FIRE: A NECESSARY EVIL

12. Fire: a Necessary Evil

12.1 Background: Why Fire is perceived harmful

Uncontrolled fire has become one of the main environmental issues facing the global community, and in fact, the most important global disturbances, considering the observed effects it has on land area and biodiversity. At global level an estimated 150 to 250 million ha (Mha) of the recorded 1.8 billion ha of tropical forests are affected by wildfire annually. Many mature and immature forest trees are killed by high intensity fires annually. In the Amazonian forests for instance, wildfire has been reported to cause high mortality in many useful species with the rate ranging between 36-96%. Consequently fires affect timber supplies from which income and other livelihood needs are generated for the majority of people, particularly, in developing countries.

In Ghana, (one of the leading exporters of timber in Africa), for instance, wildfires caused more than 4 million m^3 of exportable timber in losses between1982-1983. An estimated annual loss of 3% of GDP was recorded for the past two decades, due to wild fires. In South East Asia, the loss of tropical forest resources was much higher. Areas (in Java, Borneo, Sulawesi, Irian Jaya and Sumatra) in Indonesia which were the most affected in Asia lost about 9.5 Mha of land to fires, out of which about 4.6 Mha (49%) was forested. For the same period, Brazil lost an estimated 3.3 Mha hectares of land of which 1.5 million was rainforest in northern Amazonia alone. In Mexico and Central America a further 1.5 million hectares was burnt affecting biodiversity and ecosystem processes. During the same period, over 5 million hectares of temperate forests were also affected in the United States and Canada and 2 million hectares in Russia (Rowell and Moore, 2000).

In many cases, wildfire caused heavy financial losses in terms of people loosing their homes and property. Wildfires also pollute the air with smoke that causes health hazards and making aerial communication difficult. Also the carbon emitted during wild fires also contributes significantly to the build-up of greenhouse gases in the atmosphere. Further more the destruction of forests by wild fires terminates the role of forests to act as sinks for carbon.

Obviously, the harmful effect of wildfire is very clear and explains why the public generally have the opinion, that fires are always harmful to nature. However, for some of us, fire is a necessary ”evil”. Thus, despite the destructiveness of fire, it can be a legitimate land management tool, if carefully timed and used (Goldammer, 1999)”. As a result, FAO, (2006) projects the idea that there is good fire and should be advocated and supported”. However, the dilemma faced by particularly the public, rural communities, is that fire can be very destructive and at the same time, act as a useful tool in the enhancement of ecosystems. This section of the book presents a review of the role of fire in global ecosystems. This review, seeks to, particularly, highlight the importance in the application of the ”right kind of fire” by local people, to enhance the ecosystem and their livelihoods.

12.2 Fire as Conservation and Livelihood issue[1]

Fires are increasingly damaging the world's forests, impacting ecosystem processes and shaping landscapes. Today, among globally important ecoregions for conservation, 84% of the area assessed is at risk from altered fire regimes (judged to be degraded" or "very degraded") (Figure 1) and 46% of the area assessed is classified as fire-dependent/influenced, 36% as fire-sensitive, and 18% as fire-independent (Figure 2) (TNC, 2004). See pages: 49 and 245 for Figures 1 & 2 respectively.

In recent years interests to adopt comprehensive fire management programmes and to consider fire as a conservation issue has grown internationally. The reasons for the growth in interest are two-fold. Firstly, there is the recognition of the increase in occurrence of extremely sever fires and excessive application of fire in land use system, which threaten natural resources and livelihood systems. Secondly, the recognition of how some of the current approaches to fire prevention are out of step. Both issues have led, among others, to the emergence of the concept of integrated forest fire management (IFFM) during the recent years.

Myers defined IFFM as the integration of science and society with fire management technologies at multiple levels. This implies an integrated approach to forest fire management where fire programs are not limited to the traditional efforts of fire prevention and fire suppression only, but also embraces the use of prescribed or managed fire as a tool, community involvement, and law enforcement. This also imply integrating fire-related issues with other ecological (e.g. climate change) socio-economic (e.g. culture), and technical factors and forest management practices during conservation and land use planning efforts.

12.2.1 The Role of Fire in Ecosystems

In discussing and addressing fire as a conservation issue, it is important to recognize and understand the different roles that fire plays in different ecosystems. The Nature Conservancy (TNC), in its preliminary global assessment of fire as a conservation threat, identified three broad categories of vegetation responses to fire: fire-dependent, fire-sensitive and fire-independent. That report focused on the predominant fire effect at the level of biome and ecoregion, recognizing that within ecoregions there can be a variety of ecosystems and habitats that have responses different from the predominant effect. Because this report focuses on potential management actions to fire within conservation areas where multiple responses may be manifested, a fourth category is included: fire-influenced. These ecosystems may be linked hierarchically to fire-dependent and fire-sensitive ecosystems because they are frequently found as transitions between them. All ecosystems or native vegetation types do not fit perfectly into each of these categories, but the groupings provide a means of illustrating and discussing the threats and conservation needs and opportunities associated with fire in diverse vegetation types and how management actions may vary among them.

1 Text copied with permission from the publication" Living with Fire – Sustaining Ecosystems & Livelihoods through Integrated Fire Management; Ronald R. Myers TNC, 2006.

12.2.2 Fire-Independent Ecosystems

Fire-independent ecosystems are those where fire normally plays little or no role. They are too cold, too wet or too dry to burn. Examples are deserts, tundra and rain forests in a seasonal environment. Fire becomes a threat only if there are significant changes to these ecosystems brought about by land use activities, species invasions or climate change. The preliminary assessment of fire as a conservation issue, which focused on 200 priority (i.e. based on their biodiversity value) ecoregions worldwide, identified 18 percent by area as dominated by fire-independent ecosystems.

12.2.3 Fire-Dependent Ecosystems

Fire-dependent ecosystems are those where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire's spread, i.e. the vegetation is fire-prone and flammable. They are often called **fire-adapted** or **fire-maintained** ecosystems. Fire in these areas is an absolutely essential process. If fire is removed, or if the fire regime is altered beyond its normal range of variability, the ecosystem changes to something else, and habitats and species are lost. Individual species within fire-dependent ecosystems have evolved in response to specific fire regime characteristics such as frequency, intensity and season of burn, and to the variability of those characteristics. Types of fire regimes vary greatly, ranging from frequent, low-intensity, non-lethal surface fires to those characterized by mixed-severity fires (i.e. lethal and non-lethal effects varying across the landscape), to relatively infrequent, high-severity, lethal or stand replacing fires that arrest or re-set ecological succession creating a diversity of habitats in time and space as the vegetation recovers. On an area basis, approximately 46 percent of the worldís priority ecoregions are dominated by fire-dependent ecosystems, meaning they need to burn under an appropriate fire regime if they are to persist in the landscape. Examples of fire-dependent ecosystems abound around the world. In Mesoamerica, there is a wide variety of fire dependent pine forests and pine savannas. Mexico, with its temperate and tropical environments, has the highest pine species diversity in the world – 55 species and varieties.

Most species of pine are linked to disturbance, often defined by specific fire regimes. Several of these forest types extend into Central America. The same can be said of Mexicoís high diversity of oak speciesó110 species, a large number of which may require fire or are favoured by fire-induced disturbances. Elsewhere in Mesoamerica and the Caribbean, fire-dependent Pinus caribaea savannas and woodlands range from the Bahamas through Cuba and on to Belize, Honduras and Nicaragua. The Dominican Republic has forests and savannas of the endemic Pinus occidentalis, which are dependent on fire. Besides P. caribaea, Cuba has three species of endemic pines that persist in fire prone environments.

Fire-adapted pine species also form extensive open forests and woodlands in the tropical and subtropical environments of Southeast and South Asia. Fire plays a key, though poorly understood, role in the maintenance and characteristics of Pinus kesiya and/or P. merkusii forests ranging from the Assam Hills of India, across Myanmar, Thailand, Southern China, Cambodia, Laos, Vietnam and the Philippines to Sumatra. Africa has been referred to as the "fire continent" primarily because much of Sub-Saharan Africa, with the exception of the

tropical forests of western and central equatorial Africa, once consisted of a vast landscape of tropical and subtropical fire-prone savannas, and fire-influenced woodlands and shrub lands that have been shaped by the longest history of human involvement with fire in the world.

South America is just as much a ”fire continent” as Africa. A significant proportion of South America lies in the same bioclimatic zone that supports savanna in Africa. The Brazilian Cerrado, once covering 22 percent of the country or 2 million sq. km, is a mosaic of savanna and shrubland moulded by a diversity of fire regimes. Other tropical grassland types in South America are found in the Gran Sabana and Llanos of Venezuela, and in Bolivia, Peru and Paraguay. Temperate South America claims the vast Argentine pampas and other grasslands. Fireís role in other South American temperate ecosystems, such as the Araucaria forests, is poorly understood.

Fire-maintained palm forests and palm savannas are common throughout the tropics, along with a variety of fire-dependent and fire-influenced coastal and freshwater marshlands. Scientists are just beginning to understand that fire is also an integral part of tropical alpine areas such as páramo in the Americas and Afro-alpine vegetation.

Other strongly fire-dependent environments include Mediterranean-type forests, shrublands and savannas located in widely dispersed parts of the world; temperate and boreal coniferous forests and oak-dominated forests and grasslands of North America, Central Asia, China, Russia and Mongolia; and the eucalypt forests, savannas and heathlands of Australia.

12.2.4 Fire-Sensitive Ecosystems

Fire-sensitive ecosystems have not evolved with fire as a significant, recurring process. Species in these areas lack adaptations to respond to fire and mortality is high even when fire intensity is very low. Vegetation structure and composition tend to inhibit ignition and fire spread. In other words, they are not very flammable. Under natural, undisturbed conditions, fire may be such a rare event that these ecosystems could be considered fire-independent. Only when these ecosystems become fragmented by human activities, fuels are altered and ignitions increase, do fires become a problem. As fires become frequent and widespread, the ecosystem shifts to more fire-prone vegetation. Tropical forests become savannas of introduced grasses and semi-arid grasslands are invaded by non-native grasses that create a continuous fuel. On an area basis, 36 percent of ecoregions are dominated by fire-sensitive ecosystems.

Examples of fire-sensitive ecosystems are the wide variety of tropical and subtropical broadleaved forests found along both altitudinal and moisture gradients and temperate zone broadleaved and conifer forests at the wetter end of the moisture gradient. There are a number of ecosystems whose category is uncertain. An example is the Chilean Matorral, a Mediterranean-type shrubland. Although flammable, it appears to lack the regenerative responses to fire of species found in other types of Mediterranean shrublands around the world. In some ecosystems the ecological role of fire simply has not been identified.

12.2.5 Fire-Influenced Ecosystems

This category includes vegetation types that frequently lie in the transition zone between fire-dependent ecosystems and fire-sensitive or fire-independent ecosystems, but it may ultimately include broader vegetation types where the responses of species to fire have not been documented and the role of fire in maintaining biodiversity is not recognized. They are ecosystems that generally are either sensitive to fire but contain some species that are able to respond positively to fire disturbances, or they are ecosystems that would persist in the absence of fire but fire disturbances play a role in creating certain habitats, favouring the relative abundance of certain species, and maintaining biodiversity.

In fire-influenced ecosystems, fires generally originate in adjacent fire-dependent vegetation and spread to varying degrees and at varying intervals into the fire-influenced vegetation, although a low level of traditional agricultural clearing and burning may have been important endogenous sources of ignition. Here, fire may be important in creating certain habitats by opening forest or shrub canopies, initiating succession and maintaining the transitional vegetation. Fire-influenced ecosystems present challenging management issues because of the subtle role that fire may play. Examples include the transition zone of wet sclerophyll forest between savanna and rain forest that occurs in north-eastern Queensland, the riparian vegetation or gallery forests along water courses in savanna or grassland vegetation, the ”islands” of fire-sensitive vegetation often embedded in a matrix of fire-prone vegetation such as ”hammocks” in the Everglades of Florida and similar vegetation patterns in the Pantanal of Brazil, and certain types of tropical and subtropical forests like those identified in Mesoamerica where fire has maintained the dominance of mahogany (Swietenia macrophylla) and associated species.

Climate change may cause significant changes in the structure and shifts in location of fire-influenced ecosystems. In other words, it may be in these ecosystems where climate change-induced shifts in vegetation will become most apparent over the short term”.

12.3 The Source of Fire Threats to Biodiversity

The nature of fire-related threats varies depending on ecosystem responses and the adaptations of species to fire. A wide variety of fire-sensitive ecosystems in the tropics and elsewhere are threatened by land use activities and vegetation conversion efforts that either use fire or increase the probability of ignitions. Forest vegetation that rarely burns and normally resists fire is being modified by human activities such that fire is entering these ecosystems at shorter intervals. An initial fire is usually of very low intensity, but the impacts are severe - killing trees, increasing fuel loads and opening the canopy, allowing fuels to dry and grasses and ferns to grow. Without subsequent ignitions the forests can recover, but the predominant trend is toward increased ignitions leading to repeated fires and rapid changes in vegetation structure and fuel characteristics. Fire creates a positive feedback loop that leads to increasing flammability and drier conditions.

These fire-sensitive ecosystems are now being exposed to frequent ignitions and require urgent and aggressive measures to counteract the sources of the threat or to mitigate their impacts. Experience gained from preventing and fighting fires in temperate and boreal ecosystems may not be transferable to tropical environments primarily because of different social and economic

contexts and due to the costs associated with high-technology fire suppression. Greater emphasis needs to be placed on the underlying causes of the fires and on developing local and regional solutions that are sustainable.

Conversely, as governments, land management entities and scientists attempt to address fire-related threats through policy changes, incentives and community-based prevention and suppression programs, there is a danger that the vital role of, and need for, fire in many ecosystems will be overlooked, as was done in much of the United States over the last century and has occurred in portions of Australia and Canada. There is a misconception (at least by fire professionals and the interested public in temperate climes) that the tropics is a vast fire-sensitive rain forest threatened by rampant logging-induced fire and agricultural burning. In reality, the tropics include some broadleaved forest types where periodic fire is part of the system, i.e. fire-influenced ecosystems, but where excessive burning is clearly a threat. The tropics and subtropics also harbour ecosystems and habitats that require fire.

12.3.1 Case Studies: Fire as tool for Livelihood and Ecosystem improvement

Currently there are several good examples of case studies highlighting the importance and reality of anthropogenic fires in improving livelihood, improving soil conditions, controlling pest and diseases and invasive species and maintaining biodiversity, in forest ecosystems. The contexts in which fire is often used are presented below

12.3.1.1 Economic and social context

In Africa and Asia, even though in some case wild fires had been ignited for apparently no valid ecological reasons, the use of fire had been and is still an integral part of land use and livelihood systems. Fire is used for field preparation in slash-and-burn agriculture (Figure 3) on which majority of the rural people depends to meet energy and food needs.

Figure 3. Slash-and-burn agricultural land preparation method in Ghana.

(Photo by Mark Appiah)

During the agricultural activities, the local people use fire to control pest, suppress

weeds. In Ghana for instance, fire is also used to prevent the rottenness of the palm tree, and to ensure better taste and to increased yield of wine during palm wine processing. To the hunters, fire is a tool for smoking out games. This tells us some of the ways in which communities use fire to cultivate crops, manage pests and disease, hunt and ensure the availability of non-wood forest products. While the public, particularly those, in developing countries may have the opinion that fires are always harmful to nature due to the devastating effects of wildfire, they do recognize some importance of fires that are connected to their livelihood. They also have different views about wildfire which is important to consider in strategies for community-based fire management programs. Quite often there is a mismatch between the perceptions of policy makers, fire managers and those of local resources users.

12.3.1.2 Nutrient cycling

In grassland ecosystems, fire is the primary mode of decomposition, making it is crucial for returning nutrients to the soil and allowing the grasslands to sustain their high productivity. Research of two controlled burns on organic carbon, revealed, that the total and available nitrogen, phosphorus, and sulphur of surface soils (0-5cm) of the southern Caldenal region in Argentina (Castelli and Lazzari, 2002) and; confirmed the general accepted trend, that the first controlled burn generally caused a beneficial effect on the total elements, either immediately, or one or two years after the burn. It also caused a considerable flush of the available nutrients that was more persistent under the shrubs. This could be explained by the fact that grasslands burn more readily than shrub ecosystems, with fire moving through the stems and leaves of herbaceous plants and only lightly heating the underlying soil even in cases of high intensity (DeBano et al. 1998), thus, releasing nutrients that are locked up in slowly decaying woody material into the forest nutrient recycling system. These results indicated that in a fire-prone habitat such as in semiarid ecotones, long-term ecosystem health could rely upon a balance between fire-related nutrient outputs and succession-related nutrient inputs to ecosystem nutrient capital.

12.3.1.3 Plant growth initiation and forage improvement

Research conducted over the past five decades has revealed that fire not only helps to maintain the ecosystem but also helps to ensure the availability of quality forage. For instance, it was found that in South Africa and Namibia, freshly burnt savanna areas had new plant growth that provided palatable forage compared to unburnt areas with older grasses. The threshold level seems to be at 4.000 kg/ha of grass sward. Below 4.000 kg/ha burning is not required whereas anything above 4.000 kg/ha will require burning to remove unpalatable grass sward. In this part of the world animal keeping is a way of life and domestic animals like sheep, goats and cattle obtain greater than 85 % of their nutrition from forage. In addition, wildlife usually intermixes with domestic cattle in grazing in Sub-Saharan Africa. Therefore, pasture created by fire, especially on lands that is normally unsuitable for crop production, can be a useful source of forage. More importantly, the fresh forage will encourage large herbivores to move to less preferred areas in order to minimize the overuse of preferred areas which are areas kept short by constant grazing (Trollope and Trollope, 1999;

Archibald et al. 2005), and allow grazing-intolerant grass species to grow in these areas and thus persist within the ecosystem. Fire does not only helps to ensure the availability of quality forage, but also certain wildlife species like the ”grass cutter” and Giant rats do benefit significantly from periodic fires (FORIG, 2003).

12.4. Ways forward

The fact is that trying to eliminate fire from the wildland is not a practical option, and has adverse effects on regeneration of some species and biodiversity. Fire and ecosystems have been linked in many ways for millennia and that must be recognized for any wildland fire management policy to be effective. More importantly, fire should be well integrated into the practice of forest conservation and management. At least there is sufficient information from these case studies to be sure about the importance of planned burning in ecosystems to maintain biodiversity, ensure regeneration and improve soil fertility and forage production, particularly in the savanna areas where biodiversity loss, soil erosion, and availability of animal feed are environmental issues of great concern in the future.

Appendix

Figure 1 Fire Regime Status and Trend (TNC, 2004. Fire, Ecosystems & People: A Preliminary Assessment of Fire as a Global Conservation Issue, The Nature Conservancy http://www.nature.org/initiatives/fire/science

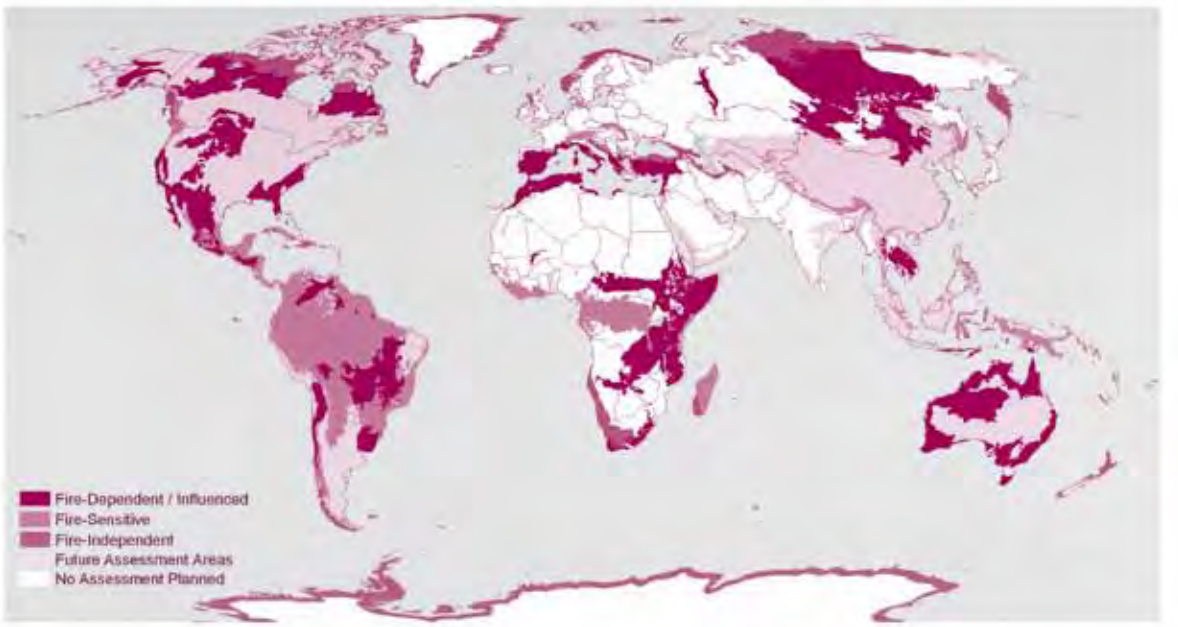

Figure 2 See page 49.

REFERENCES

The following references do not intend to provide a complete list of sources. It rather aims to facilitate the search for literature on **wildland** fire ecology, history, management; including training. The list includes also includes internet portals facilitating a literature search.

Fire Ecology

Archibald, S., Bond, W.J., Stock, W.D and Fairbanks, D.H.K. 2005. Shaping the landscape: Fire-grazer interactions in an African savanna. Ecological Applications 15:96-109.

Bond, W.J., and van Wilgen, B.W. 1996. Fire and plants. Population and Community Biology Series 14. Chapman and Hall, London, 263 pp.

Booysen, P. de V., and Tainton N.M. (eds.) 1984. Ecological effects of fire in south African Ecosystems. Ecol. Studies 48, Springer, Berlin, 426 p.

Castelli, L.M. and Lazzari, M.A. 2002. Impact of Fire on Soil Nutrients in Central Semiarid Argentina, Arid Land Research and Management, Volume 16, Number 4, 349-364(16).

DeBano, L.F., Neary, D.G., and Folliot, P.F. 1998. Fire's Effects on Ecosystems. John Wiley & Sons, Inc., New York, New York, USA.

Elias F. D. 1990. Forest Fire Behavior in Zimbabwe. Seminar on Forest Fire Control for Africa. National Board of Vocational Education, Helsinki.

Gill, A.M., Groves R.H. and Noble I.R. (eds.) 1981. Fire and the Australian biota. Austr. Acad.Sci., Canberra,582p.

Goldammer, J.G., and Furyaev V.V. (eds.) 1996. Fire in ecosystems of boreal Eurasia. Kluwer Acad. Publ., The Hague. 528 p.

Goldammer, J.G. 1999. Environmental Problems Arising from Land Use, Climate Variability, Fire and Smog in Indonesia: Development of Policies and Strategies for Land Use and Fire management. In: WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia, Singapore, 2-5 June 1998, Vol. 2 (G.R.Carmichael, comp.), 13-88. World Meteorological Organization, Global Atmosphere Watch Report Ser. No. 131, WMO TD No. 948, Geneva, 346 p.

Goldammer, J.G., and Jenkins M.J. (eds.) 1990. Fire and ecosystem dynamics. Mediterranean and northern perspectives. SPB Academic Publishers, The Hague. 199 p.

Goldammer, J.G. (ed.) 1990. Fire in the tropical biota. Ecosystem processes and global challenges. Ecological Studies 84. Springer Verlag, Berlin-Heidelberg-New York, 497 p.

Johnson, E.A., and Miyanishi K. (eds.). 2001. Forest fires. Behaviour and ecological effects. Academic Press, San Diego, 594 p.

Myers R.L. 2006. TNC Living with Fire; Sustaining Ecosystems & Livelihoods through Integrated Fire Management, Tallahassee, USA.

TNC, 2004. Fire, Ecosystems & People: A Preliminary Assessment of Fire as a Global Conservation Issue, The nature Conservancy.

Trollope, W.S.W. and Trollope, L.A. 1999. Report on the Assessment of Range Conditions and the Fire Ecology of the Savanna Vegetation on the Lewa Wildlife Conservancy in Kenya-1998 Final Report. Alice, So, Africa: Univ. of Fort Hare, Dept. of Livestock and Pasture.

van Wilgen, B., Andreae, M.O. Goldammer, J.G., and Lindesay J. (eds.) 1997. Fire in Southern African savannas. Ecological and atmospheric perspectives. The University of Witwatersrand Press, Johannesburg, South Africa, 256 p.

Wein, R.W. and MacLean D.A. (eds.) 1983. The role of fire in northern circumpolar ecosystems. John Wiley & Sons, New York, 322 p.

Wright, H.A. and Bailey A.W. 1982. Fire ecology. United States and Southern Canada. John Wiley & Sons, New York, 501 p.

Fire History

Pyne, S.J. 1982. Fire in America. Princeton Univ. Press. 654 p.
Pyne, S.J. 1991. Burning bush. A fire history of Australia. Henry Holt and Company, New York, 520 p.
Pyne, S.J. 1995. World fire. Henry Holt, New York, 379 p.
Pyne, S.J. 1997. Vestal Fire. An environmental history, told through fire, of Europe and Europe's encounter with the World. University of Washington Press, 680 p.

Atmospheric Chemistry, Climatology, Remote Sensing

Ahern, F., Goldammer, J.G. and Justice C. (eds.). 2001. Global and regional vegetation fire monitoring from space: Planning a coordinated international effort. SPB Academic Publishing bv, The Hague, The Netherlands, 302 p.
Crutzen, P.J., and Goldammer J.G. (eds.) 1993. Fire in the environment: The ecological, atmospheric, and climatic importance of vegetation fires. Dahlem Workshop Reports. Environmental Sciences Research Report 13. John Wiley & Sons, Chichester, 400 p.
Innes, J., Beniston M. and Verstraete M.M. (eds.). 2000. Biomass Burning and its Interrelationships with the Climate System. Kluwer Acad. Publ.

Fire Management & Training

Auld J. A.C. & Reynolds J. K. 1979. Forest Fire Suppression: A handbook for use by those engaged in forest fire control in Ontario. Ministry on Natural Resources of Ontario, Canada.
Balmer W.E., Hough W.A., Jackson R.S., Mobley H.E. & Ruziska W.E. 1973. A Guide for Prescribed Fire in Southern Forests, USA.
Casey J.F. 1978. The Fire Chief's Handbook. Fourth Edition. Technical Publishing Company, Dun-Donnelley Publishing Corporation, New York.
Brown, A.A., and Davis K.P. 1973. Forest fire. Control and use. McGraw Hill, New York, 686 p.
Goldammer, J.G., and de Ronde C. (eds.). 2004. Wildland Fire Management Handbook for Sub-Sahara Africa. Global Fire Management Center and Oneworldbooks, Freiburg – Cape Town.
Food and Agriculture Organization of the United Nations (FAO) 2007. Fire management - global assessment 2006, FAO, Rome
Food and Agriculture Organization of the United Nations (FAO) 2009. Forest fires and the law. A guide for national drafters based on the Fire Management Voluntary Guidelines. Elisa Morgera, Maria Teresa Cirelli, FAO, Rome
FORIG, 2003. Forest Fire Management in Ghana, Final Technical Report PD.32/98 Rev (F). Forestry Research Institute of Ghana. Kumasi. Pp 39.
Heikkilä, T.V., Grönqvist, R. and Jurvélius, M. 1993. Handbook on forest fire control. A guide for trainers. Forestry Training Programme (FTP) Publication 21, Helsinki, Finland, 239 p.
International Labour Office (ILO). 1981. Forestry: equipment planning guide for vocational and technical training and education programmes, no.17. International Labour Organisation, Geneva.
International Labour Office (ILO). 1985. Fuelwood and Charcoal Preparation. International Labour Organisation, Geneva.
Jurvélius, M. 2003. Developing Participatory Forest Fire Management strategies, with special reference to sub-Saharan Africa, FAO, Rome.
Jurvélius, M. 2004. Jurvélius Taxonomy of Learning Objectives, FAO Training Course for Instructors in Community Based Fire Management (CBFiM), CD, Rome and the GFMC.

Pyne, S.J., Andrews, P.J. and Laven. R.D. 1996. Introduction to wildland fire. Second edition, John Wiley & Sons, New York-Chichester, 769 pp.
Rowell, A. & Moore. P. F. 2000. Global Review of Forest Fires. WWF/IUCN, Gland, Switzerland.
Royal Forest Department (RFD). 1986. Forest Fire Control in Thailand. Royal Forest Department, Thailand.
Sagala Aps. 1988. Fire Control Aspect in Reforestation on the Alang-Alang Grass, Draft. WIXERE Indonesian Forestry Department.
Teie, C.W. 1997. Fire Officer´s Handbook on wildland firefighting. Deer Valley Press, 601p.
Teie, C.W. 2003. Fire Manager´s Handbook on Veld and Forest Fires - Strategy, Tactics and Safety. South African Edition (edited by Christiaan F. Pool). Southern African Institute of Forestry, 488 p.

International Fire Management Guidelines:

Food and Agriculture Organization of the United Nations (FAO) 2006. Voluntary Guidelines for Fire Management: (Principles and Strategic Actions)", Rome, Italy.
Food and Agriculture Organization of the United Nations (FAO) 2006. Planted Forests Code, Rome, Italy
Food and Agriculture Organization of the United Nations (FAO). 2002. Guidelines on Fire Management in Temperate and Boreal Forests. Forest Protection Working Papers, Working Paper FP/1/E. Forest Resources Development Service, Forest Resources Division. FAO, Rome
International Tropical Timber Organization (ITTO). 1997. ITTO Guidelines on Fire Management in Tropical Forests. ITTO Policy Development Series No.6. ITTO, Yokohama, 40 p.
Schwela, D.H., Goldammer, J.G. Morawska, L.H. and Simpson. O. 1999. Health Guidelines for Vegetation Fire Events. Guideline document. Published on behalf of UNEP, WHO, and WMO. Institute of Environmental Epidemiology, Ministry of the Environment, Singapore. Double Six Press, Singapore, 291 p.
Schwela, D.H., Morawska, L.H. and bin Jafar. Abu Bakar 1999. Health Guidelines for Vegetation Fire Events. Teachers' Guide. Published on behalf of UNEP, WHO, and WMO. Institute of Environmental Epidemiology, Ministry of the Environment, Singapore. Double Six Press, Singapore, 114 p.

International Web Portals for Wildland Fire Management Literature:

General
http://www.fire.uni-freiburg.de
Glossaries
http://www.fire.uni-freiburg.de/literature/glossary.htm
FAO Forestry Fire Management
http://www.fao.org/forestry/firemanagement
Fire Management Guidelines
http://www.fao.org/forestry/firemanagement/46135/en/
International Association of Wildland Fire
http://www.iawfonline.org/
Online Publications, Libraries and Bibliographies
http://www.fire.uni-freiburg.de/literature/onl_pub.htm
U.S. Fire Information Systems and Software Products
http://fire.org/
The Nature Conservancy Fire Initiative
http://www.tncfire.org
Wildland Fire Terminology
http://www.fao.org/forestry/firemanagement/terminology