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# INTERNATIONAL FOREST FIRE NEWS

**No. 34**

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# NOTE

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All IFFN contributions published between 1990 and this current issue are accessible through 77 country folders and other special files on the GFMC website.

**Call for contributions**

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

Contributions are preferably received by e-mail.

The deadlines for submitting contributions to the bi-annual issues are: **15 May and 15 November.**

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Due of the time lag between editing and print/distribution of IFFN, readers interested in meeting announcements are kindly requested to visit the Internet version of this issue for update and short-term announcement of meetings (continuously updated) on http://www.fire.uni-freiburg.de

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# EDITORIAL – PORTUGAL AND ASIA SPECIAL ISSUE

Dear IFFN reader: How would you respond if an analysis of the fire situation in your country would state:

- The easy aptitude of forests to burn has always been used as weapon on discord. Recently it is also a weapon of various economical interests.
- Successive burning may be used to force down the forestry profile of land into other uses. This may be the case of urban or tourism interests.
- Changes on the type of the species cover are also part of the economic causes for arson. Despite of the law, which rules that forest land cannot be occupied for other uses during ten years after a fire, this "quarantine" is not dissuading investors from setting fire.
- Despite the legal impediments to cut certain tree species, it is possible to remove them once they are dead, e.g. due to fire. Thus, your forest can be liberated from these species and afforested by the fast-growing ones …
- Wood traders are profiting from cheap wood harvested post-fire: Properly debarked salvage-logged timber can be sold as non-burned wood – increasing the profit margin…
- Private companies specialized in fire combat are to be added to the horde of the potential beneficiaries of forest fires. Episodes of commanders of fire brigades that simultaneously own business of fire combat equipment are being reported by the media.
- Forest fires are dramatic media events. Fearing electoral punishment any government gives ground to a panoply of cabinets, committees, task forces, seminars, etc. which pace of grow is dictated by the dimension of the forest fires of the previous year.
- The academic lobby is another one to be included in the horde of forest fire beneficiaries: The "fire industry" ends up to be an extra source of financing, especially in universities, that gives justification for cathedra posts and pays for research projects, studies, publication, etc. …
- In a country with a fragile economy any uncertainty of employment, even temporary jobs, attract sympathy of the common citizen.
- The subtle beneficiaries of the "fire industry", which honestly and clean is based on fire-created jobs, is finally infecting the society with an imperceptible feeling of indifference upon the fire devastation. To feel in peace requires nothing more than being certain of not having set any fire.
- Indeed like the fire-adapted species, for a part of the society forest fires are not a factor of destruction, rather an active economic sector.
- If wildfires become a rule, a part of the society may become fire-dependent, like some of the forest species …

What else should be suggested than reading this issue of IFFN, which is giving insight into the underlying causes and driving agents of fire in Southern Europe. Frank reviews of the fire situation at home may help to critically reflect about the interconnectedness between the dramatically changing natural and socio-environmental conditions on the one side, and the changing fire regimes and fire impacts on the other side.

Another cluster of reports is covering mainland South Asia. This region is impacted by rapid rural population growth and poverty – the opposite trend of the rural exodus of Southern European hinterlands. More rural inhabitants, less fuels and more fires sources in South Asia; decreasing land use and populations and more fuels in Southern Europe: the effects of demographic and land-use changes on severity and destructivity of wildfires seems to be increasing similarly.

Freiburg – Geneva, June 2006 Johann G. Goldammer

# PORTUGAL SPECIAL

## The Deep Roots of the 2003 Forest Fires in Portugal

## 1. Introduction

Portugal is Atlantic by geography, but Mediterranean by climate; the consequences of this for the forest is the susceptibility to fires, created by the long dry summers which makes wildfires a major and striking concern in the country (Table 1 and Figure 1).

**Table 1.** Rate of burn (percentage of forest area and shrub land burned) and number of fires in Southern European countries. Source: UNECE statistics and GFMC websites for the year 2000.

| Country | Burned area (ha) | Number of fires | Rate of burn (%) |
|---|---|---|---|
| France | 20.459 | 2.908 | 0.13 |
| Spain | 187.026 | 24.117 | 1.31 |
| Italy | 140.384 | 10.038 | 1.40 |
| **Portugal** | 159.605 | 34.109 | 4.31 |
| Greece | 14.650 | 14.650 | 4.64 |

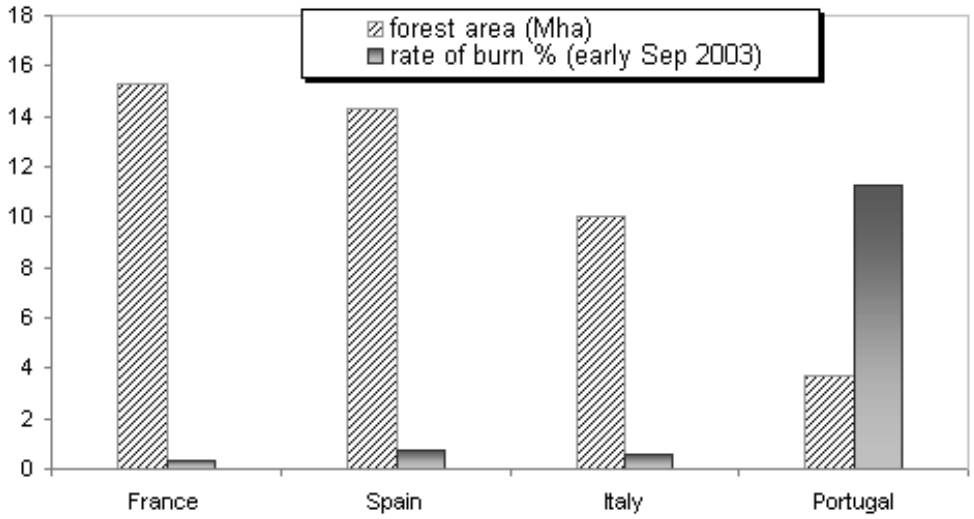


**Figure 1.** Rate of burn in 2003 by beginning of September. Source: UNECE (2003)

However the dramatic explosion of the area burned during the summer of 2003 was unprecedented when compared with previous years (Figures 2a,b, 3, 4).

Energised by an abnormal hot and dry weather wave that acted as a spark over the immense easy-burnable landscape in the Portuguese forest in 2003, the normal forest fire incidences turned into a catastrophe that gained terrifying proportions.

**Conjunctural and structural causes explain the reasons for the frequent forest fires in Portugal**

Natural phenomena linked to weather, economical interests, accidents, social conflicts, and negligent or delinquent behaviour are the conjunctural causes.

The devastation which occurred during the summer of 2003 was amplified by structural causes such as:

- the chaotic structure of small private property that encourages abandonment of many of these small holdings
- the absence of a sustainable long-term national forest policy
- lack of a strategy for the rural economy comprising forestry sector
- the deterioration of the Forest Services
- poor organisation of the fire-fighting structure and lack of specific training of fire-fighting corps
- poor education and poor public awareness campaigns on the increased risks of forest fires

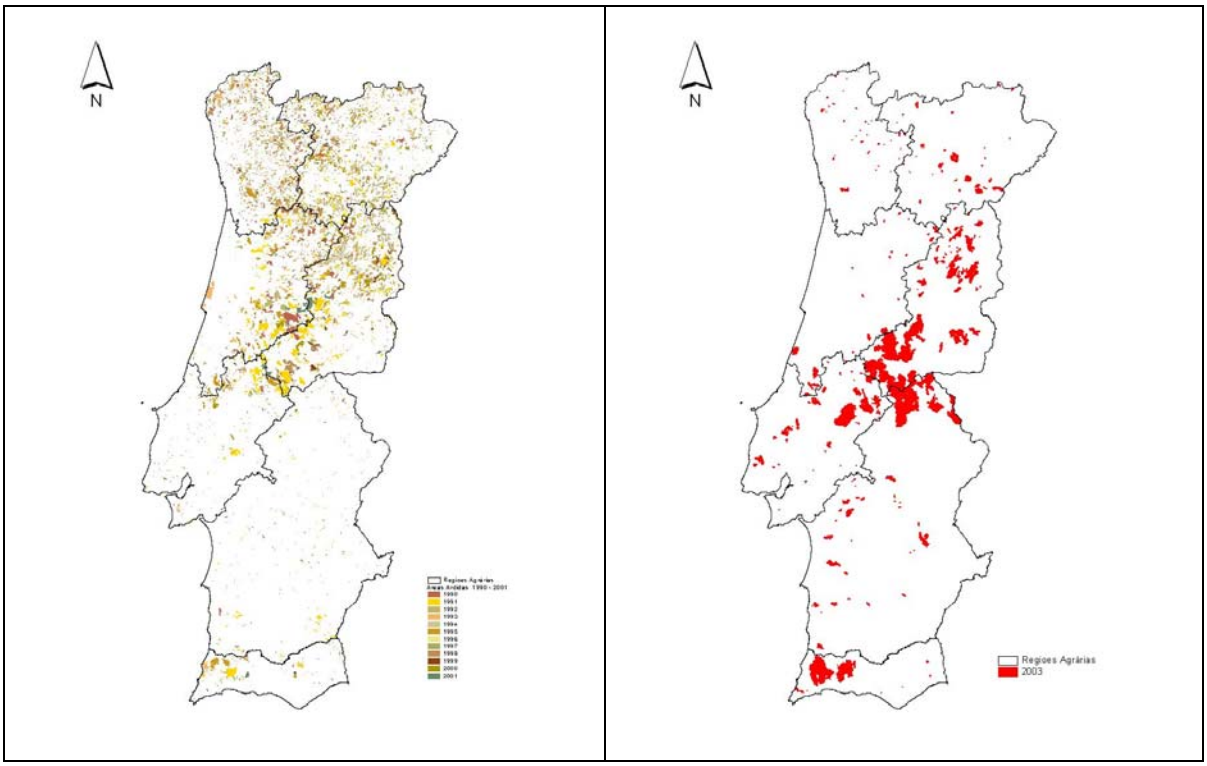


**Figure 2.** (a) Area burned by wildland fires in Portugal 1980-2001 (left), and (b) in summer of 2003 (right). Source: DGF (2003).

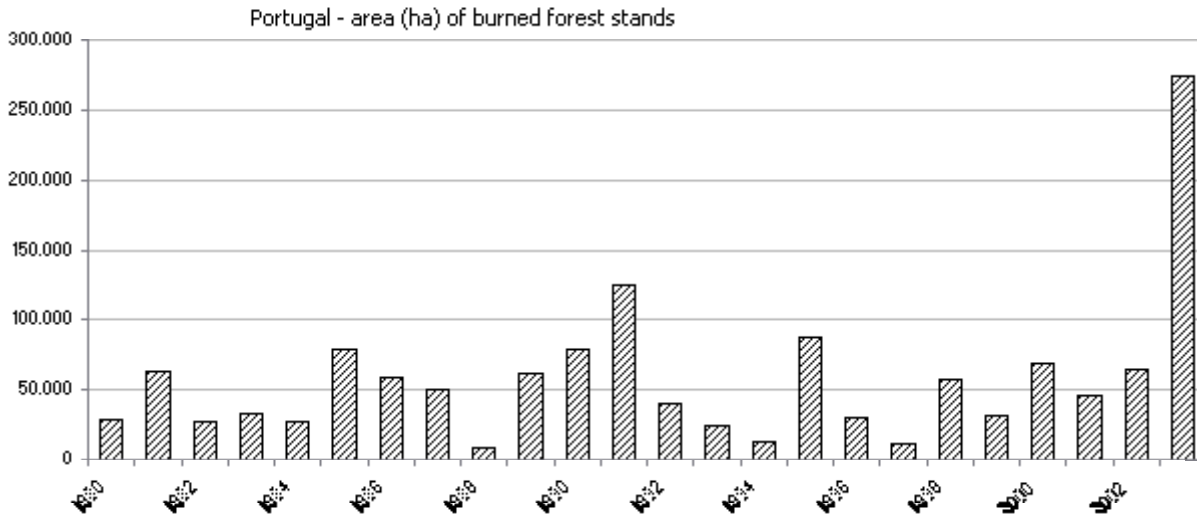


**Figure 3.** Burned area of forest stands in Portugal 1980 to 2003 (for the period 1 January – 15 October). Sources: Data from 1968 to 1979 – IPF (1987); data from 1980 to 2003 – DGF (2003).

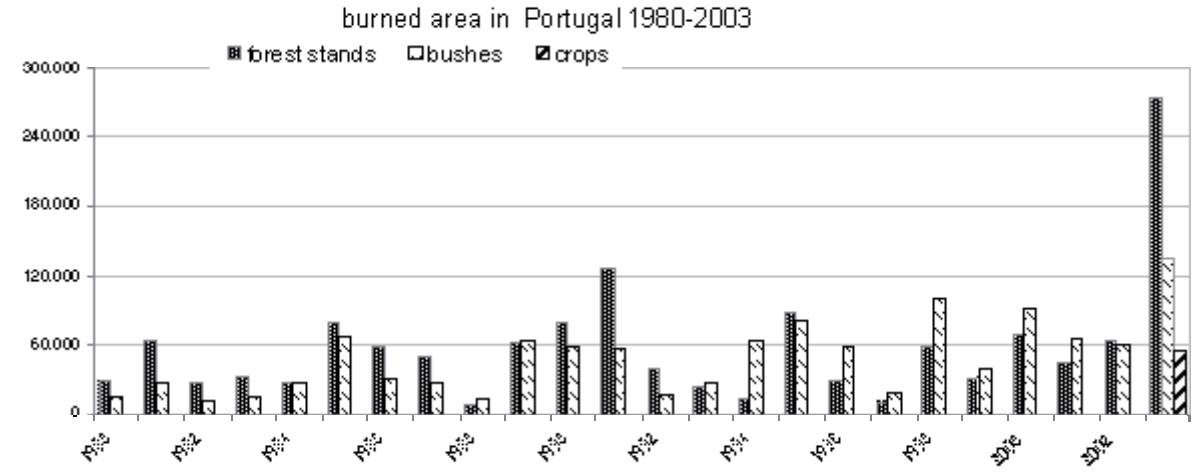


**Figure 4.** Burned areas of forest stands and other vegetated lands in Portugal 1980 to 2003 (for the period 1 January – 15 October). Source: DGF (2003).

Twenty one human lives were lost, near to 500,000 hectares of forest, shrub land and agriculture crop were burned in 2003, hundreds of domestic houses and agricultural facilities were destroyed and thousands of farm animals were killed. Losses on wildlife, soil erosion, $CO_2$ release are further negative impacts to be included. The costs of fire-fighting, especially from the air with aircrafts, were enormous.

The direct and indirect costs of the 2003 fires will be reflected on the Portuguese economy for many years to come and the delicate ecological balance will suffer long-term damages.

## 2. The economical and social importance of forest in Portugal

Forest covers more than 3,200,000 ha, about 1/3 of Portugal's surface (Figure 5). If shrub land is also considered, the percentage of vegetated cover vulnerable to fire increases to more than 50% the country's surface (see data for 1995 in Table 2).

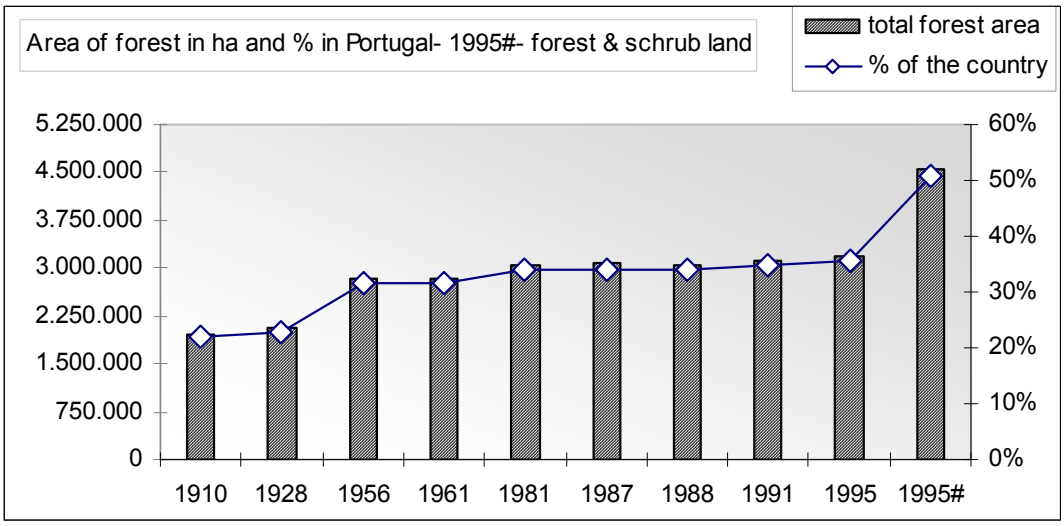


**Figure 5.** Forest area in hectares and in percentage for the country total area. Note: The percentage of cover in 1995 includes forests and shrub lands.

Apart from ecological, landscape and wildlife irreplaceable values, the forest is an important element in the overall Portuguese economy as data on Tables 2 to 5 reveal.

**Table 2.** The Portuguese forest by area of the main vegetation types and main species. Source of Tables 2-5: DGF (2003)

| Vegetation Type | Area in 2001 (ha) |
|---|---|
| Total forest area | 3,201,131 |
| Shrub land | 1,350,000 |
| **By species** | |
| *Pinus pinaster* | 976,069 |
| *Eucalyptus globules* | 672,149 |
| *Pinus pinea* | 77,650 |
| *Quercus suber* | 720,000 |
| *Quercus rotundifolia* | 441,577 |
| *Castanea sativa* | 40,579 |
| Other broadleaves | 130,899 |
| Other conifers | 27,358 |

**Table 3.** Economical profile and international trades of forest products for the year 2001

| | Import (million €) | Export (million €) | Coverage Rate [1] | Import price / ton | Export price / ton | export / import price |
|---|---|---|---|---|---|---|
| Resin products | 26 | 29 | 111% | 0.60 | 0.95 | 1.59 |
| wood | 525 | 393 | 75% | 0.33 | 0.21 | 0.63 |
| **Cork** | 89 | 894 | **639%** | 2.80 | 6.65 | **2.38** |
| Pulp | 904 | 475 | **534%** | 0.49 | 0.42 | **0.85** |
| paper | 211 | 798 | 88% | 1.14 | 0.81 | 0.71 |
| furniture | 1895 | 150 | 71% | 1.14 | 0.81 | 0.71 |
| **TOTAL** | | 2.739 | 145% | | | |

[1] Coverage rate – The ratio of export/import expressed in %

**Table 4.** International trade of forest products compared with the overall trade of Portugal

| **Export and import** | **Value (million Euro)** |
|---|---|
| Total export for Portugal | 27.090 |
| Export of forest products | 2.782 |
| % | 10% |
| Total import for Portugal | 44 054 |
| Import of forest products | 1894 |
| % | 4% |
| Coverage rate for the forest products [1] | 145% |
| Coverage rate for the overall trade of Portugal | 60% |

[1] Coverage rate – The ratio of export/import expressed in %

**Table 5**. Employment, industries and added value for the forest sector in Portugal, 2002

| **Industries (n)** | **Employment (n)** | **Value of the production (x 1000 Euro)** | **Gross added value (pm)- (x 1000 Euro)** |
|---|---|---|---|
| 12,418 | 74,170 | 5,992,181 | 1,793,584 |

The direct economic importance of forestry to the overall Portuguese economy and employment is remarkable. Forest supports more than 74,000 direct jobs, comprising a trade coverage rate of 145%, in contrast with the value of 60% for the country's overall trade (Figure 6).

Within forest sector balance cork oak holds a unique profile. For the year 2001 this species has generated near € 900 million of yearly exports under a coverage rate of 639% and very low competition.

Differences on cork oak and eucalyptus go beyond the coverage rate. The terms of trade for the respective products have critical differences since for cork it has a strong favourable value close to 3 while for eucalyptus pulp it stays under 1, being only 0.85 on the threshold of the deterioration value (Figure 6). If the overseas prices of pulp decrease the continuity of pulp production in Portugal may be in threat leaving behind thousands of hectares of a high inflammable species devoid of economical interest.

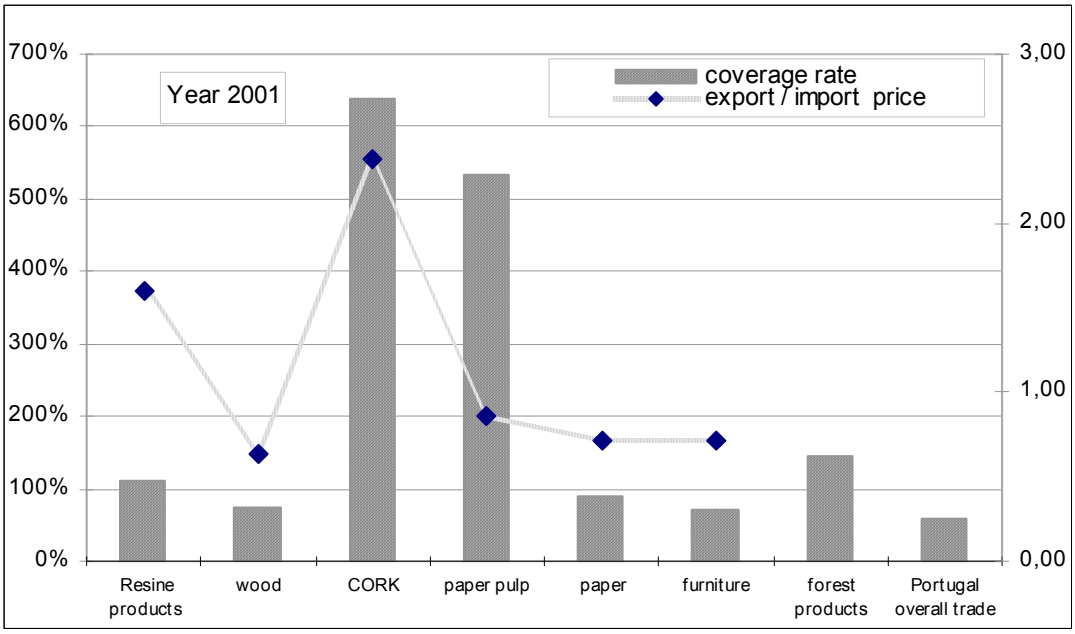


**Figure 6.** Coverage rate for forest products in bulk and individually and export/import ratio compared with the overall trade of Portugal. Sources: INE (2003), DGF (2003)

The long life span of the forest species, the long rotation and the stand's large areas instil particular inertia into the forest sector, dramatically different from the agricultural sector. Forest's inertia is shown by a slow rate of income generation and also by the effects of poorly developed policy.

The profile of the sector requires a sound national policy that must withstand short-term political changes and shot-term economical interests and be extremely vigilant towards wildland fires.

However, the history of forestry in Portugal during the last three decades shows a different picture.

## 3. Forest fires in Portugal during the last decades

The Mediterranean profile of the Portuguese climate is a major reason for the dangerous forest fire situation. The risk of forest fires and the need for strong measures on prevention are repeatedly addressed at the Portuguese forest technical and scientific works. Already by 1888 Sousa Pimentel considered that forest fires prevention should be part of forestry management programmes.

Although scientific knowledge highlights the concrete measures to minimize forest fires risk (Natividade, 1950) no echoes are seen on the forest policy.

From the seventies to date the occurrence of forest fires shows a clear increase in trend (Table 1 and Figures 3 and 4). The period coincides with several processes of profound changes in the rural economy in Portugal which interacted to increase the incidence of forest fires:

- dramatic decrease of rural population accompanied by the abandonment of cultivation of numerous zones together with decrease of animal grazing on forest and shrub lands
- incentives to afforestation disconnected from a concerted national strategy for the rural economy, that should be designed to support extensive and familial agriculture and continuing rural settling
- lack of national forest fire prevention plan integrated with traditional agriculture and a global network of compartmenting with soft fire-profile's species
- Afforestation primarily focused on highly inflammable species, mainly eucalypts (*Eucalyptus globulus*) and pines (predominantly *Pinus pinaster*)

In the first half of the 20th century the exotic genus *Eucalyptus* had an almost negligible share of the Portuguese forest. Over the past 50 years, however, its coverage grew by about 700,000 ha (Figure 7). Eucalypts are grown in monocultures for the production of cellulose pulp, managed under intensive silviculture in dense pure coppice stands, on an average rotation of 10 years. Nowadays eucalypts occupy considerable large continuous areas or are growing in mosaic amid Maritime Pine and Cork Oak. The genus spread out through the range of those two native species due to the fact that it has similar ecological requirements. However, the ecological conditions of the natural range of Holm Oak area are, generally, too dry to sustain economically profitable stands of eucalypts.

The total area of Maritime Pine and eucalypts, the species whose physiology and silviculture create the most susceptible conditions for forest fires, is currently 51% of the total forestry area.

If unmanaged after wildfires these fire-adapted species take full advantage of the fire-response mechanisms and increase the area occupied.

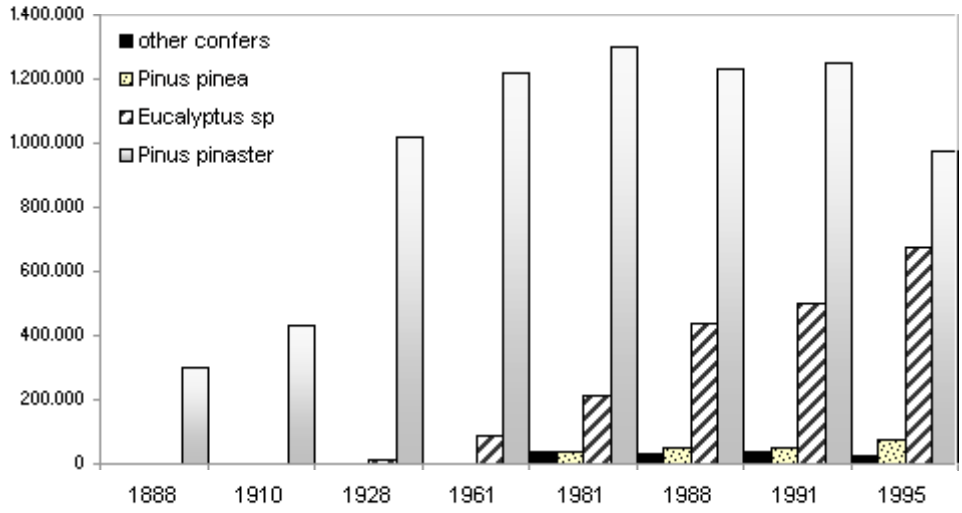


**Figure 7.** Evolution of the area of highly inflammable species between 1888 and 1995

Maritime pine and eucalyptus are extremely important species for the Portuguese forest economy. The preservation of their economical status claims severe measures for fire prevention, considering the high susceptibility to fire.

But in sites where their growth is under the economical viable threshold, those species should be completely eradicated and substituted for less prone to fire species or set-aside for natural vegetation covering for environmental and landscape benefits.

The cost-benefit analysis of the “unproductive” natural vegetation land in comparison with the fire prevention and combat on poor productive areas of pines or eucalyptus has certainly a positive balance.

## 4. Structural causes for forest fires in Portugal

### Structure of private property

About 85% of the forest area in Portugal is in private ownership, with a considerable part based on very small holdings. The 8.9 millions of hectares of the country are fragmented amid more than 10.8 millions of rural holdings (data made available by courtesy of the Direcção Geral de Contribuições e Impostos [DGCI], Lisbon) in very skew distribution. Sharp differences across the country are patent at a plain analyzes of the average size by district (Table 6). Four districts representing 32% of Portugal surface host about 270,000 rural holdings while the other 14 districts – 68% of the area host about 10.5 millions.

**Table 6.** Distribution of rural holdings in Portugal

| 14 districts - 68% of the country | | | 4 districts - 32% of the country | | |
|---|---|---|---|---|---|
| **Area (ha)** | **Number of holdings** | **Average area (ha)** | **Area (ha)** | **Number of holdings** | **Average area (ha)** |
| 6,019,700 | 10,532,916 | 0.57 | 2,874,700 | 264,949 | 10.85 |

The small size which is in itself a major obstacle to efficient economic forest management, is exacerbated whenever the plots are in compulsorily common ownership of several co-owners, as often happens.

The extreme fragmentation of the rural property has been a concern for governments since the early 20th Century. Law 5705 promulgated on 10 May 1919 encouraged individual owners to merge their dispersed plots by changing the small holdings among themselves. The law provided incentives through tax benefits and registration free of fee. However, impacts of Law 5705/1919 were deceiving, and the fractioning of the rural property among heirs into smaller and smaller holdings continued.

The failure to stop the "atomization process" of the rural estates by developing for Portugal a legal framework similar to the French's "*bien de famille insaisissable*", the Switzerland's "*asile de famille*" or the Germany's "*Erbho*f" led authorities to approve the Law No. 16731, promulgated on 13 April 1929. In Article No.107 it is declared the indivisibility and co-ownership among the co-heirs and "inalienability" of the plot in parts whenever it size is under 0.5 ha (Castro Caldas, 1998).

Whereas in cadastral maps the physical size of the rural estate will not be further divided, the arising problems are hidden behind the increasing number of heirs, and solutions are postponed.

In the following the issue will be shortly designated as "indivisible" property.

Incentives for merging of rural small property and impediments on fragmentation was a concern in the Portuguese legislation throughout the whole 20th Century. Merging is addressed is various legislative acts namely Law 2116 of 14 August 1962, and Decree No. 44647 of 26 October 1962.

However the principle of indivisibility will be maintained unquestionable, only the minimum size of the holding liable of division among heirs will change. The general indivisible area size of 0.5 ha decreed by the Law No. 16731/1929, was modified to 0.5 ha, 1 ha or 2 ha according to site (soil) productivity by Law 2116/1962 reaching 7.5 ha in the south districts by the Government Directive No. 202 of 21 April1970 – both still in force.

The principle of "indivisibility" promulgated by Law No. 16731/1929, Article No.107, aimed to prevent the fragmentation of the rural property family patrimony into unviable holdings. However the effects of the law are the opposite and presently the load of the small unviable "indivisible" rural property is inexorably divided among the compulsive co-owners.

While the rural family was living in closeness and managing the plots in cooperation, and while the forest production was for self-consumption or for local markets with low exigency standards, the "indivisibility" principle shortcomings were hidden. But during the 1960s Portugal went through deep economical and social changes. Internal migration, especially the rural mass exodus and the rapid urbanization, resulted in irreversible splitting of the rural families. At the same time, the forest market became more competitive, making the exploitation of small plots uneconomical.

Deprived of economical viability, confounded on numerous owners that know less and less about one another, lost amid remote forest areas, thousands of those small pieces of "indivisible" land are nowadays in total and irretrievable abandon.

As time goes on, heritage process over heritage process, the number of co-owners increases, while the knowledge about one another, about the location and physical limits of the estate are lost.

Left as it is the entropy of the "indivisible" property can do but increase.

In Mediterranean conditions the land, devoid of human management or animal grazing, is quickly colonised by dense vegetation of trees, shrubs and tall grasses. Maritime pine profits from the abandonment due to the high ability for natural regeneration.

Eucalypts proliferated, boosted by afforestation programmes and by the involvement of cellulose companies that rented or purchased land, often by providing juridical assistance to overcome the legal constraints of a quantity of the "indivisible" holdings.

By human hand or by its absence, maritime pine and eucalypts, the "easy" species could eliminate the chances of oaks and noble hardwoods to survive on the abandoned land.

Under this scenario, large areas of the Portuguese forest became, in some decades, dominated by species of high combustibility establishing ideal conditions for immense and incontrollable forest fires that have devastated considerable areas of Portugal during the last couple of decades (Figure 7).

When the small and unviable property is frequently overrun by fires the possibility to abandon the property is enhanced. A self-fed mad circle of abandon – increase of fire hazard – abandon becomes established.

The obsolete system of land ownership is, therefore, a structural cause for increasing wildfires in Portugal.

**Measures**

Structural changes on the "indivisible" small property are one of the key points to focus to reduce the occurrence of forest fires in Portugal. Changing the legal status is a long-term task and claims a deep commitment from the State on implementation and coordination. Furthermore it claims concerted expertise on various fields including among others, legislators, economists, foresters. The goal is to eradicate the uneconomical small holdings.

Implementation

- Survey on the level of "indivisible" small property by cartography with information on owners and location
- First phase – a time-scale for co-owners to involve themselves and to decide themselves on one single owner through purchase or compensation or on the sale of the property as a whole to an outside buyer or the State

Taking into consideration that Portugal is the EU country with lower forest state area and that some economical and social role of forest are not compatible with private ownership, the state shall allocate itself the status of first preferential purchaser. Expropriation under national interest shall also be considered.

Instruments

Since this type of property drives immense economical damage to the country, it is justified to create a special line of loan to help the acquisition whenever justified.

- "Voluntary" phase: Legal, economic and even social assistance shall be provided to the co-owners by the State
- Compulsory phase: If agreement among the co-owners is not reached within the fixed time-span the State shall purchase the property at a price agreed by independent adjudication.

In the shot term these measures will assure each small forest plot to be under the responsibility of one owner. This is a basic requirement for establishing management plans. Yet in the long run there is a need to work towards a sustainable minimum size of the forestry properties. Measures for assembling the areas under the threshold size may be needed. The minimum viable size is different in the various regions of the country according to ecological conditions and the social profile of the human settlement.

## 4. National forest strategy and diversification of forest species

National forest strategy is addressed in various official documents; however the evolution of the Portuguese forestry policy shows the theoretical profile of the enterprise.

The lack of national long-term forest strategy can be assessed when analyzing the national distribution of the species, the fire-control measures, the inconsistencies on forest inventories and the lack of effective State responsibilities on various aspects of the sustainability of the Portuguese forest system.

Since 1960 Portugal has benefited from various programmes for large scale afforestation: *Fundo de Fomento Florestal* (Portuguese funding), World Bank and recently European Union. The foremost result of those large investments is the increase of the area of eucalypts and poorly managed maritime pine areas both under inefficient compartmentalization.

The easy aptitude to spread by natural regeneration added by funding incentives gave maritime pine the opportunity to fourfold the overall area in half a century. Eucalyptus increased its area about eight times in 50 years (Table 7, Figure 8) thanks to funding programmes and large investments from pulp companies.

All these changes occurred under poor compartmenting or total absence of it in some areas. In some cases even riparian areas were afforested with those species after the natural vegetation composed of *Alnus*, *Fraxinus*, *Salix*, *Populus*, etc. were eradicated.

Some of the afforestation plans include fire breaks. However cleared from the competition of the tree story, fire-breaks become zones invaded by intolerant high-inflammable shrubs when not maintained.

Well established and well maintained firebreak networks exist only in National Forests and those eucalypt stands that managed by the cellulose companies, or in some few large estates where good practices of silviculture are applied.

In zones with considerable proportion of small unviable, “indivisible” or abandoned properties, efficient fire-break strips are extremely difficult to establish.

If fire starts the well managed properties in vicinity are easily devoured by the flames coming from by the uncontrolled spread of fire from the adjoining poorly managed areas.

The distribution of the species at the Portuguese forest has been driven by short term objectives of the cellulose companies and private owners and not by a national strategy. Approved and sometimes even supported by the state, afforestation with pines and eucalyptus took place in agricultural land, creating inflammable situations in valleys that were buffer zones when former agriculture and grazing activities were performed.

The issue of the small “indivisible” property is in itself another evidence of the lack of a solid national forestry strategy.

In the Portuguese forest scenario oaks (except Cork Oak and Holm Oak) and riparian species have a low economic profile. Their use as fire-prevention species is beyond the scope of most private owners. In some circumstances it is possible to impose a compulsory use, for instance if afforestation has benefited from State funding. Taxes benefits may also be used as a support mechanism. However in most cases it is necessary to consider financial support to these species. This support should be part of the programme on fire prevention, especially in cases of small plots and small private owners. Such multifunctional approach for fire-breaking is not feasible In the “indivisible” small property.

The Portuguese forest is presently composed by more than 50% by pines and eucalypts (Table 7, Figure 8).

**Table 7.** Evolution of the surface of "inflammable" species in Portugal

| | **1910** (1) | **1928** (1) | **1956** (3) | **1961** (4) | **1981** (5) | **1987** (6) | **1988** (7) | **1991** (8) | **1995** (9) |
|---|---|---|---|---|---|---|---|---|---|
| Total forest area | 1,956,500 | 2,050,000 | 2,826,000 | 2,830,000 | 3,041,000 | 3,062,550 | 3,055,800 | 3,102,200 | 3,201,131 |
| *Pinus pinaster* | 430,194 | 1,020,186 | 1,288,000 | 1,220,000 | 1,300,900 | 1,287,800 | 1,232,420 | 1,248,600 | 976,069 |
| | **22.0%** | **49.8%** | **45.6%** | **43.1%** | **42.8%** | **42.0%** | **40.3%** | **40.2%** | **30.5%** |
| *Pinus pinea* | | | | | 34,840 | 50,310 | 50,110 | 50,110 | 77,650 |
| | _ | _ | _ | _ | **1.1%** | **1.6%** | **1.6%** | **1.6%** | **2.4%** |
| other conifers | | | | | 35,000 | 39,400 | 32,550 | 39,600 | 27,358 |
| | _ | _ | _ | _ | **1.2%** | **1.3%** | **1.1%** | **1.3%** | **0.9%** |
| *Eucalyptus* spp. | | 10,000 | 99,000 | 88,000 | 215,390 | 434,690 | 434,690 | 500,000 | 672,149 |
| | **0.0%** | **0.5%** | **3.5%** | **3.1%** | **7.1%** | **14.2%** | **14.2%** | **16.1%** | **21.0%** |
| *Quercus suber* | 365,995 | 560,000 | 637,000 | | 654,900 | 667,600 | 668,700 | 659,800 | 712,813 |
| *Quercus rotundifolia* | 416,658 | 380,000 | 579,000 | | 535,950 | 432,510 | 472,450 | 464,200 | 441,577 |
| *Castanea sativa* | | | | | 30,320 | 30,470 | 30,680 | 32,100 | 40,579 |
| other oaks | | | | | 66,420 | 69,750 | 81,700 | 85,700 | 130,899 |
| other broadleaves | | | | | | | 81,480 | 84,810 | 85,200 |
| Percentage of conifers and eucalyptus | **22.0%** | **50.3%** | **49.1%** | **46.2%** | **52.2%** | **59.2%** | **57.3%** | **59.3%** | **54.8%** |

Sources:

(1) - C. Agrícola e Florestal (Radich and M. Alves, 2000)
(2) - A.M.Almeida;
(3) - SROA
(4) - DGF (1981) *–"Distribuição da floresta em Portugal" - Estudos e Informação nº 289;
(5) - IPF (1987)
(6) - IPF (1988)
(7) - DGF (1991)
(8) - DGF (2001)

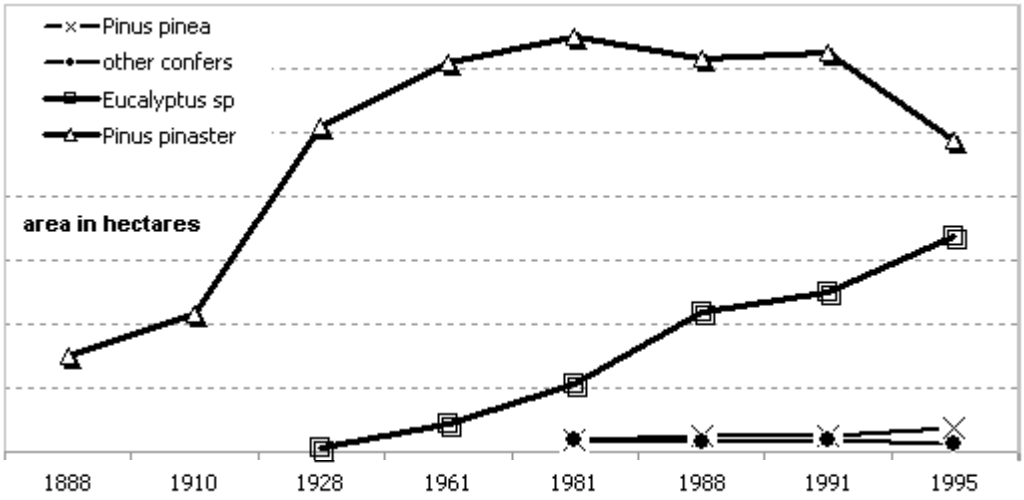


**Figure 8.** Increase of the share of highly inflammable species in Portuguese forests between 1888 and 1995

Yet the management on maritime pine is so poor that the losses on yield have been estimated on 2 million cubic meters ($m^3$) of yearly increment and 40.6 $m^3$ on the standing volume (DGF, 1983).

The percentage of burned area by species (referred to the total area covered by the respective species) is provided in Figure 9. Maritime pine and eucalypts are the species mostly affected by fire.

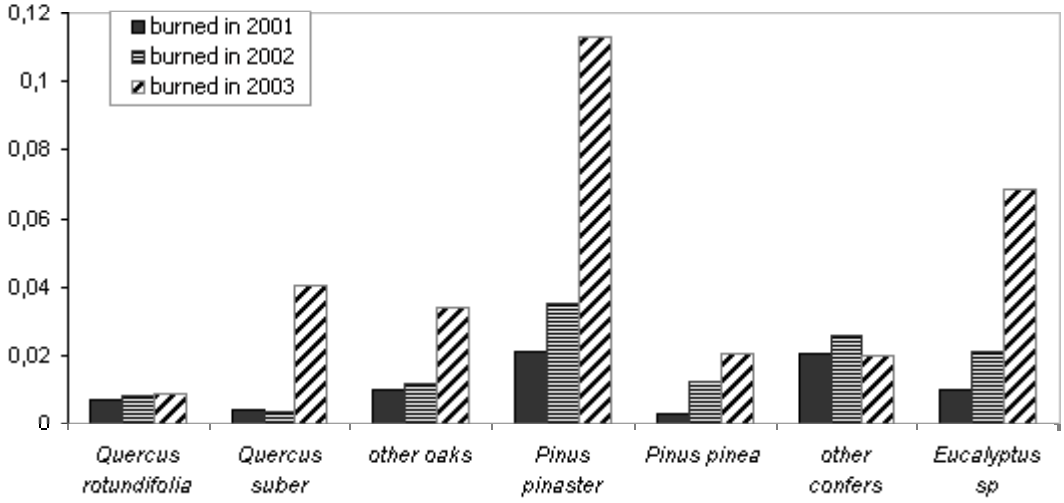


**Figure 9.** Percentage of burned area per species (referred to the total area covered by the respective species) for the years 2001-2003.

The relatively high rate of burned percentage observed for cork oak, and “other oaks” is due to pines and eucalyptus stands in close proximity from which fires – usually intense and difficult to fight – easily escape. It is generally known and confirmed by ground experience that wildfires in oak stands are easier to control than in pines or eucalypt stands.

The rate of burning of Holm Oak is lower than that of Cork Oak and “other oaks” because the species tolerates sites of dry summer harsh climate that are unsuitable for large plantations of pines and eucalypts.

The spreading effect of pines and eucalyptus on fire events is illustrated in Figures 10 and 11.

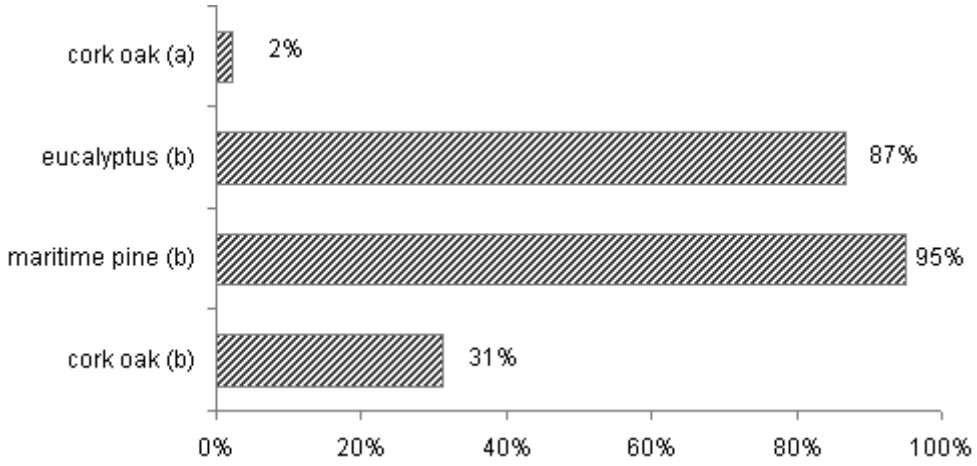


**Figure 10.** Comparison of rates of burning in 2003 – examples: (a) Monte Novo, Galveias, pure stand of cork oak, without eucalyptus in the vicinity; (b) Quinta da Lagoalva de Cima, where the fire started in a eucalypt stand, and Cork Oak stands intermixed with stands of Maritime Pine and eucalypts.

**Figure 11.** Cork Oak stand recovering after being swept by fire coming from adjacent eucalyptus stand. Portugal, 2003. Photo: MC Varela (2004)

## 5. Inconsistencies of the forest inventories

The inconsistencies of the forest inventories are simultaneously evidence and result of the lack of a solid long lasting forest strategy.

### Cork Oak and cork policy

In spite of the fact that Portugal is the major world producer of cork, the inventory of 1965 lacks data for cork oak in the most important parts of its distribution (DGF, 1961).

The document “Forest Profile” produced by IPF (1987) refers to an area of 313,000 ha for eucalypts while including in a footnote that the number given by the extraordinary inventory of 1986 (made by cellulose companies) is 434,000 ha. The discrepancy is 38.6%.

The surface of 670,000 ha appointed to eucalyptus by the National Inventory of 1995 gather among various forest experts a feeling of being underestimated.

The lack of a strategic plan for the Portuguese forest is also patent at the State’s attitude towards Cork Oak, whose economical backbone product is the stopper.

This species holds a unique profile within the Portuguese forest balance not only due to the absolute exporting value (Table 4) but because that happens from cradle to grave under little competition and lots of national knowledge, contrary to the other forest activities. Furthermore, the cork exploitation makes use of more and higher diversified employment than maritime pine and much more than eucalyptus. Additionally it generates indirect values ranging from ecology to landscaping, and is crucial for the inland rural zones where “human desertification” and aging constitute increasing social problems.

In spite of the importance of Cork Oak to the Portuguese economy, the policy of the Portuguese governmental policy to the species is abysmal. During the sixties while the wine market was showing signs of growth, Portugal dismantled the Junta Nacional da Cortiça and the Estação de Investigação do Sobreiro, the State institutions that along decades provided orientation to the cork sector on management, research, international trade and legal aspects. From the extinction of Junta Nacional da Cortiça and Estação de Investigação do Sobreiro to date Cork Oak policy responsibilities lie among various institutions, with unclear objectives that have many weaknesses where overlapping and many gaps are evident.

The main focus of the current controversy on the cork stopper is the occurrence of TCA or “cork taint”[1]. Nevertheless there is not a national agency for cork stoppers’ quality control either for the rates of occurrence of this defect, leaving room for speculation in numbers.

Since 1998 cork experienced a 300% increase on raw-material prices, while at the same time the wine industry has refused to accept a parallel rise on the price of stoppers. The oscillation on the prices is reported in numbers devoid of economical analyses or long-term forecasts.

**Measures**

Portugal has solid forest knowledge on technical and scientific aspects of the management of our main species[2] and the same holds for forest fires control. By the end of the 19$^{th}$ century the forester Sousa Pimentel produced a notorious forest compendium on the management of the main economic species of the Portuguese forest (at that time – pines, chestnut and evergreen oaks) (Sousa Pimentel, 1888). The chapter dedicated to forest fires in pine forests is impressively “modern”. Fire fighting is focused on the aspects of human behaviour, fire control on the ground, compartmentalization as a mean of developing fire-break strips and use of broadleaves, specially oaks and other broadleaves species. Even controlled fires during winter are addressed.

It is crucial to promote discontinuity with less fire-susceptible species such as oaks, hardwoods and riparian species. Yet as some of these species are of long economical return or of low economic value, it is virtually impossible to implement a sustained compartmenting and diversification of forest species when the property is scattered among a chaotic set of co-owners, as is the case of several parts of Portugal.

Species of poor economical profile such as oaks, some of the noble hardwoods and some riparian species are suffering various threats with shrinking area and fragmentation of habitats that demand conservation measures (EUFORGEN, 2004). The use of these species for constructing fuelbreaks or

[1] TCA is the short-cut wording for a set of products that can contaminate and spoil wine’s aromas, e.g. TCA – 2,4,6 trichloroanisole, 2,4 DCA – 2,4 dichloroanisole, PCA – pentachloroanisole, PCP – pentachlorophenol, TCP – 2,4,6 trichlorophenol, etc. (Pollnitz et al., 1996).

[2] Portugal also has the worlds oldest operating Fire Brigade in Porto; established in 1295, more than 700 years ago.

buffer zones is a way to establish them; these areas could also serve as conservation populations. Whenever possible the establishment or protection of populations of these species should be included on the forest fire prevention programmes. For the rationalisation of human and material means economical, environmental, social, wildfire-defence objectives and other aspects of forest approach should be merged as much possible.

## 6. Global strategy for the rural world

The mitigation of forest fires goes beyond forest and demands a strategic approach to include forest as an element of the rural economy, especially when social changes inducing decrease at the rural population and family farm level are going on.

In the Mediterranean climate, especially when meteorological conditions turn to extreme situations of heat and dryness, forest fires may attain gigantic proportions even if the landscape is managed in mosaic of diverse species and fire lines.

It is important to fragment the forest area through buffer zones of short vegetation, grasslands for cattle grazing, fruit orchards (Figure 12) and zones of irrigated crops. That is achieved when grazing and agriculture activity exists in a sustainable way amid forest areas.

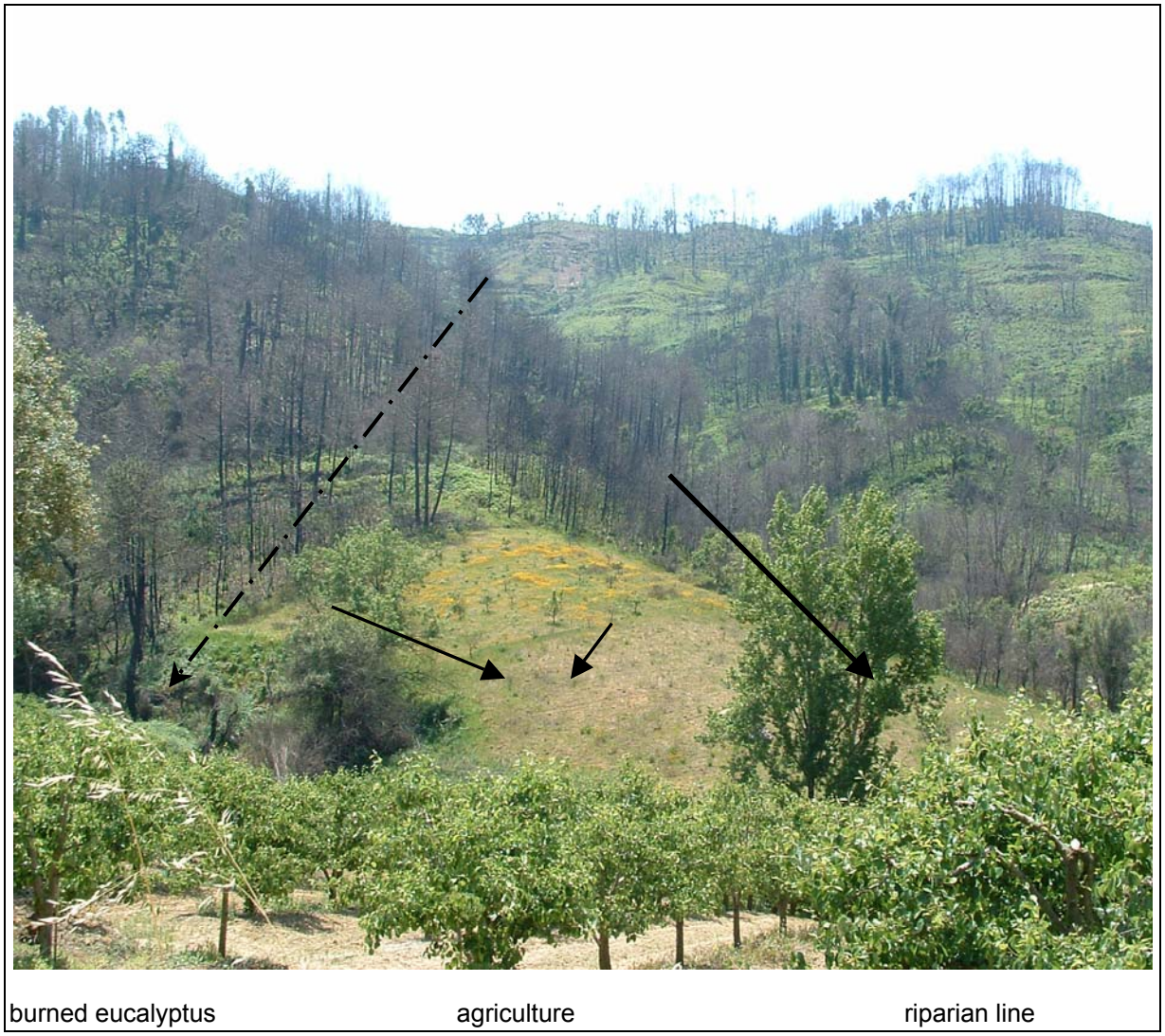


**Figure 12.** Agriculture and riparian trees acting as fire break. Location: Mafra (Portugal), after a fire of September 2003. Photo: MC Varela, 2003

Due to the human depletion in rural areas, aging of the rural population and remoteness of the consuming centres, the family agriculture and husbandry activities are not self sustained anymore. Support for these activities is dramatically needed and should be regarded not as farming subsidies, yet on the contrary as part of the investments in the rural economies that would be an integral part of forest fire prevention and combat.

In some parts of Portugal, especially where topography is unfriendly for agriculture many areas are being abandoned, allowing free space for the spread of dense shrub cover. The danger increases when invading vegetation is of tall grass type, a terrifying fuel when turning dry at the onset of the summer. These types of vegetation can easily get ignited by disposed cigarettes or sparks from train breaks. The level of abandoned agriculture land is an important factor that increases the dimension and risks of forest fires, especially when grass growth is amplified by wet springs.

During the past few years there have been some incentives to extensive animal farming and small agriculture on traditional products. However the structural results are poor, either for wildland fire reduction, or to a sustainable flow of traditional or biologic products, since the funding as been limited to some few small areas, not coordinated with an overall concerted strategy for rural Portugal.

## 7. Training and organisation of the fire combat

The dimension of the 2003 catastrophic forest fires in Portugal revealed critical deficiencies of fire suppression capabilities.

Over the last two decades forest fires combat in Portugal is executed by a corps of volunteer fire brigades devoid of special training for forest fires.

Furthermore, instead of an approach of military-command or standard Incident Command System (ICS) at the country level (as the dimension of a catastrophe is required for), the operations were overseen by local command disconnected from the national level.

Two situations provide a dramatic evidence of the need to establish a professional country-level command system for fire suppression, Mata Nacional de Leiria and Quinta da Lagoalva de Cima.

Mata Nacional de Leiria is the largest maritime pine national forest and was run by Forest Services for many decades till its disbandment by 1996. The Leiria National Forest is subjected to a long-term management plan which provides of a network of fire-lines and shrub control operations that still exist, in spite of the pullout of the Forest Service. The prevention measures were correctly implemented.

Yet the fire combat was done by about 30 volunteer fire-men poorly trained on methods of counter-fires and other forest fire peculiar ways of combat. The Forest Guard corps, an experienced group of fire-fighters, could not participate since the fire combat is now out from their responsibility. On 2 August 2003 the fire at Leiria National Forest became out of control, devastating around 2,500 ha out of the 9,000 ha in less than 24 hours.

Quinta da Lagoalva de Cima is a private estate of about 6,000 ha, where 5,000 ha are forest of Cork Oak, eucalypts and Maritime Pine. Fire prevention measures are also well established along all the forest area.

By the very same day a fire – originated by a dry thunderstorm – devastated an area of about 1500 ha, mainly eucalypt, Maritime Pine forest and a part of Cork Oak. The regional volunteer fire corps turned out to be poorly equipped in human and material means and lacking of knowledge on counter fires. Part of the combat was performed by the estate staff, while the fire corps concentrated on the surveillance of urban structures, leaving the forest area unattended.

Many other examples could be described all over the country, even in Cork Oak areas where the open character of the stands facilitates fire suppression.

Forest fires occurring in situations as described above require a response by a specifically trained forest fire corps under a strong command at country level. The specificity of forest fires also raises questions on the lack of forest experts at command level and during field operations.

Aircraft used in forest fire control are mainly a tool to facilitate ground suppression. When large forest areas are caught up by violent fires fed by strong winds, counter fires or tree felling to lower the fuel ability are, in some circumstances, the most effective tools, to contain the fire.

Counter fire is a risky intervention that claims a solid knowledge of the forest and geographic local conditions. Felling of trees by means of heavy machinery or chain-saw are also operations out of the scope of volunteer firemen. Furthermore in private property the fire corps cannot set counter fires or fell trees if not authorized by an adequate legal framework.

## 8. Disorganisation of the Forest Service

Along with other causes of forest fires of 2003 the dismantling of the structure of the Forest Service and the forest guard corps are facts to be considered.

When a third of the country is occupied by a long-lasting peculiar activity such as forest the need of a national regulator is a basic requirement for the efficient management of the sector.

The need for sustainable management of the forest claims a structure where experience can be processed into knowledge for coming generations in a continuous and enriching process. The physical and temporal dimension of forest makes it incompatible with regional institutions.

Established in 1824 under the designation of Administração Geral das Matas (General Administration for Forestry) (Radich and M Alves, 2000) the institution known by the general designation of Forest Service (a designation that has endured the various labelling and still survives at the common citizen wording) existed until 1996.

After decades of activity Forest Services left behind an overall positive balance. The accumulated knowledge is now in adrift in the Directorates of Agriculture.

The need of a strong structure to coordinate the forests of the country as well as professional corps for fire prevention and combat was also focus by Sousa Pimentel (1888).

The practical dismantling of Forest Services goes behind the “physical” extinction of the institution. Some years before the official extinction of the Forest Service, the forest guards’ corps was deprived of their forest activities and limited to some few law enforcements such as control on hunting.

## 9. Conjunctural causes

**Economic interests**

The easy aptitude of Mediterranean forests to get in fire has always been used as weapon on discord. Recently it is also a weapon of various economical interests.

Successive burning may be used to force down the forestry profile of land into other uses. This may be the case of urban or tourism interests.

Changes on the type of the species cover are also part of the economic causes for arson. Despite of the law, which rules that forest land cannot be occupied for other uses during ten years after a fire (Decree 327/1990, Law 54/1991, and Decree 34/1999) this “quarantine” is not dissuading investors from setting fire.

Despite the legal impediments in Portugal to cut evergreen oaks (*Quercus suber* and *Q. ilex*) (Decree 169/2001). it is possible to remove them once they are dead, e.g. due to fire. Thus, the forest can be liberated from these species and afforested by the fast-growing ones.

By the 1970s and 1980s the area of Maritime Pine (*Pinus pinaster*) was 1,300,000 ha while eucalypts covered less than 500,000 ha (IPF, 1987). Nowadays the areas are respectively 900,000 ha and 670,000 ha (DGF, 2002). The short rotation turns eucalyptus a more attractive species as compared to

pines and oaks, especially for private owners. At least indirectly, the expanding *Eucalyptus* area has benefited from the frequent fires on maritime pine as can be assessed when comparing former cartography of these species with the actual one.

Wood traders are profiting from cheap wood harvested post-fire: Properly debarked salvage-logged timber can be sold as non-burned wood – increasing the profit margin

Lobbies on wood trade are also liable to profit from fires since burned wood is an easy target to price speculation and attains, by rule, lower value on the field. Yet cut down shortly after fire and if debarked it may not be difficult to trade burned wood as non-burned.

Private companies specialized in fire combat are to be added to the horde of the potential beneficiaries of forest fires. Episodes of commanders of fire brigades that simultaneously own business of fire combat equipment are being reported by the media.

The fire control shall be under State responsibility. Involvement of private companies on fire combat may create conditions for arson fire to feed the fire business.

The “fire industry” creates additional economic interests. The Firefighters Corporation is a strong lobby that no government dares to face.

Forest fires are dramatic media events. Fearing electoral punishment any government gives ground to a panoply of cabinets, committees, task forces, seminars, etc. which pace of grow is dictated by the dimension of the forest fires of the previous year. As frequently happens in the Portuguese Public Administration, the temporary structures become established and go on existing and consuming tax payer’s money, especially when supported by lobbies.

The academic lobby is another one to be included in the horde of forest fire beneficiaries: The “fire industry” ends up to be an extra source of financing, especially in universities, that gives justification for cathedra posts and pays for research projects, studies, publication, etc. …

In a country with a fragile economy any uncertainty of employment, even temporary jobs, attract sympathy of the common citizen.

The subtle beneficiaries of the “fire industry”, which honestly and clean is based on fire-created jobs, is finally infecting the society with an imperceptible feeling of indifference upon the fire devastation. To feel in peace requires nothing more than being certain of not having set any fire.

Indeed like the fire-adapted species, for a part of the society forest fires are not a factor of destruction, rather an active economic sector.

If wildfires become a rule, a part of the society may become fire-dependent, like some of the forest species …

**Education and penalizing**

Education is also a point to address for minimization of forest fires; one may wonder why citizens in the European countries north of the Alps, have such a different attitude towards forests, and it is not just a question of different climate.

Negligent behaviour on debris burning, incorrect cigarette extinction, low care of barbecue fires, etc. start huge forest fires, especially during the hot and dry weather conditions of the Mediterranean summer. The forest area burned, after confessed careless events along the past years, is evidence.

However those types of jeopardy are unknown for many people, especially among the urban population.

The role of education campaigns and penalization on fire-risk behaviour is clearly included at the Decree 488 (20 October 1970) and Decree 334/1990 dedicated to prevention, detection and combat of forest fires. Looking back to the last three decades the legislation come out as an exercise of rhetoric on good intention and a painful demonstration of the dismissal of the State authority.

Intensive public awareness campaigns should run on TV and radio and panels using illustrative images should be placed at road side as well as within the forest.

Basic education programmes in Portuguese schools shall focus tangible aspects on forest fires risks in order to raise the public awareness. Children can be a very efficient way to educate adults.

Measures
Exceptional measures focused and restricted to periods of forecasted unusual hot and dry waves of weather total prohibition of barbecue, metal-cutting devices, etc. close to forest and shrub land are indispensable. Application of penalties on incorrect cigarette extinction, quarantine upon the use of summer festival rockets, already preview at the Decree 488/1970 and boost up by the Decree 334/1990, is a must on fire mitigation. Public awareness campaigns towards the common citizen for the various events that can start forest fires shall be reinforced along those periods.

**Social causes**

In Mediterranean it is said that “winter conflicts on forestry may end-up in fire during summer”.

Due to the high aptitude of Mediterranean forest to get in fire it is sometimes used to fight unfriendly autocratic uses of the forest land. The appointment of areas to environmental protection and private hunting exploitation, for instance, claim tactful approach with the surrounding human settlements, since resentful feelings may end up into anger and translated in vengeance fires.

## 10. Perspectives

Conjunctural and structural causes act in synergy enabling conditions for forest fires and other wildland fires in Portugal. Dramatic situations arise when the average hot and dry weather of the Mediterranean summer is exacerbated by extreme waves of hot and dry weather, as happened during the summer of 2003. If global warming simulation models (global circulation models) will be consolidated and become reality, and if the actual forest profile persists, worse wildland fire catastrophes will become more common.

Portugal holds a solid technical knowledge on forest fire prevention and combat. Controlled fires as a tool to minimize the summer hazards, compartmenting, civil behaviour, specific training of firefighters are aspects already discussed by Sousa in 1888. Thereafter the issue has been taken up frequently in forest technical documents in the country.

The 2003 tragedy emphasized the need of a long-term, multidisciplinary, national and comprehensive plan to manage forest fires.

The plan must be formulated through clear objectives, phases and calendar, instruments and milestones in order to assure the actors’ commitment and results.

Major ways to mitigate forest fires include:

- Structural changes on “indivisible” property
  Restructuring of the small uneconomical “indivisible” private properties under the aim to fight abandon is a basic requirement

- Forest structure
  There is a need to implement a national forest strategy for; species’ diversification and construction of firebreak and fuelbreak networks, particularly in cases when the main species are easy burnable; as is the case of pines and eucalypts.

  Maritime Pine and eucalypts are extremely important species for the Portuguese forest economy. In sites where their growth is under the economically viable threshold, those species should be completely eradicated and substituted for less fire-prone species or set aside for natural vegetation cover for environmental and landscape benefits.

  The cultivation of less fire-susceptible species such as oaks, hardwoods and riparian species should also be promoted. Yet some of these species are of long economic return or of low

economic value. Species of poor economic profile such as oaks, some of the noble hardwoods and some riparian species are demanding conservation measures. Whenever possible the establishment or protection of the populations of these species should be included on the forest fire prevention programme.

To minimize the risks and dimensions of forest fires in Portugal there is the need to carry out sharp changes on the Portuguese forest structure, profile and management taking forest as part of the rural world.

However silvicultural measures alone are insufficient to decrease the dimension and risks of huge forest fires.

- Concerted strategy for the rural world
  The trend for concentration of human population in urban centres increases the abandon of agriculture and pasturage that once existed amid the forest in remote areas. It contributes to the increase of bush lands and unmanaged impenetrable forests where uncontrollable fires easily happen.

  Incentives to create a dynamic network of sustainable small agriculture and grazing activities are needed.

- Other aspects
  - exceptional measures when hot waves of weather are forecasted
  - education, public awareness campaigns and penalties
  - dissuasion policy of interests that benefit economically from fires
  - national coordination under Sate responsibility and reorganisation of the Forest Service
  - specifically trained forest fire management personnel under national command

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## Forest Fires in Portugal in 2005 – An Overview

### Introduction

In 2005 Portugal suffered a very heavy blow from forest fires that covered an area of the order of 300,000 hectares (ha) of forest and shrub land making this the second worse year of our history after the very recent year of 2003 in which more than 430,000 ha hectares were burned. These facts raise a series of questions about what is happening, about its causes and about the future. In spite of the complexity of the problem the author will attempt to give an overall perspective of the situation of forest fires in Portugal in 2005 and in the recent years.

There are many factors that contribute to this level of destruction, some of them of structural nature, due to forest and fire management processes and other of conjuncture nature, due to climate and weather conditions. A brief analysis of both is presented.

As a consequence of these fires there is a general feeling that attitudes have to change and that more effective fuel management practices should be implemented in order to minimize the potential danger of fires and to induce a safer fire suppression effort.

### Some Numbers

Portugal has a surface of $9x10^6$ Ha that are mostly covered by forest and agricultural vegetation. Forested and agricultural lands are intermixed and the human presence is felt throughout the entire space. The forested area covers 5.3 $x10^6$ ha of the territory of which 63% are composed by woodland and 37% is non cultivated land that is covered by grass, shrubs and other light vegetation that is very prone to fire. In the period from October to April there is an average precipitation of around 700 mm that supports the growth of large amounts of herbaceous and small shrubs. These compose the fine fuels that are available to support forest fires during the summer season. On the other hand from May to October there is usually a deficit in rainfall associated to warm and dry conditions during summer; therefore it is normal to have a large number of fires and a considerably large burned area in each year.

In Figure 1 the number of fires (a) and the burned area (b) during the past years are shown. As can be seen the total number of fires has increased during the past decade with an average of the order of 25,000 fires per year during the recent years. If we consider only those fires that actually burned more than one Ha these numbers – also shown in Figure 1a – are much lower and remain fairly constant on the order of seven thousand. Practically all fires that are considered in these statistics had the intervention of the fire brigade forces. They manage to suppress the large majority of the fires at their beginning and keep them small. As they correspond to a heavy load and a dispersion of fire fighting forces they must be considered in this analysis as well although they do not contribute much to the total burned area.

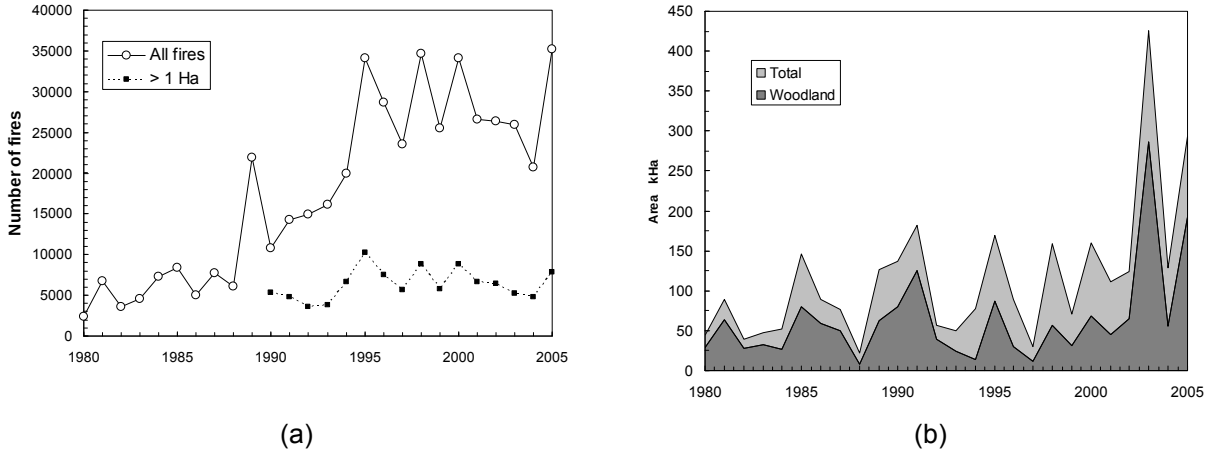


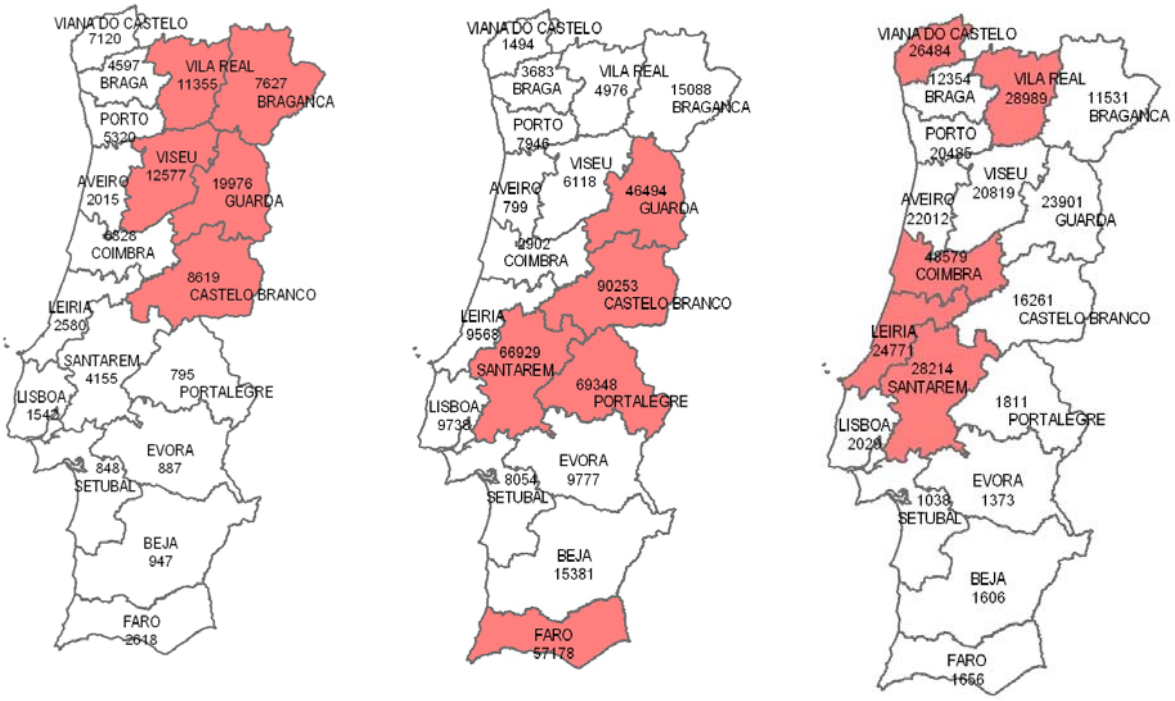

**Figure 1.** Number of fires (a) and burned area (b) in Portugal in each year from 1980 to 2005.

In spite of its large inter-annual variation the burned area has increased during the past decades, with an average of the order of 100,000 ha burned each year. As was said above, the years of 2003 and 2005 were exceptionally bad. The dark shaded area in Figure 1b corresponds to the area of woodland – tree covered land – that was burned in each year. Although most fires do not consume completely the trees the impact of fires on plantations is quite relevant. Most of the trees are killed by the fire and have to be removed from the land.

In Figure 2 the 18 administrative districts of Portugal are shown with an indication of the average values of the burned area in the previous decade from 1992 to 2002 (a), in 2003 (b) and in 2005 (c). The five districts with larger area burned in each period are shaded. Historically the districts of the interior North and Centre of Portugal are those that had the largest burned areas in the past, but the years of 2003 and 2005 were also singular in this respect as some districts that did not have such a serious problem in the past had it in these last years. This fact demonstrated also that the entire Country is susceptible to suffer from serious forest fires.

As was mentioned a matter of concern is the relatively large percentage of forested land that is affected by forest fires. As can be seen in Figure 3 there was a tendency in the period between 1980 and 1998 for this percentage to decrease from around 70% to 40%, but in the recent years the contribution of forested lands to the area burned in each year has increased to around 60% of the total. Having in mind that the areas burned in 2003 and in 2005 were very large this means that Portugal is loosing an important share of its wooded lands due to fires.

More than 90% of the fires in Portugal are caused by human activity. There is a systematic investigation of the causes of fires in Portugal. At least all fires larger than 100 hectares are investigated by the authorities. It is generally accepted that around 20 to 30% of the fires are caused by arson. In 2005 more than 100 persons were accused for arson by the authorities. The analysis of the causes of 95 of the major fires (>500 ha) in 2005 provided the results that are shown in Figure 4. As can be seen in this sample arson appears as around 35% of the causes and accidents in general – including cigarettes, machinery, rural burns, etc. - contributed to 20% of these fires.




(a) 1992 - 2002 (b) 2003 (c) 2005

**Figure 2.** The five Districts of Portugal with higher values of burned area (ha) per year in three different periods of time (Data from DGRF, 2005).

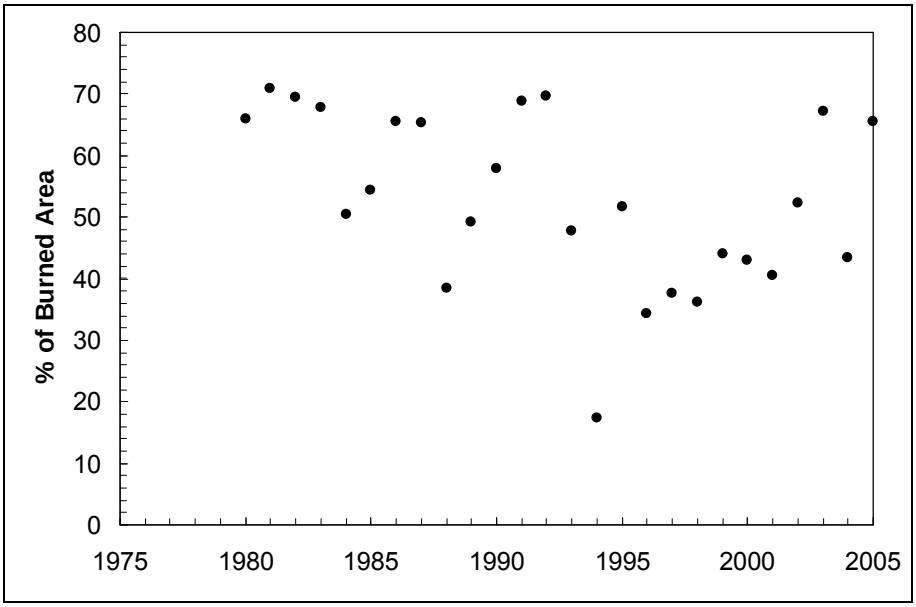



**Figure 3.** Percentage of forested land burned in each year in relation to the total burned surface in the period from 1980 to 2005.

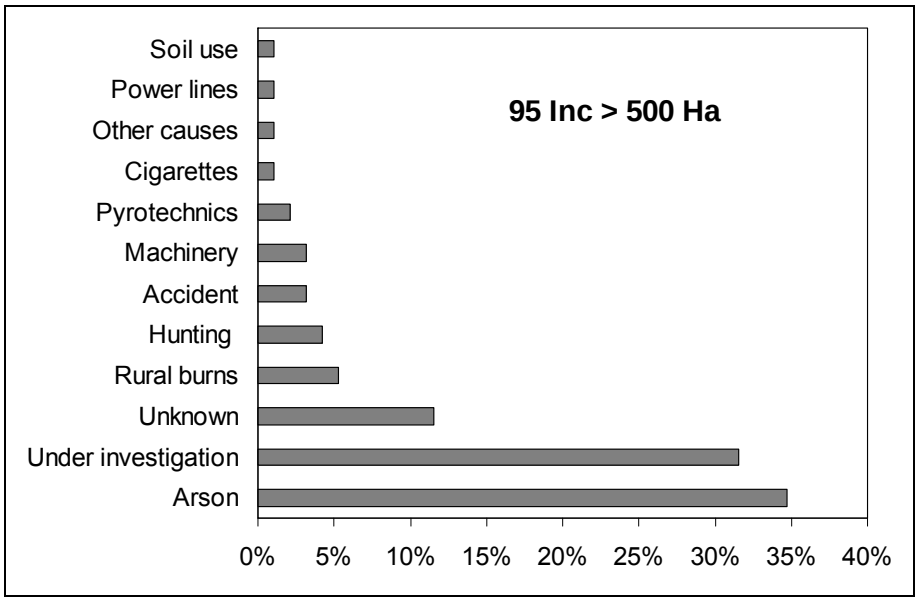



**Figure 4.** Causes of 95 fires larger than 500 ha that occurred in Portugal in 2005.

## Climate and Meteorology

As was mentioned above climatic conditions have a very important role on fire occurrence and fire spread conditions. The last three years of 2003, 2004 and 2005 were not common both in terms of precipitation and temperature in most parts of Portugal. In Figure 5 the accumulated precipitation since previous September that is registered in Coimbra in these years is shown in comparison to the normal values for the period 1960-1990. It is realized that other parts of the country had different precipitation patterns, some of them were better and other were worse, but it is found that the weather conditions in Coimbra are quite representative of the situation in most relevant forested areas of Portugal. As can be seen in that figure the year of 2003 had an excessive amount of rainfall during Winter and Spring that produced a large amount of fine vegetation. Then the Summer of 2003 was very dry and the burned area in Portugal was an absolute maximum. During some days of August of 2003 extensive dry thunderstorms caused a large number of fire ignitions many of them simultaneously in the same region. As a result many large fires started to burn under control in the Centre and interior of the Country, even in regions that had not been much affected by fires in the past, like the districts of Santarém and Portalegre. On 2 August 2003, an area of the order of 100,000 ha was burned in a single day. This value is practically the same of the average area burned in a whole year! This was certainly the worst day in the recorded history of forest fires in Portugal. Six persons lost their lives in different fire related accidents in this day (Viegas, 2004).

The year of 2004 was relatively normal although the summer months were relatively dry until mid August. As a result the burned area was as in the average years. The year of 2005 was one of extreme drought with practically no rainfall since December until mid October in most of the country.

The occurrence of extreme fire conditions in the last years can be associated to the global warming of the atmosphere that is predicted in all climate change scenario. As a matter of fact it has been observed that the fire season extends for much more days and that periods of very high air temperature are more frequent and felt in wider areas of the territory than in the previous decades. If this process continues we can only expect that the problem of forest fires may increase in the future.

The joint effect of precipitation and temperature is reflected in the Drought Code (DC) that is a sub-index of the Canadian Fire Weather Index System (cf. Van Wagner, 1987) that is used in Portugal and in many other countries of the World. The daily value of DC is a measure of the soil water content and it gives a good indication of the severity of the fire season. High values of DC correspond to high levels of dryness. Precipitation events cause a drop on the values of DC and therefore reduce the potential danger of fire occurrence and spread. The daily values of DC for the past years in Coimbra are shown in Figure 6. The average value of DC for the period from 1993 to 2002 is shown for comparison. As can be seen in that figure the years of 2003, 2004 and 2005 came in a succession,

each of them worse than the previous one. As was said before in 2004 there was rainfall in mid August and therefore the fire season was not as bad as it had started but in 2005 the DC was the highest that was recorded in the period from 1988 to present.

As a consequence of the meteorological conditions of 2005 the vegetation had a very low moisture content value $\mathbf{m}_f$. Measurements carried out by the author and his co-workers confirm this as it is shown in figure 7, where moisture content $\mathbf{m}_f$ (dry basis) of dead *Pinus pinaster* needles and leaves of standing *Chamaespartium tridentatum* are shown. We know from past experience that values of mf<10% for dead pine needles correspond to high risk of fire ignition and spread. In 2005 we had plenty of days in these conditions and even with $\mathbf{m}_f$ as low as 3 or 4%. Under these conditions fires are very easy to ignite and the probability of having many spot fires is very high. The values of mf for shrub vegetation in the summer of 2005 were also much lower than it is usual, with values in the range of 40 to 50% that correspond to very intense fires.

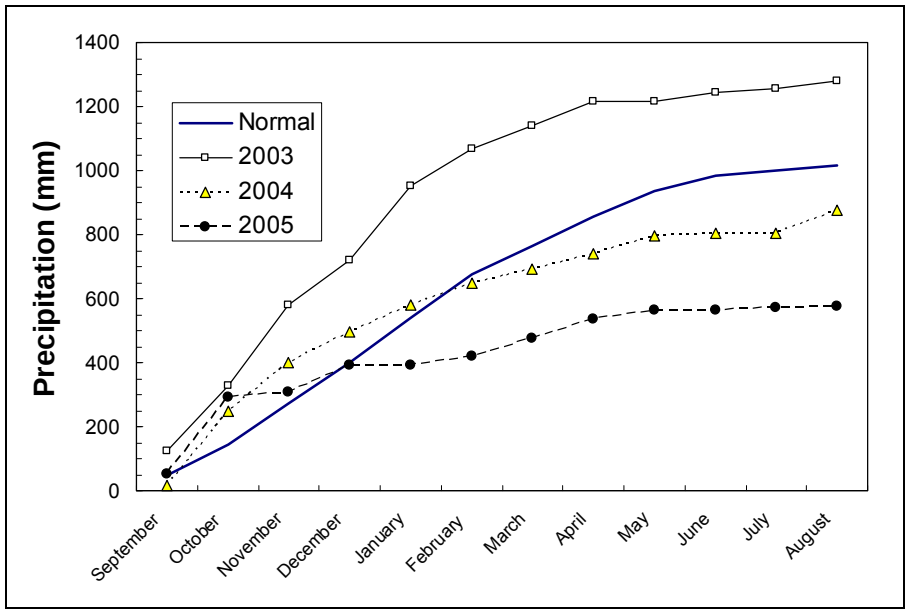



**Figure 5.** Accumulated precipitation in Coimbra since September for the years of 2003, 2004 and 2005 compared with normal values.

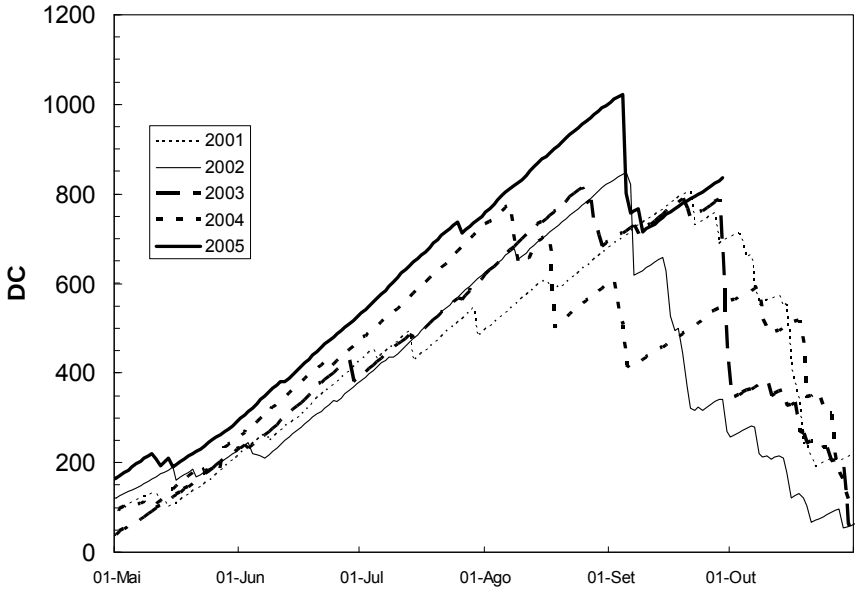



**Figure 6.** Drought Code values for Coimbra during the last five years.

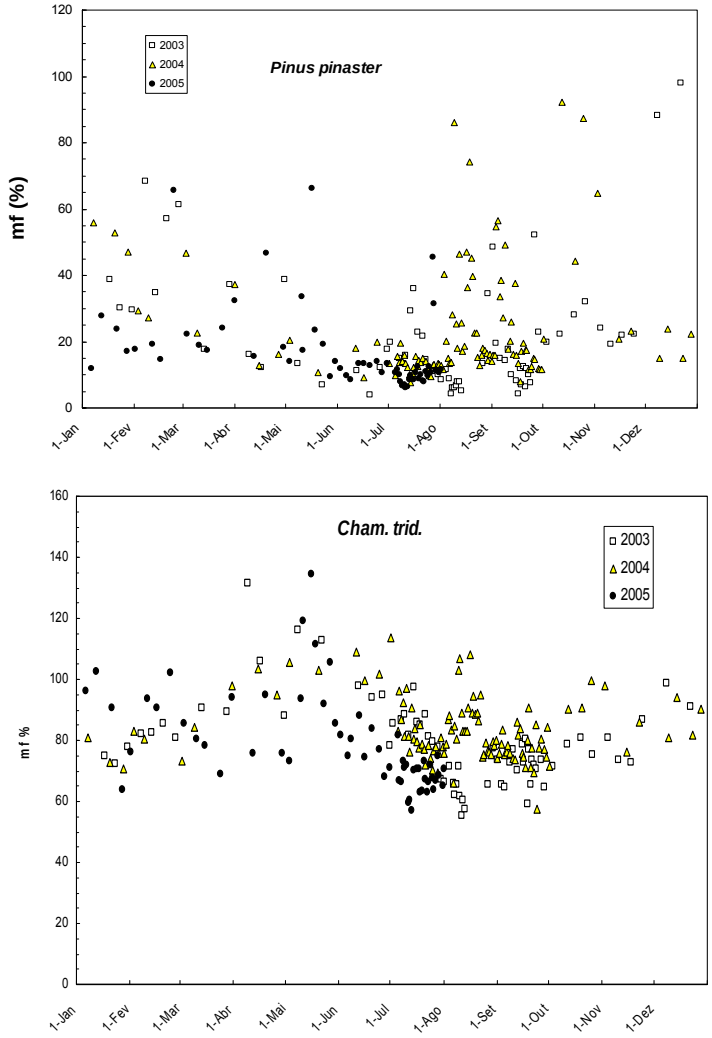



**Figure 7.** Moisture content of (a) dead needles of *Pinus pinaster* and (b) leaves of *Chamaespartium tridentatum* sampled at Lousã (Portugal).

## Fire Management

The climatic and meteorological parameters show that in 2005 there were very bad conditions for fire occurrence in Portugal but these factors alone do not justify the very large burned area that we had and the dangerous situations that were faced by many persons that live in forested areas. In the opinion of the author large areas of the forest are not managed in anticipation of such bad conditions. There are huge extensions without fire breaks or other discontinuities that might allow fire suppression in safer conditions. In the conditions that we had in 2005 it was observed that the fire could jump even wide open areas but in many situations the firefighters managed to stop the raging fires using counter fires (tactical fires).

The structure of the rural property in Portugal, including forest properties, is one of many very small properties that are owned by a large number of persons. As many of these properties are not sustainable technically and economically their management is very limited. It is very difficult to make plans that may cover wide areas of the territory as many particular interests are involved. These are some difficulties that are felt in order to overcome the general problem of forest fires in Portugal for decades.

Unlike their counterparts in other regions of the world – namely in Central and Northern Europe – farmers and foresters in Portugal have to struggle every year to manage fuel growth in order to reduce fuel loads that can facilitate fire ignition and propagation. It is very difficult and costly to open and

maintain efficient fire breaks even for normal fire conditions and it is almost impossible to assure that the forest is fire safe under the circumstances that we had in Portugal during 2003 and 2005. In spite of this it is felt that a better management of rural and forest areas, involving fuel management programs, could contribute to reduce the overall problem quite significantly.

In Portugal there is an extensive mixture between rural and urban areas that create an interface with the forest that is very difficult to manage and consequently to defend. In many cases this interface is not properly managed and the fire would come across single houses, villages or even towns spreading danger and destruction. Many houses and supporting structures were lost this year.

During the night of 21 August 2005 a fire that started at 20 km from Coimbra reached the city in few hours, encircled and even entered through some its main streets, see Figure 8. Fortunately there were no victims during this fire but that was not the case for the fire season of 2005.

In the whole 20 persons lost their lives in different accidents related to forest fires in 2005. This number includes 12 fire fighters. One of the most shocking accidents was the one that occurred on the 28th February, in which four professional fire fighters of the Coimbra Fire Brigade lost their lives. This accident occurred in an unusual winter fire with very cold, dry weather associated to very strong winds. This group of fire fighters was surprised by a sudden fire eruption in a small canyon where they had stopped their truck, see Figure 9 (Rodrigues et al., 2005).

**Figure 8.** View of the forest fire that encircled Coimbra on the night of 21 August 2005. Photo: Diário de Coimbra.

**Figure 9.** View of the accident with a vehicle of the Fire Brigade of Coimbra in which four fire fighters lost their lives. Photo: Diário de Coimbra.

Given the limitations of its resources to fight fires in the extreme conditions of 2005 Portugal requested and got the help from many other countries, including Germany, that sent some aerial means to support our fire fighters during the worst days of this fire season.

## Consequences

After the fire season heavy rainfall in the mountain areas that burned in the past months is creating bad problems with loss of soil, erosion and floods.

The repeated and apparently ever increasing incidence of forest fires is producing some loss of confidence on forest owners and managers who see a very low probability of achieving some profit from their investments in the forest. Timber price fluctuations compound to make the situation difficult for those who depend on the forest. For all these reasons forest fires are considered as a major threat and conditioning factor to the sustainability of the entire forestry system in Portugal.

It is felt that the coordination between the various institutions that deal with fire management must be improved both at national and local levels. In spite of the successive changes that were introduced in the system during the past five years another attempt is being made this year in order to improve this coordination and to promote a better efficiency of the entire fire prevention and suppression system.

## Conclusions

Portugal suffered very badly from forest fires in 2005 that was the second worst year of its history. The climatic conditions were not favourable for the valiant personnel that tried to fight the fires. This fact added to the lack of adequate fire prevention measures throughout the territory and near the houses caused the loss of lives, houses and of important forest land. There is a feeling of hope that the Country will join its resources, organize and manage them in a better way to avoid the repetition of the extensive destruction of the past.

## Acknowledgements

The author wishes to thank the *Direcção Geral dos Recursos Florestais* and the Portuguese Institute of Meteorology for the data provided to illustrate the present analysis. He is also grateful to his colleagues Pedro Palheiro, Luis Ribeiro and Luis Pita for the support given in the processing of those data and in the preparation of some of the illustrations. Critical suggestions given to this text by his colleagues M. Teresa Viegas, Carlos Rossa, A. Rui Figueiredo are also acknowledged.

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# The Portuguese National Plan for Prevention and Protection of Forest Against Fires: The First Step

## The problem

The ecological, economic and humanitarian consequences of the wildfires in Portugal in the last few decades – since 1980, more than 2.7 million hectares (ha) were burnt, equivalent to one third of the national territory – make us think over the dimension of the problem and its destructive potential. Particularly after the year 2003, when the state of national disaster was declared, setting forest fires in Portugal as top subject in the political, social, economic and environmental agenda.

The economic, social and ecological consequences of the wildfires which, in average, destroy every year more than 150,000 ha of forest land (afforested, shrub and rangelands), are piling up and will be felt along several years to come. Direct and indirect impacts upon the life of people, on the competitiveness of the pinewood, cork oak and eucalypt industries, the quality of water resources, the fauna, the soil fertility, biodiversity, preservation of natural values and the other environmental services rendered by the forest areas such as the landscape, the sequestration of carbon, among others. The country is, thus, impoverishing year after year.

It has been frequently stated that fires are the main threat for the Portuguese forest. The rate of forest being burnt (afforested, shrub and rangelands) is about 2.7% per year, whereas in European countries the average is lower than 1%: In Spain, for instance, where vegetation and weather conditions are similar, that value does not exceed 0.6% per year. In 2003, 20 persons were killed, 2500 buildings were damaged, 7000 farmers suffered severe losses, and 40,000 land owners saw 423,000 ha burnt,

which is to say that 8% of forest (5% of the national territory). Perhaps, that is the reason why in 2003, forest fires as began to be regarded as a national problem. It stands as a landmark in the history of the Portugal's forest and civil protection. The ashes revealed another country, old, forgotten and depressed, part of a reality repeatedly noted and focused in studies and diagnoses made by Portuguese and foreign experts.

Several important political and strategic essays recognized that forest can perform a structural role in the future of the country, particularly as far as environment, water resources, rural development, nature preservation, biodiversity, tourism, energy and land use policies are concerned. Therefore, in a country where 68% of its territory is occupied by forest areas (3.3 million are afforestations and 2.2 million of shrub and rangelands), one can easily come to the conclusion that the sustainability of those areas is of the utmost importance for the country and the life quality of the coming generations.

In Mediterranean ecosystems fire has performed an important role in the ecology of vegetal and animal communities, and its total exclusion is not desirable. However, along the last 25 years, its severity, intensity and frequency have increasingly destroyed the landscape. Especially when 97% of ignitions are caused by humans, and fires become catastrophic events of huge dimensions that no one wishes. The average of 25,000 ignitions which occur every year are a result of social and economic conflicts and tensions existing in agricultural and forest territories, mainly at their interface. They are related to land-use policies and instruments that lead to an inappropriate use of fire, negligence, and in arson by the rural population or peri-urban areas. The rural exodus, the lack of active management in agricultural and forest properties, the absence of efficient prevention policies and, on the other hand, the exaggerated emphasis put on suppression policies have led to the accumulation of fuel and the promotion of its vertical and horizontal continuity, resulting in larger and more severe fires.

Up to 2003 when the burnt area reached exceptionally high values, society acted towards the forest fires in a non systemic and reactive way, producing legislation and injecting more money and material means in order to solve the problem. These isolated and uncoordinated measures did not produce satisfactory results as it was to be confirmed in 2003 and 2005.

After 2003 the response was more organized and systematic. The structural reform of the forest sector started. In 2004, 124,000ha burnt, and after a very dry winter in 2005, the burned area reached 320,000 ha. After the summer of 2005, which ended in the 320,000ha burnt (5%, includes afforested, shrub and rangelands) the new Government (which had won the election in February) presented several solutions related with organization and fighting resources. One can easily understand that, in a general way, it is too early to expect results or to come to the conclusion that they have been either or efficient, inefficient or not sufficient. Whatever the effective result may have been or will be, a new cycle in forest protection has begun, with investments per ha quadruplicated in ten years and doubled in the last two years, despite the results do not have any correlation with those figures. If we compare with other countries we might say that with similar budgets (normalized by risk and forest area), we are among the worst in the world, so the system is not effective or efficient and there are a lot of opportunities to improvement. A fair evaluation of the system and his performance would be welcome, although previous reports have unanimously recognized that the tragic situations experienced in the last years were not only due to adverse weather conditions, but to some other causes, particularly structural ones. Several reports have been pointing the problems and solutions since early eighties. In recent years, a good example to quote is the report presented by Beighley and Quesinberry (2004) that wonder if the protection of forests and rural areas is a national priority and how much does the Portuguese society values his forests? They conclude that, because their 2004 report falls on the heels of three previous reports from American wildland fire experts, delivered in 1982, 1996, and 2003, and many of the same recommendations existed in all four reports.

In the next years Portugal will have to face the double ageing of the population of the inner regions, the abandon of agriculture marginal lands and the worsening of weather conditions. If, in the short time the presence of conjectural events continues, namely the insufficient forest management, the difficulties in exerting authority and law enforcement, the weaknesses in the system of fire detection and alert, the lack of training at commanding levels and the inefficiency of fire prevention and fighting systems we can tell that the National System for the Defence of the Forest against Fire is still extremely vulnerable to environmental factors which surpass the usual climatologic standards and so it will be highly feasible to foresee a catastrophic fire season, that might be equal or worse than the one that occurred in 2003 or 2005. Although we can not foresee when, I strongly believe that will happen. However, if changes that improve technical and structural aspects already discussed and presented in

the past are implemented, Portugal will be able to minimize losses from the repetition of the tragedy of these devastating years.

## Does the problem of forest fires have a solution?

To change a problem that reached exceptional proportions to a low magnitude event that do not disturb the sustainable development of national vital economic activities (form today's 150,000 ha annually burned area we must come to 50,000 ha/year, including afforested, shrub and rangelands) is a complex and apparently difficult task. Nevertheless, several countries have been able to reduce the severity and the frequency of forest fires which were reaching scaring proportions. After a catastrophe, they implemented actions that eventually transformed that terrible *momentum* into an opportunity. We can point out as an example the North and South of France, the whole Spain, particularly Galicia and Andalusia, and Chile. Those examples, with similarities with Portuguese situation, are well described study cases and lessons must be understood us. After the tragedy, each country managed the political situation, and politicians, strongly supported by a technical approach, made dramatic and structural changes at all organization levels.

We notice that in countries where successful changes occurred, those ones have come out from solutions designed by holistic approach, with a central planning and decentralized operations, where a strict control of the defined standards, responsibilities are clearly identified and objectives were quantified. These were simple solutions, based on low cost/benefit analysis, where the skills of the personnel and hand tool coordinated team work all the year round (prevention and suppression.

According to several experts, in Portugal there are all the pieces of the puzzle necessary to build one of the best forest defence systems against fire in the world, however, the same report notices the absence of a plan and a strategy that makes them work in an integrated way (Beighley and Quesinberry, 2004).

## Which are the most important trends?

For the future, several threats are identified. In the following lines the main negative trends are summarized:

**Macro-economics**

- The problem of the fragmentation of small dimension real estates, without an effective management and the fact that the authorities (local, regional and central) are unable to interfere over private properties in an effective way.
- The tendency of rural exodus, with its multiple consequences regarding the management and protection of the forest, anticipating the decrease of active population.
- Globalization, which will bring down the profit margins and the competitiveness of agricultural and forest cultures, lowering the local and regional products and the attractiveness of the primary sector.

**Increase of ignitions and fuel accumulation**

- The afforested, cultivated or uncultivated areas of the metropolitan communities of the northwest and littoral centre regions, Lisbon and from Sines to Algarve no longer have their original functions. Their owners are now expecting to get higher profits from their urbanization or sale for some other purpose. The increase of urban/forest interfaces, owing to the pressure of urbanization, the building of structures in the forest spaces, and the use of those spaces by populations who are "not educated" for fire and unaware of the origins of ignition will cause more frequent and urban-forest interface, that are hard to extinguish.
- Increasing climate variability, most likely a consequence of regional climate change, is indicated by a greater frequency and duration of heat waves.
- The loss of competitiveness of the forest sector and of agriculture will lower the owner's profits, thus negatively affecting investments in fuel management.
- The tendency for a higher abandon of agriculture in the surroundings of the inland villages where double ageing is a reality, bring about the increase of uncultivated forest spaces with high quantities of fuel loads.

Nevertheless, some opportunities that contradict these trends can be identified and regarded as positive trends**:**

**Improvement of present-day macro-economic and social environment**

- Society will be more alert to environmental issues and will promote and support solutions that reduce the causes of fire.
- The promotion of forest management as a strategic objective will have positive effects on employment in depressed zones.
- The profitability of forest and agricultural areas as producers of goods and services besides those related to wood, such as game, leisure, biodiversity, carbon sequestration and other environmental services, will revitalize the economy of some farms and woods, also as well as tourism.

**Reduction of ignitions and fuel accumulation**

- The decrease of population in inland zones reduces the origins of careless ignitions and intentional causes due to conflicts.
- The strategies to reduce the energetic dependence from oil, promotes the use woody fuel as renewable energy source.
- The technological development causes productivity profits in resource management, of information and decision support, allowing profits in operative efficiency and efficacy at the level of prevention, pre-suppression and suppression.

**The strategy for the Future**

In line with recommendation of experts and previous reports and studies the Law Nº 156/2004 (replaced by Law Nº 124/2006) foresees the conception of a National Plan of Prevention and Defence of the Forest against Fires, to be approved by the Government. In December of 2004, a team of experts was contracted to produce a technical proposal. They worked in close collaboration with all the institutions and major stakeholders were involved. Two reports were presented. The first report provides a diagnosis and a strategic analysis, encompassing several issues, such as analysis of major public policies that has important role in the fire problem, analysis of previous measurements of prevention, pre-suppression, suppression and recovery, analysis of communications, logistics and information technologies and analysis of organization, human resources and training. The second report presented a plan or technical solution that was engineered to achieve by 2010 a 0.8% average annual burned area rate. That mark, considered among the majority of users as a waterline for the sustainability of the Portuguese forest. To achieve that value a strong effort in assuring that prevention is effective was highly needed and recommended, instead, one more time, focus the attention over the suppression. The plan didn't mean a revolution but an intelligent evolution of system that have collapsed. The plan meant a supported change where actions were quantified, organization needs forecasted, procedures re-engineered, resources, pointers, milestones, economics, calendar, budget and an implementing plan or road-map were presented. Those two reports were delivered to the Government in February and September 2005, respectively, and for those who read Portuguese a full version can be downloaded at http://www.isa.utl.pt/pndfci .

The technical proposal was approved but unfortunately was not fully adopted by the authorities and Government. To accommodate the institutional inertia and resistance and due to political needs the Government adapted the contents of the technical proposal, maintaining the focus in the suppression capabilities, instead of adopting an organization that as focused in promoting an effective and efficient prevention programs, as proposed in technical study. The plan was published in April 2006 and it can be downloaded at http://www.dgrf.min-agricultura.pt/v4/dgf/ficheiros/20060329120518PF.pdf .

The Government believes that with the approved plan, that defines a strategy and articulated set of shares to promote active forest management, will be enough to achieve a gradual reduction of forest fires to a rate of 2% area burned annually by 2012, which means 100,000 ha/year (afforested lands, shrub and rangelands). To reach that goal some actions (not all presented in the technical study) were grouped in five strategic objectives:

1. Increase the resilience of the territory to forest fires;
2. Reduce the incidence of fires;
3. Improve the effectiveness and efficiency of fire suppression and fire management;
4. Recover and rehabilitate communities and ecosystems;
5. Adapt the actual structures to an efficient and functional management system.

Despite the technical problems it has, the plan reflects the need of a concrete and persistent shared action on education towards fire management, the improvement of risk management instruments, as well as the development of IT systems to manage and link the structures of prevention, detection and combat, with the overall aim of strengthening the operational capacities.

**Will the strategy and the Plan solve the problem? Will it work?**
Although the 2% burnt annual rate is too high for the sustainability of the Portuguese forests (2% means that – in average – the same hectare is burned every 50 years) it means that by 2012, at that burning rate, it will a different forest, from today. This plan is the first common effort for the future and it should be regarded as a tool and not as a final document. What is important in the plan is the process of planning, as stated by Dwight D. Eisenhower. The approved plan stands for a solution that I think is not enough, because insists in previous paradigms that have collapsed recently, and several critical actions are not included. For example, training, R&D or a budget are not presented. Although if, every year, the plan is evaluated to check if actions are being implemented as planned, and the changes are defined that need to be made for the coming years in order to built a more balanced programme, the plan will work as a tool and an accountable system. This would be in the spirit of the draft version of the Fire Management Code that was recently circulated by the FAO (http://www.fao.org/forestry/firemanagementcode).

To conclude, I strongly believe that the future of Portuguese forest lies on the successful integration of the different public policies that interfere with the forest, bringing together the different interests at all the levels, and reaching an agreement of all the partners on a common action, for example tax reduction and fiscal incentives for actions promoting silviculture operations and education of people.

In order to reduce the social conflicts that are often in the origin of ignitions and of the accumulation of fuel, future lies on the correct promotion of land use, on the development of an effective management and correct treatment of forest and agricultural lands, assuring that the purpose of that use is to improve their social utility (production of wood, fruit, game, and pastures biodiversity, carbon fixation, tourism, water and energy) incorporating the best techniques and practices of engineering on the management and planning areas, reducing the fuel load and its vertical and horizontal continuity.

In order to cope with the climatic conditions that are favourable to the spreading of fire and cannot be influenced by human action, the future lies in the education of the population, and if all the above fails, and if a fire occur, the future lies on the capacity of the system to act readily and efficiently, with trained personnel operating on a safe way, with the best techniques and tactics, minimizing the impact on the most efficient way at the lowest operative cost. To maintain the sustainability of forest, agricultural and urban spaces after the destruction by fire, if all the above fails, the future lies on the capacity to recover the destroyed potential in the shortest time and at the lowest cost, reducing unwished impacts and profiting of the opportunity to correct the causes that led to its loss and improve endurance and resilience to similar phenomena.

Maintaining the focus in the solutions, the future lies in the accountable functioning of institutions and agents, who should work as a team, on a cooperative and constructive way, steadily pursuing their objectives, maximizing the similarities and minimizing the differences, making efforts, at the national, regional and local level, to find synergies and come to an agreement upon common strategies.

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# SOUTH ASIA SPECIAL

## NEPAL

### Participatory Forest Fire Management: An Approach


## Abstract

Forest fire is considered as a problem in forest management system in Nepal. If natural disasters are excluded then forest fires come close to being the worst kind of all known disaster.

Fire-induced loss of soil cover negatively affects hydrological regimes and soil properties, leading to severe erosion and loss of productive topsoil. High economic losses are caused by damaging valuable timber and non-timber resources, natural regeneration, and planted forests.

Community involvement is proved to be successful for sustainable resource management. Community-based fire management could be the key to over-coming the recurring problems of forest fires in Nepal.

This paper attempts to shed some lights from the perspective of professional involved in forestry about *Where we are? Where we want to go? How can it be achieved?* – with some recommendations for the development of participatory forest fire management system in Nepal as a momentous approach for forest fire management in Nepal.


## 1. Introduction

Forest fire is considered as a problem in forest management systems in Nepal. If natural disasters are excluded then forest fires come close to being the worst kind of all known disaster (2).

In mixed forest of sal (*Shorea robusta*) in the Terai – a flat area in southernmost east to west belt of Nepal – the fire season starts from mid-March and the fires burn the forests 1-3 times till the end of May. All fires are surface fires. About 90 percent of the forested area in the plain was burnt out one to three times every year. This condition is more or less similar in all Terai districts (6) and mountain regions as well.

Forest fires destroy timber and non-timber forest products, although no data are available about the number of fires, severity and the amount of loss. Fires also reduce the biological diversity of the forests to a great extent. In addition, fires degrade the soil, inducing flood and landslide damage. Forest fires make the entire countryside hazy, thereby reducing aesthetic values for eco-tourism during the dry season At least one hundred villages are burned annually in Nepal, some of which are definitely destroyed by forest fires where the roofs are made of thatched grass (11).

Fire-induced loss of soil cover negatively affects hydrological regimes and soil properties, leading to severe erosion and loss of productive topsoil. High economic losses are caused by damaging valuable timber and non-timber resources, natural regeneration, and planted forests (15).

Burning for stimulation of new grass (intentional) and smokers (negligence) alone share about 45 percent of fires among all known causes of forest fires. Natural causes (e.g. thunderstorms) of fire are not reported. People set about 64 percent of fires intentionally; about 32 percent of fires are due to accidental/carelessness, and about 4 percent by unknown causes (5).

Forest fire management is not practiced in Nepal. The community forest users' groups control forest fires in their own forests, although they do not have a plan for systematic prevention and control of fires (11). Most of these community forests are located in the Middle Mountain Region where forests are severely fragmented and surrounded by villages. Here the community forest users are able to protect their respective forests from cutting and grazing. However, occasional forest fires occur due to the negligence of smoking travellers. The forest users are able to fight forest fires although they do not have proper tools and technical support. In fact, community forests are not managed properly, nor are forest fires fought in an appropriate manner.

Despite the economical, ecological adverse impacts of the forest fire, government agencies do not give priority for fire management in terms of budgets and human resource development. Forest managers often ignore economic, ecological and cultural (values) impacts of forest fire and millions of people who have been entailed with them.

Forest development, protection and utilization efforts should go hand in hand for forest fire control measures to be effective. In government-managed forest, some steps taken by the Department of Forests even though at an indicative level are positive steps in this direction. Strengthening of this Department to cover the sustainable forest management at regional, national and local level is indispensable if its efforts are to materialize in a tangible manner.

Most poor people live near to the forest and mostly depend on their livelihood on it and reasons for the fires. So, livelihood of the poor should be addressed in the whole fire management scenario.

## 2. Objectives

The main objectives of 'Participatory Forest Fire Management' is to prepare and implement fire management plans and to participate in general forest fire prevention and suppression programmes in the community forests and neighbouring government managed forests (e.g., fire lines and access trails, fire fighting tools and lookout towers, pre-attack planning, etc.).

**Fire Suppression**

1. Encourage the formation of volunteer fire fighting group from the community forest users' group.
2. Provide training on fire fighting techniques and tactics to the members of fire fighting group.
3. Develop and provide fire fighting tools to the fire fighting group.

**Fire Prevention**

1. Utilize community forest users' groups (CFUGs), local non-government organizations (NGOs), other community based organizations (CBOs), private sectors (PSs) and universities for extension, research and development activities.
2. Stimulate community cooperation in fire prevention through various incentive measures.
3. Encourage integration of agriculture and grazing land-use into fuel break systems through incentive mechanisms.

## 3. Forests and Forestry in Nepal

Total land area of the country is 14.7 million hectares (ha). Within a horizontal distance of about 150 km there is an elevation range from 150m in south to 8848m in north. Due to the east-west orientation of the mountain ranges, the country has a tropical climate in the south and temperate and alpine climates in the north. The number of ecosystems per unit area is probably greater than in any other country in the world (1). Nepal has 39.6% forest area (forest cover, i.e. at least 10% crown cover, and shrub cover including protected areas) (7). Accordingly, there are many different vegetation types in Nepal.

### 3.1 Types of Forests

The Master Plan for the Forestry Sector Nepal (MPFSN) of 1988 defines forest as "forested lands having at least 10% crown cover including small pockets of plantation and burned areas".

The Forest Act 1993 defines forest as "the area covered fully or partly by trees". It further defines National forest as "apart from private forest, all demarcated or non-demarcated forest within the Kingdom of Nepal and the term incorporates the bare or non-registered land near by or surrounded by the forest and foot trails, ponds, lakes, rivers and river banks too".

The Forestry Sector Policy 2000 classifies forests and protected areas for the purpose of conservation and management as indicated below: All forests except those designated otherwise are national forests. They are divided into the following categories:

1. Government Managed Forests: National forest area managed by His Majesty's Government of Nepal using approved forest management plans.

2. Community Forests: A part of national forests which are handed over to users' groups as community forests to conserve, manage, and utilize for their basic needs.

3. Leasehold Forests: Forests on land that has been leased by central or local government agencies to private owners including individuals, co-operatives, institutions, and commercial firms.

4. Religious Forests: Forest belonging to religious institutions.

5. Private Forests: Forests or trees raised and managed on privately owned lands.

6. Protected Areas: National forest declared by the HMGN as a protected forest pursuant to the Forest Act 1993, which considers it has a special environment or scientific or cultural importance.

7. Conservation Areas: Land such as national parks, reserves, protected areas, or other categories gazetted under the National Parks and Wildlife Conservation Act 1973.

8. Protected Watersheds: Any land under public or private ownership designated as a protected watershed under the Soil and Watershed Conservation Act 1982.

Mostly based on the Master Plan for Forestry Sector Nepal 1989, Jackson (1994) has classified forests according to the species composition in his popular book the 'Manual of Afforestation in Nepal'. He found 24 vegetation types based primarily on altitude namely:

Tropical types
1. *Shorea robusta* forest
2. *Acacia-Dalbergia* forest
3. Other riverine forest
4. Grassland
5. *Terminalia- Anogeisus* deciduous hill forest

Sub-tropical types
6. *Pinus roxburghii* forest
7. *Schima-Castanopsis* forest
8. *Alnus nepalensis* forest
9. Riverine forest with *Toona* and *Albizia*

Lower temperate types
10. *Quercus leucotrichophora* & Q. lanata forest
11. *Quercus floribunda* forest
12. *Quercus lamellosa* forest
13. Mixed broadleaved with Lauraceae forest
14. *Pinus wallichiana* forest (lower type)

Upper temperate types
15. *Quercus semecarpifolia* forest
16. Mixed broadleaved forest
17. *Rhododendron* forest
18. Coniferous forest

Sub-alpine types
19. *Abies spectabilis* forest
20. *Betula utilis* forest
21. *Rhododendron* forest
22. *Juniperus indica* steppe
23. Caragana steppe

Alpine type
24. Alpine vegetation

### 3.2 Community Forestry

The Master Plan of Forestry Sector Nepal (1988-2008) has considered the Community Forestry as first Primary Programme. The Tenth Five Year Plan of Nepal (2002-2007) has considered it as first Priority Plan (P1). Management approach in community forestry is of passive type i.e. protection.

At present, there are more than 135,700 community forest users groups including 690 (about 25%) women users group. Forest areas handed over to them are 1,115,870 ha (1.91% of total forest area and 0.76 % of country area). Total 1,533,068 households are benefited (14).

Major forest products collected from the community forests are timber, fuelwood, grass/ fodder/ litters, khair (catechin wood), medicinal herbs, and turpentine. Data of forest product collection, uses and sell revels that the total use value and stumpage value of the forest products is about NRs. 747,342,954.00 and NRs. 1838,840,495.00 respectively (Kandel, 2004) (13). [4]

### 3.3 Current Forest Fire Management Practices in Nepal

Forest fire prevention activities are being carried-out in priority districts (for instance, Saptari, Siraha, Sindhuli, Sindhupalchowk, Kathmandu, Dang, Surkhet and Dadeldhura) by the Department of Forests under the National Forest Programme on an ad-hoc basis. Very few budgets have being allocated (for instance, NRs 50,000 for each district in fiscal year 2004-2005) for paying wages for fire watchers, producing and setting up signboards and posters, distributing flyers and using loudspeaker announcements during the fire season. The major criteria for prioritizing districts for the activities are forest conditions (in terms of forest stocks) and demand.

The community itself by traditional ways and means has done forest fire suppression activity in community forests. In case of big fire, they may request for help to District Forest Office or vice versa.

In plantation forests, in Sagarnath (16,000 ha) and Nepalgunj (3,680 ha) Forest Development Project areas, there were very good forest fire management systems in pre-fire management (e.g., fuel management), fire detection and fire suppression, and post-fire management (e.g., Mopping-up) during the project period. Now, a passive forest fire management system is being applied. The forests have been developed from degraded forests converted into planted forests with some exotic species like *Tectona grandis* and *Eucalyptus camaldulensis*.

Despite the enforcement of strict law by the government of Nepal to discourage forest fire incidence, it has not been implemented properly due to procedural difficulties and human behaviour.

### 3.4 Prevailing Policies and Legislations regarding Forest Fire Prevention

**Master Plan for the Forestry Sector (MPFS) Nepal 1989**
The MPFS determines the following objectives for the development of the forestry sector mainly for forest protection particularly for forest fire protection:

- Second Long-term Objective states “to protect the land against degradation by soil erosion, floods, landslides, desertification, and other effects of ecological imbalance”.
- First Medium-term Objective states “to support decentralization and promote people’s participation in forest resource development, management, and conservation”.

**Forestry Sector Policy 2000**
Soil, water, flora and fauna constitute the main elements of forestry. Together with other biotic and abiotic factors these elements help sustain biodiversity. Some of the objectives are stipulated below:

- One of the long-term objectives of the Forestry Sector Policy is “to protect land from degradation by soil erosion, floods, landslides, desertification, and other effects of ecological disturbance”.

[4] 1000.00 Nepal Rupees = ca. $US 15.00

- One of the medium-term objectives of the policy is “to promote people’s participation in land and forest resource development, management, and conservation”.
- One of the short- term objectives of the policy is “to provide increased opportunities to the people for forestry resource management under the community, private, and leasehold forestry programmes as well as the biodiversity conservation programme provided for in the new forestry legislation”.

**Tenth Five Years’ Plan (2002- 2007) 2002**
Forestry Sector’s Objectives of the 10th Five-Years Periodic Plan of Government of Nepal are:

- To manage, develop, conserve and wise use of forest resources, and conserve the environment fulfilling the basic needs of forest products to contribute poverty alleviation, and
- To emphasize people’s demand and participation in programme implementation.

**Forest Act 1993 & Forest Rules 1995**
Forestry legislation used to be formulated to resolve past problems related to protection rather than to meet present and future needs for better management and increased production. Policy is now very clearly oriented towards “people’s participation” in contrast to previous legislation. The preceding policies are being implemented under the Forest Act of 1993 and the Forest Rules of 1995. Both the ‘Act and Rules’ aim to develop forestry sector through decentralization and the participation of individuals and groups.

Prevention
In Clause (b), Section 49 of Forest Act 1993, "setting fire, or do anything that may cause a fire accident" in national forests is prohibited. In Clause 1(b), Section 50 of the Act, any person who commits such offence shall be punished with a fine of not more than NRs. 10,000.00 or with imprisonment for a term not exceeding one year, or both. This is the only one legal provision for fire prevention but it is still ineffective because of the human behaviour and procedural difficulty to identify the offender.

Rehabilitation
In Clause (c) of Sub-rule (2) of Rule 9 of the Forest Rules 1995 has provision of construction wood (quantity determined by the District Forest Product Supply Committee) to the fire-victim household for the rehabilitation purpose with royalty price.

## 4. Fire Management Options

Fire Management incorporates all activities required for the (protection of forest and human values from fire, and the use of fire to meet land management goals and objectives.

The basic fire management options that can be considered for application within tropical forests include(15):

**Fire Exclusion** - applicable in those forest types where any fire effect would be undesirable and unproductive to the resource management and conservation objectives (e.g., conservation areas, demonstration plots, fire intolerant plantation-type forests).

**No Fire Management Measures Taken** - applicable where occurrence of uncontrolled fire may be tolerated as long as no additional degradation factors interfere, such as excessive grazing. Also applied where no alternatives exist because of lack of active fire control capabilities.

**The Fire Exclusion and No Fire Management** approaches should only be considered where it is known that forest fuels will not build up and result in extreme wildfire behaviour and damage to human values and forest ecosystems.

**Integrated Fire Management** - applicable where there is a good understanding of the impacts of fire on the specific forest types involved; where there is capability to actively manage all fire situations (e.g. to prevent and suppress all undesirable fire); and where the use of prescribed fire will promote resource management and other conservation goals. The application of the Integrated Fire Management option should be given primary consideration where wildfires have the potential to threaten human life or property and other assets identified in management plans for protection.

Integrated fire management measures include the following aspects:

- Fire prevention
- Fire pre-suppression
- Fire suppression
- Training and education
- Law enforcement and the use of incentives
- Prescribed burning for specific purposes

## 5. Participatory Approach to Forest Fire Management

### 5.1. General Approach to Forest Fire Management

Forest fire management should include administrative decisions and operational activities that involve prevention, preparedness, suppression, response, relief, rescue, recovery and rehabilitation involving all stakeholders concerned. Community involvement must always be part of the disaster management approach. The importance of community involvement can best be described with an example.

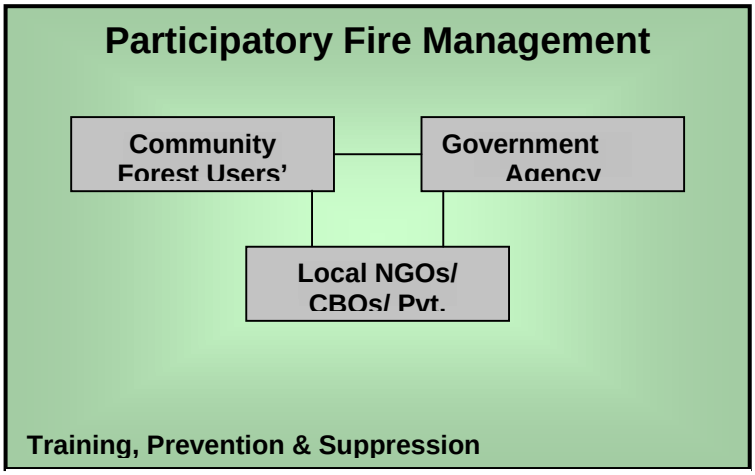


**Figure1.** Concept of Participatory Fire Management

**Table 1:** Involvement of stakeholders in Participatory Fire Management activities

| Forest type | Focal responsibility | Other Stakeholders |
|---|---|---|
| Government Managed forests | DFO | CFUGs, CBOs, NGOs, local governments, |
| Community Forests | CFUG | DFO, CBOs, NGOs, local governments, |
| Leasehold Forests | Leaseholder | DFO, CFUGs, CBOs, NGOs, local governments |
| Religious Forests | Religious Institution | DFO, CFUGs, CBOs, NGOs, local governments |
| Private Forests | Private Owner | DFO, CFUGs, CBOs, NGOs, local governments |
| Protected Areas | DFO | CFUGs, CBOs, NGOs, local governments |
| Conservation Areas | Parks and Reserve Office/ DNPWC | DFO, CA Management Authority, BZFUG, CBOs, NGOs, local governments |
| Protected Watershed | DSCO | DFO, CFUGs, CBOs, NGOs, local governments |

| Note: | | | |
|---|---|---|---|
| BZFUG | Buffer Zone Forest Users Group | DFO | District Forest Office |
| CA | Conservation Area | DNPWC | Department of National Parks and Wildlife Conservation |
| CBO | Community-based Organization | DSCO | District Soil Conservation Office |
| CFUG | Community Forest Users Group | NGO | Non-government Organization |

## 5.2 Key elements of Forest Fire Management

Some key elements of forest fire management strategies are listed below. These are not the only ways that the fire can be managed and are only meant to guide implementing institutions dealing with the fire to become better prepared for it.

**Prevention**
Government agencies and other concerned stakeholders can better prevent the forest fire by conducting certain activities before a fire occurs. These can include awareness raising among people, constructing a fire line or control burning in a forest area; and ensuring that there is proper socio-economic development and active ownership and participation of communities along the forest fire management system (all the phases of the disaster management cycle).

**Preparedness**
Preparedness measures such as the arrangement of fire-fighting tools and the training of fire fighting crews to extinguish fire are other essential components of forest fire managing. Furthermore, this should be an ongoing, regular function of government agencies. These measures can be described as logistical readiness to deal with fires and can be enhanced by having response mechanisms and procedures, drills, developing long-term and short-term strategies, public education and building early warning systems.

Risk assessments (identifying those areas e.g. demonstration plots, resin tapping areas, protected areas and villages that may be at risk before a fire occurs) are also essential and may complement development strategies in local areas.

Preparedness can also take the form of ensuring that strategic reserves of food, equipment, water, medicines and other essential materials are maintained in cases of catastrophes.

**Suppression**
Forest fire suppression refers to measures that can be taken to minimize destructive and disruptive effects of hazards and thus lessen the scale of a possible impact.

A forest fire management plan and structure (e.g., forest fire committee at the local level) should be established. Each plan will be site or local specific and as such must be tailored for the district forest office concerned. For example, a community forest users' group in the middle mountain may prohibit grazing or unauthorized entering into resin tapping area during the fire season. A District Office in the Terai plain may hire the fire-watcher(s) to detect fire to look after a block of forest during a fire season.

Forest fire mitigation can be achieved through backfiring, fire-fighting, and escaping from the fire.

**Response and relief**
If a forest fire does occur then response and relief have to take place immediately; there can be no delays. Area burned and intensity of damages will be geometric order with time. Clear plans and proper implementation of the plans have significant role to manage such events. It is therefore important to have contingency plans in place.

**Rescue, recovery and rehabilitation**
Interventions are also needed after the fire occurs. Mopping-up and revegetation in the areas need to be carried out. In some cases, forest fires enter to adjacent villages and burn houses and cattle-shed causing losses of lives and properties. In many ways this is the most difficult period for the victims and the victims should be address with proper rehabilitation.

Forest fire management, as shown by these examples, requires effort and commitment by the various stakeholders. The capacity must be built to handle such events, and training programmes are essential. It is important to note that forest fires are non-routine events that require non-routine response. Governments cannot rely on normal procedures to implement appropriate responses - they will need to learn special skills, techniques and attitudes in dealing with the fire.

The key elements of forest fire management listed above are important in providing governments with the capacity to deal with forest fire management at various stages. This is not an exhaustive list of areas, simply the most important ones.

**Table 2:** Selection and Implementation of Countermeasures

| Phases | Activities | Examples | Remarks | | | |
|---|---|---|---|---|---|---|
| **Pre-fire** | | Awareness raising | **Preventive measures** | **Mitigating Measures** | **Ensure people's participation and livelihood** | **Development of Institutional structures; Planning; Policy and legislation** |
| | Preparedness | Construction of fire-lines<br>Prescribed burning<br>Arrangement of fire-fighting tools and the training of fire fighting crews<br>Risk assessment<br>Insurance<br>Maintain warehouse with essential materials | | | | |
| **During the fire** | | Fire detection<br>Prompt mobilization of fire crews | **Suppression Measures** | | | |
| | Response | Fire fighting<br>Backfiring<br>Wildland fire fighter safety | | | | |
| **Post-fire** | | Mopping-up<br>Revegetation of burnt areas | **Rehabilitation measures** | **Rescue and relief** | | |
| | Recovery | Shelter, food, water, medicine, counselling to the victims | | | | |

This is not a complete framework of countermeasures for forest fire management. Examples of activity given above are the most important ones, not an exhaustive, but can be selected or added according to local situation.

### 5.3 Fire Fighting Tools and Equipments

The list of contents of equipment sets for a 15 members VFCG is depicted in Table 3 below.

**Table 3:** Proposal of an equipment set for a Village Fire Control Group (volunteer) of 15 members (Sources: 4, 9, 12)

| Type of Equipment | Number |
|---|---|
| Fire swatter | 3 |
| Fire shovel | 3 |
| Fire rake | 3 |
| Fire rake-hoe | 3 |
| Chain saw | 1 |
| Metal bucket | 3 |
| Improved bolo | 3 |
| Fire axe-hoe | 3 |
| First aid kit | 2 |
| Protective clothing | 15 |
| Helmet | 15 |
| Boots | 15 |

### 5.4 Some Indicators for a Forest Fire Management Plan

Following are the some important points, though not exhaustive ones, that needs to be considered while preparing a forest fire management plan (8):

- Forest area, types of fuel, climate, history of fires, local demography
- Responsible organization
- Fire suppression plan
- Fire hazards reduction
- Fire hazard measurement system
- Fire detection plan
- Fire communication information system
- Cooperative organization and human resources
- Fire fighting equipments
- Work safety
- Fire hazard maps and data

## 6. Some issues related to Forest Fire Management

**Human resources**
Human resources charged with forest fire management in the Ministry are scarce, and dedicated, research-minded, well-trained personnel in Nepal are generally not attracted to forest fire management activities. An incentive system has to be developed to generate interest in a forest fire management career and to encourage greater management productivity.

**Institutional development**
The Forest Protection Section within the Department of Forests in the Ministry is looking after forest fire management. It should grow into an effective body for managing the forest fires and coordinating and networking covering the various organizations. International linkage and cooperation should be established.

**Developing facilities and improving research technology**
Tools and equipments are not sufficiently developed and provided to field level offices and community forest users' groups. Technological constraints have not been as limiting to the development of forest fire management system as human and financial resources.

**Financial allocation for forest fire management**
Funds have not been adequate for the forest fire management. The reason for that is why only selected districts have been covered with minimum budget only for some preventive works.

**Research and Monitoring**
Forest fire research and monitoring efforts by experts are minimal.

## 7. Challenges

In one hand, in the national front, developing communication system, developing fire prevention-based livelihood of local peoples, addressing traditional right of local peoples in resources utilization, involving private sector in forest fire management, motivating universities in research activities, and promoting stakeholding of community forest user groups, District Forest Office, and local NGOs/ CBOs are the prime challenges facing by the country.

On the other hand, at the international front, for comprehensive and collaborative fire risk reduction and management between and amongst Nepal's neighbours India and China need to be promoted. At the same time, international technical and financial supports need to be sought for the development of forest fire management system in the country.

## 8. Conclusions and Recommendations

Forest fire is considered as a problem in forest management systems in Nepal. If natural disasters are excluded then forest fires come close to being the worst kind of all known disaster.

Despite the economical, ecological adverse impacts of the forest fire, government agencies do not give priority for fire management in terms of budgets and human resource development. Forest managers often ignore economic, ecological and cultural (values) impacts of forest fire and millions of people who have been entailed with them.

Forest development, protection and utilization efforts should go hand in hand for forest fire control measures to be effective. Some steps taken by the Department of Forests even though at an indicative level are positive steps in this direction. Strengthening of this Department to cover the sustainable forest management at regional, national and local level is indispensable if its efforts are to materialize in a tangible manner.

Community forest users are able to protect their respective forests from cutting and grazing. However, occasional forest fires occur due to the negligence of smoking travellers. The forest users are able to fight forest fires although they do not have proper tools and technical support. In fact, community forests are not managed properly, nor are forest fires fought in an appropriate manner. Awareness and Training programmes to community forest users' groups are significantly useful to conserve the community resources.

Community involvement is proved to be successful for sustainable resource management. Community-based fire management could be the key to overcome the recurring problems of forest fires in Nepal.

Some of the recommendations with respect to forest fire management are enlisted below:

- There needs to be a comprehensive national fire policy to reduce the social and economic costs to the community caused by forest fire. The policy should properly address problems in government-managed forests, community forests as well as other national and private forests. Principles stipulated in 'ITTO Guidelines on Fire Management in Tropical Forests' useful to policy makers and guidelines based on vegetation type need to be prepared and disseminated.
- Forest Protection Section within the Department of Forests in the Ministry should grow into an effective body for managing the forest fires and coordinating and networking covering the various organizations. International linkage and cooperation should be established.
- Human resources development at Ministry of Forests and Soil Conservation level, and Awareness and Training programs at community level should be given a prime importance.
- Forest fire seems to be neglected in overall scenario of disaster management in Nepal. It should be included in the National Program as a development work in itself.
- There is much to be done in the field of forest fire researches and studies, fire standards, economic, social, and environmental considerations. Fire hazard maps useful to forest managers and also to the local people need to be prepared and disseminated.
- Tribes and local communities have legal grazing rights in the communal pasture land that must be addressed in forest management and policy.
- There needs to be develop the 'stakeholding culture' in resource management with strengthening and motivating to all concerned stakeholders
- ***'Integrated Community Forest Fire Management'*** seems to be the more practical option for successful forest fire management.

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# Forest fire in the Terai, Nepal
# Causes and Community Management Interventions


## Summary

Forest fire, largely caused by human, has changed the Terai forest ecosystems. Of the total, 58% forest fire were deliberate burning by grazers, poachers, hunters and non-timber forest product collectors. Forest fire due to negligence (22%) and accident (20%) also had a significant share. The major causes of the fire were carelessness of passer-by, smokers and picnickers for the former and illiteracy, ignorance and fun for the latter. Analysis affirmed that most of the fires that occurred due to the aforementioned reasons were related to agricultural activity. Forest fire occurrence and awareness level of local community is, therefore, always intertwined. Public understanding of the environmental services of ecosystems is expected to help minimize the forest fire incidences.


## Introduction

Wherever there are people, there are fires, as the two have been culturally linked for centuries. Because of the nature of the farming system (small-scale and temporal) and the absence of other appropriate means of land preparation, fire is usually resorted as a way of preparing fields for crop cultivation (FAO, 2003). It is the least expensive land clearing method, and for most of the small households the only available one (Kunwar, 2004a). It has also been used for promoting annual grasses for grazing livestock, facilitating cultivation, and assisting in hunting and land clearing. Local people set fires deliberately for their livelihood particularly for agriculture and non-timber forest products (NTFPs) collection (Sharma, 1996; Bajracharya, 2002). It plays a useful role in the life cycle of a forest.

Forest fire destroys many more trees than all other natural calamities: parasite attacks, insects, frost, etc. (Alexandrian et al. 1999). It results in fuelwood shortage, displacement of people and many socio-economic problems worldwide. It not only destroys living forest vegetation, but also consumes the dead vegetation and destroys the litter. As soon as the soil has been made bare by fire it is reoccupied by invading plants of one kind or another (Toumey and Korstian, 1959). It is one of the prominent causes of forest destruction in Nepal where fire is traditionally linked with rural people's livelihood (Anonymous, 2003). Nepal's Terai (tropical) forests are decreasing at an annual rate of 1.3% (DFRS, 1999), and this is due to massive deforestation, forest encroachment, illicit felling, premature and over harvesting, overgrazing, firing, etc.

Although fire under control may be a beneficial, uncontrolled fire is always harmful. Fire is, therefore, neither innately destructive nor constructive; it simply causes changes. Whether these changes are viewed as desirable or not depends upon their compatibility with overall objectives (Wade and Lundsford 1990). In this connection, the present assessment was undertaken to identify and reveal the causes and community management interventions of forest fires in Terai, Nepal.

## Methods

This study was carried out by analyzing primary data and reviewing, compiling and collating the existing literatures. The primary data were collected through rapid rural appraisal (RRA) and participatory rural appraisal (PRA) methods. Field observation, group discussion, informal interview, meeting, schedule survey, checklist and scaling and ranking were employed as tools for primary data collection. Field visits were carried out during April-June 2004. The study sites were Basanta Kailali, Khata Bardia, Mahadevpuri Banke, Lamahi Dang, Dovan Palpa, Chitwan and Kapilbastu districts extending between 27º00' to 29º07' N latitude and 80º03' to 80º00' E longitude.

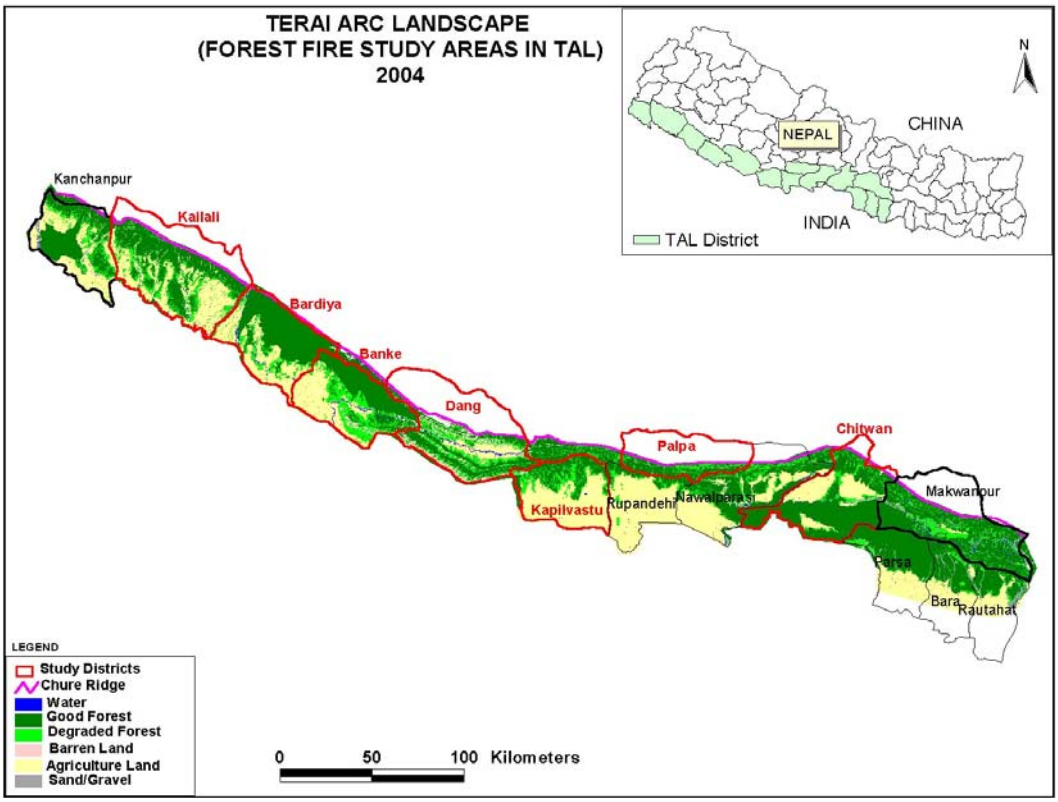


**Figure 1.** Forest fire study areas in the Terai Arc Landscape (TAL), Nepal

## Results and Discussion

### Peoples and livelihood

Population of the Terai seems to be growing rapidly due to high rate of migration from hills and mountains. Annual population growth rate in Kailali district is 3.89% followed by Banke district 3.01% while the national population growth rate is 2.25% (HMGN, 2003a, b). Terai, particularly, is the most heterogeneous area in Nepal comprising diverse ethnic groups such as Tharu, Bote, Kumal, Mushahar, Satar, Dhimal, etc. The occupation of the ethnic groups is farming followed by traditional use of NTFPs, fuelwood, fodder, wild fruits and vegetables, and fishing. Livestock farming is the secondary occupation in which people are raising buffaloes, cows, goats, sheep and pigs. All these livelihood portfolios are linked with forest fire to some extent.

Forest fire has been a major agent of land cover change in the Terai (Kunwar, 2004a) but it can also have a devastating long-term effect on ecosystems that are not adapted to such patterns of burning. Forest of Terai is composed of tropical deciduous types. Most of the tree species of these forest types shed their leaves during dry season (March to May). Large amount of dry leaves, small twigs and litter which accumulate on the forest floor accompanied by undergrowth species, grasses, weeds and alien species served as fuel for the outbreaks of forest fire.

### Causes of forest fire

Natural fires, which start directly or indirectly due to natural cause beyond the normal capacity of man to control, were absent in the present study. All the forest fires were human induced which fall under following categories.

***Forest fire due to intentional purpose***

Analysis revealed that 58.06% of the total causes of forest fires were deliberate (Figure 2). It was followed by negligence (22%) and accidental (20%). With growing human populations that have moved into forest-urban interface areas, increasing number of fires were human induced, inadvertently caused for example, by discarded cigarette butts of illegal loggers, passer-by, cattle herders and grazers, NTFPs and fuelwood collectors. Forest fires were started deliberately by livestock owners,

shepherds, grazers who ignite forest to promote new green flushes of growth for their animals which was a key threat in Terai. All these causes are linked with agriculture.

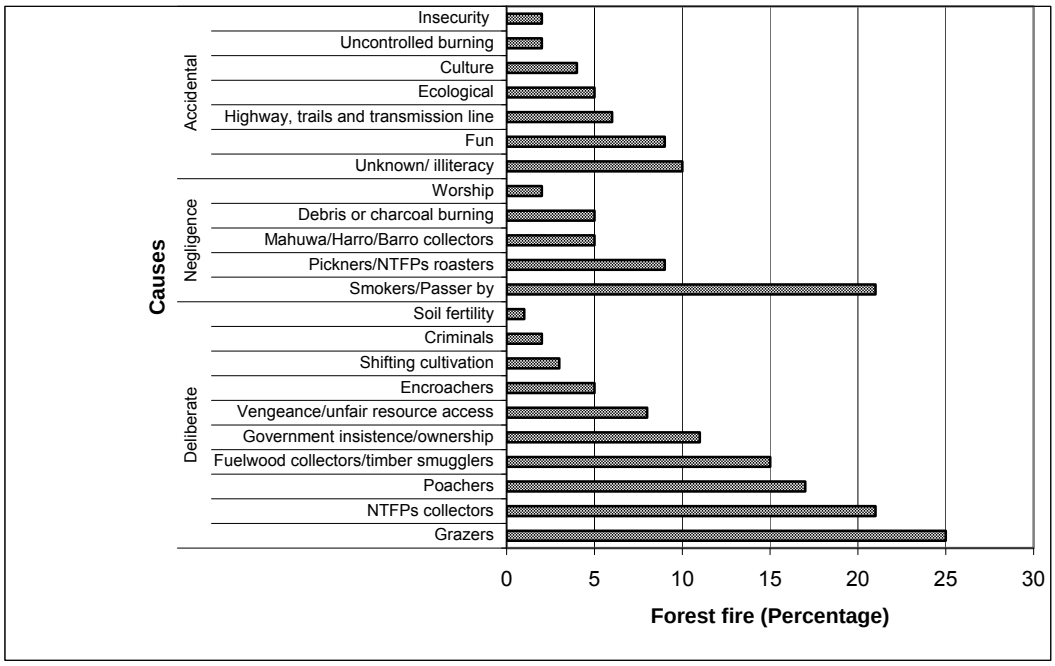


**Figure 2.** Forest fires in Nepal by causes

**Figure 3:** Forest fire in Radhakrishna CFUG, Kailali

Some forest fires are set by hunters and poachers to clear vegetation for a better sight of prey namely wild pig (*Sus scrofa*), hare (*Lepus nigricalis*), deer (*Axis axis*), wild fox (*Cuon alpinus*), etc. The fire is also set for the growth of tender shoots which entices the wildlife. It has been used to scare wild animals, snakes, mosquitoes, insects, to clear footpaths and to control pests. Other reasons behind the deliberate burning are removal of plant species in competition with desired timber species and control of soil-dwelling pathogens and weeds.

Many time people set fire for NTFPs collection. NTFPs contributing to rural people's livelihood are bidipatta (*Diospyros melanoxylon*), mushrooms, mahuwa (*Madhuca indica*), etc. Collectors of biddipatta set fire in summer to promote a better flush of leaves. Fire is also set by ethnic groups to collect phutki mushroom (*Schleroderma* sp.), vegetables, bankas (*Eulaliopsis binata*), khajuri (*Phoenix humilis*), etc. People ignite fire for encouraging a lush growth of grasses, facilitating the collection of mahuwa flowers, clearing land for cultivation, smoking out beehives, cooking and keeping warm.

Elsewhere in developing countries, clearing the area for cultivation, especially shifting cultivation is a common practice (Heikkilä et al., 1993). Shifting cultivation, locally known as *Khoria*, has been and continues to be a way of life for many of the ethnic groups both in hilly areas and in northern Terai of Nepal since the time immemorial. Particularly, it is common in Chitwan, Dhading, Makwanpur, and hilly areas of Palpa district. Since the period for slash and burn generally coincides with the dry and windy months of the year, incidences of fire spreading beyond the boundaries of designated plots into the adjoining forests are not uncommon. It is the leading cause of forest destruction and firing in the northern parts of India (Saigal, 1990).

Farmers also use fire to eliminate crop residue, and to convert the forest to agricultural land. Fire removes the organic matter and provides an ash bed, which facilitates the growth of grasses. Therefore, local people set fires to gather ash, which is locally used as manure. They also set fires for hunting and masking illegal logging. Hoffmann et al. (1999) and Vayda (1999) argued similarly.

Urban population is also dependent on forest resources; they create a huge pressure on forests. Pressures from fuelwood collectors and timber smugglers are also important to set fire in forest. Accentuating such pressures is intensified migration as people move about looking for alternatives. Inexperience and carelessness of urban dwellers might inadvertently set forest fire. Transmigrants usually do not have a good knowledge of their new environment, and may use fire inappropriately. Forest fire may also be lit for a variety of reasons including private vengeance.

People with a complaint against the forest officials sometimes start fire maliciously. Such a situation is created, as people are dissatisfied with the way of forest department staff's use of power to control resources. Another causes of forest fire are the conflicts that arise with perverse policy (e.g. community forests' revenue sharing mechanism, collaborative forest management, delaying handover the forest to community, lack of tenure security, ownership and incentives) and external forces (e.g. demographic changes, high migration) (Figure 4).

**Figure 4:** Forest fire in Hariyali CFUG, Kailali

***Forest fire due to negligence***

Carelessness of smokers and of passerby is a pertinent source of forest fire in the Terai. Grazers and the fuelwood collectors, sometimes unintentionally throw the burning butts of cigarette inside the forests. The burning buds can easily catch fire on the dried leaves and twigs, especially in summer season. Some people or children set fire for roasting the NTFPs (pine cone), prey (birds, small animals, etc.) and do not put it out which can outbreak. Forest fires are also caused by ignorance of poachers, encroachers, and charcoal traders (Upreti, 2003).

Mahuwa (*Madhuca indica*) flowers, sal (*Shorea robusta*) flowers, harro (*Terminalia chebula*), barro (*Terminalia bellirica*), tata (seed of *Bauhinia vahlii*), etc. pickers burn the dry leaves under the trees to get a clean patch of floor to facilitate desired NTFPs collection. While the intention is only to clear the small underneath patch of single tree, fire can outbreak. Since the collection of NTFPs is done during March-May, the hot and dry season aggravates the situation further.

Traditional communities use fire as a tool for burning organic matter and agricultural residue to prepare the ground for next crop cultivation. Such fire can spread from agricultural lands to the forest, from the forest to the agricultural lands, or from the forest or agricultural lands into villages and vice versa. Abandoned cooking fire in the forest and burning garbage have also been reported by local people and concession staffs to set forest fire. Annual roadside clearing and debris burning (usually from March to June) can also cause forest fire (Aryal, 2004).

***Accidental forest fire***

Some people use fire in forest for encroachment and agricultural purposes. When this is done without precautions and coincides with high climatic risks (such as wind, hot and dry climate), forest fires are practically inevitable.

Prescribed burns that get out of control also cause some forest fires. Managed fires do from the activities of smallholders for forest clearing, while uncontrolled fires can also occur in natural forests because of escaped fires from land clearing and illegal logging. However, all fires that spread from the source do not necessarily result in calamity; they may burn out at some distance away, often crossing into a different vegetation type (Frost, 1992). Degraded forests are more susceptible to fire than primary forests, and newly logged areas even more so. For their safety from fire, local people create firebreaks around their homestead (locally called *Pargelnu*); this also improves visibility.

Some forest fires of Terai are also associated with fixed installations (highways, transmission lines, trails) and some are directly related to human activity. Security problems and burning for fun also contributed to the forest fire. Least income and unemployment, which is as high as 80-90% in the Terai (Shrestha et al., 2003), compel people to resort logging, fuelwood collection, hunting and most importantly the collection of NTFPs. All these activities increase the number of deliberate and accidental forest fire.

Uncontrolled fire due to ecological factors namely hot temperature, low humidity and precipitation and high fuel accumulation are common in Terai. In addition, topography and duff/fuel moisture percentage also strongly influence the possibility of forest fire. The intensity of uncontrolled fire increases substantially with the invasion of fire-prone aliens. Uncontrolled, these aggressive plants tend to reproduce rapidly (Kunwar, 2003), pile up the fuel for fire outbreak and become impenetrable to firefighters, multiplying the risk of danger. Neighbourhood and tribal communities visit the temples situated in forests to offer prayer and sometimes they do not put out the fire properly after cooking which then spreads when the wind blows.

## Nature and intensity of forest fire

The occurrence, intensity and nature of forest fire are scientifically less understood, and the studies are scanty and non-conclusive in Nepal. Timely information on the location can help in preventing, planning and management of forest against fire.

The collected statistics of forest fire are not complete for all countries (IFFN, 2003). The recently published global burnt area product 2000 derived from space borne sensing system is the first step obtaining the benchmark data on the extent of global wildland fires for year 2000 (JRC, 2002). Initial

analysis indicates that approximately 351 million hectares globally were affected by fire in the year 2000 (JRC, 2002).

About 90% of the Terai forests were affected due to fire (Sharma 1996). Such casualty was also reflected in earlier observations of Goldammer (1993). It is very difficult to obtain the quantitative information of forest fire incidences in Nepal. According to Bajracharya (2002), forest area burnt annually in Nepal is in the order of more that 400,000 ha. However, Department of Forest (DoF), responsible institution of the government of Nepal for forest management, is yet to keep records of forest fire. Contrarily, some CFUGs have initiated keeping the records of forest fire statistics and combat locally. Present study also made efforts to measure the burnt area of community forests of Terai during the years 2003 and 2004 (Table 1). In total 14% of the community forests of study area were burnt in 2003 and 24% in 2004. Despite the institution of community forest management system, human disturbance continued in various forms, including setting fire (Kunwar, 2004b), and increased the forest fire incidence. The increase in forest fire damage in the second year was also due to the pressures of fuelwood and NTFPs collectors, poachers and hunters, etc supplemented with dryness, high rate of migration and encroachment.

**Table 1.** Total burnt area of community forest in the year 2003 and 2004. Source: 2004 field survey.

| Study area | Total area (ha) | Total number of Households | Burnt area in 2003 (ha and %) | Burnt area in 2004 (ha and %) | Total burnt area (ha and %) |
|---|---|---|---|---|---|
| Basanta, Kailali | 1594 | 2918 | 279 (17) | 199 (12) | 478 (30) |
| Khata, Bardia | 8261 | 2615 | NA | NA | NA |
| Mahadevpuri, Banke | 1422 | 744 | 30 (2) | 30 (2) | 60 (4) |
| Lamahi, Dang | 2665 | 2743 | 195 (7) | 800 (30) | 995 (37) |
| Dovan, Palpa | 889 | 409 | 75 (8) | 135 (15) | 210 (23) |
| Chitwan | 4751 | 6220 | 924 (19) | 1644 (34) | 2568 (54) |
| Kapilbastu | 817 | 1711 | 130 (16) | 46 (6) | 176 (21) |
| **Grand Total** | **11684** | **14745** | **1633 (14)** | **2854 (24)** | **4487 (38)** |

Decreasing trend of forest fire incidence in community managed forests in Basanta Kailali, Mahadevpuri Banke and Kapilbastu districts was due to establishment of community managed fire lines and trench lines (Figure 5). The extent of forest fire in government-managed forests was astonishing. It was assumed that the annual fire damage in government-managed forest was as much as ten times than that of community managed forest. The severely affected government managed forests were from Dang, Banke, Kailali and Kapilbastu districts.

Most of the forest fire incidences occur between March and May in the Terai. Once the monsoon is established, usually by the June, the fire problem disappears. Long year's experience of Sagarnath forest project showed that forest fire peaks in April. White (1988) reported a constant threat of fire from January to May. We found 59.75% medium fires (5-100 ha) followed by 27.65% small fires (1-5 ha) and 12.76% large fires (100-< ha).

## Community management interventions

Fire management planning requires the coordination of a vast array of forest information as well as data on silviculture, forest management and land use. It manages fuel loads through controlled burning, grazing or cutting. Forest fire is considered as a forest management tool in some countries, and it can be a useful conservation management tool particularly in Terai deciduous forest (Kafle 1997) but in Nepal no such practice has ever been introduced.

**Figure 5:** Community managed trench lines in Radhakrishna CFUG, Kailali

Local communities play a significant role in preventing and suppressing harmful fires because they have clear understanding of local conditions and circumstances important for successful fire management. They also possess valuable knowledge of place, fire history and fuel loading. Local site-specific knowledge of and experience with terrain, past fire behaviour and locations for emergency fire lines, could save lives, time and money during emergencies. As public awareness grows, it is hoped that forest users actively participate in forest fire management activities and maintain forest biodiversity. In general, when communities have sense of ownership, they are more inclined to take interest and action in the management of fire. The abandonment of rotational shifting cultivation practice or traditional rights (free grazing) over resource access makes fire management more difficult.

Considering the priorities of users, blockwise grazing or no grazing system has been adopted to control fire in community forests. Construction and maintenance of fire lines around and inside the forest are common method of aliening fuels, which can segregate, stop and control the spread of fire. The construction of trench line was the most noteworthy and effective mean of fire management. Trench lines helped to provide multiple services: they act as firebreaks, forest boundary, water reservoir and control illegal transports. These lines were originally made to reduce the conflict with wildlife and grazing animals in forests (WWF Nepal, 2003).

Silvicultural operations comprising pruning, tree thinning, prescribed burning, controlled grazing and species selection, all of which minimize the fuel volume, were also the pivotal interventions for lessening the fire risk. Selective logging increases the growth and survival of trees and reduces the amount of debris subjected to rotten and fire. CFUGs also carry out controlled burning and collect litter and fuelwood for domestic uses, both of which minimize the fire risk.

When a fire outbreaks, CFUGs make an attempt to control it. A first objective in fire control is to stop peripheral spread and thus keep area burnt at a minimum (Davis, 1959). Users do not delay suppressing the forest fire even if it is in government-managed forests. Local forest guards or firefighters (forest users) are often the first to respond to forest fires. There were one to four forest guards in each CFUGs in accordance to the need and capacity of forests and user groups. CFUGs have also set co-operation for fire suppression. All these activities noticeably share to prevent and minimize the forest fire.

CFUGs accustom to having penalty and rewarding system for their forest management. Penalties are generally imposed on individuals, or collectively on the entire community, for deliberately or accidentally causing forest fires. The charge was identified through user's concession and channelled to the CFUGs' fund. The system of providing or rewarding 10-50% of the penalty amount to the criminal catchers was also observed.

Degree of recovery and need for rehabilitation interventions depend on the intensity and frequency of burning (Schindele et al., 1989). It is necessary to recover the burnt areas as soon as possible for lessening the harms of forest fires. Fencing the burnt areas and lessening the disturbance for auto recovery and regeneration are the most effective effort although they are not adopted so far in Terai areas of Nepal.

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**BHUTAN**

## Fire Situation in Bhutan

## 1. Description of the fire environment, fire regimes, ecological role of fire

Bhutan occupies about 38,394 square kilometres, and is located in the eastern Himalayan region. Bhutan's forests cover 72.5 percent of the total area of the country; the long term goals of Bhutan is to maintain 60 percent of the land under forest for all time to come. However, wildfires are a consistent threat to this objective, forest fire issues have been extensively discussed in various sessions of the National Assembly since the 1960s. The rugged topographic conditions combined with high ground fuel loads and erratic wind conditions, and constrained by lack of trained manpower increases risk of fire incidents. In a span of 13 years from 1993-2005, 868 cases of wildfires have affected 128,368 ha of pristine forest area.

Forests play a vital role in sustaining rural livelihoods and food subsistence, both of which are major source of income for the people and the most important natural wealth of the country. Further, forests in Bhutan are vital for maintaining the sustainability of hydropower industry, which is at present the main source of national revenue and also maintains the geologically fragile mountain ecosystem. There is high national concern on forest protection, conservation and its management by reducing forest fires and improving methods of fire prevention and suppression.

Bhutan places high priority on forest fire prevention programs since most of the forest fires are anthropogenic in nature. The people have rights on harvesting lemon grass (*Cymbopogon flexuosus*) for lemon oil extraction and grazing rights within Government Reserved Forests. Therefore, there exists widespread practice of burning forested areas to promote new grass growth for oil and also as cattle feed. Fires result from such practices including burning of agriculture debris, the timing of which unfortunately coincides with the fire season. Evidence from incidence records show that one of the main causes of fires is escapes from agricultural debris burning. Setting forests on fire, accidentally or as an act of arson is against the law in Bhutan and hence carries severe penalties.

### 1.1. Summary tables of natural and human influenced fire regimes

**Table 1.** Extent of natural and human-influenced fire regimes in different ecosystem types in Bhutan.

| Ecosystem Type | Name / Designation[1] | Total Area of Ecosystem in the Country | Ecosystem Sensitivity[2] | Typical Fire Frequency (yrs) [3] | Fire Origin / Cause |
|---|---|---|---|---|---|
| **Wildfires (including wildfires burning within prescription)** | | | | | |
| ***Forest*** | | | | | |
| **Forest 1:** Not intensively managed and protected. | Coniferous<br>Broadleaved | 1,061,621 ha<br>1,510,661 ha | FS<br>Fire no risk | 1<br>0 | Human-caused |
| **Forest 2:** Intensively managed and / or protected (major ecological or economic assets at risk) | Chir pine (in the east)<br>Plantation | -<br>6427 ha | FT | 1 | Human-caused |
| **Prescribed Burning** | | | | | |
| ***Forestry, Conservation*** | | | | | |
| **Ecosystem Type: Chir pine forest (managed and protected) research trial** | Chir pine | 5.76 (ha) | FS-FT | 2 | Research Trial |

[1] Designation of plant association / ecosystem

[2] Note: **FS** (fire sensitive ecosystem: fire has a detrimental effect on these ecosystems in terms of ecological and/or economic damage), **FT** (fire tolerant ecosystem: fires have a minor impact on these ecosystems in terms of ecological and/or economic aspects)

**Table 2.** Distribution of natural and human-influenced fires in Bhutan throughout the year.

| Ecosystem Type | Wildfire Occurrence / Use of prescribed burning by Month and Percentage | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D |
| **Wildfires (including wildfires burning within prescription)** | | | | | | | | | | | | |
| ***Forest*** | | | | | | | | | | | | |
| **Forest 1:** Not intensively managed and protected | | | | | | | | | | | | |
| **Forest 2:** Intensively managed and / or protected (major ecological or economic assets at risk) | | | | | | | | | | | | |
| ***Other Wooded Land*** | | | | | | | | | | | | |
| **Wooded Lands / Shrubland / Savanna 1:** Not intensively managed and protected | | | | | | | | | | | | |
| **Wooded Lands / Shrubland / Savanna 2:** Intensively managed and / or protected (major ecological or economic assets at risk) | | | | | | | | | | | | |
| ***Other Land*** | | | | | | | | | | | | |
| **Open Steppe / Grassland / Pastures** (not included in Wooded Lands / Shrubland / Savanna) Both intensively and not intensively managed | | | | | | | | | | | | |
| ***Peat / Swamp / Wetland*** | | | | | | | | | | | | |
| **Indicate biome type** (e.g. peat-swamp forest, moorland, marsh) | | | | | | | | | | | | |
| **Prescribed Burning** | | | | | | | | | | | | |
| ***Forestry, Conservation*** | | | | | | | | | | | | |
| **Indicate Ecosystem Type: In research area** | | | | | | | | | | | | |
| ***Agricultural / Pastoral*** | | | | | | | | | | | | |
| **Agricultural lands / Pastures** (straw burning, e.g. corn, wheat, rice paddies, sugar cane; slash and burn systems; pasture maintenance burning) | | | | | | | | | | | | |

## 1.2 Narrative of influences on the fire regimes of the country

### Damage assessment

Bhutan is recognized as one of the 10th global biodiversity hotspots. Our forest is home to about 7000 vascular plants, 165 mammals and 770 bird species, which include two critical and eight endangered faunal species (Forestry in Bhutan Facts and Figures, 2002). Uncontrolled forest fire directly impacts the environment; damages resources, damage wildlife habitat and population, and more importantly damage property and threaten lives. Further, environmental characteristics have a major influence on the distribution of wildlife species; thus, any changes in the composition or structure of the vegetation will definitely change in the animal population and may result in the extinction of the species. It also affects the physical and chemical characteristics of soil affecting the growth rate of the ground flora and soil organisms due to intense heat released by fires. The release and leaching of soil chemicals will result in loss of soil nutrient and can be one of the factors leading to the problem of soil erosion and land slide which is very common in eastern Bhutan.

The field staffs carry out assessment on fire burnt area. They are provided with designed format for reporting which includes:

- **Description of forest type**, **area burnt** (plantation and government reserved forest and others)
- **Causes** (natural or human)
- **Crop damage** (trees, poles, small poles, saplings etc.) according to size / diameter class.

This information is further used to determine future course of action and rehabilitation of burnt areas.

### Human activities impacting fire-sensitive ecosystems

In Bhutan, the fire season usually coincides with the dry winter, which extends from November to May. Through our field report analysis and field observation there are various forest fire causes mainly human activities: burning agriculture debris, children playing with match sticks, cow herders, lemon grass harvesters, development activities such as road workers, electricity transmission lines short circuit. The above causes are most common human activities, which has impact on fire sensitive ecosystem. The impact of fires on ecosystem in Bhutan is generally perceived as negative as discussed earlier.

### Fire causes

The occurrence of wildfires has always been a persistent threat to sustainable management of forests in Bhutan. Its severity and impacts have won the attention and concern of all the individuals from different walks of life and accordingly, strategies for effective fire prevention and suppression programmes have been intensified. Since 1990s with existing data it's been observed that the fire incidences are decreasing. This is due to innovation of modern facilities in the rural communities such as education, television, clearer radio facilities where the department can timely announce and advertise providing prevention program (awareness).

**Figure 1.** Blue Pine (*Pinus wallichiana*) forests are highly susceptible to fire.

**Figure 2.** Fire scars in old Blue Pine stands reveal a long history of fire – and the tolerance of mature trees in these pine stands to surface fires of low intensity.

**Table 3.** Causes of wildfires in Bhutan.

| | **Causes** | **Percent %** |
|---|---|---|
| 1 | Intentional burning for new grass for cattle | 60 |
| 2 | Agriculture debris burning | |
| 3 | Lemon grass harvesters | |
| 4 | Smokers | 20 |
| 5 | Children playing with ignition source | |
| 6 | Road side workers | |
| 7 | Picnickers | |
| 8 | Camp fires | |
| 9 | Accidental cases | 15 |
| 10 | Unknown reasons | 5 |

**Fire season**

Forest fires usually occurs when the vegetation is dry and ground fuels are abundant during the winter months, it also (fire season) differs based on geographical locations such as tropical, sub-tropical, temperate and climatic conditions like length of dry season and frequency of rainfall. In the eastern Bhutan the fire season is between January and June. In the West the fire season is between November and May.

## 2. Fire statistical database: Wildfire and prescribed burning statistics for the period of 1988-2004

**Table 4.** Wildfire database 1988-2004. Data of the two 5-yr periods 1988-92 and 1998-2002 are highlighted because these periods are of key interest for FRA-2005 (Source: Forest Fire Management Section, SFD, 2004).

| **Year** | **Total Number of Fires on Forest, Other Wooded Land, & Other Land** | **Area of Forest Burned (ha)** |
|---|---|---|
| **1988** | **46** | **NA** |
| **1989** | **66** | **NA** |
| **1990** | **50** | **NA** |
| **1991** | **38** | **NA** |
| **1992** | **38** | **NA** |
| 1993 | **84** | **72957.44** |
| 1994 | **36** | **5601.96** |
| 1995 | **56** | **49069.31** |
| 1996 | **62** | **27030.26** |
| 1997 | **48** | **24633.30** |
| **1998** | **72** | **16218.20** |
| **1999** | **112** | **33839.88** |
| **2000** | **104** | **33638.34** |
| **2001** | **81** | **23314.20** |
| **2002** | **64** | **14644.16** |
| 2003 | **45** | **5723.49** |
| 2004 | **39** | **2561.36** |

## 3. Narrative summary of major wildfire impacts on people, property, and natural resources between 1988 and 2004

According to forest fire record of the past (1988-2004), 1993 has the major damage on forest resources. It has been observed that there was no damage on property/infrastructure. However, the forest fire recorded in Trashigang District (eastern district) in 2006 was a major one, which burnt about 1000 ha of forests; similarly in 2006-2007 record of forest fire Wangdue district (one of the western district) has burnt about 15,000 ha by a single case. In the year 2007 major forest fire outbreak occurred along the Tsirang-Wangdue National Highway damaging 5000 ha of Chir pine (*Pinus roxburghii*) forest and other vegetation. It was reported that as a consequence of these fires the road was blocked due to landslides and falling stones.

## 4. Application of prescribed burning in the region to achieve management objectives (purposes, extent, results)

Prescribed burning trials were carried out in the year 2005 in the eastern Bhutan. The objectives of the study are to explore the effects of fire in Chir pine forest ecosystems with special reference to regeneration ecology of Chir pine, the fire induced yield of lemon grass and other competing ground vegetation, and economics benefits/drawbacks resulting from forest fires in connection with lemon grass harvesting for the local population.

## 5. Operational fire management system(s) and organization(s) present in the country or region

To prevent forest fire and support sustainable management of the country's forest, different level of organisation has their area of responsibility as follows:

Government agencies (national level) are involved in designing and implementing a nationally coordinated forest fire awareness programme and enhancing people's awareness about forest fire. Develop training modules and technical manuals to backstop the district (dzongkhag) forestry sectors. Further, liaising with the media in informing and educating the public about forest fire prevention; training the field staff and community in fire prevention and suppression. Currently the program is delegating forest fire management to grassroots level through formation of village level fire management groups.

At District level community education is addressing basics in forest fire prevention and suppression. The District is responsible for coordination of firefighting. Members of local communities, businesses, students, and private organisation actively participate in forest fire suppression.

**Table 5.** Responsibilities of different stakeholders in fire management at various levels in Bhutan. Acronyms used: FP - fire prevention, FS - fire suppression, Edu – education.

| | Government Organisations / Agencies | Non-Government Organisations | Private Sector | Local Communities | Academia | Other |
|---|---|---|---|---|---|---|
| National | FP, FS, Edu | FS | FS | FS | | |
| Provincial | FP, FS | FS | FS | FS | | |
| Municipal | FS | | | | | |
| Local | FS | | | | | |
| Other | | | | | | |

**Fire management organization**

During fire incidents or in large fire situations the Department of Forests plays the lead role and arrange and coordinate the suppression activities. A large part of the manpower includes volunteers from the armed forces; Royal Bhutan Army, Royal Bhutan Police, Royal Body Guards and near by communities.

All fire incidences should be reported to Social Forestry Division (National level coordination office) of the Department of Forests, through District Forest Office or the Divisional Forest Office. In line with the decentralised forestry policy, the District Forest officers have the lead role in forest fire management at local level in close collaboration with local communities.

## 6. Sustainable land-use practices employed in the country aimed at reducing wildfire hazards and wildfire risks

The use of fire as an agriculture tool such as burning debris/slash and burn in the agriculture field adjacent to forest is a common practise every year. However, this practise has been a major cause of forest fire (unintentional escape). Establishment of Community Forest will help in reducing such cases of forest fire. Further, in Plantation forest the Department has budget provision for creating fire line or firebreak around the planted areas. More over, the Forest Fire Management Section under the Social Forestry Division is in the process for pilot scale institutionalization of village level forest fire management group aimed at forest fire prevention and suppression.

## 7. Fire management / suppression technologies, training standards and facilities

In Bhutan each district has a Divisional Forest Office and District Forest Office. They are responsible for forest fire monitoring (ground) during the fire season. In some communities fire watchers (Meesup) are appointed by the villages.

The Forest Fire Management Section under the Social Forestry Division procures and distributes the equipment, e.g. walkie-talkie handsets, knifes spades, rakes and backpack pumps for fighting fire. However, most of the Bhutanese villagers/forester uses branches to put of the fire due to limited numbers of fire fighting equipment. Walkie-talkie handsets are procured and distributed to fire prone areas (only to forestry personnel).

### National wildland fire management planning

Forest fire prevention has become challenging and important program in Bhutan. For smooth implementation of fire management plan in order to combat forest fire effectively the Forest fire protection and management were decentralized at the district level including as one of the decentralized forestry activities. Further, the Department has developed the by laws and proposal for institutionalization of village level forest fire management group to motivate and accommodate stakeholders interest and also to entrust role and responsibilities in managing forest fires. Despite such arrangement, the nature and fire frequency has not reduced with time. This is mainly due to limited budget to strengthen the human resources capacity to coordinate, disseminate forest fire awareness program and supply of fire fighting equipment at the field level.

### Wildland fire management training

Until 2002 forest fire management has not received much attention because of lack of a coordinating office. With the establishment of Forest Fire Management Section with the Social Forestry Division, forest fire training has been imparted to District Forest Officers and lecturers at the College of Natural Resources (NRTI) (15 days) thereafter. A regular training curriculum for the Diploma programme (NRTI) has been established. Subsequently, a forest fire training manual on Basic Fire Fighting (BFF), Advance Fire Fighting (AFF) and Standard Operation Procedures (SOP) has been developed with the Technical Assistant from New South Wales; Rural Fire Service, Australia with financial support from Bhutan Trust Fund for Environmental Conservation (BTFEC). The manual is been used by various agencies to train the forestry staff and community. The Forest Fire Management under the Social Forestry has been training the field staff, District Forest Officers and representative from the communities every year for 10 days. Similarly, the Social Forestry Division and District Forest Officers are also training local communities in fire-prone areas every year before the on set of fire season.

**Figure 3.** Steep terrain conditions poses high risk to firefighters and volunteers without adequate safety equipment

**Figure 4.** Army and local volunteers fighting fire with brushes and home implements.

## 8. Public policies concerning fire

Forest fire management has been a national concern. It has been debated over the National Assembly and it has been incorporated in the Forest and Nature Conservation Rules of Bhutan. In case of fire occurrence, it is a sacred responsibility of every citizen of Bhutan to extinguish fires. Deliberate setting of fire in national forests is a punishable offence. However, if no culprit is apprehended, then nearby local community has to rehabilitate the burnt area.

## 9. Wildland Fire Research

The Social Forestry Division of the Department of Forests, Ministry of Agriculture, is conducting some pilot research projects in which the application of prescribed burn is tested, particularly research on effects of fire in Chir pine forest ecosystems with special reference to regeneration ecology of Chir pine and other competing ground vegetation like lemon grass and fodder grass in pasture areas. The fire research on fire effects on Chir pine forest with lemon grass in the Eastern District in two different areas has been taken up by the Social Forestry Division, Dzongkhag Forestry Sector and RNR-RC (Research Centre) Jakar and Wengkhar with financial support from the BTFEC.

## 10. Gaps and deficits to be addressed

The management of forest fire in the country has become an important and challenging program. In order to combat forest fires effectively and enhance smooth implementation of fire related activities or research, there is need to get exposure to current fire management techniques and fire science being used both at national and international levels. Therefore, enhancing human resources development by capacity building will be the biggest asset for effective forest fire management in long run in the country.

The funding availability and the capability and capacity to carry out research, planning and implementation of wildfire management programs and the appropriate fire suppression equipment are lacking. There is minimal fire line organization and acute shortage of fire fighting equipment, which exacerbates risk to safety of people on the fire line.

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## THAILAND

# Effects of Forest Fire Protection on Plant Diversity in a Tropical Deciduous Dipterocarp - Oak Forest, Thailand


### Abstract

A two-hectare plot of a deciduous dipterocarp-oak forest of Doi Suthep-Pui National park of northern Thailand protected against fire for 28 years was compared with a similar, but frequently burnt forest nearby with respect to changes in plant diversity. The objective of the study was to find out the effects of forest fire protection on plant diversity. To survey the tree communities, six meter wide transects with a total length of 650m in each site were laid out across the slope of the mountain following a bearing of $60^0$. To survey the ground flora, quadrates of 2×2 $m^2$ area were placed in each site covering 2.3% of the total transect area. The importance value percentage (IP) of trees > 10 cm DBH, species composition and diversity for both tree and ground flora communities were calculated. The species richness of both the ground flora and tree species was higher in the protected areas. The occurrence of evergreen or tropophyllous trees was greater in the protected area than in the burnt area.


### 1. Introduction

Thailand has suffered a rapid decline in forest cover over the past three decades, loosing more than one half of its forested area. With a total forest cover of 60% in 1953, Thailand has only about 25% now (Poffenberger and McGean 1993, Kafle 2005). Recent satellite images indicate much less than this (SPOT, Landsat and ERS). This rampant destruction of forest cover in the past was due to logging concessions, encroachment and development of infrastructure such as roads, hydropower plants and mining. Nevertheless, the practices of shifting cultivation and intentional forest fires are still common in northern Thailand where forest are estimated to cover more than 40% of the land area.

Forest fire has increasingly become a frequent and problematic phenomenon in Thailand. Fires have a major impact on National Parks in particular where protection of the flora and fauna and their habitats is the primary aim. Since plant variety and abundance, flowering, fruiting, and leafing phenologies of trees and soil nutrients status are essential features for ecological niches of wild animals, studies on impacts of forest fire on these factors are essential to properly manage the bio-diversity in such areas.

### 2. Hypothesis and Objective

This study examined the following hypotheses:

- Prolonged protection of a forest from fire changes the species composition of the ground flora to be more characteristic of a mixed deciduous forest.
- There will be less disturbance effects after protection from fire, therefore, there will be higher plant diversity in protected areas.

Figure 1 shows the hypothesized mechanisms of the effects of fire protection in a deciduous dipterocarp-oak forest.

The overall objective of the research was to determine the effects of forest fire protection on plant diversity.

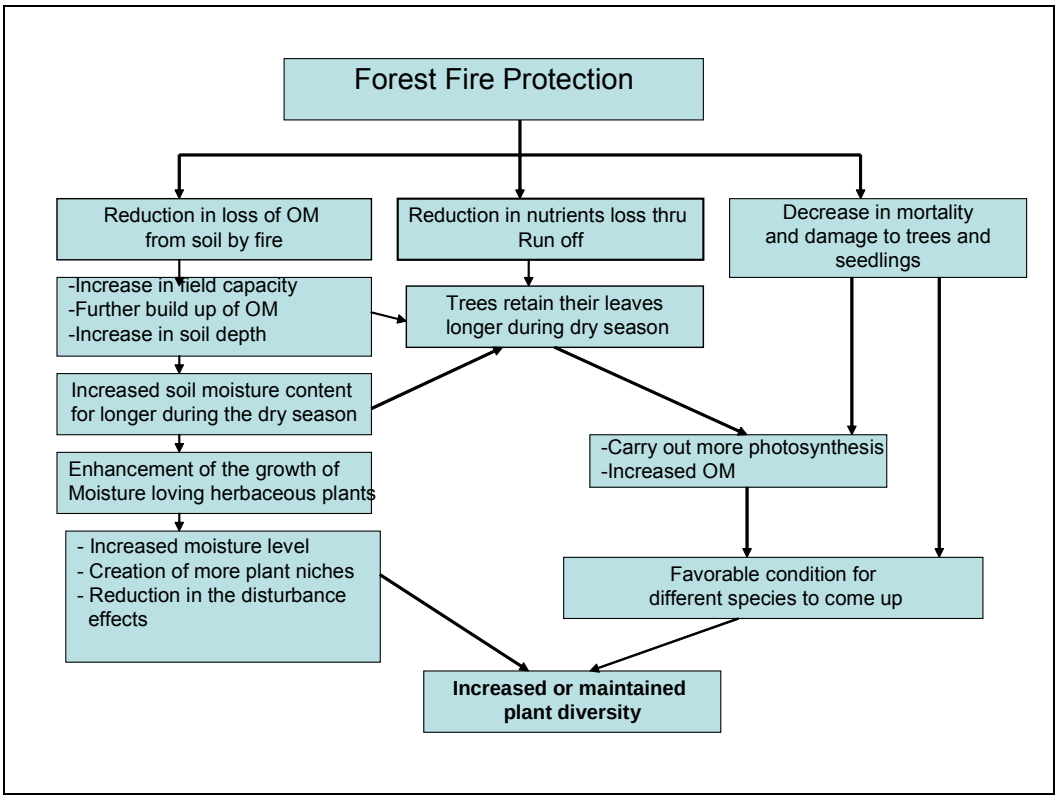


**Figure 1.** A hypothesized mechanism of the effects of fire protection in a deciduous dipterocarp-oak forest.

## 3. Methodology

### Study area

This study was carried out in deciduous dipterocarp-oak forest (DOF) in Doi Suthep-Pui National park in northern Thailand. The area lies a few kilometres west of Chiang Mai City at approximately $18^0$ 50' N latitude and 98°50' E longitude. The forest was designated as a National Park in 1981 and covers an area of 261km$^2$. The DOF is situated from the eastern base at 350 m to 950m elevation whereas the highest point of the park Doi Pui, is at an elevation of 1685 m.

Two sites were selected, one protected against fire for 28 years and the other left unprotected. When selecting the burnt are, besides similar vegetation composition and soil type, much attention was given to other site factors such as aspect, distance from water sources, rocks and elevation. Prior to the final selection, possible sites nearby were reconnoitred and site factors closely examined. GPS was used to locate the exact position of the site. In the protected area three-meter-wide firebreaks had been maintained to prevent fire spreading into the area. The elevations of both sites range from 500 to 650m. The bedrock is granite (Maxwell 1988). In most of the places, soils are shallow, highly weathered, and exposed to soil erosion.

### Sampling

Six meter wide transects were laid out across the slope of the mountain, following a bearing of $60^o$. There were 4 transects in the protected area (PA) and 5 in the burnt area (BA) laid out with varying length. However, the total length of transects in each area was 650m covering 5% of the total area.

### Data collection and Analysis

All trees greater than 10cm diameter at breast height (DBH) were labelled and identified. Similarly, ground flora community was monitored using percent cover of each species with the help of the Domin Scale (Table 1). The area over shadowed by tree seedlings and saplings was also recorded. The

ground flora community was surveyed at the beginning of rainy season (June), during the rainy season (September) and at the end of rainy season (November).

**Table 1.** Domin scale

| Category | Score |
|---|---|
| + | Single individual |
| 1 | 1-2 individual |
| 2 | <1 % cover |
| 3 | 1-4% cover |
| 4 | 5-10% cover |
| 5 | 11-25% cover |
| 6 | 26-33% cover |
| 7 | 34-50% cover |
| 8 | 51-75 cover |
| 9 | >75%< 100% cover |
| 10 | 100% complete cover |

Most of the vegetation data were analyzed statistically using ECOSTAT and SPSS computer programs.

## 4. Results

### Species Composition and Diversity

A total of 130 plant species, with 29 trees and 101 ground flora species, was recorded from the sampled area (Table 2). The protected area supported a richer ground flora community than the burnt area although the species richness of tree community was very similar in both areas. The PA also contained slightly more unique species, found only there, than the burnt area. *Dipterocarpus obtusifolius* var. *obtusifolius* was the most abundant species followed by *Shorea siamensis* var. s*iamensis* in both sites. Two deciduous trees namely *Dipterocarpus tuberculatus* var. *tuberculatus* and *Tristaniopsis burmanica* var. *rufescens* had a greater occurrence in the BA compared to PA, even though their percentage contribution was comparatively low. In the PA, *Lithocarpus elegans, Lithocarpus sootepensis, Buchanania lanzan and Quercus kerrii* var. *Kerrii* were more abundant.

**Table 2.** Species composition in the sampled area.[1]

| Composition | Number of species [2] | | | | |
|---|---|---|---|---|---|
| | **Total** | **PA** | **BA** | **% (PA)** | **% (BA)** |
| Tree spp. (>10cm dbh) | 29 | 22 (8) | 21 (7) | 76 | 72 |
| woody climbers | 3 | 3 (2) | 1 (0) | 100 | 33.3 |
| Shrubs | 14 | 10 (3) | 11 (4) | 71 | 79 |
| Vines | 10 | 9 (2) | 8 (1) | 90 | 80 |
| Herbs | 74 | 52 (27) | 47 (22) | 70 | 64 |
| Total | 131 | 96 (42) | 88 (34) | 74 | 68 |

1.The number of tree species is based on transect survey whereas ground flora is based on the quadrate made along transects.
2.Figures in parentheses indicate the number of species only found in that site.

Dipterocarpaceae was the dominant family of trees (Table 3). The percentage composition of individuals of this family was higher in the burnt area (63.58 %) than in protected area (56.8 %).

**Table 3.** Composition of major tree species >10 cm dbh in the burnt and protected areas.

| Species | Number of individuals[1] | |
|---|---|---|
| | **Protected site** | **Burnt site** |
| *Diptercocarpus obtusifolius* var. *obtusifolius* | 100 (37.45%) | 58( 35.80%) |
| *Shorea Siamensis* | 30 (11.24%) | 22 (13.58%) |
| *Buchanania lanzan* | 27 (10.11%) | 9 (5.56%) |
| *Shorea obtusa* | 22 (8.24%) | 15 (9.26%) |
| *Quercus kerrii* var. *kerrii* | 26 (9.74%) | 15 (9.26%) |
| *Lithocarpus sootepensis* | 15 (5.62%) | 4 (2.47%) |
| *Lithocarpus elegans* | 10 (3.75%) | 3 (1.85%) |
| *Craibiodendron stellatum* | 9 (3.37%) | 5 (3.09%) |
| *Tristaniopsis burmanica* var. *rufescens* | 2 (0.75%) | 8 (4.94%) |
| *Dipterocarpus tuberculatus* var. *tuberculatus* | 0 (0.00%) | 8 (4.94%) |
| Miscellaneous | 26 (9.74%) | 15 (9.26%) |
| Total | 267 (100.0%) | 162 (100.0%) |

[1]Percentage figures in parentheses indicate relative dominance of the species.

**Basal Area, Tree Density and Community Dominance**

Basal area and tree density (p>10 cm DBH) were both higher in the PA than in the BA (Table 4). However, average basal area of trees in aggregate was similar in both sites. McNaughton's community dominance index (CD) was practically the same in both sites. This indicates the higher relative dominance values of two most dominant species.

**Table 4.** Percentage and total basal area, tree density and community dominance of protected and burnt sites.

| Community statistics | Unit | Sites | |
|---|---|---|---|
| | | PA | BA |
| Basal Area $ha^{-1}$ | $m^2$ | 22.67 | 13.95 |
| Tree Density (>10 cm dbh) | no/ha | 685 | 415 |
| Community Dominance | % | 48.7 | 49.4 |

**Importance Value of Major Tree Species**

More than 50 % of the importance percentage, calculated from relative basal area (RBA), relative frequency (RF) and relative density (RD), was contributed by Dipterocarpaceae in both sites (Table 5).

**Table 5.** Importance value (iv) of major tree species in the PA and BA

| Species | Protected Area | | | | | Burnt Area | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RBA | RF | RD | IV | IP | RBA | RF | RD | IV | IP |
| *Dipterocarpus obtusifolius* | 0.48 | 0.07 | 0.37 | 0.92 | 30.7 | 0.47 | .09 | .36 | .92 | 30.7 |
| *Shorea siamensis* | 0.19 | 0.07 | 0.11 | 0.37 | 12.3 | 0.16 | .09 | .14 | .39 | 13 |
| *Buchanania lanzan* | 0.06 | 0.07 | 0.10 | 0.23 | 7.7 | 0.03 | .07 | .06 | .16 | 5.3 |
| *Quercus kerrii* | 0.08 | 0.07 | 0.10 | 0.25 | 8.3 | 0.08 | .07 | .09 | .24 | 8.0 |
| *Shorea obtusa* | 0.08 | 0.07 | 0.08 | 0.23 | 7.7 | 0.07 | .07 | .09 | .23 | 7.7 |
| *Lithocarpus sootepensis* | 0.03 | 0.07 | 0.05 | 0.16 | 5.3 | 0.01 | .07 | .03 | .11 | 3.7 |
| *Lithocarpus elegans* | 0.02 | 0.07 | 0.04 | 0.13 | 4.3 | 0.04 | .06 | .02 | .12 | 4.0 |
| *Craibiodendron stellatum* | 0.02 | 0.07 | 0.03 | 0.12 | 4.0 | 0.01 | .07 | .03 | .11 | 3.7 |
| *Tristaniopsis burmanica* | 0.034 | 0.04 | 0.01 | 0.05 | 1.7 | 0.02 | .06 | .05 | .13 | 4.3 |
| *Dipterocarpus tuberculatus* | 0 | 0 | 0 | 0 | 0 | 0.04 | .06 | .05 | .15 | 5.0 |

(RBA = relative basal area; RF = relative frequency; RD = relative density; IV =importance value; IP = importance percentage).

**Species Richness Diversity, and Evenness**

Computed values of different community statistics are given in Table 6. The results failed to show a clear distinction between the protected and burnt sites. In PA irrespective of high species abundance and richness, the diversity indices (H') was slightly lower than in BA. However, the values were not statistically different. Also, individuals were more evenly distributed in the burnt area.

**Table 6.** Species richness, species diversity and evenness indices of trees in the burnt and protected areas.

| Community statistics | | Protected Area | Burnt Area |
|---|---|---|---|
| Species richness | No | 22 | 21 |
| Diversity | $\lambda$<br>H'<br>N1<br>N2 | 0.18<br>2.18a<br>8.81<br>5.46 | 0.17<br>2.24a<br>9.43<br>5.90 |
| Evenness | E5 | 0.57 | 0.58 |

[a] Values of diversity indices of two sites are not statistically different (T-test).

***Size class distribution***

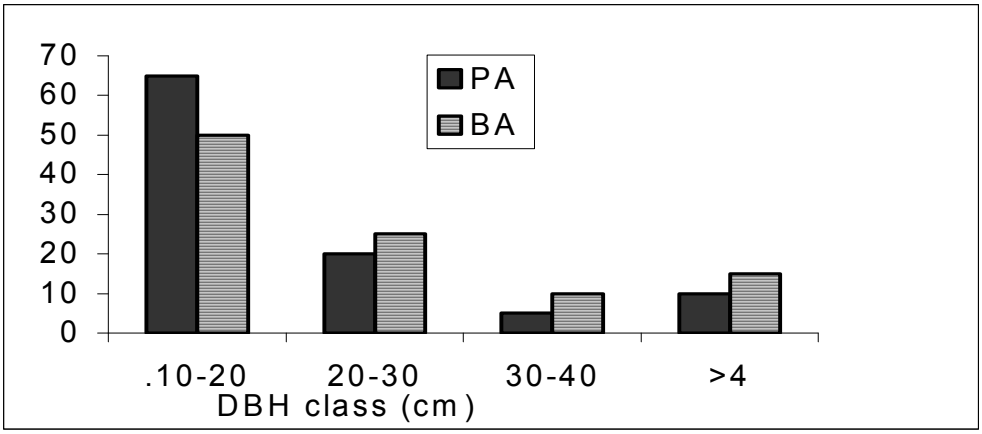


**Figure 2.** Size class distribution of trees >10 cm category

Figure 2 shows a larger amount of regeneration in the PA than in the BA. Around 73% of the tree individuals found in the PA were 10-20 cm DBH. It further reveals that very young trees were quite abundant in this site. In the BA, however, only 64% of individuals were in this category. There was no marked difference in the distribution of tree individuals in other categories.

**Ground flora diversity**

Regardless of the significantly lower percentage cover, based on the total Domin score (t-test, p>0.05), the protected area supported a greater number of ground flora species (Table 7). However, the burnt area contained higher species diversity and evenness indices than the protected area. Nevertheless, the species diversity index was not significantly different (t-test, p>0.05)

**Table 7.** Ground flora diversity, richness and evenness in the protected and burnt areas:

| Community statistics | | Protected area | Burnt area |
|---|---|---|---|
| Species richness | No | 74 | 67 |
| | R1 | 12.49 | 10.298 |
| | R2 | 3.98 | 2.91 |
| Diversity | □ | 0.812 | 0.553 |
| | H' | 3.401a | 3.477a |
| | N1 | 30.207 | 32.37 |
| | N2 | 12.316 | 18.080 |
| Evenness | E5 | 0.387 | 0.544 |
| Total Domin Score | TDS | 349.5 | 505.0 |

T-test (p>0.05)

**Frequency and Abundance Score**

In both sites, very few species were dominant in terms of their frequency and abundance scores. *Themeda triandra* Forssk. (Gramineae) was the most frequent and highly abundant in both sites followed by *Globba schomburgkii* Hk.f. (Zingiberaceae) in the BA and *Scleria lithosperma var. lithosperma* (Cyperaceae) in the PA. The most frequent and highly abundant species in both sites are given in Table 8.

**Table 8.** Ground flora species with high abundance and frequency scores in the study areas.

| Species | Av. Domin score[1] | | % Frequency | |
|---|---|---|---|---|
| | PA | BA | PA | BA |
| *Themeda triandra* | 83 | 72 | 81 | 86 |
| *Uraria lacei* | - | 15 | - | 20 |
| *Scleria lithosperm* var. *lithosperma* | 14 | 18 | 33 | 48 |
| *Scleria levis* | - | 19 | - | 43 |
| *Abrus precatorius* | 10 | 10 | 52 | 43 |
| *Globba schombergkii* | - | 32 | - | 52 |
| *Globba reflexa* | 8 | 12 | 24 | 33 |
| *Dunbaria longeracemosa* | - | 22 | - | 57 |
| *Aristolochia kerrii* | 7 | - | 33 | - |
| *Curcuma zedoaria* | - | 18 | - | 52 |
| *Lygodium flexuosum* | 9 | - | 29 | - |
| *Scutellaria glanduolosa* | 10 | - | 48 | - |
| *Murdania loureirii* | 8 | - | 24 | - |
| *Desmodium laxiflorum* ssp. *Laxiflorum* | 8 | - | 29 | - |

[1] Average of Total Domin Score of July, September and November. The blank (-) does not mean that the species is absent in the site. It indicates the species does not fall within the nine maximum abundant species.

## 5. Discussion

The greater tree population density in the protected area was a direct consequence of fire protection. The protected area contained 25% more individual trees than the burnt area. Also, it has more young trees of DBH 10-20 cm category than in the burnt area. This suggests that forest fire protection decreased the killing or damaging of trees, which ultimately leads to increased productivity and organic matter in soil, thus more favourable conditions for growing. This result also supports the findings made by Naidu and Sribasuki (1994) that young plants are more badly affected by fires than mature ones.

Another striking feature noticed during the study was that no individuals of *Dipterocarpus tuberculatus* var. *tuberculatus* greater than 10 cm DBH were found in the PA. However, a few emerging coppicing shoots were seen. This observation agrees with a statement made by Barrington (1931) in a study of forest in Burma that "… protection encourages an evergreen undergrowth which prevents the reproductions of *Dipterocarpus tuberculatus* var. *tuberculatus* and would obviously change the vegetation type to a moister type".

Fire protection seemed to have more impact on the herbaceous community than trees. Almost half of the ground flora species recorded were specific to each site. The majority of herbaceous species in the PA were typical of moist condition and some species found in the burnt area are fire resistant . *Phoenix humilis* Roy. var. *humilis (Palmae)* and *Pennisetum pedicellatum* Trin. (Gramineae) are typical examples. Although the total Domin score in the BA is much higher than in the PA, there was no significant difference in the species diversity index. This was probably due to the dominance of a few species rather than the even distribution of species. *Themeda triandra* Forssk. (Gramineae), and *Globba schomburgkii* HK. F. (Zingiberaceae) and *Scleria lithosperma* var. Lithosperma (Cyperaceae) were among the dominant ground flora species in both sites.

## 6. Conclusions and Recommendations

The greater influence of evergreen or tropophyllous trees and the presence of some shade-loving herbaceous flora in the protected area suggest that the forest environment in the protected area was favoured by plant associated with a mixed evergreen and deciduous forest. However, no distinct differentiation was observed. Hence, the hypothesis that prolonged protection of forest from fire

changes the species composition of the plant community to be more characteristic of a mixed evergreen and deciduous forest was only partially proved. In order to know whether the presence of certain shade demanders was due to changes in the local environment or chance detailed studies in different physiographic conditions are needed.

The higher tree density and more young trees of 10-20 cm DBH category in the protected area adds supports to the idea that the fire protection decreased mortality and damage to trees which ultimately leads to more favourable conditions for different species to grow.

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## INDIA

### The Indian Forest Fire Response and Assessment System (INFFRAS)

Monitoring and management of forest fires is very important in tropical countries like India where 55 percent of the total forest cover is prone to fires annually causing adverse ecological, economic and social impacts (Gubbi, 2003). Studies on the impacts of tropical wildfires on the environment indicated high carbon emissions (Hao et al., 1996; Fearnside, 2000), emissions of large amounts of trace gases and aerosol particles (Crutzen and Andreae 1990), black carbon (Dwyer et al., 1998) release of almost 100 million tons of smoke aerosols into the atmosphere as a result of biomass burning (Hao and Liu 1994). These sub-micron smoke aerosols play a major role on the radiation balance of the earth-atmospheric system (Kaufman et al. 1998). Also, there is widespread concern about the loss of biodiversity, effects on atmospheric chemistry and increase in surface albedo and water runoff due to biomass burning. In India, about 55% of the forest area, which is predominantly covered by deciduous forests, is prone to fires every year causing loss of about rupees 440 crores (~104 million US dollars). Despite the natural fires, the major sources of forest fires in India are anthropogenic, which include shifting cultivation practices, controlled burning, deforestation, fire wood burning and others. The conventional methods of fire protection cover an elaborate network of fire lines (fire breaks), fire watch towers, block lines and manual fire control systems which at times becomes practically difficult due to lack of man-power, resource constraints and time effective control mechanisms. On the other hand, application of remotely sensed data along with Geographical Information System (GIS) is capable of addressing the problem with good scientific and technical strength in a time effective and cost effective way.

Forest fires are mostly anthropogenic in nature in India and may occur due to the following reasons (Bahuguna et al., 2002):

- Forest floor is often burnt by villagers to get a good growth of grass in the following season or for a good growth of mushrooms.
- Wild grass or undergrowth is burnt to search for animals.
- Firing by miscreants.
- Attempt to destroy stumps of illicit fallings.

The user requirements in forest fire management stands at three different levels viz. pre-fire (preparatory planning for fire control), during fire (fire detection, spread and control planning) and post-fire (damage assessment and mitigation planning). These requirements could only be met from comprehensive spatial and temporal data of different dimensions emanating from satellite and ground based sources. The role of various scientific organizations and forest departments is very critical. The intricate relationships involved in generating required databases and outputs is presented (Figure 1) in conceptual diagram of the “Forest Fire Decision Support System” (FDSS).

The pre-fire scenario needs inputs on effective preparations and planning for managing and combating the fire. This process might stands at understanding of fire proneness / vulnerability and forest fire spread potential. These two parameters together reflect in the Fire Danger Rating (FDR). The spatially explicit fire danger rating of the forests would help to prioritize the areas for detailed fire control planning. Fire proneness / vulnerability could be assessed based on long term history of fire occurrence, location characteristics in relation to vegetation cover and type, climate, topography and biotic pressure. This kind of information needs to be integrated through the databases available with different organizations. Various advanced spatial modelling and analytical tools are being analyzed to characterize spatial and temporal trends to understand local and regional level processes and develop fire proneness / vulnerability zones. In addition, the FDDS is structured to accept database flows at different spatial and time scales and process at backend to generate updated fire vulnerability zones with changing scenarios. The fire-spread simulation is one of the critical process helps to assess the magnitude and direction of the fire spread. It depends on intrinsic substrate flammability properties and extrinsic factors catalyzing the fire spread. The intrinsic substrate properties depend on vegetation type, phenological patterns, and forest desiccation and fuel stick values. Using MODIS derived surface temperature information together with fire frequency information, AWiFS derived burnt area information and vegetation type fire danger index for different forest regions of India were attempted and a case study on Nagarjuna Sagar Srisailam Tiger Reserve (NSTR) was carried out in active collaboration with forest department.

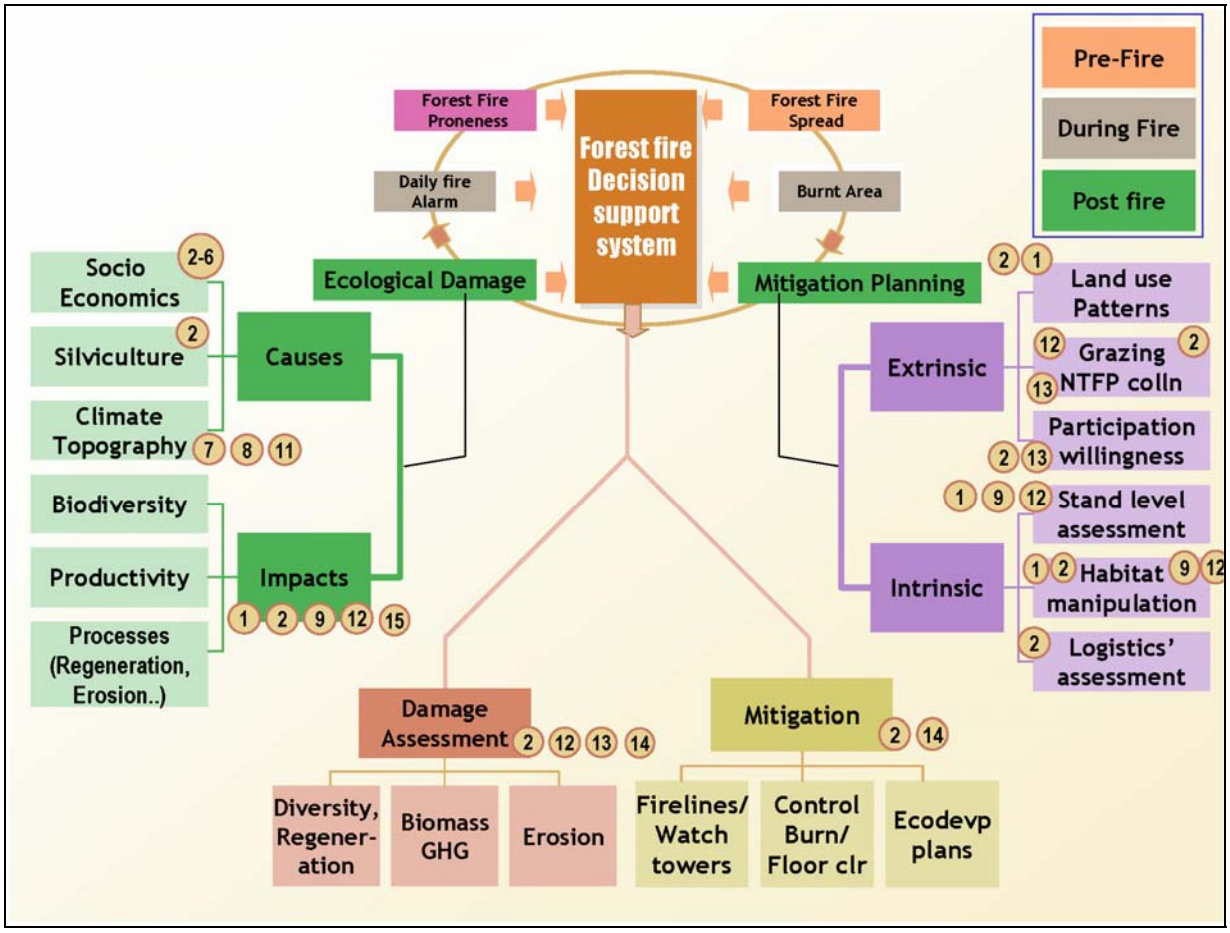


**Figure 1.** Conceptual diagram of the "Forest Fire Decision Support System" (FDSS). The institutions involved in the FDSS include:

1. Department of Space
2. State Forest Departments
3. Forest Survey of India
4. National Informatics Centre
5. Bureau of Economic and Statistics
6. State Animal Husbandry Departments
7. Indian Meteorological Department
8. Local weather Stations
9. Forest Research Institute
10. NBSSLUP
11. Survey of India
12. University Departments
13. Panchayats / Voluntary bodies / Tribal society
14. Ministry of Environment and Forests
15. Wildlife Institute of India

The information generated from multi sensor remote sensing and ground based data developed at local and regional level involving multi institutional participation will be incorporated in to the data base towards developing contours of forest ignition potential in near future. The lack of locale specific meteorological, topographic and vegetation databases limits developing fire danger rating system in the country. A concerted system involving multi institutional participation to identify existing database and protocols to collect the new databases is under way to develop fire danger ratings for Indian forests. The system upon establishment should provide the user fire prone areas, fire-spread potential in a given season on a continued basis.

Fire detection, spread and control planning are the important issues for the 'During Fire 'scenario. Considering the large extent of area of operations and huge number of fire occurrences simultaneously occurring in a day, the identification and combating becomes difficult. Conventional methods of identification of active fire locations need to be augmented with advanced technologies like satellite remote sensing. The remote sensing system should have the capability to provide 3-4 signals on a daily basis backed up with robust process algorithms, data dissemination and reception systems. This would form one of the core segments of FDDS enabling user to interact and receive the data on a daily basis for fire information. However the appropriate development of user segment to receive and utilize the data on real time basis and providing feedback forms the complete chain of events in fire monitoring. Considering the above-mentioned needs, the Indian Forest Fire Response and Assessment System (INFFRAS) is established with a scope to integrate process and disseminate various types of data bases related to pre fire, during fire and post fire scenarios. Currently the INFFRAS addresses a few issues related to fire management and has plans to augment different modules of FDSS. The current structure of INFFRAS as available on the NRSA Home Page (www.nrsa.gov.in) is shown in Figure 2. Users need to query using the appropriate query option. The site is mainly about the information on satellite-based services for forest fire detection, assessment and mitigation. The fire image generated from MODIS and DMSP-OLS sensors over Indian region are provided in the form of JPGs and PDF file on website and typical example is given in Figures 3a and 3b (Kiran Chand et al., 2006).


**Figure 2.** The structure of the Indian Forest Fire Response and Assessment System (INFFRAS) is available on the NRSA Home Page (www.nrsa.gov.in)

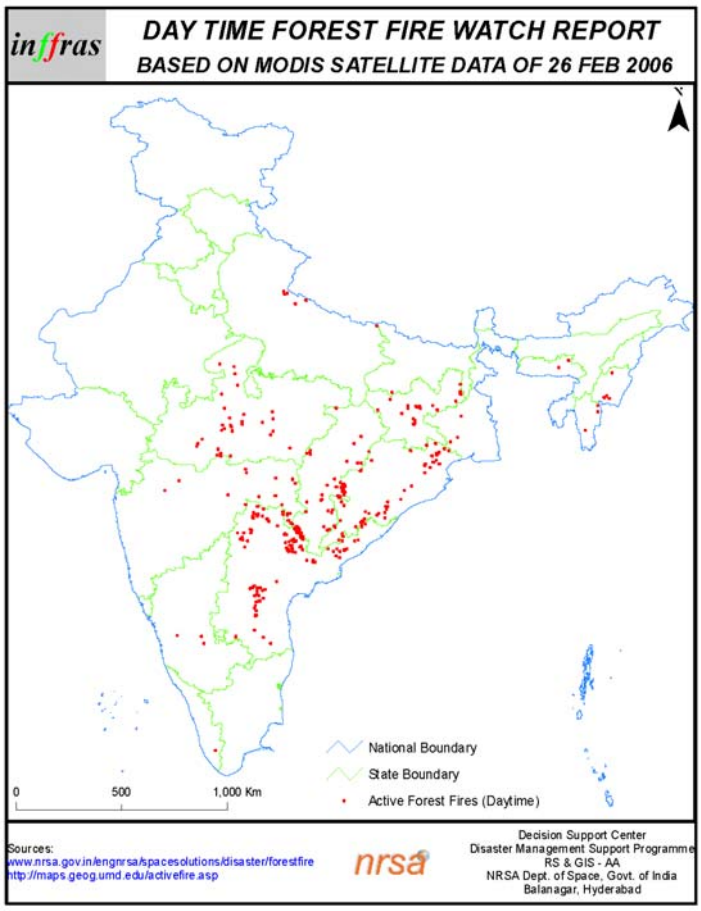


**Figure 3a.** Map showing active fires during daytime are generated by the MODIS sensor over the Indian region are provided in the form of JPGs and PDF files on the website. The typical example is dated 26 February 2006.

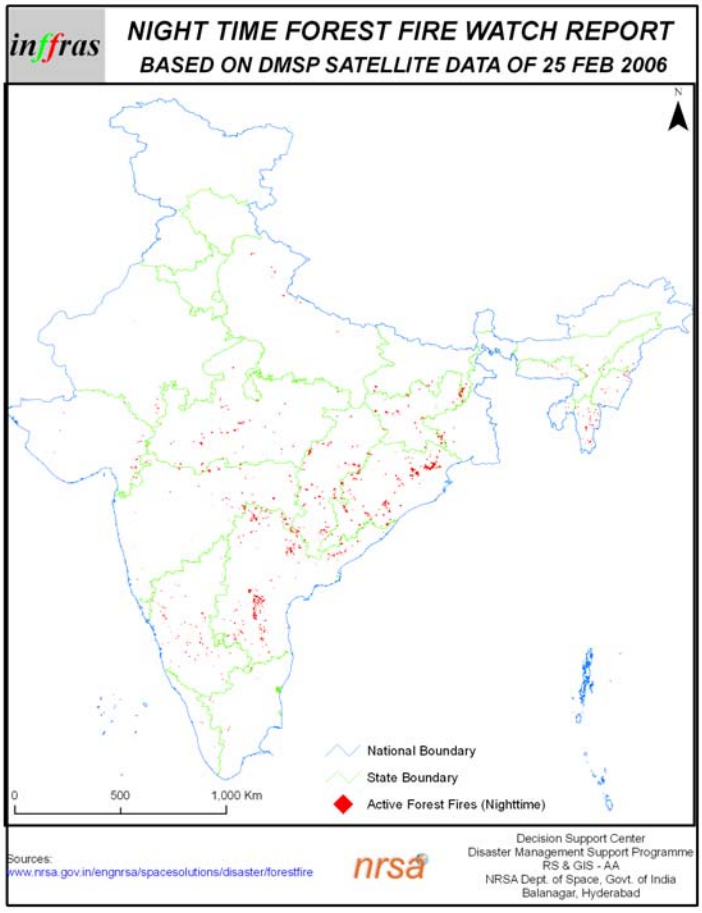


**Figure 3b.** Map showing active fires during nighttime are generated by the DMSP-OLS sensor over the Indian region are provided in the form of JPGs and PDF files on the website. The example is dated 25 February 2006.

The burnt area information in terms of area and maps will be useful and are the most required database to forest managers and scientific community at different levels. The FDDS provides burnt area assessment on an annual and inter-annual basis to enable primary damage assessment. Studies were carried out using Indian Remote Sensing Satellite (IRS) AWiFS data for assessing burnt area over different forest regions of India. Multi-resolution data sets from Indian Remote Sensing Satellite (IRS) series provide repeated observations over large forest regions and an example of near-real time damage assessment in and around Bhandavgarh National Park, Madhya Pradesh is shown in Figure.4.

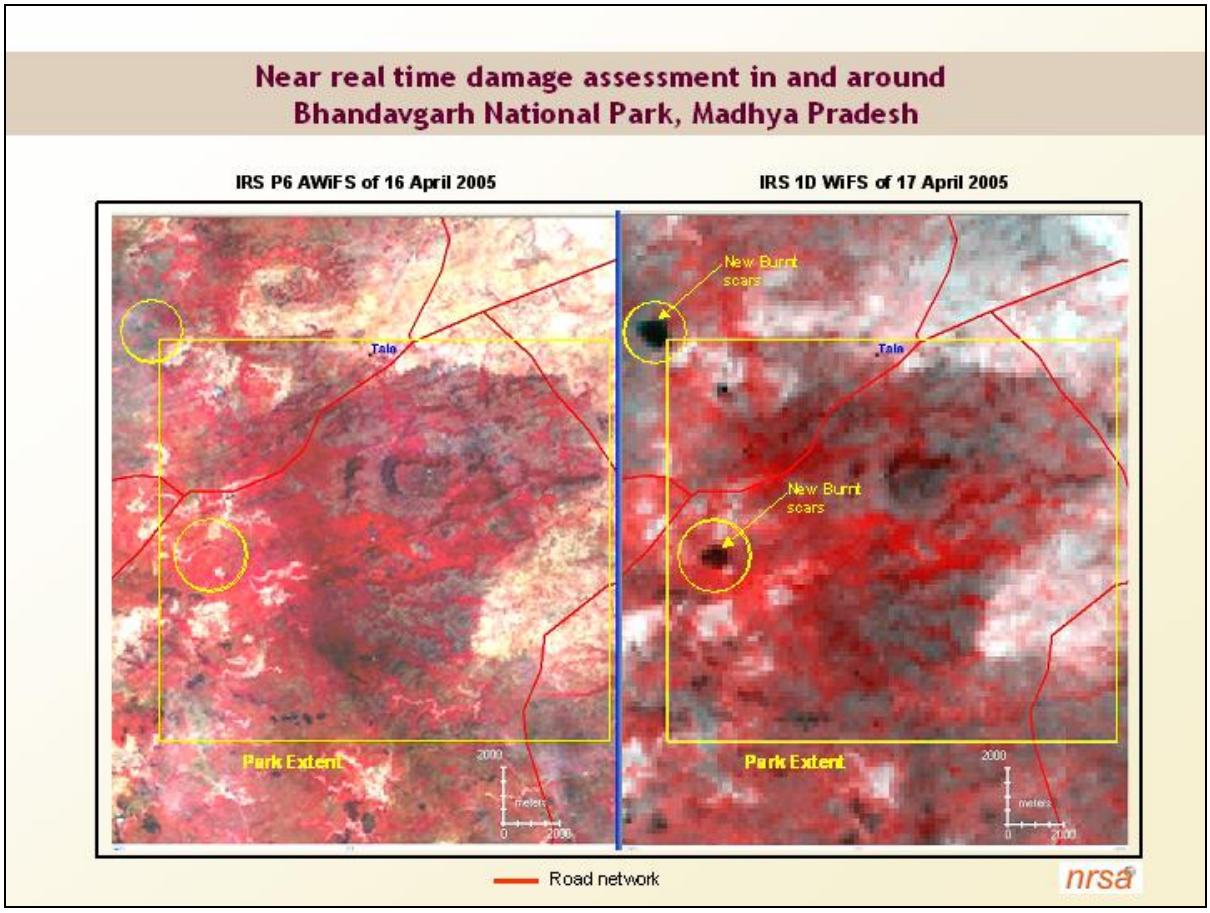


**Figure 4.** Example of near-real time damage assessment in and around Bhandavgarh National Park, Madhya Pradesh, based on multi-resolution data sets from Indian Remote Sensing Satellite (IRS) series.

The post-fire scenario involves ecological damage assessment and mitigation planning .The ecological damage assessment is complex in terms of Indian context as the fires mostly belong to ground / creeping fire category. In such situations the impacts are mainly in the form of effects on biodiversity, productivity, regeneration and soil erosion etc., which are intangible in nature. These impacts could only be understood based on long term monitoring and measurements over gradients of fire vulnerable areas across the country. So far very little database is available and collected on systematic sampling protocols to enable the measurements to upscale to regional and national context. FDSS is structured to receive such ground databases from different bioclimatic regions and spatially analyze and make explicit assessments. The damage simulation models developed based on site specific experiments become an integral part of FDSS to bring out scenarios of damage assessment and vulnerability. Ecological damage assessment due to forest fires over Orissa state were carried out using fire occurrences derived from MODIS and DMSP-OLS data, burnt area estimates from AWiFS data and phytosociological estimates from ground sampling data sets. Experiments on trace gas emissions from forest fires were carried out Indian region combining satellite

derived information on burnt areas and emission factors estimated from ground based measurements (Prasad et al., 2002).

Mitigation planning is dependent on extrinsic and intrinsic factors of forest eco system. Extrinsic factors include around 2 lakh (200,000) villages existing in the forested areas depending for fuel, food and fodder. A study conducted on satellite derived fire locations and spatial vicinity of village suggested that forest areas with in the vicinity of 3km are under more anthropogenic pressure. An assessment has been made on the occurrence of fire locations in dense, open and scrub categories using MODIS fire locations. It was observed that the fire incidences in dense, open and scrub forest constitute, 45, 51 and 4% respectively. It indicates a fact that the fire locations in dense forest on a recurrent basis might affect the regeneration patterns. However, the analysis using fire occurrences data over several years will fine-tune the estimates. The INFFRAS provides services in a continued basis with necessary incorporations from user feedback and technical updates.

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## CHINA

### Forest Fire Situation and Management in Northeast China

Northeast China includes Heilongjiang Province, Jilin Province, Liaoniing Province and Inner Mongolia autonomous region. Its natural environment is very diverse. Plantation and secondary forests account for greater proportion of the total forested area. The forest fire occurrence is induced by many factors, as the forest fires are affected by inter-annual variability of weather and the regional distribution of fuels. Forest fires are characterized by distinct spatial and temporal distribution. The provinces that have more number of occurrences and burned area concentrate on the Northeast China, and impacted by atmosphere current and seasonal monsoon, the fire season of the two regions have distinct seasonal variation. Human-caused fires dominate. Fire prevention stands to the guideline of “take prevention first and extinguish actively”. Since 1987, we have strongly enhanced the prevention, fighting, and management of forest fires. The main measures to manage forest fires are to raise public awareness through publicity and educational activities, manage forest fires by legislation, firefighting team development, and mobilize the power of society to prevent forest fires, reinforce the infrastructure construction and key fire danger zones management. They have worked out a series of products for the professional fire fighters, portable fire ignition and fire distinguishing tools and equipment designed.

### The natural environment in Northeast China

The Northeast forest region is stretching over ten degrees latitude from South to North and include territories of Liaoning, Jilin, Heilongjiang and the eastern part of the Inner Mongolia Autonomous Region. The region is characterized by temperate climate. The main forests in the region are cold-temperate conifer mixed forests, temperate conifer and broadleaf mixed forests, warm-temperate deciduous broadleaf mixed forests. As the region is located in the high and cold area, forest exploitation began relatively late and the population of the region was rather small. As climate, vegetation and the economic situation of the region were different from other areas, forest fires of the region had their own distinctive features.

The region is an important forestry of China. In the region Daxing’anling Mountains forest district, Xiaoxing’anling Mountains forest district, Changbai Mountains forest district the main timber bases are located. Due to the high fire hazard and risk in the grass and forest cover these districts were also the first forest districts, where forest fire prevention was launched.

### Forest fires in the Northeast forest region

The differences of fire occurrence were illuminated by the number of forest fires in different areas. The number of fires indicated fire frequency as well as the proportion of natural fire cause and human fire cause. The annual average fires emerged in the region between 1950 and 1987 totalled 751. 287 fires emerged in Heilongjiang, accounting for 1.8% of the total of country. As regards Jinlin, Liaoning and Inner Mongolia Autonomous Region, the numbers were 214 (1.34%), 189 (1.18%), and 61 (0.38%) respectively.

### Burned area in the Northeast forest region

According to forest fire data of the period 1950 to 1995, the annual average burned area in the region accounted for 55% of the total of the country. It indicated that the annual average burned area in the region was large while fire occurrence (number of fires) was rather small. It was also implied that the population in the region was little and the ability of fire suppression was still very weak.

The annual average burned forest district in Heilongjiang was 328,000 ha, accounting for 37.5% of the total of country. As far as Jilin, Liaoning, Inner Mongolia, the figures were 122,000 ha (1.4%), 2402 ha (0.28%), and 141,000 ha (16.1%) respectively.

Since the average burned area of these forest districts account for more than half of the total of the country, Heilongjiang, Inner Mongolia, Jilin, Liaoning. Heilongjiang and Inner Mongolia are considered the central areas in which forest fire prevention needs to be promoted.


Legend: Coniferous forest
Planted forest
Broadleaved forest
Wetland

**Figure 1.** Distribution of main ecosystem and forest types in Northeast China

## Average burned area in the Northeast forest region

According to the forest fire data during the period 1950 to 1995:

- The average burned area in Heilongjiang, Jilin, and Liaoning was 1173.3 ha, 63.2 ha, and 12.7 ha respectively.
- The sequence arranged by burned area was Inner Mongolia, Heilongjiang, Jilin, Liaoning.
- The average burned areas in the region all exceeded the average of country except Liaoning.
- The burned area of each fire in Inner Mongolia and Heilongjiang all exceeded 1000 ha. The figures had already reached and exceeded the standard of special large forest fire, and was 40~50 times of the average of country.
- The fire situation in the northwest of the region was more serious than that in the northeast of the region. The most serious forest districts were Hulunbeirmeng, Daxing'anling Mountains and Heihe of Heilongjiang.

## Forest fire environment analysis in the Northeast forest region

Large forest fires in the region are occurring during the long spring fire season, which is characterized by dry fuels and heavy wind. In addition, it was difficult in the in the past to control fires due to the large range, low population density, limited traffic infrastructures and weak fire suppression capabilities. This situation, combined with the continental, dry character of the climate, created the conditions for large conflagrations.

One of the major problems are grass fires that are easily spreading into forest and result in large forest fires, especially in eastern Inner Mongolia at the extended forest-grassland interface.

Inside forests there are lots of ruderal slopes, ditches and meadows as well as large second-growth forests – all of these being highly flammable.

Mainly because of undeveloped traffic and low density of road network, firefighters were difficult to get to fire field in time when fire took place. Poor traffic conditions delayed the response time of suppression, especially in Daxing'anling Mountains. Poor fire prevention measures and weak control ability resulting in the difficulty to put out the fire in the same day of outbreak, and strong winds many fires turned into large conflagrations.

The annual average burned area of the region was large, especially the Hulunbeirmeng of Inner Mongolia and the Daxing'anling Mountains of Heilongjiang forest districts. Thus, the two districts were critical areas of the fire prevention of country. The serious situation of forest fire could be changed to some extent only when the critical areas were well controlled.

## Forest fire characteristics in the Northeast forest region

**The fire occurrence was small while burned area was large:** In China there was no coherent relationship between number of fires and area burned. For instance, there was a higher number of fires in the southeast of the country, which burned a relatively small area. Large population density and presence of people, and more developed traffic in southeast allowed to put out fires in time. The natural environment of the northwest, characterized by cold, dry and windy conditions during spring, low population density and undeveloped traffic resulted in weak response. Though the number of fires, some of which were caused by lightning, was small in northwest, the burned area was large. The burned area roughly accounted for 55% of the total of country.

**Large forest fire was frequent:** The region belonged to continental climate. Once fire occurred, the fire was likely to result in large forest fire due to long-lasting drought and more heavy windy days in spring. In the Northeast the Daxing'anling Mountain forest district the vegetation is a cold-temperate mixed coniferous forest – a light coniferous forest in which fire was likely to occur. The vegetation in the Southeast is characterized by cold temperate conifer and broadleaf mixed forest and warm temperate deciduous broadleaf mixed forest. The combustibility of these forests is much lower than cold temperate conifer mixed forest. There were some natural fires (lightning fires) in these forests. Large fires are explained by the restricted availability of firefighting resources for fast fire attack.

**Large forest fire and conflagration forest fire were centred in several forest districts:** Large forest fires and conflagrations mainly occurred in Hulunbeirmeng, Daxing'anling Mountains and Heihe. These forest districts were the zones of highest fire occurrence in the country. The forest types of large forest fire occurrence were cold-temperate conifer mixed forests. The second was temperate conifer and broadleaf mixed forest; the last was warm temperate deciduous broadleaf mixed forest. In view of burned area in different kind of land, the largest burned area was in grassland, the second was in secondary forest; the smallest was in primary forest.

### Fire season in the Northeast forest region

Two peaks of forest fire occurrence were recorded in spring and autumn. There were few of forest fires in summer because summer is usually rainy season. However, fires might take place in extremely dry summers. Compared with autumn, the number of fires in spring was higher and the area burned was larger. The main reason for this is that the spring fire seasons were lasting 3 to 4 months, while the autumn fire season were short, lasting only 1 to 2 months.

After snow melting in spring the cured grass layer and the litter layer is highly flammable. The damages to tree stems and roots, however, is limited due to the dormancy of vegetation at this early stage of the vegetation period. In autumn the trees are not yet in dormancy and highly vulnerable to fire temperatures, especially in situations of slow fire spread and long fire residence time.

## Fire types in the Northeast forest region

Surface fires accounted for 95% of fires, crown fires 4%, and ground fires 1%. In the mixed coniferous forests that are dominated by Dahurian Larch (*Larix gmelinii* (Rupr.) Rupr.; syn. *Larix dahurica* Turcz. ex Trautv.), tree crowns are sparse and sun weeds flourish under trees. Thus, even after the spring fire season severe surface fires occurred during May and June. Crown fires did not occur. However in temperate coniferous and broadleaf mixed forest, crown fires might take place in Mongolian oak and red pinewood and lime and red pinewood, which grew on arid and steep slopes. Most secondary forests were deciduous broadleaf forest in which the prevailing fire type was surface fire.

## Fire causes in the Northeast forest region

Human fire causes were dominant in the region and accounted for more than 98% of the total of the country. Natural fire causes accounted for about 1 to 2%. Some lightning fires took place in Daxing'anling forest district. A few lightning fires occurred in the north of Yichun and Heihe forest district. There were the marks of volcano eruptions in the Changbai Mountain, Mudanjiang, Laoyeling and Xiaochangbai Mountain zones. Though this kind of natural ignition source was few, these had have impacted the evolution of primary forest vegetation at some extent.

Lightning was the main natural fire cause in the region, normally occurring during the rainy season – a time during which ignition is usually difficult. Lightning fires were more common in the north region, e.g., in the Daxing'anling forest district.

In the region, lightning storms first appeared in the last ten days of April and first lightning fires occurring in May. The distribution of lightning fires in May, June, and July accounted 10%, 80%, and 4 to 5% respectively.

## The distribution of human fire causes

Human fire causes in the region were much less than that in southern provinces. The fire causes in the region only accounted for less than 20% of the total of country, however, as mentioned above, the areas burned accounted for 60%. The distribution of human fire causes in the region was that the human-caused fires in the Southeast were more than those in the Northwest due to the earlier beginning of forest exploitation. Generally speaking, human-caused fires were more in earlier developed forest than that in later developed forest and in the colder areas. Thus importance of human-caused fires in the region changed along with time and place. Human fire causes are summed up as follows:

Forestry operations: Forest operations are leaving behind large amounts of slash. The ignitions sources include camp fires of forest workers, use of fire in creating firebreaks, forestry equipments / machinery (e.g., the conflagration of May 1987 was caused by sparks produced by a shrub cutter.

Agricultural fires: In the secondary forests, which are located at half way up mountains, forest fires can be caused due to carelessness in use of fire. The use of fire included burning on barren lands, cultivating, straw burning, burning for collecting manure and so on. Recently there were quite a few of forest fires due to cultivating in barren in Xiaoxing'anling Mountains, so more attention should be given to this problem.

Smoking: Smoking is a very common cause of wildfires. Two of the four human-ignited fires leading to the conflagration of 6 May 1987, for example, were caused by smoking in the field.

The use of fire in field: The use of fire in field meant that people used fires in the forest or in the field, such as for cooking food, heating water, smoking to drive mosquitoes, warming.

## The spatial and temporal changes of forest fire in the Northeast forest region

Since climate, vegetation and the economic situation were different from other areas of country, the forest fires in the region had their own distinctive features. The main spatial and temporal changes of forest fires meant: daily changes, monthly and seasonal variations and annual periodic rules.

The daily variation of forest fires: The occurrence of forest fire changed with time within a day. Generally, the occurrence of fire increased along with the temperature rising gradually after 8:00 h. Between 11:00 and 16:00 h, the temperature was highest, the humidity was lowest, and the wind was heaviest. Therefore the occurrence of fire during this period was most in a day, and suppression was most difficult too. After 16:00 h, with the sun descending in the West, temperature dropped, humidity rose and wind speed fell down gradually. So the occurrence of fire also reduced. After 20:00 h, owing to the lowest temperature and the highest humidity, it was optimum time to put out a fire. Thus small fire should be extinguished before 8:00 h. Otherwise with temperature rising, humidity dropping and wind speed increasing in next day, fire area might be expanded and suppression would become more difficult. During 10:00 to 17:00 h, the probability of fire occurrence was most. The suppression of fire was often carried out between 21:00 and 6:00 h of the next day. In this period, the efficiency of fire attack was best.

The seasonal variations of forest fire: Due to the differences in longitude, latitude, climate and vegetation,

The fire season and the fire characteristics of each forest district were distinctly different due to the local climate that is influenced by longitude, latitude, atmospheric circulation and monsoon, e.g. a dry and windy climate, moist and rainy climate, low-temperature climate with long-lasting snow cover, etc. The fire season in the northeast of China was from mid-March to Mid-June. In May the number of fires was highest. The fire season varied with inter-annual climate variability.

**Table 1.** Fire occurrence of country in 1992

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inner Mongolia forest district of Northeast China | | | 9 | | 1955 | 407 | 5 | | 42 | 301 | 21 | | 2929 |
| Southwest forest district of South China | 90 | 415 | 1325 | 1844 | 1156 | 4 | | | | 31 | 99 | 67 | 5031 |
| Northwest China | 6 | 141 | 404 | | | | | 35 | 147 | 9 | 25 | | 767 |
| Total | 90 | 421 | 1475 | 2437 | 3111 | 411 | 5 | 35 | 189 | 345 | 145 | 67 | 8727 |

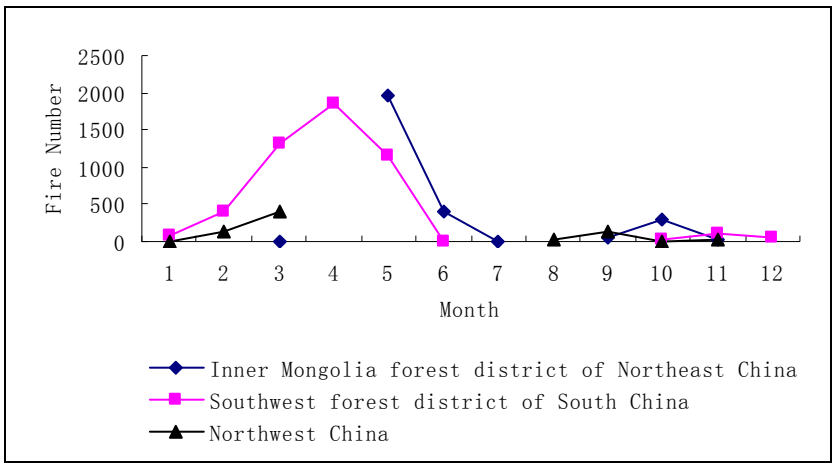


**Figure 2**. Distribution of forest fires in China in 1992

## Forest fire season zones in the Northeast forest region

The fire season was also influenced by geographic latitude. Along a gradient of 10° latitude from South to North, three forest fire season zones were identified:

The zone north of 51°N was called April forest fire zone, where fires occurred in April, May, June and the first ten days of July. From 10 May to 20 June the highest fire danger period was recorded with a maximum of about 200 fire days. The main vegetation was Dahurian Larch (*Larix gmelinii*).

The zone between 45°N ~ 51°N was called March forest fire zone, where fires occurred between March and June. The zone could be divided into two sub-zones. The sub-zone in the North is the broadleaf and Dahurian Larch sub-zone. It is located between 49°N ~ 51°N. The most dangerous period was in May. The maximum of fire days was about 200 ~ 225. The sub-zone in south was called broadleaf and coniferous forest sub-zone and includes Korean pine (*Pinus koraiensis*) forest and temperate broadleaf mixed forests. It was located between 45°N ~ 49°N. The most dangerous period was from 10 April ~ 10 May. The maximum of fire days was about 225 ~ 265.

The zone located between 41°N ~ 45°N was called February forest fire zone, where fires occurred in February, March, April and May. The most dangerous period was from March to April. The maximum of fire days was about 265 ~ 310. The main vegetation included were broad leaf and red-pine mixed forest and south red-pine forest.

## Inter-annual periodic variability of forest fire occurrence

The emergence of forest fire had its own annual periodic change rules. In some years, fires were more, burned area was large and losses were very serious. However in another some years, fires were less, burned area was little and losses were not serious. Generally speaking, fires were more and burned area was large in dry years. On the contrary, fires were less and burned area was little, losses were small as well as. Thus the annual periodic changes of fire were related to the annual periodic changes of humidity. Every 10 or 5 years there would be a peak of fires and burned area, for example in 1952, 1962, 1972, and 1982 etc. There were smaller peaks every 5 years, such as 1952, 1956, 1961, 1967, 1982, 1987, and 1993. At the peak, there would be a period of 2 ~ 3 years in which fires were more and burned area was large, followed by a period of 2 ~ 3years of low fire danger.

## Forest fire management in the Northeast forest region

The propaganda work of fire prevention should be enhanced in order to improve the fire prevention idea of local people.

Fire cause management should be strengthened. Various measures should be taken to solve inadequate energy problem in order to reduce local people’s dependence on forest. Then the activities in forest would decrease, and human fire causes would be controlled effectively.

Natural forest protection should be implemented. Fuel management should be emphasized. Some measures should be taken to decrease forest combustibility and to prevent from conflagration. Forest clearing, prescribed burning etc. were considered effective measures.

Fire monitoring technology should be improved. By using satellite remote sensing and GIS technology as well as through improving the location precision of satellite, the fire could be detected as soon as possible and the suppression could be carried out in time.

Fire attack ability should be improved as soon as possible through introducing and developing fire attack equipments. At the same time, the professional training for firefighters should be enhanced, especially in firefighter safety, to avoid the casualties in fire suppression.

## Conclusions

Northeast China includes Heilongjiang Province, Jilin Province, Liaoniing Province and Inner Mongolia Autonomous Region. Its natural environment is very complex. Plantation and secondary forest account

for greater proportion of the total forest, and forest fire is severe. The forest fire occurrence is induced by many factors, as the forest fires are affected by inter-annual variability of weather and the regional distribution of fuel. Forest fires are characterized by distinct spatial and temporal distribution. The provinces that have more number of occurrences and burned area concentrate on the Northeast China, and are impacted by atmosphere current and seasonal monsoon, the fire season of the two regions have distinct seasonal variation. Human caused fires dominate the most parts of all the fires. Fire prevention stands to the guideline of “take prevention first and extinguish actively”. Since 1987, we have strongly enhanced the prevention, fighting, and management of forest fires. The main measures to manage forest fires are to raise public awareness through publicity and educational activities, manage forest fires by legislation, firefighting team development, and mobilize the power of society to prevent forest fires, reinforce the infrastructure construction and key fire danger zones management. They have worked out a series of products for the professional fire fighters, portable fire ignition and fire distinguishing tools and equipment designed.

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# Reed Fires in Zhalong Nature Wetland Reserve in Heilongjiang Province

In recent years, the serious reed fires occur in Zhalong Nature Reserve in Heilongjiang Province. From 19 to 28 March 2005, 12 fires occurred in Zhalong nature reserve near Qiqihaer, Duerbebe, Lindian and Daqing. The burned area was about 18,666 hectares (ha). Zhalong Nature Reserve is characterized by a particular fire environment determined by the local climate. As a consequence of a pronounced dry season the reeds become withered, yellow and dry. In addition the moisture content of the litter and humus are reduced greatly. This dry-season fuels are forming the fire environment. Fast-spreading surface fires are followed by ground fires in the organic layers that are often long lasting. Since it is difficult to move people and equipment on the wetlands it is very difficult to put out a fire. People's understanding of the wetland and fire are limited. Rapid detection of and response to fires are difficult, making fire suppression and saving life and property very difficult. Wetland fires are constantly burning in Chine and need to receive appropriate attention.

## Introduction

Zhalong Nature Reserve is located in Heilongjiang Province, the border area of Qiqihaer city, Fuyu County, Lindian County, and Tailai County. The area of the nature reserve is 210,000 ha, is our country primary wetland nature reserve and for important for the protection of Red-crowned cranes (*Grus japonensis*). When most, here red-crowned crane population quantity achieves 300. Zhalong Nature Reserve is situated at Songnen Plain, the Wuyuer River downriver, is our country biggest nature reserve that aims to protect cranes and the wetland ecology. In the world there are only 15 crane species, nine of which are found in China, and six species are living in the Zhalong wetland – all of them endangered (near-extinct) species. Out of a total of 1000 Red-crowned occurring worldwide about 300 cranes in Zhalong wetland, moreover also there are other 35 species of key protected birds to perch here.

The reed meadow (*Phragmites communis* Trin.) in the wetland has an important function of self-regulating the wetland ecosystem, e.g., for purification of water and the formation of wetland peat and vegetation, as well as the overall wetland climate. The value of wetland ecology function value is considered to be higher than the economic value of reed, grass, and fish that the wetland is producing. In 2005 the long-lasting drought did not only create conditions for large forest fires. The drought also caused the rapid and complete withering and yellowing of the reed and reduced the water content of the litter and peat layers greatly (Wang et al. 2003a, b).

## 1. The forest fire situation in Heilongjiang Province in March 2005

From 19 to 28 March 2005, the fire broke out and was driven by the wind to Qiqihaer city, Duerberte Mongolian national minority Autonomous County, and Lindian County. Large areas of wetland became charred within several days.

On 19 March, the reed agriculture farmers sheared the reed. Careless fire use caused the wildfire. Hasten by the gale several spotfires developed and spread rapidly. The highest speed of fire recorded was 20 km/hour, the fire intensity was extremely strong, and the flame heights at the fire head were between 3 to 4 m high. On 21 March, the fire burned into the part of Nature Reserve that belongs to Qiqihaer city. Since the organic wetland terrain is soft and the litter accumulation very thick, the access and movement for fire fighting was very difficult. After the flaming fires were extinguished, the smouldering ground fires continued. Fanned by wind, these smouldering fires re-ignited many surface fires.

On 28 March, after fighting the fires with all the available resources, including the participation of 10,000 people, and eased in the end by rain and snowfall, the fires in Zhalong Nature Reserve were finally suppressed. A total of 12 fires affected the Nature Reserve and Qiqihaer city, the DuerBerte Mongolian National Minority Autonomous County, Lindian County and Daqing. According to the analysis of a satellite image, the burnt area of Dumeng County, Lindian County and Qiqihaer city was 10,000 ha, causing significant economic losses.

## 2. Forest Fire Environment in Zhalong, Heilongjiang Province

The drought in the entire Zhalong Nature Reserve, which was lasting since 1999, resulted in a reduced decomposition rate of organic matter and in the accumulation of litter and grass fuels. Due to continuous aridity, the fuels were extremely dry, and the reed agriculture farmers carelessly used the fire. Many of these fires got out of control and the reed fires spread very quickly, fanned by strong winds.

### 2.1 Fuels

Most of the fuel is reed and grass in the Zhalong Nature Reserve where the fires occurred. With the tendency along with the climate warm, the load of reed and the grass accumulates year by year, the load of litter and peat increased significantly, and the fire danger increased accordingly. Because the continuing drought and high temperatures, the surface fuel is extremely dry. The rate of decomposition of reed grass, reed roots, branches and leaves was reduced and the fuel loads accumulated significantly. The thickness of the dry reed layer reached 0.6~0.7m, and the fuel loading reached 12~15kg/$m^2$. Because of this high accumulation of organic matter there is a risk of large and intense fires in the Nature Reserve in the future.

### 2.2 Weather

Since 1999 Heilongjiang Province is suffering a continuous drought period. As a consequence the reed moisture content is down to 40~50% of the moisture in normal years.

Since 2004 summer, the average temperature of Heilongjiang Province continued to be high. As compared to the long-term averages the average temperature of 2004 exceeded 0.5~1°C. The precipitation was 30% to 70% less as compared to the same period of all previous years. The drought is extremely significant in Qiqihaer. The surface fuels dehydrated very seriously and can be easily ignited.

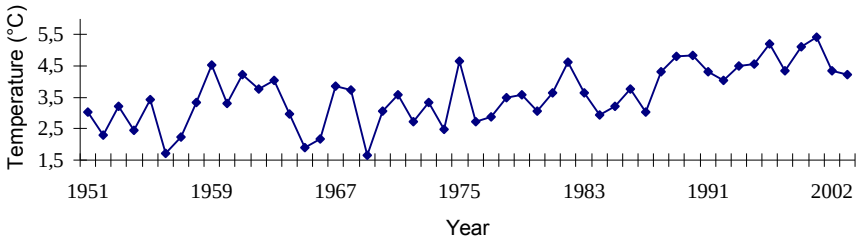


**Figure 1.** Annual average temperatures in Heilongjiang Province in the period 1951-2004

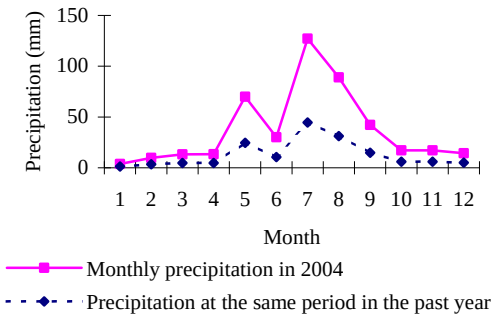


**Figure 2.** Monthly precipitation in Heilongjiang Province in 2004 compared with average precipitation during the period 1951-2003

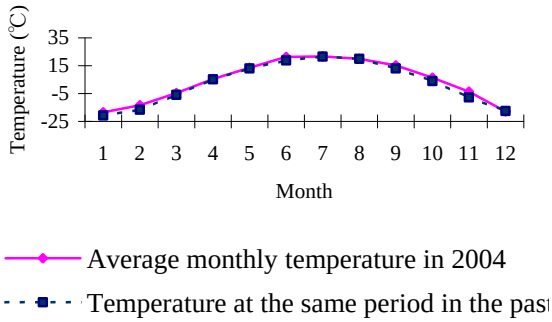


**Figure 3.** Monthly temperature in Heilongjiang Province in 2004 compared with average temperature during the period 1951-2003

### 2.3 Hydrology

The Zhalong wetlands have been formed upstream of Wuyuer river. In the recent years this upstream river is often waterless. As a consequence of a hydraulic engineering project the river was intercepted. In addition, local farmers pumped massive amounts of wetland water to irrigate agricultural lands. Although the wetland was supplied with water after the fires of 2002 the drying had serious effects. Fires occurred in the Zhalong wetland from 2001 onwards.

## 3. Flammability of the reed meadows and fires effects

### 3.1 Flammability of reed meadow

In the shoals and bogs of the wetland, reed and grass is growing abundant. The reed has a straight, high pole crop with long fibres. Dry reed is extremely inflammable. Moreover the calorific value of the reed poles and the grass poles are high. Once ignited, the fire spread is extremely rapid (up to 20 km per hour) and may result in large areas burned and sometimes can burn for very long time. Since the access to the reed meadow wetland is rather difficult, the response to fire is very slow.

Most of the fires in the Zhalong wetland are high intensity surface fires with flame lengths of 3~4m, followed by ground fires. Reed meadow fires mainly occur at a time when reed sprouts become withered and yellow and ready for harvest – a time of the year characterized by low humidity and strong winds.

**Figure 4.** The withered and yellow reed is extremely easy to burn in spring

**Figure 5.** Post-fire view of the reed

### 3.2 The effect of reed fires

While the reed resources are destroyed by fire the fire-affected wetland sites can recover after low-intensity fire already in the same year. After moderate-intensity fires the recovery time is two to three years. However, if ground fires of high severity are killing the reed roots, the area affected will degrade to grass land or wasteland. It is very difficult that these degraded lands will recover within short time. Such fire-degraded areas cannot provide sufficient grass and reed materials for the red-crowned crane and other aquatic birds. After the fire, fish and shrimp resources are also immediately reduced.

## 4. Conclusions and discussion

On 19 March 2005 reed agriculture farmers shearing the reed in Zhalong Nature Reserve carelessly used fire and caused 12 wildfires, which were responded by more than 10,000 people. The onset of rain and snow weather conditions enabled the fire fighters to control the fires on 28 March 2005. The fires affected Qiqihaer city, the DuerBerte Mongolian National Minority Autonomous County, Lindian County and Daqing. The burnt area of Dumeng County, Lindian County and Qiqihaer city was 10,000 ha and caused significant economic losses.

Because of the long-lasting drought in the Zhalong Nature Reserve in 2005, the fuel moisture content was very low, the fuel accumulation was high. Most of the fires in the Zhalong wetland were high-intensity surface fires followed by ground fires. Reed meadow fires mainly occur at a time when reed sprouts become withered and yellow and ready for harvest – a time of the year characterized by low humidity and strong winds.

People's understanding of the ecology and vulnerability of the wetlands and the threats to these ecosystems and also to human life and property by fire are scarce. Timely detection and response are limited due to lacking infrastructure. The increasing threats of wetlands by fire need to be addressed properly.

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# COUNTRY REPORTS

## NIGERIA

### Fire Situation in Nigeria

### Introduction

Nigeria is situated in West Africa (the coordinates of the center of the country are 10°00' N, 8°00' E) with a total area of 923,768 622 km², of which 910,768 km² is land (Figure 1). With a total population of more than 130 million inhabitants Nigeria is the most populous country south of the Sahara. The land use pattern of the land area is about 33% arable land, 44% permanent pasture, 12% forest and woodland, 3% permanent crops and 8% for other land use patterns. Cocoa, other cash crops, timber, grasses and other useful and non-useful vegetation are destroyed annually in Nigeria by wild fires. However quantified estimates of losses due to wildfires are not presently available.


**Figure 1.** Map of West and Central Africa showing the location of Nigeria. Source: Globalis.

### Climate and fire regimes

Nigeria is composed of various ecotypes and climatic zones, from the Sahel savanna in the north to the mangrove swamps in the south, and their associated semi-arid and humid climates (Figure 2). Over Nigeria, indeed the whole of West Africa, rainfall is of two regimes: a bi-modal maximum south of 10°N and a single maximum north of this latitude. This distribution is partly a result of the seasonal oscillation of the Intertropical Convergence Zone (ITCZ), (or Intertropical Discontinuity - ITD) (Omotosho, 1985).

In the dry season, wildfires are a constant threat to the savanna bushland and forest ecotypes in Nigeria. During this period, the soil become perched, the vegetation desiccated, and the forest and savanna ecotypes, therefore become ready fuel waiting for the crucial ignition to flare up. Figure 2 shows the spatial and temporal variations in the ecozones of Nigeria over a 42-year period (Geomatics, 2000). Notice the southward shift trend of the boundaries of the more arid ecozones and the conversion of the lowland rain forest to derived savanna. This shift apart from other anthropogenic activities is also partly a result of seasonal uncontrolled wildfires. Increased wildfire hazard is associated with high temperature, low humidity, high fuel loads and variable *Harmattan* winds (Balogun et al., 2004).

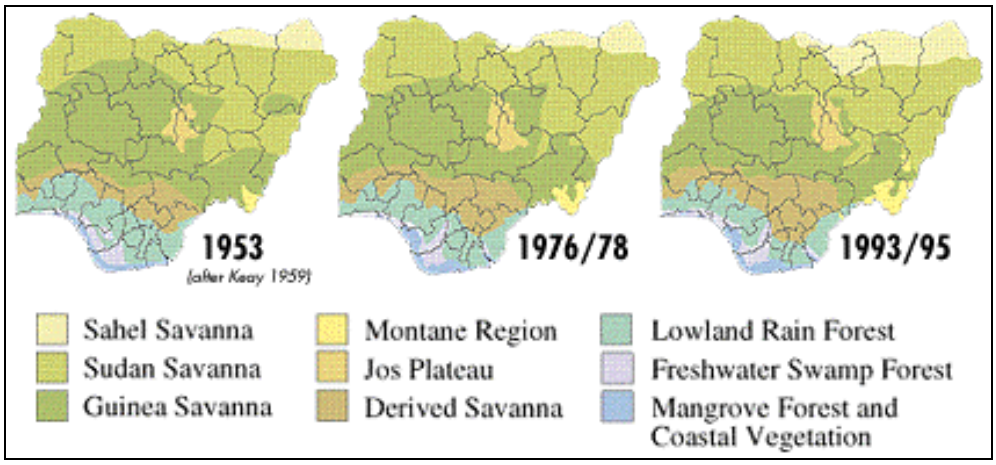


**Figure 2.** Changes of the ecozones of Nigeria over 42 years (source: © Geomatics Nigeria Limited, 2000)

## Wildfire impacts

In every part of Nigeria, burning represents a useful cultural tradition that cannot be done away with. Fire is used as a work tool generally by rural populations, fires serve for land clearing for agricultural purposes, disposal of wastes, pasture management for livestock, honey gathering and animal tracking and hunting. These practices are common in most countries in West Africa covered by dry forests, or savannah from Guinea to Nigeria. The majority of wildfires in Nigeria is caused by human activities and lightening fires are very rare because these occur mainly in the rainy season. The majority of damaging fires are observed from January onwards, due to the high temperatures during this period (above 35°C) and also to the influence of the hot and dry *Harmattan* winds flowing from North to South between December and March. However, the importance of fire varies from one zone to another. Therefore, the area situated above latitude10°N in Nigeria experience more wildfires, mainly because this is the savanna ecozones with a shorter duration of rainfall and a longer period of dryness.

## Fire Database

There are no forest fire statistics allowing for an analysis of the causes, risks and extent of damage. However, there are little general information on the occurrence and season of fires that could reveal information concerning the timing of forest fires. These few sources included the National and state fire services, the National and state forestry and wildlife services, Interested NGO's like farmers unions and educational institutions like Colleges and Universities. Fire statistics are not yet compiled or aggregated at the national level, and resources for obtaining fire statistics in the field are limited. Analysis of the few available fire information for the period 1992 to 2000 from various sources for the forest and savanna ecozones in Nigeria gave some insight into the understanding of fire activity in Nigeria (Balogun et al., 2004). Important findings are briefly discussed below.

The fire season is October-April in the savanna ecotype, while it is from November-March in the forest ecotype. January was observed to be the month of peak fire incidence in the two ecotypes in Nigeria (Figure 3). The study also established 3 fire-risk day categories (High, medium and low), based on meteorological variables (air temperature, relative humidity and wind speed and direction), under no precipitation conditions for both ecotypes. The scheme can serve as a crude fire danger warning system in the two ecotypes. The efficiency of the scheme will be greatly enhanced when more meteorological and ecological information (meteorological data, fire occurrence inventory, stage of vegetation, soil moisture, forest litter, fuel moisture content, etc) are readily available.

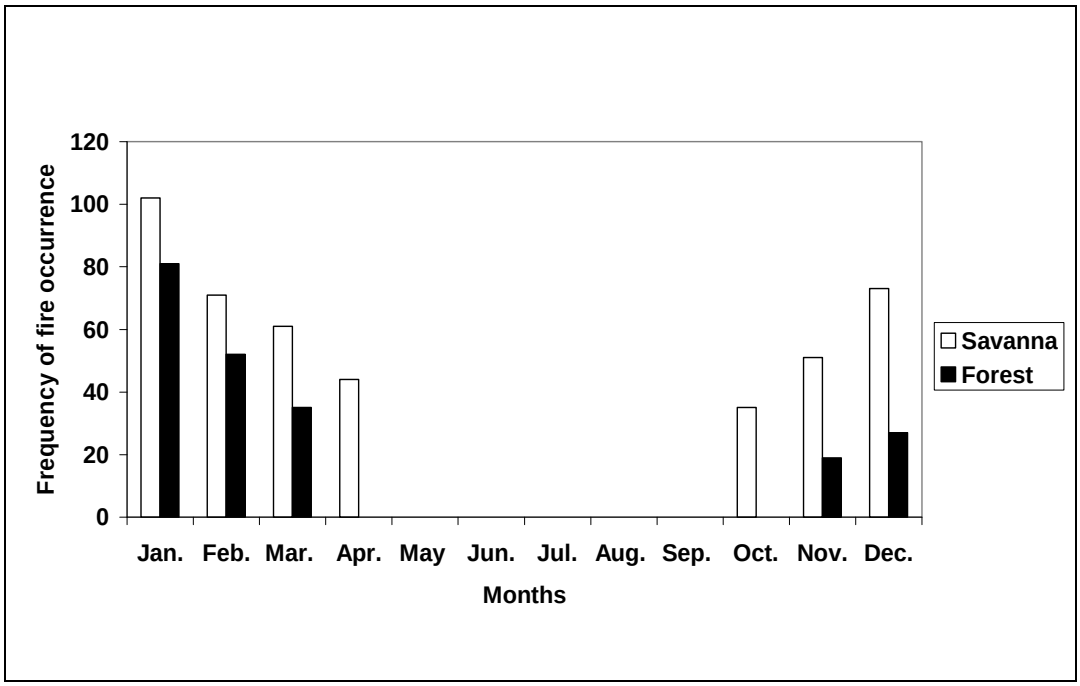


**Figure 3.** Frequency of seasonal fire occurrence in the Nigerian forest and savanna ecosystems.

## Operational fire management systems

### *Fire prevention, Suppression and fighting*

Fire fighting units only exist in urban city centres to control fires in urban areas to the detriment of fire management in rural areas, forest and Wildlife reserves. However attempts to manage fires are made in all the federal and state forest reserves and wildlife parks, under the Federal Department of Forestry and the Ministry of Environment, but efforts are limited by the lack of adequate facilities and well-trained fire personnel. Fire suppression and prevention facilities are either non-existent, not functioning or obsolete and fire breaks and towers are not well maintained. Fire fighting is done on a spontaneous and ad-hoc basis, as there are no proper routine and methodological preparations and guidelines for fire fighting in the reserves during the fire seasons. Local community mobilization and participation in fire fighting is non-existent, but farmers' associations are concerned with fire suppression, although links to government agencies have not yet been established.

### *Fire early warning, detection and monitoring*

Presently there are no operational fire early warning, detection and monitoring systems in Nigeria. However, Balogun et al. (2004) proposed a simple scheme that may be used as an early warning scheme, while the recent launch of the Nigeria Sat-1 into orbit on 27th September 2003 may encourage government to establish an agency devoted to early warning, detection and monitoring of fires using remote sensing; the Nigerian satellite is a component of the Disaster Monitoring Constellation (DMC) incorporating Britain, Algeria, China and Thailand. The satellite among others is expected to monitor water resources, soil erosion, forest fires, deforestation and desertification and environmental disasters.

### *Fire Research*

In Nigeria, research has developed a simple scheme that can be used as a warning scheme as well as a technique for assessing range condition for the suitability of carrying out control or prescribed burning in the forest and savanna ecozones (Balogun et al., 2004), this scheme presently uses only meteorological variables. The efficiency of the scheme will be greatly enhanced when more meteorological and ecological information (meteorological data, fire occurrence inventory, stage of vegetation, soil moisture, forest litter, fuel moisture content, etc) are readily available.

Earlier fire researches in Nigeria have centred on the management, roles and impacts of fire in the ecosystem development (Udo, 1990; Afolayan and Agbelusi, 1995; Oguntala, 1995 and Badejo, 2002). However, a major limitation to fire and forest resources management in Nigeria is the dearth of forest fire records, and the few that are available have not been properly documented. This realization motivated a study to develop a national wild land fire inventory and fire disaster management action plan for Nigeria, where a national fire inventory scheme was proposed and recommendations made towards achieving more effective monitoring and fire management planning through the use of currently available remotely sensed satellite products (Balogun, 2004). This study funded by the ProVention Consortium[5] was conducted under the umbrella of the Regional Subsahara Wildland Fire Network (AfriFireNet), the regional African arm of the Global Wildland Fire Network, which is facilitated by the Global Fire Monitoring Centre (GFMC), Freiburg, Germany. Research is also being conducted presently on the use of remote sensing for the monitoring and assessment of fire activities in Nigeria. Preliminary results of a comparison of TRMM / VIRS fire count products and observed fire occurrence data in the savannah and forest ecotypes in Nigeria show good agreement (Adegoke et al., 2005). Consideration is also presently being given to the comparison of fire counts and burn scar assessment using AVHRR, MODIS and Nigeria Sat1 satellite products. It is hoped that the success of this project will eventually provide the base for Nigeria's contribution of information and data to the Global Vegetation Fire Inventory (GVFI) and its successor arrangement, the Global Wildland Fire Assessment (GWFA), which aims globally among others to address the inadequacy of information on global emissions from free burning vegetation fires (wildfires, fires in land-use) and other plant biomass (burning of fuel wood and charcoal). Presently GVFI / GWFA does not get data from Nigeria.

## Public policies concerning fire

Nigeria presently does not have national regulation (laws) and policy (guidelines) on the use and control of forest and wild land fires, but a brief mention was made in the Forestry Act Cap 40 of 1970. However formulation efforts are currently ongoing. As at January 2005 the draft bill of the national forestry act 2003 and the draft national forest policy 2003 have only been endorsed by the National Council on Environment. Both the policy and act, we are informed recognises many of the complexities of fire, including; the need to reduce the occurrence and severity of uncontrolled and accidental forest fire, while still allowing controlled fire under specific circumstances; that community participation is desirable in the protection of forest resources. They also contain substantial provision for the prevention, control and management of wild fires nationwide and the setting up of forest fire units at all tiers of government. The bill and policy are currently being processed for approval by the Federal Executive Council and promulgation by the National Assembly.

Since there are presently no functional regulations and policies, government policies are persuasion rather than enforcement in the electronic media. Television and radio campaigns, warning on the risks and danger of fire during the dry season are made by most states. At present, the lack of a database on the occurrence and impact of fires is the major obstacle to the development of an effective national policy. The current initiative to develop an inventory scheme to document the occurrence of fires is an important step in this direction.

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## UNITED KINGDOM

# Country Report for the United Kingdom

### Introduction

Wildland fire in the UK was described in detail in an earlier Country Report for the United Kingdom by Bruce (2000). This report is compiled as a contribution of the UK to the Fire Management Global Assessment (2005) and summarises the main findings of the earlier document and highlights some developments that have been made over the five-year period 2001-2005.

### Summary of the fire situation in the UK

Prescribed burning is used extensively in upland Britain for habitat management for red grouse (*Lagopus lagopus scoticus*), an upland game bird that lives on heather (*Calluna vulgaris*) moorland. Fire is also used extensively to regenerate heather moorland and grassland (principally where dominated by purple moor grass, *Molinia caerulea*) for cattle, sheep and deer. In forests, fire is used to clear branches or heather from sites as a ground preparation tool prior to forest establishment by planting or natural regeneration. Firebreaks are also sometimes created alongside forests by burning. Fire is used occasionally on farmland in Scotland to burn straw, a practice that is now prohibited in England and Wales. Prescribed burning is used more frequently on privately owned estates than on publicly owned land.

Wildfires are also common in lowland heathland (dominated by heather, sometimes with western gorse, *Ulex gallii*) and in stands of gorse (*Ulex europaeus*), especially where these are close to urban sites. Fires within forests are uncommon, though do occur either in young plantations of conifers, especially where adjacent to heather or grass-dominated vegetation, or where heather has re-invaded older stands after thinning. A very high proportion of wildland fires in the UK are anthropogenic in origin, though lightning fires do occur on rare occasions (Bruce 2000).

Fire hazard is increasing in many areas. The main reason for this has been a reduction in staff available for heather burning operations on many estates due to economic pressures (Hudson 1992) which, combined with a reduction in sheep grazing pressure, has resulted in an increase in the average age and biomass of heather plants. There is also a move from some conservation organisations to extend the recommended fire cycle for heather moorlands from 10-15 years (Gimingham 1972) to 20 years in some places and to retain larger areas of unburned heather (Backshall et al. 2001), to reduce deer numbers, and to plant native pinewoods for biodiversity objectives. All of these are likely to increase fuel loads and hence future fire hazard. Recent legislation has also widened public access to the countryside both in Scotland (Land Reform (Scotland) Act 2003) and in England and Wales (Countryside and Rights of Way Act 2000, the so-called CROW Act). It is widely expected that this will increase the frequency of accidental ignition in some areas.

There is currently no systematic method established for recording wildfire events in the UK and there are no reliable statistics on numbers, sizes or causes of wildfire. Statistics published by the Home Office Statistical Bulletin (ODPM 2005), for example, include intentional straw and stubble burning as well as wildland fires, but only include fires attended by the Fire and Rescue Services and do not include management fires or wildfires that were dealt with solely by land managers. However, the statistics do show that 2003 was a particularly bad year for wildland fires with 152,700 fires reported; second only to the 174,600 fires in the dry summer of 1995. Interestingly, many of the 2003 fires (twice the monthly average) were during a particularly dry spell in March and April, rather than during the hotter summer months. Some of these fires were very severe, burning many square kilometres and, in some cases igniting peat and burning for many days.

A recent questionnaire sent by the Game Conservancy Trust and the Scottish Gamekeepers Association to private estates who practice moorland management elicited responses from 42 estates. Seventeen wildfires were reported by 13 estates during 2003, averaging about 150 ha. Four estates used helicopters to extinguish the fires, though most used a combination of hand tools and water carried on all-terrain vehicles. The Fire Brigade were only called to six of these fires, though six required help from at least 50 people to extinguish, usually workers from neighbouring estates. The causes of fires were mostly (nine fires) escaped management fires in between February and April; two

were recorded as having been started by crofters (graziers), three as accidental, two as arson and one unknown.

It is important that these wildfires are put into context both of normal prescribed burning and the particular causes of wildfires in 2003. Twenty of the 42 respondents in the survey reported active management by burning during 2003 with an estimated 4300 fires; one estate estimated that they had burned 900-1000 fires during the season. It is likely that this rather small sample of estates is biased towards those who experienced wildfires as they are perhaps more likely to respond to the questionnaire. The survey also targeted moorland estates managed for game and does not include information about the many wildfires that occurred on public land or land managed for other purposes. Some of the largest landscape-scale fires occurred during exceptional weather conditions over the period 16-25 April after the prescribed burning season had finished and in areas usually considered low risk. One such fire on the Ardnamurchan peninsular on the normally wet west coast of Scotland was 70 $km^2$ in extent.

The environmental and economic cost of these fires cannot be estimated but is considerable. The economic costs include the loss to property (forestry, fencing, etc.) and of income of up to 70 pounds sterling per ha per year from grouse moors. Re-establishment of the mosaic structure of different aged heather stands required by grouse may take some 15 years. The environmental costs are also considerable, particularly where peat was ignited resulting in destruction of the seedbank, a high risk of erosion and a complete change in ecosystem function. One such fire at Fylingdales in the North York Moors National Park effectively removed the surface peat and seedbank from 258 ha, affecting over 30 Scheduled Ancient Monuments; the cost of restoration work is estimated at 290,000 pounds sterling excluding staff time.

**Fire prevention and control**

The traditional tools used for extinguishing heather fires are long handled fire beaters or scrubbers with wire mesh or metal heads. More recently “pump and roll” techniques using very high-pressure fire fogging units mounted on all-terrain vehicles have become popular; wetting agents and foam may also be used though this remains relatively uncommon. Generally helicopters are only used when either a fire is completely out of control or is threatening a forest. There are no helicopters or fixed-wing aircraft in the UK dedicated to fire fighting. This means that commercial helicopters have to be called in when required and availability is usually limited and dependent on other work. On rare occasions helicopters have been placed on standby during periods of extreme risk, though this is expensive (ca 1500 pounds sterling per day on standby, plus 1000 pounds per hour flying time). The cost of helicopters is usually borne by the land owner or insurance companies, though insurance cover has become more difficult to obtain since 2003.

The Met Office Fire Severity Index is a web-based predictor of fire weather conditions and fire risk that has recently been produced for England and Wales (Met Office 2005). This system provides a five-day forecast using a five-point fire risk index that has been designed specifically in response to the new countryside access legislation (CROW Act) which provides for National Park Authorities to close public access to parts of the countryside during periods of exceptional fire risk.

**Organisational developments**

A number of Fire Groups have been established throughout the country (Bruce 2000). These are agreements between a number of neighbouring estates within a region and the local Fire Brigade to coordinate efforts at fire control. Their primary aims are to provide access to labour and equipment at short notice, to improve effectiveness, efficiency and communication on the fire ground, and to improve safety, training, cost sharing and general mutual assistance. Of particular value is the communication between estate managers and the Fire and Rescue Services as the estate workers have local knowledge and suitable equipment for working in remote and rough terrain that is not available to the professional fire fighters trained and equipped for structural fires.

The establishment of a Scottish Wildfire Forum was proposed at a wildfire conference in Aberdeen in October 2004 and the Forum met in December 2004 under the chairmanship of Mr Jeff Ord, Her Majesty’s Chief Inspector of Fire Services, Scotland. The Forum arose largely from the large number of severe wildfires in 2003 which stretched fire-fighting capacity and demonstrated some inadequacies of the present system for coping with such events. The aims of the forum are to bring together the fire services, land managers, and relevant agencies in Scotland in order to develop and communicate

wildfire protection strategies to ministers and stakeholders. One of the first tasks of the Forum is to identify key issues and priorities for partner agencies and to stimulate research and development where necessary. To this end the Forum has identified the need for more precise data on the incidence and nature of wildfires and is discussing suitable formats for collecting statistics that will be of value in planning and in managing wildfire events in the future. There is discussion of the extension of the Met Office Fire Severity Index to Scotland and the development of a related, fuel-type specific, Fire Behaviour Prediction System through collaboration between the Met Office and the University of Edinburgh. The Forum has also highlighted the need for the Fire and Rescue Services to have access to personal protective equipment (PPE) that is more appropriate for fighting wildfires. The Scottish Wildfire Forum is recognised by the Scottish Executive as a national forum.

The Welsh Forum for the Control of Countryside Fires is a similar forum recently established by the Countryside Council for Wales with the objective to prevent, reduce and control illegal fires in the countryside. This Forum comprises the fire and police services and the major agencies responsible for countryside management in Wales.

**Research**

Wildland fire research in the UK has mostly concentrated on the ecological effects of fires and the post-fire succession of vegetation (e.g. Gimingham 1981, Hobbs and Gimingham 1984a), though a small number of fire behaviour research programmes have been completed (e.g. Kayll 1966, Thomas 1968, Hobbs and Gimingham 1984b, Hamilton 2000). Recent research conducted by the University of Edinburgh and The Game Conservancy Trust has looked at the relationship between fuel, weather and fire behaviour. A simple technique based on visual obstruction has been developed to enable field surveying of heather fuel loading and structure. The technique is able to predict loading for total above-ground biomass, fine fuels and the moss/litter layer. The methodology also provides an index of canopy density which can be compared to the bulk density of the canopy. It has been adopted as the survey method of choice for a number of fire research programmes.

Extremely low fuel moisture was implicated as a potential causal factor for many of the large fires seen in the spring of 2003. Fuel moisture measurements conducted at a number of spatial and temporal scales have revealed how live heather fuel moisture contents vary on a seasonal, day to day and diurnal basis as well as over landscapes and between different heather stands and plants.

Replicated burning experiments with fires of constant size have successfully been completed in a range of different fuel loadings. Relationships between fuel loading, fuel moisture and weather conditions will be established which will allow the prediction of rate of spread, fireline intensity and flame length which are vital to fire control.

Finally data on fire behaviour from these and previous studies will be used to begin the process of testing, ground-truthing and calibrating existing fire behaviour models including BehavePlus and the Canadian Forest Fire Behaviour Prediction System.

Other fire related research projects on going in the UK include experimental fire conducted within Scots pine (*Pinus sylvestris*) forest at both Abernethy forest by the RSPB and at Glen Tanar (Bruce and Servant 2003). The primary objective here has been to test the potential use of surface fire for conservation management of habitat for capercaillie (*Tetrao urogallus*). The heather is being burnt off beneath mature pine canopy to encourage the growth of blaeberry (*Vaccinium myrtillus*). It is anticipated that fire will have the added benefits of encouraging seedling regeneration of the pine and reducing fire hazard by removing the excess fuel that has accumulated following a reduction in deer numbers.

The Urban Heaths Life Programme, funded by the EU Life Programme has developed a comprehensive GIS system for recording disturbance events, including fires, in the lowland heaths of Dorset in the south of England (Dorset County Council, undated). This project has developed from the reports by Kirby and Tantram 1999 and Tantram *et al*. 1999, and permits detailed spatial and temporal analysis of the occurrence of wildland fires in a semi-urban environment. This project has a strong educational component with the objective of reducing the incidence of accidental and malicious fires in this threatened habitat.

As well as the Wildfire conference in Aberdeen in 2004, two other very successful seminars and equipment demonstration events have been held: ‘Wildfire 2003’ and ‘Wildfire 2005’, both organised

by Northwoods. These events brought together people from the Fire and Rescue Services, National Parks and countryside agencies from across the UK. A questionnaire survey of some of the participants at Wildfire 2005 showed the value of the recently developed Met Office Fire Severity Index, but also showed the perceived need to develop other tools for predicting fire behaviour including both simple nomographs for predicting rate of spread and flame length for typical UK fuels and more complex computer-based models of fire spread. An essential task in order to achieve this will be the development of a fuel moisture model for heather. Initial data indicates that heather can, under certain circumstances, have very low live-fuel moisture levels. This is particularly true in late winter and early spring and when the ground is frozen and when plants have been damaged by frost. At such times this can significantly increase fire intensity under quite moderate fire weather conditions.

**Figures 1 and 2.** Prescribed burning in the Scottish Highlands – a method, which meanwhile successfully transited from experimental stages into practice. Photograph: Michael Bruce

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