

**White Paper
on
Use of Prescribed Fire
in Land Management,
Nature Conservation
and Forestry
in Temperate-Boreal Eurasia**





Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia
Freiburg, Germany, 25-27 January 2008

White Paper
on
Use of Prescribed Fire in Land Management, Nature Conservation and Forestry in Temperate-Boreal Eurasia

Edited and published on behalf of the participants of the Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia and members of the Eurasian Fire in Nature Conservation Network (EFNCN)

by the
Global Fire Monitoring Center / Fire Ecology Research Group
Freiburg, Germany
10 February 2010

Background and Rationale

In large parts of temperate-boreal Eurasia the use of fire, including historic swidden (shifting) agriculture, and other disturbances by land cultivation have contributed to shape landscape patterns of high ecological and cultural diversity and value, e.g. heathlands, open grasslands and meadows. In the eastern Euro-Siberian biota, e.g. in the light taiga, natural fire contributed to the shaping of open and stress-resilient forest ecosystems. The rapid socio-economic changes in the past four decades and the recently increasing trend of rural exodus all over Eurasia, however, have resulted in abandonment of traditional land-use methods. With the elimination of these disturbances by cultivation, including traditional burning practices, large areas of Europe are converting to fallow lands, a process that is associated with ecological succession towards brush cover and forest, and an overall loss of open habitats. Besides the loss of valuable biodiversity the abandoned lands constitute an increase of wildfire hazard – a trend that is revealed by a growing number of extremely severe fire disasters. Similarly, the exclusion of fire in natural ecosystems such as northern boreal and sub-boreal coniferous forests in Eurasia has resulted in changing vegetation composition and an increase of wildfire hazard, notably in Central-Eastern Eurasia. Changing paradigms in ecology and nature conservation currently have led to reconsideration of fire-exclusion policies in certain sectors of land / landscape management, nature conservation and forestry.

The Symposium

Between 25 and 27 January 2008 the Symposium on “Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia” was held in Freiburg, Germany, at the Fire Ecology Research Group / Global Fire Monitoring Center (GFMC), Max Planck Institute for Chemistry, c/o Freiburg University / United Nations University, Freiburg, Germany.¹ The symposium was an activity of the Eurasian Fire in Nature Conservation Network (EFNCN)². The EFNCN, which has been founded in 2000, is facilitated by the GFMC. The Symposium was organized in close association with the EU FIRE PARADOX project, the EU LIFE Project “Rohrhardsberg, Obere Elz und Wilde Gutach”, the EU Leonardo da Vinci project “EuroFire”, the UNECE Team of Specialists on Forest Fire, the UNISDR Regional Baltic Wildland Fire Network and the United Nations University (UNU).

The symposium provided a platform for the exchange of data, expertise, and views of institutions and individuals who are actively applying or conducting research in prescribed burning for the purpose of nature conservation (biodiversity management, habitat management), land and landscape management, and forestry, notably in forest fire management. As the EFNCN is operating at the science-management and science-policy interfaces, members of institutions representing land managers and land owners, public services, e.g. fire services, had been invited to attend to discuss and share views on the recent developments in the use of prescribed fire.

Overall, the symposium supported the advancement of the use of prescribed fire in Eurasia with exclusive emphasis on the Euro-Siberian ecoregion, particularly by considering the involvement of local communities in land and fire management. After the Symposium the participants agreed on the following “White Paper on the Use of Prescribed Fire in Land Management, Nature Conservation and Forestry in Temperate-Boreal Eurasia”.



¹ <http://www.fire.uni-freiburg.de/programmes/natcon/EFNCN-meetings-1-2008.html>

² <http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm>



**White Paper
on
Use of Prescribed Fire in Land Management, Nature Conservation and Forestry
in Temperate-Boreal Eurasia**

In the landscapes of temperate-boreal Europe – the western part of the Euro-Siberian region of the Holarctic Floral Kingdom³ – the prevailing fire regimes are shaped by human-ignited fires. Direct fire application in land-use systems and human-caused wildfires – ignited accidentally, by negligence or otherwise deliberately set – have influenced cultural and natural landscape since the beginning of land cultivation. Only in Northern Europe and the adjoining Western and Central Asian region natural fires constitute a significant factor, which is influencing the natural composition and dynamics of ecosystems. Thus, the targeted use of fire in ecosystem management in Europe is predominantly in those vegetation types that either have been shaped by human-ignited fires over historic time scales or where the application of prescribed fire reduces the vulnerability to and damages of uncontrolled fires. Fire is also used as a tool to substitute abandoned cultivation practices and for the control of wildfires.

In the following broad classification of fire regimes and burning practices a number of examples of fire use in ecosystem management are provided which reflect a highly diverse range of applications.

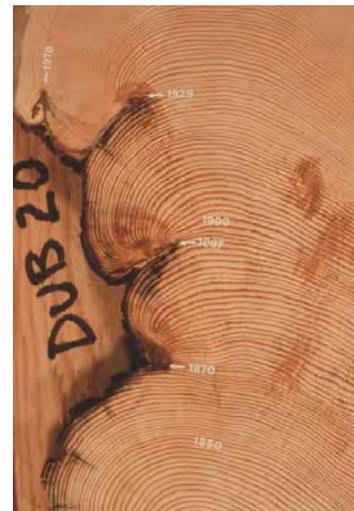
1. Natural Fire Regimes

The integration of naturally ignited fires (by lightning) in vegetation management aims at maintaining the natural dynamics of fire-dependent or at least fire-adapted or fire-tolerant ecosystems. In North America, a continent hosting a broad range of fire-adapted ecosystems, the use or “integration” of natural fire under controlled conditions in the overall management of the ecosystems dates back to the 1960s and was referred to as “Let Burn”, “Prescribed Natural Fire”, and more recently “Wildland Fire Use” (van Wagtendonk, 2007). In the greater European / Eurasian space the use or the management of naturally ignited wildland fire to accomplish resource management objectives is not yet developed. In Western Europe (including the Euro-Mediterranean region and the Nordic countries) the functional role of natural fire had limited impact on the evolution of ecosystem properties and thus to their future maintenance – despite the presence of remarkable adaptations to fire, e.g. in some Mediterranean ecosystems (Naveh, 1975). Thus, there is a limited acceptance of

³ This White Paper follows the definition of “landscape” in accordance with the European Landscape Convention (Council of Europe, 2000): “Landscape means an area, as perceived by people, whose character is the result of action and interaction of natural and / or human factors”. The geographic region is the Euro-Siberian region of the Holarctic Floral Kingdom.

allowing a naturally ignited fire to burn – even if the wildfire would burn within the “prescriptions” set by the ecosystem management plan.

However, in the Western and Central Asian region there are large tracts of forest ecosystems that have been shaped by natural fire, e.g. the pine (*Pinus* spp.) and larch (*Larix* spp.) forests that constitute the “light taiga” in Siberia and adjacent regions. In this rather extended biome there is a strong need to introduce the concept of allowing natural fires to burn, mainly in order to maintain open, fire-resilient stand structures and to reduce the risk of stand-replacement fires. Starting with the first East-West international conference “Fire in Ecosystems of Boreal Eurasia” (Goldammer and Furyaev, 1996) and the Fire Research Campaign Asia-North (FIRESKAN) (FIRESKAN Science Team, 1996) a dialogue with the forestry authorities of Russia (and the predecessor administration in the former Soviet Union, the State Forest Committee) has been initiated to replace the fire exclusion policy in the protected zone of Russia by an integrated fire management approach, which would include the use of natural fire and prescribed burning. While this approach has not yet been introduced in practice, there is a progress in the scientific and the policy acceptance of the concept. Given the magnitude and importance of wildfires in Central Eurasia there is need to prioritize the implementation of such a concept in the region, particularly in the Russian Federation.



Dendrochronological analyses provide historic evidence of recurrence of natural surface fires in the “light taiga” of Siberia and thus the influence of fire in shaping the composition and dynamics of pine (*Pinus* spp.) and larch (*Larix* spp.) forest ecosystems. Photos: GFMC.

2. Cultural Fire Regimes

Pollen and charcoal records in Western Europe reveal the advent of slash-and-burn agriculture in the late Neolithic between 4300 and 2300 BC. (Rösch et al., 2004). Since then the historic use of fire has been manifested in the development and shaping of a variety of land-use systems in the region (Goldammer et al., 1997a,b; Pyne, 1997). Mechanical treatment, intensive utilization of biomass for domestic

purposes, the impact of domestic livestock grazing and the application of fire modified formerly forested lands to open lands and shaped distinct landscape mosaics. These open land ecosystems provided habitat requirements for a flora and fauna that otherwise is not occurring in forest ecosystems. Modern agricultural practices and the reduction of fire use due to legal restrictions or prohibitions in most European countries on the one side, and the rural exodus associated with the abandonment of traditional land management practices, including fire use, on the other side are dramatically altering these ecosystems. The rural depopulation and the rapid increase of fallow is resulting in a loss of open land ecosystems and habitats and is even resulting in an alteration of whole landscape patterns. At the same time the increasing availability of phytomass – a consequence of the decrease of its use – has resulted in an increase of fuel loads at landscape level and thus in increasing wildfire hazard.

There are a number of reasons and approaches in Europe to maintain or to restore the traditional use of fire in some ecosystems or land-use systems.

2.1 Restoration of traditional practices of swidden agriculture

There are a few cases in Europe where a reconstruction or restoration of abandoned slash-and-burn agriculture practices is demonstrated. These attempts have primarily a “museum” character and are serving educational purposes with a touch of landscape pattern restoration. Until the middle of the 20th Century slash-and-burn agriculture with a spatio-temporal land-use pattern similar to the “shifting cultivation” system was widely practiced in Europe and has left landscape features that are still visible today, e.g. the still visible small-sized burning plots with their distinct successional patterns (Goldammer et al., 1997). There are two regions where this kind of fire treatment is practiced for demonstration purpose:

- Koli National Park in Finland is the only national park in the world that has a fire symbol in its logo. In Koli the traditional slash-and-burn practice is demonstrated regularly and reveals the importance of this traditional land use on the composition of Finland’s boreal coniferous forest that has been shaped by this cultivation over centuries (Lovén and Äänismaa, 2004).
- Historic slash-and-burn practice in the Black Forest of Germany: There are two sites near Freiburg (Yach, Vorderlehengericht) where the procedure of rotational cutting and use of coppice trees, the burning of residuals, followed by seeding and harvest of wheat, with subsequent fallow and forest regrowth period, are demonstrated (Lutz, 2008).

There is also a scientific interest to reconstruct earlier slash-and-burn practices, e.g. those that evolved in the late Neolithic. The most recent experiment to reconstruct Neolithic fire cultivation was conducted in 1999 in Forchtenberg, Germany (Rösch et al., 2002).



Swidden agriculture in the Black Forest, Germany, around the late 19th Century.
Source: Historic copperplate print, archive of GFMC.



Demonstration traditional slash-and-burn practice in Koli National Park, Finland. Photo: Koli National Park.



Demonstration of traditional fire cultivation practices in the Black Forest, Germany (Vorderlehengericht, June 2007). Photo: GFMC.

2.2 Maintenance of grazing lands

The use of fire in maintaining openness and species composition on grazing lands is the most common practice that has survived its early application throughout Eurasia. Pastures that are threatened by succession are traditionally burned in a region stretching from the Western Mediterranean via the Balkans to East Europe. Although banned by law in most countries, the burnings are still practiced in many places. Together with burning of agricultural residuals (c.f. section 2.4) pasture burnings are a major cause of wildfires that are also affecting forests and even the wildland-residential interface. The illegality of burning is often resulting in “hit-and-run” practices, i.e. pastoralists setting fires and disappear from the site in order not to be sued. This is often resulting in uncontrolled fires with a high likelihood of developing and spread of devastating wildfires to adjoining terrain. While many countries did not yet attempt to introduce a solution to this problem, Spain has made significant progress by developing a government-supported permit and support system for the use of prescribed fire for grazing improvement and fire social prevention (Velez, 2007). Similarly, prescribed burning for rangeland improvement is practiced by several French prescribed burning teams, including the Department Pyrénées-Orientales (Faerber, 2008). For a European survey on prescribed burning practices, including grazing land management, see Lázaro (2008).



Prescribed burning of a *Cystisus purgans* heath in the Pyrénées-Orientales (Sournia, February 2008). Photo: J. Faerber.

2.3 Nature conservation and biodiversity management

The major focus and activities in the use of prescribed fire in Western Europe is for the conservation and restoration of the biodiversity heritage of former cultivated lands or lands otherwise affected by human-ignited fires (habitat and biodiversity management). The range of application is rather wide, as reflected by the activities conducted in the frame of the Eurasian Network for Fire in Nature Conservation (ENFNC).⁴ The following examples represent the main target systems for the application of prescribed fire:

- Heathlands: The composition and extent of Atlantic and continental heathlands (mainly dominated by *Calluna vulgaris*) has been shaped by grazing, cutting of heath, sod and turf layers and by burning throughout centuries. Burning is conducted in the United Kingdom (Davies et al., 2008; Scotland Government, 2008), to a lesser extent in Southern European countries such as Portugal and Italy (Ascoli et al., 2009), and predominantly in Central and Northern Europe, e.g. in Denmark (Jensen, 2004), the Netherlands (Vogels, 2008; Bobbink et al., 2009), Norway (Kvamme and Kaland, 2008) and Germany (e.g., Brunn, 2009; Mause, 2008; Goldammer et al., 2009). Endangered target species for habitat conservation burning include e.g. the Black Grouse (*Tetrao tetrix*) or game species such as Red Grouse (*Lagopus scoticus*).
- Wetlands: Maintenance of peat bogs, open fen mires, e.g. in Poland and Belarus, is practiced to maintain the habitat requirements of endangered plant and animal species, e.g. birds such as the Aquatic Warbler (*Acrocephalus paludicola*) or the Spotted Eagle (*Aquila clanga*) (Tanneberger et al., 2009). Moorlands in Germany that are threatened by succession are treated with prescribed fire in addition to other means such as waterlogging, tree cutting, mowing and mulching (Niemeyer, 2004).
- Grasslands: Similarly to the wetlands, xerothermic grasslands or *Molinia* meadows are hosting birdlife or plant species threatened by extinction, e.g. orchids, steppe grasslands plants or calcareous grasslands plants. Prescribed burning the Münsingen range in Southern Germany, a former military exercise and shooting range in which fires caused by the military had created and maintained openness for a century, is used for preserving the open habitats for endangered birds such as the Northern Wheatear (*Oenanthe oenanthe*) and the Woodlark (*Lullula arborea*).
- Forests: The use of prescribed fire in the restoration and maintenance of habitats of species dwelling in forests is pioneered by management in Finland and Sweden. Traditionally fire has been used in the boreal forests of the Nordic countries in order to improve growth and productivity of tree stands by removing the temperature-isolating raw humus layers or to facilitate natural forest regeneration (Viro, 1974; Mälkönen and Levula, 1996). Since the 1990s there are first experiments and currently extended application underway to use fire for creating forest stands under the pre-industrial conditions, i.e. more open stand structures, and to create habitats of endangered insect species (e.g. *Stephanopachys linearis* and *S. substriatus*; *Aradus* spp.) and wood-decaying fungi as well as habitats for vascular plants (Rydkvist, 2008).

⁴ <http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm>. See also the special issue of UNECE/FAO International Forest Fire News at http://www.fire.uni-freiburg.de/iffn/iffn_30/content30.htm



Danish postcard showing a fire set in Randbøl Hede – today Randbøl Hede Nature Reserve – in the early 20th Century. Source: GFMC archive.



Modern farmers learning the ancient farming technique of heathland burning in Norway in 2005. Source: Kvamme and Kaland (2008), photo by Aslaug Aalen.



Structurally rich heath-juniper ecosystems with individual pine and birch trees in Lunenburg Heath Nature Park shaped by fire, grazing and mechanical treatment. Photos: R. Köpsell and J. Prüter).



Control of birch and pine succession (left) in Zschornoer Heide Nature Reserve (Brandenburg State, Germany) is controlled by prescribed fire (middle and right: prescribed burning in 2002). Photos: GFMC.



Post-fire views of prescribed burns in Zschornoer Heide Nature Reserve immediately after the burn (left) and two years after the fire. Photos: GFMC / E. Brunn.

3. Substitutional Fire Use

The use of fire as a tool to substitute or replace another form of vegetation treatment is referred to as substitutional fire use. In Central Europe there are abundant open vegetation types that were shaped by agriculture, grazing or other land use (e.g., extraction of biomass for harvesting domestic fuels, stable litter, thatching material, etc.). Some of these open land habitats have a high biodiversity or landscape conservation value. In the late 20th Century many sites threatened by succession have been maintained by mechanical (mowing, mulching, etc.) or prescribed grazing measures that were financed by public subsidies. However, increasing costs and financial constraints of public budgets on the one side, and a rapid increase of fallow on the other side during the last three decades, have prompted scientists and conservationists to replace costly mechanical and grazing measures by prescribed fire.

3.1 Fallow management on small-scale and extreme habitats

The problem of increasing fallow is not only restricted to former grazing lands. The abandonment of traditional land use is also affecting sites that have been utilized for hay production by mowing. In regions where the open grasslands have a high value for landscape aesthetics and tourism, major public subsidies have been used in the past to keep these lands open by mechanical means. However, besides the limitations due to increasing costs there are also limitations to use machinery on small-sized private property plots, on open lands on steep slopes or on sites intermixed with trees, e.g., high-conservation value xerothermic grasslands with interspersed trees. Long-term investigations in using fire to maintain openness on small-scale fallow plots in Southwest Germany were initiated and monitored since the mid-1970s (Schreiber, 2004).

Another example of using fire as a substitutional tool is practiced in the viticulture region of Southwest Germany. Traditionally the xerothermic slopes between vineyard terraces in Southwest Germany (Kaiserstuhl) were mowed by the landowners and the hay used to feed cattle. The mowing of the grass strata on the slopes was very labor intensive and could not be mechanized. Thus, with the socio-economic changes in the viticulture sector beginning in the 1950s the winegrowers abandoned the treatment of slope vegetation, which very rapidly responded by bush encroachment and succession towards tree stands – a development detrimental to the microclimate for wine growing and also not well perceived for landscape-aesthetic reasons by the local populations. Excessive use of fire to maintain openness during the 1960s did not observe the rules necessary to protect vulnerable flora and fauna, especially when burning was conducted large scale and at progressed development stages in springtime. A complete fire ban imposed by law in the 1970s resulted in progressing succession as a consequence of neglected maintenance of the xerothermic sites. Since the late 1990s a scientific research project elaborated a framework of a prescribed fire regime (Page and Goldammer, 2004) which is now replacing mechanical treatment and is practiced by ecologically sound small-sized burnings during the winter period in two counties of Southwest Germany (Rietze, 2008; Goldammer et al., 2009).



Prescribed fire is used to maintain openness of fallow slopes in the Kaiserstuhl viticulture region. Fire is now replacing traditional mowing (Southwest Germany). Photos: GFMC.

The targeted application of small-sized fires for creating mosaic- or edge-rich habitat structures is common in the management endangered bird species, e.g. Black Grouse (*Tetrao tetrix*) (cf. 2.2.3), capercaillie (*Tetrao urogallus*) and Hazel Grouse (*Tetrastes bonasia*). While capercaillie habitat management by fire has been proven successful in Scottish pine-heath forests (Bruce and Servant, 2004), similar approaches elsewhere in Europe were less successful. For instance, capercaillie populations increased in some sites of the Black Forest (Germany) that were disturbed by hurricane “Lothar” in 1999. Wind throws and wind falls, partially salvage-logged but with snags remaining, resulted in the formation of edge-rich habitat structures preferred by capercaillie. The populations began to disappear with the onset of regeneration of spruce (*Picea abies*) and the development of succession towards dense forest. Small-scale, mosaic-rich prescribed burning application was intended to

- control abundant regeneration of spruce (*Picea abies*) to maintain general openness
- create vegetation-free areas (mineral soil exposed) for food search / scratching
- maintain refuge areas (small groups of young stands and thickets)
- foster berry/shrub cover, particularly black berry (*Vaccinium myrtillus*), as a key source of nutrition

- foster softwoods
- foster structural diversity through a detention of the development of closed high forests in parts of the stands
- maintain tree stumps and snags as sitting places
- maintain appropriate trees as sleeping and singing places

However, in the long run these burnings could not be implemented on a regular basis because of the prevailing moist conditions on altitudes of around 1000 m a.s.l. of the Black Forest.

3.2 Landscape management

The Middle Rhine Valley (Germany) represents a typical example of the widespread conflict between a high nature conservation value of the cultural landscape on the one hand and the abandonment of traditional land use on the other hand. The Valley constitutes one of the largest coherent xerothermic areas of Germany with habitats and vegetation types that are classified as endangered at European level. The necessity for the development of management concepts to protect this landscape was emphasized by the inscription of the Upper Middle Rhine Valley in the UNESCO World Heritage List as a protected cultural landscape in 2002 (Bonn, 2004). In order to prevent further loss of the characteristic open habitats as a consequence of dramatic reduction of vine cultivation and other land use, a research and development project investigated the more or less uncontrolled (“semi-wild”), extensive grazing by horses and goats on the steep slopes, clearing the shrub-dominated shallow slopes with tank-tracks, and prescribed burning (Bonn et al., 2009). Prescribed burning was applied successfully during the experimental phase of the project, especially in the grass stage and earlier succession dominated by *Rubus* spp., but turned out to be limited as a tool for restoring overgrown xerothermic habitats on sites in progressed development stages dominated by *Prunus mahaleb* and *Cornus sanguinea* (Driessen et al., 2006).



The Middle Rhine cultural landscape with small-scale viticulture terraces is rapidly changing under fallow and succession. Combined grazing, mechanical and fire treatments are possible solutions for maintaining the aesthetic impressions of this unique cultural asset. Photos: S. Bonn and S. Bonn / GFMC Archive.

There are areas where the objectives of both nature conservation and landscape management are matching and prescribed fire is used for biodiversity management and maintenance of landscape aesthetics, mainly for recreational purpose. Nature conservation sites and nature parks (national parks) hosting *Calluna* heathlands are the most prominent examples of this dual use of fire, especially in Central Europe where these protected areas are important spots for national and regional tourism. The aesthetic impression of the old cultural landscape dominated by the colorful flowering of heath is a high attraction for visitors. A prominent example of such an area is the Lunenburg heath (Germany) with the Lunenburg Heath Nature Park (area: 1,130 square kilometres) and at its center the Lunenburg Heath Nature Reserve. As mentioned above, the composition and extent of Atlantic and continental heathlands (mainly dominated by *Calluna vulgaris*) historically has been shaped by grazing, cutting of heath, sod and turf layers and by burning throughout centuries. The use of fire for regeneration of over-aged heath, however, played a role as one of many disturbance agents and has now been restored successfully in Lunenburg heath (Keienburg and Prüter, 2006).

4. Waste Disposal

The use of fire in biomass waste disposal merits to be regarded at separately. While all burning objectives mentioned previously are targeting for a removal or suppression of unwanted, competitive dead or live vegetation elements – either by combustion or by the impact of heat – the removal of unused dead biomass by burning in agriculture (e.g., stubble burning after harvest) and forestry (slash / harvest residual burning after timber harvest, notably on clearcuts) aims at facilitating the growing of the next crops or the regeneration or reforestation of forest stands.

Burning of stubble fields and other agricultural crop residuals in Europe has a long tradition, similar to other regions and continents, but is now largely banned by law since these burnings are a major source of wildfires and air pollution. In Eastern Europe and Central Asia, however, agricultural burning – despite its legal ban – is very widespread and constitutes one of the major areas worldwide that are burned annually (Korontzi et al., 2006).

Burning of forest slash – the unused materials left on site after timber harvest – is still practiced in Europe, although to a decreasing extent. In the Nordic countries the main aim is site preparation for regeneration, i.e. to improve accessibility of the site for planting, including the use of machinery. Two techniques are practiced: burning on piles and broadcast burning over a larger area, usually on clearcuts with or without seed trees (particularly in the Nordic countries). At the same time slash burning is also serving to improve site conditions by reducing the raw humus layers and, as a silvicultural tool, to facilitate the germination of natural regeneration. In Russia the use of broadcast slash burning is now practiced to decrease fire hazard on logged sites and promote natural regeneration (Valendik et al., 2000; 2001). Also prescribed burning was used to restore forests killed at large scale by insects (Valendik et al., 2006). In the Mediterranean countries, burning on piles is used for eliminating tree branches and other residues after tree clearing and thinning on fuel breaks.

The recent move towards more intensive use of renewable energy is calling for the use of forest slash for bioenergy production. At medium- to long-term perspective this may result in a reduction of open forest residual burning.

5. Wildfire Hazard Reduction Burning

In Europe the concept of using prescribed fire as a management tool to reduce the combustible materials on the surface inside of forest stands, and thus the energy potential and the risk of high-intensity and -severity wildfires, has a relatively short history. It was only after the pioneering work of U.S. scientists in the 1970s and the official recognition of the use of “fire by prescription” by the U.S. Forest Service in 1976 when Europeans formulated the first ideas to consider prescribed burning as a tool for wildfire hazard reduction and presented the first research. The Fire Ecology Symposia held at Freiburg University in 1977 and 1983 (Forstzoologisches Institut, 1978; Goldammer 1978, 1983) and a dedicated workshop in Avignon in 1988 (INRA, 1988) brought together a community that intended to investigate prescribed fire as a forest and fire management tool. First practical applications and increasingly sophisticated approaches in fundamental prescribed fire research were conducted in Southern and Central Europe starting in the late 1970s (e.g., Goldammer, 1979; Delabraze and Valette, 1983; Rego et al., 1983; Trabaud, 1983; Vega et al., 1983). The use of fire to reduce wildfire hazard in open lands, including brush lands, namely for the creation and maintenance of fuelbreaks, then entered practice in the Southern European countries Spain, France and Portugal (Valette et al., 1993). In the Mediterranean part of France, prescribed burning for hazard reduction has continuously been developed and consolidated along years (Rigolot, 2000; Lambert, 2008). Prescribed burning for fuel reduction inside forests was practiced first in Portugal in the 1980s (Rego et al., 1983; Fernandes and Botelho, 2004). Subsequently, in this country, its application became dormant until its recent revival in the frame of the EU Fire Paradox project.

None of the forest ecosystems in Southern and Central Europe, including the natural pine forests, are natural fire ecosystems. Thus, the introduction of prescribed fire for wildfire hazard reduction can be considered as an innovative tool, applicable only in forests with target species resilient or tolerant to low-severity surface fires, such as *Pinus* spp. or *Quercus* spp.. In some cases prescribed fire can be regarded as a substitution tool for replacing historic fuel reduction methods, e.g. the intensive use of biomass for domestic use, or silvopastoral forest use.

In the overall context of landscape ecology the use of prescribed fire on open (non-forest) lands may serve several objectives. On the one hand well-maintained open landscape fragments – either a heritage of the cultural history or strategically planned to reduce “fuel bridges” between fire-vulnerable forests or other ecosystem – allow better access, ease the control of wildfires and enhance safety for firefighting operations. On the other hand the open lands may serve as pasture or for conservation purposes.



Use of prescribed broadcast burning in a coniferous forest clearcut in Siberia (“dark taiga” – with main species *Abies sibirica*, *Picea sibirica*, *Pinus sibirica*, *Betula pendula*, *Populus tremula*) east of Yenisey river (Yenisey Ridge), Bolshaya Murta leskhoz, in June 1997, for slash removal and stimulation of forest regeneration. Photo: Y. Kisilyakhov.



Prescribed burning inside of standing coniferous forests for wildfire hazard reduction is not yet practiced systematically in the region, although demonstrated occasionally such as here in a pine stand (*Pinus sylvestris*) in Southwest Germany in 2008. Its future application in the Western part of the Euro-Siberian region is probably less likely, whereas its application is strongly recommended in natural coniferous forests of the Central Asian region. Photos: GFMC.



The main objective of prescribed fire application in the Stormyrän-Lommyran nature reserve (Sweden) is to restore open stand structures and provide habitats for fire-dependent and fire-adapted species, e.g. the insect species *Stephanopachys linearis* and *S. substriatus*, *Aradus* spp.. Photo: T. Rydkvist



Joint training of professionals and local villagers in the use of prescribed fire for wildfire hazard reduction in native mountain pine forests (*Pinus sylvestris*) in northern Mongolia. The hand-over of prescribed fire by scientists to the practitioners is a high priority issue aimed at reducing destructive wildfires. Photos: GFMC.

6. Limitations for Prescribed Burning: Contaminated Terrains

In some Eurasian countries high-value nature conservation sites are located on former military training areas or shooting ranges. In Germany many of these areas have been used by the military since more than 100 years, others were newly created and especially used during the Cold War. The total extent of sites in Germany contaminated by Unexploded Ordnance (UXO) is ca. 700,000 ha on active and former military training and combat theater sites, i.e. 2% of Germany's land cover. Many of these military exercise areas were located on the territory of the former German Democratic Republic, used by the Soviet Army and the Warsaw Pact allies. The disturbances caused by military activities (e.g., mechanical impacts of direct shooting, fires started by shooting, mechanical impacts by tanks and other vehicles) have resulted in the creation and maintenance of valuable open ecosystems. With the closing of the exercise areas many vegetation types, notably the *Calluna vulgaris* heathlands, are becoming subjected to succession and development towards forests – a trend that is rather undesirable from the point of view of landscape and biodiversity conservation.

On these former military sites there are some obstacles for using prescribed fire as they are densely contaminated with UXO, which may explode during prescribed burning operations and also during wildfires. A new approach in the use of prescribed fire to maintain openness of UXO-contaminated terrain has been launched in 2009 in Brandenburg State in the nature conservation site „Heidehof-Golmberg“ in Teltow-Flaeming County, South of Berlin. This site is classified according to the “Fauna-Flora-Habitat Directive“ (FFH) of the European Commission and belong to an overall area of ca. 70,000 ha of FFH lands in Brandenburg State that are endangered by succession and loss of open habitats. The new approach is going to use armored vehicles (former combat tanks converted to fire extinguishing vehicles) to secure personnel during ignition, control of the prescribed fire and mop-up). In future it is envisaged to use aerial incendiary ignition systems to start the prescribed fires from safe distance and over large areas simultaneously, and use Unmanned Aerial Vehicles (UAV) to monitor progress and safety (Goldammer, 2009; Goldammer et al., 2009). This first project of its kind reveals that prescribed burning operations under such circumstances are rather complex and costly.

Similarly there are problems on lands contaminated with UXO and land mines inherited from recent conflicts, e.g. the extended areas covered by land mines on the Balkans, notably in Croatia, Bosnia and Herzegovina and Serbia, totaling ca. 300,000 ha. Not all of these territories may be candidates for prescribed burning. In the context of wildfire prevention and control, however, the connected ness between contamination by explosives, must be kept in mind.



The use of prescribed fire in the maintenance of open habitats on former military exercise areas or shooting ranges requires special safety precautions as unexploded ordnance may detonate during the burning. Photo: GFMC.

This refers also particularly to the terrains contaminated by radioactivity, notably in the impact zone of the fallout from the Chernobyl nuclear power plant failure in 1986. Territories most affected and contaminated by long-resident radionuclides of ^{238}Pu , $^{239+240}\text{Pu}$, ^{137}Cs and ^{90}Sr are posing a potential threat to human health and security if lifted, redistributed and newly deposited after lifted by an extremely intense wildfire and dispersed by smoke. In the most affected territories of Ukraine, Belarus and Russia the application of low-intensity prescribed fire for wildfire reduction and biodiversity conservation may be feasible but is not yet acceptable under the current psycho-social settings (Goldammer and Zibtsev, 2009).

7. Conclusions and Recommendations

In evaluating the presentations discussed during the symposium⁵ the participants concluded that recent research and the revival of prescribed burning practices in some regions of Europe have revealed the role and importance of fire in the maintenance and restoration of biodiversity in the cultural and natural landscapes of Europe.

The current trend of rural exodus and abandonment of land cultivation in some regions of Europe and the loss of traditional land use is leading to an alarmingly increasing rate of loss of open land habitats with its inherent biodiversity.

The maintenance and in many cases also the restoration of open land habitats by grazing, mechanical treatment and fire use is imperative if threatened biodiversity and landscape features are to be preserved.

Prescribed fire may be used in those ecosystems which historically were shaped by cultural fire, or in which prescribed fire may substitute other historic land-use techniques.

A sound understanding of the “pros and cons” of prescribed fire application is necessary as well as the consideration of side effects of fire use. Large areas threatened by land abandonment are embedded in industrialized regions in which society is becoming increasingly unreceptive to smoke emissions. Legal restrictions for open burning must be understood in the context of clean-air rules and overall goal of reducing gaseous and particle emissions that are threatening human health. This perception is reinforced by a hysteria of some who consider prescribed fire emissions to increase the anthropogenic “greenhouse effect” and thus global warming.

On the other side it is noted that nature conservation agencies, non-government actors and the general public meanwhile turn out to have a rather sound understanding of the natural role of fire in various ecosystems. Thus the general perception of the “nature of fire” nowadays is better as compared to the situation two to three decades ago.

Based on the facts and recent trends presented in the Symposium on “Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia” the following recommendations are given:

⁵ See symposium report available at: <http://www.fire.uni-freiburg.de/programmes/natcon/EFNCN-meetings-1-2008.html>

Prescribed Fire Research

The symposium revealed that there is a need in:

- Continued support for prescribed burning research
- Clear analysis of the pro's and con's of prescribed burning in a European context, e.g., via meta analysis and expert knowledge regarding, environmental, economic and societal issues
- Studies of additional, not yet identified areas / ecosystems that require prescribed fire treatment
- Identification of possible vulnerabilities of systems subjected to prescribed fire
- Setting up a European group of scientists, managers and policy makers who are involved in management of temperate grazing systems and have adopted (or not yet) fire as an additional management tool. Besides the Eurasian Fire in Nature Conservation Network supporting groups/ organizations could include the European Heathland Network, the Husbandry Animal Group, the European Grassland Group, Aquatic Warbler Conservation Team, the UK Heather Trust and Moorland Forum
- Special emphasis on the use of fire in open fen mire habitats, e.g. in Eastern Germany, Belarus, and Poland

Prescribed Fire Management and Capacity Building

Since prescribed fire in ecosystem management is not yet largely applied, despite its recent revival, tools and systems must be developed to develop and support fire management capability. Action is needed to:

- Adjust the Canadian Fire Behavior Prediction System to European conditions with fuel types from every country
- Develop expert systems to assist burners to understand whether they should burn and to guide them to burn safely
- Enhance closer cooperation on the issue of prescribed burning for nature conservancy and landscape management between Temperate-Boreal Eurasia and the Mediterranean Region
- Develop prescribed specific regional fire guidelines which consider the biophysical and social settings, for the use of agencies, land owners and other stakeholders involved
- Limit bureaucracy and develop easier rules for permitting the application of traditional burning as well as advanced prescribed burning practices
- Develop specific prescribed burning training systems
- Develop a scheme for the certification of Burn Boss and Ignition Specialist on a European level and with national modifications
- Assist in capacity building of fire specialists in countries in transition
- Establishment of regional Training / Education Centers for Fire Management for the Balkans and for East European and adjoining Central Asian / Far East countries

Modified Fire Policies

The legislative framework in most European and neighboring Eurasian countries does not provide regulations for the use of prescribed fire. In contrary, in general the use of fire is banned by law – although law enforcement in some countries is nil. Besides national legal instruments a regional European framework directive would be needed to create an enabling environment for the sound use of prescribed fire in nature conservation, landscape management and forestry. Thus it is needed to:

- Emphasize at national level on the importance of prescribed burning and the consequences of not burning
- Using model projects (examples of “good practices”) to demonstrate to local to national authorities in the need of the application of prescribed fire in combination with other complementing means of vegetations treatment
- Create an appendix with list of reference books / publications explaining core methods and showing the examples of “good practices” (aimed at informing influencing decision / policy makers)
- Cooperate with the EU *Fire Paradox* project⁶ and its follow-up arrangement to support the development of a European Fire Framework Directive, which would create an enabling policy supporting the use of fire⁷

Public Relations and Education

Most important is to inform society on the dual role of fire on ecosystems, to allow the general public to understand the use of prescribed fire in some land-use system vs. the need to prevent and combat fires in others. Collectively we need to:

- Show the policy makers that there is a strong alliance and cooperation in promoting the use of fire at European level
- Show the public and policy makers that the severity and impacts of wildfires are increasing as a consequence of land-use change (increase of wildfire hazard resulting from rural exodus, land abandonment and fallow)
- Prove that prescribed burning is cost-efficient to restore and regenerate important and threatened habitats
- Prove that prescribed burning will contribute to stabilizing some forest ecosystems by making them less vulnerable to destructive wildfires, thus reduce the threat of land degradation and a decrease of net carbon emission to the atmosphere

General Remarks on Fire and livelihood of some Rural Populations

There are also some very pragmatic aspects for fire use that are crucial for livelihoods of people all over Eurasia. For instance, in the coastal heathlands of Norway it is important to maintain the traditional vegetation mosaic between heath-dominated and grass-dominated vegetation. The grassland represents the main fodder for the animals during the summer season, while evergreen heath species

⁶ <http://www.fireparadox.org/>

⁷ see Agudo and Montiel (2009)

provide the main fodder during the winter. Heath burning is an important tool to maintain the mosaic, which does not only shape the highest possible biological diversity within the heath ecosystem but also the highest fodder value over the year. Similarly, many shepherds and their families throughout Southern and Southeastern Europe and the Balkans are dependent for their livelihood on the productivity of grazing lands regularly maintained by fire.

The International Context

In 2007 the 4th International Wildland Fire Conference was held in Sevilla, Spain. Participants from 88 countries, representing government organizations and civil society from all regions of the world, the United Nations and other international organizations, recommended in particular⁸:

- Regional strategies for fire management be developed and designed to the specific needs of regions;
- An international framework for fire management standards be developed and regional wildland fire training be supported, especially to meet the needs for capacity building in developing countries;

This White Paper – a call of the Eurasian Fire in Nature Conservation Network (EFNCCN) through the conclusions of the Freiburg Symposium on “Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia” – is in line with these recommendations and also the outcomes of the “Fire Paradox” project (Sande Silva et al., 2010).

8. References

- Agudo, J., and C. Montiel. 2009. Basis to start the process for a proposal of a new legislation at EU level. Deliverable D7.1-1-3 of the Integrated Project “Fire Paradox”, Project n° FP6-08505. European Commission, 66 p.
- Ascoli, D., R. Beghin, R. Ceccato, A. Gorlier, G. Lombardi, M. Lonati, R. Marzano, G. Bovio, and A. Cavallero. 2009. Developing an Adaptive Management approach to prescribed burning: a long-term heathland conservation experiment in north-west Italy. *International Journal of Wildland Fire* 18, 727-735.
- Bobbink, R., M. Weijters, M. Nijssen, J. Vogels, R. Haveman, and L. Kuiters. 2009. Branden als EGM-maatregel. Ede: Directie Kennis, Ministerie LNV (Rapport / DK 2009/dk117-O)
- Bonn, S. 2004. Research and development project “Sustainable development of xerothermic slopes of the Middle Rhine Valley, Germany”. *Int. Forest Fire News* No. 30, 59-62.
- Bonn, S., J. Albrecht, K. Bylebyl, N. Driessen, P. Poschlod, U. Sander, and M. Veith. 2009. Offenlandmanagement mit Panzerketten. *Naturschutz und Biologische Vielfalt* 73, 189-205.
- Bruce, M., and G. Servant. 2004. Prescribed Fire in a Scottish Pinewood: A Summary of Recent Research at Glen Tanar Estate, Aberdeenshire. *Int. Forest Fire News* No. 30, 84-93.

⁸ <http://www.fire.uni-freiburg.de/sevilla-2007/Conference-Statement-en.pdf>

- Brunn, E. 2009. Feuermanagement auf Truppenübungsplätzen in Brandenburg. *Naturschutz und Biologische Vielfalt* 73, 165-178.
- Davies, M.G., A. Gray, A. Hamilton, and C.J. Legg. 2008. The future of fire management in the British uplands. *International Journal of Biodiversity Science and Management* 4 (3), 127-147.
- Delabraze, P., and J.Ch. Valette. 1983. The fire, a tool for clearing the French Mediterranean forest associations. In: DFG-Symposion Feuerökologie. Symposionsbeiträge (J.G. Goldammer, ed.), 27-38. *Freiburger Waldschutz-Abh.* 4, Institute of Forest Zoology, Freiburg University, 301 p.
- Driessen, N., J. Albrech, S. Bonn, K. Bylebyl, P. Poschlod, U. Sander, P. Sound, and M. Veith. 2006. Nachhaltige Entwicklung xerothermer Hanglagen am Beispiel des Mittelrheintals (Sustainable development of xerothermic hillsides in the Middle Rhine valley). *Natur und Landschaft* 81, 130-137.
- Faerber, J. 2008. Prescribed range burning in the Pyrenees: From a traditional practice to a modern management tool. *Int. Forest Fire News* No. 38 (in press).
- FAO-GFMC. 1999. Wildland Fire Management Terminology. Update of the FAO Wildland Fire Management Terminology of 1986 (Food and Agriculture Organization of the United Nations, FAO Forestry Paper 70, 257 p.), published online at GFMC: <http://www.fire.uni-freiburg.de/literature/glossary.htm>
- Fernandes, P., and H. Botelho. 2004. Analysis of the prescribed burning practice in the pine forest of northwestern Portugal. *Journal of Environmental Management* 70, 15-26.
- FIRESCAN Science Team. 1996. Fire in ecosystems of boreal Eurasia: The Bor Forest Island Fire Experiment, Fire Research Campaign Asia-North (FIRESCAN). In: Biomass burning and global change. Vol.II (J.S.Levine, ed.), 848-873. The MIT Press, Cambridge, MA.
- Forstzoologisches Institut. 1978. VW-Symposium Feuerökologie. Symposionsbeiträge. *Freiburger Waldschutz-Abh.* 1 (1), 1-159. Institute for Forest Zoology, Freiburg University, Freiburg, Germany.
- GFMC Team. 2008. The LIFE Rohrhardsberg project: The use of Prescribed Fire in Maintaining Endangered Habitats and Landscape Feature in the Foothills of the Black Forest. *Int. Forest Fire News* No. 38 (in press).
- Goldammer, J.G. 1978. Feuerökologie und Feuer-Management. *Freiburger Waldschutz Abh.* 1 (2), 1-50. Institute for Forest Zoology, Freiburg University, Freiburg, Germany.
- Goldammer, J.G. 1979. Der Einsatz von kontrolliertem Feuer im Forstschutz. *Allg. Forst- u. J. Ztg.* 150, 41-44.
- Goldammer, J.G. (ed.). 1983. DFG-Symposion Feuerökologie. Symposionsbeiträge. *Freiburger Waldschutz-Abh.* 4, 301 p.

- Goldammer, J.G. 2009. The use of Prescribed Fire on Nature Conservation Areas in Germany contaminated by Unexploded Ordnance (UXO). In: Advanced Seminar "Wildfires and Human Security: Fire Management on Terrain Contaminated by Radioactivity, Unexploded Ordnance (UXO) and Land Mines", Kyiv / Chornobyl, Ukraine, 6-8 October 2009, Abstract Volume (J.G. Goldammer, ed.), 21-22. – <http://www.fire.uni-freiburg.de/GlobalNetworks/SEEurope/GFMC-CoE-OSCE-Seminar-Ukraine-Brochure-Final-06-Oct-2009.pdf>
- Goldammer, J.G., and V.V. Furyaev (eds.). 1996. Fire in ecosystems of boreal Eurasia. Kluwer Academic Publ., Dordrecht, 528 pp.
- Goldammer, J.G., S. Montag, and H. Page. 1997a. Nutzung des Feuers in mittel- und nordeuropäischen Landschaften. Geschichte, Methoden, Probleme, Perspektiven. Alfred Toepfer Akademie für Naturschutz, Schneverdingen, NNA-Berichte 10, Heft 5, 18-38.
- Goldammer, J.G., J. Prüter, and H. Page. 1997b. Feuereinsatz im Naturschutz in Mitteleuropa. Ein Positionspapier. Alfred Toepfer Akademie für Naturschutz, Schneverdingen, NNA-Berichte 10, Heft 5, 2-17.
- Goldammer, J.G., E. Brunn, G. Hoffmann, T. Keienburg, R. Mause, H. Page, J. Prüter, E. Remke, and M. Spielmann. 2009. Einsatz des Kontrollierten Feuers in Naturschutz, Landschaftspflege und Forstwirtschaft – Erfahrungen und Perspektiven für Deutschland. Naturschutz und Biologische Vielfalt 73, 137-164.
- Goldammer, J.G., and S. Zibtsev (eds.) 2009. Advanced Seminar "Wildfires and Human Security: Fire Management on Terrain Contaminated by Radioactivity, Unexploded Ordnance (UXO) and Land Mines", Kyiv / Chornobyl, Ukraine, 6-8 October 2009, Abstract Volume, 41 p. – <http://www.fire.uni-freiburg.de/GlobalNetworks/SEEurope/GFMC-CoE-OSCE-Seminar-Ukraine-Brochure-Final-06-Oct-2009.pdf>
- INRA. 1988. Proceedings, International Prescribed Burning Workshop, Avignon, 14-18 March 1988. Institut National de la Recherche Agronomique (INRA), Station de Sylviculture Méditerranéenne.
- Jensen, H.S. 2004. Restoration of dune habitats along the Danish west coast. Int. Forest Fire News No. 30, 14-15.
- Keienburg, T., and J. Prüter. 2006. Naturschutzgebiet Lüneburger Heide – Erhaltung und Entwicklung einer alten Kulturlandschaft. Mitteilungen aus der NNA 17 (1), 68 p.
- Korontzi, S., J. McCarty, T. Loboda, S. Kumar, and C. Justice. 2006. Global distribution of agricultural fires in croplands from 3 years of Moderate Resolution Imaging Spectroradiometer (MODIS) data. Global Biogeochem. Cycles 20, GB2021, doi:10.1029/2005GB002529.
- Kvamme, M., and P.E. Kaland. 2008. Prescribed burning of coastal heathlands in Western Norway: History and present day experiences. Int. Forest Fire News No. 38 (in press).
- Lambert, B. 2008. Bilan et perspectives du réseau brûlage dirigé. Réseau des équipes de brûlage dirigé, SUAMME, Conservatoire de la Forêt Méditerranéenne. 32p.+CDRom.
- Lázaro, A. 2008. Collection and mapping of prescribed burning practices in Europe: A first approach. Int. Forest Fire News No. 38 (in press).

- Lobanov, D. 1994. Russian Federation: Airborne Fire Disaster Control by the Russian Civil Defense Organization. *International Forest Fire News* No. 11, 18-19.
- Lovén, L., and P. Äänismaa. 2004. Planning of the Sustainable Slash-and-Burn Cultivation Programme in Koli National Park, Finland. *Int. Forest Fire News* No. 30, 16-21.
- Lutz, P. 2008. Traditional slash-and-burn agriculture in the Black Forest: Reconstruction of burning and agricultural techniques. Paper presented at the Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia, Freiburg, Germany, 25-27 January 2008. <http://www.fire.uni-freiburg.de/programmes/natcon/ppt/23-EFNCN-2008-1-Germany-Swidden-Lutz.pdf>
- Mälkönen, E., and T. Levula. 1996. Impacts of Prescribed Burning on Soil Fertility and Regeneration of Scots Pine (*Pinus sylvestris* L.). In: *Fire in ecosystems of boreal Eurasia* (J.G. Goldammer and V.V. Furyaev, eds.), 453-464. Kluwer Academic Publ., Dordrecht, 528 pp.
- Mause, R. 2008. The Use of Prescribed Fire for Maintaining open Calluna Heathlands in North Rhine-Westphalia, Germany. *Int. Forest Fire News* No. 38 (in press).
- Montiel, C., P. Costa, and M. Galán. 2010. Overview of suppression fire policies and practices in Europe. *Fire Paradox White Book - Section IV. Suppression Fire: a tool to control wildfires* (in prep.).
- Naveh, Z. 1975. The Evolutionary significance of fire in the Mediterranean Region. *Vegetatio* 29, 199-208.
- Niemeyer, F. 2004. Prescribed Burning of Moorlands in the Diepholzer Moorniederung, Lower Saxony State, Germany. *Int. Forest Fire News* No. 30, 43-44.
- Page, H., and J.G. Goldammer. 2004. Prescribed Burning in Landscape Management and Nature Conservation: The First Long-Term Pilot Project in Germany in the Kaiserstuhl Viticulture Area, Baden-Württemberg, Germany *Int. Forest Fire News* No. 30, 49-58.
- Pyne, S.J. 1997. *Vestal Fire. An environmental history, told through fire, of Europe and Europe's encounter with the World.* University of Washington Press, 680 p.
- Rego, F.G., J.M. da Silva, and M.T. Cabral. 1983. The use of prescribed burning in the Northwest of Portugal. In: *DFG-Symposium Feuerökologie. Symposionsbeiträge* (J.G. Goldammer, ed.), 88-104. *Freiburger Waldschutz-Abh. 4*, Institute of Forest Zoology, Freiburg University, 301 p.
- Rietze, J. 2008. Ecological monitoring of the management of slope-vegetation by prescribed burning in the Kaiserstuhl-Region, Germany. *Int. Forest Fire News* No. 38 (in press).
- Rigolot, E., 2000. Le brûlage dirigé en France: outil de gestion et recherches associées. In: Vega, J.A., Vélez, R. (Eds.), *Actas de la Reunión sobre Quemadas Prescritas, Cuadernos de la Sociedade Española de Ciencias Forestales* 9, 165-178.
- Rösch, M., O. Ehrmann, L. Herrmann, E. Schulz, A. Bogenrieder, J.G. Goldammer, M. Hall, H. Page, and W. Schier. 2002. An experimental approach to Neolithic shifting cultivation. *Vegetation History and Archaeobotany* 11, 143-154.
- Rösch, M., O. Ehrmann, L. Herrmann, E. Schulz, A. Bogenrieder, J.G. Goldammer, H. Page, M. Hall, and W. Schier. 2004. Slash-and-burn experiments to reconstruct late Neolithic shifting cultivation. *Int. Forest Fire News* No. 30, 70-74.

- Rydkvist, T. 2008. Prescribed fire as a restoration tool and its past, present and future use in the County of Västernorrland, Sweden. *Int. Forest Fire News* No. 38 (in press).
- Sande Silva, J., F. Rego, P. Fernandes, and E. Rigolot (eds.). 2010. *Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox*. European Forest Institute Research Report 23.
- Schreiber, K.-F. 2004. Germany: Use of Prescribed Fire in Maintaining Open Cultural Landscapes in Baden-Württemberg State. *Int. Forest Fire News* No. 30, 45-48.
- Scotland Government. 2008. *The Muirburn Code. Guidance on safe burning of heather (principal legislation constraints that apply for the wise use of fire in moorland management of Scotland)*. ISBN 978-0-7559-1004-5.
<http://www.scotland.gov.uk/Publications/2008/04/08154231/0>
- Tanneberger, F., J. Krogulec, and A. Kozulin. 2009. Feuermanagement im Niedermoor - Beispiele aus Polen und Weißrussland. *Naturschutz und Biologische Vielfalt* 73, 179-188.
- Valendik, E.N., V.N. Vekshin, S.V. Verkhovets, A.I. Zabelin, G.A. Ivanova, and Ye.K. Kisilyakhov. 2000. Prescribed burning of logged sites in dark coniferous forests. *Siberian Branch Russ. Acad. Sci. Publishing, Novosibirsk*. 209 pp <in Russian>.
- Valendik, E.N., V.N. Vekshin, G.A. Ivanova, Ye. K. Kisilyakhov, V.D. Perevoznikova, A.V. Brukhanov, V.A. Bychkov, and S.V. Verkhovets. 2001. Prescribed burning of logged mountain forest sites. *Siberian Branch Russ. Acad. Sci. Publishing, Novosibirsk*, 172 pp. <in Russian>.
- Valendik, E.N., J.C. Brissette, Ye.K. Kisilyakhov, R.J. Lasko, S.V. Verkhovets, S.T. Eubanks, I.V. Kosov, and A.Yu. Lantukh. 2006. An experimental burn to restore a moth killed boreal conifer forest, Krasnoyarsk Region, Russia. *Mitigation and Adaptation Strategies for Global Change* 11 (4), 883-896.
- Valette, J.Ch., E. Rigolot, and M. Etienne. 1993. Intégration des techniques de débroussaillage dans l'aménagement de défense de la forêt contre les incendies. *Forêt Méditerranéenne*. XIV(2), 141-154.
- van Wagtenonk, J.W. 2007. History and evolution of wildland fire use. *Fire Ecology Special Issue* Vol. 3 (2), 3-17.
- Vega, J.A., S. Bará, and C. Gil. 1983. Prescribed burning in pine stands for fire prevention in the Northwest of Spain: Some results and effects. In: *DFG-Symposium Feuerökologie. Symposionsbeiträge* (J.G. Goldammer, ed.), 49-74. *Freiburger Waldschutz-Abh.* 4, Institute of Forest Zoology, Freiburg University, 301 p.
- Vélez Muñoz, R. 2007. Experiences in Spain of Community Based Fire Management. Paper presented at the 4th International Wildland Fire Conference, Sevilla, Spain 13-17 May 2007.
http://www.fire.uni-freiburg.de/sevilla-2007/contributions/doc/cd/SESSIONES_TEMATICAS/ST2/Velez_SPAIN_DGB_ExpeEnglish.pdf
- Viro, P.J. 1974. Effects of forest fire on soil. In: *Fire and ecosystems* (T.T. Kozlowski and C.E. Ahlgren, eds.), 7-45. Academic Press, New York.
- Vogels, J. 2008. Fire as a restoration tool in the Netherlands – first results from Dutch dune areas indicate potential pitfalls and possibilities. *Int. Forest Fire News* No. 38 (in press).

Responsible Editor and Contact

The Global Fire Monitoring Center (GFMC) / Fire Ecology Research Group
Max Planck Institute for Chemistry, c/o Freiburg University / United Nations University (UNU)
Georges-Koehler-Allee 75, D - 79110 Freiburg, Germany

Tel: +49-761-808011 / Fax: +49-761-808012 / e-mail: fire@fire.uni-freiburg.de
GFMC Website: <http://www.fire.uni-freiburg.de>
Eurasian Fire in Nature Conservation Network (EFNCN) website: <http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm>

Cover photo: P.E. Kaland, Department of Biology, University of Bergen, Norway.