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INTERNATIONAL FOREST FIRE NEWS

No. 42
January – December 2012

UNITED NATIONS

ECE/TIM/IFFN/2012

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New York and Geneva, 2012

NOTE

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UNITED NATIONS PUBLICATION
ISSN 1029-0864 (web version)

International Forest Fire News (IFFN) is an activity of the UNECE/FAO Team of Specialists on Forest Fire and the Global Fire Monitoring Center (GFMC). IFFN is published on behalf of UNECE Timber Committee and the FAO European Forestry Commission. Copies are distributed and available on request from:

UNECE Trade Development and Timber Division
Timber Branch
Palais des Nations
1211 Geneva 10
SWITZERLAND
Fax: +41-22-917-0041
E-mail: info.timber@unece.org

The publication is edited and prepared by Johann G. Goldammer, Leader of the UNECE/FAO Team of Specialists on Forest Fire, at the Global Fire Monitoring Center (GFMC), Germany.

Mailing address, telephone and fax numbers of the editor:

Johann Georg Goldammer
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
79110 Freiburg
GERMANY

Fax: +49-761-80 80 12
Tel: +49-761-80 80 11
E-mail: fire@fire.uni-freiburg.de

All IFFN contributions published between 1990 and this current issue are accessible through country folders and other special files on this GFMC website:

http://www.fire.uni-freiburg.de/iffn/iffn.htm

Call for contributions

Readers of the International Forest Fire News are warmly invited to send written contributions to the editor at the above address. These may be in the form of concise reports on activities in wildland fire management, research, public relations campaigns, recent national legislation related to wildfire, reports from national organizations involved in fire management, publications or personal opinions (letters to the editor). Photographs (black and white) and graphs, figures and drawings (originals, not photocopies, also black and white) are also welcome. Contributions are preferably received by e-mail.

INTERNATIONAL FOREST FIRE NEWS (IFFN)
IS AN ACTIVITY OF THE TEAM OF SPECIALISTS ON FOREST FIRE OF THE UNECE TIMBER COMMITTEE, THE FAO EUROPEAN FORESTRY COMMISSION, AND THE GLOBAL FIRE MONITORING CENTER (GFMC)

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The IGBP International Global Atmospheric Chemistry Project (IGAC) Focus Impact of Biomass Burning on the Atmosphere and Biosphere "Biomass Burning Experiment" (BIBEX)

The International Union of Forestry Research Organizations (IUFRO)
Forest Fire Research Group 8.05

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Acknowledgements

The Secretariat takes this opportunity to thank the editor of the IFFN, Professor Johann Georg Goldammer of the Global Fire Monitoring Center (GFMC) and his team for preparing this issue of IFFN.

The Secretariat also wishes to express its appreciation to the national and international agencies who work together and are co-sponsoring the IFFN and GFMC: Deutsche Gesellschaft für Internationale Zusammenarbeit, the International Boreal Forest Research Association Fire Working Group, the International Global Atmospheric Chemistry Project, the International Union of Forestry Research Organizations, the United Nations International Strategy for Disaster Reduction, the United Nations University, the U.S. Department of the Interior Bureau of Land Management, and the World Conservation Union.

EDITORIAL

In following up the IFFN issue No. 39 (2010) in which we published two essays by the environmental and fire historian Stephen J. Pyne the Global Fire Monitoring Center is proud to present an essay authored by a former staff of GFMC – Jessica O'Brien. "Blazing a Trail" reviews the global physical, ecological and social drivers of landscape fire in an era of unprecedented global change. The essay provides a comprehensive analysis of the role fire in the Earth System, spanning from prehistoric, evolutionary times to the late Anthropocene and beyond.

The Regional and Country Reports of this issue are bringing us back to the realities, needs and options for response in fire management. In the Asia-Pacific region priorities are increasingly given to fire management approaches by involving and challenging local communities to take responsibility in local, participatory fire management. Under the leadership of the UNISDR Regional South Asia Wildland Fire Network Nepal hosted the "Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities" and could demonstrate its advances in expanding principles of community-based forest management to include fire management.

Two reports about consultations in fire management from the Eastern Mediterranean – from the Aegean See of Greece and from Israel – reveal the problems that go along with demographic and land-use changes, regional climate change and changing fire regimes – with severe impacts of fire on ecosystems and society.

Last not least – the report from the 2011 fires season in the Russian Federation reveals the challenges for managing fires in a country that owns the largest forest resources in the world, which are becoming increasingly vulnerable to changes of climate and fire regimes.

Enjoy reading these articles!

Freiburg – Geneva, December 2012 Johann G. Goldammer

Essay

Blazing a Trail:
A Review of the Physical, Ecological and Social Drivers of Landscape Fire in an Era of Unprecedented Global Change

Jessica O'Brien, Global Fire Monitoring Center (GFMC)

Summary

The complexity of the interaction between humans, ecosystems, climate and fire makes finding suitable management practices and policy for human societies to sustainably coexist with fire an immense challenge. This process is hampered by failure to understand landscape fire as the function of interrelated ecological, biophysical and cultural components which operate, with feedbacks, across temporal and spatial scales. A recent series of disastrous fire events around the world indicate that landscape fires are threatening societies as never before; impacts include smoke-related health problems, loss of human life and property, loss of biodiversity, the diminished provision of ecosystem services and accelerated flux of atmospheric greenhouse gas. Landscape fire, however, is a critical and essential component that underpins ecosystem function in many terrestrial ecosystems.

Across the globe, anthropogenic global change is destabilizing fire regimes with harmful and unexpected consequences for ecosystems and for people. Failure to regard landscape fire in its totality; its drivers, its constraints, and its interaction with humans and the environment will lead to a greater incidence of the types of disastrous fire events witnessed across all inhabited continents in recent years. This paper aims to review recent literature on landscape fire by examining the complex interactions between the physical, ecological and social realms of fire. This is timely given that unprecedented global change is likely to make sustainable human existence with fire more problematic.

Introduction

The Earth is an inherently flammable planet. Currently there are two dominant forms of combustion: terrestrial biomass burnt by landscape fires and fossil and harvested biomass burnt by humans for many purposes (Pyne 2004). Landscape-scale fires are critically important for both human societies and to the majority of terrestrial ecosystems worldwide (Bowman et al. 2009). Tensions exist, however, between the potential for uncontrolled fires to cause deleterious social, economic and environmental impacts and the inherent need of some ecosystems for recurrent fire disturbances. More problematically, anthropogenic climatic change driven by fossil fuel combustion and land use changes are leading to novel patterns of fire on Earth (Flannigan et al. 2009). These unprecedented changes have the capacity to alter the structure and function of ecosystems and to impact atmospheric and biogeochemical cycles. Collectively, these changes will further transform the way in which humanity coexists with fire via direct and indirect feedbacks (Lavorel et al. 2007).

Humans have an ancient and unique relationship to fire and have utilized and spread fire around the earth since the early stages of hominine evolution. The antiquity and complexity of the human-fire-vegetation nexus blurs the distinction between natural and anthropogenic landscape fire. Throughout history people have manipulated fire activity by modifying ecosystems, altering vegetation and controlling ignition (Marlon et al. 2008; Carmenta et al. 2011). The relationship between humankind, fire and landscapes is thus so entangled that disaggregation is an implausible objective (Pyne 1994). Nonetheless, debate continues about the relative influences of humans versus climate on current and historical fire activity (Marlon et al. 2008; Pausas and Keeley 2009); as the extent to which anthropogenically mediated fire activity deviates from background 'natural' levels of fire has important ramifications for our capacity to manage and persist in fire-prone landscapes. For example, it remains unclear whether recent large disastrous fire events (Flannigan et al. 2009) represent a natural disturbance or they indicate clear failures of human management. Disturbingly, there is strong evidence that severe fire incidents have been increasing in recent years in many parts of the world (Goldammer and Stocks 2011) and the need to understand the drivers of these fire events is therefore urgent. In order to outline the complexity of fire activity on earth, we will artificially disaggregate the biological, climatic and human components of landscape fire and examine each individually, while

underscoring the complex relationship and feedbacks that exist between the drivers of fire activity on Earth.

Contemporary societies remain fundamentally dependent on fire, but this dependency has many different guises, from swidden agriculture to industrial combustion of fossil fuels (Bowman et al. 2011). More than ever before humans are altering patterns of fire on Earth by land clearance, by mixing agricultural and invasive exotic species with native biota, by changing patterns of ignition and by actively suppressing fires. A relatively recent permutation of human-fire interaction, fossil fuel combustion, is causing profound global change. Besides altering vegetation and ignition, humans now directly impact the ultimate control on fire activity, climate, via the release of greenhouse gases from combustion (Flannigan et al. 2009). Alarmingly, the amplification of fire activity linked to global warming may overwhelm our capacity to manage landscape fire and further, may represent a positive feedback loop to climate change as changing global patterns of fire have the potential to accelerate the flux of greenhouse gas to the atmosphere, enhancing global warming and potentially leading to further increases in fire activity (Crutzen and Goldammer 1993; Stocks et al. 1998; Bowman et al. 2009).

Globally, landscape fires are responsible for enormous, albeit difficult to quantify, social and economic costs (Gonzalez-Cabán 2013). The negative impacts of uncontrolled fires include loss of human life, loss of livelihood and property (e.g. animals and agricultural assets), indirect costs of settlement evacuations and impacts on regional economies stemming from resource loss and the enormous expense of fire suppression activity. Beyond the immediate damage to lives and property, landscape fires are causing wide-ranging negative health impacts which stem from the release of smoke and other pollutants that are transported long-distances from the initial fire via global teleconnections (Heil and Goldammer 2001; Goldammer et al. 2009). Global pre-mature deaths attributed to smoke pollution from landscape fires have been recently estimated at an annual average of 339,000 (Johnston et al. 2012). It is therefore critical that we comprehend the culturally mediated drivers of fire and the relative deviation from background levels of ‘natural’ fire activity, in order to minimise the impacts of landscape fire on human health, property, and ecosystems. Clearly the path to a sustainable relationship with fire demands an integrated perspective of fire in the earth system, considering the interlinked physical, biological and social dimensions of landscape combustion (Pyne 2007).

Rationale for Review

There are scholars who have argued the need for a more synergistic understanding of the interconnected social, ecological and biophysical drivers of fire (Crutzen and Goldammer 1993; Pyne 1994) but regrettably, their call to broaden fire scholarship to include human and ecological elements, interactions and feedbacks, has been muffled among prevailing traditions of scientific reductionism whereby landscape fire has long been regarded as an abstract physiochemical reaction and the study of its drivers and impacts arbitrarily divided amongst various disciplines with little cross-referencing between them (Pyne 2007). Indeed, there is a gap between the visionary work of those few scholars and the majority of the scientific literature centerd on the physical aspects of fire and fire behaviour. This disproportionate focus on the physical realm has hindered the appreciation of landscape fire as a biological and cultural phenomenon of immense evolutionary, ecological and social importance (Pyne 2007). The primary motivation of this review is to provide a timely synthesis of the tripartite ecological, physical and cultural dimensions of fire, reviewing significant recent literature. To do this I will outline fire’s ancient evolutionary role in the earth system, consider human’s unique relationship with fire and examine how anthropogenic global change is leading to new patterns of fire on Earth with the potential for adverse impacts from local to global scale. Finally, I will discuss how a more integrated discourse on landscape fire is prerequisite to developing management options to coexist with the potential for fire events of unprecedented scale and impact under global change conditions.

Fire in the Earth System

Fire’s ancient presence in the earth system, predating humans by hundreds of millions of years, indicates that natural landscape fire was characterised by a complex interaction between biotic and abiotic factors. Charcoal data show that fires began to burn on Earth shortly after plants colonized land (420 million years ago), thus creating the necessary preconditions for burning: flammable fuel and sufficient atmospheric oxygen to sustain combustion (Scott 2000; Glasspool et al. 2004). Landscape

fire additionally requires an ignition source, climatic conditions that allow for the growth of ample vegetation for fire to spread, subsequent climatic conditions that lead to desiccation of the vegetation (typically, a seasonal dry period) and atmospheric and weather conditions conducive to combustion (Krawchuk and Moritz 2011).

Pre-human fire was therefore dependent on the interplay between ecological variables: controls on vegetation, and physical variables: climate, weather, topography and ignition sources such as lightning and volcanoes. There are an array of different sources and proxies that provide data about landscape fire over very different temporal and spatial resolutions. Satellite remote sensing records daily fire events, tree-ring data and chemical isotopes span decades, centuries or even millennia; and written documentation and long-term sediment go back several thousands of years and finally, charcoal and geologic records offer evidence of fires that burnt millions of years ago as shown in Figure 1.

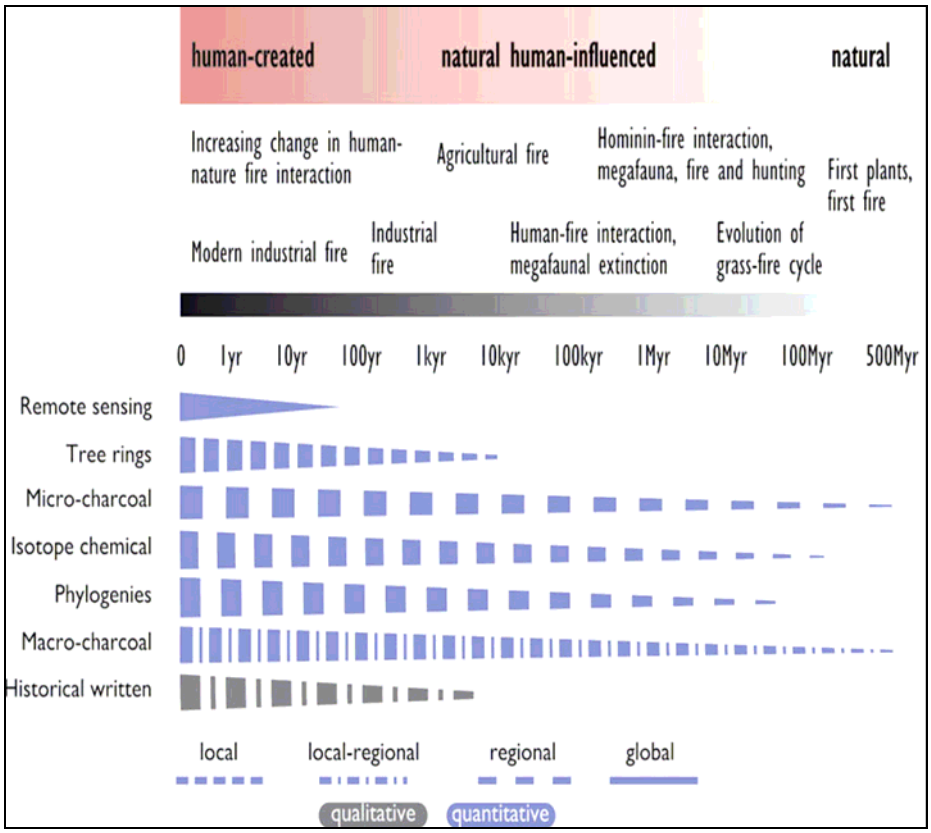


Figure 1. Sources of information about landscape fire at varying spatial and temporal resolutions, spanning the period from the advent of fire on Earth 400 million years ago to the present day Anthropocene, where landscape fires form only a partial picture of combustion on earth, augmented by the prolific burning of fossil fuels. The various sources and palaeoecological proxies for fire cover different spatial and temporal scales. Source: Whitlock et al. (2010).

Palaeoecology of Fire

Charcoal preserved in sediment layers is an important source of information about fire activity in the Earth system over millions of years of geological history (Scott 2000). Other proxies for burning, such as tree-rings and chemical isotopes, allow us to trace historical fire activity over narrower temporal resolutions; decades, centuries and millennia. Together these data sets provide insight into the palaeoecology of both pre-human and anthropogenically influenced fire; however, there are limitations and biases. Vegetation and charcoal tend to fossilize more readily in areas of humid climate, around lakes and rivers, while fossil evidence of fire is scarce in precisely the areas of the world which are most likely to burn, semi-arid systems, because sedimentary layers are less likely to accumulate in these drier environments (Midgley and Bond 2011). Nonetheless, advances in palaeoecology have uncovered evidence of landscape fires which have ignited naturally across the entire range of terrestrial biomes, throughout deep time (Scott 2008).

Palaeoecological records reveal correlations between fluctuating fire activity and levels of atmospheric oxygen. In the late Permian (ca. 270 million years ago) with atmospheric oxygen levels at 30% (significantly higher than the current 21%), fires began to occur in a wider range of ecosystems across the globe (Scott and Glasspool 2006). Scott and Glasspool (2006) showed that the higher the relative proportion of oxygen in the atmosphere, the greater the probability that the vegetation will burn. Conversely, decreases in atmospheric oxygen are paralleled by declines in charcoal, indicating a significant reduction in biomass burning, with seldom evidence of fires in periods when atmospheric oxygen levels have fallen below 13%.

While there have been attempts to identify trends in climatic variation and fire activity throughout geological history (Marlon et al. 2008; Pausas and Keeley 2009), correlations between fire and climate are not as clearly discerned as trends between atmospheric oxygen and fire at a global scale. The signals are less clear because of the complexity and feedback loops that characterise interaction between climate, fire and vegetation. We will return to discuss fire and climate interactions in detail at a later stage.

Evolutionary Significance of Fire

Evidence of wide-spread landscape fire dates from ca. 350 million years ago (Scott 2000) and charcoal records indicate that fire has interacted with plants and animals for several tens of millions of years (Scott 2000; Pausas and Keeley 2009). However, the ecological and evolutionary significance of fire in shaping landscape patterns and vegetation distribution, forging diversity and regulating energy and biochemical cycles, has historically been under-appreciated and rather poorly understood (Bond and Keeley 2005; Goldammer 2006). Darwin himself failed to recognize fire as a key selection pressure (Bowman 2003a). For example, it was traditionally thought that the global distribution of biomes was a function of climate and, to a lesser extent, geology. In a seminal study Bond, Woodward et al. (2005) refute this long-held view, using process models to show that there are many places on Earth where fire decouples vegetation from climate. Satellite imagery has shown that approximately 40% of Earth's land surface is covered by flammable ecosystems that experience frequent fire, such as tropical savannas, grasslands, Mediterranean shrublands and pyrophytic forests (Chuvieco et al. 2008) and in these ecosystems fire is the primary driver of vegetation form and assembly. Bond et al. (2005) proposed that if fire were to be hypothetically removed from the earth system, global forest area would consequently double, notably replacing C4 grasslands and savannas which are the most frequently burnt ecosystems on Earth (Bond and Keeley 2005; Chuvieco et al. 2008). In other words, many parts of the world experience climatic conditions that could theoretically support forest yet flammable, non-forest vegetation dominates the landscape due to recurrent fire disturbance (Bond et al. 2005).

Advances in palaeoecology have highlighted fire's pronounced evolutionary impact and shown that long before humans prevailed on Earth, many ecological assemblages had evolved to require intermittent disturbance by fire. Bond and Scott (2010) proposed that the radiation and spread of angiosperms in the Cretaceous (135 Ma – 65 Ma), a momentous evolutionary event, was underpinned by novel fire activity which resulted from physical conditions conducive to fire; high atmospheric oxygen, warm temperatures, seasonally dry climate and dry lightning. Bond and Scott (2010) argue that angiosperms displayed higher rates of productivity and reproduction than their predecessors, which allowed them to recover quickly after fire and meant that they could accumulate flammable biomass more rapidly, and thereby promote more frequent fire. This represented a positive feedback loop which was advantageous to angiosperms, allowing them to withstand successive fires, to spread and to diversify (Bond and Scott 2010). A recent review by Bond and Midgley (2012) expands on this paper and analyses the profound impact that angiosperms had on global fire ecology, identifying two divergent mechanisms. Bond and Midgley (2012) propose that flowering plants not only narrowed fire return intervals via rapid rates of productivity but they also formed uniquely fire-resistant assemblages. Certain tall, broadleaf forests they argue are exceptional in their ability to resist fire because their closed canopies and deeply shaded understorey preclude the accumulation of flammable surface fuels and therefore exclude fire as the understorey is too sparse and/or too moist to burn (Bond and Midgley 2012).

Novel molecular-dating techniques have also reframed our understanding of fire's antiquity and evolutionary role. Crisp, Burrows et al. (2011) analyzed phylogenetic relationships to show that 'fire-dependent' communities in Australia date back as far as 60 Ma, 50 million years earlier than previously thought. By tracing the evolutionary history of epicormic resprouting (a trait which allows

trees to recover after fire) in the Myrtaceae family, Crisp, Burrows et al. (2011) showed that it emerged concomitant with the rise of fire-prone sclerophyllous biomes in Australia. Similarly, He, Lamont et al. (2011) used dated molecular phylogenetic methods to demonstrate that serotiny (i.e., the presence of seed in the canopy which is dependent on crown fire for regeneration) arose in the Australian Banksia genus 60 million years ago. Midgley and Bond (2011) suggest that the remarkable temporal overlap between the results of the two studies is evidence of ancient fire regimes on the Australian continent which selected for communities of fire dependent species millions of years prior to human arrival. The advent of phylogenetic and palaeo-methodologies illuminate the importance of fire in shaping ecosystems through deep time, and its continued ecological significance in ecosystems of the contemporary world.

Fire is linked to the evolution of tropical savanna biomes and the expansion of C4 grasses in the late Miocene, a time when atmospheric CO_2 was much lower than today (Beerling and Osborne 2006). C4 grasses evolved a photosynthetic pathway to more effectively utilize scarce CO_2, although it was complex interaction between climate, fire and low atmospheric CO_2 which led to the expansion of savanna biomes across Asia, Africa, and the Americas 7-8 Ma (Keeley and Rundel 2005). Fire, facilitated by wet-dry monsoonal cycles, allowed C4 grasses to invade and replace woodlands. During wet periods, high photosynthetic efficiency allowed C4 grasses to produce large amounts of fine, aerated biomass which then cured to highly flammable fuels during the subsequent dry season. Further, monsoonal climate provided abundant ignitions sources in the way of lightning. In a positive feedback loop, fire allowed C4 grasses to expand into forest whereby their high productivity increased fire frequency and severity, conferring them advantage over tree species that could not grow quickly enough to escape being killed by successive fires. Today, C4 savannas burn more frequently than any other ecosystem globally, with fires routinely returning every 2-3 years (Hoffmann et al. 2002) and sometimes twice annually (Cochrane, Alencar et al. 1999). The same fire cycle mechanism that drove the global expansion of C4 grasses underpins the current dominance of C4 grasslands in areas that could climatically support forest (Bond and Midgley 2012).

Fire is a predominant control on vegetation distribution across various spatial scales. Under common climatic and geological conditions, fire has been shown to maintain two or more coexisting alternative stable vegetation states. The alternative states are maintained by feedbacks between the vegetation, fire and the environment. In Australia, pyrophobic (fire-sensitive) rainforest is found adjacent to, or even completely engulfed by, highly pyrophytic (fire-adapted) Eucalyptus forests (Bowman 2000). The two alternative states have highly contrasting fire regimes and display traits which promote their own dominance and therefore, resist a switch to the alternative state. In the flammable eucalypt forests, interactions between biotic and abiotic factors promote the frequent return of fire, which in turn, promotes the presence of flammable, fire-tolerant vegetation which regenerate quickly after fire. In contrast, the rainforest is highly resistant to fire and rarely burns, and its fire-sensitive vegetation has properties which deter fire such as perennially high moisture content under a fully closed canopy, and thus prevent the encroachment of fire-promoting species such as eucalypts (Warman and Moles 2009; Wood and Bowman 2012). The states can remain highly resistant to change as they are reinforced by complex feedbacks between fire, vegetation and other environmental factors (Jackson 1968). However, a dramatic shift in fire regime and subsequent disintegration of the fire-vegetation interaction can lead to a rapid state change (Scheffer et al. 2001). Murphy and Bowman (2012) developed a conceptual model to describe the fire-driven mechanisms that maintain savannas and closed forest as alternative stable states. They argue that forest development is limited by the interaction between tree growth rates and fire frequency and that forest encroachment and subsequent canopy closure will be promoted by factors that increase tree growth rates (e.g. elevated availability of water, nutrients, CO_2) or decrease fire frequency.

Globally, plant species across an enormously wide range of genera possess traits which allow them to persist and reproduce in environments prone to recurrent landscape fires. However, species and biotic communities are not adapted to fire per se, but rather to the particular spatial and temporal pattern of a series of recurring fires, known as the ‘fire regime’ (see text box) (Bond and van Wilgen 1996). The relationship between landscape fire and vegetation is interdependent; fire influences ecosystem form, structure and composition, while the quantity and the moisture content of the vegetation directly influence probability of ignition, the intensity and spread of fire. Given, that climate is a predominant control on vegetation form, species composition and on weather patterns conducive to fire, climate is therefore a significant component of fire regimes. Nonetheless, fire regimes cannot be easily predicted by either climate or vegetation alone because of the interactions between these and other variables. Vegetation, for instance, is also controlled by soil fertility, topography and human land use, and

vegetation can in turn modify local climate. These interactions and feedbacks complicate simple predictive relationships between climate, fire and vegetation.

The idea of landscape fire as an endogenous and necessary ecological disturbance factor which is controlled by a complex web of interaction between physical, biological and human aspects of the landscape is still an emergent concept in the study of fire (Attiwill 1994; Whitlock et al. 2010). Furthermore, the biological response in an ecosystem to a single fire can take many forms, depending on the fire's physical parameters and on the ecological response of the assembled species to successive fires.

Fire Regimes

A single fire may disturb less than 1 ha or burn over a million hectares at one time. Similarly, the interval between successive fires in an ecosystem may be as brief as intra-annual, or several hundred years long (Bond and van Wilgen 1996). The pattern of fire in a particular ecosystem is characterized by the scale (area burnt), frequency, intensity, heterogeneity, severity, seasonality and type (crown or surface fire) of successive fires; together these characteristics are known as the "fire regime".

Over evolutionary time scales, fire regimes select for a suite of fire response traits in the organisms that they impact. Species that display adaptive traits to fire can be broadly split between "sprouters"; those which survive and recover from a fire, and "seeders"; those which are killed by fire but reproduce quickly afterwards from seed (Gill 1981). Plant species can display either one (obligate), or both of these traits (facultative) (Vivian et al. 2010). Fire adaptive traits are strongly influenced by the fire regime of an ecosystem and parallel suites of traits have convergently evolved in discrete vegetation assemblages that share similar fire regimes across the globe. For example, in surface fire regimes, plants commonly survive fire and regenerate; analogous mechanisms are found in highly diverse plant taxa. For example, thick bark protects the cambial meristem of conifer trees of the Pinus genus worldwide and allows for resprouting post-fire (He et al. 2012), while many angiosperm species, such as Cork Oak (*Quercus suber*) produce epicormic branches after fire (Pausas 1997), and the monocot Xanthorrhoeaceae grass tree family of Australia retains thick leaf bases which protect the growing tissue from the intense heat of fire and allow them to withstand successive fires and regrow (Brennan et al. 2011).

Serotiny is another convergently evolved fire adaptive trait, which appears to have evolved in separate lineages across the globe in response to crown fire regimes. Serotiny is the presence of seed held in woody capsules in the canopy which is released in response to fire. In the Northern hemisphere, serotiny is unique to conifer species, while in the South, serotiny is a characteristic feature of shrublands in Mediterranean climate regions including the South African Fynbos and Western Australian heathlands, all of these ecosystems are characterized by a crown fire regime (Bond and van Wilgen 1996).

Fire and Biogeochemistry

Beyond direct impacts to vegetation, landscape fires can affect many other processes and components of ecosystems, including soils and nutrient cycles, hydrology, the atmosphere and trophic webs with knock-on impacts for fauna. Accordingly, fires can significantly alter the capacity of an ecosystem to provide services that humans rely upon including inter alia, the provision of clean air and water, soil stability and fertility and carbon sequestration. Certini (2005) reviewed the impacts on forest soils from fires of different intensities (characterized by temperature and duration of the burn). Fires can have biological, chemical and physical effects on soils and the impact of fire on soils depends on the fire's intensity and the temperature the soil is exposed to during fire. In general, only the top few centimeters of soil are affected as they are subjected to the highest temperatures. In high intensity fires, rocks can split and break down due to the extreme temperatures. Fire influences the chemical composition of soil by abruptly changing the cycling of nutrients between plants and soils. Nutrient losses following fire are influenced by soil type, soil biota, vegetation type, fire intensity and the nutrient content in the above ground biomass. Fires of low to moderate severity such as slow-burning surface fires cause a quick pulse of nutrients released from burnt biomass and organic matter which are quickly taken up again by the standing and regenerating vegetation (Certini 2005). Such fires, however, can render soils hydrophobic, meaning that water is less able to penetrate them and runs off laterally, leading to erosion.

Severe fires, such as intense crown fires, can have more profound and long lasting impacts on soil chemistry, soil organisms and soil structure (Certini 2005). Additionally, severe fires can significantly impact water catchments in two ways; firstly because regenerating vegetation display higher rates of evapotranspiration than unburned mature vegetation, water yields in burnt catchments can sharply decrease for several decades following fire (Attiwill 1994). Secondly, fires can alter infiltration characteristics and erodibility of the soil and increased erosion following severe fires can cause large quantities of sediment (soil, nutrients and ash) to runoff into rivers and lakes (Parise and Cannon 2012). These heavy loads of suspended sediment can alter water chemistry, reduce light penetration through the water column and thus change rates of aquatic primary productivity which subsequently causes flow-on effects in aquatic trophic webs. Erosion following fires can have dramatic impacts on watersheds, polluting drinking water supplies for humans and increasing the probability of landslides (Parise and Cannon 2012).

However, just as plants possess traits to survive recurrent fires, the nutrient and water cycling of a given ecosystem can display high levels of resilience to the impacts of a stable fire regime. Plants are very effective at capturing nutrients released into the soil by fire, and in many ecosystems, early successional species colonize rapidly following fire and display mechanisms, such as symbioses with N-fixing mycorrhizal fungi, which allow them to rapidly re-accumulate nutrients released by fire (Romme et al. 2011).

Effect of Fire on Wildlife Populations

Like plants, many faunal assemblages have evolved to survive fire events and some even demonstrate specialized relationships with fire. Animals survive the fire by fleeing (e.g. birds) or by taking refuge underground (e.g. some mammals, reptiles) or in unburned patches of vegetation that are protected from fire (e.g. in wet gullies). Fire also plays an important role in maintaining populations of certain animal species. Fire affects the age, structure and composition of vegetation thus creating habitats that suit different animal species. In the Kapalga Fire Experiment in Northern Australia, results showed that no single fire regime benefits all animals in that ecosystem (Andersen et al. 2005). Depending on frequency, intensity or timing of a fire some animal species benefit and others are disadvantaged. The results also showed that small mammals were most sensitive to fire frequency in general. Frequent fires decreased the population size of small mammals in tropical savannas, although no two species showed the same response. In particular, arboreal species such as possums were most impacted by high intensity fires late in the dry season (Andersen et al. 2005).

Although many species of animals do suffer reductions in populations during or immediately after a fire, most populations will recover. After a fire many animals are vulnerable due to shortages of food and/or predation by other species. The 1998 enormous wildfires burnt through Yellowstone National Park in the USA, consuming more than 1.4 million ha and taking three months to extinguish (Pausas and Keeley 2009). These fires drew vast public and scientific attention due to the unprecedented nature of their extent. At the time, science knew little about the impacts such a large disturbance would have on the ecosystems and Yellowstone became a hub of scientific inquiry into the effects of the fire. Scientists made predictions about the short and long term impacts of the fires on vegetation, biogeochemistry, primary productivity, wildlife and aquatic ecosystems (Romme et al. 2011) and long term monitoring has allowed the quantification of such impacts. Focusing on the ungulate species in the park, the actual fires caused surprisingly low levels of mortality but it was predicted that the indirect impacts of changes to vegetation would influence wildlife populations both short and long term (Singer et al. 1989). The loss of food sources due to the fires, coupled with harsh winters saw a drop in elk population in the park in the immediate years following the fires. However, 2-5 years after the fire, forage quantity and quality has recovered in burned area and by 1995, 7 years post fire, the Elk population had returned to pre-fire levels (Singer and Harter 1996).

Anthropogenic Landscape Fire

Fire has a deep history in the Earth system clearly pre-dating humans by hundreds of millions of years, however, when early humans gained the ability to carry and utilise fire they irreversibly altered patterns of fire on Earth. Earliest evidence of hominine use of controlled fire dates back to 1.0 Ma in South Africa (Berna et al. 2012), however, more robust evidence for human use of controlled fire is prevalent from 400,000 years ago (Bar-Yosef 2002; Roebroeks and Villa 2011). Humans evolved in fire-prone savannas and undoubtedly early hominins coexisted with fire (Bowman et al. 2009). This habitation of flammable ecosystems complicates precise estimates of the time of domestication of fire by people, however, it is generally attributed to the late Pleistocene, ca. 50,000 years ago, at which point humans began to alter the distribution, frequency and scale of landscape fire, carrying and spreading fire as they colonised new lands (Pausas and Keeley 2009). Fire became an indispensable universal tool for human societies and its use became integral to myriad subsistence and cultural practices, including hunting, clearing land for settlement, seeing by night, cooking, facilitating travel, controlling dangerous animals, promotion of plant food sources and even as a weapon (Pausas and Keeley 2009; Bowman et al. 2011). In certain places on earth, use of fire by humans has altered background patterns of fire so much that they drastically modified the landscape, altered distribution of vegetation and began to forge new anthropogenic fire regimes (Bowman et al. 2011).

In Australia, the magnitude of impact that controlled use of fire by Aboriginal people, sometimes referred to as “fire-stick farming” (Jones 1969), had on the Australian biota is a contentious issue. Some authors have claimed that Aboriginal used fire skillfully to manage “the greatest estate on Earth” across the entire Australian continent (Gammage 2011), while others such as (Mooney et al. 2011) claim that climate has been a far more influential driver of fire activity than indigenous burning. Indeed in Australia, where the biota has evolved with fire over millions of years, separating the impacts of climate from many millennia of human impacts on past fire regimes is extremely complicated. Nonetheless, it is widely accepted that Aboriginal strategic use of fire to facilitate resource availability, for instance to promote suitable habitats for herbivores or to increase the local abundance of food plants, has had profound impacts not only on fire regimes but also on the landscape vegetation and biodiversity (Bowman 1998). Indigenous burning practices have been shown to have created a fine-scale mosaic of seral stages across landscapes which became critical habitat for small animals such as reptiles and small-to-medium sized mammals (Bird et al. 2008), which in turn were important food species in Indigenous economies. Bowman (1998) demonstrated that Aboriginal fire management practices were important for maintaining infrequently burnt patches of fire-sensitive vegetation, such as rainforest or Callitris woodlands, in otherwise flammable landscapes, as these fire-sensitive refuges contained species of value to Aboriginal societies.

Internationally the ecological impact of pre-historic human use of fire is a hotly debated topic. While there is general agreement that humans used fire purposefully over long periods of time, contention arises over the spatial extent of anthropogenic burning and the degree to which humans were able to deviate from natural fire regimes. In spite of the difficulties in differentiating between ‘natural’ fire regimes and the influence of pre-industrial human societies on fire activity, there is evidence that humans have had significant impacts on fire activity for tens of thousands of years both directly by modifying the number and timing of ignitions and indirectly, by altering fuel structure and abundance (Bowman 1998; Pausas and Keeley 2009) and these impacts would have significantly influenced ecosystem structure, composition and function. Controlled fire has been a critical component of agricultural systems since the Neolithic revolution, ca. 12,000 years ago, when many societies transitioned from hunter-gatherer economies to more sedentary agricultural-based societies (Pausas and Keeley 2009). We will return to discuss the interrelationship between agriculture and fire further.

There are few unequivocal examples of the effects of fire use by humans in transforming vegetation and ecosystems because of the difficulty in disentangling climate influences from anthropogenic impacts on fire regimes. The best examples come from islands that have been colonised by people in recent centuries, during a period of relative climatic stability. Pollen and charcoal records show that the arrival of Māori people to the south island of New Zealand in the 13th century AD was accompanied by wide-scale burning and resultant destruction of temperate rainforests (McWethy et al. 2009). By the time Europeans colonised in the mid nineteenth century ca. 40% of the forest had been destroyed by fires. This is a remarkable example because it shows that anthropogenic fires lit by small, transient and non-agricultural societies had immense, irreversible impacts on these forests (McWethy et al. 2010). What’s more, this prodigious burning by Māori people took place in a very brief time frame, within two centuries, and the massive increase in fire activity in this time is appears to be independent

of climate. The use of fire to clear forests had subsequent harmful impacts on local ecosystem, notably increased erosion and changes to soil chemistry which also impacted aquatic systems.

In New Zealand, the effects of anthropogenic fire on vegetation and biochemistry were particularly profound because these ecosystems were historically characterized by an absence of (or extremely rare) fire activity and accordingly the species comprising these temperate rainforests possessed few adaptive strategies to withstand fire. McWethy et al. (2010) note that the example of anthropogenic fire activity and subsequent switch from forest to non-forested vegetation on the South Island of New Zealand underscores the susceptibility of closed-canopy forests to novel fire regimes and they suggest that similar vegetation types will be particularly vulnerable to changes in fire regimes that may be induced by climate change or changes in human patterns of burning in the future.

Climate and Fire Activity

Disaggregating the relative influence of climate from anthropogenic impacts on fire regimes throughout history is most difficult in parts of the world where humans and their ancestors have coexisted with flammable vegetation over many millennia, such as Africa and Australia (Bowman et al. 2011). Many important studies have identified climate as the primary driver of fire regimes across the globe, however this does not discount the profound impact humans have had, and continue to have, on fire activity via manipulation of vegetation, fuel loads and ignition at regional and local scales (Aldersley et al. 2011; Coughlan and Petty 2012). Power et al. (2008) analysed palaeoecological data from around the world since the last glacial maximum and showed over the last 21,000 years fire activity has varied across the globe, corresponding to long-term changes in global climate and shorter-term regional changes in climate, vegetation, and human land-use. During the end of the last glacial period (21-16 ka) there was less fire activity on Earth than there is today largely explained by cooler, drier global climate and lower levels of CO2 which suppressed plant growth, meaning that there was less biomass to burn (Power et al. 2008). Power et al. (2008) detected an increasing trend in biomass burning since the start of the current interglacial period (ca. 12 Ka), however, this increase has been paralleled by increased spatial heterogeneity of fire activity, with some regions burning more than present and others burning less.

Focusing on the last 2000 years, Marlon et al. (2008) conducted a similar global analysis of charcoal data and found that although climate is the primary control on fire activity globally, patterns of landscape fire have increasingly been influenced by human land use over the last two millennia. They found that global biomass burning decreased from AD 1 to ca. 1750, affiliated with a global cooling trend. Between 1750 and 1870 they detected an abrupt increase in global fire activity which they ascribe to prolific burning and land use change in Europe associated with the industrial revolution and forest clearance in the Americas and Australia following European colonisation. Since 1870, biomass burning at a global scale fell sharply despite a warming climate and population growth, which they believe is explained by land-use changes and practices that have reduced fire prevalence and include forest clearance, intensive grazing and agriculture, fire suppression policies and the substitution of fossil fuel combustion for biomass burning (Marlon et al. 2008). These palaeo studies underscore the importance of climate on patterns of fire globally, but fail to adequately capture regional variance and explain demographic and localised climate influences on fire at smaller spatial scales.

At a regional scale, historical and current patterns of fire activity also show strong climate signals, particularly in association with large scale ocean-atmosphere circulation patterns such as the El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Atlantic Multi-decadal Oscillation (AMO), which operate over multi-annual to decadal scales, and are also referred to as ‘teleconnections’ (Kitzberger et al. 2001; Goldammer and Stocks 2011). In the Amazon and across South East Asia extended drought events during El Niño phases cause the normally moist fuels in tropical rainforests to dry out and render them susceptible to fires. Accordingly, there is a strong correlation between high fire activity and El Niño periods in these regions (Cochrane et al. 1999; Goldammer 2007). Likewise, fires of extreme intensity and scale in Southern Australia tend to occur under drought conditions during El Niño events, especially when preceded by a wet La Niña period which has led to high accumulation of biomass (Verdon et al. 2004). Similarly, drying conditions caused by the La Niña phase of the ENSO in other regions of the word have been shown to increase fire activity in places such as Patagonia and Southern USA (Swetnam and Betancourt 1990; Kitzberger 2002; van der Werf et al. 2004).

In summary, at a global scale fire activity is strongly sensitive to climate, while at regional and local levels, human land use, vegetation and local climate factors also strongly influence how and when fire occurs. Given that humans, via the release of greenhouse gasses, are now impacting climate, which we know to be the ultimate control on fire activity in the Earth system, it is likely that the effects of global warming will lead to shifts in fire activity across the globe (Flannigan et al. 2009). However, forecasting what these changes may look like and how they will impact human societies is complicated by the myriad ways that humans influence fire activity through land use and impacts on vegetation.

Global Pyrogeography

Fire, unlike any other terrestrial disturbance, can be thought of as having its own ecology. The drivers and constraints of landscape fire across time and space may be conceptualized in terms of traditional ecological concepts such as resource availability (a function of vegetation and climate) and dispersal ability (a function of natural or human ignition source and suitable weather conditions) (Krawchuk et al. 2009; Parisien and Moritz 2009). The advent of satellite technology to detect landscape fire has precipitated a deeper appreciation of the truly global-nature of landscape fire (Justice et al. 2003; Csiszar et al. 2005) and has strongly contributed to the development of the discipline of 'pyrogeography' (Murphy et al. 2011). Pyrogeography seeks to understand landscape fire as a product of interaction between vegetation, climate and humans, and to explain the distribution of fire in time and space, on the explicit premise that the drivers and impacts of ecosystem fire occur at multiple spatial and temporal scales (Whitlock et al. 2010). Satellite data show that landscape fire exhibits distinct patterns on earth and have revealed geographical hotspots of fire which shift seasonally over the course of the year (see Figure 2). Recent studies have attempted to explain these patterns over gradients of rainfall, temperature, primary productivity, human population density and socio-economic metrics and to evaluate the relative influences of climate, ignitions and land use on fire activity across the globe (Meyn et al. 2007; Parisien and Moritz 2009; Krawchuk and Moritz 2011).

Le Page et al. (2010) used MODIS (Moderate Resolution Imaging Spectroradiometer) images such as those pictured in Figure 2 above to broadly describe windows of burning, or 'fire seasons', over the course of the year around the globe. In temperate and Mediterranean-climate regions of the Southern Hemisphere (Southern Australia, Sub-Saharan Africa and South America) most landscape fires occur during the southern summer months between October and March. Similarly, in the Northern Hemisphere, fires in the temperate and boreal regions burn predominantly during the dry summer months of May to September. In tropical regions the movement of the Inter-Tropical Convergence Zone(ITCZ) brings a distinct dry period to each hemisphere which allows the vegetation to desiccate and fires to ignite. Accordingly in the tropics North of the equator most fires occur during the seasonal dry period of November and March, while fires in the southern hemisphere tropical savannas and forests generally take place during the dry period of June to October (Le Page et al. 2010).

A conceptual model for the pyrogeography of Australia (although it may also be applied in other parts of the world) identifies four key drivers of fire regimes: 1) rates of fuel accumulation, 2) rates of fuel desiccation, 3) suitable weather for fire spread and 4) ignition (Bradstock 2010; Murphy et al. 2011). These four factors can be thought of as "switches" and all four must be activated in order for fire to occur. However, the switches operate over different time scales as illustrated below in Figure 3. The first switch is biomass growth, or fuel quantity. In arid environments fuel quantity is strongly controlled by preceding wet years (or 'antecedent rainfall'), while in wetter places the amount of time since the last fire strongly influences fuel quantity ('post-fire accumulation'). The second switch is the availability of the biomass to burn, which essentially is a function of fuel moisture and is influenced by climate. In wetter places, anomalously dry years or droughts, are often required to sufficiently dry out fuels enough to burn. Seasonality of fire is also an important control on fuel moisture, in the monsoonal tropics, fuels continue to desiccate during the dry season and are more combustible late in the dry season compared to early in the dry season. The third switch is the capacity of the fire to spread, which is controlled by immediate weather conditions such as strong wind speeds, low humidity and high temperatures. Finally, the fourth switch is the presence of ignitions from either lightning or humans. Variance in the relative influence of the four switches and the rates of 'switching' between ecosystems results in high diversity of fire regimes, or 'pyrodiversity' (Bradstock 2010).

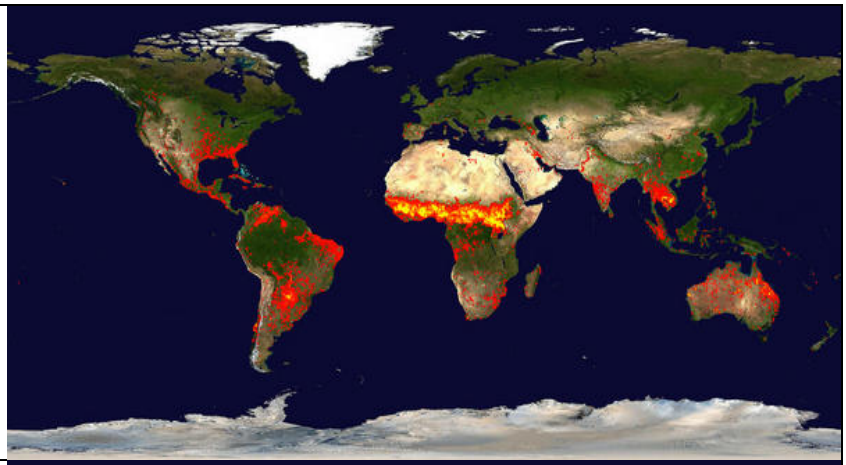
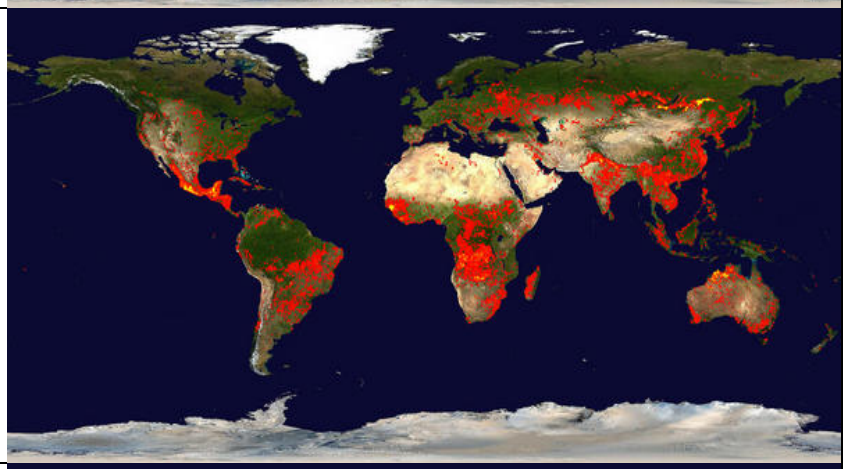
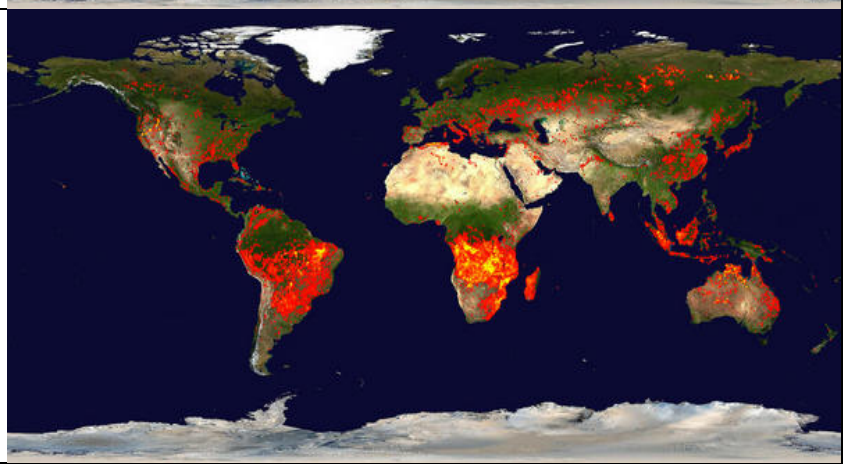
January (01/01/2012 - 01/10/2012)	
April/May: (04/30/2012 - 05/09/2012)	
August: (08/08/2012 - 08/17/2012)	

Figure 2. Satellite imagery shows fire activity across the globe for 10 day periods for different months throughout 2011 and 2012. Clear patterns are discerned, with concentrated areas of burning shifting seasonally. Moderate Resolution Imaging Spectroradiometer (MODIS) Sensors on board NASA's Terra and Aqua satellites record the locations of fires burning across the globe over 10-day periods. Each colored dot indicates a location where MODIS detected at least one fire during the compositing period. Color ranges from red where the fire count is low to yellow where number of fires is large. Source: NASA rapid response Global Fire Maps (http://rapidfire.sci.gsfc.nasa.gov/firemaps/).

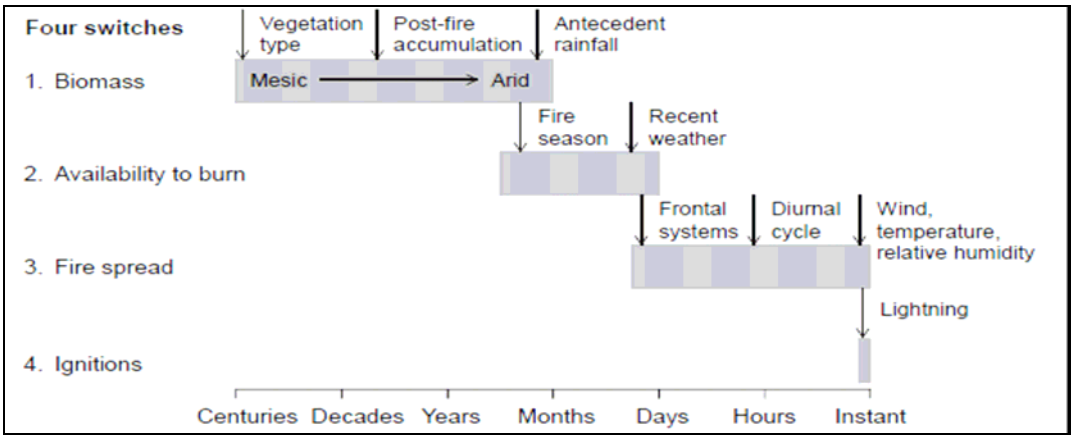


Figure 3. The four switches concept of Bradstock (2010) is a pyrogeographical framework for explaining variation in fire regimes based on variance in the rates of switching. All four switches: biomass growth, biomass desiccation, fire weather and ignition, must be in alignment for landscape fire to occur. However, these limits to fire activity, or the rates of switching, occur at different time scales as shown by the x-axis. In different ecosystems, different processes or 'switches' limit landscape fire activity. Source: Murphy et al. (2011).

Fire activity has been shown to be constrained along gradients of precipitation and primary productivity, with variation across such gradients in the relative importance of fuel quantity and fuel moisture as limits to fire activity (Meyn et al. 2007; Bradstock 2010; Krawchuk and Moritz 2011). In xeric places, aridity limits the growth of sufficient, continuous vegetation to burn while conversely in mesic places where there is abundant vegetation, high rainfall precludes fire as the vegetation does not dry out sufficiently to burn (Krawchuk and Moritz 2011). This concept is known as the 'varying constraints' hypothesis and has been shown to be a strong predictor of the distribution of large, infrequent fires (Meyn et al. 2007) and an explanatory framework for patterns of landscape fire activity more generally across the globe (Krawchuk and Moritz 2011). In biomass rich, rarely dry ecosystems, such as tropical rainforests, fire activity is limited more by fuel moisture content than by amount of fuels. In the humid tropics, fire activity is strongly linked to long-term climatic oscillations, such as El Niño which cause long-term drought and allow the normally moist vegetation to dry out sufficiently in order to burn (Goldammer 1993). In biomass-poor ecosystems which have seasonal dry periods, such as African savannas or temperate grasslands, the main limiting factor on fire is the quantity and connectivity of flammable vegetation which is controlled by antecedent rainfall to promote ample biomass growth. At a broad scale, climate is the predominant control over both fuel amount and arrangement and also over weather conditions that lead to fuel desiccation (Meyn et al. 2007). Additionally, studies using satellite data have found that landscape fire tends to occupy an environmental middle ground; in tropical and subtropical regions, areas that experience frequent fire activity correlate well with areas of medium levels of net primary productivity and intermediate levels of precipitation and temperature (van der Werf et al. 2008). Krawchuk et al. (2009) found that net primary production was the most significant explanatory variable in fire frequency around the globe.

Pyrogeographical studies have also greatly expanded our understanding of anthropogenic impacts on global fire activity, although the difficulty in disaggregating human influence from climatic controls on fire regimes remains a clear obstacle. Nonetheless, there is strong evidence of humans as drivers of fire activity across the globe (Krawchuk et al. 2009; Lauk and Erb 2009). In some places, humans are significantly augmenting background rates of fire while in others, anthropogenic land-use and activity have significantly decreased fire activity to levels below pre-industrial levels (Pyne 2007). For example, in wet tropical regions such as South America and South-East Asia humans are significantly increasing fire activity in closed forests that would have burnt only very rarely in the past as historically climate has precluded fire via the high moisture content of the vegetation (Cochrane 2003; Krawchuk et al. 2009). In these regions humans currently promote fire through intentional ignition during drier seasons, via accidental escape of deliberately lit burns, by fragmentation of the closed forest and subsequent change in the 'fire-resistant' structure of the vegetation due to logging for example, and often in correlation with periods of drought (Goldammer 1990; Cochrane and Laurance 2002). Accordingly, humans are effectively circumventing climatic limits to fire in these regions.

In order to quantify human drivers of fire activity around the world Chuvieco et al. (2008) attempted to detect relationships between human population density, economic conditions and proxies for land use intensity with satellite data of global fire activity for the period from 2001-2006. Clear anthropogenic signals in inter-annual variation were detected in fire activity across the two regions on Earth that experience most frequent fire, the Southern Boreal zone across Asia and the sub-equatorial belt across Africa, America and South-East Asia, strongly associated with agricultural burning practices. Chuvieco et al. (2008) note that increases in human factors such as population density and economic status tend to make fire activity more uniform in time. That is, where humans and resources are concentrated, the extent of landscape burning seems to be more stable inter-annually, whereas in regions where anthropogenic influence is lower, inter-annual variability in fire activity is higher due to the superordinate influence of climatic cycling. However, the limited time series of the data constrained the study and they were not able to detect activity in areas where fire return intervals are longer than the five-year period and as such failed to capture anthropogenic influences on fire in parts of the world where fire plays an important role but at longer multi-annual or decadal scales.

Agricultural Fire

Deliberate controlled burning is widely employed in agricultural systems around the world for a range of purposes including field-preparation, soil fertilization and disposal of crop residues, consequently agricultural fires remain a significant component of landscape fire activity globally. Using satellite data Korontzi et al. (2006) found that agricultural fires contribute 8-11% of global fire activity each year. In some regions the proportion of total landscape fire comprised of agricultural burning can be significantly higher, demonstrating that in certain parts of the globe human management has a significant effect on the timing and distribution of landscape fire. For example, more than a third of the world's total agricultural fires occur in the Russian Federation (Korontzi et al. 2006). Worldwide, agricultural fire activity displays two distinct peaks over the course of a year; from April to May dominated by cropland burning in Eastern Europe and European Russia, and cropland burning across central Asia and Asiatic Russia in August.

Le Page et al. (2010) further investigated the seasonality of fire across the globe as revealed by MODIS satellite imagery (Figure 2) and detected clear anthropogenic influences. They found that while climate determines the window of potential fire activity, humans exert significant control on the timing of fires within those climatic windows. Le Page et al. (2010) describe three main categories of anthropogenic burning which significantly impact the timing of fire within the climatically delineated windows for burning; firstly, fires associated with crop production (the major focus of the paper of Korontzi et al. [2006]). Secondly, tropical deforestation fires deliberately lit for land clearance and agricultural expansion purposes in ecosystems that would otherwise rarely burn. In these tropical forests, the vegetation is generally cut late in the wet season and burnt at the end of the dry season in order to maximise biomass consumption. Finally, the third category comprises anthropogenic fire practices in the tropical savannas of Africa and Australia, these are the most frequently burnt parts of the globe and here human activities strongly bias the seasonality of fire activity. These three categories highlight the diversity of anthropogenic landscape burning practices and show that humans deliberately light fires at preferential times in order to achieve specific agricultural or land practice aims.

Modelling the quantity of biomass burnt in anthropogenic vegetation fires across the globe Lauk and Erb (2009) calculated a range between 3.5 and 3.9 billion tons dry matter per year (Pg dm/yr), which equates to more than a quarter of the annual total biomass harvested by humans. They found that patterns of landscape fire across socio-political boundaries could be delineated. Shifting cultivation practices in least developed countries contribute one third of the total biomass consumed in anthropogenic fires each year (Lauk and Erb 2009). In the less economically-developed regions across the sub-equatorial belt, anthropogenic fires remain highly prevalent and economically important (Goldammer 1990). Global hotspots of anthropogenic landscape fire include Sub-Saharan Africa, Latin America, South-East Asia and Central Asia. By contrast, anthropogenic vegetation fires are not as common in industrialized regions. Pyne (2013, in press) has referred to this dichotomy as the "two grand combustion realms": One that relies on the combustion of fossil fuels, the other dominated by open biomass burning, as illustrated in Figure 4. Pyne (2004) notes that the two spheres of burning tend to overlap only temporarily during periods of 'pyric' transition.

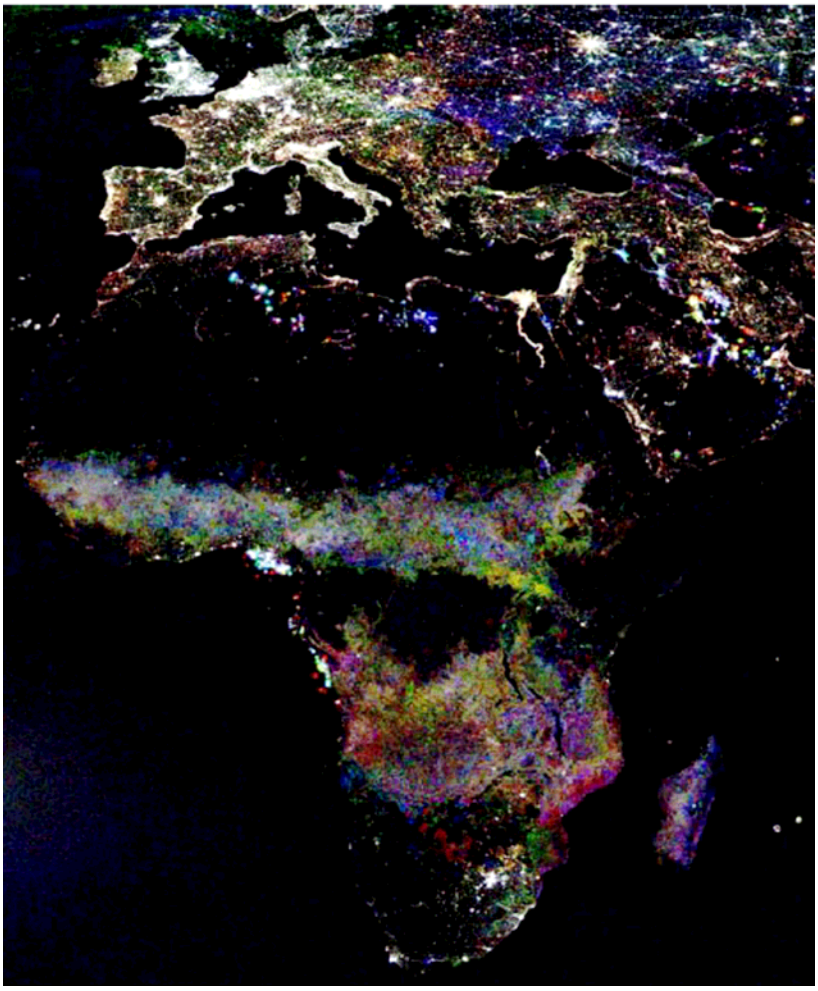


Figure 4. The two realms of Earthly combustion as described by Pyne (2013, in press). One lit by the industrial burning of fossil biomass and the other by the burning of surface biomass; a three-year composite (blue: 1992, green: 2000, red: 2008). Source: DMSP nightlights process by the NOAA National Geophysical Data Centre; from Pyne (2013, in press).

Pyric Transitions

Bowman et al. (2011) expand the concept first outlined by Pyne (2001, 2004, 2009) to describe transitions in human-fire interactions, which they refer to as 'pyric phases'. As Bowman et al. (2011) point out, these transitions have taken place at different times in different parts of the world and all these stages continue to exist on earth today. Accordingly there is enormous scope for examining the ways in which complex ecological, economic, political, technological, and social factors shape human-fire relationships. Changes in human societies and modes of production, for example, from hunter-gatherers to shifting cultivation to sedentary agriculture to industrial and finally, to post-industrial societies, translate into changes in fire regimes (Pausas and Keeley 2009).

Depicted in Figure 5 below, the 'pyric phases' framework appropriates the classic fire triangle (A), which represents fire as a physiochemical process between oxygen, heat and fuel. Modifying this triangle, they show that with the arrival of plants on land, fire became an important biochemical process on the pre-human Earth (B) – plants provided the atmospheric oxygen and flammable fuels and abiotic environmental components such as lightning and volcanoes supplied the necessary source of ignition. The next triangle includes an initial human presence (C) and shows that when prehistoric humans began to domesticate fire they did so by influencing vegetation and the timing of ignitions in order to promote resources, such as food and land clearings. In very remote areas with very low human population densities, variations of these wildland-anthropogenic burning practices still occur today. The next triangle emphasises the importance of fire in agricultural land management (D) and fire's routine use for land clearance and conversion for agricultural purposes. Agricultural burning practices are employed to unlock nutrients held in biomass pre- and post- harvest as this flush of

nutrients promotes crop and pasture growth. In tropical developing nations, swidden or 'slash-and-burn' agriculture remains an important source of subsistence for millions of people (Reyes-García et al. 2008; Mertz et al. 2009). Industrialized societies meanwhile have fundamentally altered patterns of landscape fire in recent centuries (E), in places such as Europe, North America and Australia. Humans alter the timing and quantity of ignitions, modify vegetation and landscape, and therefore disrupt fuel quantity and connectivity. Further, in many parts of the world, fire management practices of the last century have allowed humans to suppress wildfire, which has altered the frequency and intensity of fire regimes. Triangles (E) and (F) correspond to the realm of fossil fuel combustion as described by Pyne (2001, 2009).

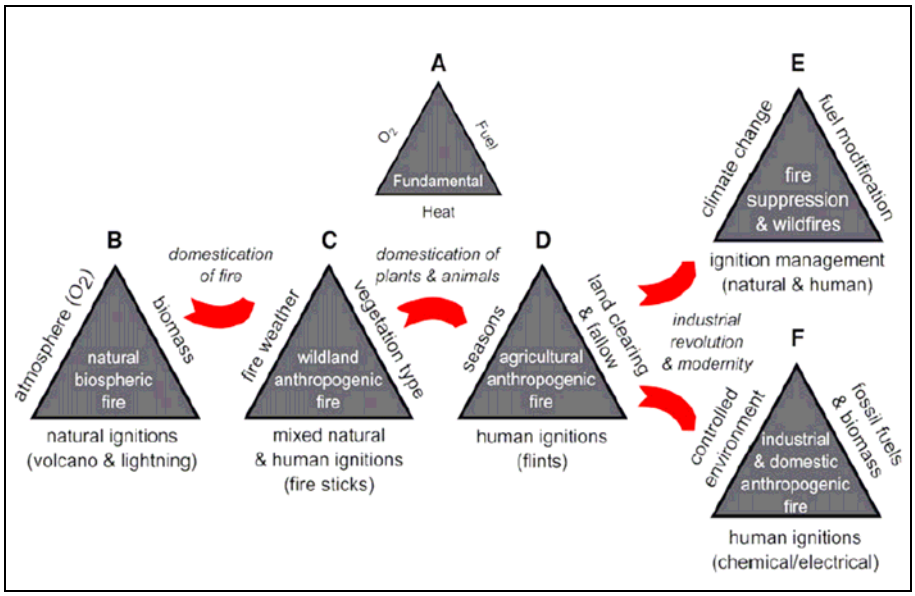


Figure 5. The pyric phases concept of Bowman et al. (2011) depicts the complexity of human relationships to fire, mediated by cultural, economic, environmental and physical landscapes. These triangles do not represent a linear progression, but rather, highlight the diversity of anthropogenic impacts of fire regimes across the globe. All of the stages are still currently found on Earth.

The industrial revolution refers to the radical changes in agriculture, manufacturing, transport and technology that were precipitated by the invention of the internal combustion engine and which led to profound shifts in social, economic and cultural conditions across Western Europe in the mid eighteenth century, later spreading to North America and other parts of the world. The study of global charcoal records by Marlon et al. (2008) demonstrates that the pyric transition sensu Pyne (2001) that accompanied the industrial revolution was characterized by prolific, unconstrained landscape burning between 1750 and 1870, as vast areas of forest were burnt and cleared during European colonization of the Americas and many parts of the Southern Hemisphere. This period of extensive burning was followed by an abrupt global decline in landscape fire from 1870 largely explained by vast agricultural expansion and population growth that fragmented landscapes in many parts of the world and generally rendered them less flammable, in addition to policies of deliberate fire suppression in Northern America and other European colonies (Marlon et al. 2008). More profoundly, however, the advent of fossil fuel combustion represents the beginning of an era characterized by unparalleled human manipulation of the Earth system. Atmospheric chemist Paul Crutzen recognized that the unprecedented extent to which newly industrialized societies had begun to transform ecosystems, landscapes, the atmosphere and finally, global climate via industrial combustion and land use intensification was so profound that it represented the beginning of a distinct geological period, the 'Anthropocene' (Crutzen 2002). In many parts of the industrialized world, human activity has profoundly changed fire regimes and in many places, significantly reduced landscape fire to below pre-industrial levels (Bowman et al. 2011).

Fire in the Anthropocene

Since the industrial revolution, fossil fuel combustion has replaced biomass combustion in many parts of the world (for energy and countless other purposes) and has resulted in the release of enormous quantities of greenhouse gases to the atmosphere. Greenhouse gas from fossil fuel combustion and deforestation have a well-described global warming effect (IPCC 2007) and it is predicted that changing global climate will in turn lead to new patterns of fire on earth given climate's dominant control on landscape fire. Further, humans have simultaneously altered landscapes as never before, between 1700 and 2000 a critical shift occurred as human impacts transformed the terrestrial biosphere from predominantly natural environments to predominantly anthropogenic landscapes (Ellis et al. 2010). By the beginning of the 21st century land-use expansion into wildlands and intensification of land use in semi-natural settings had resulted in the majority of the earth's land surface being occupied by agricultural and settled 'anthromes' (human dominated biomes), with less than 20% remaining in a semi-natural state and only a quarter evading human appropriation entirely (Ellis et al. 2010). This means that currently and in the future, ecosystem and fire management will take place in primarily anthropogenic landscapes. There are countless ways in which humans modify the landscape around them that impact fire activity, which will in turn affect human coexistence with fire into the future. These include, but are not limited to, the spread of exotic species, the pollution of soils and the atmosphere, logging, fire suppression policies, grazing and agricultural land abandonment. We will discuss each of these further in detail.

Fire and Climate Change

There is much uncertainty over how anthropogenically induced climate change will influence fire regimes in the future. As discussed earlier, climate is a dominant driver of fire; influencing both fire fuels (vegetation) and the conditions for fire (Krawchuk et al. 2009). In the long-term climate determines distribution and quantity of flammable fuels and in the short term influences weather conditions conducive to fire spread and fuel moisture. Krawchuk et al. (2009) used multivariate statistical generalized additive models (GAMs) to examine how global patterns of wildfire may change under future climate change conditions. Their modeling refutes simplistic predictions that a warmer climate will necessary lead to more fire in the earth system and found that under climate change conditions some regions are likely to experience more frequent fires, while others may see a decrease in fire activity. The predicted spatial variation among regions in future fire activity reflects the underlying interaction between temperature and precipitation variables which influence the constraints on fire, or the 'switches' (Bradstock 2010). Although Krawchuk et al. (2009) predicted no net increase in the amount of fire on the globe, they note that the ecological or social impacts of altered fire regimes are likely to be significant, with many parts of the world experiencing 'invasion or retreat' of fire activity (Krawchuk et al. 2009).

A meta-analysis by Flannigan et al. (2009) of fire and climate change studies from around the world (although the vast majority of studies are based on North America) found that research to date indicates an increasing trend in global area burned and fire occurrence under global warming scenarios. However they also predict great spatial variability in future landscape fire trends, with some areas likely to experience no change or even decreases in area burned and fire occurrence.

Moritz et al. (2012) found that there is significant disagreement between global climate models on the direction of change of fire activity (increasing or decreasing) for more than half the world's land area in coming decades, but found some general agreement between models further into the future. Their work indicates that regions in the mid- to high-latitudes will experience higher probabilities of fire occurrence, while in the tropics there may be a decrease in the probability of fire activity. There are several significant limitations to modeling techniques for forecasting future fire activity under global change conditions, making long-range predictions of patterns of landscape fire complicated. Aspects of the fire regime beyond area burned, such as fire intensity and severity are more difficult to predict and need further research (Flannigan et al. 2005). For example, the seasonality of potential fire activity is likely to shift in parts of the globe, particularly temperate and boreal regions of the world, where there is evidence that fire seasons are already increasing and will likely continue to lengthen in the future (Stocks et al. 1998). Westerling et al. (2006) examined fire data from the Western United States for the last quarter of the twentieth century. They found a sudden, significant rise in wildfire activity in the mid-1980s, with more frequent large-wildfire events, longer wildfire durations, and longer wildfire seasons. The underlying driver to these increases were higher spring and summer temperatures and

an earlier spring snowmelt associated with warming climate, particularly in areas where human land-use has relatively little effect on fire risks (Westerling et al. 2006).

Extreme weather events predicted under climate change are also likely to alter patterns of landscape fire, yet despite the significance they may have for future fire activity, incorporating extreme weather anomalies into models is particularly difficult (Bradstock 2010). Weather data from south-Eastern Australia, an area that has witnessed a string of disastrous fire events in recent decades, show that fire danger, predominantly a function of weather conditions, increased by 10-40% from 2001-2007 relative to 1980-2000 (Williams et al. 2009). Additionally, modelling indicates a significant rise (up to 65% increase) in days with extreme fire danger conditions by 2020 (Williams et al. 2009) which are likely to have serious consequences for human ability to manage fire during these extreme weather events.

One of the biggest constraints to forecasting fire activity under a warming global climate is that statistical models currently do not incorporate fire-climate-vegetation feedbacks that could have a further warming effect on global climate and as such, contemporary projections may significantly underestimate changes to fire activity (Bowman 2009; Flannigan et al. 2009). For example, elevated CO2 may promote plant growth and therefore increase fuel loads, while conversely, extended drought may decrease plant productivity in the long term (decreasing fuel loads) and desiccate fuels (increasing propensity to burn). The interactions between high CO2, vegetation, fire, climate and people are tightly interrelated and changes to these interactions are extremely difficult to predict (Bond and Midgley 2012). For example, Hoffmann et al. (2002) identified a positive feedback loop whereby anthropogenic clearing and land-use change in tropical savannas results in warmer and drier climate, accelerated fire frequencies, and further tree cover loss. Humans play a central role in this fire-vegetation-climate feedback because the majority of fires in tropical savannas are lit by people. Fire remains an economic land management tool for millions of subsistence farmers who live in these savannas. As population pressure increases in these regions, humans are likely to overcome climatic limitations on fire frequency and accelerate this fire cycle, resulting in vast ecosystem degradation (Hoffmann et al. 2002). Due to the complexity of feedbacks and links between climate, vegetation, people and fire, forecasting future fire regimes involves very high degrees of uncertainty.

Alarmingly, increased fire activity may represent a positive feed-back to climate change as greater fire activity could potentially generate a massive flux of carbon and other greenhouse gases to the atmosphere, which may in turn lead to accelerated rates of global warming and potentially more fire (Bond-Lamberty et al. 2007; Bowman et al. 2009). There remains great uncertainty over how human behaviours may interact with changing climate and vegetation to influence fire activity in coming decades. The interactions between people, vegetation, climate and fire follow non-linear patterns and are likely to include unpredictable positive and negative feedbacks (Flannigan et al. 2009). The case of the Boreal forests highlights the complexity of interactions and possible feedbacks between fire and climate change.

Climate Change, Fire and the Boreal Forests

The circumboreal zone covers ca. 12 million km^2, stretching across North America and Eurasia (Goldammer and Stocks 2011) and represents a very significant global carbon pool as it is home to 20% of global vegetation cover (Mouillot and Field 2005) and a third of total terrestrial stored carbon (Apps et al. 1993). Organic-rich soils of the boreal contain double the amount of carbon than the atmosphere (Tarnocai et al. 2009). In the boreal forests, fire is the dominant disturbance, driving forest structure and function and carbon cycling. It is estimated than an average of 5-15 million hectares burn annually in boreal forests, mainly in Canada, Alaska and Siberia, with significant inter-annual variation influenced by climate (Flannigan et al. 2005). Over the last 40 years, area burnt has been increasing in the Canadian boreal forests, a trend which has been attributed to anthropogenic climate change (Gillett et al. 2004).

Global warming is expected to significantly increase fire activity in the Boreal forests (Flannigan et al. 2009). The season of potential fire activity is anticipated to lengthen under warming conditions. Studies show that climate change will increase both the frequency and severity of forest fires. This will result in larger areas burnt, shorter fire-return intervals, change in forest structure and potentially species distribution (Stocks et al. 1998; Kasischke 2000). Further, altered fire regimes in the Boreal will have significant implications for global carbon cycle and may lead to a positive feedback to global warming. Increased fire activity could accelerate the release of the vast quantities of carbon and other

greenhouse gases, such as methane, currently stored in the vegetation and in soils under permafrost to the atmosphere which would lead to greater warming and potentially more fire (Bond-Lamberty et al. 2007) see Figure 6. However, the magnitude and direction of influence that increased fire activity in the Boreal may have on climate remains unclear due to the cooling effects of increased albedo by fire. Fire, could potentially slow warming because loss of dark forest after fire exposes more snow and increases albedo (solar energy reflectance) in winter, which has a cooling effect on the land surface (Randerson et al. 2006). The net influence of increased fire activity on climate in the boreal remains unclear and needs further investigation given the complex interactions and feedbacks between these elements (Hinzman et al. 2003).

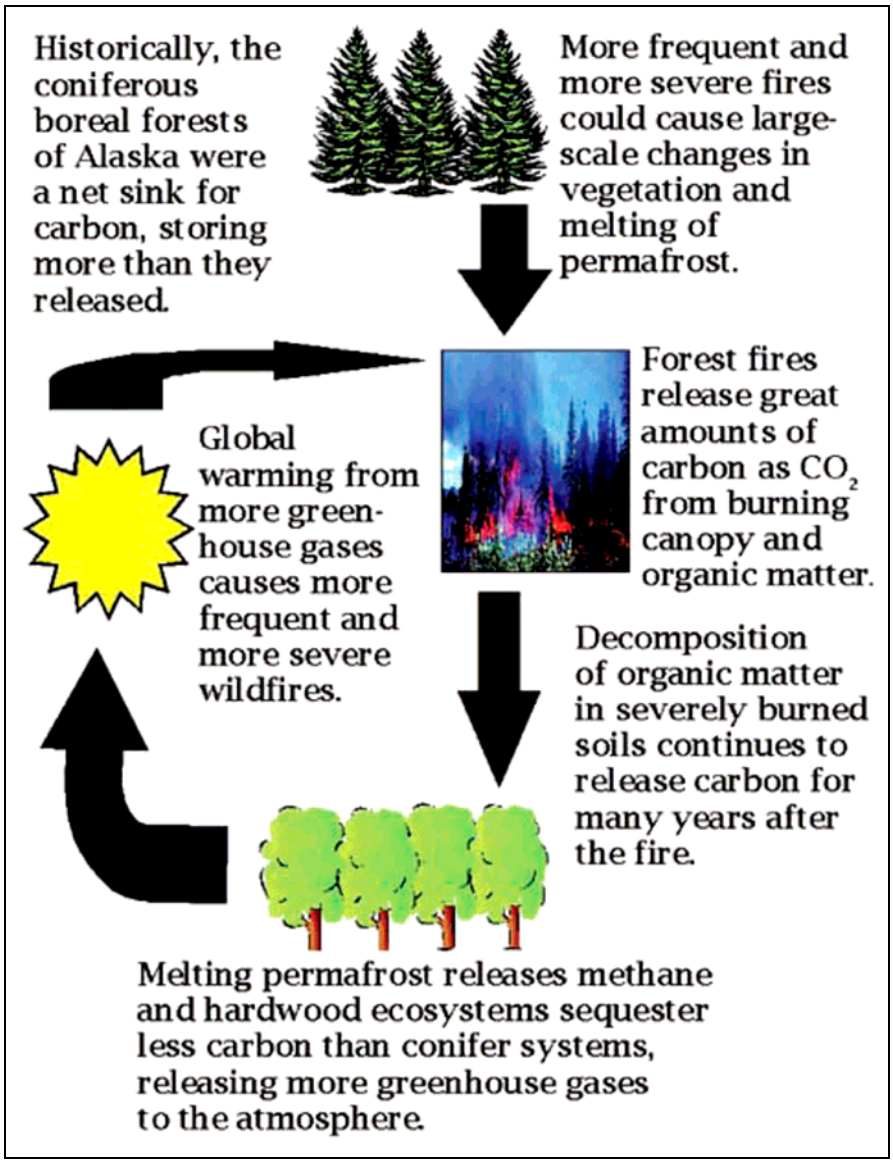


Figure 6. The interaction between changing climate and fire activity in the Boreal forest has several complicated interactions and feedbacks. Increased fire activity in the Boreal under a warming climate may have important global climatic and biogeochemical consequences, including a potential positive feedback cycle leading to accelerated release of CO_2 and methane from permafrost. Source: Hinzman et al. (2003).

Landscape fire and biomass combustion impact climate in two primary ways; via the release of gases (water vapor, CO_2, CH_4, NO_X, SO_X, etc.) and other aerosols which alter the radiative energy balance of the atmosphere and by changing the albedo (or light-reflective properties) of the land surface (Bowman et al. 2009). Landscape fire is a critical component of the global carbon cycle, and annually landscape fires release ca. 2-4 Pg of carbon to the atmosphere, more than half of which derives from savanna regions and with strong inter-annual variability from forests worldwide (van der Werf et al.

2006). Biomass combustion (including landscape fire) releases approximately one third as much CO_2 as fossil fuel burning and industrial processes (Raupach et al. 2007). In terms of carbon dioxide, landscape fire emissions are thought to be in equilibrium in the long-term as the CO_2 released by fire is taken up by regenerating vegetation post-fire, however, this balance is currently being disrupted by anthropogenic deforestation fires and burning of peatlands in the tropics. Biomass burning is shifting to a net flux of carbon to the atmosphere because unsustainable land clearance practices are inhibiting the ability of terrestrial systems to re-absorb this CO_2 from the atmosphere. DeFries et al. (2002) estimated that between 1980-2000 tropical deforestation released a net average of 0.6-0.9 Pg C per year. Further, it is estimated that deforestation globally has contributed ca. 20% of the CO_2 accumulated in the atmosphere since the industrial revolution (Houghton 2003).

Biomass burning contributes equivalent amounts of other potent greenhouse gases and atmospheric pollutants as fossil fuel combustion (Crutzen and Andreae 1990). For example, landscape fire is a predominant source of emissions for methane and nitrous oxide. The gases have different radiative forcing properties, for example methane is approximately 25 times more potent as greenhouse gas than CO_2 and vegetation fires release more methane than fossil fuel combustion, similarly for nitrous oxide, making biomass burning a globally important source of greenhouse gases (Andreae and Merlet 2001). Currently, most biomass burning emissions originate from savanna and forest conversion fires in the tropics, however, there is evidence that under global warming conditions emissions from boreal and temperate forest fires may increase significantly (Stocks et al. 1998).

The net impacts of emissions from landscape fire on global climate are highly complicated and as yet unclear, owing to the diverse radiative properties of aerosol components and effects of albedo. Biomass burning produces 40% of total global emissions of black carbon, the second strongest contribution to current global warming after CO_2 (Bond et al. 2004). Furthermore, deposition of black carbon over snow and ice significantly alters surface albedo and increases solar absorption and melting, which may be strongly increasing rates of Arctic sea ice retreat (Flannigan et al. 2009). Shindell and Faluvegi (2009) demonstrated that increasing concentrations of black carbon over the last 30 years had significantly accelerated Arctic warming. Additionally, smoke from biomass burning contains particles which scatter sunlight and result in a cooling effect on terrestrial land surfaces. Smoke particles can also reduce the evaporation of water from oceans and land. Biomass smoke can further influence regional water budgets as aerosols from fires can impact clouds formation (leading to a greater number, but smaller size of cloud droplets) and therefore decrease local precipitation or lead to more intense storm events (Andreae and Rosenfeld 2008). While biomass burning is a significant source of atmospheric aerosols and greenhouse gases, there is much uncertainty over interannual variability and the underlying drivers of biomass burning emissions from regional to global scales (van der Werf et al. 2010). Randerson et al. (2006) argue that the net impact of landscape fire and biomass burning may not result in a positive feedback to climate change when considering the impacts of greenhouse gases, aerosols, black carbon deposition, and changes in albedo over the long term. Further investigation is needed in order to better understand the balance of positive and negative radiative-forcing properties of emissions from landscape fires (Bowman et al. 2009).

Smoke from Landscape Fire and Health

Landscape fires and biomass burning are a major source of atmospheric pollutants, impacting air quality locally and across international borders and as such represent a serious public health issue (Andreae and Merlet 2001; Goldammer et al. 2009). Globally, the majority of smoke emissions are derived from anthropogenic burning in tropical rainforests and savannas, where they have been recurrent episodes of severe pollution that affect some of the poorest regions of the world (van der Werf et al. 2010). Smoke from biomass burning contains a large and diverse number of chemicals, many of which have been associated with adverse health impacts (Naeher et al. 2007). In terms of impact on human health, particulate matter smaller than 10 micrometers (PM_{10}) and less than 2.5 micrometers in diameter ($PM_{2.5}$) in biomass smoke are particularly important and concentration of these particles increase dramatically during air pollution episodes caused by vegetation fires. Additionally, carbon monoxide and volatile organic compounds in smoke from vegetation fires can significantly impact the health of people who are close to the areas of burning (Schwela 2004). These particles can cause spikes of respiratory and cardiovascular illness in populations exposed to smoke from landscape fire and given that smoke plumes can be transported in the atmosphere long-distances via global teleconnections, can also impact people in areas far removed from the origin of the burning (Schwela 2004). For example, extremely hot and dry weather conditions combined with significant changes in land management practices led to an extreme episode of fire activity in Western

Russia in the summer of 2010, with more than 80,000 hectares of forests, agricultural land and peatlands burned between July and September (Goldammer 2010). These fires generated extensive smoke and air pollution, which enveloped Moscow and impacted ca. 15 million people for several weeks. Compounded by high temperature and minimal precipitation, this smoke pollution event had serious health consequences for the people of Moscow. Goldammer (2010) reports an increase in mortality in Russia of 18% compared to background levels for this period, attributed to the extreme heat and respiratory and cardiovascular disease associated with the smoke pollution. Indeed, according to official Russian government sources the heat wave and smoke pollution was directly responsible for ca. 56,000 deaths more than the corresponding months in previous years (O'Brien and Goldammer 2011). Furthermore, smoke from the Russian fires had trans-boundary consequences, impacting China, Japan and reaching as fire as North America.

Most of the fires that led to the 2010 Russian smoke pollution event were deliberately or accidentally lit by humans yet occurred in concert with extreme weather conditions. Similarly, extensive and recurrent trans-boundary smoke events from landscape fires across South East Asia arise predominantly from anthropogenic burning practices but are most severe during dry weather conditions associated with El Niño drought events (Cochrane 2003). In the study of Johnston et al. (2012) the highest number of annual deaths attributable to exposure to biomass smoke occurred during a strong El Niño year. During an extended El Niño dry season in 1997, fires in Indonesia, particularly forest and peat fires deliberately lit for land clearance purposes, created dense smoke pollution that spread and settled over much of the region, impacting numerous countries including Indonesia, Malaysia, Singapore, Philippines and Thailand and tens of millions of people in the region (Schwela 2000). An estimated 20 million people suffered respiratory illness as a result of the smoke pollution in Indonesia alone (Heil and Goldammer 2001). While similar smoke pollution events are documented in South-East Asia, the 1997 episode was considered unprecedented in extent and intensity (Heil and Goldammer 2001). In response to the health crisis created by the smoke pollution, the World Health Organization in tandem with the United Nations Environment Program, the Global Fire Monitoring Centre, the World Meteorological Organization (WMO) and Japanese and Singaporean governments developed guidelines to cope with transboundary vegetation fire events (WHO/UNEP/WMO 1999).

In South East Asia fire is a prevalent land management tool utilized on a small scale by local farmers and also on a much larger scale by business enterprises and governments that seek to clear and convert forests to establish agricultural crops (Page et al. 2002). During the extended ENSO-related drought of 1997 the exceedingly dry conditions meant than many deliberately lit fires spread out of control and entered into the carbon-rich peatlands. In addition to the thick haze of smoke pollution that settled over Southeast Asia and the associated severe deterioration in air quality and health problems, it is estimated that the 1997 fire episode in Indonesia released between 0.81 and 2.57 Gt of carbon to the atmosphere (Page et al. 2002). This is of enormous global significance as it is the equivalent of 13-40% of annual global carbon emissions from fossil fuels. Furthermore, it is thought that smoke emissions from biomass burning in the tropics may inhibit cloud formation and lead to regional decreases in precipitation during smoke pollution events. This is a potentially alarming feedback as anthropogenic burning may lead to intensification of drought stress during El Niño and increase the susceptibility of tropical forests to fire (Tosca et al. 2010).

The severity of impacts of smoke from biomass burning on human health has only begun to attract widespread international political and scientific attention in recent years (Johnston et al. 2012). Given the trans-boundary nature of the problem, there is an urgent need for international cooperation to reduce the impacts of vegetation fire smoke pollution. These include formulation of international and national policies to address the underlying causes of smoke pollution, such as decreasing excessive, unsustainable burning practices (particularly in Tropical regions), the establishment of sound fire and smoke management practices and protocols, and international cooperation on fire management issues. In this regard, international collaborative efforts, such as those facilitated by the Global Fire Monitoring Centre have been pioneering (Schwela 2004; Goldammer and Zibtsev 2010).

Fire and Other Hazardous Emissions

Landscape fires are also an important source of other dangerous pollutants, such as mercury and radioactive compounds. Biomass burning accounts for 8% of global annual mercury emissions (Friedli et al. 2009) and interestingly, distribution of mercury emissions are decoupled from global carbon emissions from biomass burning. While most carbon released through biomass burning is emitted from fires in African savannas, the majority of mercury emissions from biomass burning originate from

fires in equatorial Asia, boreal Asia, and southern hemisphere South America. Mercury emissions can form harmful compounds, such as methyl mercury, which is toxic to humans and other animals (Friedli et al. 2009). The largest terrestrial pool of mercury lies in the soils of the boreal zone, and similarly to carbon, there is a risk that under global warming, increasing temperature in boreal regions may lead to larger, more frequent fires and therefore accelerate mercury emissions which could have hazardous impacts on human health and lead to mercury toxicities in food chains in the northern hemisphere (Sigler et al. 2003; Turetsky et al. 2006).

In some parts of the world, there is an alarming risk that landscape fire will release to the atmosphere and spread radionuclides and other hazardous chemical if wildfires burn across land contaminated by hazardous chemical and radioactive pollution. For example, the nuclear disaster that occurred in Chernobyl in 1986 has left 6 million hectares of radioactively contaminated terrain in Ukraine, Belarus and Russia (Statheropoulos et al. 2013). In the Chernobyl exclusion zone, radioactive material has largely accumulated in the peat layers of the soils. International collaboration efforts between scientists from the Ukraine, USA, and Germany have been initiated to assess the situations and find strategies to minimise the risk of catastrophic wildfire burning across the contaminated forests and abandoned agricultural lands, as the subsequent release of radioactive material which would have a disastrous impact on human populations (Goldammer and Zibtsev 2010).

Furthermore, there are other hazardous materials, such as unexploded ordnance (UXO) - the terrible legacy of military conflict, which complicate fire management in certain parts of the world, such as Eastern Europe and Eurasia. Unexploded ordnance (UXO) (landmines, artillery ammunition, bombs) contaminant hundreds of thousands of hectares of forest and other lands across Western, Eastern and Southeastern Europe (Goldammer and Zibtsev 2010). Fires burning through territory which contains UXO pose an extreme risk to civilian populations, and particularly to fire-fighters, as the heat and force of the fires can trigger the explosion of undetonated material. A pioneering project is underway on abandoned military land in the German state of Brandenburg (formerly part of the German Democratic Republic) which is heavily contaminated by unexploded artillery grenades and bombs (GFMC 2010; Goldammer et al. 2012). The project is trialing application of low intensity prescribed fire to contaminated terrain, ignited from the protection of armored military tanks, with the aim of reducing the risk of uncontrolled, intense wildfires that are likely to detonate the UXO and threaten the safety of fire-fighters and others.

Fire Disasters – Economic and Social Costs

In addition to the health impacts of smoke pollution and the potential mobilisation of hazardous materials, landscape fires threaten and impact people and property on all inhabited continents. In recent decades, there has been an increasing incidence of large, uncontrolled fire events that have severely impacted ecosystems, people's lives and livelihoods and public and private infrastructure around the world (FAO 2006; Bowman et al. 2009). Disastrous fire episodes in which many people have been killed or impacted in other ways, such as the 2007 fires in Greece, the 2009 Black Saturday Fires in Australia, 2010 fires in Western Russia, fires in Israel in 2010, fires around Slave Lake in Canada in 2011, and a severe wildfire season across many states of the USA in 2011 are drawing both public and political attention to the dangers posed by uncontrolled fires (Goldammer and Stocks 2011). A new term "megafires" has been coined – albeit disputed and often unreflectedly used – to describe these large-scale fire events with corresponding severe impacts on people, property and ecosystems (Flannigan et al. 2009).

The social and economic costs associated large disastrous fires are known to be extremely high, however, they are very difficult to quantify. Along with the direct economic costs of burnt infrastructure and loss of livelihoods (e.g., agricultural crops, livestock) annual investment in fire management, in terms of responding to fire outbreaks, fire suppression and fire management to reduce risk (e.g., prescribed burning) are in the order of several billions of dollars each year around the world (Flannigan et al. 2009). For example, the 1997 fire episode in South East Asia is estimate to have caused ca. $US 9 billion of economic costs, of which only approximately $US 1 billion were from health impacts from smoke pollution (Schweithelm et al. 1999). During the same period, fires in South America also associated with extreme El Niño weather events are estimated to have burnt an area greater than 20 million hectares and caused between $US 10-15 million of damages (Cochrane 2003). Indeed, the economic impact of fires in tropical developing nations is disproportionate to the funding these countries have available to spend on fire management. Cochrane (2003) outlines the contrasts in fire management budgets between developed and developing states, reporting that in 2000 the USA

faced one of its worst fire seasons in recent history and nearly 3.4 million hectares were burnt. The cost of fire suppression in the USA that year was in the order of $US 1.4 billion dollars. Contrastingly, Indonesia had a firefighting budget of only $US 25 million dollars to manage the disastrous 1997 episode, a large proportion of which came from foreign aid (Cochrane 2003).

Social and Economic Drivers of Fire Activity

According to the United Nations Food and Agriculture Organization, people are the main cause of fires which negatively impact society and the environment (FAO 2007). Deliberate or accidental fires lit by humans, and those that accidentally escape control, are contributing to the rise in extreme fire events that, as outlined above, are having severe impacts on ecosystems, people and property. The growing awareness of the impacts of uncontrolled fires has drawn attention to ways in which humans have altered patterns of fire around the world in recent decades. In addition to climate change there is a suite of social and economic factors that have contributed to the rise of extreme fire events that challenge the limits of human ability to manage fire and minimize fire's deleterious impacts. Such changes result from shifting demographics, migration of people, growing populations, diverse socioeconomic factors and land management practices (Pausas and Keeley 2009). Globally, changes in fire regimes and underlying causes of change are extremely diverse and vary significantly between regions. Some of the factors include, but are not limited to: the introduction of exotic species that are dramatically altering fire regimes by increasing fine fuels and shortening fire return intervals, land clearance and deforestation in tropical forests that historically experienced fire only very rarely, increasing fuel loads caused by land abandonment and migration (e.g., in Mediterranean Europe) and policies of fire suppression in temperate states such as Canada, the USA and Australia where fire activity declines in the short term but may ultimately lead to extremely large and intense fires in the long term as fuels accumulate (Pausas and Keeley 2009; Goldammer and Stocks 2011).

In recent decades there have been changes to fire incidence across Mediterranean Europe, largely as a result of socioeconomic changes and shifts in population demographics (FAO 2006). Industrialization and economic development have caused major changes in land use including mass migration away from the countryside to urban areas, resulting in abandonment of agricultural lands and an associated decrease in livestock grazing pressure (Pausas 1999). In combination with large areas converted to timber plantations this has led to an accumulation of available fuels. Further, the migration of people to industrial centers has caused a loss of local knowledge and skills about how to manage fire and also a decrease in interest in managing fire due to lower values placed on these lands (Pausas and Keeley 2009). Subsequently there has been a rise in the number of number of large, intense fires across Spain, France, Italy and Greece in recent decades, indicating a shift from frequent small fires to large, difficult to control wildfires that cause the loss of lives and property. The idea that this new fire problem has arisen out of social causes is underscored by the fact that anthropogenic burning dominates fire activity in this region and that similar trends in increasing numbers of large, dangerous fires have not been observed in the Southern Mediterranean basin where there has been less dramatic socio-economic change and traditional land use practices are still employed (Dimitrakopoulos and Mitsopoulos 2006).

The Grass Fire Cycle

Humans have deliberately and unintentionally spread alien grasses into diverse ecosystems around the world. These flammable invasive grasses are able to drastically alter fire regimes, impacting biodiversity, ecosystem function and in some cases leading to local extirpation of native woody species. This process is known as the 'grass-fire cycle' and was first described by D'Antonio and Vitousek (1992) with the example of invasive C4 perennial grasses altering fire regimes and transforming woodlands in Hawai'i. The grass-fire cycle is a feedback loop whereby exotic grasses invade and promote frequent fire due to their abundance of dry and aerated fine fuels. This grass invasion and accompanying increase in fire frequency sets into motion a cycle that is able to transform a fire-sensitive, native woodland or savanna into flammable, frequently burnt exotic-dominated grassland (D'Antonio and Vitousek 1992). The exotic grasses recover quickly after fire (their reproductive tissue is protected below ground) and rapidly produce prolific biomass, thereby promoting recurrent fire which kills any juvenile native trees that have regenerated. Woody species become 'trapped' and killed by successive fire unless as juveniles they are able to grow sufficiently quickly to escape the fires that burn repeatedly through the grass layer. The frequent fires promoted by the

grasses can also alter nutrient cycles which further favors the invading grasses over native woody species (Mack and D'Antonio 2003).

In Northern Australia high-biomass exotic grasses, such as Gamba grass (*Andropogon gayanus*) and Buffel Grass (*Cenchrus ciliaris*) have been introduced to large areas as cattle pasture (Setterfield et al. 2010). These grasses overcome the primary limit to fire activity in native savannas: sufficient biomass. In these semi-arid systems fires occur only when enough vegetation grows during periods of above average rainfall. The invasive grasses however produce abundant biomass even in dry years and are leading to frequent intense fires that cause high mortality of native woody species and in the worst cases, a biome switch from native savanna to exotic grassland. Similar grass-fire cycles are described for alien grasses in many parts of the world. Some of the most aggressive cases include *Bromus tectorum* (Cheat Grass) in Western North America, *Hyparrhenia rufa* (Thatch Grass) in tropical Central America, *Melinis minutiflora* (Molasses) in Hawai'i and tropical Northern Australia and *Schizachyrium condensatum* (Tufted Beard Grass) in Hawai'i (Keeley 2006).

The Wildland-Urban Interface

Conversely, there has been a growing trend of migration from urban centres to the periphery of highly flammable ecosystems in places such as North America, Australia and elsewhere in Europe, and a corresponding increase in housing and population in areas adjacent to vegetation types that are prone to high-intensity crown fires (Mell et al. 2010; Bradstock et al. 2012). This expansion of settlement at the 'Wildland-Urban Interface' (WUI) is contributing to increasingly disastrous impacts of wildfire, given the dangerous mixture of communities and infrastructure, increased anthropogenic ignitions and highly flammable ecosystems (Stephens et al. 2009). Fires at the WUI represent a severe threat to people and property as tragically demonstrated by recent catastrophic fire in Southern Australian, the USA, Canada, Greece and Israel. In addition to highly vulnerable populations and property, settlement on the WUI makes management of fire to reduce risk and to maintain fire's critical biological role in these ecosystems extremely complicated.

For most of the twentieth century governments in temperate states, such as Canada, the USA and Australia adopted policies of complete fire suppression in an attempt to minimise risk to people and structures at the WUI, however, suppression has been shown to have led to several perverse outcomes including the accumulation of high fuel loads and thus increased risk of intense wildfire, a shift in fire regime in some vegetation types and increased stress on biodiversity, despite ever-increasing budgets allocated to fire management activities and more sophisticated fire suppression technology such as water-bombing aircraft (Gill and Stephens 2009; Bowman et al. 2011). There are other management practices that are employed in order to make fire suppression more effective, which also include many trade-offs and a significant amount of controversy, these include clearance of vegetation to form buffers, or 'fire breaks', between high fuel loads and human assets and prescribed burning under controlled conditions to reduce fuel loads. Continued catastrophic fire events call in to question the efficacy of suppression methods. Under extreme conditions these approaches fail to prevent fires which start in forests and shrublands from encroaching into settled areas as fuel loads do not limit the spread of fire (Bowman et al. 2011).

(Beyond) Fire Suppression in the Ponderosa Pine Forests of the USA

Throughout the 20th century in the Western USA a policy of fire exclusion was widely pursued in an attempt to protect people, property and timber assets from fire damage. Policies of fire exclusion, however, ignore the biological role of fire in ecosystems and subsequently led to changes in forest structure. Changes such as forest thickening are thought to have rendered large areas of forest more susceptible to high-intensity crown fires and to outbreaks of pests and disease (Veblen et al. 2000). The forests of Ponderosa Pine (*Pinus ponderosa*) were traditionally characterized by a regime of frequent surface fires but fire exclusion practices have led to significant increases in stand density and high fuel accumulations. Accordingly there has been a shift in fire regime in these forests from frequent low-intensity surface fires that caused limited tree mortality to severe, high-intensity crown fires (Allen et al. 2002). A denser understorey forms a 'fuel ladder' by which flames can enter the tree canopy and kill entire stands of surface-fire-resistant trees (Syphard et al. 2009). Further, Berry and Hesseln (2004) argue that overstocked stands of trees due to fire exclusion are stressed by high competition for resources and are therefore more vulnerable to disease and insect outbreaks.

Concomitant with fire suppression policies that instead of protecting resources and communities have made them more susceptible to large intense fires, has been massive expansion of the WUI and subsequent increase in population at risk from large fires. Alternatives to fire exclusion, including reintroduction of fire via prescribed low intensity burning of the surface layer and mechanical thinning are now being employed for the dual aims of improving forest health and reducing fuel loads (Covington et al. 1997). However, fragmentation of the landscape, public opposition and high population densities make implementing these management prescriptions difficult. There is also uncertainty about the amount of forest management required to significantly reduce risk of catastrophic wildfire, which is also significantly influenced by climatic variability (Veblen et al. 2000). Veblen, Kitzberger et al. (2000) hypothesized that while thinning and prescribed burning may reduce the probability of small fires spreading and becoming uncontrollable during average years, extreme weather conditions and droughts may still lead to high-intensity crown fires that pose high risks to people and infrastructure.

Management Options

Continued large catastrophic fire events have shown that complete fire exclusion is both an impractical and ineffective way to minimize fire risk in the landscape in the long-term and that not only has it failed in its aims of protection of people and property, it has had detrimental impacts on ecosystems and biodiversity in many places where it has been attempted (Dombeck et al. 2004). In recent years, there has been an increasing trend to allow fires that are started by lightning to burn (so far as they do not pose immediate risk to people or infrastructure) in order to reinstate the biological role of fire in natural ecosystems and to reduce the extremely high costs associated with suppression. This approach of course, is feasible only when the fires do not pose threat to communities or other assets and requires large areas of predominantly natural ecosystems and low human population density. As exemplified by the shift in fire regime in the Ponderosa Pine forests of the Western USA, allowing the return of naturally-lit fires to burn in forests that have had fire excluded from them for several decades can result in large, destructive crown fires that are difficult to control due to the high fuel loads that have accumulated in the absence of fire (Allen et al. 2002). As such, the proximity of such forests to the WUI mandates intervention to reduce fuel loads, such as mechanical thinning and prescribed fire, to reduce the probability of destructive crown fires.

The use of prescribed fire is increasingly being seen as a means not to eliminate wildfire altogether, but rather, to decrease fuel loads in order to minimize high-intensity fires that overwhelm fire-fighting capabilities and cause destruction (Jensen 2006). Fuel quantity is the only component of the fundamental fire triangle (ignition – fuel – weather) that we can actively control. With climate change is likely to make conditions hotter and drier in many parts of the world, the need to reduce fire risk becomes more urgent (Adams and Attiwill 2011). Further as outlined above, the sprawl of suburban communities into flammable environments restricts management options while increasing vulnerability of people and property (Dellasala et al. 2004). Management options cannot significantly alter the trajectory of a hotter, drier future of more extreme fire weather, but they may be able to influence the timing and intensity of wildfires. Decreasing fire intensities, by lowering fuels loads through prescribed burning and mechanical thinning in ecosystems that historically had a fire regime of frequent, low-medium intensity fires, can improve ecosystem function and the maintenance of soils, water supplies and biodiversity, in addition to reducing risk to human communities (Dellasala et al. 2004).

In fragmented landscapes, with communities and infrastructure surrounded by areas of flammable vegetation and various forms of land tenure (public and private), landscape scale fire management is challenging. Further, resources available for fire management are finite and it is often argued that priorities for fuel management should be those places where communities and flammable ecosystems meet: the WUI (Dombeck et al. 2004). The focus on fire management treatments at the perimeters of human settlements has obvious tradeoffs between reduction of risk and biodiversity. The complex challenge for managers is to be able to understand and predict the effects of fire management treatments on biodiversity (Gill and Stephens 2009). Here, the concept of fire regime is important, particularly for understanding plant response to fire. Commonly, ecosystems to be treated with prescribed fire will contain a number of threatened species that may become the focus of management objectives. Managers are then faced with the conflicted task of trying to balance fire regimes that suit certain threatened species against the requirements of other species while maximizing risk reduction (Dellasala et al. 2004). Any particular combination of fire severity and fire frequency will naturally favor some species and disadvantage other. However, rather than trying to manage on the basis of single species, it has been argued that there is far too much uncertainty in fire regimes for entire ecosystems,

with the responses of microfauna and macrofauna being much more poorly understood than the fire response of plants, and that a more robust approach would be to aim for diversity of fire regimes in a given area, with high heterogeneity of time since fire across the landscape (Adams and Attiwill 2011). Additionally, it is important to keep in mind the trade-offs for biodiversity if prescribed burning is not implemented. In this regards, the consequences of large-scale high-intensity fires on biodiversity must be kept in perspective. An extreme intense and uncontrolled wildfire that burns over an extensive area can be far more detrimental to biodiversity than a series of low-intensity burns aimed at minimizing catastrophic fire (Williams et al. 2009).

Management Trade-Offs

The concept of reinstating a 'natural' fire regime is hindered by the challenges we face in terms of ecosystem fragmentation, weeds and invasive species and other anthropogenic pressure placed on native ecosystems and native species by proximity to human settlements. There are no simple solutions for managing the coexistence of people and property amid flammable ecosystems and management necessarily involves a series of trade-offs, largely informed by social values and the economic restrictions of management budgets. The debate over how to best manage fire, for instance the role of hazard reduction burning, is inherently cyclical because it is continuously influenced and informed by scientific research and real-world experience (Bowman 2003a). Fire management can only realistically aim to achieve a finite set of objectives. Because of the difficulty of balancing conflicting values, such as biodiversity protection with hazard reduction, managers in the past have often failed to state clear objectives or to formulate achievable operational guidelines for landscape fire management (Bowman 2003a). Of the Australian context, (Bowman 2003b) writes:

"There can be no doubt that some styles of management are more sympathetic to biodiversity and ecosystem services than others. I believe the currently ascendant 'bushfire disaster' mode of management is ultimately more destructive of biodiversity than a program of recurrent fires to reduce fuel loads."

Sustainable fire management mandates that clear and specific objectives are stated and should acknowledge the complicated trade-offs inherent in management. The coexistence of humans in flammable landscapes represents an on-going challenge, without quick or simple solutions. The nature of a particular fire risk, and therefore potential management solutions, are context specific and will likely change as they are impacted by increasing changes in social and biophysical systems associated with population growth, cultural change, vegetation change and climatic shifts (Gill and Stephens 2009). Management objectives should be focused on long-term goals, rather than short-term fixes and should be strongly informed by ecological principles (Dombeck et al. 2004). Accordingly, fire management and planning in flammable ecosystems should be based on understanding of ecosystem dynamics and processes such as biogeochemical cycles, fire history, potential fire behavior, past management actions, land-use changes, threatened species and relative risk to human communities (Adams and Attiwill 2011). This is best addressed by a framework of adaptive management that allows management options to be informed by up-to-date information about these factors. Adaptive management is the process of monitoring, evaluating and making informed changes to management based on monitoring results (Dombeck et al. 2004).

Besides management options that manipulate vegetation and fuel loads, an obvious and much-neglected option for minimizing risk to people and property from landscape fires is land-use planning to minimize the juxtaposition of residential estates and people to inherently flammable ecosystems (Bowman et al. 2011). Planning, however, has received very poor political support in the past as it is perceived to conflict with people's right to live in proximity to beautiful, albeit dangerous, environments. Additionally, community engagement with issues surrounding fire management and active intervention by residents to prepare their homes against wildfires are important factors that impact the loss of lives and property (Bihari and Ryan 2012). In this regard, community engagement can be a powerful fire management tool. Given that fire danger at the WUI results from a 'complex mix of physical, ecological, economic and social developments' (Carroll et al. 2007), community support for fire planning and management is critical to the long-term success of landscape planning and management practices in minimizing fire risk at the WUI and maintaining the critical ecological role of fire in many ecosystems (Bihari and Ryan 2012).

Community Based Fire Management

Community Based Fire Management ('CBFiM') is increasingly being seen as a potentially powerful tool in the prevention of damaging wildfires and the application of fire for specific, useful purposes particularly in places where landscape fires are primarily anthropogenic in origin and the ecosystems naturally experience low levels of fire activity. CBFiM is similar to community based forest management, which has been promoted largely throughout tropical developing countries with mixed success in recent decades, in that local people play a central role in planning and carrying out management activities. CBFiM generally centres on activities associated with fire prevention and knowledge transfer to the community.

Social Institutions

While community participation and engagement in fire management is increasingly recognised as important, government institutions remain the central body of fire management and planning in most parts of the world (Pyne 2007). During the 20th century in states such as the USA, Canada and Australia fire management and research was conducted almost entirely by state institutions (Pyne 2007). Lavorel et al. (2007) believe that many of the problems that we face in fire management globally stem from a misfit between ecosystems with shifting fire regimes and the political, economic and environmental institutions that societies use to deal with fire. They claim that the catastrophic fire events in Indonesia in 1997 and large-scale disastrous fires in Southern Australia over the last decade may be 'interpreted as a temporary misfit between institutions regulating fire use and management and ecosystem conditions under the climate anomalies associated with El Niño' (Lavorel et al. 2007). Further, they argue that land-use change associated with economic and social shifts globally are also increasingly exposing the inadequacies of traditional fire-related institutions to deal with changing ecosystems and fire regimes. The influence of social institutions and cultural factors on fire activity is illustrated in Figure 7 below, with clear differences across political boundaries in some areas and no discernible pattern in others.

Similarly, political transitions can also have a significant impact on fire activity as old institutions break down. For example, under the administration of the former Union of Soviet Socialist Republics (USSR), Russia boasted a large and effective forest fire suppression capability, however, after the collapse of the Soviet Union in 1991, budgets for fire control (prevention, detection, monitoring, and suppression) were greatly reduced (Goldammer 2006; Goldammer and Stocks 2011). As a consequence of these political and economic changes and the subsequent reduction in investment in fire management, Russia has been experiencing very extensive, uncontrolled fires which burn over large areas. Goldammer and Stocks (2011) claim that these institutional issues, as much as the extreme heat wave and drought, contributed greatly to Russia's inability to manage the catastrophic fires of 2010.

The international nature of landscape fire problems, such as trans-boundary pollutions events, means that management should include international perspectives and international cooperation. Multinational institutions such as the Global Fire Monitoring Center (GFMC), supported by the United Nations, are encouraging countries to collaborate and build mutual institutions that recognise the shared benefits to be gained from improving fire management capacity across borders. This involves building regional networks that work together to solve regional fire problems and enhancing capacity to multilaterally share scientific and technical expertise and resources to manage landscape fire (Goldammer 2013).

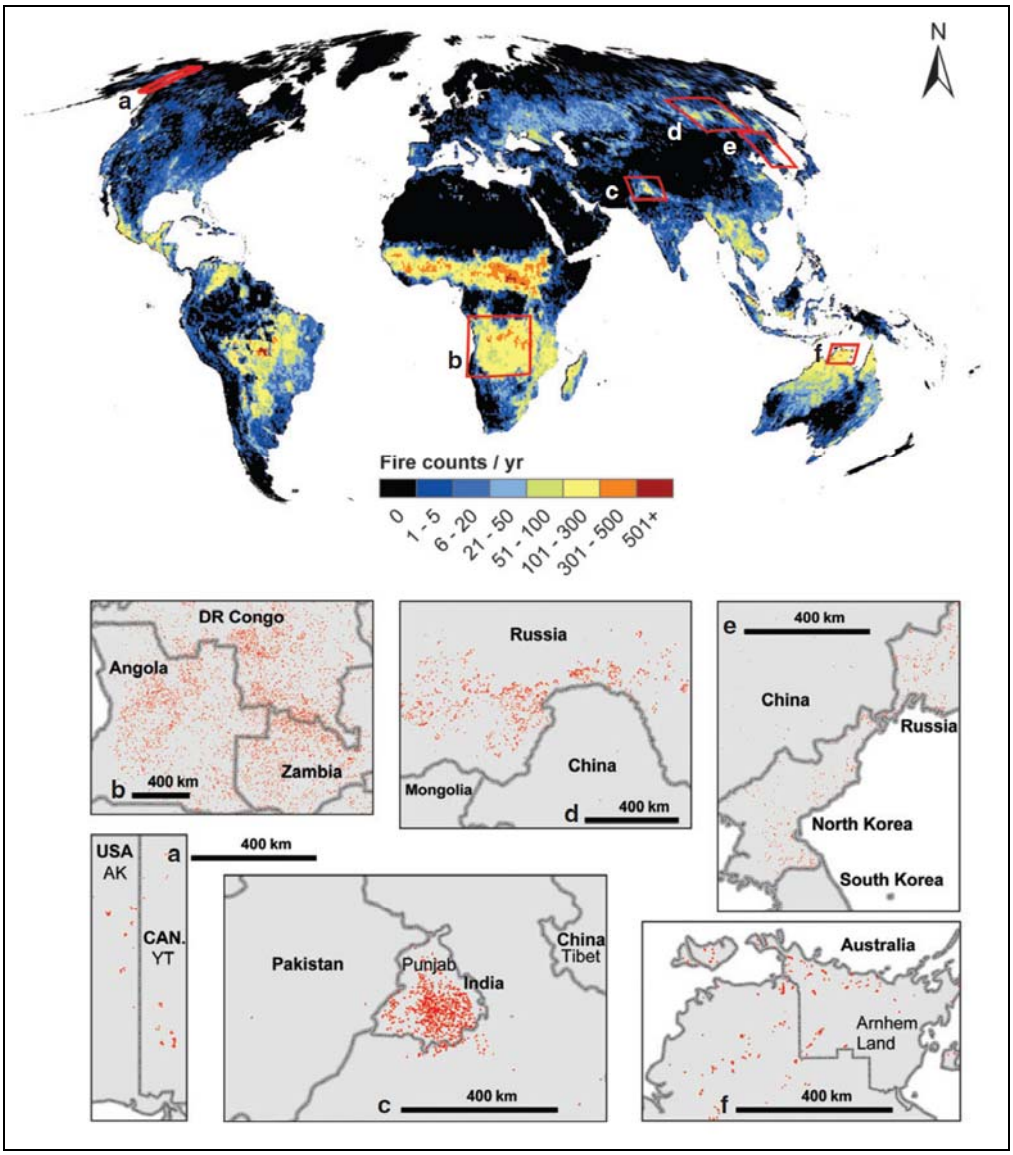


Figure 7. Active fire counts demonstrate global distribution of fires, both anthropogenic and natural, for the period 2001–2007 (above). Fire counts per year data recorded with the MODIS sensor on board the NASA TERRA satellite. Source: Giglio et al. (2006). Variation in fire activity stemming from differences in fire management policy and cultural practices are seen across political boundaries in c, d and e. In other regions, such as a, b and f cultural and social differences across political boundaries do not appear to influence fire. Source: Bowman et al. (2011).

According to Pyne (2007) fire problems are socially constructed, arising from human values and perception of risk. He believes that fire problems are problems only because humans define them as such and that the vast majority of the diversity fire management problems that we face across the globe can be resolved by social means. Pyne (2007) does not suggest that we can eliminate risk altogether or suppress fire entirely, but rather argues that humans have the ability to manipulate fire activity, within climatic restrictions, to determine the type and quantity of fire that we will accept. More concretely, Pyne (2007) claims that through land management, careful land-use planning and regulating activities we can come closer to finding solutions to our most urgent fire management problems. In order to do this though we must broaden the scholarship of fire to examine, understand and offer alternatives to the institutions, social values, and cultural choices that mediate human-fire interaction. A more multidisciplinary scholarship of fire that places humans and social values at its centre is critical to inform decision-making that impacts our landscapes and the role of fire in those settings. Furthermore, sustainable fire management demands that we rethink the role and structure of the institutions we charge with managing fire in the landscape, at local, national and international levels. In order to find ways to sustainably coexist with fire we must fundamentally re-evaluate the aims and objectives of fire management while recognising that the diversity of factors that are leading

to fire regime shift will require equally diverse strategies to manage them and will necessarily involve trade-offs.

Conclusions

Landscape fires are critically important for both human societies and to the majority of terrestrial ecosystems worldwide. Palaeoecological sources have revealed that fire has an ancient presence in the Earth system and was a key factor that influenced the evolution of many terrestrial ecosystems. Pre-historic humans developed a species monopoly over fire with the ability to start and manipulate fires and for many millennia people have carried and spread fire with them as they traversed the Earth. Today, fire remains a central component of human societies and cultures and is used for myriad purposes, indeed human relationships to fire are extremely diverse and many forms are currently found around the world.

We live in an era of unprecedented global change as humans have fundamentally altered landscapes as never before. Furthermore, humans have been able to increase or decrease fire activity through land use activities such as clearance and deforestation, or by agriculture and grazing, urban settlement, accidental and deliberate introduction of alien species, by altering ignition patterns and actively suppressing fires. Some places are now experiencing much more burning than historical background rates, while others are witnessing a decrease in burning or a change in the frequency and intensity of fire activity. In some environments which rarely burned in the past due to climatic constraints, such as the tropical rainforests, humans are increasing fire activity as a means to clear vegetation to intensify land use. Burning of tropical rainforests is causing widespread ecosystem damage, impacting biodiversity and releasing large quantities of greenhouse gases. Additionally, humans have begun to influence the ultimate control of fire activity across the globe. Global warming driven by anthropogenic combustion of fossil fuels and deforestation is leading to novel fire regimes on Earth. These shifts in global fire activity have serious ramifications for biodiversity and ecosystems that rely on recurrent fire disturbance to underpin nutrient cycling and regeneration, and for human societies that coexist in flammable landscapes. Changes to fire regimes have the capacity to alter the structure and function of ecosystems and to impact atmospheric and biogeochemical cycles. Collectively, these changes will further transform the way in which humanity coexists with fire via direct and indirect feedbacks.

In many places tensions exist between fire's biological role in ecosystems, fire's cultural role as a land management tool and the potential for fire to cause deleterious social, economic and environmental impacts. Human coexistence with fire has inherent risk involved as uncontrolled fires can have catastrophic impacts on people and property. Globally, landscape fires are responsible for enormous, albeit difficult to quantify, social and economic costs. These include loss of human life, loss of livelihood and property (e.g. animals and agricultural assets), indirect costs of settlement evacuations and impacts on regional economies stemming from resource loss and the enormous expense of fire suppression activity. Furthermore, smoke and other atmospheric pollutants released by landscape fire can significantly impact air quality and human health both locally and across international borders.

Alarmingly, there is strong evidence that severe fire incidents have been increasing in recent years in many parts of the world. A recent suite of catastrophic fire events on all inhabited continents have drawn political and public attention to the destructive effects that landscape fire can have on communities, ecosystems and economies. Under global warming conditions, fire activity is predicted to further change throughout the world, with some places likely to experience more frequent and intense fires, while others may see a decline in fire activity. It has been suggested that amplified fire activity in regions such as the Boreal forests may represent a positive feedback loop to climate change whereby larger, more frequent fires accelerate the release of Carbon and other greenhouse gases to the atmosphere, leading to more warming and more fire. The need to understand the drivers of these fire events is therefore urgent.

This review has argued the need for a more holistic study of the drivers of fire activity across the globe, focusing on the interconnected biological, physical and social components of landscape fire. In the past, the relationship of people to fire and the culturally mediated ways in which people influence landscape fire have been peripheral to the core study of fire science and management that has traditionally centred on the physical components of landscape fire. Finding ways to sustainably coexist with fire must start by recognising fire's critical biological role in terrestrial ecosystems and by the

acknowledgement that fire problems are socially constructed. It is therefore imperative that we try to comprehend the way human behavior and choices about landscape drive patterns of landscape fire.

In order to frame sustainable management options that minimize the deleterious impacts of landscape fire on human health, property, and ecosystems, we need to conceive landscape fire as a critical Earth system process which links and impacts biological systems, human activities and regional and global biogeochemical cycles. We can address our most urgent fire problems through social means but this requires a revaluation of the institutions we employ to manage fire and a clear statement of values and priorities for landscape and fire management. Humans cannot eliminate risk altogether or suppress fire entirely but societies, through their choices about land use and management, can inform the type and quantity of fire that they will accept. Clearly, finding a balance between reduction of risk to communities and infrastructure from fire and the ecological role of fire will be challenging. Our choices must necessarily be context specific and must acknowledge that the diversity of factors that are leading to fire regime shifts will require equally diverse strategies to manage them and will necessarily involve trade-offs. In some places, fire management may require reinstating fire into ecosystems, while in others it may need to restrict burning in ecosystems where prolific fire can be harmful. Given the social, economic and environmental challenges we face in an era of anthropogenic climate change and unprecedented land use intensity, sustainable fire-management demands a multidisciplinary, holistic approach.

IFFN contribution by

Jessica O'Brien
Global Fire Monitoring Center (GFMC)
Georges-Koehler-Allee 75
D-79110 Freiburg
Germany

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Government of Nepal
Department of Forests

United Nations
International Strategy for Disaster Reduction

Nepal Forest Fire Management Chapter (NFMC)

APAFRI

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Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities

20-22 November 2012, Lalitpur, Nepal

Summary

The Regional Pan-Asia / Pacific consultation "Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities" was held under the auspices of the Ministry of Forests and Soil Conservation (MFSC), Government of Nepal, the Korean Forest Research Institute (KFRI) and the Global Fire Monitoring Center (GFMC) representing the UNISDR Global Wildland Fire Network. The consultation was funded by the Korean Forest Research Institute (KFRI) through an administrative agreement and supported by the Asia Pacific Association of Forestry Research Institutions (APAFRI). Additional support was provided by the Global Fire Monitoring Center (GFMC) and the facilitation support by the UNISDR-Regional South Asia Wildland Fire Network and the Nepal Forest Fire Management Chapter (NFMC). The consultation was hosted by Nepal and successfully held in Lalitpur, Nepal, 20-22 November 2012.

The main objectives of the meeting were:

- To share knowledge and experiences of good practices in Community-based Fire Management (CBFiM) among countries of the Asia-Pacific region and outside of Asia
- To discuss global, regional as well as national level issues and concerns of wildland fire paradigms and management of wildland fire involving local communities
- To develop the concept of a regional activity in community-based fire management in the Asia-Pacific region
- To develop a draft concept of building a pilot activity in Nepal and at regional level to promote CBFiM approaches by establishing a Regional Fire Management Resource Center for monitoring, capacity building and advisory services in fire management.

Seventy-two participants from 10 countries (Bhutan, Germany, Ghana, India, Indonesia, Mongolia, Nepal, People's Republic of China, Republic of Korea and Thailand) attended and contributed to the meeting. Additionally input papers were received from the Russian Federation and Indonesia.

The participants of the consultative meeting assessed that within the four regions of Asia that are belonging to the UNISDR Global Wildland Fire Network and the Pan-Asia Wildland Fire Network, forest fires and other vegetation fires are increasingly impacting the environment and societies. The

Northeast Asian Region, which includes the Korean Peninsula, the Far East of the Russian Federation, Japan and China, is experiencing increasing occurrence of forest fires with negative consequences on sustainability of ecosystems, biodiversity and forest productivity. The Central Asian Region, which includes Mongolia, Northern China, the Russian Federation (Siberia), and the Central Asian States (Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan), is affected by continental dryness, widespread illegal logging and increasing wildfires, which are threatening sustainable forest management and regularly resulting in regional smoke pollution. The Southeast Asian region, covering the member states of the Association of Southeast Asian Nations (ASEAN), is faced by impacts of excessive fire application in land-use change, notably in rain forest and peat biomes, as well as wildfires in seasonally dry forests. The South Asian region, which is including countries of mainland South Asia not members of ASEAN, is faced with increasing pressure of forest fires, particularly in mountainous terrain, with severe consequences of secondary disasters such as landslides, erosion and floods. Many countries within the four regions of Asia are partners in economic and cultural activities. Some of them are sharing common forest fire problems, including transboundary fires and smoke pollution.

Participants of the consultative meeting discussed and agreed upon the following recommendations to the governments of countries in the Asia-Pacific Region:

- To develop / strengthen the institutional and financial base for fire management
- To formulate / review legal and policy frameworks
- To emphasize community based fire management, institutional and technological capacity development at all levels
- To establish Regional Fire Management Resource Centers in South Asia, South-East Asia, North-East Asia and Central Asia for monitoring, capacity building and advisory services in fire management
- To develop / enhance transboundary cooperation among the countries of Asia for information and technology sharing, training, preparedness and response during wildfire emergencies
- To encourage countries inside the Asia Pacific region and at international level to develop bilateral, multi-lateral projects and programmes aimed at enhancing fire management capabilities
- To consider implementation of the recommendations of previous regional and international meetings / conferences / summits
- To support and participate in the 6th International Wildland Fire Conference in South Korea in 2015

1. Introduction

Community-Based Fire Management (CBFiM) is a type of land and forest management in which a locally resident community (with or without the collaboration of other stakeholders) has substantial involvement in deciding the objectives and practices involved in preventing, controlling or utilizing fires.

The CBFiM approach is based on the principles of including local communities in the proper application of land-use fires (managed beneficial fires for controlling weeds, reducing the impact of pests and diseases, generating income from non-timber forest products, creating forage and hunting, etc.), wildfire prevention, and in preparedness and suppression of wildfires. CBFiM approaches can play a significant role in fire management, especially in those parts of the world where human-based ignitions are the primary source of wildfires that affect livelihood, health and security of people. The activities and knowledge communities generally practiced are primarily those associated with prevention. They include planning and supervision of activities, joint action for prescribed fire and fire monitoring and response, applying sanctions, and providing support to individuals to enhance their fire management tasks. Communities can be an important, perhaps pivotal, component in large-scale fire suppression, but should not be expected to shoulder the entire burden.

Faced with increasing fire occurrence and decreasing public budgets, government departments, local organizations, and forest users must consider a range of fire management options and experiences from around the world. Increasingly the solutions to the fire problems and the persistence of them year after year are suggesting that the reaction to fires to date in many countries needs to be reviewed. An active role of communities as proactive actors in fire management – in particular those which recognize the responsibility of civil society to plan and perform fire management activities -- may avoid pitfalls and mistakes of the past. These approaches are seen as more effective, less costly, and more sustainable over the long term.

At present, some countries of the Asia-Pacific region, particularly in the developing countries, are initiating CBFiM approaches to wildland fire management.

This is happening at a time when many countries of the Asia-Pacific region are noting an increase of forest fires and other vegetation fires. The increasing occurrence of extreme dry spells and heat waves currently observed, as well as climate modeling-based predictions (general circulation models), suggest that extreme weather periods favoring the recurrence of more frequent and larger wildfires and higher associated damages will aggravate in the coming years and decades in the Asia-Pacific region.

Wildfires if not well managed might pose not only immediate risk to the sustainability of forest and non-forest ecosystems, threat to biodiversity and the recreational, scenic, environmental and cultural value of forests. Populations of the surrounding areas may become seriously affected by injuries, death, and losses in properties. Post-fire secondary disasters such as landslides, mudflows or floods are additional threats to human populations, especially in the mountain terrains of the Asia-Pacific region.

The majority of wildfires are started by human activities, notably in the context of agricultural and pastoral land use. In the regions of the Asia-Pacific region several expert consultations have been held within the UNISDR Regional Wildland Fire Networks of South Asia, Northeast Asia, Southeast Asia and Central Asia on the future need of forest fire management. Key stakeholders directly and indirectly responsible in forest and land management, fire protection and emergency response, as well as representatives of local communities and civil society organizations, with support by international experts, were involved in these consultations. Altogether the problems of forest fires in the region are complex and should not be addressed on a sectoral level. In order to overcome the limited capacity in fire management there is a need to strengthen human and technical resources of agencies and local communities that deal with fire prevention and response. In addition, transboundary cooperation in fire management is needed to share the best appropriate knowledge in advanced approaches in fire management.

2. Objectives

The objectives of the consultation included:

- To bring together fire scientists, practitioners / managers, and policy makers to discuss global, regional as well as national level issues and concerns of wildland fire paradigms and management of wildland fire involving local communities as a key national approach in developing sustainable capacities in fire management
- To share knowledge and experiences of good practices in CBFiM among countries of the Asia-Pacific region and outside of Asia
- To elaborate the differences, opportunities and challenges of the role of communities in fire management throughout the region, especially under the light of changing socio-economic conditions, e.g.:
  - Increase of the rural exodus in some countries, resulting in abandonment of land cultivation (agriculture, pastoralism), weakening of the young work force
  - Reversed trends, e.g. ex-urban migration in some countries, e.g. in those regions where overpopulated urban areas do not offer sufficient resources for the livelihood of migrants

- Role of traditional and changing nomadic communities and fire management
- Role of modern “nomadic” communities: tourism

- To develop the concept of a regional activity in community-based fire management in the Asia-Pacific region
- To develop a draft concept of building a pilot activity in Nepal and at regional level to promote CBFiM approaches by establishing a Regional Fire Management Center for monitoring, capacity building and advisory services in fire management.

3. Conveners, Auspices, Sponsorship, Partners and Target Audience

Conveners:
- Government of Nepal / Department of Forests (DoF)
- UNISDR-Regional South Asia Wildland Fire Network (RSAWFN)
- Nepal Forest Fire Management Chapter (NFMC)
- Global Fire Monitoring Center (GFMC)

Sponsorship:
- Korea Forest Research Institute (KFRI)
- Asia Pacific Association of Forestry Research Institutions (APAFRI)
- Global Fire Monitoring Center (GFMC)

Partners:
- The Korea International Cooperation Agency (KOICA)

Target Audience:
- Fire scientists, managers, professionals, policy makers, international institutions and representatives of civil society (local actors, NGOs) had been invited to contribute to the meeting.

5. Agenda and Contributions of the Consultative Meeting

Three and half days have been allocated for following thematic and open sessions:
- Sharing regional and international experiences in CBFiM
- Field visit to local forests and communities, as well as exchange of experiences between communities
- Elaboration of contents of a draft project proposal in building a pilot activity in Nepal and at regional level to promote CBFiM approaches by establishing a Regional Fire Management Center
- Integration of National and Regional Needs for Informed, Capacitated and Coordinated Fire Management
- Pan-Asia Wildland Fire Network Meeting (invited participants)

The opening session had been graced by Dr. Krishna Chandra Paudel, the Secretary and the closing session by Mr. Yadu Bansh Jha, the honorable Minister of Forests and Soil Conservation (MFSC), Government of Nepal as chief guests.

The participants of the consultative meeting presented a ‘state-of-the-art’ on CBFiM experiences in respective areas in the first day. Summary of impressions from all the sessions is given in Annex III-A.

The extended summaries of the papers presented in the meeting are included in Annex II.[1]

Experience sharing on fire incident and Community-based Fire Management (CBFiM) at the field in Bajhghari Community Forest User Group in Kabhre District was held in 21 November 2012. The model firefighting volunteer group developed in Sundar Community Forest User Group in Hetauda demonstrated CBFiM activities in their area. The 'Summary of Impression of study tour' is included in Annex III-B.

5.5 Resolution of the Meeting

In the closing of the consultative meeting Mr. Sundar P. Sharma declared the resolution agreed by the participants of the "Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities". The full text of the resolution is given in Annex I.

ANNEXES

- Annex I: Resolution Agreed by the Participants
- Annex II: Abstracts and field visit report
- Annex III: Summary of Impressions from all Sessions and the Field Visit
- Annex IV: Photo Gallery

[1] The PPT presentations are posted (in PDF format) in the website of the UNISDR-Regional South Asia Wildland Fire Network within the web portal of the Global Fire Monitoring Center (GFMC): http://www.fire.uni-freiburg.de/GlobalNetworks/South_Asia/Meetings_activities/Southasia-Panasia_Consultation_ppt.html

ANNEX I

Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities

20-22 November 2012, Lalitpur, Nepal

Resolution
Agreed by the Participants

Within the four regions of Asia that are belonging to the UNISDR Global Wildland Fire Network and the Pan-Asia Wildland Fire Network, forest fires and other vegetation fires are increasingly impacting the environment and societies. The Northeast Asian Region, which includes the Korean Peninsula, the Far East of the Russian Federation, Japan and China, is experiencing increasing occurrence of forest fires with negative consequences on sustainability of ecosystems, biodiversity and forest productivity. The Central Asian Region, which includes Mongolia, Northern China, the Russian Federation (Siberia), and the Central Asian States (Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan), is affected by continental dryness, widespread illegal logging and increasing wildfires, which are threatening sustainable forest management and regularly resulting in regional smoke pollution. The Southeast Asian region, covering the member states of the Association of Southeast Asian Nations (ASEAN), is faced by impacts of excessive fire application in land-use change, notably in rain forest and peat biomes, as well as wildfires in seasonally dry forests. The South Asian region, which is including countries of mainland South Asia not members of ASEAN, is faced with increasing pressure of forest fires, particularly in mountainous terrain, with severe consequences of secondary disasters such as landslides, erosion and floods. Many countries within the four regions of Asia are partners in economic and cultural activities. Some of them are sharing common forest fire problems, including transboundary fires and smoke pollution.

The Regional Pan-Asia / Pacific consultation “Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities” was held under the auspices of the Ministry of Forests and Soil Conservation (MFSC), Government of Nepal, the Korean Forest Research Institute (KFRI) and the Global Fire Monitoring Center (GFMC) representing the UNISDR Global Wildland Fire Network. The consultation was funded by the Korean Forest Research Institute (KFRI) through an administrative agreement and supported by the Asia Pacific Association of Forestry Research Institutions (APAFRI). Additional support was provided by the Global Fire Monitoring Center (GFMC) and the facilitation support by the UNISDR-Regional South Asia Wildland Fire Network and the Nepal Forest Fire Management Chapter (NFMC). The consultation was hosted by Nepal and successfully held in Lalitpur, Nepal, 20-22 November 2012. Seventy-two participants from 10 countries (Bhutan, Germany, Ghana, India, Indonesia, Mongolia, Nepal, People’s Republic of China, Republic of Korea and Thailand) attended and contributed to the meeting. Additionally input papers were received from the Russian Federation and Indonesia.

The participants of the Consultative Meeting:

Assessing the national / regional fire situation:

Ecosystems throughout the Asian region are undergoing changes in wildland fire regimes. These changes are primarily induced by humans and aggravated by climate extremes. In equatorial Asia the use of fire in converting native primary or secondary vegetation is highest in the region. Main current

burning activities are related to conversion of peatlands to plantations, notably biofuel plantations, clearing agriculture land and slash-and-burn agriculture. Wildfires spreading from land-use fires are favored by dry spells or extended droughts during El Niño-Southern Oscillation (ENSO) events. Increasing severity and frequency of ENSO events are a consequence of global climate change.

South and Southeast Asia: In the seasonal forests of mainland of the regions, regular seasonal smoke pollution caused by wildland fires are aggravated by industrial pollution and other burning activities such as trash burning. The so-called Asian Brown Cloud or the seasonal smoke pollution in Northern Thailand and southern range of Hindu Kush Himalayan region are a consequence of multiple sources of fire. In the mountain regions of the Himalayas in the South Asia, wildfires are increasingly affecting the high mountain ecosystems. In Nepal in the past four years an unprecedented number and impacts of wildfires resulted in severe environmental, economic and human losses. Wildfires and fire smoke pollution are crossing national borders. Regional warming linked to climate change is predicted to alter the snow and ice regimes in high-altitude ecosystems. Rapidly melting glaciers will not only impact the drinking water supply of around one billion people but also affecting regional vegetation dryness and fire regimes.

Central and Northeast Asia: Wildfire-generated smoke pollution at local level but also in remote locations due to long-range transport is also regularly observed in the regions, with negative consequences on human health and security. The accumulating effects of land-use change, widespread non-sustainable forest use including illegal logging, regional climate change and wildfires are resulting in an expansion of grassland / steppe ecosystems at the expense of forest cover. In the Far East of Russia, mixed forest ecosystems are becoming increasingly vulnerable to fire as a consequence of regional climate, careless fire use and reduced institutional capacities to manage fires.

Aiming at enhancing regional existing capability in fire management, including monitoring, early warning and impact assessment, and facilitate international cooperation in wildland fire management;

Recalling to the Recommendations of the 4th International Wildland Fire Conference in Seville, Spain in 2007, Conclusions and Recommendations of the "Pan-Asia Forest Fire Consultation for the UNISDR Regional Wildland Fire Networks of Northeast Asia, Central Asia, Southeast Asia (ASEAN), and South Asia in Busan, South Korea in 2009" and Conclusions and Recommendations of Regional Session III (Asia Cluster): The Pan-Asia Wildland Fire Network – Northeast, Southeast, Central and South Asia of the 5th International Wildland Fire Conference in Sun City, South Africa in 2011;

Recognizing the values of forests as providers of economic, social, and ecological benefits and environmental services to humankind;

Recognizing the region has diversified ecosystems and forest types resulting from wide range of landforms and climate consequently having diverse fire regimes and vulnerabilities;

Recognizing the importance of information sharing, technology transfer with collaborative efforts for transboundary haze pollution reduction, establishing upstream-downstream linkage within the greater Hindu Kush – Himalaya region for reducing disaster risk caused by wildfires;

Recognizing that not all fires are destructive and that fire management is an essential part in sustainable forest management;

Being concerned about the carbon stored in forest biomass in Asia decreased in the last decades. Forests, a vital carbon sink, are decreasing and degrading mainly due to wildfires which are reducing carbon storage capacities of some forests. Wise use of fire as an integrated measure of sustainable forest management can stabilize or increase the carbon sequestration potential;

Recognizing the high expectations of the common-pool resources providing forest products including non-wood forest products, maintain biological diversity, adapt climate change, conserve watersheds, provide recreation facilities, improve air quality and help alleviate poverty through livelihood support to rural population;

Recognizing the wise use of fire giving due recognition of social and cultural values of use of fire in reducing the incidence and impact of wildfires by improved prediction, prevention, monitoring, rapid response to emergencies and restoration following fires; using planned fire for wildfire hazard and fuel reduction, silvicultural purposes and habitat management; increase capacity of local communities with resistance and resilience to the wildfire;

Supporting the objectives of work / terms of references of the UN-ISDR Wildland Fire Advisory Group / Global Wildland Fire Network and the Global Fire Monitoring Center (GFMC);

Expressing the intent to prevail over current gaps, problems and low capability in wildland fire management in prevention, preparedness, suppression, response and relief, rescue, and recovery and rehabilitation measures, integration of socio-cultural, economic, environmental considerations and institutions in developing policies and practices related to wildland fire, consistent information and statistics about fires, their causes and their effects, integration of fire as a component of land use and forest management, integrated community-based approaches to fire management, capability in the appropriate use of fire, capability in the safe and efficient use of resources for fire suppression, capability in remote sensing and use of satellite-derived information for wildland fire management, development and use of community-based fire hazard mapping, and measures to cope with fire emergencies;

Expressing interest in partnering and assisting in human resources development, institutional development, developing facilities and improving research, technology development and fire monitoring;

Expressing gratitude to the Korea Forest Research Institute (KFRI), Government of South Korea, and the Global Fire Monitoring Center (GFMC) for the support of the consultation;

Being Aware that in most countries of the region, the problems associated with excessive application of fire in land use and the humanitarian and security consequences of fires and fire emissions are not yet solved

Recognizing the increasing interest and proactive actions in participatory and community-based approaches in fire management in most of the countries of the Asia-Pacific region;

Participants of the consultative meeting discussed and agreed upon the following recommendations to the governments of countries in the Asia-Pacific Region:

- To develop / strengthen the institutional and financial base for fire management
- To formulate / review legal and policy frameworks
- To emphasize community based fire management, institutional and technological capacity development at all levels
- To establish Regional Fire Management Resource Centers in South Asia, South-East Asia, North-East Asia and Central Asia for monitoring, capacity building and advisory services in fire management
- To develop / enhance transboundary cooperation among the countries of Asia for information and technology sharing, training, preparedness and response during wildfire emergencies
- To encourage countries inside the Asia Pacific region and at international level to develop bilateral, multi-lateral projects and programmes aimed at enhancing fire management capabilities
- To consider implementation of the recommendations of previous regional and international meetings / conferences / summits
- To support and participate in the 6th International Wildland Fire Conference in South Korea in 2015

The participants of the consultative meeting thanked the organizers and hosts of the meeting for bringing together the fire community responsible for wildland fire science and management. The participants thanked South Korea to host the 6th International Wildland Fire Conference in 2015 and encouraged countries of the Asia-Pacific Region to attend the conference.

ANNEX II: Abstracts and Field Visit Report

Welcome Address – Opening Ceremony

Yam Bahadur Thapa, Head, National Organizing Committee
Deputy Director General, Department of Forests, Ministry of Forests and Soil Conservation
Government of Nepal

On behalf of the Department of Forests and also of the conveners and on my own behalf, I would like to welcome you all to this *Regional Pan-Asia / Pacific Consultation: Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities* being held in the beautiful mountainous country Nepal.

It is our great pleasure that our honorable Minister of the Ministry of Forests and Soil Conservation is with us despite his busy schedule to give this event a high value. I warmly welcome him this meeting.

Similarly, our respected Secretary of the Minister of the Ministry of Forests and Soil Conservation guided us from the inception of the meeting to date. I thank him welcome to this meeting.

Professor Johann Goldammer, a global fire leader is also with us. We deeply value his advice, guidance and support towards wildland fire management particularly to Nepal for many years. It's my great pleasure to welcome him again in Nepal.

Most importantly, I would like to welcome Dr. Koo and Dr. Lee from Korea Forest Research Institute as an emerging partner not only to Nepal but also to the Pan-Asia region, especially in the arena of wildland fire management. I warmly welcome them.

The Executive Secretary from Asia Pacific Association of Forestry Research Institutions, Dr. Sim's presence in this meeting will certainly open the areas of cooperation in wildland fire research in the Pan-Asia/ Pacific region. I also warmly welcome him in the meeting.

It's my great pleasure to welcome high level fire scientists, managers/ practitioners and policy makers from the four regions of Asia and beyond from 12 countries. I warmly welcome you all.

- Participants from international institutions, INGOs, NGOs, civil society organizations, universities, students and the media, representing from
- The Federation of community Forestry Users, Nepal (FECOFUN)
- Association of Collaborative Forest Users of Nepal (ACOFUN)
- United Nations Development Programme (UNDP)
- The International Centre for Integrated Mountain Development, ICIMOD
- Deutsche Gesellschaft für Internationale Zusammenarbeit [German Agency for International Cooperation] (GIZ)
- World Wide Fund for Nature (WWF)
- KANTIPU Daily
- Annapurna Post, and
- Nepal TV are also welcome

Fire hazard has remained as a major factor in forest destruction in Nepal. There are several reasons for the initiation of fire in the forest, but most of the forest fire events take place due to carelessness of people walking through forest trails connecting villages. The smokers throw cigarette butts on a dry forest floor without realizing the consequences. Sometimes the farmers in the lower areas make fire to prepare land and the fire goes uncontrolled taking the nearby forest in its grip. There are also cases where farmers deliberately use fire as a tool to burn the dead grass on the forest floor before the monsoon, so that the grass grows profusely in the following monsoon and thus providing a steady fodder supply to the animals. These anecdotes reveal that there are different causes of uncontrolled forest fires, but the consequences are always same: destruction and degradation of forests and biodiversity. Once the trees die, it takes years to grow back to forest. In the meantime, erosion and landslides damage the forest floor in the steep slopes.

In the pursuit of developing and managing forests, the government in the last five decades placed a high priority on its socioeconomic aspect. It was important because the forest condition in the country deteriorated and came to a dismal state due to high demand for forest products. The resulting adverse impacts were visible everywhere. People faced shortage of firewood, fodder, and timber: the most crucial livelihood support of the majority of them. It was clear that pressure on the forest had to be reduced and the resource managed at the local level. The results of the past policies to involve people in management have been felt by the forest managers as well by policy makers. It makes all of us happy that forest cover is steadily increasing and the users have been empowered to make decision about forest resources at their will. Now, it is time for us to move beyond and look at other factors that destroy this valuable resource so that we can further empower the users with additional technical knowledge in reducing damages to the forests. Forest fire is one area that needs our immediate attention.

I hope that the experience shared, opinions expressed, here and the outcome of the meeting will help us develop an understanding of the way we need to follow in the coming days.

I once again welcome you all to the meeting and wish you a pleasant and comfortable stay in Kathmandu.

Inaugural Address – Opening Ceremony

Krishna Chandra Paudel, Chief Guest
Secretary, Ministry of Forests and Soil Conservation, Government of Nepal

It gives me an immense pleasure to join you in this important events and inaugurate the '*Regional Consultation workshop on Building Advanced National and Regional Capacities in Integrated Fire Management*' being organized here in Godavari, Nepal. Allow me to extend our warm welcome to you all, particularly our foreign delegates, scientists and experts from different countries in this special meeting. I thank you very much for your valuable time, efforts and expertise to make this meeting happens in Godavari. I would like to express my sincere gratitude to the Korea Forest Research institute (KFRI) for its generous initiation to support forest fire management initiatives in the Pan- Asia region.

Distinguished delegates, we all know forests are important. So is fire if used carefully .However, the world is facing more problems and challenges on forest fire ever before due to climatic changes, increased temperature and population growth. Studies shows that 300-400 million ha (3-4 million km^2) of forests and other lands are annually affected by wildfires. Increasing occurrence of forest fire and inadequate public investment has warned all of us, including governments, local organizations and forest users to consider a range of fire management options and experiences from around the world. In this regards, I consider this meetings very timely and important to learn and share from each other so that we can better understand the forest fire dynamics and prepare ourselves with practical solutions to keep our forests safe from fire.

Many countries in our regions share common forest fire problems, including Transboundary fires and smoke pollution. At present, some countries of the Asia-Pacific region, in the developing world, are initiating CBFiM approaches to wildland fire management.

We are here to discuss and plan for better forest fire management. Taking this opportunity, I would like to mention current forest fire situation in Nepal.

In 2009 alone forest fires claimed 49 lives injured 9 people. It destroyed about 147,000 ha of forests. In 2010, a total of 9 people were reported dead, 3 people seriously injured, 431 houses were completely destroyed, and 92 animals killed. More than 82,000 ha forests were burned. Most of these fires were spread either from community activities or someone set fire in forest for various reasons. It is also true that local people are the one to be in the forefront while beating such fires. This scenario urges us for immediate actions to prevent unwanted forest fires.

The government of Nepal has approved 'Forest Fire Management Strategy in 2010. The strategy focuses mainly on 'preventive measures', 'control measures' and rehabilitation of the burnt areas. Now, we are working on to implementation of this strategy.

We have about 40% forest area in Nepal. At present, over 20,000 community-based forest user groups are managing about 1.8 million hectares (about 30%) forest of the country. This approach has contributed in the conservation of overall natural environment and biodiversity. In addition, the community-managed forest areas are the source of basic forest products such as fire wood, timber, medicinal and other non-timber forest products of daily need to our people. Engagement of local communities has been an effective approach for the conservation and management of forest resource including for community empowerment, local institution development, forest governance and economic prosperity.

However, Nepal is not free from other forest related problems such as forest encroachment, illegal cutting, hunting and illegal trading of wildlife articles. Forest fire is considered as one of the main causes of forest destruction leading to loss of biodiversity, life and property of our people. We consider forest fire management as an indispensable part of our natural resource management efforts.

Also, we are engaged in preparing new strategy with new vision and priorities. Our Ministry is responsible policy formulation and capacity building of forestry staff, local stakeholder including communities living around the forest fringes. We are now organizing better for effective forest fire management, strengthening technological capacities and strengthening capacities of our staff.

I consider this 'consultative meeting' very timely and important to share our experience and knowledge on CBFiM in this region and beyond .This meeting is also important for the development of regional activity in community-based fire management in the Asia-Pacific region. I wish you all to think and sort out possible regional activities to promote CBFiM approaches. I am confident that this meeting will certainly draw a further direction for 'collaborative efforts' through enhancing 'inter-regional cooperation' for capacities building, networking and collective actions for wild land fire management.

Nepal stands with you all for any possible supports and collaboration in managing forest fire.

Finally, I would like to thanks Dr. Gil Koo from (KFRI), Dr. Sim from (APAFRI), Prof Goldammer from GFMC for your gracious presence and contribution.

I wish you all the very best in your deliberations and look forward to receive your inputs for a concrete road map for enhancing regional cooperation in forest fire management.

I also wish you all a pleasant stay in Godavari.

Thank you very much!!

Introduction of the Agenda and Programme of the Meeting – Opening Ceremony

Sundar Prasad Sharma, Under Secretary (Tech.), Department of Water Induced Disaster Prevention, and Coordinator, UNISDR Regional South Asia Wildland Fire Network

This “Regional Pan-Asia / Pacific Consultative Meeting” is being held in Nepal with Financial support from Korea Forest Research Institute (KFRI), the Global Fire Monitoring Center (GFMC) and the Asia Pacific Association of Forestry Research Institutions (APAFRI). I appreciate the support received from KFRI, GFMC and APAFRI which make it possible to bring participants from 11 countries of five regions including Sub-Saharan Africa in one place to discuss and share experience and knowledge on CBFiM.

To convene this meeting, the Department of Forests under the MFSC of Nepal took a lead together with the Regional South Asia Wildland Fire Network (RSAWFN), its Nepal Forest Fire Management Chapter (NFMC) and GFMC. For this, we have received a continuous guidance and advice from Prof Johann Goldammer, the Head of GFMC, in the preparation of this meeting.

Let me allow giving a brief account of the *Pan-Asia Wildland Fire Network* which is a ‘Network of the Networks’ within the four regions of Asia (North East Asia, Central Asia, South East Asia and South Asia) which are belonging to the UNISDR Global Wildland Fire Network.

- The Northeast Asia Region, which includes the Korean Peninsula, the Far East of the Russian Federation, Japan and China. This region is experiencing increasing occurrence of forest fires with negative consequences on sustainability of ecosystems, biodiversity and forest productivity.
- The Central Asia Region, which includes Mongolia, Northern China, the Russian Federation (Siberia), and the Central Asian States (Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan). The region is affected by continental dryness, widespread illegal logging and increasing wildfires, which are threatening sustainable forest management and regularly resulting in regional smoke pollution.
- The Southeast Asia Region, covering the member states of the Association of Southeast Asian Nations (ASEAN). The region is faced by impacts of excessive fire application in land-use change, notably in rain forest and peat biomes, as well as wildfires in seasonally dry forests.
- The South Asia region, which is including countries of mainland South Asia, member countries the South Asian Association for Regional Cooperation (SAARC). This region is faced with increasing pressure of forest fires, particularly in mountainous terrain, with severe consequences of secondary disasters such as landslides, erosion and floods.

Many countries within the four regions of Asia are partners in economic and cultural activities. Some of them are sharing common forest fire problems, including transboundary fires and smoke pollution.

I would like to take this opportunity to brief the important audience of this Meeting about the recent past activities regarding wildland fire management initiatives under the Global Wildland Fire Network towards need for establishing Pan Asia Wildland Fire Network to enhance inter-regional cooperation.

The Joint Meeting of the Wildland Fire Advisory Group / Global Wildland Fire Network in Freiburg, Germany in 2008:

- recognized the need for collective action of countries of Pan Asia region technology and data sharing for wildfires disaster risk reduction

The 1st Pan-Asia Forest Fire Consultation in Busan, South Korea in 2009:

- agreed to established Pan Asia Wildland Fire Network under UNISDR-Global Wildland Fire Network – The secretariat of the Network to be established in South Korea.

The 2nd Pan-Asia & 7th North-East Asia Wildland Fire Network Meeting in South Korea 2011 expressed the:

- Need to enhance cooperation among countries in the Asia region aimed at sharing technology, expertise and data in fire management

In the 5th International Wildland Fire Conference in South Africa 2011, delegates of Regional Session of Asia cluster recommended, among other:

- Member countries should promote inter-regional cooperation, including joint investigations, joint fire management demonstration projects, consultations, and conferences;
- To strengthen the UNISDR Pan-Asia Wildland Fire Network;
- Technological and financial support must be provided by donor communities to financially disadvantage countries in building capability to wildland fire management.
- To hold a consultative inter-regional meeting among the networks of South Asia, Southeast Asia, Northeast Asia and Central Asia, by inviting the Sub-Sahara Africa Wildland Fire Network for sharing knowledge on Community-based Fire Management (CBFiM) approaches in 2012.

His consultation is one of the outcomes of the recommendations of the 5th International Conference. The main objectives are:

- To share knowledge and experiences of good practices in CBFiM among countries of the Asia-Pacific region and beyond.
- To elaborate the strength, differences, opportunities and challenges of the role of communities in fire management throughout the region, especially under the light of changing socio-economic and political conditions,

- To develop the concept of a regional activity in community-based fire management in the Asia-Pacific region
- And, to develop a draft concept of building a pilot activity in Nepal and at regional level to promote CBFiM approaches by establishing a Regional Fire Management Center for monitoring, capacity building and advisory services in fire management.

Today, after this opening session, we basically share regional and international experiences in CBFiM targeting towards integration of National and Regional Needs for Informed, Capacitated and Coordinated Fire Management.

Tomorrow, we will go for a field visit to Kavre and Bhaktapur districts. Please refer the programme of the field visit in your folder. The Nepalese participants who have not visited to the site before and interested in are requested to register your name for the field visit.

In the third day, in the first half we will

- Summarize impressions of regional and international experience in CBFiM towards strength, differences, opportunities and challenges of the role of communities in fire management throughout the region
- Discuss on new regional initiatives and pilot projects

In the second half, we will

- Discuss and solicit thematic inputs from all participants and come up with the 'Conclusions and Recommendations' of the meeting for the future direction.

At last, I also on behalf of Nepal Forest Fire Management Chapter (NFMC), would like to thank you all for your participation to this very important meeting and wish you all the bests for a productive meeting to draw a road map towards wildland fire management in the Pan-Asia Region.

Opening Address

Gil Bon Koo, Director General, Korea Forest Research Institute
Seoul, Republic of Korea

I am truly honored to have this opportunity to deliver an opening address to this special occasion today for "Community based Fire Management and Implementation". Especially I express my wholehearted appreciation to the Minister of the Ministry of Forests and Soil Conservation, staff members and guests for attending the 'Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities' despite your tight schedule in this busy season in dealing with forest fire.

On behalf of the Korea Forest Research Institute, I would like to express my gratitude to Mr. Yam Bahadur Thapa, Head, National Organizing Committee, Professor Johann Goldammer, chair of the Global Fire Monitoring Center, Dr. Abd Latif Mohmod, chair of Asia Pacific Association of Forestry Research Institutions, for your efforts in making this consultation happen.

Today, the global community is faced with a major challenge of climate change induced by global warming. More forest fires are occurring than in the past, bringing about more property damages. This negatively affects the sustainability of the ecosystems, biological diversity and forest productivity, as well as local communities that make their living out of forests. Most of wildfires are caused by human activities, notably in the context of agricultural and pastoral land use. Therefore, participatory involvement of local communities is very important for the successful forest fire management. In this aspect, Community-Based Fire Management approach is the proper solution in some countries of the Asia and Africa region, especially in the developing countries.

I hope that this consultation will be an opportunity for an international discussion in search of better fire management strategies by establishing matters of common interest, and sharing their views and experiences of good practices in CBFiM and international cooperation.

I would like to thank all the staff members for your endeavors in preparing for this symposium. In closing, I wish all of you good luck and good health.

Opening Address

Abd Latif Mohmod
Chairman, Asia Pacific Association of Forestry Research Institutions (APAFRI)
Director General, Forest Research Institute Malaysia
Presented by Sim Heok-Choh, APAFRI Secretariat

First and foremost, allow me to apologize on behalf of the Chair of APAFRI, Dr Abd Latif Mohmod, who is also the Director General of Forest Research Institute Malaysia (FRIM), for unable to be with us here this morning due to other pressing matters.

On behalf of the Asia Pacific Association of Forestry Research Institutions (APAFRI), permit me to take this opportunity to congratulate the Nepal Forest Fire Management Chapter for organizing this very important meeting for the Asian region.

APAFRI is honored to be given a chance to support this important international meeting, with generous financial contributions from the Korea Forest Research Institute.

Since 2007, the Korean Government, through the Korea Forest Research Institute (KFRI), has allocated a portion of its contributions to IUFRO for activities to be carried out in the Asia Pacific for forestry practitioners of this region. APAFRI is honored to be entrusted with the responsibilities of managing this portion of the fund. APAFRI has used the 2007 allocation for partially financed the International Conference on Traditional Forest-related Knowledge in Kunming China, the 2008 allocation for organizing an Asia Pacific Forest Health Workshop in Kuala Lumpur, the 2009 allocation for an Asia Pacific Forest Products Workshop in Sri Lanka, the 2010 allocation for the Asia and the Pacific Symposium on Vulnerability Assessment in Manila Philippines, and last year, 2011, APAFRI has organized an Asia and Pacific Workshop on Multinational and Transboundary Conservation of Valuable and Endangered Forest Tress Species in Guangzhou, China. Proceedings for these five events have already been published by IUFRO as IUFRO World Series Volumes 21, 24, 27, 29 and 30.

Forest fires not only destroy tens and hundreds of thousand hectares of forests every year, they also produced haze which could be swept across a wide area affecting the environment and vegetations, and hence could harm the health and livelihoods of millions of people in many countries.

Many factors could contribute to the increase of severity and frequency of forest fires including climate change and growing population, and efforts at both national and regional levels have over the years strived to manage this hazard with the aims of reducing its impacts on human wellbeing.

The ASEAN countries, for example, had signed an agreement on Transboundary Haze Pollution in 2002, to prevent and monitor transboundary haze pollution as a result of land and/or forest fires which should be mitigated, through concerted national efforts and international cooperation. Internationally, the Food and Agriculture Organization of United Nations (FAO) had compiled a set of guidelines on fire management, and APAFRI has assisted FAO in organizing a workshop in Pekan Baru, Indonesia, in 2008, to introduce this set of voluntary guidelines to the ASEAN countries.

With an ambitious aim of ***Greening the Asia Pacific***, APAFRI is an NGO with over 66 institution members from over 20 countries in the Asia Pacific region. Its secretariat is currently hosted by the Forest Research Institute Malaysia (FRIM). Officially launched in 1995 during a meeting of the Heads of Forestry Research in the Asia Pacific in Indonesia, over the past nearly 20 years APAFRI has organized many events in the form of meetings, workshops, seminars, symposiums and conferences, within the region with the primary objective to enhance collaboration between the members and also for information exchange. These events cover a very wide scope, ranging from general forestry, poverty reduction, traditional knowledge, pest and diseases, conservation and sustainable utilization, to forestry for climate change mitigation and adaptation. The ultimate aim is to contribute to building up the critical mass necessary for the sustainable management of the precious forest resources in the region.

APAFRI is continuously exploring opportunities to work with the other regional and international organizations on activities and programmes which will, directly or indirectly, contributing to forestry research and development in greening the Asia Pacific region. The opportunity to participate in forums

such as this one here this week would be invaluable for APAFRI, both to promote our efforts in raising the awareness of the vital contributions of forests to human wellbeing, and in the process to further enhance our linkages with other organizations with similar and related objectives.

Thank you very much and I wish you all a very successful and fruitful meeting here in this beautiful resort in Nepal.

The Paradigm of Community-based Fire Management: From a Narrow Concept to a Broader Epistemic Application

Johann G. Goldammer, Global Fire Monitoring Center (GFMC)

During the last two decades the need has been recognized globally that the participation of civil society in fire management is the key for a successful approach in reducing the inappropriate application of fire in land-use systems and in the prevention of wildfires. The approaches of involving civil society in fire management, however, are facet-rich, largely depending on the cultural context and the ecosystems, land-use systems and landscapes concerned.

Inhabitants of landscapes throughout the world have possessed inherited traditions and customs in fire management, many of them rooted in the empiric experience of rural societies who had learned to live with fire, utilize fire, and to protect their assets and lives from fire. Many cultural fire regimes, however, have been affected, changed and in many regions cultural fire regimes have been lost as a consequence of the transition of indigenous rural societies to colonial, industrialized and otherwise globalized societies. In some regions, in which historically people have not been confronted with wildfires, new problems are arising: Human-made disturbances coupled with the effects of climate change are creating conditions of high fire hazard that are unprecedented in the recent history.

In the industrial countries a culture of civil society involvement gave birth to voluntary fire brigades and later on to environmental protection movements, which created public awareness and civil engagement in the protection of natural resources, including protection of forests and other vegetation to become affected by wildfires.

The last two decades of the 20th Century saw an increasing acceleration of inappropriate, damaging application of fire in land use and land-use change, notably in the tropics and the adjoining developing world. Rapidly increasing rural populations seeking for land and livelihood brought fire into rainforests, mountain forests and wetlands, places that had not been subjected to anthropogenic or natural fire in historic timescales.

At the same time industrialized countries experienced an unprecedented encounter with wildland fires. Two opposite trends are noted:

- Migration of rural inhabitants to urban areas, seeking employment opportunities and urban lifestyle
- Movements of urban inhabitants to the “countryside” to flee overcrowded, polluted and otherwise stressed metropolitan areas and to settle in adjoining natural landscapes

Both directions of population movements are involving a change or increase of wildfire threats, both have a social and economic background. Poverty-driven migrants using fire in opening natural ecosystems for agricultural use and applying fire to clean fields and pastures, are still the major causative agent for wildfires in many regions of the tropics, where – besides industrial land exploitation – subsistence farmers continue to convert native vegetation by fire, in the Amazon and Zaire basins, or in Southeast Asia. We will hear more about it by the contributions from Indonesia. And there is a similar trend of encroachment and fire use in mountain ecosystems such as in the Himalaya and Hindu Kush region. Associated with an acceleration of regional warming and dryness land-use fires in the Himalayas have resulted in major wildfires during the last years. Examples will be given by the presentations of our colleagues from Bhutan and Nepal

The opposite migratory movements – rural people driven by poverty to the growing urban centers – often leave behind formerly cultivated landscapes, which, on their development “back to nature”, represent are forming stages of extremely high wildfire hazard. Rural exodus and abandonment of land cultivation is resulting in succession and increasing availability of combustible materials to wildfire hazard and thus increasing sizes, intensities and severities of wildfires, a trend that can particularly be observed in the Eurasian region

Conversely, exurban movements of metropolitan inhabitants to the “countryside” are trend in many industrial countries and involve increasing spread of building homes for commuters, weekenders, vacationing people and urban pensioners to highly flammable wildlands. Predominantly these populations have an urban lifestyle involving sometimes some gardening, but not land cultivation. As a consequence both the structures and the encroached wildlands are becoming more vulnerable to wildfires, as fire causers and recipients.

So, no wonder when fire users, causers, defenders and victims have to overcome rather different fire problems in a broad range of diversity of natural, environmental and socio-economic settings, additionally diversified by the superimposed political systems and cultural regimes.

So, how different are, or how much in common have the variety of people-centered approaches in fire management?

These are questions which will be addressed during this consultation. We will see that traditional participatory approaches in forest and fire management have commons, as is the case in some African and Asian landscapes – we will hear the commons of community involvement in Ghana and India. Within Asia alone the confrontation of communities with fire differ extremely between high-mountain Nepal and Bhutan, equatorial lowland tropical Indonesia and seasonal tropical Thailand. And other countries industrializing with a rapid pace like South Korea and Japan have left a decreasing number of rural communities using fire or being confronted with wildfires.

In the following I would like to report provide some thoughts on the recent development in temperate-boreal Eurasia, i.e. in the “greater Europe” stretching from the Atlantic coast in the West to the Pacific shores in the Far East.

In many regions of Eurasia rural settlements (villages, towns, scattered farmsteads) and other rural assets (agricultural fields / crops, infrastructures and other values at risk) are increasingly endangered by wildfires. This trend is driven by the consequences of land-use change, regional climate change and particularly by the rural exodus, which has resulted in the weakening of rural work force and self-protection ability, and increasing wildfire hazard on abandoned lands.

Vice-versa, increasing industrialization and concentration of populations in some areas exert a high pressure on natural resources for land use change, which is reflected by the high frequency of arson and ‘unknown’-cause fires in the wildlands. The intermix of human settlements with natural ecosystems and the fires burning at the interface between wildlands and rural settlements in many places create severe problems, which have become a major issue of political debate and confrontation.

Recent major wildfire disasters in Europe reveal that government authorities and civil society, notably rural communities, are not sufficiently prepared to prevent and reduce the risk of wildfires, to defend rural communities and rural assets at risk, and to protect human health and altogether human security against the adverse direct and indirect impacts and consequences of wildfires.

Guidelines are needed that will provide information to local inhabitants (farmers, community leaders, local fire service units, volunteer firefighters and village defense committees) with state-of-the-art information on wildfire damage prevention measures, and pragmatic measures for the defense of settlements and rural assets threatened by wildfires. With such guidelines local communities will be capacitated to apply all fire safety regulations for protecting the structures of the community (clearing vegetation, provide extra sources of water, application of appropriate building codes and use of appropriate materials, etc.) and for the protection of rural populations against the adverse effects of vegetation fire smoke pollution on human health and security. Also, the problem of fires burning on terrain altered by human activities, such as fires affecting dispersed, sometimes abandoned structures, waste deposits / garbage dumps and otherwise contaminated lands, needs to be

addressed due to the highly toxic emissions generated by co-burning of natural vegetation and technical / chemical produce.

In order to meet the demands for enhancing the capabilities of local rural communities to defend themselves against wildfires we are now developing guidelines entitled “Guidelines for the Defense of Rural Populations, Settlements and Other Assets against Wildfires and Smoke Pollution” in order to:

- Provide a practical technical document designed as a support tool for the protection of people and communities in temperate-boreal Eurasia from wildfires;
- Serve as a starting point and basis for the exchange of expertise and concepts within the Council of Europe / UNECE member states to continuously expand capacities in rural fire management.

The Guidelines will be prepared with the support from the European and Mediterranean Major Hazards Agreement (EUR-OPA) set up by the Committee of Ministers of the Council of Europe. The collaborating centers are the European Forest Fire Center (GR), the Global Fire Monitoring Center (DE), the Regional Southeast Europe / Caucasus Fire Monitoring Center (MK) and the Eastern European Fire Monitoring Center (UA). Members of the UNECE/FAO Team of Specialists on Forest Fire and the UNISDR Regional Eurasian and SE Europe / Caucasus Wildland Fire Networks will contribute to the development of the guidelines.

In the development of these guidelines we are carefully looking at the differences and the common issues of the role of civil society to take responsibility to preserve the cultural, ecological and socio-economic environment of their homeland, as well as the protection of human health and security from the adverse impacts of wildfires are explained.

The main objectives of the Guidelines are to empower individuals and local communities to take responsibility and action in the prevention of wildfires, and in the preparedness and defense of their lives, homes, villages and rural assets against wildfires.

Both ethical and pragmatic considerations are highlighted why there is a need to have leaders who take responsibility. On the ethical side civil society has the prime responsibility to manage and protect their homeland on a sustainable base for maintaining the ecological and environmental functions, the productivity and the carrying capacity of their homeland for future generations. This responsibility os increasing since climate change all over the Eurasian region is already resulting in the recurrence of extreme weather events, including extended droughts, which effect land-use systems and favour the occurrence of severe wildfires. With accelerating problems of national and global economies, expected migration of human populations threatened by climate change, the capacities of governments will become limited in taking all measures and responsibility for fire protection. Thus, civil society shall encourage and recognize those who are capable to guide, instruct and take responsible leadership within rural communities to empower the community to defend their homeland against the adverse effects of wildfires, and to be available as liaison (contact) to the public authorities in case of wildfire emergencies.

The Kathmandu Consultation and Beyond

The approaches in community involvement in fire management are facet-rich and include fundamental participatory principles, consideration of land tenure and forest-user rights, concepts of volunteerism, or programmes of poverty-alleviation or job-creation. Programmes called *Firewise* and *Firesmart* are aimed for reducing the loss of investments and human lives in the subdivisions spreading to the wildlands of the industrial countries.

Community-Based Fire Management as a term and philosophy received its main attention in the aftermath of one of the most significant fire episodes in human history – the extended fires used for the removal of native vegetation during a drought associated with an El Niño-Southern Oscillation (ENSO) event in 1997-98 in Southeast Asia. The amount of vegetation burned by vegetation conversion fires and wildfires in Indonesia within a few months may have corresponded to similar historic land-clearing in other continents, but with the distinction that similar land clearings in other regions globally stretched over decades or centuries, and not occurring during a few weeks or months, and less populations and observers were present to record magnitudes and impacts of such historic events.

In response to the situation in Indonesia principles of Community-Based Fire Management were tested in a number of pilot projects in the region, many of which were abandoned after the termination of international donor support.

Similarly, continuing community involvement failed in places where government provided incentives or subsidies for successful fire prevention and exclusion, but projects fell apart when government funding dried up.

Other approaches have been disconnected from a cohesive national approach; or a cohesive national approach did not exist and thus community-based approaches were isolated, inefficient and often silently phased out and were forgotten.

Based on the experiences in community involvement in fire management in the region and recognizing the need that countries need to develop and implement national cohesive fire management policies and implementation strategies it is worth to consider the early experiences in community involvement throughout the globe. In Asia the Indonesian experience, very much reflected by the work of the "CBFiM pioneers", Hartmut Abberger and Edy Marbyanto, as expressed in their 2004 report "Community Based Fire Management (CBFiM) in East Kalimantan – Concept and Strategies", needs to be taken out of the shelves and explored for application. The toolboxes are there, glossy meta-brochures are not needed any longer, what is needed is implementation.

Numerous other approaches on mainland South Asia, e.g. in Nepal and Thailand, need to be considered and should be put in the context of the need of building national capacities in fire management in which advanced technologies of fire early warning, satellite based monitoring systems, communication and decision-support systems, are needed as much as the grassroot-level approaches in fire management. Here I see an opportunity for a cooperation between the host and the main sponsor of the conference, the Democratic Republic of Nepal and the Republic of Korea. Dr. Lee of the Korea Forest Research Institute will report about his experiences in Korea and we need to define if they are applicable in Nepal and adjoining countries.

This consultation is offering a first opportunity for discussion of concepts and directions of building capacities from national to local level, and even considering the transboundary cooperation between neighbouring countries and specialized institutions are regional to global level, to supply information for fire management decisions, which would finally reach the communities in need. Enhancing national capacities in fire management would greatly benefit from the strengthening of regional cooperation through which the South Asia nations will continue to share information, data and expertise. The establishment of a Regional Fire Management Resource Center for South Asia (or Regional Fire Monitoring Center) could strengthen the already existing work of the UNISDR Regional South Asia Wildland Fire Network – a development which has good examples in the recently established Regional Southeast Europe / Caucasus Fire Monitoring Center in the FYR Macedonia, the Eastern European Fire Monitoring Center in Ukraine, and the planned Central Asian Fire Monitoring Center in Mongolia.

In conclusion of these initial thoughts I would like to refer to the opening address of UN Secretary General Ban Ki-moon to the last International Wildland Fire Conference in South Africa in May 2011, which I had the honor to convey to the conference attendees. Secretary General Ban Ki-moon stressed:

> *"Wildland fires destabilize ecosystems and the global atmosphere, and have clear implications for human health and security. Unlike other natural hazards, wildland fires are primarily caused by human activities. Measures to prevent them – such as education, awareness-raising and capacity-building – are well known and within reach. Community-Based Fire Management is particularly important."*
>
> *Globally as well as here in the Asian region the vast majority of fires are caused by people, thus they can be prevented and controlled. Thus, any fire management system, regardless if based on advanced technologies, or on traditional knowledge, can only work if people are participating actively and taking responsibility.*

The Secretary General further stated:

> *The transboundary effects of wildland fires associated with long-range smoke transport and emissions are prompting the international community to strengthen cooperation in fire management. International organizations and civil society groups are working to build capacity, develop advanced technologies and promote sustainable land-use practices.*
>
> *The UN system is strongly committed to this effort. Our work encompasses many aspects of fire management, including agriculture, forestry, health, science, the environment, emergency response and weather forecasting and monitoring.*
>
> *We welcome the efforts of fire specialists to build a culture of prevention and to develop a spirit of global cooperation.*

The UN system is available to provide the best professional advice, to support countries in developing land and fire management policies and fire management capacity with the ultimate aim to make natural and cultural ecosystems resilient to damaging fires. But the success of all these efforts is depending on the active participation and taking responsibility of civil society. I thank the sponsors, organizers, hosts and contributors of this consultation to work together this week for obtaining the best results by drawing expertise from the specialists attending, and the local views and visions of the host country Nepal. The Global Fire Monitoring Center and the Global Wildland Fire Network are offering the continuation of support to the Democratic Republic of Nepal and the Republic of Korea in building partnerships, creating synergies and generate the necessary political awareness to address the increasingly pressing problems of wildfires globally.

Inaugural Address – Opening Ceremony

Krishna Chandra Paudel, Chief Guest
Secretary, Ministry of Forests and Soil Conservation, Government of Nepal

On behalf of the Ministry of Forests and Soil Conservation, I would like to express my sincere gratitude to the Korea Forest Research Institute (KFRI) for its generous initiation to support forest fire management initiatives in the Pan-Asia region. I also extend my warm welcome to the delegates who join us at this major event '*Regional Pan-Asia / Pacific Consultation on Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities'* in Nepal.

Faced with increasing fire occurrence and decreasing public budgets, government departments, local organizations, and forest users must consider a range of fire management options and experiences from around the world. One study shows that 300-400 million hectares (3-4 million km^2) of forest and other lands annually affected by wildfires.

Many countries within the four regions of Asia are also sharing common forest fire problems, including transboundary fires and smoke pollution and are partners in economic and cultural activities. At present, some countries of the Asia-Pacific region, in the developing countries, are initiating CBFiM approaches to wildland fire management.

We are here to discuss forest fire management, because in most countries in this region, has been a crucial problem. Taking this opportunity, I would like to mention current forest fire situation and forestry sector in Nepal.

In 2009 alone forest fires claimed 49 lives injured 9 people. Fires destroyed about 146,742 hectares of forests. In 2010, a total of 9 people were reported dead, 3 people seriously injured, 431 houses were completely destroyed, and 92 animals killed. More than 82,000 hectares forests were burned. This scenario urges us for immediate actions to prevent unwanted forest fires.

The Government of Nepal has approved 'Forest Fire Management Strategy in 2010. The strategy focuses mainly on 'preventive measures', 'control measures' and rehabilitation of the burnt areas. Now, we are working on to implement the strategy.

The total area covered by forest in Nepal is about 40 per cent. At present, more than 24,000 community-based forest user groups are managing about 1.8 million hectares (about 30 per cent) of the forest areas, with resulting protection of the environment and biodiversity. In addition, the community-managed forest areas, through sustainable management approaches, serve as supplies of basic forest products such as fire wood, timber and medicines. This kind of approach by collaborating with local communities has been a valid strategy for forest resources management. The implementation modality has achieved gender-balanced principles, community empowerment, and sustainable institutional development in forestry governance and economic prosperity.

Forest fire is considered as the main cause of forest destruction in Nepal. Forest fire management is an indispensable part of our natural resources management efforts.

The Ministry of Forests and Soil Conservation is responsible for implementing forestry sector policies and monitoring their impact. Although, the Ministry is responsible for policy formulation our staff have insufficient managerial capacity in wildfire management. Therefore, the capacity for implementing and monitoring on fire management certainly demands further strengthening.

We are prepared to take necessary initiative in strengthening technological capacities on wildfire management. We are reviewing the Master Plan and formulating new strategy.

I am sure that this 'consultative meeting' having the objectives of (a) sharing the experience and knowledge on CBFiM in this region and beyond and (b) to develop the concept of a regional activity in community-based fire management in the Asia-Pacific region, and (c) to develop a concept of building a pilot activity in Nepal and at regional level to promote CBFiM approaches will certainly draw a future direction for 'collaborative efforts' through enhancing 'inter-regional cooperation' for capacity building, networking and collective actions for wildland fire management.

Also, I would like to appreciate and acknowledge KFRI initiation for their generous support towards Wildland fire management in Nepal in particular and in Pan-Asia region in general. And I also thank to Prof Goldammer from GFMC for creating an enabling environment in this regards.

I wish you the very best in your deliberations and look forward to receive your inputs for a concrete road map for enhancing regional cooperation in general and forest fire management in Nepal in particular by sharing experience, analyzing regional capabilities.

I also wish you all a pleasant stay in the beautiful Godawari Resort in Nepal.

I now declare this meet open and I thank you very much.

Closing Remarks of the Opening Session

Braj Kishor Yadav, Chair, Director General, Department of Forests
Ministry of Forests and Soil Conservation, Government of Nepal

On behalf of the Department of Forests and also from the National Organizing Committee, I would like to express my sincere gratitude to the Korea Forest Research Institute and the Global Fire Monitoring Center for their generous initiation to support forest fire management in the Pan-Asia region. I also extend a warm welcome to the delegates who will join us at this ‘Consultative Meeting of Pan-Asia / Pacific Region on Forest Fire Management’. As it is appropriate to the occasion, I would like to mention current situation of forest resources and forestry sector. Community-based resource management is the main ‘management’ regime of our natural resources. However, Nepal is facing technological and financial resources constraints to manage our forest sustainably. Forest fire management is the key component to sustainable forest management. But, due to lack of awareness and capability, every year we helplessly witness human casualties, loss of properties and destruction forest resources. I think the situation is also similar to many countries in the Asia region particularly to the developing countries.

I believe your deliberation during these three days will certainly draw common guidelines applicable to the Asia region dealing with forest fire. At last, I warmly welcome you all and wish for a pleasant stay in Nepal. With this, now I declare closing of the opening session and I thank you very much.

Forest Fire Regimes in the Hindu Kush-Himalayan Region and Community-based Fire Management in Nepal

Sundar P. Sharma, Department of Water Induced Disaster Prevention (DWIDP)
Ministry of Water Resources, Government of Nepal
Coordinator, UNISDR-Regional South Asia Wildland Fire Network
Member, UN-ISDR Wildland Fire Advisory Group and Global Wildland Fire Network

Forest fires are more common in lowlands in the Hindu Kush-Himalayan region during the hot dry and windy summer seasons (February to May). These fires are often associated with agricultural burning. Wildfires occurring in the highlands of Tibet, Sikkim, Bhutan and the northern part of Nepal at altitudes from 2,700 to 3,800m above sea level often cross national borders, especially during the dry winter fire seasons (November to January). Observations indicate that the occurrence of wildfires is increasing as a consequence of regional warming and increasingly extended dry spells. The southern slopes of the mountains are primarily affected, since they are generally warmer and drier compared to northern slopes and are therefore exposed to high human pressure. Increasing trend of wildfires in the recent past in the southern stretch of the Hindu Kush-Himalayan region are not only contributing to regional and the overall global problem, but also posing a higher risk to the communities if looked at from the point of view of the fragile Himalayan ecology.

Wildfires in high altitude Hindu Kush-Himalayas ecosystems are a major driver for destruction of pristine biodiversity, including the habitats of many rare species. During the long and intense dry seasons occurring annually in the region, wildfires are a regular phenomenon, many of them having a potential to cause major damages; e.g., serious degradation of forests, changes of ecosystem properties, and deterioration of social and economic conditions in some land-use systems and natural vegetation types.

Incidents of forest fires and total burning days are increasing in Nepal with increasing dry and hot seasons – as compared to the recent past – and the consequences of these wildfires do not only contribute to regional and the overall global problem but also posing a higher risk to the local communities, on economy, culture and ecology. The ecosystems and society are very vulnerable to wildfires, in general, and to the secondary disasters, such as landslides and flash floods, which often follow disastrous wildfires.

Forest fires are considered one of the climate-induced disasters. In 2009 alone forest fires claimed 49 lives injured 9 people. Wildfires destroyed about 146,742 hectares of forests and caused the loss of about Rs 134,415,000 (corresponding to $US 1.5 million). A total of 9 people were reported dead, 3 people seriously injured, 431 houses were completely destroyed, and 92 animals killed. More than 82,000 hectares forests were burned in the 2010 fire season. A proper damage assessment of a fire and systematic fire management is not developed yet in Nepal. Moreover, there is no any record of impacts of fire on wildlife, medicinal plants, secondary disasters (health and water induced disasters) and, regional climate. However, there is recent new development in fire detection, monitoring and response system involving local communities.

There is increasing interest in Community-Based Fire Management (CBFiM) and the need for institutional and technological capability development at all levels in Nepal. Some key factors that urge for CBFiM are:

- Fire is used by the rural population as a traditional tool for clearing and managing agricultural and pasture lands. It is also used to facilitate the gathering of Non-Timber Forest Products and in hunting and herding. Uncontrolled fires are common in the country, with a long and intense dry season. Many of these fires have the potential to cause major damages;
- Consequences of uncontrolled fires in country, inter alia, lead serious degradation of forests, ecological changes, as well as deterioration of social and economic conditions in some land-use systems and regional climate (e.g., the Asian Brown Cloud) and natural vegetation types;
- Nepal has diverse ecosystems, socio-economic and cultural settings and vegetation types resulting from a wide range of land-use systems and climatic conditions, consequently having diverse fire regimes and vulnerabilities;
- Fire management can be an essential part in ecosystem management (not all fires are destructive);

- Sustainable management and protection of vegetation cover, which provides goods and services including non-timber forest products and recreation, maintain biological diversity, mitigates the consequences of climate change, conserves watersheds, improves air quality and helps to reduce poverty through livelihood support to rural populations.

There is a lack of existing local and national capability in fire research and management, including firefighting, monitoring, early warning and ecological and socio-economic impact assessment, and facilitating international cooperation in fire management in Nepal.

Therefore, it has been recommended to:

- Focus on education, awareness raising and capacity building of rural populations
- Develop leadership, cooperation and communication capacities to empower local communities to take an active role in fire management
- Develop a national and regional (transboundary) policy and an implementation strategy for building / enhancing forest fire management capacities
- Establish a Regional Fire Management Center in Kathmandu
- Conduct country-level fire management training courses
    - Mid-level technicians
    - Field level technicians
    - Community level people
- Assist Nepal in capacity building in the use of information technologies, e.g.
    - Fire monitoring and early warning
    - Fire damage assessment
    - Land cover monitoring
- Disseminate of knowledge and expertise gained in CBFiM pilot projects in Nepal to a wider application inside the country and neighboring countries

Community-Based Forest Fire Management in Relation to Greenhouse Gas Emission Reduction in Indonesia

Bambang Hero Saharjo, Head of Forest Fire Laboratory, Division of Forest Protection, Department of Silviculture, and Dean, Faculty of Forestry, Bogor Agricultural University, West Java, Indonesia
Chair of the Regional Southeast Asia Wildland Fire Network

It has been scientifically demonstrated beyond reasonable doubt that fire has been part of some natural ecosystems in Indonesia for many thousands of years, and burning coal seams have been part of the landscape since that time. Today the vulnerability of Indonesian forests is mainly linked to more fundamental issues of forest management and the role of communities and local governments. There is very little attention given to the existence of local communities living close to the forests, including those that are vulnerable to fire.

Forest fires and land fires in Indonesia direct or indirectly had been well recognized as one of the main contributor to deforestation and land conversion which responsible for mostly of greenhouse gas produced which finally impact global climate change. To solve the problem, reduction of forest and land fire is a key strategic goal in Indonesia, and land conversion hopefully will minimize the negative feedbacks of global climate change to the Indonesian environment, and prevention efforts is the best solution through community involvement. The local people who live near and inside forests must be approached, giving them the best alternative solutions, so that their life style will be highly appreciated.

Historically local indigenous populations and early settlers used fire for land preparation wisely and environmentally sound, as it was inherited by the old people. These traditional practices did not have significant negative impacts to humans and the environment. Unfortunately in the end of the 20th Century the way to use fire for land preparation and forest clearing changed as the burned areas became larger and the many burned areas became connected and created vast burned, devastated landscapes. This development was depicted by satellite detection of active fires and the extent of area burned, with main fire activities in Sumatra and Kalimantan. The consequences of the fires, illegally applied without observing any clear guidelines and conducted by people who were not familiar with traditional burning like the indigenous local people. Hence, severe environmental damages occurred such as the extreme, annually recurring smoke pollution and destruction fire-sensitive rain forests and peatland ecosystems. These destructive and non-sustainable land-use and land-use change practices need to be banned and alternative solutions be recommended.

To solve the problem and to reduce extended ecosystem destruction and release of smoke affecting human health and the atmosphere by land preparation of local communities, field research was conducted in West Kalimantan and South Sumatra at different periods of time. The purpose of the research is to reduce the smoke from burning of surface fuel that dominated by shrubs, grasses, litter and left stumps. Those materials found in the surface were collected and separated into woody and non-woody materials. Woody materials are used for making charcoal and briquette, while non-woody materials are converted to organic fertilizers. Organic fertilizers return to the area that is used for planting crops, while charcoal and briquettes were used by the farmers for cooking. The research site that has 44 ton/ha of fuel load that usually burned but used as materials for making organic fertilizers, charcoal and briquette, so that no more fire used, finally found reduce greenhouse gasses as follows: 3.5 t CO_2; 0.04 t CH_4; 0.001 t NO_x; 0.04 t NH_3; 0.04 t O_3; and 0.64 t CO. These facts show that land preparation without fire is a possible solution which could be done by the community. The benefits include the production of organic fertilizers, charcoal and briquettes, and the environmentally sound reduction of greenhouse gas and particle emissions.

Community-based Fire Management in China

Xiaorui Tian and Lifu Shu, Research Institute of Forest Ecology, Environment and Protection
Chinese Academy of Forestry, State Forestry Administration's Key Open Laboratory of Forest Protection, Beijing, China

Currently there are 195.4522 million hectares covered by forest in China, corresponding to a forest coverage rate of 20.36% and including a forest plantation of 61.6884 million hectares. Plantation is mainly distributed in south China, and natural forest mainly in the northeast and southwest regions. In 2010 the total population is 1.37 billion for the Chinese mainland, in which 49.68% of them living in towns and 50.32% in rural areas. In recent years, the urbanization rate of the population is more than 1% per year. It is expected that more than 300 million people would transfer from rural lands to cities during 2004-2020. Thus, forest fire management in China needs the involvement of communities.

Human fire sources are main causes for forest fires, including agricultural burning, burning paper for ancestor worship, smoking, etc. It is custom for Chinese to burn paper and fireworks for ancestor worship on the tomb-sweeping day (5 April). That day often falls in a period of high forest fire danger. But in past decade, the government advocated to use flowers for ancestor worship, and restricted open burning in wildlands. Consequently, human-caused forest fires were reduced significantly.

Laws define the units or individuals who manage forests or other forest land to take the responsibility for fire prevention. The people's government at the county level or above is required to prepare emergency plans for forest fire outbreaks and organize the town administration to make the plan. The villagers committee shall help the government to deal with forest fire in accordance with the forest fire emergency plan. Professional fire brigades are the main source for fire-fighting. The masses just do some logistics work in firefighting operations. In forest regions, all counties have at least one professional forest fire brigade. There are a lot of rangers in the communities or villages to patrol the forest during the fire season, to respond to arising fire sources and to monitor forest fires.

The local people's governments at the county level or above define the forest fire season for the local people and publish the fire danger to the public. In each fire season, the local governments sign a fire prevention agreement with the leaders of the villages and towns, including the villagers or units who manage the forest. All open burnings in wildlands are banned during the fire season.

Warning signs and fire alarm telephones are set up on the walls of villages, roads and key locations. Any unit and individual should report forest fire immediately when they detect it. In order arouse the enthusiasm of the masses to participate in forest fire prevention and to improve the consciousness of people concerning fire safety, the fire agencies popularized forest fire prevention knowledge and self-rescue method through the radio, mobile messages, networks, slogans and other ways. The most important measure is to strictly reduce fire sources in wildlands.

Fire Management with Local communities in Bhutan: Current Practices and Future Perspective

Ram Bahadhur Mongar, Senior Forest Ranger, Department of Forest and Park Service
Ministry of Agriculture and Forests, Bhutan

Rural people in Bhutan, about 69% of the total population, are engaged in farming, mainly subsistence farming, involving highly integrated farming system such as crops, livestock and forest components (interdependent). However, pressures are mounting on the forests to provide an increasing range of goods and services. Forest fire is one of the main causes of forest degradation in the country. The main causes of forest fire are anthropogenic.

In late 1990s the devolution of power to the community was granted. The protection of forest from fire and some of the forestry activities decentralized to the local government in accordance with the decentralization policy of the Royal Government. People's participation in the development activities was priority of the Royal Government of Bhutan and focused mainly in infrastructure development

(road construction, rural water schemes, irrigation, health facility, school). Community-based natural resource management was secondary concern although government policy is to maintain 60% of forests cover of the total area. The breakthrough was with initiation of the Community Forest Program which streamlined forest fire management.

Forest fires in Reserved Forest in Bhutan, which are government-owned, are managed by state. In forests with traditional use the communities are responsible. These activities include e.g., appointment of fire watchers on a rotation basis among the villagers or collection of leaf litter and grasses. Since Buddhists believe that killing is a sin the prohibition of access for certain periods are traditional and conventional management principles practiced. A rewards system to fire-free sub-district/village is one approach encouraged. Reducing forest fires through volunteerism is also a program in the process. Volunteers have played important role, performing live theater in advocating prevention of forest fire awareness to the community of fire prone districts. Distribution of posters, erection of signboards at strategic locations, education through the media, such as of national TV and radio, are popular ways of information dissemination. Fire prevention and control messages published in both national languages (Dzongkha) and in English in the national newspaper (Kuensel) and in other print media. Back-up to combat forest fires is provided by both the local community and government.

The preparedness of forest fire is carried out by capacity building training. A manual covering the basics of forest firefighting has been developed with the technical assistance from the New South Wales Rural Fire Service, Australia. Workshops on environmental awareness also conducted. Few basic hand tools have been distributed to some communities in fire-prone areas. Some communities seem to have fair knowledge of symbiotic relationships between humans and nature, and the goods and various services provided by the forest. There is some awareness of different forest fire regimes, firefighting tools and the concept of fire lines and fire breaks. To save forest from fire, fire lines/breaks are constructed by some communities within their community forest.

To strengthen the Community-Based Forest Fire Management (CBFiM) programme, three pilot CBFiM projects have been set up at Damkhar-Umling under Lhuntshe, Dozam Community in Monggar and Nahi in Wangdiphodrang, with financial support from Bhutan Trust Fund for Environmental Conservation (BTFEC) through the Global Trust Fund / United Nation Development Programme (GTF/UNDP). The communities have participated in prescribed burning practical exercise conducted in the research plots located within their community areas. The other partner is the Participatory Forest Management Project (SDC, Helvetas) which has a focus on forest fire management especially with the Community Forest Management Groups.

In the structure of community-level forest fire management, the head of the Administration of the local government is the chairperson and constitute of a Forest Extension Officer, a Secretary, the Head of the village concerned (small unit of sub-district), fire watchers and ultimately, at the lowest level, the community forest firefighters. The fire watcher patrols the area and submits the report.

Challenges and issues

The rugged terrain, scattered settlements, low educational background, old traditional fire suppression methods, lack of adequate training (which has resulted in firefighter casualties), lack of projects sustainability to continuously support the activities, lack of basic tools/implements, time clashes (coinciding some agricultural activities with fire season), lack of communication facilities and firefighting resources are the constraints encountered. And the lack of immediate tangible returns discouraged people to participate,

The way forward and perspectives

While positive basic experience has been gained to involve local communities in fire management in Bhutan there is a need for more action and broadening of the approach:

- Training and application of prescribed burning should be enhanced
- Fire management programmes should be included in non-formal education, and in primary, secondary and tertiary education curriculums.
- New Forest Fire Rules (2012) are in place and should be implemented systematically
- Volunteerism to replicate experiences in other districts
- Poverty-eradication through fire management program should be fostered

- A project on monitoring of fire effects (fire severity) should be conducted in Bhutan
- A national forest fire management strategy will be developed

Bhutan has a strong legislation and a policy addressing forest fires. The communities have cultural attachment to forest since immemorial time. Despite of this fact, not much success has achieved in fire management with communities in Bhutan. Large fires continue to burn every year. Thus, the fire management challenges remains to be overcome.

Fire Management with Local communities in Mongolia: Current Practices and Future Perspective

Oyunsanaa Byambasuren and Johann G. Goldammer
Global Fire Monitoring Center (GFMC), Freiburg, Germany

Due to its geographical location, topography and ecological systems Mongolia is characterized by highly sensitive landscapes. Over the past 60 years, the annual average air temperature in Mongolia has increased by ~2°C. Significant changes also occurred in rainfall (17% of decrease in spring) and evaporation patterns, which are directly related to an increasing recurrence and severity of droughts and wildfires. Adverse impacts of these changes are creating a challenge for the country's economy, social life and people's livelihoods. In recent few decades due to frequent harsh climatic events (e.g. dry summers followed by extremely cold winters) many nomadic herders lost their livestock. This resulted in a concentration of population and livestock and created high pressure on natural resources in some central regions. Conversely, large areas of formerly utilized lands were abandoned.

On the other hand, the increased number and size of wildfires could also be related to the change of the political and administrative system. A wide range of government tasks, including forest fire management, has been decentralized, responsibilities are neglected and policy implementation has suffered as a consequence. Apparently, the blurred division of authority has made decision-making less transparent and also less legitimate in some localities, as compared to the state of affairs before the introduction of democratic reforms in local governance. However, fire management was always state governed.

The catastrophic fires of 1996 and 1997 brought the government's attention to the fire management situation in the country. Since that time the responsible agencies have been implemented a number of wildland fire management projects and programmes with a support of international donor organizations. However, knowledge and experience obtained during the project implementation often is not mirrored to the practice because of discontinuation of financial resources of authorities.

The new Forest Law (2011) allows the establishment of Forest User Groups or other kind of forestry "communities". In the law stated that the local communities should be the main managers of forest fire, especially in collectively owned forests. This is an important step in terms of community involvement in natural resource management including fire management. However, this development is in very early stage with many challenges ahead. The experiences from elsewhere have shown that for successful and sustainable forestry and forest fire management, continuing training and awareness raising to communities is a prerequisite.

Because of vast territory and insufficient road system the firefighting organization units are often not able to rapidly reach remote areas. The remote local communities are causing the most fire cases and also they are affected by the fires. Therefore, the application of Community-Based Fire Management principles will continue to be an important approach in fire management. Recent pilot projects on fire management show that since local communities owned the forest areas the number of fire incidents has decreased. Communities act more responsibly as compared to the time when forests were owned by the state.

The country needs to reconsider achievements from fire management consultations and further design and develop community-based forest fire management plan and including precise regulations, organize practical demonstrations and training on the targeted area and targeted local communities, that will govern and spell out roles and responsibilities of each key player (Forestry User Groups,

Local Government, Provincial Emergency Management Departments, State Emergency Management Agency and the Forest Department) and other relevant stakeholders in preventing and combating fire incidences and their consequences.

In 2008 the Global Fire Monitoring Center (GFMC), financially sponsored by the German Agency for International Cooperation (GIZ), worked with the Forest Agency (now Forest Department within the Ministry for Environment and Green Development) and the National Emergency Management Agency (NEMA) to set up an inter-agency and cross-sectoral dialogue for developing a future fire management system for Mongolia. During the First International Central Asian Wildland Fire Joint Conference and Consultation "Wildland Fires in Natural Ecosystems of the Central Asian Region: Ecology and Management Implications", associated with the First Central Asian Forest Fire Experiment, representatives of local communities (Mandal soum, Selenge aimag) participated. They demonstrated that taking ownership of forest use results in great awareness and action to protect the forests against illegal logging and wildfires.

After the establishment of a "National Council for Regulating Activities on Prevention of Forest and Steppe Fires" a "Sustainable Forest Fire Management Activity Plan" was developed in 2009 which called for the „improvement of the participation of NGOs and residents" in fire management. With the administrative and political reforms in Mongolia in 2012 this approach of community involvement will be actively developed.

The establishment of the Central Asia Fire Monitoring Center, an currently ongoing activity of the UNISDR Regional Central Asia Wildland Fire Network, aims to share information, knowledge, and expertise in the development of participatory approaches in fire management with the neighbor countries China, Kazakhstan and the Russian Federation. Furthermore partnerships are envisaged with the UNISDR Regional South Asia Wildland Fire Network and the Pan-Asia Wildland Fire Network Cluster. The proposal to set up a Regional South Asia Fire Monitoring Center in Nepal offers the opportunity to establish partnership between the two regional centers and networks.

Fire Management with Local Communities in Russia: Current Practices and Future Perspectives

Andrey V. Kalinin, Chief, Aerial Forest Fire Center "Avialesookhrana"
Andrey M. Eritsov, Deputy Chief, Aerial Forest Fire Center "Avialesookhrana"
Pushkino, Russia
Johann G. Goldammer, Director, Global Fire Monitoring Center (GFMC)
Freiburg, Germany

The global ecological value of forest of Russia, its huge economic and social potential role obliges the Russian Federation to have a long-term advanced forest policy in place, in which principles and the main directions of the development of the Forest Sector is defined in the interests of current and future generations of Russia. The forest policy is implemented by the state and needs to have a high level of acceptance by civil society,

Among many different problems in the forest sector during the last few years wildfires affecting protected (managed) forests and other lands, e.g. natural peatlands, natural pastures and agricultural lands, have resulted in high economic and environmental damages. The most recent extreme fire season occurred in 2010, the most severe season since the major fire episodes in 1972, 1987 and 2003. Forest fires and fires burning on managed and abandoned agricultural lands run out of control in 19 regions of Russian Federation, affected many villages and destroyed over 3,000 homes and infrastructures. A total of 62 people – both firefighters and civilians – were killed by wildfires. In all that regions local communities tried to save their homes, assist firefighters before the disaster came to the villages, but they were not well prepared and trained. Villagers did not have any safety clothes, hand tools and equipment. However there were some regions where volunteers took active part in fighting wildfires.

There are huge problems in the last decades in the villages of Russia. Because of agriculture activity and farming business collapsed tens of thousands villages have been abandoned. Some of these

areas are now used as recreational places, e.g. weekend and summer houses. In the forests near settlements and on abandoned agricultural fields succession is taking place, and the abandonment of land and forest use is resulting in the accumulation of large amounts of fuels and thus an increased wildfire disaster hazard. While most of the young local work force is migrating to towns and cities, there are only a few people staying in the villages and still use traditional methods to clean their lots they used for grazing, hay fields and hunting areas. Following the instructions at Federal level in Yakutia region a regional law was enacted in 2011 to restrict agricultural burnings since many of these fires spread to forests. However, in many remote areas people still were not informed about fire use restrictions and continued uncontrolled burnings.

In the forest sector there is traditional use of prescribed burning as well, but these operations are very limited. There is still a lack of legal documents to regulate prescribed burning operations. Therefore a comprehensive approach is required to protect villages and forests from uncontrolled and destructive fires and to involve local citizens and municipalities in this activity.

Between 3 and 8 September 2012 the „International Fire Management Week“ was organized under the joint umbrella of the Federal Forestry Agency ROSLEZKHOZ of Russia and the Global Fire Monitoring Center (GFMC), both cooperating partners under the bilateral Russian-German Agreement on Cooperation in Sustainable Forest Management, and under the framework of the UN International Strategy for Disaster Reduction (UNISDR) and the UN Economic Commission for Europe (UNECE).

During this event the latest and up-to-date state of the art of fire ecology and advanced fire management methods on the use of prescribed fire for wildfire hazard reduction in temperate-boreal Eurasia were presented and discussed between scientists, practitioners and policy makers at national level of the Russian Federation, and with representatives of the administrations of Krasnoyarsk Krai.

In a seminar basic statements and papers were presented on the role of fire in ecosystems and the implications on fire management.

At a field demonstration on prescribed burning under canopy of a pine stand nearby Krasnoyarsk media representatives were briefed about the objectives of prescribed sub-canopy burning in pine forests. Attendees of this demonstration witnessed for the first time that a prescribed low-intensity surface fire can be set in a forest to safely reduce surface fuels without damaging the stand.

An expedition to the site of Bor Forest Island Fire Experiment of 1993, located between the settlements Yartsevo and Bor, demonstrated the concept of a long-time research project of the consequences of a severe, high-intensity fire. The experiment, scheduled for the 200-years research period 1992-2192, investigates the consequences of a high-intensity forest fire, followed by secondary pests, on the regeneration of a natural forest.

A Round Table on the 4th day of the International Fire Management Week evaluated the seminar, the prescribed burning experiment and the visit of the Bor Forest Island Fire Experiment.

The Round Table concluded that there is an urgent need to revise the policy and practice of fire management in the Russian Federation, and agreed 10 recommendations including:

- Legal and other normative documents that are regulating forest management and forest fire protection need to be complemented concerning the use of prescribed fires and prophylactic burning under forest canopy.
- Methodological guidelines for prescribed burning under forest canopy need to be developed at federal level.
- Educational programs for the training of forest firefighters and fire management specialists at different educational levels (Including programs for volunteer firefighters) need to be developed and approved at Federal level.
- Programs of advanced continuous professional education for foresters on prescribed burning need to be developed and approved
- Further scientific research concerning prescribed fires needs to be supported at Federal level.
- The Order of the Federal Forestry Agency № 174 of 27 April 2012 “Approval of the normative for forest fire management plans” need to be changed in the section on planning the prophylactic burnings at forest district level and to determine the normatives for fire prevention operation plans in the 1-km zone around settlements.

- Concepts for the use of fire on agricultural and other non-forested lands of the Russian Federation need to be developed.
- A new system of statistical accounting and classification of types of forest and other vegetation fires and their consequences needs to be developed and appropriate changes to be made in the GOST № 17.6.1.01-83 (approved by Decree of the State Committee on Standards, 19 December 1983).
- International expertise in the field of fire management needs to be used, including the system of statistical accounting and classification of vegetation fires proposed by GFMC.

It was obvious after fire season 2010 that it is necessary to develop guidelines, rules and regulations to involve voluntary citizens and local people for defending villages against wildfires. Subsequently by the Government of Russia passed Federal Law No. 100-FZ (6 May 2011) on “Voluntary Fire Brigades for the Prevention and Suppression of Forest Fires”.

The creation of Voluntary Fire Brigades three main steps need to be taken:

- Setting up organizational procedures on creation of voluntary units to be actively involved in the prevention and suppression of wildfires;
- Development of a draft charter (a legal document); and
- Registration at the State to become a legal entity.

“Voluntary Fire Brigades for the Prevention and Suppression of Forest Fires” can be created at the initiative of citizens and any public association. A Public Association is understood as a voluntary, non-commercial association created by an initiative of citizens. A Charter needs to be developed, which defines the interests and common goals of the community and the procedures for the realization these goals as specified in the Charter.

Founders of public associations can be individuals and legal entities. The Public Association has to call for a convention (congress) at which the charter of the Public Association is presented and approved. Founders of Public Associations – Individuals and legal entities – have equal rights and perform equal duties. Federal and Regional Government monitor the rights and legitimate interests of public associations, support their activities and regulate grants and other privileges by legal acts.

Regulations to become a member of a Voluntary Fire Brigade require physical fitness of applicants. Every member of a brigade has a contract with the brigade about insurance and other regulations.

The activities of voluntary fire brigades include:

- Monitoring of the Forest Fund (patrolling)
- Organization of meetings with local people and providing fire propaganda for awareness rising and public information and education
- Participation in prevention and preparedness operations (building fire lines, access routes, water sources, distribution of fire propaganda booklets, construction of informative billboards, etc.)
- Participation in fire suppression operations
- Participation in the evacuation of local people
- Participation in rehabilitation operations

According to that Federal law voluntary fire brigades are allowed to take part in fire suppression operations without having a special license if the members of the brigades have successfully passed training classes and physical fitness tests.

According to the labor legislation it is permitted for men in the age between 18 to 60 years and for women from 18 to 55 years (except pregnant and feeding women) to perform this work if they do not have any physical defects and have passed a medical examination and are in a state of health that is recognized suitable to allow the performance of this work. Women, as a rule, perform auxiliary works (consumer services, cooking, paper works, etc.). These requirements concern for professionals as well, i.e. professional working in fire brigades or aerial firefighting organizations.

Firefighting operations in large fires by Voluntary Fire Brigades take place under the command and control of forest firefighting organizations, such as fire chemical stations and/or aerial firefighting forces. The Public Associations which are the organizers of the Voluntary Fire Brigades provide all

organizational support, including training, safety clothes, fire trucks, equipment. However, during firefighting operations the forest service authorities provide transportation, food and water supply, and observe all safety requirements.

The normal duration of working hours shall not exceed 40 hours per week. However, during the suppression of forest fires, especially when the return of volunteers to a residence is impossible for some time because of the remoteness of a scene of action on a fire, the operating mode is established by the head of fire suppression operations. The allowable operating time should not exceed 10-12 hours per day, and all working hours spent during firefighting will be noted. According to the regulations the volunteers will be compensated after the completion of firefighting operations. The amount of accumulated work hours during firefighting operations will entitle the volunteer to be awarded days off or work time reduction in their main profession after returning home. At present the Aerial Forest Fire Center jointly with the Greenpeace of Russia is developing Guidelines for Voluntary Firefighters that will be published and recommended for training and firefighting.

The Global Fire Monitoring Center in cooperation with the All Russian Institute of Continuous Education in Forestry translated advanced training materials from English to Russian that will be distributed to train Voluntary Fire Brigades and Municipality Authorities.

The Aerial Forest Fire Center, All Russian Institute of Continuous Education in Forestry on behalf of Federal Forest Agency supported by the Global Fire Monitoring Center (GFMC) and in cooperation with the U.S. Forest Service are planning to organize in 2013 educational international seminars on Village Defense against Forest Fires.

The implementation and success of building Voluntary Fire Brigades is in the responsibility of the regional authorities of the Russian Federation. There are some regions such as Altai Region, Primorski Krai, where Regional and Public Authorities set up special programs. Some projects have been supported by grants of international organizations.

Information Communication Technology onto CBFiM

Byungdoo Lee, Division of Forest Disaster Management
Korea Forest Research Institute, Seoul, Republic of Korea

It is estimated that 80% of fires globally burning in forested areas, stem from escaped agricultural fires. It is therefore more important to educate and train local residents for reducing unwanted fires than to establish the expensive fire suppression resources relatively. The participation of local people is the prerequisite of successful fire management. In this aspect, Community Based Fire Management (CBFiM) is the proper and unique solution. In the CBFiM, the accurate and timely information communication between local community and the authorities of forest fire management is important. The system based on Information Communication Technology (ICT) plays a major role in fire information sharing.

Korea is running several fire information systems. For example, the National Forest Fire Danger Rating Index System, the Forest Fire Behavior Prediction System, the Fire Ignition Point Reporting System, and the Aerial Suppression Resource Flight Path Tracing System are elements of the comprehensive National Fire Information System.

1. To strengthen the fire information delivery system to the local residents

If the fire danger index is high in certain areas, a warning message from the fire danger rating index system is transferred, automatically, to a head of a village who will notify the people of fire danger. He also informs the villagers that some acts are prohibited, such as waste burning or setting camp fires near mountain areas.

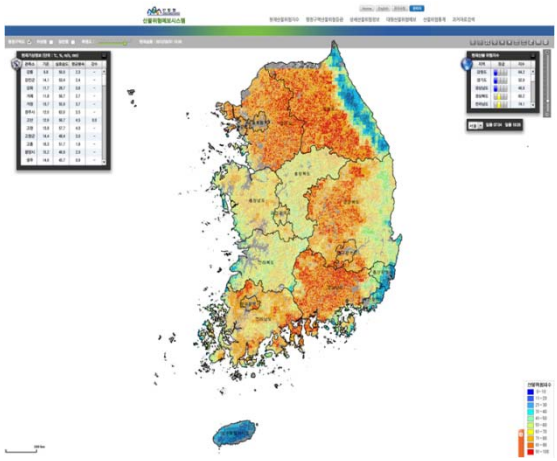


Figure 1. National forest fire danger rating system

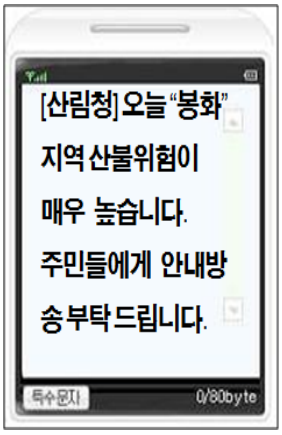
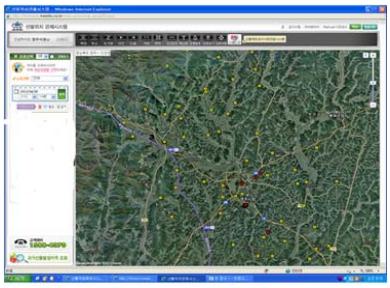


Figure 2. Forest fire danger index message to the head of a village

2. The participation of local people in the prevention and suppression fire

The local people are employed as firefighters. 25,000 local residents are taking part in the activities of fire prevention and initial suppression across the nation. The fire ignition reporting assistant is provided to these people for the accurate and quick reporting from field to fire control headquarters. Also the application of smart-phone for ignition reporting has been developed.



Figures 3 and 4. Forest fire prevention by a local resident

Figure 5. Smart-phone application for fire reporting

3. Fire information sharing using web-site

Information on restricted mountain areas and trail closures is serviced by the Korea Forest Service website. Local people are employed to patrol these areas.

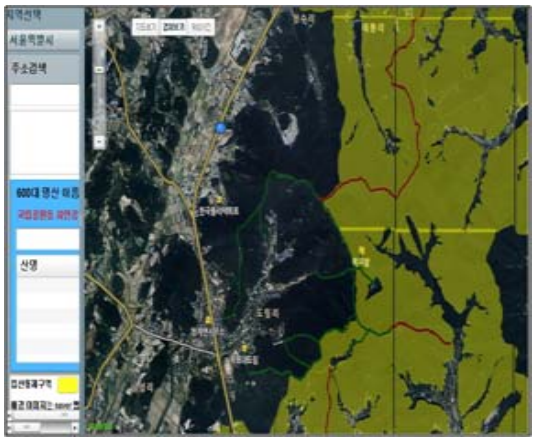


Figure 6. Web-based service of trail closure and restricted mountain area for fire prevention.

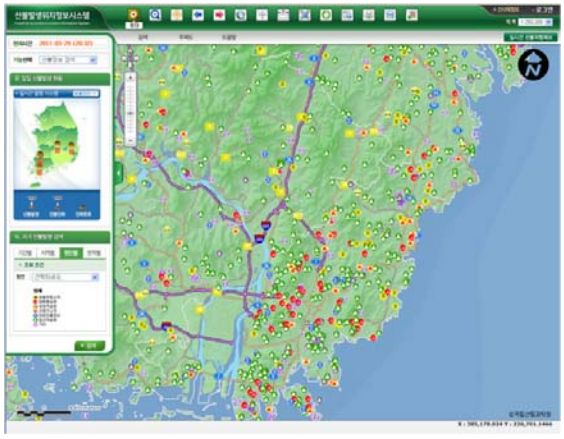


Figure 7. Forest fire database

Community-based Fire Management: Strategies and implementation in Ghana

David Asare, Resource Management Support Centre
Forestry Commission of Ghana, Kumasi, Ghana
Focal Point, Regional Subsahara Wildland Fire Network (AfriFireNet), West African Subregion

The global environment has over the years been under threat as a result of identifiable environmental problems militating against the sustainable management and development of the environment. Key amongst these environmental problems is wildland fire. Wildland fires have assumed an increasingly destructive dimension on the global environment that nations across the world are making frantic efforts at addressing the situation.

As one of Africa's fastest developing resource rich nations, Ghana has made crucial efforts towards improving the socioeconomic conditions of its people. In particular, the forest sector of the economy is widely recognized as having the most significant potential to impact Ghana's economic growth and development in the foreseeable future.

This potential is seriously threatened due to a dramatic increase in the number and severity of wildfires experienced in the country. Fire is perhaps the most important single threat to the integrity of forests in Ghana. In recent years, Ghana has lost an ever-increasing percentage of its gross domestic product to the indiscriminate ravages of fire.

Wildfires are also the direct cause of irreversible environmental damages in Ghana. In certain areas of the country the process of desertification has been hastened due to fires which have permanently destroyed delicate but vital organic soil material. At present, most fire-affected areas show progressive degradation. The loss of forest cover in the country has seriously affected local communities by its effects on local hydrology and the loss of a wide a range of non-timber forest products. A comprehensive fire management programme especially at the community level is needed to change the balance from a degrading to an aggrading system. Effective management of fire within forest fringe communities will allow forest rehabilitation and enhance the livelihoods of people living in these areas.

The Wildfire Management Project made significant progress under the six components through strategies and interventions rolled out to curb the unpleasant effect of wildland fires on some fringe

forest communities in Ghana. It implemented a comprehensive public awareness campaign and developed effective communication systems for fire detection and suppression as well as the identification and validation of 19 weather posts and stations. It further established 34 Wildfire Clubs in second cycle institutions across the country.

A National Wildfire Management Policy was developed with government approval and disseminated throughout the implementing areas within the country.

Training manuals were also developed for fire volunteer training and a total of 9,982 members of Fire Volunteer Squads trained. A Wildfire Management Manual has been developed and serves as a training manual for resource managers in Ghana.

A total of 616 km of green firebreaks was established in 28 forest reserves thereby creating employment for target communities and enhancing poverty alleviation within such communities. Incidences of wildfire had tremendously reduced in the project coverage areas as a result of the wildfire management interventions and efforts are being made to consolidate the gains.

Currently, the Wildfire Management Project has dovetailed into the Natural Resources and Environmental Governance Programme (NREG) with a view of further strengthening interagency support and collaboration as well as extending the success story of the wildfire management strategies to other parts of the country.

People's Participation in Forest Fire Management Thailand's Experiences

Siri Akaakara, Forest Protection and Fire Control Expert
Department of National Parks, Wildlife and Plant Conservation, Thailand

In Thailand, all forest fires are caused by human activities. This was widely known long before the establishment of the Fire Control Agency of Thailand back in 1980. It was later backed up by the official fire statistics. Due to this fact, the first priority of fire control activities is to work with people to prevent setting fire. Since without people's cooperation, fire prevention is a mission impossible, therefore people's participation is the only key to success.

Within these last three decades, Thailand has introduced and practiced various models and approaches of people's participation in fire management with the different degrees of success and failures from each approach. All models practiced are as follows:

- "Village Fire Volunteer Brigade" where the government provides training and equipment to villagers in fire-prone areas and expecting them to take care of fire in their respective area.

- "NGOs Village Fire Volunteer Brigade" This model is run by NGOs either international or local. It is the same as the 1st model, only NGOs pay salary to volunteers for full time participation.

- "The Reward for Smoke-free Village" The government ask villagers to prevent fire in forests in adjacent to their villages. If there is no fire throughout fire season, they will be rewarded with money for community usages.

- "Decentralizing Fire Management Task to Local Administration Organization" This is done under "Decentralization to Local Administration Organization Law 1999" The law mandates the transfer of fire management task in all National Forest Reserve to Local Administration Organizations.

- "Self-Established Fire Management in Communities Forests" The government promotes local communities to manage communities forests within National Forest Reserve. The locals have to protect and rehabilitate their community forests. In return they directly benefit from collecting all kinds of non-timber products. Also they enjoy better water supply from forests they protect. Moreover they earn more income from home stay and eco-tourism.

Due to the poverty in rural areas, local people will participate in fire management only when they have financial incentives or other direct benefit.

Lesson Learnt from Community Based Fire Management (CBFiM) Implementation in East Kalimantan

Edy Marbyanto, Hartmut M. Abberger and Helmut Dotzauer[2]

1. History

The total area of East Kalimantan Province – Indonesia is 19.84 million hectares. Forest area in East Kalimantan amounts to 14.65 million ha or around 70% of the total area of the province. Total population in East Kalimantan is about 3.56 million people (2010). The population is very heterogeneous because East Kalimantan has several indigenous people ethnic groups (such as Dayak, Banjar, Kutai, etc.) and also migrants (Javanese, Buginese, Sundanese, etc.). The indigenous people have a long history of fire management, especially by using slash-and-burn techniques for shifting cultivation. Forest and land fires are an especially difficult problem in East Kalimantan because of the vast peat forests and coal layers providing huge amounts of fuel for forest and underground fires.

Since the early 1980s, almost every three to four years, the El Niño phenomenon occurs causing droughts and providing prime conditions for extended wildfires in East Kalimantan Province, Indonesia. The most severe events in recent history occurred in 1997/98, when wildfires burnt 5.2 million hectares of forests and other land vegetation causing huge damages to man and nature. Most ignitions resulted from forest conversion activities for industrial plantations and from escaped small-scale agricultural fires. Fire management capacities were limited and couldn't cope with the extreme situation.

Between 1994 and 2004 the Indonesian government was supported by the German government (GTZ) through the Integrated Forest Fire Management Project (IFFM) for developing a forest fire management system for the Province of East Kalimantan. Part of the concept was to cooperate with local communities. IFFM designed a concept to establish a Community Based Fire Management System (CBFiM) in East Kalimantan. The programme covered all relevant aspects of fire management in the framework of community development and was aimed at community-driven participation to avoid and suppress wildfires. The CBFiM concept developed consists of the following modules:

- Capacity and risks assessment and village selection
- Village prevention campaigns and extension work
- The building-up of village fire crews
- Fire management training
- The provision of hand tools
- Institutional strengthening of a village fire management system
- The drafting of village fire regulations
- Yearly planning for fire management
- The establishment of a fire management network.

The most important aspect, in the course of developing CBFiM, was setting up of village fire crews and subsequently providing training for the crews. Once established, village fire crews had to define their objectives and elaborate Standard Operating Procedures (SOP), job descriptions, products and services. The module of drafting village fire management regulations was designed to determine all fire relevant aspects important to a community – and therefore also regulating the framework for the use of fire as a tool for field preparations. In addition, village regulations potentially strengthen the

[2] Edy Marbyanto, Hartmut Abberger and Helmut Dotzauer worked for the GTZ "Integrated Forest Fire Management (IFFM)" Project in East Kalimantan until 2004. Currently Edy Marbyanto and Helmut Dotzauer are working for GIZ's Forests and Climate Change Program in East and West Kalimantan.

position of village fire crews within their communities. This is critical for giving fire management some importance in villages and subsequently increasing the motivation and participation of people as members of fire crews.

Fire information aspects such as readiness levels (alert levels), seasonal calendars, weather forecasts (early warning aspect) together with the determination of response areas are important to define strategies and resources needed for CBFiM.

Networking with other village fire crews, the government, and also with forest concessions and plantation companies is necessary in order to share resources and increase capacities in fire prevention, preparedness, response to fires and rehabilitation efforts. Therefore communication strategies needed to be set up. In rural areas, the use of modern communication technologies might still somehow be limited. However, tools such as hand phones are very efficient and can be found already in many villages.

After the IFFM project was closed in 2004, the Provincial Fire Management Center took over and is continuing forest fire management in East Kalimantan.

Table 1. Number of villages with fire crews in East Kalimantan

District	Number of villages in district	Villages which fire management training	Number of fire crews	Number of personnel
Pasir	110	15	27	270
Kukar	195	26	33	330
Tarakan	18	10	10	100
Balikpapan	27	2	10	100
Kutai Timur	115	15	19	190
Bontang	14	6	6	60
Bulungan	85	11	11	110
Kutai Barat	209	20	20	200
Berau	85	15	15	165
Samarinda	42	3	8	80
Malinau	135	13	15	150
Nunukan	216	6	8	80
PPU	46	5	5	50
Total	**1,307**	**147**	**187**	**1,885**

2. Lesson Learnt from CBFiM Implementation

From the implementation of CBFiM in East Kalimantan, the following lessons learned have been identified:

2.1 CBFiM is a Capacity Building Process

Moore described CBFiM as “an approach to the management of fire in the landscape that adequately includes communities in decision making about the role, application and control of fire.” Participation in decision making processes is the highest level of participation, other types of participation are: participation in providing inputs to or for proposals fire management, participation in meetings and providing information, participation which raised from a persuasive approach or campaigns, participation which raised from incentives (Arner, 1997). From our field activities, we got the experience that community participation very often started from a low level of participation such as participation which was caused by using incentive systems or a persuasive approach. If they got benefits (economic, ecological or social ones) from their participation usually participation increased. To improve community participation, capacity building efforts, such as training, extension activities, trust building measures (e.g. through community meetings) and campaigns were needed. Capacity

Building efforts have to be conducted continuously until local communities are able to manage a CBFiM system by themselves.

2.2 Right and Benefit for community

A lot of communities living in or close to forests are poor people. They will participate in CBFiM if they get benefit from their effort, especially economic benefits. It is easier to encourage the local communities to develop and apply a CBFiM system on their own land than on state owned forests. On their own land CBFiM will help local communities to protect their economic assets. But on state forests such as National park or production forest, which are managed by forest concessionaries, sometimes it is difficult to invite local community to get involved in forest fire management because they will not get direct economic benefits. CBFiM will be easier to be implemented if local communities have access and rights to manage the forest resources in the proximity of the villages. A partnership with equal rights between communities, government institutions and/or the private sector need to be developed because local communities are the main actor of CBFiM and not its object.

2.3 Respect local knowledge and local resources and integrate with “modern” technology

East Kalimantan has a population of about 3.56 million people with a mix of indigenous people (such as Dayak ethnics, Banjar ethnics, Kutai ethnics) and migrants (such as Javanese, Balinese, Sundanese, Buginese, etc.). Indigenous people usually use slash and burnt techniques for their shifting cultivation activities. Indigenous people have traditional knowledge on fire management (and they have several traditional hand tools too). Therefore it is easier to introduce CBFiM by using their traditional knowledge and their local institutions as a base to develop CBFiM than using “outsider” knowledge. However, sometimes modern knowledge and technology need to be introduced in order to be more effective and efficient such as using modern hand tools, early warning system using hotspot monitoring etc.. Deforestation and forest degradation has changed the environmental conditions. Open forest canopies change the micro climate of forest stands and therefore influencing factors such as humidity, fuel amount etc.. These altered conditions also need an adaptation of local knowledge to the changed situation and long used, traditional techniques might become harmful under these much more drier and fire prone conditions. For example in the 1970s it was safe if local community built a fire break of one to two meters, but now, under much drier conditions, fire brakes need to be much wider to prevent fires to get out of control when they prepare their land for the next agricultural season.

2.4 Local specific and not uniformity approach

Communities in East Kalimantan are heterogeneous. They have different knowledge, resources, institutional arrangement etc. It needs a local specific approach taking into account local conditions and not a uniform approach. It is not only the differences between indigenous people vs. migrants, but in some cases within the same ethnic groups they have different knowledge and approaches because they live and work under different environmental conditions.

2.5 Integrating CBFiM with Sustainable Livelihood

Many local communities have traditional/indigenous knowledge on fire management. However, they need support from other stakeholders to improve or modify their knowledge and traditional fire management systems in order to adapt to the changed environment they are now living in. Support is also needed to develop sustainable livelihood system and establish income generating programmes. A multi-stakeholder and multidisciplinary approach is needed to support CBFiM implementation at the local level.

3. Challenges

3.1 Fire management policy is not suitable with local situation

Indonesia already declared its commitment to reduce carbon emission. As a consequence of that Indonesia is applying a zero burning policy. This policy will not render results and have any positive impact on the local situations because many indigenous people still practice slash and burnt technology and the government does not offer alternative (non burn) technologies and incentives that are not involving burning practices, which can be offered instead to local communities.

3.2 Limited legal access for local communities to manage the forest

East Kalimantan has still a very large part of its land covered with forests. However, the biggest part of the forests are manage by the government (such as National Parks and Protected Forests) or by forest concessionaires (production forests). It will be difficult to encourage local communities to get involved in fire management if they still do not benefit from the forests surrounding their villages and in their opinion belonging to them anyway. To support CBFiM the government must change its paradigm applying gradually a policy of “community based forest management” instead of “large scale and capital based forest management” as well as changing from “timber management” to “forest ecosystem management”.

3.3 Lack of coordination among stakeholders

CBFiM needs a multi-disciplinary and multi-stakeholder approach. But right now only the Forestry Service or the Environmental Service tackles this issues. Sharing of resources and responsibilities among stakeholders and community empowerment in general and for CBFiM is still very limited.

3.4 Lack capacity of Human Resources

The development of CBFiM requires intensive support from the Forestry Service and other governmental institutions. So far very often no personnel of the Forestry Service or other institutions is assigned to cooperate routinely and regularly with local communities at the province and district level of East Kalimantan. However, this is a critical issue for the success of CBFiM-DP. Other issues are that available personnel sometimes does not have enough knowledge and skills on social and participatory approaches. Consequence is they tend to use a top down approach when they work with the communities instead a bottom up approach and very regularly fail to achieve anything at all. Personnel working with and for communities have to be trained in applying participatory methods in workshops and other events and need a good knowledge and skills in the design and implementation of trainings (visualization methods and didactics).

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Community-Based Fire Management in China

Xiaorui Tian and Lifu Shu
Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, State Forestry Administration's Key Open Laboratory of Forest Protection, Beijing 100091, China

1. Introduction

China has 282.8 million ha of forest land, in which the state forest accounts for 40%, and collective forest for 60%. Total forest area is 174.9 million ha, in which the state forest accounted for 42.5%, and collectively forest 57.5%.The forest are mainly distributed in the northeast forest region, southwest high mountain area, southeast hilly forest region, northwest high mountain region and tropical regions. Most forest distribution concentrates in the main river basin and in the mountain-hilly areas. In the geographical distribution, there are more forest in the outlying provinces in Northeast and Southeast China, and hilly lands of Southern China, while less forest in the vast northwest area, central Inner Mongolia, most of Tibet, as well as densely developed economy regions of north China, the Yangtze River range, the lower reaches of the Yellow River.

The state managed forest areas comprise about 41.33 million ha, which accounted for total forest land 15.5%, and stumpage volume 25.8%. Southern collective forest regions include Hainan, Guangdong, Guangxi, Fujian, Zhejiang, Anhui, Jiangxi, Hubei, Hunan and Guizhou and parts of Sichuan Province, with area of 151.2 million ha, 15.75% of the national land area. In the region, collective forest occupies more than 90% of the total, and its ownership belongs to farmer, collective and enterprise, in which farmer are main body.

In 2010, the total population is 1.37 billion in China mainland, in which 49.68% of the populations live in towns or cities, and 50.32% in the countryside. According to the statistics, in 2004 there were 9.43 years educations in urban, and 7 years for people in countryside. Urban illiteracy rate was 4.91%, and 10.71% in the village. The population aged 0-14 years accounted for 21.50%, and aged 15-64 years 70.92%. In recent years, the population urbanization rate is more than 1% annually. It is expected that there about 300 million people would transfer from the countryside to cities during 2004-2020.

During 1950-2011 the average annual forest fires is 12,810 in China, in which 4630, 3614, 28 and 4 fires in size <1, 1-100, 101-1000, and >1000 ha respectively. Average annual 613,645 ha forest were burned. In 1989-2011 there were 7415 forest fires in annual, in which 4197, 3198, 18 and 3 fires in size <1, 1-100, 101-1000, and >1000 ha respectively. The annual burned area was 260,580 ha for the period, of which 85,674 ha were covered by forest (41,135 ha natural forest and 29,477 ha plantations).

2. China's forest fire management organization

"Forest Fire Prevention Ordinance" stipulates that the forest fire prevention implement administrative leadership responsibility system of the people's governments at all levels, and the people's governments at all levels should put forest fire prevention as an important task. The work need to be under the unified leadership and take comprehensive measures. The local people's governments set up forest fire management headquarters, and the principal leaders of the Government or the competent leadership take as commander. The leaders from the relevant departments or local military take the deputy commander or headquarter members. Forest fire management headquarters take the responsible for forest fire management in the administration. The county government should organize the town government to develop the forest fire emergency response approach based on the forest fire management plan. Village committee should help to deal with emergencies in accordance with the provisions of the forest fire emergency plan and forest fires approach.

The units and individuals of ownership for forests, trees or woodlands should establish forest fire prevention responsibility system, delineate of forest fire area of responsibility, and design a responsible person for forest fire prevention in accordance with the provisions of the competent forestry departments. They also need to prepare forest fire prevention facilities and equipment. The Local people's governments and state-owned forestry enterprises, institutions should establish the professional fire brigades based on actual needs. local people's governments at county level or above should guide forest management units and villagers' committees, businesses and institutions in forest regions to establish volunteer brigades (masses forest firefighting team). Professional and volunteer brigades should conduct regular training and drills. The part-time or full-time rangers from the ownership of woodland are responsible for patrol forest, manage and report the fire in wild, and assist the relevant authorities to investigate forest fire cases.

By the end of 2011, there are 3342 forest fire prevention headquarters, 3679 fire management offices, and 22,194 full-time staffs in all fire agencies. In nine provinces (autonomous regions or municipalities) it is establish a full-time commander system. Now forest fire prevention organization and command system has been constructed initially, with the central government leadership, local governments take responsibility, and cooperation among the divisions.

3. Community involvement in forest fire management

3.1 Clear the forest fire prevention responsibility

County Governments need to sign responsibility agreements on forest fire prevention with town government, and there are similar agreements between towns and villages, and village committees and village groups. The responsibility agreements define the leaders at all levels who take responsibility on forest fire prevention work and also define the management responsibilities of other persons clearly. This ensures that everyone will comply with the relevant requirements, and ensures forest fire safety.

There is a forest fire prevention command in the town government, and forest fire prevention leading group in the villages. Meanwhile, the county and township government organize professional or seasonal fire brigades.

3.2 Fire prevention

3.2.1 Publicity on forest fire prevention

Forest fire prevention publicity set out based on local forest fire management, and mainly includes introduction of forest fire damage, basic knowledge of preventing and extinguishing forest fire, laws, policies and guidelines of the state and local on forest fire prevention.

A variety means were used such as broadcasting, mobile message, Internet, slogans, etc. It is all-around propaganda in forest fire prevention. That would let masses know the forest fire prevention knowledge and self-help methods, improve people safety consciousness, arouse the masses participation in forest fire prevention initiative, and actively involved in the work.

The local government posts forest fire prevention command through radio, television, newspapers and other ways. Boards with slogans were set up on key roads and forests. Leaflets and brochures were sent out to average people. Some local fire agencies held knowledge competition on forest fire prevention to carry out publicity activities.

In fire peak season, the fire agencies put up boards of forest fire danger rating and fire warning flags on key roads or entrances. They also conduct propaganda to tourists in forest parks and let them understand the forest fire prevention regulations. Special session education are carried out in primary and secondary schools to popularize basic knowledge of forest fire and regulations.

3.2.2 Fire sources management

The local fire agencies can establish fire check station, or border check station according to the needs of forest fire prevention, and get the permit from governments at county level or above. In key areas, the fire source is strictly controlled to bring into the forest. During the fire season, all motor vehicles entered forest areas should install fire apparatus in accordance with the provisions, and equip with fire extinguishment equipment. The persons who engaged in production in forests are not allowed to carry fire sources and also forbidden to smoke in the wildlands.

In most areas of China, there is a tradition to burning papers and firecrackers in front of tombs for ancestor worship. Especially, the Qingming Festival (April 5th) is the traditional Tomb-Sweeping Festival, and that is a period with high fire danger easy to cause a forest fire. In recent years, local governments guide people to make use of flowers to substitute the burning of papers, which reduce man-made fire sources in forest. Some local governments also guide the villagers to move the dispersed tombs to the public cemetery.

It is important to educate and supervise to the minors and the mentally deficient personnel. The guardian shall bear the corresponding legal responsibility and economic loss if those persons made cause of forest fires.

3.2.3 Forest fire monitoring

Local forest units should have full-time rangers. Most of the rangers are local villagers. The Rangers patrol forest and monitor fire. In fire season, the village in focal region will establish one or two forest fire patrol groups to manage fires in wildlands. Billboards with the fire alarm telephone number were put up in villages and along the roads, which facilitates masses alarm timely.

In addition, the masses participate in fuel management, clean-up weeds on forest edge, and building fire line. The fuel breaks also were built in afforestation.

3.3 Fire security

Local governments at county level or above can delimit Forest Fire Districts, define the fire season, and release to the public, according to forest resource distribution and forest fire occurrence. During the fire season, fire agencies at all levels and units or individuals who manage forest have to take corresponding prevention measures and emergency preparedness based on fire danger.

Fire is banned in forest fire prevention zone in fire season. During the extreme fire danger period, local governments at county level or above can issue orders to prohibit all fire in wildlands. If the fire used indoor may cause a forest fire, it also need to strict management. Due to production needs for field use, that needs to be approved by the government at county level, and take fire prevention measures in accordance with the requirements. Prescribed burning and agriculture fire need to comply with the regulations.

Seasonal fire brigades were established in some villages, especially in remote forest areas. The members can combined with their production and fulfill their responsibility to control wild fire. In Guangxi province, the masses uses fire in habit to burn sugar cane leaf and cleaning for land preparedness. The seasonal fire brigades can help them to carry out prescribed burning and eliminate the illegal burning.

3.4 Forest fire suppression

Laws defined that professional firefighting team is the main force for forest firefighting. Ordinary people are not directly involved in firefighting on fire line, and they just do some logistics work. Minors and the elderly personnel are prohibited to participate in forest firefighting.

In recent years, all counties in forest regions established more than one professional fire brigade. In 2011, there are 17,000 fire brigades in professional or semi-professional (seasonal) in China, comprising about more than 510,000 personnel. For example, Yunnan province has more than 12,000

professional firefighters. All counties, towns and streets set up fire teams prepared to their forest fire prevention task. Headquarters regularly organized those fire brigades trained and drills.

Along with the reform of forestry property right, some private forestry enterprises began to organize fire prevention association, and set up their own fire brigades. For example, in 2012 the town government in Laibin (Guangxi) established 63 semi-professional fire brigades, which main constitute from young cadres and workers in town. Village and forest society established 68 semi-professional forest fire brigades with about 2297 persons involved.

In Jiangsu Province, the militia emergency teams become a main force of forest firefighting. At present, the 39 counties (cities, districts) in the province have set up 44 militia forest fire emergency response teams, comprising about thousand people. Every year, militia was arranged no less than 3 days training for forest fire prevention.

4. Summary

Current forest fire in China is still relatively serious, and man-made fire source is the main reason for the forest fires. China's forest fire management is universal participation under the leadership of governments at all levels. Especially in the vast rural areas, the masses actively involved in forest fire management, and promote the development of the economy and society.

Closing Remarks

Sim Heok-Choh
Secretariat, Asia Pacific Association of Forestry Research Institutions (APAFRI)

Thank you very much for the invitation to say a few words during the closing of this very important meeting on forest fire management. I would like to, again, apologize on behalf of the Chair of APAFRI, Dr. Abd Latif Mohmod, who is also the Director General of Forest Research Institute Malaysia (FRIM), for unable to be with us here for this consultative meeting due to other pressing matters.

Allow me to congratulate the Organizers for the very successful and fruitful meeting, including the very tiring, yet exciting, field trip to a rather remote pine plantation up in the mountains. I personally had learned a great deal about community involvement in forest fire management, and was taken aback by the extremely committed local community in voluntarily managing the pine plantation, including fire management.

I would also like to express my special thanks to Mr. Sundar Sharma, for the invitation to this meeting, which among others, gave me the rare and much treasured opportunity to rekindle my linkage with many Nepali colleagues, some whom I have not met for many years.

The Honorable Minister, for your information, your Department of Forestry Research and Survey has been an active member of APAFRI since 1997, and many of your staff members had actively involved in APAFRI activities over all these years. We hope to continue this cordial relationship and close collaboration, contributing to capacity building, not just at the national level, but also at the regional level.

Thank you very much, and I wish all a good farewell and safe journey home.

Closing Statement

Yadu Bansh Jha, Honorable Minister
Ministry of Forests and Soil Conservation, Government of Nepal

It gives me an immense pleasure to be here on the occasion of the closing of this 'Consultative Meeting' in the Pan-Asia region, organized by Department of Forests. It is my honor to have the opportunity to welcome you all to this discussion programme.

By appreciating the concern of 'Forest Fires in Mountain Ecosystem in Nepal' by the Secretary General of the United Nations, Mr. Ban Ki-moon in his opening speech of the Fifth International Wildland Fire Conference in South Africa in 2011 and his expression of emphasis on "Community-based Fire Management", I would like to elaborate our local situation and our efforts so far.[3]

The Government of Nepal has made appropriate decisions in the last two decades to preserve the forest resources of Nepal by encouraging forest users in managing forests. Credit goes to the efforts of millions of forest users, who have successfully taken roles to protect and manage our forests. These forests were once degraded extensively causing adverse impacts to the livelihood of the people as well as the mountain environment.

These efforts have enabled us to address the human induced pressure on forest. Today we feel proud to have improved forest cover as well as its productivity.

However, we are not without problems. Forest fire has been a prolonged problem in forest management in Nepal. The denser the forests, the higher are the fire risks. As a developing country, Nepal does not have the resources to afford to maintain a fleet of equipment and trained firefighters to go out to the mountains and attend the fire hazards. Moreover, the dry period of February to May is also the hottest months in Nepal. The rivers flow at their minimum. Springs and wells dry out. When fire breaks out, it only stops after all the fuels in the forest have even burnt and that only happens when the fire reaches the mountain tops.

Forest fire is not only a serious hazard to forests, but are also damaging community homes and injuring and killing humans. We need to find the ways and means to address this issue. First of all, we need to understand what fire hazard means to our forest resources, our economy and to our overall environment. When we understand these, then we need to develop strategy to address the issue. The ways identified must be suitable to our situation and affordable to the people. It also must be effective so that our action can be faster than the rate at which forest fire spread across.

Finally, your deliberations during these three days have come up with fruitful results and recommendations for enhancing regional cooperation fighting against forest fire. I assure you that the Government of Nepal will join you to address this crucial issue of forest fires through regional cooperation.

I thank all the organizers and participants. I wish you all very good evening and happy stay in Godawari.

Thank you.

[3] Editorial note: See last issue of IFFN (No. 41)
http://www.fire.uni-freiburg.de/iffn/iffn_41/02-IFFN-41-IWFC-5-UN-Secretary-General-Opening-Statement.pdf

Vote of Thanks

Yam Bahadur Thapa, Head, National Organizing Committee
Deputy Director General, Department of Forests, Ministry of Forests and Soil Conservation
Government of Nepal

On behalf of the Department of Forests, on behalf of the conveners and on my own behalf, I would like to thank you all to bring this 'Regional Pan-Asia / Pacific Consultation: Building Advanced National and Regional Capacities in Integrated Fire Management based on Participatory Involvement of Local Communities' to a successful end.

Its our great pleasure that the our honorable Minister of Forests and Soil Conservation is with us despite his busy schedule to give this event a high value. I warmly welcome him this meeting and heartily thanks for his presence.

Similarly, our respected Secretary of the Ministry of Forests and Soil Conservation guided us from the inception of the meeting to date. I thank him for his close guidance through this meeting.

Most importantly, I would like to thank Professor Johann Goldammer from the Global Fire Monitoring Center (GFMC) for his continuous support not only for Nepal but also to the global arena. Thank you also, Professor, for your valuable time given to this meeting. We further hope to receive similar support in future, too.

And, I would like to thank Korea Forest Research Institute (KFRI) for the funding support to this consultative meeting. I further thank Dr. Gil Bon Koo, Director General of the Korea Forest Research Institute, for the opening remarks, and I thank Dr. Koo and Dr. Lee for their continuous support in preparation to this meeting.

I thank the Asia Pacific Association of Forestry Research Institutions (APAFRI) for financial arrangement for this meeting. I personally thank to the Executive Secretary Dr. SIM Heok-Choh and his valuable contribution to the meeting.

Apart from the Department of Forests, I would also like to thank Regional South Asia Wildland Fire Network, the Nepal Forest Fire Management Chapter and the Global Fire Monitoring Center to convene and generously support this meeting.

The contributions from all the delegates from Nepal and abroad are highly valued and appreciated. I thank you all for your valuable deliberations.

I am really delighted to mention the works of the members of the 'National Organizing Committee' for their hard works to make this meeting a grand success. Please give a 'big hand' for Mr Pashupati Koirala, Mr. Sundar Sharma, Mr. Anuj Raj Sharma and Mr. Ajeet Karna.

Last but not the least, I thank to the friends from media for your positive comments and to hotel management for excellent logistic arrangement.

At last, I once again thank you all and wish for a safe return back home.

Thank you.

Field Visit to Bajhghari Community Forest User Group Sharing Experiences on Fire Incident and Community-based Fire Management (CBFiM)

Kabhre, Nepal, 21 November 2012

1. Banjhghari Community Forest

Banjhghari Community Forest is located in Kanpur Village Development Committee, central Eastern part of Kabhrepalanchowk District, Nepal (about 65 km, 4 hours drive east to Kathmandu in mid-hills valley). This community forest covers an area of 96.5 ha of forests in the south-west aspect of the Mahabharat range.

Figure 1. The forest plot of Banjhghari Community Forest, Kanpur-7, Kabhre. Photo: P. Koirala.

The forest primarily consists of pines (*Pinus roxburghii* and *Pinus patula*) dominated pole stage plantation forest; however, it consists of few scattered natural trees of Oak. About 95% of the forest is covered by *Pinus* spp. followed by *Quercus* spp..

2. Banjhghari Community Forest User Group

The Banjhghari CF was handed over to the local community, organized as Banjhghari Community Forest User Group (CFUG), in 1995 by the District Forest Office (DFO) to protect, manage and sustainable use. A total of 275 households are involved in the group. The CFUG is heterogeneous in caste and ethnic composition and mainly includes Brahmin, Chhetri and Tamang. The majority of the households (about 80% of the total) depend on farming for their livelihoods.

The socio-economic status better off, mid-wealthier and poor is divided of the users themselves based on various economic and social criteria. This kind of criteria is being used to distribute the benefits based on equity concept. The main criteria set for the well-being ranking includes income sources, landholdings, livestock, condition of house and other infrastructures, social and political status, education and employment.

3. CBFiM in Banjhghari CFUG

Training for fire management was held in February 2010 and during the training a network committee was also formed. The members had received fire management techniques and preventive measures by a technical team of District Forest Office, Kabhre. However, they could not get the modern firefighting equipment.

Meantime, recently followed after the training, a very sad event occurred in which a big crown fire occurred and almost 90 per cent forest were affected by the fire. The uncontrolled fire damaged about 8000 pole tress and still the fire scars are on the field. During fire incident to control the fire a team of military and police had been deployed and took control over the boundary of the forests and themselves they practiced counter fire on the forest land.

Mostly damaged trees were harvested and cleared from the forest land after one year after granting permission from the District Forest Office. However, still the forest is not so much cleared.

How the incident had been occurred still mystery for them. According to them, the incident not only damaged the forest it also impacted on the crop field and private houses around the forest land and particularly over the top of the hilly hamlets

Figure 2. Fire damage scars on pine trees (Photo by P. Koirala, 2012)

ANNEX III-A

Summary of Impressions from all Sessions

The participants of the consultative meeting expressed their concerns about the increasing vulnerability to the consequences of wildfires at global level primarily caused by human activities, but also influenced by climate change, notably on:

- Destabilization of ecosystems and water regimes
- Change of the composition and functioning of the global atmosphere
- Threats to human health and security
- Loss of property and livelihood

Since the majority of wildfires are human-caused and thus can be prevented, the susceptibility of ecosystems, landscapes and communities to become affected by uncontrolled fire can be mitigated and resilience be enhanced by proper management, the participants emphasized the need to

- Prioritize measures to prevent of unwanted wildfires – such as education, awareness-raising and capacity-building
- Capacitate land users and authorities in the safe use of fire (controlled / prescribed fire) where ecologically sound and needed

Furthermore, the participants stressed the need to enhance capacities at local to national and regional level to

- Focus on community-based, participatory forest and fire management solutions because
  - People are the main source of fire incidences
  - Rural populations are mainly affected by wildfires
  - Communities recognize their responsibility to protect their lands and assets against destruction by wildfire
- Emphasize community involvement in fire management with the sustenance of principles, e.g. as regulated by law and practice by Community Forest User Groups (CFUG) in Nepal. The socio-economic needs of rural dwellers and forest fringe communities must be taken into account when designing and implementing fire management programmes.
- Explore capacity building / training methods in the use of simple, basic and – if applicable – traditional methods of fire and forest management which are easy to be understood and practiced by rural populations.
- Provide technical assistance in the provision of adequate basic equipment and other resources to enable local communities to practice fire prevention and wildfire defense
- Explore how advanced technologies, e.g. remote sensing, GIS and Information Communication Technologies can be tapped into community-based fire management mechanisms for timely, precise and reliable early warning, detection, monitoring and response of wildland fires.
- Ensure that land tenure systems and policies be clear and beneficial to local communities engaged in participatory fire management
- Develop incentive and reward schemes to communities involved in community-based fire management
- Develop national fire management policies and appropriate legal frameworks addressing the reasons for burning practices, causes of wildfires, and impacts on society and environment
- Strengthen the institutional and operational capacities in fire management at national level
- Establish interagency coordination and support mechanisms, including participation of stakeholder groups of civil society.
- Enhance and support international cooperation in fire management to facilitate exchange of experiences through bilateral and multilateral agreements, including agreements on mutual assistance during wildland fire emergencies.

The participants of the consultative meeting expressed appreciation for the opportunity to share experience and views, and formulated a set of recommendations to be submitted to the government of the host country and the countries of the Asia-Pacific Region, as well as to international organizations active in the field of scientific and technical cooperation.

ANNEX III-B

Summary of Impressions of the Study Tour to Banjhghari Community Forest User Group: Field Demonstration and Discussion of Principles in Community-based Fire Management

During the consultation a one-day field visit of Banjhghari Community Forest was organized on 21 November 2012. The Banjhghari Community Forest (CF) lies in Bhakunde 7 of Kanpur Village Development Committee in Kabhre District. Banjhghari CF covers an area of 96.5 hectares of planted conifer forests (*Pinus roxburghii* and *Pinus patula*) on the south-west aspect of a middle mountain in Mahabharat range, which was severely burned by a wildfire in 2011.

The main objective of the visit was to expose the participants to 'community forestry management regime' and the state of the art in 'community-based fire management' in Nepal with emphasis to

- Visit the burned forest in which no specific fire management measures had been taken before the fire
- Listen to the experience of the members of the Community Forest User Group (CFUG) how the fire was controlled with limited technical knowledge and resources
- Listen to the expectations of the villagers to receive technical advice and training for the self-defense of their forests, village and fields, and to reduce the threats of wildfires to people
- To demonstrate how a Model Fire Management Volunteer Group, which had been set up in a different region of the country, could assist and capacitate the users of the Banjhghari Community Forest to protect their forest against wildfires.

The lively discussion among the Banjhghari CFUG members, the Model Fire Management Volunteer Group from Sundar CF, Hetauda, and the international participants revealed that

- Banjhghari CFUG is managing their forest properly but they lack technical capacity and knowledge to protect their forest from uncontrolled fires.
- Participants were impressed with the demonstration of Model Fire Management Volunteer Group from Sundar CF, Hetauda. Particularly, international participants were very impressed to see their strong determination to protect their forests and their ability to transfer knowledge to other communities.
- There was a general consensus that every community forest user group of Nepal should have a 'Fire Management Volunteer Group' like in Sundar CF in Hetauda.
- The Banjhghari CFUG members are motivated to develop community-based fire management capabilities like in Sundar CF in Hetauda.
- Since forest firefighting in mountain terrain is a serious and dangerous job (globally most fatalities during firefight occur on steep slopes or canyons) the training in personal fire safety of CFUG volunteers shall receive highest priority.
- Awareness raising and advising on principles in fire prevention at local community level should be the prime concern.

The participants felt honored and thankful to the local community people of Banjhghari when they received wonderful traditional greetings from them and their enthusiasm to brief the management of their forest. The local community showed their eagerness to protect their forest from fire, although at moment they are still lacking knowledge and experience in fighting wildfires.

ANNEX IV – Photo Gallery

Group photo of the participants

Inaugural address, The Secretary, MFSC, Dr. Krishna Chandra Paudel

Opening remarks by the Director General, Department of Forests, Mr. Braj Kishor Yadav

Opening remarks by Prof. Goldammer, GFMC

Opening remarks by Dr. Koo Kyosang, KFRI

Mr. Sundar P. Sharma, DWIDP

Dr. SIM Heok-Choh, APAFRI

Prof. Dr. Bambang Hero Saharjo, Bogor Agricultural University, Indonesia

Mr. Siri Akaakara, National Park, Wildlife and Plant Conservation Department, Thailand

Dr. Oyunsanaa Byambasuren, GFMC

Dr. Lee Byungdoo, KFRI

Mr. Ram Badhur Mongar, Department of forest and Park Service, Bhutan

Dr. Xiaorui Tian, Chinese Academy of Forestry, China

Mr. David Asare, Forestry Commission, Ghana

Meeting

Meeting

Field visit to the Demonstration plot

Meeting

Demonstration plot

Field discussion

Traditional welcoming ceremony by local CFUG, Banjhghari Community Forest

Traditional welcoming ceremony by local CFUG, Banjhghari Community Forest

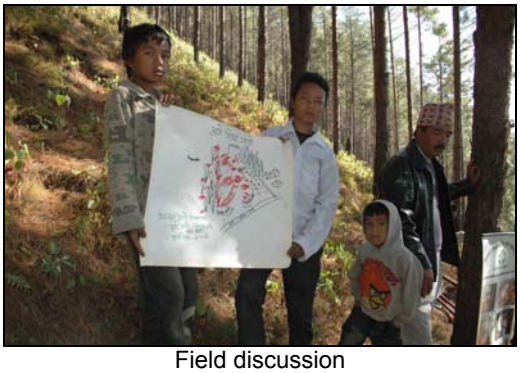
View of the Banjhghari Community Forest

Closing Ceremony

Young firefighter

Young firefighters

Local community members are demonstrating their experience on fire management



Field discussion

Field discussion

Field discussion

Honorable Minister of Forests and Soil Conservation Mr. Yadu Bansh Jha

Two local community members

Field discussion

Closing Statement by Honorable Minister, MFSC, Mr. Yadubansh Jha

Cultural event

Group photo of the international participants

Group photo after the field visit

Public Education, Training and Focus on Involvement on Women in Fire Management

The expertise of the Nepal Chapter of the Regional South Asia Wildland Fire Network

Website of the Nepal Chapter: http://www.nffmc.org/

Response to the Wildfires affecting the Island of Chios, Greece, in 2012

Between 18 and 22 August 2012 the Greek island Chios was affected by a severe wildfire. More than 12,700 hectares of forests, pastures and other vegetation types were burned. While fires are not an unusual phenomenon on Chios (Fig. 1) the wildfire of 2012 was very severe with regards to the ecological and socio-economic consequences. The fires were burning at extremely dry and windy conditions and were difficult to control (Fig. 2 and 3) and sent a smoke plume across, the Aegean Sea towards Crete Island, which was visible from space (Fig. 4).

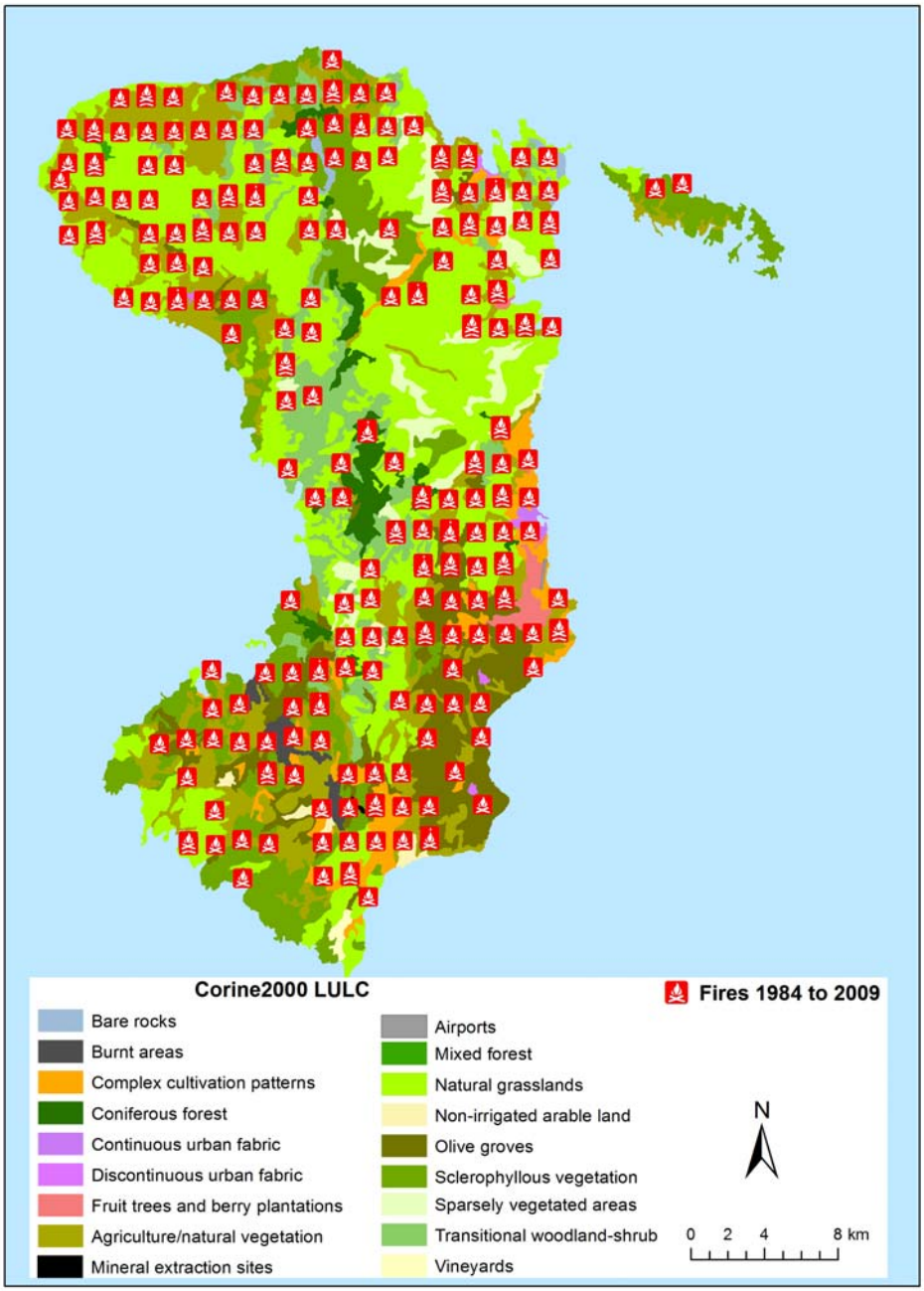


Figure 1. Reconstruction of wildfire occurrence on Chios Island between 1984 and 2009. Source: Ioannis Mitsopoulos, Global Fire Monitoring Center (GFMC)

Figures 2 and 3. The fast spread and the large size of the wildfires on Chios exceeded the capacities of local fire service to bring the fires swiftly under control. Source: Municipality of Chios. Source: Local media.

Figure 4. On 18 August 2012 the MODIS sensor on NASA's satellite Aqua the smoke plume stretching from Chios Island to the Southwest and reaching Crete Island. Source: NASA.

Most importantly, however, were the devastating impacts of the wildfire on the island's trademark mastic gum industry, which is based on the world's only mastic tree plantations. About a quarter of the island's mastic groves have been wiped out. In cash terms, producers were facing losing up to three million Euros a year, because after replanting, it takes up to a decade before producers can start tapping the trees for their aromatic gum. With its distinctive flavor, the gum-like resin – used in confectionery, cooking, cosmetics and medicines – is only produced by trees in southern Chios.

In the southern village of Pirgi, set among rolling hills once covered by tens of thousands of mastic trees that provided a quarter of the island's output, farmers say up to 45 percent of their trees have been lost. In addition, Associated Press reported that Chios beekeepers had lost an estimated 60 percent of their hives. In addition large tracts of grazing lands were affected by the wildfires, resulting in the loss of pasture resources for the 2013-13 season and beyond.

Figure 5. The burning patterns in the highland forests of Chios reveal severity of the wildfires, which occurred at the end of an extraordinarily dry summer in the Eastern Mediterranean region. Photo: GFMC.

Figure 6. Nea Moni Monasteri, a UNESCO Cultural Heritage Property, was severely threatened by the wildfires – but fortunately could be saved. Photo: GFMC.

Figures 7 and 8. The severity of the fire could be seen in places where even sparse and low fuel loads, e.g. on steep, rocky slope, resulted in mortality of wide-spaced individual trees (left). Abandoned villages and terraces, overgrown by succession, were exposed by the fires and became visible as testimonies of a rich cultural history of the island (right). Photos: GFMC.

The severity and destructive consequences of the wildfires became immediately evident after the fires had been brought under control. The situation prompted Captain Panagiotis N. Tsakos, founder of the "Maria Tsakos Foundation – International Center of Maritime Research and Tradition N.G.O." and owner of the Tsakos Shipping Company, to approach the United Nations Secretary General Ban Ki-moon. In a letter dated 31 August 2012 Captain Panagiotis asked the Secretary General for assistance to organize and follow up a congress, which should analyze the situation on Chios Island and to come up with measures that would contribute to prevent and mitigate the consequences of climate-change driven wildfires in this particular sensitive and vulnerable island. The UN Secretary General entrusted the UN Office for the Coordination of Humanitarian Affairs (UN OCHA) to seek advice through the Global Fire Monitoring Center (GFMC).

THE SECRETARY-GENERAL

18 September 2012

Dear Captain Tsakos,

I would like to thank you for your letter dated 31 August 2012 and express my regret for the consequences of a series of fires that caused widespread damage on the island of Chios, Greece, earlier in the month.

The Office for the Coordination of Humanitarian Affairs (OCHA) was made aware of your request and advised me that the Global Fire Monitoring Centre – a programme of the United Nations International Strategy for Disaster Reduction located in Freiburg, Germany – may have the required technical expertise on fires and their consequences.

OCHA will forward your request to the aforementioned Centre for their consideration and advice on whether experts could be made available to participate in your event scheduled for 15 and 16 October 2012.

Yours sincerely,

BAN Ki-moon

Captain Panagiotis N. Tsakos
"Maria Tsakos" Foundation
for Maritime Research and Tradition
Athens

Letter of the UN Secretary General to the enquiry from Captain P.N. Tsakos, with the indication that the GFMC would be requested to provide support to the proposed activities. Source: United Nations, Headquarters, New York, Office of the Secretary General.

On 15–16 October 2012 the "Maria Tsakos Foundation – International Center of Maritime Research and Tradition N.G.O.", organized the Congress "Our Response to the Fires: Working together for a better Chios".

The Congress was held under the auspices of the Minister of Mercantile Marine and the Aegean, Mr. Kostis Mousouroulis, MP, and in co-operation with the Chios Municipality and Regional Unit.

The event was held at the Homerion Cultural Center of Chios.

Figures 9 and 10. Captain Panagiotis Tsakos and Johann G. Goldammer addressing the conference. Photos: Maria Tsakos Foundation.

The Congress adopted the following Resolutions:

RESOLUTION No 1

The CONGRESS,

HELD under the auspices of the Minister of Mercantile Marine and the Aegean of Greece, Mr. Kostis Moussouroulis, in cooperation with the Regional Unit and Municipality of Chios, and in cooperation with related entities of Chios, by the "Maria Tsakos Foundation – International Center of Maritime Research and Tradition N.G.O." (hereinafter referred to as the "Maria Tsakos" Foundation) for the

purpose of providing a forum aiming to discuss, examine and provide recommendations towards the recovery of the Island of Chios and healing of the wounds it suffered from the devastating fires of August 2012 and, in parallel, establishing the foundations of the sound infrastructures necessitated for the prevention, response to, and elimination of, similar disasters in the future, as well as for the reconstruction, further development and economic growth of the island,

BEING ADVISED on the magnitude of the devastation caused by the fires in rural Chios and its agriculture (with a special effect upon the mastic producing villages and mastic production); the impact they have had on the local transportation network; and the subsequent landslide risks to the deforested areas,

HAVING CONSIDERED the scientific facts and evidence, the related recommendations and the substantive proposals made during the Congress by speakers, panelists and the audience,

TAKING INTO CONSIDERATION that, amongst others, the causes of forest fires are related to:

a. Recently observed urbanization trend, resulting, among other, in the abandonment of traditional land cultivation, weakening of the rural work force and consequently in the accumulation of combustible materials in forests areas
b. Insufficient preventive clearing of the forests
c. Climatic changes and the negative impact they may have in the future
d. Escalating value of land, in conjunction with the absence of forest charting and associated Registries, and
e. Autumn fires, particularly those attributed to negligence on the past of farmers and breeders

RECOGNIZING that the restoration of all damages suffered should be carried out only in accordance with strict scientific criteria,

RESOLVES TO:

1. EXPRESS its deep grief for the devastation caused to the ecology and economy of Chios by the fires – particularly, to the mastic producing villages and the mastic production of the island, the worldwide uniqueness of which should be sustained and preserved for the present and future generations;
2. SHARE the grief and STAND BY the people of Chios, who have been affected by the fires in any way;
3. RECOGNIZE the urgent character of reviving economy of Chios; the reinforcement of the mastic villages aiming to their resurgence; and the revitalization of the island's flora;
4. CONGRATULATE the "Maria Tsakos" Foundation for its prompt initiative to convene this Congress and related entities (governmental and non-governmental), which have co-operated in its organization,
5. EXPRESS warm thanks to Prime Minister Antonis Samaras, to the Ministries concerned and, in particular, to the Minister of Mercantile Marine and the Aegean Kostis Moussouroulis, for the immediate response and effective coordination and mobilization of all competent public and private bodies to eliminate the destructive effects of the fires and for undertaking all urgently needed measures to that effect;
6. CONGRATULATE and PRAISE the representatives of the Armed Forces and Security Services for effectively organizing and actively participating in the fire extinguishing operations;
7. CONGRATULATE and PRAISE all volunteers both from Chios and other Aegean Sea islands, who selflessly participated in the firefighting operations;
8. WARMLY THANK the United Nations Secretary-General, Mr. Ban Ki-Moon, and the European Union Commissioner for Regional Policy, Mr. Johannes Hahn, for delegating their representatives to the Congress, as a true expression of their support and solidarity towards the people of Chios;
9. ALSO EXPRESS warm thanks to His All Holiness the Ecumenical Patriarch Bartholomew and His designated representative to the Congress, His Eminence Markos, Bishop of Chios, Psara and Oinousses, for their support, affection and blessings demonstrated, in various ways, to those affected by the fires;
10. THANK the representatives of the Ministry of Merchant Marine and the Aegean, the Ministry of Development, Competitiveness, Infrastructure, Transport and Communications, the Ministry of the Environment, Energy and Climate Change and the, Ministry of Rural

Development and Food for their substantial contribution to the successful running of the Congress and the adoption of pertinent recommendations aiming at promoting its set objectives;

11. ALSO THANK the chairpersons and speakers for delivering appropriate lectures as well as the participants who actively contributed to the presentation of the fire- related problems and the subsequent success of the Congress,
12. ADOPT the Conclusions and Recommendations of the Congress (as shown in the Annex) and, for the purpose of their implementation:
13. INVITES the competent Ministries, the local Authorities of Chios and the relevant public and private sector bodies to take as soon as possible appropriate and necessary action, within the framework of the attached recommendations, towards strengthening and revitalizing the economy of Chios; the recovery and further development of its qualitative and quantitative productivity and trade; the modernization of means and procedures of agricultural and rural development; and the promotion and implementation of relevant educational programmes;
14. EXPRESS grateful thanks to the “Maria Tsakos” Foundation for convening, organizing and running the Congress, inviting distinguished personalities and high-level speakers from Greece and abroad; and for the overall financial support provided; and
15. EXPRESS warm thanks to the Homerion Cultural Center of Chios (donation of the late Michael and Stamatia Xyla) for hosting the event and providing excellent facilities for its smooth running.

ANNEX

Conclusions and Recommendations of the Congress

Conclusions

- In the course of the second half of the last century and thereafter, an alarming upward trend has been evidenced in Greece, both in terms of the burnt area outliers and the number of forest fires.
- The number of forest fires and the total burnt area appears to be highly correlated to a new climate index defined as the ratio of the average temperature to the average relative humidity during the months of July and August.
- The average summer temperature in the Greek region and, in particular, the eastern Aegean Sea, has increased over the last 50 years by about 0.5 degree Celsius per decade, while it is anticipated that, in the forthcoming decades, this trend will continue, with a respective decrease of relative humidity and increase of wind force in the Aegean.
- By the end of the 21st century, it is expected that these variations will eventually increase the duration of the hazard period by more than a month per year.

Recommendations

- Immediate declaration of disaster stricken areas as reforestable.
- Immediate declaration of the Island of Chios as a fire-ravaged area and subsequent submission of a relevant application to the European Solidarity Fund.
- Close and continuous monitoring of the regeneration of the burnt areas by competent authorities. No intervention should be allowed to the burnt mastic trees and forests up to the beginning of spring 2013, when an accurate assessment of their natural recovery will be possible.
- Immediate redesign of preventive plans and fire protection strategies should be undertaken. Thus, the implementation of the resolutions adopted by the Congress will provide guidance for a more effective prevention of hazards and protection of the remaining forests.
- Taking into account that the forest areas of the island not be burnt in the last 20 years will regenerate by natural processes, there is no need of any additional action of reforestation. However, a scientific depiction of the regeneration capacity in disaster stricken areas is required in order to establish whether there is a need for intervention. Scientific substantiation can be performed by methods successfully applied in the past, both in Greece and in other Mediterranean countries, e.g. Spain.

- Any anti-flood/ anti-erosion works, if and when decided, must be executed under strict criteria and with due respect for the affected environment, taking into consideration the existing biodiversity. Such works are recommended to be undertaken using – where possible bigger materials and resources locally available thereby avoiding further damage to the natural environment.
- Under the provisions of the applicable law, concerning forests, widespread logging should be prohibited, as this causes soil compaction, destruction of the structure of the ground and of its biological elements, and alteration of the hydrological conditions – while the existence of trees helps the retention of the soil and its regeneration. The selective removal of burnt trees is recommended.
- There is no need for the construction of bundles of logs and of grids of branches on flat or rocky areas.
- With respect to the mastic trees (originating from the variety of the species *Pistacia lentiscus* var. Chia "schinos", which has a high post-damage recovery potential), it is expected that such regeneration will take place, unless their root system has been damaged. This must be ascertained on the spot and per site, depending on the severity of the damage. What is not easy to ascertain is the time frame within which the re-born sprouts will evolve. An initial assessment is that trees whose trunks are not completely destroyed may regenerate in a faster pace than expected. It is further recommended to avoid the removal of burnt mastic branches or of the fallen branches in order to avoid erosion.
- The grazing and hunting must be prohibited as natural regeneration is hindered by grazing. Consequently, in order to minimize the load on burned sites, non-productive animals must be curtailed; cattle should be herded in adjacent unburned areas and alternative animal feeding sourced.
- The creation of a grazing management plan is necessary not only in order to minimize any negative impacts but also in order to benefit the animals themselves (for example, the improvement of the abandoned fields and the potential fertilization of unburned areas) is recommended.
- The qualitative and quantitative monitoring of the water resources throughout the island and their efficient management should be undertaken.
- Measures must be taken for the protection and restoration of apiculture, while ensuring that the production is adequate and quality of honey is not affected.
- Special care must be taken by expert bodies towards the relief of victims of possible psychosomatic effects arising in some groups of the population from the devastating fires.
- The establishment and completion of a Land Registry and forest maps is necessary.
- The creation of a hiking path network, spread out to the whole of Chios, by opening, maintaining, upgrading and signaling existing, abandoned routes and historical paths, is also recommended.
- The local creation of "natural parks" for scientific research and education purposes, as well as for the promotion of public awareness on environmental protection in conjunction with the materialization of sport and environmental activities, should be encouraged.
- A general and specific spatial landscape plan should be designed for Chios in which zones of mixed land use, e.g., mastic plantations, agricultural fields, pastures intermixed with scattered structures and villages, should be obliged to develop a fire management plan.
- A pilot project aimed at assessing and planning how local rural inhabitants be involved to prevent forest fires and to be properly prepared, instructed, and trained in defending their homes, villages, gardens, mastic plantations and surrounding forests and brush vegetation against wildfires.
- Given the similarity of problems on other Aegean islands, on mainland Greece and in neighboring countries, it should be considered to organize a regional consultation addressing the "Defense of Natural and Cultural Assets and Human Populations against Wildfires", associated with a "National Round Table on Fire Management in Greece", involving national and regional expertise at both events to formulate recommendations to the government of Greece to address the future challenges in fire management.[4]

[4] IFFN Editorial Note: The regional consultation addressing the "Defense of Natural and Cultural Assets and Human Populations against Wildfires", associated with a "National Round Table on Fire Management in Greece", will be held in 2013. The outcomes will be published in IFFN Issue No. 43 (2013).

The Congress was informed by the North Aegean Prefecture Authorities that their strategy for the reconstruction of the stricken areas of Chios will aim at:

- Administrative proceedings and measures towards the immediate support and relief of affected citizens;
- Medium-term infrastructure reconstruction of the local economy and the production structure; and
- Long-term planning for the completion and full utilization of the existing infrastructure aiming at the revival of the local economy.

Essential means in this planning will be:

- The use of existing financial resources (Finance Ministries, the National Strategic Reference Framework and private donations);
- The declaration and affirmation of the areas concerned as fire-affected; and
- The exploration of potential funding from the European Solidarity Fund.

Moreover, the Congress noted the following proposals seeking governmental support:

1. Establishment of an institutional network under the legal entity of a Non-Profit Organization, in accordance with article 101 of Law 3852/20012 (KALLIKRATIS), providing for a joint participation of the Chios Municipality and District authorities, the University of the Aegean, the Chios Mastic Producers Union, the Chamber of Chios and the Regional Development Company of Chios aiming at the reconstruction management of the region.
2. Strengthening support and provision of incentives towards distinct business and manufacturing clusters, such as the tourism industry and local agricultural producers (mastic-tree growers, apiculture and farming).
3. Elaboration and implementation of developmental projects for the tourism industry and promulgation of awareness campaigns of local unique qualities, both domestically and internationally.
4. Upgrading and reconstruction of existing production infrastructures.

Specific proposals concerning impending actions were adopted as follows:

1. Compensation to all affected mastic gum growers, not only in terms of this year's production, but on a 5-year timeline horizon.
2. Full recuperation of the affected mastic cultivation and production.
3. Governmental and associated authorities support towards the creation of a mastic trees seedling nursery.
4. The design and implementation of appropriate European Union (EU) legislation and policies related to the protection of unique remote areas and/or islands, regardless of the EU country they belong to.
5. Volunteer action acknowledgement and reward, both of local groups and from areas beyond Chios, such as Mytilini, Samos and Ikaria (see Resolution No. 2)
6. Declaration of certain unique trees and flora, in specific areas of Chios, as monuments of natural heritage under national or UNESCO rules (see Resolution No. 3)
7. Design and establishment of a holistic business plan by and under the supervision of the General Secretariat of Aegean and Island Policy (Ministry of Merchant Marine and the Aegean) for the actual implementation of the recommendations adopted by the Congress.
8. The "Maria Tsakos" Foundation to undertake a follow-up process, at regular time intervals (e.g. 3 months), to monitor the progress, execution and implementation of the aforementioned business plan, in cooperation with competent entities.

RESOLUTION No 2

The CONGRESS,

HAVING BEEN INFORMED about the wide-ranging acts of volunteerism committed during the August 2012 fires on the island of Chios, and

RECOGNIZING the immense and critical contribution to the extinction of the said fires by volunteers from the islands of Chios, Lesvos, Samos and Ikaria, in support of the substantial efforts of local authorities and agencies.

RESOLVES TO:

1. ACKNOWLEDGE AND CONGRATULATE all volunteers, especially those who placed their lives at risk while offering valuable preventive and fire combating services;
2. ENCOURAGE AND REWARD such acts of volunteerism;
3. EXPRESS THE WISH that the very notion of volunteerism be spread and extended throughout the country; and
4. INVITE the "Maria Tsakos" Foundation to take all necessary measures to support the establishment of networks of volunteers so that they may expand their activities to arising needs all over the country.

RESOLUTION No 3.

The CONGRESS,

HAVING BEEN INFORMED, by the Federation of Cultural Association Settlements of Southern Chios, of the existence of trees, many of which, according to experts, exceed the age of one thousand years,

RECOGNIZING the specificity of these trees, together with "Prina" and "Shina", in the overall cultural heritage of Chios and their contribution to the development of the island's tourism,

DESIRING to contribute to the protection of the flora of Chios,

RESOLVES TO:

DECLARE the trees, 'Prina' and 'Shina' (as they are described in the attached letter of the said Federation of 16th October 2012) as Monuments of Natural Interest and INVITE the appropriate authorities to adopt all measures necessary to ensure that, henceforth, such Monuments are treated with appropriate care and are preserved.

ANNEX

Message of the Federation of Cultural Associations of Settlements of South Chios to the Committee of the Congress "Our response to the fires"

The Federation of Cultural Associations of Settlements of South Chios (O.P.S.O.N.CH.) greets the convergence of the international conference on countering the effects of the fires, which affected the island of Chios, causing disasters among others and to the mastic trees.

The O.P.S.O.N.CH., wishing to contribute to the protection of the flora of the island notifies about the existence of trees, some of which, according to the opinion of experts, exceed the age of 1000 years:

1. Olive (Liverani) in Pera Mylos of Kallimasia, height perimeter of the parapet: 12.50 meters
2. Oak (Orphanides) in St. John of Sklavia, minimum perimeter: 8.20 m
3. Prina of gigantic dimensions in the areas of St. George Kydiantas and of Flori at Epos.
4. Shina that survived from the low temperatures of 1850 near Tholopotami.
5. Tsikoudia (Pistachia terebinthus atlantica) in Kambia of Kallimasia

A relevant resolution, by your committee, concerning their declaration as Monuments of Nature, would not only contribute to their protection but also to the development of tourism of the island.

Chios, 16 October 2012

Upon instruction of the President of O.P.S.O.N.CH
Dim. Melachroinoudis, Secretary

ΥΠΟΥΡΓΕΙΟ ΝΑΥΤΙΛΙΑΣ ΚΑΙ ΑΙΓΑΙΟΥ

MINISTRY OF MERCANTILE MARINE AND THE AEGEAN

Municipality of Chios

OUR RESPONSE TO THE FIRES
Working together for a better Chios

Congress organized by the
"Maria Tsakos" Foundation – International Center of Maritime Research and Tradition N.G.O.
under the auspices of the Minister of Mercantile Marine and the Aegean
and in co-operation with the Chios Municipality and Regional Unit

Homerion Cultural Center of Chios and
"Maria Tsakos" Foundation – International Center for Maritime Research and Tradition
15-16 October 2012

United Nations Partnerships in Strengthening the Role of Civil Society in Fire Management

Prof. Dr. Dr. h.c. Johann Georg Goldammer
Director, Global Fire Monitoring Center

Captain Tsakos
Excellencies
Ladies and Gentlemen

Looking down from space to the planet Earth during the year 2012, the crew of the International Space Station observed smoke columns from fires burning in all continents. While in some ecosystems of the world fires occurred as a natural factor, or fires used as traditional and sustainable tool in land management, there were some smoke columns arising from locations which were considered safe haven of fire-sensitive ecosystems and biodiversity. This year severe fires destroyed large parts of such vulnerable ecosystems, for instance in the UNESCO World Natural Heritage sites in Southern Patagonia of Chile, or on the Canary Islands in the Atlantic. However, society was affected, too. In 2012 massive fires burning in North America, the Mediterranean region and Australia forced evacuations of more than 75.000 people. Wildfires also caused a large number of fatalities and high economic damages. Globally more than 160 firefighters and civilians lost their lives in wildfires in 2012, almost 3000 people were injured.

On 18 August 2012 Earth observation satellites registered an extended smoke column arising from the Island of Chios and spreading from the Aegean Sea southward toward the island of Crete. What the satellites could not see: The severity and impact of a disaster which deeply affected the ecology and society of Chios. The destruction of a major part of the world's unique resource of mastic is a tragedy that is unprecedented in the fire history of the Aegean and of Greece. The fires of August 2012 affected the heart of Hellenic culture.

Chios, an island with a rich, ancient land-based cultural history, cannot be understood without the surrounding maritime environment of the Aegean and the Hellenic tradition of seafarers. Born and rooted in the culture of Chios young men were motivated to become seafarers, and, as once stated by Captain Panagiotis Tsakos, the founder of the Tsakos Foundation, to become a *kalos kapetanios* – a *good captain* – who would become a global envoy of the Hellenic maritime spirit.

The Aegean history, not very much different from the Hanseatic environment from where I am stemming, is telling us that no captain, no ship in the world can serve its mission without a homeland, without the land base, from where they are leaving – and to which they always will return, sometimes following the lights of a fire set ashore, fires that were set to signal both – farewell and welcome back home. A land-sea symbiosis to which I would like to return at the end.

The core mission of the "Maria Tsakos Foundation – International Center of Maritime Research and Tradition" is the promotion of maritime culture and tradition in Greece and abroad. It was established

as part of the Tsakos Group's inherent social responsibility vis-à-vis the shipping industry, the marine environment and the society as a whole. Alerted and concerned by this destructive fire Captain Tsakos approached the Secretary General of the United Nations, Mr. Ban Ki-moon, in August 2012, to seek for advice to follow up this major disaster. The Secretary General responded by expressing his regrets about the destructive fire that affected Chios and suggested that the Global Fire Monitoring Center would work with the Foundation.

Indeed, the United Nations system is mandated and available to serve nations and people, and to protect the global environment. But there is a need for a sound symbiosis between the “political and administrative” arm of the United Nations and those who own the United Nations system – the people. Without the spirit and the engagement of civil society in preserving the global environment the UN system would not be in the position to manage this mammoth task.

Similarly, there is a symbiosis between humans and fire. In an opening address to the last International Wildland Fire Conference in South Africa in May 2011, which I had the honor to convey to the conference attendees, Secretary General Ban Ki-moon stressed:

> *“Wildland fires destabilize ecosystems and the global atmosphere, and have clear implications for human health and security. Unlike other natural hazards, wildland fires are primarily caused by human activities. Measures to prevent them – such as education, awareness-raising and capacity-building – are well known and within reach. Community-Based Fire Management is particularly important.”*

Globally the vast majority of fires are caused by people, thus they can be prevented and controlled. Thus, any fire management system, regardless if based on advanced technologies, or on traditional knowledge, can only work if people are participating actively and taking responsibility.

The Secretary General further stated:

> *The transboundary effects of wildland fires associated with long-range smoke transport and emissions are prompting the international community to strengthen cooperation in fire management. International organizations and civil society groups are working to build capacity, develop advanced technologies and promote sustainable land-use practices.*
>
> *The UN system is strongly committed to this effort. Our work encompasses many aspects of fire management, including agriculture, forestry, health, science, the environment, emergency response and weather forecasting and monitoring.*
>
> *We welcome the efforts of fire specialists to build a culture of prevention and to develop a spirit of global cooperation.*

The UN system is available to provide the best professional advice, to support countries in developing land and fire management policies and fire management capacity with the ultimate aim to make natural and cultural ecosystems resilient to damaging fires. But the success of all these efforts are depending on the active participation and taking responsibility of civil society.

The Global Fire Monitoring Center, based in Germany, is serving the United Nations International Strategy for Disaster Reduction. Its most efficient mechanism is the Global Wildland Fire Network, within which numerous regional networks, government bodies, and civil society organizations, together with the UN specialized agencies and other non-UN international organizations, are cooperating. The Global Fire Monitoring Center and the Global Network are available to facilitate the dialogue between the science community, the people responsible for and affected by fire, and the policy makers.

In its relationships with Greece the Global Fire Monitoring Center is looking back to a long tradition of cooperation. Since the late 1970s we have exchanged expertise and views on fire management in the Mediterranean Basin. The first European Symposia on Fire Ecology took place in 1977 and 1982 in Freiburg (Germany) and explored the environmental and human ecology of fire. Close relationships with Greece developed in the 1980s and have resulted in efficient networking and partnerships, such as our cooperative work with the European Center on Forest Fires based in Athens, academics at the Aristotelion University of Thessaloniki, and the Hellenic Agricultural Organization "Demeter".

These institutions are working together in order to understand the changes of land-use and the changes of cultural fire regimes over time. We intend to explore why the many fires that historically occurred or were used in the Mediterranean Basin, including the islands of the Aegean islands and mainland Greece were different, were less destructive. Why was the historic cultural environment more resilient to fire? Was this due to more intensive land cultivation, more intensive use of biomass, due to more dependencies of people on the produce, and thus a more active the protection of their lands? What are the consequences of the rural exodus, the urbanization of the young generation with regards to land cultivation?

The reflections about the Aegean brings me to my personal insight in the fires in Greece. Back in 1985 the Greek Foundation *Idryma Kratikon Ypotrophion*, invited me to visit the country and to enter in a dialogue with Greek scientists on forest fire ecology and management.

The summer of 1985 was a hot summer in Greece during which many large, devastating fires affected the country. On Sunday, 18 August 1985, I took the boat from Kavala to Thassos Island. From a long distance I could see the huge smoke column rising over the island and a fast developing forest fire. On this very day it was one of more than 50 wildfires burning in Greece.

Arriving in the harbor of Limenaria I saw a detachment and command post of the Greek Navy, led by an Admiral, several ships, including Greek Navy warships anchoring in the Bay of Limenaria, and Navy soldiers getting ready to fight fires.

I talked to the Admiral and offered assistance, explaining that I was a reserve officer of the Federal Germany Navy, commanding officer of a Navy ship, but also a forest fire expert, my civilian profession. Some 15 minutes later a Navy Lieutenant knocked at the door of my hotel room and reported to me: “Sir, the government in Athens has authorized us to use your assistance.”

What followed was the finally successful attempt to save some of the forests of Thassos, and the village of Maries. I did my best to support decisions of the governor of Thassos, who was in charge of handling this the emergency situation. And I worked with General Skoulas, Greek Army, who had put up his firefighting headquarters at the community building of Maries – a carefully, calmly and responsibly acting officer.

Navy soldiers arrived from Limenaria. I gathered and instructed them how to fight the fires with the few water buckets, hand tools and wet towels they brought uphill from the coast. We called aerial assistance by water bombers, they did several successful drops. I instructed the villagers how to defend their gardens and houses against the flames. In the end, the fire on Thassos Island had caused huge damages, but Maries and other villages were safe, and the mariners had bravely contributed to this success.

When the fires around Maries calmed down I checked the situation in the forests nearby, which were still smoldering. There I encountered a burning old chestnut tree. This tree had caught flames, the inside of the trunk of the tree was glowing, but the tree was still standing, alive with green branches. I sat down nearby and accompanied tree in its final way to destiny.

Here I felt that there were two different souls in the two chambers of my heart which had governed my response to the fire in Thassos. In one chamber was the heart of a forester and ecologist, the mission to protect our forest from fire destruction. The other chamber was the heart of the Captain of a ship, used to command seafarers, and now for the first time to guide the mariners to battle a forest blaze. Here in Thassos I felt the unity, the symbiosis of both.

By reflecting about these experiences in 1985 I would like to congratulate and encourage Captain Tsakos to support the next generation of Chios islanders to become a *kalos kapetanios* – a *good captain* – in the spirit of the preservation of the Hellenic culture and the environment, both at sea and at home ashore.

Thank you, Captain, Excellencies, ladies and gentlemen, for your attention and your patience.

International Conference
Climate Change and Forest Fires in the Mediterranean Basin: Management and Risk Reduction

Nir Etzion, Mount Carmel, 24-26 January 2012

Statement by the Ministry of Environmental Protection, Israel

30 January 2012.

The Ministry of Environmental Protection, in cooperation with the Keren Kayemeth LeIsrael-Jewish National Fund (KKL) within a framework of the EU ERA-NET CIRCLE 2 for promoting research and cooperation on climate change adaptation held an international conference on Climate Change & Forest Fires in the Nir Etzion Hotel on Mount Carmel near Haifa. The conference took place between 24 and 26 January 2012.

The objectives of the conference were to share scientific knowledge, policy tools and practical experience for effective management for the prevention of forest fires and for ecological rehabilitation following fires under conditions of climate change.

Approximately 150 people participated in the conference including government ministries, local government, the Fire and Rescue Services, the Nature and Parks Authority, KKL-JNF, researchers from academia, the private sector and NGOs.

This international conference also hosted lecturers and guests from Jordan, Kosovo, Greece, Italy, Portugal, Spain, Canada and the USA. Among our guests from abroad were Prof. Johann Georg Goldammer, director of the Global Fire Monitoring Center (GFMC) / UN University); Prof. José Moreno from the University of Castilla de la Mancha, and Prof. Jon E. Keeley, US Geological Survey and adjunct professor of the University of California, Los Angeles, with other distinguished guests.

The first day involved sharing scientific knowledge and focused on the relation between climate change and forest fires; forest fire management; post fire ecological assessment & rehabilitation; and knowledge gaps and research needs.

Climate change affects temperature increases and heat waves which have an increasing impact on wildfires. The fire, its size and its intensity are correlated to weather conditions in the months and days prior to the fire's ignition. The increasing risks and the 2010 Mt. Carmel Forest wildfire disaster were the main incentives to organize this conference. Interesting findings that came up during the lectures presented in the first day were:

- In Europe, it was found that the massive emigration from rural areas to cities have left agricultural areas susceptible to forest growth and takeover, increasing the fire risk in many areas. The EU representative claimed that the number of fires and the burned area did not increase with time. However, the damages are more severe due to the proximity of forests to human settlements.
- In California, the growth in population increases the man made fires and the proximity of the fires to settlements increases damages.
- In Israel the vast majority of fires are human-made.
- Military activity is a major cause of fires around the world, and in Israel it was shown that they are amongst the costliest to extinguish. The leading method to control and prevent fires is to reduce the amount of forest vegetation materials. One suggestion is to bring back herds of goats to forest areas. Natural rehabilitation of the forest, as opposed to planting trees, was raised as an issue to be further examined.
- The Carmel fire started after 8 months of no rain and under extreme dry conditions. One of the main causes for the fire abating was a quick change in wind direction from east to west together with a rapid increase in humidity from 10 to 90%.
- There are a number of monitoring and fire tracking systems in Europe whose high costs demand collaboration between many countries. Israel was invited to participate in a number of such programs.

The second day of the conference concentrated on the transition between science and policy and from policy to application and management. The Carmel rehabilitation status after the fire, decreasing

rehabilitation costs, and forest management plans for reducing fire risks were among the main topics that were discussed.

- The Ministry of Environmental Protection presented the main results obtained by the committee that was selected by the Minister of Environmental Protection. The main results were:
  - Natural system rehabilitation based on natural processes
  - Reducing the dense pine forest component of the Carmel landscape
  - Desired landscape - a variety of patches: open areas, groves, woods and mixed patches
  - Establishment of buffer zones between landscape units and around settlements
  - Landscaping development for the communities in areas that are prone to fire
  - Preserving the local pine tree population that is natural to the Carmel, which is genetically distinct
- The importance of goat herding in the buffer zones and in the forest for maintaining the clearings was presented.
- The heads of the two regional municipalities, Dalyat el Carmel and Usafia said they consider the forest an important resource. They added they would like to work with KKL and the NPA and that they would like for discussions and decisions regarding the Carmel forest management to be made together with the local population.
- Ecosystem services coming from nature but needing to serve people were emphasized. Thus in every system the human factor should be considered by using social science tools and need to consider cultural preferences which other ecologic and economic tools cannot asses.
- The role of the local population should also be understood including the benefits of the forests as green lungs, pollution filters, improvers of local climate and noise reducers and a general ad wide education program should be established among the local population.
- The day ended with a session about technological tools, remote sensing, aerial photography and special analyses to assess fire risks and projections. Another interesting tool presented was a Canadian thermal camera which helps fire fighters track the fire front, hot spots and roots fires.

On the third day participants took a field tour to the Carmel Forest to assess the rehabilitation efforts, soil erosion and management successes and difficulties in the Carmel area. The tour concluded with an open discussion where the foreign visitors commented on the rehabilitation efforts, emphasizing the importance of a long-term strategic plan for forest management and mapping risky areas in the forest including soil erosion and areas required fuel brakes.

Minutes of the Conference

Climate Change and Forest Fires in the Mediterranean Basin: Management and Risk Reduction

24-26 January 2012, Nir Etzion, Israel

By the Global Fire Monitoring Center (GFMC)

Sharing of Scientific Knowledge

In the Opening Session and Kenotes Sinaia Netanyahu, Chief Scientist, Israeli Ministry of Environmental Protection, welcomed the participants and notably the foreign guests. Netanyahu elaborated on the goals of the policy of the government of Israel to reduce greenhouse gas emissions under an Inter-Ministerial Committee founded in 2009, and a national action plan, with a commitment of $US 620 million for greenhouse gas reduction investments. Following the wildfire, which affected the Mount Carmel Biosphere Reserve in 2010, initiative was taken to investigate the causes and consequences of wildfires, and the action to be taken.

Yael Shaltieli, Director General of the Jewish National Fund (JNF), reflected about increasing fire threats globally. The wildfire on Mount Carmel in December 2010 burned 250 homes, required the evacuation of three communities with 20,000 people. 44 people were killed during the fire. Yael Shaltieli stressed that the conference will provide a platform for exchange of experience of scientists and practitioners.

Orna Matzner, Israeli Ministry of Environmental Protection, introduced the first speaker, Tiago Capela Lourenço, **CIRCLE2 ERA-NET** Project Coordinator, University of Lisbon, Portugal. In his presentation "Climate Impact Research & Response Coordination for a Larger Europe" he introduced the objectives, structure, context and activities of CIRCLE2 ERA-NET, a network of 34 institutions from 23 countries committed to fund climate change and adaptation research. Forest fires were defined in 2011 as one of the priority areas. Israel took the lead in implementing the initiative. This meeting is aimed at exchanging views and experiences in new decision making methods on climate change adaptation and fire management and risk reduction in the Mediterranean Basin, and particularly addressing research needs, policies and networking in the region.

GFMC was kindly asked to look at **Wildland fires in the Eastern Mediterranean & Near East from the perspective of the International Strategy for Disaster Reduction.** GFMC Director Johann Georg Goldammer, who is serving also as Coordinator of the Global Wildland Fire Network of the United Nations International Strategy for Disaster Reduction (UNISDR) and the UNECE/FAO Team of Specialists on Forest Fire, reviewed the socio-economic conditions and public policies in the Eastern Mediterranean and Near East Region. Land-use change is the most prevailing and common determinant of fire use and wildfire occurrence and impacts. Rural exodus caused by urbanization of the young generation in many countries has resulted in the depletion of the rural work force and their role in land cultivation and fire protection. Rapidly growing fallow in many countries contributes to an increase of wildfire hazard. Climate extremes, possibly already a precursor of regional climate change, are another common determinant of increasing wildfire risk. The problem of fires burning in terrain contaminated by unexploded ordnance (UXO) and landmines stemming from previous conflicts, and wildfires started intentionally or as collateral damages during armed conflicts, or as consequences of political tensions, constitute additional threats to human security in the region.

Insights in the **Relationship of climate and fires in California** were given by Jon E. Keeley, U.S. Geological Survey, and University of California, Los Angeles. He first referred to an investigation in the Western US revealing that fires seasons are becoming prolonged. Databases of the U.S. Forest Service 1970-2009 (focusing on forests) and CalFire 1960-2009 (including also other lands, lower elevations areas, where more humans are living) were evaluated as well as meteorological records (increase of rainfall and temperatures), decrease of regular fire use and allowing natural fires to burn, resulting in increased wildfire threats. Population increase in Northern California brought increasing fire activity, and less fires in the lesser populated South. Large fires are occurring more frequently, possibly a consequence of increasing dead fine fuel availability.

In the following session **Climate Change and Forest Fires** José M. Moreno (University of Castilla-La Mancha, Toledo, Spain) elaborated on the **Likely impact of climate change on vegetation and fire regimes in the Mediterranean Basin** and concluded that climate change will expand the fire season and increase seasonal severity in the Mediterranean region, while Ricardo Trigo (University of Lisbon Campo Grande, Portugal) looked at the **Role of climate extremes (heat waves) driving large wildfires in southern Europe & Meteorological fire risk in the Mediterranean**. The contributions of meteorologists and fire scientists from Israel followed by analyzing the **Weather conditions during the Mount Carmel 2010 Forest Fire and other fires in Israel** (Dan Malkinson and Haim Kutiel, Haifa University, Israel).

In the sessions **Forest Fire Management** Noam Levin (The Hebrew University of Jerusalem, Israel) looked at **Wildfire regime in Israel in the 2000s: A national analysis using satellite images** and concluded that most fires had been burning in herbaceous vegetation, not in forests. The theme of **Post-fire restoration in the perspective of climate change** was highlighted by Ramon Vallejo (CEAM, Spain) who looked at approaches to assess post-fire restoration needs. The next speaker Shay Levy (Haifa University, Israel) analyzed **Forest Fire Management in Israel: Ecological and Economical Aspects** using a unified database that includes all existing data in the authorities that are involved in firefighting and fire-prevention. The data were collected from 12 firefighting unions, JNF-KKL (Forestry Department), and from airborne firefighting operations. The evaluation revealed, among other, that wildfires management policy and planning should be based on a holistic approach considering plant biomass as potential fuel, plant flammability, topography, weather conditions, consequent fire intensity and fire spread.

With the presentation on **Livestock grazing in managed pine forests: Fire hazard reduction vs. forest regeneration and diversity** by Yagil Osem (Agricultural Research Organization, Israel) the

benefits and the adverse effects of grazing were analyzed. His survey showed that there are three general trends in the country:

- Total exploitation of grazing area in the North and the South, and a lack of grazing in central Israel
- Permanent cattle grazing in the north and prevailing seasonal sheep grazing in the south
- A good control of seasonal grazing vs. limited control on permanent grazing lands

Target-oriented management should support maintenance of fuel break zones (fuel reduction) and recreation zones (infrastructure, human activities), and contribute to multifunctional landscape management with regards to biodiversity conservation, natural regeneration, landscape aesthetics, and human activities. In future "grazing services" may take over the role – "prescribed grazing" as formulated by GFMC.

The theme of soil erosion was addressed by the papers **Soil erosion assessment and mitigation following wildfires in Portugal: The state-of-affairs of the EROSFIRE decision-support tool for post-fire land management and impact assessment of future scenarios** (by Jan Jacob Keizer, Centre for Environmental and marine Studies (CESAM), University of Aveiro, Portugal), **Fire effects on soil properties and erosion dynamics: New perspectives** (by Lea Wittenberg, Haifa University, Israel), **Using synthetic polymers to prevent soil erosion after fire in Mediterranean forests** (by Meni Ben-Hur, Institute of Soils, Water and Environmental Sciences, Volcani Center, Israel).

Presentations on post-fire ecosystem development included **Resilience and natural post-fire regeneration of Mediterranean trees – implications for post-fire management** (Gidi Ne'eman, University of Haifa-Oranim, Israel) who recommended among other to shape future forests according to local needs, conserve landscape patchiness, and the use of fuelbreaks. Grazing, logging and pruning, as well as the use of prescribed fire as management tools.

The paper **The effect of fire on the fauna of the Mediterranean basin: An overview and synthesis** by Ido Izhaki (University of Haifa, Israel) was based on a review of the literature (50 papers) of the last 15 years with the aim to summarize the major knowledge of the short- and long-term effects of wildfires on vertebrates in shrub lands and forests in the Mediterranean basin, from the population to the community levels, and to identify practical aspects for conservation and management, based on the information reviewed. He concluded that the impact of climate change will govern future development.

In the session **Knowledge Gaps, Research and Networks** The Joint Research Centre of the European Commission, Institute for Environment and Sustainability, provided the EU perspective on forest fires in Europe where every year on average 65,000 fires are affecting 500,000 ha vegetated lands (thereof 85% in PT, ES, FR, IT and GR). He elaborated on the role of the EU in international collaboration by highlighting the contribution of European Commission Directorate Generals (DGs) in the field of forest fires, European Forest Fire Information System (EFFIS), the role of the Monitoring and Information Centre (MIC). The next presentation on the **Israeli perspective in light of the 2010 Mount Carmel Fire** (by Avi Perevolotsky, Agricultural Research Organization, Israel) looked at the knowledge gaps, e.g. by asking if these are real or artificial; assumed that there is a tendency to "re-invent the wheel" and not to rely on information from other countries.

Regional perspectives: The role of formal and informal networks was the title of the presentation of Johann G. Goldammer (Global Fire Monitoring Center [GFMC], Max Planck Society for the Advancement of Science and United Nations University [UNU], Germany). He stressed that globally the need has been recognized by nations and international organizations to share knowledge, human and technical resources in fire management. Transboundary cooperation in fire management aims at taking advantage of and sharing the specific technical and scientific expertise developed in the various countries and regions globally, including concepts and methodologies of best practices and capacity building in fire management. In addition, international assistance is often needed in wildfire emergency situations during which a country may run out of resources and require international assistance. Informal networking within the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network (a regional network of the Global Wildland Fire Network) is receiving increasing support. Partners in cooperation in fire management in the region are financed by the Environment and Security Initiative (ENVSEC), a partnership of six international organizations – the Organization for Security and Co-operation in Europe (OSCE), Regional Environment Centre for Central and Eastern Europe (REC), United Nations Development Programme (UNDP), United Nations Economic Commission for Europe

(UNECE), United Nations Environment Programme (UNEP), and the North Atlantic Treaty Organization (NATO). Recent experience in multinational response to fire emergencies in Israel and Russia in 2010 have revealed the lack of agreed international standards for ground and aerial firefighting missions. The beginning for a new standard will be addressed by the "International Fire Aviation Working Group" (IFAWG), which is operating under the auspices of the UNISDR Wildland Fire Advisory Group. The participation of Israel in the work of the GFMC was offered.

On the second day in the session **From Science to Policy and from Policy to Practice** David Brand (Chief Forester, Head of the Forest Department, KKL-JNF, Israel) welcomed the participants on behalf of Yael Shaltieli, Director General, KKL-JNF, Israel. Contributions in this session addressed the publicly and scientifically debated **Rehabilitation of Mount Carmel after the fire in December 2010** (Yeshayahu Bar-Or, Ministry of Environmental Protection, Israel). The discussion after his presentation among other addressed the problem of wildfires caused by the military. In this discussion GFMC repeated what was said in the introductory speech that this is a problem similar to other countries, and that the military should actively participate with increased awareness but also specialized units that may serve also outside military areas / exercises.

The **Wildland fire urban interface in Israel, a methodological approach to prevention and reduction of the social and economic impact** was presented by F. Rodríguez y Silva (University of Cordoba, Spain) followed by the presentation of Hugh D. Safford (USDA Forest Service, California, USA) on **Making fuels management compatible with restoration objectives: case studies from the US Mediterranean-climate zone** who concluded with regards to the applications to Mt. Carmel that maquis and *Pinus halepensis* are adapted to Fire Regime IV of California and most oaks can tolerate frequent fire; and that Wildland fuel breaks can serve to "compartmentalize" fires, but only under moderate conditions and when they can be accessed safely; and fuel break networks can be integrated into trail and park systems, but will need constant maintenance.

In the session **Forest Fire Management** David Brand (Chief Forester, Head of the Forest Department, KKL-JNF, Israel) presented his views on **Prevention management of forest fires in Israel** in which he introduced the history of JNF-KKL, and the history of forest cover of Israel, fire hazard and risk reduction. He detailed about the role of fuel breaks around residential communities, their maintenance, the roles of grazing services, and the role of fuel breaks inside forests. Investments of two million dollars for fuel break establishment are planned. He called explicitly for testing the application of prescribed burning in maintaining fuel breaks. The presentation **Forests fires prevention programs in natural reserves and forests in the region of the Mediterranean** by Yehoshua Shkedy (Nature & Parks Authority, Israel) showed that Israel Nature & Parks Authority is closely working hand in hand with JNF-KKL and the Ministry of Agriculture. One of the problems in Israel is that the Maquis is closing up and that open habitats for species that need these open-land conditions are disappearing, along with an increasing wildfire hazard. „We have too many trees. When trees are closing up, we are losing species / habitats" he said and "grazing is essential".

Shmuel Fridman (Ministry of Agriculture, Israel) in his paper **Grazing as a tool for fire prevention** looked back to the history of the Authority of Grazing, which was established in 1977 by Ministry of Agriculture, Israel Lands Administration and the Jewish National Fund. Professional grazing requires the mapping of grazing zones and vegetation formations, and matching the pastures to different types of animals. The paper **Governmental involvement and regulation in determining forest management policy** by Hagai Snir (Ministry of Agriculture & Rural Development, Israel) looked first back to history, notably the British Forest Ordinance of 1926-1960 which focused, among other, on supporting the growth of woodland and forest, protecting trees, tree nursery establishment, dune stabilization. The Governmental policy 1948-1960 supported forest reserves declaration, conducted massive afforestation, mainly by the JNF, and enforced the ordinance. The convent between the state and the JNF resulted in the closure of the governmental forest department, and JNF became responsible for managing state forests and forest reserves. In 2001 a new era began after the Supreme Court brought the state back into the game, and the Minister of Agriculture returns to be the Forest Commissioner. The Vision is to complete an updated forest law together with JNF and the Ministry of Environmental Protection.

In the **discussion with local authorities from M. Carmel Druze villages** a representative of local authorities stressed that authorities would not recognize and understand the people living in the forest and that they should not consider people as a threat to the Mt Carmel Park. He asked how can a Biosphere Reserve be established without a community? After the 2010 fire he said he had hoped that KKL would "come to us and we would build a common authority". He asked "Does fire know borders?

No. We need to think regional", and "I want my village to participate. We want tourism, we want life quality. It is possible to work with us …. We need a green culture. We need partnerships and need to look for formulas. Let us look what the biosphere will tell us to do.

The second speaker agreed. "The JNF and others still see us as enemy. Before establishment of the Park we had 10 Druze settlements, only two are left." According to the State Ombudsman there should be an escape route. This could become a buffer zone, allow the residents of the villages to evacuate or to receive help. 1 km road, paved, needed, but there was lot of resistance. We need this for security, and we want to cooperate and need your help. It will become the most beautiful biosphere reserve of the world. Through education and dissemination, an authority should be created, and inevitable fires will become less severe.

The representative of the Nature & Parks Authority replied that indeed the authorities are talking among each other and not to the Druze communities. However, your communities are also not talking among you. You have the possibility to address government.

A representative of the community elaborated on the concept of a Biosphere Reserve. It is about preservation of nature and local people. Section 5 of the Biosphere Document refers to the role of education. "I want to give my son environmental education. I do not have the tools, but you have them."

In the session **Community Engagement in Forest Fire Management** Uriel Safriel (Hebrew University, Jerusalem, Israel) asked **The Biosphere Reserve – A paradigm shift in nature conservation?** The reserves need legal protection & community participation. It is better to go for bottom-up decisions with community participation, instead of top down like it happens in many nature reserves. Besides the esthetic and ethic value conservation paradigm and the paradigm "human survival, value of nature" the MAB Action Plan 2008 is looking after ecosystem services. Missing incentives include community involvement. **Research for people, but without people: What is missing in research on forest ecosystem services?** was the theme of the paper presented by Daniel Orenstein (Center for Urban and Regional Studies, Faculty of Architecture and Town Planning, Technion Haifa, Israel) in which he asked why expert policy recommendations for fire adaptation were not adopted and why there is a continuing conflict between preservation goals and development. He considers the Millennium Ecosystem Assessment as human-centered. He suggested that the inclusion of social ES assessment in the Carmel Forest might strengthen post-fire policy making and fill gaps in knowledge regarding how stakeholders perceive the forest and its management. **FireSmart: Forest and land Management options to prevent unwanted forest fires** were presented by Ana Sebastián López (GMV Aerospace & Defense, Spain) recommended better targeted and optimized awareness raising. **Protecting each other: The Forest and the Community** by Salman Aburukun (Nature & Parks Authority, Israel) said "What we need is for communities to become reacquainted with forests on a new and different level. We should get to know the forest with all of our senses and understanding the variety of services we enjoy thanks to it. This should be done by inculcating two principles: Trees and forests have a right to live, just like we do, and for the forest to protect us, we have to protect the forest. This is our moral obligation."

In the following general **Discussion** themes included benefits of the Biosphere Reserve for Druze and other communities, questions whether fenced goats without shepherds will work under the threats of jackals and stealing. How much money needed for fuelbreaks?

In the session **Technologies and Innovative Approaches in Forest Fire Management** Kostas D. Kalabokidis and Palaiologos Palaiologou (University of the Aegean, Greece) reported about the advancements of **Forest Fire Modeling aided by Web GIS in a Changing Climate**, followed by the paper **Assessing fire risk: post-fire analysis of pre-fire mapping – A recent case study from Mount Carmel** by Yohay Carmel (University of Haifa, Israel), **Evaluating drought stress changes in planted forests by means of remote sensing** by Michael Dorman (Ben-Gurion University of the Negev, Israel) who observed increased mortality of *Pinus halepensis* in the planted forests during the last decade. Stephen Achal (Itres Research Limited, Canada) provided insight in his work on **Very Large-Scale, High Spatial Resolution Airborne Thermal Mapping of Wildfires in Northern Canada using the TABI-1800** using the Thermal Airborne Broadband Imager, a new type of high performance airborne thermal imager delivering large-scale and traceable apparent radiant temperature maps.

On 26 January 2012 a field excursion to Mt Carmel allowed conference participants to get a close insight in the ecological conditions of the Biosphere Reserve, the history of wildfires pre-2010 and during the 2010 fire. At the end of the excursion a closing discussion focused on the problems of erosion, salvage logging, wood removal, the future of forests, landscapes and on fuel break. Foreign participants of the conference and excursion were challenged to provide a one-page statement on the utility and concepts of fuel breaks.

Reflections about the Conference

Climate Change and Forest Fires in the Mediterranean Basin: Management and Risk Reduction

24-26 January 2012, Nir Etzion, Israel

by Global Fire Monitoring Center (GFMC)

1. Pre-conference I

Cooperation of GFMC with Israel started in 1989 with invited participation of Israeli fire scientists at the Third International Symposium on Fire Ecology, hosted by the Fire Ecology Research Group (since 1998: GFMC) at Freiburg University, Germany.[5] In the 1990s GFMC cooperated with Israeli scientists and KKL forest management staff in publishing scientific and technical forest fire reports in International Forest Fire News (IFFN) (edited by GFMC).[6] In 1995 GFMC cooperated with KKL and scientists in Israel with emphasis on an assessment of the fire ecology and wildfire threat of Mt. Carmel, one year before its designation of Biosphere Reserve.

During the Mt. Carmel wildfire in December 2010 GFMC monitored the situation and provided advice to countries offering firefighting support to Israel.[7] After the 2010 fire emergency GFMC monitored national Israeli and international reactions, reports and analyses of the fire, as well as follow discussions and discourses, notably the debate on reforestation / rehabilitation and improvement of Israel's ground and aerial firefighting capacities. The GFMC logbook is available on request. GFMC through UNECE (Geneva) was in contact with the Embassy of Israel to the UN Geneva and offered its availability to conduct a post-fire assessment mission with UNEP and provide advisory support by GFMC staff, the expertise of members of the Global Wildland Fire Network (GWFN)[8] and the International Fire Aviation Working Group (IFAWG).[9] These offers, although officially conveyed to the government of Israel, remained unanswered.

2. Pre-conference II

The Conference was convened as a contribution of Israel to the CIRCLE-2 ERA-NET (Climate Impact Research & Response Coordination for a Larger Europe) programme in which Israel is participating. At the Bologna meeting in 2011 (CIRCLE2 Design Workshop, 22 July 2011) it was decided to organize a conference preliminarily entitled "Forest Fires in the Mediterranean basin and Climate Change – tools for risk reduction and management", to be hosted by Israel in January 2012. In September 2011 the Federal Environment Office of Austria, Environmental Impact Assessment and Climate Change Division, CIRCLE-2 ERA-NET member, contacted the Global Fire Monitoring Center (GFMC) and

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[5] Contribution of Dres. Zev Naveh, Pua Kutiel, Haim Kutiel and Jacob Garty were published in the book volume / proceedings of the symposium: Goldammer, J.G., and M.J. Jenkins (eds.) 1990. Fire in ecosystem dynamics. Mediterranean and northern perspectives. SPB Academic Publishing, The Hague, 199 p.

[6] IFFN website: http://www.fire.uni-freiburg.de/iffn/iffn.htm, country folder with articles published by Israeli fire specialists: http://www.fire.uni-freiburg.de/iffn/country/country.htm#ISRAEL

[7] The daily monitoring reports of GFMC are available at GFMC archive (country folder Israel): http://www.fire.uni-freiburg.de/current/archive/archive.htm#ISRAEL. Access of encoded web pages by User ID: fire; Password: 1

[8] http://www.fire.uni-freiburg.de/GlobalNetworks/globalNet.html

[9] http://www.ifawg.org/

suggested a cooperation with the Ministry of Environmental Protection of Israel to prepare the conference.

This suggestion was positively responded by the Global Fire Monitoring Center (GFMC) [10] as it was in line with the interest and engagement of GFMC in forest fire and climate change issues in the Eastern Mediterranean region and in Israel since the 1990s.

3. The Conference: Objectives and contributions

The carefully prepared agenda of the conference with a balanced thematic selection of national and international contributions, organized in sessions

- Sharing of Scientific Knowledge
- Climate Change and Forest Fires
- Forest Fire Management
- Knowledge Gaps, Research and Networks
- From Science to Policy and from Policy to Practice
- Forest Fire Management Panel Discussion
- Community Engagement in Forest Fire Management
- Technologies and Innovative Approaches in Forest Fire Management

provided a logic walk through the world of wildland fire – from the fundamentals of fire science to policy and practice. Presentations by national and international experts addressed issues that are indeed of general relevance to the situation in the Mediterranean.

However, last not least most presentations addressed the situation in Israel. Thus, was the conference theme either misleading, or did the event not address the conference theme?

Clearly, the overall scope of the CIRCLE-2 ERA-NET programme is to coordinate European transnational research funding on climate change impacts, vulnerability and adaptation, and to facilitate the transfer of research outcomes that European and national decision makers need to design effective yet economically efficient adaptation initiatives and strategies. Thus the network is pan-European. The theme agreed upon at the CIRCLE-2 Design Workshop in Bologna, July 2011, aimed at addressing “forest fires” at pan-Mediterranean level.[11]

During the last two decades scores of scientific and technical conferences have addressed the theme of wildland fires (including forest fires) in the Euro-Mediterranean region. The Eastern Mediterranean region, however, had been neglected largely, especially from the point of view of the ecological, socio-economic and political conditions determining wildland fires in the Near East / Middle East. The only regional conference so far was the “Conference on Forest Fire Management and International Cooperation in Fire Emergencies in the Eastern Mediterranean, Balkans and adjoining Regions of the Near East and Central Asia”, an activity of the UNECE/FAO Team of Specialists on Forest Fire convened in Antalya, Turkey (2004). The conference, which was not attended by Israel, provided a forum for the exchange of information of forest services and fire services of the region and resulted in the release of the “Antalya Declaration on Cooperation in Wildland Fire Management in the Balkans, Eastern Mediterranean, Near East and Central Asia”.[12] [13]

Israel took advantage of the opportunity of hosting a CIRCLE-2 ERA-NET climate change / fire conference to direct national and international attention to the proper fire problems of Israel.

4. Impressions

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[10] http://www.fire.uni-freiburg.de/

[11] In average 60% of the area affected by wildfires in the Euro-Mediterranean region are non-forest ecosystems. The Nir Etzion conference contributions and discussion confirmed the need to look at forest and non-forest ecosystems and to both the positive role and the negative effects of fire.

[12] http://www.fire.uni-freiburg.de/iffn/iffn_31/05-IFFN-31-Antalya-Conference-2.pdf

[13] In the follow up and the spirit of the Antalya declaration bilateral assistance in fire emergencies was provided by several participating nations, notably by Turkey (firefighting assistance provided to Syria and Georgia).

From the international perspective it is suggested to review if the contributions and discussion had provided new insights or “added value” for the international and national Israeli community (by themes of sessions):

- **Sharing of Scientific Knowledge**: The contributions and discussion with national and international wildland fire scientists provided a unique opportunity for exchange. While this kind of conferences had been held in almost all European countries before, the benefit was certainly highest for Israeli participants.
- **Climate Change and Forest Fires**: Main drivers of fire and change of fire regimes all over the UNECE region, the Near and Middle East, and Israel in particular, are socio-economic changes, land-use change (notably rural exodus and abandonment of traditional land cultivation methods) affecting landscape flammability and vulnerability; and in some cases socio-political and ideological conflicts that are bearing wildfire ignition potential. Compared to other regions in the world the assumed impacts of climate change on fire regimes may be less important than the above-mentioned consequences of changes of society.
- **Forest Fire Management**: A key issue was the discussion of prescribed grazing for fuel reduction and maintenance of openness of landscape elements and fuel breaks. This discussion was important and mutually beneficial for international and national Israeli attendees. Presentations and discussion concerning post-fire erosion did not bring new insights. Exchange of experience in the use of prescribed fire was not covered adequately.
- **Knowledge Gaps, Research and Networks**: This session was rather beneficial for Israeli attendees, probably also for international participants who were not all involved in international, regional or thematic scientific or fire management networks. Although Israeli fire specialists had been in occasional contact with the “outside” world, mainly in the scientific arena, the session was quite informative and resulted in many questions & discussions on networking arrangements, especially in the corridors and during the excursion.
- **From Science to Policy and from Policy to Practice**: This relatively short session could not provide sufficient space considering the significance of the need to develop comprehensive fire management policy at national level and to bring this to practice. However, the discussion of the rehabilitation of Mt. Carmel, which over the last year had been monitored from outside Israel, and the decision to have a 1-year “moratorium”, is reflecting the desire to develop a policy that would address the complexity of ecosystem management pre- and post-fire in a Biosphere Reserve and elsewhere. The wildland-urban interface discussion will become more important for Israel as overall landscape flammability will increase as a consequence of land-use abandonment and takeover of forest vegetation.
- **Forest Fire Management Panel Discussion**: An important element of the presentations and discussions was the maintenance of open land ecosystems which in some places are endangered by the invasion of forest. This theme was scratched at the surface only, but certainly could not be covered in detail by a short conference. However, inspirations were generated.
- **Community Engagement in Forest Fire Management**: The discussion with local authorities and the presentations revealed a lack of experience in involving community participation in fire management (Community-based Fire Management) in Israel. International participation in providing examples on the role of civil society and communities in fire management was inadequate.
- **Technologies and Innovative Approaches in Forest Fire Management**: This session could also scratch the surface only, but certainly provided insight in some projects and advances of technology. Added value, however, was limited.
- **Field Excursion to Mt. Carmel**: The field trip provided an excellent opportunity for national and international attendees to exchange views. Very beneficial for all.

5. Media coverage

Besides the report by the Ministry of Environment of 30 January 2012[14] the only media coverage known to GFMC is the report "Climate Change and Forest Fires Conference" published in Jerusalem Post on 1 February 2012.[15] There was no opportunity to publicly express international views of the Mt. Carmel fire by an institution like GFMC.

6. Expert impressions

From the international perspective the conference was not designed to address the pan-Mediterranean fire issues affected by climate change.

From the point of view of Israel, however, the conference was overdue and needed.

As it happens often, disasters unveil gaps and deficits in policy and state institutional capacity, but also public awareness and attention. The Mt. Carmel fire of December 2010 brought a dormant problem to the surface and to public and political discussions and challenged the country to respond.

The fire has been perceived as an unprecedented disaster. And indeed the tragic accident, the death of 43 cadets and a police officer, resulted from a decision by local police and happened in a situation in which local police officers globally, who were not capacitated at all in the basics of wildland fire behaviour and fire safety, would have done a similar decision (or "mistake"). This loss of lives was a tragic accident. This accident is not a key issue of discussing future policy and action.

For the Mt. Carmel Biosphere Reserve the fire was neither a disaster nor unforeseeable. Only the time and the reason (cause) of the inevitable fire could not be predetermined.

The post-fire development of fire-affected ecosystems must be monitored carefully, e.g. will introduced / systematically afforested pyrophytic species such as Aleppo Pine become so dominant that the wild growth of forest will become dominant over the native maquis?

Most important will be how the authorities concerned with / responsible for fire management, land-use planning and land management, including forestry and authorities concerned with fire suppression, will collectively respond to the general "fire situation" in the country, i.e. to respond to

- changing fire regimes likely to be associated with increasing wildfire risks and threats – consequences of rural exodus, decreasing intensity of land cultivation and increasing wildfire hazard; and
- changing vulnerability of predominantly urbanized society and ecosystems to fire.

Compared to neighboring Near East / Middle East countries Israel is facing a rather unique future, the consequence of massive afforestation which besides the desired effect of "greening the country" is bringing fire to the desert.

This challenging and demanding situation will require to take advantage of the expertise of the international wildland fire community which has been dealing with the problems encountered in Israel but not necessarily in one single country. No country in size of Israel can afford to provide scientific and institutional capacity to address all the fire problems that are accumulating these days.

7. Recommendations

Thus, from the point of view of GFMC the following major themes need to be addressed

- Networking: Israel to urgently seek cooperation with dedicated regional and global networks of specialists, institutions and countries cooperating in fire science and management. Post

[14] http://www.mfa.gov.il/MFA/InnovativeIsrael/International_conference_Climate_Change_Forest_Fires_31-Jan-2012.htm

[15] Original URL expired

conference (29 January 2012) GFMC has sent a letter to the Ministry of Environmental Protection, JNF / KKL and the Ministry of Agriculture and Rural Development providing suggestions;

- Israel needs a coordinated national structure in the form of a permanent body at inter-agency level with participation of civil society, tentatively called "National Wildland Fire Management Board". In this board agencies, academia and civil society would jointly work on solutions of the complex problems and have a coordinated voice in the national and international community, allowing to build national capacity based on a sustainable memory;
- Development of a National Fire Management Policy, which would address the underlying causes of environmental and society changes affecting wildland fire, and action to be taken to implement the policy;[16]
- Assessment of the role and need for sustainable management of cultural landscapes opposite reforestation / afforestation or traditional conservation approaches (conserving by prohibiting any ecosystem treatment / manipulation);
- As the country is transiting from desert country to flammable: Investigate the use of prescribed grazing and prescribed fire as integrated management tool[17];
- Give emphasis on Community-based Fire Management approaches to address wildland fire management at the level of those who are primarily affected by wildfires.

The offer to Israel to become involved in major thematic and geographic networks addressing wildland fire, including the Global Wildland Fire Network or the International Fire Aviation Working Group (IFAWG), is repeated.

I suggest strongly convening a National Round Table on Fire Management, if the *Lindenstrauss Report* would render this proposal superfluous.

Some Visual Impressions of the Conference

The Conference Group

[16] The report of the State Comptroller Lindenstrauss *The Carmel Fire December 2010 – Omissions, Failures and Conclusions*, submitted to government on 9 February 2012, is not yet available to GFMC.

[17] See the recent developments in temperate-boreal Eurasia concerning the use of prescribed fire via the *Eurasian Fire in Nature Conservation Network*: http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm

Field visit of the burned area, fire history trees, post-fire seed sources and seedlings of rather aggressive post-fire pine colonization, and post-fire erosion.

The Forest Fire Season in the Russian Federation in 2011

Forests in the Russian Federation occupy 69 % of the total territory and cover 1183.3 million hectares (ha) of forests, including the State Forest Fund (1144.1 million ha), the Special Protected Natural Territories (26.2 million ha), forests of other categories (forests of under the jurisdiction of the Ministry for Agriculture, Ministry for Public Transport, etc.) (6.8 million ha), forests under the jurisdiction of the Ministry of Defense (4.8 million ha), and municipality forests (1.4 million ha).

The Forest Fund of Russia subdivided into the following zones of monitoring (Fig. 1):

1) Zone of Ground Monitoring (densely populated territories with a developed road network where detection and suppression is made by mainly ground forces that capable to arrive to a fire within 3 hours from the time of fire detection) – 90.4 million ha;
2) Zone of Aviation Monitoring (forests with a low-developed road network, detection is made by aviation means; fire suppression is made mainly by aerial firefighting teams (smokejumpers, helirapellers) firefighting aircraft) – 481.2 million ha;
3) Zone of Space Monitoring (remote territories). The zone of space monitoring is subdivided into two levels. In the Sub-zone Level 1 fires are detected and monitored by satellite remote sensing, and suppression is carried out by aerial means. In the Sub-zone Level 2 wires will be suppressed only if settlements, other economic values at risk are threatened or controlling those wildfires that would spread to other Zones or to Sub-zone Level 1 – 571.3 million ha.

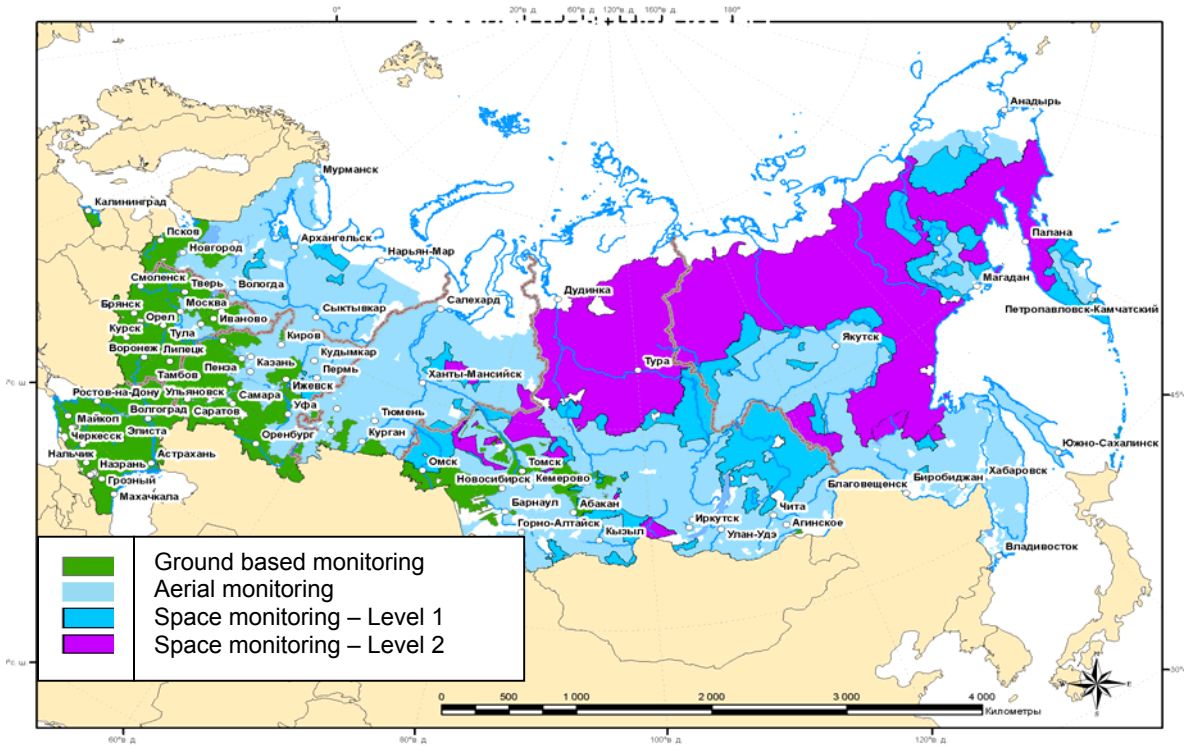


Figure 1. Forest Fire Monitoring Zones. Explanations: See text above.

According to the Forest Code of Russia fire prevention, mitigation and fire management is carried out by:

- Federal Forestry Agency – concerning the forests on which responsibilities are not transferred to public authorities of the regions of the Russian Federation according to a part 2 of Article 83 of the Forest Code of the Russian Federation (Note: Enacted on 1 July 2012 responsibilities on forest management in the Moscow region including fire prevention, mitigation and suppression given to the Moscow Region Government that was before under Federal Forest Agency's responsibility);
- The Ministry of Natural Resources and Ecology of the Russian Federation – concerning the forests located on lands of Special Protected Natural Territories at Federal level;
- The Authorities of State Defense – concerning the forests located on the lands belonging to the jurisdiction of the Ministry of Defense;
- Public authorities of the regions of the Russian Federation or local governments – concerning the forests located on the lands belonging to the regions and municipalities;
- Public authorities of the regions of the Russian Federation – concerning to the forests located on State forest lands of the regions, implementation of responsibilities on which transferred to Authorities of the Regions of the Russian Federation according to Part 1 of Article 83 of the Forest Code of the Russian Federation.

On the Forest lots provided for a long-term ***use & rent for forest users*** prevention and mitigation activities carried out by the users based on Forest Use Project, but fire fighting operations carried out by special fire centers and brigades build up in every region.

The most important activities on fire prevention and preparation include:

- Fire prevention arrangement of the forests (construction, reconstruction the forest roads, maintenance of observation towers, prevention fire lines; creation of fire-prevention water reservoirs, etc.);
- Provision of fire suppression equipment and engines, communication systems, etc.;
- Public information and education through mass media.

In preparation of the 2011 fire season in the Russian Federation a total of 3058 plans of suppression of forest fires were prepared and 1,046,200 km of patrol routes approved. Voluntary fire teams are organized and included 67,347 volunteers.

Fire Prevention activities in the Russian Federation:

- Construction of forest roads for fire-prevention, 6,200 km
- Reconstruction and Maintenance of roads of fire-prevention appointment, over 20,000 km
- Construction of the fire-prevention mineralized lines, barriers, over 200,000 km
- Care of the fire-prevention mineralized strips, barriers, over 600,000 km
- Prescribed burning – 1.2 million ha

Fire danger rating

In comparison with 2010 it is noted the increase of monthly average temperatures in the Siberian Federal District – in April – June, in the North West Federal District – in June, in the Ural Federal District in September. For all territory of the Russian Federation October was abnormally warm. High fire danger rating was observed in Southern Siberia and Far East in April (Fig.2).

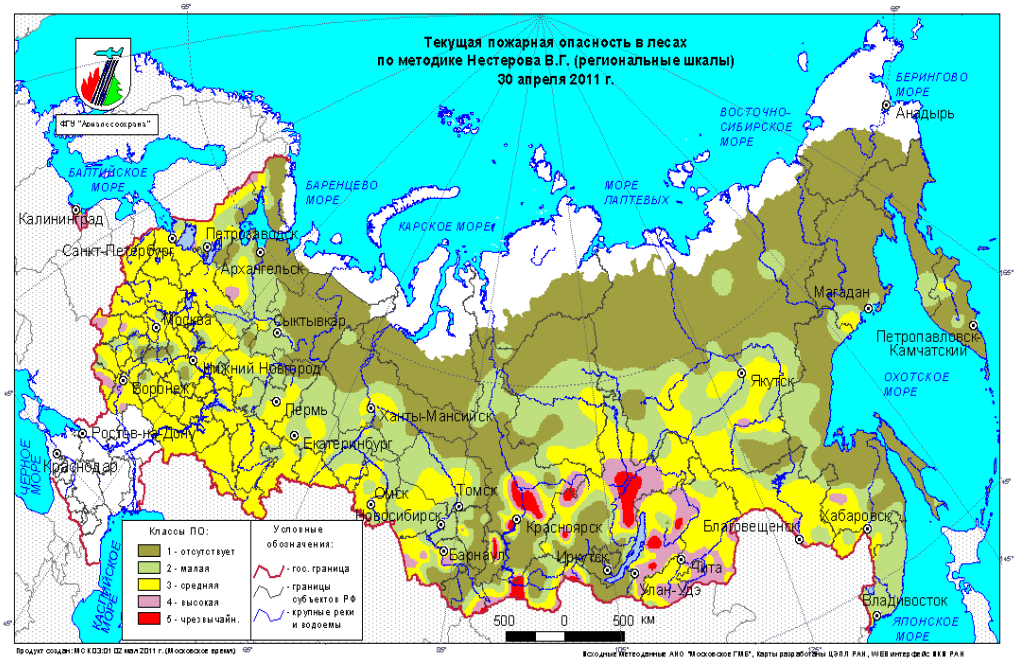


Figure 2. Fire danger rating as for 30 April 2011

So first fires started in southern regions of Siberia and Far East in April (Buriatia, Altai, Zabaikalie and Primorski regions) where first fires burned thousands of hectares of forests in the beginning of fire season (Fig.3).

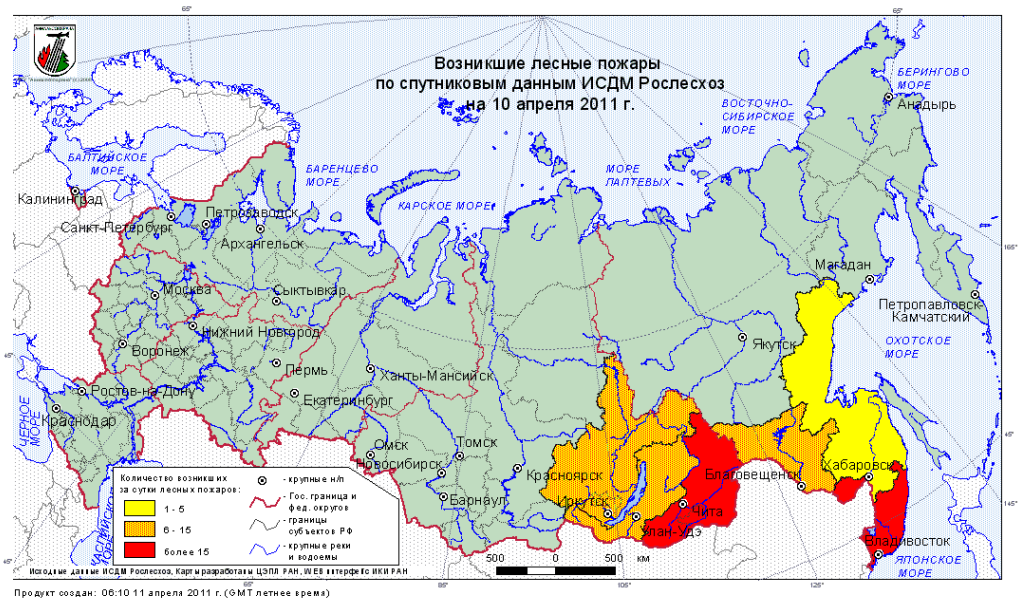


Figure 3. Regions of Russia with major active wildfires between the start of the fire season up for 10 April 2011. (Legend: Number of fire starts during the last day – Yellow 1-5, Ochre 6-15, Red <15)

Decrease of average amount of precipitation in comparison with 2010 is noted: In the Central Federal District – in May, in the Northwest Federal District – in June, in the Far East Federal District – in July. In the majority of other regions the average amount of precipitation increased.

As a whole for Russia in 2011 the average amount of precipitation was for 22% higher than in 2010. Forest Fire Danger Rating is based on weather conditions in the Russian Federation and determined by the Nesterov Index. Fire danger classes (KPO) on a scale from 1 (Low) to 5 (Extreme) are determined by the number of rainless days, relative air humidity and temperature.

The analysis of fire danger shows that in comparison with last year High and Extreme fire danger was observed in Far East Federal District (April, August, October), Siberian Federal District (April, May, October), and also in North West Federal District (June). In the majority of other regions average value of KPO was up to standard or decreased.

In 2011 a total of 20,851 forest fires were recorded in the Russian Federation. The area burned on Special Protected Natural Territories was 1,636,232 ha. According to remote sensing data of the Space Research Institute of Russia the total vegetated area burned is about 5 million ha. Large fires occurred mainly in Siberia, the Far East and the Northwest Federal Districts (90% out of total area burned), with most fires occurring in 11 subjects (regions) of the Russian Federation: Republics of Sakha (Yakutia), Buryatiya, Komi, Zabaykalsky Krai, Krasnoyarsk, Khabarovsk, Amur, Arkhangelsk, Irkutsk, Sverdlovsk and Khanty-Mansi Autonomous Okrug).

The main reason for the raised number of forest fires and area burned in that regions were agricultural burnings that went out of control and abnormal weather conditions.

Over 17,000 fire engines, tractors and other equipment and over 200 aircraft were mobilized during the season nationwide.

Figures 4 and 5. Aerial and ground fire suppression forces operating in 2011. Photos: *Avialesookhrana*.

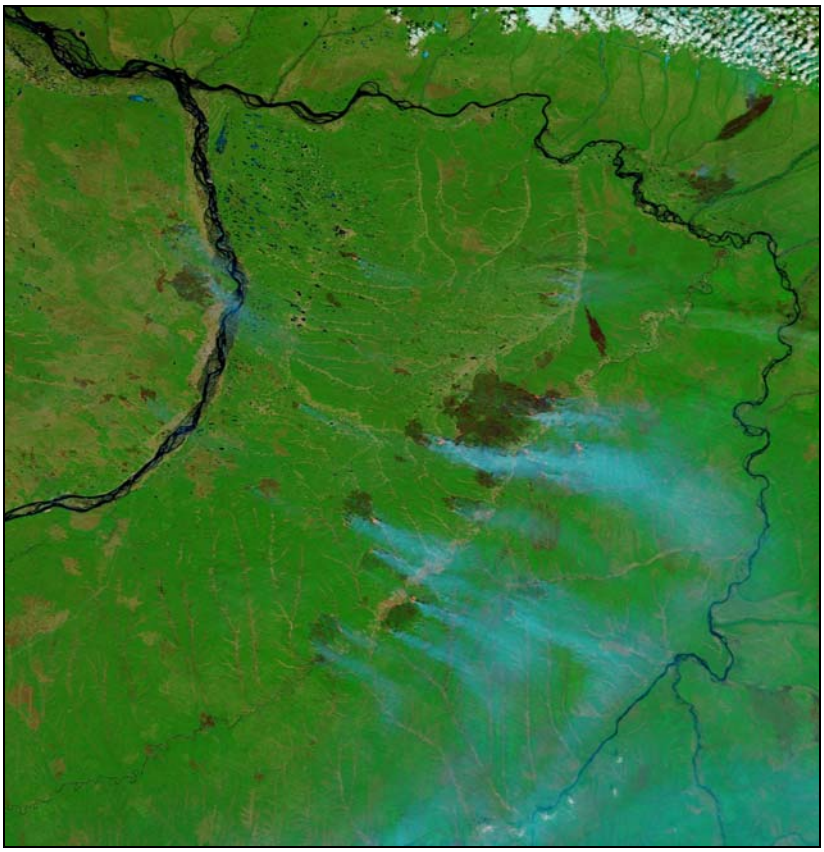
Unfortunately there were several fatalities and injuries during the 2011 fire season. One fire fighter died in Rostov Oblast during a high-intensity crowning fire. One pilot died and one was severely injured in Republic of Tyva after the crash of a Bekas X-32 airplane that was deployed for aerial wildfire monitoring.

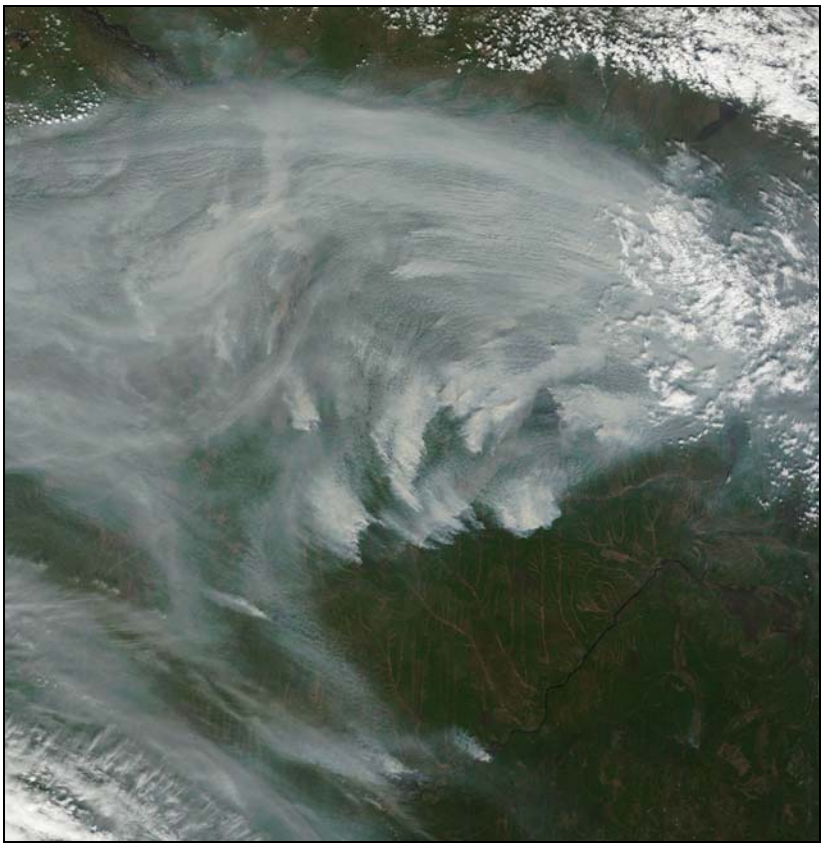
Under the Interagency Agreement fire suppression forces of Avialesookhrana, the Emergency Ministry and other agencies were involved and coordinated during these extreme fire events. Based on interregional agreements 1600 firefighters were exchanged / dispatched between the regions of the Russian Federation.

In comparison with 2010 the number of fires decreased by 1.6 times, the area burned in Special Protected Natural Territories decreased by 471,000 ha. The damage caused by forest fires in 2011 amounted about 20 billion rubles – almost 6 times less in comparison to last year.

In the territory of the Moscow Region the Federal Forest Agency (*Rosleskhoz*) together with the Government of the Moscow region defined sites of peatlands for rehabilitation and wildfire hazard reduction by irrigation. Also *Rosleskhoz* together with the Government of Moscow Region coordinated the irrigation of sites of the Forest Fund in 2012 and 2013. In 2010-2011 the area of irrigated peat lands of the Forest Fund amounted 17,000 ha out of the total area of 20,000 ha.

On the Special Protected Natural Territories 331 wildfires (in 2010 – 732 wildfires) affected 83,000 ha (thereof 32,000 ha forested), i.e. 30% less than in 2010. Most fires were registered in the Far East and the Siberian Federal Districts (95% of all fires occurring in Special Protected Natural Territories).





Figures 6 and 7. The wildfires burning in Yakutia were continuously monitored from space. The upper image was captured by the MODIS instrument on NASA's satellite Terra (infrared image, showing active fire fronts and burned area on 22 May 2011). The lower image shows the wildfire smoke covering Yakutia on 27 May 2011 as depicted by MODIS on NASA's satellite Aqua. Source: Courtesy NASA

On the lands under the jurisdiction of the Ministry of Defense 126 forest fires burned 19,600 ha of vegetated land, thereof 19,000 ha forested lands. The number of fire incidents was 1.9 times higher than the in 2010 (67 fires).

Compared to 2010 the budget for forest the protection of forests in the Russian Federation increased by about two times and amounted about 8.0 billion rubles, including 5.0 billion rubles for the acquisition of firefighting engines and tractors.

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IFFN Contribution by

Andrey Eritsov
Fire Management Programs
All Russian Institute of Continuous Education in Forestry
Federal Forest Agency of Russia
141200, Institutskaya street 17
Pushkino, Moscow Region
Russia

and

Johann Georg Goldammer
Director, Global Fire Monitoring Center
Georges-Koehler-Allee 75
D-79110 Freiburg
Germany