International Forest Fire News (IFFN) No. 34 (January – June 2006, 78-84) ISSN 1029-0864

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

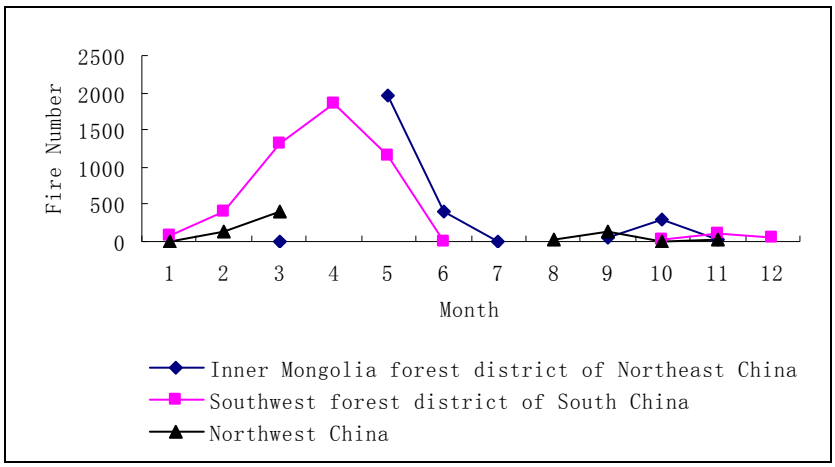

Figure 2. Distribution of forest fires in China in 1992

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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