RELATIONS AMONG FOREST FIRE SPREAD, ENERGY RELEASE AND NATURAL WIND FIELD

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ABSTRACT

In this article,according to observing material of forest experimental fire field,of actual fire field,and available research achievements at home and abroad , classifications of different forest fire intensity, time scale and vertical space scale are further analysed and discussed. Relations among way, direction,rate of forest fire spread, forest fire intensity and natural wind field. i. e. (1) Spread way and spread rate of different forest fire intensity, affected by natural wind field; (2) Condition and mechanism of continuous spread and surmount spread of different forest fire intensity affected by natural wind field.

Key word: Forest fire, fire spread, continuous spread and surmount spread.

1. INTRODUCTION

Forest fire behavior, i. e. forest fire character indicates the whole process of Forest combustion in broad sense, i. e.the whole process of forest fire occurence, development, spread and going out; it indicates forest fire development and spread in narrow sense. Forest fire development depends on change of forest combustion process.Forest fire spread depends on way, direction and rate of spread. Forest fire behavior expressed by flame height, intensity, width, length of fire front,fire spread direction and rate.

Velocity of energy release of forest fire is usually narrated by Byram G.M,as fire front intensity,which is called fire intensity for short.

Forest fire spread and intensity have close relations.Different forest fire intensity has different spread character. Low intensity fire spreads continuously when forest fuels continuously distribute. While higher intensity fire can spread. When forest fuels distribute either continuously or not continuously. Then surmount spread occurs, which characterized by jumping fire and leaping fire. Both continuous spread and surmount spread can occur in medium intensity fire, which depends on natural wind field.In this article,only relations among forest fire spread,fire intensity and natural wind field are discussed.

2. FOREST FIRE TIME SCALE & SPACE SCALE

Forest fire is classified as surface fire, ground fire, trunk fire and crown fire. Surface fire may occur only on place where there are thick humus layer and peat layer in special drought year, which account for little proprtion.Therefore only surface fire,trunk fire and crown fire are discussed.

Different intensity forest fire is usually classified by Byram fire front intensity. I think that classification standard of different intensity forest fire should be considered,combined with characters of spread and spread ways. Low intensity fire is all surface fire; Medium intensity fire is mostly surface fire ,lessly cause shrub forest fire, young forest fire or high tree trunk fire; High intensity forest fire may be surface fire, shrub forest fire, young forest fire or high tree forest fire and crown fire. Different intensity forest fires have obviously different forest fire spread characters. Time scale,vertical space scale and relative character scale of different intensity forest fire are narrated in the article,see table 1.

Table 1, Feature scale of different intensity forest fire

Fire Int. / Feat. Scale		Low intensity fire	Medium intensity fire	High intensity fire
		<300 KW/M	300-2700 KW/M	>2700 KW/M
Time Scale		from a few min to a few ten days	from a few days to tens days	from ten days to a several ten-days
vertic space scale	flame height	< 1 m	1 ~ 3 m	> 3 m
	smoke height	a few meters to hundred meters	a hundred m.to several hundreds m	several hundreds m. to several thousanda m
convection velocity over fire field		< 2.1 m/s	2.1 - 4.5 m/s	> 4.5 m/s

3. WAY, DIRECTION, RATE OF FOREST FIRE SPREAD

Spread way, direction and rate of different intensity forest fire mainly depend on fire intensity and natural wind field. Fire spread direction depends on wind direction. On basis of spread direction, down - wind fire, side -wind fire and contrary wind fire are classified. On basis of fire field position, down wind fire is called fire head, side wind fire is called fire wing, contrary wind fire is called fire tail. The spread of fire tail is always continuous spread. The spread of fire wing is mostly continuous spread, a few surmount spreads in way of jumping fire. But spread of fire head can be both continuous spread and surmount spread in way of jumping fire or leaping fire.

Many research and forest fire men call jumping fire and leaping fire which cause surmount spread, as spot fire. spot fire so called can also be classified as: short distance, medium distance and long distance leaping fire. Short distance is approximately from a few metres to several ten metres; medium distance is from several ten metres to several hundred metres; Long distance is from several hundred to several throusand metres even longer . The author think that, On bosis of observation of experimental fire field and actual fire field, many spot fire so called should actually be called jumping fire. These jumping fires are mostly of short distance, i.e. from several metres to several ten metres, a few are of medium distance i. e. from several metres to several hundred metres. While most spot fires of medium distance and long distance are truly called as leaping fire.

4. CONDITION & MECHANISM OF FOREST FIRE SPREAD

Byram G. M. who has done theoretical caculation and study, thinks that when lower atmosphere is moderate stability, the nesessary condition which convective air current can exist and hold, is that flux (P_r) of kinetic energy of convenctive air current which is transformed from heat energy of fire field is equal to or larger than flux (P_w) of kinetic energy of wind field, i.e. $P_r \geq P_w$ [1]

In order to distinguish and determine contrast relation of convection air current of fire field, which is transformed from fire intensity, and wind velocity, the value of P_r and P_w of different wind velocity and fire intensity can be caculated in advance, see table 2. [2]

Table 2 Fire intensity of convection air current which can adaquately form in different wind velocity

Wind velocity (m/s)	$P_w = P_f$ (kg • m/s • m)	Fire line intensity	
		(kcal/m • min)	(k • w/m)
0.5	0.008	28.8	2.0
1.0	0.06	231	16.1
1.5	0.21	780	54.4
2.0	0.49	1848	129
2.5	0.95	3612	252
3.0	1.65	6242	435
3.5	2.62	9912	691
4.0	3.91	14796	1032
4.5	5.57	21066	1470
5.0	7.64	28896	2015
6.0	13.20	49932	3483
8.0	31.28	118362	8256
10.0	61.10	231180	16127
12.0	105.60	399480	27868

On basis of Byram G.M.Theory,the necessary conditions which convective air current of fire field exist are determined by table 2. i. e. convective air current of fire field,at different wind velocity,should have certain fire intensity. Therefore,Mr.Waliejek and so on have made lots of field experiments in order to clarify that mutual relation of two kinds of energy has influence on existence of convective air current of field.experimental reaults indicates that Byram's theory is correct.

Obviously, when P_f/P_w is less than 1, convective air current is difficult to form and exist.Fuels continuously spread along and ground surface, jumping fire and leaping fire can not happen. It is only when the value of P_f/P_w is larger than or equal to 1 that jumping fire or leaping fire can happen. When value of P_f/P_w is very large, convective air current is strong, the angle of inclination of convective air current is small or vertical to ground, then jumping fire or leaping fire occur easily.

On basis of analysed and caculated results,low intensity fire (<300 kw / m),only when wind velocity lower than 2.5m/s,is advantageous to form convective air current. Medium intensity fire(300-2700 kw/m),only when wind velocity is 2. 5-5. 5m/s, is advantageous to form convective air

current, it may be either continuous spread or surmount spread in way of jumping fire. High intensity fire (> 2700 kw /m),when wind velocity is higher than 5. 5 m/s, can still form convective air current, now surmount spread in way of jumping fire or leaping fire can occur.It is evident that it is only on condition that convective air current take shape over forest fire field, the surmount spread of short distance in way of jumping fire, or surmount spread of medium distance and long distance in way of spot fire may occur. To sum up,the way and velocity of forest fire spread mainly depends on fire intensity and wind velocity.

Whatever jumping fire or leaping fire, in addition to fire intenisty and wind velocity, they also have close relations with characters and scale of fuels which are hoisted over fire field by heat convection of fire field.Obviously,heavy fuels have large scale,are xylem fuels,even which are hoisted over fire field by heat convection,once they are out of convective air current, they will drop down ground, which form so called jumping fire. Light fuels have small scale, they may be xylem fuels or herb fuels, which are hoisted by heat convection. Burning of herb fuels takes short time, burning of xylem fuels takes longer time, they can leap or flutter far away by natural wind field,then gradually drop down ground,and ignite fuels on the ground,form so called leaping fire. But light fuels, on condition of lower fire intensity and weak convective air current,belong to jumping fire instead of leaping fire.

5. CONCLUDING REMARKS

The analysis and discussion of this article are just rough exposition, not precise conclusion.

When forest fire in large area occurs, low intensity fire hold a dominiant position accompanying with medium intensity fire and high intensity fire; or medium intensity fire hold a dominiant position, accompanying with low intensity fire and high intensity fire. However restriced by forest fuels and weather condition, high intensity fire can occur only in partial period or area.

Low and medium intensity forest fire can be studied on basis of indoor experiments and field experiments. High intensity fire can still be studied on basis of indoor and field experiments. As for very high or extremely high intensity fires can be observed and studied only when

they actually occur in nature. Such a high intensity fire rarely happens, so it is difficult to study.The research of spot fire of long distance has not got practical meaningful results untill now. Obviously, when high intensity fire of large area is studied, it must be considered that quantitative change of flame temperature, wind velocity and other parameters transforms into qualitative change of fire behavior. Regularity revealed by low-medium to high intensity fire of large area. Therefore, in order to reveal regularity of high intensity fire,long- term and thorough study must be taken.

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