The Eurasian Fire in Nature Conservation Network (EFNCN): Advances in the use of prescribed fire in nature conservation, landscape management, forestry and carbon management in temperate-boreal Europe and adjoining countries in Southeast Europe, Caucasus, Central Asia and Northeast Asia

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Abstract

In the history of land-use in Eurasia fire has been an important element in forestry, agriculture and pastoralism. The use of fire has contributed to shape landscape patterns of high ecological and cultural diversity, e.g. heathlands, open grasslands, meadows, and swidden (shifting) agriculture sites. In the boreal forest belt historic natural fires caused by lightning and burning practises have also significantly influenced the composition and structure of forest ecosystems. The rapid socio-economic changes in the past four decades have also led to a change of land-use systems and landscape patterns, resulting in the elimination of traditional burning practises. New air quality standards and the generally prevailing opinion by government administrations that fire is likely to damage ecosystem stability and biodiversity, has led to the imposition of fire bans in most European countries. However it is now

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becoming apparent that the abandonment of traditional land-use methods has also resulted in the elimination of disturbances, which have characteristically shaped many valuable landscape types and ecosystems. Changing paradigms in ecology and nature conservation is now leading to the reconsideration of fire-exclusion policies in certain sectors of nature conservation, forestry and landscape management. New policies will also need to take into consideration regional climate change, which will be associated with more frequent and severe droughts; resulting in an increase in the risk of high-severity wildfires. These fires are likely to affect sustainability with increasing threats to communities, economic assets and damage to the environment, including an increase in the export of terrestrial carbon to the atmosphere. The *Eurasian Fire in Nature Conservation Network* provides a platform and networking mechanism for those who actively apply or conduct research in prescribed burning techniques for the purpose of nature conservation (biodiversity management, habitat management), landscape management, forestry and carbon management. The region of interest is temperate-boreal Eurasia and the adjoining countries of Southeast Europe, Caucasus, Central and Northeast Asia. The network is closely associated with the EU Fire Paradox project, the EU LIFE project "Rohrhardsberg, Obere Elz und Wilde Gutach" and the EU Leonardo da Vinci EuroFire project and supports the advancement of the use of prescribed fire in Eurasia. Key projects and advances in developing new fire policies are highlighted and views for future developments presented.
Website: http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm.

Introduction

The use of fire as a key ecosystem driver in many disturbance shaped landscapes of Eurasia has modified ecosystems into significant cultural landscapes (Goldammer and Bruce 2004, Küster 1999, Pyne 1997). In these ecosystems, people over time have played a significant role in creating, maintaining, expanding or changing the landscape components (Radkau 2002) that now have high conservation value. Many landscapes that are now important to conservation were created, shaped and/or maintained by human burning (Pyne 1997, Goldammer 1998, 2000). It is increasingly being recognised, with the weaknesses in the balance-of-nature paradigm and equilibrium theory, that ecological systems are dynamic (Mentis and Bailey 1990). Fire bans and complete fire suppression policies remove the positive benefits of natural and prescribed fire that both the cultural and natural heritage of many areas need. Prescribed fire can mimic disturbance events and maintain open and diverse habitats and landscapes. The structural diversity of these landscapes and habitats has also allowed significant biodiversity interests to develop over time. Given the important role of fire in these environments, trained fire managers are essential for achieving conservation goals effectively.

Fire use takes on various forms and creates various effects in Eurasia. The more traditional practices of fire use by rural people (Goldammer and Bruce 2004, Bruce 2000) that are either needed to maintain ecosystem productivity, agricultural, forestry or wildlife management outputs can still be found in some countries. In many other areas the use of fire as a land management tool has vanished as the social and economic context of a region has changed. Also lost with these changes is the role that people have played in creating, and maintaining desired landscape components, ecosystem states and ecosystem goods and services within conservation areas.

The human intervention in fire regimes ranges from: controlled burning with no written plans supported by Codes of Practise (SEERAD 2001), to prescribed fire in disturbance-shaped landscapes, to allowing wildfires to continue burning within prescription in some ecosystems. The purpose of such fires often includes a hazard reduction objective or the creation of firebreaks.

In Eurasia the new ideas embedded in prescribed burning concepts, are often used to support nature conservation and landscape management objectives (Goldammer and Bruce 2004). There are now prescribed burning projects in many of the Eurasian countries supporting a wide variety of land management objectives using a variety of techniques. Information on the work being carried out in the United Kingdom, Germany, Sweden, Finland and the Transbaikal region are given later in this paper. The Eurasian Fire in Nature Conservation Network (EFNCN) website is an important platform for discussion (EFNCN 2004).

Prescribed Fire

A prescribed fire is a management-ignited fire where the fire is confined to a predetermined area and produces the fire behaviour and fire characteristics required to achieve a planned fire treatment and/or resource management objectives. The act or procedure of setting a prescribed fire is called prescribed burning (FAO / GFMC 2003).

A prescribed fire should involve a written plan. The objectives may involve desired fire effects of a specific burn to maintain an area in its most productive state or to maintain a full range of species in an area, as well as long-term goals from the disturbance event that allows ecological processes to change over time. A repeated pattern of burning designed to reach some desired or predicted outcome can be used to either maintain a larger area in a similar condition or it can be used on a smaller scale to create a more diverse habitat structure. Recently fire-management strategies aimed to introduce increased fire variability into the landscape through the use of dynamic mosaics across space and time, often referred to as patch mosaic burning (Parr and Andersen 2006; Brockett et al. 2001).

A wildfire burning within prescription may result from a human-caused fire or a natural fire. In the U.S.A. the designation of an unplanned wildfire to obtain beneficial outcomes that lead to management goals is “wildland fire use” (USDA Forest Service 2006). Wildfires burning within prescription are likely to play an important role in remote areas of the Transbaikal region and the Russian Far East under future climate change scenarios, where the lack of resources may not allow the application of management-ignited prescribed fires on a large scale and effectively. However, prerequisites for making good wildland fire use decisions include a sound technical background in fire behaviour and a good understanding of fuel complexes, especially fuel moisture relationships.

Furthermore, effective prescribed burning is best supported by, intensive training in fire behaviour, fuels, weather, topography, and fire effects. There is also no substitute for experience. The level of training needed varies with the complexity and size of the area to be burned and the associated risks to the surrounding area in case the fire escapes control. Detailed planning and the capacity to suppress escaped fires are essential.

One of the aims of the Eurasian Fire in Nature Conservation Network (EFNCN) is to promote the use of prescribed management-ignited fires as well as wildfires burning within prescription. Recently several projects sponsored by the European Commission have supported this or are currently underway, namely two LIFE projects addressing the restoration of coastal dune heathlands in Denmark (Jensen 2004) and habitat management in the Black Forest in Germany (Anonymous 2006), the Fire Paradox project, which is currently operational (2006-2010) and promotes the use of prescribed fire and suppression fire in forestry, and the EuroFire project,

which is currently developing training materials for fire management, including prescribed burning, for land managers and fire services in Europe (Fire Paradox 2006, EuroFire 2006).

Prescribed fire also has some limitations. There are often difficulties in achieving or restoring particular fire regimes. These could be due to lack of resources, inexperience, lack of training support, difficulties with insurance or money. Also operations are sometimes driven by logistical or safety concerns to the detriment of ecological objectives (Bradstock et al, 1995). In this context it is also important to understand the difference between restoration and maintenance burning. Restoration burning focuses on very specific outcomes for each burn and may also lead to recognition that fire alone is not able to restore the desired outcome. Whereas maintenance burning calls for various fire applications within the appropriate ranges of fire conditions for a specific ecosystem. Other problems may arise from the failure in understanding the habitat size requirements of desired species, and the relationship between habitat size and habitat diversity and fragmentation of landscape components.

Smoke management techniques for prescribed fire are available to offset the negative effects on air quality, people's health and well-being that may occur when the burning is uncontrolled. The appropriate application of these techniques under European conditions is essential to shape people's perception and acceptance of prescribed fire.

Also the impact of climate change on biomass burning in boreal-temperate Eurasia is serious, especially in the ecotones of the steppe-forest transition zone of Central Asia, particularly in the Transbaikal region. Various climate change scenarios predict that the greatest temperature increase will be observed at high latitudes, in continental climate and in late winter/ early spring (Stocks 2004). It is forecast that there will be changes in temperature and fewer but more extreme precipitation events, which in turn means higher fire danger levels. This will lead to more frequent and severe fires and larger areas burned. Shorter fire return intervals may also lead to less terrestrial carbon storage and drive a shift in vegetation type. Vegetation fires can be a significant source of atmospheric carbon. Used appropriately though, ecosystems under the appropriate fire regime can be in a quasi-steady state with respect to carbon, because the amount of carbon released during a fire is recaptured between subsequent fire events. However, fire exclusion policies can also indirectly increase total carbon emissions with the most damaging fires occurring in abnormally high fuel loads. This challenge or "paradox" can only be addressed by changing the fire ban policies through the careful introduction of prescribed fire.

In the following examples of recent approaches in the use of prescribed fire in the Eurasian Region between Central Europe and Russia's Far East are given.

United Kingdom

Traditional burning techniques are used extensively for habitat management for Red Grouse (*Lagopus lagopus scoticus*) (Miller and Watson 1973, Hudson 1992), an upland game bird that lives in heather (*Calluna vulgaris*). Fire is also used extensively to regenerate grazing land for cattle, sheep and deer. In forests, fire is used to clear branches or heather from sites as a ground preparation tool prior to forest establishment by planting or natural regeneration. Firebreaks are also sometimes created alongside forests by burning. Fire is used occasionally on farmland in Scotland to burn straw, a practise that has been stopped in England and

Wales due to smoke management problems. Prescribed burning is used more frequently on private land than on publicly owned land (Bruce 2002). The continuous use of fire by shepherds and gamekeepers provides a continuous cultural link back to swidden practises used when the land was originally brought in to production thousands of years ago.

2003 was an important year for developments in fire management in the UK. Like other parts of Europe 2003 saw a significant increase in the number of wildfires and the extent of damage in the UK (Bruce, 2003). The Met Office used the data from 2003 and other difficult fire seasons to calibrate the Canadian Fire Weather Index (FWI) for conditions in England and Wales. The system, known as the Met Office Fire Severity Index (MOFSI) (Marno and Hough 2005), was launched in 2004. The Scottish Wildfire Forum was established in 2004 and the Canadian FWI was extended to cover Scotland in 2007 (The Scottish Executive 2007). Further research continues on the fire behaviour characteristics of heather fires to improve fire behaviour prediction capabilities.

Prescribed burning to improve the habitat of the woodland grouse, the Capercaillie (*Tetrao urogallus*), has been carried out in the period 2003 – 2006 as part of the EU Capercaillie Life Project. Areas of pinewoods where heather growth is suppressing blueberry (*Vaccinium myrtillus*) under the pine tree canopy are being burnt. Initial results indicate successful regeneration of blueberry is occurring. No pine trees were killed by initial crown scorch (Bruce and Servant, 2004). A fire prescription for this work was developed using a mixture of American, Australian and European (Rheinhard and Ryan 1988, Wade 1986, AFAC 1996, Uggla 1973, Sirén 1973) The results indicate that it is possible to achieve conservation objectives even with high fire intensities. Also that minor changes to technique, for example changing ignition pattern, can bring fires back within prescription.

Germany

Until recently burning was completely banned in Germany. Mechanical treatments such as “Plaggen” or sod cutting were used to conserve heathlands (Prüter et al. 2004) and replaced the traditional combination of burning and grazing. However, these techniques turned out to be very cost intensive and did not always reach the ecological goals to full satisfaction (Hoffmann and Goldammer 2004). As a consequence a variety of prescribed burning projects is now being carried out. These vary from heathland restoration projects with mainly biodiversity objectives, over culturally important swidden agricultural sites, to maintain open landscape in vineyards and for tourism in certain areas. Recently there have been on-site consultations for an overall management concept of former military training sites (shooting ranges) for maintaining open, biodiversity-rich *Calluna vulgaris* sites with explosive ordnances as one of the problems to be targeted by prescribed burning operations. A first outcome of these projects is the development of a local regulation that contains the prescriptions for the application of fire on vineyard slopes to maintain them open. A key feature of all the projects is extensive consultation with stakeholders.

Heathland restoration work using prescribed burning is occurring at: Schleswig-Holstein (Hoffmann and Goldammer, 2004), Lower Saxony (Niemeyer, 2004), Lüneburg (Prüter et al. 2004), and at Lausitz in Brandenburg (Plettenberg et al. 2004). The latter project also has the objective of improving Black Grouse (*Tetrao tetrix*) habitat.

Grassland and pasture maintenance and restoration using prescribed fire, especially on fallow land, has been investigated in long-term observations in Baden-Württemberg State and is now practised by farmers in some counties of the State. This is particularly the case on steep slopes or on poor soils where agriculture is no longer profitable. The abandonment of farmland is leading to secondary succession to scrub and forest. A number of endangered species have become threatened by this change in habitat and there is a need for secondary disturbance mechanism, such as prescribed fire (Page 2000, Schreiber 2004).

Some long term studies such as at Diepholz in Lower Saxony have shown that prescribed burning in the winter has allowed better nutrient cycling, higher quality feed, a reduction in vegetation height that has helped birds, insects and reptiles (Niemeyer 2004).

In general the results of the projects are indicating that biodiversity is stable or increasing after the prescribed burning interventions. They are also achieving most of their direct objectives of heathland regeneration or the maintenance of open landscapes at reasonable cost. Operationally the burns have been successfully coping with a variety of fire behaviour resulting in a mosaic with very high intra- and inter-patch heterogeneity.

Recent projects that are approved and currently being designed include the use of prescribed fire in fuel and biodiversity management in Scotch pine (*Pinus sylvestris*) forests in Baden-Württemberg State. This project is the first of its kind since a pilot project was conducted in 1977 (Goldammer 1979), followed by an era of rejection of the concept of almost 30 years (Goldammer 2007). Another special target for prescribed burning research and development is the application of fire on nature reserves and forested lands contaminated by unexploded ordnances on theatres of World War II and post-war military exercise areas in Germany.

Sweden

Historic evidence reveals that natural and human-caused wildfires and land-use fires are an important ecological factor in the hemi-boreal and boreal zone of the country, which contributed significantly to forest dynamics, biodiversity and landscape features (Zackrisson 1977, Page et al. 1997, Granström 2001, Niklasson and Granström 2004). Recently Swedish industrial forestry has been coming under increasing pressure both economically and from the environmental movement. In the past it is estimated that the fire return interval was 58 years when 1.7% of the forest burned annually. The level of burning today is only a fraction of this (Niklasson and Granström 2004). The absence of fire in Swedish forests has pushed several hundred of fire-adapted and fire-requiring species, predominantly invertebrates, from being common to being rare or even extinct in the country. A few of these species are strictly dependent on fire per se while the major part of this group depend on structures and processes that fire events provided in the past such as: openness and sun-exposure, dead wood, damaged trees with lowered vitality, fire scars and burnt ground. Another strongly negative effect of the combination of intensive forestry and fire suppression is the lack of seral stages dominated by deciduous trees such as *Betula*, *Populus* and *Salix* species. The reproduction from seeds of *Populus* and *Salix* is strongly promoted by fires and is now a rather rare event. The flagship species white-backed woodpecker (*Dendrocopus leucotos*) is now on the verge of extinction in Sweden as it has been confined to older deciduous dominated forest, typically created by fire. Only a hundred years ago this bird was common all over the country.

Burning was used extensively between 1950 and 1970 when around 10,000 hectares were burnt annually. The objective of this burning was to prepare the forest floor for natural regeneration in areas that had been clear felled. The gradual mechanisation of the forest industry reduced labour availability and at the same time labour costs grew rapidly so the practice stopped.

The awareness about the role of fire as an important ecological factor has increased dramatically among foresters and the public but with few exceptions this interest has not yet been turned into action when it comes to using prescribed fire as a tool. The structures, substrates and effects of fire have influenced the design of alternative management regimes. For example the Swedish Forestry Stewardship Council (FSC) certification scheme indicates that 5% of felled areas must now be burnt. This level of burning has not been achieved. This is largely due to a lack of practitioners, concerns over the risk of escapes, and a lack of resources. The example of systematic application and public acceptance of prescribed fire to achieve nature conservation goals in the Jämtgaveln and Stormyran-Lommyran nature conservation areas in Västernorrland County, however, are promising signs for future expansion of work.

Finland

With the end of the era of shifting cultivation in Finland in the early part of the 20th century, methods derived from this practice began to find use in the regeneration of under-productive forests. Burning of logging waste and the raw humus layer was recommended as a means of promoting the natural restocking of regeneration sites. Broadcast-seeding-on-snow in spring, with prescribed burning preceding it, found widespread use in the 1920s. Prescribed burning in those times amounted to approx. 8,000 ha per year. With time, however, this method's popularity declined; in the 1930s, the annual area burnt in this manner was only a few hundred hectares a year.

Prescribed burning enjoyed a comeback after World War II as a consequence of the displacement of people from parts of Karelia annexed by the Soviet Union and their need for new farmland to be created. Another aspect was the regeneration of northern Finland's spruce stands to pine with thick layers of raw humus, but this prescribed burning practices were increasingly replaced by mechanized site preparation.

The reasons behind the decline in prescribed burning have primarily been technical. The success of prescribed burning depends on weather conditions and this leads to difficulties in organising the operation. The risk of fire getting out of control, the increasing popularity of mechanised site preparation, the risk of nutrients being leached from the soil, and the increased risk for fungal or insect epidemics in the dense young pine stands are the most common forest regeneration problems associated with prescribed burning.

However, the cultural importance of burning in Finland is very significant (Pyne 1997). The eastern part of Finland was one of the last areas where the slash-and-burn agriculture was carried out in Europe. The Koli National Park in eastern Finland was established in 1991 where there are still many deciduous mixed forests and slash-and-burn meadows (in Finnish: *aho*) on burned sites in the park (Lovén and Äänismaa 2004). Since 1994, every year a small area ranging from 0.3 to 2.5 ha of forest has been cut down and traditionally burned and cultivated to maintain the cultural tradition. Other objectives include creating a better habitat for endangered species that require fire sites and meadow sites. There is also an extensive information

programme for the project. In the future, the slash-and-burn activities will be extended in the national park using up to 150 hectares. Constraints on the prescribed fire activities include the conservation of old growth forest, mixed forests with high biodiversity, distance from heritage dwellings and the resources required for burning operations. Another goal is to make it possible to practice different slash-and-burn methods with local people to maintain the cultural heritage and to avoid political controversies extensive consultations have been made with stakeholders.

The Balkans and Caucasus Regions

The use of fire, especially in agriculture and farming, has a long tradition in the Balkan and Caucasus regions. Traditionally fire has been used for regeneration and clearing of pastures as well as for clearing and regeneration of agricultural land (Merou and Papanastasis 2002). In the past, controlled fires were also used for eradication of vegetation and debris leftover after forest felling, in the process of expansion of agriculture on new areas. This was particularly common in lower mountainous regions.

Only recently prescribed burning used for reducing debris after felling, especially after sanitation felling (Konstantinov 2003). In this case, fire reduces wood material that would otherwise be available for development of plant diseases and insect pests, particularly outbreaks of bark beetle infestations (Nikolov et al. 2003). Apart from being used after sanitation felling, fire is sometimes used for fuel reduction after regular tree cuttings. So far the application of prescribed fire for fuel reduction under canopy has not yet been applied in the regions.

Apart from this, in the past and at present, fire is used for reducing grass and shrub vegetation alongside roads, railways and other objects, which may cause a fire or are at risk. However, these fires are often set in the vicinity of forests and often result in uncontrolled forest fires.

As a consequence of human migration in the past 50 years and particularly as the consequence of the recent socio-economic and political changes in the Balkans, large rural areas have been abandoned and are now uninhabited. Former agriculture land has been invaded by vegetation succession resulting in increasingly accelerating fuel build-up. In conjunction with the consequences of regional climate changes the overall fire hazard and risk of extreme wildfires has increased dramatically. One measure to tackle this situation could be the application of prescribed fire.

In Hungary where until the middle of the last century the use of fire was a common method in open land management, the Nature Protection Act is prohibiting the use of fire. However, the new Forest Fire Protection Act (in preparation) most likely will allowed the use of prescribed fire as a wildfire prevention measure. In 2005 first experiments were conducted in Hungary to test the effects of prescribed fires on Hungarian forest ecosystems. After initial trials in 2005 involving a total of 5 ha burned in two national parks, already 50 ha were prescribed burned in spring of 2007 (at the time of finalizing this manuscript). In Hungary it is planned to use prescribed fire in the following four vegetation types:

- Partly managed non-forested vegetation, such as grass and bush land, where the other management methods where costly mechanical methods will be substituted by fire. These ecosystems are predominantly managed under natural protection rules and are experiencing an increase of fuel loads.

Prescribed fire effects will be monitored Arrhenatheretalia, Luzulo albidae-Callunetum, and Prunetum spinose crataegetum associations.

- Pine (*Pinus* spp.) forest logging slash (broadcast burning and under canopy burning)
- Fuel reduction and regeneration-inducing burnings in oak stands (natural stands, plantations) (Querco petraeae-cerris, Querco petraeae- pubescenti associations).
- Cleaning of fire lines in low mountain ranges area replacing mechanical methods.

First experiences in the application of prescribed fire in Hungary confirm that prescribed burning could be a near-natural and cost-effective management method for these vegetation types (Nagy 2006a, 2006b). However, the lack of training and equipment of the authorities with land and forest management is a major impediment for technology transfer. Currently Hungary is addressing this problem by appropriate measures in capacity building and public relation programmes.

This challenging task of technology transfer in the region is currently being addressed by the UNISDR Regional South Europe / Caucasus Wildland Fire Network. The network recently developed a proposal for a "Strategy on International Cooperation in Wildland Fire Management in the Regional South East European / Caucasus Wildland Fire Network" (UNISDR 2007a). The strategy will also address problems arising from the heritage of armed conflicts in the region. On the Balkans and in the Caucasus region large areas are contaminated by unexploded ordnance (UXO): minefields and other terrain with uncontrolled contamination of landmines, and UXOs on former combat theatres. Between Croatia, Serbia and the Line of Contact between the disputed territories of Azerbaijan and Nagorno-Karabakh large areas of land cannot be managed or otherwise be stepped on, e.g. for fire management, because wildfire-triggered explosions represent a deadly risk for humans (GFMC 2007b). The use of prescribed fire to facilitate UXO clearing, however, is investigated as mentioned above in the case of the large UXO contaminated terrains of Germany.

Russia's Far East

The general development including logging, recreation use, frequent and long droughts, and decrease of forest protection forces of Russia's Far East with its mammoth resources and territory (6.2 million km^2) intensify the problem of forest fires, make the scientist and practitioners to find different approaches to this problem solution. The concept of full exclusion of fire from the forest life, which was implemented for decades in Russia, also did not justify itself. At the same time, active forest fire protection led to excessive fuel accumulation and resulted in extremely severe fires in some regions of the Far East.

Though the number of opponents of prescribed burning use is still great there appeared a trend in utilizing fire as a useful tool for a series of forest tasks including fuel reduction to decrease wildfire hazard. Some of the authors arrived at the conclusion that reiterated introduction of fire, e.g. in the north and middle subzones of taiga can be considered as a force returning climax forest systems to a more juvenile (initial) stage of development (Sheshukov et al. 1992; Sheshukov 1984).

Prescribed fires in the Far East of Russia are used mostly to remove dry grass as a measure of preventing fires and in sufficiently less extent to eliminate logging debris (fuel management) and promote regeneration. Just before the 2005 fire season the Russian Forest Service (*Rosleskhoz*) realized prescribed burnings on an area of 1.5 million hectares all over Russia. Every forest enterprise (*leskhoz*) was obliged to include preventive burning in their management plans (about 1000 hectares in the European part of Russia). However, there are doubts that during the last decade the *leskhozes* were able to fulfil these tasks. At the same time, burnings conducted by unskilled people frequently resulted in harmful peat fires, which made more harm than good relating to public education.

The Russian Forest Research Institute *VNIIPOMleskhoz* began investigations and experiments of controlled preventive burnings under the forest canopy from 1997 on. It is established that controlled burnings are a comparatively cheap method of decreasing fire danger and facilitating natural regeneration. The Institute proved the possibility and appropriateness of prescribed burnings under the canopy of pine and larch stands in the sub zone of southern taiga, forest-steppe zone, and in high belts of submontane and low montane taiga. The institute recommend so-called stripe burnings (burning on stripes or those sites that had higher anthropogenic fuel loads, to create fire barriers) since such technology on the whole does not contradict the existing rules of fire safety in the forests of the Russian Federation. These rules allow prescribed burning on forest lands in early spring, by creating fire barriers by burning vegetation cover between two mineralized stripes.

The Far East is clearly behind in the awareness of the use of fire as an integrated tool for fire and forest management. M. Sheshukov, on the basis of his experimental and theoretical works, came to the following conclusions: The use of prescribed fire under conditions of the Far East is useful mainly to foster forest forming processes and improve vegetation growth conditions on the respective habitats. Prescribed burnings with such a goal are suitable for the north and middle taiga sub zones in those regions that have continuous or discontinuous permafrost resulting in accumulation of litter and raw humus, and finally in the formation of *Sphagnum* mosses and peat bogs (Goldammer and Kondrashov 2006). M. Sheshukov, in finalizing his approach to prescribed burning in the conditions of the Far East, repeatedly demonstrated his method of prescribed burning under canopy in larch stands in Khabarovsk Territory. Experimental prescribed burnings were implemented in Okhotski *leskhoz* (Khabarovsk Territory) in dispersed stands and under the canopy of mature and overmature larch stands. [12]

Thus, there is still a gap between the theoretical acknowledgement of the necessity of prescribed burning and the possibility to realize this method in practice. However, in the frame of the above-mentioned Fire Paradox project a series of prescribed burning experiments will be conducted in Russia and Mongolia, which for sure will increase the number of adherents of this method. Before a wider introduction of this prescribed burning technology into practice it is necessary to create the prerequisite conditions in capacity building by introducing appropriate training of the foresters and fire managers. In connection with the restructuring of the

12 Note: These materials are currently prepared for publication. Some data relating prescribed burning on pigweed (*Axyris amaranthoides*) were summarized by H.P. Telitsyn and V.V. Ostroshenko.

Russian forestry sector this task is challenging but currently jointly addressed by the Global Fire Monitoring Center (GFMC) and *Rosleskhoz*. [13]

Central Siberia

The history of forestry in Central Russia (Central Siberia) shows a wide use of fire as understory "refreshing" measure for fuel reduction and stimulation of mushroom growth, as well as for fuel reduction burns on logged areas by broadcast burning (Tkachenko 1931). The third goal of fire use was and still is the renewal of honey meadows. Until the middle of the 20th century the use of fire in Russian forest management was almost fully forbidden, with the exception of slash burning on piles during the winter period. However, positive influence of surface fires had been noted in the beginning of last century and it was offered to use fire as helpful instrument for planting (Tkachenko 1911). Some authors offered prescribed fires for broadcast burning of slash fuels after logging (Pobedinsky 1955), understory burning in mature pine stands 5-10 years before logging (Belov 1973), surface fire using as thinning instrument of pine saplings (Furyaev 1974), broadcast prescribed understory burning of pine and larch stands of 40-50 years for wildfire hazard reduction (Melekhov 1983).

The new era of fire use in forestry of Russia encouraged foresters and scientists to look for more effective and cheap methods of cleaning logged areas and facilitating reforestation. Following the large basic scientific experiment and a regional fire analysis in the frame of the Fire Research Campaign Asia-North (FIRESCAN) in Krasnoyarsk Region in 1993 (FIRESCAN Science Team 1996; Goldammer and Furyaev 1996) the development of prescribed burning techniques was supported by international projects, such as Sustainable Forestry, FIREBEAR, ROLL USAID (Valendik et al. 2000). Starting from 1996 experimental prescribed fires in logging slash in Siberia have been conducted under the auspices of the Russian-American Central Siberian Sustainable Forest Management Project, which is a joint venture between the V.N. Sukachev Institute of Forest (Siberian Branch of the Russian Academy of Sciences), the Krasnoyarsk Forest Committee of the Russian Federal Forest Service, and the USDA Forest Service (Valendik et al. 1997, 2000, 2001, 2004).

The experimental fires were studied on clearcuts at coniferous forests on flat and mountainous terrains, as well as understory burning in pine stands and broadcast burning of stands dead after defoliation by insects, notably the Siberian silk worm (*Dendrolimus superans sibiricus* Tschetverikov).

High load of slash fuels is the main cause of logged areas high fire danger. Mechanical removal of slash fuels practically impossible due to the labour-consuming character and the absence of suitable equipment. As the costs of mechanical slash and debris piling and removal increased considerably during the last decades, the forest enterprises rejected these mechanical methods. Alternatively, prescribed burnings on logged areas showed that under certain conditions, including fire behavior, the goals of post-harvest treatments can be reached by cutting costs half or more for slash removal for site preparation to facilitate natural regeneration or reforestation by planting. Removal of natural forest and slash fuels using broadcast prescribed burning on logged areas starting from 1996 by 2001 in area summed more

13 Concept for advanced 3-level fire management training in Russia is currently developed by the two organizations.

than 900 ha in Krasnoyarsk Region (Central Siberia) allow to solve three main issues. First, logged area fire danger fully disappears during 2-3 years and it is very low during 5-10 years after prescribed burning. Second, prescribed burning creates conditions for natural and artificial regeneration. The last involves planting seedlings or sowing seeds. Third, prescribed fire excludes soil erosion inherent in mechanical treatment and strengthens fireweed growth favouring the development of coniferous seedlings (Valendik et al. 2000, 2001).

Forest pests cause great annual wood loss and are a major economic problem in forest management. During the end of the last century Siberia experienced the outbreak of Siberian silk worm, resulting in huge areas of dead forests. One decade after mass infestation these stands are collapsing (Furyaev 1966; Grodnickiy 2001). Defoliated forests represent two major problems for resource managers: they have high potential for forest fires and they may become unproductive wastelands. Because the volume of standing and down dead wood is high, moth-killed areas attain high flammability in early spring and fires can occur throughout the fire season (Valendik et al. 2006).

The average area burned per fire can increase dramatically. For example, in the Usolsky *leskhoz*, the number of fires 6 to 8 years after the most recent outbreak of Siberian moth doubled compared to before the outbreak but the total area burned increased many fold (Valendik et al. 2004).

Mechanical treatment and prescribed fire were used to restore a mixed conifer stand (*Picea-Abies-Pinus*) following mortality from an outbreak of Siberian moth (*Dendrolimus superans sibiricus*). Moth-killed stands often become dominated by *Calamagrostis*, a sod-forming grass. The large amount of woody debris and the sod hinder coniferous seedling establishment and development as well as creating conditions favourable to the establishment and spread of wildfires. Fire has been demonstrated to be an effective method of reducing woody debris and eliminating sod, but the random nature and timing of wildfires often do not create conditions favourable for conifer regeneration. A study was conducted in a mature fir dominated stand that died during an outbreak 6-8 years before the study with most of the dead trees still standing. A bulldozer drove through the stand downing standing snags in late summer with 15-20 m between passes. Snags knocked down by the bulldozer and additional snag fall throughout the following winter increased downed dead wood 50-60% and large downed dead wood 80% compared to an adjacent untreated area. In June, a prescribed fire was set and fuel load consumption averaged 70%. Average soil temperatures during the burn ranged from 47°C at a depth of 2 cm to 10°C at 10 cm; hot enough to kill the grass. Following treatment, the potential for wildfire was reduced and the area was suitable for either natural conifer regeneration or planting without further mechanical site preparation (Valendik et al. 2006).

Another issue related to fire and forest management is forest fires in wildland-urban interface. People can be injured in fire and homes and properties could be destroyed not only in small-populated areas but small cities. The suppression of any fire in the forest surrounding villages all over the country led an unnatural increase of fuel loads, resulting in high-intensity crown fires that threaten settlements. These kinds of catastrophic forest fires occur not only in Eurasian boreal forests but also in other forests of our planet. The creation of park like stand without regrowth and understory with minimal surface fuel load near populated areas will exclude catastrophic forest fires (Valendik et al. 2002).

To develop methodologies of fuel reduction in these forest areas, experimental understory prescribed burnings have been conducted. As a result of these studies understory spring prescribed burnings in the light coniferous stands around the villages and along the roads have been introduced into the practice of forest management.

Special rules and guidelines for prescribed burning have been developed and published in cooperation with regional forest enterprises. Crews of foresters and firefighters have been trained during these experiments. A range of demonstration plots of prescribed burning was established to serve for long-term monitoring of post-fire succession. These plots will be integrated into the Eurasian Fire in Nature Conservation Network as well as in the Fire Paradox demonstration plot network. The cooperation with these networks will allow further studies of both prescribed burnings (fire danger, fire behaviour, fire effects) and long-term fire successions in Siberian forests. The results will be important to extend to other regions of the Russian Federation.

Central Asia: Mongolia and Trans-Baikal Russia

In Central Asia – in the region between Kazakhstan, Mongolia, Russia's Transbaikal region (Chita, Buryatia) and Amur Region, as well as North China – large tracts of the landscape are covered by Siberian Larch (*Larix sibirica* Ldb.), Scots Pine (*Pinus sylvestris* L.) and birch stands (*Betula platyphylla* Sukach.) stands and steppe vegetation. Recurrent wildfires and the long-term consequences of anthropogenic fires have resulted in widespread formation of open coniferous stands with a grass stratum, locally called "grass forests". These open forest ecosystems are quite well adapted to regular surface fires. However, as a consequence of recurrent droughts in Central Asia an increasing occurrence of high-intensity and high-severity fires has been noted, resulting in fire-induced forest decline and a gradual expansion of steppe ecosystems (Chuluunbaatar 2002, Goldammer 2006). In the early 1990s prescribed burning of the grass layer has been used extensively Chita, Buryatia and Amur regions in spring time in order to reduce highly flammable surface fuels under canopy and to create fuel breaks to reduce spread of uncontrolled grass fires into forests. However, as a consequence of reduced budgets the annual area treated by prescribed fire has been reduced considerably (Table 1).

***Table**—1. Forest and grassland area treated by prescribed fire in Chita, Buryatia and Amur regions. The numbers reveal a decline of prescribed burning activities. Source: GFMC database*

Year	Area prescribed burned
1993-1996	1.0 - 4.0 million ha / yr
1997	4.2 million ha
1998	3.9 million ha
1999	1.4 million ha
2000	1.3 million ha
2001	50,000 ha
2002	40,000 ha
2003	60,000 ha

A paper highlighting future concepts of forest fire protection in Russia presented by Davidenko (2004) at the Regional Baltic Wildland Fire Network Meeting

(Helsinki, Finland, May 2004) postulates the application of prescribed burning for fuel reduction and underscores the need for legalizing prescribed burning and developing regulation and budgets for regular application of prescribed burnings.

In Mongolia the application of prescribed fire for fuel and high-severity wildfire reduction has been proposed in the late 1990s (Goldammer 1991) for reducing fuels in coniferous forests that are adapted to low- to medium intensity fires but susceptible to high-intensity / severity fires. Between 2007 and 2010 the first prescribed burning experiments will be conducted in the frame of the partnership between the Eurasian Fire in Nature Conservation Network (EFNCN) and Fire Paradox, aimed at establishing demonstration sites for the use of prescribed fire, which will be closely coordinated with demonstration plots in Central Siberia and Russia's Far East.

Discussion

It is said that the seeds of failure are sown in success and the swings in the use of fire in land management in Western and Baltic Europe have been significant. There have been periods when fire has been used skilfully and sustainably. There have been other periods, when often due to excessive population growth, fire has been used too intensively and ecological damage has resulted.

The rise of "rational" thinking in the Enlightenment from the 18th century led to an emphasis on manurial systems for agricultural fertilisation, rather than fire based systems, in most of Europe. Fire was regarded at best as a necessary evil. The rise of input dominated production systems further drew land management away from the use of fire except in pastoral or hunting areas. Some use of prescribed fire continued as part of forestry practise. Politically fire was not popular. The potentially positive ecological value of fire was rarely considered.

There has also always been an economic and a technical influence on the use of fire. It has a cost and it has extensive risks. In some places it has a positive influence and in other situations a negative influence. With the upsurge in interest in heritage issues, both ecological and cultural, over the last 30 years there has been a gradual re-evaluation of the role of fire. Sometimes this has produced a constraining influence such as in the production of Best Practise Guidance in the United Kingdom. In other parts of Western and Baltic Europe, where the use of fire has almost disappeared, some positive uses of fire are being re-established. A key difference compared to previous approaches are the extensive consultations that are carried out with stakeholders, especially environmental organisations, at different levels in society.

Practical safety issues relating to the build up of fuel loads, especially fine fuel loads, have yet to be addressed by policy makers. There will always be ignition sources and this leads to significant fire seasons occurring in unusual places when there are droughts, such as happened in the spring of 2003 in the United Kingdom and in summer of the same year all over Europe.

Conclusions

The history of the use of fire in land management provokes mixed reactions, usually a negative one, from people who are not closely associated with the need for fire. The development of the full panoply of support systems for prescribed burning such as: fire ecology, fire science, fire models, fire danger rating systems and modern fire suppression systems has been slower than in more fire prone and fire adapted parts of the world such as Australia, the USA and Canada but progress is now being made.

The concept of fire ecology and prescribed fire is developing a new language and framework that will support a better dialogue between stakeholders and a more targeted use of fire in the management of land in many parts of Eurasia. A recent analysis of the introduction of the term "Feuerökologie" in the German scientific language and in the public reveals that the acceptance of this concept has gained an enormous momentum (Goldammer 2007). The key benefits of the developing Eurasian Fire in Nature Conservation Network is the improvement in communication between people managing similar ecosystems in similar climates bridging the old barriers of language and culture. The improved dialogue and the new prescribed fire projects will also help to inform policy makers about the factors that influence fire behaviour and consequent fire effects. This should hopefully lead to the creation of a more sustainable policy framework for prescribed fire in Eurasia.

Opportunities and challenges ahead

At the end of a pan-European dormancy in the application of advanced concepts of fire management there is currently an enormous momentum of development underway to develop user-oriented prescribed burning practices for those ecosystems in which fire is needed as an important disturbance agent. The consolidation and expansion efforts of the Eurasian Fire in Nature Conservation Network (EFNCN), involving international cooperation and personnel exchange, will play an important role in technology transfer and enhancing a dialogue between those countries that had abandoned fire practices for too long time. This process will be flanked and supported by the UNISDR Global Wildland Fire Network and its four regional networks that are operational in Eurasia (Baltic Region, Southeast Europe/Caucasus Region, Central Asia, Northeast Asia) (UNISDR 2007b). The Fire Paradox programme, which will be active between 2006 and 2010, will essentially contribute to this momentum by a systematic exchange of expertise in prescribed burning methodologies between Southern Europe, temperate-boreal Eurasia and North Africa. Together with the EuroFire project these regional initiatives will contribute to enhance capacity building in fire management, including wildland fire suppression, for the public and private stakeholders in Europe.

The prescribed burning projects and programmes that are currently conducted in the greater Eurasian region are largely in the hands of a restricted number of specialized teams. The initiation of a policy dialogue in Europe is necessary to revise legislation and to sanction best practices in prescribed burning. In this context a clarification is needed on the role and contribution of future fire management concepts in Europe in relation to the Kyoto Protocol. While it is clear to the fire management specialists that sound prescribed burning technologies will keep the terrestrial carbon stocks on burned sites in a long-term equilibrium, although a dynamic process of release and sequestration of carbon is involved, they also need to be sensitive to the concerns of those who fear that excessive fire use may lead to site degradation and a depletion of terrestrial carbon stocks. This perception is particularly relevant in the political context of climate-change and the desiccation and vulnerability of organic soils and peatlands. The discourse on the increase of prescribed burning activities in the United Kingdom, recently fanned by the study of Yallop et al. (2006), will certainly be followed-up by those who are concerned about fire smoke impacts on human health and security (see Stratheropoulos and Goldammer 2007). The threats of unexploded ordnance including land mines on former military exercise areas and combat theatres as well as the contamination of forests and other ecosystems by radionuclides as a consequence of nuclear accidents

or nuclear weapons tests during the Cold War constitute further limitations in the use of prescribed fire in Eurasia (Dusha-Gudym 2005, Goldammer 2006).

This shows that there are opportunities and limitations for the new generation of fire managers in Europe, which is eager to define a new role for an ancient land management tool.

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