The Effects of Climate Var
Forest Fires in Saskat

by

W. J. De Groot[2]

Introduction

According to provincial records for 1951-1979, Saskatchewan averaged 290 wildfires a year which burned approximately 128,174 ha. However, there was a substantial increase in provincial fire statistics during 1980-90 when the annual average for that period was 782 fires and 404,645 ha. burned. There are a number of factors affecting fires (e.g., fuel, topography, ignition source) which would influence these statistics to a certain degree, but such a considerable change over an 11-year period is best explained by longer term changes in the weather. Forest fire activity can be significantly affected by relatively minor changes in weather conditions. Therefore, the effects of climate variation on forest fires can be quite dramatic.

Fuel and Weather Factors

Of all the factors affecting forest fires, fuel and weather are the most influential. The kind of forest (or fuel type) that a fire burns in, and the associated weather conditions, determine how intense a fire burns and how quickly it spreads. A change in either of these factors can considerably alter fire activity.

There are five different fuel type groups in Saskatchewan: coniferous, deciduous, mixedwood, slash, and open (grass) (De Groot 1987). The primary characteristic that separates the various fuel types within each group is the amount and distribution of fine fuels in the stand. This is because fine fuels directly influence the rate of fire spread and the intensity of the fire at it's edge. If the fine fuels are well-distributed in the vertical profile of a stand, then it is possible for a fire burning on the forest floor to be 'carried' into the crowns of the trees where there is a large amount of fine fuels and access to increased wind speeds above the forest canopy. This combination of conditions can cause a 'running' crown fire which has an extremely high fire intensity and rate of spread.

In the coniferous fuel type group, immature pine has a large

[1]A presentation made at the Saskatchewan Climate Advisory Committee Annual Workshop, October 30, 1990, Regina.

[2]Fire Research Officer, Saskatchewan District Office, Forestry Canada (Northwest Region), 1288 Central Ave., Prince Albert, Sask., S6V 4V8.

amount of dead branches, twigs, needles and other fine fuels on the forest floor. There is also a lot of dead branches, tree lichens, and flakey bark on the tree stems and branches close to the ground which can carry a surface fire into the tree crowns. Fires burn intensely and spread quite quickly in this fuel type, even in relatively low burning conditions. Mature pine, on the other hand, has less fine fuels on the ground and on the stems so it burns less intensely and spreads less quickly (unless severe burning conditions exist). Black spruce stands react similar to immature pine because of fast-drying mosses on the forest floor and live branches which often reach to the ground.

Poplar stands usually only burn in the spring and fall when the lower vegetation is cured. Once green-up has occurred, the lower vegetation in this fuel type contains too much moisture to carry a fire. The grass fuel type is similar in its seasonal burning trends. However, a spring or fall fire in either of these fuel types can spread rapidly and burn with high intensity because both have a high fine fuel component.

The last major fuel type group are the slash fuels. These are comprised of the branches and tops of trees that remain after a logging operation. There is an extremely large amount of fine fuels on the ground, and therefore, fires are usually very intense and fast-spreading.

Forest fuels are a fixed factor of the fire environment and their general distribution can be seen in Figure 1. Weather is a variable factor affecting forest fuels and determines the level of fire activity in any particular stand. Figure 2 presents a national map of generalized forest fire weather zones which illustrates that Saskatchewan experiences a substantial amount of severe burning conditions. Fortunately, the occurrence of these conditions is only moderate to high in the commercial forest zone, while very high and extremely high occurrence is typical of the non-forested portion of the province (with the exception of the Cypress Hills). It should be noted that Figure 2 was based on fire weather data from 1957-66.

The sensitivity of fire to changes in weather can be seen in Table 1 which uses a 'typical' summer day in Saskatchewan (temperature = 28°C, relative humidity = 30%, wind speed = 20 km/h, no rain) to illustrate the singular effect of each weather parameter. Table 1a shows that fire rate of spread (ROS) and area burned are strongly affected by relative humidity, particularly below 30%. Table 1b indicates a similar relationship for wind speed, except that wind speed is considerably more influential on ROS and slightly less so on area burned (because higher wind speeds limit lateral fire spread). Rain, of course, greatly affects ROS and area burned (Table 1c), although the first 0.5mm has no effect because it is intercepted by the forest canopy. Temperature has the least effect (Table 1d). However, it indirectly has a significant effect on ROS and area burned by directly affecting relative humidity.

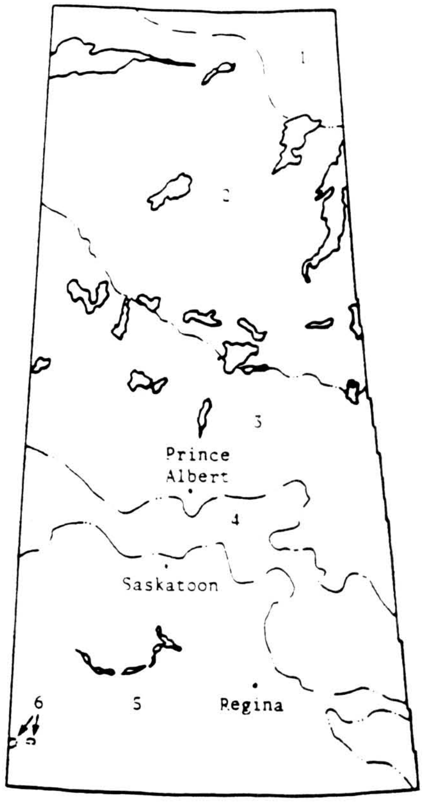

Figure 1. Ecological regions of Saskatchewan and associated major forest (or fuel) types (adapted from Harris et al 1989).

Legend

1 Subarctic Boreal Ecoregion
- black spruce

2 Northern Boreal Ecoregion
- jack pine, black spruce

3 Southern Boreal Ecoregion
- jack pine, black spruce, white spruce, poplar

4 Parkland Ecoregion
- aspen dominated

5 Grassland Ecoregion
- various grasses

6 Cypress Hills Ecoregion
- lodgepole pine

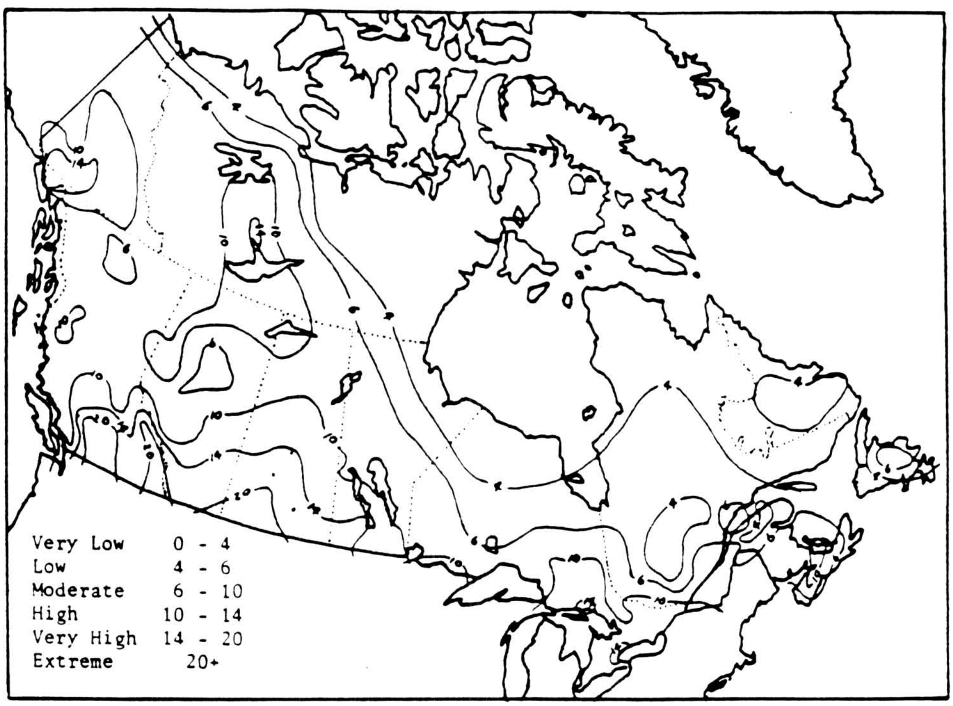

Figure 2. Forest fire weather zones of Canada based on average Fire Weather Index values for June, July, and August during 1957-66 (adapted from Simard 1973).

Table 1. Effects of various weather parameters[a] on fire rate of spread (ROS) and area burned in 1 hour following ignition (excluding acceleration phase) in the boreal spruce fuel type (Alexander et al 1984) on level ground with a previous day's Fine Fuel Moisture Code (Canadian Forestry Service 1984; Van Wagner 1987) of 89.

a) Temperature = 28°C; wind speed = 20km/h; rain = 0.0mm.

Relative Humidity (%)	ROS (m/min)	Area Burned (ha)
15	25.0	280
20	30.5	180
25	25.5	125
30	21.0	85
35	17.0	55

b) Temperature = 28°C; relative humidity = 30%; rain = 0.0mm.

Wind Speed (km/h)	ROS (m/min)	Area Burned (ha)
15	14.5	60
20	21.0	85
25	30.0	125
30	41.0	180
35	35.0	250

c) Temperature = 28°C; relative humidity = 30%; wind speed = 20km/h

Rain (mm)	ROS (m/min)	Area Burned (ha)
0.0	21.0	85
0.5	21.0	85
1.0	16.5	52
1.5	14.0	38
2.0	10.0	19
2.5	8.5	14

d) Relative humidity = 30%; wind speed = 20km/h; rain = 0.0mm.

Temperature (°C)	ROS (m/min)	Area Burned (ha)
15	13.5	35
20	15.5	45
25	19.0	70
30	23.0	100
35	27.0	140

[a] Noon weather readings (LST).

Historical Forest Fire Statistics

Two key indicators of fire activity are the number of fire starts and area burned. Examining their historical trends provides some insight into a changing fire environment (including fuel, weather and ignition sources). Examining national trends as well as provincial trends will show whether or not these changes are regional in scope.

Figure 3 shows national fire starts from 1918 (when records began) to 1989. It should be noted that statistics on fire starts and area burned became more accurate through time due to increased detection and surveillance capabilities. Although this may have a certain amount of influence on the statistics, there is a clear trend of increasing fire starts during the last three decades. Prior to that time period, there are two other notable trends. One is a general 8-11 year cycle of high and low fire starts. Although some authors have linked this pattern in some way to sunspot cycles (Wright 1940; Armstrong and Vines 1973), there has never been any generally accepted cause for this fire cycle. If a continuation of the previous cycle of fire years exists beyond 1960, it has become less distinct (or more variable) and perhaps shorter (4-8 years). A second trend is a slightly declining occurrence of fire starts up until 1960.

The national area burned statistics (Fig. 4) show similar trends to Figure 3. Prior to the mid-1960's, there appears to be a general cyclical nature to years of high and low area burned, while an overall decreasing trend prevailed. Following this period, there is a considerable increase in average annual area burned with peak years reaching unprecedented highs. This change in pattern is highly significant and the random chance of such an occurrence is very low (Van Wagner 1988).

A review of similar statistics for Saskatchewan (Figures 5 and 6) for 1951-90 indicates that the same trends exist. However, because the statistics only go back to 1951, only the pattern of increasing fire starts and area burned are seen. Also, the magnitude of the area burned in 1980 and 1981 prevents any pattern from being clearly visible in years with less than 250,000ha burned.

In regards to fire occurrence in Saskatchewan, total fire starts are divided into lightning fires (Figure 7) and man-caused fires (Figure 8). Although both show a general increasing trend for 1961-90, there does not appear to be any strong correlation between the two. For instance, a large increase in man-caused fires in 1976 is not similarly represented by lightning fires. Figure 7 also shows more year-to-year variability for lightning fires.

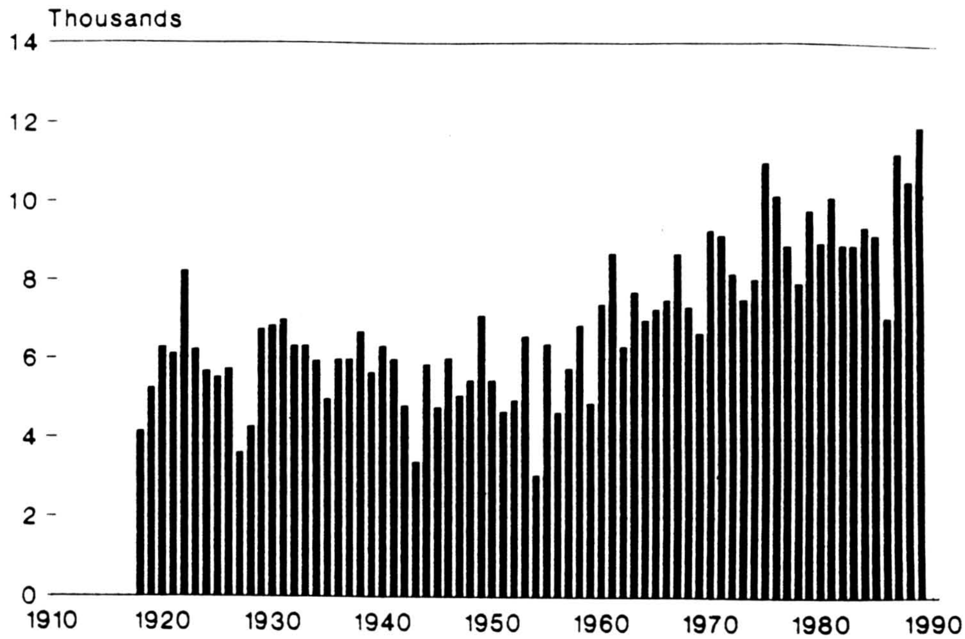

Figure 3. Annual forest fire starts in Canada (source: Forestry Canada (Petawawa) statistics and Canadian Committee on Forest Fire Management 1989, 1990).

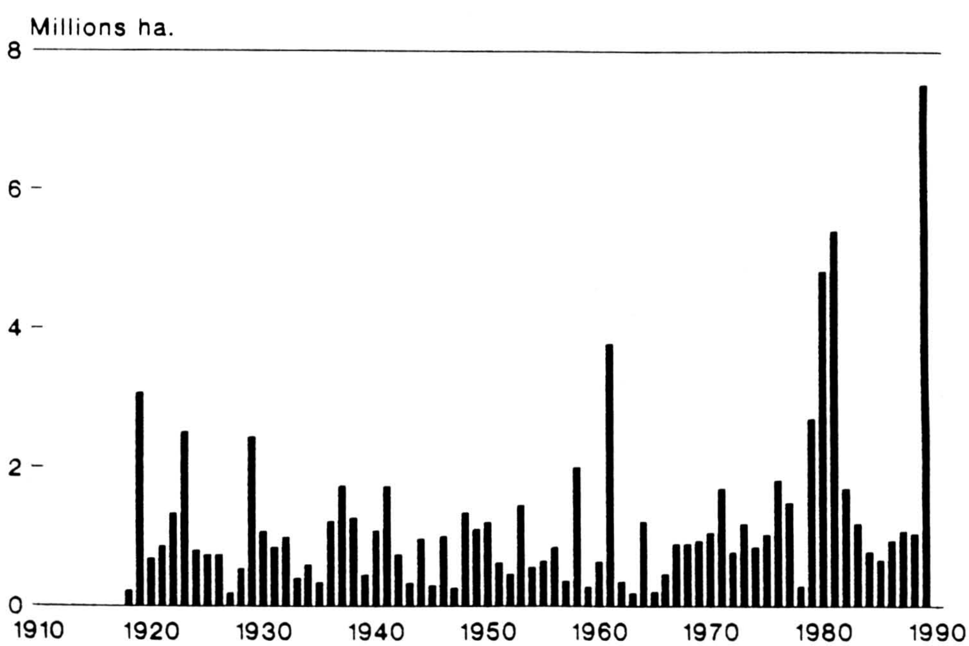

Figure 4. Annual area burned in Canada (source: Forestry Canada (Petawawa) statistics and Canadian Committee on Forest Fire Management 1989, 1990).

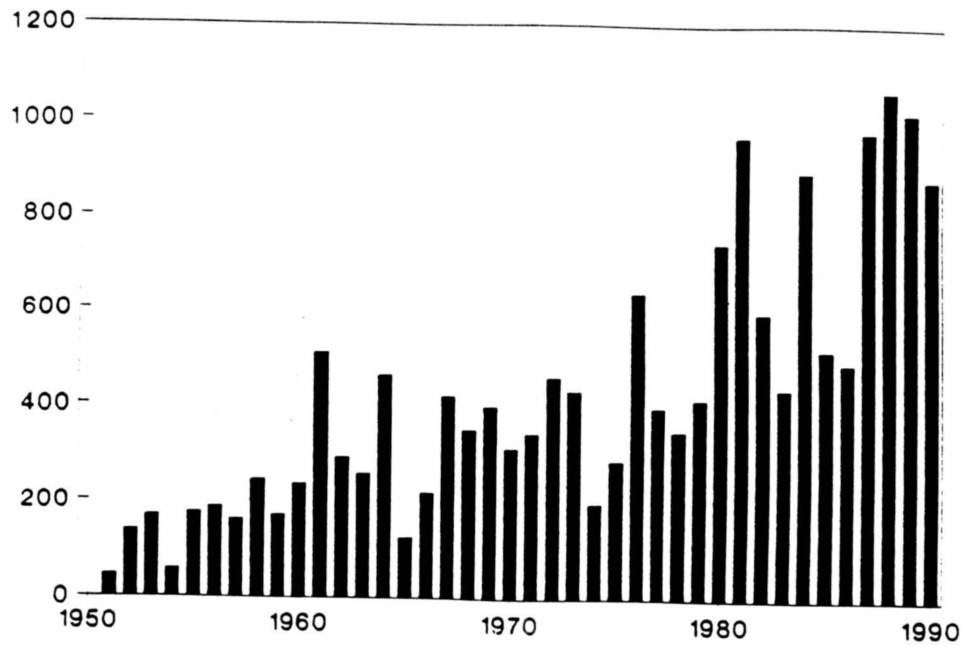

Figure 5. Annual forest fire starts in Saskatchewan (source: Forestry Canada (Petawawa) and Saskatchewan Dept. of Parks and Renewable Resources statistics).

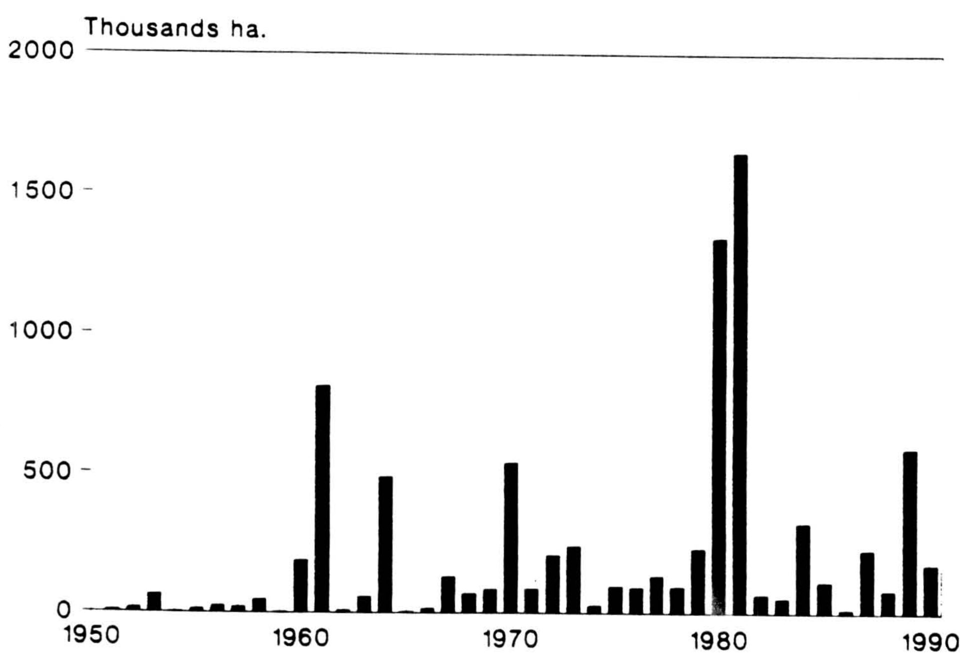

Figure 6. Annual area burned in Saskatchewan (source: Forestry Canada (Petawawa) and Saskatchewan Dept. of Parks and Renewable Resources statistics).

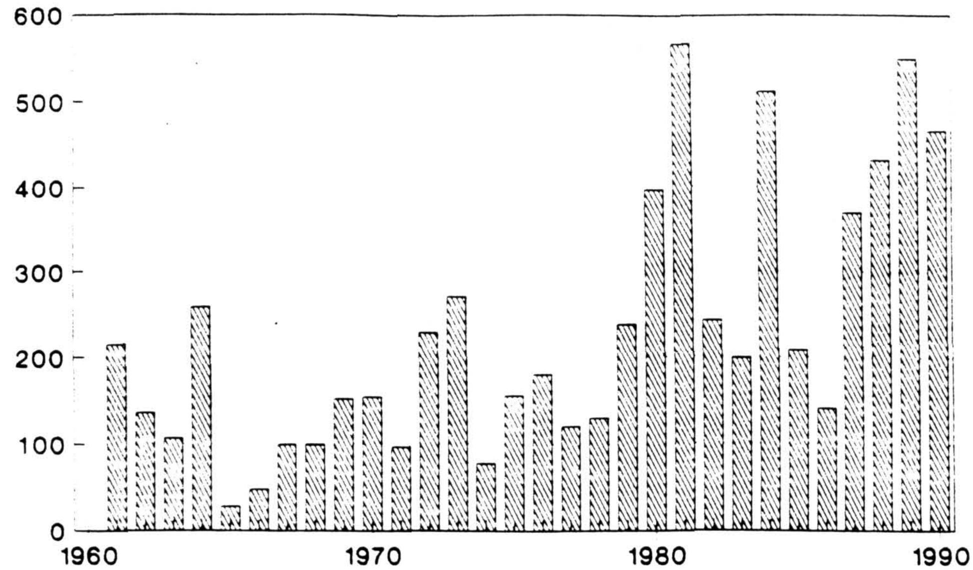

Figure 7. Annual lightning-caused fire starts in Saskatchewan (source: Sakatchewan Dept. of Parks and Renewable Resources statistics).

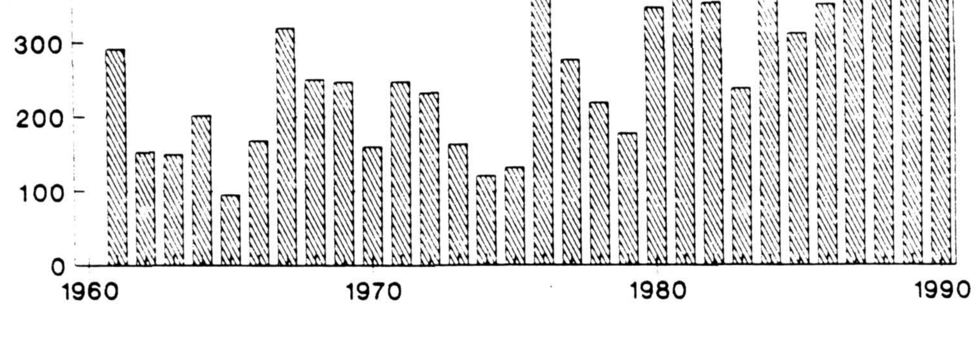

Figure 8. Annual man-caused fire starts in Saskatchewan (source: Sakatchewan Dept. of Parks and Renewable Resources statistics).

Discussion

The historical pattern of national fire starts can be divided into two periods: the slightly decreasing trend prior to 1960, and an increasing trend following. Although statistics for the period prior to 1951 are not available for Saskatchewan, it is presumed that a similar pattern likely exists.

The pre-1960 trend could be stronger than indicated because of poor detection capabilities during earlier years. The slight decrease during this period may be explained by normal variation (i.e., weather), or it could reflect an increased effort towards the reduction of man-caused fires.

Whatever the situation prior to 1960, the period following shows a substantial, but gradual increase. Figures 7 and 8 show that, in Saskatchewan, this is not caused specifically by either man or lightning alone. Both have increased during the last 3 decades, but not with similar patterns. Therefore, this increase in total fire starts does not appear to be caused solely by one factor which affects both ignition sources, such as weather. An increase in lightning frequency is possible, although it has not been clearly shown (Price and Rind 1990). The wide variation in lightning fires is best explained by weather conditions, and perhaps only slightly by lightning occurrence. On the other hand, increases in man-caused fires during the last 30 years could be explained by a combination of weather and increased access and use of the forest (including deliberate and accidental fires).

When dealing with the severity of any fire season, area burned is a good indicator because it shows general evidence of the occurrence, extent and duration of severe burning conditions. The only time this is not true is when severe burning conditions exist and ignition sources are extremely limited (which is a relatively infrequent occurrence).

The general decreasing trend prior to 1960 (Fig. 4) could be explained by increasing fire suppression capabilities. However, there has also been a large (but gradual) increase in area burned over the last 30 years despite dramatic increases in suppression capabilities during this same time period. This indicates how significant the increase in general fire season severity has been, especially during the last decade.

It is not possible for any fire management agency to stop all fires; indeed, there is an upper threshold of burning conditions where suppression resources are no longer effective. The 'peaks' in annual area burned in Figure 6 indicate years of extreme fire activity; this is also a reflection of years when the threshold of suppression capability was surpassed. There is clear separation between peak years and less severe years. What is important to note though, is that the amount of area burned during non-peak years has increased substantially since the 1950's, and the peak years are setting new highs. This occurred despite tremendous advances in suppression capability. Again, this indicates the immense change in burning conditions which has taken place during that time period.

Because the current level of area burned during non-peak years is greater than earlier years (Figs. 4 and 6), an increase in the level of suppression capabilities is also indicated. In other words, the present level of 'average' seasonal fire severity would likely result in a 'peak' if it occurred in earlier years. The threshold of successful suppression action has been raised in recent years as a result of advances in research, technology and fire management operations. The importance of this higher threshold is apparent when the increases in fire starts and burning conditions are noted.

Finally, the effect of forest fuels on recent statistics should be mentioned. As stated previously, fuel and weather are the primary factors affecting fire activity. It is generally accepted that the last 5-7 decades of fire suppression have had an effect on forest fuel loads. It has been postulated that changes in fuel load and condition (Day et al 1990) and age-class distribution (Van Wagner 1978), as a result of successful fire suppression programs in the past, may be contributing to greater wildfire control problems today. It is possible that this may be increasing the suppression problems already being experienced as a result of the occurrence of extreme burning conditions.

Conclusion

Although there are many factors affecting the severity of any forest fire season, it is obvious that weather plays a lead role in determining its eventual outcome. There is no doubt that the increases in fire starts and area burned during the last 2-3 decades is substantial. Even though it is not known whether this period of increasing fire activity will continue (or for how long), it is known that recent increases in suppression capabilities have prevented significant additional losses. The direct effect of climate variation is seen in fire statistics; the indirect effect is that fire management agencies have been forced to stay on the forefront of fire science and technology in order to meet their objectives.

Acknowledgements

Thanks are due Doug Higgins (Forestry Canada - Petawawa) for providing national and provincial statistics; and Wendy De Groot (Saskatchewan Forest Fire Management Branch) for providing additional provincial statistics.

References Cited

Alexander, M.E.; Lawson, B.D.; Stocks, B.J.; Van Wagner, C.E. 1984. User guide to the Canadian Forest Fire Behavior Prediction System: rate of spread relationships. Interim edition. Environment Canada, Canadian Forestry Service, Fire Danger Group. 73 p. + supplements. [1st printing - July 1984; revision and 2nd printing - Sept. 1984].

Armstrong, J.; Vines, R.G. 1973. Possible periodicities in weather patterns and Canadian forest fire seasons. Canadian Forestry Service, Forest Fire Research Institute, Information Report FF-X-39. 22 p.

Canadian Forestry Service. 1984. Tables for the Canadian Forest Fire Weather Index System. Fourth edition. Environment Canada, Canadian Forestry Service, Ottawa, Ontario. Forestry Technical Report 25. 48 p.

Canadian Committee on Forest Fire Management. 1989. Reports tabled at 1989 annual meeting, Quebec City, Que. (Jan. 24-26, 1989). National Research Council, Ottawa.

Canadian Committee on Forest Fire Management. 1990. Reports tabled at 1990 annual meeting, Sault Ste. Marie, Ont. (Jan. 23-25, 1990). National Research Council, Ottawa.

Day, D.L.; White, C.A.; Lopoukhine, N. 1990. Keeping the flame: Fire management in the Canadian Parks Service. Pages 35-47 in The Art and Science of Fire Management, Proceedings of the First Interior West Fire Council Annual Meeting and Workshop (Oct. 24-27, 1988, Kananaskis Village, Alberta), M.E. Alexander and G.F. Bisgrove (eds). Forestry Canada, Edmonton, Alberta. Information Report NOR-X-309.

De Groot, W.J. 1987. Examples of Canadian Forest Fire Behavior Prediction System fuel types in Saskatchewan. Canadian Forestry Service, Saskatchewan District Office, Prince Albert, Saskatchewan. Poster (w/text).

Harris, W.C.; Kabzems, A.; Kosowan, A.L.; Padbury, G.A.; Rowe, J.S. 1989. Ecological regions of Saskatchewan. Saskatchewan Parks, Recreation and Culture, Forestry Branch, Regina, Saskatchewan. Technical Bulletin No. 10. 57 p.

Price, Colin; Rind, David. 1990. The effect of global warming on lightning frequencies. Pages 748-751 in 16th Conference on Severe Local Storms - Conference on Atmospheric Electricity (Oct. 22-26, 1990, Kananaskis Park, Alberta). American Meteorological Society, Boston, Mass.

Simard, A. 1973. Forest fire weather zones of Canada. Canadian Forestry Service, Forest Fire Research Institute. (poster)

Van Wagner, C.E. 1978. Age-class distribution and the forest fire cycle. Canadian Journal of Forest Research 8:220-227.

Van Wagner, C.E. 1987. Development and structure of the Canadian Forest Fire Weather Index System. Canadian Forestry Service, Forestry Technical Report 35. 37 p.

Van Wagner, C.E. 1988. The historical pattern of annual burned area in Canada. Forestry Chronicle 64:182-185.

Wright, J.G. 1940. Sun spots and forest fires in New Brunswick. Forestry Chronicle 16:231-238.

SASKATCHEWAN CLIMATE ADVISORY COMMITTEE

PROCEEDING OF THE WORKSHOP

"NATURAL RESPONSE TO CLIMATE VARIABILITY"

October 30, 1990

Regina, Saskatchewan

Table of Contents