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FOREST FIRE DISASTER MANAGEMENT

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Towards a disaster free India

National Institute of Disaster Management

Ministry of Home Affairs
Government of India

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FOREST FIRE DISASTER MANAGEMENT

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सत्यमेव जयते

MESSAGE

Disasters have been mankind's constant though inconvenient companions since time immemorial. India, due to its geographical conditions, geo-physical environment and climatic conditions is one of the worst disaster prone countries of the world. Environmental degradation mainly due to deforestation and related activities has further accelerated the intensity and frequency of natural disasters, mainly the hydro-meteorological disasters.

Forest fires, one of the main causes of forest degradation, pose a serious threat not only to the forest wealth but also to the entire regime of flora and fauna, as a result disturbing the bio-diversity of ecology and environment. Almost 50% of total forest area of the country is prone to forest fires. The impact of forest fire, however, does not remain confined to its physical component only but transcends beyond it and affect the socio-economic condition of the affected population. Forest fires also affect global carbon cycle and thus the climate change. Forest fire are obviously one of the major reasons to climate change, as they feed back to global warming, resulted due to burning of vegetation and release of stored carbon.

About 95% of the forest fires in India are caused by human beings, especially to promote new flush of grasses, collection of minor forest produce or to pare land for shifting cultivation. Creating awareness about forest fire prevention amoung community and other role players can play an important role in reducing forest fire risks and thus saving our environment from further degradation.

The present book on 'Forest Fire Disaster Management' is a good attempt to compile various important information about forest fire and its management. The book will certainly help various researchers, students, policy makers, implementators and trainers in their attempt to manage forest fires in more effective and efficient manner. I congratulate NIDM for its contribution in this endeavour.

(Kiren Rijiju)

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MESSAGE

Since times immemorial, forests have been an integral part of human ecosystem and its environment. Besides providing shelter and protection to a large number of living beings, including pre-historic man, they have been a major source of food, wood and a great variety of other products. Since ancient times, forests have played important role in the social, economic and religious activities in human life in a variety of ways, both material and psychological. Globally, forests face growing challenges and risks from the natural disasters, which continue to strike unabated without notice and are perceived to be on the increase in their magnitude, complexity, frequency and the economic impact.

The most common hazard in forests is the forests fire. Forests fires are as old as the forests themselves. Forest fire is one of the major disasters responsible for the degradation of forests. India is highly vulnerable towards forest fires, which are recurrent phenomena. These pose a threat not only to the forest wealth but also to the flora & fauna, thus seriously disturbing the bio-diversity and ecology as well as polluting the environment of a region.

The National Disaster Management Act, which was enacted in November 2005, has brought about a paradigm shift in India's approach to Disaster Management. The centre of gravity stands visibly shifted to preparedness, prevention and planning from the earlier response and relief centric approach. Such holistic approach needs not only the institutional mechanism for better coordination between the various sectors, but also strengthening of the Disaster Risk Reduction (DRR) efforts.

The present book entitled "Forest Fire Disaster Management" developed by NIDM is vital to build a robust and sound information database on the basic knowledge, information dissemination and public awareness towards the management of forest fire disasters. This book will be helpful to various institutes and other stakeholders for their training programmes, research and documentation in the field of Forest Fire Disaster Management.

I congratulate NIDM and acknowledge its contribution in this endeavour. I hope this book will also help in promoting the collaboration among different stakeholders in Disaster Management.

(SNEH LATA KUMAR)
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Preface

This book is the outcome of a team work and support from many persons and organizations. We owe a special debt of gratitude to various officials and experts from NDMA and Disaster Management Division of Ministry of Home Affairs, Govt. of India for the encouragement and support throughout the work. We would like to thank other experts, particularly faculties of FRI, Dehradun, Forest Survey of India, Dehradun and other forestry departments for their support and suggestions in the design of this book. We are grateful to Dr. V. K. Bahuguna, IFS, Ex-Director General, ICFRE, Dehradun and Prof. V.K. Sharma, Vice Chairman, SDMA of Sikkim State who had reviewed and discussed various issues related to forest fire risk mitigation, particularly preparedness aspects with us in detail and suggested some comments to improve the book content. We have had several rounds of discussions with many other experts engaged in forest fire for their comments before finalizing the book. However, we take the responsibility for any inadequacy in the book.

This book comprises seven chapters equipped with the latest information on forests, forest fire & its impacts, forest fire management strategies and related issues at national and international levels. An update and good annotated bibliography on forest fire has also been given in this book, which may be definitely useful for trainers, researchers and foresters.

At last but not the least, we are thankful to our colleagues of NIDM for their time to time discussions, valuable suggestions and support on different aspects of forest fire. We are also thankful to Dr. V.K. Naik, Consultant, NIDM for his valuable suggestions in the designing of the book.

A book of this nature, prepared for use anywhere in the country, is bound to have certain shortcomings; we trust that users will communicate their views to us so that we can strive to make this book more effective.

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ABBREVIATIONS

AD	Anno Domini
ASEAN	Association of Southeast Asian Nations
AVHRR	Advanced Very High Resolution Radiometer
BALTEX	Baltic Exercise for Fire Information and Resources Exchange
BC	Before Christ
BLM	Bureau of Land Management
CBOs	Community Based Organisations
CC	Command Centre
CSS	Centrally Sponsored Schemes
CU	Cubic
DIG	Deputy Inspector General
DMF	Disaster Management Facility
DM	Disaster Management
ECE	Economic Commission for Europe
ENSO	El – Nino – Southern Oscillation
ESF	Emergency Support Function
FAO	Food and Agriculture Organization
FCA	Forest Conservation Act
FFM	Forest Financing Mechanism
FFM	Forest Fire Management
FFP	Fire Fighter Property
FFPC	Forestry and Forest Products Committee
FEBBRG	Fire Ecology and Biomass Burning Research Group
FIG.	Figure
FRI	Forest Research Institute

FSI	Forest Survey of India
GCMs	General Circulation Models
GDP	Gross Domestic Product
GFRA/FRA	Global Forest Resources Assessment
GFMC	Global Fire Monitoring Centre
GOI	Government of India
GTZ	Gesellschaft fur Technische Zusammenarbeit
GWFN	Global Wildland Fire Network
HA	Hectare
HP	Himachal Pradesh
HPC	High Powered Committee
HRD	Human Resource Development
IC	Incident Commander
ICFRE	Indian Council of Forest Research and Education
ICIMOD	International Centre for Integrated Mountain Development
ICS	Incident Command System
IDNDR	International Decade of Natural Disaster Reduction
IEC	Information, Education and Communication
IG	Inspector General
IMO	Information & Media Officer
INSARAG	International Search and Rescue Advisory Group
IRS	Incident Response System
IRTs	Incident Response Teams
ISDR	International Strategy for Disaster Reduction
ISFR	India State of Forest Report
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature

JFM	Joint Forest Management
Km	Kilometer
KML	Keyhole Markup Language
LO	Liaison Officer
LS	Logistics Section
MDF	Moderately Dense Forest
MODIS	Management of Data Information Systems / Moderate Resolution Imaging Spectrometer
MoEF	Ministry of Environment and Forests
MRA	Main Results Areas
NAFP	Nepal-Australia Forestry Project
NCMRWF	National Centre for Medium Range Weather Forecasting
NDMA	National Disaster Management Authority
NFAP	National Forestry Action Plan
NGOs	Non Governmental Organizations
NO	Nodal Officer
NOAA	National Oceanic and Atmospheric Administration
NASA	National Aeronautics and Space Administration
NRSC	National Remote Sensing Centre
NTFP	Non Timber Forest Produce
NWFP	Non Wood Forest Products
OF	Open Forest
OS	Operations Section
PF	Protected Forest
PRIs	Panchayati Raj Institutions
PS	Planning Section
RF	Reserved Forest
RO	Responsible Officer

SFDs	State Forest Departments
SMS	Short Message Service
SO	Safety Officer
Sq	Square
SSR	Seasonal Severity Rating
TACIS	Technical Assistance to the Commonwealth of Independent States
TCPs	Technical Cooperation Programmes
TOF	Trees Outside Forests
UF	Unclassified Forest
U.K.	United Kingdom
UN	United Nation
UNESCO	United Nations Educational and Scientific Organization
UNU	United Nations University
U.P.	Uttar Pradesh
US	United States
USA	United States of America
USDA	United States Department of Agriculture
UTs	Union Territories
VDF	Very Dense Forest
VFC	Village Forest Committee
WCN	World Conservation Network
WFAG	Wildland Fire Advisory Group
WG	Working Group
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wide Fund
YR	Year

Chapter 1

FOREST : AN OVERVIEW

1.1 Introduction

Since time immemorial, forests have been an integral part of human ecosystem. They are nature's greatest bounty to mankind and play a very significant role in its life. Besides providing shelter and protection to a large number of living beings, including pre-historic man, they have been a major source of food, wood and a great variety of other products. Since ancient times forests have played important role in social, economic and religious activities and have enriched human life in variety of ways both material and psychological.

How to define forests?

Forests have been defined in various ways, however, an ideal definition of forest may be:

"Forests constitute the largest, complex & most important natural resource mostly dominated by trees or continuous forest with trees usually growing to more than about seven meters in height & able to produce wood. This includes both closed forest formations where trees of various storey and undergrowth cover a high proportion of the ground and open forest formations with a continuous grass layer in which tree synusia covers at least 10% of the ground. It is also defined as the land with tree crown cover (stand density) of more than 20 percent of its area."

Food and Agriculture Organization (FAO) of United Nations defines forest in a bit technical sense as *"Land with a tree canopy cover of more than 10 percent and area of more than 0.5 hectare"*. In this context the forest is defined not only by the presence of trees but also by the absence of other predominant land uses. However, this definition of the forest does not cover its legal aspect. As far as the legal aspect is concerned, it has nothing to do with tree canopy or the tree cover and is simply defined as an area of land accorded as "Forest" in the revenue records or proclaimed to be forest under "Forest Law or Act". In India, while describing forest area, only this legal status of the forest is taken into consideration and according to this *"forest area" is an area recorded as forest in the government records and is commonly known as "the recoded forest area".* The recorded forest area can be classified as *reserved, protected and unclassified* as defined below-

Reserved Forest (RF): An area notified under the provisions of Indian Forest Acts or the State Forest Acts having full degree of protection. In Reserved Forests all activities are prohibited unless permitted.

Protected Forest (PF): An area notified under the provisions of Indian Forest Act or the State Forest Act.

Unclassified Forest (UF): An area recorded as forest but not included in reserved or protected forest category. Ownership status of such forests varies from state to state.

In whatever way it is defined; the forests are the major forms of natural landscape and are the most important natural resources of the world. Unlike other natural resources, such as minerals, mineral oils and natural gas, forests have the great advantage of being renewable and its productivity in use depends considerably upon the way its benefits are reaped by man.

For million of years most of the parts of the terrestrial habitats i.e. the natural vegetation were forests. For several thousands of years, primitive man lived in forests as hunter and food gatherer component of forest ecosystem. In the later stages, forests were invaded and cleared for suitable agricultural pursuits, this was at such an early stage that man yet did not develop the iron implements and he had to girdle the tree with stone implements. From that stage to the present time, forests are viewed from two angles:

I. Firstly they give valuable raw material and secondly,
II. They are considered rivals for the space needed for crops and flocks.

1.2 Forests through Geological Ages

A careful perusal or study of ecosystem is of paramount importance to understand the scientific secrets of the life and its continuity on this living planet, the ***EARTH***. Since origin of life in the geological past, diverse ecosystems have evolved on earth, the factors, which are governing climate and are the main geographical dimensions of our planet Earth. Earth is an unique and the only known planet with ***LIFE -*** the power that an organism possesses to maintain and reproduce itself.

The evidences of organic evolution indicate that present forms of life have arisen by gradual changes from pre-existing forms and the more complex forms that have evolved from simpler forms. The distribution of plants and animals in time ***(palaeontology)*** and space ***(geographical distribution)*** assumed a great significance. For about 1600 million years ago, when the first simpler form of life evolved on Earth, the vegetation of this planet has passed through a long chain of changes and evolution and the present form of forest on earth is a result of continuous evolution through geological ages. Various phases of forest evolution through geological ages are shown in Table-1.1.

Table-1.1: Geological Time Scale

Era	Period	Epoch	Approx. Beginning (millions yrs. B.P.)	Approx. Duration (millions yrs.)	Plants	Animals
Cenozoic	Quaternary	Recent	0.01	0.01	Decline of woody plants, rise of herbaceous plants	Modern Humans
		Pleistocene	3	3	Extinction of many Species	Ice Ages; evolution of humans; giant mammals
	Tertiary	Pliocene	10	7	Forests decline;	Early hominids
		Miocene	25	15	Grasslands spread	Spread of anthropoid apes
		Oligocene	40	15	Monocotyledons become common	First anthropoids; some modern genera of mammals
		Eocene	60	20	Rise of monocots;	Many modern mammalian families appear
		Paleocene	70	10	Dicots common	Most modern orders of mammals appear
Mesozoic	Cretaceous		135	65	Flowering plants spread; gymnosperms decline	First modern birds; some modern orders of mammals; dinosaurs become extinct at end of period
	Jurassic		180	45	Cycads and conifers common; probable origin of angiosperms	Dinosaurs dominant; first birds and mammals
	Triassic		225	45	Extinction of seed ferns; gymnosperms dominant	Labyrinthodont amphibians; mammal-like reptiles; first dinosaurs
Paleozoic	Permian		270	45	Decline of lycopods and horsetails; seed ferns and gymnosperms dominate	Reptiles replace amphibians as dominant land animals
	Carboni-ferous		350	80	Tropical Coal Forests; lycopods and horsetails dominant	First reptiles; amphibians dominant; insects common
	Devonian		400	50	First seed plants (gymnosperms); forests	Fish dominant; sharks abundant; first amphibians

	Silurian		440	40	Evidence of primitive land plants	Marine arachnids dominant; arthropods invade land
	Ordovician		500	60	Probable origin of land plants	First vertebrates (jawless fishes); invertebrates dominate the seas
	Cambrian		600	100	Marine algae diversify	All major invertebrate phyla appear suddenly; trilobites, branchiopods dominant
Pre-Cambrian			From origin of Earth 4.5-5.0 billion years ago		Primitive aquatic plants—algae, fungi	Marine protozoa; few mollusks, some worms and other soft metazoans

Source:* *Life Science of Evolution by William D. Stansfield (2003), Macmillan Publishing Co., INC, New York

1.3 World forest scenario

As evident from the table 1.1, the forests of the planet Earth were continuous on change due to evolution. In the early history of the earth, these changes were very slow and natural, however, with the introduction of the *homo sapiens* on the planet Earth and its interference with the nature, these changes accelerated with an abnormal speed. The present forest status of the world is the result of these changes, both natural and anthropogenic.

At present the world's total forest area is just over 4 billion hectares, which corresponds to an average of 0.6 ha per capita (Global Forest Resources Assessment 2010). This forest cover is not uniformly distributed throughout the land mass. As per State of Worlds Forest Report 2011, Europe is the richest in forest cover forming around 45 percent of the total forest cover of the world. In term of percentage of land under forest cover, South America is on the top, having nearly half of its land mass under forest and in term of per capita forest area, Oceania stands the first (Table-1.2 & Fig.-1.1).

Table-1.2: Forest Area by Region 2011

Country/ Area	Forest Area (1000 ha)	% of Land Area	Area per 1000 people	1990-2000 (1000 ha)	%	2000-2010 (1000 ha)	%
Africa	674419	23	683	-4067	-0.6	-3414	-0.5
Asia	592512	19	145	-595	-0.1	2235	0.4
Europe	1005001	45	1371	877	0.1	676	0.1
Caribbean	6933	30	166	53	0.9	50	0.7
North and Central America	705393	33	1315	-289	0	-10	0
South America	864351	49	2246	-4213	-0.5	-3997	-0.5
Oceania	191384	23	5478	-36	0	-700	-4
Total World	4033060	31	597	-8323	-0.2	-5211	-0.1

Source: State of the World Forests Report, 2011; FAO.

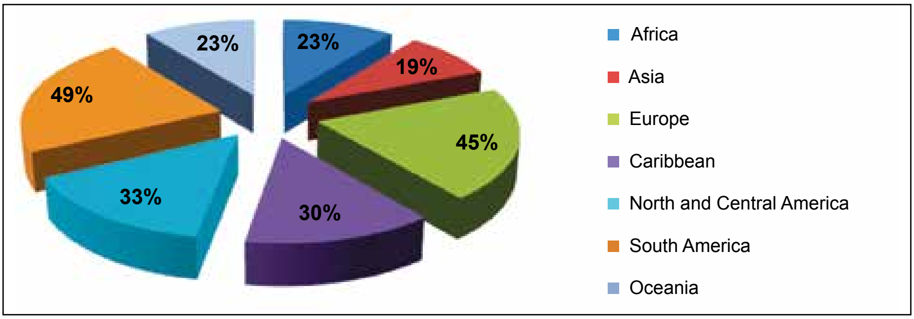


Fig.-1.1: Forest Areas by Region (%)

Distribution of the forest cover over globe is dependent on many factors, mainly geographical characteristics i.e. altitude, geology/ soil type and climate. Climatic conditions i.e. the temperature and the rainfall are strategic factors in determining the forest distribution. Based on these two factors four types of forests have been identified globally i.e. tropical, subtropical, temperate and boreal forests, which are further sub grouped into thirteen sub types as detailed in Table-1.3 & Fig.-1.2.

Table-1.3: Distribution of Forests by Ecological Zone, 2000

Ecological Zone	Total Forest (%)	Africa (%)	Asia (%)	Europe (%)	North and Central America (%)	Oceania (%)	South America (%)
Tropical rain forest	28	24	17	–	1	–	58
Tropical moist deciduous	11	40	14	–	9	6	31
Tropical dry	5	39	23	–	6	–	33
Tropical mountain	4	11	29	–	30	–	30
Total tropical forests	**48**	**28**	**19**		**5**	**1**	**47**
Sub-tropical humid forest	4	–	52	–	34	8	6
Sub-tropical humid forest	1	16	11	30	6	22	14
Sub-tropical mountain	3	1	47	13	38	–	1
Total sub-tropical forests	**8**	**2**	**42**	**7**	**37**	**7**	**5**
Temperate oceanic forest	1	–	–	33	9	33	25
Temperate continental forest	7	–	13	40	46	–	–
Temperate mountain	3	–	26	40	29	5	–
Total temperate forests	11	–	17	39	39	4	2
Boreal coniferous forest	19	–	2	74	24	–	–
Boreal tundra woodland	3	–	-	19	81	–	–
Boreal mountain	11	–	1	63	36	–	–
Total boreal forests	**33**	**–**	**2**	**65**	**34**	**–**	**–**
Total forests	**100**	**17**	**14**	**27**	**14**	**5**	**23**

Source: State of the World Forests Report, 2001

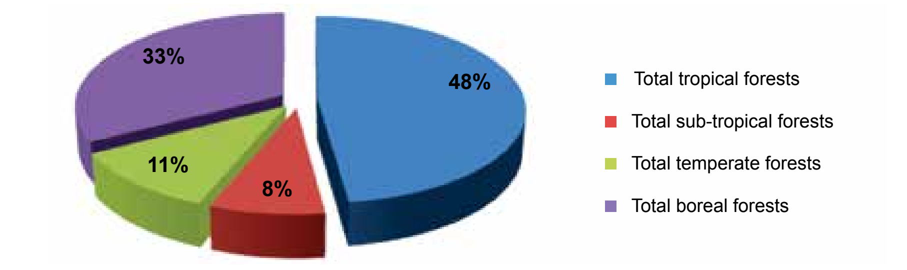


Fig.-1.2: Global Forest Distribution by major Ecological Zones

Box-1.1: Key Findings of the Global Forest Resource Assessment- 2010

Global Forest Resource Assessment (FRA) is carried out by Food and Agriculture Organization of the United Nations at five years intervals. It provides valuable data and information related to forestry and allied sectors needed to support policies, decisions and negotiations in all matters where forestry plays a part.

FRA 2010 is based on report from 233 countries. Key findings of the report are summarized in the following text:

- **Forests cover 31% of total land area:** The world's total forest area is just over 4 billion hectares, which corresponds to average of 0.6 ha per capita.
- **The rate of deforestation shows sign of decrease, but are still alarmingly high:** Around 1.3 million hectares of forest were converted to other uses or lost through natural causes each year in the last decade compared with 16 million hectares per year in 1990s.
- **Large-scale planting of trees is significantly reducing the net loss of forest area globally:** The net change in the forest area in the period 2000-2010 is estimated at -5.2 million hectares per year down from -8.3 million hectares per year in the period 1990-2000.
- **South America and Africa continue to have the largest net loss of forest:** At a regional level, South America suffered the largest net loss of forests between 2000 and 2010- about 4.0 million hectares per year- followed by Africa, which lost 3.4 million hectares annually.
- **Forest stores a vast amount of carbon:** World's forests store 289 gigatonnes (Gt) of carbon in their biomass alone.
- **Primary forests account for 36% of forest area- but have decreased by more than 40 million hectares since 2000:** The decrease of primary forest area, 0.4 percent annually over a ten year period, is largely due to reclassification of primary forest to 'other naturally regenerated forest' because of selective logging and other human interventions.
- **The area of planted forest is increasing and now accounts for 7 percent of total forest area:** Between 2000 and 2010, the area of planted forest increased by about 5 million hectares per year
- **Twelve percent of the world's forests are designated for the conservation of the biological diversity:** Account for 12 % of the total forest area or more than 460 million hectares.

- **Legally established protected areas cover an estimate of 13 percent of the world's forests:** The area of forest within a protected area system has increased by 94 million hectares since 1990. Two thirds of this increase has been since 2000.
- **Forest Fire is severely underreported at global level:** Forest fires can be devastating and also frequently cause loss of property and human life. However, the area of forest affected by fires was severely underreported, with information missing from many countries, especially in Africa. Less than 10 percent of all forests are prescribed burning; the rest are classified as wildfires.
- **Insect pests and diseases, natural disasters and invasive species are causing severe damage in some countries:** Outbreaks of forest insect pests damage 35 million hectares of forest annually primarily in the temperate and boreal zone.
- **Thirty percent of the world's forests are primarily used for production of wood and non-wood forest products.**
- **Wood removals increased between 2000 and 2005 following a fall in the 1990s.**
- **Eight percent of the world's forests have protection of soil and water resources as their primary objective:** Around 330 million hectares of forest are designated for soil and water conservation avalanche control, sand dune stabilization, desertification control or costal protection.
- **The management of forests for social and cultural functions is increasing, but the area is difficult to quantify.**
- **The value of wood removals is high, but fluctuating:** Wood removals valued just over US$100 billion annually in the period 2003-2007, mainly accounted for industrial round wood.
- **The value of non-wood forest products remain underestimated:** The reported value of non-wood forest product removals amounted to about US$18.5 billion in 2005.
- **Around 10 million people are employed in forest management and conservation- but many more are directly dependent on forests for their livelihoods.**
- **Governments generally spend more on forestry than they collect in revenue:** On average, total forest revenue collection was about US$ 4.5 per hectare, ranging from under US$1 per hectare in Africa to just over US$ 6 per hectare in Europe. Public expenditure on forestry was about US$ 7.5 per hectare on average.

- **Significant progress has been made in developing forest policies, laws and national forest programmes:** Of the 143 countries that have a forest policy statement, 76 countries have issued or updated their statements since 2000. Of the 156 countries that have a specific forest law, 69 countries- primarily in Europe and Africa- reported that their current forest law has been enacted or amended by since 2005.
- **Staff numbers in public forest institutions are decreasing:** Around 1.3 million people were reported to work in public forest institutions in 2008. At global level, the number of staff had declined by 1.2 percent annually since 2000.
- **The number of university students graduating in forestry is increasing:** More than 60,000 university students graduate in forestry annually.
- **Eighty percent of the world's forests are publicly owned, but ownership and management of forests by communities, individuals and private companies is on rise.**
- **Forests are managed for multitude of uses and values.**
- **More than 1.6 billion hectares of forest have a management plan.**

Source: Food and Agriculture Organization of the United Nations, 2010

1.4 Forests in India

1.4.1 India is one of the few countries rich in bio diversity. As per the Forest Survey of India Report, 2011, India has forest cover of 692,027 km2, comprising 21.05 percent of the total geographic area of the country. The country shows much variation in its forest vegetation due to its diversified climatic and physiographic conditions. The forest vegetation in India varies from tropical evergreen forests in the Andaman & Nicobar Islands to dry Alpine forests high up in Himalayas. In between the two extremes, the country has semi-evergreen, Deciduous, Littoral and Swamp, Thorn, Sub-tropical broad-leaved hill pine, and Montana-temperate forests. In physical terms, the forests of the country vary from those that contain trees over 70 meters in height to those that have trees less than 7 meters in height and has stratification of trees that varies from single to many storied. According to Forest survey of India, the country has sixteen types of major forests (Table-1.4).

Table-1.4: Forest Types - Distribution & Extent

S.No	Forest Type	% of forest area	Occurrence in States/ UTs of India.
1.	Tropical wet evergreen forest	2.92	Arunachal Pradesh, Assam, Karnataka, Kerala, Mizoram, Minipur, Nagaland, Tamil Nadu, Sikkim, Anadaman & Nicobar, Islands and Goa.
2.	Tropical semi-evergreen forest	13.79	Assam, Karnataka, Kerala, Maharashtra, Nagaland, Orrissa, Tamil Nadu, Andaman & Nicobar, Islands and Goa
3.	Tropical moist deciduous forest.	19.73	Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, M.P., Maharashtra, Manipur, Meghalaya, Mizoram, Tripura, Nagaland, Orissa, Tamil Nadu, U.P., West Bengal, Andaman & Nicobar Islands, Goa and Dadra & Nagar Havelli.
4.	Littoral and swamp forest	0.69	Andhra Pradesh, Gujarat, Maharasshtra, Orissa, Tamil Nadu, West Bengal and Andaman & Nicobar Islands.
5.	Tropical dry deciduous forest	41.87	Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, M.P., Maharashtra, Jammu & Kashmir, Punjab, Rajasthan, Tamil Nadu and U.P.
6.	Tropical thorn forest	2.25	Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Karnataka, M.P., Maharashtra, Punjab, Rajasthan, Tamil Nadu and U.P.
7.	Tropical dry evergreen forest.	0.13	Andhra Pradesh , Gujarat, Haryana, Himachal Pradesh, Karnataka, M.P., Maharashtra, Punjab, Rajasthan, Tamil Nadu and U.P.
8.	Sub tropical broad-leafed hill forest.	2.69	Assam and Meghalaya.
9.	Sub tropical pine forest	2.63	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalya, Nagaland, Sikkim, Haryana, U.P. and Punjab.
10.	Sub tropical dry evergreen forest	0.03	Himachal Pradesh and Jammu & Kashmir.
11.	Montane wet temperate Forest.	0.69	Arunachal Pradesh, Karnataka, Manipur, Nagaland, Sikkim and Tamil Nadu.
12.	Himalayan moist temperate forests	4.12	Himachal Pradesh, Jammu & Kashmir and U.P.
13.	Himalayan dry temperate forests	0.84	Jammu & Kashmir and Himachal Pradesh
14., 15. & 16.	Sub-alpine forest, Moist alpine- scrub & Alpine scrub	2.55	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and U.P.; Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and U.P.; Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and U.P.
15.	Plantation/TOF	5.07	
	Total	**100**	

Source: India State of Forest Report 2011

1.4.2 Rich in Bio-Diversity

Because of its diverse physiographic and climatic conditions, India's forests are rich in biodiversity. India falls in the confluence of three major bio-geographic realms, the Indo-Malayan, Eurasian and Afro-tropical and is one of the 12-mega biodiversity countries of the world. The country is divided into ten bio-geographic zones:

I. Trans-Himalayan,

II. Himalayan,

III. Indian deserts,

IV. Semi-arid areas,

V. Western Ghats,

VI. Deccan peninsula,

VII. Gangetic plain,

VIII. North-East India,

IX. Islands, and

X. Coasts.

1.4.3 Flora and Fauna

Forest consists of two major components i.e. flora and fauna. As far as flora is concerned, a number of detailed ethno-botanical explorations have been conducted in different parts of the country and more than 800 plant species of ethno-botanical interest have been collected and identified. As per Botanical Survey of India, the country can be divided into eight distinct floristic regions namely: Western Himalayas, Eastern Himalayas, Assam and North-East, the Gangetic plain, Indus plain, Deccan, Malabar and Andaman.

(i) The Western Himalayan region extending from Kashmir to Kumaon and characterized by the temperate zone is rich in forests of spruce, fir, cedrus, chir pine, other conifers and broad-leaved trees. The higher altitude area of this region named Alpine Zone extends from the upper limit of the temperate zone to about 4,750 meter elevation or even higher. The characteristic trees of the zone are the silver fir, birch, juniper and dwarf willows.

(ii) The Eastern Himalayan region extends from Sikkim eastwards and embraces Darjeeling, Kurseong and the adjacent tracts. The temperate zone of the region has forests of oak, laurel, maple, rhododendrons, alder and birch; different types of conifers, juniper and dwarf willows.

(iii) The Assam and northeastern region comprising of the valleys of Brahmaputra and Surma and the intervening hill regions is rich and luxurious with evergreen forests, occasional thick clumps of bamboo, and tall grasses.

(iv) The Gangetic plain region covers the area from the Aravalli ranges to Bengal and Orissa. A large part of the area is alluvial plain and is under cultivation for wheat, sugar cane and rice. Only small area of the region supports forests of different types.

(v) The Indus plain region comprises of the plains of Punjab, western Rajasthan and northern Gujarat. The region is dry and hot and supports scanty natural vegetation.

(vi) The Deccan region, characterized by the entire tableland of the Indian peninsula supports vegetation of various kinds from scrub areas to mixed deciduous forests.

(vii) The Malabar region covers the excessively humid belt of mountain running parallel to the southwest coast and contains evergreen and moist deciduous forests. This region, besides being rich in forest vegetation, produces important commercial crops like coconut, betel nut, pepper, coffee and tea. Rubber, cashew nut and eucalyptus trees have also been successfully introduced in some parts of this region.

(viii) The Andaman region comprises the Andaman and Nicobar Islands. It bounds in evergreen, semi-evergreen and mangrove forests.

As reported by the Zoological Survey of the country, India has about 90,000 known species of fauna of which 2546 are fishes, 210 amphibians, 425 reptiles, 2000 birds, 397 mammals and the remaining are invertebrates, including protozoa, worms, insects (arthropod), mollusks, crustaceans, etc.

1.4.4 Factors influencing forests

Despite being rich in bio-diversity, the country presents a very poor picture, as far as its forest cover is concerned. With only 2.5 of the world's geographic area and 1.8 % of the total forest cover, the country has to support more than 16% of the total human and about 18% of the cattle population. The forest cover of the country is closely associated with various factors, both natural and man-made. The geology, climate, socio-economic conditions etc. are various such factors which directly or indirectly influence the forest and its bio-diversity. Before going into details about the forest cover, it will be worth to have a glimpse of various facts and figures, influencing forest ecosystem in the country.

(a) Physical features

Covering an area of 3,287,263 km2, India is the seventh largest county of the world. India physically comprises of four broad geographical areas, namely the Great Himalayas (East and West), the vast Indo-Gangetic Plains, the Great Thar Desert, and the Southern peninsula bounded by Western and Eastern Ghats. India, which is bounded by the Himalayas in the North, stretches south flanked by the Bay of Bengal and Arabian Sea and tapers off into the Indian Ocean. The land mass of the country lies within latitudes 8.4 and 37.6 degrees North and longitudes 68.7 and 97.25 degrees East. Physiologically and biologically India is primarily tropical, however, due to altitude variations and other habitat factors, a range of climates can be observed influencing its ecology, flora and fauna. There are also considerable differences among the States, in their pattern of development and other socio-economic and demographic profiles influencing forest eco-system.

Geology and Soils- The geological regions of India broadly follows the physical features and may be grouped into three regions: The Himalayas and their associated group of mountains, the Indo-Gangetic plain and the Peninsular shield. About 600 million years ago, most of the Himalayan region was under sea. About 70 million ago, in a series of mountain building movements through northward movement, the sediment and the basement rocks rose to great heights and the weathering and erosive agencies worked on these to produce all that we see today. The Indo-Gangetic plain as a great alluvial tract separates the Himalayas in north from the peninsula to the south.

The peninsular region has a relative stability. Highly metamorphosed rocks of the earliest periods, dating as far back as 4,000 million years are found here; the rest being covered by the coal-bearing Gondwana formations, lava flows belonging to the Deccan Trap formation and younger sediments.

Each type being particular to a specific locality, India has a wide range of soils. The two important soil types from point of view of agriculture production are Alluvial and Black Cotton Soils. The Alluvial soil composed of sediments of silt and sand deposited by rivers in the interior constitutes the great Indo-Gangetic plains. Alluvial soils, also occurring in the valleys of Narmada and Tapti in Madhya Pradesh and the Cauvery in Tamil Nadu, are considered good for the production of wheat, rice, other cereals, pulses, oil seeds, potato, and sugarcane etc.

Distributing through Maharashtra, Gujarat, Madhya Pradesh, Karnataka, and Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Rajasthan, Black Cotton Soil cover about 51.8 million hectare land mass. These soils are considered good for cultivation of cotton, cereals, pulses, oil seeds, citrus fruits, and vegetables etc. Red soils are found primarily in Tamil Nadu, Karnataka, Kerala, Maharashtra, Andhra Pradesh, Madhya Pradesh, Bihar and West Bengal. Almost all types of crops are grown in these soils but these soils are most suited for rice, ragi, tobacco and vegetable cultivation. Laterite and lateritic soils, covering over 12.6 million hectare area are usually not fertile. The area of desert soils in the country is around 37 million hectares and is also not good for agriculture because of climatic and physiographic factors.

The country is drained by 14 major river systems, broadly classified into four broad basins i.e. Himalayan, Peninsular, Coastal and Inland drainage basins. Himalayan rivers are generally snow fed and perennial. During the monsoon months, the Himalayas receive very high rainfall which leads to discharge of huge quantities of water causing frequent floods and landslides. The Ganga sub-basin, a part of the larger Ganga- Brahmaputra- Meghana basin is the largest in the country. About one-quarter of the India's total area comprises of its catchments area. The peninsular rivers of the country are generally rain fed and therefore, fluctuate in volume. The inland drainage basin streams of Western Rajasthan are few and most of them are of an ephemeral character by draining into either individual basins or into salt lakes, like the Sambhar, or are lost in the sands, having no outlet to the sea.

Climate- Despite being a tropical country, due to great altitudinal variations, almost all climatic conditions from hot desert to cold desert exists in the country. The climate of India may be broadly described as being mostly tropical, tropical-monsoon and montane- temperate in the Himalayas. The four main seasons prevalent in India are winter, summer, south-western monsoon and post-monsoon period. Among all these climatic seasons, post monsoon period commonly known as the winter monsoon begins over north India and passes over the Bay of Bengal before bringing monsoon to the Andaman and to India's southeast coast. The southwest or summer monsoon provides 80 % of the total precipitation in the country. One and a half times of the world's average rainfall per sq. km area is received by India i.e. a total of 400 million hectare meters of annual rainfall and 20 million hectare meters of snowfall in the Himalayas. However, rainfall is confined mostly to the monsoon months leading to 180 million hectare meters of runoff. Out of the balance of 240 million hectare meters, around 140 million hectare meter percolates in the soil, 70 million hectare meters evaporates, around 26 million hectare meters are stored in major and minor irrigation projects and around 4 million hectare meters remains in small tanks.

(b) Land use pattern

Out of the total 3,287,263 km^2 (329 mha) geographical area in the country, the land use data available is only for about 305 million hectares. As per the latest information available, major portion of the land is used for agriculture purpose (around 142.2 million hectares). The agriculture constitutes about 30 % of the country’s GDP and makes major contribution in its economy. Of the total sown area in the country, 84.82 million hectares (i.e. 63%) is rain fed and completely depends on rain for its irrigation.

The forest cover of the country is about 692,027 km^2, 22 million hectare is used for urban and non agriculture purposes, the barren land (without any vegetation due to natural reasons viz. snow bound or rocky in nature) is around 19 million hectare. A major portion of the land is degraded due to wind/ water erosion, water logging and shifting cultivation (approximately 107.4 million hectare). There is around 2.38 million hectare of land suffered due to shifting cultivation, mainly in the northeastern states.

(c) Socio-economic condition

Agriculture is the mainstay of India's economy, contributing approximately 30% to GDP and 65% to the employment. There are 105.29 million operational land holdings in India. The net cropped area of the country is around 140 million-hectare, which comprises around 45.1 of the total land area. Estimates of land use suggest that in addition to denudation of non-agricultural land, 85 million hectare or 59% of agricultural land suffer from soil degradation.

India supports approximately 17.64 % of world's population with only 2.4% of the world's geographic area. India's estimated population has crossed one billion, resulting in an average density of around 382 persons per sq. km. Population density varies between States, e.g. there are about 17 people per sq. km. in Arunachal Pradesh, while 1102 people per sq.km in Bihar as per Census 2011. About 70% of the total population and 80% of the population below poverty line live in rural villages. About half of the country's population and more than two thirds of all women over 15 years of age are illiterate.

The indices of low socio-economic development in India include heavy pressure of population; improper land use and inappropriate systems of farming; deforestation; unplanned development of industries; infrastructure and urban settlements; uncontrolled use of water resources; lack of adequate sanitation; unhealthy working conditions; improper planning of development activities; over-exploitation and non-replenishment of renewable resources; and poor level of education.

Irrational systems of resource have led to floods, droughts, erosion and impoverishment of soil, lowering of water level, water logging, sedimentation, lack of clean drinking water, fall in agricultural productivity, depletion of fishery and forestry resources, water pollution, health hazards, extinction and endangerment of plant and animal species, loss of bio-diversity and poverty.

In India, approximately 37% of the total population is below the poverty line (Tendulkar Committee, 2011). Despite the significant progress in areas such as nutrition and health over the last 65 years, much remains to be done for certain regions and population groups. The poverty and dearth of livelihood and other income generating resources have increased the dependency of the man on natural resources, among which forest is the most vulnerable and easily accessible resource. Along with supplying fuel wood, fodder and other minor forest produce, poor people of the country are forced to exploit forests to earn livelihood.

1.4.5 Indian forests through ages

The existing forest scenario of the country is consequence of natural evolution and changes (both natural and man made). Evidences reveal that the first plant in India appeared around 450 million years ago. Rich coal deposits in India confirm that 300 million years ago the country was very rich in forests. According to paleo-botanical evidences, the Bengal, eastern Bihar and Assam regions were covered by rich forests more than 135 million years ago.

a) Ancient period

In two great epics of India, the *Ramayana* and the *Mahabharatha* there are extensive references to forests and trees, which indicate that forests were generally worshiped and protected during that period. There is also an account of the destruction of the *Khandawa* forest by fire in the *Mahabharatha*. In the *Vishnu Purana* and other *Puranas,* there is reference to *vanas* (forests) existing across the length and breadth of the country, from Kashmir down to peninsular India.

The earliest historical evidence of forests and their use in human life in India relates to the *Mohenjodaro- Harappa* civilization (about 5000-4000 B.C.). The seals and painted pottery recovered from the Indus Valley shows the *pipal* and *babul* trees. From 2000-1500 B.C., the migration of Aryans to India carried forward the process of extensive clearing of forests, especially in areas like Punjab in northwestern India to meet the needs of their numerous settlements, including need for vehicles, housing and fuel. Their use of iron for agriculture implements was a contributory factor in the diffusion of agriculture.

Description about forests in the Mauryan period is also available in *Kautilya's Arthasastra* (321 B.C.), *Indika of Megasthenes, Mudrarakshasas of Visakhadatta* and inscriptions of Emperor Ashoka. The study of these books and inscriptions shows that the *Mauryan* kings were well aware about the significance of forests and wildlife and probably had an independent forest department to look after the conservation of this valuable natural resource. The forest and wildlife offences and corresponding penalties described in these books also confirm this.

Despite centuries separating the two periods, the Gupta period (A.D. 200-600) witnessed a distribution of forests similar to that of the *Mauryan* period. During the period, while the forests were dense in Himalayan foothills and *Dandakaranya,* the western region had a desert climate and sparse vegetation and the Indo-Gangetic plains had flourishing agriculture.

In the post Gupta period, characterized by fragmentation of the country into a large number of states ruled by fratricidal strife, large-scale felling and destruction of forests were caused by hunting, demand for timber and by forest fires. Continuous destruction of forests for timber and clearance for cultivation was the characteristic of the *Moghual* period (1526-1700). The northern and eastern provinces during this period had the best forests, in which wildlife flourished. Widespread deforestation to meet the demands of firewood, etc. was one of the major factors of reducing forest cover during this period. The other biotic factors, which led to the destruction of vegetation was clearing of land for cultivation and grazing by domestic animals.

b) The colonial period

During the colonial rule, the major task undertaken by Britishers was creation of forest department and classification of forests into reserved and protected forests and therein settlement of rights. In British India period, out of 788,156 square miles of total land area, 42.56 % was under cultivation, 44.38 % for common use of the community and only 13.06 % was notified as reserved and protected forest. Most of the exploitable areas and important tree species were brought under working plans. Selection and selection-cum-improvement felling, conversion to uniform system, standard/reserves as well as the *taungya* system (Agri-silviculture), involving clear felling and strip plantation with short duration of agriculture crops between the strips and finally the clear felling and plantation of economically viable species come under various silvicultural systems.

The Britishers also introduced an institutional framework for better management of forests in the country and established Imperial Forest Institute in 1906. Chief Conservators of forests began to be appointed for each province by 1907 and in 1910 a "Forestry Board" comprised of representative chief conservators under the presidentship of the Inspector General of Forests, was set up, which met once in three years to discuss the forestry programmes. In 1927, the new Indian Forest Act was passed. With the passing of the Government of India Act of 1935, forests became entirely the concern of the provinces, though Inspector General of Forests of India continued to provide technical guidance and advice.

c) Post Independence

After independence too, forests of the country remained under tremendous pressure due to various factors. Industrialization and green revolution to make the country self sufficient resulted into enormous loss of forest land. Lack of adequate financial inputs has also adversely affected sustainable development of forests and conservation of biodiversity in the country. Inspite of growing demands resulting into degradation of forests, in recent past number of initiatives by foresters and local people have created areas of new hope for regeneration and development of sustainable use of forest areas all over the country. During the last two – three decades, Social, Agro-forestry and Community Forestry Programmes in India gave emphasis to bring both forests and foresters closer to the community. The Government of India's new participatory forest management systems, being developed by forest departments and forest committees, hold a great promise of a new direction in forest management.

India has a total landmass of around 3.29 million sq. km, out of which the total forest area in the country is around 769,512. sq. km. i.e. 23.41 percentage of the total geographic area. According to State of Forest Report of FSI (2009), the recorded forest area comprises of three categories i.e. reserved (51.6%), protected (26.79%) and un-classed forest (17.24%). The State / UTs wise contribution of the recorded forest area is given in Table-1.5 and Fig.-1.3.

Table-1.5: State and UTs wise forest cover in India

(Area in sq.km)

State/UT	Geographical Area (G.A.)	Recorded Forest Area				% of G.A.
		Reserved Forests	Protected Forests	Unclassed Forests	Total	
Andhra Pradesh	275,069	61,210	1,967	637	63,814	23.2
Arunachal Pradesh	83,743	10,546	9,528	31,466	51,540	61.55
Assam	78,438	17,864	–	8,968	26,832	34.21
Bihar	94,163	693	5,779	1	6,473	6.87
Chhattisgarh	135,191	25,782	24,036	9,954	59,772	44.21
Delhi	1,483	78	7	–	85	5.73
Goa	3,702	253	845	126	1,224	33.06
Gujarat	196,022	14,122	479	4,326	18,927	9.66
Haryana	44,212	249	1,158	152	1,559	3.53
Himachal Pradesh	55,673	1,898	33,060	2,075	37,033	66.52
Jammu & Kashmir	222,236	17,643	2,551	36	20,230	9.1
Jharkhand	79,714	4,387	19,185	33	23,605	29.61
Karnataka	191,791	28,690	3,931	5,663	38,284	19.96
Kerala	38,863	11,123	142	–	11,265	28.99
Madhya Pradesh	308,245	61,886	31,098	1,705	94,689	30.72
Maharashtra	307,713	49,226	8,195	4,518	61,939	20.13
Manipur	22,327	1,467	4,171	11,780	17,418	78.01
Meghalaya	22,429	1,113	12	8,371	9,496	42.34
Mizoram	21,081	7,909	3,568	5,240	16,717	79.3
Nagaland	16,579	86	508	8,628	9,222	55.62
Orissa	155,707	26,329	15,525	16,282	58,136	37.34
Punjab	50,362	44	1,153	1,861	3,058	6.12
Rajasthan	342,239	12,454	17,416	2,769	32,639	9.54
Sikkim	7,096	5,452	389	-	5,841	82.31
Tamil Nadu	130,058	19,388	2,183	1,306	22,877	17.59
Tripura	10,486	4175	2	2117	6,294	60.02
Uttar Pradesh	240,928	11,660	1,420	3,503	16,583	6.88
Uttarakhand	53,483	24,638	9,882	131	34,651	64.79
West Bengal	88,752	7,054	3,772	1,053	11,879	13.38
Andaman & Nicobar	8,249	2,929	4,242	–	7,171	86.93
Chandigarh	114	31	-	3	34	29.82
Dadra & Nagar Haveli	491	199	5	–	204	41.55
Daman & Diu	112	0	8	0	8	7.38
Lakshadweep	32	0	0	0	0	0
Puducherry	480	4	2	7	13	2.71
Total	3,287,263	430,582	206,219	132,711	769,512	23.41

Source: State of Forest Report of Forest Survey of India: 2009

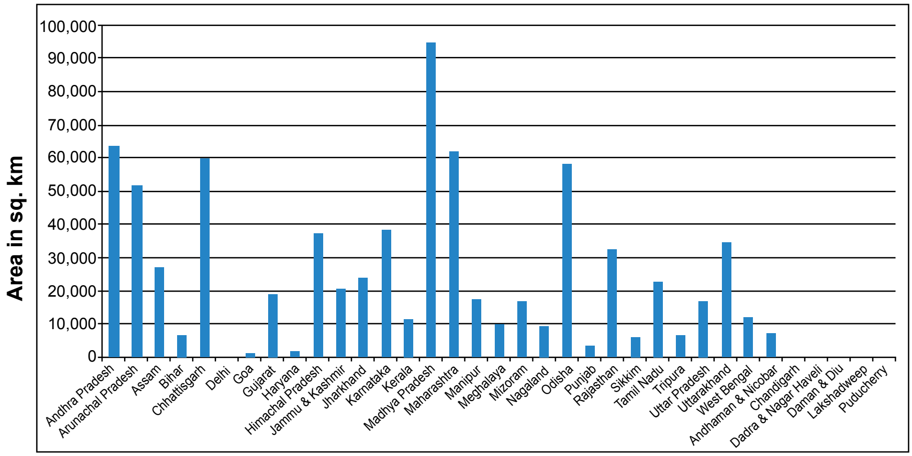


Fig.-1.3: Recorded Forest Area in States/ UTs.

(Source: State Forest Report- 2009, FSI)

Though as per the India State Forest Report, 2009, the recorded forest area of the country was more than 23%, major chunk of this area is without any tree cover. Out of the total recorded forest area i.e. 769,512 sq. km, only 690,899 sq. km was under forest cover (the land mass having tree canopy of more than ten percent). Further, depending upon the crown density, the forest cover in the country has been classified into Very Dense Forest (VDF), Moderately Dense Forest (MDF) and Open Forest (OF). While the forest land with tree canopy of more than 70% has been classified as Very dense, between 40% to 70% and between 10% to 40% have been put in categories of Moderately dense and Open forest, respectively. The state wise details of the forest cover under these three categories i.e. VDF, MDF & OF are given in Table-1.6 & Fig.-1.4.

Table-1.6 : Forest cover area in States and UTs in India

(Area in sq.km)

State/UT	Geographical Area	2011 Assessment				Forest Cover Reported in ISFR 2009	Interpretational Change	Forest Cover 2009 as Revised (7+8)	Real Change from SFR-09 (6-9)
		Very Dense Forest	Mod. Dense Forest	Open Forest	Total (3+4+5)				
1	2	3	4	5	6	7	8	9	10
Andhra Pradesh	275069	850	26242	19297	46389	45102	1568	46670	-281
Arunachal Pradesh	83743	20868	31519	15023	67410	67353	131	67484	-74
Assam	78438	1444	11404	14825	27673	27692	0	27692	-19
Bihar	94163	231	3280	3334	6845	6804	0	6804	41
Chhattisgarh	135191	4163	34911	16600	55674	55870	-192	55678	-4
Delhi	1483	7	49	120	176	177	0	177	0
Goa	3702	543	585	1091	2219	2151	61	2212	7
Gujarat	196022	376	5231	9012	14619	14620	0	14620	-1
Haryana	44212	27	457	1124	1608	1594	0	1594	14
Himachal Pradesh	55673	3224	6381	5074	14679	14668	0	14668	11
Jammu & Kashmir	222236	4140	8760	9639	22539	22686	-149	22537	2
Jharkhand	79714	2590	9917	10470	22977	22894	0	2894	83
Karnataka	191791	1777	20179	14238	36194	36190	0	36190	4
Kerala	38863	1442	9394	6464	17300	17324	0	17324	-24
Madhya Pradesh	308245	6640	34986	36074	77700	77700	0	77700	0
Maharashtra	307713	8736	20815	21095	50646	50650	0	50650	-4
Manipur	22327	730	6151	10209	17090	17280	0	17280	-190
Meghalaya	22429	433	9775	7067	17275	17321	0	17321	-46
Mizoram	21081	134	6086	12897	19117	19240	-57	19183	-66
Nagaland	16579	1293	4931	7094	13318	13464	0	13464	-146
Orissa	155707	7060	21366	20477	48903	48855	0	48855	48
Punjab	50362	0	736	1028	1764	1664	0	1664	100
Rajasthan	342239	72	4448	11567	16087	16036	0	16036	51
Sikkim	7096	500	2161	698	3359	3357	2	3359	0
Tamil Nadu	130058	2948	10321	10356	23625	23338	213	23551	74
Tripura	10486	109	4686	3182	7977	8073	-88	7985	-8
Uttar Pradesh	240928	1626	4559	8153	14338	14341	0	14341	-3
Uttarakhand	53483	4762	14167	5567	24496	24495	0	24495	1

1	2	3	4	5	6	7	8	9	10
A & N Islands	8249	3761	2416	547	6724	6662	0	6662	62
Chandigarh	114	1	10	6	17	17	0	17	0
Dadra & Nagar Haveli	491	0	114	97	211	211	0	211	0
Daman & Diu	112	0	0.62	5.53	6	6	0	6	0
Lakshadweep	32	0	17.18	9.88	27	26	0	26	1
Puducherry	480	0	35.37	14.69	50	44	6	50	0
Grand Total	3287263	83471	320736	287820	692027	690899	1495	692394	-367

* **The change in the above table refers to change in the area with respect to 2009 assessment after incorporating interpretational changes.**

Source: India State of Forest Report 2011

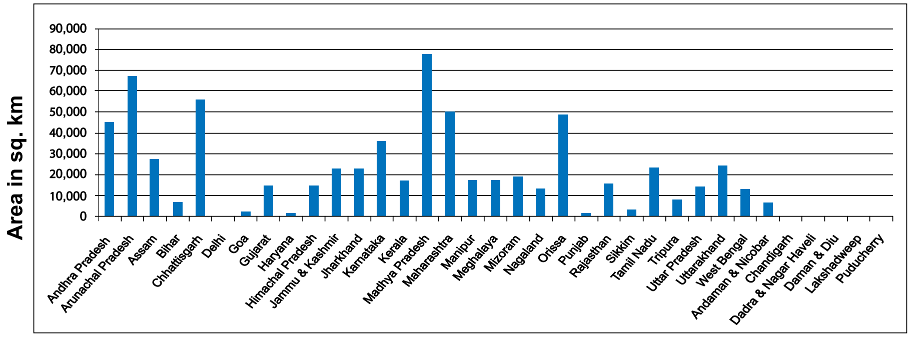


Fig.-1.4: Total Forest cover area under VDF, MDF and OF in States/ UTs of India

The forest cover of the country, though quite rich in biodiversity is under tremendous pressure as it supports more than one billion people i.e. equivalent to about 16% of world's population and 450 million livestock heads. Immense biotic pressure, low productivity and acute degradation characterize the Indian forests. About 78% of the forest in the country is subject to grazing and 51% is open to occasional forest fire. Against the world's average forest productivity of 2.1 cu m/ha/yr., Indian forest has productivity of 0.7 cu m/ha/yr only.

1.5 Significance of forests

1.5.1 Since ancient times forests have been integral parts of Indian society. Ancient literature of Hindu Mythology like *Puranas, Vedas* etc. have mentioned the significance of this natural resource for the community. Forests have not only proved significant for economic utility, but also influenced the social and economic life of the mankind, modified their views and provided new thoughts to poets and artists too. Number of different scriptures in the past have talked about these roles of forests. The *Agni Purana* (Hindu Scripture) while discussing the role of forests in human life goes so far as to say ***"That Man who plant trees for the welfare of the public obtains obsolete bliss."*** The *Geeta* (Another Hindu Scripture) mentions ***"Living beings survive on food. Food is produced by rain, rain depends on forests. Therefore, conservation of forests is necessary to keep it in a healthy state."***

Our historical past is full of examples, which show that our ancestors recognizing forest's significance tried their best to conserve and protect this valuable natural resource. Not only in the past, but in Modern Indian Society also forests are treated sacred and there are many evidences when different sects of Indian Society at times have raised voice against deforestation successfully. *"Chipko Movement"* of Uttarakhand is the recent example of such awareness in our society.

But unfortunately this awareness is restricted to very limited section of our society and a major population in the country is still unaware about significance of forests. As a result, the forests of the country are suffering at the hand of its own people. In such circumstances, it is very important that people are made aware of the significance of forests, so that they themselves take initiative to protect and conserve them successfully. Some of the significant features of forests are as follows:

1.5.2 Socio - economic significance of the forests

Forestry makes several contributions, which are supporting sustained human welfare. These include direct benefits (physical products such as wood, food, medicines, fuel, fodder, fiber and organic fertilizer) as well as indirect and attributable benefits. As an inseparable component of the total land use systems, forestry has significant inter-relationship with agricultural, pastoral and food-producing systems also. Through soil and water conservation and maintenance of soil fertility, forestry provides critical support for agricultural development. In addition, forest-based enterprises help increase rural employment and raise income and living standards of rural people, including forest dwellers and indigenous groups. The quality of life in rural areas depends upon the management of adjacent forests. Some of the following figures, especially in Indian context clearly show importance of forests.

- Over two-thirds of rural and half of the urban population use fuel wood for cooking purposes.
- About a quarter of India's livestock population, which is the largest in the world, is almost totally dependent on forestlands.
- About 70 per cent of India's population uses traditional medicine (mainly forest-based), and many of the rural poor have no access to other systems of medicine.
- Forest-based activities are often an important source of cash income for the poor, especially during lean seasons.
- The wild relatives of avocado, banana, cashew, cacao, cinnamon, coconut, coffee, grapefruit, lemon, paprika, oil, palm, rubber etc. worth billion of rupees are found in tropical forests.

1.5.3 Livelihood Generation

Forestry is a comparatively labour-intensive activity. Forests and the diverse forest-based enterprises provide direct and indirect employment. As per Global Forest Resources Assessment (GFRA) 2010 about ten million people are employed in forest management and conservation globally, but many more are directly dependent on forest for their livelihood.. It is estimated that about 250 million person days are generated annually under various plan schemes taken up for forestry development in forest areas and other government lands. In addition, about 75 million person days are generated annually under agro-forestry and farm-forestry programmes. Non-plan activities, which include protection, maintenance and harvesting of forests, are estimated to generate about 100 million person days. Forests provide considerable employment to rural poor and tribal people in and around forest areas, who make a living either by consumption or sale/barter of various produce collected from the forest. The employment generated in the processing of the forest produce, both in the organized and unorganized sector, is also considerable.

1.5.4 Forests and Tribal population

Tribal population has intimate relationship with forests. Socio-cultural and socio-economic pattern of the tribal population are inextricably linked with forests. Forests are source of subsistence and livelihood for the tribal communities. The tribal population is spread over in almost 188 districts of 26 states/ UTs in the country. This tribal land is very rich in forest, where almost 37.32% of the area is under forest (Table-1.7). The tribal population is very intimately related with the forest and depends on forest for its many needs viz.-

- Food in the forms of yams and other tubers, mushroom, bamboo shoots, several kinds of fruit and nuts, honey, red ants, eggs and meat;
- Fiber from the barks of trees and climbers, with which to fashion different kinds of rope and even clothes;
- Herbal Medicine, for common ailments;
- Oils, from seeds of different plant species for cooking, medicine and other purposes;
- Wood for building, agricultural implements and fuels;
- Bamboo- for fences and buildings, other daily use articles like baskets, bows, arrows and flutes;
- Twigs, used as toothbrushes, etc.

Table-1.7: Forest cover in tribal districts

(Area in km²)

State/UT	No. of Tribal Districts	Geographical Area in Tribal Districts	Very Dense Forest	Mod. Dense Forest	Open Forest	Total Forest	% of G.A	Change* in forest cover	Scrub
			Forest Cover 2011						
Andhra Pradesh	8	87,090	239	16,613	8,449	25,301	29.05	-266	2,368
Arunachal Pradesh	13	83,743	20,868	31,519	15,023	67,410	80.50	-74	122
Assam	16	50,137	648	4,599	6,749	11,996	23.93	-12	93
Chhattisgarh	9	92,656	3,614	24,477	11,966	40,057	43.23	-3	89
Gujarat	8	48,409	322	2,944	3,500	6,766	13.98	-1	393
Himachal Pradesh	3	26,764	950	1,067	1,214	3,231	12.07	0	139
Jharkhand	8	44,413	1,677	6,067	6,218	13,962	31.44	73	341
Karnataka	5	26,597	1,248	7,642	4,249	13,139	49.40	0	55
Kerala	9	27,228	1,073	7,017	5,006	13,096	48.10	-13	52
Madhya Pradesh	18	139,448	5,639	20,275	16,387	42,301	30.33	-11	2,097
Maharashtra	11	138,272	7,275	11,389	10,848	29,512	21.34	3	2,127
Manipur	9	22,327	730	6,151	10,209	17,090	76.54	-190	1
Meghalaya	7	22,429	433	9,775	7,067	17,275	77.02	-46	485
Mizoram	8	21,081	134	6,086	12,897	19,117	90.68	-66	1
Nagaland	8	16,579	1,293	4,931	7,094	13,318	80.33	-146	3
Orissa	12	86,124	5,268	14,442	13,588	33,298	38.66	-1	2,552
Rajasthan	5	38,218	0	2,442	3,907	6,349	16.61	1	941
Sikkim	4	7,096	500	2,161	698	3,359	47.34	0	363
Tamil Nadu	6	30,720	697	2,392	3,653	6,742	21.95	18	404
Tripura	4	10,486	109	4,686	3,182	7,977	76.04	-8	72
Uttar Pradesh	1	7,680	409	475	435	1,319	17	-1	1
West Bengal	11	69,403	2,962	4,475	4,863	12,300	17.72	1	28
Andaman & Nicobar	2	8,249	3,761	2,416	547	6,724	81.51	62	57
Dadra & Nagar Haveli	1	491	0	114	97	211	42.97	0	1
Daman & Diu	1	72	0	1	3	4	5.03	0	0
Lakshadweep	1	32	0	17	10	27	84.56	1	0
Grand Total	188	1,105,744	59,849	194,173	157,859	411,881	37.25	-679	12,785

- **The change in the above table refers to change in the area with respect to revised assessment for 2009 after incorporating interpretational changes.**

Source: India State of Forest Report- 2011, FSI.

1.5.5 Forest as integral component of water cycle

Forest is the best water manager of the earth ecosystem. Forests absorb rainwater and release it gradually into streams, preventing flooding and extending water availability into dry months, when it is most needed. Some 40% of third world farmers depend on forested watersheds for water to irrigate crops or for livestock. As per GFRA report 2010 around 330 million hectares of forests are designated for soil and water conservation, avalanche control, sand dune stabilization, coastal protection etc. In India, forests provide water regulation and flood control valued at $72 billion per year. They also keep soil from eroding into rivers. Silting of reservoirs costs the world economy about $8 billion per year in lost hydroelectricity and irrigation water. Forest helps in reducing siltation in the rivers and reservoirs in an effective manner.

1.5.6 Forest as source of Gene pool

Forest vegetation provides the gene pool that can protect commercial plant strains against pests and changing conditions of climate and soil and also provide the raw material for breeding higher-yielding strains.

1.5.7 Forest as conservator of biological diversity

Biological diversity encompasses the variety of life forms, the ecological roles they perform and the genetic diversity they contain (FAO- 1989). In forests biological diversity allows species to evolve and adapt, to maintain the potential for tree breeding and movement and to support their ecosystem. As per GFRA- 2010 at present about 12 percent of the world's forests are designated for the conservation of the biological diversity.

1.5.8 Natural climate stabilizer

Forests stabilize climate and work as natural air conditioner. They work as store houses for Carbon and as per an estimate the world's forest at present stores around 289 gigatonnes of Carbon in their biomass (GFRA, 2010). Deforestation releases greenhouse gases, viz. carbon dioxide, methane and nitrous oxide, which accounts for 25 per cent of the warming effect of all greenhouse gas emissions. Replacing the carbon storage function of all tropical forests would cost an estimated $3.7 billion-equal to the gross national product of Japan. Forest, by working as natural air conditioner helps in climate stabilization.

1.5.9 Forests- source for recreation

Forests serve people directly for recreation. National Parks, wild life sanctuaries, bird sanctuaries and other forest associated recreation attract millions of tourists every year and earn good amount of revenue.

In addition to above mentioned benefits, forests contribute significantly in the following ways-

- Forests afford protection to wildlife against strong cold (or hot) & dry winds.
- It affords protection against adverse effects of solar radiation.
- They help in balancing carbon-di-oxide & oxygen of the atmosphere.
- Forests maintain fertility of the soil by returning nutrients to it through litter.
- Forests regulate the earth's temperature regime & water cycle.
- Forests check soil erosion, landslides, shifting of sands & silting.
- Forests reduce danger of floods.
- The forests help in biological rejuvenation of soils by opening soil and improve it by adding organic litter or humus.

Chapter 2

THE DIMINISHING FOREST COVER AND FOREST FIRE

2.1 Introduction

Forests have had historical similarities throughout the world. When the population was small, forests were plentiful and provided most of the basic needs. With the shift from a nomadic existence to a settled livelihood by man, forests were cleared for agriculture and habitations. In due course of time, society recognized the need to manage forests as a resource for its benefit and earning revenue, ultimately resulting into forest depletion. When forests were plentiful, the impact of deforestation was not much and the eco-balance between human being and its environment was still maintained. However, with increasing need and demand for forest produce this impact became more visible and deteriorating.

Though deforestation / forest degradation has been a worldwide phenomenon, it has affected developing countries more adversely. The poor socio-economic condition of the people in these countries (increasing their dependency on natural forests) has been the major cause for deterioration.

2.2 Global Scenario

Before pre-agriculture period, forests in the world were almost intact. With the invasion of agriculture, the prehistoric man started clearing forest for farming land leading to non-ending process of deforestation, which persists till date. As per an estimate, since pre-agriculture period almost 900 million hectares of forestland has been deforested by man. The historical evidences suggest that situation was not much deteriorated till 1000 years ago, when the forests were almost stable and covered around 34 per cent of the land. But with the onset of industrialization and demand for land and timber, forest cover began growing threadbare in scattered parts of Europe, Central America, China and India. Two centuries ago, the thinning spread, leaving parts of Europe and China bare, while only a century ago, and in the wake of the Industrial Revolution, eastern North America was deforested. Still little had changed and forests covered almost 32 per cent of the land during the period.

However, in the recent past i.e. 50 years ago this change has accelerated explosively. Vast tracts of forest have vanished from the Far East and the mainland of South-East Asia; Central America, western North America and eastern South America, the Indian subcontinent and sub-Saharan Africa, the Amazon Basin and Central Europe. As per the Food and Agriculture Organization-U.N. "Production Year Book", 1987, during the period 1975 to 1985, the average loss of the forest has been about two percent. During these ten years, about eighty million hectares of the forest was lost (Table-2.1). According to the GFRA Report, the situation improved a bit after 1990. The global forest area was reduced by around 8.3 million hectares (0.2%) per year between 1990 and 2000 and by around 5.2 million hectares (0.1%) per year between 2000 and 2010. The forest area has reduced in most regions since 1990, except Europe (where the area increased in both the decades) and Asia (where the area reduced between 1990 and 2000 but has increased between 2000 and 2010) (GFRA, 2010) (Table-2.2 and Fig.-2.1).

Between 2000 and 2010, the largest decrease in forest area was in Brazil (2.6 million hectares per year on average) and the largest increase was in China (3.0 million hectares per year on average).

Table-2.1: Net Change in Areas of Forest and Woodland 1975-85

Global Region	Area in million hectares	Change in per cent
World	-82.9	-1.99
Developed world	-12.9	-0.70
Developing world	-70.0	-3.01

Source: FAO- U.N. "Production Year Book", 1987

Table-2.2: Annual change in forest area by region

(Area in sq. km)

Annual changes in forest area by region, 1990-2010				
Region	1990-2000		2000-2010	
	(thousand ha)	(%)	(thousand ha)	(%)
Europe	**877**	**0.09**	**676**	**0.07**
Africa	-4067	-0.56	-3414	-0.49
Asia	-595	-0.1	2235	0.39
North and Central America	-289	-0.04	-10	0
Oceania	-36	-0.02	-700	-0.36
South America	-4213	-0.45	-3997	-0.45
World	-8323	-0.2	-5211	-0.13

Source GFRA- 2010

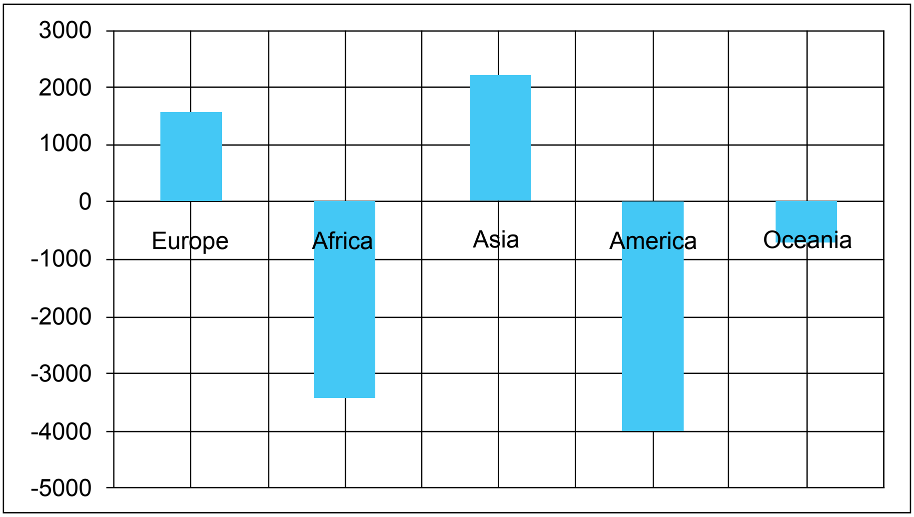


Fig.-2.1: Change in forest cover during 1990-2010 (area in sq km)

Source GFRA- 2010

The overall impact of large scale deforestation has been very devastating, while on one hand the indigenous people in the tropical forests have faced poverty and alienation due to diminishing supplies of forest products and farm yields, on the other; it caused immense loss to environment and ecology. There have been profound ecological effects of forest loss, as evident in the exacerbation of droughts and floods, release of heat trapping temperatures, advent of new pests into cropped lands, much sedimentation in river beds and hydroelectric reservoirs, and loss of productive fisheries.

The decline in forests along with other adverse effects also threatened the genetic diversity of the world's plants and animals. The World Conservation Union calculated that about 12.5 per cent of the world's 270,000 species of plants and about 75 per cent of the world's mammals are threatened by forest decline (McNeely *et al.,* 1990). The Commission concluded that *"forests can no longer be used in the same way as they have been in the past. Forest products and services must be assured through new political choices and policy decisions that ensure the survival of forests."*

2.3 Growing pressure on forest in India

Due to various monogenetic reasons, the pressure on natural forest is increasing throughout the world. The forests today have at least five times more pressure than what they can withstand. Like many other developing countries, forests in India are also under tremendous pressure mainly as a result of increased demand for forest produce viz. fuel, fodder, timber, non timber forest produce (NTFP) etc. by ever exploiting population of the country. Presently a major chunk of forest area in the country is under illegal encroachment. The collection of fuel wood is considerably higher than what can sustainably be removed from the forests. Forests also contribute major percentage of the fodder requirement for the cattle, including 178 million tons of green fodder and 145 million tons of dry fodder. It has been estimated that half of the livestock population i.e. 270 millions graze in forests. This demand gets accentuated due to the extraction of green fodder to the tune of 175-200 million ton annually.

Currently people occupy around 1.5 million hectares of forestland for agricultural purposes. The trend of diversion of forestlands for non-forestry purposes though arrested after the Forest Conservation Act, 1980 came into force, still continues. These effects cumulatively cause loss of ecological stability and bio-diversity, reduction in carbon sink capability, climate change, floods, droughts, desertification, damages to watersheds, silting of reservoirs, estuarine & river beds, changes in hydrological regimes, etc. According to World Bank, approximately 10 million hectares of land mass is reported to be under shifting cultivation, involving several million people spread over 16 states in India. According to Forest Survey of India estimate 53-54% of the forest area is annually affected by forest fires incidence (mostly due to practices such as agriculture and shifting cultivation).

The maximum forest loss in India has been estimated between 1950 and 1980, just before the enactment of Forest Conservation Act. During this period, a huge forest area was allotted to various sectors in the name of development. The non-forestry uses, for which forest area was converted during the period included agriculture, river valley projects, industries/ townships, transmission, roads etc. (Table-2.3 & Fig.-2.2).

Table-2.3: Diversion of forest land for non-farming purposes between 1951 and 1980

Purpose	Area covered in million hectares
Agriculture	2.623
River valley projects	0.502
Industries and Townships	0.134
Transmission lines and roads	0.061
Miscellaneous	1.008
Total	**4.328**

Sources: The State of Forest Report 1987, FSI; Forestry Statistics India, 1995, ICFRE, Dehradun

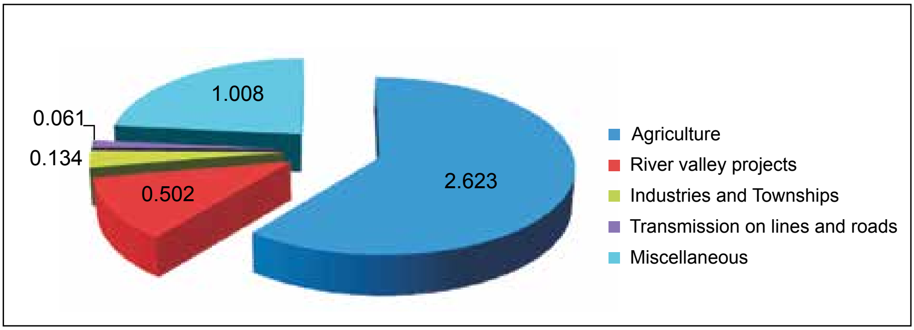


Fig.-2.2: Agriculture and river valley projects grabbed major chunk of forest between 1951 and 1980

(Sources: The State of Forest Report 1987, FSI; Forestry Statistics India, 1995, ICFRE, Dehradun)

A rough picture based on available information from different reports is that the gross annual depletion rate during 1980-90 was 339,000 hectares or a total of 3.39 million hectares for the ten years period. During the same period, there were afforestation efforts too, which added about one million hectare annually to the plantation area. While comparing various assessments made in Forest Survey of India Report, it is visible that as a result of various efforts made at government and other levels after 1997, the forest cover in India showed a positive sign. Though there may be some technical reasons also for this growth in the data, yet the forest cover in the country in general shows a positive change. The detail of the forest change since 1987 is given in the Table-2.4 & Fig.-2.3.

Table-2.4: Forest cover as estimated by the FSI from 1987 to 2009 (sq. km.)

SFR Year	Forest Cover (as reported in SFR)	Forest cover corrected for change in scale inclusion of small patches and vector approach	Percent of GA
1987	640,819	–	–
1989	638,804	662,803	20.16
1991	639,364	662,308	20.14
1993	639,386	662,334	20.15

1995	638,879	660,273	20.08
1997	633,397	659,550	20.06
1999	637,293	664,737	20.22
2001	653,898	668,806	20.34
2003	677,816	686,767	20.89
2005	690,171	690,171	20.99
2007	690899	690899	21.02
2009	692,027	692,027	21.05

Source: Forest Survey of India; State of Forest Report- 2009& ISFR 2011

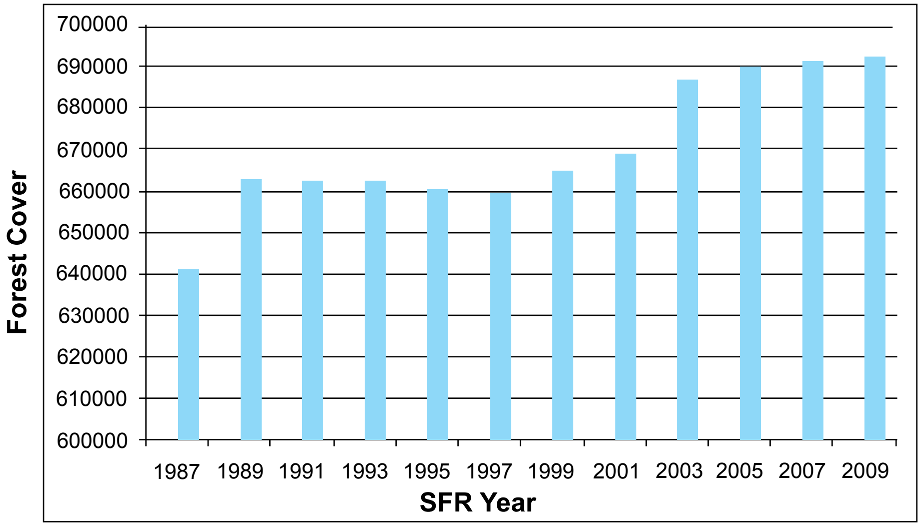


Fig.-2.3: Change in forest cover (Area in sq.km)

Source: Forest Survey of India; State of Forest Report- 2009& ISFR 2011

Despite increase in the forest cover, the overall forest ecosystems in India are reeling under acute form of degradation. The direct causes of this degradation are poverty, landlessness, derivation of livelihood from forests, lack of land use planning, uncertainties in land tenure system, biotic interference, inadequate institutional capacity, lack of restrictive covenants and punitive legislation and last but not the least the frequent forest fire incidences.

While efforts are being made to increase forest area through tree planting activities, loss of natural forests continues to be the main concern for the country. Tree planting and social forestry activities cannot fully compensate for the loss of natural forests, since they have very different attributes. The remaining natural forests, and as well as the forest plantations) are becoming progressively degraded due to overuse and lack of protection. The deterioration of the quality, stocking condition and productivity of forests is a matter of serious concern, as is deforestation.

2.4 Forest degradation and its impact

Despite that the overall forest cover in the country is on increase, most of the forest areas in the country are ecologically in various stages of retrogression. The forest ecosystems are reeling under acute form of degradation, which has adversely affected the Indian society, both socially and economically. Owing to various other factors, the deterioration of the forest is the major cause for increase in both physical as well as socio-economic vulnerability of country to disasters. It has been widely accepted that deforestation increases the intensity of natural disasters and is often the factor that transforms a natural hazard or climatic extreme into a disaster

In ecologically more sensitive and destabilized areas like Himalayas and Western Ghats, the impact of deforestation/ degradation has been more severe. In the recent past, as a result of so called developmental activities, particularly in sensitive regions, the environment has been very adversely affected, resulting into exponential increase in fragility of land mass.

Deforestation and other allied land degradation activities such as water logging, flooding, ravines, shifting cultivation, mining, salinisation, soil erosion, landslides / rock falls and desertification have affected more than half of the total geographical area of the country. The deforestation in the form of mangrove removal has made coastal regions of the country susceptible to erosion and damage to human settlements.

The deforestation and destruction of other natural resources have compelled people from rural areas to migrate in search of new livelihood in urban areas, resulting into unplanned settlement even in high risk zones i.e. seismic zones, steep hillsides and flood-prone areas. The mushroom growths of slums in various metropolitan cities of the country are also at maximum risk to natural and human induced disasters.

Deforestation

In ecologically fragile and more sensitive or destabilized areas like Himalayas, the impact of deforestation has been more severe, which directly or indirectly affect the lower plains of the country. Deforestation in Himalayas has increased the severity of floods during rainy season and reduced stream flows and dried up springs during dry seasons. The increase of soil erosion has reduced water carrying capacity of the rivers resulting into shallowing of riverbeds leading to floods in the plains. Ever increasing population pressure and increasing demand for food and fodder, with no alternative source of livelihood have forced the people to convert forest land, even in very sensitive zones, to agricultural fields, causing enormous loss to environment and stability of the region. Rapid deforestation in the Himalayas and resulting degradation of its ecology has posed a potential threat to the greenery of the Indo-Gangetic belt, causing sporadic floods in one and drought in other area. About two-third of the agricultural land of the country is affected by drought and about one-fifth is very frequently exposed to floods.

Large scale industrialization, deforestation and non-sustainable overuse of other natural resources have increased pollution leading to global change in the environment. This human induced climate change has increased the overall global temperature, resulting into excessive melting of glaciers in the Himalayas and consequent increase in water-related disasters. The main reason for this climate change or increase in temperature is excessive burning of fuels (coal, petrol, diesel etc.), large-scale deforestation and forest fires, resulting into substantial increase of carbon dioxide and other harmful gases in the atmosphere. This increased carbon dioxide prevents heat rays returning back to the atmosphere. Thus a part of the heat energy absorbed by the earth and its objects partially remains in the atmosphere, resulting into overall increase of global temperature. This phenomenon called “Green House Effect” along with excessive snow melting causes many other adverse impacts on environment and society. The global warming, up to an extent is responsible for the rainfall variation, accelerating desertification and land degradation. Loss in agriculture production (particularly in rain-fed regions), human and cattle health deterioration, scarcity of water resources are other adverse impact of this phenomenon on society.

2.5 Causes of deforestation/ forest degradation

Due to various factors, mostly anthropogenic, Indian forests have been experiencing significant loss since long. In the colonial period the forests were exploited mainly for timber. During Second World War, a major portion of good quality timber was exported from India for making warships and for certain other purposes. The introduction of Railways in India was also to some extent responsible for large-scale forest cutting, mainly for railway sleepers.

Along with the increasing population pressure, the low productivity and imbalance between demand and supply are the other major factors for forest loss in the country. The forests of India have a growing stock of 4, 740 million m^3 with an annual increment of 87.62 million m^3. Since 78% of the forest area is subjected to grazing, as well as heavy removal of forest products and 51% is subjected to occasional fires (the net annual loss being about 74,000 hectares), the productivity of the forests is rather low. The paradox is that forest produce 70% timber and 30% of fuel wood, while the demand for wood is around 70% as fuel wood and 30% for timber; further exacerbating the situation. Despite its richness in variety and species, if compared at a global scale, the forest cover in the country is very less. Human and cattle population explosion around forest land and increase in demand of various forest produce have adversely affected the Indian forests. Agriculture (including shifting cultivation), multipurpose projects, irrigation structures, industries, mining, quarrying for minerals, road construction, erection of transmission lines, and clearing for encroachments (industrialization, urbanization and human settlements) etc. have been some of the major factors responsible for the present poor situation of forests in the country.

In addition to these direct and visible reasons, many other socio-political and socio- economic factors responsible for poor state of the forests of the country are- poverty and unemployment, poor legislative provisions, impractical management tactics, gender inequality etc. Unlike the developed countries, the forest in the country is inextricably linked with socio-economic status of the society. The people living within or near the forests are directly or indirectly dependent on forests for their daily needs. Till recent past, due to low population pressure, this relationship had been very harmonious, however, with increasing demand, the situation deteriorated and as a result forests suffered adversely.

2.5.1 Demographic pressure and poor socio- economic condition

As mentioned earlier too, the increasing demographic pressure has been the major factor for deforestation. The growth in population has increased the demand for livelihood. Scarcity of other livelihood resources, especially in rural areas has forced people to exploit natural resources, particularly the forests. Along with demographic pressure, poverty has been another important factor, responsible for forest degradation. As per the Planning Commission of India about 37% of the country population is forced to survive below poverty line. Poor in the country are compelled to exploit natural resources for their survival. Dependency on forests for fuel, wood, grazing, encroachment etc. is the issues that is directly linked with the poverty (Fig.-2.4).

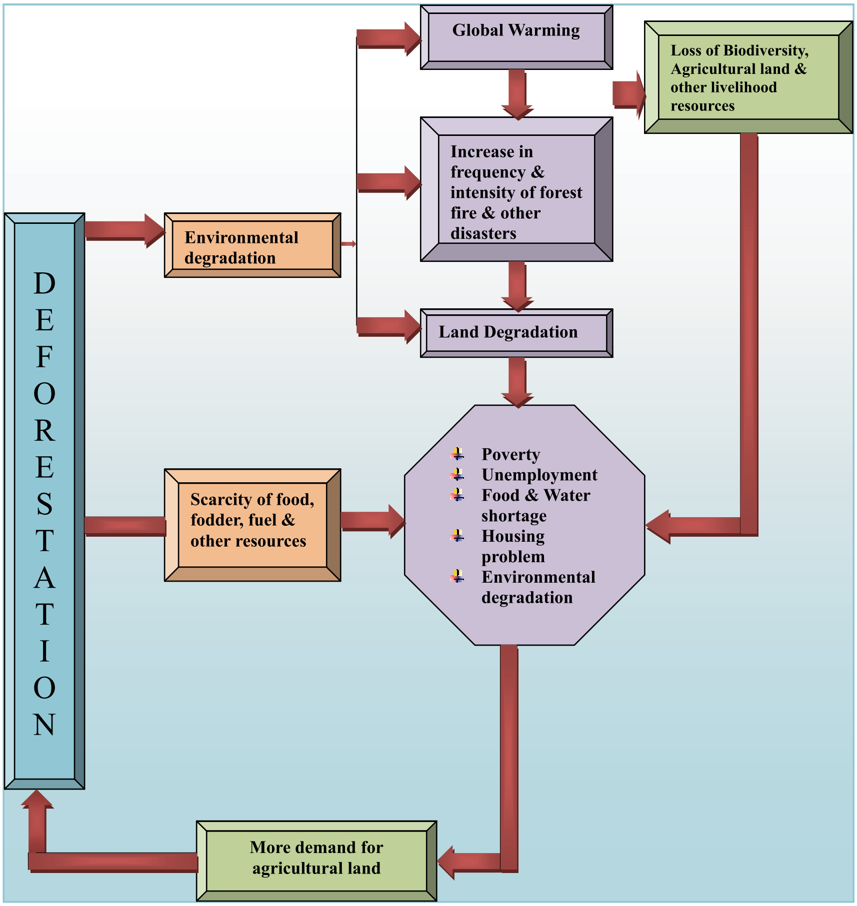


Fig.-2.4: Adverse impacts of Deforestation (Satendra, 2003)

2.5.2 Increasing demand for fuel wood and timber

Fuel wood burning is the major source of energy for cooking and other small scale industries in India .The consumption of fuel wood in our country is about five times higher than what can sustainably be removed from forests. Fuel wood meets about 40% energy needs of the country. The estimated fuel wood consumption in the country is about 320 million tones. About 70% of the fuel wood is accounted for by households and the rest by commercial and industrial units. Around 80% of the rural people and some 48% of urban people use fuel wood for cooking.

Box-2.1: Demographic Status of the Country

According to the Census of India 2011, the population of India at 00.00 hrs on March 1st, 2011 stood at 1,201,193,422 comprising 623,724,248 males and 586,469,174 females.

- India accounts for only 2.4 percent of the world surface area and yet it support and sustain 16.87 percent of the world population.
- It is estimated that by 2050, India will overtake China to become the most populous country on earth with about 17.2 percent world population living here.
- The population of India at the turn of the twentieth century was only around 238 million which increased by over four times to reach 1027 million at the dawn of the twenty first century. Interestingly, the population grew up one-and-half times in the first half of the twentieth century.
- Uttar Pradesh and Sikkim continuous to be the most populous and smallest state respectively in the country (excluding the Union Territories).
- There has been decline in the population growth rate. According to the Census of India 2011, it is 17.64 percent as against 21.34 percent in 2001.
- Results from the Census of India 2011 shows that the average population density of the country is 382 persons per sq km as against 324 in 2001. Among the states, Bihar recorded the highest population density (1102) followed by Kerala (1084) and West Bengal (1029). The lowest density of population is found in Arunachal Pradesh with 17 persons per sq km as against 13 in 2001.
- Sex Ratio is an important social indicator to measure the extent of prevailing equity between males and females in a society. The sex ratio for India as a whole is increases to 940 as against 933 in 2001. It is highest in Kerala with 1084 females per 1000 males and least is in Sikkim (889).
- The literacy rate for India is 74.04 percent in 2011 improving upon 65.38 per cent in 2001. Among the states, Kerala has the highest literacy rate (93.9%), followed by Mizoram (91.6%) and Tripura (87.8%)

As per Forest Survey of India Report, during 1996 the total consumption of fuel wood in the country was 201 million tons, out of which 103 million tons was directly extracted from the forest and rest 98 million tons was made available from farm forestry sector. Out of 103 million tons extracted from the forest, only 17 million tons is available on sustainable basis and the rest 86 million tons is removed in excess, causing enormous damage to forest and its eco system.

The demand and supply data for fuel wood indicates an increasing gap. As major portion for this gap is filled from over exploitation of forest, beyond its carrying capacity, it gives an alarming signal for forest health. Not only fuel wood, the timber extraction is other major problem associated with forest degradation in the country. According to estimates made, about 64 million cubic meters timber was consumed in the country during 1996. Out of this, around fifty percent was directly extracted from the forests and rest was from the farm forestry.

2.5.3 Cattle grazing and fodder supply

India has the largest cattle population in the world. In the absence of adequate productive pasturelands and appropriate grazing policy, forests have become the major source of grazing and fodder. Grazing not only directly harm the forest, it also increase soil erosion and deteriorate soil quality, thus having adverse impact on forest regeneration and growth.

As per an estimate, around 60% of the livestock (about 300 million) graze in forests. These include traditional sedentary village livestock and migratory animals herded by ethnic grazers. Additionally, grazers collect about 175 million tones of green fodder annually, by lopping and harvesting grasses, which adversely affect regeneration of forests. A sample survey by Forest Survey of India estimates that the grazing affects approximately 78 per cent of country’s forests. Grazing occurs even in protected areas (67 percent of national parks and 83% of wildlife sanctuaries surveyed reported grazing incidences).

2.5.4 Illicit felling & encroachments

As a result of increased demand of wood, the pressure on forest has gone up, encouraging illicit felling. Illicit felling by timber mafia, fuel wood gatherers, land encroachers etc. is very common in India. The increasing demand of wood products and its increasing value has made illicit felling a profitable business for timber mafia. The sandalwood, teak, rosewood, sals etc. are the major species, which are smuggled from forest by organised gangs. Due to increasing profit involved, these gangs are usually armed with sophisticated arms and ammunitions, which make the work of forest protection very difficult and risky. In some states, these gangs have become so powerful and daring that they do not hesitate in attacking senior forest and police officials also.

In addition to illicit felling, forest land encroachment for agriculture and other purposes has geared up in the recent past. The escalating land price has further accelerated this practice in rural and urban areas both. The most evident impact of weak forest protection practices is encroachment by violating forest boundaries through organized massive efforts. Boundaries also recede through illegal peripheral occupation by communities living around the forests. Though exact figures are not available for the cumulative deforested area resulting from forest encroachments, it is estimated that people illegally occupy about 1.5 million hectares of forest area for agriculture and other uses.

2.5.5 Development vs. Deforestation

With increasing population and subsequent development/ industrialization, the demand of land has increased substantially. The major impact of this has been on forestland. One of the major factors leading to deforestation and / or forest degradation is transfer of forest land for various non-forestry uses. This forest land diversion, particularly for developmental projects has been very harmful for forest ecosystem. A development project starts destroying the forest even before it goes into production. The process begins with building of infrastructure in the form of roads, railway lines, offices, township, electricity etc.

Construction of roads in fragile belt of hilly areas affects the stability of hill slopes; damage the vegetation cover and the environment. The construction of roads has adversely affected the eco-balance in all the hill states of Himalayas and also in some southern States of

Nilgiri hills. After China War in 1962, the main emphasis of the Central Government was to increase connectivity in Himalayan region through roads. During this period even the interior villages were connected by roads. But the most unfortunate part of this development had been that these roads were constructed without giving much consideration to environmental issues. This activity has generated huge amount of debris and other waste, which ultimately became major factor for forest degradation and other environment related problems.

Industrialization and urbanization are two other major causes for forest degradation. After independence, availability of natural resource (forest, minerals, raw material etc.), electricity, communication and cheap labor have encouraged prospective industrialists to establish industries in various towns and cities of the country, resulting into environmental problems like pollution, deforestation etc.

Dam construction, obstructing the natural water flow, not only affects the ecological balance in an area but also causes environmental loss to natural resources and wildlife. Adversely attacking the forest regeneration and growth, construction of dams causes massive damage to forest and wildlife. A large part of the forest gets drowned under the reservoir. The labour force also causes destruction to forest for its fuel need. There is change in water table in the rocks/soil along the reservoir leading to increased soil erosion. The other reason for increased rate of erosion is clearance of vegetation in the upstream side.

Thus all unscientific development practices result into enormous loss to vegetation and environment. Keeping in view the severity of the problem the Government of India in 1980 enacted the Forest Conservation Act (FCA) with an objective to check diversion of forestland for non-forestry purposes. Forest Conservation Act stipulates that State governments or any other authority is prevented from diverting forest lands for non-forestry purposes and that prior approval of the central government is required for any such diversion. Wherever, diversion of forest land is unavoidable for developmental purposes, approvals granted to concern State governments are subject to safeguards, which include compensatory afforestation on non-forest land with equivalent characteristics or double the area of forest land cleared. As result of enactment of Forest Conservation Act the rate of land diversion, approximately 1, 50,000 hectares per year between 1950 and 1980, fell to 25,000 hectares per year between 1980 and 1995. There has been a further decrease in the area of forest land diverted for non-forestry uses in the last few years to around 15,500 hectares per year (Table-2.5).

Table-2.5: Diversion of Forest land for non forest use (Since the Enforcement of Forest Conservation Act, 1980)

Year	Forest Land Diverted (area in sq.km)
1980	Nil
1981	2672.04
1982	3246.54
1983	5702.01
1984	7837.59
1985	10608.07
1986	11963.11
1987	72780.05
1988	18765.35
1989	20365.05
1990	138551.38
1991	625.21
1992	5686.94
1993	11785.64
1994	13527.69
1995	46158.52
1996	8764.79
1997	16313.20
1998	12630.00

Source: Ministry of Environment & Forests, DIG (FCA)

Along with developmental projects, industrialization has been other major reason for large scale deforestation/ forest degradation in the country. Despite modernization and shift of dependency from wood to steel and plastic, wood is being used for several industrial processes, such as making boxes, crates, packing cases, furniture, match boxes, paper, pulp, plywood etc. The paper industry accounts for about 2% of country's total annual consumption of wood.

2.5.6 Shifting Cultivation

Shifting cultivation or *Jhum* farming, characterized by rotation of fields rather than crops, is a thousand of years old practice. Also known as slash and burn method of farming, this practice is responsible for about 5,000 km^2 of deforestation annually. According to archaeological evidence, the practice of shifting cultivation can be traced as far back as 7000 BC. Shifting cultivation has been practiced throughout the world covering many tropical countries in Africa, South America, Oceania and Southeast Asia.

Shifting Cultivation

Different estimates for the area involved under-shifting cultivation in India ranges from 5 million hectares to 11.5 million hectares. Though there is no consensus on the number of people involved in shifting cultivation, estimate ranges from 3 to 26 million. In India, shifting cultivation is practiced at least in 16 States, predominantly in the northeastern parts in the country. The increase in the number of shifting cultivators and the declining productivity of forest soils have resulted in the shifting cultivation cycle shortening from about 20 years to 4 years. Such intense farming on poor quality forest soils has made such region ecologically very unstable. The other serious issue with the shifting cultivation tradition is that till recent past restricted to few sections of society, it is being adopted by more and more people. Many rural people, without secure access to land are also becoming shifting cultivators. Shifting cultivation is the major cause of forest fire. According to Forest Survey of India estimate (1995), 53 to 54 per cent of the forest area in India is annually affected by the incidence of forest fires *(mostly from agricultural practices such as shifting cultivation)*.

2.6 Forest fire- the major cause of forest degradation

Alongwith other factors discussed, forest fire is a major cause of injury and loss to forests. With the population increase, the frequency and subsequent damage due to forest fire is increasing day by day. The impact of the fire is diverse on the forest ecosystem. Besides directly damaging the forest trees, the fire also adversely affects forest regeneration, microclimate, soil erosion, and wild life etc. In most of the cases, the forest fire causes retrogression of forest vegetation. Forest fire is one of the major degenerating factors, which extensively damages the growing stock and its generations and making area vulnerable to erosion. It has wide-ranging adverse ecological, economic and social implications. Globally speaking, forest fires all over the world are under reported due to various factors. As per the information compiled in GFRA- 2010, on an average one percent of all forests were reported to be significantly affected by forest fire each year. However, the areas affected by fires are severely underreported, with information missing from many countries.

Forest fires in India are generally ground fires. About 35 million hectares of forest area is affected by fires annually. About 95 per cent of the forest fires are caused by human beings, especially to promote new flush of grasses, collection of minor forest produce or to prepare land for shifting cultivation. While statistical data on fire loss in India are very weak, it is estimated that the proportion of the forest areas prone to forest fire annually ranges from 33% to over 90% in different states. As per an estimate of the United Nations Development Programme and Food and Agriculture Organisation project in Maharashtra State, the economic loss due to forest fire is around Rs. 9000/- per hectare per annum. If multiplied to the total forest cover of the country, this comes to a very substantial amount. The severity of the problem may be judged from the forest fire data of the year 1995 and 1999 in the two States- Uttar Pradesh and Himachal Pradesh where forest worth crores of rupees was turned to ashes during the period.

Chapter 3

FOREST FIRE AND ITS IMPACTS

3.1 Introduction

The word “fire” evolved from the Greek word *“pyra”* meaning growing embers. Fire is actually the heat and the light that results when three elements i.e. fuel, oxygen and the source are combined. The other elements, which determine the behavior of the fire, are weather, the landscape and the presence of the fuel. As far as the birth of fire is concerned, fire emerged on the earth with its origin only. From the time our planet came into existence, lightening has sparked landscape. Artificial or the human induced fire began when the earlier human being first rubbed two stones. Discovery of fire has been a revolutionary invention of human civilization. The nomadic life saw a sudden change in its life style after this invention. It is interesting to know that the first experience of fire, which ancient human being felt was of forest fire. Thus forest fire has been an integral part of human civilization. The discovery of fire has perhaps been one of the greatest innovations of all time. It had so much significance in the earlier history of mankind that they started worshipping it as God. In Indian mythology there are many evidences, where fire or *Agni* was worshiped and respected as *Agni Devta.* In Hindu mythology a full volume on *Agni Purana* already exists, which is solely about the praise of this mighty source of energy. Not only in Hindu Mythology, other ancient mythologies also have more or less description of fire in its religious books. In Greek mythology, fire has been considered one of the four essential elements, along with water, earth and air.

Forest fire may be defined as an unclosed and freely spreading combustion that consumes the natural fuels. Combustion is another word for fire. When a fire burns out of control it is known as *Wild Fire.*

Almost everyone basically knows what a fire looks and feels like, but in reality fire consists of four parts i.e. gas, flame, heat and smoke.

Fire Gas: These are the gases created by the combustion process. They are invisible to the naked eye, but they exist and include such poisonous substances as Carbon monoxide.

Flame: This is the light given off by the burning gas. As long as the three essential ingredients, fuel, oxygen, and heat are there, it can be seen.

Heat: This is the part of the fire that one feels as warmth. A normal fire usually burns at around 1,100º C.

Smoke: Smoke is a harmful vapor cloud mixed with a fine powder of solid particles and some gases. The solid particles in smoke create breathing and viewing problem during fire.

3.2 Forest fire through ages

Fire has been a major influencing factor on the development and management of many of the world's forests. Some forest ecosystems have evolved in response to frequent fires from natural causes, but most others are susceptible to the effects of wildfire. Each year millions of hectares of the world's forests are consumed by fire, which results in enormous economic losses because of burnt timber; degraded real estate; high costs of suppression; damage to environmental, recreational and amnesty values; and loss of life.

Forest fires are not new to the world; they have burned across the earth for millions of years. Evidence of fires that burned in the past exists today in petrified trees that lived long ago and have over many years turned into hard rock. Some petrified trees have fossilized charcoal called ***"Fusain"*** in their trunks. The charcoal marks, which indicate that the tree was once in the path of a fire, are called fire scars on a living tree. All these evidences support that our temperate world's forest ecosystem has developed with fire.

During prehistoric period, mankind used fire as a cultural tool. Of the many ways in which pre-historic man modified the forest, fire was effective enough to significantly influence the forest types. Fire, today is the single most important tool in converting tropical forests to agricultural land. Man in prehistoric time used fire to clear fields for cultivation, to drive game, and as a means of communication.

Thus forest fire since prehistoric time has been a part of man's cultural traditions and was not of much damage to forest ecosystem. Actually small and limited forest fires are integral part of the forest ecosystem and are very essential for healthy and proper growth and development of forests. However, the large uncontrolled fire badly damages the forest in many ways because of its increased intensity and frequency and also its uncontrollable nature. Forest fire has really become a matter of much concern for society.

3.3 Forest fire – part of ecosystem

Fires in forests are not unnatural. It has been a natural part of the ecosystem since origin of forest on this planet. Most of the fires are very useful and essential for good natural forest development and regeneration. Throughout historic time forest fires have been ignited and burned naturally through the forest. These low intensity fires in past kept the forest floor free from the natural annual build up of the litter i.e. tree needles, dead grass, senescent leaves & twigs, thick brush, and dead trees. As a result, fire has shaped vegetation patterns and wildlife distributions in the forests.

Fire effects on all forests are not equal. While same fire, beneficial for one ecosystem, may be dreadful for the other, depending upon the climatic conditions and type of vegetation. Tropical rain forests choked in fog and continuously drenched by mists and down pours are least affected by fires. In deciduous forests of temperate region, as a result of heavy rainfall and dampness and relatively high humidity, fire is very occasional and less damaging. Evergreen forests with broad leaves of dry areas and conifer forest are more susceptible to fire in general.

Fire severity affects the survival and establishment of many shrub species, organic matter consumption, soil heating and the biological response of soil, flora and fauna. The extent of soil heating depends on the physical characteristics of the fire, in particular to the quantity of fuel consumed. In some ecosystems, fire may be considered as a component of great importance, particularly in promoting primary productivity. Fire may also stimulate flowering, increase the branching behavior, seed production and seedling establishment.

Soil heating due to fire changes its chemical, physical and microbial properties. The direct chemical changes during soil heating and combustion of soil organic matter lead to a massive volatilization of simple nitrogenous compounds, mainly nitrate and ammonium and to some extent sulphur, phosphorus, and other ions depending on the fire intensity and temperature. But at the same time, fire transforms soil nitrogen bound in organic substances into ammonium, a form readily available to either plants or subsequent microbial nitrification. The increase in ammonium and nitrate concentrations in many ecosystems has also been reported as a result of fire incidences. This increase in the availability of nutrients (nitrogen, phosphorous and other mineral nutrients) is certainly beneficial for the vegetation and enhances its growth.

Prescribed burning is used as a way to put the fire back into a specific unit of land i.e. ecosystem. Fallen trees and limbs left to rot on the forest floor decay at a very slow rate. In fact, large logs can take more than hundred years to decompose. This process is aided by the numerous species of bacteria, insects, and wildlife that live in the decomposing materials. All this rotting is one way through which nature recycles nutrients back into the soil. Pine needles decompose very slowly. It takes more than a year for ten percent of the pine needles to decay. As a result, year after year, pine needles continue to build up until they are eliminated by fire. In brief, natural recycling is a very lengthy and time-consuming phenomenon in forest. Fire is the best process to intensify this natural process. Faster recycling occurs during a fire and gases are released into the atmosphere in the form of smoke.

In the burned area, nitrogen and other nutrient remains are leached back into the soil as rain soaks the ground. This is nature's way of rapidly feeding nutrients to the soil. Unfortunately, when there is too much fuel on the ground and it is burned, an intense severe fire occurs, where these benefits are often missing. Intense fire tends to scorch the ground and kill the trees. In brief, the forest needs both slow recycling from decomposition and fast recycling from fires.

Thus forest fires are not always harmful. Small and controlled fires in the form of prescribed burning are very essential and useful. In the absence of fire, vegetative changes may result in fuel loads far exceeding safety levels, which would pose a serious threat to forest if ignited. The small scale controlled fires provide social and ecological benefits too, like reducing risk of catastrophic forest fire, improving silvicultural opportunities, increasing forage and habitat opportunities for wildlife, enhancing biodiversity and so on.

3.4 Forest fire – as management tool

Although fire has been the primary agent of deforestation, yet as a natural process it serves an important function in maintaining the health of certain ecosystems. The traditional view of fire as a destructive agent requiring immediate suppression has given way to the view that fire can and should be used to meet land management goals under specific ecological conditions. For decades, controlled burning has been used as a genuine forest management measure in the developed countries. In western countries, especially Britain, U.S.A., Canada etc. controlled fires are burnt at intervals of 10-12 years to maintain uniform growth. In South and Southeast Asia, including India, "Slash and Burn" method of farming is used by the tribals of hilly areas, in which they cut down and burn small areas of the forest and use the cleared land for cultivation. This method of burning offers them not only the cheapest means to clear the forest, but also supplies free fertilizers in the form of ash from the burnt vegetation on limited scales.

Most of the limited fires are very useful and essential for good natural forest development and regeneration. Many cultures have stories about great fire creatures and recognize fire as a part of nature. The Egyptians believed story of a brightly colored bird named the *Phoenix,* which lived for as long as 600 years! At the end of its life the *Phoenix* would burn itself in a fire. The new *Phoenix* would then live for another 600 years. Fire was a way for the *Phoenix* to renew itself.

Natural resource managers use fires as a means to renew the natural environment. To protect natural resources and keep the environment healthy, managers study an area and write a fire prescription for that area. A prescription indicates when trained professionals ignite fire or how long a fire ignited by lightening will be allowed to burn. A prescription may include the information that how wet fuels must be, the maximum speed wind may be blowing or the highest outside temperature. Fire managers suggest exact fire prescriptions before burning is allowed. These fire prescriptions are based on weather, moisture content of the fuels, and how the fire can be lighted (ignition patterns).

This prescribed fire called "management-ignited prescribed fires" allows natural processes to occur. Such fires are permitted usually in large parks or forests that have a prescribed fire plan (a prescription) and where humans and their property are not in danger. When a management-ignited fire occurs or when a fire is started by a lightning strike (also called a prescribed natural fire), the blaze is monitored daily by fire experts. Laws and regulations also determine when a prescribed fire may be ignited. Air quality regulations play an important role during such process. Prescribed burning takes place when laws, regulations, and forest needs are all in balance. Prescribed burnings don't take place when there are safety, health, and aesthetic concerns.

3.5 Forest fire- a bad master

"Fire is a good servant but a bad master" the saying is true for forest fire too. Limited and controlled forest fires have been very useful and essential for healthy forest growth. But uncontrolled forest fire may engulf and destroy healthy thick forest cover within no time. Besides direct loss to forest cover, forest fire also kills wildlife, damages environment, degrade soil quality and retrogrades forest regeneration. Since historical times, forest throughout the world has been adversely affected by fire. Fire always causes many direct or indirect effects on the forest ecosystem. They may merely be beneficial but at most of the times these effects are deteriorating. The damage to a forest by fire depends mainly on size of the fire.

The main adverse impact of the uncontrollable forest fire includes damage to growing stock of forests, loss of biodiversity, increase in soil erosion, scorching of soil and reduction in its permeability and water retaining capacity and volatization of the nutrients like Nitrogen. Not only for forest vegetation and environment, the forest fire causes direct loss to human being also in the form of damage to life and property. Extreme forest fire burns thousand of houses and kills many human beings and cattle throughout the world. As reported in the Global Forest Resources Assessment (GFRA), 2010 the recent examples of human lives loss due to forest fire include- Victoria in Australia in 2003 causing 73 fatalities and Greece fires in 2007 resulting into 70 deaths. Large uncontrolled forest fires result into health problems due to fire generated smoke. Breathing problems, skin irritation, loss of visibility and other related problems are very common during forest fires. Researchers have revealed that extreme forest fires may create conditions, which ultimately result into floods and landslides, causing enormous loss to life and property. The loss to timber increment, loss of soil fertility, soil erosion, loss of employment, drying up of water sources and loss to bio-diversity are immeasurable losses by forest fire.

Forest fires during the summer of 1995 and 1999 in the Himalayan hills give an idea about the damage forest fires may result into. These fires were very severe and attracted the attention of whole nation. Fires that affected an area of 6, 77,700 hectares resulted into quantifiable timber loss worth around crores of rupees. The fires also created heavy smoke in the region, which covered the surrounding area for quite a few days. These fires caused changes in the microclimate of the area in the form of soil- moisture balance and increased evaporation.

Not only the large fires, but in certain cases the small fires may also cause immense loss. In the month of February, 2001, one small fire in the Gwar Forest area of Rudraprayag district, Uttarakhand claimed four lives and injured many more. The fire broke out in a grass field, when some women were busy in harvesting the fodder grass.

3.6 Components of forest fire

3.6.1 Fire is the naturally occurring companion of energy released in the form of heat and light, when oxygen combines with a combustible or burnable material at a suitable high temperature (about 617 degrees F, temperature or 325 degrees C for wood to burn). There are basically three components i.e. fuel, heat and oxygen that are needed in right combination to produce fire. Combination of these components, produces the **"fire triangle".** By nature, triangle needs three sides, missing of any of the one side will collapse the triangle. The same is true for fire. Take away any of the three components of fire - fuel, heat or oxygen, the fire collapses. Firefighters to suppress the fire, try to do just that and remove one of the three essential components of fire.

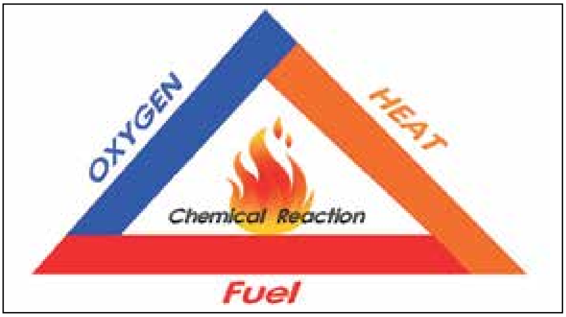


Fig.-3.1: Forest fire triangle

Source: Forest Encyclopedia Network & Ward, 2001

With a steady supply of oxygen (a fire needs air that contains at least 16 percent oxygen; the earth's atmosphere contains 21 percent oxygen), fuel and temperature become critical for sustaining a fire once it is ignited. The general relationship between fuel and temperature is simple: the more fuel, higher the heat; the more heat, the faster the fire spreads. When there is plenty of heat and fuel, fires start at its own. In the words of one fire behavior expert, *"Large fires live to feed themselves."* Large fires can create their own winds and weather, increasing flow of oxygen. A large fire can generate hurricane – force winds with a speed of up to 120 miles an hour. The key to fire management is understanding its nature- how it is created, what it takes to create fire, and more important during difficult fire seasons- what is to be done to control it?

3.6.2 Fuels for forest Fire

Among the three components required for fire, the basic necessity to initiate and continue a forest fire is the presence of suitable fuel. Forest fire has different kind of fuels. The important among them are as follows:

a) Ground fuels

Ground fuel involves all the combustible material below the loose litter of the surface. The materials which constitutes the ground fuels can be summarized as follows-

- various decayed stages of the humus,
- trees, shrubs and roots,
- muck and peat.

Ground fuel always supports the glowing combustion and not the flame. They don't ignite till the moisture content drops very low (less than 20 percent). The combustion becomes very persistent once the ground fuels ignite.

b) Surface fuels

All the combustible material on the forest floor is included in surface fuels. This type of fuel is the most common type of fire fuels. This may include-

- tree leaves and the fine litter,
- grasses, weeds, ferns and the other herbaceous plants,
- ow brush, seedlings and saplings of trees,
- fine deadwood on the forest floor,
- large logs and stumps, and
- roots of trees.

These fuels ignite very readily and provide the basic combustible material for the forest fires.

c) Aerial fuels

All the combustible dead or live material located in the under storey and above the forest canopy is included in this type of fuels. These fuels are separated from the ground by more than a meter. The main aerial fuels include:

- branches and foliage of trees,
- trees and shrubs of the under storey,
- standing dead trees, and
- mosses, lichens and epiphytic plants on trees.

The aerial fuels provide much needed combustible material for the spread of forest fire. The inferno in case of crown fires spreads by consuming aerial fuels.

The primary factor that helps in the spread of forest fire is the continuity of fuels. Fuel continuity is also one of the most important factors in controlling forest fire. This is due to the fact that they transfer heat by radiation, conduction and convection. Continuity, a relative term denotes both the forms of continuity i.e. vertical and horizontal. These are very essential for the fire spread and are taken into account while planning forest fire control.

3.7 Types of forest fire

Forest fires are not always same; they may differ, depending upon its nature, size, spreading speed, behavior etc. Basically forest fires can be sub grouped into four types depending upon their nature and size –

3.7.1 Surface fires

Fig.-3.2: Surface Fire

Surface fire is the most common forest fires that burn undergrowth and dead material along the floor of the forest. It is the type of fire that burns surface litter, other loose debris of the forest floor and small vegetation. In general, it is very useful for the forest growth and regeneration. But if grown in size, this fire not only burns ground flora but also results to engulf the undergrowth and the middle storey of the forest. Surface fires spread by flaming combustion through fuels at or near the surface- grass, dead and down limbs, forest needle and leaf litter, or debris from harvesting or land clearing. This is the most common type of fire in timber stand of all species. It may be a mild, low-energy fire in sparse grass and pine needle litter, or it may be a very hot, fast moving fire where slash, flammable under story shrubs or other abundant fuel prevails. A surface fire if spread may burn up to the taller vegetation and tree crowns as it progresses (Fig.-3.2).

3.7.2 Underground fires

The fires of low intensity, consuming the organic matter beneath and the surface litter of forest floor are sub-grouped as underground fire. In most of the dense forests a thick mantle of organic matter is found on top of the mineral soil. This fire spreads in by consuming such material. These fires usually spread entirely underground and burn for some meters below the surface.

This fire spreads very slowly and in most of the cases it becomes very hard to detect and control such type of fires. It may continue to burn for months and destroy vegetative cover of the soil. The other terminology for this type of fire is *Muck fires.*

3.7.3 Ground fires

These fires are fires in the sub surface organic fuels, such as duff layers under forest stands, Arctic tundra or taiga, and organic soils of swamps or bogs. There is no clear distinction between underground and ground fires. The smoldering underground fire sometime changes into ground fire. This fire burns root and other material on or beneath the surface i.e. burns the herbaceous growth on forest floor together with the layer of organic matter in various stages of decay. They are more damaging than surface fires, as they can destroy vegetation completely. Ground fires burn underneath the surface by smoldering combustion and are more often ignited by surface fires. Thus a ground fire consumes the organic material beneath the surface litter of the forest floor. A true ground fire spreads by a slowly smoldering edge with no flame and little smoke. These fires are often hard to detect and are the least spectacular and slowest moving. Fighting such fire is very difficult (Fig.-3.3).

Fig.-3.3: Ground Fire

3.7.4 Crown fires

Crown fire is the most unpredictable fires that burn the top of trees and spread rapidly by wind. In most of the cases these fires are invariably ignited by surface fires. This is one of the most spectacular kinds of forest fires which usually advance from top to down of trees or shrubs, more or less interdependent of surface fires. In dense conifer stands with a brisk wind, the crown fire may race ahead of the supporting surface fire (Fig.-3.4). Since it is over the heads of ground force it is uncontrollable until it again drops to the ground, and since it is usually fast moving, it poses grave danger to the fire fighters becoming trapped and burned.

Fig.-3.4: Crown Fire

3.7.5 Firestorms

Among the forest fires, the fire spreading most rapidly is the firestorm, which is an intense fire over a large area. As the fire burns, heat rises and air rushes in, causing the fire to grow. More air makes the fire spin violently like a storm. Flames fly out from the base and burning ember spew out the top of the fiery twister, starting smaller fires around it. Temperatures inside these storms can reach around 2,000 degrees Fahrenheit (Fig.3.5).

Fig.-3.5: Fire storm

Along with nature and behavior, the forest fires can also be categorized according to human management action. On this basis, fires in forest may be categorized as *management ignited fires* and *prescribed natural fires*. Management ignited prescribed fires are ignited in order to meet a land management plan objectives, such as debris removal or wildlife habitat improvement. Prescribed natural fires are those that are allowed to burn under an approved plan and preserve the natural role of fires in the ecosystem. Besides these, the fire may further be categorized based on their peculiar behaviour. There is specialized vocabulary used by the wild fire community for describing different types of fire behavior.

- A fire is said to be **running** when it is spreading rapidly

- It is **creeping** when it is spreading slowly with low flames
- A fire is **smoldering** when it burns without a flame and is barely spreading.
- A fire is said to be **spotting** when it is producing sparks or embers that are carried by the wind or by the combustion column caused by the fire and start new fires beyond the main fire. The new ignition points are called spot fires.
- A fire is **torching** when it moves from one crown to another fire into the crowns of individual trees, but not necessary from one crown to another.
- It is **crowning** when it spreads from tree to tree usually in conjunction with, but sometimes completely independent of the surface fire.
- A **flare-up** is a sudden acceleration of fire spread or intensity, of relatively short duration for a portion of the fire.
- A **blowup,** on the other hand is a dramatic change in the behavior of the whole fire, the point of rapid transition to a severe fire.

3.8 Why forests fire?

3.8.1 More than ninety five percent forest fires are caused either by negligence or unknowingly by the human being. The rest of the fires are caused by natural reasons i. e. lightning, extreme rise in the temperature etc., which are very rare. In general all over the world the main causes of forest fires are anthropogenic. According to FAO report “Fire Management- Global Assessment 2006”, regional estimates of human induced forest fires as follows:

a. Mediterranean- 95%

b. South Asia 90 %

c. South America 85 %

d. North America 80 %

e. Balkan countries 59 %

The natural causes of forest fires are common in remote areas only.

Out of three essential components of fire triangle, two components i.e. fuel and oxygen are naturally available in forest. It is the third component i.e. heat that really initiates fire in the forest. Heat may be supplied by either natural or artificial reasons. Depending upon the source of the heat, the causes for forest fire may be classified as natural or artificial. While lightening, volcanic explosion, friction of rolling stone etc. are the natural causes for forest fire; the anthropogenic causes may be subdivided into two categories i.e. deliberate causes and unintentional or accidental causes.

Natural	**Anthropogenic**	
	Deliberate causes	**Accidental causes**
1. Lightning	1 Shifting Cultivation	1 Collection of Non Timber Forest Produce
2. Friction of rolling stone	2 To flush growth of *tendu* leaves	2 Burning farm residues
3. Rubbing of dry bamboo clumps	3 To have good growth of grass and fodder	3 Driving away wild animals
4. Volcanic explosion	4 To settle score with forest department or personal rivalry	4 Throwing burning *bidi*/ cigarettes
.	5 To clear path by villagers	5. Camp fires by picnickers
.	6 To encroach upon the forest land	6. Sparks from vehicle –exhaust
.	7. For concealing illicit felling	7. Sparks from transformers
.	8. Tribal traditions/ customs	8. Uncontrolled prescribed burning
	.	9. Resin tapping

.		10. Making charcoal in forests
.		11 Extracting wine in forest
.		12. Sparks from cooking near the forest
		13 Heating coal tar for road construction in forest

3.8.2 Natural causes

Natural causes, that originate the Forest Fire, can be summarized as follows: -

- Lightning during thunderstorms may lead to the occurrence of forest fires. Many forest fires start from natural causes such as lightning which set trees on fire. Periodic lightning induced fires have been recorded throughout history from India, Southeastern and Central United States, Australia, Finland and Eastern and Southern Africa (Kaushik, 2004). Natural or prescribed fire sometimes may become a potential hazard to the forest by causing damage to vegetation and wildlife, and releasing huge amount of particulate and gaseous pollutants into the atmosphere.

- In dry season, friction leading to sparks by rolling stones in the mountainous areas may lead to forest fires. This occurs only when there is considerable combustible material present on the floor. Even small sparks are enough to generate a fire, which may be fanned by strong winds. A devastating forest fire taking lives of four innocent ladies in Gwar village, located 40 km towards north-east from Rudraprayag district of Uttarakhand in February 2001 is an example of such fire. In this region there was no winter rainfall from December, 2000 and thus there was lack of moisture both in the soil and air, resulting in less decomposition of senescent leaves. The dry grass worked as a fuel, fast blowing wind supplied oxygen in plenty resulting in speedy spread of fire and according to the villagers falling of hard quartzite stones produced sparks which ignited the fuel.

- In bamboo areas, forest fires may occur by the rubbing together of clumps of dry bamboos.
- Volcanic eruptions also lead to forest fires naturally.

3.8.3 Anthropogenic causes

More than 90% forest fires are caused by human beings, deliberately (for personal gains or rivalry) or merely due to negligence or just by accident. Forest fires sometimes originate due to accidental or unintentional reasons. Some of the instances are as follows-

a) Deliberate or intentional causes- Intentional forest fire is caused by people for some personal gain or rivalry with forest department. Examples are:

i) Shifting cultivation- Most of the forest fires in India are deliberately set by small-scale farmers or landless rural people. In the northeastern parts of India, the practice of slash-and-burn shifting cultivation is the leading cause of forest destruction. The most heavily affected areas by slash and burning methods are Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Nationally, estimated 4.35 million hectare areas are affected by fire as part of shifting cultivation. This is especially significant in that with the growth of population and consequent decrease in the land/person ratio, not only more areas are subjected to shifting cultivation, but also the fallow period for regeneration has been reduced from the initial thirty years to two years.

ii) To get good grass / fodder crop- Forest fires are also caused intentionally to meet the need of fodder for grazing cattle. In the country although some 12.5 million hectares of land is officially classified as permanent pasture or grazing land, most of this area is virtually devoid of grass. Thus a major portion of the grazing requirement is met from forest area by setting fires to produce new flushes of grass in the dry season.

iii) To get better flush for *tendu* leaves- In central India, fires are ignited in forest to increase the production of *tendu* leaves. *Tendu* leaves collectors set fires in the summer months to promote a better flush of leaves. The problem is compounded by the fact that tendu areas are leased for the collection of leaves on an annual basis; the purchasers are therefore reluctant to make long-term investments in crop improvement. The most economical and quick alternative for this is to set *tendu* areas on fire; which often extends to other forest areas owing to negligence and carelessness.

iv) For concealing the illicit felling - Smugglers and poachers many times start forest fires to hide the stumps of illicit felling. The poachers use forest fires for terrorizing wild animals and hunting too.

v) For cleaning forest paths by the villagers- Many times villagers set small fires to clear off path from dry litter i.e. tree twigs, branches, leaves etc. This fire, when becomes uncontrollable, turns disastrous.

vi) To settle scores - In some cases forests may also be set on fire by some miscreants in order to settle scores with the forest department or its staff.

b) Accidental or Unintentional causes

Many times due to negligence, even small fires may result into devastating fires. Some of the main unintentional reasons for such fires are-

i) Collection of Non Timber Forest Produce (NTFP) – Collection of NTFP by tribal or other local habitants residing near the forest has been one of the major causes of forest fire. To facilitate collection of NTFP the collectors ignite fire, which accidentally may spread in the forest, resulting into major fire. The main non-wood forest product that contributes to forest fire in India is the *mahua* flower (*Madhuca indica*) collection by local people in north-central India to produce a popular beverage, or boiled with *sal* seeds (*Shorea robusta*) as a seasonal grain substitute. *Mahua* pickers burn the dry leaves under the trees to get a clean patch of floor to facilitate flower collection. While the intention is only to clear a small patch beneath a single tree, these fires often spread out of control. Since the collection of *mahua* flowers is done during the summer months, the hot dry weather aggravates the situation.

ii) Burning farm residue- After a harvest, farmers set fire to their agricultural fields. Many times, when these fires are not put out completely, may spread to the adjoining forest areas.

iii) Protecting crops from the wild animals- Villagers residing in or near the forest many times light up fire in the forest to keep the wild animals away from their crop and cattle. Sometimes when this fire is not put out completely, it may result in a disastrous forest fire.

iv) Careless throwing of cigarettes, bidi stubs, match sticks by grazers/ travelers- Travelers, picnickers, nomadic grazers, villagers or even forest labourers some time throw un-extinguished cigarettes, *bidis,* and match sticks in the forest areas. When accompanied by little/ strong winds, this may result in fires capable of destroying valuable timber worth millions of rupees.

v) Negligence in camp fires and working operations near camping ground and fairs - Un-extinguished camp fires of trekkers, labour camps, nomads moving through the forest with their animals or the fires of road side charcoal panniers, when not put out properly lead to devastating forest fires.

vi) Sparks from transformers or vehicles passing through the forest- The sparks from transformers installed in the forest or near it may sometimes results into fires in forest. Similarly the sparkles from the vehicles passing through the area may also ignite fires in the forest areas.

vii) Uncontrolled prescribed burning- Just before the onset of the fire prone season, forest department do controlled burning in forest areas. Controlled burning is done to burn all the combustible material in the forest before the dry season to prevent major forest fires. Sometimes due to carelessness this fire may spread and result into large inferno.

viii) Resin tapping- Negligence in extracting resin from *Chir* Pine cones and careless burning of torchwood of *Chir* by pedestrian during night also result into forest fires. Careless handling of resin during resin tapping in the summer season may also start a fire, if the wind begins to blow at high speeds.

xi) Charcoal making and wine extracting in the forest- Small and medium scale charcoal making industries (both legal and illegal) and illegal wine extracting are common in Indian forests. Sparks from these activities may lead to fires in the forest.

x) Sparks from the house kitchens near the forest- Habitations are common within or near the forests in India. The households residing here use fire wood as fuel for cooking and other purposes. Sparks from such burning may sometime result in fire in the nearby forest.

xi) Heating coal tar for road construction – During road construction in forest areas, the charcoal heat to smelt coal tar may light up the dry litter resulting in huge forest fire.

xii) Hunting by tribals- Forest tribal for searching wild animals and their nests/ homes often set wild grass on fire. For preventing growth of leeches also, fires are ignited by local inhabitants.

3.9 Adverse impacts of forest fire

Forest fires are a major cause of degradation of forests/ environment. Despite lack of reliable information about forest fire, it is clear that the acreage of forest area burnt today is much more than ever before, all over the world. The area burnt due to forest fires in the United States of America (USA), which was of the order of 1.62 million ha in 2002, has gone up to 4.05 million ha in 2006. It is estimated that in India the proportion of forest areas prone to forest fires annually ranges from 33 percent in some States to over 90 percent in others. Forest fires in about 95 percent cases are anthropogenic and result into wide ranging adverse ecological, economical and social impacts.

The Forest Survey of India data on forest fire attribute around 50 percent of the forest areas as fire prone. This does not mean that fires affect country's 50 percent area annually. Very Heavy fire, Heavy fire, Frequent forest fire and Occasional fire damage is noticed only over 0.84 percent, 0.14 percent, 5.16 percent and 43.06 percent of the forest areas, respectively (Fig.-3.6). Only 6.17 percent of the Indian forests are subjected to severe fire damage annually. In absolute terms, out of around 63 million hectares of forests, an area of around 3.73 million hectares can be presumed to be affected by fires annually.

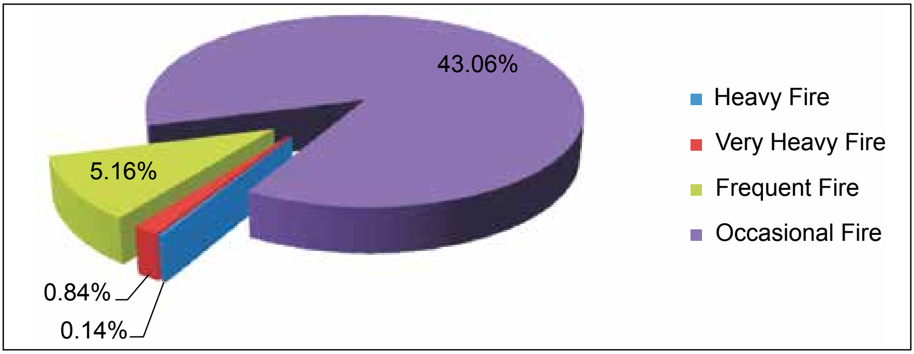


Fig.-3.6: Annual forest area prone to fire in India

Uncontrolled fires not only burn down the vegetation, but also the surface organic matter, increasing the frequency of flooding and causing soil erosion. In addition, wildlife patterns and habitat are also disrupted by fire. The situation is exacerbated by lack of fire protection planning knowledge and incentive.

A single fire in 1995, in east Kalimantan (Indonesia) burnt over 3 million hectares and caused health problems in adjoining countries too. Impact of fires on forests even after decades includes diseases, insect attacks, and watershed damages. If one restricts consideration of damage due to forest fires only to loss of lives, then fires do negligible damage and that is why damage due to fires does not get the attention it deserves. Fortunately, the whole world is now concerned about climate change and one of the culprits of climate change is forest fire.

Forest fire management has become important now not only because of loss of timber and other property but also because of the environmental pollution that forest fires cause. The statistics on forest fire damage are very poor in the country. In the absence of proper data, it is difficult to arrive at the accurate losses from the forest fires. Moreover, the losses from fires in respect of changes in biodiversity, carbon sequential capability, soil moisture and nutrient losses etc. cannot be measured exactly, but nevertheless, are very significant from the point of view of ecological stability and environmental conservation. To a certain extent, the loss due to forest fires can be based on the inventories made by the Forest Survey of India as reported in the State of Forest Report, 1995 and subsequent field observations conducted by them. The statistics of losses by forest fires from various states and union territories is still very sketchy and fragmented (Table-3.1). Much of the data available does not reflect the ground situation and is grossly under reported.

Table-3.1: Number of incidents of forest fire reported in 15 States of India.

STATE	1991/92	1992/93	1993/94
Andhra Pradesh	None	None	None
Arunachal Pradesh	1	2	2
Assam	None	None	None
Bihar	7	15	10
Gujarat	507	633	654
Haryana	None	None	None
Karnataka	106	16	None
Kerala	211	90	112
Maharashtra	1456	1428	None
Manipur	2	4	6
Mizoram	None	None	None
Punjab	15	31	107
Tamil Nadu	101	93	90
Tripura	None	None	None
Andamans	None	None	None

Source: Forest Survey of India; State Forest Report; 1998

Uncontrolled fires affect forest resources in a variety of ways. Regeneration is killed or dies back, thereby delaying the establishment of a new crop and extending the rotation. When newly planted teak plantations are bumt, it is standard practice to cut the young trees down to ground level; this stimulates a new vigorous shoot from the base, but at least one year's growth is lost. Fires are reported to damage seriously the regeneration of important tree species in *Sal forest. Chir* pine regeneration is similarly killed or set back by fire. Young eucalyptus plantations frequently require replanting as coppice regeneration dies back (or must be cut back) after fire.

Although in older crops the trees develop thick bark, which protect them from small fires; intense fires may destroy them too. During fire incidences, Eucalyptus appears to suffer more than the indigenous species and the effects of fires are apparent in reduced stocking per hectare and lower yields at maturity.

Repeated burnings result into destruction of the ground flora, ultimately leading to site deterioration and thus changes in soil nutrient status and accelerated erosion. This also reduces the vegetative growth rate. No research appears to have been done in India on the growth losses attributable to wildfires. Australian studies indicate that the volume increment of various species of eucalyptus is reduced after fires and the effect persists for several years. The cumulative loss of annual increment depends on the severity of the fire, but generally lies in the range of one to three years' growth.

Timber quality is affected by scorching from the base of the tree, which damages the cambium, leading to defective butt logs. Fungal infection may occur through the damaged tissues and cause rot. In chir pine forests, resin tapping affects the yield of merchantable timber by damaging the lower part of the tree; the scars enable fires to bum into the heartwood and, in some cases, kill the tree.

Main losses from extensive forest fires are discussed in the succeeding text:

i) Loss of valuable timber resources

Forest fires cause indispensable loss to timber and deteriorate its quality. Valuable timber species like *teak, sal, chir, deodar, sheesam*, rosewood etc. are adversely affected by fire. However, the adhesive impact of forest fire varies from species to species, depending upon its susceptibility.

Pine Forest: In Himalayas the periodicity of the fire in pine forest is 2 to 5 years. Eleven percent of the pine forest experiences fire every year. Most of the pine forests experience the surface fire, while some other may experience more damaging crown fire also. The total area affected by a single fire normally limits within a range of 5 sq. km. The fire in pine forest in hilly terrain, moving downward from the hill top is normally slow and less damaging. The fire moving upward from the bottom of the hills is more damaging and usually turns into crown fire and is very difficult to control.

Teak Plantations: Teak is vulnerable to damage from low intensity fires only for its first five years, thereafter low intensity fire has no effect on the tree or on wood quality. From about five years onward, the dense canopy of teak during the growing season suppresses most under storey weeds.

Eucalyptus Plantations: The eucalyptus, although a smooth barked variety, once they are older than about 5 years, are quite tolerant of low intensity ground fires. They can be control burnt from age five onwards safely. Fires after that age do not cause any noticeable loss of timber quality for pulpwood. Therefore, it is only during the period 2-5 years that they are vulnerable to fire and need protection measures.

Mahua: It is likely that forest fires have very little impact on *mahua* trees. This species occurs as scattered single trees in mixed species stands. It is understood that virtually every tree is visited each year for the *mahua* harvest. The practice of burning under the trees to clear the undergrowth in preparation for harvest means that each tree has its own fire trace created for it. Even if subsequent leaf fall occurs, the litter is very light and does not carry a damaging fire.

ii) Impact of forest fire on eco- system- The most damaging impact of forest fire on ecosystem is very evident in the Himalayas, where hills existing between the heights of 1000 to 1800 meters are dominated by pine forests and seem to be more fire prone. Most of these forests have preceding fire history; repeated fires have converted mixed forests of oak and chir to pure *chir* forest. Of course, *chir* pine was also planted in these areas but one of the principal reasons for the conversion of mixed forests of oak and chir is the occurrence of repeated and uncontrolled fires. Uncontrolled fires have made the situation less favourable for oaks to grow and more favourable for *chir* to grow. The uncontrolled fires in such areas help in spreading pine forest at the cost of indigenous oak forest, which is very serious threat to the ecological balance in the Himalayan region.

iii) Degradation of water catchments areas resulting into loss of water- After forest fire, soil moisture is decreased and litter decomposition becomes almost negligible, which creates a possibility of forest fire in future. Just after fire, the chemical and physical changes in upper layer of soil make it impervious and thus reduce water infiltration. The removal of litter also decreases water holding capacity of soil and most of the rainwater is washed away removing top fertile soil of the forest resulting into loss of soil fertility.

iv) Loss of wildlife habitat and depletion of wildlife- Forests are the habitat of many wild animals. Sometimes the local people put the fire and drum beats to keep the wild animals away, but when fire becomes uncontrolled, the problem of survival of animals and their habitat arises. Wildfire along with killing wild animals also destroys their habitat and thus makes their survival at stake. The forest fires in Sankhuwasabha and Ilam in Nepal claimed red pandas, leopards as well as monkeys, deer, bear and other species.

Forest fire dramatically impacts the animal life. Animals are first to lose their lives due to heat generated. Eggs of birds and insects are destroyed due to fire impact. Some animals have a natural threat warning system and usually migrate from the danger areas. The birds also save themselves by migration, but their eggs are usually destroyed. Such migration of birds and the animals in normal condition is not permanent and they return back when the conditions are normalized.

v) Loss of natural vegetation and reduction of forest cover- As a result of fires, millions of hectares of the forest area turn to ashes and remains of no use. Among various degradation factors, forest fire is also one of the major factors for overall loss in forest cover. The wild fires have adverse impact on forest tree growth. Researches in United States have shown that today many low elevations forest in the west are thick with small trees, while historic photographs and personal accounts tell of these forests characterized by large trees spaced far enough.

vi) Global warming- One of the major culprits of climate change is forest fire. The immediate effect of vegetation burning is the production and release of gases including carbon dioxide, carbon monoxide, methane, non-methane hydrocarbons, nitric oxide, methyl chloride and various other gases, which are released and returned to the atmosphere in a matter of hours. The burning of forest also destroys an important sink for atmospheric carbon dioxide. Hence, burning has a significant role in the world's carbon dioxide budget. If the burned ecosystem regrows, the carbon dioxide is eventually removed from the atmosphere via photosynthesis and is incorporated into the new vegetative growth. Other gaseous emission, however, remain in the atmosphere. The depletion of ozone layer gets started as a result of these noxious gases. This ozone layer depletion not only results in various adverse impacts but also further increases the chances of forest fire in future. International Centre for Integrated Mountain Development (ICIMOD) working in Hindukush Mountains pins the blame on global warming for creating the conditions that led to fires. Some foresters blame record high temperatures and the failure of winter rains for destruction through fire of hundreds of hectares of natural forest in the Garhwal Himalayas in India and in eastern and central regions of Nepal in 2006.

Green house gases released during the combustion of vegetations lead to an increased warming of the earth or human induced global climate change. Studies suggest that biomass burning has increased on a global scale over the last 100 years and calculations indicate that hotter earth resulted from global warming will lead to more frequent water related calamities and larger fires.

As per FAO report "Fire Management- Global Assessment 2006", the quantity of biomass burned each year from all resources is about 9200 million tones. Overall global fires in vegetation consume 5130 million tones, 42 percent of which is in Africa. This burning releases about 3431 million tones of CO_2 and other emissions. However due to cyclic nature of disturbances in fire dependant and fire dependant eco systems involves sequestration of atmospheric carbon for regrowth of the plant biomass and thus fire generated CO_2 is not contributing to a net release of carbon in atmosphere.

Box-3.1: Forest Fire and Global Warming

Climate plays a vital role in determining fire patterns and intensity and, in turn, fire influences the climate system via the release of carbon. Forest fires and global warming have created dangerous relationship. The close linkage between high fire activity and inter annual and decadal-scale climate oscillations indicates that fire occurrence increases during the La Nina phase of the ENSO southern United States and Patagonia, Argentina. Whereas a marked increase in fire activity occurs in tropical rainforests during EI Nino phases. Sedimentary charcoal records also show a strong link between climate and fire activity, with reduced fire in cold intervals and increased fire in warm intervals, regardless of whether humans were present. The changing weather pattern in one of the major factor is contributing to current increase in instances of forest fires. The main reason for this is change in overall increase in the temperature; change in precipitation pattern and moisture content in the atmosphere. Drier soil leads less evaporation and so the heat goes into higher temperatures, less recycled moisture in the atmosphere, and hence less rain during summer. This results into increased heat waves and thus increased risk of wildfires.

The Climate change is affecting various climate related variables like – soil moisture content, vegetation density, affecting the fire season severity. Extended periods of above normal temperatures and below – normal rainfall are key factors that contribute to an active wildfire season. It is not only the global warming that is affecting the forest fire, but is true in the reverse way also i.e. the forest fires are also contributing to global warming. As per an assessment based on scientific research, the combination of intentional and unintentional fires – by burning carbon-storing vegetation has contributing a whopping 20% of all human caused green house gas emission since the Industrial Revolution.

vii) Microclimate change: The changed microclimate caused by removal of litter and duff, opening of the canopy by killing over storey shrubs and trees and darkening of the soil surface by residual soot and charcoal can increase insulation causing temperature increase. As a result the changed area becomes unhealthy for living of both wild habitats and local people.

viii) Soil erosion: The scientific studies indicate that erosion of the soil from the forest land depends on many factors i.e. the soil porosity, its mineral composition, the texture, the gradient of the land and length etc. All these factors decide the ease with which the individual soil particles are detached. Though the erosion of soil during low scale forest fire is a natural phenomenon, yet during severe fire conditions, this process turns into more serious problems, both for environment and habitat. Anthropogenic activities such as fire suppression, logging and road construction in forest areas have adversely affected the soil stability. The fire impact on forest floor may vary from just removing the litter to the total consumption of the forest fuel and alteration of the soil mineral structure.

The most intense forest fire always has a direct heating effect on the soil at the depth below 7 to 10 cm. As a result, the soil of the fire affected area loses its water holding capacity and becomes vulnerable for erosion. Due to consumption of the forest organic residue by fires, the mineral soil is exposed and consequently its infiltration and water holding capacity are automatically reduced. Burning of vegetation also reduces the amount of rain fall infiltration by the forest canopy and reduces evaporation by the forest vegetation.

The soil and water response to wild fire is often a function of fire severity and occurrence of hydrologic events. For a wide range of severities, the impact of hydrology and sediment loss can be minimized if the precipitation is less. However, when the precipitation follows a severe fire, the impact of the water is very high and substantial. This increase in soil erosion, especially in the hilly terrain has very long lasting impact on the ecosystem of the region. The duration of the increased vulnerability also depends upon the severity of the forest fire.

In moderate fire conditions, the normalcy in soil erosion may return back within a year or two. However, in the case of very severe fire conditions, the return period to normalcy may vary from 5-7 and even ten years.

In hilly terrains, the rate of the soil erosion shows spatial variability, which is an important characteristic of hill slopes. Field experiments show that when two third of the upper portion of the hill slopes is in high severity burn conditions, it produces twice as much sediment as compared to when the upper two- third lies in low severity burn conditions. The earlier conditions are very common in field and thus lead to severe soil erosion.

ix) Soil erosion and impact on ecosystems- The fire initiated soil erosion has very adverse impact on various eco- systems near the burned area. Loss of soil from hill slopes produces several significant ecosystem impacts. Soil movement in the streams, lakes etc. may degrade water quality and change the geomorphic and hydrologic characteristics of these systems. The soil loss from hill slopes may also alter future soil productivity. As a result of the increased soil erosion, the delivery of the sediment in large quantities to water bodies may also affect aquatic animals and their habitat.

x) Forest fire and floods- The water yield of a water body depends on the quantity of the rain, evapotranspiration, type of the soil and vegetation etc. During the first year after a fire, the magnitude of the total water yield suddenly increases. The magnitude may vary greatly within a location or between locations, depending upon the fire intensity, rainfall, geomorphology, the type of soil & vegetation and the proportion of the vegetation burned. In some exceptional conditions this may lead to flood also. Water repellent soils and cover loss cause flood peaks to arrive faster, rise to higher levels and entrain significant amount of bed load and suspended sediments. These floods may have devastating impacts on soil and water quality and also affect the ecosystem prevailing in the region.

xi) Deteriorating Biological Environment- Forest fires also pose serious health hazard by creating polluting smoke and noxious gases. The burning of vegetation gives off not only carbon dioxide but also many other noxious gases (Green House gases) such as carbon monoxide, methane hydrocarbons, nitric oxide and nitrous oxide that lead to global warming and ozone layer depletion. Thousands of people suffer from serious respiratory problems due to these toxic gases.

Burning forests and grasslands also add to already serious threat of global warming. Forests play a vital role in keeping the level of carbon di oxide in the atmosphere in check. Forests, grasslands and agricultural lands make up bulk of the global biomass burning in a global phenomenon. Recent research suggests that biomass burning may be a significant global source of methyl bromide, which is an active ozone depleting substance.

Researchers have also come out with very significant information about the impact of forest fire on environment as a result of green house gas- nitrous oxide through bacteria. Nitrification is a biological process where bacteria convert ammonia (found naturally in soil and fire ash) to nitric oxide and nitrous oxides. The increased concentration of ammonia in the ash leads to more nitrification after a fire, thereby releasing additional nitric and nitrous oxide.

xii) Adverse impact on Health system- The fires in the forest are source of smoke that cause air pollution and rise in the temperature. The forest fires in 1995 and 1999 in Himalayan states gutted the mountains with the smoke, resulting into loss of visibility to about 200 meters. The temperature in the region also rose by 2 to 3 degree Celsius. This resulted into uneasiness among the local population of the region. Scientific studies of major forest fire of South East Asia of 1997 came out with many new findings. These fires were unique, since they involved both the burning of above ground vegetation, as well as the below ground i.e. peat (a form of coal). Smoldering peat vegetation produces much more smoke than the burning of normal vegetation. This fire generated smoke covered almost all of South East Asia resulting into more than 20 million cases of smoke related health problems.

xiii) Socio-economic impact- Fire is a major factor of destruction of human settlelement and often causes deterioration of site by subsequent increased erosion. Thus fire is threatening human life and property both. If the weather conditions are very dry or windy, fire burns much faster. A fire near settlements may also damage the houses. Damage also can be caused by smoke. Smoke in building smells unpleasant, leaves ashes and impacts human health. Forest fire also adversely affect livelihood resources, especially for tribals, who habitat within or near the forest. In India, where approximately 65 million people are classified as tribal and directly depend upon collection of non-timber forest products from the forest areas for their livelihood are directly affected by forest fire.

xiv) Carbon sequestration potential- Trees act as carbon sinks when they absorb carbon dioxide from atmosphere and build up the same in the form of wood. Hardwood contains 48 percent of carbon in the form of cellulose and wood and it is estimated that 2.2 tones of wood are required to sequester one ton of carbon. On the other hand, while the wood is burnt the reverse process takes place in which the atmospheric oxygen is used and carbon- di-oxide is released into the atmosphere. Hence, forests act both as source as well as sink of carbon, depending upon the manner and purpose for which they are raised and managed. Burning of the vegetation release hundreds of years of stored carbon-di- oxide (CO_2) into the atmosphere, and thus results into permanent destruction of important sink of carbon dioxide.

xv) Threat to Life and Property- Forest fires affect human life and property in different ways. Human life is at risk when fire crews fight fires either at the fire front or from conflict with animals, especially elephants. A forest fire that spreads outside the forest can consume buildings or infrastructure. There are also indirect dangers to life and property due to forest fire. If too much forage is lost within the reserve, elephants move out of the forest searching for food and in doing so destroy crops and property. In certain cases forest fire directly cause loss of life as observed in Gwar village of Rudraprayag district in the year 2001, when four ladies were killed while harvesting grass near forest area. In hills, the management practices of forest fire are interrupted by various types of constraints such as poor knowledge & data base, lack of cooperation among sectors, resources, training of staff and paucity of funds etc.

In the western countries, especially in the United States, forest fires cause enormous loss to house buildings. As per an estimate, forest fires burned around 10,000 houses in the United States between 1985 and 2000. In 2000 alone, at least 800 family houses were destroyed by wild fires in that country.

xvi) Reducing Tourism Values - Smoke and haze generated by fires are inimical to a good tourist experience, especially when a significant part of the tourist experience depends on views of the mountains. Fire in forest gives a negative impression to the tourists. Smoke due to fires affects the visibility and air quality which adversely affect tourism industry. From the overall tourism industry perspective, the generation of smoke needs to be minimized, especially during the peak tourist season of April-June.

3.10 Forest fire and Climate change

"Fires are obviously one of the major responses to climate change, but fires are not only a response -- they feed back to warming, which feeds more fires." When vegetation burns, the resulting release of stored carbon increases global warming. The more fires, the more carbon dioxide released the more warming -- and the more warming, the more fires. The very fine soot, known as black carbon, that is released into the atmosphere by fires also contributes to warming (Fig.3.7).

Forest fires affect the global carbon cycle, and thus the climate, in three main ways (Kasischke and Stocks, 2000). First, fire releases large quantities of carbon into the atmosphere through the combustion of plant material and surface soil organic matter. Second, fire-killed vegetation decomposes over time emitting carbon. Third, the vegetation on newly burned sites may not absorb as much carbon from the atmosphere as the decaying vegetation emits, or as much as the pre-fire vegetation absorbed, for several years or decades after a fire. Fires are thus an

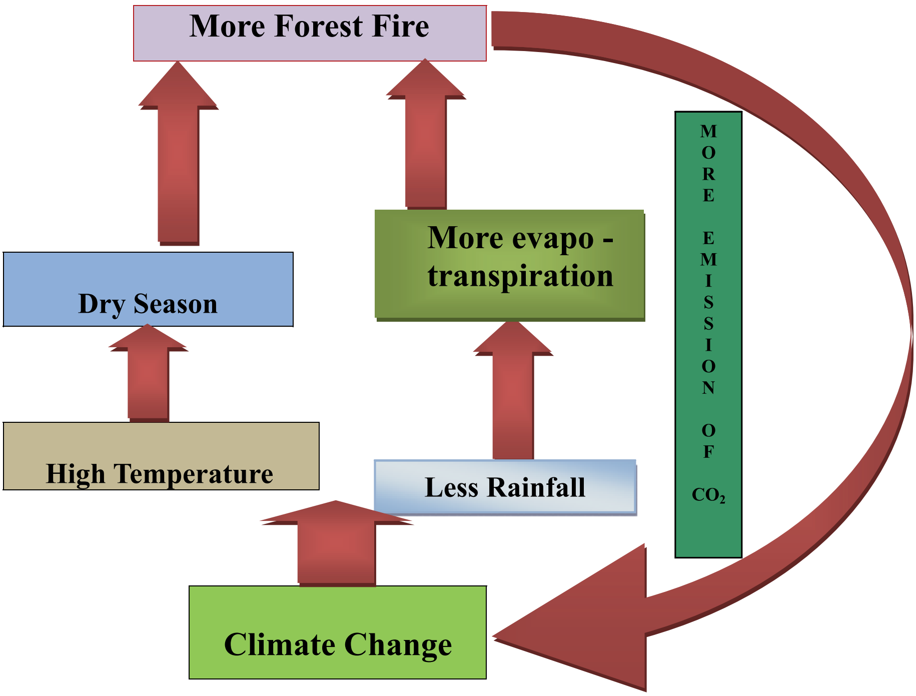


Fig.-3.7: Forest fire and Climate change (Satendra, 2003)

important part of the global carbon cycle, with increased fire frequency generally causing a net reduction in biospheric carbon storage.

Flannigan *et.al.* (2000) reviewed the existing studies on climate change and forest fires by using two transient general circulation models (GCMs), namely the Hadley Centre and the Canadian GCMs, to estimate fire season severity in the middle of the next century. Ratios of $2\times CO_2$ seasonal severity rating (SSR) over present day SSR were calculated for the means and maximums for North America. The results suggest that the SSR will increase by 10–50% over most of North America; although, there are regions of little change or where the SSR may decrease by the middle of the next century. Increased SSRs should translate into increased forest fire activity. Thus, forest fires could be viewed as an agent of change for US forests as the fire regime will respond rapidly to climate warming. This change in the fire regime has the potential to overshadow the direct effects of climate change on species distribution and migration.

Bowman *et.al.* (2009), said, "We're most concerned that fire has not been rigorously and adequately incorporated in the climate models. It's remarkable that such an integral part of the landscape has been so sidelined." Because fire on Earth predates humans, its ubiquitous activity is simultaneously accepted and overlooked. "Fire is extraordinarily obvious, but deeply subtle." A more complete understanding of how the Earth works requires recognizing how fire is interwined with and also a driver of human history and the Earth's history, the authors write. Balch (2009) observed that "The synthesis is a prerequisite for adaptation to the apparent recent intensification of fire feedbacks, which have been exacerbated by climate change, rapid land-cover transformation, and exotic species introductions" and further commented about "fires where we don't normally see fires," and pointed to the occurrence of bigger and more frequent fires from the western U.S. to the tropics. Swetnam (2009) said that, in addition to the burning in the tropics, huge tracts of the boreal forests of Siberia, Canada and northern Europe burn each year. "The role of fire in forests in the boreal zone is unappreciated," he said. "Russian forests alone contain more than 50 percent of the carbon stored on land in the Northern Hemisphere," and warming is happening fastest at high latitudes. In some recent years, the acreage burned in the forests of Siberia exceeded the size of the U.S. state of Virginia, he said. As the world warms, more of those regions are likely to burn, accelerating the warming.

Chapter 4

FOREST FIRE: THE GLOBAL SCENARIO

4.1 Introduction

The problem of wild fire is a universal phenomenon which is a dominant disturbing factor in all types of vegetation throughout the world. Though in world-ecosystem fire is a natural phenomenon and helps the vegetation by organizing physical and biological attributes, influencing energy flows and biological cycles, yet its adverse impact in ecosystem is quite well known. Due to various natural and mostly the human induced factors, the severity of forest fires in general is increasing day by day. The adverse impacts of this increased forest fire and its severity have brought this menace in the category of other natural disasters like floods, droughts, earthquakes etc.

Forest fires are common in almost all types of vegetation. In the temperate and northern boreal forests, it occurs regularly during the dry summers. On an average 5 to 20 million hectares of forest are burned annually in North America and Eurasia due to fire hazard. In the Mediterranean forests also the situation is similar and around 0.6 million hectare forest is burned here annually. Though equatorial rain forests are bit moist, however extreme droughts associated with other human induced activities make it too vulnerable to fire. In South Africa, cyclic climate variability caused by El-Nino-Southern Oscillation (ENSO) phenomenon is responsible for extreme fire events in the forests.

In tropical forests, fire is a regular phenomenon at the short interval of one to five years. The Tropical Sub-montane Conifers Forests due its specific vegetation (pine), rich in resin and susceptible to fire, are subjected to forest fire regularly. In addition to standing forest crop, fire is very common in tropical grass- land and Savannas. Tropical Savannas spread over an area of about 2.6 billion hectare (consisting of more or less continuous spread of grass with interrupted trees and shrubs) are prone to fire and are burnt regularly. On an average hundred millions hectares land in these grasslands are burnt annually, mostly in dry season. As per an estimate about 3 million tones of vegetation are burned here every year, resulting into three times more gas and particles emission than that by other burning. The intensity of fire in Savannas has increased in the recent past due to population pressure also. Though all forests bearing countries are hit by fire menace, one or other time, some are more prone.

A brief about the susceptibility of ten countries to fire, their fire situation, fire season (phenology), major fire incidences, fire management strategies/ plans etc. are briefed in Table-4.1.

Table-4.1: Susceptibility to fire, fire situation, fire season, fire incidences and management strategies at Global level.

SN	COUNTRY PROFILE	VEGETATION	FOREST FIRE SITUATION	MAJOR FIRES AND IMPACTS	GENREAL IMPACTS	CAUSES	MEASURES TAKEN
(A)	**(B)**	**(C)**	**(D)**	**(E)**	**(F)**	**(G)**	**(H)**
1	**AUSTRALIA**-Total Area-7.9 mln.km2 Relatively flat with mountains of moderate height. Large Arid and semiarid zones also. Climate varies- with northern part- wet dry, south west-Mediterranean, south-east-quasi-Mediterranean. Large portion is arid and semiarid, both tropical and temperate.	• Diverse forest species- - • Savannah • Eucalyptus • Acacia • Hummock grassland • Acacia dominated shrub land	Wide range of fire regime. Between 1956 &1971 on an average1945 fires were noticed burning an area of around 362000 hectares.. During the period from 1978 to 1996 -------- of forest land was burned in the continent.	Major forest fire incidences during 1980 and 1990. During 1980 in South Australia and Victoria- resulting into loss of 70 human life and burning of > 2000 houses. Major fire erupted in1990 in Sydney and New south Wales causing 4 deaths and loss of 206 houses.	• Extinction of local fauna and flora. • Change in pasture palatability. • Change in soil erosion rate. • Change in water quality and yield. • Life loss (majority of fire fighters). Since 1980 52 fire fighters are killed while fighting forest fire.	• Lightning is the natural cause. • Burning of farm residue and camp fire. • Prescription fire by the forest department and other agencies	Fire suppression by volunteers, recruited by may agencies, which provide them training and equip. These agencies have good mechanism and equipment to detect and suppress fire. Preventive measure like prescribed burning, disposal of debris after silviculture operation etc. also commonly used. Public awareness and training programmes also conducted.
2	**MALAYSIA-** **Location:** Southeastern Asia, partly on Malay Peninsula, south of Thailand and on the northern one-third	Dipiterocarp forests i.e. Tropical lowland moist forest, which comprises of following plant trees- • *Aralia dasyphylla* • *Areca triandra*	Most of the fires occur in plantation, degraded peat swamps and logged over forest The frequency increases in ENSO year due	The worst fire in 1982-83, burned almost one million hectare of natural forest in Sabah region. Other major fires	Extensive damage to flora, and wildlife. Fires caused smoke result into health related problems in the people.	Main causes human induced including- • Land preparation by farmers and other	Fire suppression mainly by Fire and Rescue Department assisted by Forest, Public defense etc. Preventive measures like awareness and

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	of the island of Borneo, bordering Indonesia, Brunei, and the South China Sea, south of Vietnam. Total Area: 330 000 sq. km. (127 316 sq. mi.) Terrain: Coastal plains and interior, jungle-covered mountains. The South China Sea separates peninsular Malaysia from East Malaysia on Borneo. **Climate:** Tropical, annual southwest (Apr to Oct) and northeast (Oct to Feb) monsoons. **People:** Nationality: Malaysian(s). Population: 25.5 million.	• Bamboo orchid • *Dacrydium gibbsiae* • Durian • Nepenthes rajah • *Rafflesia arnoldii* • *Rafflesia kerrii* • Vietnamese White Pine	to dry spells.	in degraded or secondary forest viz. plantation etc. during 1970 in pine plantation and acacia plantation in 1980.	Economic losses in term of production, tourism, airtime, etc. due to haze caused by the fire.	plantation. • Control burning fires get out and spread. • Shifting cultivation by the indigenous • Electric spark in the forest area.	training programmes run by the administration. The fire fighting agencies are being equipped by modern and easy to handle equipments and training.
3.	**NEPAL -** Hill state with elevation varying between 300 to 3500 mts. The climatic	Vegetation vary with altitude. • Subtropical pine Dry scrubby • *Schima castanopsis* forest	Each year fire destroys timber and non-timber produces between Jan to June. In Tarai region fire	Fires are common phenomena in Nepal. Major fire in 1995 when as per an estimate 90%	• Destroy both timber and non timber produce. • Reduce biological diversity.	Most of the fires are man made. • By burning farm residue • Shifting cultivation	No systematic management for forest fire control However some emphasis is given on sustainable land use.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	conditions vary with the altitudes million Geographic from subtropical in south to Alpine snow covered in the north.	• Lr. Temperate forest • Upper temperate • Alpine • Shrub land • Grassland	more common on dry southern slopes. In the Middle mountain region the pine forest being very susceptible are burned annually during summer. In the high hilly regions the coniferous forest also got burnt during the dry and windy days.	of the forest got burnt in Tarai region. As per estimate by Goldammer (1993), annually 400,000 hectre of forest are burnt in Nepal.	• Make country side very dirty looking during summer reducing tourism values • Degrade soil quality • Also result into increase in soil erosion, flood, land slide	Drive away wild animals • Lightning in higher altitudes • Collection of NTFC • Growth of good grass cover	Forest departments use the services of temporary forest fire watcher during the summers. Litter burning and collection of pine needle for some purposes also help in fire control. Some awareness and training programmes also conducted occasionally. Recently measures are being taken to involve community in fire control.
4.	**MANGOLIA -** Located in central Asia. Population-2.3 million Geographic area= 1565000 km^2. Climate and natural conditions very harsh, water resources very poor and soil fertility also not good. Climate condition very	Forest Cover 8.1% of the total area. Grassland.- 70% Main Species are :- Pine, birch, larch, cedar and spruce. A large portion of forest is degraded due to felling of trees.	Around 20% of the total forest area is affected by forest fire. Central and Eastern part more fire prone. Pine and Birch are vulnerable spices to fire. March to June peak fire season. Few fires during autumn also 50-60 forest fires occur annually	Major fire's during 1996 to 1998, between February to June During the period 26.3 million hectare of forest destroyed. Heavy loss to life (29 people and . > 10000 cattle killed). Besides these	On an average 1.74 m.h. forest is burned annually by fire causing immense loss to life and property. • During 1996-97, about 22% of the total land area was affected by fire • Life and property adversely	Majority of fires are man- made, unintentionally. Most common in pine and larch forest major causes are :- • Hunting practice • Sparks from s exhaust pipe of motor vehicles • Camp fire	• International Support in the form of expert, staff, training and equipment. • Preparation of fire management plan for fire prone areas. • Community involvement through training, awareness generation, school

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	extreme. Floods, heavy snowfall, hot summer; tornadoes etc. are natural disasters; the country is prone to them.		.	fires also caused damage to ecology and environment of the area.	affected by fire. The socio –economic condition of people and their livelihood resources deteriorated. • Fire consumed about 14% of forest resources. Adversely affected vegetation of forest crop and water resources badly.	in the forest during winter • Throwing cigarette butts in forest area • Susceptibilities of vegetation of fire (pine and larch prone to fire) • Collapse of earlier existed air bore fire fighting system, due to lack of resources.	education etc. • Establishment of "fire management Agency" to look after the forest fire. • Early warning and communication system is being strengthened. • Cooperation of civil defense and state police being sought for fire suppression.
5.	**SRILANKA-** A neighboring country to India. Tropical Island in Indian Ocean with total geographical area = 65000 km^2. Total Population is around 18 million. Economy is agriculture based. Climatically it is warm and humid,	More than 30% of the country's total land is covered with forest. A large area is under coconut and rubber plantation Dense forest = 1.58 m.h. Open forest = 0.464 m.h. Plantation = 0.72 m.h. Coconut and other plantation = 1.4 m.h.	Due to favorable climatic condition, forest fire situation not much serious. Scrub and grass land (1.2 m.h.) is the only forest area affected by fire. 50 to 200 forest fires reported, every year and about 10 hectors area burnt annually.	No major fire reported, small size fires in plantation and grass land. Most of the fires are surface fire.	Major impact of forest fire on plantation and environment. Hardly any threat to life and properly, as all fires are small fires lasting for few hours only	• Burning debris while making roads. etc • Shifting Cultivation • To get good crop of grass and fodder • Drive away wild animals. • Throwing burning cigarette butts	• All prevention and suppression activities by State Forest Department only • Community also involve in preventing and suppression activity. • Training and awareness programme to

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	rainfall heavy, but not even (1000 to 5000 mm). Two Monsoon seasons (April to July) and (September to January)	Scrub and grassland = 1.2 m.h. Forest Type – • Tropical rain forest • Sub Tropical Montana • Evergreen • Tropical Semi deciduous	• Majority of this is in plantation area only			in the forest • Burning farm residence	community and forest staff. • Prescribed burning of debris.
6.	**THAILAND** **Location:** Southeastern Asia mainland, bordering the Andaman Sea (West) and the Gulf of Thailand (East), southeast of Burma (Myanmar). Area: 513 115 sq. km. (198 114 sq. mi.). Terrain: Densely populated central plain; northeastern plateau; mountain range in the west; southern isthmus joins the land mass with Malaysia. **Climate:** Thailand is a warm and rather humid	Forest is spread over 25% and area i.e. 12.00 m.h Major forests are - • Deciduous forest • Tropical Rain Forest • Dry Ever green forest • Hill ever green forest • Peat swamp forest.	Fire is very common annually. Fire season spread from December to May; peak season during two month i.e. February and March. Not only surface, some time crown fire, underground fires are also very common.	Major fire during 1998, mainly due to El-Nino effect. 4 areas most affected • In Doi-Intron National Park-damaged around 500 h. Forest • Pan-To-Dang-12, 80 h. forest mainly Peat-Swamp burnt. • Kao-Yai about 1400 h. forest burn.	Impacts of forest fire are very diversified and deep in eco-system. Natural regeneration of crop is most affected. The fires also change forest structure. Evergreen forest most affected by fires. it kills tree and wild life both in large number. Environment is also worst affected by large fires. Fire generated smoke cause many health problems.	Most of the fires are initiated by man due to negligence or careless ness, during dry season the vegetation and debris catch fire immediately. EI-Nino effect was major reason for 1997-98 major fire, Shifting cultivation practices, camp fire, burning farm residues, drive away wild animal, throwing burning cigarette	Thailand has well organized fire fighting setup divided into many wings, which look after – planning and supervision, research and development, training, campaign and public awareness etc. Forest fire control stations are the main executing agency. Volunteers are trained and equipped here. International cooperation is also sought for modernizing the existing system. A National Forest Fire Research Center

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	tropical country with monsoonal climate. Seasons- -Dry: March to May, Rainy: June to October, Cool: November to February. Population (1999): 62 million				Soil erosion and land cutting also increase due to fire. Tourist spots also damaged.	butts are major sources of heat for fire initiation.	opened during 1999. Attempt being made to aware and train local population also.
7.	**KOREA -** A peninsular country on the western coast of Pacific ocean, with 33°06 to 43 °01 N latitude and 124° 11 to 131° 53 E longitude. Continental climate with summer monsoons. Hot and humid during summer. The rains are very frequent. Autumn and spring season are very short. The terrain is very irregular with scattered hills.	Forest vegetation is quite variable with 16 eco – region based on climatic conditions - • Warm-Temperate Vegetation • Temperate Vegetation • Cold-Temperate Vegetation • Flowering Periods	Forest fires common between February to May and November to December. Less fire during summer due to sufficient rainfall. Out of 16 Eco-regions, fire frequent in three regions due to scarcity of rain and comparatively dry weather fire usually starts from the bottom of mountain and spread upward. During 1990-99 around 360 fires occurred, damaging about 1400 hectares of forest per year.	During 1996 large fire broke in Kosung Kangwon region which burned 3700 hectare of forest approximately.	Fire Impacts on vegetation are devastating, especially in pine forest, occasionally burning complete vegetation and some time affect human settlements also and crops. In 1996 forest fire caused major loss to pine mushroom, residential houses and other property amounting to 66 million.	Majority of the fires are man caused, due to burning of farms- residue, drive away wild animals, killing harmful insects and up to some extent agriculture practices. Throwing burning cigarettes also cause fire.	Korean forest service is the social agency for forest fire management. Separate department i.e. forest fire prevention Department and Arrival forest Counter officer to look after the issue. Main emp hasis is on fire suppression. Education and training also provided through these departments. Country has a planning to draw effective and regulation to tackle problem effectively.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
8.	**FIJI -** Cluster of islands in the S.W. Pacific ocean, mostly hilly. The islands are volcanic in origin. The lee-ward side of the islands experience dry climate. The dry weather expands between May and October.	The vegetation is variegated in nature :- • Coastal mangrove • Pines spp. plantation • Secondary swidden forest • Grasslands	No systematic record of forest fires in the country. Fire is a regular seasonal phenomenon in the pine and grassland forest. Majority of fires are escape fires from farm residue burning, mostly by the cane growers. The incidence of fire increased after 1970, as a result of law-less ness.	Fire common during dry season, about 70% of the land fired every five years. Between 1987-97, about 20% of the total managed area (43200 hector) were written off due to fire problems. Major fires reported in 1987, 1988, 1992 and 1994 years	Large forest tracts are burnt during fire every year. This affects the economy of the country. Timber fetches good price, the fire affect its cost very drastically. Though habitations are rarely affected, yet major fires results into some health problems. Soil erosion and decrease in its fertility values has adversely affected many back word communities. The pine and sugar cane crop mostly affected.	All forest fires are man made main causes include:- • For good grass fodder crop • Drive away wild animals. • Cleaning of land for plantation • Killing insects and pests, to control diseases both in plant and man • Other reasons include- care-less ness during driving, throwing burning cigarette, burning farm residues (cane farming) etc.	• The most used practice is prescribed burning, which is carried out is a controlled manner • Though there are rules and regulations regarding forest fire protection and control, they are hardly followed. There is a need for strict enforcement of laws and also aware and educate people about the adverse impact of forest fire
9.	**CHINA -** The country with highest population is large in geographic	The 16.55% of the total land mass (960.12 m.h.) is covered with	Forest fire is a very common phenomenon every year. The major	The major fires hit during 1951, 55, 56, 61, 62, 72, 76, 77, 79 and	Forest fire not only cause mortality of forest vegetation but	More than 95% forest fires are man made, however in north-	Special forest fire offices established in 30 provinces by Govt. of China to look after

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	area also. The terrain is variegated from plains to high snow covered peaks. The country is basically an agriculture country, however in the recent past, the country excelled in small scale industrial field also. The country prone to normal disasters – earthquake, flood, landslide and of course forest fire etc.	variegated forest species. However, due to population pressure the forest cover per capita is very low i.e. 0.128 hectares.	factors deciding the nature of fire are :- the weather conditions, the availability of fuel material in forest etc. The North – East part of country is worst affected (area wise), where as the number of fires are more in southern portion. There is a contrast in the nature also of north and south forest fires.	1987. 1987 fire was very devastating, which resulted into death of more than 200 people and burned around 1.3 m.h. of forest area. Around 15000 fires occurred during last 50 years, resulting into enormous loss. During last decade around 5000 fires occur annually.	also affect the forest structure; bio diversity, water regime, soil permeability and fertility etc. The climate pattern i.e. micro and macro both showed a remarkable change due to extreme forest fires during the last fifty years.	eastern parts, some fires are by natural causes – predominantly by lightning. Other common causes are- • Escaped fire from burning farm residue • Drive away wild animals, camp fires and throwing away burning cigarettes in forest.	over all Forest Fire Management. Special rules and regulation also formulated after 1987 fire incidence. Constitution of special fire fighting Team and Aerial Forest Fire Protection teams are other steps. Campaign / awareness and education programme also made by govt. for more people participation.
10.	**INDONESIA -** **Location:** Southeastern Asia, archipelago between the Indian Ocean and the Pacific Ocean. 5 00 S, 120 00 E. total areas: 1,904,569 sq km. land: 1,811,569 sq km, water: I93,000 sq	The most important determinant is rainfall, followed by temperature which affects water availability. The distribution of Indonesian flora is dominated by the broadleaf evergreen forests. This is mostly seen in	Extreme forest fire conditions prevalent in the country. On an average forest fire affect 15 to 20000 hectares of forest per year. Fire damage both primary and secondary forests. Most of the fires initiate during	Most severe fire during 1982-83 and 1997-98: 1982-83: fire damaged around 5m.h. area, including peat forest (1991: 1,99000 hectare and 1994: 406,000 hectare forest affected)	In addition to economic loss, adversely affected bio-diversity, soil erosion and reduced soil productivity in near by area. Loss to NTFS and livelihood for many people. The smoke due	• Escape fires from land clearing exercise • Slash and burn practice • Drive away wild animals • Lack of an establishment	In response to severe economics loss due to 1997-98 fires, the Indonesia govt. took many initiatives: • Ban on splash and burn practices, including clearing of land using fire • With the help of many international NGOs, many new

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	km. Terrain- mostly coastal lowlands; larger islands have interior mountains. Climate- tropical; hot, humid; more moderate in highlands. Population- approximately 237 million.	the regions where population density is still relatively low, such as Sumatra, Borneo, Sulawesi and West Papua. On Java and Bali the vegetation is dominated by cultivated plants. Swamp forests, mangrove, and *Nypa fruticans* forests are found along the coast. On the mountainous regions subalpine and alpine vegetation is dominant. In the lesser Sunda islands, where rainfall is not as plentiful as in other parts of Indonesia, grasslands are regularly seen.	rought season, trigged by EI-Nino – Southern Oscillation (ENSO). Peat fire is also very frequent and continues for long period.	1997-98: The most disastrous fire in the history caused burning of around 5.2 m.h. of forest. Loss approximately 2 billion dollar timber. Major fire during 1999 also, but not so severe.	to fire caused serious problem, especially during (1997-98), which remained for many days. Number of people suffered from various diseases and treated for.	functioning system is also major cause. • Burning cigarettes thrown by careless treespassers	projects started in fire prone area. • Separate Directorate to look after the problem at national level.

Source: Global Forest Resources Assessment, 2010

4.2 Fire statistics and causes

The basic problem with fire research and development is lack of reliable statistics about the number of incidence, damage, area burnt, etc. This type of information is rarely available and if available, its reliability is question marked. The reliable data on occurrence of fires, area burned and damage are available only for limited countries. Economic Commission for Europe (ECE) publishes such data for Northern Hemisphere countries, including Eastern and Western European countries, U.S.A., Canada and Russia. For other countries data are collected from various sources and published regularly in different reports and journals. "International Forest Fire News" published from Germany, is a popular Journal publishing such reports regularly. "Global Fire Monitoring Centre" is another organisation, which is bringing out such reports on updated forest fire data worldwide.

Recently Global Forest Resources Assessment -2010 (a report prepared by FAO- UN) compiled information about forest fires from different countries all over the world. The main findings of the report about forest fire situation are as follows-

- In 118 countries (having 65 percent of world forest cover) 19.8 million hectare of forest is affected by fire annually. This area represents less than one percent of the forest in these countries. (Table-4.2 & Fig.-4.1)
- The largest areas of forest affected by fire were reported by Chad, Australia, United States of America, India and Canada, which all reported an average of more than 1 million hectares of forest burnt annually
- Regarding the number of fires; as per the data compiled from 64 countries (representing 60 percent of the global forest area) an average of 487000 vegetation fires occurred per year during the period 2003-2007 in forests.
- In terms of the number of forest fires, 81 countries, representing 50

percent of the global forest area, reported an average of 156,000 forest fires per year during the period 2003-2007 (i.e. an average of around 1900 forest fires per country per year)

- 94 percent of the total forest area affected by fire was due to wildfires and only 6 percent due to planned fires.
- As far as the trend of the forest fires is concerned, the Report could compile information from 96 countries, which account for approximately 59 percent of the total forest cover (Table 4.3 & Fig. 4.2). The analysis of the available information indicates:
- The forest area affected by fires is lower in recent years compared to the period around 1990. Countries such as Thailand and Indonesia have significantly reduced the area of forest burnt annually.
- The number of forest fires has decreased slightly over the years while the proportion of wild land forest has remained relatively constant for the reporting countries.

Table-4.2: Average area of forest annually affected by fire by region and sub-region, 2005

Region/sub region	Information Availability		Area of forest affected by fire	
	Number of countries	% of total forest area	1000 ha	% of forest area
Eastern and Southern Africa	8	29.3	452	0.6
Northern Africa	5	10	17	0.2
Western and Central Africa	8	19.7	7849	11.9
Total Africa	**21**	**22.4**	**8318**	**5.4**
East Asia	5	100	549	0.2
South and Southeast Asia	8	83.3	1859	0.7
Western and Central Asia	16	51.7	50	0.2
Total Asia	**29**	**87.9**	**2457**	**0.5**
Europe excl. Russian Federation	41	96.6	270	0.1
Total Europe	**42**	**99.4**	**1262**	**0.1**
Caribbean	7	74.1	15	0.3

Central America	4	72.6	107	0.7
North America	4	100	3437	0.5
Total North and Central America	**15**	**98.9**	**3558**	**0.5**
Total Oceania	**6**	**82.5**	**3903**	**2.4**
Total South America	**5**	**14**	**333**	**0.3**

Source : FAO FRA- 2010

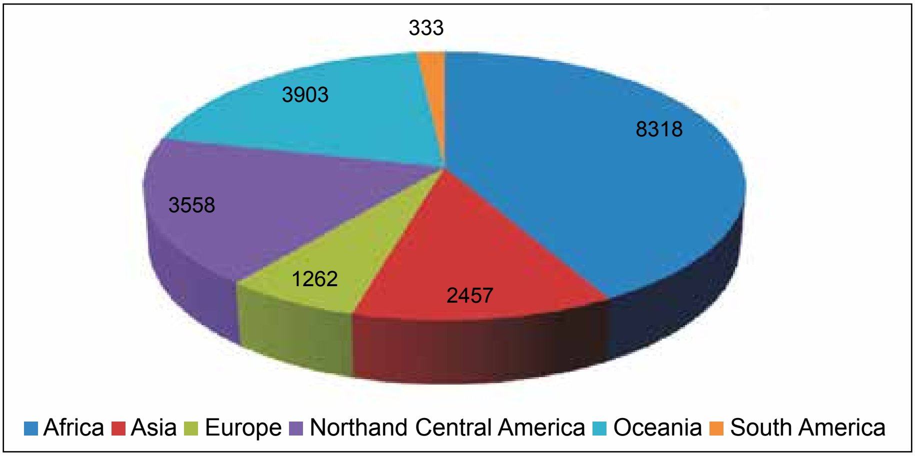


Fig.-4.1: Average area affected by forest fire annually by region (area in thousand hectares)

Source : FAO FRA- 2010

Table-4.3: Trends in forest annually affected by fire by region and sub-region, 1990-2005.

Region/sub- region	**Information Availability**		**Area of forest affected by fire (1000 ha)**		
	Number of countries	**% of total forest area**	**1990**	**2000**	**2005**
Easter and Southern Africa	6	25	88	50	53
Northern Africa	4	9.6	14	21	16
Western and Central Africa	4	9.2	12141	8462	7157
Total Africa	**14**	**15.6**	**12243**	**8533**	**7226**
East Asia	5	100	318	417	549
South and Southeast Asia	7	82.2	3090	2149	1852
Western and Central Asia	13	48.7	19	79	47

Total Asia	25	87.1	3427	2644	2448
Europe excl. Russian Federation	36	80.2	273	225	261
Total Europe	**37**	**96.2**	**896**	**1387**	**1252**
Caribbean	6	73.8	11	18	15
Central America	0	-	-	-	-
North America	4	100	2781	3112	3437
Total North and Central America	**10**	**96.8**	**2793**	**3130**	**3452**
Total Oceania	**5**	**4.2**	**0**	**0**	**0**
Total South America	**5**	**14**	**490**	**708**	**333**
World	**96**	**59**	**19849**	**16402**	**14710**

Source: FAO FRA-2010

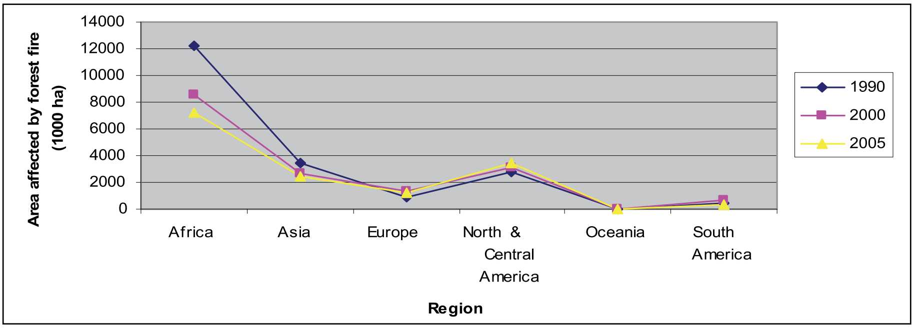


Fig.-4.2: Trends in forest annually affected by fire by region, 1990-2005

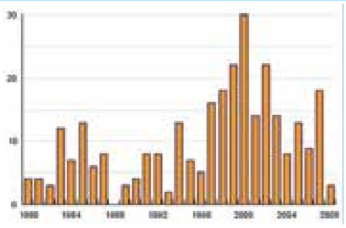
In addition to traditional practices of collecting reports and publishing, modern scientific techniques like remote sensing is also being used to collect and compile global information about forest fire. NOAA and AVHRR sources are frequently being used for compiling such global data set. This database provides the temporal and spatial distribution of forest fires. Space born sources are also being used frequently world wide to prepare quantitative inventory of fire events. A summary of data on wild fire events from 1980 to 2008, as well as the top 10 disasters as reported by EMDAT in Disaster Statistics, is given in box-4.1.

Box-4.1: Wild Fire Disasters from 1980 - 2008

Overview

No of events:	294
No of people killed:	1,666
Average people killed per year:	57
No of people affected:	5,766,092
Average people affected per year:	198,831
Economic Damage (US$ X 1,000):	42,806,705
Economic Damage per year (US$ X 1,000):	1,476,093

Number of events

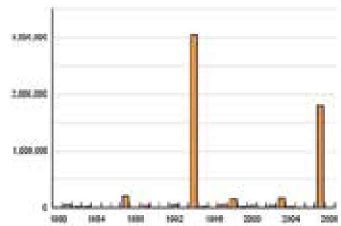


Top 10 Disasters Reported

Affected people

Disaster	Date	Affected (no. of people)
Indonesia	1994	3,000,000
Macedonia FRY	2007	1,000,000
United States	2007	640,064
Argentina	1987	152,752
Portugal	2003	150,000
Paraguay	2007	125,000
Russia	1998	100,683
China P Rep	1987	56,313
Nepal	1992	50,000
Myanmar	1981	48,588

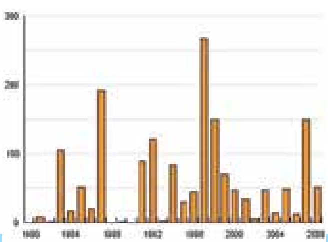
Number of people affected



Killed people

Disaster	Date	Killed (no. of people)
Indonesia	1997	240
China P Rep	1987	191
Australia	1983	75
Greece	2007	67
Indonesia	1991	57
Nepal	1992	56
Mexico	1998	50
Mozambique	2008	49
Sudan	1998	47
Poland	1992	35

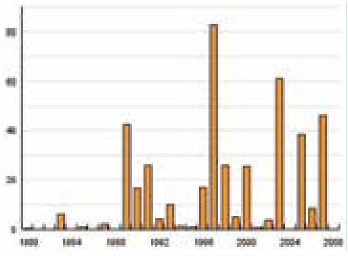
Number of people killed



Economic damages

Disaster	Date	Cost (US$ X 1,000)
Indonesia	1997	8,000,000
Canada	1989	4,200,000
United States	2003	3,500,000
United States	2007	2,500,000
United States	1991	2,500,000
Spain	2005	2,050,000
Greece	2007	1,750,000
Portugal	2003	1,730,000
Mongolia	1996	1,712,800
Portugal	2005	1,650,000

Reported economic damages (US$ in billion



Source: *"EM-DAT: The OFDA/CRED International Disaster Database, University catholique de Louvain, Brussels, Bel." Data version: v11.08*

4.3 Worldwide causes of forest fire

More than 90 percent forest fires all over the world are initiated due to anthropogenic activities, in which majority is related to land use pattern. Conversion of forestland to agriculture, pastureland and plantation are the main eminent factors for such incidences. In tropics, two types of practices for conversion of forest land are common i.e. shifting cultivation and permanent conversion.

a) Shifting Cultivation: The shifting cultivation is the farming practice where forest land is allowed to return to forest crop after a shorter period of use. In such practices, the forest vegetation are cut at the end of rainy season and allowed over to dry for some period and then burnt. The vegetation ash is left in the area, which provides sufficient nutrient for the agriculture crop. This cleared area is used for agriculture for few years until the crop production decline. After this the land is left for natural forest regeneration and new forest area is searched for agriculture purpose. The practice is commonly used by millions of people throughout the world causing immense loss to forest. In the recent past, due to increasing population pressure and lack of other alternative livelihood resources, this traditional land use techniques has not only increased but also lead to shortening of shifting cultivation cycle.

b) Permanent Conversion: With the increasing population pressure, the forest areas in many countries are permanently converted to non forestry purposes, such as pastures, agriculture land, resettlement and orchards. Such conversion of forest also follows after clear felling and setting the permanent forest vegetation on fire. The resettlement in Tarai belt of U.P. and other states in India are the recent example of such conversion, where thousand of hectares of forest area are cut and burnt to resettle the migrant population and do agriculture practice.

These two practices discussed above are the major causes of forest fire and degradation of forest cover dominant in tropical countries. Though reliable data is not available, yet as per an estimate, almost one to two billion metric tons of forest vegetation is destroyed by these practices, resulting into enormous social, economical, ecological and environmental damage.

c) Other causes: In addition to agricultural use, the forest fire issues are linked with other economical and social factors also. Collection of non timber forest produce (NTFP) like *mahua, Sal*-seeds, *kendu* leaves etc. are other major causes for initiating forest fire in many developing countries. Besides economical issues, in some tribal clans forest is ignited to celebrate some ritual customs. This ignited fire usually spreads in the adjoining forest and results into catastrophe.

The aggressive fire suppression has also been up to an extent responsible for extreme fire events by altering the composition of the tree species, which are more fire prone. As a result the forests, specially the dry forests are dominated by heavy ground fuels and high tree densities, which are much more likely to have severe fires. Conversion of fire resistant old forests to plantation is also up to an extent responsible for increased fire risk in the forests.

Among the developmental activities, road construction has been the most devastating factor for increase in forest-fire incidences. Roads are turned as ignition source that contribute to fire risk by providing access to forests, where people can ignite it. Increase in grazing by livestock is another common cause of forest fire throughout the world. Grazing removes the grassy fuels that carry frequent surface fires and often ushers in fire prone exotic plants and shrubs. Fires are initiated by picnickers, grazers, tourists etc. due to negligence. Throwing burning cigarette butts, camp fires, cooking food within or near the forest areas are examples when fire is caused merely by negligence.

4.4 International Cooperation in Forest Fire Management

4.4.1 Global initiatives are essential to deal with regional issues, like global climate change, rise of sea levels, melting of glaciers and of course forest fire. During the recent past forest fire has emerged as a severe problem adversely affecting the health and sustainability of the global vegetation. Keeping in view the severity of the problem, a need has been felt worldwide to evolve an effective strategy for fire management planning and practices by seeking international cooperation. It has been felt that communities, being the first responder, be engaged in its management vigorously and experience and expertise of countries be shared for capacity building of individual countries to effectively tackle the problem. Joint research and development network, especially in advancing knowledge about forest fire and in learning from one another's experience carry a lot of advantage and strengthen the prevailing system. Early warning techniques, use of satellite data, suppression techniques, sending experts at the time of fire breakout etc. are the field activities, where such cooperation may be of immense use and significance. In the case of severe fire, it is natural for friendly countries to share expertise and rush helpful agencies that carry rich experiences and could be of great service in the hours of need.

The Global Fire Monitoring Centre (GFMC) is the foremost pioneer organization providing individual support and relevant information useful in strengthening an international cooperation. The Centre is hosted by the Fire Ecology and Biomass Burning Research Group (FEBBRG) of the Max Planck Institute of Chemistry, Bio geochemistry Department, Germany. The Centre was established initially by Government of Germany as a German contribution to the UN sponsored International Decade of Natural Disaster Reduction (IDNDR) 1990-2000 programme. The GFMC, carrying out extensive research and demonstration in the subject of forest fire is providing consultancy services to many countries. Cooperation with Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) projects was implemented in Brazil 1980-82, Indonesia-1987, Algeria-1992, Argentina-1991-97, Srilanka-1991 etc. The Centre has close partnership and association with several international agencies and institutions i.e.

- The UN International Decade of Natural Disaster Reduction (IDNDR) and its successor arrangement, the International Strategy for Disaster Reduction (ISDR).

- The World Conservation Network (WCN).
- The Deutsche Gesellschaft fur Technische Zusammenarbeit mbH (GTZ).
- The United Nations Economic Commission for Europe (ECE).
- UN International Search and Rescue Advisory Group (INSARAG), Fire Group.
- The International Tropical Timber Organization (ITTO).
- The World Health Organization (WHO).
- The United Nations Educational and Scientific Organization (UNESCO).
- The World Bank, Disaster Management Facility (DMF) and its associated pro- Vention Consortium on Natural and Technological Catastrophes and the World Institute for Disaster Risk Management.
- The Technical Assistance to the Commonwealth of Independent States (TACIS) programme in Russia.
- The U.S. Bureau of Land Management (BLM).

In the recent past an increasing collaboration among countries and among regions in the field of forest fire management is observed and many more agencies are getting involved in it. The regional analysis by FAO- UN in its report “Fire management: global assessment 2006” mentions -

- 22 international emergency response agreements, 16 international agreements on other matters and 6 national inland agreements dealing with forest fires globally.
- Bilateral and other agreements for joint fire suppression or the exchange of fire crews are in force in several places, especially in border areas, for example Canada with the United States, China

with Russia, among some countries of Meso-America, Mexico with the United States; Mongolia with China and Russia, Russia with Finland; and Russia with the Islamic Republic of Iran.

- Adhoc agreements have been formulated to respond to emergency situations such as between Brazil and Colombia in 1998.
- The three North American countries have jointly adopted the Incident Command System, enabling them to work together using a unified command structure and terminology.
- Bilateral and multilateral emergency assistance are also in place, for example the assistance offered by Australia and Singapore to Indonesia in 2005, or by the United States to Mexico.
- International fire response exercises have been conducted with multilateral cooperation in the Baltic region (BALTEX Fire 2000), the European Union (France 2004) and Balkans ("Taming the Dragon" 2002, organized by North Atlantic Treaty Organization)
- In 2000, the World conservation Union and Global Fire Monitoring Centre (GFMC) suggested the creation of an interagency working group (WG) on wild land fire as a contribution to and in accordance with- the framework for implementation of the United Nations International Strategy for Disaster Reduction (UN-ISDR). The working group formally came into existence in 2000 with the name of WG-4. It ultimately provided an international, interagency and intersectoral forum in which United Nations agencies and civil society worked together to formulate a vision and common goals to enhance interagency and international cooperation towards "reducing the negative impacts of fire on the environment and humanity".
- WG-4 emphasized the establishment of a "global network of regional-to national- level focal point for early warning of wild land fire, fire monitoring and impact assessment".

- The 3rd International Wild Land Fire Conference and the International Wild Land First Summit were held in Sydney, Australia, in October 2003. This helped in formulating a development strategy i.e. "Strategy for Future Development of International cooperation in Wild Land Fire Management", aiming to develop and strengthen regional Wildland Fire Networks through networking in information sharing, capacity building, preparation of bilateral and multilateral agreements.

- At the end of 2003, WG-4 became the Wildland Fire Advisory Group (WFAG) under the auspices of UN-ISDR. It represents an advisory body to the United Nations system, providing technical, scientific and policy- supporting advice through UN-ISDR and IATF and acting as a liaison between the United Nations system and GWFN and its supporting partners.

Regional Wild land Fire Networks with the support of GWFN are involved in following important activities:

- Regional agreements such as the ASEAN Agreement on Transboundary Haze Pollution in 2001, which entered into force in 2003, and the Congo Basin Conservation Treaty, signed at the Congo Basin Forest Summit in 2005;

- Regional plans for cooperation in fire management

- Establishment of training centres

- Regional meetings and declarations

In addition to above, various UN agencies are also involved in strengthening international cooperation in the field of forest fire management. The significant contributions of such agencies may be enlisted as-

- FAO- promotion of international cooperation in vegetation fire management; technical cooperation programmes (TCPs) in the field and information dissemination through seven regional forest commissions;

- World Health Organization (WHO)- development of Health guidelines for vegetation fire events;
- World Meteorological Organization (WMO)- forecasting/ early warning of EL Nino, fire weather and smoke transport phenomena involving the global network of hydrometerological stations;
- International Tropical Timber Organization (ITTO)- support to national fire management and participation of producer countries in the International Wild land Fire Conference;
- United Nations University- vegetation fire research and training focus through establishment of University of Freiburg as an associate institute of UNU;
- UN conventions- agreement by the secretariats of the three Rio Conventions.

4.4.2 Guiding Principles for International Cooperation:

While seeking or providing help at international level, urgent need of a well-drawn strategy is very much felt, which can guide and help the countries and even the communities facing the menace of forest fire? The International Wild Land Fire Summit, held at Sydney in October, 2003 came out with some significant guiding principles in this regard, which may be effective while formulating international cooperation projects for forest fire management. While carrying out international cooperation some issues which need due consideration are-

a) General issues

- Developing countries are especially challenged by fires because of their important links with land use practices, socio-economic and other social issues and food production; management practices here must take all these aspects into consideration.
- The result and outcome of forest fire management projects in different countries must be published and made available for experience sharing and lesson learning.

- Community-based fire management forms the basis of effective fire management programs at the community level, in both developed and developing countries.
- The contributions, commitments and responsibilities of all those involved must clearly be stated, especially in relation to accountability, command and control, and financial, human resource and other non-financial inputs of the project.
- Must try to achieve sustainable institutional strengthening and capacity building within government agencies and in appropriate circumstances include Non-Government Organizations (NGOs) etc. for effective forest fire management.
- Should have as one objective the delivery of sustainable outcomes for end users at the local community level.
- Should be undertaken using agreed international procedures and protocols.
- Systematic monitoring, accurate reporting and accessible information archiving.
- Appropriate initiatives suited to the culture, technology, environmental conditions, educational and economic circumstances of the recipient country.
- Holistic approach for forest fire management, including fire protection, planning, prevention, suppression and rehabilitation.
- All fire management activities should be safe, cost- effective and support sound natural resources management.
- Consistent with a more inclusive style of fire management that incorporates the needs and expectations of people.
- Fire management and suppression plans must incorporate and understand the need and expectations of communities and local stakeholders.

- Fire suppression operations must be in accordance with a previously agreed command and control structure.

b) Fire Protection Plans- A Fire Protection Plan is must to carry out preparedness and response activities. A well developed Plan must include:

- An assessment of the threat to human life, property, forest, other wooded land and other land assets and values, in conjunction with the management objectives for the area.
- Preparedness for the fire suppression must reflect the variable nature of fire dangers.
- Developing appropriate modern early warning capability of wild-land fire danger.
- Initiate prevention activities to reduce the hazards and potential losses.
- Must ensure a measured fire suppression response that reflects the threat, the safety of fire fighting personnel and the public, and the impact on the environment.
- Must formalize a single management structure for all personnel.
- Trained, well equipped, assessed and accredited personnel must be appointed.
- Striving for consistent funding that enables fire managers to adequately meet the goals of the guiding principles safely and efficiently.

c) Fuel Management- Out of three integral components of fire i.e. heat, oxygen and fuel; better fuel management practices may reduce the vulnerability of an area to fire. In conducting fuels management operations, the following should be considered:

- Fuels management programs need to be planned to provide protection to human life and property, by reducing the potential hazards associated with wild-land fires and at the same time maintaining the environmental integrity of the landscape and preserving cultural resources.

- Reducing fuels through mechanical or physical means or through the use of prescribed burning to management objectives must satisfy legal requirements and be thoroughly planned.
- Using or excluding prescribed fire, based on scientific knowledge.
- Basing prescribed burning operations on clearly defined objectives and prescriptions, providing a safe working environment, and minimizing the risk of fire escape.
- Incorporating during the fuels management planning process, the principles of environmental care, in accordance with approved standards, prescriptions and guidelines.

d) Environmental Protection- Forest fire cause immense loss to environment, to minimize it the following principles need to be observed:

- Fire management activities should be based upon good scientific studies and follow sound management principles.
- These activities should be planned and conducted in an environmentally sensitive manner taking into account fire regimes and fire management activities appropriate to maintain the vigor and diversity in populations of species and communities of the area's indigenous flora and fauna.
- Appropriate measure to be taken to safeguard water quality and quantity. Also ensure to minimize the impact of fire management activities on streams, springs, soaks, swampy ground and bodies of standing water, and their physical and biological quality.
- Landscape values, geomorphologic features, cultural and historical sites being considered when planning operations.
- Soil being protected by measures which prevent inappropriate

destruction of its physical and chemical properties or which promote stabilization of bare or disturbed earth following disturbance.

- Indigenous flora and fauna being protected following wildfire suppression by measures which promote the re-establishment of the ecological processes existing prior to the wildfire.

e) Capacity-building in fire management

Another area of importance in international collaboration is capacity building in fire management. There is quite good scope to enhance the capacity of individual country through training of its officials and other staff (mainly forest department personnel) and exposure visits in countries having good infrastructures and experience in handling forest fires.

Need based research and dissemination of outcomes is of utmost significance in enhancing capacity of individual country in managing forest fire. There is need for regional research in the field of forest fire management, including fire impact on ecosystem, development of fire danger ratings, fire behavior prediction, socio- economic aspect of forest fire etc. Use of modern techniques including remote sensing in fire detection, use of prescribed fires, fire suppression techniques and innovative equipments, impact assessment etc. are some of the other burning research topics, which need immediate attention and further research at regional levels. The outcomes of the research need to be shared for its optimum utilization.

f) Strengthening early warning

The UN Secretary General had requested development of a global vegetation fire information system, as laid out in the Hyogo Framework for Action 2005-2015: building the resilience of nations and communities to disasters (GFMC, 2006b). In 2005 an international consortium of institutions endorsed such an information system as a thematic component of the global multi hazard early warning system.

The objectives of the global fire early warning systems are to:

- develop a global early warning system for vegetation fire.
- develop an information network to quickly disseminate early warning of fire danger globally to local communities;
- develop a historical record of global fire danger information for early warning product enhancement, validation and strategic planning purposes;
- design and implement a technology transfer programme to provide the following training for global, regional, national and local community applications;
  - Early warning system operation,
  - Methods for local to global calibration of the system,
  - Use of the system for prevention, preparedness, detection and where appropriate, fire response decision- making.

4.5 Incident Command System (ICS) & International cooperation

4.5.1 Experiences in the past have shown that at the time of emergency situations, as in the case of forest fire suppression, parochial attitudes, internal politics and the lack of communication result into poorly managed operations. Lack of coordination among various agencies and unclear accountability often result in safety issues being neglected. Therefore, there is a professional, social, economic and political demand for a well coordinated and timely effective system to tackle any emergency situation in an efficient manner. Incident Command System (ICS) is a model tool for command, coordination and use of resources at the site of the incident. The system was evolved after a major forest fire in Southern California during 1970. The system is based on the management and direction tools, experts and Disaster Managers are already aware of.

Incident Command System has proved to be very effective in managing not only forest fires but also other common disasters, such as floods, earthquakes, volcanic explosions etc. In the recent past, many countries have adopted the ICS or similar systems for addressing emergencies. In addition, a number of them have adopted fire-fighting agreements based on a common system enabling interoperability when lending support to other countries. Australia and New Zealand faced with emergency response issues, evaluated incident management systems around the world, elected to adopt the ICS and modify it to their specific requirements. The system has proved very effective, not only in these countries but has also proved useful in rendering help to others at the time of need. They even helped USA by sending critically needed incident managers to tackle the emergency situation in the past. ICS was also used during forest fire in Ethiopia during 2000.

Thus ICS has been very popular and effective, while incorporating International Cooperation at the time of emergency, including forest fire. ICS has considerable flexibility and can grow/shrink or adopt to meet different area specific needs. The system may need to be adopted to suit a particular country's existing political, cultural, social and administrative systems. Such adaptations are beneficial in making system more useful during international cooperation in managing emergency situations. It is in real sense very essential that the helping country and the receiving country both use the same emergency management systems, which facilitates the management operation in all aspects.

Why ICS is required? While managing a disastrous emergency situation, many management problems emerge. The ICS system has been specially designed to adhere to the majority of such problems viz.:

(1) Inefficient supervision.

(2) Incomplete communication.

(3) Lack of proper coordination among stake holders.

(4) In-efficient organizational structure.

(5) In-consistent terminology.

(6) Poor information flow network.

(7) Unclear line of authority.

ICS is a system evolved after considerable effort and investment of time to address all these issues and effectively tackle them simultaneously. The basic characteristics of an efficient ICS system are that it must-

– be cost effective,

– be flexible to suit the local needs and condition,

– facilitate common management structures that integrate with officials from different agencies, and

– be able to be used on a daily basis for routine situations and major emergencies.

4.5.2 Essential components of ICS- In addition to the basic characteristics discussed above, the ICS system must be equipped with following components to make it more suitable and useful:

(i) Common Technology: - Essential in any emergency management, especially when diverse groups or agencies are involved as responders.

(ii) Integrated Communication: - Requires a common communication plan, standard operating procedures, common frequency and common terminology.

(iii) Identified functionaries: - There must be well designated and identified functionaries, working as primary and secondary support systems with clearly defined functions to assist in the effective management of an incidence.

(iv) Appropriate and comprehensive resource management:- Organizing resources across all agencies involved in incident management including-

- Optimizing resources use.
- Providing accountability.
- Maintaining resources during long duration incidents.
- Managing day and night shift resources.
- Reducing communication load.
- Maximum personnel safety.

(v) Appropriate Action Plan: - Incident action must cover all objectives and support activities during the operation. It should preferably be a written document clearly describing, the responsibility and accountability of every individual.

(vi) Manageable Span of Control: - It describes the number of individuals or functions to be effectively managed by one single person. Depending upon the situation and availability of the resource person, the span of control may be ticked.

4.5.3 Frame work and organizational structures required

ICS framework provides a well coordinated inter-agency management plan to tackle an emergency situation more effectively and efficiently. This framework provides opportunity to establish a united command of the respective agencies together at a single location, so that a single incident action is developed to achieve the following objectives:-

1. Duplication of effort is reduced or eliminated reducing the chance of confusion.
2. The combined effects of all agencies are optimized as they perform their respective assignments under single Incident Action Plan.

3. One set of objectives for the incident.
4. A collective approach to develop strategies to achieve set objectives.
5. Coordination and information flow between agencies involved.
6. No agency's authority or legal requirement will be compromised or neglected.
7. Each agency is fully aware of the plan, action, and constraints of other agencies.

The organizational structure of ICS is based around the following five major management authorities:-

Command	-	Sets objectives and priorities
	-	Has overall responsibility of the incident or event
Operations	-	Conducts tactical operations to carry out the plan
	-	Develops tactical objectives
	-	Organisation
	-	Directs all resources
Planning	-	Develops the action plan to accomplish the objectives
	-	Collects and evaluates information
	-	Maintains resource status
Logistics	-	Provides support to meet incident needs
	-	Provides resources and all other services needed to support the incident
Finance/	-	Monitors costs related to incident
Administration	-	Provides accounting

- Procurement time
- Recording cost analysis

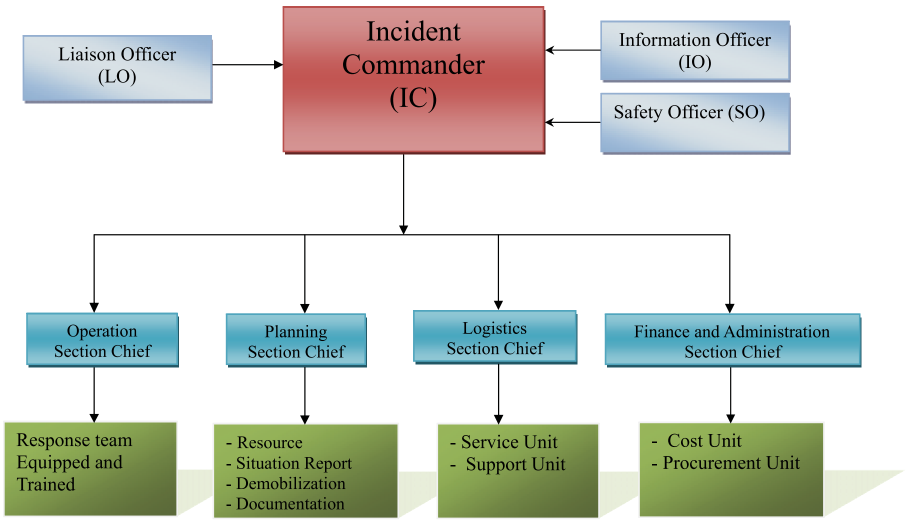


Fig.-4.3: Organizational structure of Incident Command System in Forest fire management

ICS is therefore an effective model for centralized management. In the ICS model the base of operations For response to a disaster i.e. incident is recognized as Command Centre (CC). Upon activation of a plan, the Incident Commander establishes and initiates ICS (Fig.-4.3).

The staffing position in the ICS is as follows:

– Incident Commander
– Liaison Officer
– Information Officer
– Safety Officer
– Intra-agency Coordinator

- Operations Section Chief
- Planning Section Chief
- Logistics Section Chief
- Finance & Administration Section Chief
- Operation Teams
  - Damage Assessment
  - Search and Rescue
  - Medical Assistance
  - Donation Management
  - Restoration of each ESF (Emergency Support Functions)
  - Relief Camps Team

Chapter 5

FOREST FIRE: THE INDIAN SCENARIO

5.1 Introduction

India constitutes one of the mega bio-diversity zones of the world, abundant with unique and diversified floral and faunal wealth. With 6, 92,027 square kilometers of forest cover, India is one of the richest areas of bio-diversity in the world. Including environmental benefits, the forests of the country are economically also very rich. If we take the example of conifers only, India has about 1.7 mh of productive conifer forest, with various valuable timber species i.e. *fir, spruce, deodar, kail, teak, sal* and *chir pine.* Estimated growing stock of these forests is over 200 million cubic meters, the monitory value of which comes to be more than Rs. 40,000 to 60,000 millions (Bahuguna, 1999). In the country, with about 17 percent of the world human and 18 percent of cattle population, forests meet nearly 40 percent of the energy and 30 percent of the fodder needs. It is estimated that about 270 million tons of fuel wood, 280 million tons of fodder, over 12 million cubic meters of timber and a large quantity of Non-Timber Forest Produces (NTFPs) are removed from the forests annually. Due to increasing population pressure need, this exemplary land ecosystem of the world is struggling for its survival. Increasing human interference in the natural forest ecosystem has also tremendously increased the forest fire incidences. Forest fire is one of the causative factors, which periodically covers large forest areas destroying timber, other properties and wild life etc. The ecosystems are under severe threat due to recurrent fires, which is attributed to the forest degradation, soil erosion, reduced productivity etc. Every year one or other part of the forests in India is facing the agony in the cruel hands of mankind by putting fire intentionally or unintentionally in the forests causing severe damage to the regeneration as well as to the soils.

Forest Survey of India (FSI) is conducting field investigations since 1965 in different parts of the country to keep records of forest fire in its sample plots. To get indicative data on forest fire, observations of more than 25 years were compiled, analyzed and published in State of Forest Report of 1995. As per FSI analysis more than 95 percent of the forest fires in the country are man made. The Forest Survey of India, 1995 data on forest fire attribute around 50 percent of the forest areas as fire prone (Table-5.1 and Fig.-5.1).

Table-5.1: Data on Forest fire prone forest area in India.

Type of fire damage	Percent area of forest (%)	Area of forest in sq. km.
Very high	0.84	5426.664
High	0.14	949.6662
Frequent	5.16	35001.9828
Occasional	43.06	292090.1898
No fire	50.80	317188.5108
Total	100	650657.0136

Source: State of Forest Report of 1995 (FSI)

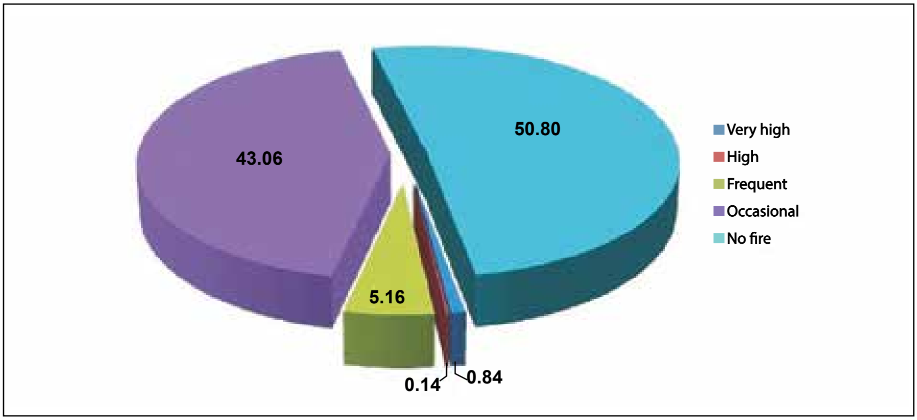


Fig.-5.1: Forest fire prone forest area in India

Source: State of Forest Report of 1995 (FSI)

Out of total forest area, very high, high and frequent forest fires damage are noticed over 0.84 percent, 0.14 percent and 5.16 percent of the forest areas respectively. Thus, about 6.14 percent of the forests are prone to severe fire damage.

This forest fires spread over large forest area in the country cause immense loss to the environment and the property. As far as the annual loss in economic term is concerned, it is estimated that loss from the forest fire comes to be Rs. 4,400 million approximately. However, this estimate only counts the replacement cost of the seedlings and does not include the losses to bio- diversity, timber, increment, carbon sequestration capacity, soil moisture and nutrient loss etc. (Bahuguna, 1999). Ecological, economic and social impacts of the forest fire in India in brief may be enlisted as: loss of timber, loss of bio-diversity, loss of the wild life habitat, global warming, soil erosion and depletion of soil quality, loss of fuel wood and fodder, damage to water and the other natural resources, loss of natural regeneration, loss of NTFPs, Ozone layer depletion, change in micro-climate leading to health problems, other health problems due to smoke, soil erosion and floods, loss of livelihood for the people living in or near the forest etc.

5.2 Forest Fire Statistics

In India there is no compressive study data made to indicate the loss of forests in terms of area burnt and value, volume, regeneration etc. The available forest fire statistics are not reliable, as in most of the cases it is under estimated. The reason behind this is probably the fear of accountability. Despite all this, some scanty data is available about forest fire in various forms. Forest Survey of India in a countrywide study in 1995 estimated that about 1.45 million hectares of forest area is affected by fire annually in the country. According to assessment of the Forest Protection Division of the Ministry of Environment and Forest, Government of India, fires in India annually affect 3.73 million hectares of forests (Table-5.2).

Table-5.2: Incidents of forest fire occurred in selected States of India

Fire Incidents in Forest Areas of India (area in km²)									
State/ District	Forest Area	Sample Plots	Extent of Fire Incidence (area in km²)						
			Very Heavy	Heavy	Frequent	Occa-sional	No Fire	Un-recorded	Total
Andhra Pradesh	14,826.71	2,037	60.58	5.75	521.99	3,335.27	10,016.34	886.78	14,826.71
Assam	15,427.88	2,482	70.91	0.00	590.25	4,551.13	10,176.68	38.91	15,826.88
Bihar	5,347.01	296	57.72	0.00	452.62	3,330.74	1,505.93	0.00	5,347.01
Himachal Pradesh	10,269.40	4,878	163.70	0.00	671.45	3,811.38	5,054.92	567.98	10,269.43
Jammu and Kashmir	3,331.75	428	7.50	0.00	60.98	1,089.58	2,088.05	85.64	3,331.75
Haryana and Punjab	1,180.72	145	0.00	0.00	41.54	332.48	806.70	0.00	1,180.72
Karnataka	13,223.30	1,780	59.71	30.33	470.64	3,342.94	9,309.79	9.89	13,223.30
Manipur	15,154	1,880	0.00	151.54	454.62	5,758.52	8,789.32	0.00	15,154.00
Madhya Pradesh	19,625.91	1,947	136.53	23.07	1838.83	10,644.29	6,983.19	0.00	19,625.91
Maharashtra	8,165.54	1,355	0.00	0,00	186.83	4,222.57	3,756.94	0.00	8,166.34
Meghalaya	9,905.66	1,659	26.75	0.00	269.12	3,347.25	5,230.91	1,031.60	9,905.63
Nagaland	14,954.91	1,128	0.00	0.00	1084.23	12,038.70	1,831.98	0.00	14,954.91
Orissa	20,143.38	2,972	204.42	78.50	923.19	11,345.34	7,258.18	333.52	20,143.16
Rajasthan	20,178.79	2,446	71.39	0.00	99.03	4,348.12	14,763.26	896.99	20,178.79
Sikkim	1,707.77	401	47.12	0.00	18.14	544.84	1,097.67	0.00	1,707.77
Tripura	6,445.36	555	34.59	0.00	361.75	5,293.65	755.37	0.00	6,445.36
Uttar Pradesh	23,164.09	2,825	871.43	0.00	2092.51	11,124.10	9,076.05	0.00	23,164.09
West Bengal	5,764.81	1,471	4,77397	0.00	656.43	1,356.52	3,444.32	302.76	5,764.81
Dadra and Nagar Haveli	186.49	62	0.00	0.00	0.00	180.89	5.5947	0.00	186.49
Total	**209,003.48**	**30,747**	**1,817.13**	**289.19**	**10,794.16**	**89,998.33**	**101,951.19**	**4,154.07**	**209,004.10**
Percentage			**0.87**	**0.14**	**5.16**	**43.06**	**48.78**	**1.99**	**100.00**

Source: ***India Disaster Report, Lok Sabha, Un-starred Question No. 1314, 7 December 1998.***

Though Forest Survey of India started monitoring forest fire since 2004, yet the uninterrupted forest fire records are available only after November, 2005. Table-5.3 shows number of forest fire incidences in different states for two seasons. From the table it is clear that more than 50 percent of the forest fires in the country took place in north eastern states. The numbers of forest fire spots detected were highest in the state of Mizoram in both the seasons. Table-5.3 enlists 29 most fire prone districts in the country.

Table-5.3: Districts with high incidence of forest fires

S. No.	District	State	Forest fire spots Nov 2006-June 2007	Forest fire spots Nov 2005- June 2007
1	Aizwal	Mizoram	1,800	1,180
2	Linglei	Mizoram	1,166	632
3	North Tripura	Tripura	787	506
4	Dantewara	Chhattisgarh	245	798
5	Churachandpur	Manipur	600	410
6	Koraput	Orissa	466	469
7	Tamenglong	Manipur	505	364
8	Bastar	Chhattisgarh	178	686
9	Lawngtlai	Mizoram	502	335
10	North Cachar Hills	Assam	472	315
11	Champhai	Meghalaya	518	263
12	Phulabani	Orissa	353	425
13	Karbi Anglong	Assam	475	267
14	South Tripura	Tripura	479	205
15	Gadhchiroli	Maharashtra	257	379
16	Saiha	Mizoram	314	232
17	Ganjam	Orissa	280	240
18	Khammam	Andhra Pradesh	222	236
19	Tuensang	Nagaland	223	228
20	Cuddapah	Andhra Pradesh	199	250
21	Kohima	Nagaland	280	151
22	Kalahandi	Orissa	238	192
23	East Garo Hills	Meghalaya	310	116
24	Prakasam	Andhra Pradesh	186	221
25	Chandrapur	Maharashtra	163	223
26	Chandel	Manipur	189	194
27	East Godavari	Andhra Pradesh	177	195
28	Ukhrul	Manipur	206	155
29	West Khasi hills	Meghalaya	260	96

Source: State of Forest Report (FSI), 2009

Along with Forest Survey of India and state forest departments, some NGOs (national and international) are engaged in gathering information about forest fires. WWF- India has carried out number of case studies in different parts of the country about the forest fire incidences and compiled it in the form of a booklet (Forest Fires in India: Lessons from Case Studies by Rajeev L. Semwal, WWF for Nature-India, 2003).

Despite all these attempts, still the data bank about the forest fire in the country is very weak and needs more serious attempts. To overcome this problem, new innovative methods need to be used. Satellite data may be of quite significance to evolve new innovative techniques in the field of Forest Fire Management. Along with the satellite data many field-based attempts should also be made at various levels to collect forest fire statistics in the country. The information and the data feed by the researchers present a very grim situation about the calamity in the country and need a serious thought to overcome the problem and tackle the situation in more effective manner.

5.3 Vulnerability of Indian forests towards fire

The forest fire is dependent on three essential components i.e. fuel, oxygen and heat. Availability of these three components is not uniform throughout the country's forest and thus the forest fire situation in the country is not uniform. Depending upon the susceptibility of the tree species and climatic conditions, the fire situation is very diverse in different forest areas. The vulnerability of the Indian forests towards fire varies from place to place depending upon the type of vegetation, the climate and various other factors- both natural as well as man made. The coniferous forest in the Himalayan region comprising of fir (*Albies spp*), spruce (*Picea smithiana*), *Cedrus deodra, Pinus roxburgii and P. Wallichiana* etc. is very prone to fire. The most vulnerable stretches of the world to forest fire are the youngest mountain ranges of Himalayas. Because of the more rain density, the forests of Eastern Himalayas are less vulnerable to forest fires as compared to those in Western Himalayas. With large scale expansion of chir forests in Himalayan mountains, the frequency and intensity of forest fires have increased alarmingly. In 1995, the fires, particularly in the Uttarakhand hills had destroyed more than 3, 75,000 hectares of forest wealth. In all around 34, 24,857 hectares or 63.91percent forest area of Uttarakhand is vulnerable to forest fire (Table-5.4).

The other affected area to fire in the country happens to be in the Ganga-Yamuna watershed, the most vital of the country's four watersheds. Frequent vast fire incidences are reported from this basin. In the year 1999, the region experienced a huge fire, which caused major devastation over an area of more than 80,000 hectares of forests, turning it into ashes.

Table:-5.4: Estimates of forest area affected by fire in U.P./ Uttarakhand

Year	Area	Percentage of forest area affected by fire		
		Frequent	Occasional	Total
1998	Whole Uttar Pradesh	–	–	58.00
1995	Tarai area	40.50	34.10	74.60
.	South U.P	4.80	41.80	46.30
	Uttaranchal			
	Tehri Garhwal	5.20		30.30
	U.P. Hills	2.31		61.01

Source: Journal of Indian Buildings Congress, Vol.4, No.1, 1997

Type of vegetation is the other major factor in deciding the vulnerability of the forests to fire. Following are some of examples of tree species and forest types, which are more prone / vulnerable to fire in different parts of the country (Table-5.5).

a) Chir- Due to resin content, the chir tree is very prone to forest fire. As a result of fire the lower stem of chir tree (previously used for resin tapping) becomes black. It is clear for this tree that this species regenerates strongly if the over storey density is sufficiently low. Crown fire is rarity in the chir forests and the most forest fires are in fact, ground fires.

b) Other coniferous species- Like chir, other conifers including, *fir (Abies sp.), Spruce (Picea smithiana), Cedrus deodara* are also very susceptible to forest fire.

c) Sal- The butt damage of this species occurs, even if the fire intensity is not much.

d) Other Plantations - The plantations like *Eucalyptus, Teak, Poplar, Sisham* and several other species are also vulnerable to fire. Among these species, Eucalyptus is grown on 8 years rotation for pulpwood, while other species are grown on longer rotations for larger and higher value timber products. From the age of about 5 years, both *Teak* and *Eucalyptus* are quite resistant to ground fire. There is only three-year period i.e. between the ages of 2 and 5, when *Eucalyptus* and *Teak* are at maximum risk from forest fire.

e) Mixed Dry Forest- Fire is commonly used by tribal people in such forests to prepare the ground for harvesting *mahua* flowers and fruit, and it is apparent that they use fire skill for this purpose. But when these practices are used indiscriminately, it causes much damage to the surrounding species and soil.

In addition to the susceptibility of particular species, other factors viz. the age of the trees, climate, the terrain etc. also decide the incidence of forest fire in a particular forest. The socio- economic and sociocultural pattern of the society also decides the vulnerability of forest to fire.

Table-5.5: Percentage of the forest types affected by fires annually

Types of the forest	Percentage of forest area affected by frequent fires	Percentage of forest area affected by occasional fires
Coniferous	8	40
Moist deciduous	15	60
Dry deciduous	5	35
Wet semi- ever green	9	40
North Eastern region	50	45

Source: http://www.fire.uni-freiburg.de/iffn/country/in/in_5.htm

Some major events of forest fire occurred in different parts of India during 1990-2011 are given in Table-5.6.

Table-5.6: Major forest fire in Indian States during 1990-2011

S. No.	State/ Year	Location	Area affected (ha)	Source
1.	Uttrakhand, 1995	Uttarakhand hills	3, 75,000	Kaushik, 2004
2.	India, 1999	Ganga Yamuna watershed	80,000	Kaushik, 2004
3.	Himachal Pradesh June 2007	Shimla & Solan Districts	2000 (Reserve forest)	EMDAT
4.	Maharastra 15 June 2008	Melghat-gugamal National park in Maharastra	10000	Anonymous
5.	Gujarat Feb-09	Gir forest, Gujrat	32.38	Anonymous
6.	2009- March India	Taboda Researve forest	50	Anonymous
7.	2009- March India	Chamundi Hills	20	Anonymous
8.	Aprill 2009,India	BaHadson Beer	200	Anonymous
9.	Uttrakhand, April 2009	Chamoli/Gochar/ Devprayag/Hrishikesh	5	The Hindu, Apr 21, 2009
10.	2009 India	Way Land	424	Anonymous
11.	Maharashtra Jan-May2010	Mumbai	10300	Anonymous
12.	Nagaland 18-Feb-10	Tuesang District in nagaland	4	Anonymous
13.	Himachal Pradesh Jun-10	Himachal Pradesh	19,109	Anonymous
14.	TamilNadu, 2011	Ooty in Nilgiris	10 hectares (Reserve forest)	TOI,TNN Mar 8, 2011

5.4 Forest fire season (Phenology) in India

The forest fire season throughout the country is not same. Depending upon the type of vegetation, the climate and various other factors, the fire season varies from one part to other. Though the major forest fire season in the country varies from February to June, even some forests are not safe from fires throughout the year (Table-5.7).

Table-5.7: Forest fire season in India (Annual)

State and UTs	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Assam	*	**	**	*	*	X	X	X	X	X	X	*
Andaman and Nicobar Islands	**	**	**	*	*	X	X	X	X	X	X	*
Andhra Pradesh	X	*	**	**	**	*	X	X	X	X	X	X
Bihar	X	*	**	**	**	X	X	X	X	X	X	X
Dadra and Nagar Haveli	*	*	**	**	**	*	X	X	X	X	X	X
Gujarat	*	*	**	**	**	*	X	X	X	X	X	X
Goa, Daman and Diu	X	*	**	**	**	X	X	X	X	X	X	X
Haryana	*	*	*	**	**	**	X	X	X	*	*	*
Himachal Pradesh	*	*	*	**	**	**	X	X	X	*	*	*
Karnataka	*	**	**	**	*	*	X	X	X	X	*	*
Kerala	*	*	**	**	**	*	X	X	X	X	X	*
Maharasthra	X	*	**	**	**	*	X	X	X	*	*	X
Madhya Pradesh	*	*	**	**	**	X	X	X	X	*	*	*
Nagaland	X	*	**	*	X	X	X	X	X	X	X	X
Punjab	X	*	*	**	**	**	X	X	X	X	X	X
Rajasthan	*	*	**	**	**	*	X	X	X	X	X	X
Sikkim	*	*	**	**	*	X	X	X	X	X	X	X
Tamil Nadu	*	**	**	**	**	X	X	X	X	X	*	*
Uttar Pradesh	*	*	**	**	**	X	X	X	X	X	X	*

Source: FORTECH: FAO: TCP/IND/4452

(** Peak fires Season;; * Additional months of fire occurrence; X No fire.)

The forest fire data compiled by FSI in two consecutive years (2005-06 and 2006-07) also helps in identifying the crucial period of forest fire in different States of the country. The data indicates that peak fire season in the country lies between February to May. The State wise crucial forest fire peak season is given in Table-5.8.

Table-5.8: Crucial forest fire periods in the States and Union Territories

State & UTs	No. of forest fires		Crucial period of forest fire	
	Forest fire spots Nov 2005-June 2006	Forest fire spots Nov 2006-June 2007	From	To
Andaman and Nicobar	6	1	03-Apr	15-May
Andhra Pradesh	1,855	1,569	02-Feb	16-May
Arunachal Pradesh	593	474	11-Feb	17-May
Assam	881	1,344	28-Feb	02-May
Bihar	84	147	23-Feb	09-Apr
Chhattisgarh	1,738	792	22-Feb	02-Apr
Dadra and Nagar Haveli	3	0	05-Apr	02-May
Goa	1	8	06-Feb	23-Apr
Gujarat	92	200	04-Feb	21-May
Haryana	14	11	28-Feb	10-Jun
Himachal Pradesh	43	12	05-Mar	10-Jun
Jammu and Kashmir	92	78	30-May	11-Jun
Jharkhand	140	548	23-Feb	06-May
Karnataka	324	541	02-Feb	05-Apr
Kerala	120	48	09-Feb	21-Mar
Madhya Pradesh	838	1,066	03-Feb	14-May
Maharashtra	1,244	947	17-Mar	08-May
Manipur	1,213	1,654	01-Mar	02-May
Meghalaya	507	1,285	28-Feb	03-Apr
Mizoram	2,830	4,467	28-Feb	30-Apr
Nagaland	767	1,132	02-Feb	11-Apr
Orissa	1,457	1,646	23-Feb	08-May
Punjab	18	33	03-Mar	16-Jun
Rajasthan	53	47	22-Feb	26-May
Sikkim	0	2	06-Mar	14-Apr
Tamil Nadu	112	107	02-Feb	10-Jun
Tripura	738	1,421	17-Mar	03-Apr
Uttar Pradesh	297	242	02-Apr	14-Apr
Uttaranchal	221	170	01-Feb	09-Jun
West Bengal	6	164	23-Feb	26-Feb
Total	16,287	20,156		

Source: State Forest Report (FSI), 2009

5.5 State wise types of vegetation, causes of forest fire and management practices in India

Based on local socio-economic and climatic conditions, types of vegetation / forest type, the fire situations, causes of forest fire and fire management system of different States of India is briefed in Table-5.9.

Table-5.9: State wise types of vegetation, causes of forest fire and management practices. (P= Population in lakhs, PD= Population Density – persons per sq.km, C= Cattle Population in thousands and ST= Schedule Tribals in percentage

State profile	Vegetation/ forest type	Fire situation and fire season	Causes of forest fire	Prevention, Preparedness & Response; Including Community participation
A	**B**	**C**	**D**	**E**
ARUNACHAL PRADESH- Hilly, elevation gradient varying from 100 to 7000 mts., Climate-humid, tropical to alpine. P-13,82,611 C-1413 PD-17 ST- 64.63	Second among states in terms of forest cover. Tropical ever green subtropical pine, sub alpine, moist alpine, alpine scrubs are common forest species.	Fire prone forest species include- tropical evergreen, subtropical pine, temperate forest. Large area is affected by shifting cultivation and thus prone to fire. The area affected by shifting cultivation during 1987-1997= 0.23 m.h. Fire season- February to May	The main cause of forest fire is shifting cultivation. People cut/girdle the trees and set fire for cultivation. Forest department also set degraded forest on fire. Also burn forest - • For good grass growth, • Resin taping • To control weed & pest attack	Forest Department used techniques i. e • Creation of fire lines, back counter fire, control burning Occasionally fire • Brigade also used for fire control • Community participation and in some areas committees also formed in the areas, • Committees empowered to fine the offenders. Vigorous environmental education, awareness programmes and providing alternative livelihood resources may help in fire prevention.
ANDHRA PRADESH- Situated in peninsula India, partly hilly, highest park is Mahendra giri-1500 mts height, climate is hot & humid rainfall-125 mm/year. P-8,46,65,533 C-60175 PD-308 ST-6.63	Sixth in terms of area under forest cover. The main types include -Tropical moist deciduous -Littoral & swamp -Littoral & swamp -Tropical dry deciduous -Tropical thorn -Tropical dry ever green.	February to June, Extreme fire conditions are during March, April and May.	-NWFP collection -Timber mafia -Practices used to drive away animals by farmers. -Burning farm residues. -Throwing burning biri, cigarettes in forest.	• Traditional methods used by forest department, like fire line clearance. • Some modern technique adopted under central assistance. • FFP Committees also organised in some divisions. • Awareness programmes also run by forest department

A	B	C	D	E
ASSAM- Situated in Brahmaputra valley surrounded by hills on both side. Rainfall 70 to 120 inch/year. August hottest temp.-28°C January-10°C P-3,11,69,272 C-17227 PD-397 ST-12.42	Ranks 8th in terms of area under forest cover. Main species include -Tropical wet green -Tropical moist deciduous -Subtropical broad leaf forests.	January to May. However, major fires are in two months of February and March. Occasional fires noticed during December also.	Shifting cultivation is the major cause for fires in forest. Other reasons include- -For good grass growth by people. -Control burning by forest department. -Unintentional escape of fire during road construction, - From exhaust of vehicles etc.	• Preventive measures taken by the forest department include silvicultural practices like fire line clearance, litter burning etc. • Some time village councils and other local NGOs also involved in the fire suppression activities. Measures are being taken to involve local communities also in such activities. The State Govt is planning to modernize its existing fire fighting system with the cooperation of Central government.
BIHAR- Alluvial plain, in north bordering Nepal. Climate is hot in summer and winter very cold. P-10,38,04,637 C- 30342 PD-1102 ST – 0.92	Only 7.23 percent of Geographical Area (GA) under forest cover. Tropical moist deciduous forest in more common type.	February to May, However, peak season March to May	-NWFP collection, -Burning farm residues -Unintentional by people while throwing *biri* and cigarettes butts	-Forest department takes measures like fire line clearance, litter burning etc. -Education and awareness programs also run. -Attempts are being made to involve JFM in forest fire protection.
CHHATTISHGARH- P=2,55,40,196 C - 14418 PD- 189 ST-31.82	Rank 3rd in terms of area under forest cover –Tropical moist deciduous.	- January to May; however crucial period February to April.	-NTFP Collection -Drive away wild animals -Slash and burn also common in some parts. -Traditional customs in some tribes to burn forest at few ceremonial occasions. -Timber mafia and hunting	-In addition to technical measurement by forest department, attempts are being made to involve people in fire protection. FFPC formed in some divisions. -Awareness and campaign progress also run.

A	B	C	D	E
GUJARAT- Alluvial plain, partially hilly and marshy. Three seasons- summer, winter & rainy, rainfall very low. P-6,03,83,628 C-23515 PD-308 ST-14.79	Only 7.46 percent of GA under tree cover. Main forest types are -Tropical moist deciduous. -Littoral & swamp -Tropical dry deciduous. -Tropical thorn -Tropical dry evergreen	Main fire season February to May Mixed deciduous forest is more fire prone. Teak, bamboo forests are also fire prone	All forest fire are man made -For collection of *mahua*, honey & NTFP -Traditionally some tribes burn forest at the birth of a male child (*Raab* cultivation) -for good growth of grass - Also due to unintentional causes like throwing *biri* – cigarette butts - Sparks from transport exhaust etc.	-State Forest Department is being equipped with various modern techniques for early detection of fire. -Awareness programmes run by the forest department to seek people cooperation. -Strict vigilance in the National Parks and other strategic area. -Constitution of JFM and seeking their cooperation in fire prevention and suppression activities.
HIMACHAL PRADESH- Hilly terrain, including snow covered high peaks and glaciers. Climate varies from Temperate to Alpine Cold. Annual rainfall- 900 mm P- 68,56,509 C- 5217 PD- 123 ST – 4.02	Around 26.35 percent of GA under forest cover. Subtropical to temperate flora. Major species are *Chir, Deodar, Kail, Oaks, Alder,* etc. Forest types- Tropical deciduous, Tropical thorn, Him. Moist temperate, Him. Dry temperate, Sub Alpine to Alpine.	Main fire season is between March to June. Crucial period is from March to Mid June. However, some fires take place in the month of February also. Forest fires are annual phenomena in the State; however, major fires took place during 1995 and 1999. During 1995 forest worth Rs. 1750 million was lost due to fire.	Majority are man made. Collection of fuel wood, NTFP collection, shifting cultivation, for good pasture growth, ignition by graziers, throwing burning *biri* and cigarettes, burning Farm residues are some of the common causes. Resin tapping is another major cause for forest fire in H.P.	Forest department has taken many initiatives under Forest Fire Control Scheme of Central govt. Traditional Methods viz. forest line clearance, burning debris etc. frequently used. Community participation has proved very useful. In many divisions FFPC also constituted.
JAMMU & KASHMIR- Hilly terrain, comprising of valleys and snow covered high peaks. Snow desert in Laddakh region, foot hills of Jammu and plain area in South P - 1,25,48,926	Ranks 12th in respect of area under forest cover. Main forest types are- -Himalayan moist temperate -Himalayan dry temperate -Sub Alpine to Alpine.	The general fire season varies from March to June. However, the numbers of fires are maximum in the months of April and May. Fires are common during crop harvesting season also.	Anthropogenic Causes including- -By graziers for pasture development - Clearing land for horticulture purposes. - Picnickers and tourists etc.- Being border area forest fire	The Terrorist activities worst affected the silvicultural practices in the forest. This has increased the vulnerability of the forest to fire. The Department takes some measures in protecting and preventing fire in some restricted areas only. Recently the State is being provided some

A	B	C	D	E
C - 10987 PD- 124 ST – 10.98			occasionally caused by the bombing and explosions too.	assistance under the centrally sponsored scheme to take preventive steps. Some training and awareness programmes also initiated by the State Forest Department.
JHARKHAND- Plateaus and plain land, rich in mineral resources and forest both P - 3,29,66,238 C - 18100 PD - 414 ST - 26.34	Ranks-11th in terms of the forest cover area.	February to May, however main season in three months between March to May	-Shifting cultivation and burn and slash agriculture practices used by tribals. -NTFP collection - Rivalry with forest department. - Hunting and poaching - Timber mafia - Throwing burning *biri*-cigarette butts and burning camp fire. - Traditional customs in some tribes to burn forest to celebrate some good occasions. - Trespassers and picnickers.	-Forest divisions are being equipped with mobile vans, modern equipments etc. -Traditional methods like burning debris, clearing forest fire lines etc. also used - Fire watchers also appointed. - JFM help is also being sought.
KARNATAKA- Situated on western edge of Deccan Plateau. P - 6,11,30,704 C - 30859 PD - 319 ST – 6.55	Ranks seventh in terms of area under forest cover Main species are- —Tropical wet evergreen —Tropical semi evergreen —Tropical moist deciduous —Tropical dry deciduous —Tropical thorn —Tropical dry ever green	January to June and November to December. Peak fire season in between February to April.	NTFP collection - Rivalry with forest department. - Hunting and poaching - timber mafia - Throwing burning *biri*-cigarette butts and burning camp fire. - Traditional customs in some tribes - Driving away wild animals viz. elephants	- Karnataka Forest department has slightly better facilities to tackle forest fire. - Modern methods and equipment used under Central Govt. Scheme. - Community is also being involved in forest fire protection through the FFPC.

A	B	C	D	E
KERALA- Located in Western Ghats. Topography varies from coastal belt at sea level to mountainous region up to height of 2600 meters. Climatically very rich in rain. Dry season from December to April. P - 3,33,87,677 C - 3587 PD - 859 ST - 1.14	The state ranks 14th in respect of area under forest cover. The main forest types are- Tropical evergreen, Tropical semi evergreen Tropical moist deciduous Montana shoals Grass lands	Fire season from December to June. Peak season in summer between March and May. Major fires: Year — Area affected (ha) 1988-89 — 9049.12 1989-90 — 1950.00 1990-91 — 2080.00 1991-92 — 3388.00 1993-94 — 3337.00 1995-96 — 1804.58 1997-98 — 2062026	Main causes for fire are man induced- – Collection of NTFP – Promotion of fodder growth – Charcoal making in the forest – Forest deptt. Control burning – Unintentional fires by picnickers, tourists, by pilgrims etc.	– Traditional methods by the forest deptt. like fire line clearance, back fire, burning debris etc. -- – Local communities also participate in fire suppression activities. – Forest protection committees also constituted by the Forest Deptt, which along with forest protection also save forest from fire
MADHYA PRADESH- Second largest state. Topography- plain with plateaus. P - 7,25,97,565 C - 40696 PD - 236 ST – 20.26	The state ranks first in terms of recorded forest area and in forest cover. The main species are- -Tropical dry deciduous. -Tropical evergreen - tropical thorn	October to May. Peak season between March and May. Forest fire common every where, however, Panchmarhi Area is very prone. As per Forest Deptt. about 50,000 hectare of forest area is affected by fire between 1999 and 2001. During the same time 70 incidence of fire were noticed.	-Collection of NTFP -Religious activity- *Dammar by tribal.* -Burning of agriculture residues -Unintentional by throwing burning cigarettes -Torch light by night travellers.	-Forest Deptt. uses method like fire line clearance, appointment of fire watchers, burning of litter etc. -In case of fire it is beaten by the green branches. -Some time people also help in fire suppression. - Department using satellite data to locate fires and immediate response.
MAHARASHTRA- Lies between 16 04' & 22 01' North latitudes and 72 06' & 80 09' E longitudes	Fourth in terms of forest cover area. Main species are- -Tropical moist deciduous	October to November in winter and between May and June in the summer. Peak season is three months	- NTFP (*mahua*) collection – Raab- a traditional shifting cultivation system	Along with traditional methods , modern techniques and methods also used by the Forest Deptt. to detect and suppress the fire.

A	B	C	D	E
P - 11,23,72,972 C - 35954 PD - 365 ST - 8.87	-Tropical dry deciduous - Tropical thorn	period between March and May. Since 1996 up to 2001 total 9290 incidences of forest fire took place in the state, which burnt almost 2300 hectares of forest area. The total estimated loss of Rs. Eighty crores	– popular among the tribal community – Poachers for hunting – Rituals by the tribes – Controlled burning by the forest deptt.	Structural measures as watch tower, wireless, quick transport etc. also very frequently used.
MANIPUR- Hilly state. P - 27,21,756 C - 789 PD - 122 ST – 38.96	Ranks third in terms of % age of recorded forest area. Main species are- -Tropical wet evergreen -Tropical moist deciduous -Subtropical pine -Montana wet temperate	January to May is the fire season, however, peak fires season in March and April.	Main causes- Shifting cultivation, other causes include- -Management of grass land -Hunting and Timber mafia -Occasional fires by lightning also. -Trespassers to forest	Forest department uses traditional methods like fire line clearance, appointment of fire watchers, litter burning. Forest Department is modernizing its fire fighting system with the help of Central government under the scheme of Modern Forest Fire Control Methods.
MEGHALAYA- Hill state with narrow river valleys. Climatically very rich in rain. Cherapunzi and Mawsynrdin are the town with highest rain fall in the world. P - 29,64,007 C - 1823 PD - 132 ST – 86.43	Ranks 7th in terms of % age of geographic area under forest cover. Main species are- -Tropical moist deciduous -Subtropical pine.	February to April. Maximum fires in the month of March.	Like in other NE state main cause of forest fire is Shifting Cultivation. In addition, hunting, driving away wild animals, collection of NTFP, throwing burning cigarette butts etc. also causes fire in the forest.	Traditional methods commonly used to detect and suppress fire. During fire green twigs are used by the forest people to suppress the fire. Some time local people also help in locating and suppressing fire in forest area.
MIZORAM- Situated in the southern part of NE India. Hilly terrain.	Ranks 1st in terms of forest cover % age of geographic area. Main Species-	February to May, however maximum fire incidences in the months of April and May.	-Shifting Cultivation -Collection of NTFP -Throwing burning biri – cigarette butts	People participation is being given more emphasis in forest fire prevention and control. Forest department is taking some

A	B	C	D	E
P - 10,91,014 C - 328 PD - 52 ST - 94.19	- Tropical wet evergreen - Tropical moist deciduous		-Burning farm residues -For good grass growth. -Clearance of land for various purposes.	initiatives and getting fund from the MOEF for making appropriate arrangements. Public awareness and training programmes also conducted by the Forest Department.
NAGALAND- Hilly state in the NE India. P - 19,80,602 C - 1419 PD - 119 ST - 88.98	Ranks 3rd in terms of % age of geographic area under forest cover. Main species- - Tropical wet evergreen - Tropical Semi evergreen - Sub Tropical Pine - Montana Wet temperate.	Fire season from February to May. However, the peak season in the month of March.	Jhoom or shifting cultivation is the most common cause for forest fire. The other minor causes are- - NTFP Collection - Drive away wild animals to save crops. - Throwing smouldering biri – cigarettes butts by the careless trespassers. - Escape fires from the burning of farm residues or cooking near the forest area.	Forest department seeks people help in suppressing and detecting forest fire. Village Councils- the local self government bodies also cooperate with the forest department.
ORISSA- Situated on the East coast of Bay of Bengal. P - 4,19,47,358 C - 23057 PD - 269 ST – 22.19	Ranks 5th in terms of area under forest cover. Main species- -Tropical moist deciduous -Tropical semi evergreen.	Fire season February to June; Crucial period in March and April	- Shifting Cultivation. - Collection of NTFP, - Burning of farm residues to clear the land. - Escape fires from the cooking fires - Throwing burning biri and cigarettes.	Forest department takes preventive steps by appointing fire watchers, clearing fire lines, burning litter etc. In some forest divisions modern equipment also acquired with the assistance of MOEF, GOI. FFPC and JFM also being engaged in checking fire incidences in the forest.
RAJASTHAN- Largest state characterized by scanty rain. Partly hilly- Aravalli	Only 4.69 percent of GA under forest cover. Main species-	Fire season is from January to June. Peak fire season in the month of May.	Being hot and dry climate the vegetation catches fire immediately. The source of	Forest department appoints fire watchers during the summer. In National Parks and Wild Life

A	B	C	D	E
range. Some part is desert. Climate dry hot P - 6,86,21,012 C - 56663 PD – 201 ST – 12.57	-Tropical dry deciduous -Tropical thorn -Tropical dry ever green		ignition are- - Escape fire from the burning of farm residues to clear the land. - Tribal fire forest for good grass growth - Graziers and cooking food in the forest area also ignite fires - To scare wild animals	Sanctuaries various silvicultural practices i.e. clearance of fire line, burning of litter, back fire are adopted to prevent fire.
SIKKIM- Mountainous state having some highest peaks of the world. Elevation varies from 250 to 8595 mts. Climate sub tropical to cold temperate and Alpine. P - 6,07,688 C - 270 PD - 86 ST – 20.61	Ranks second in terms of % age of geographic area under recorded forest area. Main Species -Tropical evergreen -Sub tropical pine -Montana wet temperate	January to May is the main fire season, however maximum fire incidence take place during two months i.e. March and April. Occasional fires in the months of November and December also. Lower elevation face fire every year, which in most of the cases is surface fire. During 1999 fierce fire hit the forest of Chingrhong area worst.	Most of the fires are intentional/ unintentional by people- - To grow good grass crop. - Bonfire during winter - Hunting and illegal felling. - To keep away wild life away from the agriculture farms. - Using torch by trespassers during night. - By natural lightening on high hills.	Forest department uses some traditional methods to control and prevent fire. However, there is lack of institutional mechanism. Unawareness among community is the main cause of forest fire. State forest Department is planning to involve community in forest fire management. Constitution of Forest Fire Protection Committees is under consideration.
TAMILNADU- 80 05' & 13 35' North latitude and 76° 15' & 80 20' East longitude. Facing Indian Ocean with coast line of 1000 kms. P - 7,21,38,958 C - 30759 PD - 555 ST – 1.05	Ranks tenth in terms of area under forest cover. The main species are- -Dry deciduous -Savannahs -Semi ever green -Southern thorn	Fire season between March and May, however the peak season in the month of March and April only. During 1996-97 a major fire took place in the Sandal wood forest of the State resulting into	- Collection of NTFP (tamarind, *Mahua*, wild jacks etc.). - Farm residue burning - Drive away wild animals (especially wild animals) - Timber mafia	- Traditional methods not working well due to population pressure. - Forest Fire Protection Committees constituted in many divisions by Forest -Department. - Awareness and campaign programmes also conducted. - FFP Committees members given proper training.

A	B	C	D	E
		economic loss of approximately US $ 43 millions.	- Stimulating flush of leaf crop i.e. *tendu*.	- Strict action is taken against offenders. - Recently the Department has established Fire Disaster management Centre to ensure quick detection and suppression of forest fire.
TRIPURA- Located in the N-E part of the country. The state is with hilly terrain. P - 36,71,032 C - 1869 PD – 350 ST – 31.13	Ranks 8th in terms of % age of recorded forest area.	January to May is the fire season, however, peak fires between February and April.	The shifting cultivation is the main cause. The other causes are- - NTFP Collection - Drive away wild animals to save crops. - Throwing smouldering biri – cigarettes butts by the careless trespassers. - Escape fires from the burning of farm residues or cooking near the forest area.	Forest department uses traditional methods like fire line clearance, appointment of fire watchers, litter burning. Forest Department is modernizing its fire fighting system with the help of central government under the scheme of Modern Forest Fire Control Methods.
UTTAR PRADESH- After bifurcation, the state is left with mostly plain area- Ganga Yamuna alluvium plain. In the North –East there is *Tarai* belt. Most populous state in the country. P - 19,95,81,477 C - 60272 PD - 828 ST – 0.07	Rank 1st & after separation of Uttarakhand, the State has only 5.95 percent of GA under forest cover. The main species are- -Tropical moist deciduous -Tropical dry deciduous -Tropical ever green	Fire season from Dec to May. Maximum fire during the month of March, April, and May. Occasional fires during winter also, especially in the dry years. The *Tara*i forest in the state is very vulnerable to fire. Number of fires in some fire prone divisions between 1981 and 2001 are- Baharaich- 115	Fires in the forest are ninety nine percent man caused. The main reasons include- - NTFP collection, mainly honey is one of the main reasons. - Fire also caused unintentionally by throwing burning *biri* and cigarettes in the forest. - Burning farm residue near the forest.	Measures taken by the forest department does not seem to be sufficient. Silvicultural practices like fire line clearance, burring of litter etc. are carried out for very limited area only. Recently efforts are being made to involve local people through JFM in forest fire prevention and suppression practices.

A	B	C	D	E
		Kheri- 468 Dudhwa- 95	- The other causes include personal enmity with forest department, - Making wine in the forest area. - To scare away wild animals.	Some divisions recently equipped with the modern equipments and fire proof clothing to suppress fire in more effective manner. State department provides training and create awareness among the people.
UTTARAKHAND- It is mostly a hilly state with southern portion plain. Landslides, earthquakes and forest fire are common disasters in the state. P - 1,01,16,752 C - 5141 PD - 189 ST – 3.02	Ranks 6th in terms of recorded forest area with 45.60 percent of GA under forest. Main species are- - Tropical moist deciduous. - Tropical dry deciduous - Sub alpine Moist Alpine - Alpine	Fire season from December to June. Peak fire season from March to June. Major fires occurred during 1995 and 1999. During 1999, 22.64 % forest area got affected by the fire. During 1995, 19.32 % of the total forest area was affected by severe fires. Both the fires along with damaging forest vegetation also caused immense loss to environment and people health. During these two major fires many people suffered from breathing related diseases in the near by areas. Forest fires during 2001 killed four persons in the Garhwal region- Rudraprayg district.	All fires are man made, except very few due to lightening. Escape fire from the burning farm residues and from the fires lit to drive away wild animals cause damaging fire. Rivalry with forest department. NTFP collection. Throwing away smouldering *biri*- cigarettes etc. Camp fires by the picnickers etc.	Forest department uses traditional methods to prevent and suppress forest fire. Though some divisions are having modern equipment also but they are rarely used by the forest official as they are very heavy and not convenient to use in the hilly terrain. Forest department also seeks help from local people in suppression of forest fire. In some villages attempts are being made to involve local people through JFM in controlling the menace of forest fire.

A	B	C	D	E
WEST BENGAL- The State has variegated topography, starting from the hilly terrain in the north to plain and the coastal delta belt in the extreme south. P - 9,13,47,736 C - 37419 and PD - 1029 ST – 5.49	Total 14.64 percent of GA under forest cover. Main species are- -Tropical moist deciduous -Tropical dry deciduous -Tropical pine	February to May, however peak season in three months between March to May	-Shifting Cultivation. -Collection of NTFP, -Burning of farm residues to clear the land. -Escape fires from the cooking fires -Throwing burning biri and cigarettes	Forest department takes preventive steps by appointing fire watchers, clearing fire lines, burning litter etc. In some divisions modern equipment also acquired with the assistance of MOEF, GOI. FFPC and JFM also being engaged in checking fire incidences in the forest.

Source: State Forest Report, 2009.

Chapter 6

MANAGING FOREST FIRE

6.1 Introduction

Exact information about deforestation and forest degradation in the country, though very limited, yet whatever data available, predicts a very sad situation about forest health. Taking into consideration the seriousness of the problem, just after independence the Government of India started giving the issue of forest conservation and protection (including protection against forest fire) a serious thought. The first progressive step taken in this regard was the formulation of National Forest Policy in 1952, when the erstwhile Ministry of Food and Agriculture, Government of India enunciated a Forest Policy for the management of State Forests in the country. Indian Constitution provided guidelines under the Forest Policy for protection of forests and wildlife. According to this policy the State shall endeavoring to protect and to improve the environment and to safeguard the forests and wildlife of the country and the citizens are to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures. The first main issue laid down in the Indian Forest Policy, 1952 is that one-third of the land area of the country should be under forest cover for ensuring a balanced and complementary land use system. It provided scope for the management and control of private forests, containment of shifting cultivation, creation of village forests etc. In addition to formulation of the Forest Policy, the Government of India took numbers of the progressive steps for protection, preservation and management of forests, including:

I. The Indian Forest Service was revived in 1966 to ensure co-ordinated professional management of Forests. The purpose of establishing this cadre of officers has been safety and protection of environment and taking care of national interest.

II. The subject 'Forest' was transferred from the State List to the Concurrent List of the Constitution of India in 1976 to ensure uniform policy and management throughout the nation.

III. The Forest Conservation Act, 1980 was enacted which was later amended in 1988. It provides that areas recorded as Forests in Government records cannot be transferred for non-forestry use without the prior approval of the Government of India.

IV. A separate Ministry i.e. “Ministry of Environment and Forest” was created in the Union Government in 1985 and the Forest wing from the Ministry of Agriculture was transferred to the new ministry.

6.2 Amendment in National Forest Policy

Despite these steps taken from time to time, forests in the country continued to suffer serious depletion. This is attributable to relentless pressures arising from ever-increasing demand for fuelwood, fodder and timber; inadequacy of protection measures; diversion of forest lands to non-forest uses without ensuring compensatory aforestation and essential environmental safeguards; and above all the tendency to look upon forests as revenue earning resource. A need was felt to review the situation and evolve for future a new strategy of forest conservation. Keeping this in view, the India’s National Forest Policy was amended in 1988. This amended policy presents a visionary strategy for future forest conservation and management, laying emphasis on protection of forest against encroachment, fire and grazing. The main objectives set out by new National Forest Policy (1988) include:

1) Maintaining environmental stability.
2) Conserving the natural heritage of the country.
3) Checking soil erosion and denudation.
4) Checking the extension of sand dunes.
5) Increasing forests and tree cover.

6) Meeting the requirements for fuel wood, fodder, minor forest produce, and small timber.

7) Increasing productivity of the forests.

8) Encouraging efficient utilization of the forest produce.

9) Creating a massive people's movement, including involvement of women, for achieving these objectives.

The principle aim of the New National Forest Policy is *to ensure environmental stability and maintenance of ecological balance.* The policy discusses the steps to be taken for forest conservation, including forest fire management in more effective manner. The policy addresses the problem of forest fires in the following specific terms:

"The incidence of the forest fires in the country is high. Standing trees and fodder are destroyed on a large scale and natural regeneration annihilated by such fires. Special precautions should be taken during the fire season. Improved and modern management practices should be adopted to deal with forest fires."

The text clearly indicates that the legal and policy framework already exists in favour of forest fire management; however, there is need for proper action plan and its implementation to generate public opinion against negligence, ignorance, and indifference towards fire.

6.3 Changing forest management practices and forest fire

Historically, the management of forest in India started with the objective of sustained yields of outputs through scientifically based knowledge application in project form for a division, named "Working Plan". It continued as such up to 1960, however, the pressure of growing population put these plans out of gear. In 1976 Social Forestry programme was launched followed by "Participatory Forest Management Programme" in 1990. Under this programme seedling distribution and tree planting activities were undertaken through a large number of projects and programmes. Many State Governments have already passed resolutions favoring participatory management of forests. The system provides the scope, nature and intensity of the participation as well as the purpose, methods, rights, responsibilities and incentives to the stakeholders. The transition from production forestry to participatory forest management also changed forest management scenario and has posed various challenges before the foresters, as well as the researchers.

In the recent past, a holistic approach has been adopted in managing the forest in more effective manner by giving more emphasis to other related issues too. The forests management is currently relying upon massive afforestation, efficient use of wastelands, reclamation of waste lands, management of natural forests, increasing productivity of existing ecosystems, efficient utilization of wood and non timber forest produce (NTFP), management, protection of fragile ecosystems and conservation of existing bio-diversity, germplasm collection and biotechnological research, participatory forest management and various sustainability issues.

The latest forestry management practices are ushering a new culture amongst the rural masses i.e. the culture of community/ community based organisations involvement. The Panchayats, local bodies, *Mahila Mandals,* NGOs etc. are influencing the behaviour of rural masses towards forests. They have achieved it through training, creating awareness, mobilization of the people, building confidence, multi-disciplinary applied research and providing analytical studies. At present the rural masses are no longer ignorant about their rights, benefits and concessions. Right to Information has transformed the society's knowledge levels. Today's rural women, though still in shackles of old culture, are tending to be more progressive in public life as well as developmental processes. Knowledge is being given due importance in conservation and protection of forests. Village people now have a culture, which is well integrated with forest cycle from collection of seeds to harvesting of crops. Forestry operation and societal rituals are also well connected. This changing scenario is the strength of the

Modern Forest Management in the county.

This paradigm shift in the forest management has brought a revolutionary change in the forest fire management system too. The National Forest policy states that at least one third of the county's geographic area (around 110 million ha) should be under adequately stocked forest cover as compared to the present 69.09 million hectares. One of the ways to increase forest cover is to protect existing forests from the damaging effects of forest fire, especially in the areas of natural regeneration.

The issue of effective forest fire management in the countries like India, where so many issues are clubbed with forest management is not so simple. Due to population explosion and its ever-increasing pressure on forest, the problem of managing forest fire has become more complicated in comparison to the past, when the fire situation in the country was totally different. In earlier days, as there was not much population pressure, the traditional methods were quite satisfactory and sufficient for forest fire management. The most successful method during that time was an elaborate network of fire lines, block lines and their early clearing and burning. These traditional methods became insufficient and ineffective with changing scenario. The dependency of the people on forest residing near the forest area for fuel wood, timber, grazing of cattle and over exploitation of non timber forest produce has turned the traditional fire protection methods almost outdated. The situation has further deteriorated due to inefficient forest fire management measures in the past.

To achieve the target set by new National Forest Policy of 110 million hectares under forest cover, it becomes imperative to evolve and implement intensive result oriented forest fire management programme in the country. For this Indian forests deserve a full-fledged fire management system institutionalized at the State level with strategic inputs of training, research, and awareness building. In this regard, Government of India has recently started taking initiatives and various attempts have been made to come out with a comprehensive plan for tackling the issue more effectively and efficiently. To overcome the issue successfully, the Government has taken cooperation and technical assistance from international organizations too. In this context, the FAO–UN cooperation and support in the form of implementation of Technical Cooperation Programme (TCP) project on Training in Forest Fire Management Planning is worth mentioning, where a number of recommendations have been made for effective forest fire management in the country.

6.4 FAO Recommendations on Forest Fire Management

The FAO has run a special TCP project program in the country under which main emphasis was given to human resource development in forest fire management. The FAO aided TCP project on training in Forest Fire Management Planning was started during May, 1995 and concluded in December, 1995. The main objective of this project was to review India's current forest fire problem, provide training in strategic fire planning to key forestry personnel at the State and National levels to enable them to develop fire plans based on ecological, economical and social conditions for their respective States and to develop at least one model State Forest Fire Management Plan.

To achieve the set objectives of the project, the work plan was divided into following four phases:

(I) To conduct comprehensive analysis of the forest fire situation in India, including the study of number of fires and area burnt; the effects of ecological, economical and social impacts, current capacity for forest fire management at the National and States levels, including review of existing laws, regulations and policies covering forest fire management.

(II) To design a training package on strategic forest fire management planning which would enable Indian foresters to prepare site specific fire plans for all the forest types in the country.

(III) To conduct training courses for the foresters and planners, who would then be capable of preparing strategic Forest Fire Management Plans and providing identical training to large number of field foresters throughout the country.

(IV) To develop minimum one model State Forest Fire Management Plan to serve as an example for subsequent State plans and National plan. Plans are to be organized into a series of program components, which can be considered for development assistance by international donors and financiers.

The international consultant team in their Technical Report made many recommendations for an effective forest fire management. The main among them are-

- As prevention is better than cure, a preventive program of zoning, danger rating, early warning and real time monitoring has to be designed and installed.
- At the strategy level, coordination with Government agencies like the National Remote Sensing Agency, Forest Survey of India, the Meteorological Department, the All India Radio and the State-owned television should be promoted by the forest departments of the States to plan their actions in the fire season.
- A national awareness compaign on fire damage, prevention, detection and communication and suppression should be launched involving schools, Joint Forest Management (JFM) committees, non-Government and other voluntary organizations during the onset of fire season every year.
- A central fire management research and training institute for foresters and public agencies should be set up for providing knowledge and skills for fire managers, including trainers at JFM unit levels.
- Fire experiment stations should be set up in representative regions to study various effects of fires in different ecosystems

and provide extension services to the concerned States.

- Prevention and Management programmes should be integrated in the Joint Forest Management framework by State Governments.
- Fire management should be named specifically as element of "Protection" in the list of priority strategies of National Forestry Action Plan.

The committee in its report suggested following measures for prevention and control of forest fires:

i. Increased vigilance by appointment of adequate number of firewatchers during the month of April, May and June, which used to be the practice earlier.

ii. Clearing and maintenance practice of fire lines, which have been virtually abandoned due to shortage of funds, must be carried out regularly.

iii. The practice of controlled burning to deal with accumulation of combustible pine needles on the forest floor, which has been abandoned as a result of shortage of funds, has to be reintroduced.

iv. Proper forest management and silvicultural practices, particularly in pine forests, which have been abandoned as a result of imposition of the ban on green felling, must be reintroduced to ensure proper health and protection of the forest. For this purpose, ban on felling of pine should immediately be revoked and the forestry activities must be carried out as per working plans.

v. Efforts for finding alternative uses for pine needles should be supported by the Government so as to demonstrate their economic viability. This will help to reduce the accumulation of combustible material on the forest floor.

vi. The forest department staff should be provided with complete communication network through wireless to enable quick response in dealing with forest fires and also with the problems of illicit felling.

vii. The communication network has to be supported with improved mobility to enable quick transport of human and materials from one area to another. For this at least one additional jeep may be provided at divisional level, especially in the hill areas.

viii. Where villagers do not come to assist the forest department in extinguishing forest fires, their timber rights should be curtailed if not forfeited.

In its report, the committee emphasized that the State Governments must ensure that adequate funds are provided to the forest department for proper care, maintenance and protection of the forests. The steady reduction in such funds has seriously affected the activities of the forest department. These funds should be provided through a centrally sponsored scheme for this purpose.

6.5 Forest fire management - some initiatives

As per Indian constitution the Central and State Governments are enabled to legislate on forestry issues; however, the implementation part of the programme / policy lies exclusively with the later. Fire prevention, detection and suppression activities are the responsibilities of the State government, where it lies exclusively with the State Forest Department, which unfortunately has no separate wing or unit for carrying out this strategic activity. The regular staff of the forest department has to carry out this task without any extra support or assistance. In most of the cases there is no exclusive fund to look after fire management related activities and in such circumstances it becomes very difficult for the department to carry out its duties honestly. Taking into consideration this pitiable situation, the Union Ministry of Environment and Forests initiated a project “Modern Forest Fire Control Project" in 1984 –1990 assisted by United Nations Development Program in two States of U.P. and Maharashtra. The purpose of this project was to introduce and evaluate integrated forest fire management systems in both the States and come out with an appropriate plan of action. The project was highly successful from the standpoints of technical soundness and economic efficiencies. Motivated by the success of this project the Ministry of Environment and Forests has introduced a centrally sponsored scheme namely “Modern Forest Fire Control Methods” since 1992-93 in the eleven selected States of Andhra Pradesh, Bihar , Gujarat, Himachal Pradesh, Kerala, Karnataka, Madhya Pradesh, Maharashtra , Orissa, Tamil Nadu and Uttar Pradesh. The project continued during the first three years of the Ninth Plan period i.e. from 1997 to 2000. In 2000 the scheme was extended to all the States and Union Territories of the country.

The objectives of this scheme are:

(i) To control forest fires with a view to protect and conserve forests.

(ii) To devise, test and demonstrate the principles and techniques of forest fire management.

(iii) To improve the productivity of forests by reducing incidence and extent of fire.

(iv) To create awareness among the masses about the effects of forest fires on the forests and environment.

(v) To conduct training programmes for the forest officials and local people to prevent, detect and control forest fires.

To meet the aforementioned objectives financial support is provided under following subheads:

Prevention: Creation of fire lines, training and demonstration publicity.

Detection: Construction of watch towers, network of wireless sets, fire finders.

Suppression: Hand tools, fire resistant clothing and fire tenders.

During the Tenth Plan period, the States and UTs were financially supported for forest fire management under the new Scheme “Integrated Forest Protection Scheme”.

The Government of India also developed various guidelines and advisories to help State governments in managing forest fires in more effective and efficient manners. In addition to guidelines, the Government of India also issued Protocol on Forest Fire Proforma for Forest Fire Reporting at different levels. The main issues have been raised in the “Guidelines on Fire Management and Preparedness”.

In addition to the ongoing schemes for forest fire management, the Government is also considering the setting up of a National Institute of Forest Fire Management with satellite centres in different parts of India with an objective to bring the latest forest fire fighting technologies to India through proper research, training of personnel and technology transfer on a long-term basis. Notwithstanding the existing efforts, it is still felt that there is an acute shortage of resources for forest fire prevention, detection, and control and also for research, training and equipment.

6.6 National plan for forest fire management

6.6.1 In continuation of its efforts to effectively deal the forest fire issues, Ministry of Environment and Forest, Government of India has made essential provisions in National Forest Policy. The modified National Forest Policy has addressed a systematic plan for Forest Fire Management, according to which special precautions need to be taken during the fire season in addition to improved and modern management practices to deal with forest fires. In general this plan aims to prepare a strong data base / network on forest fires and evolve an appropriate strategy to deal the forest fire situation in more effective manner. The capacity building, community involvement, awareness generation etc. are integral components of this plan.

The main objectives of the National Plan for Forest Fire Management are:

- To strengthen the Organizations responsible for forest fire management including–
    - Communication network of wireless system/ satellite

network.

  - Effective transportation
  - Improved fire resistant clothing
  - Fire fighting equipment
  - Fire finder
  - Fire tenders
  - Watch towers and other fire detecting systems etc.

- To coordinate the States/UT's plans for systematic forest fire management.
- To provide input regarding training, research, extension, and publicity.
- To coordinate international transfer of technology and training in the field of forest fire management.
- Creation of a strong database for:
  - Numbers of fires.
  - Area burnt.
  - Damage caused to flora and fauna.
  - Effect of fire on land and soil.
  - Causes of Forest fire.
  - Measures taken.
  - Extent and effect of prescribed fires.
- Assessment of ecological, social, and economic impact of fires.
- Strong national extension strategy for people's awareness and their participation in forest fire management through JFM, VFC, and NGOs.
- Develop necessary human resources by imparting training and encouraging research in forest fire management.
- Develop organisational structures at National and State levels.
- To assess technical and financial assistance required by various States/UTs for forest fire management.

- To develop necessary mechanism for monitoring and evaluating management practices.
- To provide strong legal base by amending Indian Forest Act, National Code for writing Working Plans and giving due importance to forest fire management in the National Forestry Action Programme.

Number of initiatives have been taken under the plan to strengthen the forest fire management system in the country. A strong central component for the development of an Early Warning Fire Forecasting System using satellite data and Fire Danger Rating System for early detection of forest fire has been introduced. Forest Survey of India (FSI) is working in collaboration with the National Centre for Medium Range Weather Forecasting (NCMRWF) for this project. The Forest Research Institute (FRI), based at Dehradun is also being involved in the plan to assess the impact of forest fire on vegetation and micro-climate.

6.6.2 Strategies- To make the plan successful and meet the objectives, there is need to have a systematic strategic planning including following components-

- Publicity and extension- Covering preparation of publication/ extension material e.g. pamphlets, handouts, circulars, posters and media programs through TV, radio, video tapes, etc.
- Training and education- Designing syllabus for planning, management and ground level firefighting courses in Forestry Institutions.
- Strengthening of organizational framework- Though appropriate modification and alteration in State Forest Departments' structural framework and providing sufficient human power.
- Research and development, by strengthening the existing and introducing new R&D institutions dealing with forest fire management.
- National Forest Fire Danger Rating System- Designing uniform

system of Forest Fire Danger Rating and reporting for all States/UT's. Also designing and installing a network of fire forecasting at National and State levels in collaboration with the Meteorological Department.

- Monitoring, evaluation and updating prescription- Designing uniform formats for reporting, monitoring and evaluation.
- International coordination and transfer of technology- Organising seminars, training programs, conferences, and study tours in different countries leading in Forest Fire Management, e.g., U.S.A., Australia, U.K., Spain, France, etc.
- Institution of National Awards- Institution of Gallantry Awards for exemplary works in forest fire prevention, protection, and suppression.
- Revision of guidelines for working plan- Introduction of a chapter on Forest Fire Working Circle.
- Effective fire fighting tools and machinery- Provisions of modern and effective tools and machinery e.g. Fire Beaters, Forest Fire Showel, Pulaskis Tools, Fire Rakes, McLeod Tools, Brush Tools, Power Blowers, Back-Pack Pump Sets, Fire Tenders etc.
- Financial support to States- Provision of Aids/Loans from GOI to States/UT's according to their action plan for Systematic Forest Fire Management.
- Promotion of people's participation-Through involvement of NGOs, Voluntary Organisations, Village Forest Committees (VFCs) etc.
- Inclusion of Forest fire management in National Forestry Action Plan (NFAP) - Sufficient mention of strategic Forest Fire Management in the document of NFAP.
- Revision of Indian Forest Act- The relevant section of the Indian Forest Act needs to be revised to give due importance to legal protection against man-made forest fire.

- Creation of a national forest fire control board- With the task of supervising the control of devastating forest fire in exigencies in fragile areas like Himalayan zone, Western Ghats etc.

6.6.3 Forest Fire Monitoring

Since the year 2005, FSI has been monitoring forest fires across the country using inputs received from MODIS satellite system, a joint collaboration of NASA and Geography Department of University of Maryland. In March 2010, FSI started a system of sending SMS/email alerts through its website www.fsi.nic.in. Any user can register for the alert system by providing his/her mobile phone number and email address and the names of district/state/UT for which the information is sought. Every day, between 1100 -1200 hrs email and SMS alerts reach the registered users giving a summary of total number of forest fires detected in their chosen areas.

FSI is monitoring (Near Real Time Monitoring of Forest Fires) forest fires of the country since 2004 using remote sensing based system developed by the University of Maryland (USA) and NASA viz MODIS Rapid Response System. The detection of forest fires is made on the daily basis through the website http://maps.geog.umd.edu. After collecting the coordinates of the fire spots, FSI maps the forest fires through GIS analysis. The coordinates of all the forest fire spots are then sent to the respective State Forest Departments through fax and email for control during fire season (Fig.-6.1). From the feedback received from SFDs, it has been observed that the detected forest fires are correct on more than 95% points.

6.6.4 Methodology

The near real time monitoring of forest fires involves dissemination of forest fire alerts through mobile SMS system. FSI has initiated Real time monitoring of forest fires in collaboration with National Remote Sensing Centre (NRSC) wherein the forest fire alerts for the active fire locations would be generated as KML (Keyhole Markup Language) file which is Google-Earth compatible. The entire exercise right from the acquisition of ground image by satellite, processing and dissemination of the fire signals to SFDs would involve a time period of 2 hours. The current mechanism would facilitate the quick dissemination of information to the SFDs. Besides with the present file format i.e. KML, the SFD would be able to precisely locate the position of hotspot (active fire location) at compartment level with the Google-Earth picture in the background. To minimize the technical gap and share knowledge with SFDs, four regional consultations have been organized by FSI at four zones of the country. FSI zonal offices at these locations will be the facilitators for resolving the technical problems. The overall objective of the process is to utilize the role of technology in curtailing the severity of forest fire which if unnoticed may turn into wildfire and become difficult to control.

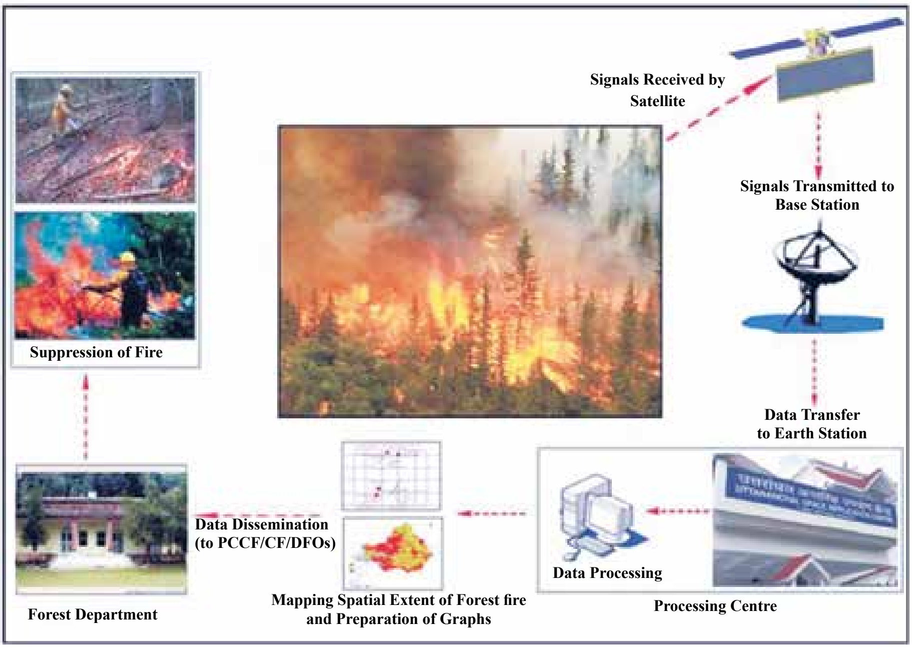


Fig.-6.1: Near Real Time monitoring of forest fires being used by FSI.

Source: PPT by Forest Survey of India, 2012

The detailed geo-coordinates of the forest fire point locations are also made available on the FSI website. All the archival forest fire data is also available on the website and is being used by a sizeable number of users. The service was widely publicised amongst the SFDs and the feedback received from them indicates that the forest fire detection has an accuracy of over 95%. The on-going exercise has helped in identifying the forest fire prone areas in the country and also the critical time period of fire occurrence for each State and UT. The identification of fire sensitive zones as well as the fire seasons is likely to help in formulation of effective forest fire control strategy in terms of prevention, alertness, mitigation, fund allocation and deployment of personnel and equipment. The work has generated basic data on the pattern of forest fire in the country which can be used for preparing national level strategy for early warning and burnt area assessment. A total of 13,898 fire incidences were reported by FSI to the States in the year 2010-11 (Table-6.1 & Fig.-6.2).

Table-6.1: Forest Fire Incidences in Indian States & UTs during 2008- 2011

S.No.	STATE/UTs	2010-2011	2009-10	2008-09
1	Andaman & Nicobar	0	7	1
2	Andhra Pradesh	1119	1837	2442
3	Arunachal Pradesh	485	576	786
4	Assam	1322	2511	1901
5	Bihar	81	397	143
6	Chandigarh	0	0	0
7	Chhattisgarh	1074	2835	2849
8	Dadra & Nagar Haveli	0	0	0
9	Daman & Diu	0	0	0
10	Delhi	1	0	0
11	Goa	3	0	2
12	Gujarat	101	179	182
13	Haryana	5	29	21
14	Himachal Pradesh	6	125	168
15	Jammu & Kashmir	7	30	117
16	Jharkhand	192	1314	430
17	Karnataka	370	428	604

18	Kerala	10	106	166
19	Lakshadweep	0	0	0
20	Madhya Pradesh	1451	2386	2894
21	Maharashtra	882	1789	2257
22	Manipur	1275	2487	1477
23	Meghalaya	879	1743	1010
24	Mizoram	1691	4675	3434
25	Nagaland	919	1654	984
26	Orissa	780	2515	2087
27	Puducherry	0	0	0
28	Punjab	10	56	41
29	Rajasthan	86	117	96
30	Sikkim	1	5	1
31	Tamil nadu	34	148	276
32	Tripura	634	1127	717
33	Uttar Pradesh	198	737	370
34	Uttarakhand	85	855	631
35	West Bengal	197	224	100
	Total	**13898**	**30892**	**26187**

Source: India State of Forest Report 2011

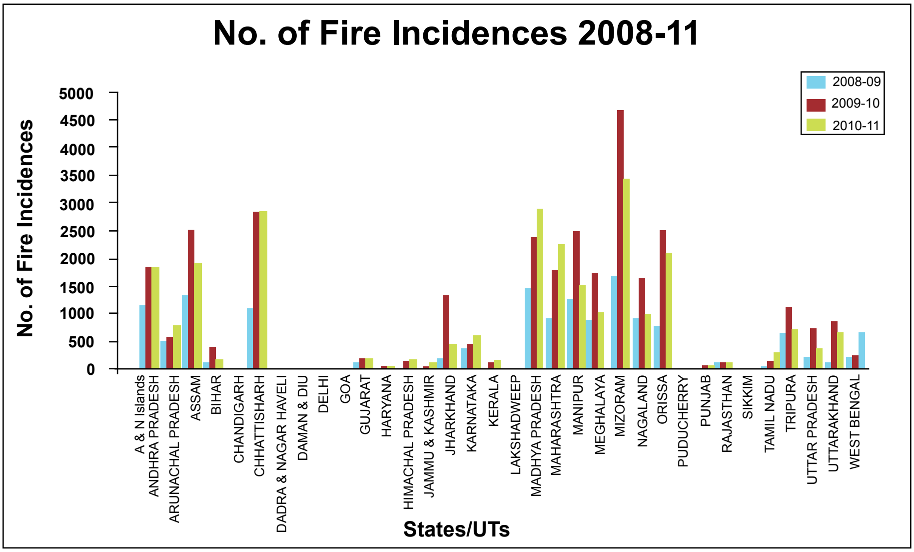


Fig.-6.2: Number of fire incidences occurred in Indian States & UTs during 2008-11.

Source: India State of Forest Report 2011

6.7 Incident Command System / Incident Response System (IRS) in India

The Government of India in 2003 adopted the Incident Command System (ICS) in the country as practiced in USA to address the critical gaps in disaster response mechanism of the country even though there were certain specific modifications which were necessary to be addressed. There was a need to prepare an Indian version which would fit into the Indian Administrative Structure. National Disaster Management Authority (NDMA) took up the responsibility of the adaptation of the ICS which incorporates the existing administrative structure and the provisions of Disaster Management Act, 2005. The principles and features of ICS have been followed and comprehensive guidelines have been prepared. This adapted version has now been referred as the Incident Response System (IRS) in India.

The IRS organization functions through Incident Response Teams (IRTs) for disaster management. In Indian administrative structure and DM Act, 2005, the Responsible Officers (ROs) have been designated at State and District levels as overall in charge of the Incident Commander (IC) who manages the incident through IRTs, which are pre-designated at all levels i.e. State, district, sub-division and tehsil and block. The role of RO is to activate IRTs on receipt of any early warning of the disasters. In case a disaster occurs without any warning, the local IRT will respond and contact RO for further support, if needed. The function of Nodal officer (NO) is to maintain proper coordination between the District, State and National levels in activating air support for response. The structure of IRS is shown in Fig.-6.3.

Apart from the RO and NO, the IRS has two main components as follows:

1. Command Staff
    - Incident Commander (IC)
    - Information & Media Officer (IMO)
    - Safety Officer (SO) and

- Liaison Officer (LO)

2. General Staff
   - Operations Section (OS)
   - Planning Section (PS)
   - Logistics Section (LS)

The features and significance of various forms of IRS in detail with reference to the Indian context have been discussed in National Disaster Management Guidelines- IRS, NDMA (2010), GOI publication.

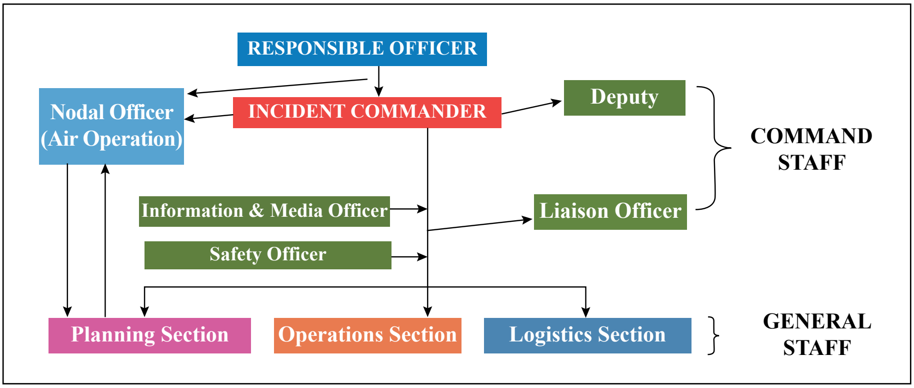


Fig.-6.3: Incident Response System (IRS) Organisation in India.

Source: National Disaster Management Guidelines- IRS, NDMA (2010), GOI

The IRS provides a participatory, well structured, fail safe, multi disciplinary, multi departmental and systematic approach to guide administrative mechanisms at all levels of the Government. It also provides scope for private sector, NGOs, CBOs, PRIs and communities to work seamlessly in the response activities. It has been implemented irrespective of size, location, type and complexity of the disaster in India like the ICS in USA.

Chapter 7

FOREST FIRE MANAGEMENT: ACTION PLAN

7.1 Introduction

The “disaster” brought by fire is though usually very small in geographical scales, yet its effects can spell devastation. The High Powered Committee (HPC) on Disaster Management, constituted on behalf of Prime minister in 1999, in its report submitted in October' 2002 identified forest fire as one of the 33 major types of disasters prevalent in the country enlisted under the category of "Accident Related Disasters".

In general there is a lack of concern about the detrimental impact of forest fire on society, mainly because the direct loss in terms of human lives and property damage (houses buildings, infrastructure etc.) is not much in comparison to other natural disasters like flood, cyclones, tsunami etc. However, if viewed in terms of intangible impact of forest fire, it is much more than that of other common disasters. The intangible loss due to forest fire includes impact on biodiversity, damage to watershed services, loss of soil fertility, increase in soil erosion and landslides etc. In the present day context forest fire is said to have developed a dangerous relationship with the global warming by adding Green House Gases. Albeit, the direct loss due to forest fire may not be much evident in economic terms, its long term impacts mainly on environment are more devastating and need serious efforts to manage forest fires in more effective manner.

7.2 Forest fire management -the key gaps

The analysis of secondary as well as primary information collected from various stakeholders i.e. forest officials, policy makers and implementers, district and local level administrative officials and staff, NGOs and CBOs representatives, and community through interaction, meetings, workshops etc. reveals that the forest fire management in India still lacks a systematic and scientific approach. The key gaps in the system are enlisted as –

a) Lack of appropriate policy and planning to tackle forest fire: Existing forest policy and other documents, including plans etc. lack clear guidelines for forest fire management.

b) Lack of proper institutional mechanism: In general forest fire management in the country is looked after by the forest department. There is no institutional mechanism available within the forest department, with sole responsibility of fire management. There is no separate establishment, even in higher fire prone regions to look after the forest fire.

c) Emphasis on response only: Though the forest departments are taking care of forest fire, but in general in present scenario, response is their main concern. Very less or negligible importance is given to other issues i.e. mitigation, preparedness, human resource development, providing scientific input, awareness creation, etc.

d) Lack of scientific approach to collect fire data and document it for forest fire management: The Forest Survey of India has recently started compiling forest fire data, however, at State level still there is not much sincere effort to collect and document these data and use it in research and planning. There is a need to collect and compile fire information related to area burnt, damage to forest crop, environment and wild life along with indirect loss to soil and water resources. This information is possible only thorough research and investigation. The forest department is also required to develop forest fire vulnerability map at beat level based on forest vegetation and past history.

e) Lack of funding: There is no provision for separate budget for forest fire management at State level in general. Forest fire management activities are usually carried out using forest protection fund. The State

Forest Departments are being financially supported under CSS Schemes; however this allocation is not sufficient to meet the challenges.

f) Not many initiatives to involve local community: The local community may play significant role in forest fire management, however, except few states; there is not much sincere efforts done in this regard. There is a need to involve community by providing them some initiatives to protect forest from fires.

g) Poor response to HRD and other capacity building initiatives: The forest fire in general is looked after by forest department; however, the officials and other staff of the forest departments in most of the cases are not trained and lack complete knowledge about forest fire and its behavior. The forest department training institutes are also not well equipped to provide training in the field of forest fire management. Though forest fire has been included in the list of disasters, but it is not being given due consideration in the training programmes being conducted at national and regional levels by disaster management training institutes.

h) Lack of proper contingency plans and rehearsals/ drills for fire suppression: There is need to develop proper contingency plans at beat level and update them every year before the fire season. The forest officials are also required to rehearse and practice the fire suppression exercise, involving community. However, these important components of forest fire management area not given much significance by the forest departments at state levels.

i) Poor early warning system: In the recent past there are many new developments in the field of detection of forest fire using various indicators and disseminating the information received to the field staff to take quick possible action. However, the techniques and methodology used by most of the forest departments are not showing changes. They still use the traditional methods to detect fires and disseminate information at field levels. There is an urgent need to revitalize the system using modern techniques and train the field staff to use them more effectively.

j) **Lack of preventive and preparedness measures to ensure better response:** Preparedness activities like clearing fire lines, removing the fuel (dead wood, leaves etc.), recruiting forest fire watchers, making the equipment ready to use, rehearsal and drill practices, reuniting fire protection committees etc. are very essential to prevent and prepare for any forest fire incident.

k) **Lack of coordination:** Coordination of forest departments with other agencies, whose support may be very important in forest fire management, is very poor. The sharing of information is very minimal, causing extreme gaps in knowledge sharing and using knowledge available for better forest fire management planning. There is lack of proper coordination among research institutes in forestry sector and the service provider. Similar situation exists for the data generating institutes and the user groups. The meteorological, fire, disaster management departments etc. may play significant role in forest fire management; however, the forest department coordination with these departments and their regional and local level offices is very poor; which prevents their valuable support in detecting/ identifying forest fire and its suppression.

7.3 Action plan for forest fire management

7.3.1 Forest Fire Management (FFM) in India is the mandate of the forest department, therefore it is imperative that forest department be capacitated at national, regional and local levels for making forest fire management system more effective and reduce the vulnerability of the Indian forest to fires. This needs a comprehensive action plan, incorporating various issues mentioned in the preceding text. With this background an Action Plan for Forest Departments is being suggested. The plan briefed in the succeeding text discusses various strategic areas, which need to be strengthened to make the department at different levels more capable in dealing the menace of forest fire in the country.

The plan has been developed through an interactive consultation process with a variety of key stakeholders on forest fire management within and outside the forest department.

7.3.2 Objective and purpose: The objective of the plan is to strengthen forest fire prevention, preparedness and response mechanism within the forest departments at various levels to deal with forest fire more effectively.

The plan of action will be used to:

- provide Forest Department with a framework to strengthen skills and increase capacities for FFM, enabling it to play effectively the role of a service provider in times of need;
- upgrade forest personnel's services to manage forest fire and reduce the risks
- contribute towards better coordination between key stakeholders at different levels, and in particular at local levels; and
- provide a framework within which to report performance and success.

7.3.3 Principles and philosophy: The plan is building on the vision of the Government of India policy statement on Forest Fire "Resolution No.13/52-F, dated the 12th May 1952", as well as New Forest policy, 1988. Within this context the Plan of Action includes:

- considers Forest Fire Management as an integral component of forest management planning,
- proposes management to upgrade the existing capacity of forest department in context of forest fire management.
- counts on partnerships with other stakeholders, including GOs, NGOs and CBOs, based on complementarities and mutual comparative advantages
- promotes the development of high professionalism in forest department on forest fire management.
- defines forest dwellers and community as the ultimate beneficiaries

7.3.4 Main result areas and entry points proposed for forest department interventions

Following entry points & main result areas (MRA) have been identified to strengthen Forest Department in respect of Forest Fire Management:

A. Institutional Setup for Forest Fire Management and stakeholders coordination

B. Policy framework

C. Assess and monitor forest fire risks and enhance sustainable application of warning systems

D. Knowledge management, capacity building and awareness generation

E. Technical options for forest fire management

A. Institutional Setup for Forest Fire Management (FFM) and Stakeholders coordination

At present there is no specific entity mandated within Forest Department to be responsible for fire risk reduction. The new role of Forest Department in FFM requires a well defined institutional set up, partnerships and networks.

Goal: The goal of this exercise is to ensure efficient institutional mechanism within Forest Department at various levels covering all aspects of FFM and coordinating with other stakeholders and role players.

Proposed strategies: What needs to be done?

- Institutionalize capacities for FFM in forest department.
- Develop a well defined institutional framework within forest department at national and state levels.

- Identify duties and responsibilities of various role players in the newly developed framework.

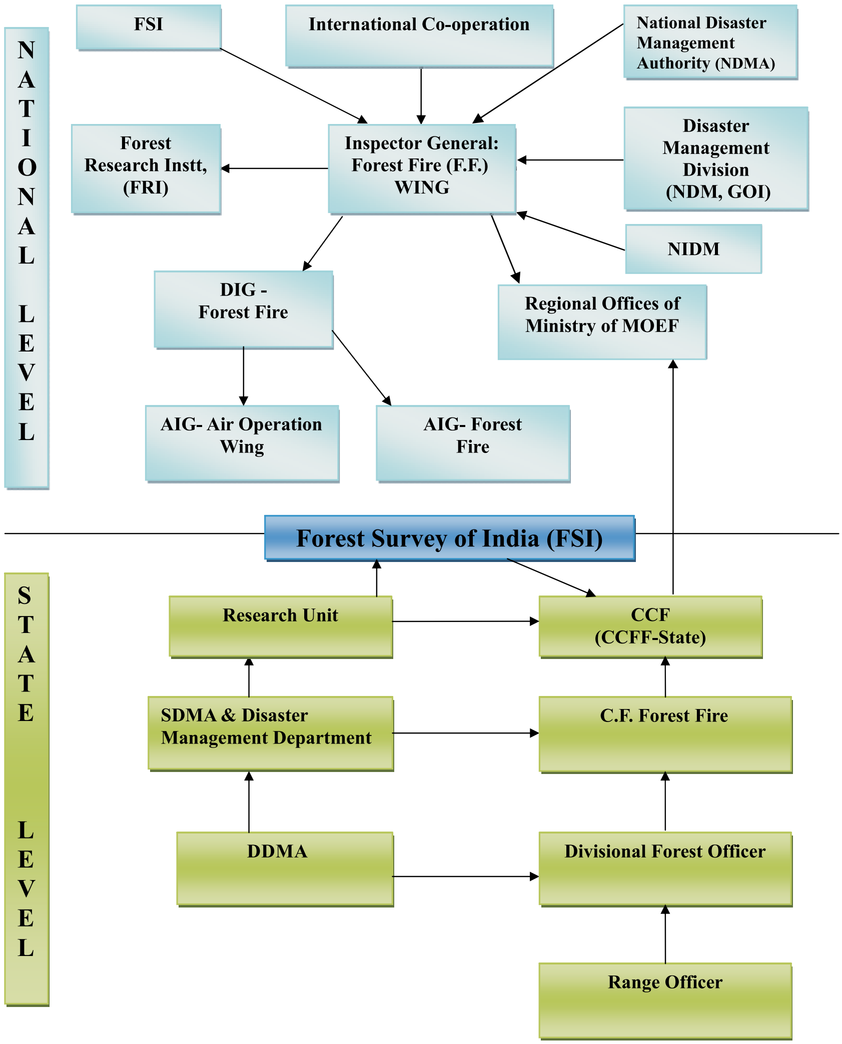
Keeping in view the severity of forest fire, the existing organizational structure, both at central and state level seems to be unsatisfactory. At present, the Forest Protection Division, headed by Inspector General (IG) level officer looks after the forest fire management work at National level with the cooperation of National Disaster Management Authority (NDMA), Disaster Management (NDM) Division of Government of India, National Institute of Disaster Management (NIDM), International organizations, Forest Survey of India (FSI), Forest Research Institute (FRI) and other regional offices of MoEF in the country. It is required that for effective dealing, a separate division be established for forest fire management, which could exclusively deal with the issue. Air Operation Wing, which has been wrapped up long back, may again be operated to tackle any unforeseen severe forest fire as that of 1995 in U.P. & H.P. Establishing such wing, though a costly affair, may also be useful for regular forest surveys and other associated activities. The wing is to be established at par with international standard to face any type of mis-happening. The air-craft or helicopters of the wing may also be utilized during other types of disasters like flood, earthquake etc. and may be very useful in supplying relief and rescue work without wasting time.

The Ministry of Environment & Forests (MoEF) has six regional offices in the country acting as coordinating offices with the state forest departments. These offices may be used to regulate forest fire management activities and for this separate wing may be established, exclusively to look after forest fire.

At state level, the forest fire management operations are looked after by regular forest staff, which is already over burdened. It will be appropriate, if a separate wing is established at state forest headquaters, headed by Chief Conservator of Forest level officer. This wing may work in collaboration with central level unit and provide all types of guidance, supervision etc. to all forest divisions of the state regarding forest fire management. In the lean period, the wing may work on data compilation, preparedness and mitigation measures. Training programmes for forest officials in fire fighting may also be organized at forest training schools. Sufficient fund provision is to be made for research and development and suitable projects may be sanctioned to state level research institutions to establish a strong data- base. The wing in collaboration with publicity division of the forest department may carry out effective awareness generation programmes among community through various IEC materials. In sensitive areas, Forest Fire Protection Committees may be established ensuring community participation.

During forest fire situation, this wing may work as Emergency Operation Centre (EOC) equipped with all communication and other facilities and may supervise and guide suppression work. In case of severe fire conditions, necessary assistance may be sought from State Disaster Management Authority (SDMA), Disaster Management Department at State level and at central level too, if required.

Depending upon the severity of the situation, similar arrangements may be made at Divisional level too. In fire prone divisions, a range office or Assistant Conservator of Forest (ACF) level officer may be deputed to look after all forest fire related activities of the division under the overall supervision of Divisional Forest Officer who can be assisted by District Disaster Management Authority (DDMA) and Range Officer (Fig.-7.1).



FRI = Forest Research Institute, Dehradum, IG = Inspector General,

FF. = Forest Fire, DIG = Deputy Inspector General, CF = Conservator of Forest

AIG = Asstt. Inspector General CCF = Chief Conservator of Forest, CCFF = Chief Conservator of Forest Fire, MoEF = Ministry of Environment & Forest, MoHA = Ministry of Home Affairs, DM = Disaster Management, GOI = Government of India, FSI = Forest Survey of India, SDMA = State Disaster Management Authority, DDMA = District Disaster Management Authority. NIDM=National Institute of Disaster Management.

Fig.-7.1: Proposed Institutional Framework for Forest Fire Management

B. Policy framework

Gaps to be addressed: The present policy/ planning documents do not give due consideration to Forest Fire Management. Revised key policy documents need to incorporate clear guidance about Forest Department and other stakeholders' role and contributions to FFM.

Goal: Revised policy and planning framework which includes FFM in more comprehensive and systematic manner

Proposed strategies

- Incorporate FFM issues in existing policy and planning documents in more systematic way: There is a need to incorporate clear cut guidelines and responsibilities of different role players to capacitate forest department and other stakeholders to manage forest fire in more systematic manner.
- Develop/ update forest fire manuals for field staff guiding them in simple way to detect/ report about and suppress forest fire.
- Incorporate FFM issues into other national / regional/ local level Disaster Risk Management programmes.

Though legal and policy framework exists in favour of fire protection, there is a need to strengthen and make it more practical and implementable. Existing acts though quite effective in forest and wild life conservation, do not give specific attention to forest fire management. As in more than 90 % cases forest fire is a human induced phenomenon, there is urgent need that some special Act be enacted to provide appropriate legal frame-work at national and state level both. Such Forest Fire Prevention Act will also strengthen the forest department in controlling and checking the illegal activities within or near the forest, leading to severe forest fires.

Subject to the enactment of suitable legislation, it is also necessary to evolve detail regulations to help in enforcement of the law. The existing codes/regulations/laws related to forest / wildlife protection and preservation are to be reviewed and suitable mechanism be evolved for their effective enforcement.

C. Assess and monitor forest fire risks and enhance sustainable application of warning systems

Gaps to be addressed: For an efficient and timely generation and transfer of information related to fire warning, it is necessary to enhance the capacity of forest management functionaries at various levels to generate timely warning and translate it into useful information for field staff and others. In addition there is need to prepare forest fire vulnerability maps based on past history and other variables like forest vegetation, weather conditions etc.

Goal: Increased capacity in generating relevant warning, increased understanding of warning systems by forest management functionaries and sustained support and coordination between the partner organizations

Proposed strategies

- Capacity building for the better use of early warning (technical efficiency & HRD): The forest officials need to be trained in using various indicators to get prior information about forest fire at the earliest time possible to take timely action. The forest department may be provided with necessary equipment in detecting forest fire at the earliest possible. Forest officials are to be trained in using various valuable information, available at national and international levels and translate it for local use.

- Strengthen collaboration with partner organizations involved in generating warning: Necessary collaboration is required with organisations involved in generating early warning about forest fire. Meteorological Departments and other national and international sources providing weather related information may be collaborated to get prior information about the temperature and rainfall situation- two main deciding factors for forest fires.

- Disseminate refined early warning product outputs at field levels in user- friendly way: The information available from different sources need to be dovetailed for making use at local level and necessary arrangement be made to disseminate this information at field level to make use in taking appropriate preventive, preparedness and response actions in time.
- Assess risks and prepare vulnerability and risk maps: To get prepared and take necessary preventive measures in time, it is necessary that the vulnerability/ risk maps be prepared of forest area, depending mainly on past history, climatic conditions and other human induced factors like population density, socio-economic conditions etc.

D. Knowledge management, capacity building and awareness generation

Gaps to be addressed: The knowledge of forest staff about FFM and the operational skills needed to implement fire prevention, preparedness and suppression activities need to be updated and upgraded. Therefore, awareness creation and capacity building on FFM are important keys. There is also a lack of knowledge and awareness about FFM at the community level. Forest department can play a crucial role in creating awareness and translating FFM policies into concrete field action.

Goal: Use knowledge and training to build a culture of innovation, safety and resilience, and institutionalize training on FFM for Forest Department, other role players and also at community levels.

Proposed strategies

- Enhance and maintain forest fire specific data base and enlist good practices: Forest fire specific data is very limited and if available is not very reliable. For most of the States, forest fire database is either not available and if available is very sketchy. This prevents in developing appropriate forest fire management planning and avails necessary resources to deal with the problem effectively. There is need to use modern scientific technique to collect, compile and document forest fire related data. To prepare effective strategy for forest fire management, it will be of significance that a robust and sound information data-base is prepared. The Forest Survey of India may be strengthened to collect and compile strategic information regarding forest fire at national level. Efforts be made at state level also to verify and enrich data network.

The data network may consist of:

- Information about climate, weather, etc.
- Historical documentation of forest fires, including location, type of vegetation, history, causes and other details.
- Number of forest fires, the area burnt and other adverse impact,
- Type of vegetation burnt, the flora and fauna of the area.
- Resources, including human resource available with the state govt. to detect and combat forest fire,
- Other area specific relevant information.

Various modern techniques including remote sensing may be used to collect and compile information related to forest fire. Remote sensing, GIS etc. can provide data base which can be used in forecasting and locating forest fire, its extent and appropriate technique to suppress the same.

- **Documentation of good practices:** At national and international levels there are number of good practices in forest fire management. There is need to document such practices in proper way so that good lessons be learnt from them and utilize them in making forest fire management system more effective and practical.
- **Systematically utilize outputs and knowledge created by**

other projects for FFM: Many forest fire management related projects have been implemented in different States in the past with national and international support. The learning and outputs of these projects will be of immense utility in making forest fire machinery at national and state level more effective.

- **Develop / up-date operational field manuals and guidelines for field staff with sufficient inputs on FFM:** Several state forest departments have developed field manuals for forest staff; however, such manuals in general lack proper guidelines to detect, communicate and techniques to suppress forest fires. There is need to upgrade such manuals and develop new ones in the states where such manuals are not available.

- **Enhance capacities of Forest Department training institutes & trainers:** Almost all the State Governments have their State Forest Training Institutes and Colleges. Forest Fire Management (FFM) needs to be an integral part of course curricula of these institutes. The course being taught in such institutes about the forest fire management should be updated and enriched with latest information about forest fire detection, suppression and rehabilitation.

- **Disaster Management Institutes:** For wider dissemination of forest fire management knowledge and capacitating more resources and skilled force, it is required that FFM may be included in the course curricula of the Disaster Management Institutes at national and regional levels. It will also help in better coordination among forest department and disaster management functionaries.

- **Increase community awareness:** Community participation has proved very useful in forest fire management. More people participation may only be ensured by making community aware about the significance of FFM and its benefit to community. Different methodology and IEC means may be used for it. As in more than ninety percent cases of forest fires are ignited by human being, community awareness may certainly play a significant role in preventing forest fire.

Box-7.1: Central Fire Management Research and Training Institute

The Food and Agriculture Organisation of United Nation (FAO) has run a special TCP programme in India during 1995, under which main emphasis was given to training in forest fire management. In its report, the FAO has strongly emphasized the need of "Central Fire Management Research and Training Institute" for foresters and public agencies to provide knowledge and skill for forest fire managers. The report had suggested establishing Fire Experiment Stations in representative regions to study various effects of fires in different eco-systems and provide extension services to the concerned states.

The establishment of such research centres and training institutes is very much needed to manage increasing forest fire incidences in the country in more systematic manner. Such national level" Central Fire Management Research and Training Institute" should be established as a centre of excellence in the area of creation of knowledge and its dissemination, including training and capacity building. The institute will suppose to conduct fundamental research in the field of forest fire management and creating data-base at national levels. It will also coordinate and cooperate with other institutions at national and international level. In the field of capacity building, the institute will help state government in preparing a team of trainees, who will further disseminate knowledge at state level institutes to other stakeholders viz. foresters, NGOs, JFM committee members etc. in the field of forest fire management.

***The basic objectives of such institute will be*:**

(1) Human Resource Development, covering multiple aspects of forest fire management and play a lead role in national level policy formulation.

(2) To establish an exhaustive national level information base on forest fire management policies, prevention mechanism and region wise preparedness and response plans.

(3) To coordinate various role players within the field of forest fire management, including government and non-government bodies, JFM committees, international organisations etc.

(4) To forge, promote and sustain international and regional partnership for launching joint projects and programmes in partnership.

(5)	To help state forest departments in strengthening their forest fire management systems and capacity building of various stake holders and role-players.
(6)	To help state forest department in preparing forest fire management plan and formulate policy in this regard.
(7)	Cooperation and experience sharing with various international organizations working in the field of forest fire management.

National forest fire knowledge network

A national forest fire knowledge network must be established to cover all dimensions of forest fire in the country. Such network must be tuned to the felt need of all stakeholders, including forest fire managers, policy makers and planners, decision makers, community etc. Central Level Forest Fire Management Institute may be handed over this responsibility. The network should exhibit a deep concern for its uses and knowledge packed should be available easily in time.

Necessary steps to be taken in this regard must include -

– All knowledge scattered in research institutions, universities etc. related to fire management must be compiled and form part of the network.

– Relevant projects related to forest fire research development may be sanctioned to universities/research institution to enrich the forest fire knowledge. The outcome of such research may be published and publicized for the benefit of all stake-holders.

– Traditional knowledge about forest fire management available with villagers and forest dwellers may be of significant use in forest fire management planning. Such knowledge may be collected and compiled in the form of compendium for further use.

– Necessary steps must be taken for national and international networking of knowledge on all spheres of forest fire management.

– The experts, researchers, the administration people and institutes having knowledge and experience in the field of forest fire management must be enlisted in the form of a directory, which must be updated from time to time.

E. Technical options to reduce underlying risks

Gaps to be addressed: A significant amount of technical options to assist Forest Department in increasing their resilience, preparedness and response capacities against forest fire are known and available at regional, national and international levels. However, the spectrum of available options is often not known or easily accessible. To make FFM more effective, it is of utmost significance that available options are systematically assessed, documented, shared and adapted to location specific needs in a participatory way.

Goal: Increased capacity to manage forest fire, involving community and using a variety of tested technical interventions.

Proposed strategies:

- **Stock taking:** Assess indigenous knowledge and techniques to detect and suppress forest fire, and upgrade it with scientific inputs and research: At local and regional levels there are many indigenous techniques and knowledge available, there is a need to compile and collect such information and upgrade it with scientific inputs and field tests to find its suitability in making forest fire system more effective, useful and less expensive.

- **Promote FFM related research and technology innovations:** The research institutes, involved in forestry and related research, may be pursued to do research in developing appropriate techniques in getting prior information about forest fire, detecting it, and suitable mechanism to suppress it.

- **Technology transfers at various levels and use it with location specific required modification, involving scientific inputs:** Already tested and found technologies useful in forest fire management may be shared at regional, national and international levels. The technologies so borrowed need to be further modified as per the location specific requirement.

GLOSSARY

aerial fuel

The standing and supported live and dead fuels not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, bark, lianas and other vines, moss and high brush. In general they easily dry out and may carry surface fires into the canopy.

agrosilvopastoral system

Land-use system in which woody perennials are used on the same land as agricultural crops and animals, in some form of spatial arrangement or temporal sequence. In fire management agrosilvopastoral systems are planned as fuelbreaks (particularly shaded fuelbreaks) to reduce fire risk by modifying understory vegetation and soil cover (cf. fuelbreak).

backfire

A fire spreading, or set to spread, into or against the wind: (1) As used in **fire suppression:** A fire set along the inner edge of a control line to consume the fuel in the path of a forest fire and/or change the direction of force of the fire's convection column (Note: doing this on a small scale and with closer control, in order to consume patches of unburned fuel and aid control-line construction (as in mopping-up) is distinguished as "burning out, firing out, clean burning"); (2) As used in **prescribed burning:** designation of fire movement in relation to wind.

backfiring

A form of indirect attack where extensive fire is set along the inner edge of a control line or natural barrier, usually some distance from the wildfire and taking advantage of indrafts, to consume fuels in the path of the fire, and thereby halt or retard the progress of the fire front.

biomass

(1) The amount of living matter in a given habitat, expressed either as the weight of organisms per unit area or as the volume of organisms per unit volume of habitat. (2) Organic matter that can be converted to fuel and is therefore regarded as a potential energy source. Note: Organisms include plant biomass (phytomass) and animal biomass (zoomass). (3) In fire science the term biomass is often used synonymously with the term "fuel" and includes both living and dead phytomass (necromass); the zoomass is usually excluded.

buffer strip / buffer zone

A fuel break on the form of a strip of land along or adjacent to roads, trails, watercourses and recreation sites, or between (separating) fuel complexes (cf. fuelbreak).

candle bark

Long streamers of bark decorticated from some gum-barked *Eucalyptus* species forming a firebrand responsible for long-distance spotting.

combustion

Consumption of fuels by oxidation, evolving heat and generally flame (neither necessarily sensible) and/or incandescence. Combustion can be divided into four phases: pre-ignition (or preheating), flaming, smouldering, and glowing.

control line

Comprehensive term for all constructed or natural barriers and treated fire edges used to control a fire.

dead fuel

Fuels with no living tissue in which moisture content is governed almost entirely by atmospheric moisture (relative humidity and precipitation), dry-bulb temperature, and solar radiation (cf. Live Fuel).

dispatcher

A person employed to receive reports of discovery and status of fires, confirm their locations, take action promptly to provide the firefighters and equipment likely to be needed for control in first attack, send them to the proper place and provide support as needed.

draped fuels

Needles, leaves, and twigs that have fallen from tree branches and have lodged on lower branches or brush. Comprises a part of aerial fuels.

drip torch

A hand-held apparatus for igniting prescribed fires and backfires by dripping flaming fuel on the materials to be burned. The device consists of a fuel fount, burner arm, and ignition source. Fuel used is generally a mixture of 65-80% diesel and 20-35% gasoline.

early burning

Prescribed burning early in the dry season, before the leaves and undergrowth are completely dry or before the leaves are shed; carried out as a precaution against more severe fire damage later in the fire season.

escaped fire

Fire which has exceeded or is expected to exceed initial attack capabilities or planned prescription.

fine fuel

Fast-drying dead fuels, generally characterized by a comparatively high surface area-to-volume ratio, which are less than 0.5 cm in diameter and have a timelag of one hour or less. These fuels (grass, leaves, needles, etc.) ignite readily and are consumed rapidly by fire when dry. (cf. flash fuel, medium fuel, heavy fuel).

fire behaviour

The manner in which fuel ignites, flame develops, and fire spreads and exhibits other related phenomena as determined by the interaction of fuels, weather, and topography. Some common terms used to describe fire behaviour include the following:

smouldering - A fire burning without flame and barely spreading.

creeping - A fire spreading slowly over the ground, generally with a low flame.

running - A fire rapidly spreading and with a well-defined head.

torching - Ignition and flare up of foliage of a single tree or a small clump of trees, usually from bottom to top (syn. candling).

spotting - A fire producing firebrands carried by the surface wind, a fire whirl, and/or convection column that fall beyond the main fire perimeter and result in spot fires. Note: Solid Mass or Ember Transport under Heat Transfer.

crowning - A fire ascending into the crowns of trees and spreading from crown to crown.

Note: Three classes of Crown Fire under Forest Fire (I).

fire belt

A strip, cleared or planted with trees, maintained as a firebreak or fuelbreak.

firebreak

Any natural or constructed discontinuity in a fuelbed utilized to segregate, stop, and control the spread of fire or to provide a control line from which to suppress a fire; characterized by complete lack of combustibles down to mineral soil (as distinguished from fuelbreak).

fire climax

A plant community at a stage of succession maintained by periodic fires.

fire control

All activities concerned with protection of vegetation from fire.

fire cycle

The number of years required to burn over an area equal to the entire area of interest.

fire danger

A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and fire impact; often expressed as an index.

fire danger rating

A component of a fire management system that integrates the effects of selected fire danger factors into one or more qualitative or numerical indices of current protection needs.

fire-dependent species

Plant and animal species which require regular fire influence which triggers or facilitates regeneration mechanisms, or regulates competition. Without the influence of fire these species would become extinct.

fire ecology

The study of the relationships and interactions between fire, living organisms, and the environment.

fire exclusion

Planned (systematic) protection of an ecosystem from any wildfire, including any prescribed fire, by all means of fire prevention and suppression in order to obtain management objectives (cf. fire control).

fire frequency

The average number of fires or regularly occurring fire events per unit time in a designated area.

fire hazard

(1) A fuel complex, defined by volume, type, condition, arrangement, and location, that determines the degree both of ease of ignition and of fire suppression difficulty; (2) a measure of that part of the fire danger contributed by the fuels available for burning. Note: Is worked out from their relative amount, type, and condition, particularly their moisture contents.

fire history

The reconstruction and interpretation of the chronological record, causes and impacts of fire occurrence in an ecosystem in relation to changes of past environmental, cultural and socio-economic conditions. Fire history evidence is based on analysis of charcoal deposits in soils, sediments, and ice, dendrochronology (fire scar analysis), historical documents, and fire reports.

fire information system

An information system designed to support fire management decisions. Advanced fire information systems integrate different sources of information required (e.g., vegetation conditions including fire history, topography, fire weather, fire behaviour models, real-or near-real time fire detection and monitoring data, fire management resources, infrastructures and pre-suppression information) on the base of a Geographic Information System (GIS) and allows real-time distribution or access via telecommunication.

fire interval or fire-return interval

The number of years between two successive fires documented in a designated area (i.e., the interval between two successive fire occurrences); the size of the area must be clearly specified.

fire management

All activities required for the protection of burnable forest and other vegetation values from fire and the use of fire to meet land management goals and objectives. It involves the strategic integration of such factors as a knowledge of fire regimes, probable fire effects, values-at-risk, level of forest protection required, cost of fire-related activities, and prescribed fire technology into multiple-use planning, decision making, and day-to-day activities to accomplish stated resource management objectives. Successful fire management depends on effective fire prevention, detection, and pre-suppression, having an adequate fire suppression capability, and consideration of fire ecology relationships.

fire management plan

(1) A statement, for a specific area, of fire policy and prescribed action; (2) The systematic, technological, and administrative management process of determining the organization, facilities, resources, and procedures required to protect people, property, and forest areas from fire and to use fire to accomplish forest management and other land use objectives (cf. fire prevention plan or fire Campaign, pre-suppression planning, pre-attack plan, fire suppression plan, end-of-season appraisal).

fire pre-suppression

Activities undertaken in advance of fire occurrence to help ensure more effective fire suppression; includes overall planning, recruitment and training of fire personnel, procurement and maintenance of firefighting equipment and supplies, fuel treatment, and creating, maintaining, and improving a system of fuel breaks, roads, water sources, and control lines.

fire prevention

All measures in fire management, fuel management, forest management, forest utilization and concerning the land users and the general public, including law enforcement, that may result in the prevention of outbreak of fires or the reduction of fire severity and spread.

fire protection

All actions taken to limit the adverse environmental, social, political, cultural and economical effects of wild land fire.

fire regime

The patterns of fire occurrence, size, and severity - and sometimes, vegetation and fire effects as well - in a given area or ecosystem. It integrates various fire characteristics. A natural fire regime is the total pattern of fires over time that is characteristic of a natural region or ecosystem. The classification of fire regimes includes variations in ignition, fire intensity and behaviour, typical fire size, fire return intervals, and ecological effects.

fire season

(1) Period(s) of the year during which wildland fires are likely to occur and affect resources sufficiently to warrant organized fire management activities; (2) a legally enacted time during which burning activities are regulated by State or local authority.

fire suppression

All activities concerned with controlling and extinguishing a fire following its detection. (Syn. Fire Control, Fire Fighting). Methods of suppression are:

direct attack - A method whereby the fire is attacked immediately adjacent to the burning fuel.

parallel attack - A method whereby a fireguard is constructed as close to the fire as heat and flame permit, and burning out the fuel between the fire and the fireguard.

indirect attack - A method whereby the control line is strategically located to take advantage of favourable terrain and natural breaks in advance of the fire perimeter and the intervening strip is usually burned out or backfired.

hot spotting - A method to check the spread and intensity of a fire at those points that exhibit the most rapid spread or that otherwise pose some special threat to control of the situation. This is incontrast to systematically working all parts of the fire at the same time, or progressively, in a step-by-step manner.

cold trailing - A method of determining whether or not a fire is still burning, involving careful inspection and feeling with the hand, or by use of a hand-held infrared scanner, to detect any heat source.

mop-up - The act of extinguishing a fire after it has been brought under control.

fire weather

Weather conditions which influence fire ignition, behaviour, and suppression. Weather parameters are dry-bulb temperature, relative humidity, wind speed and direction, precipitation, atmospheric stability, winds aloft.

flammability

Relative ease of igniting and burning of a given fuel under controlled conditions, with or without a pilot flame. Flammability of a fuel is characterised quantitatively by the ignition delay of a sample of fuel exposed to a normalised radiation source.

flash fuel

Fuels, e.g. grass, ferns, leaves, draped (i.e., intercepted when falling) needles, tree moss, and light slash, that ignite readily and are consumed rapidly by fire when dry; generally characterized by a comparatively high surface-to-volume ratio.

forest fire

I. Definition of forest fire

Any wildfire or prescribed fire that is burning in a forest, variously defined for legal purposes. The FAO Forest Resource Assessment 2000 aims towards global standardization of the terminology:

forest: Land with tree crown cover of more than 10 percent and area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 meters at maturity.

other wooded land: Land either with a crown cover of 5-10 percent of trees able to reach a height of 5 meters at maturity; or a crown cover of more than 10 percent of trees not able to reach a height of 5 meters at maturity; or with shrub or bush cover of more than 10 percent.

other land: Land with less crown cover, tree height, or shrub cover as defined under "Other wooded land". Indication is desired if recurring wildfires affect "Other land" by inhibiting regeneration to the "Forest" and "Other wooded land" categories.

I. Typology

ground fire: A fire that burns in the ground fuel layer (syn. Subsurface fire, below surface fire).

surface fire: A fire that burns in the surface fuel layer, excluding the crowns of the trees, as either a head fire, flank fire, or backfire.

crown fire: A fire that advances through the crown fuel layer, usually in conjunction with the surface fire. Crown fires can be classified according to the degree of dependence on the surface fire phase:

intermittent crown fire: A fire in which trees discontinuously torch, but rate of spread is controlled by the surface fire phase (syn. Passive Crown Fire).

active crown fire: A fire that advances with a well-defined wall of flame extending from the ground surface to above the crown fuel layer. Probably most crown fires are of this class. Development of an active crown fire requires a substantial surface fire, and thereafter the surface and crown phases spread as a linked unit (syn. Dependent Crown Fire).

independent crown fire: A fire that advances in the crown fuel layer only (syn. Running Crown Fire).

forest protection

That section of forestry concerned with the management of biotic and non-biotic damage to forests, arising from the action of humans (particularly unauthorized use of fire, human-caused wildfires, grazing and browsing, felling), natural wildfires, pests, pathogens, and extreme climatic events (wind, frost, precipitation).

fragmentation

The process of transforming large continuous vegetation or landscape patterns into smaller patches by disturbance. Natural agents of fragmentation are fire, landslides, windthrow, insects, erosion. Human-induced fragmentations include land use (e.g., agriculture, grazing, forestry), construction of residential areas, roads and other infrastructures. Fragmentation involves change of fire regimes due to alteration and discontinuity of fuels.

fuel

All combustible organic material in forests and other vegetation types, including agricultural bio-mass such as grass, branches and wood, infrastructure in urban interface areas; which create heat during the combustion process.

fuel accumulation

Process or result of build-up of those elements of a vegetation complex which are not subject to biological decay, reduction by fire, animal grazing and browsing, or harvest by humans; used in characterizing fuel dynamics between two fires and implications on fire behaviour.

fuel arrangement

The horizontal and vertical distribution of all combustible materials within a particular fuel type.

fuelbreak

Generally wide (20 - 300 meters) strips of land on which either less flammable native vegetation is maintained and integrated into fire management planning, or vegetation has been permanently modified so that fires burning into them can be more readily controlled (as distinguished from firebreak). In some countries fuelbreaks are integrated elements of agro-silvopastoral systems in which the vegetative cover is intensively treated by crop cultivation or grazing. Some fuelbreaks contain narrow firebreaks which may be roads or narrower hand-constructed lines. During fires, these firebreaks can quickly be widened either with hand tools or by firing out. Fuelbreaks have the advantages of preventing erosion, offering a safe place for firefighters to work, low maintenance, and a pleasing appearance (cf. control line, agrosilvopastoral system, buffer strip/zone).

fuel consumption

The amount of a specified fuel type or strata that is removed through the fire process, often expressed as a percentage of the pre-burn fuel weight (or fuel load). It includes available fuel plus fuel consumed after the fire front passes.

fuel loading

The amount of fuel present expressed quantitatively in terms of weight of fuel per unit area. This may be available fuel (consumable fuel) or total fuel, usually expressed as ovendry weight.

fuel management

Act or practice of controlling flammability and reducing resistance to control of wildland fuels through mechanical, chemical, biological, or manual means, or by fire, in support of land management objectives.

fuel reduction

Manipulation, including combustion, or removal of fuels to reduce the likelihood of ignition, the potential fire intensity, and/or to lessen potential damage and resistance to control.

greenbelt

(1) A fuelbreak maintained by the cultivation of strips of less flammable plants within a zone of high fire hazard, e.g., an irrigated,

landscaped, and regularly maintained fuelbreak put to some additional use (e.g., golf course, park, playground).

hazard reduction

Treatment of living and dead forest fuels to reduce the likelihood of a fire starting, and to lessen its damage potential and resistance to control (cf. Fuel Treatment). Activity gaining special importance in residential/wildland interface areas.

Incident Command System

A standardized on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries. (element of the Incident Command System [ICS]).

Integrated Forest Fire Management (IFFM)

Designation of fire management systems which include one or both of the following concepts of integration: (1) Integration of prescribed natural or human-caused wildfires and/or planned application of fire in forestry and other land-use systems in accordance with the objectives of prescribed burning; (2) Integration of the activities and the use of the capabilities of the rural populations (communities, individual land users), government agencies, NGOs, POs to meet the overall objectives of land management, vegetation (forest) protection, and smoke management including "community-based fire management" or CBFiM. The term IFFM is common for fire management approaches in less developed regions including forest and non-forest ecosystems. Note: In case of absence of forests in the area concerned the term *Integrated Fire Management* (IFM) is used instead (cf. prescribed burning).

ladder fuel

Fuels which provide vertical continuity between strata and allow fire to carry from surface fuels into the crowns of trees or shrubs (torching, crowning) and support continuation of crown fires (cf. crown fuel, ground fuel, and surface fuel).

late burning

Prescribed burning activities towards the end of the dry season.

low intensity fire

Fire which burns with a relatively low intensity, e.g. a prescribed surface fire as opposed to a high-intensity crown fire.

pre-attack plan

A plan detailing predetermined fire suppression strategy and tactics to be deployed following fire occurrence in a given land management unit. A pre-attack plan contains data on fuel types and topographic conditions including fuelbreaks, access routes and travel times, water supply sources, lakes suitable for skimmer aircraft, and existing heliports. It also includes information on existing and/or proposed locations for control lines (including the types and number of fire suppression resources that may be required and probable rates of fireguard construction, and possible constraints), base and line camps, helispots, and the priorities for construction and/or improvement of pre-suppression facilities (syn. pre-attack planning, pre-attack, cf. fire management plan, fire suppression plan, pre-suppression planning).

prescribed burning

Controlled application of fire to vegetation in either their natural or modified state, under specified environmental conditions which allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to attain planned resource management objectives (cf. Prescribed Fire). Note: This term has replaced the earlier term "Controlled Burning".

prescribed fire

A management-ignited wildland fire or a wildfire that burns within prescription, i.e. the fire is confined to a predetermined area and produces the fire behavior and fire characteristics required to attain planned fire treatment and/or resource management objectives. The act or procedure of setting a prescribed fire is called prescribed burning (cf.

Prescribed Burning). A wildfire burning within prescription may result from a human-caused fire or a natural fire (cf. prescribed natural fire, integrated forest fire management, wildfire).

prescribed natural fire

Naturally ignited fires , such as those started by lightning, which are further used to burn under specific management prescriptions without initial fire suppression and which are managed to achieve resource benefits under close supervision (cf. prescribed fire, wildfire).

prescription

Written statement defining the objectives to be attained as well as the conditions of temperature, humidity, wind direction and speed, fuel moisture, and soil moisture, under which a fire will be allowed to burn. A prescription is generally expressed as acceptable ranges of the prescription elements, and the limit of the geographic area to be covered.

rate of spread

The speed at which a fire extends its horizontal dimensions, expressed in terms of distance per unit of time (m/min or km/h) (syn. fire spread, cf. rate of area growth, rate of perimeter growth).

reclamation burning

Prescribed burning for restoration of ecosystem characteristics and functioning (cf. restoration).

rehabilitation

The activities necessary to repair damage or disturbance caused by wildfire or the wildfire suppression activity (cf. restoration).

residence time

(1) The time required for the flaming zone of a fire to pass a stationary point. (2) The time an emission component is in the air between emission and removal from the air or change into another

chemical configuration.

residential / wildland interface

The transition zone between residential areas and wildlands or vegetated fuels (cf. Urban, Urban/Wildland Interface, Wildland, Wildland Fire, Rural Urban Interface).

restoration

Restoration of biophysical capacity of ecosystems to previous (desired) conditions. Restoration includes rehabilitation measures after fire, or prescribed burning where certain fire effects are desired (cf. rehabilitation, reclamation burning).

ring fire

A fire started by igniting the full perimeter of the intended burn area so that the ensuing fire fronts converge toward the centre of the burn.

risk

(1) The probability of fire initiation due to the presence and activity of a causative agent. (2) A causative agent.

rural fire protection

Fire protection and firefighting problems that are outside of areas covered by municipal Fire & Rescue Services and its Fire Ordinance; these areas are usually remote from public water supplies and require all terrain vehicles to reach.

serotiny

Storage of seeds in closed seed containers in the canopy of shrubs and trees. For instance, serotinous cones of Lodgepole Pine do not open until subjected to temperatures of 45 to 50°C, causing the melting of the resin bond that seals the cone scales.

slash

Debris (fuels) resulting from natural events (wind/ fire) or human activities like forest harvesting.

slash disposal

Treatment of slash to reduce fire hazard or for other purposes (cf. Fuel Management).

smoke haze

An aggregation (suspension) in the atmosphere of very fine, widely dispersed, solid or liquid particles generated by vegetation fires giving the air an opalescent appearance.

smoke management

The application of knowledge of fire behaviour and meteorological processes to minimize air quality degradation during prescribed fires.

spot fire

(1) Fire ignited outside the perimeter of the main fire by a firebrand (by flying sparks or embers transported by air currents, gravity, or fire whirls). (2) A very small fire which jumped over the fireline, that requires little time and resources to extinguish by air currents, gravity, and/or fire whirls (cf. Long-Range Spotting).

stand replacement fire

Fire which kills all or most living overstory trees in a forest and initiates secondary succession or regrowth.

underburning

Prescribed burning with a low intensity fire in activity-created or natural fuels under a timber canopy.

urban / wildland interface

The transition zone (1) between cities and wildland (cf. urban, wildland, wildland fire), (2) where structures and other human development meets undeveloped wildland or vegetative fuels (syn. residential/wildland interface, wildland/urban interface, rural urban interface).

values-at-risk

Natural resources, developments, or other values that may be jeopardized if a fire occurs.

wilderness

(1) A wild, uncultivated, uninhabited region, vegetated and non-vegetated. (2) Area of remarkable natural beauty and ecological diversity. (3) Area established to conserve its primeval character and influence for public enjoyment, under uncultivated conditions, in perpetuity.

wildfire

(1) Any unplanned and uncontrolled wildland fire which regardless of ignition source may require suppression response, or other action according to agency policy. (2) Any free burning wildland fire unaffected by fire suppression measures which meets management objectives (cf. wildland, wildland fire, prescribed natural fire, prescribed fire).

wildland

Vegetated and non-vegetated land in which development is essentially non-existent, except for roads, railroads, powerlines, and similar transportation facilities; structures, if any, are widely scattered. In fire management terminology this general term includes all burnable vegetation resources including managed forests and forest plantations (cf. residential/wildland interface, wildfire).

wildland fire

Any fire occurring on wildland regardless of ignition sources, damages or benefits (cf. wildland, wildfire, residential/wildland interface).

Source: FAO terminology (FAO 2003).

For additional fire terms please refer to the revised FAO Wildland Fire Management Terminology. FAO Forestry Paper 70. FAO, Rome 2003.

FOREST FIRE: SAFETY TIPS

Unlike many natural disasters, most wildfires are caused by people—and can be prevented by people, too. Meteorologists are not yet able to forecast wildfire outbreaks, so people in fire-prone areas should plan ahead and prepare to evacuate with little notice. The safety tips will help keep you and the forests safe. Here are some tips on how to prevent wildfires and what to do if you're caught in the middle of one.

How to Prevent a Wildfire

- Contact to your local fire department or the park service if you notice an unattended or out-of-control fire.
- Never leave a campfire unattended. Completely extinguish the fire—by dousing it with water and stirring the ashes until cold—before sleeping or leaving the campsite.
- When camping, take care when using and fueling lanterns, stoves, and heaters. Make sure lighting and heating devices are cool before refueling. Avoid spilling flammable liquids and store fuel away from appliances.
- Do not discard cigarettes, matches, and smoking materials from moving vehicles, or anywhere on park grounds. Be certain to completely extinguish cigarettes before disposing of them.
- Follow local ordinances when burning yard waste. Avoid backyard burning in windy conditions, and keep a shovel, water, and fire retardant nearby to keep fires in check. Remove all flammables from yard when burning.

Evacuation Tips

- If advised to evacuate, do so immediately.
- Know your evacuation route ahead of time and prepare an evacuation checklist and emergency supplies.
- Wear protective clothing and footwear to protect yourself from flying sparks and ashes.

Before You Leave, Prepare Your House

- Remove combustibles, including firewood, yard waste, barbecue grills, and fuel cans, from your yard.
- Close all windows, vents, and doors to prevent a draft.
- Shut off natural gas, propane, or fuel oil supplies.
- Fill any large vessels—pools, hot tubs, garbage cans, or tubs—with water to slow or discourage fire.

If Caught in a Wildfire

- Don't try to outrun the blaze. Instead, look for a body of water such as a pond or river to crouch in.
- If there is no water nearby, find a depressed, cleared area with little vegetation, lie low to the ground, and cover your body with wet clothing, a blanket, or soil. Stay low and covered until the fire passes.
- Protect your lungs by breathing air closest to the ground, through a moist cloth, if possible, to avoid inhaling smoke.

Fire Safety Tips for Kids

Ways you can prevent wildfires

There are many ways that you can help to prevent wildfires.

NEVER leave a campfire unattended.

- Don't start a fire outdoors unless conditions will allow the fire to burn safely from when it is started until it is put out.
- Always have adult supervision when you are around a fire.
- Build a campfire on rocks or sand.
- Don't put rocks around a campfire. When you go to put it out, the rocks can hide small pieces of wood that are still burning.
- Keep your campfire small and under control.
- Don't build campfires underneath trees.
- Always leave a bucket of water and a shovel near a campfire.
- Make sure your fire is out before you leave it.
- Have an adult put out the campfire completely.

Here is the correct way to put out a campfire (have an adult do this)

1. Pour lots of water on the campfire
2. Stir the ashes with a stick
3. Pour more water over top of it

Repeat these three steps until…

1. The ashes don't hiss anymore
2. Everything looks wet
3. No more smoke comes from the ashes

Have an adult hold their hand over the ashes to see if they are still warm. If they are, stir and pour more water on them until they are cold.

NEVER play with matches or fireworks. Put out smoking materials thoroughly.

If you see a fire burning out of control tell an adult immediately.

- **Please don't be careless. Many of the wildfires started each year are because of humans being careless.**
- **Do your part to protect the home of the animals and trees that live in the forest.**
- **Do your part to prevent wildfires by learning these safety rules and letting**

General Forest fire safety tips for Family

Before a Wildfire

The following are things you can do to protect yourself, your family and your property in the event of a fire.

- To begin preparing, you should build an emergency kit and make a family communications plan.
- Design and landscape your home with wildfire safety in mind. Select materials and plants that can help contain fire rather than fuel it.
- Use fire-resistant or noncombustible materials on the roof and exterior structure of the dwelling, or treat wood or combustible material used in roofs, siding, decking or trim with fire-retardant chemicals evaluated by a nationally recognized laboratory.
- Plant fire-resistant shrubs and trees. For example, hardwood trees are less flammable than pine, evergreen, eucalyptus or fir trees.
- Regularly clean roof and gutters.
- Inspect chimneys at least twice a year. Clean them at least once a year. Keep the dampers in good working order. Equip chimneys and stovepipes with a spark arrester that meets the requirements

of National Fire Protection Standard. (Contact your local fire department for exact specifications.)

- Use 1/8-inch mesh screen beneath porches, decks, floor areas, and the home itself. Also, screen openings to floors, roof and attic.
- Install a dual-sensor smoke alarm on each level of your home, especially near bedrooms; test monthly and change the batteries at least once each year.
- Teach each family member how to use a fire extinguisher (ABC type) and show them where it's kept.
- Keep handy household items that can be used as fire tools: a rake, axe, handsaw or chain saw, bucket and shovel.
- Keep a ladder that will reach the roof.
- Consider installing protective shutters or heavy fire-resistant drapes.
- Clear items that will burn from around the house, including wood piles, lawn furniture, barbecue grills, tarp coverings, etc. Move them outside of your defensible space.

Plan Your Water Needs

- Identify and maintain an adequate outside water source such as a small pond, cistern, well, swimming pool, or hydrant.
- Have a garden hose that is long enough to reach any area of the home and other structures on the property.
- Install freeze-proof exterior water outlets on at least two sides of the home and near other structures on the property. Install additional outlets at least 50 feet from the home.

- Consider obtaining a portable gasoline powered pump in case electrical power is cut off.

After a Wildfire

The following are guidelines for different circumstances in the period following a fire:

- Go to a designated public shelter if you have been told to evacuate or you feel it is unsafe to remain in your home.
- If you are with burn victims, or are a burn victim yourself, seek help immediately; cool and cover burns to reduce chance of further injury or infection.
- If you remained at home, check the roof immediately after the fire danger has passed. Put out any roof fires, sparks or embers. Check the attic for hidden burning sparks.
- For several hours after the fire, maintain a "fire watch." Re-check for smoke and sparks throughout the house.
- If you have evacuated, do not enter your home until fire officials say it is safe.
- If a building inspector has placed a color-coded sign on the home, do not enter it until you get more information, advice and instructions about what the sign means and whether it is safe to enter your home.
- If you must leave your home because a building inspector says the building is unsafe, ask someone you trust to watch the property during your absence.
- Use caution when entering burned areas as hazards may still exist, including hot spots, which can flare up without warning.
- If you detect heat or smoke when entering a damaged building, evacuate immediately.

- If you have a safe or strong box, do not try to open it. It can hold intense heat for several hours. If the door is opened before the box has cooled, the contents could burst into flames.
- Avoid damaged or fallen power lines, poles and downed wires.
- Watch for ash pits and mark them for safety and warn family and neighbors to keep clear of the pits also.
- Watch animals closely and keep them under your direct control. Hidden embers and hot spots could burn your pets' paws or hooves.
- Follow public health guidance on safe cleanup of fire ash and safe use of masks.
- Wet debris down to minimize breathing dust particles.
- Wear leather gloves and heavy soled shoes to protect hands and feet.
- Cleaning products, paint, batteries and damaged fuel containers need to be disposed of properly to avoid risk.
- Discard any food that has been exposed to heat, smoke or soot.
- Do NOT use water that you think may be contaminated to wash dishes, brush teeth, prepare food, wash hands, make ice or make baby formula.
- Remain calm. Pace yourself. You may find yourself in the position of taking charge of other people. Listen carefully to what people are telling you, and deal patiently with urgent situations first.

During a Wildfire

If advised to evacuate, do so immediately. Take your disaster supply kit, lock your home and choose a route away from the fire hazard. Watch for changes in the speed and direction of the fire and smoke. Tell someone when you left and where you are going.

If you see a wildfire and haven't received evacuation orders yet, call 101. Don't assume that someone else has already called. Describe the location of the fire, speak slowly and clearly, and answer any questions asked by the dispatcher.

If you are not ordered to evacuate, and have time to prepare your home, Forest Department recommends you to take the following actions:

- Arrange temporary housing at a friend or relative's home outside the threatened area in case you need to evacuate.
- Wear protective clothing when outside – sturdy shoes, cotton or woolen clothes, long pants, a long-sleeved shirt, gloves and a handkerchief to protect your face.
- Gather fire tools such as a rake, axe, handsaw or chainsaw, bucket and shovel.
- Close outside attic, eaves and basement vents, windows, doors, pet doors, etc. Remove flammable drapes and curtains. Close all shutters, blinds or heavy non-combustible window coverings to reduce radiant heat.
- Close all doors inside the house to prevent draft. Open the damper on your fireplace, but close the fireplace screen.
- Shut off any natural gas, propane or fuel oil supplies at the source.
- Connect garden hoses to outdoor water faucet and fill any pools, hot tubs, garbage cans, tubs or other large containers with water.
- Place lawn sprinklers on the roof and near above-ground fuel tanks. Leave sprinklers on and dowsing these structures as long as possible.
- If you have gas-powered pumps for water, make sure they are fueled and ready.

- Place a ladder against the house in clear view.
- Disconnect any automatic garage door openers so that doors can still be opened by hand if the power goes out. Close all garage doors.
- Place valuable papers, mementos and anything "you can't live without" inside the car in the garage, ready for quick departure. Any pets still with you should also be put in the car.
- Place valuables that will not be damaged by water in a pool or pond.
- Move flammable furniture into the center of the residence away from the windows and sliding-glass doors.
- Turn on outside lights and leave a light on in every room to make the house more visible in heavy smoke.

Source: http://www.ready.gov/wildfires.

Forestry Firefighting Tools

Wildfires burn hundreds of thousands of acres every year. While aircraft tankers launch an assault from the air, firefighters attack fires on the ground. Crack firefighting teams trained by the Forest Departments are on standby throughout the fire season to be deployed at a moment's notice anywhere they're needed. They're often airlifted to remote locations where vehicles are unable to travel, and forced to rely on firefighting hand tools.

Firefighter Shovel and Broom

A firefighter's shovel has a smaller blade and longer handle than a regular garden shovel and the head is angled forward to facilitate scooping and scraping dirt. The edges of a fire shovel blade are sharpened up to one and a half inches of the top of the blade. The shovels are used to

scrape vegetation off the ground and throw dirt onto the flames.

Pulaski, Axes and Hoes

A pulaski is a tool with a wooden handle and both an axe head and hoe at the end. Used for clearing vegetation, the axe head is used to cut thick roots and the hoe is use to dig them away and clear the ground. Forest firefighters may also carry a single or double bit or brush axe and a regular hoe. A bush hook looks like an axe, but has a hook for pulling and cutting vegetation at the same time.

Rakes and Brooms

A McLeod rake is a thick-toothed rake with a wide hoe on the back to remove needle, leaf and bark litter. A council rake is sharpened and used to rake burning material and cut small shrubs away at the same time. A fire rake is similar to a leaf rake with long steel teeth. A firefighting broom and council fire swatter flap are made of non-combustible material for pushing flaming embers off a cleared area.

Fuel Bottles and Firing Devices

Wildfire fighters may carry fuel bottles on their belts for use with chainsaws and other mechanical tools. They also keep "fusees," firing devices used to set back-burning fires and burn small isolated areas to help contain the fire. A drip torch, used in damp conditions when fusees won't fire, can be used to spread gasoline and diesel fuel onto the vegetation.

ANNOTATED BIBLIOGRAPHY

Articles, Papers & Reports

- **Wink, R.L., and H.A. Wright. 1973. Effects of fire on an Ashe juniper community. Journal of Range Management. 26(5):326-329.**

In an Ashe juniper community, a minimum of 1000 kg/ha of fine fuel was needed to carry a fire to kill juniper seedlings and burn piles of dozed juniper. Grasses recovered quickly and soil erosion was minimal when burned during a wet winter and spring. During a dry winter and spring, however, burning increased drought stress on plants, reduced herbaceous yields, and exposed soil to wind and water erosion for a long period of time when soil moisture was low.

- **Mutch, R.W., 1976. Fire management and land use planning today: tradition and change in the Forest Service. *Western Wildlands* 3(1): 13-19.**

The author discusses the necessity of changing from fire control to fire management, in which fire management is integrated with fire ecology principles and land-use planning requirements. The author presents traditional approaches and current trends by using a survey of fire management personnel, which shows that managers are interested in natural fire management, while also aiming to improve suppression ability. The author points out that wildland fire should be regarded as an ecological process as well as a management tool. The author also argues that successful fire management may be achieved by informing the public, applying research results, and increasing understanding of the role of both fire prevention and prescribed burning in total fire management.

- **Stankey, G.H. 1976. *Wilderness Fire Policy: An Investigation of Visitor Knowledge and Beliefs,* Research Paper INT-180, USDA Forest Service, Intermountain Forest and Range**

Experiment Station, Ogden, UT.

The author conducted a research survey of visitors to the Selway-Bitterroot Wilderness in Idaho and Montana to investigate knowledge and beliefs about wilderness fire policies. The survey indicates that while the majority favored fire suppression, a substantial minority (34%) supported the more natural role of fire. The results also demonstrate that most respondents had a fairly low degree of understanding regarding the role of fire in forests, but as their level of knowledge increased, so did the likelihood that they would support the more natural role of fire. Several management actions are recommended that would enhance public support for a modification of wilderness fire suppression policies.

- **Lee, R.G. 1977. Institutional change and fire management, in *Proceedings of the Symposium on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems, Palo Alto, CA, August 1-5, 1977,* HA Mooney and CE Conrad, ed. General Technical Services Report, WO; 3, USDA Forest Service, Washington, DC.**

The author examines the development of wildfire control by social organization. The author describes three types of institutions: local volunteers, fire control bureaucracies, and possible new organizations that integrate fire, fuel, and land management.

- **Lee, RG, and TM Bonnicksen. 1978. *Brushland Watershed Fire Management Policy in Southern California: Biosocial Consideration.* Water Resources Center, University of California, Davis.**

The authors present a biosocial system model that can be useful for analysis on brush-land fire management policy. The author addresses two advantages of this model. First, the biosocial system model enhances examination of fire management policy from various disciplines. The authors argue that environmental policy should be tested within different perspectives. The biosocial system model provides systematic models for understanding various environmental issues. Second, the model permits managers and researchers to anticipate how a fire control agency will adjust to possible changes in its social environment. This model also makes it possible to anticipate organizational responses to major changes in the biophysical environment. The author describes the actual application of this model to San Diego County's brushland fire management.

- **Lee, R.G. 1979. *Organizational Adaptation and Wildfire Control, Association Paper 027 Rural Sociological Society (RSS),***

The author examines organized efforts to control wildfire in the United States by using methods for studying social history. Records and documents reveal that fire-control practices developed and changed in response to institutionalized actions in the larger society. The author points out that informal community organization had institutionalized control over fire by using it as a tool for clearing land and protecting valued resources and improvements before government assumed jurisdiction over wildfires. The nationalization of forest-management policy that accompanied the Progressive Era led to the formation of formal social organizations that institutionalized the exclusion of fire from the forest environment. This commitment to fire exclusion persisted de-spite scientific evidence and experience showing that fire was beneficial as well as destructive to valued resources. Organizations periodically re-legitimized their commitment to fire exclusion by reenacting traditional heroic myths of control over fire, which was symbolized as a demonic power. Rationalization of the institutional environment associated with the emergence of an advanced-industrial society caused fire control organizations to reconstitute legitimacy through adopting new practices and enacting myths of rationality that empower professional agents to pursue multipurpose fire management. Results from this analysis support the theory that organizations adapt to changing environmental conditions by ceremonially enacting practices institutionalized in their social environment.

- **Wright, H.A., and A.W. Bailey. 1982. Fire Ecology: United**

States and Southern Canada. John Wiley and Sons, New York. 501p.

Wright and Bailey present a historical perspective on the role of fire in the major ecosystems of the United States and southern Canada. They describe the impact of fire on plant species, particularly native plant communities, with detailed discussion from an ecological perspective. The book highlights the potential role that fire can play in managing ecosystems for both plants and animals.

- **Donoghue, L.R. 1983. *The American Legal System and its Relations to the USDA Forest Service and Human-Caused Wildfires.* MS thesis, Michigan State University, East Lansing.**

The author points out that information and education programs have helped reduce the occurrence of human-caused wildfires, but that agencies should also offer law enforcement education programs, which could significantly reduce fire ignitions. The author argues that whether law enforcement is beneficial depends in part on what managers know about the legal system and how they use it to prevent human-caused wildfires. The author examines the American legal system, defining and describing its major components and interactions. The study results illustrate several findings: (1) increasing a state's legal efforts against wildfire violations decreases that state's wildfires; (2) law enforcement efforts differ significantly in the North and South; (3) legal efforts have a greater impact on incendiary and debris-burning fires than on other fire causes; (4) compared to the South, legal efforts in the North have a greater impact on combined incendiary and debris-burning fires; and (5) law enforcement in both regions affects the occurrence of incendiary fires more than it affects debris-burning fires.

- **Cortner, H.J., M.J. Zwolinski, E.H. Carpenter, and J.G. Taylor. 1984. Public support for fire management policies. *Journal of Forestry* 82(6): 359—361.**

The authors conducted a telephone survey to investigate the public's perception and acceptance of prescribed fire policy in the Tucson, AZ, metropolitan area. The survey showed that the public recognized that forest fires could be beneficial as well as harmful. Public acceptance and understanding of the purposes and benefits of fire management were high. The authors suggest that the public was generally well-informed, and that entirely new approaches to fire education were not necessary, although modifications (pertaining to local knowledge and conditions) are recommended. Finally, the authors recommend that public education focus on local forest conditions as well as on local knowledge and acceptance of fire management.

- **Taylor, J.G., and T.C. Daniel. 1984. Prescribed fire: public education and perception.** ***Journal of Forestry*** **82(6): 361-365.**

The authors conducted a survey to investigate the public's acceptability of prescribed burning. The survey respondents were residents in Tucson, Arizona, who rated slides of forest scenes. The respondents also read brochures about fire effects and took a post test that measured both knowledge and attitudes about fire. The survey results showed that ratings of scenic quality were improved by light fires, but were diminished by severe burns. Acceptability ratings for recreation depended on what type of activity people engaged in. For instance, campers expressed the greatest sensitivity to fire effects. The survey also showed that reading the brochures increased respondents' knowledge and tolerance of fire, but did not affect their ratings of scenic or recreational quality. Overall, the results indicated that the respondents support prescribed burning.

- **McCool, S.F., and G.H. Stankey, 1985.** ***Visitor Attitudes Toward Wilderness Fire Management Policy: 1971-84.*** **Research Report INT-357, USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.**

The authors conducted a survey of visitors to the Selway-Bitterroot Wilderness, Montana, to investigate knowledge of fire effects and attitudes toward fire management in a wilderness setting. Visitors were more knowledgeable about fire effects and were more supportive of fire management, rather than fire suppression, than were respondents to a similar study in 1971. The results also demonstrate that about 50% of the visitors felt that manager-ignited fires would be beneficial to wilderness, about 16% felt these fires would be detrimental, and about 33% were unsure.

- **McDowell, H. 1985. Fire management policies and programs: an industry view, pp. 53— 54 in *Proceedings, Symposium and Workshop on Wilderness Fire, Missoula, MT, November 15-18, 1983,* JM Lotam, BM Kilgore, WC Fischer, and RW Mutch, ed. General Technical Report INT-182, USDA Forest Service, Intermountain Forest and Range Experi-ment Station, Ogden, UT.**

The author points out that the recreation industry may be most influenced by wilderness fire activities. This industry includes guides, packers, and outfitters. Current wilderness fire management programs and policies do not seriously affect forest industries, miners, and grazers. However, according to the author, many of these industries are also involved as wilderness users and will maintain their interest in their management on a personal basis.

- **Gardner, P.D., H.J. Cortner, and J.A. Bridges. 1985. Wildfire: managing the hazard in urbanizing areas. *Journal of Soil and Water Conservation* 40(4): 318—321.**

The authors argue that although a number of policy responses have been suggested to reduce the impacts of wild land fires on the physical environment and human activities, how acceptable they are to the general public is another question. This is because the wild land fire hazard depends not only on the physical environment, but on human interactions with the physical environment as well. The authors present five classes of mitigation: (1) reducing the intensity, frequency, or magnitude of the hazardous event by physically changing the environment; (2) limiting exposure to the hazard through local and state land-use regulations; (3) reducing the vulnerability of structures and people; (4) increasing homeowners' awareness of the wild land fire through education; and (5) taking care of individuals who are negatively impacted by wild land fire. The authors suggest that the implementation of any policy option depends not only on the expertise of the natural resource manager or local planner, but also on the public's receptivity.

- **Gardner, P.D., HJ Cortner, K.F. Widaman, and K.J. Stenberg, 1985. Forest-user attitudes toward alternative fire management policies. *Environmental Management* 9 (4): 303—311.**

The authors point out that the formulation and implementation of new fire policies in the national forests depend upon public acceptance. A national survey of organized groups of forest users indicates that, contrary to the concern of many forest managers, considerable support exists for flexible fire suppression policies. Forest users are also willing to accept the risk associated with the manager's use of prescribed fire. However, survey results demonstrate intergroup differences on the acceptability of prescribed fire management. The authors discuss this variation in relation to a number of socioeconomic variables, general fire knowledge, specific knowledge about the effects of low-intensity fires, and risk preference levels.

- **Saveland, J.M. 1985. Risk in fire management, pp. 85—97 in *Fire Management: The Challenge of Protection and Use, Proceedings of a Symposium, Logan, UT, April 17-19, 1985,* JN Long, ed. Department of Forest Resources, Utah State University, Logan.**

The author points out that the amount of wildfire protection and prescribed fire use is determined by an individual decision maker's propensity for accepting risk. Risk assessment consists of risk identification, risk estimation, and risk evaluation. The major risk that concerns fire management is identified as the threat of catastrophic fire. The author indicates that estimation of risk consists of determining the probability of occurrence and the magnitude of various events. According to the author, decision theory and utility theory are useful tools for risk estimation. Risk averse, risk neutral, and risk taker profiles are shown by using a utility function. Cost effectiveness and cost-benefit models are presented as means to evaluate how much risk reduction, if any, is necessary. The author presents the cost effectiveness model to show the tradeoff between the costs of risk reduction and the amount of risk reduced. A decrease in funding implies an increase in risk. The author concludes that a combination of prescribed fire use and wildfire protection will achieve a cost-effective level of risk and associated benefits that are optimum.

- **Taylor, J.G., and T.C. Daniel. 1985. Perceived scenic and recreational quality of forest burn areas, pp. 398^06 in *Proceedings, Symposium and Workshop on Wilderness Fire, Missoula, M..T, November 15-18, 1883,* J.M. Lotan, B.M. Kilgore, W.C. Fischer, and R.W. Mutch, ed. Research Paper INT-182, US DA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.**

The authors conducted a study to compare (1) public perception of scenic quality after both severe and light fires and (2) effects of both types of fires on perceptions of recreational acceptability. The study also aimed to construct and test documents for educating and informing the public about effects of fire, and to test the effects of fire information levels on attitudes toward fire. The results showed that the public's perception of recreational acceptability was more adversely affected by severe fire than by light fire. However, the study also demonstrates that perceptions of the effect of fire vary, depending upon types of recreation activities. Overall, the public supports prescribed burning. The authors point out that prescribed fires (light) should enhance perceived scenic quality for three or more years, but they may have some adverse effects on camping. Severe forest fires should be expected to cause significant deterioration in scenic quality and recreational acceptability for a prolonged time; camping and picnicking are essentially precluded in burned areas.

- **Carpenter, E.H., J.G. Taylor, H.J. Cortner, P.D. Gardner,**

M.J. Zwolinski, andT.C. Daniel., 1986. Target audiences and content for forest fire information programs. *Journal of Environmental Education* 17(3): 33-42.

The authors present data from three independent surveys on the public attitude toward prescribed burning policy. The survey results indicate a high level of support for fire management practices initiated and controlled by the manager. The results also show that the public can differentiate between situations that result in beneficial effects and those that have harmful effects, suggesting a sophisticated understanding of fire management. Additional analysis reveals the extent to which socio-demographic characteristics and beliefs about the effects of fire in forest environments can predict public approval. The authors suggest that the content of fire information programs should be directed toward a broad, cross-section of adults, and should directly address factors such as fire size, intensity, and impact upon animals, which can cause emotional concern. The authors also recommend that fire information programs clearly describe situations where fire should be suppressed, as well as where fire can be used to achieve beneficial management objectives; public acceptance of fires increases as more information is given and as control is specified. Finally, the authors suggest that fire information programs include discussions on the beneficial effects that can be realized from wildfires and from prescribed burning, and on the responsibilities, as well as risks, of prescribed fire.

- **Chambers, J.W. 1987. The evolution of wild land fire management and policy. *Fire Management Notes* 48 (2): 5-8.**

The author describes the evolution of wild land fire management and its policy in the United States. The first fire policy was generated because of the "cut and run" timber harvest practices on private lands in the Lake States during the late 1800s and early 1900s. The policy was control oriented and was carried out by the U.S. Army. The "10 a.m. policy" was dominant from the 1930s to the early 1970s. World War II led to the age of mechanization in fire control, as the development and surplus of war equipment provided suitable equipment. The age of specialization began in the 1970s. The FIRESCOPE program was initiated in 1970 as a result of wild land-urban interface fire suppression. Expenditures for fire suppression skyrocketed in the mid 1970s. The passage of the Forest and Rangeland Renewable Resource Planning Act of 1974 changed fire policy in the U.S. The Act demands that both the use of prescribed fire and the control of wildfire be integral parts of the Forest Service land management planning process. The National Wildfire Coordination group was established in 1976.

- **Gardner, P.D., H.J. Cortner, and K. Widaman. 1987. The risk perceptions and policy response toward wild land fire hazards by urban home-owners. *Landscape and Urban Planning* 14: 163-172.**

The authors point out that expanding urban areas have brought an increasing number of people into the wild land-urban interface, creating a fire hazard. Public officials in southern California, for example, have suggested programs for protecting urban residents. However, the programs have not gained attention from residents in the wild land-urban interface. The authors investigate why the urban public has not been receptive to adopting these programs. Their results indicate that urban residents have a low initial awareness of fire severity, assign low probabilities to occurrences, and prefer policy strategies that shift the hazard management responsibility to public resource managers.

- **Lee, R.G., 1987. Community fragmentation: implications for future wildfire management, in *Proceedings of Symposium on Wild land Fire 2000, South Lake Tahoe, CA, April 27-30, 1987,* JB Davis and RE Martin, ed. General Technical Report PSW-101, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.**

The author points out that modern fire management is an alternative to conventional fire management, which assumes that all fires must be put out. The author argues that modern fire management conflicts with conventional fire control because the two are based upon different assumptions: "all fire is bad" versus "fire is an integral component of natural ecosystems."

- **Stine, S.E. 1987. User attitudes toward fire policy in wilderness areas.** ***Fire Management Notes*** **(2): 16-17.**

The author conducted a survey to investigate wilderness visitors' perception about prescribed fire. The results demonstrate that wilderness users support prescribed fire if fires are ignited by natural causes rather than through an agency's intervention. The results also show that wilderness users support putting out fires that were caused by humans. The wilderness users also support prescribed burning in seldom-used areas. Based upon the survey, it appears that user perceptions may conflict with current fire management policies and purposes. The author suggests that further educational programs about prescribed burning are needed.

- **Apsey, M.T. 1988. Fire management in the media age, in** ***Fire Management in a Climate of Change: Proceedings from 1988 Northwest Fire Council Annual Meeting, Dunsmuir Lodge, Victoria, BC, November 14-15, 1988,*** **BD Lawson, BC Hawkes, and GN Dalrymple, ed. Northwest Fire Council, Victoria, BC.**

The author points out that fire management today not only requires technological improvement, but also entails communication with the media. That is because wildfire is often televised as a dramatic event, attracting the public's criticism. The public's perception of the way firefighters deal with wildfire may be modified by the way in which the media televise it. Therefore, establishing regular contact with the media may help to eliminate unnecessary misconceptions and misunderstandings of fire management. The author insists that it is no longer enough to simply do the job well. In many cases, public confidence in the fire management profession depends on public understanding of what the job is all about.

- **Mills, T.J., and F.W. Bratten, 1988.** ***Economic Efficiency and Risk Character of Fire management Programs, Northern***

***Rocky Mountains,* Research Paper PSW-192, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.**

The authors used the Fire Economics Evaluation System (FEES) to test three hypotheses about fire system performance on selected public lands in the northern Rocky Mountains. The hypotheses were as follows: (1) Economic efficiency is affected by the size of the fire management budget and the mix or emphasis of the fire management inputs purchased with the budget; (2) risk in the fire management system decreases with increasing fire management funding; and (3) the most efficient funding for a risk-averse manager is higher than for a risk-neutral manager. The study results indicate that efficiency is strongly affected by the program level, but the effect of the fire management mix or emphasis on efficiency was relatively minor. The most economically efficient initial attack program level was the lowest of those tested, 75% below the base level funding for the study period. The decrease in risk with increase in funding was relatively minor. Furthermore, the conclusions of the study were not affected by realistic changes in two major model inputs: fire prevention and large-fire suppression effectiveness, and resource management objectives.

- **Sommers, W.T. 1988. Fire management in the wildland/urban interface—a challenge for research and management, in *Protecting People and Homes from Wildfire in the Interior West: Proceedings of the Symposium and Workshop, Missoula, MT, October 6—8, 1987.* General Technical Report INT-251, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author points out that although fire management issues in the wildland-urban interface have received increased attention, there is little information on the magnitude or significance of the problem. The author stresses that managers and researchers should define, describe, and quantify the wildland-urban interface from a fire management perspective. The behavioral sciences represent the area most critically deficient in knowledge about wildland-urban interface fire problems. Fire managers need to know how to work effectively with local governing bodies in implementing fire safety and risk-reduction programs. Finally, incentives that influence the residents' behavior must be understood.

- **Turpin, J.C. 1988. Changes in public attitudes to prescribed fire, pp. 49-52 in *Fire Management in a Climate of Change: Proceedings from 1988 Northwest Fire Council Annual Meeting, Dunamuir Lodge, Victoria, BC, November 14—15, 1988,* BD Lawson, BC Hawkes, and GN Dalrymple, ed. Northwest Fire Council, Victoria, BC.**

The author (a representative of the Washington Environmental Council) presents several concerns about prescribed burning. The author points out that agencies should not ignore or dismiss concerns expressed by environmental organizations and citizens, otherwise suspicions and negative perceptions about prescribed burning may be amplified. The author recommends that agencies keep communication lines open and provide credible information from independent sources. According to the author, these efforts can influence opinion leaders, both from the general public and within environmental organizations.

- **Wittaker, D., 1988. Public perception of fire management, pp 30-31 in *Fire Management in a Climate of Change: Proceedings from 1988 Northwest Fire Council Annual Meeting, Dunsmuir Lodge, Victoria BC, November 14—15, 1988,7BD* Lawson, BC Hawkes, and GN Dalrymple, ed. Northwest Fire Council, Victoria, BC.**

The author (who is the mayor of Penticion, BC) argues that a law allowing municipal government to regulate zoning is imperative for fire prevention. The author also points out that the development of forest lands must be carefully considered by the Ministry of Forests, municipal government, and the public.

- **Agee, J.K. 1989. Wildfire in the Pacific West: A brief history and implications for the future, in *Proceedings of the***

Symposium on Fire andWatershed Management, **Sacramento, CA, October 26-28, 1988, NH Berg, ed. General Technical Report PSW-109, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.**

The author points out that wildfire is a natural component of forested land. Its frequency, severity, and effects vary depending on the specific environment, type of fire, and adaptation of the forest biota to fire. The author argues that the socio-political environment in which these forests exist has had a much more significant impact on public and private policy towards fire than has the physical-biological environment. Although ecological criteria are important in technical planning, they will be overshadowed by socio-political criteria in problem definition and solutions for the future.

- **Wakimoto, R.H., 1989. National fire management policy: A look at the need for change.** ***Western Wildlands*** **15(2): 35-39.**

The fire management policy review team was established in order to review the fire policy for the Yellowstone fire in 1988. The review team conducted several hearings to get input from the public in the vicinity of Yellowstone National Park. Seven issues were raised through the sessions: (1) The objectives of prescribed natural fire programs in national parks and wilderness are sound, but the policies need to be refined, strengthened, and reaffirmed. These policies permit fires to burn under predetermined conditions. (2) Many current fire management plans do not meet current policies; the prescriptions in them are inadequate, and decision making needs to be tightened. (3) There are risks inherent in trying to manage fire, but they can be reduced by careful planning and preparation. Planned burning and other efforts to reduce fuel hazards near high-value structures, along with the creation of fuel breaks along boundaries, can help reduce risks from both prescribed natural fires and wildfire. (4) The ecological effects of prescribed natural fire support resource objectives, but the social and economic effects may be unacceptable in some cases. Prescribed natural fires may affect uses of parks and wilderness, and may impact outside areas through smoke and stream sedimentation. (5) Dissemination of information before and during prescribed natural fires must be improved. There should be more public participation in the development of fire management plans. (6) Internal management processes, such as training more personnel, developing uniform terminology, and utilizing similar budget structures, would significantly improve fire management. (7) Claims were heard that some managers support naturalness above all else, allowing fires to burn outside of prescription requirements without taking appropriate action to suppress them.

- **Cortner, H.J., P.D. Gardner, and J.G. Taylor. 1990. Fire hazards at the urban-wildland interface: what the public expects. *Environmental Management.* 14(1): 57-62.**

The authors point out that wildland-urban interface issues have become problematic for forest managers. The authors conducted surveys on how public knowledge and perceptions of fire policies and fire hazards change over time, what kind of policy responses homeowners prefer as a way of preventing fire hazards at the urban-wildland interface, and how citizens view their own obligations as participants in interface issues. The authors present data from the surveys and discuss some findings and implications of their results. The data show that public attitudes toward fire have changed significantly over the past two decades, and that educating the public about fire and managers' use of fire can have positive effects on behavior. Yet, when attempting to modify individuals' be¬havior concerning interface fire risks, managers must also consider important issues of incentives, distribution of costs, and unanticipated policy impacts.

- **Daniel, T.C. 1990. Social/political obstacles and opportunities in prescribed fire manage-ment, in *Proceedings: Effects of Fire Management of Southwestern Natural Resources, Tucson, AZ, November 15-17, 1988,* JS Krammes, ed. General Technical Report RM-191, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.**

The author describes several obstacles to implementing prescribed fire management. The obstacles include misunderstanding of fire in forest ecosystems; concern about risks to life and property; and overestimation of adverse effects on scenic impact and recreational safety. The author points out that the above concerns might stem from several factors: (1) some resource management policies and practices are not sufficiently sensitive to the value that the public places on nature; (2) the public is not always well informed about the natural processes that they want protected; (3) management of the forest tends to be viewed as in direct conflict with the desire to be near nature and to live in a pristine environment; and (4) earlier fire prevention campaigns were very successful, in part because they were very simple—forest fires are bad and should be prevented. The author suggests that environmental education would be helpful if public accep-tance of prescribed burning stems from the lack of adequate understanding of the role of fire in forest ecosystems.

- **Manfredo, M.J., M. Fishbein, G.E. Haas, and A.E. Watson. 1990. Attitudes toward prescribed fire policies. *Journal of Forestry* 88(7): 19—23.**

The authors argue that although biological information may provide support for prescribed fire policy that alone is not sufficient justification for its implementation. Fire policy has societal and political components, and the fact that people appear poorly informed about the consequences of fire policy and the effects of fire adds controversy to the issue. Two telephone surveys were conducted to investigate attitudes towards the "let-burn" prescribed fire policy used during the Yellowstone fires of 1988. The results indicate slightly positive overall support for the prescribed burn policy, whereas the national sample was evenly divided. The authors discuss beliefs about outcomes of the prescribed fire policy and knowledge about wildfire in relation to attitudes (positive or negative) about the policy in the two survey groups. The results suggested no clear direction for managers and policy makers for meeting public preferences, but highlighted the difficulty of making decisions about prescribed fire policies that would be approved by a large majority of citizens.

- **Shelby, B, and R.W. Speaker. 1990. Public attitudes and perceptions about prescribed burning, pp. 253-260 in *Natural and Prescribed Fire in Pacific Northwest Forests,* JD Walstad, SR Radosevich, and DV Sandberg, ed. Oregon State University Press, Corvallis.**

The authors point out that public perceptions of fire management mainly depend on public knowledge and understanding about fire. The authors argue that despite increasing support for fire management from the public, there are also often concerns about air quality and water pollution induced by fire management. The authors suggest that further implementation of prescribed burning will necessitate a consensus about the use and effects of fire, as well as a long-term effort to provide information to the public about fire management, and a willingness to adequately and scientifically address specific concerns.

- **Taylor, J.G. 1990. Playing with fire: effects of fire in management of southwestern recreation resources, in *Effects of Fire Management of Southwestern Natural Resources: Proceedings of the Symposium, Tucson, AZ, November 15-17, 1988,* JS Krammes, ed. General Technical Report RM-191, US DA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.**

The author summarizes previous studies about fire management and public attitudes toward it. Growing acceptance and sophistication characterize the public's attitude toward current fire management. Prescribed burning is generally well accepted, but fires started by human carelessness or by lightning are not. As the nature and degree of control of fire are better understood, people tend to be more accepting of prescribed burning. It is important to note, however, that the public is not likely to accept lightning-caused fire. Understanding the beneficial effects of fire on forest ecosystems is important in accepting various types of fire. Knowing that lightning is the usual cause of forest fires in many western forest types also is significant in peoples' acceptance of a variety of fires, but this knowledge is not widespread. Knowing that most fires in forest ecosystems are small and that most animals are able to escape from wildfires is important to the public's acceptance of fires that are not specifically designated, set, and controlled by managers. The author points out that four factors are essential for successful information and education programs about fire management for the public: (1) a long-term effort to inform the public about the natural role of fire in undisturbed ecosystems; (2) a strong consensus among managers and concerned people about the correct use and beneficial effects of prescribed fire; (3) public perception that the information is scientifically sound and does not stem from an interest group with a biased position; and (4) adequate treatment of specific public concerns related to the use of fire, including the risks of prescribed burning getting out of control, smoke, intrusion into populated areas and related effects on public health, potential health hazards of burning chemically treated sites, and aesthetic impacts.

- **McConnell, DWII, and S.B. Baldwin. 1991. Private, non-industrial forest owner's perceptions of controlled burning influencing forest management, in *Fire and the Environment, Ecological and Cultural Perspectives: Proceedings of an International Symposium, Knoxville, TN, March 20-24, 1990,* SC Nodvin, and TA Waldrop, ed. General Technical Report SE-69, USDA Forest Service, Southeastern Forest Experiment Station, Ashville, NC.**

The authors point out that perceptions of controlled burning by private and non-industrial forest (PNIF) owners provide insight into forest management behavior of these owners. The authors conducted personal interview of randomly selected forest owners in the Wiregrass Region of Alabama in order to determine relationships between their perceptions, ownership objectives, and forest management activities. The interviews reveal that more than 66% of owners felt that controlled burning was a useful forest management practice on their land, although only 25% were currently using controlled burning. Both positive and negative perceptions of controlled burning are presented. The authors emphasize the relationship of these perceptions to owners' forest management behavior and the subsequent importance of this information to professional foresters who work with owners.

- **Phillips, C.B., and C.W. George. 1991. Wildland fire in the 1990s: problems, solutions, and priorities as seen by fire managers. *Fire Management Notes* 52(1): 3—10.**

The authors discuss problems associated with fire suppression. These problems are (1) inefficient communication among firefighters and agencies, (2) lack of standardization in training and equipping firefighters, (3) inefficient incident command systems, (4) lack of alternatives in tactics and strategies for fire suppression, (5) inadequate management for information and data flow, (6) barrier of laws and policies for cooperation among different agencies, (7) lack of new tools, techniques, and staffing standards, and (8) growing fire suppression in the wildland-urban interface. The authors suggest recommendations for solving each problem.

- **Rice, C.L., and J.B. Davis. 1991. Land-use planning may reduce fire damage in the urban-wildland intermix. General Technical Report PSW-127, US DA Forest Service, Pacific Southwest Research Station, Berkeley, CA.**

The authors conducted a study of fire damage after a wildfire, along with general plans, local planning regulations, and the real estate development process in three counties in California. Their studies support the idea that good fire-safe planning protects homes threatened by fire, and that loss occurs in the absence of good planning.

- **Chambers, V. 1992. Public involvement in fire management. *Fire Management Notes* 53— 54(2): 8-9.**

The author points out that fire management is now scrutinized by a well-educated and sophisticated public. The public often expresses concerns about the economic efficiency of fire suppression, air quality, and other environmental issues resulting from fire management; therefore, fire managers must shift from the public information end of the spectrum to true public involvement, where the public is engaged in open dialogue on various issues. According to the author, trust may be established between managers and the public through public involvement, which will enhance public support for fire management policies.

- **Magill, Arthur. W. 1992-1993. People, fire managers must talk with them. *Fire Manage-ment Notes* 53-54(2): 3-7.**

The author points out those fire managers know that wildland-urban interface fire problems are "people problems" and they recognize that such problems are not all the same. Managers have repeatedly warned about the risk of building structures with flammable materials in landscapes with fire-prone vegetation. Yet, they are continually frustrated because residents do not heed these warnings. The author describes several factors that may prevent managers from achieving their fire management goals. First, people not only respond poorly to warnings, but tend to be oblivious to events that can disastrously influence their property and lives. Second, the building trade builds to satisfy people's desire to live in the wildland-urban interface. Third, community plans frequently do not address the wildland-urban interface fire issue. Finally, local govern-ments have been unwilling to enact ordinances that control construction. The author argues that these situations may be changed if fire managers overcome their reluctance to public involvement and become leaders in two-way communication with the people they wish to influence. These goals may be achieved if fire managers will seek training in social sciences that emphasizes interpersonal relations, multicultural relations, and com¬munication strategies.

- **Beebe, G.S., and P.N. Omi. 1993. Wildland burning: The perception of risk. *Journal of Forestry* 91(9): 19-24.**

The authors discuss the risks of natural and technological hazards, and how public perception of risk is shaped, in relation to the implications of wildfire in public lands and at the urban/wildland interface. The authors point out that fire managers have to simultaneously protect public safety and use fire as a tool of management. The authors indicate that the media plays a critical role in forming public perceptions of fire risks;

media reports are often distorted, resulting in public misconceptions about forest fire. The authors insist that public participation is a key to implementing the current fire management policy.

- **Hough, J.L. 1993. Why burn the bush? Social approaches to bush-fire management in West African national parks. *Biological Conservation* 65(1): 23—28.**

The author presents social research into local residents' perceptions of the effects of fire in northern Benin. The results indicate that local residents' perceptions correspond to scientific understanding. The author predicts that the establishment and protection of national parks will increase the incidence of human-caused bush-fires.

- **Bradley, J. 1995. Political considerations of park and wilderness management, in P*roceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March 30-April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The authors discuss the basis for subcommittee and congressional support of a natural fire policy and its implementation. The authors argue that the natural fire program is critical for quality land management. Natural fire is important because it is based on correct science, which must underlie land management policy, and because we cannot have true wilderness without natural fire.

- **Cook, S. 1995. *Wildfire at the Wildland/Urban Interface: A Survey of Meso-Level Decision-makers and Their Support of Wildfire Hazard Mitigation Measures.* MS thesis, Geography Department, University of Florida, Gainesville.**

The natural hazard of wildfire at the wildland/urban interface is investigated. The author points out that lack of action on this hazard are derived from poor coordination and understanding among government officials at three levels—federal, state and county— who administer the areas involved. Federal and state officials tend to be similar in background, hold similar beliefs, and exhibit similar behavior. County officials are more uniform than either of their peer groups in the same categories; however, the individuals working at the county level are very different from individuals at the other two levels of government. To investigate why counties with similar wildfire histories differ in their responses to the problem, the Kingdon "Garbage Can" model of decision making was applied to responses from individuals lin the involved counties. The author found that officials in counties that have not developed wildfire hazard mitigation plans are less likely to recognize a problem, less likely to recognize solutions, and less likely to have people available to work on the issue than are officials from counties that have developed wildfire hazard mitigation plans.

- **Murphy, E.M. 1995. Public involvement in wilderness fire planning and decision making, in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March 30-April 1, 1993.* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author points out that public involvement is crucial to the success of any prescribed natural fire program; however, according to the author, it is a job that few fire managers are comfortable doing. The author describes some of the attitudes that keep agencies from public involvement, such as the "it's not my job syndrome", "we know best belief", and "doing things right versus doing the right things". The author demonstrates some key approaches for developing a public involvement plan: (1) deciding the goals of public involvement, (2) identifying potentially affected interests, (3) considering available tools, and (4) implementing.

- **Pyne, S.J. 1995. *World Fire: The Culture of Fire on Earth.* Holt, New York.**

The author illustrates how fire and humans have coevolved throughout history. The author points out that the prevalence of humans is largely attributable to their control over fire, and that the distribution and characteristics of fire have become deeply dependent on humans. The author argues that humans and fire are inseparable, and that they have repeatedly played a critical role in shaping the landscape. The author also contends that there is less fire on earth today than in the time of Columbus, contrary to popular belief. The author argues that eliminating fire will not save the planet from destruction, but will only eradicate the regenerative powers it once implemented.

- **Schmoyer-Weber, J. 1995. Public information on actively burning prescribed natural fires, in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Mon¬tana, March 30-April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author presents three phases of public information on prescribed burning. Conflicting emotions are stirred in wilderness users and neighbors when an agency monitors fire rather than suppressing it. The author emphasizes that members of the public who will be affected by a fire should be informed so they will know what is going on and what action they should take.

- **Smith, C. 1995. Fire issues and communication by the media, in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March 30—April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author examines 320 stories about wildfire published since 1988. The author points out that journalists did not learn from the mistakes they made in reporting the Yellowstone fires. The conventions of journalism, which value drama over explanation, suggest that wildfire and other natural catastrophes will often be reported in apocalyptic terms, rather than as the predictable outcomes of natural forces. Studies of how journalists reported five major stories suggest five factors that determine how wildfires are reported: (1) source enterprise, (2) cultural resonance, (3) issue salience, (4) newness, and (5) the degree to which the setting is rural or urban. Because of these criteria, news organizations sometimes do a poor job of providing the kinds of information needed by news consumers to reach intelligent conclusions about how public lands should be managed.

- **Stankey, G.H., and S.F. McCool. 1995. Evolving conceptions of wilderness: implications for management of fire, in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March 30-April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320. USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The authors point out that we view wilderness as a sometimes ugly and dangerous place where natural processes dominate the landscape. Such an attitude toward wilderness influences methods of fire management because the appropriateness of fire management is determined by social definitions of the resource and how to protect it. The authors suggest that an interactive approach to decision making should be used, wherein fire managers work with the public to determine appropriate and effective management programs.

- **Veto J.L., 1995. A vision for the future of fire in wilderness, in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March 30-April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author argues that suppression of fire in wilderness areas is expensive. Therefore, prescribed burning is a good tool for forest management. However, prescribed burning policy often confronts criticisms expressed by elected officials, who must be expected to reflect their constituents' views. Public education is key to implementing prescribed burning. An effective educational program for the public may necessitate different types of expertise. If three agencies (USFS, BLM, and NPS) cooperate, such a program can be generated.

- **Williams, J.T., 1995. Managing risk in wilderness fire management, pp. 22—23 in *Proceedings, Symposium on Fire in Wilderness and Park Management, Missoula, Montana, March30-April 1, 1993,* JK Brown, RW Mutch, CW Spoon, and RH Wakimoto, ed. General Technical Report INT-320, USDA Forest Service, Intermountain Research Station, Ogden, UT.**

The author presents four criteria by which prescribed natural burning may be implemented in wilderness settings: (1) fuel treatment measures taken outside of wilderness are not sufficient to mitigate the risks within wilderness; (2) the potential for lightning-caused fires represents too great a risk; (3) the public is involved in discussions leading to the decision; and (4) an interdisciplinary team has reached consensus on the manage¬ment ignition option. The author also raises the question, "How do we sustain the fire-adapted ecosystem within acceptable limits of risks?" The author points out that we need creative new techniques that will enable us to implement fire policies.

- **Apicella, M. 1996. *Federal Wildland Fire Management Policy and Program Review Implementation Action Plan Report.* Federal Wildland Fire Policy, USDA Forest Service, Washington, DC.**

The report describes the background of current fire management policies of various federal agencies. The report presents several issues of fire management with which federal agencies currently are confronted. The report concludes that interagency cooperation is necessary in order to deal with various issues in fire management.

- **Shindler, B, and M. Reed. 1996. *Forest Management in the Blue Mountains: Public Perspectives on Prescribed Fire and***

Mechanical Thinning. **Department of Forest Resources, Oregon State University Press, Corvallis.**

The authors conducted research on residents' perceptions of prescribed fire and mechanical thinning. Samples were drawn from the residents of the Blue Mountains in Oregon. This study demonstrates that most respondents are receptive, and that many strongly support the use of both prescribed fire and mechanical thinning. The authors point out that although very vocal interest groups often attract agencies' attention, they do not necessarily represent the general public's view of prescribed fire and mechanical thinning. The authors also present several factors that contribute to public acceptance of prescribed fire and mechanical thinning: (1) how a decision influences the local economy, (2) how a practice detracts or contributes to people's understanding of sustainable forestry, (3) the visual quality aspects of management, and (4) how the final management decisions are made. The authors present five factors that are key to understanding the public's acceptance of these practices: (1) people need to see things with their own eyes; (2) people want both natural conditions and forest products; (3) credible information is essential; (4) paying attention to agency/public barriers is important; and (5) people will only support what they understand.

- **Suckling, K. 1996. Fire and forest ecosystem health in the American Southwest: A brief primer. Southwest Forest Alliance. Southwest Center for Biological Diversity.** http://www.sw-center.org/swcbd/papers/fire-prm.html

A brief introduction to the issues, arguments, and concepts behind policy debates surrounding logging and wildfire.

- **Swetnam, T. W., and C. H. Baisan. 1996. Historical fire regime patterns in the southwestern United States since AD 1700, pp. 11-32. *In:* C. D. Allen (tech ed.), Fire effects in southwestern forests, proceedings of the second La Mesa Fire symposium. Gen. Tech. Rep. RM-GTR-286. Los Alamos, NM: U.S. Dept. of Agriculture, Forest Service.**

This article argues that fuel and climate have historically been the primary driving and regulating forces in fire regimes. While Native Americans may have set some fires now documented in fire-scar records, the fires would not have burned over large areas had not the requisite fuels been present along with necessary climatological conditions. The authors argue that ignition sources were usually not limiting, but that, rather, it was the fuels and related climatic conditions that were. Thus, it is usually unnecessary to invoke human-set fires as an explanation of the cause of fire regime patterns in the Southwest. Even if humans had never crossed from Asia to North America, historical fire regimes in most southwestern forests would nonetheless have been similar in most respects to the fire regimes that have been documented.

- **Cook, S. 1997. Wildfire adapted ecosystems meet man's development. *Australian Journal of Emergency Management* 12(2): 24-31.**

The author points out that population pressure of the twentieth century have pushed humans into fire-prone areas. This trend necessitates the identification of potential wildfire hazards by trained observers, followed by communication to homeowners in the affected areas. Although efforts to reduce the wildfire hazard have increased, threats to wildland/urban communities have not been addressed because of the inability of agencies to cooperate, poor decision-making processes, low priority accorded to such threats, and the unavailability of sufficient funds to deal with these threats.

- **Daniel, T.C., M. Meitner, and E. Weidemann. 1997. Human desires and fears in ecologically rational wildland fire management, in *Fire effects in Southwestern Forests: Proceedings of the Second LaMesa Fire Symposium, Los Alamos, N.M., March 29-31, 1994,* C.D. Allen, ed. General Technical Report RM-286, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.**

The authors point out that while natural areas are generally perceived as safe places by city dwellers, the potential danger of fire is not always fully recognized. City dwellers may correctly perceive the risks, but may be unwilling to compromise their perceptions of natural beauty, because environmental fears and desires are based largely on emotions rather than logic. That is, human desires and fears may have relatively little to do with "understanding", as environmental perception research has shown. It may be too ambitious for manicagers to assume that people understand the risks associated with a technical dimension. In fact, past studies show that people's risk perceptions are often not consistent with such technical assessments. The authors argue that words do not elicit realistic emotional responses, such as fears and desires. To understand people's actions (and inaction) regarding fire hazards, the processes by which those actions are determined must be taken into account. The authors suggest that computer visualization technology may be more effective than words in motivating a realistic response to fire danger in the wildland-urban interface.

- **Daniels, S.E. 1997. Human reactions to large-scale wildfires: contrasting the response of U.S. Forest Service personnel and the general public to the 1994 Wenatchee fires. Unpublished paper, Steven E. Daniels, Director, Western Rural Development Center, Utah State University, Logan.**

The author conducted qualitative research on human reactions to Wenatchee fires in 1994. The primary focus of the research was to investigate the response of Forest Service personnel and the general public to the fire. The study found that Forest Service personnel's reactions to the fire were cognitive and intellectual, whereas the general public's reaction to the fire was affective. The author points out that this difference may interfere with smooth communication between the Forest Service and the general public. The author's recommendations to Forest Service personnel are as follows: (1) they should not belittle the public's affective response to fire or be dismissive toward them, (2) they should recognize the legitimacy of the public's grief and assist with the process, (3) they should shift out of the crisis-team mind-set after the fire is controlled and allow people more opportunities for reflection and discussion, and (4) they should acknowledge that the agency may have lost trustworthiness in the eyes of the public.

- **Martin, R.E. 1997. Prescribed fire as social issue, in Conference Proceedings: *Environmental Regulation and Prescribed Fire: Legal and Social Challenges, Tampa Airport Hilton, Tampa, FL, March 14-17, 1995,* DC Bryan, ed. Center for Professional Development, Florida State University, Tallahassee.**

The author points out that prescribed fire is a social issue, and it automatically becomes an ecological, political, and economic issue. The author argues that a century-long fire exclusion program has worsened the health of wild lands. Therefore fire must be used as the most economically and ecologically sound tool to improve natural ecosystems. However, the public views prescribed fire suspiciously because the public often pays attention to problematic fires. Thus, although prescribed fire in wild lands faces strong opposition, it must be used in conjunction with other tools to properly manage those lands. The author stresses that the issues of prescribed fire must be addressed through education and public involvement, and studied in context with the total "ecologic-socio-politico-economic" picture.

- **Lavin, M.J. 1997. Managing fire risk to people, structures, and the environment. *Fire Management Notes* 57(4): 4—6.**

The author points out that the wildland-urban interface fire problem has recently received increased national attention. The author insists that the risk of fire can be managed. However, it can be reduced only when landowners and residents cooperate with state and/or local agencies. The author suggests that managing fire risk in the wildland-urban interface is a shared responsibility. Federal, state, and local fire agencies are realizing that without homeowners' involvement little can be done to reverse the trend of fire losses from the wildland-urban interface. Thus, the wildland-urban interface is a political minefield.

- **Pyne, S.J. 1997. Fire in America: A Cultural History of**

Wildland and Rural Fire. University of Washington Press, Seattle, WA. 654p.

Pyne explores the efforts of American cultures to control fire and use it to manage the landscape from prehistory to the present day. The book also examines the historical role of fire in cultures around the world and discusses how these different cultures have influenced Americans' views and uses of fire.

- **Pyne, S.J., 1997. *America's Fires: Management on Wildlands and Forests.* Issues Series, Forest History Society, Durham, NC.**

The author describes the history of fire management in the United States. The author also illustrates how fire agencies transform their fire policies from control to management.

- **Pyne, S.J. 1997. *Vestal Fire: An Environmental History, Told Through Fire, of Europe and Europe's Encounter with the World.* Weyerhaeuser Cycle of Fire Series, University of Wash¬ington Press, Seattle.**

The author examines how humans struggle to control the natural force of fire. The author also describes a history of fire usage and its various roles on the European continent.

- **Reeves, S, F.T. Cole, and J. Savery, 1997. Fire management challenges and opportunities for land managers: using Okefenokee and Pocosin Lakes National Wildlife Refuge as examples, in *Conference Proceedings, Environmental Regulation and Prescribed Fire: Legal and Social Challenges, Tampa Airport Hilton, Tampa, FL, March 14-17,1995,* DC Bryan, ed. Center for Professional Development, Florida State University, Tallahassee.**

The authors point out that managers of wilderness or conservation areas often face dilemmas concerning fire. Fire performs a natural role in rejuvenating ecosystems; however, implementing a professionally developed prescribed fire program often means confronting various regulations, stewardship responsibilities, and social liabilities. The authors contend that the above barriers all become more complex as the wildland-urban interface increases and as the number of habitat classifications increases. The authors emphasize that fire management policy must be developed according to both the above regulations and conservation of fire-dependent habitats.

- **Schuster, E.G., D.A. Cleaves, and E.F. Bell, 1997. *Analysis of USDA Forest Service Fire-Related Expenditures 1970-1995.* Research Paper PSW-230, USDA Forest Service, Pacific Southwest Research Station, Berkeley, CA.**

The authors analyze the expenditures for fire pre-suppression and suppression activities of the Forest Service. The analysis shows that expenditures increased from $61 million in fiscal year (FY) 1970 to $951 million in FY1994. Yet, real (net after inflation) expenditures have not increased significantly since FY 1970, if FY 1994 expenditures are excluded. The analysis also demonstrates that during any given year, 56% of suppression expenditures are spent on supplies and services, including aircraft and food, and 32% on salaries and wages. Weather, access, and firefighter availability and skills were key contributors to suppression costs. Real expenditures for fuel treatments have declined over the past 25 years, but are currently rising because of renewed interest in prescribed burning. The future challenge for fire managers is reducing fire-related ex-penditures in light of how fire is dealt with in ecosystem management.

- **Lichtman, P. 1998. The politics of wildfire: lessons from Yellowstone. *Journal of Forestry* 96(5): 4-9.**

The author points out that land managers and ecologists generally agree that the 1988 fires in the Greater Yellowstone Ecosystem were an ecologically important part of a natural disturbance pattern, and that little could have been done to stop them. For policymakers, however, the fires were a major public relations failure. The author argues that forest managers and decision makers must understand how the public and politicians perceive fire. The author suggests that it is not sufficient for managers to just consider the technological and ecological dimensions of fire in natural resource management. The author emphasizes that interaction between the public and elected officials is indispensable for gaining support for natural fire.

- **Policies Affecting Forest Fires (FAO 1999) and the FAO/ ITTO International Expert Meeting on Forest Fire Management (FAO 2001a) and Legal Frameworks for Forest Fire Management:International Agreements and National Legislation (FAO 2002a).**

The guidelines also address the objectives of the United Nations International Strategy for Disaster Reduction (ISDR) that has been established by the UN Economic and Social Council (ECOSOC) and the General Assembly of the United Nations (UN 1999), particularly the ISDR Interagency Task Force on Natural Disaster Reduction, Working Group on Wildland Fire. The Working Group on Wildland Fire supports the UN and other international stakeholders by providing an inter-sectoral and interdisciplinary global platform for policy support. The guidelines recognize that many forest fires originate in agricultural and pastoral systems; and in degraded vegetation, outside of forest areas. Therefore, fire management on former and degraded forest lands may help to re-establish productive forests and to safeguard the success of reforestation programs.

- **Carroll, M.S., A.J. Findley, K.A. Blatner, S.R. Mendez, S.E. Daniels, and G.B. Walker. 2000. *Social Assesment for the Wenatchee National Forest Wildfires of 1994: Targeted Analysis for the Leavenworth, Entiat, and Chelan Ranger District. USDA* Forest Service, General Technical Report, PNW-479.**

The authors conducted a social assessment to explore local residents' reaction to the Wenatchee Complex Fires in 1994. A primary purpose of the study was to identify local residents' various beliefs and values about wildfire and forest management. The study results were presented based on five social entities: political coalition, stakeholder groups, residency tenure distinctions, geographical divisions, or ethnic communities. The authors concluded that improving public involvement processes was crucial in the wake of natural disaster.

- **Federal Emergency Management Agency. (2000). Surviving the storm: A guide to wildfire preparedness.** Retrieved from https://www.fema.gov/pdf/library/98surst_wf.pdf [PDF 237 Kb]

This guide explains how to keep safe before, during, and after a wildfire.

- **M.D. Flannigan, B.J. Stocks & B.M. Wotton, 2000. Climate change and forest fires: Science of The Total Environment, Volume 262, Issue 3, 15 November 2000, Pages 221–229,** www.elsevier.com/locate/scitotenv

This paper addresses the impacts of climate change on forest fires and describes how this, in turn, will impact on the forests of the United States. In addition to reviewing existing studies on climate change and forest fires we have used two transient general circulation models (GCMs), namely the Hadley Centre and the Canadian GCMs, to estimate fire season severity in the middle of the next century. Ratios of $2\times CO_2$ seasonal severity rating (SSR) over present day SSR were calculated for the means and maximums for North America. The results suggest that the SSR will increase by 10–50% over most of North America; although, there are regions of little change or where the SSR may decrease by the middle of the next century. Increased SSRs should translate into increased forest fire activity. Thus, forest fires could be viewed as an agent of change for US forests as the fire regime will respond rapidly to climate warming. This change in the fire regime has the potential to overshadow the direct effects of climate change on species distribution and migration. http://www.sciencedirect.com/science/article/pii/S0048969700005246 - AFF2#AFF2

- **Winter, Greg, and Fried, Jeremy. 2000. Homeowner Perspectives on Fire Hazard, Responsibility, and**

Management Strategies at the Wildland Urban Interface. *Society and Natural Resources* 13: 33-49.

The authors conducted focus group discussions with subset of survey participants to investigate how forest homeowners, who lived in wildland-urban interface in Michigan, perceived wildfire hazard, allocation of fire protection responsibility, and their preferred fire management strategies. Study results show that participants tended to regard forest fire as an uncontrollable natural event, and forest fire damage as random. Due to these attributes the participants were lees likely to support investing firefighting infra- structure, take all possible fire preventive actions for their home, and resolute in their emphasis on solutions that reduce the number of fire ignitions. The authors argue that participants' negative perception of prescribed burning may be a barrier to using it as fuel treatment in wildland-urban interface in Michigan.

- **Yoshitaka Kumagai. 2001. "Causal Reasoning of Wildfire Damage." Oregon State University. Ph.D. dissertation.**

The author conducted research to investigate how people in wildfire hazard zones who had experiencied wildfire perceived the cause of wildfire damage. A pre-fire mail survey, realtime filed interviews, and a follow-up mail survey were conducted on the western slope of the Sierra Nevada in 1999. Survey results revealed that people who had experienced wildfire attributed the cause of damage to other people's actions more than did those who had not experienced wildfire. Field interview data suggest that whether residents incurred damage, maintained a sense of control in their situation, or had personal relationships with firefighters influenced the way in which they attributed the cause of damage. Results also indicated that people without past wildfire experience tended to attribute the cause of wildfire to a simplistic schema such as cigarette, while people with past wildfire experience tended to attribute the cause of wildfire to more specific notions and factors associated with firefighters, such as out-of-control prescribed burning or inadequate past fuel treatment.

- **Forest protection working papers (2002): guidelines on fire**

management in temperate and boral forests

Source(s): Food and Agricultural Organization of the United Nations (FAO) . Reference code: DRR7940, Publication date: 2002 , Number of pages: 78 p.

These fire management guidelines are designed to provide a base for policy makers and managers at various levels to develop programs and projects in which the specific national, socio-economic, and natural problems related to fire in temperate and boreal natural and planted forests will be addressed. The scope of the guidelines is to assist countries in developing programs for reducing damage caused by fire; and to help forest managers and rural residents to safely use and take advantage of the beneficial effects of fire in land-use systems. The guidelines are in accordance with the FAO policy and take into account the recommendations of the FAO Meeting on Public

- **Morehouse, B.J. 2002. Climate, Forest Fires, and Recreation: Insights from the U.S. Southwest. University of Arizona, Institute for the Study of Planet Earth, pp. 195-226. In: A. Matzarakis and C.R. de Freitas (eds.), Proceedings of the First International Workshop on Climate, Tourism, and Recreation. International Society of Biometeorology. Report of a Workshop Held at Porto Carras, Neos Marmaras, Halkidiki, Greece, 5-10 Oct.**

This report investigates the dangers of juxtaposing recreational density and high wildfire risk, specifically in the U.S. Southwest. In this region, the hazards of wildfire are elevated because of high fuel load buildups resulting from long-term policies of fire suppression and climatic influences. Knowledge of climate history and processes might improve the planning process although such information is not yet well integrated into such processes, nor do managers deal with the possible implications of relation of such climate information to the public, information that could influence tourism marketing and recreational activity patterns.

- **Omi, P.N., and E.J. Martinson. 2002. Effect of fuels treatment on wildfire severity. Final report to the Joint Fire Science Program Governing Board. Fort Collins, CO: Western Forest Fire Research Center.**

The authors evaluate fire severity in treated and untreated stands of eight recent wildfires and conclude that some fuel treatments, especially those that remove large trees, tend to make forests more fire prone, cause fires of higher intensity, and exacerbate the ecological impacts of a given fire.

- **Carter, R. 2003. Climate, forest management stoke Western wildfires. End in Sight. Climate Assessment for the Southwest. 4p. http://www.ispe.arizona.edu/climas/forecasts/articles/wildfire_April2003.pdf -**

A short but well researched essay addressing the extent of wildfire activity during FY2002. Addresses the various possible causes of what was an especially busy fire year, including drought, fire suppression policy, grazing, logging, bark beetles, and the controversy surrounding logging versus thinning.

- **Coronado National Forest (CNF). 2003b. Coronado National Forest Fire Management Plan. U.S. Dept. of Agriculture, Forest Service. 164p.**

  http://www.fs.fed.us/r3/coronado/forest/projects/fire_mgt/wfa/documents/fmp/fmp.pdf -

Following the fire program based in the Coronado National Forest Land and Resource Management Plan (LRMP), this document sets the parameters for fulfilling the objectives of fire prevention on the Coronado NF.

- **National Association of School Psychologists. (2003). Helping children after a wildfire: Tips for parents and teachers.** Retrieved from http://www.nasponline.org/resources/crisis_safety/ wildfire_teachers.pdf [PDF 31.4 Kb]

This tip sheet discusses what parents and teachers can do to help children cope after a wildfire.

- **National Association of School Psychologists. (2003). Responding to wildfires: Helping children and families; Information for school crisis teams.** Retrieved from http://www.caspsurveys.org/NEW/pdfs/fires.pdf [PDF 167 Kb]

This article provides possible stress reactions experienced by children after a wildfire and how crisis response teams can help them and their families.

- **P.S. Roy, 2003. Forest Fire and Degradation Assessment Using Satellite Remote Sensing and Geographic Information System- Indian Institute of Remote Sensing (NRSA) Dehra Dun, Satellite Remote Sensing and GIS Applications in Agricultural Meteorology pp. 361-400**

The paper focused that according to a Forest Survey of India report, about 50 per cent of forest areas in the country are prone to fire. It is estimated that the proportion of forest areas prone to forest fires annually ranges from 33% in some states to over 90% in others. While statistical data and geospatial information on forest fire are very weak or even not available. About 90% of the forest fires in India are started by humans. The degree of forest fire risk analysis and frequency of fire incidents are very important factors for taking preventive measures and post fire degradation assessment. Geospatial techniques are proving to be powerful tools to assess the forest fire risk and degradation assessment. The present paper also describes the present state of forests, methodology, models and case studies of forest fire risk and degradation assessment in context to Indian forests.

- **Woolf, N.B. 2003. Raging fires devastate forests, destroy homes, and wipe out wildlife. National Animal Interest Alliance. http://www.naiaonline.org/body/articles/archives/fires.htm.**

A brief article noted the recent prevalence of fires and its connection to logging activity or lack thereof.

- **Arizona State Cartographer's Office (ASCO). 2004. Southwest Community Wildfire Protection Plan (SCWPP) for At-Risk Communities of the Sitgreaves National Forest in Apache, Coconino, and Navajo Counties. Logan Simpson Design, Tempe AZ. 67p. http://sco.az.gov/fire/SitgreavesCWPP.pdf**

The Sitgreaves Communities' Wildfire Protection Plan for the "at-risk" communities located in the Sitgreaves National Forest (SNF) was developed in response to the Healthy Forests Restoration Act of 2003 (HFRA). This legislation established incentives for communities to develop comprehensive wildfire protection plans. The legislation also directs the Departments of Interior and Agriculture to address local community priorities in fuel reduction treatments on federal and non-federal lands.

- **General Accounting Office (GAO). 2004b. Wildfire suppression: Funding transfers cause project cancellations and delays, strained relationships, and management disruptions. GAO 04-612. Report to Congressional Requesters. 63p.** http://www.gao.gov/new.items/d04612.pdf **-**

This report assesses Forest Service and BLM response to the 2003 fire season, noting the tactics used to reduce wildfire, the costs incurred to the agencies and other federal programs, and suggestions for prioritizing controlled-burn and fuel-reduction activities.

- **Graham, R.T., S. McCaffrey, and T.B. Jain (tech. eds.). 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station. 43p.** http://www.fs.fed.us/rm/pubs/rmrs gtr120.html

A discussion on the causes behind severe wildfires, this article identifies various methods of fuel treatment to prevent the types of recent fires that put local communities into jeopardy.

- **Laughlin D.C., J.D. Baker, M.T. Stoddard, M.L. Daniels, J.D. Springer, C.N. Gildar, A.M. Green, and W.W. Covington. 2004. Toward reference conditions: Wildfire effects on flora in an old-growth ponderosa pine forest. Forest Ecology and Management. 199:137-152.**

The paper examines the impacts of wildfire on a relatively undisturbed ponderosa pine forest on the north rim of the Grand Canyon National Park. This site had not burned in seventy-six years. After the fire, understory vegetation in the forest shifted, and there was an increase in annual and biennial forbs. Fire at this site did not increase species richness, plant cover, or plant diversity after two years. This paper supports the use of wildfire to maintain and improve forest health in old-growth forests, by altering understory species composition and reducing fuel loads.

- **Richard T. Brown,* James K. Agee, F and Jerry F. Franklin.2004. Forest Restoration and Fire: Principles in the Context of Place by ♦Defenders of Wildlife, 1880 Willamette Falls Drive, Suite 200, West linn, OR 97068, U.S.A., Division of Ecosystem Sciences, College of Forest Resources, Box 352100, University of Washington, Seattle, WA 98915, U.S.A. Conservation Biology, Pages 903-912 Volume 18, No. 4, August 2004**

There is broad consensus that active management through thinning and fire is urgently needed in many forests of the western United States. This consensus stems from physically based models of fire behavior and substantial empirical evidence. But the types of thinning and fire and where they are applied are the subjects of much debate. We propose that low thinning is the most appropriate type of thinning practice. Treating surface fuels, reducing ladder fuels, and opening overstory canopies generally produce fire-safe forest conditions, but large, fire-resistant trees are also important components of fire-safe forests. The context of place is critical in assigning priority for the limited resources that will be available for restoration treatments. Historical low-severity fire regimes, because of their current high hazards and dominance by fire-resistant species, are the highest priority for treatment. Mixed-severity fire regimes are of intermediate priority, and high-severity fire regimes are of lowest priority. Classification systems based on potential vegetation will help identify these fire regimes at a local scale.

- **Rinne, J.N. 2004. Forests, fish and fire: Relationships and management implications for fishes in the Southwestern U.S.A., pp. 151-156. In: G.J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins, and M. Monita (eds.), Forest Land-Fish Conference II-Ecosystem Stewardship through Collaboration. Proc. Forest-Land-Fish Conf. II, 26-28 Apr., Edmonton, Alberta.**

  http://www.tucanada.org/forestlandfish2/pdfs/abstracts/pages%20151-156.pdf

This report addresses the impact of wildfire on fish populations and their related aquatic ecosystems. It notes that all native species offish in the southwestern stream ecosystems could be affected by post-wildfire impacts.

- **Southwest Area Interagency Wildland Fire Operation. 2004. Monsoon arrival helps reduce fire restrictions and closures. Southwest Area News Release. 1p.**

  http://kp12m.as.arizona.edu/new articles/nuttall fire 2004/docs/news release 072204.pdf

A brief news update reporting the beneficial effects of monsoons around 22 July, 2004, but noting the continued dangers of wildfire despite wetter weather.

- **Teelman, T.A. and D. Bell. 2004. Community response to wildlife fire threats: Heber-Overgaard Arizona case study. North Carolina State University Department of Forestry,**

7-11 Jun. 10p. http: //www .ncsu. edu/proj ect/wildfire/Arizona/ H-OCase Study .pdf

This case study traces wildfire risk in the communities surrounding the Apache-Sitgreaves National Forests in the Heber-Overgaard district.

- **Healthy Forest Initiative. 2005. Fact sheet: Making a difference, community wildfire protection plan, Arizona. U.S. Dept. of Agriculture/U.S. Dept. of the Interior. 1p. http:// www.healthyforests.gov/projects/state_projects/arizona-cwpp.pdf**

A brief fact sheet addressing the progress made by local community action groups regarding the prevention of wildfires in Arizona.

- **Meck, Stuart, and James C. Schwab. 2005. *Planning for Wildfires.* APA Planning Advisory Service Report no. 529/530. Chicago: American Planning Association.**

A report written in collaboration with the National Wildland/ Urban Interface Fire Program, this is a great work to begin a discussion of wildfire prevention. The authors' research was split into two main areas: best practice examples and plan considerations for communities with wildfire hazards.

- **M. D. Flannigan, B. D. Amiro, K. A. Logan, B. J. Stocks and B. M. Wotton. 2005. Forest Fires and Climate Change in the 21ST Century : Mitigation and Adaptation Strategies for Global Change, Volume 11, Number 4, 847-859, DOI: 10.1007/ s11027-005-9020-7, ISSN: 13812386, ISBN: 1102700590207**

Fire is the major stand-renewing disturbance in the circumboreal forest. Weather and climate are the most important factors influencing fire activity and these factors are changing due to human-caused climate change. This paper discusses and synthesises the current state of fire and climate change research and the potential direction for future studies on fire and climate change. In the future, under a warmer climate, we expect more severe fire weather, more area burned, more ignitions and a longer fire season. Although there will be large spatial and temporal variation in the fire activity response to climate change. This field of research allows us to better understand the interactions and feedbacks between fire, climate, vegetation and humans and to identify vulnerable regions. Lastly, projections of fire activity for this century can be used to explore options for mitigation and adaptation.

- **Meahl, J. 2005. More wildfires likely as restrictions in effect. Eloy News. 19 May.**

  http://www.zwire.com/site/news.cfm?newsid=14555409&BRD=1817&PAG=461&dept id=2220 71&rfi=8

Identifies bans on open fires enacted by the BLM and other land trust agencies to prevent the occurrence of large wildfires this year (2005). The bans include such activities as campfires and smoking outdoors.

- **National Interagency Fire Center (NIFC). 2005. Wildland Fire Statistics. Boise, ID: U.S. Dept. of Agriculture, U.S. Dept. of the Interior. National Fire and Aviation Executive Board. Federal Fire Policy Directives Task Group. http://www.nifc.gov/stats/wildlandfirestats.html**

Provides data for the years 1960-2004 identifying number of fires, acres affected, and the cost of suppression.

- **FAO Forestry Paper 151: Fire management global assessment 2006**

Fire management is an essential part of sustainable forest management. This publication complements the Global Forest Resources Assessment 2005 (FRA 2005) as an in-depth thematic study on the incidence, impact and management of forest fires in different regions of the world.

- **Reinhardt, B. (2007). For anyone affected by the California**

wildfires. Retrieved from http://www20.csueastbay.edu/news/category-pages/archive-pre-2009/the-view/top-stories/article-465.html

This tip sheet explains the stress reactions that someone affected by a wildfire may experience.

- **American Red Cross. (2009). Be Red Cross ready: Wild fire safety checklist.** Retrieved from http://www.redcross.org/www-files/Documents/pdf/Preparedness/checklists/Wildfire.pdf [PDF 256 Kb]

  This fact sheet provides information on how to prepare for a wildfire. **(Also available in Spanish at** *http://www.redcross.org/www-files/Documents/pdf/ foreignmat/Spanish/WildFire_SP_9_09.pdf [PDF 186 Kb])*

- **FAO. 2009. FIRE-** ***Fire disturbance.*** T13 Assessment of the status of the development of the standards for the Terrestrial Essential Climate Variables. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) Rome, 2009. Electronic Publishing Policy and Support Branch Communication Division - FAO Viale delle Terme di Caracalla, 00153 Rome, Italy or by e-mail to: copyright@fao.org

Fire is an important ecosystem disturbance with varying return frequencies, resulting in land cover alteration and change, and atmospheric emissions on multiple time scales. Fire is also an important land management practice and is an important natural abiotic agent in fire dependent ecosystems. It is also used for fire and ecosystem management planning and operational purposes (fire use, preparedness and wildfire suppression) and development of informed policies. The Fire Disturbance Essential Climate Variable includes Burned Area as the primary variable and two supplementary variables: Active Fire and Fire Radiated Power (or Fire Radiative Power - FRP). Active Fire is the location of burning at the time of the observation and is expressed in spatial coordinates or by an indicator of presence of absence of fire in a spatially explicit digital raster map, such as a satellite image. FRP is the rate of emitted radiative energy by the fire at the time of the observation and is expressed in units of power, such as Watts (W). Fire activity is a global phenomenon characterized by strong spatial and temporal variability. Documentation of fire activity by aerial means (including manned or unmanned aircraft), such as GPS plotting, post-fire photography or high resolution radiometers, is done traditionally in some countries, notably in Russia and other countries of the former Soviet Union. Data from satellite remote sensing are the most suitable and useful means for large and global scale monitoring. Observing systems have been developed using sensors on board both polar orbiting and geostationary satellites.

- **Alexander, M. E. and M. G. Cruz (2011). "Interdependences between flame length and fireline intensity in predicting crown fire initiation and crown scorch height." International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF11001**

This state-of-knowledge review examines some of the underlying assumptions and limitations associated with the inter-relationships among four widely used descriptors of surface fire behaviour and post-fire impacts in wildland fire science and management, namely Byram's fireline intensity, flame length, stem-bark char height and crown scorch height. More specifically, the following topical areas are critically examined based on a comprehensive review of the pertinent literature: (i) estimating fireline intensity from flame length; (ii) substituting flame length for fireline intensity in Van Wagner's crown fire initiation model; (iii) the validity of linkages between the Rothermel surface fire behaviour and Van Wagner's crown scorch height models; (iv) estimating flame height from post-fire observations of stem-bark char height; and (v) estimating fireline intensity from post-fire observations of crown scorch height. There has been an overwhelming tendency within the wildland fire community to regard Byram's flame length-fireline intensity and Van Wagner's crown scorch height-fireline intensity models as universal in nature. However, research has subsequently shown that such linkages among fire behaviour and post-fire impact characteristics are in fact strongly influenced by fuelbed structure, thereby necessitating consideration of fuel complex specific-type models of such relationships.

- **B. Mike Wotton, James S. Gould, W. Lachlan McCaw, N. Phillip Cheney and Stephen Taylor. 2011. Flame temperature and residence time of fires in dry eucalypt forest.** *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF10127, Submitted: 12 November 2010 Accepted: 26 May 2011 Published online: 15 December 2011

Temperature profiles of flames were measured using arrays of thermocouples on towers located in experimental bushfires of varying intensity, carried out in dry eucalypt forest of different fuel age and structure. In-fire video of flame-front passage and time series data from very fine exposed thermocouples were used to estimate the duration of passage of the main flaming front in these experimental fires. Flame temperature measured at points within the flame was found to vary with height; maximum flame temperature was greater in the tall shrub fuel than in the low shrub fuel sites. A model to estimate flame temperature at any height within a flame of a specific height was developed. The maximum flame temperature observed was ~1100°C near the flame base and, when observation height was normalised by flame height, flame temperature exponentially decreased to the visible flame tip where temperatures were ~300°C. Maximum flame temperature was significantly correlated with rate of spread, fire intensity, flame height and surface fuel bulk density. Average flame-front residence time for eucalypt forest fuels was 37s and did not vary significantly with fine fuel moisture, fuel quantity or bulk density.

- **Beck, P. S. A. and S. J. Goetz (2011). "Satellite observations of high northern latitude vegetation productivity changes between 1982 and 2008: ecological variability and regional differences." Environmental Research Letters 6(4): 045501. http://stacks.iop.org/1748-9326/6/i=4/a=045501**

To assess ongoing changes in high latitude vegetation productivity, authors compared spatiotemporal patterns in remotely sensed vegetation productivity in the tundra and boreal zones of North America and Eurasia. Authors compared the long-term GIMMS (Global Inventory Modeling and Mapping Studies) NDVI (Normalized Difference Vegetation Index) to the more recent and advanced MODIS (Moderate Resolution Imaging Spectroradiometer) NDVI data set, and mapped circumpolar trends in a gross productivity metric derived from the former. Authors then analyzed how temporal changes in productivity differed along an evergreen-deciduous gradient in boreal Alaska, along a shrub cover gradient in Arctic Alaska, and during succession after fire in boreal North America and northern Eurasia. Authors find that the earlier reported contrast between trends of increasing tundra and decreasing boreal forest productivity has amplified in recent years, particularly in North America. Decreases in boreal forest productivity are most prominent in areas of denser tree cover and, particularly in Alaska, evergreen forest stands. On the North Slope of Alaska, however, increases in tundra productivity do not appear restricted to areas of higher shrub cover, which suggests enhanced productivity across functional vegetation types. Differences in the recovery of post-disturbance vegetation productivity between North America and Eurasia are described using burn chronosequences, and the potential factors driving regional differences are discussed.

- **Iwata, H., M. Ueyama, et al. (2011). "Quick Recovery of Carbon Exchanges in a Burned Black Spruce Forest in Interior Alaska." Sola 7: 105-108. http://www.istage.ist.go.Jp/article/sola/7/0/7 105/ article**

Observations of carbon dioxide (CO_2) flux with the eddy covariance technique were conducted at a burned boreal forest site five years after a wildfire and at a mature forest site in Interior Alaska to investigate the effects of wildfire on CO_2 exchange in a boreal forest. Both gross primary productivity and ecosystem respiration were lower at the burned site. The lower amount of vegetation explains the lower gross primary productivity and ecosystem respiration at the burned site. The reduced soil organic layer at the burned site further explains the lower respiration. On an annual basis, the five-year-old burned site was a CO_2 sink, which indicated earlier recovery of CO_2 exchange compared to other burned boreal forests in North America

- **Kasischke, E. S. and E. E. Hoy (2011). "Controls on carbon consumption during Alaskan wildland fires." Global Change Biology: n/a-n/a. http://dx.doi.Org/10.llll/i.1365-2486.2011.02573.x**

A method was developed to estimate carbon consumed during wildland fires in interior Alaska based on medium-spatial scale data (60 m cell size) generated on a daily basis. Carbon consumption estimates were developed for 41 fire events in the large fire year of 2004 and 34 fire events from the small fire years of 2006 to 2008. Total carbon consumed during the large fire year (2.72 x 106 ha burned) was 64.7 Tg C, and the average carbon consumption during the small fire years (0.09 x 106 ha burned) was 1.3 Tg C. Uncertainties for the annual carbon emissions ranged from 13 to 21%. Carbon consumed from burning of black spruce forests represented 76% of the total during large fire years and 57% during small fire years. This was the result of the widespread distribution of black spruce forests across the landscape and the deep burning of the surface organic layers common to these ecosystems. Average carbon consumed was 3.01 kg m-2 during the large fire year and 1.69 kg m-2 during the small fire years. Most of the carbon consumption was from burning of ground layer fuels (85% in the large fire year and 78% in small fire years). Most of the difference in average carbon consumption between large and small fire years was in the consumption of ground layer fuels (2.60 vs. 1.31 kg m-2 during large and small fire years, respectively). There was great variation in average fuel consumption between individual fire events (0.56 to 5.06 kg m-2) controlled by variations in fuel types and topography, timing of the fires during the fire season, and variations in fuel moisture at the time of burning.

- **Makoto, K., N. Kamata, et al. (2011). "Bark-beetle-attacked trees produced more charcoal than unattacked trees during a forest fire on the Kenai Peninsula, Southern Alaska."**

Scandinavian Journal of Forest Research: 1-6. http://dx.doi.org/10.1080/02827581.2011.619566

Alaskan boreal forests frequently suffer from outbreaks of bark beetles and fires, factors that appear to combine to alter charcoal production. Charcoal (black carbon) production in forest ecosystems is an important pathway to clarify for a more complete understanding of the effects of fire on carbon cycling in boreal forests. In this study, we aimed to clarify the effects of prevalent outbreaks of the spruce beetle, Dendroctonus rufipennis (Kirby), on charcoal production during forest fires in boreal forests. Snags with prefire damage by the spruce beetle (infested snags) have significantly more charcoal than those undamaged before fire (noninfested snags). This increased amount of charcoal in spruce beetle-damaged trees was probably the result of dried biomass in the canopies of these trees. The results of this study suggest that with changing environmental conditions, the proliferation of insect damage in the boreal forest can modify the effects of fire on carbon sink via a change in the amount of charcoal production.

- **Nicholas J. Gralewicz, Trisalyn A. Nelson and Michael A. Wulder. 2011. Spatial and temporal patterns of wildfire ignitions in Canada from 1980 to 2006.** ***International Journal of Wildland Fire*** **- http://dx.doi.org/10.1071/WF10095 Submitted: 14 August 2010 Accepted: 7 June 2011 Published online: 20 December 2011**

A spatially explicit baseline measure of historic, current and future wildfire ignition expectations is required to monitor and understand changes in fire occurrence, the distribution of which climate change is anticipated to modify. Using spatial–temporal patterns of fire in Canada, we present a method to identify baseline expectations and ignition trends between 1980 and 2006 across 1-km spatial units. Kernel density estimates of wildfire ignitions and temporal trajectory metrics were calculated to describe expected ignition density, variability from expected density, and increasing or decreasing density trends. Baseline ignition expectations and trends were used to create unique fire ignition regimes and assess anthropogenic influence on ignitions. Fire ignition densities decreased exponentially as distance to road or populated place increased, and largest ignition trends occurred closest to both variables. Fire ignition regime delineation was more dependent on human transportation networks than human settlement. These findings provide a unique approach to quantifying ignition expectations. This research highlights the potential of this baseline approach for monitoring efforts and fire–environment interaction research and offers a preliminary spatially explicit model of wildfire occurrence expectations in Canada.

- **Rykhus, R. and Z. Lu (2011). "Monitoring a boreal wildfire using multi-temporal Radarsat-1 intensity and coherence images." Geomatics, Natural Hazards and Risk 2(1): 15 - 32. http://www.informaworld.com/10.1080/19475705.2010.532971**

Twenty-five C-band Radarsat-1 synthetic aperture radar (SAR) images acquired from the summer of 2002 to the summer of 2005 are used to map a 2003 boreal wildfire (B346) in the Yukon Flats National Wildlife Refuge, Alaska under conditions of near-persistent cloud cover. Our analysis is primarily based on the 15 SAR scenes acquired during arctic growing seasons. The Radarsat-1 intensity data are used to map the onset and progression of the fire, and interferometric coherence images are used to qualify burn severity and monitor post-fire recovery. We base our analysis of the fire on three test sites, two from within the fire and one unburned site. The B346 fire increased backscattered intensity values for the two burn study sites by approximately 5-6 dB and substantially reduced coherence from background levels of approximately 0.8 in unburned background forested areas to approximately 0.2 in the burned area. Using ancillary vegetation information from the National Land Cover Database (NLCD) and information on burn severity from Normalized Burn Ratio (NBR) data, we conclude that burn site 2 was more severely burned than burn site 1 and that C-band interferometric coherence data are useful for mapping landscape changes due to fire. Differences in burn severity and topography are determined to be the likely reasons for the observed differences in post-fire intensity and coherence trends between burn sites.

- **Turetsky, M. R., W. F. Donahue, et al. (2011). "Experimental drying intensifies burning and carbon losses in a northern peatland." Nat Commun 2: 514. http://dx.doi.org/10.1038/ncommsl523**

For millennia, peatlands have served as an important sink for atmospheric CO_2 and today represent a large soil carbon reservoir. While recent land use and wildfires have reduced carbon sequestration in tropical peatlands, the influence of disturbance on boreal peatlands is uncertain, yet it is important for predicting the fate of northern high-latitude carbon reserves. Here we quantify rates of organic matter storage and combustion losses in a boreal peatland subjected to long-term experimental drainage, a portion of which subsequently burned during a wildfire. We show that drainage doubled rates of organic matter accumulation in the soils of unburned plots. However, drainage also increased carbon losses during wildfire nine fold to 16.8±0.2 kg C m-2, equivalent to a loss of more than 450 years of peat accumulation. Interactions between peatland drainage and fire are likely to cause long-term carbon emissions to far exceed rates of carbon uptake, diminishing the northern peatland carbon sink.

- **Waddington, J. M., D. K. Thompson, et al. (2011). "Examining the utility of the Canadian Forest Fire Weather Index System in boreal peatlands." Canadian Journal of Forest Research: 47-58. http://www.nrcresearchpress.com/doi/abs/10.1139/xll-162**

The Duff Moisture Code (DMC) and Drought Code (DC) components of the Canadian Forest Fire Weather Index (FWI) System are used by fire managers to assess the vulnerability of organic soils to ignition and depth of burn despite being developed for upland soils. Given the need to assess wildfire risk in peatlands, we compared the DMC and DC in eight peatlands located in five regions in boreal Canada with water table position (WT) and surface volumetric moisture content (VMC). The slope of the change in WT and DC relationship ranged greatly (-0.01 to -0.11 cm) between sites and years likely due to differences in site-specific peat properties, catchment water supply, and presence of seasonal ice. A DC of 400, which has been associated with wildfire vulnerability in uplands, corresponded to a seasonal drop in WT in the range of 4-36 cm. The slopes of the relationships between DMC and DC with 5 and 15 cm VMC also varied greatly between sites. Our findings suggest that these FWI components are suitable for predicting the general moisture status and fire danger in boreal peatlands. However, there is a need for a modified DC for specific peat types to indicate when the WT has reached a critical depth upon which fire danger increases. We also present a suggested framework for the development of a new peat moisture code within the FWI.

- **Werth, P. A., B. E. Potter, et al. (2011). Synthesis of knowledge of extreme fire behavior: volume I for fire managers. Portland, OR: 144. http://www.nwccweb.us/content/products/fwx/pnwgtr854.pdf**

The National Wildfire Coordinating Group definition of extreme fire behavior (EFB) indicates a level of fire behavior characteristics that ordinarily precludes methods of direct control action. One or more of the following is usually involved: high rate of spread, prolific crowning/ spotting, presence of fire whirls, and strong convection column. Predictability is difficult because such fires often exercise some degree of influence on their environment and behave erratically, sometimes dangerously. Alternate terms include "blow up" and "fire storm."

Fire managers examining fires over the last 100 years have come to understand many of the factors necessary for EFB development. This work produced guidelines included in current firefighter training, which presents the current methods of predicting EFB by using the crown fire model, which is based on the environmental influences of weather, fuels, and topography.

Current training does not include the full extent of scientific understanding. Material in current training programs is also not the most recent scientific knowledge. National Fire Plan funds have sponsored newer research related to wind profiles' influence on fire behavior, plume growth, crown fires, fire dynamics in live fuels, and conditions associated with vortex development. Of significant concern is that characteristic features of EFB depend on conditions undetectable on the ground, relying fundamentally on invisible properties such as wind shear or atmospheric stability.

Obviously no one completely understands all the factors contributing to EFB because of gaps in our knowledge. These gaps, as well as the limitations as to when various models or indices apply should be noted to avoid application where they are not appropriate or warranted. This synthesis will serve as a summary of existing extreme fire behavior knowledge for use by fire managers, firefighters, and fire researchers. This synthesis will focus on the state of the science, but will also consider how that science is currently presented to the fire management community, including incident commanders, fire behavior analysts, incident meteorologists, National Weather Service office forecasters, and firefighters. It will seek to clearly delineate the known, the unknown, and areas of research with the greatest potential impact on firefighter protection.

- **Wolken, J. M., T. N. Hollingsworth, et al. (2011). "Evidence and implications of recent and projected climate change in Alaska's forest ecosystems." Ecosphere 2(11): artl24. http://dx.doi.Org/10.1890/ESll-00288.l**

The structure and function of Alaska's forests have changed significantly in response to a changing climate, including alterations in species composition and climate feedbacks (e.g., carbon, radiation budgets) that have important regional societal consequences and human feedbacks to forest ecosystems. In this paper we present the first comprehensive synthesis of climate-change impacts on all forested ecosystems of Alaska, highlighting changes in the most critical biophysical factors of each region. We developed a conceptual framework describing climate drivers, biophysical factors and types of change to illustrate how the biophysical and social subsystems of

Alaskan forests interact and respond directly and indirectly to a changing climate. We then identify the regional and global implications to the climate system and associated socio-economic impacts, as presented in the current literature. Projections of temperature and precipitation suggest wildfire will continue to be the dominant biophysical factor in the Interior-boreal forest, leading to shifts from conifer-to deciduous-dominated forests. Based on existing research, projected increases in temperature in the Southcentral-and Kenai-boreal forests will likely increase the frequency and severity of insect outbreaks and associated wildfires, and increase the probability of establishment by invasive plant species. In the Coastal-temperate forest region snow and ice is regarded as the dominant biophysical factor. With continued warming, hydrologic changes related to more rapidly melting glaciers and rising elevation of the winter snowline will alter discharge in many rivers, which will have important consequences for terrestrial and marine ecosystem productivity. These climate-related changes will affect plant species distribution and wildlife habitat, which have regional societal consequences, and trace-gas emissions and radiation budgets, which are globally important. Our conceptual framework facilitates assessment of current and future consequences of a changing climate, emphasizes regional differences in biophysical factors, and points to linkages that may exist but that currently lack supporting research. The framework also serves as a visual tool for resource managers and policy makers to develop regional and global management strategies and to inform policies related to climate mitigation and adaptation.

- **Gralewicz, N. J., T. A. Nelson, et al. (2012). "Factors influencing national scale wildfire susceptibility in Canada." Forest Ecology and Management 265(0): 20-29. http://www.sciencedirect.com/science/article/pii/S0378112711006542**

Wildfires are expected to increase as a result of climate change. In order to effectively manage and monitor climate-induced changes in Canadian forests, a national-scale understanding of factors influencing wildfire susceptibility is necessary. The goal of this study is to better understand factors influencing large area wildfire susceptibility in

Canada. Using year 2000 Canadian land cover data, we identify locations that burned before and after 2000. Pre- and post-fire landscape patterns were assessed and regression tree analyses were used to identify factors influencing national-scale fire susceptibility. Land cover composition, forest pattern, elevation, and anthropogenic influences were quantified for both pre- and post-fire environments. We examined recovery of forest pattern following wildfire events and derived a large-area fire susceptibility model using decision tree classification. Our results indicate that 11.88% of forested ecozones were impacted by large fires. The majority of large wildfires occur in coniferous forests characterized by high forest cover (greater than 45%), few forest patches, large mean forest patch area, and fragmentation-limited forest. Forests occurring at low to intermediate distances from populated places (50-150 km) and roads (12-72 km) experienced unexpectedly high amounts of fire, as did lower elevation forests. After fire, percentage forest cover, number of forest patches, forest patch size, and proportion forest patches regenerated to pre-fire forest pattern conditions within approximately 20 years. Anthropogenic influences on wildfire susceptibility indicate that human activity still dictates national fire regimes. Additionally, knowledge of space-time patterns of fire-landscape interaction and landscape pattern regeneration provides useful baselines for future comparisons with responses to climate change.

- **Kalamees, R., K. Pussa, et al. (2012). "Adaptation to boreal forest wildfire in herbs: Responses to post-fire environmental cues in two Pulsatilla species." Acta Oecologica 38(0): 1-7. http://www.sciencedirect.com/science/article/pii/S1146609X11001147**

Although boreal forests are biomes which are characterized by periodical forest wildfires, very little is known about adaptations to fire in forest herbs. We investigated whether a putatively fire-dependent herbaceous species - Pulsatilla patens - demonstrated adaptive responses to environmental cues that reflect differences in pre-fire and post-fire environments (the presence of ericoid litter and charcoal, and light levels). For comparison, we included in the experiment a close congeneric species that is less bound to forest ecosystems (Pulsatilla pratensis) and a morphologically similar mesic grassland species from the same family (Ranunculus polyanthemos), as examples of species for which adaptations to fire should be of lower value, or of no value at all, respectively. The addition of ericoid litter to the soil generally enhanced plant growth, suggesting that its negative effect on plant germination and growth is not as widespread as previously thought. In both Pulsatilla species charcoal without forest litter retarded plant growth, but in combination with ericoid litter the negative effect disappeared or was even replaced by a slightly positive effect. Such an interactive effect was absent in the grassland species R. polyanthemos. The response of Pulsatilla species to different post-fire signals may be explained by adaptive down-regulation of growth after high-intensity fire - small plant size can be advantageous in sparse and well illuminated field-layer vegetation - and intense growth in the more competitive situation following weak fire. An additional experiment demonstrated that the effects of fire-related treatments were not mediated by differential AM infection.

- **Ordonez, C, A. Saavedra, et al. (2012). "Using model-based geostatistics to predict lightning-caused wildfires." Environmental Modelling & Software 29(1): 44-50. http://www.sciencedirect.com/science/article/pii/S1364815211002155**

The probability of fire in a particular area depends on a range of environmental and geographic variables. Fire prevention planning can be assisted by the construction of models to identify the variables that have a significant influence on the occurrence of fires and by building maps showing the spatial probability distribution for fires occurring in specific geographic areas. We used generalized spatial linear models to predict spatially distributed probabilities for fire occurrence in locations where storms featuring lightning occurred, on the basis of a set of variables related to climatology, orography, vegetation and lightning characteristics, and to assess the relative importance of these variables. A comparison of this model with simple logistic regression models used by other researchers to resolve similar problems demonstrates the importance of bearing in mind spatial correlation between variables.

- **Quentin Renard , Raphaël Pélissier , B. R. Ramesh and Narendran Kodandapani. 2012. Environmental susceptibility model for predicting forest fire occurrence in the Western Ghats of India.**

Forest fires are a recurrent management problem in the Western Ghats of India. Although most fires occur during the dry season, information on the spatial distribution of fires is needed to improve fire prevention. We used the MODIS Hotspots database and Maxent algorithm to provide a quantitative understanding of the environmental controls regulating the spatial distribution of forest fires over the period 2003–07 in the entire Western Ghats and in two nested subregions with contrasting characteristics. We used hierarchical partitioning to assess the independent contributions of climate, topography and vegetation to the goodness-of-fit of models and to build the most parsimonious fire susceptibility model in each study area. Results show that although areas predicted as highly prone to forest fires were mainly localised on the eastern slopes of the Ghats, spatial predictions and model accuracies differed significantly between study areas. We suggest accordingly a two-step approach to identify: first, large fire-prone areas by paying special attention to the climatic conditions of the monsoon season before the fire season, which determine the fuels moisture content during the fire season; second, the most vulnerable sites within the fire-prone areas using local models mainly based on the type of vegetation.

Books

- **S B Shows, B Clarke. 1994. Forest Fire Control. International Book Distributors. Book Condition: New. pp. vi + 109 , Illus. Bookseller Inventory # 7457217. ISBN 10: 8170891906 / ISBN 13: 9788170891901.**

This book discussed about the policy at national level, effect of fire on forest values, planning of protection, prevention strategies and forest management along with various steps of Presuspression and suspression in controlling of forest fire.

- **Five Fires: Race, Catastrophe, and the Shaping of California**

Book by David Wyatt; Addison-Wesley, 1997. Persus publicizing,Reading, MA. Publication.

Earthquake and forest fire and drought and "the Santa Ana is to accept," Joan Didion argues...James and the Californians he wrote about survived the earthquake and fire by subsuming the experiencing into the spectatorial self.

- **Opportunities, Fire Protection Services Careers**

Book by Ronny J. Coleman; VGM Career Books, 2003. Chicago. Publication Year: 2003. Page Number: ii.

The U.S. **Forest** Service protects the areas of the country that are called national **forests.** These are primarily areas...watershed. There are national forests in almost all of the fifty...nations natural resources from **fire.** During any given year, the U.S. **Forest** Service may fight hundreds of thousands of fires that are caused by either.

- **Indonesia's Fires and Haze: The Cost of Catastrophe**

Book by David Glover, Timothy Jessup; International Development Research Centre, 2006. Publisher: International Development Research Centre. Ottawa. Publication Year: 2006. Page Number: iii.

The need to improve **forest** management is at the heart...issues in Indonesia, including **forest fires.** The Indonesian government... industry have treated Indonesias **forests** as though they were of low... invest- ments in improved **forest** management despite the value...causes of the 1997/98 **forest fires** as well as other social and...that is largely destroyed by **fire**. Despite warnings from environmental.

- **R.K. Luna. 2007. Principles and Practices of Forest Fire**

Control. International Book Distributors, 9/3, Rajpur Road, (Ist Floor), DehraDun – 248001 (India). ISBN: 9788170893429. E-mail: ibdbooks2003@yahoo.co.in, gahlotrps@hotmail.com & rpsinghgahlot@gmail.com. Website: www.ibdbooks.com.

Through recurrent fires cause a great harm to the structure and the functions of the forest ecosystems, wildlife and biodiversity and economic wealth, they had not been given an appropriate place in the forest management schemes of India. Fires still annihilate millions of hectares of forest area annually causing irreparable damage to the plantations raises of a considerable cost and effort. Forest fires in India are still fought with age-old methods, when systematic modern fire management techniques and methods are followed in rest of the world. This book after presenting a comprehensive overview of the fire history in India, enlists the faces and dimensions of the fire problem and explores the causes and effects of fires on the forest watersheds productivity and national economy. The unpredictable fire behavior due to variable weather and fuel elements has been discussed with respects to fire size, fire shape, fire growth, fire frequency, and fire intensity. Various principles and practices of fire control measures have been dealt under fire prevention fire presuppression activities and fire suppression along with tools and mechanized equipment strategy.

- **Jha, M.K. (Ed.). 2010. Natural and Anthropogenic Disasters-Vulnerability, Preparedness and Mitigation.** Springer jointly published with Capital Publishing Company, ISBN 978-90-481-2497-8

The major challenges of the 21st century faced by human beings are how to achieve water security, food security, energy security and environmental security. Owing to enhanced natural/anthropogenic disasters worldwide, these challenges become much more complicated and daunting especially for developing countries. Therefore, it is important to highlight the risk of different disasters as well as the modern tools and techniques for minimizing disaster incidence and losses.

Disaster management being highly multidisciplinary in nature, a comprehensive book dealing with different aspects of disaster management, and encompassing important disasters faced by humankind is presently not available. This book is an attempt to fulfill this gap. It provides clear, comprehensive, and up-to-date information about different facets of disaster management along with salient case studies including management of forest fire disaster: Perspectives from Swaziland. The book highlights the current status of disaster management focusing on developing nations, discusses vital issues such as climate change and sustainable development, modern approaches and tools/techniques, and the challenges of and future R&D needs for sustainable disaster management.

Source:

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