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GLOBAL LANDSCAPE FIRE CHALLENGES: A DECADE OF PROGRESS



United States Department of Agriculture
Forest Service

In this Issue ...

Note: This issue of *Fire Management Today* contains articles about issues pertaining to wildland fire management around the world. The information presented here reflects the authors' own research and does not necessarily suggest endorsement by the U.S. Department of Agriculture (USDA). Likewise, the fire management practices portrayed are in accordance with the policies of the countries in question and do not necessarily reflect the policies of USDA.



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Victoria Christiansen, Chief
Forest Service

Kaari Carpenter, General Manager

Shawna A. Legarza, Psy.D., Director
Fire and Aviation Management

Hutch Brown, Editor

Jameson Karns and Lindon Pronto, Guest Editors

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On the Cover:



Top left: Using prescribed fires for wildfire hazard reduction in pine plantations in Ukraine. Top right: Early-season prescribed fire in the Cerrado, Brazil. Center: Metal container of unexploded ordnance in eastern Europe, a hazard to firefighters. Bottom: Participants from nine countries at the Second Regional Symposium and Consultation on Regional Cooperation in Cross-Boundary Fire Management in South America, hosted by Chile in Viña del Mar on October 3–4, 2017.

The USDA Forest Service's Fire and Aviation Management Staff has adopted a logo reflecting three central principles of wildland fire management:

- **Innovation:** We will respect and value thinking minds, voices, and thoughts of those that challenge the status quo while focusing on the greater good.
- **Execution:** We will do what we say we will do. Achieving program objectives, improving diversity, and accomplishing targets are essential to our credibility.
- **Discipline:** What we do, we will do well. Fiscal, managerial, and operational discipline are at the core of our ability to fulfill our mission.



Firefighter and public safety is our first priority.

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A GLOBAL COMMITMENT TO WILDLAND FIRE MANAGEMENT

As you know, our primary job—and the expectation of the American people—is that we do our best to safely manage and protect natural resources in the United States. But the Forest Service found out long ago, through the Great Fires of 1910, that we could never succeed alone. The Weeks Act of 1911 gave us the cooperative framework we have today for wildland fire management through partnerships with other Federal, State, Tribal, and private entities.

Over the decades, we have extended that same spirit of cooperative wildland fire management to include our international partners. The Forest Service, together with the U.S. Department of the Interior, has longstanding bilateral agreements with Australia, Canada, Mexico, and New Zealand to give mutual firefighting expertise and support in time of need. These international partners have graciously responded with overhead and crews when we have requested assistance. When they have requested assistance from us, we have responded to their call.

However, fire suppression assistance is only part of how we work with international partners. The Forest Service has offered international fire support for decades. In partnership with Forest Service International Programs or through memoranda of understanding, fire managers at all levels have traveled around the world to educate and mentor international fire managers. We have shared our toolbox with others to help them accomplish prefire mitigation work, better manage wildland fires, and respond to all-hazard emergencies.

We have benefited from these trips as well. On each trip, we see a different perspective and learn to appreciate other, sometimes better ways of doing things. We bring that knowledge home and

... no matter where we are from, the issues and challenges we face in managing wildland fire are not ours alone.

share it with our fellow fire managers. We have also discovered that our own fire management issues and challenges are not ours alone but cross oceans and continental boundaries. The international fire program affords the Forest Service with a unique opportunity to compare our own firefighting problems with similar issues that other countries face.

So does this issue of *Fire Management Today*. In it, you will find articles about a broad range of fire-related challenges from around the world, in various regions on four different continents—Africa, Asia, Europe, and South America. No matter what continent you are from, some of the challenges you can read about will strike a chord, allowing you to see your own fire-related issues from a fresh perspective and perhaps learn something new.

In short, no matter where we are from, the issues and challenges we face in managing wildland fire are not ours alone. Through our international fire programs—and through various international articles in *Fire Management Today* over the years (see, for example, volumes 68(3) and 68(4) at <https://www.fs.fed.us/managing-land/fire/fire-management-today/archives/>), the Forest Service has had the opportunity to take a look at how our international counterparts deal with the same types of issues we face here at home.

We also have the invaluable opportunity to see how different the cultural, socioeconomic, and environmental issues, policies, and management solutions are in other countries. One of our core qualities as an agency—*how we work*—is through curiosity, and by sharing these differences collectively, we just might come up with new ways of looking at our own issues, policies, and management solutions. Precisely this has always enabled us to become smarter in our work and to do it more safely.

Beginning with Gifford Pinchot's legendary trips to Europe and the South Pacific, the Forest Service has always been curious about forests worldwide, the global challenges of sustainable forest management, and how other countries cope. We have long been eager to learn from and support the global fire community, for example when former Forest Service Chief Dale Bosworth endorsed the goals and work of the Global Wildland Fire Network at the Hemispheric Conference on Forest Fires in San Jose, Costa Rica, on October 23, 2004.

Although language, customs, and culture can separate us, wildfires are the same, no matter whether we call them forest fires, bush fires, or fires in the wildlands. A strong wildland fire program is important, but alone it will never be enough. We are grateful for the international fire assistance and support we received in the past, and we are deeply indebted to the countries who stand ready, willing, and able to offer it again when we ask. We pledge to continue working with our international counterparts, not only in the role of reciprocal assistance but also with the goal of better managing our own wildlands while promoting well-accepted international fire management principles. Together, we can help each other succeed, whether we are giving or receiving. ■

SALUTATIONS FROM THE GLOBAL FIRE MONITORING CENTER!

Jameson Karns and Lindon N. Pronto

We can hardly believe it has been 10 years since our last collaborative effort with *Fire Management Today* (see “International Fire Management,” parts 1 and 2, volumes 68(3) and 68(4), at <https://www.fs.fed.us/managing-land/fire/fire-management-today?page=3>). This special issue of *Fire Management Today* is a continuation of this tradition set forth a decade ago. It is a snapshot of the Global Fire Monitoring Center (GFMC) and its many efforts and accomplishments on behalf of the Global Wildland Fire Network (GWFN), as well as future challenges.

For more than 15 years, the GFMC, which is based in Freiburg, Germany, has served as the GWFN Secretariat and has supported the development of national policies, capacity building, and cross-boundary cooperation in fire management around the globe. As fire management continues to advance internationally, the GFMC and regional wildland fire networks have begun to decentralize efforts by establishing regional centers of excellence in fire management. By

Jameson Karns is a graduate student in the Department of History at the University of California in Berkeley, Berkeley, CA, and an associate partner at the Global Fire Monitoring Center; and Lindon Pronto is an officer of the Global Fire Monitoring Center, Max Planck Institute for Chemistry, Freiburg, Germany.

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This issue provides the North American fire management community with a sample of some of the Global Fire Monitoring Center’s efforts.

the close of 2018, 2 decades after the establishment of the GFMC, six regional fire monitoring centers and regional fire management resource centers will be operational and autonomous within their respective regions.

This specially curated issue of *Fire Management Today* provides the North American fire management community with a brief yet informed sample of some of the GFMC’s efforts. The first article orients readers to the background and mission of the GFMC. This is followed by contributions from seven regions:

- The contribution from Southeast Asia highlights various challenges, notably the need for reducing the collateral damages of excessive fire application in land use and land use change—the damaging effects on ecosystems, regional and the global climate, and human health and security.
- The report from West Africa shows that effective fire management relies on participatory approaches and for local communities to take initiative in balancing traditional practices with frequent fire occurring in a drying climate.
- Similarly, the rapporteurs from the Hindu Kush–Himalayan region of South Asia point out that future success in sustainable fire management will depend on more empowerment for local communities.
- Conversely, the dwindling presence of local rural communities in the Eastern Mediterranean, Southeast Europe, and Middle East regions are contributing to increasing wildfire problems. The buildup of fuel loads, a consequence of the rural exodus and associated land abandonment, is creating unprecedented wildfire threats.
- South America is faced with facet-rich developments that are influencing fire regimes, including the consequences of climate change. The regional follow-up to the wildfire emergency in Chile in 2017 highlights the willingness of South American countries to collectively improve governance, interoperability, and effectiveness of transboundary cooperation in fire management. The contribution from Brazil also highlights the progress of approaches in applying principles of integrated fire management.
- Countries of Eastern Europe are dealing with various challenges, such as the management of

fires burning on radioactively contaminated terrain with the potential for cross-border transport of hazardous smoke; and, on the other hand, intensive crop burning on agricultural lands is resulting in severe episodes of air pollution.

- In Central-Eastern Eurasia, wildfires burning in vast and remote territories require management decisions regarding fire precursors and consequences, supported through satellite monitoring from space.

We hope to highlight solidarity in the international fire community.

The fire season of 2017 in the United States and Canada was, in some respects, unprecedented in recent history. As guest editors for this issue of *Fire Management Today*, the first in 2019, we hope to highlight solidarity in the international fire community—to

show that the global community stands together in facing the challenges of rapidly changing fire regimes and increased vulnerability of ecosystems and society to fire. We hope this issue proves interesting, informative, and inspirational for our readers. ■

CONTRIBUTORS WANTED!

We need your fire-related articles and photographs for *Fire Management Today*!

Subjects of published material include:

- Aviation
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- Ecological Restoration
- Education
- Equipment and Technology
- Fire Behavior
- Fire Ecology
- Fire Effects
- Fire History
- Fire Use (*including Prescribed Fire*)
- Fuels Management
- Firefighting Experiences
- Incident Management
- Information Management (*including Systems*)
- Personnel
- Planning (*including Budgeting*)
- Preparedness
- Prevention
- Safety
- Suppression
- Training
- Weather
- Wildland–Urban Interface

Contact the editor via email at firemanagementtoday@fs.fed.us.

AN INTERNATIONAL EFFORT: THE HISTORY OF THE GLOBAL FIRE MONITORING CENTER

Jameson Karns

My first visit to the Global Fire Monitoring Center (GFMC) was disorienting. As I walked through the entryway, I was hit with the familiar aroma of burnt vegetation. Nearby, well-used wildland turnouts hung above boxes of fuses. Radios capable of receiving fire dispatches anywhere in the world adorned the desk closest to me. As a former firefighter, I consider these objects to be familiar tools of the trade.

Upon further exploring the building, I stumbled through mountains of fire ecology research reports pertaining to nearly every corner of the globe. Studies with endorsements from the United Nations, the Council of Europe, and the Organization for Security and Cooperation in Europe were the norm. Like me, the staff was made up of former members of the fire management community who felt as comfortable with a driptorch as they did penning policies and research documents. It became clear that the GFMC is neither a fire station nor a fire ecology laboratory but rather an informed medium between the two.

Jameson Karns is a graduate student in the Department of History at the University of California in Berkeley, Berkeley, CA, and an associate partner at the Global Fire Monitoring Center, Max Planck Institute for Chemistry, Freiburg, Germany.

The Global Fire Monitoring Center is the only institution that monitors, assesses, and assists in the management of fires on a global scale.



Figure 1—The Fireglobe, emblem of the Global Fire Monitoring Center. Five leaves are set against the backdrop of a global flame. The five leaves represent the continents with wildland fire as a natural phenomenon.

Global Reach

We are all familiar with fire management agencies at the municipal, State, and Federal levels. Yet is there an organization that assesses wildfire at an international level? When I speak with my colleagues in the American fire management community, they are often unaware and stunned that such an agency exists.

The GFMC is the only institution that monitors, assesses, and assists in the management of fires affecting natural, cultural, and urban–industrial landscapes on a global scale. The nongovernmental organization belongs to the Max Planck Society for the Advancement of Science. It is headquartered in Freiburg, within the famed Black

Forest, a forested mountain range in southwestern Germany.

The Freiburg office is the heart of a global array of networks and institutions addressing the interface between vegetation fire science and the community of policymakers and practitioners, often referred to as the science-policy-practitioners interface. The GFMC operates through 14 regional wildland fire networks covering all continents; collectively, they make up the Global Wildland Fire Network.

Each regional network has common climatic, ecological, and cultural features. This allows for the sharing of local expertise to jointly address regional fire abatement and ecology concerns. The regional networks have various origins and histories. They include Subsaharan Africa, South Asia, South East Asia, Australasia, Northeast Asia, Central Asia, South America, North America, Mesoamerica, the Caribbean, Eurasia, the Mediterranean, Southeast Europe/Caucasus, and the rather small Euro-Alpine subregion.

The Global Wildland Fire Network is united under a common mandate—to provide policy advice and facilitate science and technology

transfer, thereby enabling nations to reduce “the negative impacts of vegetation fires (wildland fires) on the environment and humanity” and to advance “the knowledge and application of the ecologically and environmentally benign role of natural fire in fire-dependent ecosystems, and sustainable application of fire in land-use systems” (Goldammer 2013).

History

Despite its broad ambitions, the GFMC comes from a humble beginning. Its heritage, much like its operations, is a product of addressing international issues by seeking global solutions in fire management.

The founder of GFMC is Dr. Johann Georg Goldammer, a former naval officer and Hessian forester with a profound interest in fire ecology (Pyne 2015). Goldammer was one of a handful of foreign participants in the Tall Timbers Fire Ecology community during the 1970s and 1980s (Goldammer 2000). Through Tall Timbers, he participated in a number of prescribed burns throughout the American South. His American colleagues’ willingness and ability to apply fire ecology scholarship to land management had a profound impact on him and on building transatlantic cooperation in fire management.

With a renewed interest in fire ecology, Goldammer returned to his homeland of Germany. Creating a German vanguard for fire ecology, his master’s thesis introduced the word for fire ecology, *Feuerökologie*, to the German lexicon (Goldammer 1975). Goldammer’s hope was to conduct similar field experiments to those he witnessed in America.

In 1976, however, the German Federal legislature passed a revised

The Global Fire Monitoring Center helps countries develop national fire management policies and build their capacity for landscape-scale fire management.

Federal Conservation Law. The law forbade the use of fire, including prescribed burns, throughout Germany, with a few exceptions. It was followed by regulations forbidding the burning of vegetation. Deterred but still determined, Goldammer began researching fire ecology on the global arena. He formed the Fire Ecology Research Group at the Max Planck Institute of Chemistry (*Arbeitsgruppe Feuerökologie, Max-Planck-Institut für Chemie*).

In the 1990s, however, while working on extended fire and smoke pollution episodes in Southeast Asia, the research group hit a roadblock. The group recognized that the scientific community had accumulated a surplus of fire ecology research but that applied policy was lacking. The group reoriented their efforts to become the conduit between fire ecology research and policy implementation. (Goldammer 1990).

Within the group, Goldammer became the leading advocate for developing and carrying out policies related to fire ecology. His goal to establish such an organization was supported by the Max Planck Institut of Chemistry, and in 1998 the Global Fire Monitoring Center was established.

Under Goldammer’s leadership and with a new direction, the GFMC selected the “Fireglobe” as its emblem (fig. 1). The Fireglobe is a globe with a five-leafed branch in the foreground, contrasted against a flame. Each leaf represents a continent with

vegetation that burns as a naturally occurring phenomenon.

As the GFMC began to grow, it acquired more and more professional affiliations. In 1998, the United Nations (UN) Educational, Scientific, and Cultural Organization formally endorsed the overall goal of the work of the GFMC, leading to numerous memoranda of understanding, letters of intent, and formal agreements with specialized UN agencies, such as the UN Environment Programme/Office for Humanitarian Affairs Joint Unit, the World Health Organization, and the Food and Agriculture Organization (FAO). In 2001, the GFMC became a member of the Interagency Task Force for Disaster Reduction of the UN International Strategy on Disaster Reduction (UNISDR) and established the Working Group of Wildland Fires. This group builds coordinated international approaches to wildfire disaster risk reduction. The UNISDR continues to support the operations of the GFMC and the Global Wildland Fire Network and its Wildland Fire Advisory Group, an advisory body to the UN. In 2005, the GFMC became affiliated with the UN University, the think tank of the UN (fig. 2).

After leading the UN Economic Commission for Europe/FAO Team of Specialists on Forest Fire, the GFMC is now serving the Council of Europe’s Major Hazards Agreement and the Organization for Security and Cooperation in Europe. The GFMC is helping countries develop national fire management



Figure 2—Signing ceremony of the cooperative agreement between UN University (UNU) and the Max Planck Institute for Chemistry/Global Fire Monitoring Center. From left: Meinrat O. Andreae (Director, Biogeochemistry Department, Max Planck Institute for Chemistry) and Hans J.A. Van Ginkel (Rector, UNU) (sitting); Johann G. Goldammer (Director, GFMC) and Janos Bogardi (Director, UNU EHS). Photo: Global Fire Monitoring Center.

From 2010 to 2017, the Global Fire Monitoring Center established six regional centers serving the science-policy-practitioners interface.

policies and build their capacity for landscape-scale fire management.

In 2009, the GFMC began to restructure itself. The goal was to develop a decentralized horizontal institutional structure. The intent was to build on the growing scientific and technical potential around the world, capitalizing on regional knowledge of fire ecology and cultural fire history and on localized and innovative fire management techniques. The strategy was to pursue a multivariied approach to fire ecology, with no single technique or approach dominating, as had often happened in development aid projects. From 2010 to 2017, the GFMC established six regional centers serving the

science-policy-practitioners interface, including centers for:

- Southeast Europe and the Caucasus (in the former Yugoslav Republic of Macedonia, 2010),
- Eastern Europe (in Ukraine, 2013),
- Central Eurasia (in the Russian Federation, 2017),
- Central Asia (in Mongolia, 2015),
- Southeast Asia (in Indonesia, 2017), and
- South America (in Brazil and Chile, 2017, to become operational in 2018).

All centers are operating autonomously yet collaboratively in ongoing research, education, and field operations.

In the diaries and archives of the GFMC (Global Fire Monitoring Center, n.d.), I have noticed many institutional highlights, such as meetings with former UN Secretary Generals Kofi Anan and Ban Ki-moon; speeches at International Association of Wildland Fire conferences; and the records of Dr. Johann Goldammer, including his correspondence with ministers and heads of states and his first testimony before a commission of the German Federal legislature, held in 1990. To me, these milestones confirm that the initiatives and functions of the GFMC are all based on vast pragmatic and political experience woven into international fire management (Goldammer 2013).

Operations

Attempting to address wildfire across the world is an enormous feat. The GFMC has three primary functions: data aggregation, research, and field operations.

The GFMC collects all data related to wildfires. Each day, fire ecology experts comb through thousands of articles pertaining to wildfires in a multitude of languages. Their task is continual and relentless because the global fire season is 365 days a year. The GFMC researchers mine the articles for data pertaining to burnt acreage, injuries, fatalities, secondary damage, and much more. This aggregated data is collected by an international array of fire ecology experts and made readily available to the public through daily updates.

The GFMC is also a major institution for research in fire ecology and fire management. The center's archive has collections dating back to the early 19th century (fig. 3), and the GFMC frequently hosts academics from around the world, inviting them to explore its collections. Alumni

of the GFMC include the historian Stephen J. Pyne, the current leaders of the fire management resource centers, and myself. The GFMC's research culminates in regular regional conferences and is featured in the quadrennial International Association of Wildland Fire conferences.

The third GFMC function is to aid in field operations and experiments involving fire management. The center maintains equipment caches and assists governments and organizations in the management of active fire as

well as in custodial techniques such as prescribed burning.

The GFMC also plays a role in aiding nations in fire management, best exemplified following the 2017 fire season in Chile. On January 27–28, the worst wildfire in Chile's modern history killed 11 people, including 5 firefighters; displaced thousands of people; and completely destroyed the city of Santa Olga. Fire suppression was truly an international endeavor, with over 20 countries participating. Following the crisis, the GFMC organized a Regional Consultation

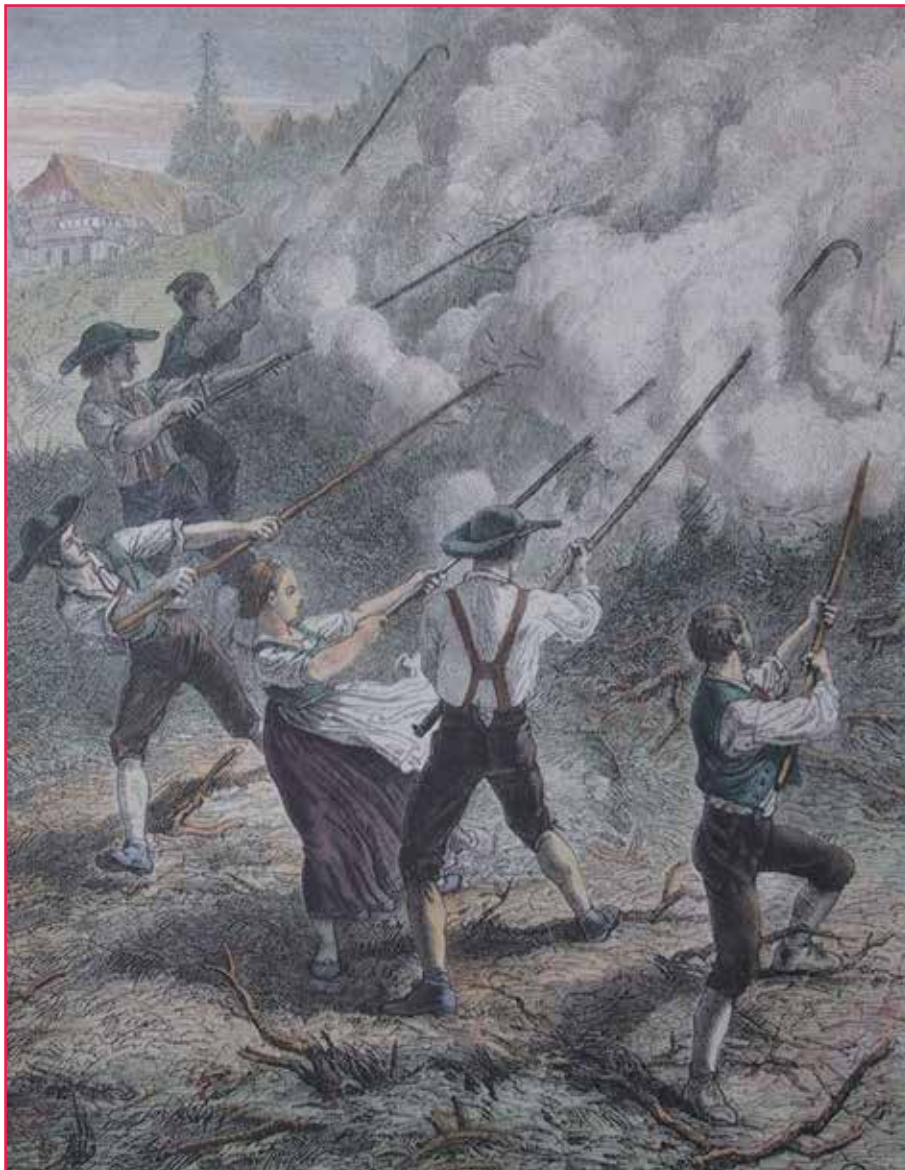
on Transboundary Cooperation in Fire Management in South America, with the attendance of nine countries. Its goal was to review the horrific event and to provide avenues for preventing such conflagrations in the future. The Chilean hosts presented the GFMC with a symbol of appreciation—a shovel belonging to one of the fallen firefighters.

Global Voice

Founded in 1998, the GFMC has become a leading voice for international fire management. No other institution works within the same global framework of fire monitoring and management or has a similar global capacity. The GFMC's ability to combine nationwide fire management policies, coupled with its skill and capacity to support bottom-up approaches in fire science and fire management, has allowed the center to grow and to facilitate real progress in global fire management.

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A sample from the GFMC historical archives. In the 1800s, farmers in southern Germany used idiosyncratic techniques to roll burning materials down slopes.

SOUTHEAST ASIA—FIRE AND POLITICS IN LAND USE CHANGE: INDONESIA IN FOCUS

Bambang H. Saharjo and Lindon N. Pronto



A large area of forest in Indonesia's Riau Province has been cleared and burned, opening up space for a palm oil plantation. Photo: Bambang Saharjo (2016).

For millennia, fire has been used in Southeast Asia as a tool in farming and land clearing. By the 20th century, population growth, migration, and economic development had resulted in rampant conversion of native forests and peatlands for agricultural purposes. Biodiversity- and carbon-rich pristine forest and peat swamp ecosystems were

cleared, drained and burned, and replaced by agroindustrial systems. Periodic occurrences of the El Niño–Southern Oscillation weather pattern produced severe droughts in Southeast Asia, during which traditional land use fires often burned out of control. While these challenges are present across the region, Indonesia—by no small margin—has seen the worst.

Impacts of Fire on Indonesia

In 1982–83, El Niño-induced drought contributed to 12.4 million acres (5 million ha) of land in Indonesia being burned, including 8.6 million acres (3.5 million ha) in East Kalimantan Province alone (Goldammer and Seibert 1990). The magnitude of these fires remained

largely unnoticed by the global community. By 1994, Indonesia was increasingly affected by excessive fire application in land use and land use change; an estimated 13.3 million acres (5.4 million ha) burned that year (Saharjo 2016). Despite mounting scientific evidence of negative environmental consequences of large-scale fire application, in the 1997–98 season—once again coupled with El Niño drought—fires damaged an estimated area of 24.7–27.2 million acres (10–11 million ha) (Goldammer 2007). Similar conditions reoccurred in 2006, when another 19.8 million acres (8 million ha) burned, and they contributed again to the detrimental fires of 2015–16 (Saharjo 2016).

The 1997–98 episode garnered international attention. Assistance centered on constructing fire

Bambang Saharjo is head of the newly established Regional Southeast Asia Fire Management Resource Center and coordinator of the UNISDR–Regional Southeast Asia Wildland Fire Network as well as a professor of forest protection at the Faculty of Forestry, Bogor Agricultural University, West Java, Indonesia; and Lindon Pronto is an officer of the Global Fire Monitoring Center, Max Planck Institute, Freiburg, Germany.

management capacity through dozens of projects, investments, and advisory support for environmental and land use policies. Despite hundreds of millions of dollars in foreign investments, the effectiveness of these efforts remained low due to the complexity of the issue and a misguided emphasis on suppression-oriented interventions (such as deployment of firefighting aircraft); even with political engagement and a legally binding transboundary agreement and response mechanism, the root causes were never sufficiently addressed, and many symptoms persisted.

While the situation on the ground showed little improvement, the crisis of the late 1990s did refocus efforts by the scientific community: higher capabilities in aerial observations and atmospheric measurements were pursued, coupled with more detailed research on the ground. Studies attempted to quantify fire damages—including one study showing that emissions releases by the 1997–98 fires constituted nearly one-third of the annual global anthropogenic emissions and up to 40 percent of carbon emissions from fossil fuels for 1997 (Page and others 2002).

The El Niño of 2015 resulted in fire spread affecting more than 6.4 million acres (2.6 million ha) (Wardhana 2016). Fires burning in September and October 2015 released about 11.3 teragrams of carbon dioxide per day (1 teragram = 1 million metric tons) (Huijnen and others 2016)—or, by another estimate, roughly 15 teragrams of carbon dioxide per day (van der Werf 2015). Both figures were much greater than the daily release of 8.9 teragrams of carbon dioxide from fossil fuel burning in the entire European Union. More recent research from field measurements, however, found significantly lower

emissions releases, signaling a need for more in-depth research to accurately calculate peat fire emission factors because these may differ from lab experiments (Stockwell and others 2016).

As with fire events anywhere in the world, quantifying fiscal damage and economic impact means roughly estimating at best. The National Disaster Management Authority (Badan Nasional Penanggulangan Bencana) of Indonesia put the damages to the national economy

By 1994, Indonesia was increasingly affected by excessive fire application in land use and land use change.

in 2015 at about \$16.5 billion, equivalent to 1.9 percent of the country's gross domestic product (Wardhana 2016). Additionally, the World Bank estimated that Indonesia's fires cost upwards of \$295 million in biodiversity-related losses in 2015. Not included in these estimates are potentially billions of dollars previously invested towards Indonesian fire management since the mid-1980s. After 1998, heavy investments into community-based fire management and fire suppression capacity in general were triggered by a study positing that the most cost-effective method for industrialized nations to battle climate change was through the protection of at-risk forests in developing countries. Norway, for example, has offered \$1 billion to Indonesia to halt deforestation (Spolar 2016).¹

Smoke and haze from land use fires have significantly impacted the livelihoods and health of the population of Indonesia and neighboring countries. At times, smoke has blanketed 70 to 80 percent of the region, including Brunei, Malaysia, Singapore, Thailand, and The Philippines. Regional and cross-border smoke pollution has also contributed to political tensions between Southeast Asian nations, especially between Singapore and Indonesia. Some even termed the 2015 event as “a crime against humanity.”

For local peoples, the continual degradation of forest and peatland areas as well as the loss of biodiversity and other valuable resources contribute to social conflicts that further diminish livelihoods. In addition to impacting critical social and physical infrastructure (such as closing schools and interrupting shipping and aviation), smoke pollution has had a severe toll on human health. Recent studies emphasized these impacts, with one study estimating over 180,000 premature annual deaths from smoke pollution caused by vegetation fires worldwide (Lelieveld and others 2015). Indonesia alone had 583,925 cases of acute respiratory tract illness between July and November 2015.

The same year also saw 26 fire-related fatalities (Kamaruzzaman 2016). A recent health impact modeling study estimated that the 2015–16 smoke crisis cost up to 100,300 Southeast Asian lives by way of premature mortality (Koplitz and others 2016). Another study estimated that 69 million people were persistently exposed to unhealthy smoke pollution levels in fall 2015, resulting in up to 17,000 deaths (Crippa and others 2016).

Oil Palm Plantations and Logging

Large plantation companies have been responsible for widespread illegal fire application, but they are also important drivers of economic growth for Indonesia. The exports of palm oil alone generate \$20 billion a year and employ millions of citizens (Hermansyah 2016).

However, after the 2015 fire outbreak and resulting economic losses, the Government initiated dozens of investigations against palm oil and pulp-and-paper outfits. The Government is under increasing pressure from neighboring countries—Malaysia, Singapore, and Thailand—due to the haze, and the issue has drawn global attention. New technologies, such as satellite imagery and drone footage, have also limited the effectiveness of narratives designed

The continual degradation of forest and peatland areas as well as the loss of biodiversity and other valuable resources contribute to social conflicts.

to minimize the extent of fire- and smoke-related disasters. Palm oil and pulp-and-paper companies are heavily intertwined with other stakeholder groups, making their roles in the fire and haze crises difficult to follow. They are known to exert influence over national and local governments, and they allegedly hire local citizens to illegally use fire to prepare land for commercial uses.

International Efforts

Throughout the 1990s and early 2000s, probably 30-plus mainly short-term national and internationally supported projects were implemented aimed at tackling

the regional problem of fire and smoke. Among these were the Integrated Fire Management Project in East Kalimantan (1994–2003), supported by German funds; and the Forest Fire Management Project in South Sumatra (1999–2008), funded by the European Union through the German International Development Corporation Agency (Deutsche Gesellschaft für Internationale Zusammenarbeit). These two major projects “tested the waters” for similar efforts while developing methodological approaches of integrated fire management under the relatively unknown conditions present in Indonesia. The projects produced valuable insight into the underlying causes of fire application and uncontrolled wildfires, including the problems of poverty and questions of land use rights and land tenure/use conflicts.

Such international efforts, however, came during a period of rapidly increasing international market demands, especially for palm oil as well as pulp and paper. Widespread provision and conversion of land to meet such demands could not be reconciled with a growing population, social problems connected to agroindustrialization, and the persistent problems of land tenure and land use rights. Additionally, international development projects coincided with the democratization of Indonesia (reformasi) after the end of the Suharto era and the subsequent decentralization of the country’s administrative functions as of 1999, further complicating international assistance and involvement.



Fire set by local citizens to a logging deck owned by a large plantation in Indonesia’s Riau Province. While large palm oil and pulp-and-paper companies are blamed for many of the fires burning in the region, there are two sides to the story: fire is also used as a weapon by local communities with no other way of contesting concessions to large companies. Photo: Brad Sanders (2005).

The Politics of Haze

Smoke (haze) pollution in Southeast Asia has become increasingly political. Efforts to address the social, economic, environmental, and other implications of the El Niño-fueled fire outbreaks have spiked following each incident. Transboundary mechanisms and national policies have had years of development: the Association of Southeast Asian Nations (ASEAN) Agreement on Transboundary Haze Pollution, signed in 2002, is the only legally binding multilateral agreement pertaining to fire management issues anywhere in the world and is the most advanced and utilized approach of its kind. Since ratification of the ASEAN agreement by all member states in 2014, all 10 countries are obligated to implement it. Ministerial-level meetings have been conducted regularly and are convened and

Smoke (haze) pollution in Southeast Asia has become increasingly political.

hosted on a country-rotation basis; unfortunately, cross-border political tensions over haze issues have sometimes lowered the effectiveness of the meetings, leading a country's representatives to walk out on at least one occasion. The fickle nature of international cooperation supports the argument for developing national capacities, especially through local efforts. International recognition of the problem prior to and at the Conference of the Parties (COP 21) convened in Paris in December 2015 under the United Nations Framework Convention on Climate Change spurred Indonesia to enforce existing laws regulating the use of fire and to enhance governance

in fire management at all levels. International fire scientists, managers, and policymakers at the 6th International Wildland Fire Conference in Pyeongchang, Korea, in October 2015 also called on COP 21 for action.

A New Approach

Following the 2015 fires, the environmental conditions changed drastically as a wet La Niña weather pattern produced more rain in 2016 than in 2015, significantly reducing the number of fire outbreaks. Figure 1 shows an example from Riau Province in Indonesia of rainfall versus detected wildfires (“hotspots”). While governments

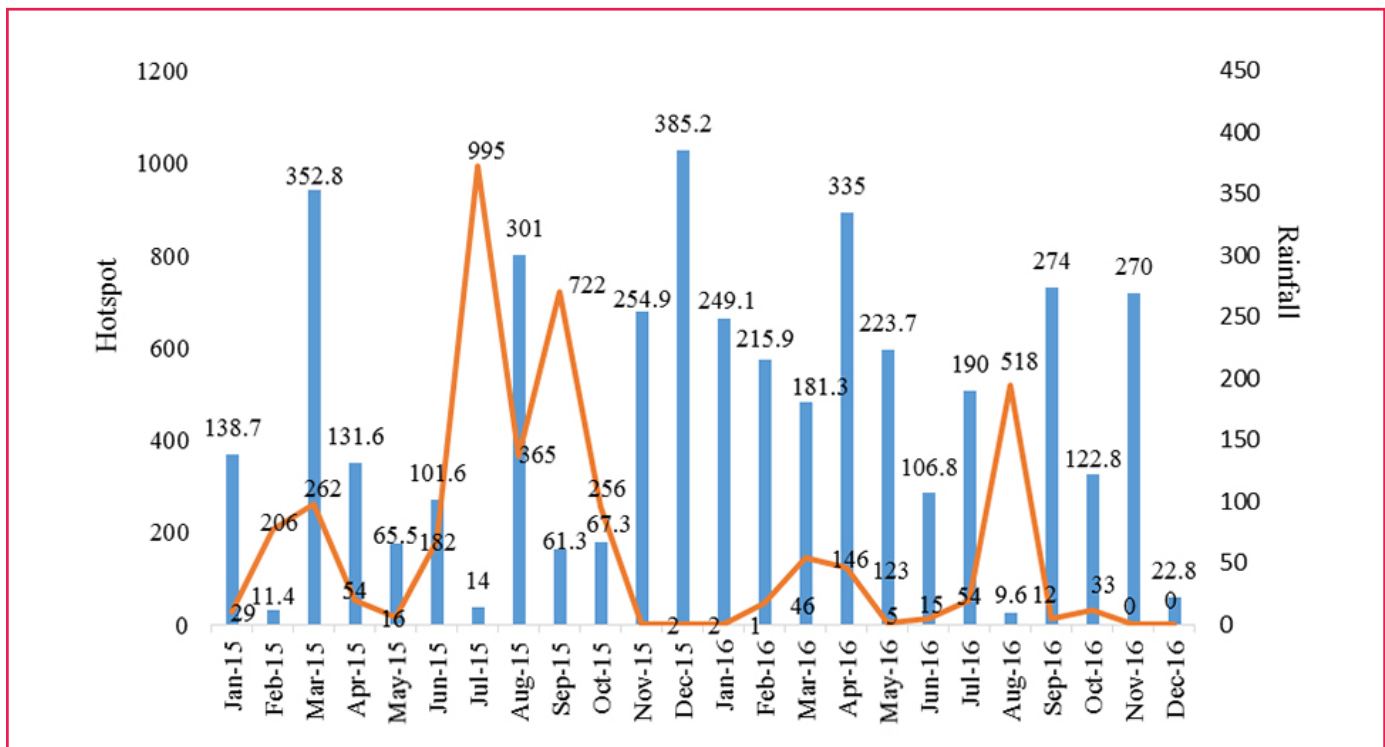


Figure 1—The number of wildfires (orange line tracking “hotspots”) and levels of rainfall (blue bars tracking rainfall in centimeters) from January 2015 to December 2016, showing an inverse correlation between rainfall levels and number of wildfires. High rainfall levels from November 2015 to December 2016 were associated with low numbers of wildfires (except in August 2016, when a decrease in rainfall resulted in a significant increase in fire incidents). Source: Velicia (2017).

in the region were quick to tout the successes of efforts to combat regional fire outbreaks and haze, it was clear to many that the reduction of these incidents was not a result of suddenly effective policy and local law enforcement changes but simply a result of a wet year.

Nevertheless, to anticipate future severe fires and save and restore burned and degraded peatlands, in 2016 the Indonesian Government launched the Peat Restoration Agency (Badan Restorasi Gambut), led by Mr. Nazir Foead and supported by many peatland experts. The agency aims to restore 4.9 million acres (2 million ha) by 2020. These restoration activities are being legislatively backed by the regulatory framework of Government Law No. 71 from 2014, which stipulates that ground water levels must remain within 4.9 inches (40 cm) from the peat's surface. This regulation is based on scientific observations determining that 4.9 inches (40 cm) is a critical water table threshold: if drained further, the peatland may dry out and become susceptible to fire. In 2016, Government Law No. 57 added further provisions to Law No. 71, giving the Government more executive enforcement power; in 2017, the Ministry of Environment and Forestry launched a guide to better facilitate the application of the 4.9-inch (40-cm) rule in the field at local level.

In January 2016, Indonesian President Joko Widodo made explicit calls for more preventive measures, tougher law enforcement, more community involvement, and better governance of private land and company concessions. Furthermore, the Indonesian Government halted the granting of new land concessions for palm oil plantations on peatland. A 5-year peatland moratorium on the issuance of new permits for palm oil concessions and for pulp-and-paper

industry was ordered, especially in deep peat areas, further limiting economic activities in these sectors. The moratorium, an effort to prevent peatlands from being drained, is a direct strategy for protecting these biologically rich carbon reservoirs.

Indonesia's moratorium on peatland development has been praised by the United Nations Environment Programme.

Unfortunately, the implementation of such regulations at the field level has not been as satisfactory as hoped, and it is apparent that several large companies continue to run operations in nonpermitted areas.

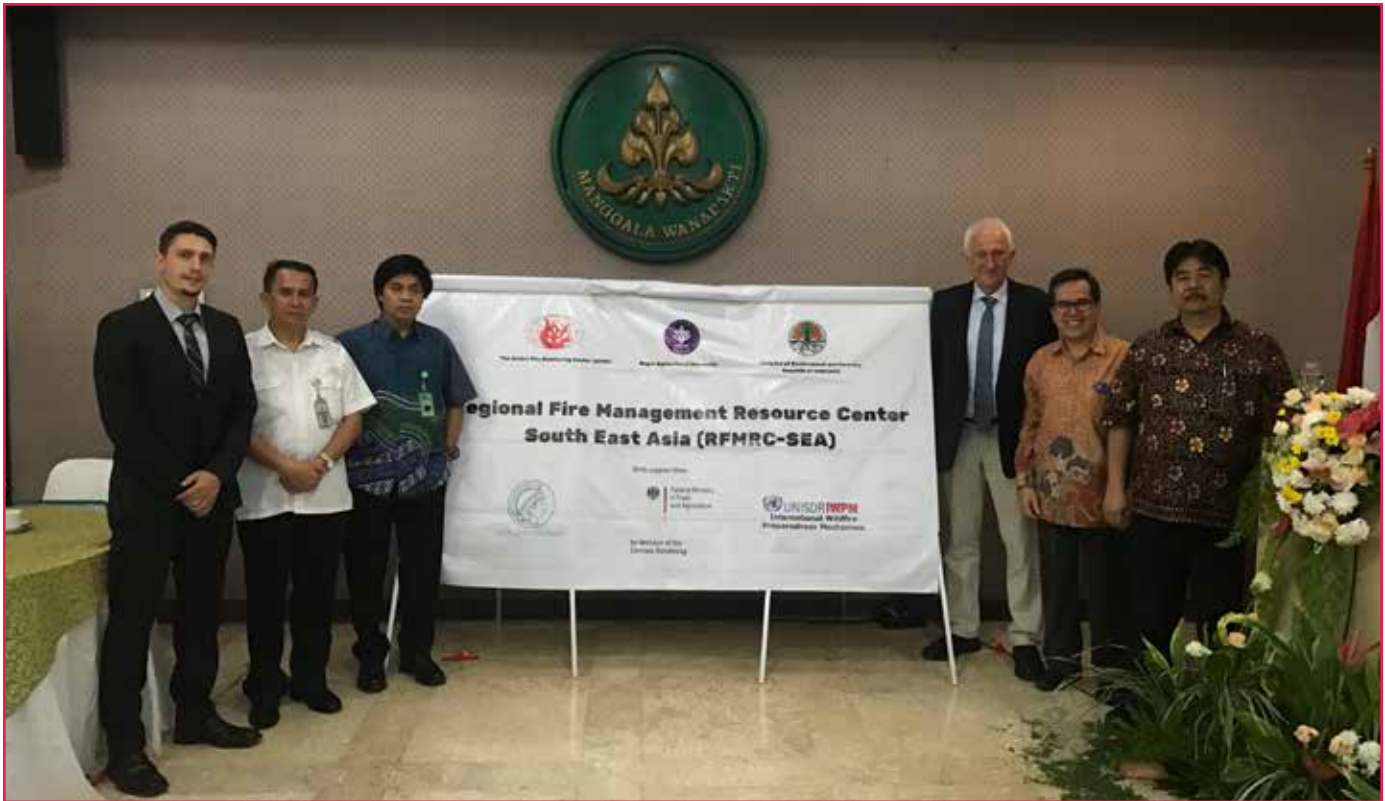
Indonesia is the world's most populous Muslim country. The Quran forbids humans from harming the environment, yet forest and peatland burning damage not only the environment but also people's health. In 2016, the country's leading Islamic clerical body issued a fatwa (religious decree) against the willful starting of fires in a bid to prevent a return of the choking haze. Though a very rare intervention by a religious body to address an environmental issue—and specifically a fire issue—the move was welcomed by the country's Ministry of Environment and Forestry, which encouraged Islamic preachers to spread news of the fatwa at a local level.

The Indonesian Meteorology, Climatology, and Geophysics Agency predicted that the climate in 2018 and beyond will become drier again,

prompting President Widodo to request detailed action plans for land and forest fire mitigation and to urge emergency preparedness as early as possible leading into dry seasons. Judging from hasty emergency response declarations by local authorities during the much more moderate dry season of 2017, it appears that the President's orders have at least in part been observed. The President also emphasized a need to strengthen early detection systems in fire-prone regions such as Riau, West Kalimantan, East Kalimantan, Central Kalimantan, and Papua Provinces. At the President's urging, agencies such as the Indonesian National Police and Defense Forces, anticorruption agencies, and the Ministry of Environment and Forestry have also begun handing out rewards for fire prevention successes—and punishments for regions failing to prevent illegal fires.

President Widodo ordered the law enforcement apparatus to be more assertive in solving forest and land fire cases, and he reminded all private companies to follow the rules. Although such (politicized) rhetoric is rarely enforceable, the Indonesian authorities have made it a very high priority to address fire management challenges. Between 2015 and 2017, many companies had cultivation permits revoked or suspended or were otherwise warned.

In a major departure from previous dealings, significant improvements in legal precedent as well as proper legal training and political will have resulted in dozens of prosecutions in the past 3 years. Convictions have led to hundreds of millions of dollars in fines, with many more verdicts on the way (see, for example, Munthe 2016). In November 2016, a landmark Supreme Court ruling handed one pulp-and-paper company



Launch of the Regional Fire Management Resource Center South East Asia (RFMRC–SEA) by the Ministry for Environment and Forestry, the Ambassador of Germany, and the Global Fire Monitoring Center. As a bridge among the scientific, practitioner, and policy communities, the RFMRC–SEA will act as an information repository and resource for best practices and international best practices in integrated fire management. Photo: RFMRC–SEA.

a fine of \$1.19 billion for illegal land clearing, the largest such ruling in the nation's history (Jong 2016). As the government continues this strong-arm approach while boosting investments in field patrols, law enforcement and community involvement will be critical to continue to pressure corporations to better comply with the law—and to counteract years of corruption in this economic sector. Unfortunately, however, not a single rupiah has been paid out as yet. The court cases remain trapped in the legal system, with a waiting period of several years for hearings. Another challenge is finding expert witnesses (that is, fire investigators) to testify against powerful corporations. Expert witnesses generally hold academic/scientific positions, but if their credibility is attacked by corporate defendants, testifying in court can have serious repercussions—they

must fear for their personal safety and careers. Compounding matters, only a handful of experts are equipped to make such testimony, which requires extensive (voluntary) field investigations in the burned areas in question and knowledge of regulatory frameworks. A current initiative to address this deficit by training more legal professionals in fire investigation and environmental law has already noticeably increased the Indonesian Government's ability to counter the power of the financially and legally well-lubricated apparatus of corporate defenders.

Outlook

Countries in ASEAN aim to achieve a smoke-free zone by 2020. Indonesia has taken such measures as adopting a long-term action plan to address land and forest fires. Indonesia's moratorium on peatland development was praised by the United Nations Environment

Programme as a historic contribution to global efforts to tackle climate change.

Aside from ancient coal seam fires in Borneo (Goldammer and Seibert 1990), Indonesia historically has not been a fire-prone landscape. Institutionalizing a line of communication for science, policy advice, and international standards of best practices in integrated fire management is needed, as well as a repository to store and utilize this knowledge. The recently established Regional Fire Management Resource Center serving Southeast Asia (RFMRC–SEA), hosted by the University of Bogor, is taking on this task. The RFMRC–SEA is a sister center to three other effective RFMRCs as an integral part of the United Nations International Strategy for Disaster Reduction's Global Wildland Fire Network (ISDR, n.d.). The other three RFMRCs (also

mentioned in this special issue) were established between 2010 and 2015.

Commonly, there is a disconnect between the state of knowledge (science) and policymakers and the decisions they make. Uncertainties play a role in policy lags across environmental issues, especially extremely complex and shifting issues. Fortunately, in the case of Indonesia, there is no debate on the need to act against future outbreaks of fire and haze. The challenge now is integrating recent science into the policy process while ensuring that policies are effective at the local level. And it seems that the actors in the region—even corporate ones—are rising to the task, rolling up their sleeves and getting to work.

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Endnote

¹ Norway has since completed a similar \$1 billion payout to Brazil (offered in 2008); while there were many contributing factors, the unprecedented investment likely played a pivotal role in Brazil's success in rapidly reducing deforestation rates.

WILDFIRE MANAGEMENT IN WEST AFRICA: A COMMUNITY EFFORT

Lucy Amissah and Richard K. Ninnoni

Wildfires are a regular feature in the landscape of most West African countries and are increasingly responsible for forest degradation and its effects on sustainable livelihoods in the region. Wildfires are also a threat to the success of many initiatives that are being implemented in the region to curb the impacts of climate change. For instance, the continuing occurrence of wildfire is likely to erode progress being made under programs to reduce emissions from deforestation and forest degradation (better known as REDD+) in developing countries in the region (Barlow and others 2012).

Lucy Amissah is a senior scientist with the Biodiversity Conservation and Ecosystem Services Division of the CSIR–Forestry Research Institute of Ghana, Kumasi, Ghana; and Richard Ninnoni is the environmental conservation manager at the Ghana Forestry Commission, Resource Management Support Centre, Kumasi, Ghana.

In West Africa, local communities have been involved in fire management over several decades.

Fire Management Context

The effort to curb wildfire occurrence has spanned many years and been at various levels involving state institutions, nongovernmental organizations (NGOs), and local communities. Many of these efforts have been funded by bilateral and multilateral institutions, NGOs, and governmental institutions across the region. Activities have involved enactment of legislation, development of national fire management strategies and associated implementation plans, development of national wildfire policy, and the introduction of community-based forest fire

management as well as a broad spectrum of wildfire prevention education initiatives.

Additionally, postfire restoration has been carried out to restore fire-damaged areas. Although these efforts have contributed to the reduction of wildfire occurrences in some countries of the region, annual wildfires continue to be of major concern for the sustainable management of land resources (including forests, wildlife, and agricultural crops) and, in extreme cases, the preservation of human life.

Data from the National Aeronautics and Space Administration's (NASA's) MODIS satellite from 2016 show fires covering about a 1,400-mile (2,250-km) swath stretching from Ivory Coast through Ghana, Nigeria, and Cameroon across the Central African Republic, Congo, and Gabon (fig. 1). These fires are a result of a combination of factors related to changes in climate, land use, and livelihood activities. Recently, soil

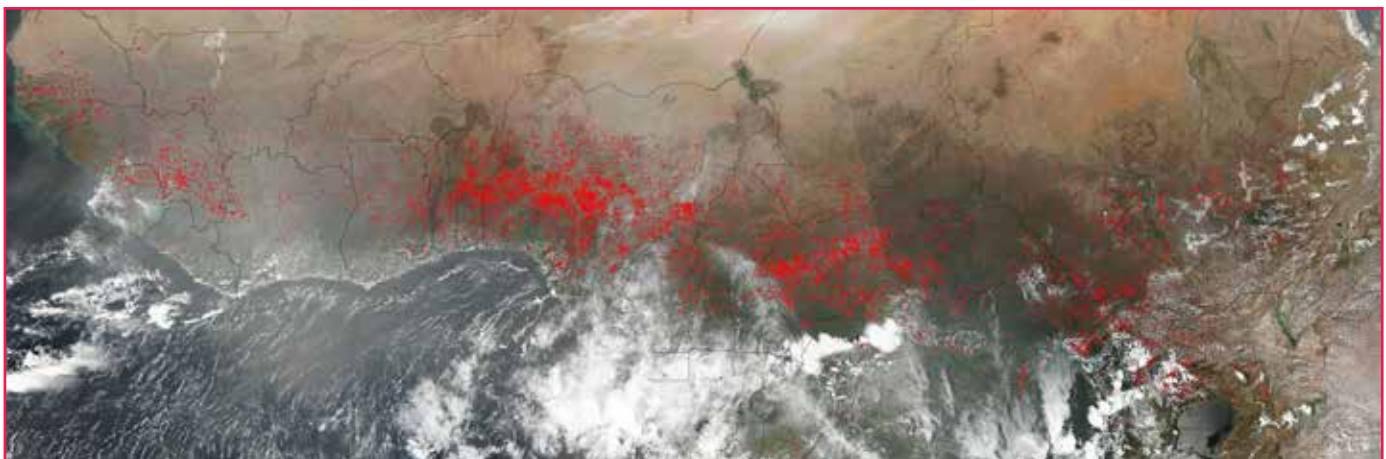


Figure 1—Fires burning across West and Central Africa on February 6, 2017. Source: NASA (2017).

moisture levels shown by the Africa Flood and Drought Monitor have hit their lowest rating levels across many areas in West Africa, which has led to more intense burning. The wildfire risk is likely to increase, with global temperatures reaching 1.1 °C higher than in the late 19th century (IPCC 2014).

NASA's Suomi NPP satellite imagery using the visible infrared imaging radiometer suite instrument on February 6, 2017, showed fires that were widespread in nature, suggesting that these fires were deliberately set to manage land (fig. 1). Farmers across West Africa often use fire to clear the ground of unwanted plants and improve soil nutrients in the short term. Occasionally, these well-intended fires get out of control and cause extensive damage.

Therefore, the appropriate and regulated use of fire in West Africa will reduce the occurrence of wildfires significantly. Active participation by local people has been recognized as a prerequisite for the successful implementation of fire management programs in many regions, including West Africa (Goldammer and others 2002). It is important that appropriate annual budgetary allocations are made to sensitize communities and create awareness in them of wildfire prevention and control techniques, especially in the face of increasing global wildfire risks.

Community Involvement in Wildfire Management

In West Africa, local communities have been involved in fire management over several decades through the application of fire in land use activities and suppression of occasional wildfires. These activities have largely been both communal

Since the early 1990s, the concept of volunteer firefighting has become prominent across Africa.

in nature and at the individual community dweller level (where they are less structured).

In recent times, when wildfires became a regular phenomenon in many countries in West Africa, community-based organizations as well as individuals have constituted the primary bodies involved in wildfire management. Those involved have included volunteer firefighters, civil society groups, local NGOs, traditional authorities, and faith-based organizations. The impetus for the formation of these groups, and their subsequent emphasis are diverse, but important themes are the protection of personal property (such as farms and farm products, including

livestock) or even the protection of entire landscapes.

The authority and motivation to prevent and/or fight wildfires in most cases are backed by legislation, policy, bylaws, or a combination of these. In Ghana, for example, the current legislation and policy on fire management are the Control and Prevention of Bushfires Act of 1990 (P.N.D.C.L. 229) and the National Wildfire Management Policy of 2006. Provisions in these pieces of legislation and policy empower local communities to participate in wildfire management, with specific roles that include creating education and awareness, conducting fire patrols, creating firebreaks (fig. 2),



Figure 2—Creation of a firebreak. Photos: Lucy Amissah.

mobilizing resources and logistics, performing active fire suppression, and enacting bylaws as well as making arrests and prosecutions of offenders.

In Burkina Faso, decree number 98–310/PRES/PM/MEE/MATS of 1998 and a National Fire Management Strategy set the framework within which fire management activities are carried out on rural lands. The law clearly recognizes that fire is a tool and therefore certain conditions must be respected when handling it (Mäkelä and Hermunen 2007). Therefore, fire management activities are planned and implemented locally in a participatory manner by communities to ensure that fire is used more safely as a tool for sustainable management of natural resources.

In Ivory Coast, a wildfire fighting strategy has been implemented by SODEFOR (Société de Développement des Forêts) over the past 2 decades. The strategy focuses on using the services of village fire committees. Each village committee is made up of 10 members. Equipped with appropriate equipment (such as a firetruck, communication equipment, and backpack pumps), the members are assigned to manage a forest or reforestation zone.

In the initial implementation of the strategy, village committees were made to work only in the dry season. However, the implementation of the strategy has been reviewed more recently, and the village committees now work on fire management-related activities all year around, but with an emphasis on the dry season. The activities of such groups include creation of awareness of fire risk, creation of firebreaks, and the mobilization of community members as firefighters in the event of a fire occurrence.

Successful Involvement of Volunteer Firefighting Groups

Since the early 1990s, the concept of volunteer firefighting has become prominent across Africa and especially in Ghana; this was largely in response to the pandemic wildfires resulting from the El Niño phenomena that plagued the country in the early 1980s. The economy was in distress because large tracts of cocoa farms and forests—the mainstays of the economy—were destroyed by wildfires. As the government struggled to repair the damage done, citizens felt the need to volunteer through various economic recovery programs,

A regional center of excellence for raising the fire management capacity of institutions and civil society would be helpful.

including volunteer firefighting. Many volunteer firefighters have been recruited and trained under various projects, such as the forest fire management project in Ghana funded by the International Tropical Timber Organization and the wildfire management project (WFMP) funded by the Dutch Government in the Forest–Savanna Transition Zone of Ghana.

Under the WFMP, volunteer firefighting squads were formed in 234 communities, with a total strength of 4,482 volunteers. In addition, 497 field staff from the Forest Services Division of the Ghana Forestry Commission and

from the Ghana National Fire Service were trained in wildfire management techniques. All volunteers were trained and structured into a common firefighting organization to ensure quick response to a distress call and so that a team from one community could easily support another team in case of a fire outbreak. Each of these volunteer firefighting groups developed a local code of conduct to ensure discipline.

After the WFMP ended, these volunteer firefighting groups became largely defunct for lack of logistics and support. Under a new program, the Forest Investment Programme funded by the World Bank, a number of the defunct volunteer groups from previous initiatives (including the WFMP) are being revived and reequipped. In addition, communities are trained to develop community wildfire management plans to guide their actions.

Impact of Community Efforts on Wildfire Occurrences

The initiatives on fire prevention and control, implemented in close collaboration with local communities, have had a positive impact on agricultural production. In the 1990s, most farmers shifted to the cultivation of annual crops such as maize due to annual wildfires (Amissah and others 2011). However, there is currently renewed interest in the cultivation of perennial crops such as cocoa in some farming communities in the Forest–Savanna Transition Zone of Ghana.

Available records from the Forestry Commission of Ghana indicate a sharp decline of fire occurrence in some communities. The frequency of wildfire occurrences in the Forest–Savanna Transition Zone of Ghana

has shown a significant decrease from 247 wildfires in the 2015–16 fire season to 24 in the 2016–17 fire season (fig. 3). The estimated total area affected by wildfires over the same period decreased from 345,504 acres (139,880 ha) in 2015–16 to 9,554 acres (3,868 ha) in the 2016–17 season. The decrease in the area affected by wildfires from the 2015–16 season to the 2016–17 season was about 97 percent.

The observed trend is attributable to several factors, including good fire weather conditions during the reporting period. Another factor was extensive countrywide awareness creation carried out by community groups, local government agents, and volunteer firefighting groups. Furthermore, effective presuppression measures (such as creating firebreaks and conducting regular patrols), especially in fire-prone areas, have contributed to reduction in occurrence and spread of wildfires in some communities. Similar reduction in wildfire incidence was observed in Burkina Faso after the introduction of community-based fire management approaches.

Challenges to Community-Led Fire Management

Today, although many community members are enthusiastic about volunteering to help manage fires across West Africa, the success stories are mixed due to several challenges. Principal among these are:

- Nonpayment of insurance and inadequate incentives and logistics (in Ghana),

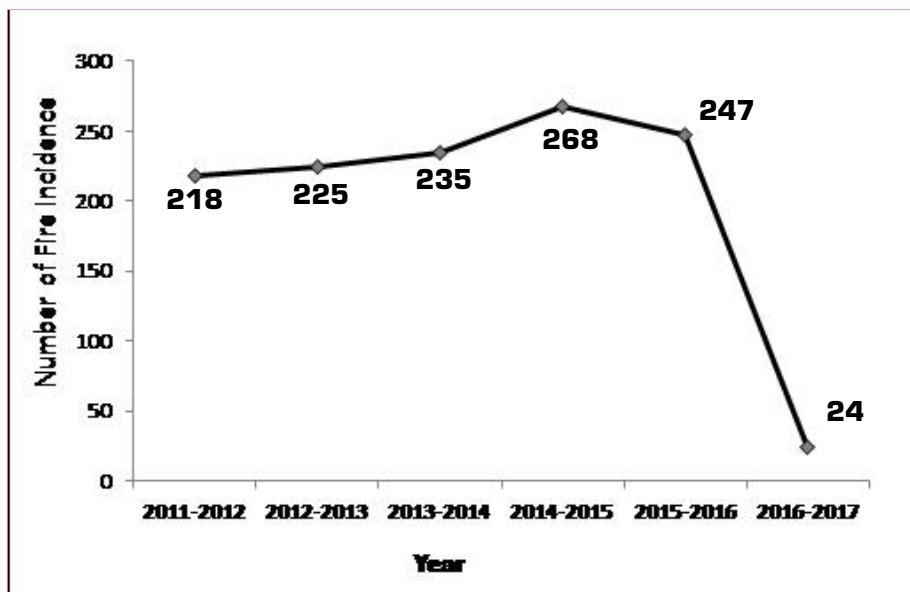


Figure 3—The number of wildfires in the Forest–Savanna Transition Zone of Ghana showed a sharp decline in 2016–17 from previous fire seasons. Source: Annual Report on Wildfire Incidences, Forestry Commission 2017.

- Irregular payment of premiums to fire committees (in Ivory Coast),
- Delay and inadequate supply of equipment, and
- Disbandment of volunteer firefighter groups/committees after the fire season.

Additionally, with access to tools and equipment lacking, tree branches and cutlasses are the main tools used by volunteer groups and other community members for suppressing moderate fires in some countries (such as Ghana). During larger and more intense wildfires, the communities are usually rendered helpless.

Most initiatives focus on the training of volunteer firefighting groups. However, a study by IUCN/FORIG (2011) revealed that, during wildfire occurrences, most community members react swiftly to assist in their suppression. The study recommended that training in fire prevention and control need not target only volunteer firefighters but can extend to all social groups within the community. No explicit fire management plans exist in most communities, although community-

based fire management is being promoted. In Ghana, a manual for community-based fire management has been produced through a fire management and postfire restoration project funded by the International Tropical Timber Organization and is expected to guide communities in the development of their wildfire management plans.

Conclusions and Recommendations for Future Work

In many countries across West Africa, volunteers continue to work on fire management despite the many challenges and limitations. They do so, in part, out of motivation to protect farms and property. To ensure the sustainability of the work of volunteer firefighting groups and village committees that are at the forefront of fire prevention and control, many issues need to be urgently addressed.

Efforts should be made to develop or identify more sustainable funding sources for wildfire management activities that are not totally dependent on donors (for example,

by facilitating the creation of a national wildfire management fund). In addition, there is the need to improve political support for mainstream wildfire management in government institutions. To achieve this, developing policy briefs on wildfire problems is recommended, along with highlighting success stories from around West Africa. A strategy to raise further funds for wildfire management activities should be part of the annual budget for each nation's institution(s) responsible for natural resource management. The strategy should include timely provision of basic firefighting tools and protective clothing for local community groups tasked with community-based fire management.

Communities or countries that have developed safe, effective, and efficient wildfire management strategies should share their success stories and transfer the corresponding technologies to regions where expertise, technologies, or systems are lacking. A regional center of excellence for raising the fire management capacity of institutions

and civil society would be helpful in this regard.

We therefore propose seeking international support to set up a regional fire management resource center for Sub-Saharan Africa, similar to those established in Southeast Europe/Caucasus (in 2010), Eastern Europe (in 2013), Central Asia (in 2015), Southeast Asia (in 2017), and now in South America and in Central Eurasia/Russia (both in 2017–18) (Goldammer 2013).

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WILDFIRES IN THE HINDU KUSH–HIMALAYAN REGION AND COMMUNITY-LED FIRE MANAGEMENT IN NEPAL AND BHUTAN

Sundar Prasad Sharma and Kinley Tshering

In countries of the South Asia region, wildfires commonly occur during the hot, dry, and windy summer seasons and are often associated with agricultural burning. In Nepal, incidents of forest fire have been increasing as summer seasons have gotten drier and hotter in recent years; the number of hot dry days are increasing also, as compared to the recent past.

These wildfires not only contribute to regional and global challenges such as smoke pollution but also threaten local communities, economies, and cultures. This recent and increasing trend of wildfires in the southern stretch of the Hindu Kush–Himalayan region is particularly devastating for the fragile Himalayan ecology. Ecosystems and communities are in general very vulnerable to wildfires, not to mention secondary disasters like landslides and flash floods, which often follow disastrous wildfires.

Sundar Prasad Sharma is coordinator of the United Nations Office for Disaster Risk Reduction (UNISDR)–Regional South Asia Wildland Fire Network and a district soil conservation officer with the Nepalese Ministry of Forest and Soil Conservation, Kathmandu, Nepal; and Kinley Tshering, also a member of the UNISDR–Regional South Asia Wildland Fire Network, is the chief forestry officer at the Forest Protection and Enforcement Division, Ministry of Agriculture and Forests, Royal Government of Bhutan, Thimphu, Bhutan.

Wildfires in high-altitude Hindu Kush–Himalayan ecosystems drive the destruction of pristine biodiversity, including the habitats of many rare species.

Wildfires in the High-Altitude Himalaya

Wildfires in high-altitude Hindu Kush–Himalayan ecosystems are a major driver in the destruction of pristine biodiversity, including the habitats of many rare species. Much of the high-altitude Himalayan region and the adjoining lowlands have been impacted by incidences of extreme seasonal drought, revealing the overall underlying moisture deficit in the region. The vulnerability of South Asia to climate variability and wildfire incidence during these droughts increases the potential for fire to cause major damages, including fatalities and injuries, loss of property, serious degradation of forests, changes to ecosystem properties, and deterioration of social and economic conditions in some land use systems and natural vegetation types. The increase of climate extremes and its consequences are clearly attributable to regional and global climate change.

Table 1—Wildfire-related deaths and injuries in South Asia, 2010–17.

Year	Country	Killed	Injured
2010	Bhutan	2	0
	India	11	6
	Nepal	9	35
	Pakistan	5	0
2011	India	5	0
	Nepal	1	8
2012	Bhutan	6	23
	India	4	2
	Nepal	5	0
2013	India	2	16
	Nepal	2	1
2014	India	3	5
	Nepal	21	36
2015	India	2	1
2016	India	21	21
	Nepal	4	5
2017	India	5	11
	Nepal	0	1
2010–17	All	108	171

Note: Data were not collected or not available for all of South Asia, so the actual number of deaths and injuries in the region is likely higher. Source: GFMC (2010–2017).

In 2009, wildfires were particularly devastating in terms of human casualties in Nepal and India. Forty-nine people died, including 13 soldiers, and 9 people were seriously injured while fighting fires in Nepal. In India, 30 people died and 21 were injured. Table 1 shows documented incidences of wildfire-related death and injury in South Asian countries from 2010 to 2017. Firefighters, soldiers, and police were frequently among the killed and injured. Nepal thankfully had a historic zero-fatality year in 2017 (GFMC 2010–17).

Transboundary Fires and Haze Pollution

Fires occurring in the highlands of Tibet, Sikkim, Bhutan, and the northern part of Nepal at altitudes from 8,860 to 12,470 feet (2,700–3,800 m) above sea level often cross national borders, especially during the dry winter fire season (November to January) (Schmidt-Vogt 1990). By contrast, fires are more common in lowlands in the Hindu Kush–Himalayan region during the hot, dry, and windy summer season (February to May) (also associated with agricultural burning). Observations indicate that the occurrence of wildfire is increasing because of regional warming and 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.

Transboundary wildfires and haze pollution are an emerging issue in South Asia. Globally, fire is the most important disturbance agent in vegetation cover worldwide, affecting from 740 million to 990 million acres (3–4 million km²) annually (Goldammer 2013).

There is clear evidence of the historical role and timescale of fire in many fire-dependent ecosystems. The current trend shows increasing use of fire in land use and land use change as well as an increase of destructive wildfires (uncontrolled and unwanted fires) (fig. 1).

Community Involvement in Wildland Fire Management: Cases From Nepal and Bhutan

As in most countries around the world, almost all fires in the South

In 2009, wildfires were particularly devastating in terms of human casualties in Nepal and India.

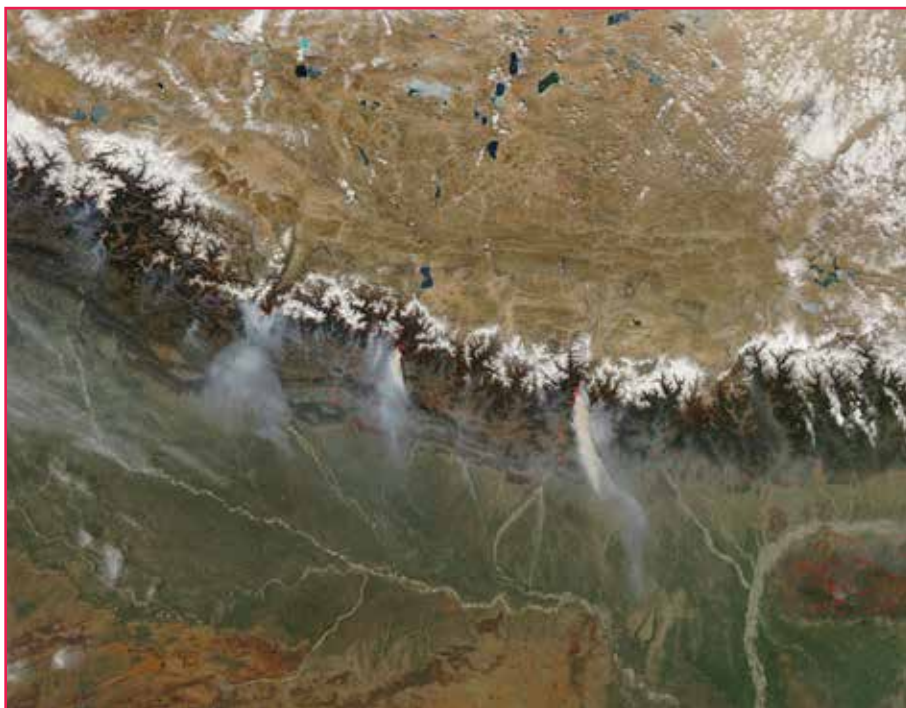


Figure 1—Nepal has seen an increasing incidence of damaging wildfires, as shown in this image from March 12, 2009, taken from the MODIS Aqua satellite belonging to the U.S. National Aeronautics and Space Administration's Earth Observatory. The image shows 141 fires, which severely burned much of the high Himalayan national parks and conservation areas in Nepal. Smoke from those wildfires crossed the Indian border to the south. Source: National Aeronautics and Space Administration.

Asia region are human caused. Also, consistent with elsewhere, people in the region have a general perception that fire is the main driver of forest degradation. However, because the livelihoods of mountain people are mostly subsistence based (the economy is agricultural) and people rely heavily on sustainable vegetation cover for their survival, wildfire damages can wreak havoc.

It is widely regarded that community-led fire management is a system/method implemented by a rural community based solely on indigenous knowledge and skill. This is in fact somewhat misleading because the system is a dynamic process in a context of disaster risk reduction. The task of increasing

community resilience and adaptation to wildfire disasters must involve all stakeholders concerned, and it includes the incorporation of recent scientific knowledge. What is crucial is that this “new” scientific knowledge is combined with local/indigenous knowledge and implemented at the community level.

Nepal

In 2007, a three-level wildland fire management project for Nepal was funded by the German Foreign Office and implemented by the Global Fire Monitoring Center, in collaboration with Nepal's Department of Forests and the Regional South Asia Wildland Fire Network (fig. 2). The project effectively gathered multiple kinds of experiences from the community,

Transboundary wildfires and haze pollution are an emerging issue in South Asia.

district, and national levels. Since then, 67 fire management volunteer groups (with 20 to 30 persons per group) have been successfully formed in different forest management regimes in Nepal (see the sidebar on the following page); each group has been outfitted with firefighting handtools and safety gear.

The community-led fire management planning process involved:

- Identifying users, expectations (needs) of users, and geographic planning areas;
- Identifying zones, changes, contrasts, conditions, and physical features in the village environment; and
- Presenting and analyzing information on land use, forests, water and other resources, and risk zones (participatory resource mapping).

Three principles were followed:

- Inclusion of the perspectives of all interest groups (inclusive and gender balance),
- Recognition of indigenous knowledge on fire management, and
- Incorporation of training components within the planning process.

Bhutan

The forest fire volunteer program began in 2008. The members, mostly from Thimphu, included civil servants, students, the business

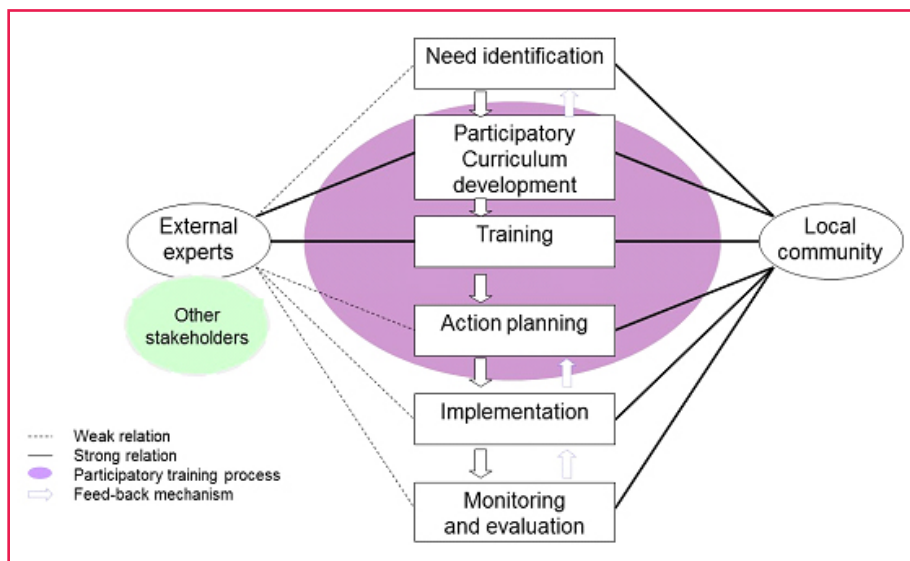


Figure 2—Community-led participatory forest fire management flow diagram. Source: Sharma 2012.

community, and graduates. With support from the National Adaptation Programme for Action, the first forest fire management community groups were formed in 2015. To date, 20 community forest fire management groups have been established across the country. They received basic firefighting equipment and hands-on training in firefighting skills, personal safety, and basic forest fire behavior. Each

group has been involved in planning and implementing community fire management plans for a more effective establishment of fire management at the grassroots level.

The Royal Government has long recognized the need for integration of community and volunteer services in effective prevention and control of forest fires in Bhutan. The current mechanism for community-led



Forest fire volunteers conducting a door-to-door awareness campaign in local communities. Photo: Forest Fire Management Section, Forest Protection and Enforcement Division.

Community-Level Fire Management Training in Nepal

Fire management courses are tailored to villagers and other members of a community forest user group to allow them to develop their own fire management plan and fire risk maps. Each course features:

- Participation-oriented tools for community-led fire management planning;
- Training designed for application to any village environment in Nepal; and
- Creative training formats, including role play, where participants act as instructors.



Participatory curriculum development involving trainees, Hetauda, Nepal, 2007. Photo: Sundar P. Sharma.



A model firefighting volunteer group was formed in Hetauda, Makawanpur, Nepal, with support from the German Foreign Office and the Global Fire Monitoring Center in 2007. Photo: Sundar P. Sharma.



Orientation training in fire management for a community volunteer group in Sundevi Community Forest, Kanchanpur district, Nepal, implemented by the Nepal Forest Fire Management Chapter and supported by the U.S. Agency for International Development and the WWF Nepal in 2012. Photo: Nepal Forest Fire Management Chapter.



Forest fire volunteers in Bhutan being trained by experts from the Department of Forests and Park Services. Photo: Forest Fire Management Section, Forest Protection and Enforcement Division.

Fire is used by the rural population as a traditional tool for clearing and managing agricultural and pastoral lands.

planning and for volunteers in the prevention and suppression of wildfires will be scaled up in the 12th Five Year Plan by the Department of Forests and Park Services, Royal Government of Bhutan. It is expected that all 205 administrative blocks in all 20 districts will be covered under block- and district-level fire management plans. The volunteer groups and communities will be the key implementers of these plans.

In assessing the fire situation in South Asia in general and Nepal and Bhutan in particular, the following points need to be considered:

- Fire is used by the rural population as a traditional tool for clearing and

managing agricultural and pastoral lands. It is also used in gathering nontimber forest products and in hunting and herding. Uncontrolled and potentially catastrophic fires are therefore common during the dry season.

- Uncontrolled fires in countries in South Asia lead to serious degradation of forests and other vegetation types as well as deterioration of social and economic conditions in some land use systems, along with regional pollution (for example, the so-called Asian Brown Cloud—a severe regional pollution phenomenon generated by the accumulating effects of agricultural burning and industrial pollution).

- Fire management can be an essential part of ecosystem management (not all fires are destructive). Hazard reduction activities such as prescribed burning, fuel removal, and fireline construction are also carried out to prevent fires from destroying important land management zones, assets, and infrastructure.
- Sustainable management and protection of vegetation cover provide goods and services, including nontimber forest products and recreation. They also maintain biological diversity, mitigate the consequences of climate change, conserve watersheds, improve air quality, and help to reduce poverty through livelihood support for rural populations.
- Nepal has diverse ecosystems, socioeconomic and cultural settings, and vegetation types resulting from a wide range of land use systems and climatic conditions. The result is diverse fire regimes and vulnerabilities.

- There is a lack of local, national, and regional capability in fire research and management, including firefighting, monitoring, early warning, and ecological and socioeconomic impact assessment. The facilitation of international cooperation in fire management in countries in South Asia is also lacking.

National and Regional Implications

Several initiatives were adopted after the 2007 foundation of the United Nations Office for Disaster Risk Reduction–Regional South Asia Wildland Fire Network, established in Nepal by the Global Fire Monitoring Center. National issues and concerns were raised at several national, regional, and international forums and garnered attention in the international community. National-level activities included a three-level wildland fire management project for Nepal, a Nepal forest and wildfire management project, multistakeholders’ roundtable meetings, and workshops supported by different international organizations. At the regional as well as Pan-Asia/Pacific level, several consultations and training programs were conducted. Similarly, at the international level, national and regional issues were discussed at the last three International Wildland Fire Conferences between 2007 and 2015.

A result of these many regional network activities in the South Asia region and beyond is a roadmap for future priorities, including:

- Enhanced international cooperation and collaboration in fire management, emphasizing community-led approaches that incorporate scientific tools for fire detection and monitoring;

There is a lack of local, national, and regional capability in fire research and management.

- Translated and adapted EuroFire competency standards and training materials for use in Bhutanese, Hindi, and Nepalese;
- Translation of fire management glossaries into local languages to support common understandings;
- Development of additional fire management programs/projects and the search for international support for their implementation;
- Creation of an enabling environment for all possible donors, including national, international, bilateral, and multilateral entities as well as private foundations, for the delivery of financial, technical, and other support for wildland fire management in countries in South Asia;
- Wildland fire management involving local community-led and participatory approaches at the forest user group level, incorporating field-level forestry and security personnel as a model strategy for countries in South Asia; and
- Establishment of a fire management resource center for the South Asia region, to be based in Nepal.

In sum, wildfires pose a serious threat to fire-sensitive ecosystems and communities in the Hindu Kush–Himalayan region. With increasing urbanization, cities and communities are encroaching on fire-prone areas. The lack of trained personnel and applied research

not only hampers suppression and prevention efforts but also impedes the application of science-based techniques. Another critical area is the lack of adequate manpower for fire management-related activities. Therefore, community-led initiatives are being institutionalized to garner greater public support and decentralize fire management activities.

Despite several national, regional, and international initiatives in countries in the South Asia region, wildfire challenges remain unchanged while impacts are increasing due to lack of concerted interventions. There is an immediate need for international cooperation and collaboration in fire management in the Hindu Kush–Himalayan region.

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WILDFIRES AND FIRE MANAGEMENT IN THE EASTERN MEDITERRANEAN, SOUTHEASTERN EUROPE, AND MIDDLE EAST REGIONS

Gavriil Xanthopoulos and Nikola Nikolov

The Eastern Mediterranean, Southeastern Europe, and Middle East regions have experienced tremendous political, social, and economic changes in the last 3 decades. This period has seen population movement

Weekend/summer houses are embedded in increasingly flammable vegetated areas.

difficult sociopolitical postconflict conditions on the one hand and serious economic crises on the other have affected many aspects of life and development. In addition to the number of migrants, the number of international tourists has increased steeply—all of them equally at risk of becoming wildfire causers and victims.

Gavriil Xanthopoulos is a forest fire researcher for the Hellenic Agricultural Organization “Demeter,” Institute of Mediterranean Forest Ecosystems, Athens, Greece; and Nikola Nikolov is the head of the Regional Fire Monitoring Center and a professor at the Faculty of Forestry, Skopje, the former Yugoslav Republic of Macedonia.

through internal displacement, border-crossing refugees, and general migration and immigration; in some cases, even borders have shifted. Armed conflicts and

Additionally, very high income and wealth disparity in many countries, with the great majority of people in poverty, have led to the development of fire-prone areas with highly

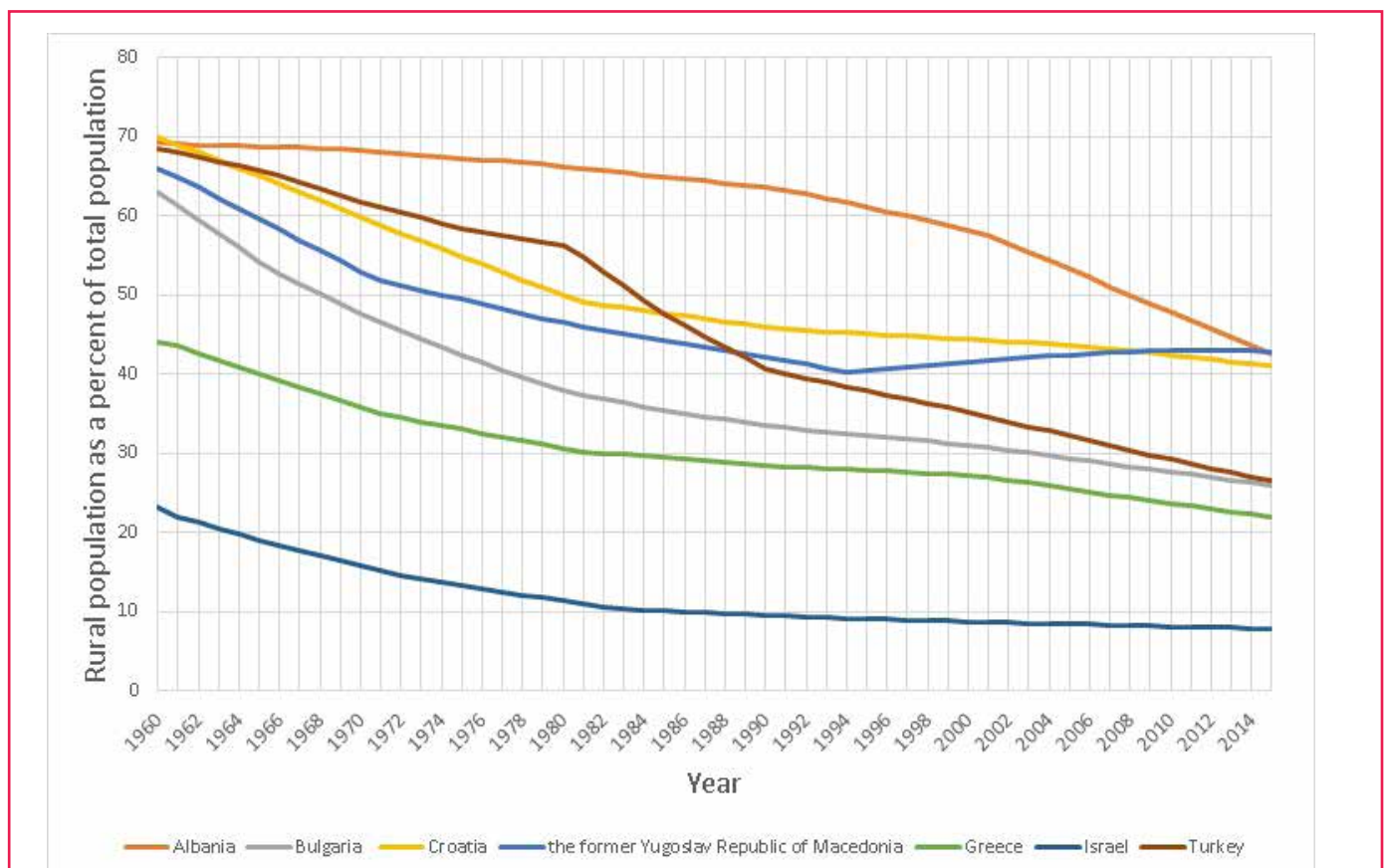


Figure 1—Rural population evolution as a percent of total population in seven countries in the region. Source: Gavriil Xanthopoulos, based on data from IndexMundi (2017).

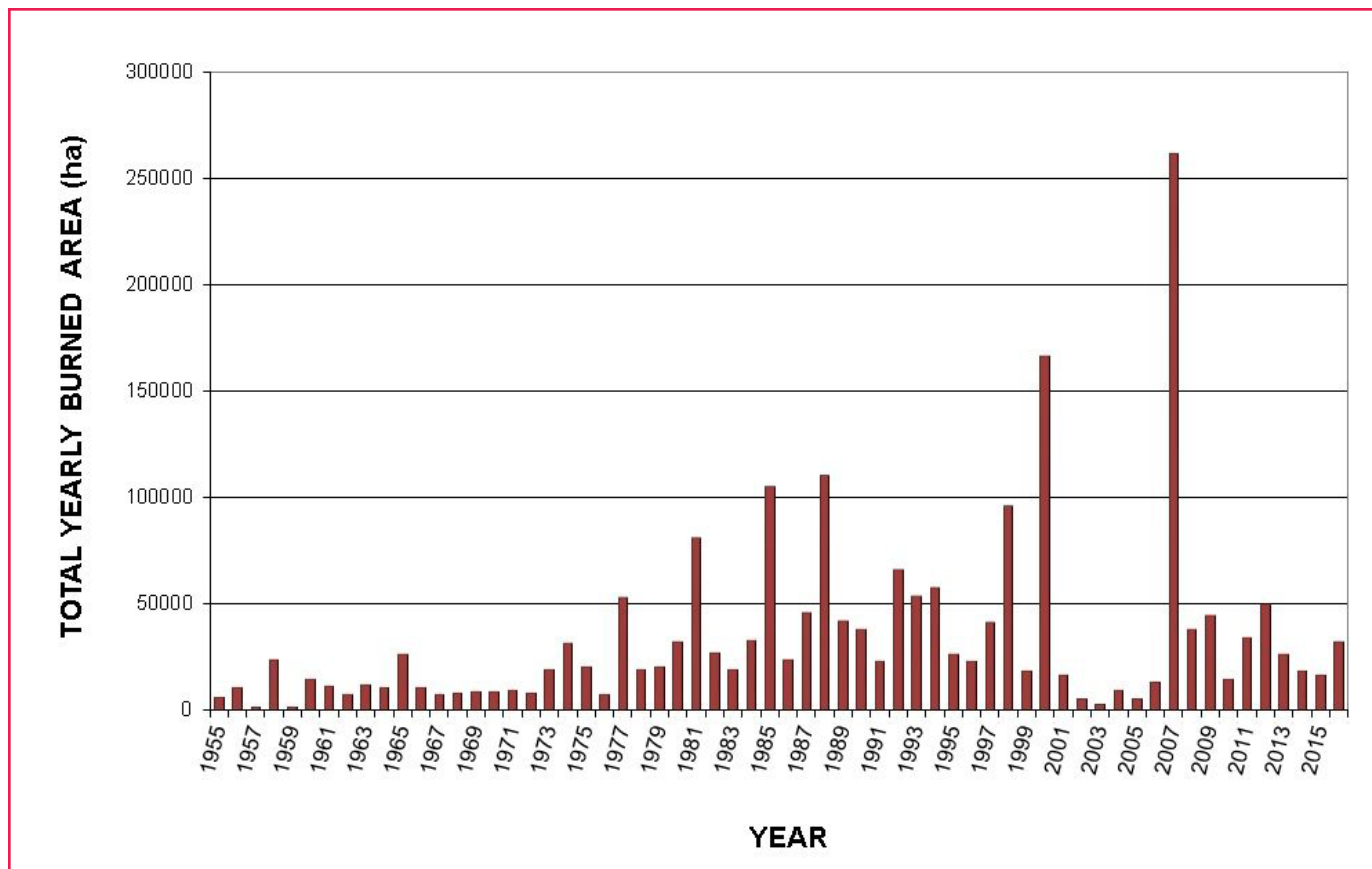


Figure 2—Evolution of the annual area burned in Greece, 1955–2016. Source: Gavriil Xanthopoulos, based on Greek Forest Service and Greek Fire Service annual reports.

contrasting characteristics regarding settlement planning and function, building construction quality, and population behavior. The young are fleeing unemployment and poverty in rural areas and moving to big cities, leaving the old behind. At the same time, the wealthy can afford to flee overcrowded, polluted, and increasingly warming cities to build their residences on the urban fringes. Weekend/summer homes are embedded in increasingly flammable vegetated areas. The desired aesthetics and air quality of the countryside may become a death trap, mirroring the situation in the Western United States or parts of Australia.

Changing Demographics: Impacts on Wildfires

The rural exodus (fig. 1) has greatly affected the demographics and social

structure of countries in the Eastern Mediterranean, Southeastern Europe, and Middle East regions as well as their financial conditions. For instance, the average age of the people remaining in farmsteads and villages is constantly increasing. Most important, however, are the consequences of reduced land cultivation: increasing fuel loads, uncontrolled ecological succession, replacement of traditional agropastoral land use by industrial forest plantations in some countries, and the resulting reduction of breaks in fuel continuity have led to an unprecedented increase in the flammability of landscapes. The increasing average size, intensity, and severity of wildfires throughout the Mediterranean Basin and its vicinity are evident.

The consequences of demographic change for wildfires are quite evident in Greece, for example, where the rural population as a percent of the total population has dropped from 44 percent in 1960 to 22 percent in 2016 (fig. 1). Concurrently, the annual area burned grew substantially (fig. 2), despite significantly increased investments for wildfire suppression after 1998 (fig. 3), when firefighting responsibilities were moved from the Greek Forest Service to the Fire Service. The lack of results can largely be attributed to a very low emphasis on and budget for fire prevention, as opposed to spending on suppression. On average, the annual area burned from 1979 to 1997 was 117,756 acres (47,654 ha), nearly identical to the 114,756 acres (46,440 ha) burned annually from 1998 to 2016, even though investments

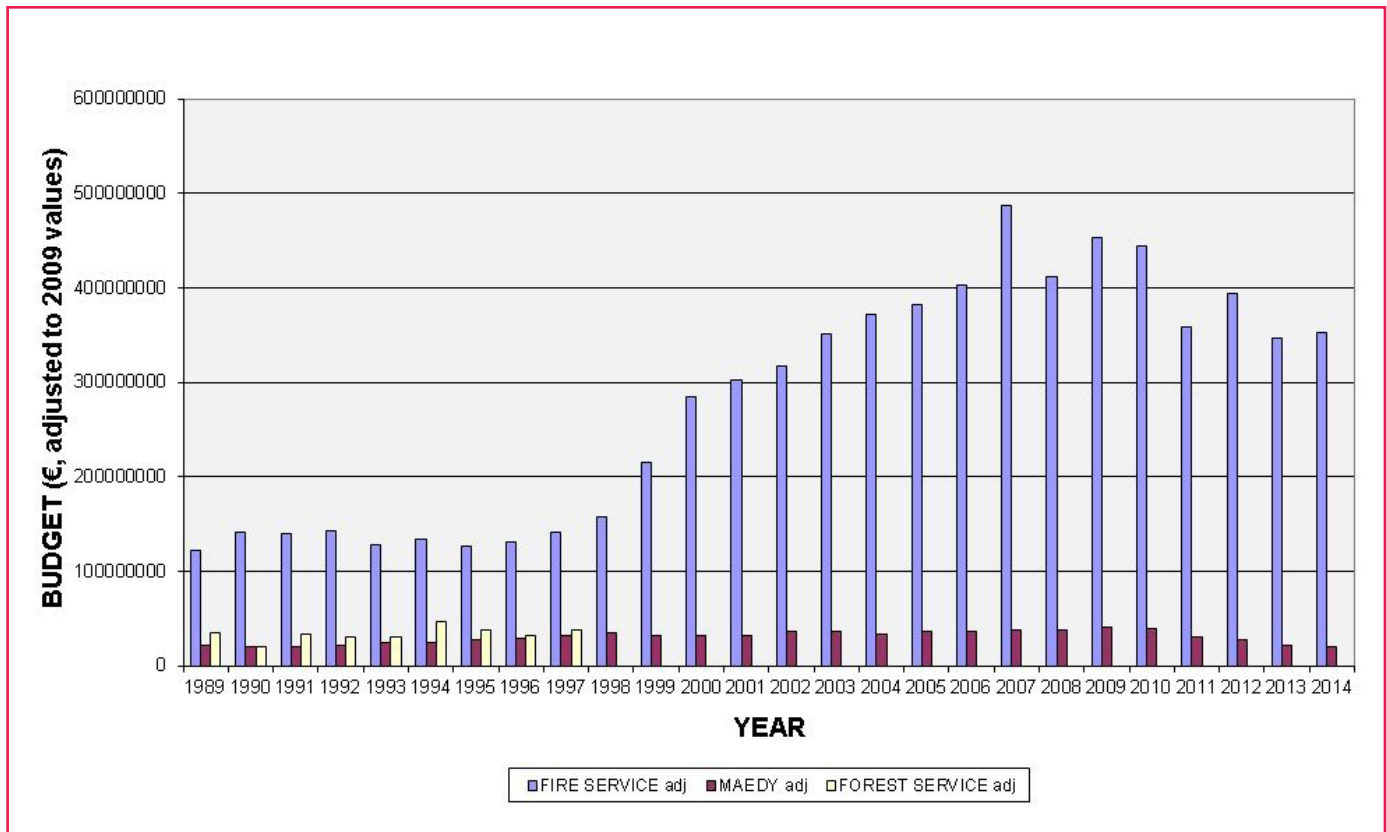


Figure 3—Fire suppression budget evolution in Greece, 1989–2014. The graph includes total fire-related budgets of the Fire Service; the Air Force unit MAEDY, which operates the fleet of light firefighting planes; and the Forest Service, which lost the responsibility for forest firefighting in 1998. The cost of the fleet of Canadair water bombers is not included. Source: Gavriil Xanthopoulos, based on Greek Forest Service and Greek Fire Service annual reports.

in firefighting in the latter period increased significantly. Despite higher investments, in 2007 Greece experienced its worst fire season in history, with 80 fatalities (mostly civilians) and 3,000 homes seriously damaged or destroyed. Furthermore, on July 23, 2018, a single fire that hit a wildland–urban interface area called Mati, which is situated next to the coast 16 miles (25 km) east of central Athens, destroyed the whole community, causing 99 fatalities (figs. 4, 5, 6). The community and the citizens were totally unprepared for an intense wildfire.

The situation is similar in the former Yugoslav Republic of Macedonia. The rural percentage of the population dropped from 72.4 percent in 1948 to 31 percent in 2008; more specifically, the agrarian percentage of the

population dropped from 71.52 percent in 1948 to 11.79 percent in 1994. As a result, large areas of arable land and pastures have been abandoned in the last 6 to

7 decades, and they have become grasslands, shrublands, or even forests. That is one reason for the growing annual area burned (fig. 7).

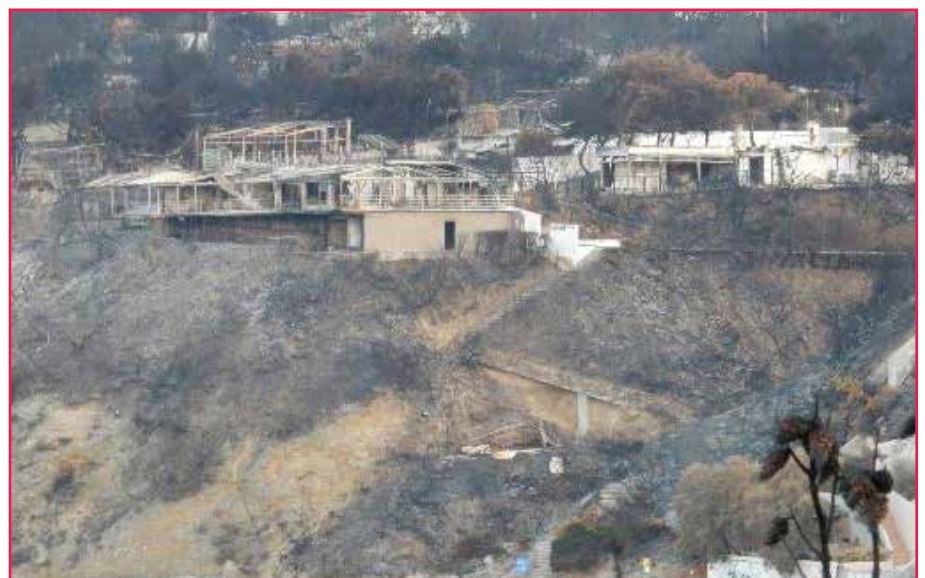


Figure 4—Burned buildings at the crest of the hill above the sea. People reached the sea in panic, with the fire behind them, but access down the cliff towards the water was not always possible.

Efforts to improve forest fire protection systems started in the early 1990s and strengthened during the last 10 to 15 years.

Political and Economic Crises: Impacts on Wildfires

The 1990s were an extremely difficult decade for Southeastern Europe due to the breakup of the Federal Republic of Yugoslavia and the creation of new countries. Ethnic conflicts and civil war affected all countries in the region either directly or indirectly, exacting a high price. The impact of armed conflicts and the legacy of the former centrally planned economy created obstacles to the adoption of effective reforms and hindered socio-economic progress. Delayed and often unimplemented reforms made it impossible to establish fully



Figure 6—One of the narrow streets near the sea where many people fleeing with their cars were caught in a traffic jam with flames burning trees, structures, and cars around them. The photo, taken 4 days later and after the burned cars had been removed, shows a traffic jam at the same point under “normal” conditions, without flames, smoke, or panic.

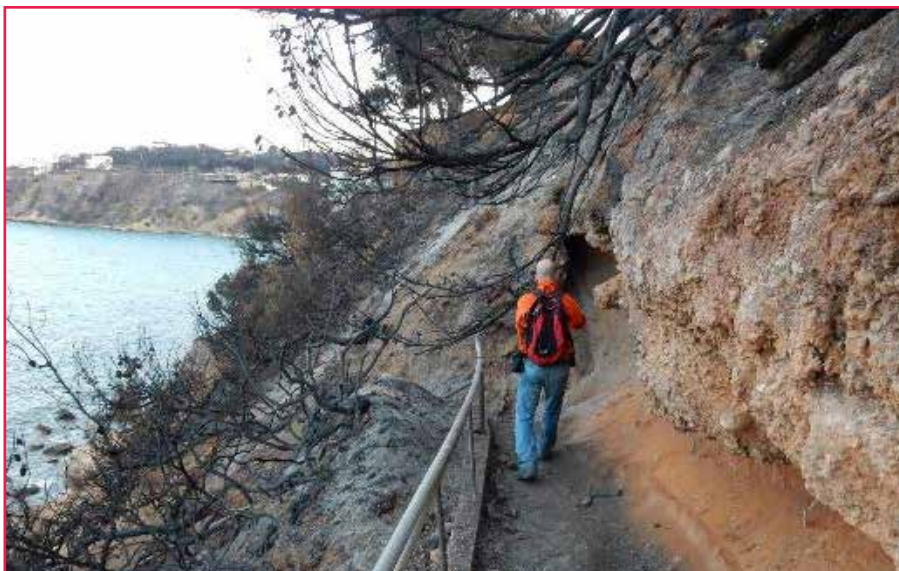


Figure 5—One of the extremely challenging paths along the cliff that many people used to get to the sea, with fire burning around them. Many people did not make it, while those who made it to the sea had to wait for hours to be rescued by boats, some of them finally drowning.

functioning market economies, which led to inferior economic performance, declining living standards, rising unemployment, and poverty. Underdeveloped infrastructure networks, limited foreign direct investment, and weak administrative structures also pose significant challenges.

In addition, the global economic crisis of 2007–8 has affected the region, raising additional financial constraints. External trade,

industrial production, and economic growth dropped sharply in 2009. Unemployment rates, which had been decreasing from very high levels, are predicted to rise sharply again, and the level of public debt remains very high across the region. After most Southeastern European countries performed well in the 2000s, studies show that almost all of their economies are declining or stagnating due to the economic crisis and the decrease in foreign direct investment.

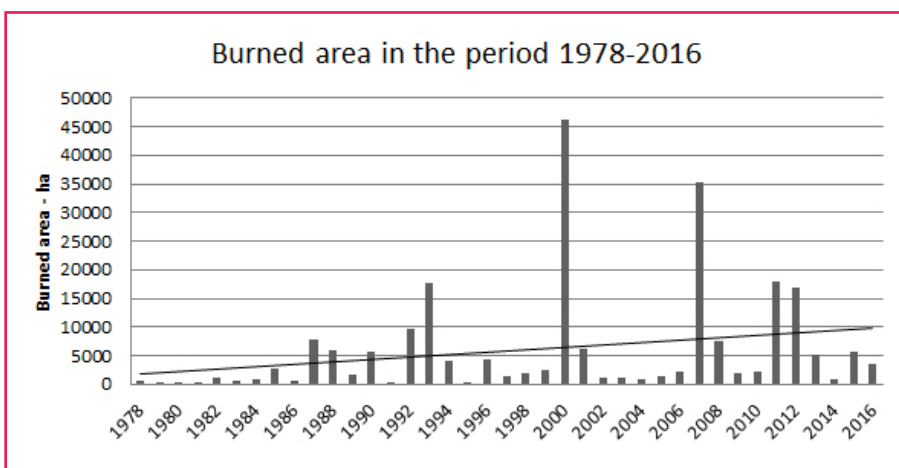


Figure 7—Evolution of the annual area burned in the former Yugoslav Republic of Macedonia, 1978–2016. Source: Regional Fire Monitoring Center, based on information from the Ministry of Agriculture, Forestry and Water Supply and Public Enterprise Macedonian Forests.

Political, social, and economic changes have significantly influenced fires on the landscape. Rural population decreases, changing age demographics, and land use changes worsened forest and rural fire problems due to increasing fire starts and fuel buildups. However, other factors have also contributed to variable fuel buildups across the region. Since the 1980s in Greece, for instance, the use of wood for heating and cooking has been gradually replaced by more convenient energy sources, a major reason for the accelerating accumulation of fuels. In other Southeastern European countries, the use of wood has continued, so fuel buildups have been less. Nevertheless, the Balkan countries gradually became aware of the problem of landscape fires and have begun investing in national fire protection systems.

Enhancing Fire Management Capabilities

Efforts to improve forest fire protection systems started in the early 1990s and strengthened during the last 10 to 15 years. However, it is evident from the generally growing area burned across the region and the growing



Figure 8—A fierce wildfire burning on the fringes of the Greek capital Athens. The Mt. Hymettos Fire on July 18, 2015, revealed the vulnerability of urban and periurban as well as protected areas and greenbelts in the Eastern Mediterranean. Photo: Gavriil Xanthopoulos.

Sharing fire management expertise between Southeast Europe and the countries of the Near and Middle East has become a notable regional effort.

frequency of disastrous fire seasons (including numerous fatalities) that the effectiveness and efficiency of forest fire protection systems is inadequate and that improvements are needed (fig. 8). Because funding for fire management programs will

continue to be limited in this time of financial difficulties, improvements will depend on higher effectiveness and efficiency of investments. These in turn will come through better utilization of scientific knowledge and strengthened



Figure 9—The final seminar of the project called Enhancing of the Ground and Aerial Forest Fire Suppression Capacities in the former Yugoslav Republic of Macedonia was supported by the USDA Forest Service and the Global Fire Monitoring Center and attended by fire management specialists from Serbia and the former Yugoslav Republic of Macedonia. Photos: Regional Fire Monitoring Center.



Figure 10—The first Regional Consultation on Cross-boundary Cooperation in Fire Management was opened by the Minister for Agriculture, Forestry and Water Economy on November 11, 2016, in Skopje, Former Yugoslav Republic of Macedonia. Representatives from Albania, Bulgaria, the former Yugoslav Republic of Macedonia, Greece, Kosovo, and Serbia decided on high-priority actions to improve interoperability in joint cross-boundary responses to wildfires. Photo: Regional Fire Monitoring Center.

- Institutional and sectoral responsibilities in forest fire management,
- Fire management on terrain contaminated by unexploded ordnance and landmines,
- Specialized training and personnel,
- Volunteer firefighters,
- Specialized vehicles and equipment,
- Participation of civil society,
- Use of advanced data processing and information systems (wildland fire early warning and decision support systems), and
- Fire research and its application in forest and fire management.

At a closing workshop for the regional study, a roadmap was developed for reducing wildfire disaster risk by focusing on high-priority strategic activities. Priorities included focusing on fire prevention and strengthening international/cross-boundary cooperation in fire management (REC 2015).

Sharing Expertise Through International Cooperation

International cooperation projects with tangible results are achievable

In Lebanon, like in the Balkans, abandonment of land cultivation is the main driver of increasing landscape flammability.

regional cooperation, including the proactive support of nonstate actors. To meet these challenges, in 2010 the Regional Fire Monitoring Center was established in Skopje, former Yugoslav Republic of Macedonia, with the support of the Global Fire Monitoring Center and the Council of Europe’s Major Hazards Agreement (RFMC 2010a).

A regional analysis commissioned by the Hungary-based Regional Environmental Center titled “Environment and Security Initiative: Addressing the Risk of Forest Fires in the South Eastern Europe” analyzed the situation in six Southeastern European countries (Albania, Bosnia and Herzegovina, Kosovo, Former Yugoslav Republic of Macedonia, Montenegro, and Serbia) (Nikolov 2015). One of the goals of the project was to identify measures that could close the existing gaps in legislation, policy, implementation, and enforcement to

reduce the occurrence and impacts of wildfires in Southeastern Europe. The regional analysis included recommendations for improvements in the following areas related to forest fire management:



Figure 11—Abandoned terraces and collapsing former farmsteads in Lebanon’s Qadisha Valley reflect the trend of declining land cultivation and increasing fuel buildup and wildfire risk in the Eastern Mediterranean region. Photo: Global Fire Monitoring Center.



Figure 12—Forest fires burning in the mountain range of Golestan Province, Islamic Republic of Iran, close to the Caspian Sea and Turkmenistan border. The satellite image (MODIS Aqua, 250-meter resolution) captured wildfires and smoke plumes on December 6, 2010. Source: National Aeronautics and Space Administration.

by exchanging expertise in fire management. For instance, the Regional Fire Monitoring Center and the U.S. Department of Agriculture (USDA) Forest Service’s International Programs launched a project called “Enhancing of the Ground and Aerial Forest Fire Suppression Capacities in the Former Yugoslav Republic of Macedonia” (RFMC 2010b). The project conveyed the experience and knowledge of the USDA Forest Service in coordinating ground and aerial resources in wildfire suppression. Experts from the former Yugoslav Republic of Macedonia and Serbia participated and benefited from this cooperative project (fig. 9).

In November 2016, in response to severe fire seasons in the region in the previous 10 years—and also to the growing effectiveness of the national forest fire protection systems and improving regional cooperation—the first Regional Consultation on Cross-boundary Cooperation in Fire Management was organized in Skopje, former Yugoslav Republic of Macedonia.

The consultation, an initiative by the Global Fire Monitoring Center and Regional Fire Monitoring Center, was supported by the Secretariat of the Council of Europe’s Major Hazards Agreement.

Fire prevention activities must become a priority, especially to maximize the effectiveness of limited funding.

The regional consultation was attended by 39 participants from institutions, state organizations, and nongovernmental organizations responsible for fire management and land management in the former Yugoslav Republic of Macedonia and neighboring countries (Albania, Bulgaria, Greece, Kosovo, and Serbia) (fig. 10). The consultation highlighted the contributions of cross-boundary cooperation in improving the effectiveness and

efficiency of fire management. Key recommendations included:

- Sharing expertise in interagency coordination and cross-boundary cooperation in fire management,
- Holding annual preparedness meetings and exercises,
- Coordinating aerial firefighting, and
- Providing early warning of wildfires near borders and timely communication about other relevant fire management issues.

Sharing fire management expertise between Southeastern Europe and the countries of the Near and Middle East has become a notable regional effort. Cooperation between Israel and its neighbors during fire emergencies in 2010 and 2016 has been followed by cooperative projects between Lebanon and the Islamic Republic of Iran.

In Lebanon, like in the Balkans, abandonment of land cultivation is the main driver of increasing landscape flammability. For instance, the Qadisha Valley, a UNESCO World Heritage Site since 1998, is



Figure 13—The International Fire Management Week in Mazandaran, Kelarabad, Islamic Republic of Iran, was opened by Colonel Ghasem Sabz Ali, Commander of the Forest Guard (Forest, Rangeland and Watershed Management Organization). The meetings were an opportunity to exchange fire management methods with neighboring countries. Local hand crews demonstrated their rapid-attack equipment and initial-attack skills. Photos: Global Fire Monitoring Center.

in a region where landscapes have been shaped by hundreds of years of land cultivation. Recent changes in demographics and land use, along with political instability, resulted in dramatic changes to the Qadisha Valley. As the intensive cultivation of olive groves, terraces, and gardens ended, live and dead vegetation accumulated, resulting in a growing wildfire hazard (fig. 11). Integrated fire management principles have therefore been introduced to strengthen local community-based participatory approaches aimed at protecting the area’s natural, cultural, and spiritual values from wildfire (GFMC 2010).

Close cooperation between two of the Global Fire Monitoring Center’s regional wildland fire networks (for Southeast Europe/Caucasus and for Central Asia) also resulted in cooperative strategic conferences. The meetings were held in the South Caucasus and the Middle East, a region in which fire-sensitive mountain forests are increasingly affected by climate change and wildfires (fig. 12). In 2016, the first International Fire Management Week was held in the Islamic Republic of Iran, where the EuroFire Competency Standards were introduced in the Persian language

and regional cooperation in fire management was discussed (fig. 13). In Greece, the Government responded to the wildfire disaster that affected Mati on July 23, 2018. Prime Minister Alexis Tsipras established an independent commission headed by Professor Johann Georg Goldammer of the Global Fire Monitoring Center and staffed by well-known Greek forest fire experts to study the underlying causes of the worsening fire problem in the natural, cultural, and periurban landscapes of the country and to present a forward-looking plan that will address the current gaps and weaknesses and will guide future fire management.

In February 2019, the commission handed over the report to the Government of Greece. The recommendations for new holistic approaches in landscape fire management are currently being reviewed by the Parliament and the key ministries concerned (Goldammer and others 2019).

Fire Prevention

Fire prevention activities must become a priority, especially to maximize the effectiveness of limited funding for fire

management. Reducing the number of fires, particularly during high fire danger conditions, limits the occurrence of severe events that exceed the suppression capacity of national fire management organizations. The correlation between high fire incidences and very large fires has been recognized by studies internationally. Furthermore, the potential for arson as a method of terrorism becomes a challenge for planning. The terrorism threat and the lessons learned from fire disasters since 2007, including the weaknesses of fire management organizations, have spurred fire prevention efforts.

The European research project “Linking Civil Protection and Planning by Agreement on Objectives” developed a disaster prevention methodology. The methodology was applied to forest fire prevention in many parts of Greece from 2013 to 2014. The approach was participatory; it involved convening local authorities, volunteers, and the public to discuss problems associated with local forest fires. The goal was to identify the most important fire causes, to reach an agreement on specific prevention

objectives, and to develop ideas for risk mitigation through open brainstorming (Greiving and others 2012). An ad hoc working group, formed on the spot by volunteering participants, undertook to act on the ideas with support from the others and from local authorities as needed; the results were encouraging.

An additional initiative is a handbook under the title “Defense of Villages, Farms and Other Assets Against Wildfires: Guidelines for Rural Populations, Local Communities and Municipality Leaders in the Balkan Region,” published by the Global Fire Monitoring Center under the Council of Europe’s Major Hazards Agreement. The handbook was translated from English into other languages and adapted for use in Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Greece, Montenegro, and Serbia, with more languages to follow (GWFN, n.d.).

The examples above highlight the need to:

- Involve the public in and inform the public about efforts to reduce fire starts, and
- Solicit public comment on and contributions toward making wildland–urban interface and periurban areas (and people themselves) safer in the event of devastating fires.

Insightful and pragmatic approaches based on evidence from around Europe point to the need for changes in legislation to support the development of *Fire Smart Territories*, a new concept for sustainable land management. *Fire Smart Territories* includes the use of fire and is based on training and empowering people (Tedim and others 2016).

Fire Suppression

Many weaknesses in fire management, including fire suppression, have become evident in the last 10 to 15 years throughout the Eastern Mediterranean region. Many countries have witnessed terrible disasters. During the 2007 fire season, Greece suffered 80 fatalities; international assistance from numerous countries in the form of both aerial resources and ground crews helped the country bring the blazes under control (Xanthopoulos 2007). Similarly, the Mount Carmel Fire in Israel on December 2–4, 2010, claimed 44 lives. Because Israel lacked the necessary resources to control the blaze, especially from the air, 17 countries responded to Israel’s call for assistance and generously gave aid, including the use of firefighting planes. In 2011, in response to the Mount Carmel Fire, Israel formed an aerial firefighting squadron consisting of seven Air Tractor F-802 planes.

Since these events, there have been numerous cases of cross-border cooperation in the region, especially through aerial assistance. An example was the Eurichou Fire in Cyprus in June 2016, when the country received aerial resources from France, Great Britain, Greece, Israel, and Italy. Unfortunately, due to a prolonged financial crisis since 2009, Greece has been unable to maintain the sizable contracted aerial resources it once could afford. The national aerial fleet of Canadair CL-215s and CL-415s has continued to deteriorate due to old age and imperfect maintenance.

With countries facing tough times financially and wildfires becoming more aggressive, future steps must include careful selection and better use of aerial resources. At the same

time, ground firefighting must improve. European fire managers must revive forgotten methods, such as the use of prescribed fire and backfiring techniques, especially when high-intensity wildfires preclude direct attack. Firefighter training is required for adopting these tools and for improving overall ground fire suppression.

Training in Fire Management and Suppression

In some of the Balkan countries, firefighters are recruited from the forestry sector’s permanent employees (such as forest workers and forestry engineers) but generally only for fire suppression activities, not for prevention. Emergency responders are often given some level of specialized training in fighting wildfires to complement their primary roles in civil protection, urban firefighting, or military service. But when wildfire suppression is only one aspect of the firefighters’ work rather than their professional focus—as is the general rule in most Balkan countries—then their effectiveness falls short. It is therefore important that actors involved in fire prevention and suppression activities acquire additional skills and specialized equipment to meet all the challenges of landscape-scale fire management.

Xanthopoulos and others (2016) give an overview of training systems in Mediterranean Europe, with an emphasis on the Balkan countries. The report discusses significant weaknesses in training, such as the failure to consider the impacts of fire challenges in the context of what the authors call “global change” (“planetary-scale changes in the Earth system,” including changes in population, climate, resource use, energy development,

and other areas). Overall, more advanced firefighter training is needed, including standardization and exchange of experiences between countries. Training must be specialized—specifically tailored to forest firefighting—because such training is lacking in countries where urban fire services carry the responsibility for this task.

During its European EuroFire research project (2006–2008), the Global Fire Monitoring Center produced some very useful training material that can form the basis for standardized forest firefighting training (GFMC 2006). By early 2016, the freely available EuroFire Competency Standards and Training Materials had been translated for use in Armenia, Azerbaijan, Bosnia and Herzegovina, Brazil (Portuguese), Croatia, France, the former Yugoslav Republic of Macedonia, Georgia, Germany, Greece, Iran, Korea, Latin America (Spanish), Mongolia, Montenegro, Russia, Serbia, Turkey, and Ukraine. In 2018, translations into languages serving Southeast Asia will follow (in Indonesian, Malaysian, and Thai).

Region-Specific Solutions

The challenges of forest fire management in the Eastern Mediterranean, Southeastern Europe, and Middle East regions have much in common with the challenges faced around the world. However, the challenges are also associated with characteristics specific to these regions, ranging

from historical development to population characteristics and from financial development to environmental influences on the forest fire problem.

Region-specific difficulties will require locally tailored solutions—solutions that will achieve effective and efficient fire management. Rational, scientifically based fire management policy and organization, supported by careful international knowledge transfer and strengthened regional cooperation, are the best way forward.

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FIRE MANAGEMENT CHALLENGES IN SOUTH AMERICA: COOPERATION AND INTEGRATION

Lara Steil, Patricio Sanhueza, and Marcos Giongo

Readers of *Fire Management Today* may recall the wildfires burning in Chile in early 2017. Chile's catastrophic wildfires resembled last year's extreme fires affecting California, Canada, Portugal, Russia, and South Africa. It is obvious that fire regimes are changing in landscapes around the world—and that the combined effects of climate and land use change are leading factors in the extended duration of fire seasons.

Associated with this development, the vulnerability of ecosystems and people living therein is increasing. South American landscapes are also a part of this trend—from the lowland equatorial rain forests in the Amazon Basin, to the neotropical savannas, to the high-elevation forests of the Andes Mountains. Fires used for clearing and maintenance of agricultural and

Lara Steil is an environmental analyst at the National Center for Prevention and Combat of Forest Fires of the Brazilian Institute for Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), Brasília, Brazil; Patricio Sanhueza is a senior wildfire management specialist for the Development and Investigation Department of the Chilean Forest Service (Corporación Nacional Forestal—CONAF), Santiago de Chile, Chile; and Marcos Giongo is a teacher at the Federal University of Tocantins (Universidade Federal do Tocantins—UFT) and coordinator of the Environment Monitoring and Fire Management Center (Centro de Monitoramento Ambiental e Manejo do Fogo—CeMAF), Gurupí, Tocantins, Brazil.

Fires used for clearing and maintenance of agricultural and pasture lands are the main causes for wildfires in South America.

pasture lands are the main causes of wildfires in South America.

In the first part of this article, we highlight the needs and progress made in responding to the challenges of managing wildfire emergencies by cross-boundary cooperation. In the second part, we look at experiences in applying the principles of Integrated Fire Management in one of the natural landscapes of the continent in order to reduce the vulnerabilities of ecosystems and society to wildfires and the impact on the global environment.

Regional Cooperation in Wildfire Emergency Response

In recent years, some South American countries faced extended droughts and severe fire seasons that exceeded the response capabilities of the nations affected. In order to cope with the wildfire emergencies, many Governments have needed to rely upon the assistance of neighboring and distant countries. Mutual

international assistance is effective and efficient if participating nations have prepared agreements, protocols, and common and regularly exercised procedures. Therefore, the Regional South America Wildland Fire Network, which is operating under the Global Wildland Fire Network and the United Nations International Strategy for Disaster Reduction (UNISDR), took the initiative to strengthen and formalize cross-boundary cooperation in fire management (GWFN 2017).

The activities of the regional network are under the Amazon Cooperation Treaty Organization (ACTO), which is responsible for implementing the Amazon Cooperation Treaty signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela. An important precursor framework of regional cooperation, ACTO takes action in various thematic areas. One of these is related to the implementation of an advisory and training program that allows the strengthening of knowledge and capacities for prevention and control of forest fires. In this context, a proposal under the title Regional Project for Strengthening of Capacities for the Integrated Fire Management in the Member Countries of ACTO has been discussed among the eight countries of the Amazon basin since 2017. The proposal aims to support strategies proposed by the member countries of ACTO to decrease wildfire occurrence and their impacts.

First Targeted Steps Towards Enhancing Effective Cross-Boundary Cooperation

In May 2016, 9 months before the wildfire emergency in Chile, the First Regional Symposium and Consultation on Cooperation in Cross-Boundary Fire Management was held in Parque Nacional Santa Teresa, Uruguay. The symposium was facilitated by the Global Fire Monitoring Center (GFMC) and sponsored by the German Federal Ministry for Food and Agriculture. The consultation was attended by representatives of the forestry and fire services of Argentina, Brazil, Chile, Paraguay, and Uruguay. The meeting addressed the exchange among the participating nations at national and regional levels of information on wildfire occurrence, fire management, and fire emergency response. Participating countries were briefed about international legal agreements and voluntary initiatives in cooperation on fire management, including the activities of UNISDR and the voluntary International Wildfire Preparedness Mechanism (IWPM 2017). The information presented included an introduction of training materials for capacity building in cross-boundary fire management, notably the presentation of the Spanish- and Brazilian-language versions of the EuroFire Competency Standards and Training Materials for future use in regional joint training and exercises in fire management and fire emergency response (GFMC 2006). The concept and draft of the International Fire Aviation Guidelines were introduced (IFAWG 2017).

The regional symposium's development of recommendations for official bilateral agreements or multilateral frameworks

In order to cope with wildfire emergencies, many Governments rely upon assistance from neighboring and distant countries.

within South America aimed at systematically enhancing preparedness and response to wildfire emergencies through cross-border cooperation. The recommendations stressed, among other things, the need for addressing vegetation fires in the context of climate change and the development of policies and actions with regard to mitigation and adaptation. Governments were encouraged to consider Integrated Fire Management as a tool to meet their obligations under the Paris Agreement within the framework of the United Nations Framework Convention on Climate Change of 2015. Furthermore, the recommendations called for a systematic improvement of cooperation in fire management

between South American countries through formal membership in and activities under the Regional South America Wildland Fire Network. The symposium overcame the most significant regional obstacle by calling for guidelines and standard operating procedures for enhancing interoperability among countries in cross-boundary fire management, notably to improve the effectiveness and efficiency of cross-border cooperation and mutual assistance during wildfire emergencies.

The 2017 Wildfire Emergency in Chile and the Followup

Before the recommendations of the consultation of 2016 could be implemented, a severe and long-



Figure 1—The time elapsed between request (red line) and arrival (green line) of international assistance (such as a fire crew, an aerial resource, or an incident management team) to Chile shows that some of the dispatched resources arrived after delays. After arrival, the foreign assistance needed to be accommodated, briefed, and deployed to the most critical fires—for more time-consuming delays. The delays reveal the need for enhancing preparedness and governance of multinational incident management through protocols, standard operating procedures, and rules of engagement. Source: Corporación Nacional Forestal.



Figure 2—Aerial view of smoke from 2017 wildfires in Chile (left) and a satellite image of wildfires (right) south of Concepción, Chile, on the early afternoon of 25 January 2017 taken from the Moderate Resolution Imaging Spectroradiometer on the National Aeronautics and Space Administration’s Terra satellite. Sources: Jordi Brull, Corporación Nacional Forestal (left); National Aeronautics and Space Administration (right).

lasting drought arrived in Chile. Conditions favored the large-scale spread of extremely intense wildfires, many with an explosive “blowup” character. In January and February 2017, about 1.2 million acres (0.5 million ha) in Chile were affected by wildfires, notably in the regions of O’Higgins, Maule, and Biobío (GFMC 2017). In addition to 0.7 million acres (280,500 ha) of industrial forest plantations and 190,000 acres (77,000 ha) of native forests, more than 247,000 acres (100,000 ha) of agricultural and pasture lands as well as bushlands were affected. Eleven people were killed and more than 1,600 homes were destroyed.

The control of the extremely intense, fast-spreading, and severe wildfires exceeded the capacities of the Chilean authorities and the private sector. Numerous countries around the world deployed assistance, including 5 airplanes and more than 600 firefighters. The effectiveness of foreign assistance, however, was rather limited due to delays in arrival and lack of preparedness (fig.1). It became obvious that a lack of

The wildfire emergency
in early 2017
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for interoperability
between neighboring
nations for wildfire crisis
management.

commonly agreed-upon rules and standards for cross-boundary fire management was responsible for a lack of interoperability and swift and effective action.

The wildfire emergency in early 2017 demonstrated the urgent need for taking the next steps to create interoperability between neighboring nations for wildfire crisis management. Common standards for training and firefighting operations are essential for preparing a safe, effective, and efficient cooperative wildfire response (figs. 2–4).

In April 2017, the GFMC and the Chilean agencies concerned with fire management and fire emergency response evaluated the wildfire emergency to identify lessons concerning the effectiveness of international assistance, including the use of aerial assets in firefighting. Discussions between the Chilean Forest Service (Corporación Nacional Forestal, or CONAF), the National Emergency Office (Oficina Nacional de Emergencia del Ministerio del Interior, or ONEMI), and the Ministry for Foreign Affairs revealed a desire and need to transform the existing informal cooperation among South American countries into formalized policy and agreements. This would include the development of guidelines, protocols, and agreements to regulate and ensure effective preparedness and interoperability in bilateral and multilateral ground and aerial fire response operations.

Consequently, a Second Regional Symposium and Consultation on Regional Cooperation in Cross-Boundary Fire Management in



Figure 3—Mobile and stationary incident command posts operated by the Chilean Forest Service (CONAF). Photos: Corporación Nacional Forestal (CONAF 2017).

South America was hosted by Chile in Viña del Mar on October 3–4, 2017, sponsored by the German Federal Ministry for Food and Agriculture and GFMC. The consultation was attended by fire management agencies from Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay, and Venezuela (fig. 5). The concluding declaration—a detailed 18-page document (see the sidebar on pages 43–44)—was an agreement on a set of recommendations aimed at developing formal regional agreements and procedures for cross-boundary cooperation in fire

management. In addition, CONAF and GFMC signed a Memorandum of Understanding on Cooperation in Fire Management within the Global Wildland Fire Network (fig. 6).

Integrated Fire Management Across Landscapes

Since its establishment in 2004, the Regional South America Wildland Fire Network has focused on the scientific and technical exchange of experiences and solutions for strengthening capabilities in Integrated Fire Management.

Integrated Fire Management addresses the causative agents that determine the flammability and susceptibility of landscapes as well as the vulnerability of society living therein. One of the South American landscapes in which Integrated Fire Management has been applied successfully is the Brazilian Cerrado.

The Brazilian Cerrado is considered to be the most species-rich savanna region in the world, containing approximately 5 percent of the global biodiversity. Biodiversity in the region has great socioeconomic importance for local populations, including many indigenous and traditional populations (Coutinho 1990). The Cerrado covers more than 500 million acres (200 million ha). With the advancement of the agricultural frontier, the native vegetation cover of the Cerrado has been diminished by half of its original size. Moreover, the recurrent annual late-season wildfires have severe consequences, such as loss of biodiversity, increased greenhouse gas emissions, and health problems caused by the increased amount of smoke. In 2012, around 60 percent of the emissions of carbon dioxide in Brazil from land



Figure 4—A B-747 Global SuperTanker (United States) and an Ilyushin 76 (Russian Federation) operating jointly in Chile, an unprecedented picture of global cooperation in wildfire emergency support. The ad hoc deployment of foreign air tankers raised many questions about the effectiveness and efficiency of their use without having agreed-upon protocols and common rules/procedures in place before the onset of an emergency. Photo: Corporación Nacional Forestal (CONAF 2017).

Declaration of Viña del Mar on Cross-Boundary Cooperation in Fire Management in South America, 2017



Figure 5—The representatives of nine South American countries jointly elaborated the recommendations for formalizing and strengthening the effectiveness and efficiency of cross-boundary cooperation in fire emergency response. Photo: Corporación Nacional Forestal (CONAF 2017).

The Second Regional Symposium and Consultation on Cross-Boundary Cooperation in Fire Management in South America, which was held in the city of Viña del Mar, Chile, on October 3–4, 2017, was attended by representatives of agencies responsible for fire management from Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay, and Venezuela. In the concluding declaration—a detailed 18-page document—the participants recommended, among other things:

- To constitute a South American Regional Network for cooperation in managing cross-border fires and the management of wildfire emergencies, with the participation of public and private entities from Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay, and Venezuela, with focal points officially nominated in every country.
- To recognize the Union of South American Nations (Unión de Naciones Suramericanas, or UNASUR) as the platform of cooperation in the region responsible for sustaining and supporting the constitution and strengthening the activities of the network.
- To consider the Southern Common Market Treaty (Tratado Mercado Común del Sur, or MERCOSUR), the Andean Community (Pacto Andino–Comunidad Andina de Naciones), and the Amazon Cooperation Treaty Organization as forums for the work of the network.
- To develop and use guidelines and standard operating procedures to improve the interoperability of countries cooperating in cross-border fire management, especially to improve the effectiveness and efficiency of cooperation and mutual assistance in wildfire emergencies, based on the documents reviewed by the symposium.
- To use the International Fire Aviation Guidelines for the application of procedures and operational standard protocols and to develop joint training to enhance interoperability in preparedness and response for cross-border cooperation during forest fire emergencies.

In this spirit, the participants agreed to establish the following Agenda for Regional Cooperation in Fire Management:

- To prepare in joint form an Addendum and a Manual of Procedures for International Cross-Border Cooperation for Enhancing Preparedness for Managing Wildfire Emergencies in the Region, to be presented on the part of the chancelleries of the countries of the region to UNASUR for approval and endorsement.
- To create the Regional Fire Management Resource Center–South American Region based on

a “decentralized” model of two specialized institutions that will cooperate and interact jointly:

1. An institution specializing in research, education, and capacity building in fundamental fire science and fire management, with a head office in the Center of Environmental Monitoring and Fire Management (Centro de Monitoramento Ambiental e Manejo do Fogo) in Gurupí, Tocantins, Brazil. The center will serve as the scientific branch (for fire ecology and fire management research) and as the educational branch of the regional center, including academic education and training in fire management.
2. An institution dedicated to and specializing in the control of wildfires and in emergency management, with a head office at the Corporación Nacional Forestal, Chile. The institution will constitute the operational entity of the regional center, focusing on cross-border cooperation in fire management, training, prevention, and combat of forest fires in South America.

- To accept that the Corporación Nacional Forestal of Chile assumes the function of secretariat for facilitating the process of implementing the recommendations of the Second Regional Symposium and Consultation.
- To promote the development and implementation of protocols, procedures, and memorandums of understandings or agreements between countries of the region for integrated fire management,

- with special emphasis on technical assistance and improving the response to wildfire emergencies by enhancing interoperability and effectiveness in fire management.
- To advance systematically the adoption and application of the Incident Command System as a common approach in South America for the control and coordination of the response to bilateral or multilateral wildfire emergencies.



Figure 6—Signing of the Memorandum of Understanding on Cooperation in Fire Management within the Global Wildland Fire Network between the Chilean Forest Service (Executive Director Aaron Cavieres, right) and the Global Fire Monitoring Center (Director Johann Georg Goldammer, left). Photo: Corporación Nacional Forestal (CONAF 2017).

use, land use change, and forestry were generated in the Cerrado. Extensive wildfires also recur in the protected areas of the biome (which comprise approximately 8 percent of the Cerrado), representing serious threats to the flora and fauna and generating considerable greenhouse gas emissions.

The application of Integrated Fire Management in the Cerrado is based on the ecological adaptation of this ecosystem to fire and involves targeted burning in the early dry season. At this stage of the fire

season, the fires are burning at low intensity, reducing fuel loads that otherwise could lead to high-intensity and high-severity fires in the late dry season (fig. 7). These practices contribute to the preservation of the biome’s functions as a global carbon sink.

A Pioneering Project for South America

Between 2012 and the end of 2017, the Government of Germany supported the Brazilian Ministry of Environment through

the framework of Germany’s International Climate Initiative in achieving the objective of applying Integrated Fire Management in the Cerrado. The activities were developed based on Brazil’s National Action Plan on Climate Change and its Action Plan for the Prevention and Control of Deforestation and Wildfires in the Cerrado. The executing partners were the Brazilian authorities for nature conservation and environment on the federal level, supported on the regional level in Tocantins by the National Institute of Space Research, among others.

The cooperation focused on several key areas, including capacity development for planning and implementing prescribed burning, utilization of modern geoprocessing technologies, and operational training in fire management. Planning tools and environmental education principles were introduced showing alternatives to the use of fire in agriculture as well as ways of decentralizing the authority to conduct controlled burning in agriculture.

Participatory management processes for protected areas through agreements with local communities were applied to improve the controlled use of fire and the sustainable use of natural resources. In addition, research studies were carried out on the impacts of wildfires on biodiversity and climate. Furthermore, methodologies based on remote sensing for monitoring burned areas and deforestation were developed to provide updated information for prevention and suppression of wildfires and to estimate greenhouse gas emissions.

In order to scale up Integrated Fire Management, the corresponding instruments and approaches were and continue to be systematized and disseminated. The goal is to promote public policies that lead to the institutionalization of Integrated Fire Management in Brazil.

The 6 years of cooperation have resulted in a substantial paradigm shift. The zero-burning policy has been replaced by the use of fire as a management tool to reduce fuel loads and the severity of late dry-season wildfires (figs. 8–9), which can affect and damage large areas. This contributes to the conservation of biodiversity and climate. For instance, habitat structures with mosaic characteristics of different



Figure 7—Application of early-season prescribed fire in the Cerrado contributes to reducing the occurrence and severity of late dry-season fires. Photo: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

Participatory management and the application of Integrated Fire Management in protected areas have contributed to reducing conflicts.

fire regimes are created, favoring the survival of biological diversity in this unique landscape.

Participatory management and the application of Integrated Fire Management principles in protected areas have contributed to reducing conflicts and striking a balance between conservation goals and the use of natural resources by local communities. These approaches are supported by an operational automated burned-area mapping system. Combined with information on the fuel loads available for burning, the system contributes to improved planning

and implementation of prescribed burning and management strategies for preventing and combating wildfires. The results of the project, that is, the approaches, tools, and lessons learned from implementing Integrated Fire Management in Brazil, are available on the web (MMA 2017).

Capacity Building for the Next Generation

One of the five objectives of the Second Regional Symposium and Consultation was to discuss the establishment “of a Regional Fire Management Resource Center with two main proposed branches to foster regional capacities in (a) vegetation fire science, education and training, and (b) operational coordination of cross-boundary fire management.” Following the models of the regional centers that have been established by the GFMC in Southeast Europe/South Caucasus (Skopje, Macedonia), Eastern Europe (Kiev, Ukraine), Central Asia (Ulan Bator, Mongolia), South East Asia (Bogor, Indonesia), and Central Eurasia (Krasnoyarsk, Russia), the



Figure 8—Local farmers receive assistance from specialized Integrated Fire Management teams to conduct safe and environmentally beneficial prescribed fires for managing agricultural subsistence farming in the Cerrado. Photo: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.



Figure 9—Between 2012 and 2017, a number of hands-on expeditions and prescribed burning operations have contributed to exchanging international experiences and spreading expertise in fire management to local actors. Photos: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

proposed Regional Fire Management Resource Center for South America will have a focus on research, education, and capacity building in the fundamentals of fire science and fire management.

In 2016, the Center for Environmental Monitoring and Fire Management (Centro de Monitoramento Ambiental e Manejo do Fogo) was inaugurated in Gurupí, Tocantins, Brazil. Gurupí will serve as the scientific and educational branch of the proposed Regional Fire Management Resource Center under the GFMC, including academic education and fire management training (CEMAF 2017). Integrated Fire Management capacity building will be the focus of its role, including the provision of science-based advisory services for sustainable fire management and development of relevant policies.

The center will focus its work on the science-policy-practitioners interface and promote the dialogue between the science community and specialized governmental institutions and civil society organizations. The development of an internet-based information portal will facilitate the application of scientific principles in Integrated Fire Management training and education at the academic level and training of local communities in fire management.

The Way Ahead

In January 2018, CONAF established a secretariat and a task force entrusted with following up on the implementation of the Declaration of Viña del Mar and focusing on raising resources for the establishment of an operations center for the Regional Fire Management Resource Center, with its decentralized branches in Chile and Brazil.

The future of success in enhancing national and regional capabilities in fire management in South America will include and be built on the success of those processes and projects that have been initiated and conducted over the last 4 decades. At the same time, the South American countries will demonstrate their intent to actively participate in and contribute to shaping the development of a cohesive global fire management strategy. This is why the 7th International Wildland Fire Conference will be held in Brazil in 2019, with the international community invited to attend (see the sidebar).

In conclusion, it can be stated that South American countries have taken decisive steps towards addressing the escalating problems arising from excessive fire use and the increasing occurrence of severe wildfires. However, we are not yet where we want to be. Many of the challenges ahead are related to rapid demographic and land use changes. Climate change will become a main driver of transformation in South America's landscape-scale fire regimes, with some uncertainties ahead.

Solutions for fire management will benefit from regional and international cooperation. South America will play its role and contribute to developing a cohesive global fire management strategy. But the region certainly needs support from the international community to address the manifold challenges.

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Coming up:

The 7th International Wildland Fire Conference • Brazil—May 2019

Since 2007, Brazil, through the National Center for Prevention and Combat of Forest Fires (PREVFOGO), a specialized center within the structure of the Brazilian Institute of Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, or IBAMA), has partnered with the Chilean Forest Service (Corporación Nacional Forestal, or CONAF) as coordinator of the Regional South America Wildland Fire Network. Within the framework of the agency networking activities, Brazil has promoted and implemented cooperation programs, projects, and activities at national and international levels. Building on these achievements, Brazil expressed its interest in hosting the 7th International Wildland Fire Conference (IWFC) in 2019. The official announcement of the 7th IWFC in Brazil was made at the 6th IWFC in South Korea in 2015.

The main aim of the conferences is to bring together both the technical members of the fire community and the authorities concerned with policy and national practices in wildland fire management to realize their common interests in wildland fire risk management and disaster reduction at local, national, regional, and global scales. The series of International Wildland Fire Conferences was initiated in Boston (United States) in 1989, followed by Vancouver (Canada) in 1997, Sydney (Australia) in 2003, Sevilla (Spain) in 2007, Sun City/Pilanesberg (South Africa) in 2011, and Pyeongchang (South Korea) in 2015. After being held on most other continents, the IWFC will be held for the first time in South America in Campo Grande, Mato Grosso do Sul, Brazil, from May 6 to May 10, 2019. Online information will be available soon—or contact wildfire2019br@gmail.com.

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CHALLENGES IN MANAGING LANDSCAPE FIRES IN EASTERN EUROPE

Sergiy Zibtsev and Johann Georg Goldammer

This report from Eastern Europe provides insight into the multifaceted problem of managing fire in the landscapes of Ukraine, a country that is experiencing dramatic changes in its environment and society. Many of the problems highlighted in this paper exemplify the problems that are common in the countries of the region from the shores of the Eastern Baltic Sea down to the Black Sea, including the cultural and natural landscapes of the Baltic States, eastern Germany, Belarus, Poland, and Moldova.

Regional Context

Climate change, land use change, and the deterioration of the socioeconomic and political situation are main drivers of the worsening wildfire situation in Ukraine. Most importantly, the country faces the challenge of dealing with fires burning in extended areas of forests and other vegetation types that were contaminated by radionuclides after the failure of the Chernobyl Nuclear Power Plant in 1986. The legacy of unexploded ordnance and

Sergiy Zibtsev is a professor at the Institute of Forestry and Landscape Park Management, National University of Life and Environmental Sciences of Ukraine, and head of the Regional Eastern Europe Fire Monitoring Center in Kiev, Ukraine.

Johann Georg Goldammer is a fire ecologist and director of the Global Fire Monitoring Center, Max Planck Institute for Chemistry and Freiburg University, Freiburg, Germany.

collateral damages caused by the armed conflict in the southeastern Ukraine region creates additional, nonstandard risks for firefighters.

Eastern Europe is experiencing the consequences of climate change, which already have led to more frequent dry spells and heat waves and the extension of fire seasons. For instance, in the southern part of the country, Ukraine is facing challenging fire weather conditions year round, with an increased risk of

landscape-scale ecological function by preventing desertification and sandstorms in the region.

The economic crisis in the country and the Government cut of financial support for forestry since January 2014, as well as the process of reformation of forestry in Ukraine, have resulted in a sharp reduction of budgets for fire management activities, which state forest enterprises used to generate from their timber sales. As a consequence

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uncontrollable large fires. Massive dieback of Scotch pine (*Pinus sylvestris*) has occurred all over the Polesie region (the north of Ukraine from Chernihiv oblast to Volyn).* Here, a ban of sanitary cutting has resulted in a dramatic increase of fuel loads within forests. It is estimated that the combined impacts of climate change, wildfires, and illegal logging have resulted in a loss up to 2 million acres (0.8 million ha) of protected forests and forest belts (windbreak systems) in the southern part of the country. This includes the loss of a substantial part of the Oleshki pine forest in Kherson oblast, which has an important

of reduced state budgets, from 50 to 70 percent of the fire management staff (forest fire station employees, firefighters, and fire observers) had to be released in the southern region of Ukraine (Dnipropetrovsk, Donetsk, Kherson, Kirovograd, Lugansk, Odessa, Mykolaiv, and Zaporizhka oblasts). The forest enterprises in this steppe zone could not compensate for the reduced budgets because they do not generate income from timber sales due to the low quality and

* "Oblast" is the Ukrainian and Russian term for region, more or less equivalent to a State.

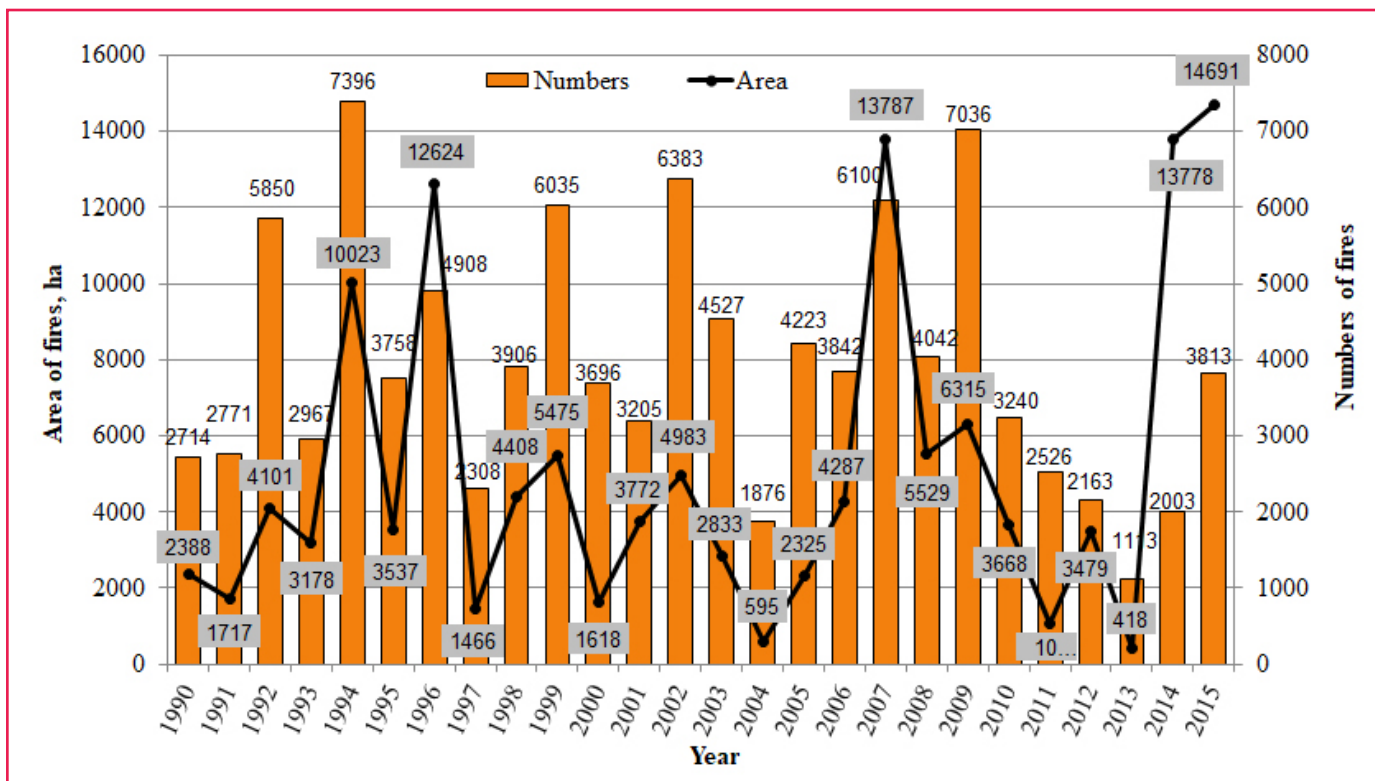


Figure 1—Number (line) and area of forest fires in Ukraine, 1990–2015. Source: Soshenskyi and others, *in press*.

productivity of forests. Thus, these rapid changes in environmental, social, and economic conditions require urgent attention and analysis that could be used for development of a national fire management policy.

Forest Fires in Ukraine

The total area of forests in Ukraine is about 23.7 million acres (9.6 million ha), covering less than 17 percent of the total land area. The share of coniferous forests is about 42 percent (that is, around 10 million acres (4 million ha)), of which about 33 percent comprises Scotch pine forests. Most forest fires in Ukraine occur in the pine forests in the north of the country (in Polissia) and in the central and southern regions, where forest belts are stocking alluvial sands along the main rivers (Dnipro, Dnister, Yuzgnii Bug, Desna, and Siverskii Donets).

The annual number of forest fires and area burned have been increasing rapidly during the last 25 years. In

the 1980s, between 2,000 and 3,000 wildfires were recorded annually; the last decade experienced an increase, with about 7,000 fires on average per year. Figure 1 shows the wildfire statistics for the period from 1990 to 2015. During this period, the average size of forest fires increased from 0.3 ha in 1990 to 2.6 ha in 2015.

It is highly probable that the actual areas of burned forests are even higher since the national system of fire statistics mainly includes fires reported in forests under management by the State Agency of Forest Resources of Ukraine. Fires that occurred in forests under the jurisdiction of other agencies (27 percent of the total forest area) often were not registered and reported.

Despite the reduced fire management budgets in Ukraine, forests still are better protected from wildfires than are agricultural and other lands, including protected territories. Apart from the current difficult economic situation, forest fire management is

relatively well regulated. More than 300 state forest enterprises rely on 270 forest fire stations distributed throughout Ukraine. Fire brigades in the stations are responsible for fire prevention and initial attack in the state enterprises. Wide implementation of video surveillance for fire detection has significantly reduced the time of response and contributed to improved and more effective initial attack.

However, pressing problems in the country include outdated fire engines, often more than 30 years old, and a generally low level of forest firefighter training. The paramount challenge for fire suppression is the lack of trained incident commanders who are able to manage the complex and large fire incidents that have increasingly occurred in recent years.

Agricultural Burning

Significant land use changes have occurred in Ukraine in recent

decades. From a total of 149.25 million acres (60.4 million ha) of Ukrainian lands that were state owned in 1991, up to 77.6 million acres (31.4 million ha) became private lands and 190,000 acres (77,000 ha) were transferred to collective and communal ownership by 2014. The drastic changes in land use and ownership were not accompanied by new institutional systems that would support the new landowners through appropriate extension services and subsidies. Small landowners are not in a position to protect their lands from fires due to lack of resources and training.

Most importantly, however, the majority of farmers burn agriculture residues instead of plowing or using no-till conservation agricultural methods. As a result, fires on agricultural and other lands in Ukraine have become a regular practice in spring and late

Most farmers burn agriculture residues instead of plowing or using no-till conservation agricultural methods.

summer, resulting in considerable environmental pollution and also becoming the major cause of wildfires spreading to forests and protected areas.

One of the regional problems associated with agricultural burning is the emission of so-called black carbon, also called elemental carbon or soot. With the prevailing southerly winds during the burning seasons, the black carbon particles are transported to the Arctic environment. The black carbon deposits reduce the albedo and accelerate the melting of ice and snow (Zibtsev and others 2017).

Within the framework of cooperation between the Regional Eastern Europe Fire Monitoring Center and the Global Fire Monitoring Center (sponsored by the research and development portfolio of the Council of Europe in the implementation of the European Major Hazards Agreement), the spatial and temporal patterns of open burning in Ukraine were studied for the time period 2010–16 (Zibtsev and others 2017). The analysis of satellite data (MODIS sensor) showed that during the investigation period, an average of about 6,500 instances of large-scale agricultural burning were recorded annually, with an apex in 2014 and 2015, when more than 8,000 and

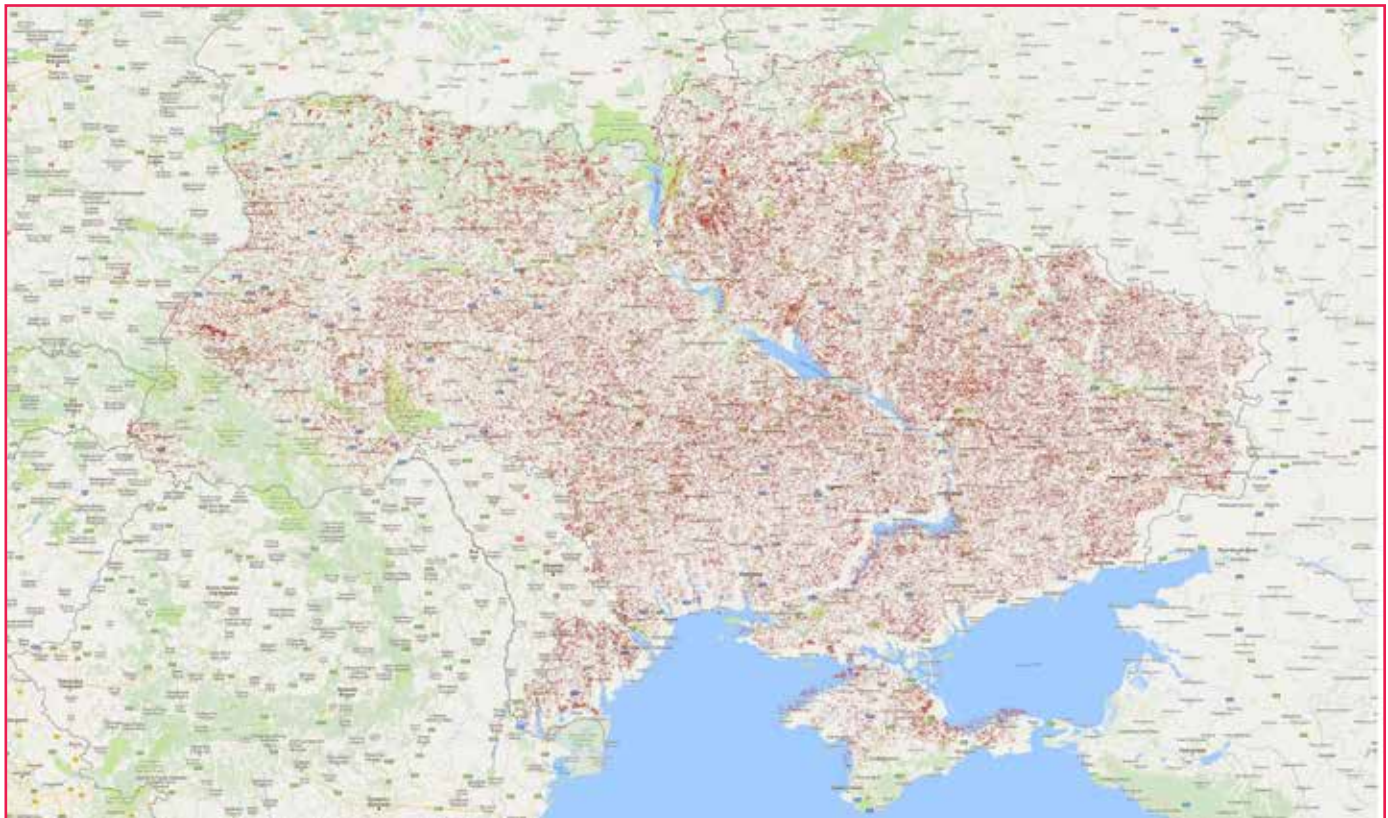


Figure 2—Distribution of open burning activities (red dots) on the territory of Ukraine in 2015. Source: Zibtsev and others (2017).

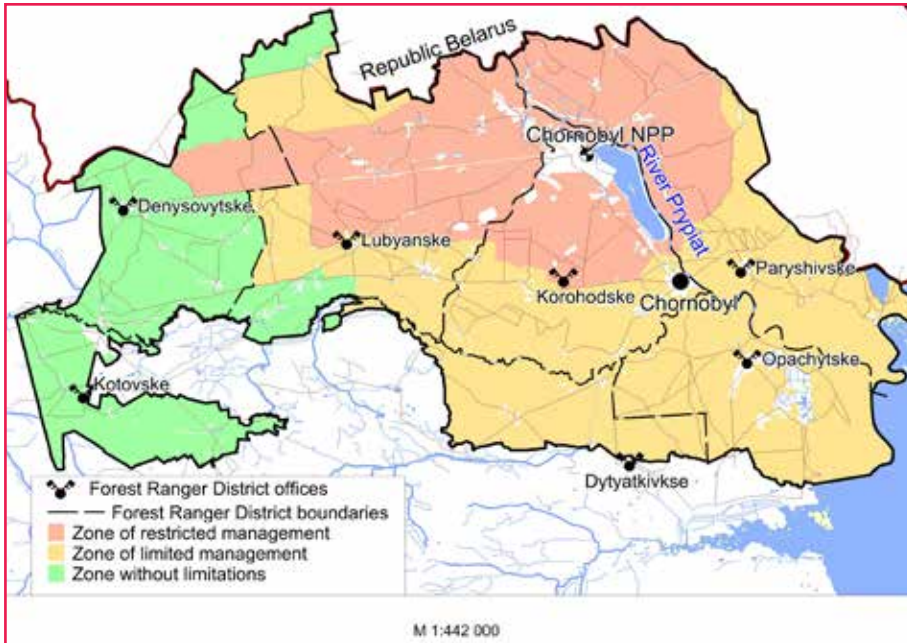


Figure 3—Locations of the forest ranger district offices in the different contamination areas within the Chernobyl Exclusion Zone. Each district office has a forest fire station. Scale of map: 1:442,000. Source: Zibtsev and others (2015b).

9,000 fires occurred, respectively. Agricultural burning is practiced primarily in spring (March–April) and after the summer harvest (July–August), mainly in the south of Ukraine (fig. 2).

The total annual area of open burning in Ukraine during the study period varied from a low of 3.16 million acres (1.28 million ha) in

2010 to a high of 13 million acres (5.27 million ha) of agricultural lands burned in 2014 (fig. 2). It needs to be pointed out that extreme drought affected Eastern Europe during the summer of 2010. While the drought created a problematic situation in the European part of Russia, the situation was different in Ukraine. The implementation of an order of the Government of Ukraine

on July 31, 2010, resulted in the prevention and swift initial control of agricultural burning, thus reducing the amount of wildfires significantly.

Overall, it must be stated that wildfire threats for rural populations, their assets, and the regional environment increased during the last decade. The amount of rural houses lost to wildfires has increased. Fires affecting protected areas, fire-sensitive landscape types, flood plains, and swamps are negatively affecting the functioning and biodiversity of these ecosystems.

Fire Management on Terrain Contaminated by Radioactivity

Ukraine and Belarus are the two countries with the largest terrains that were contaminated by radionuclides after the failure of the Chernobyl Nuclear Power Plant in 1986 (Zibtsev and others 2011). In Ukraine alone, over 2.4 million acres (1 million ha) of pine and softwood forests in Chernihiv, Kiev, Zhytomyr, Rivne, and Volyn oblasts were contaminated in the Polissia region along the border with Belarus.



Figure 4—Left: example of a 35-year-old jack pine (*Pinus banksiana* Lamb.) stand in the Chernobyl Exclusion Zone (Korogod Forest Ranger District). Right: a 40-year-old Scotch Pine (*Pinus sylvestris* L.) plantation, also in the zone. Both stands were classified as in fire hazard class I. Photos: Sergiy Zibtsev (August 2014).

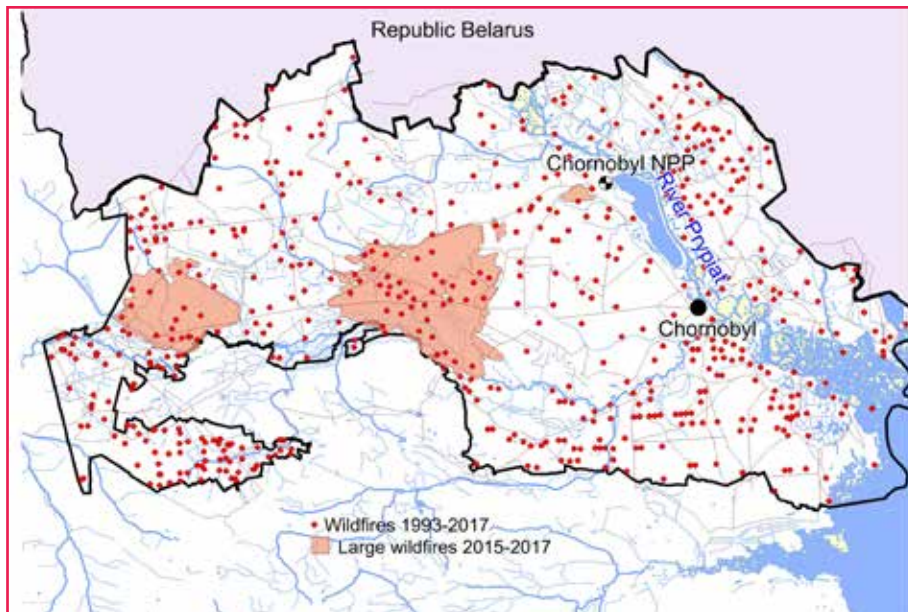


Figure 5—Spatial distribution of wildfires in the Chernobyl Exclusion Zone from 1993 to 2017, including two large wildfires. The one on the right was in April 2015 (22,800 acres (9,241 ha)), and the one on the left was in August 2015 (14,000 acres (5,698 ha)). Source: Regional Eastern Europe Fire Monitoring Center.

Consequently, a special system of limited forest management was put in place right after the accident based on the level of contamination of the soil and vegetation and the potential doses of radioactivity to which forestry personnel and population would be exposed.

Firefighting in such a contaminated terrain is extremely problematic because personnel are subject to the risk of inhaling additional doses of radionuclides due to the radioactive particles in the smoke and dust released during firefighting.



Figure 6—Wildfire (red and black/gray, center left) burning in the Red Forest area, which has the highest level of radiation in the Chernobyl Exclusion Zone. The fire was 1.9 miles (3 km) west of the failed Reactor No. 4 of the Chernobyl Nuclear Power Plant (the bright area in the upper center right of the satellite imagery shows the newly constructed sarcophagus, which is covering the destroyed Reactor No. 4). The total area burned was 600 acres (250 ha). Source: Copernicus Sentinel, 17 July 2016.

Since 2014, armed conflict has resulted in significant collateral damage to the natural and cultural landscapes of eastern Ukraine.

Six main types of radionuclides have contaminated the soils and fuels in the environment around the Chernobyl Nuclear Power Plant: Cesium (^{137}Cs), strontium (^{90}Sr), plutonium (^{238}Pu , $^{239-240}\text{Pu}$, and ^{241}Pu), and americium (^{241}Am). With half-life periods of up to 24,065 years, these radionuclides release all types of radiation—alpha, beta, and gamma. They are found in all fuel types in contaminated forests, mostly in forest litter, the duff/humus layer, mosses, mushrooms, and the understory vegetation. In grass fires and surface forest fires, most of the radionuclides stay within the inhalation zone of firefighters and are transported by wind and deposited within kilometers around the fire. During large high-intensity fires, vertical convection columns may lift the radionuclides into the higher altitude atmosphere (3 or more miles (5+ km)) and are subjected to long-range transport at regional and even global levels.

After the failure of the Chernobyl Nuclear Power Plant in April 1986, all forest and fire management activities were stopped in the most contaminated terrain, which was designated as the Chernobyl Exclusion Zone (CEZ). Only personnel engaged in the construction of the first concrete-built sarcophagus were allowed to stay. After several large wildfires occurred in the CEZ in 1992, a special forest management

enterprise was reinstalled, with 400 forestry and fire personnel tasked to prevent and fight fires (fig. 3). Although the region enjoyed a period of fire exclusion, major wildfires occurred in 1996, 2003, and 2007. During this period, ecosystems in the CEZ became more and more fire prone due to increasing fuel loads in unmanaged forests and grasslands. The level of the fire hazard on forest lands in the CEZ has been classified, with radioactive contamination taken into account. In particular, the highest hazard class (hazard class I) includes all conifer forests less than 40 years old, all conifers on dry and sandy soils, sites affected previously by fires, clearcuts, grasslands, and all sites with contamination levels higher than $55,500 \text{ Bq m}^{-2}$ (fig. 4). The forest fire brigades in the CEZ are very good in responding to small wildfires burning under moderate weather conditions. Each of the six forest fire stations in the CEZ has two to four fire engines and between three and five firefighters; each is responsible for initial suppression on areas up to 99,000 acres (40,000 ha).

The intensity and size of wildfires that affected the CEZ from 2015 to 2017 are due to growing fuel loads and fire hazards, mitigated by effective early response (figs. 5 and 6). However, the management of large fires in 2015–17 revealed weaknesses in preparedness for and response to large/high-complexity fires.

Wildfires and Armed Conflicts

Apart from the problems associated with the nuclear accident of 1986, Ukraine is currently confronted with the consequences of the armed conflict in Donbas. Donbas is an old cultural landscape that has been subject to intensive land use for centuries. The fertile black soils of the former natural



Figure 7—Uncontrolled burning of the steppe (top) and postfire dieback of a pine stand in the Cretaceous Flora Reserve (bottom). Photos: Sergey Limanskij.

steppe ecosystems are productive agricultural lands.

The main types of forest include mixed oak–maple–ash forests on rich but eroded black soils, extended pine forests growing on sandy soils along the river Siversky Donets, and forests on river delta governed by poplars, willows, and hardwoods. The total area of forests in Donetsk and Lugansk oblasts is 786,780 acres (318,400 ha). More than 80 percent of the forested area is planted forest stands, which are protected and managed to perform exclusively environmental and recreational functions. In addition, there are special protected territories in the region: the Lugansk Nature Reserve,

Khomutovskaya Steppe Nature Reserve, Ukrainian Steppe Nature Reserve, and Meotida National Park.

Since 2014, armed conflict has resulted in significant collateral damage to the natural and cultural landscapes of eastern Ukraine. Wildfires also damaged the industrial and social infrastructure and thus contributed to the worsening economic situation and security in the region. Apart from damages to agricultural lands and burned forests, some settlements and critical infrastructure (the electricity grid) have been destroyed by conflict-related wildfires. Additional factors contributing to the situation included the cessation of regular activities to

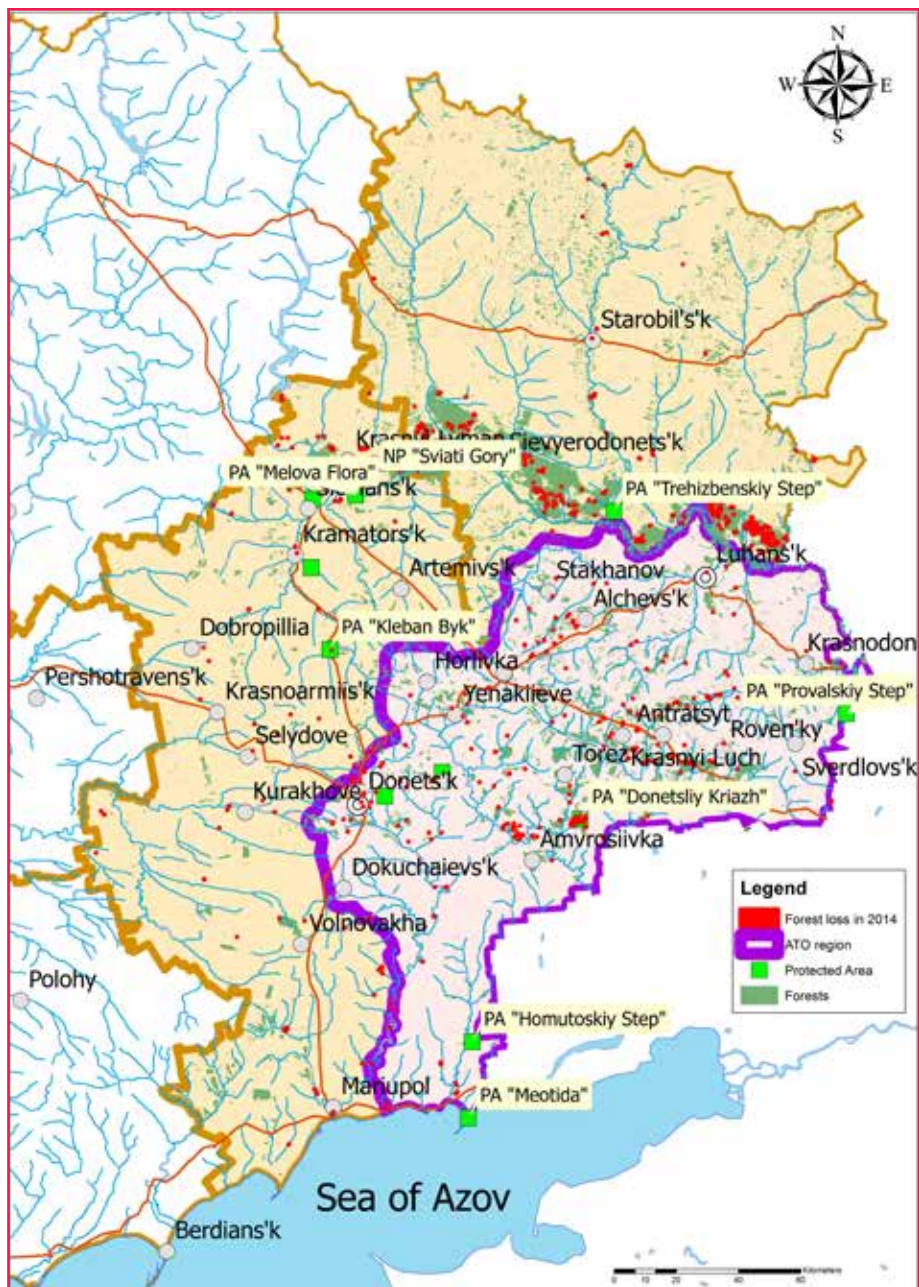


Figure 8—The locations of wildfires, protected areas, and forests in the conflict zone in eastern Ukraine. (The ATO region is contested, as are areas throughout the conflict zone.) Source: Zibtsev and others (2015a).

maintain residential and industrial infrastructure and the protection of ecosystems, continuing military operations, and the resettlement of more than 1.5 million citizens from the region (Zibtsev and others 2015a).

Some protected areas bordering on conflict territory have been severely affected by the armed conflict: the Trekhizbenskaya Steppe Reserve, Pridontsovskaya Delta Reserve, Cretaceous Flora

Reserve, Preserve “Stone Graves,” National Park Svyatiye Gory, Natural Reserves Donetsk Ridge, Zuevsky, and Kleban-Bik (fig. 7). Military operations have even led to significant changes in protected areas remote from the conflict zone, such as the Kremenskiy Preserve, Kramatorskiy Preserve, and others.

Fire management activities in the regions with active military

fighting were halted due to the risk to the lives and safety of forest fire personnel, both from direct attack and from unexploded ordnance. Exploding land mines were the main cause of wildfires in Scotch pine stands in Donbas. Fire suppression operations were not carried out in zones at risk from shelling. In most cases, wildfires continued to burn until they were halted by natural breaks.

According to the Luhansk Forest Amelioration Station (Zyatkov 2018), fires in the conflict zones have already destroyed at least 49,400 acres (20,000 ha) of pine forests, equivalent to about 22 percent of all pine forests in the region. A total of 4,867 wildfires were recorded in the conflict zone by satellite sensors during military operations. Seasonal dynamics of fires correlate well with combat operations, in particular near Ilovaisk city in August 2014 (fig. 8).

Protection of forests from fires in a 9-mile (15-km) zone along the line of contact between the sides stopped shortly after the outbreak of the conflict. The reason was a number of fatalities and injuries of fire management personnel on fire towers caused by snipers and the effects of exploding ordnance on ground firefighters. Furthermore, several fire engines belonging to the forest fire stations were seized by the other side. Often, the military did not allow firetrucks to respond to fires. Since the region is highly fire prone, the halting of fire management activities has led to a significant increase in the number, area, and intensity of fires.

Apart from the direct impacts of fires, the collateral damage caused by the armed conflict has included significant damage to forests. Exploding ordnance has caused widespread damage to the roots, bark,



Figure 9—Contamination of forest litter by unexploded ordnance (left), along with a shell crater (center) and a booby trap (right), exemplifies the threats and damage caused by the armed conflict in the Donbas region. Photos: Sergey Limanskij.

and crowns of trees, resulting in the weakening and increased mortality of trees and the formation of gaps in the forest canopy and root sponge. The contamination by unexploded ordnance of significant areas constitutes a high threat to the local population (fig. 9), which continues to visit the forests in order to harvest traditional products—mushrooms, berries, and medicinal herbs.

Sharing Fire Management Solutions Through International Cooperation

In order to benefit from international expertise in fire management in dangerous terrains, the National University of Life and Environmental Sciences of Ukraine contacted the Global Fire Monitoring Center (GFMC) in 2006. At that time, the GFMC was entrusted by the United Nations International Strategy for Disaster Reduction, the Council of Europe, and the Organization for Security and Cooperation in Europe (OSCE) with assisting countries in Southeast and Eastern Europe and the South Caucasus in developing fire management concepts in regions affected by armed conflicts, especially in terrains contaminated by unexploded ordnance and other contaminants (Goldammer 2013a).

In 2007, the Council of Europe and the OSCE supported the

organization of the first conference on Reducing Risk of Disaster from Catastrophic Wildfires in the Chernobyl Irradiated Forests, held in Kiev, Ukraine. The conference was followed by an event called Advanced Seminar—Wildfires and Human Security: Fire Management on Terrain Contaminated by Radioactivity, Unexploded Ordnance (UXO) and Land Mines, held in Kiev and Chernobyl in 2009.

Following the recommendations of experts in these meetings, the

Council of Europe, through its European Major Hazards Agreement, and the GFMC provided financial and technical support to the National University of Life and Environmental Sciences of Ukraine to set up the Regional Eastern Europe Fire Monitoring Center (REEFMC). Since its establishment in 2013, the REEFMC has been supported by and has cooperated with a number of academic and specialized institutions. Apart from the continuing cooperation with and support of the GFMC and the

European countries are actively exchanging expertise in fire management.



Figure 10—Sand table exercise for Chernobyl firefighters, conducted jointly by fire specialists from the U.S. Forest Service and the Ukrainian fire response teams. Photo: Regional Eastern Europe Fire Monitoring Center.

Most important is the creation of interoperability between countries that share common problems along their national boundaries.

Global Institute of Sustainable Forestry at Yale University, the REEFMC is currently working with the Global Environment Facility and United Nations Environment Programme within the framework of the project Conserving, Enhancing and Managing Carbon Stocks and Biodiversity in the Chernobyl Exclusion Zone and the OSCE project Improving Radiological and Environmental Awareness in Territories Affected by the Chernobyl Accident in Belarus and Ukraine, with a focus on wildfire management. The OSCE project provided a set of guidelines and best practices for fire management in contaminated terrain, which was applied in May 2018 in the first bilateral exercise on cross-boundary cooperation in wildfire emergency response between Ukraine and Belarus (Goldammer and others 2014, 2016a).

After several large wildfires in the CEZ in 2015, a project funded by

the U.S. Department of Agriculture Forest Service and the U.S. Department of State, with the support of the U.S. Embassy in Ukraine, was initiated in 2016. The project, operational from 2016 to 2018 and built on previous activities since 2005, aimed to increase the capacity and safety of fire management in the CEZ. It included facilitating an interagency dialogue

with the aim of determining urgent mid- to long-term actions/needs for reducing the risk of catastrophic, uncontrollable fires in the CEZ and increasing the safety of firefighters engaged in suppression. A total of 431 Ukrainian specialists in fire management in the CEZ participated in the project meetings and training sessions during the past 16 months of project activity (fig. 10).

At the policy level, Ukraine is supported by the Council of Europe through the European Major Hazards Agreement—the so-called European Open Partial Agreement



Figure 11—The first joint tabletop exercise by Ukrainian and Belarussian agencies responsible for fire management and emergency situations was conducted in Gomel, Belarus, under the auspices and sponsorship of the Organization for Security and Cooperation in Europe. Incident commanders from Belarus (left) and Ukraine (right) were supported by a team of moderators (middle, blue vests), administrators (red), and observers/rapporteurs (yellow). Photos: Organization for Security and Cooperation in Europe; Evgeniy Maloletka.



Figure 12—Prescribed fires and wildfires in Brandenburg State (Germany) on terrain contaminated by unexploded ordnance are safely controlled by armored firefighting engines. The SPOT-55 is a converted former T-55 combat tank with high-pressure firefighting equipment and a volume of 11 tons of water or other fire suppressants. Photos: Global Fire Monitoring Center.

(EUR-OPA), to which Ukraine is a party—and the GFMC, a mandated specialized center and coordinator of the Eurasian Team of Specialists on Landscape Fire Management serving the implementation of EUR-OPA. In light of the still unresolved problems of fire management in areas affected by radioactivity, agricultural burning, and climate change, the REEFMC and GFMC convened the first National Round Table on Fire Management under the title Fires in the Natural and Cultural Landscapes of Ukraine: Towards the Development of a National Fire Management Policy. The outcomes of the roundtable, held in Kiev in

October 2017, include a statement on the need for developing legal and administrative regulations as well as law enforcement to address the complex problems of fire use and wildfires in the natural, cultural, and industrial landscapes of Ukraine.

Regional Exchange I: Fire Management in Contaminated Terrain

European countries are actively exchanging expertise in fire management. While the Euro-Mediterranean countries have a strong focus on wildfire suppression, the countries of the temperate

zones of Western-Central and Northern Europe prioritize a fire prevention agenda and the use of prescribed fire for wildfire hazard reduction and conservation. These themes, based on several years of cooperation among the GFMC, Ukraine, and Poland, were presented at the Regional Consultation on Cross-boundary Cooperation in Fire Management, which was held in tandem with Ukraine’s National Round Table in October 2017.

Most important is the creation of interoperability between countries that share common problems along their national boundaries, such



Figure 13—A former BMP OTR-5 command tank is used for safe ignition of prescribed fires on terrain contaminated by unexploded ordnance. The ignition devices include a Pyroshot Green Dragon and a driptorch from an all-terrain vehicle. Photos: Global Fire Monitoring Center.



Figure 14—Fire triggers explosions of munitions mainly during the summer months, after metal containers of unexploded ordnance are preheated by high temperatures and solar radiation. During burns in winter, the most suitable time of the year from the perspective of conservation and fireline safety, the munitions are cold or frozen due to ambient temperatures and are exposed to view without exploding. Photos: Global Fire Monitoring Center.

as the radioactively contaminated terrain on the territories of Ukraine and Belarus. On May 17–18, 2018, the OSCE, together with the REEFMC and GFMC, conducted a tabletop exercise with agencies responsible for fire management in the contaminated border regions of the two countries. The main aim was to define capabilities and gaps of interoperability in fire management cooperation across borders. The exercise resulted in valuable insights and conclusions for effective and safe cooperation in addressing the nonstandard wildfire threats in the future (fig. 11).

Some of the technologies and methods that are applied in Germany include the use of armored vehicles for setting prescribed fires and for safe wildfire suppression on terrain with unexploded ordnance. The ordnance, which stems from military action during World War II and from former military shooting ranges, is putting firefighters at extreme risk (Goldammer and others 2016b) (figs. 12–14). Apart from the use of unmanned aerial systems, these techniques offer safe tools for managing fires on terrain contaminated by radioactivity,

chemical residues, or deposits of asbestos.

Regional Exchange II: Use of Fire in Wildfire Prevention and Suppression

In Ukraine—as in other Eastern European countries—the objectives and experiences in the use of prescribed fire for wildfire hazard reduction and wildfire suppression were largely unknown. Starting in 2014, the REEFMC and GFMC organized training sessions for practitioners in the use of prescribed fire for wildfire hazard reduction



Figure 15—Using prescribed fires for wildfire hazard reduction in pine plantations (left) and in suppression firing (backfiring, right) under the guidance of the Global Fire Monitoring Center on open grasslands in the Boyarska Forest Experimental Station and Ukrainian Center of Advanced Training of Forestry Professionals within the framework of the 6th International Fire Management Week in Ukraine (2015). Photos: Regional Eastern Europe Fire Monitoring Center.



Figure 16—Prescribed conservation burn for the maintenance and rehabilitation of *Calluna vulgaris* heathlands in Zschorno Forest, a former military exercise area in Brandenburg State, eastern Germany. Located near the border with Poland, the area was converted to a nature reserve in 2002. From 2001 to 2015, significant advances were made in the practical application of fire as a tool for regenerating species endangered by overaging and ecological succession as a consequence of decreased disturbances such as grazing and mowing and of fires caused by former military activities (Goldammer and others 2016b). Photos: Global Fire Monitoring Center.

inside of pine stands (fig. 15), a practice that is receiving increasing interest for application in Eastern Europe and Russia (Goldammer 2013b).

In the training of suppression firing (the European term for backfiring), the EuroFire Competency Standards are applied in Ukraine (fig. 15) (GFMC 2006). This kind of training will be the core activity of the Eastern European Fire Management Training and Research Center, which was established in late 2018 near Kiev at the Boyarska Forest Experimental Station and Ukrainian Center of Advanced Training of Forestry Professionals, National University of Life and Environmental Sciences

of Ukraine, and managed by the REEFMC.

Regional Exchange III: Use of Prescribed Fire in Conservation

In Western and Central Europe, the use of fire in land management is an established tradition and practice. The region has witnessed centuries of burning, which has contributed to shaping landscape patterns of high ecological and cultural diversity and value, such as heathlands, open grasslands, and meadows. The rapid socioeconomic changes in the past 4 decades and the recently increasing trend of rural exodus all over Eurasia, however, have resulted

in abandonment of traditional land use methods and, in many areas, a complete abandonment of land cultivation. With the elimination of disturbance by cultivation, including traditional burning practices, some areas of Europe are converting to fallow lands, a process that is associated with ecological succession towards brush cover and forest and an overall loss of open habitats and biodiversity.

Changing paradigms in ecology and nature conservation have led to reconsideration of fire exclusion policies in certain sectors of land/landscape management, nature conservation, and forestry. In 2008, the GFMC organized a first major



Figure 17—In 2015, the Global Fire Monitoring Center supported the Forest Fire Protection Laboratory, Forest Research Institute of Poland, and the Ministry of Interior of Poland in conducting the country's first prescribed burning experiment. This demonstration pilot resulted in a change to Poland's legal provisions to allow the use of prescribed fire in conservation. The Polish fire team (left) was supported by an unmanned aerial vehicle, which provided real-time imagery on the progress of the fire (right)—a technology that is becoming common for fire monitoring and rescue operations all over Europe (Szczygiel and others 2016). Photos: Forest Research Institute of Poland; Global Fire Monitoring Center.

regional conference under the title Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia. This event allowed scientists and fire managers from Central and Eastern Europe and from Central Asia to exchange scientific knowledge and pragmatic management experiences on the use of prescribed fire in conservation and land management. Consent was reached to release the White Paper on Use of Prescribed Fire in Land Management, Nature Conservation and Forestry in Temperate-Boreal Eurasia, which challenged the agencies concerned to reconsider the prohibition of fire use in land management in most of the European countries (Goldammer 2009). Over the last 10 years, the exchange of expertise between scientists and fire managers in temperate-boreal Eurasia has made remarkable progress, particularly in the restoration and maintenance of open-land ecosystems such as the high-conservation value *Calluna vulgaris* heathlands (figs. 16, 17).

Final Remarks

It is the intent of the authors of this report to shed light on the ensemble of landscape-scale fire problems in Eastern Europe, which are globally unprecedented. The example of Ukraine shows that the occurrence and consequences of fire use and wildfires in this region are affected by the interaction and mutual reinforcement of multiple factors:

- Social and political changes affecting land use,
- Threats caused by the most serious nuclear accident in the history of humanity, and
- Collateral damages caused by a lasting armed conflict and the increasing consequences of climate change.

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REMOTE SENSING FOR WILDFIRE MONITORING IN SIBERIAN FORESTS *

Evgenii Ponomarev, Oyunsanaa Byambasuren, and Andrey Eritsov

Satellite monitoring has documented rising wildfire activity in central and eastern Siberia. Plans for developing satellite monitoring in the region constitute a promising development for fire management in Russia.

Rising Wildfire Activity

An estimated 70 to 90 percent of annual wildfires in Russia occur in Siberia (Ponomarev and Kharuk 2016; Ponomarev and others 2016) (fig. 1). The level of forests burning in the region has increased due to climate, anthropogenic, and technogenic changes. Annually, 30 percent of affected forest areas are accompanied by a high percentage of forest mortality, with severe fires replacing tree stands (Krylov and others 2014). The average annual area of forest killed by wildfire in

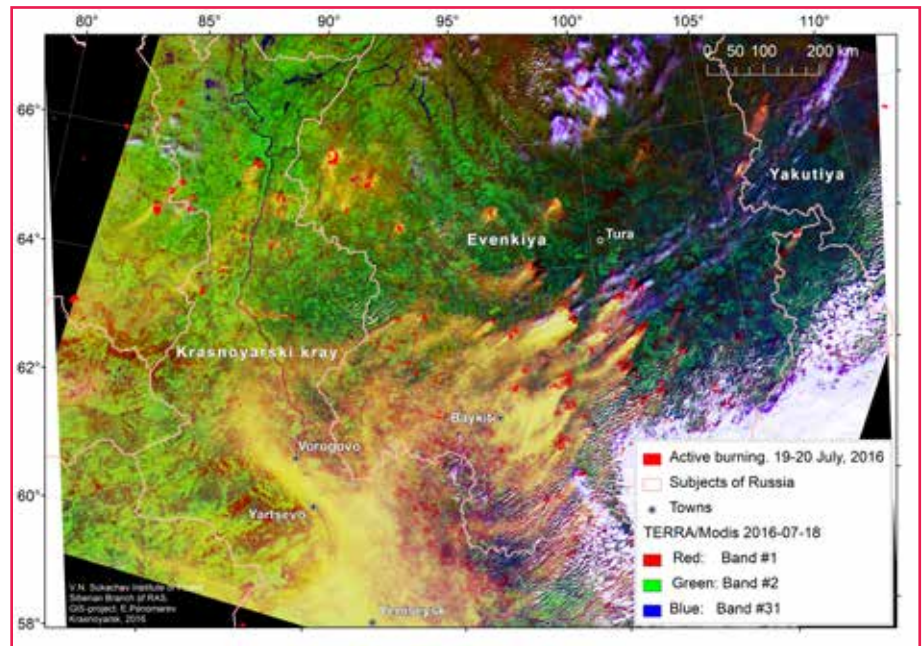


Figure 1—Satellite imagery showing active wildfires in the Evenkiya region of central Siberia on July 18, 2016. Wildfire smoke emissions are colored yellow. Source: Albert Ludwigs University of Freiburg (2016).

The level of forests burning in Siberia has increased due to climate, anthropogenic, and technogenic changes.

Evgenii Ponomarev is a senior staff scientist and Remote Group supervisor/leader for the Regional Eurasia Fire Monitoring Center, Forest Fire Monitoring Laboratory, V.N. Sukachev Institute of Forest, SB RAS, Federal Research Center in Krasnoyarsk, Russian Federation; Oyunsanaa Byambasuren is the Director of the Fire Management Resource Center—Central Asia Region, National University of Mongolia, Ulaanbaatar, Mongolia; and Andrey Eritsov is the Deputy Chief of the Aerial Forest Fire Center Avialesookhrana in Pushkino, Russian Federation.

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Russia includes 3.7 to 7.4 million acres (1.5–3 million ha) in remote parts of central and eastern Siberia (Bartalev and others 2015).

A shift of fire regimes in the boreal zone of Siberia is expected due to predicted climatic changes. In the second half of this century, carbon emissions from wildfires in Siberian forests could rise from an estimated 120–140 teragrams to 230–240

teragrams per year (Shvidenko and others 2011; Zamolodchikov and others 2011). The number of fires burning in the forest–steppes and steppes of southern Siberia is also predicted to increase.

Satellite Monitoring

Today, more than 50 percent of Siberia's forests are in zones that cannot be accessed for monitoring on the ground and that are not

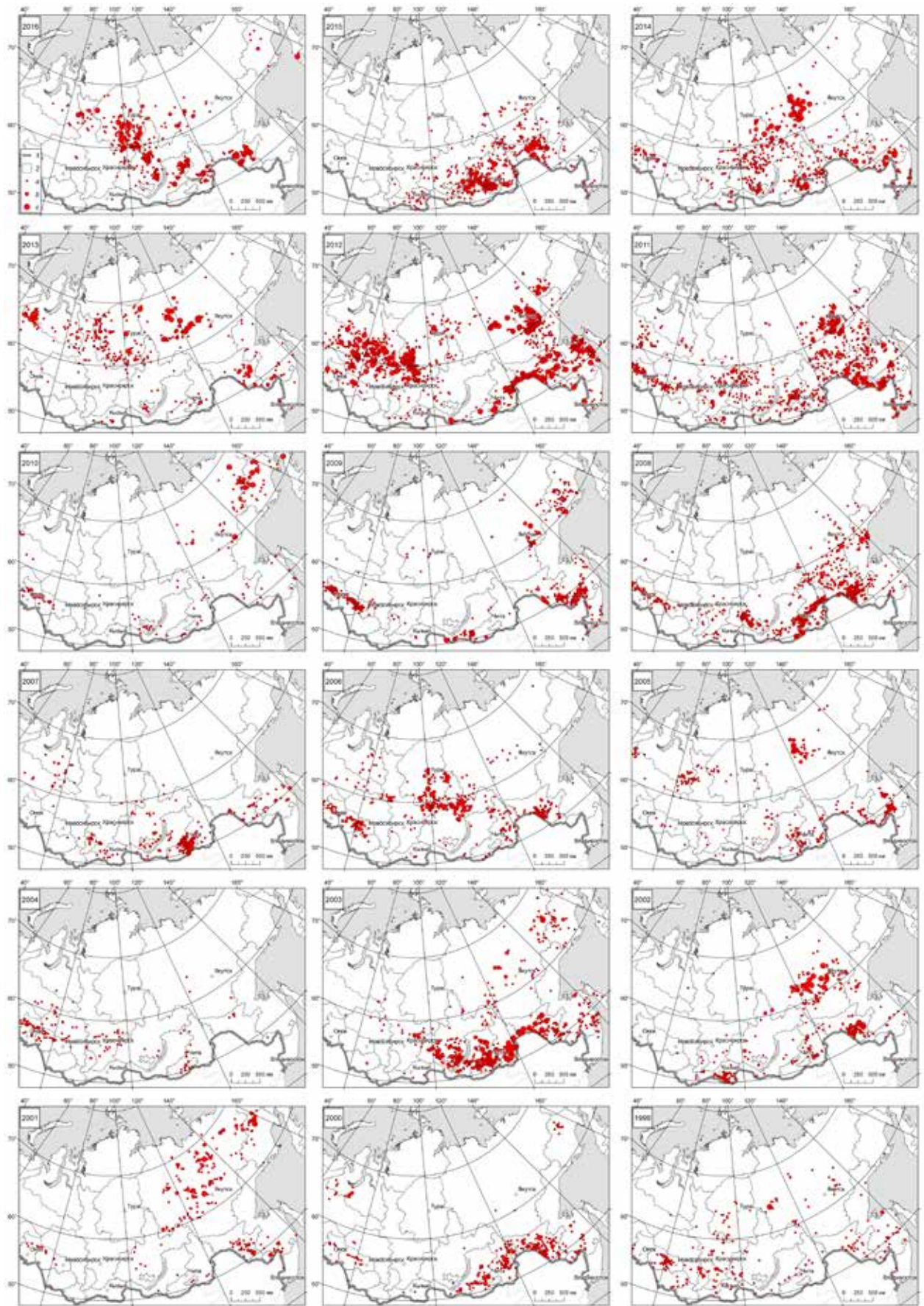


Figure 2—Geospatial distribution of the largest fires for fire seasons from 1999 to 2016. a = less than 49,400 acres (20,000 ha); b = 49,400 to 123,500 acres (20,000–50,000 ha); c = more than 123,500 acres (50,000 ha). Source: Sukachev Institute of Forest.

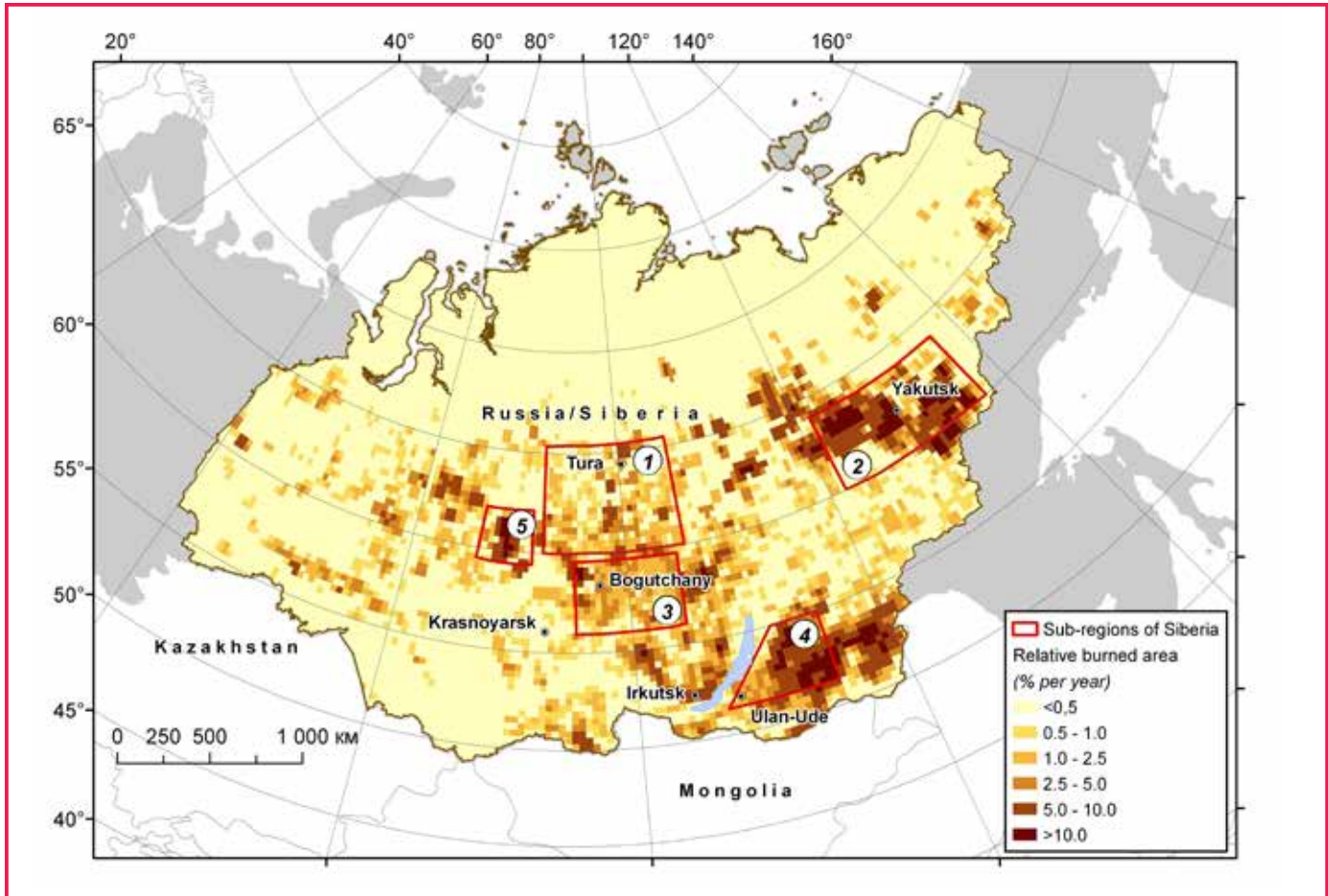


Figure 3—The rate of burning (percent of area per year) in clusters of the regular spatial network in geographic information systems (30 × 20 minutes, cluster area of about 247,000 acres (~100,000 ha)). Satellite fire monitoring data are for 1996–2016. Subregions and forest regions of Siberia: 1 = Evenkia, central Siberian flat taiga region; 2 = central Yakutia, eastern Siberian taiga–permafrost region; 3 = middle Angara, Angara forest region; 4 = Transbaikal, mountain and permafrost forest region; 5 = central Siberian plain–taiga region. Source: Sukachev Institute of Forest.

served by aerial monitoring. These zones can be monitored only by satellites. The monitoring is performed by the V.N. Sukachev Institute of Forest, SB RAS/Federal Research Center in Krasnoyarsk, Russia, in association with the Russian Emergency Situations Committee. These entities jointly provide satellite monitoring in Siberia and collect data on forest fires based on imagery with a spatial resolution of 1,000 meters.

Monitoring has been taking place since 1995. The wildfire database was obtained from processed multispectral satellite images from the U.S. National Oceanic and Atmospheric Administration's Advanced Very

**High-intensity wildfires
make up 5.5 ± 1.2
percent of all wildfires
in the forests of Siberia
each year.**

High Resolution Radiometer (from 1996 to 2006) and from the U.S. National Aeronautics and Space Administration's Moderate Resolution Imaging Spectroradiometer aboard the Terra and Aqua satellites (from 2006 to now). The database contains more than 2 million records for the 22 years of observation (fig. 2).

Available attributive databases contain a number of fire parameters, including:

- The area of thermal anomalies (active burning zones for each 4–6 hours);
- The area of the fire polygon calculated by geographic information system;
- The wildfire coordinates (data for the polygon center);
- Estimations of fire intensity (fire radiative power) (Kaufman and others 1996; Kumar and others 2011); and
- The total duration of fire development (time from the first to the last registration of the thermal anomaly).

Planned Development

Plans for developing the satellite fire monitoring system in Russia for large forest areas in central and eastern Siberia include basing it on the platform of visible infrared imaging radiometer suite (VIIRS) information from the Suomi National Polar-orbiting Partnership satellites. Spatial resolution of VIIRS imagery is up to 375 meters. A substantial amount of satellite imagery is already used in daily monitoring and wildfire analysis, including verification of forest disturbances and analysis of the condition and postfire dynamics of tree stands. The data come from a new generation of satellites (Landsat-8/OLI or Sentinel-2) as well as from Russian satellite information (Resource-P, Kanopus).

In 2017, an agreement was signed between the Sukachev Institute of Forest and the Global Fire Monitoring Center to make the institute an associate partner in the Global Wildland Fire Network. The current approach is for the Regional Eurasian Fire Monitoring Center in Krasnoyarsk, Russia, to closely collaborate with the Fire Management Resource Center—Central Asia Region in Ulaanbaatar, Mongolia. The goal is to serve countries in the Central Asia and Eurasian Region through data procurement as well as through archiving and interpreting satellite-derived information and historical data on wildland fires. Data on current and near-term wildfires in Siberia will thereby supplement the world system of fire monitoring. This

will allow managers to consider the problem of forests burning in central and eastern Eurasia at regional and larger scales.

Wildfire Dynamics in Siberia

The dynamics of wildfires in Siberia over the past 20 years correlate highly with meteorological anomalies, such as extremes in temperature variation, precipitation, and the thermal-moisture index. Long-term meteorological data for Siberia show regular intraseasonal decreases in precipitation availability, which has been 25 percent of the mean optimum level. Thus, decreasing trends in the thermal-moisture index indicate the redistribution of precipitation over the subregions of Siberia during the current year.



Figure 4—Forest Fire Danger Rating Map of the Russian Federation for July 25, 2017. The five ratings range from low (dark green) to high (red). Source: Aerial Forest Fire Center Avialesookhrana.



Figure 5—Forest fire management zones in the Russian Federation. In the Forest Fire Monitoring and Management Zone, regional authorities may decide to let wildfires burn under controlled conditions. Source: Aerial Forest Fire Center Avialesookhrana.

In the past 20 years, conditions regularly favored large wildfire occurrence and extreme burning at the local scale in Siberia. Figure 3 shows the spatial distribution of forests burning in different parts of Siberia from 1996 to 2016. The annual area burned varied from less than 0.5 percent to more than 10 percent of the total forested area (fig. 3); the average for all Siberian forests was 1.5 percent. That was almost three times greater, for example, than the average annual area burned (0.56 percent) for forests in western Canada (de Groot and others 2013).

Four fire season scenarios were characterized after long-term meteorological data preprocessing:

1. Season of low fire danger;
2. Season of moderate fire danger with maximum burning in spring;
3. Season of moderate fire danger

- with maximum burning in mid-summer; and
4. Season of extreme fire danger.

The probability of extreme fire danger is about 18 ± 5 percent. The recurrence of extreme fire weather conditions was assessed at 5–11 years for different subregions of Siberia. Thus, under current climate conditions and future climate scenarios, all services, municipalities, and local governments should be ready to manage periodic extreme levels of burning, with up to 14.5 percent of the forested area burned in a single fire season.

Wildfires in central and eastern Siberia are classified in three categories:

1. Wildfires burning up to 2,470 acres (1,000 ha);
2. Large-scale or extreme wildfires

- with areas of 2,470 to 123,500 acres (1,000–50,000 ha); and
3. “Short-lived” fires, mostly steppe fires or fires caused by agricultural burning.

Statistically, 30 to 70 percent of the total area burned annually resulted from large-scale fires, which make up no more than 3 to 5 percent of all wildfires each year. All cases of extreme burning are distributed across remote subregions with low population densities and poor infrastructure. Accounting for half of Siberia, these areas are currently under satellite monitoring only. They lack any capacity for wildfire monitoring by aircraft or on the ground.

In other parts of central and eastern Siberia, observation by air or on the ground is available, but satellite monitoring provides alternative daily (or 6-hourly) updated information

about wildfire activity. Moreover, satellite-derived information about fire radiative power allows researchers to estimate the energy or intensity of active fires. According to annual statistics, high-intensity wildfires make up 5.5 ±1.2 percent of all wildfires in the forests of Siberia each year. High-energy/intensity burning damages an estimated 8.5 percent of Siberia's forested areas annually and up to 15 percent during fire seasons with extreme weather conditions (Ponomarev and others 2017).

Distance Monitoring of Forest Fires

The federal forestry agency's Information System of Distance Monitoring for forest fires has been operating since 2005. The system uses remote sensing technologies to monitor forest fires. It constantly expands opportunities to predict the development of fire hazards in forests based on weather conditions, allowing fire managers to detect fires in remote areas, analyze their development, and take the necessary operational measures.

The system also allows fire managers to analyze the use of firefighting resources and to compare fire information from regional forestry authorities with remote monitoring data. The system also contains a lightning registration unit, allowing it to accurately record thunderstorm activity and to detect any resulting fires so they can be attacked in a timely manner.

The Nesterov Index is used to determine fire danger ratings based on weather conditions in the Russian Federation (fig. 4). The index classifies fire danger on a scale from 1 to 5; the main criteria are number of rainless days, relative humidity, and temperature. Over

1,500 weather stations feed the necessary weather information into the system.

All stakeholders, including forestry authorities, emergency services, and regional governments, have access to the entirety of the information system. The information is available on the internet, including fire danger ratings and information about operational activities.

Fire Management Zones

The Forest Code of Russia of 2006 divides the forested area of Russia into three Forest Fire Management Zones (fig. 5). Each zone designation depends on the economic and ecological value of the forests in the area, the socioeconomic development of the area, and the danger posed in the area by wildland fire.

Once a designation is made, then protection zones are delineated using ground, aerial, and satellite resources for fire monitoring and management. Aerial Fire Suppression Zones are established where ground forces are not able to access remote areas within 3 hours. In the Fire Monitoring and Management Zone, regional authorities may decide to let forest fires burn under controlled conditions. According to the Forest Fire Fighting Regulation of 2014, the executive authorities of the Commission for Prevention and Elimination of Emergency Situations in the regions of the Russian Federation are authorized to decide whether or not to fight a wildfire. If they decide to let a wildland fire burn, satellite remote sensing information becomes critical for monitoring the fire.

Progress Needed

Decision support for wildland fire management in the remote parts

of central and eastern Siberia will depend on advances made in remote monitoring as well as on improvements in ground observations and information from aerial patrols. We conclude that the effectiveness of fire management could be enhanced by:

- Developing and operationalizing early fire detection technologies;
- Improving the accuracy of satellite-derived information in detecting and classifying active fires, notably small fires, and the area burned; and
- Improving technologies for classifying fire intensity/fire radiative power.

Such improvements would yield more precise and reliable information about wildfires. Better information would in turn help fire managers mitigate local and global changes affecting forests in the region, including the challenge of global climate change.

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FACING THE FLAMES—LOOKING FORWARD AS A GLOBAL COMMUNITY

Lindon Pronto and Jameson Karns

A decade ago, the Global Fire Monitoring Center (GFMC) published its first collection of articles in *Fire Management Today* to establish a greater awareness of international fire management. With this issue, our intent remains the same. The preceding articles offer snapshots of international fire management achievements, obstacles, and studies from nearly every region on the globe. As the matrix of human-environmental conditions continues to shift, it is clear that fire management as an interdisciplinary field will continue to grow globally.

Challenges Before Us

The past 2 years (2017–18) have once again validated the challenges before us. A changing climate, with increased human influence on the atmosphere, continues to intersect with weather extremes. The North American fire management community is aware of the devastating and record-setting fires in Fort McMurray, Canada; in Wine Country and Redding, CA; and across the Great Basin and Rocky Mountains.

We would be remiss if we did not illustrate similar episodes in

Lindon Pronto is an officer of the Global Fire Monitoring Center, Max Planck Institute for Chemistry, Freiburg, Germany; and Jameson Karns is a graduate student in the Department of History at the University of California in Berkeley, Berkeley, CA, and an associate partner at the Global Fire Monitoring Center, Max Planck Institute for Chemistry, Freiburg, Germany.

other parts of the world where fire is considered a less common phenomenon: Sweden, Norway, Finland, Greenland, and at very high latitudes across Russia, to name a handful. The Nordic countries aside, countries across middle Europe that have been generally spared from fire, like Germany, Ireland, and the United Kingdom, saw fire activity

emergency response and evacuation systems and, more importantly, are highlighting critical failures in landscape management and periurban planning. From these crises, there is hope for progress as agencies and governmental bodies begin to reach beyond their borders for collaboration and as they come together under these trying circumstances.

These “fire stakeholders” live in or influence the landscapes in which the fires occur that require a response from policymakers and practitioners.

at its highest levels in decades. In southern Europe, Spain, Portugal, and Greece were devastated, with thousands of homes destroyed and hundreds of lives lost. In 2017, Chile and Argentina experienced unprecedented fire seasons; South Africa, Zimbabwe, and Syria were also hard hit. Israel/Palestine, Iran, and Turkey are in the midst of a crisis where fire is being used as a weapon in armed conflict.

All this is to say that countries well accustomed to fire are being confronted with new extremes that are challenging contemporary suppression tactics, while countries less frequented by fire are confronted with significant limitations to their ability to respond to a hazard that, until now, has been rather benign. The more extreme events, as we have witnessed in Portugal in 2017 and in Greece in 2018, are overwhelming

Taking a step back, fire is part of our planet’s heritage as well as our own. In our shared environmental history, fire has endured as a natural and vital process that—with or without human intervention—has sought equilibrium in the biophysical world. Today’s challenges in fire management are intricate and complicated. Across the globe, as the articles in this issue demonstrate, landscape degradation and land use change are resulting in the decreased resilience of ecosystems and resources, leading to higher susceptibility to fire. Across the world, the ability of ecosystems to adapt to stressors is becoming more limited, affecting fire regime shifts because of edge effects, invasive species, speciation/vegetation cover changes from high-mortality fires, more frequent fire return intervals, drought, and nonfire-related human activities. A vulnerable environment

is less likely to withstand strains, and a diminished capacity to generate ecosystem services can have negative consequences for all life forms and certainly the power to force changes or adaptations in daily human life.

Despite mostly human-induced changes to the landscape, Nature, it seems, has a keen memory concerning our environmental trespasses, and she “remembers” a presettlement landscape. Yet, as Holling (2001) points out, “hierarchies and adaptive cycles comprise the basis of ecosystems and social-ecological systems across scales.” Consequently, in North America, nearly a century of fire exclusion is now being followed by a period of “revolt,” with fires of growing size and severity as Nature’s way of “remembering” stable presettlement fire regimes, when landscapes had a much different equilibrium, before the buildup of fuels in our forests. The resulting extremely severe, often almost “explosive” landscape fires can be viewed as Nature’s attempt to restore herself.

The same pattern is observable around the world, in localities disrupted by human activities. Many of these places are now being overrun with fire, the effect of which is the gradual ecological “remembrance” of a landscape prior to human disturbances. A critical but often overlooked point is that people are integral to the health and success of these landscapes. Fire managers and decision makers often struggle to engage and connect with wider audiences who have a stake in fire challenges; chief among these is the fire use community, not just the fire response community. These “fire stakeholders” live in or influence the landscapes in which the fires occur that require a response from policymakers and practitioners.

As the articles on West Africa and South Asia show, this is especially true in countries where agricultural burning is widespread, comprising the primary source of wildfires. Yet this is a nuanced arena because fire-tolerant/fire-dependent landscapes may need fire or because fire use is among cultural/cultivation activities that have spanned generations of land managers.

The science–policy–practitioner interface must inform decision makers and support the development of policies that not only deal with current challenges but also anticipate future ones.

Outlook

Guest editor Jameson Karns began this special issue of *Fire Management Today* by exploring the history of the GFMC and the Global Wildland Fire Network; together, both guest editors are closing it with the long-view perspective. On the one hand, land managers are suffering the worldwide consequences of our past mistakes, be it the exclusion of fire from fire-dependent ecosystems or the replacement of natural landscapes with manmade monoforests. On the other hand, we can now observe complex processes of social-ecological revolts and ecological self-restoration. In this respect, it may prove constructive to consider what our landscapes might look like in 50 years if humans disappeared tomorrow. We could then design landscape planning and management strategies based on compatibility with the (scientifically

informed) projection of natural evolutionary processes. Learning the hard way, we are discovering that Nature aims to correct and restore herself regardless of human ambitions, needs, or wants.

As land managers, we must respond to immediate challenges, but we must also prioritize and invest in identifying and resolving root problems. Anticipating increased funding for prevention and adaptation work may seem unpredictable at best; but remember that elsewhere in the world, where resources are in much shorter supply, people have learned to do more with less. The world over, our indigenous ancestors have been (and still are) resilient custodians of fire. While sustainable fire use in Sub-Saharan Africa or by the Dayak people of Borneo may not seem comparable with fire outbreaks in California’s Central Valley or Greece’s resort town of Mati, “advanced” fire management could certainly stand to gain some insight from less “developed” country contexts. The knowledge of “living with fire” can and should be shared around the proverbial campfire, regardless of borders, socioeconomic standing, or the sophistication of fire management approaches.

The GFMC and network partners are continually engaged in this conversation—a process that often includes calling for a review of current practices and assumptions and working across barriers of language, experience, or technical or financial resources. We advocate for a discipline for assessing and designing human-ecological systems in ways that allow us to be resilient in the face of landscape fire because controlling fire is an undesirable and futile exercise; it is imperative, however, to adapt to fire. For instance, we have been duly warned that a paradigm shift is imminent (for example, see Olsen and Bengtson 2015).

In summation, the GFMC and our partners in the Global Wildland Fire Network address landscape fire policies and practices through holistic approaches with cross-disciplinary stakeholder involvement. This means recognizing the value of science, the accumulated experience of professionals and communities alike, and the knowledge held by indigenous peoples. The final piece of the puzzle, in our view, is ecological knowledge derived through science. The science–policy–practitioner interface (SPPI) must inform decision makers and support the development of policies that not only deal with current challenges but also anticipate future ones—especially the extremely complex systems we have alluded to above. While this task is daunting, the good news is that developing or reforming fire management policy is a task often brokered by single dedicated individuals who persistently operate within the SPPI (Pronto 2016).

International Approach

Broadly speaking, fire now poses a threat on a variety of fronts: environmental stability, economic security, and human health and safety—but internationally it still lacks effective political recognition and legitimization inside and across borders. For this reason, government representatives, land management institutions, and professionals and experts have been convening for over 25 years as an international fire management community to assess challenges at multiple governance levels and encourage a deeper understanding of contemporary fire management complexities at the International Wildland Fire Conferences. The series originated in Boston in 1989, traveled to Canada in 1997, and has since been held every

4 years, respectively, in Australia, Spain, South Africa, and Asia. We look forward to seeing you at the 7th International Wildland Fire Conference in Campo Grande, Brazil, from October 28 to November 1, 2019 (<http://gfmc.online/conferences/iwfc.html>).

As evidenced by this ever-expanding series, both acknowledging and acting on the global implications of vegetation fires has become an important contribution to understanding fire outside of its local context. It is our hope that the spirit of international engagement will give way to a more globally coherent and officially recognized forum, convention, or other arrangement that addresses landscape fire challenges at a supranational level. It is worth noting that, of the four classical elements, fire is the only element that is not explicitly addressed by international agreements, frameworks, or conventions of the sort that exist for soils, water, and the atmosphere. And when it comes to natural disasters challenging us in an era of global change, landscape fires are arguably the only natural disaster that in theory can be anticipated, prevented, mitigated, or stopped before or while it is happening (Pronto 2016).

We hope to see the continual development of such dialogue, inquiry, and policy implementation. Expanding partnerships and open dialogue is crucial in this endeavor, and we would like to invite readers of *Fire Management Today* to participate in the Global Wildland Fire Network. There are a number of opportunities to engage with or join the GFMC community—if nothing else, you can explore the GFMC website (<http://www.gfmc.online>), which provides a collection of breaking news items on the policies and politics shaping or responding to landscape fires,

cooperative multilateral and global efforts and events, as well as extensive data collection. The events and ongoing involvements of the GFMC can also be tracked through the GFMC Calendar. Nearly all of our work has been digitized and made available for free online. We have created several hundred thousand documents and web pages, including publications, the International Forest Fire News archive (1989–2014), international analyses and reports, white papers, a trove of gray literature, global outreach essays, events and milestones, and so much more.

Finally, this edition of *Fire Management Today* has provided an opportunity for us at the GFMC to reflect on the efforts of the international fire management community and allowed us to also look towards the forthcoming obstacles and opportunities. Assembling the studies and efforts of fire managers across the globe into a single collection has been a daunting feat. Foreign languages, time zones, and the duty each of us shares to respond to incidents (it is always fire season somewhere) made this edition a particularly challenging and long process. Therefore, all of us in the Global Wildland Fire Network would like to recognize that this publication would not have been possible without the patience, time, energy, and efforts of Managing Editor Hutch Brown.

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