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World Bank Policy Note:

Managing Wildfires in a Changing Climate

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ACRONYMS

EUCPM	European Union Civil Protection Mechanism
GFED	Global Fire Emissions Database
GHGs	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
IUFRO	International Union of Forest Research Organizations
PROFOR	Program on Forests
NDC	Nationally Determined Contribution
PM	Particulate matter
tCO2e	tons of carbon dioxide equivalent
WUI	Wildland Urban Interface

FOREWORD

In recent years, wildfire seasons have become longer and harsher, causing significant ecological, economic and social damage. In 2019 and into 2020, fires burned across the globe—in the Amazon, Alaska, Australia, California, Europe, Indonesia and Russia—ravaging ecosystems, communities and economies.

For the most part, such extreme wildfires are the result of policy, planning and governance decisions related to land use, coupled with increasingly adverse weather conditions due to climate change. When combined, these factors create the conditions for wildfires to grow into extreme wildfires that exceed humanity's ability to control and suppress them. The global context for wildfires is changing and countries must take more action to proactively prevent wildfires and to suppress fires when needed to prevent them from becoming extreme wildfires.

This paper takes stock of factors that contribute to extreme wildfires, including climate change, land-use change, and demographic shifts, and recommends policy actions that can be taken to improve wildfire prevention and management depending on national circumstances.

The biggest shift from the current reactive approach, which often relies on emergency response and fire suppression, is increased investment in prevention. Governments can help prevent extreme wildfires through measures such as improved land-use planning, eliminating perverse incentives for using fire to change land use, and clarifying land tenure rights. Other actions include implementing existing fire management techniques such as integrated fire management and fire danger rating, improving fire monitoring and early detection and strengthening stakeholder involvement in fire management planning.

Although investment in wildfire prevention may get less recognition than suppression efforts, it is essential if we are to reduce the social, economic and ecological costs of extreme wildfires. Such preventive and proactive wildfire management is needed if we are to support countries to end extreme poverty, increase shared prosperity, and meet their objectives under the Sustainable Development Goals, the Paris Agreement on climate change and the post-2020 biodiversity framework.

We hope this paper provides countries with the needed policy guidance to shift their approach to one that is more effective in a changing climate.

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KEY MESSAGES

- A potentially vicious cycle of climate change and wildfire is emerging. Fire seasons are becoming longer and harsher and the frequency, intensity and magnitude of extreme wildfires is increasing across the globe.
- Less than 10 percent of wildfires result in more than 90 percent of the total area burned annually. These are often extreme wildfires that cannot be brought under control.
- Extreme wildfires are the result of past and present policy, planning and governance decisions that, coupled with increasingly adverse weather conditions due to climate change, create the conditions for fires to ignite and spread across landscapes beyond societies' capacity to suppress them.
- Such wildfires result in severe economic, social and environmental costs. For example, fire cost an estimated $16.1 billion[1] in Indonesia in 2015, 10 billion in Europe in 2017 and $5.2 billion in Indonesia in 2019.
- Immediate action is required to prevent extreme wildfires where possible and limit the disastrous results of such events elsewhere.
- The impacts of extreme wildfires can be significantly reduced with the right fire-smart approaches such as investments in wildfire prevention and integrated fire management. Application of such approaches, tools and technologies is more cost-effective than fighting larger and fast-spreading wildfires.

1 All dollar figures are U.S. dollars.

INTRODUCTION

Fire is a natural element of many ecosystems, with several species dependent on fire for their survival and reproduction. Fire has also been used by humans for millennia, and today remains an important and cost-efficient tool for land management in many parts of the world, particularly for the poor. Today, the most destructive blazes are forest fires, and what this policy note refers to as wildfires.

The term "wildfire" is based on the FAO definition[2] of any unplanned and uncontrolled wildland fire and any free burning wildland fire. Most of these fires are brought under control, with approximately 90% of them affecting 10% or less of the total area burned annually. It is the remaining 10% of wildfires, extreme wildfires that cannot be supressed that cause 90% of the area burned every year.[3]

Extreme wildfires[4] exceed societies' capacity to suppress them and are a growing problem. Such fires result in devastating loss of life, destruction of property, and severe infrastructure and environmental impacts with high economic, social, health, and ecological costs.

At the same time, the total area burned annually has decreased in recent decades, and in general, there is less fire in the global landscape today than centuries ago.[5] Each year between 2003 and 2012, approximately 67 million hectares of forest burned across the globe,[6] whereas the Global Fire Emissions Database identified over 54 million hectares of forest burned in 2015.

The drivers behind extreme wildfires are complex and involve changes in the global climate and changes in how societies use land. In particular, as the world faces a changing climate, all regions of the planet are faced with impacts on a scale that no single country or community can mitigate. The hotter temperatures, shifting precipitation patterns, increasing winds and other impacts of climate change are expanding the risks of wildfire ignition and spread, especially in regions where societal shifts, such as human developments in fire-prone areas, have increased vulnerability to wildfires.

The extreme wildfires of recent years demonstrate the scope of the problem. For example, the Indonesia fires of 2015 cost the country more than twice as much as the reconstruction following the Aceh tsunami a decade earlier.

This World Bank Policy Note aims to explain the complexity and challenge of the global wildfire situation, which is evolving in unknown proportions due to climate change, and to promote strategies and policies to help communities and nations prevent extreme wildfires and better protect themselves when they happen. It includes recommendations for addressing the issue as a follow-up to the Global Expert Workshop on Fire and Climate Change hosted in Vienna, Austria, in July 2018 convened by IUFRO and PROFOR.

RECENT WILDFIRE EVENTS

A number of extreme wildfires have occurred across the world in the past decade, some in places that were not prone to fires in the past.

Higher-profile damaging wildfires include Indonesia (2019 and 2015); Australia (2020, 2019, 2009); the Amazon and Arctic regions (2019); the United Kingdom (2019 and 2018); Sweden (2018); Greece (2018 and 2007); USA (2019, 2018, 2017 and 2013); Canada (2016); Chile (2017); Portugal (2017, 2005, and 2003); and Russia (2010).

Box 1 details some of the most extreme wildfires in recent years:

2 The term "wildfire" in this paper uses the definition in (FAO 2003): (1) Any unplanned and uncontrolled wildland fire which regardless of ignition source may require suppression response, or other action according to agency policy; (2) Any free burning wildland fire unaffected by fire suppression measures which meets management objectives (cf. Wildland, Wildland Fire, Prescribed Natural Fire, Prescribed Fire). Other names such as brush fire, bushfire, forest fire, grass fire, hill fire, peat fire, vegetation fire, veldfire and wildland fire may be used to describe the same phenomenon depending on the type of vegetation being burned.

3 Catry et al, 2010; Goldammer and Stocks, 2011; US Department of Interior, 2014; and Williams 2014

4 Extreme wildfire events, regardless of the cause, are driven by meteorological conditions (weather). Nearly all disastrous wildfires are associated with meteorological conditions including high winds and high temperatures, or climatic conditions such as drought. Extreme wildfire events exceed the limits of suppression. In this paper, the term extreme wildfire is used to describe such events.

5 Doerr and Santin, 2016

6 van Lierop et al., 2015

BOX 1: RECENT EXTREME WILDFIRE INCIDENTS

- In 2019 and continuing into 2020, wildfires burned across Australia. More than 10 million hectares burned[1], 33 people were killed, more than 3,000 homes destroyed, and millions of animals died.[2] In some places the fires burned for months. The fires started in late July and continued to grow as Australia experiences its driest spring on record and a heatwave in December that broke the record for the highest nationwide average temperature.[3]

- In June 2019, initially controlled fires went out of control, burning across parts of the Brazilian Amazon, Bolivia, and Paraguay in South America. These wildfires increased significantly in August, attracting the widespread attention of international media, civil society and global leaders.

- During the summer of 2019 wildfires broke out across the Arctic region — including Alaska, Greenland and Siberia, in places that have not typically burned in the past. Temperatures in the Arctic are rising at a faster rate than the global average contributing to the conditions for wildfires.

- The United Kingdom saw a record-breaking series of wildfires burning across its territory during the hot, dry weather of 2018, with 79 fires over the course of the year. This record was surpassed in early 2019 with 96 fires by April 23.

- In 2018, with the hottest July recorded in the 150 years of records, Sweden saw hundreds of fires burn an estimated 25,000 hectares, representing an estimated value of just over $100 million.

- In 2018, Greece experienced a wildfire that started east of Athens in late July and burned rapidly into a number of coastal towns driven by very strong winds. The wildfires resulted in the deaths of more than 90 people, with widespread losses of infrastructure, houses, and other property.

1 The 2019-20 bushfires: a CSIRO explainer https://www.csiro.au/en/Research/Environment/Extreme-Events/Bushfire/preparing-for-climate-change/2019-20-bushfires-explainer
2 Green, Matthew (14 January 2020). "Australia's massive fires could become routine, climate scientists warn". Reuters. Retrieved 14 January 2020.
3 Australian Government Bureau of Meteorology. Annual Climate Statement 2019. http://www.bom.gov.au/

- The 2018 wildfire season was the deadliest and most destructive wildfire season ever recorded in California, with over 8,000 wildfires burning more than 750,000 hectares and insurance claims exceeding $12 billion.

- Wildfires destroyed over 1.2 million hectares of forests and land in Europe in 2017, claiming the lives of 127 civilians and firefighters and causing an estimated economic damage of EUR 10 billion. Although the Mediterranean region remained the most affected area, unusually dry summers in central and northern Europe led to large wildfires in countries such as Sweden, Germany and Poland, which have historically seen very few wildfires.

- The California 2017 wildfire season was described at that time as the most destructive wildfire season on record. Over 9,000 wildfires burned 559,035 hectares with 43 people killed and 10,000 structures reported damaged or destroyed with the total cost of the wildfires estimated at approximately $180 billion, including $700 million spent on fire fighting.

- In 2017, wildfires burned in the historic Chilean port city of Valparaiso, forcing authorities to evacuate hundreds of people with 19 people hurt and 100 homes damaged on the city's outskirts. As the fire season continued, the government of Chile declared a state of emergency and requested international assistance to combat wildfires. There was loss of commercial forests estimated at $350 million with agriculture losses at $20 million including olive trees, vineyards and infrastructure.

- In 2017, Algeria suffered damage and loss that included 220,000 olive trees, 74,000 fruit trees and over 5,000 bee hives. The total amount of compensation for losses was over $4.4 million, representing a considerable impact for national agriculture.

- The Fort McMurray wildfire in 2016 was the costliest natural disaster in Canadian history. It burned 600,000 hectares and 2,400 buildings, and 88,000 people were evacuated, leading to the loss of more than 7 million job-hours, a 16% drop in refined energy product exports, a 0.4% drop in Canada's gross domestic product, and insured losses assessed at about $2.9 billion.

THE COSTS OF EXTREME WILDFIRES

Extreme wildfires carry significant economic, environmental and societal costs.

ECONOMIC DAMAGE AND LOSS

Extreme wildfires carry a heavy economic toll. They cause damage to infrastructure and services, including power and communication lines, water systems, roads and railways, as well as the immediate costs of firefighting.

Additionally, there are tremendous costs associated with rebuilding homes, businesses and entire communities that have been damaged or destroyed by a major fire event. A fire can force industrial shutdowns, cutting productivity and halting economic activity; disrupt transportation routes and supply chains; increase health costs due to air pollution; decrease tax revenues, and affect property values. Businesses may be forced to close and lay off employees, workers may have to relocate, and customers may take their business elsewhere, causing further losses. Extreme wildfires pose significant risks to banks and insurers from rising instances of catastrophic events, which could result in significant losses.

The World Bank estimated the costs of the 2015 fires in Indonesia at $16.1 billion (IDR 221 trillion) in damage and loss, with regional and global costs making the total figures much higher. This was roughly equivalent to 1.9% of the country's GDP and more than twice the reconstruction cost following the Aceh tsunami. Costs to the environment were substantial — 26 percent of the total — and included losses to biodiversity (applying the government's biodiversity value per hectare) as well as losses to ecosystem services. The haze forced school closures for up to 34 days, resulting in $34 million in costs from lost productivity in seven provinces. High levels of haze through most of September and October cost the transportation sector $372 million, most of the losses were born by seaports as cargo shipping was interrupted by poor visibility. The haze also contributed to the death of 19 people and more than 500,000 cases of acute respiratory infections. Immediate health costs totaled $151 million.[7]

In 2017, wildfires destroyed over 1,600 houses in Chile and 1,200 structures in Knysna, South Africa. The 2011 Flat Top Complex wildland fire caused more than $533 million in losses in and around Slave Lake, Alberta, with more than 10,000 people evacuated and hundreds of homes and businesses destroyed, while in Quebec, the 2013 fires in the James Bay area shut down the main highway into the region impacting deliveries, and smoke triggered power failures including a shutdown of Montréal's Metro rapid transit system.

Fire suppression can be very costly and firefighting expenses are increasing in many countries. Over the last decade, annual firefighting costs on US federal lands exceeded $1.7 billion. In Canada, total costs for national wildland fire management activities range between $600 million and $1 billion per year. Costs in Canada have risen by about $114 million per decade since the 1970s.

Forest fire prevention tools and actions under the European Union Civil Protection Mechanism (EUCPM) have seen $2.45 billion in firefighting, with 65,000 wildfire incidents burning across 480,000 hectares. France, Greece, Italy, Portugal, and Spain spent a total of $2.8 billion on firefighting costs.

In other parts of the world, such spending on firefighting is beyond countries' financial capacity.

SOCIAL DAMAGE AND LOSS

Wildfire events have severe effects on human health and can strain regional health services.

In the EU between 2000 and 2017, 611 people were killed, 8.5 million hectares burned, and 54 billion in damage and loss incurred.[8] Other regions were heavily affected as well during the same period: the Americas saw 1,785 deaths (mainly in the United States and Canada); Oceania 501 deaths (mainly in Australia); Africa 287 deaths, and 841 deaths in Asia.[9]

The indirect effect of forest fires also results in significant loss of life. Indirect effects include the longer-term health implications of smoke from landscape fires contributing to premature deaths,

7 World Bank Group, 2015

8 Ciscar et al 2014

9 EM-DAT: The OFDA/CRED International Disaster Database

with estimates for the period 1997–2006 of more than 300,000 people per year. As an example, the haze from the 2015 Indonesian fires was estimated to have caused 100,300 additional deaths across Indonesia, Malaysia and Singapore[10] and more than 500,000 cases of acute respiratory infections in Indonesia alone.[11] Even for people living hundreds of kilometers away, smoke from a fire event can irritate eyes and throats, trigger chronic respiratory and cardiac conditions, and, in some cases, lead to premature death.

The combustion products of fire have long-term effects on human health.[12] The most important risk-related measure of smoke is particulate matter (PM) with an aerodynamic diameter smaller than 2.5 micrometers (PM2.5) which mainly consists of carbon, but smoke also contains carbon monoxide, oxides of nitrogen and many other combustion products, some of which are toxic. Impacts from exposure to smoke include respiratory issues, deaths, and lower fetal and infant survival rates.[13]

In 2010, Russia reported a doubling of the daily mortality rate from about 350 to 700 in the Moscow region, with some of the increased mortality due to the impact of peat derived smoke and heat exhaustion as a result of record maximum temperatures.[14]

Less well known is the significant psychological effect that some people experience after close contact with wildfire.[15] A wildfire event can cause confusion, anger, sadness, and fear, and leave an enormous imprint on the people and communities that experience them. For individuals, families and communities, the loss of homes; personal effects; mementos and cherished items, including pet animals; and irreplaceable photos, documents and memorabilia, is highly distressing and contributes to the psychological effects of wildfires.

ENVIRONMENTAL DAMAGE AND LOSS

Wildfires cause considerable damage to landscapes and impact environmental services.

Changes in global fire activity in terms of location, intensity, severity, and frequency (technically known as "the fire regime") will have deep and long-lasting impacts on biodiversity and ecosystem services.

10 Johnston et al 2012
11 World Bank 2015
12 Johnston et al., 2016; Capistrano et al., 2017; Cascio, 2018
13 Jayachandran, 2009; Cascio, 2018; Fann et al., 2018
14 Goldammer 2010
15 Eisenman et al., 2015

Fire can remove large amounts of biomass and cause negative impacts on the production of ecosystem goods and services such as soil erosion, water runoff, air pollution, and timber loss. Fire is also a factor in desertification and land degradation.[16] For example, the loss of fire-maintained habitat mosaics, an area comprising multiple environment types, created by indigenous fire management practices is one cause of biodiversity decline and landscape changes.

The costs of forest fires in India are estimated at $164 million per year for timber value alone. An analysis of how wildfires affect timber production in the Brazilian Amazon found that fire could impact roughly 2% of the production areas projected to be harvested between 2012 and 2041, reducing returns by an average of $39per hectare per year. These losses could reach up to $183per hectare per year in areas around timber milling centers hit by recurrent fires in the southern and eastern Amazon. Estimated economic losses were approximately $500-875 million at Net Present Value, representing a 4% reduction in total net revenues from sustainable timber harvest. Potential losses would exceed $7 billion if all burned areas had been planned to be logged.[17]

There is potential for countries to meet GHG reduction commitments and benefit from climate change funding flows through improved fire management.

Fires are a significant contributor of greenhouse gases (GHGs) to the atmosphere. When fire is used to transform forest areas into open lands or for other land-use changes, the result is a net addition of GHGs to the atmosphere. Furthermore, other gases produced in fires — such as oxides of nitrogen and methane — also become a net emission to the atmosphere. In particular, fuels that would not burn unless subjected to land-use change, such as tropical peatlands, are significant contributors to GHG emissions. However, when fires in forests, savannas or grasslands do not substantially alter the land use, CO_2 is subsequently removed from the atmosphere when the vegetation regrows.

The Global Fire Emissions Database estimates that in 2015, the Indonesian fires contributed roughly 1,750 million tons of carbon dioxide equivalent (tCO_2e) to global emissions. That's almost equivalent to the nation's estimated total annual emissions of 1,800 million tCO_2e, according to the UN Framework Convention on Climate Change.

16 Neary, 2009; Kosmas et al., 2014; Miao et al., 2016; Cherlet et al., 2018
17 Soares-Filho, B. S. et al., 2017

TABLE 1: GHG EMISSIONS (CO2E) FROM VARIOUS FIRE CATEGORIES BASED ON THE GLOBAL FIRE EMISSIONS DATABASE (GFED4S).

FIRE CATEGORY	CO_2	CH_4	N_2O	ALL	CONTRIBUTION (%)
Savanna	4.85	0.19	0.17	5.21	65
Boreal Forest	0.51	0.07	0.04	0.62	8
Temperate forest	0.17	0.01	0.00	0.19	2
Tropical forest	1.07	0.11	0.04	1.22	15
Tropical peatland	0.23	0.10	0.01	0.33	4
Agricultural waste burning	0.44	0.06	0.01	0.50	6
Total	**7.27**	**0.53**	**0.27**	**8.08**	**100**

Source: IUFRO 2018

Achieving Nationally Determined Contributions (NDCs) under the Paris Climate Agreement would be challenging without improved management of wildfires. Some countries where fires are a significant source of GHG emissions have promised enhancement of forest carbon sinks as a significant climate-change mitigation measure. Many developing countries have included land-use change in their NDCs, but few have noted fires as a source of GHG emissions that they will likely be required to report in the future.

Changes in freshwater availability and degradation of water supply are another indirect impact of wildfires that can potentially leave millions of people — including those living in major cities — at risk of water shortages. For example, wildfire activity in watersheds in Chile in 2017 caused erosion and siltation that affected water supply infrastructure. In places where human development is in areas susceptible to wildfires, waste as well as materials used in buildings such as plastics, paints, and other finishes may burn and lead to contamination of the water supply.[18]

18 Hallema et al In Press

THE DRIVERS OF WILDFIRES

Extreme wildfires are a landscape problem. They are the result of policy, planning and governance decisions that, coupled with increasingly adverse weather conditions due to climate change, result in wildfires igniting and spreading across landscapes causing significant damage and loss. The drivers of wildfire disasters need to be further analyzed and clearly described to find solutions.

Vegetation, topography, and weather conditions across space and time, including climate change, combine with fire ignitions to create fires, including some that become extreme wildfires. Factors that determine a fire's severity and ability to spread include insufficient or inadequate means of suppression, as well as fuel accumulation and fuel continuity from vegetation, land use, and fire use as well as accidental ignitions. Fuel accumulation can occur for several reasons, including rural populations migrating to urban areas, resulting in downed timber that would previously have been harvested for firewood remaining on the ground.

Fuel accumulation can also result from the spread of pests and diseases, such as the bark beetle infestations in North America and Europe. In such instances, weakened and dead trees add to the fuel load, open the canopy and thus contribute to drier conditions.

PEOPLE AND WEATHER

Human activity, combined with adverse weather conditions, is the most common cause of wildfires. In the FAO Global Fire Assessment 2006, several regions estimated the proportion of fires that were caused by humans: Mediterranean 95%, South Asia 90%, South America 85%, Northeast Asia 80% and the Balkans 59%. The rest of the fires were a result of natural causes, such as lightning, particularly in remote and uninhabited areas. Human sources of fires differ across geographic regions. In tropical regions not naturally prone to burning, fires are most closely linked to economic development when there is less access to alternative tools to fire for land management, poor practices driven by perverse incentives, and weak understanding of fire risk. In temperate and boreal regions where fire is more common, causes are more related to mismanagement, human error, accidents, negligence, carelessness, and natural phenomena.

Regardless of the initial cause, extreme wildfires are driven by meteorological conditions (weather). Nearly all disastrous wildfires are associated with meteorological conditions including high winds and high temperatures, or climatic conditions such as drought. All these conditions are exacerbated by climate change.

LAND USE AND LAND USE CHANGE POLICIES

Fire plays a crucial role in the clearing of forests to create permanent fields for more profitable land uses.

Landscapes can show increased occurrence of fires due in part to factors like the price of commodities on international markets. Since the 1980s, fires have been used to clear land—mostly tropical forests as land use is converted to agriculture production to meet growing global demand for agricultural commodities. For example, in the Amazon and Indonesia, fire, often illegally deployed, continues to be a leading means of clearing land for meat, oil palm, wood fiber plantations, and other crops.

Forestry and land use policy can affect how fire naturally occurs in a particular ecosystem. Forestry incentives often favor large-scale plantations, as well as post-fire salvage logging that may have negative impacts on biodiversity and soil erosion. Establishing industrial plantations or woodlots of commercial species such as Pinus and Eucalyptus can contribute to fire hazards. Such plantations contributed to the damaging wildfires in Chile and Portugal. In low-productivity forests, declining management leads to fuel accumulation, fuel connectivity, and hence increased fire hazard such as in some countries in Europe.

Land use policies promoting the opening of land for cultivation and agricultural expansion often favor the extensive but detrimental use of fire. Policy formulation, or a lack of it, with weak integration within sector, across sectors or without checks and balances on unintended risks and consequences are sometimes conducive to wildfires in the landscape.

A recent study in Brazil suggests that deforestation that converts rainforest to agricultural land could expand areas at risk of wildfires by more than 70 percent by the end of the century. Policies that support the construction and paving of new highways, increased deforestation, and reduced effectiveness of protected areas could dramatically increase the risk of wildfires. When considered with the IPCC´s pessimistic climate change scenario, the area with high probability of wildfires could increase by up to 110%. The biggest driver is poorly planned use of land, involving issues that can be addressed through better planning measures.[19]

Improving fire management can involve access and use rights being made clear for local communities and strengthening land use governance and legal frameworks.

Lack of clear land tenure and access/use rights can create the situation where local people have no sense of resource ownership or responsibility and may use fire carelessly or with the aim of retaining their access to resources.[20] Unclear land tenure and land use zoning also creates the conditions for careless burning, with people using fire as a cheap and low-risk way for clearing land and laying claim to it for agricultural or real estate development without fear of detection and penalization.[21]

The growth in the prevalence of fire in Indonesia correlates with the expansion of lucrative agricultural commodities such as palm oil and acacia for wood fiber. Land conversion by fire is prohibited by law and penalties include fines and prison terms. Yet, the alternative of mechanical clearing with heavy equipment can be many times more expensive. Looking at 11 sites outside of plantation concessions across four districts in Riau Province, CIFOR concluded that using fire for land acquisition and clearing generates a cashflow of at least $3,077 per hectare of oil palm in just three years.[22]

LAND ABANDONMENT AND THE WILDLAND URBAN INTERFACE (WUI)

The area at risk of wildfires is continuously expanding as a result of land abandonment and the increase of the WUI through human developments in areas prone to wildfires in many countries.

Rural landscapes across the world are expected to be increasingly emptied and abandoned as people move to urban areas for work and access to services. The land area covered by cities is predicted to triple, with the doubling of urban populations in developing countries. Globally, six out of every 10 people in the world are expected to reside in urban areas by 2030, with nearly all of this growth in Africa, Asia, Latin America and the Caribbean.[23]

Urbanization invariably involves the accompanying abandonment by landowners of areas of rural lands, which are then covered by grasses, shrubs and potentially in time, trees. The trend of rural-to-city migration, with accompanying socio-economic and policy changes, sees fewer people, less activity and altered management in rural areas leading to increased fuel loads, fuel continuity and wildfire hazard.[24] As countries have developed and people moved from rural land to cities, the landscape of fields, pastures, and forests have been left to themselves, replacing the mosaic of different vegetation and land use with large areas of continuous and heavier fire fuels.

As cities grow, the expansion of the WUI leads to increased fire risk, increased complexity of management, higher costs, and increased damage and loss.[25] In California, Oregon and Washington states in the United States, housing in the WUI comprised 61% of all new homes built during the 1990s, and 43% of the total housing in the region. Therefore, approximately four in 10 homes are in a zone of wildfire hazard.

Investment in wildfire prevention in rural landscapes will make emergency responses more effective.

In the absence of effective urban planning, the consequences of this rapid urbanization will be dramatic, including for wildfire impacts. The loss of life, damage bills, interruption to business and livelihoods are already being felt in rapidly growing cities such as Valparaiso in Chile (see Box 1). In European Mediterranean nations and north-eastern states of India, where shifting cultivation is still practiced, the cessation of community fire management practices linked to rural land abandonment is a cause of increased fire events. In addition, traditional methods for suppressing fires — with water and equipment — are still being used instead of investing in long-term efforts needed for

19 Fonseca et al 2019
20 Rakyutidharm, A. 2002
21 Byron and Shepherd, 1998, and observed up to the present
22 Purnomo et al, 2015

23 UN Habitat 2018
24 Plana et al 2016; Sande Silva et al 2010
25 San Miguel et al 2017, IUFRO 2018

prevention. Developing countries can benefit from the knowledge, experience and research on wildfires and the WUI that has already taken place as they transition from predominantly rural populations to increasingly urbanized populations.

AGENCY COORDINATION AND EFFECTIVE EMERGENCY READINESS AND RESPONSE

No actor alone can address a wildfire when it burns out of control. The risk of unplanned, unwanted fires getting out of control is always present. As such, Emergency Readiness and Response capability will always be required and must be appropriately organized, collaborative, scaled, and sustainably resourced. Over-emphasis on command-and-control solutions, often found in emergency response approaches to fire management, are unlikely to help communities and regions` ability to absorb increasing fire risk without significant negative social impacts. Interactive and cooperative efforts that can more effectively identify mutual concerns and creative solutions are more likely to lead to risk reduction.

The World Bank identified in its projects that to cope with an emergency situation, it is crucial to define roles and responsibilities well in advance in order to achieve a harmonious collaboration among different institutions and organizations involved in firefighting. In the initial stages of an emergency, there is often considerable commitment from all participating agencies. To translate this commitment into coordinated actions during firefighting in the field, it is necessary to have an agreed chain of command.

Readiness and Response requires collaboration and cooperation under a well-defined legal framework supported by clear policy and procedures, and definitions of functions, tasks and responsibilities for the agencies required in fire management, including land management, civil protection, health and transport among others. Geographical area responsibility is an important part of crisis preparedness. For the local, provincial and national level, there needs to be a clear regulation of this responsibility of different conditions at different levels. In many countries, fire management and response capacity need to be strengthened.

Awareness is also needed for the institutions of emergency management to ensure they cooperate effectively, flexibly, consistently, and continuously with each other and with stakeholders, including local communities, all levels of government, other arms of government, the private sector and civil society organizations.

Building social capital to enable effective collaboration in fire management and response is important for the long-term sustainability of wildfire mitigation and prevention efforts. World Bank projects have contributed, directly or indirectly, to the creation of social capital at all levels, especially in terms of understanding the importance of communal actions and partnerships to prevent wildfires and seek alternatives. Conditions must be established for coordinating partnerships and obtaining the cooperation of government agencies at all levels, including potentially non-governmental and community-based organizations, particularly across large and remote regions where no agency alone is able to take on all fire management responsibilities. Prevention and suppression activities have often been designed to start at the community level, with the organization of community fire prevention groups that functioned long after a project has ended.

THE LIMITS OF CURRENT APPROACHES

Extreme wildfires are uncontainable when they exceed the limits of suppression. Under severe fire danger conditions, available firefighting capacity is insufficient to stop or contain wildfires that surpass a fire line intensity of 10,000 kW/m. Calculated using Byram's equation, fire line intensity is the rate of heat release, a function of heat yield of fuel (kilojoules/kg), amount of fuel per unit area (kg/m2) and the rate of forward spread of the fire front (km/h).

Research on the limits of suppression confirms the firefighting efforts of people, tools and machines are orders of magnitude below the energy release rates of extreme wildfires (see Table 2). The effectiveness data for firefighting equipment, including aircraft along with other types, makes clear that suppression can only be effective at the lower levels of fire intensity. Fire fighters cannot stop or contain extreme wildfires until weather or fuel conditions change.[26]

Even with highly sophisticated technical firefighting capacity, countries are unable to contain their extreme wildfire events. In Portugal in 2017, the Emergency Response Coordinating Centre of DG ECHO, at the request of the government, coordinated the mobilization of support provided by France (two

26 Plana et al 2016; San-Miguel-Ayanz et al 2012

TABLE 2: FIRE INTENSITY LEVELS KW/M — LIMITS FOR METHODS OF SUCCESSFUL ATTACK

METHOD AUTHOR	GROUND CREWS	BULLDOZERS	HEAVY TANKERS	LARGE AIRCRAFT
Cheney (1994)	1000	2000	2000-3000/3500	2500
Alexander (2000)	<500	2000	2000	2000-4000
Loane & Gould 1985)				3000 airtankers 1000 small aircraft

Canadairs[27] and one Beech reconnaissance aircraft), Spain (two Air Tractors) and Italy (two Canadairs) to bolster Portuguese fire-fighting capacity. Spain made four additional Canadairs available through its bilateral agreement with Portugal, and Morocco provided one Canadair. The fires were only contained when weather conditions eased.

27 Canadair is a large firefighting plane with a capacity of ~6000 liters of water for dropping that can be mixed with retardants.

Given this reality, countries should broaden their focus from suppression alone to both suppression and prevention through fire-smart landscape approaches such as thinning of forests and undergrowth, creating fire breaks, land-use planning, and diversifying vegetation and forests across the landscape.

THE FUTURE OF WILDFIRES

Climate change is making extreme wildfires more frequent and damaging and expanding the locations where they occur.

The future of wildfire is longer fire seasons and larger fires due to increasingly difficult fire weather conditions, higher intensity fires, and increased fuel availability caused by a lack of effective land management. These trends will result in more GHG emissions. Estimates of future fire seasons based on modeling are likely conservative, meaning that changes in fire activity might be worse than anticipated.

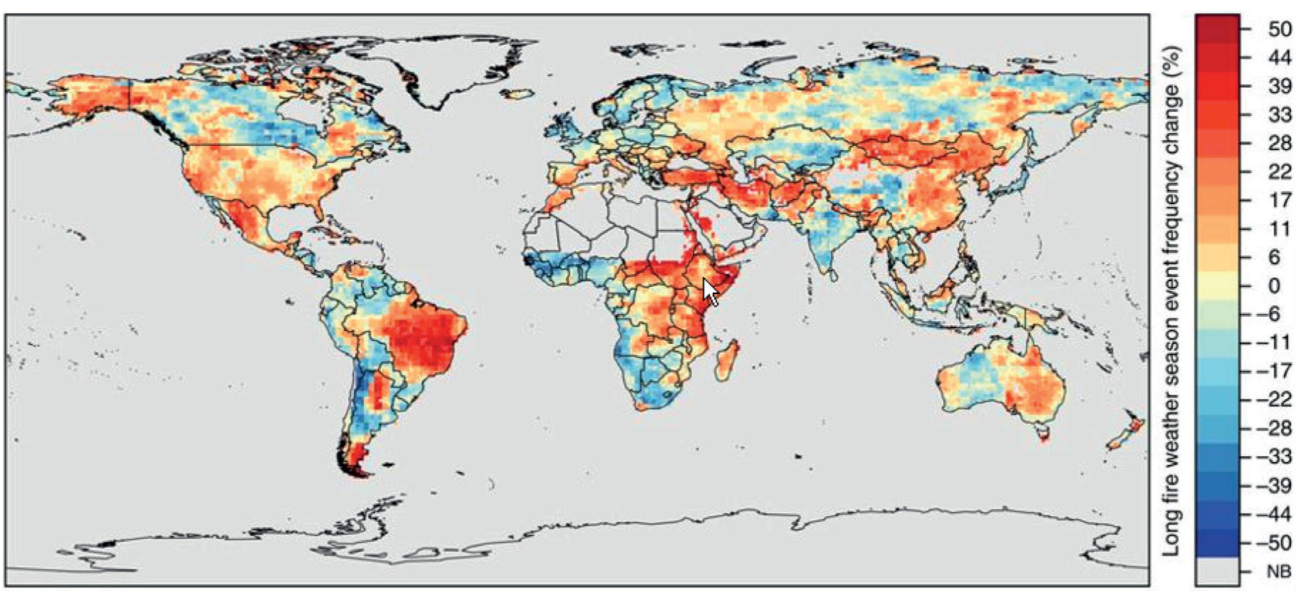
Despite complexities in global climate modeling, the scientific consensus is for drier ecosystems in some places in the future, resulting in more frequent and intense fire activity. IUFRO has noted that climate change will influence the trend of fires through:

1. Warmer temperatures increasing evapotranspiration (transfer of water from forests to the atmosphere);
2. Warmer temperatures that may lead to a lengthening of the fire season; and,
3. Warmer temperatures that result in more lightning, leading to increased wildfire ignitions.

The duration, starting, and finishing times of fire seasons and fire extent, intensity and impacts are all being influenced by climate change.[28] Trends to longer, hotter, and drier fire seasons have been confirmed by research (Figure 1). Ongoing changes in global fire activity in terms of location, intensity, severity, and frequency will likely have immense costs to biodiversity, ecosystem services, human well-being, livelihoods, national economies, and increase risks of reaching ecological tipping points (see Box 2). Modeling done for Europe estimated a potential increase of average annual burned areas under the "no adaptation"

28 Bowman et al, 2017; Sankey, 2018; San Miguel et al, 2017; IUFRO, 2018; Jolly et al 2015

FIGURE 1: GLOBAL CHANGES IN THE FREQUENCY OF LONG FIRE WEATHER SEASONS OVER 1979–2013 DUE TO CLIMATE



Reds indicate areas where fire weather seasons have lengthened or long fire weather seasons have become more frequent. Blues indicate areas where fire weather seasons have shortened or long fire weather seasons have become less frequent. Source: Jolly et al. 2015 in IUFRO 2019

BOX 2: RISK OF ECOLOGICAL TIPPING POINT IN THE SOUTHERN AMAZON

Recent simulations of future fire regimes, the pattern of fire in an ecosystem, under climate change indicate that the Southern Amazon is on the verge of a drastic tipping point from which the extent of areas burned in drought years may even double, threatening to convert the Amazon from a net carbon sink to a net carbon source. This happens consistently in a variety of scenarios modeled after 2030, with and without deforestation. In other words, a rise in temperature of approximately 1-degree oC relative to previous averages (2010-2015) could trigger a series of large forest fires during the most severe droughts in the region. In those years, areas burned in the Southern Amazon could extend to over 3.6 million hectares, an increase of about 110% relative to the extent of the 2007 fires.

In general, models forecast an increase in burned forest area from 17% to 41% after 2030 compared to 2002-2010.

The advance of deforestation at current rates implies that an additional 7-16% of land will be burned between 2011-50 relative to scenarios with climate change alone. Although forest fragmentation plays an important role in facilitating fire spread, the results show that drought is the key determinant of the fire regime. This points to a virtually catastrophic effect of droughts powered by global warming, even in a scenario of robust climate change mitigation and a sharp reduction in deforestation rates.[1]

1 Soares Filho et al., 2017; Brando et al., 2019

scenario to be within the range of 120-270% by the 2090s relative to the 2000s.

Given the anticipated growth in wildfires costs, damage and loss will start to be felt in countries not usually associated with major, severe wildfires. India, Lebanon and South Africa have experienced damaging fires in recent years, as have Sweden, the UK, and the Arctic region. All countries — especially developing ones where mortality and economic losses from disasters are higher proportionally to developed countries — face increasing exposure to hidden costs and challenges to meet financial and other obligations.

Policy actions that can be implemented to mitigate these types of negative impacts, depending on national circumstances, are outlined in the next section. Implementing such policies is critical to conserving forests and biodiversity, ensuring the availability of ecosystem services, keeping people out of poverty, and ultimately to achieving global targets like the World Bank twin goals, the Sustainable Development Goals, and the Paris Climate Agreement.

POLICY RECOMMENDATIONS

Extreme wildfires, such as the ones observed recently across the globe, reflect a complex interaction between global (climate change, globalization, trade) and local level processes and factors (e.g. land use change, development policies, and fire preparedness). To date, inadequate attention has been paid to address the underlying causes of damaging wildfires and to prevent a pattern of recurrent fire and degradation in burned areas.[29] Worldwide, wildfire management is often treated as an emergency event rather than part of routine landscape management. Governments often appear prepared to fund firefighting equipment and other resources to try to suppress fires, but not risk reduction, for example through prescribed burning or community education.

Climate change and the trends to longer, hotter, and drier fire seasons will make rapid and effective response arrangements ever more important. But these must be in balance with the elements of review and analysis, risk reduction, and emergency readiness and recovery. Resources need to be focused on long-term and sustainable solutions by integrating fire management into land management, land use planning, and the routines of operations.

Effective action towards reducing the risks and increasing the resistance and resilience of landscapes and people to extreme wildfires will require a concerted and multi-sectoral effort with actions at the global, national, and local levels. Traditional fire knowledge will be key for adapting to local changes in fire activity, using known techniques for the reduction of dangerous fuel loads, prescribed burning, and sustainable landscape management practices. Also important will be recognizing good management practices that can be expanded and become more widespread among countries.

Through its project portfolio,[30] the World Bank has supported, where needed and appropriate, the enhancement of capacity to respond to fire incidents, improvement of knowledge of forest fires, development of new fire-fighting zoning, assessment of unmanaged landscapes that pose fire risks, strengthened fire detection and monitoring measures, and improved fire suppression efforts through provision of equipment and training.

Building on this experience and the considerations outlined above, the following are policy recommendations for improving wildfire prevention and management:

1. REFOCUS POLICIES AND INCENTIVES TO PROMOTE FIRE-SMART LANDSCAPE APPROACHES

Transitioning to more fire-smart land management requires a well-designed and balanced combination of policies, clear legal settings, and appropriate incentives that remove distortions and encourage appropriate land allocation, land management and fire use. Decision-makers need to get the right mix of fire-smart landscape policies and incentives by: eliminating perverse economic incentives that drive land-use change through use of fire, addressing land tenure security to enable improved practices and long-term investments, and promoting positive incentives in support of fire-smart land management. Additional measures include ensuring fire considerations are incorporated into land use planning, strengthening cross-sectoral coordination to increase transparency and reduce conflicting approaches, and setting up preparedness and disaster risk management plans that include investing to enhance the adaptive capacity of vulnerable communities.

29 Hoffmann et al 2003, Hardesty et al 2005

30 Some highlights from the World Bank portfolio of project with a significant component addressing wildfires, include: Indonesia Integrated Landscapes; India Forest Fire Prevention and Management; Russia Forest Fire Response Project; Brazil Amazon Emergency Fire Prevention & Control Project; Brazil Forest Fires Prevention and Management in the Brazilian Cerrado; Brazil Development of Systems To Prevent Forest Fires And Monitor Vegetation Cover In The Brazilian Cerrado; Kazakhstan Forest Protection & Reforestation; Belarus Forestry Development Project.

POSSIBLE ACTIONS

LOCAL	NATIONAL	GLOBAL
• Rapidly scale up good management practices and technologies (e.g. to address the need to manage fuel loads); demonstrating the economic feasibility of these practices in different locales and identifying what is needed to maintain and expand them. • Invest in planning and systems to maintain a range of landscapes and environments that provide a diversity of habitats, species, resources and opportunities for recreation, commerce, community enjoyment, and cultural and religious practices. • Take stock of existing fire management guidance, tools, processes, and practices (including traditional practices involving the use of fire).	• Strategic planning and policy development for landscape approaches that build synergies and manage trade-offs among different land uses that can represent a source of fire ignition and/or spread. • Develop and implement clear policy and legislation to address land use change driven by perverse economic incentives and poor tenure, and design and implement effective incentives, monitoring and compliance enforcement. • Recognize the need for natural fires in the landscape so ecosystems are maintained and manage the use of fires as a nature-based solution against damaging wildfires. • Stimulate economic development to improve livelihoods in ways that reduce vulnerability to fires and identify practices that improve the landscape's fire resilience and invest in them. • Influence the planning and implementation of fire-prone activities in agriculture, forestry and other industries in order to minimize the risk of damage from unplanned fires to lives, property and resources. • Set policy and mobilize investment for post-fire restoration actions to reduce fire incidence, which may include forest restoration, ensuring peatlands are not drained or changed to become fire prone, and managing invasive species that contribute to fuel loading and continuity.	• Facilitate opportunities for participating in international organizations, networks, fora and activities to enhance domestic and international capacity, including initiatives to support global climate and biodiversity action.

2. INVESTMENT IN BOTH FIRE PREVENTION AND SUPPRESSION

Balanced investment is needed across the fire management cycle which includes prevention and detection, suppression, and post-fire management to ensure that each link in the chain is effective and optimized. Targeted investments in prevention and early detection measures can result in significant cost-savings and avoidance of loss and damage. Fire prevention and detection activities represent a sound return on investment against increasing fire risk and save more than what is usually estimated by current methodologies.

POSSIBLE ACTIONS

LOCAL	NATIONAL	GLOBAL
• Ignition Reduction Strategies: Regulate fire use, educate fire users, technology improvements, development planning controls. • Impact Mitigation Strategies: Fuel reduction (e.g. by burning, grazing and other means); Reduce asset vulnerability (e.g. construction standards); Establish/maintain containment features (e.g. fuel breaks). • Fire Use Strategies: Ecosystem maintenance and fire regime (the natural pattern of fire in an ecosystem) restoration and integration of the traditional use of fire.	• Address underlying risk factors cost-effectively through funding in risk reduction and striking a balance of firefighting readiness and response versus relying primarily on post-disaster response and recovery. • Recognize the value of environmental services and allocate responsibility for their management and maintenance (along with legal, human and funding resources to do so). • Influence the planning, construction and location of new buildings and adjacent vegetation to minimize the risk of damage from fires and discourage inappropriate development in fire-prone ecosystems. • Systematize and operationalize fire danger rating and early warning systems, including the improved integration of weather data in fire forecasting and the development of triggers for actions based on fire danger rating and allocated to appropriate agencies.	• Further develop methodologies for cost-benefit analysis of avoided damage and loss through fire prevention investments.

3. IMPLEMENT EXISTING FIRE MANAGEMENT TECHNOLOGIES AT THE LANDSCAPE LEVEL

Early action for fire-smart landscape management involves scaling up good practices such as strengthening detection and fire danger systems, fuel load management, reducing asset vulnerability, and working with communities to restore ecosystems and their natural fire patterns and implement integrated fire management. There is a critical need to make sure existing technologies are available to and used by forest and land managers and communities. Proven guidance, practices and tools already exist in many places and can allow solid progress in an efficient and economical way (see Annex 1 for a compilation of existing tools and best practices). By combining different fire management tools in a landscape, it is possible to shift from managing disasters to managing risks in a cost-effective manner.

POSSIBLE ACTIONS

LOCAL	NATIONAL	GLOBAL
• Adapt and adopt fire-smart practices such as better weather forecasting, early warning systems and risk insurance. • Create incentives for those dependent on and responsible for managing fire on landscapes such as forest agencies, protected area management, communities, smallholders, and indigenous peoples. • In countries with highly populated rural areas, timing of burning for agriculture and pastures needs to be managed in order to avoid escaped fires in the landscape.	• Integrate existing tools (see Annex 1) in National Fire Management Programs. • Invest in capacity building and technological improvements to apply and scale up existing tools. • Invest in filling knowledge gaps and in research.	• Engage organizations and institutions in quality scientific research for the creation of new knowledge and to support improvement of policies, regulations, guidelines, and practices.

4. IMPROVE WILDFIRE DATA COLLECTION, ANALYSIS AND REVIEW

Direct resources to support fire data collection and analysis to improve the understanding of fire causes and gaps in prevention and response capacities. Review management practices to identify and discourage practices that encourage harmful fires and promote management systems that take advantage of well-established fire use.

POSSIBLE ACTIONS

LOCAL	NATIONAL	GLOBAL
• Improve monitoring of loss and damage (direct and indirect) due to fires and evaluate the costs and impacts for the local community; business stability and continuity; the provision of ecosystem services (such as drinking water); and costs linked to health, among others. • Gather and maintain the traditional knowledge of indigenous peoples and integrate their practices into a modern fire management program.	• Identify the key causes and drivers of wildfires and establish alternatives to any perverse incentives that may exist. • Evaluate the economics of land use change and develop alternatives.	• Methodology development for damage and loss assessment. • Make available remote sensing and other data sets in usable forms and products. • Improve GHG accounting methodologies for fire emissions estimation. • Ensure that Integrated Fire Management is considered in NDCs under the UNFCCC, the Bonn Challenge, Sustainable Development Goals, and the Sendai Framework for Disaster Risk Reduction.

5. STRENGTHEN STAKEHOLDER COORDINATION AND PREPAREDNESS

Clearly define the functions, tasks, and responsibilities of all institutions involved in fire management at the national and subnational levels and establish procedures to enable effective coordination, especially during emergency responses. Engage routinely with all levels of agencies and stakeholders required for fire management so that requirements risks are understood and acted upon. Involve key stakeholders, especially local communities, in fire management planning.

POSSIBLE ACTIONS

LOCAL	NATIONAL	GLOBAL
• Create participatory approaches to leadership and management — which successful fire management requires — that are appropriately shared by public and private landholders, the fire services, and communities of interest. • Recognize and use the knowledge, leadership and expertise of local citizens and community groups by involving community members at the local, subnational, national, regional, and international level to ensure that processes are open and accessible to people of different backgrounds and cultures (especially indigenous communities).	• Ensure that all fire management activities are based on a legal framework and supported by clear policy and procedures, definitions of functions, tasks and responsibilities for the agencies required in fire management including land management, civil protection, health and transport among others. • Invest in identification and rectification of weak governance, unclear mandates and poor institutional coordination. • Create processes for routine engagement at all levels of the agencies and stakeholders so that the requirements, risks and understanding is developed, shared, understood and acted upon, Investment in routine processes is critical. • Develop a two-way flow of information so that local knowledge of the environment and the historical uses of fire can be considered and used by managers and researchers.	• Facilitate opportunities for participating in international organizations, networks, fora and activities to enhance domestic and international capacity.

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ANNEX 1. FIRE MANAGEMENT TOOLS AND APPROACHES

INTEGRATED FIRE MANAGEMENT

Integrated Fire Management (IFM) is the term for the integration of science and fire management approaches with socio-economic elements for the planning and implementation of a balanced approach to managing fires. IFM includes "all activities associated with the management of fire prone land, including the use of fire to meet land management goals and objectives." What is needed is focusing resources on long-term and sustainable solutions by integrating fire management into land management and the routines of planning and operations, termed "fire smart" (Faivre et al 2018).

Integrated approaches to fire management place greater emphasis on addressing underlying causes and seek long-term, sustainable solutions that incorporate five essential elements (the 5Rs) that are the same as the globally adopted characterization used in dealing with disasters and their management:

1. **REVIEW**—Analysis of the fire issue and identification of options for positive change;
2. **RISK REDUCTION**—Prevention —focusing resources on the underlying causes of fires;
3. **READINESS** —Preparing to fight fires;
4. **RESPONSE** —Ensuring appropriate responses to unwanted damaging fires; and
5. **RECOVERY** —Community welfare, Repairing infrastructure and Restoration of fire-damaged landscapes.

PRESCRIBED BURNING AND CONTROLLED FIRE USE

Activities to address fires generally include fuel breaks and fuel management often using prescribed burning. These are focused on reducing fuel load, fuel arrangement and fuel continuity. The use of prescribed burning has the potential to reduce the area burned and resulting impacts through reducing fire intensity. Studies in the US and Australia on the effectiveness of prescribed burning for fire hazard reduction suggest a decrease in the average size of fires in treated versus untreated areas. Prescribed fire is also required to

FIRE DANGER RATING

Fire danger rating is the cornerstone of fire management and provides a metric that is used to support many daily operational decisions (suppression resource needs, alert levels, mobilization and positioning), and longer-term strategic planning (defining burn prescriptions, justifying financial requirements, assessing future fire risk, etc.). Fire danger rating is a mature science with almost a century of research, development and applications. As such, it forms the basis of many global and regional fire models. Due to the extensive history and experience in using fire danger rating systems, many new national systems have been successfully developed through technology transfer and local adaptation for countries without the necessary financial or institutional capacity. Global and regional early warning systems have also been developed by combining fire danger rating information with various remotely sensed landscapes, active fire and medium range forecast weather data. These early warning systems provide key information to support international suppression resource-sharing agreements, which is an important fire management strategy recognized by the global fire community for combatting the increasing severity of fire seasons under climate change.

The application of the information and products from fire danger rating systems should routinely trigger decisions for action in relation to Risk Reduction (hazard reduction operations for example), Readiness (mobilizing staff for duty, ensuring fire detection is operational and so on) and Response (competent fire control staff, first response capability and command and control).

restore fire into adapted ecosystems to correct long periods of fire suppression that result in fire exclusion. Restoring the historical fire regime (the natural pattern of fires in an ecosystem) may be the way to avoid high severity wildfire in the future through prescribed burning or allowing wildfires to burn safely.

Unfortunately, in most countries suppressing fires and prohibition of fire use has dominated thinking and efforts. In many cases, societies do not appreciate the role of fire and are becoming increasingly intolerant of it. Part of the concern is of emissions that impact on health but there is also the complication of prescribed fire smoke contributing to GHG emissions.

Using fire in the landscape is not a guarantee of fireproofing it, and a singular approach using prescribed burning alone will not work. In developing countries with highly populated rural areas, timing of burning for agriculture and pasture management is the issue, in order to avoid escaped fires into the natural vegetation. The solution lies in awareness, better weather information to time burning, and community fire management to organize effective suppression when fires get out of control.

FIRE MANAGEMENT VOLUNTARY GUIDELINES, PRINCIPLES AND STRATEGIC ACTIONS

These Voluntary Guidelines set out and encourage the use of a framework of non-legally binding principles and internationally accepted strategic actions. They address the cultural, social, environmental and economic dimensions of fire management at all levels and are intended to support countries to review or develop:

1. Principles for responsible fire management activities, taking into account all relevant biological, technological, economic, social, cultural and environmental aspects;
2. The establishment and implementation of national and subnational fire management policies and planning mechanisms;
3. The formulation and implementation of international instruments;
4. Mutual assistance and technical, financial or other forms of cooperation in fire management;
5. The contribution of effective community-based fire management in providing food security and meeting people's livelihood needs; and advocating sustainable land and resource management programs and management of fire, where permitted, and the suppression of unwanted, damaging fire.
6. Special consideration is given to social and community values and to engaging the community in fire management planning and implementation.

FAO. 2006. Fire management: voluntary guidelines. Principles and strategic actions. Fire Management Working Paper 17. Available at www.fao.org/forestry/site/35853/en.

FOREST FIRES AND THE LAW: A GUIDE FOR NATIONAL DRAFTERS BASED ON THE FIRE MANAGEMENT VOLUNTARY GUIDELINES

Based on the Fire Management Voluntary Guidelines, this guide seeks to systematically identify the elements of solid legislation on forest fires, capitalizing on the experience gained by FAO in advising on the improvement of forest fire legislation in member countries. Emerging trends (such as common approaches and tools, as well as common gaps), best practices and innovative legal solutions were identified in national and subnational legislation on forest fires in a representative group of countries from different regions, having different ecosystems and different legal traditions. This comparative analysis leads to the formulation of systematic recommendations for the analysis, review and drafting of forest fire legislation to support a holistic approach to fire management.

FAO. 2009. Forest fires and the law: A guide for national drafters based on the Fire Management Voluntary Guidelines. FAO Legislative Study 99. Available at:

http://www.fao.org/3/i0488e/i0488e00.htm

COMMUNITY-BASED FIRE MANAGEMENT

For more than 60 years, FAO has made dedicated efforts to strengthen the capacities of member countries in forest fire management. Most fire management projects of FAO focus on the participatory approach known as community-based fire management. Globally, people cause most fires and involving the population in all aspects of relevant policy development and fire management practices is, therefore, a logical approach. Like integrated fire management, community-based fire management (CBFiM) also promotes activities that extend beyond suppression and provision of equipment to emphasize prevention and preparedness in a landscape perspective. The document redefines the concept, reviews some implementation and training case studies, reflects on related policy and legal frameworks for CBFiM.

FAO. 2011. Community-Based Fire Management: A Review. FAO Forestry Paper 166. Available at: http://www.fao.org/3/i2495e/i2495e00.htm

CARBON ASSESSMENT TOOL FOR FOREST FIRE MANAGEMENT (FIRECAT)

A variety of tools have been developed to estimate the GHG emissions of the World Bank's forestry projects. These include the Carbon Assessment Tool for Forest Fire Management (FireCAT). The tool is easy-to-use and allows calculation of ex-ante GHG emissions related to forestry projects. The tool helps to characterize baseline emissions from wildfires and managed fires and serves as a decision tool that compares the most suitable combination of baselines and project activities for achieving the highest overall climate benefit. The tool can also help in ex-ante financial analysis.

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