a potentially efficient and relatively cheap tool to achieve the land management objectives of the areas in question.

4. Fire Management on the Vineyard Slopes in the Kaiserstuhl Area

In the following an example is given how prescribed burning can be used as a substitute measure in landscape management. The aim of the research project is the investigation of the application of prescribed burning for maintaining the traditional open meadow-type vegetation structures on slope sites which are threatened by secondary succession.

The study is currently conducted in the Kaiserstuhl area, an old volcano fragment dating back to the Tertiary, located in the Rhine valley in southwest Germany. Most of the lower parts are covered by an up to 16 m-deep loess layer. The history of wine cultivation in the area dates back to the 8th century. Since then farmers grew wine on terraces built on the hilly terrain. The traditional vegetation cover on the slopes between the terraces was of a meadow-like grassland (Fig.1).

Fig.1. The typical structure of the old historical vineyards is an alternation of small steep slopes covered by a meadow-like vegetation with the narrow terraces where the vines are cultivated.

Although the natural vegetation cover in the area is of a bush- and tree-dominated forest type, vineyard slopes have a distinct vegetation cover dominated by grass. These ecosystems were maintained by mowing and occasional burning until World War II. After the war the area experienced a dramatic increase in wine growing and sharp decrease of animal husbandry with its associated mowing and cutting practices. As the farmers no longer needed hay to feed their cattle, they began to burn the slopes in winter so as to suppress the growth of bush and tree species in order to maintain open vegetation structure:

In 1975, following the Federal German nature conservation law, the State of Baden Württemberg imposed a ban of the free burning (broadcast burning) of vegetation. Since then the slopes were cultivated only in some exceptions. The consequence was the ever increasing expansion of bush and trees into these areas due to secondary succession. The result was a decrease or loss of habitats for many plants and animal species that are adapted to or found in these ecosystems, and require more light and higher ground temperatures, conditions that prevail in open ecosystems:

The slopes in the old historical vineyards were only up to 8 m high. But with the consolidation and restructuring of farmland property in the 1960s and 1970s, bigger slopes of up to 40 m high and with over 100% inclination were constructed (Fig.2). Except for the initial grass layer establishment on the slopes, no human intervention has taken place in the area. Today, both the new and the historical slopes serve as a medium for secondary succession to run its course. Given the extent of the area (four square kilometres only in the central part of the Kaiserstuhl area), a major investment of time and money is required to maintain the traditional grass-dominated open structures by cutting and/or mowing. As an alternative, this project proposes the use of prescribed burning to achieve the landscape objectives set for the area:

Fig.2. With the consolidation and restructuring of farmland in the 1960's and 70's, large terraces were constructed with slope heights stretching up to 40 m with over 100% inclination. Since their establishment they have been treated only in exceptional cases.

4.1 Objectives of a Prescribed Burning Project

The objectives of the research project were to determine whether prescribed burning of small plots in late winter could be used to maintain and promote the traditional open vegetation structure, the habitats and occurrences of typical and characteristic animal and plant species on the slopes of the vineyards of the Kaiserstuhl area. Three project studies are conducted:

4.2 Vegetation study

Effects of different fire types on the composition, structure and distribution of the vegetation types of the open, meadow-like ecosystems were monitored. The reaction of some typical species which immigrate and extend since the beginning of the succession period 20 years ago were observed. In addition temperature and soil moisture measurements on burned and unburned plots were undertaken. The first results of the investigations are as follows:

Measurements of the soil temperature (at 10cm depth) and the soil moisture content (0 to 20 cm depth) on burned and unburned plots were taken (Fig.3). Depending on the location, an increase of the monthly average temperature up to 7°C on the burned plot in comparison with the unburned plots was discovered in the first vegetation period after burning. At the same time there was a partially significant decrease of the soil-moisture content on the burned plots. So the burned stands became warmer and dryer. In a longer perspective this could be of interest because it is especially the xerothermic fauna and flora which suffers under the abandonment and the secondary succession. The former use of the slopes produced relatively warm and dry conditions which gave the opportunity for continental and sub-Mediterranean species to find habitats here.

To observe the effects of different fire-types on the grassy and herbaceous dominated vegetation, permanent investigation plots were installed. Six or eight observation plots of the size of $1m^2$ were distributed on every treatment unit. With the help of a "frequency analysis" changes of the species composition and distribution were observed over three years. To investigate the reaction of the vegetation, evenness/number of species diagrams were used. Figure 4 gives an example how the vegetation of an relatively moist stand reacts of different fire treatments.

carry out the frequency analysis a $1m^2$ frame subdivided in 16 sub-units (25x25 cm) was laid over the vegetation. In each sub-unit the species and their cover (%) were recorded. This method provides a very high resolution inventory and even very small changes in species distribution can be detected (Fischer 1986). In the diagram the average evenness and the average number of species of every treatment-unit were plotted and the changes from year to year were marked with arrows. The number of species is a parameter to describe the richness of an ecosystem. The evenness (%) describes the distribution of the species. 100% means that there is no hierarchy and all species are equally distributed. The smaller the evenness number the more dominated is the ecosystem by one or a few species (Häupler 1982).

The overall results reveal that on the investigated slopes in general there was no major shift observed, neither in the number and composition of species nor in the distribution (evenness). However, an observation period of three years is rather short to obtain reliable results on long-term response of vegetation. But from other studies on comparable sites in the state Baden-Württemberg where such investigations were carried out over 20 years, it is known that the structure of fallow meadows can be maintained with the help of prescribed burning (Schreiber 1997).

Another question was how brushes and trees respond to fire. It was noted that sprouts with a diameter of less that 2 cm (at 30 cm height) are generally killed by fire, but most of the species resprout in the following spring. Under a prescribed burning regime with short fire intervals of two to three years it seems to be possible to keep young succession stages at its early stage, but it is not possible to remove them completely. It cannot yet be concluded whether the spread of shrubs and trees can be stopped with the help of fire. It seems that under a broad range of conditions the still open, grass-herb dominated vegetation structures may be maintained by fire, while it is doubtful that brushes which spread through rhizomes can be stopped in a long term.

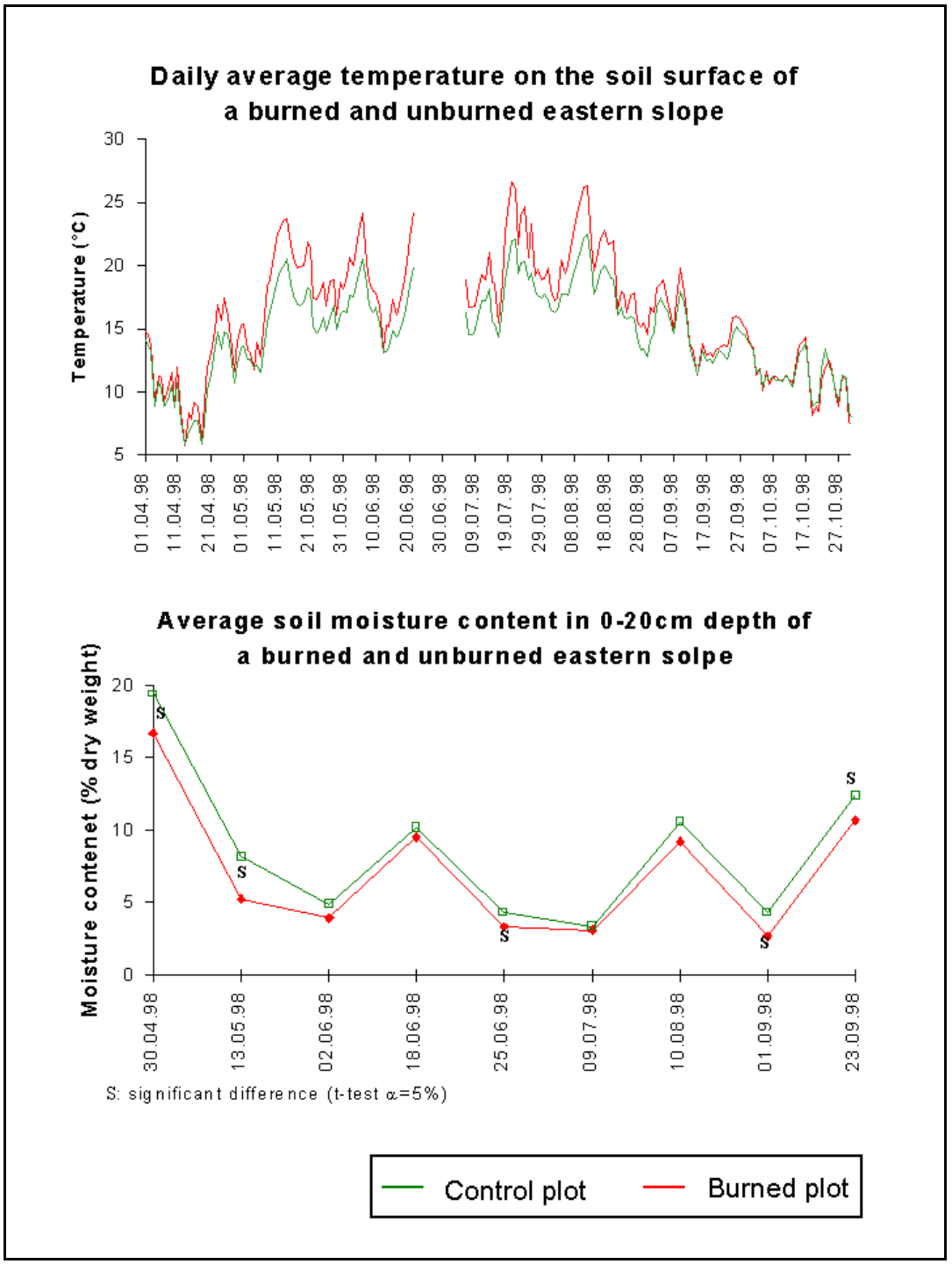

Fig.3. Soil temperature and soil moisture content in the vegetation period after the winter burning session 1997-98 on a burned and on a control plot on an eastern slope.

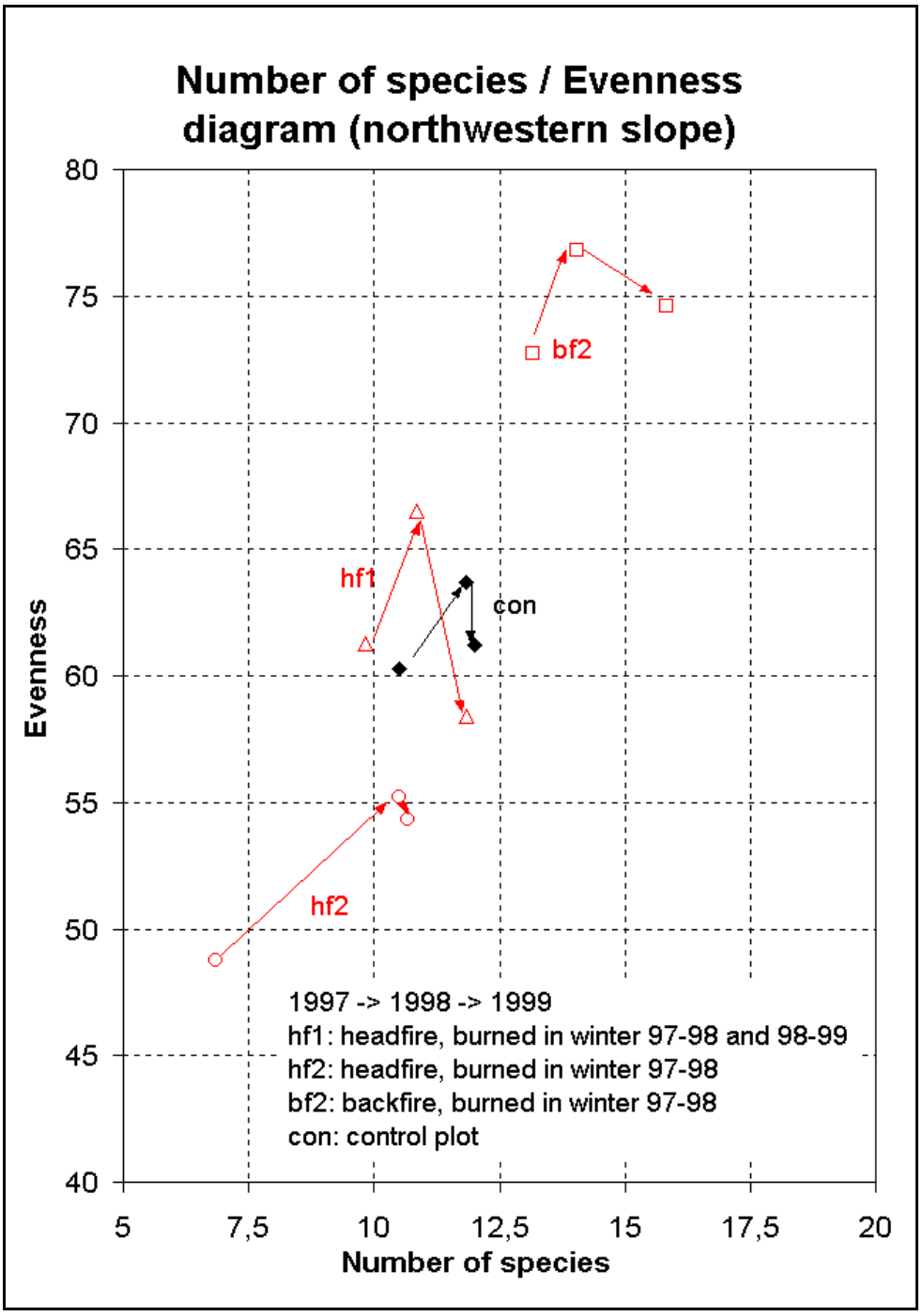

Fig.4. Number of species / Evenness diagram of a north-western slope. Neither on the burned or the unburned plots a significant shift in the distribution or average number of species can be observed in the last three years. Also the species combination is more or less the same. Note: To carry out the frequency analysis a $1m^2$ frame subdivided in 16 sub-units (25x25 cm) was laid over the vegetation. In each sub-unit the species and their cover (%) were recorded. This method provides a very high resolution inventory and even very small changes in species distribution can be detected (Fischer 1986). In the diagram the average evenness and the average number of species of every treatment-unit were plotted and the changes from year to year were marked with arrows. The number of species is a parameter to describe the richness of an ecosystem. The evenness (%) describes the distribution of the species. 100% means that there is no hierarchy and all species are equally distributed. The smaller the evenness number the more dominated is the ecosystem by one or a few species.

4.3 Faunistic Study

Earlier investigations conducted in the 1980s on the slopes of the Kaiserstuhl area indicate that arthropods hibernating in the grass-layer are killed by prescribed fire conducted in wintertime. Individuals which hibernate in the soil usually survive. The concern about the loss of individuals affected by fire is of minor concern because the burned plots are relatively small and surrounded by unburned plots. Thus, the immigration rate after fire is very high and takes place very rapidly. Therefore there is just a temporary shift of populations, and no sustainable change in the species composition was observed so far (Lunau and Rupp 1988). In this project, the direct and indirect effects of fires on snails is being investigated. The snail populations serve as indicators for the rate of spread of the post-fire re-colonisation.

Fig.5 a,b. a: Burning of an experimental plot in January 1998 by an upslope headfire. The red-white sticks are used to determine the rate of fire spread. **b:** The same slope immediately after burning. The typical mosaic of burned and unburned patches generated by prescribed burning is clearly recognisable. Unburned patches are important for the re-colonisation by animals.

The results of the faunistic study indicate that no shift was found in species composition of snails on burned and unburned plots. In most cases the number of the individuals were significantly reduced on the burned plots. The migration rate of big snail species is very small (average: 5 to 10m/year). The maximum distance covered was about 30m/year.

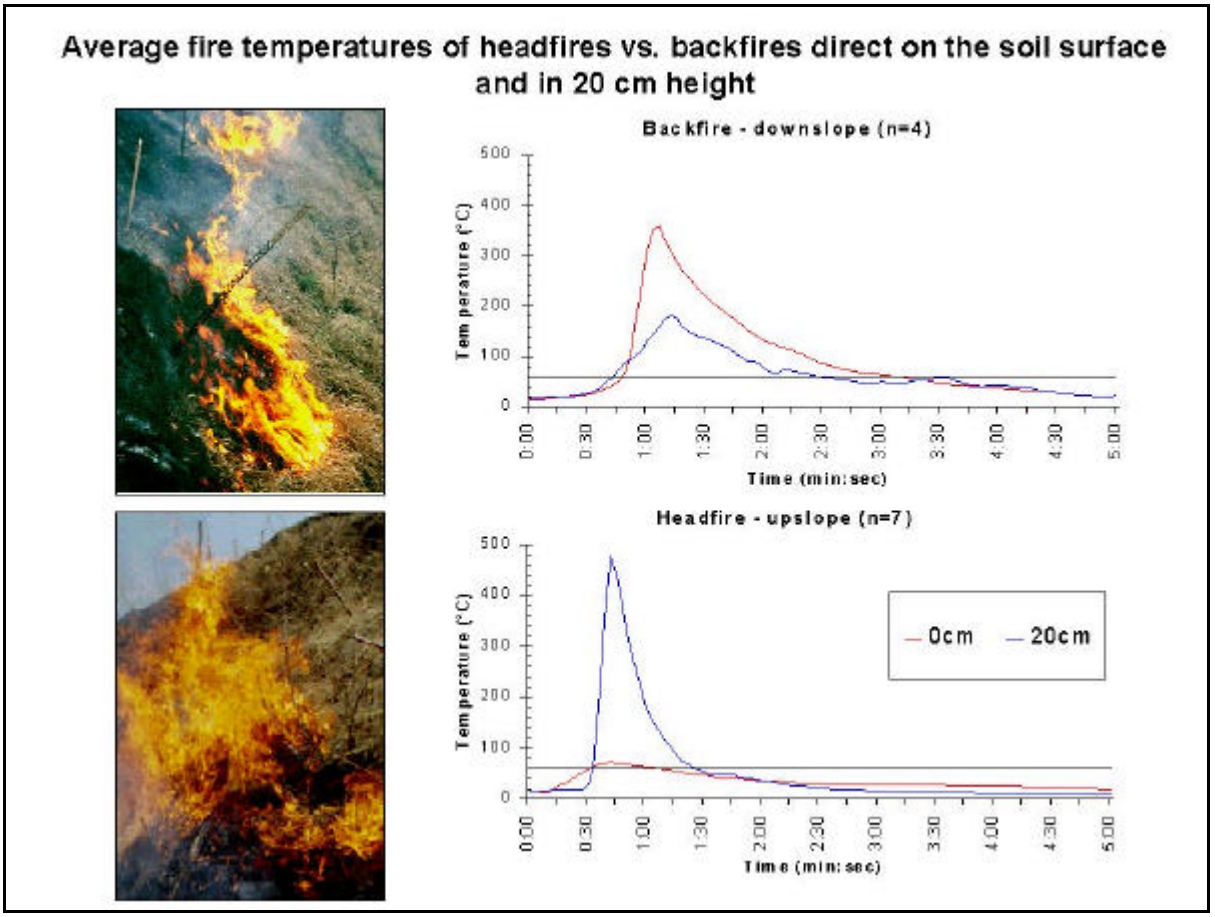

Fig.6. Average temperatures of headfire and backfire on the ground and in 20 cm height. The backfire creates very high temperatures directly on the ground. The animal and plant species which hibernate on or in the ground are much more affected by this type of fire as compared to a headfire which has its maximum temperature some decimeters above ground.

4.3 Socio-Economic Component

At the start of the project discussions with different groups of society which are involved in agriculture, viticulture and landscape management in the region (farmers, municipality, governmental and non-governmental nature conservation organisations) revealed conflicting views on the potential application of prescribed burning. While farmers and local municipalities unanimously requested for a restoration of general permission to use prescribed fire as a tool to suppress succession, the governmental nature conservation bodies and NGOs were concerned about the negative impact of burning on ecosystems concerned and on the environment in general. In order to create a common discussion platform, to overcome controversial views and to develop a mutually acceptable and

harmonised management strategy a "Round Table on Slope Management in the Kaiserstuhl Area" was created.

During four round-table sessions in winter 1999-2000 an agreement was achieved which was accepted by all parties. The first result was a general strategic paper called "Model for the future development of the vineyard slopes in the Kaiserstuhl area". In this paper it is stated that the open vegetation structures which still exist in the region should be maintained and that different management tools which include prescribed burning must be applied to obtain the desired results. This agreement and statement for the first time in Central Europe accepted prescribed burning as a tool for landscape management. In the Appendix of the strategic paper a detailed prescription is given how fire has to be (re-)introduced in landscape management in the future. The general framework states:

- Prescribed burning will be restricted to the winter season (between November and February) under specifically defined weather conditions.

- The burned parts have to be small (not more than half of a slope which belongs to one section of land (often but not necessarily identical with ownership; the absolute maximum is a 50m-wide portion of an individual slope) and it is not allowed that two burned parts border on each other. With this prescription a mosaic of burned and unburned plots is guaranteed which is a vital prerequisite for re-colonising of damaged fauna, particularly arthropods.

- The owner of the slope is responsible for the management. Everybody is eligible to obtain a permission for the use of prescribed burning under the condition that he/she has participated in an information and training programme.

- With the beginning of the winter 2000-01 prescribed burning will be introduced in one municipality. Based on the results and experience the whole Kaiserstuhl area shall be included from the winter 2001-02.

After a six-years test period an efficiency control project will be carried out to validate whether the determined management goals can be accomplished with the introduction of prescribed burning.

5. Conclusions

This short overview on the history of fire use in Central Europe and the future potentials for the application of prescribed burning for maintaining open vegetation structures in the case study Kaiserstuhl was prepared to demonstrate the progress made after the First Baltic Conference on Forest Fire in 1998. BALTEX FIRE 2000 provides an excellent opportunity to share expertise with the foresters of the Nordic countries and ecosystem managers of Western Europe, particularly the heathland managers of the United Kingdom, where the use of prescribed fire has been practised more frequently during in the second part of the 20th century. However, controversial discussions on the use of fire in Western and Northern Europe also led to a decrease in prescribed fire application. The current trend indicates a

revival of burning practises in the countries bordering the Baltic Sea and elsewhere in Europe. Scientists and managers are encouraged to join the ***European Fire in Nature Conservation Network (EFNCN)*** which is accessible through the Global Fire Monitoring Center (GFMC) website in order to take advantage and to support sharing of expertise by networking. EFNCN and GFMC contribute to the spirit of BALTEX FIRE 2000 by providing information exchange (see Goldammer 1998a and this conference report).

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