Forest Research Branch

A METHOD OF MEASURING FIRE RATE-OF-SPREAD IN EXTRACTED SAMPLES OF GROUND VEGETATION

by

S. J. MURARO

Sommaire en français

DEPARTMENT OF FORESTRY PUBLICATION No. 1081

1964

ABSTRACT

A method of extracting undisturbed samples of ground vegetation and of burning whereby weight loss, area of burn and flame height were determined, is described.

Using the method, fire rate-of-spread was measured in the litter and in other ground cover occurring in lodgepole pine stands. Rate-of-spread was found to be independent of litter depth.

Published under the authority of

The Honourable Maurice Sauvé, P.C., M.P.,

Minister of Forestry

Ottawa, 1964

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1964

Catalogue No. Fo 47–1081

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by

S. J. MURARO[2]

INTRODUCTION

The weight and depth of the unconsolidated and consolidated forest litter layers were measured in 1961 in an evaluation of fuel complexes near Kamloops, B.C. (Muraro, 1962). The work was time-consuming and the results questionable due to the human judgment involved and the difficulty of separating the two fuel components. This prompted further consideration of the litter layer and its effects on the spread of wild fires. The hypothesis was advanced that, although the litter layer under coniferous stands furnishes a continuous fuel bed, the compaction of litter from all except long needle species allows for little more than a two-dimensional fuel complex at the fire front, regardless of the depth of the litter layer. The hypothesis was qualified to exclude the long-needled pines, because the relatively loose litter layer resulting from these species allows better aeration and consequently, a three-dimensional fuel complex. In a study of the fuel complex in red pine plantations in the Lake States, only the upper ½ inch of litter was classed as flash fuel, regardless of the total depth of litter (LaMois, 1958).

This project was designed (a) to test this hypothesis in litter occurring under stands of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) near Merritt in south central British Columbia; and, (b) to obtain some potential fire rate-of-spread values for surface fuel types commonly associated with lodgepole pine. Because of adverse weather conditions during the 1962 field season, vandalism of apparatus and camera breakdown, the results were rather disappointing. However, the sampling and testing techniques may be of interest.

SAMPLING

Fifty-nine samples of surface fuels under 80-year-old lodgepole pine stands of varying densities were extracted for testing. Thirty-one were of the litter type consisting wholly of needles and twigs under 1/10 inch in diameter; 11 of dwarf huckleberry (*Vaccinium* spp.); 6 of pine grass (*Calamogrostis* spp.); 6 of false box (*Pachystime* spp.); and 5 of a moss type.

Two-foot-square samples were extracted using the following procedure: The downslope edge of a sample area was exposed with a vertical-faced trench 6″ deep, slightly longer than the sample and wide enough to provide the necessary working area. A sharpened edge of a two-foot-square sheet-iron plate was driven into the vertical face about 3 inches below the AH layer, parallel to the surface. With the plate driven in to its full extent, the three remaining edges of the sample were trimmed using the buried plate as a guide. The plate with the sample was lifted clear and the sample slid into a shallow, two-foot-square, cardboard tray for transportation. Samples were left in the trays for uniform exposure on elevated racks at a test site. This technique provided undisturbed samples if areas of surface rock or large roots were not encountered. A total of nine man-days of labour provided the 59 samples.

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[1]Department of Forestry, Canada, Forest Research Branch Contribution No. 633.

[2]Research Officer, Dept. of Forestry, Forest Research Branch, Victoria, B.C.

BURNING TESTS

A burning apparatus was constructed to allow a progressive measure of flame length, area of burn and loss of weight due to combustion (Figure 1). It consisted of a 12-foot balanced wooden beam with the sample suspended from one end. At the opposite end a weight was suspended which slightly more than counter-balanced the system. One side of the sample holder supported a gallows arrangement to which was attached a 35 mm. sequence camera 6 feet above the sample. At the same edge of the holder, a scale to measure the height of the flame was attached so that both the flame and the scale would be reflected to the camera from a mirror placed at a 45° angle at the opposite side of the holder. A 500-gram spring balance supported the weighted end of the system, establishing equilibrium and providing a means of measuring the loss of weight resulting from combustion. A psychrometer and a sensitive anemometer were used to measure relative humidity and wind speed at the burning level. Three plywood walls shielded the structure from wind and provided shade for the burning platform.

The apparatus worked exceptionally well and proved to be a suitable arrangement for measuring very small changes in weight of relatively heavy objects. Weight losses as small as 10 grams were measured with no difficulty in samples weighing up to 34 kilograms. A similar arrangement would be useful for determining changes in moisture content of heavy samples of fuels.

It was originally intended that the samples be burned after being uniformly exposed to a drying regime of at least one week. August 1962 had no such drying regime and very few days suitable for burning, so the burning tests were not completed until late September. No photographic record of flame heights was obtained because the plywood screen and mirror were destroyed by vandals while the apparatus was unattended.

Following a two-week period of clear warm weather, the samples were burned during the period 1300 to 1700 hours, standard time, on September 23, 24 and 25. One operator loaded the sample and recorded the depth of litter at four points, one at each of the four diagonal radii 10 inches from the centre. The second operator counterbalanced the system and recorded the relative humidity and weight on the balance. The sample was ignited at the centre using small alcohol-soaked wads of cotton batten, and the anemometer and stopwatch were set in motion. At pre-arranged intervals the balance, was read and a photograph taken of the burning sample. When the fire had progressed to one edge of the sample, the test was concluded. Total time, relative humidity, and total passage of wind were recorded on a prepared form. To avoid disturbing the samples, and because a section from the edge of the tray would be representative of only the perimeter, fuel moisture content of the surface litter was determined using equilibrium moisture content tables. After only 13 samples were burned, the film rewind mechanism in the camera became faulty; only lineal rate-of-spread data were recorded for the remainder of the fires. In all, 59 samples were burned. (Table 1).

The film negative strips of the 13 photographed samples were mounted in cardboard holders and projected for tracing, at a constant scale, on squared paper. Poor contrast on some of the negatives was first rectified by placing them on a ground glass light table and outlining the burned areas. (Figure 2). Preliminary tests showed that photo contrast between burned and unburned areas was more pronounced when the sample was shaded—another purpose of the plywood screen which was not available at the time of burning.

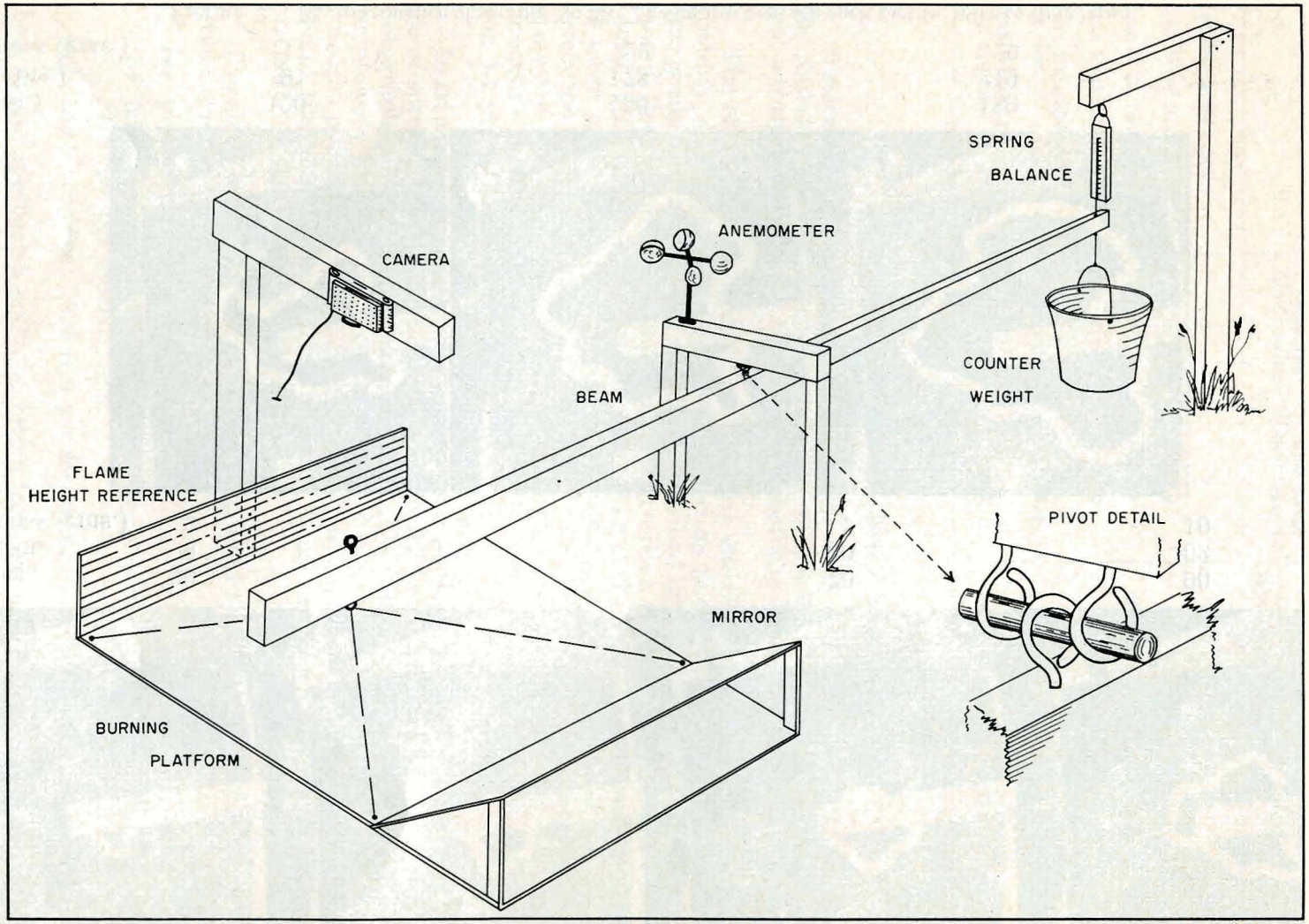
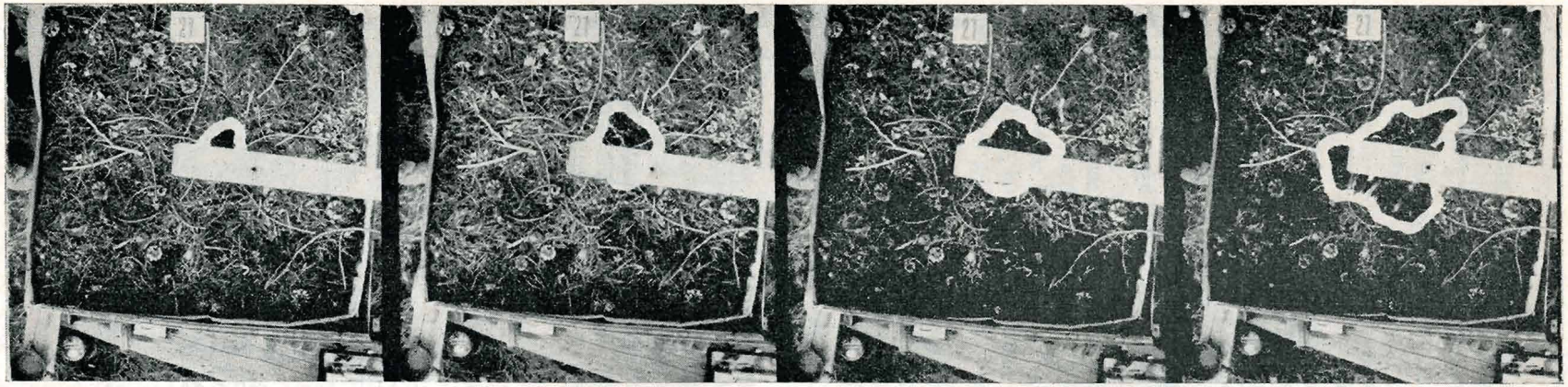
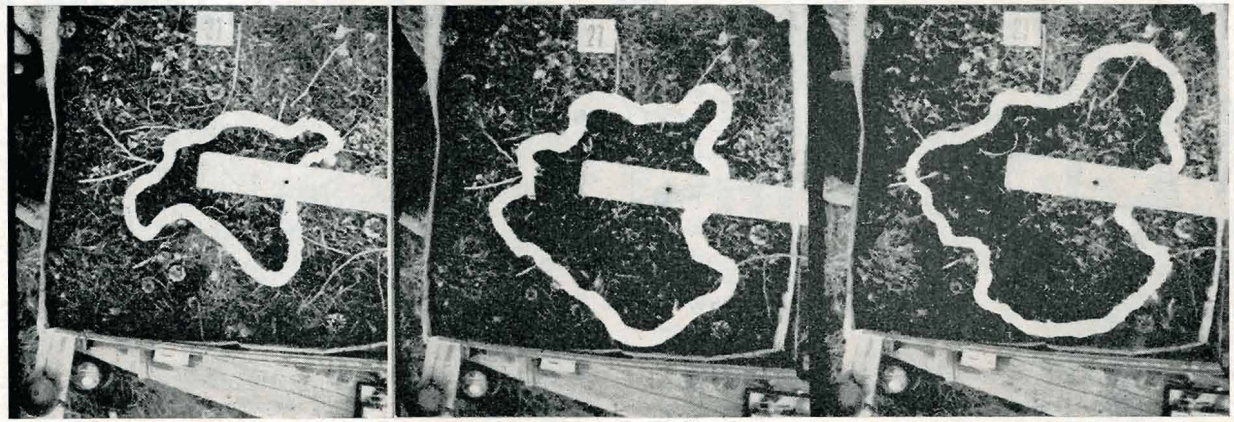


FIGURE 1. Apparatus used to determine area of burn, flame height and weight loss



Time (secs.)	30	50	70	90
Area (sq. ins.)	9	22	30	62
Weight Loss (gms.)	2	5	7	10



Time (secs.)	120	150	180
Area (sq. ins.)	91	173	219
Weight Loss (gms.)	17	22	29

FIGURE 2. Photo sequence of sample No. 27. The figures beneath each picture refer to time lapse after ignition, measured area, and weight loss on the burned area.

TABLE 1. BURNING CONDITIONS AND CHARACTERISTICS OF SIX GROUND VEGETATION TYPES

	False Box (Pachystima)	Pine Grass (Calamogrostis)	Dwarf Huckleberry (Vaccinium)		Pine Litter	Mosses
			Moderate	Light		
Number of Samples	6	6	6	5	31	5
Mean Wind ft./sec	4.5	6.9	4.9	4.2	4.4	4.2
Mean R.H. %	34.0	31.8	32.3	31.6	33.4	36.4
Mean Depth inches	5.1	5.3	4.0	1.6	1.3	1.5
Mean Rate-of-Spread ft./sec	.018	.079	.017	.017	.009	.015
Mean Weight Loss grams/min	31.6	33.7	34.9	19.4	13.8	17.2

ANALYSIS AND DISCUSSION

Snedecor's F test (Moroney, 1951) was used to test the variability of the four measurements of litter depth taken on the 31 litter samples. Differences were not significant at the 10 per cent probability level.

The effect of each of three independent variables — wind velocity, relative humidity, and depth of litter — was tested on lineal rate of fire spread for the same group of samples using a method described by Beall (1938). These analyses showed that wind speed had a marked positive correlation with fire rate-of-spread (Figure 3); relative humidity showed a slight negative correlation, becoming more pronounced at 38 per cent (Figure 4); and depth of litter showed no correlation. Moisture content was not used as a variable in any of these analyses because of the relatively small differences measured — from 6.7 per cent to 9.0 per cent in the photographed samples. In all the samples, moisture content ranged from 5.1 per cent to 9.0 per cent.

In an attempt to find a relationship between depth of litter and the measured rate-of-spread, further methods of graphically analyzing the results of the 13 photographed litter samples were explored. Dependent variables tested included fire intensity in Btu's per second per foot of fire front (Davis, 1959), mean loss of weight per unit area burned, and loss of weight per unit area burned at the time of the lineal rate-of-spread measure. None of these variables showed any correlation with depth of litter.

The lineal rate-of-spread values for all ground vegetation types fell into three distinct classes:

(a) pine grass, (.079 feet per second);

(b) false box, two densities of dwarf huckleberry and the moss type (.015 to .018 feet per second); and

(c) the litter type, (.009 feet per second).

These values approach a potential rather than normal rate-of-spread for the false box and vaccinium types since it is doubtful that as high a percentage of dead vegetation would occur under normal habitats. The moss type, did not change in appearance during the exposure period, while the pine grass attained a state of cure often evident in the fall or in the spring prior to "greenup".

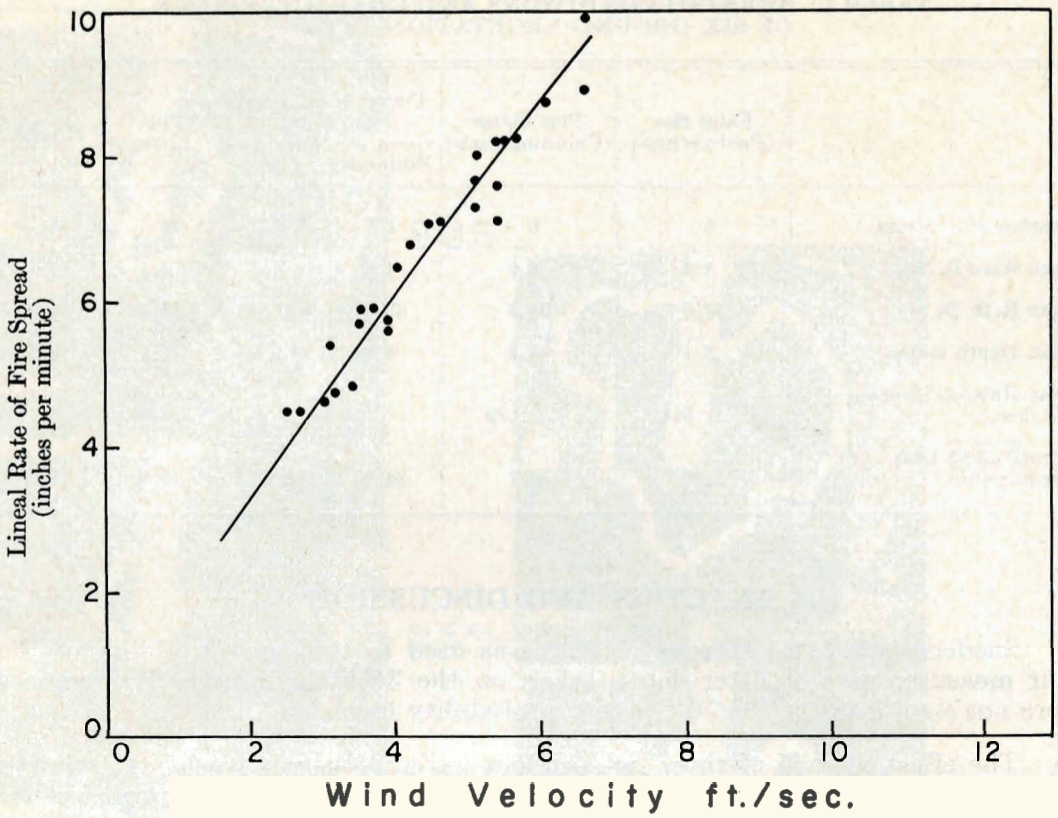


FIGURE 3. Effect of Wind on Fire Rate-of-Spread at 37.5% R.H.

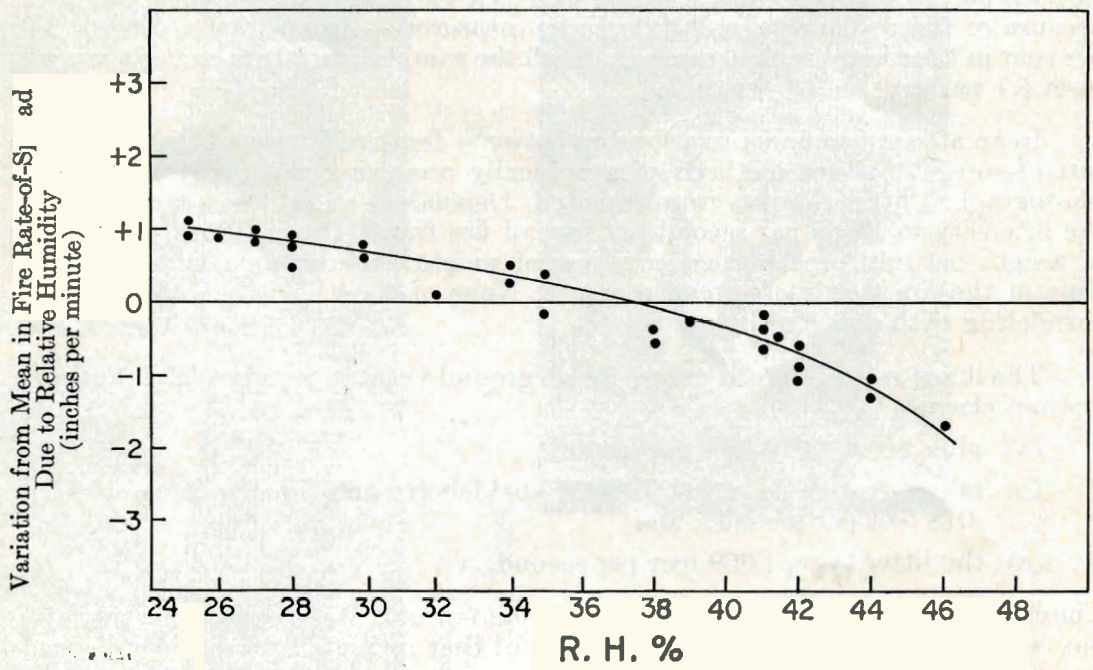


FIGURE 4. Effect of Relative Humidity on Fire Rate-of-Spread

CONCLUSIONS

Within the limited variability of litter depth tested in this study, there was no apparent relationship between depth of litter and fire rate-of-spread. This indicates that no measurement of the depth of litter may be necessary when evaluating rate-of-spread in the lodgepole pine fuel complex. A marked positive correlation between wind velocity and rate-of-spread and a slight negative correlation with relative humidity and rate-of-spread were shown.

This study has also shown the feasibility of the method used for extracting undisturbed samples of ground vegetation, and a technique for determining small changes in the weight of a relatively heavy sample.

SUMMARY

Fifty-nine extracted samples of ground vegetation, measuring two feet square and including 31 samples of litter, were burned using a device designed to measure fire rate-of-spread, weight loss due to combustion, and flame height.

The limited number of tests that were tried in pine litter showed that, in the range of litter depth tested, fire rate-of-spread was independent of litter depth. A pronounced direct variation with wind velocity and a weak inverse relation with relative humidity and rate-of-spread were indicated.

SOMMAIRE

Cinquante-neuf échantillons de végétation basse, dont 31 étaient de la litière, et provenant chacun d'un carré de deux pieds carrés de superficie, ont été brûlés à l'aide d'un appareil à mesurer l'allure de propagation du feu, la perte de poids causée par la combustion, ainsi que la hauteur des flammes.

Le nombre limité d'essais portant sur la litière de pin a révélé que, dans la marge d'épaisseur de litière étudiée, l'allure de propagation du feu est la même, quelle que soit l'épaisseur de la litière. Les résultats des expériences indiquent qu'il existe un rapport progressif direct entre la vitesse du vent et la vitesse de propagation du feu, d'une part, et un faible rapport inverse entre la teneur en humidité de la litière et de la végétation, et la vitesse de propagation du feu, d'autre part.

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