A CONTROLLED EXPERIMENT TO STUDY FACTORS INFLUENCING FIRE RATE OF SPREAD IN P. PINASTER LITTER

by

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INTRODUCTION

To study fire rate of spread in relation to independent variables under natural conditions can be compared with attempting to play bridge without knowing the rules. An attempt has been made therefore, to discover some of the rules of fire rate of spread by burning beds of P. pinaster needles under controlled conditions. The independent variables studied were fuel depth, moisture content, slope, and wind speed.

APPARATUS AND METHOD

(a) Fire Model

The fire model was circular, of two-foot radius. Such a circle was described upon a metal-covered board by a perimeter of upright six-inch nails. After ignition at the centre, rate of spread was timed with a stop-watch over the radius, a visual estimate of flame height being recorded at the same time. Sufficient interval was allowed between fires for the metal sheeting to cool.

(b) Control of Litter Moisture Content

The bulk fuel was stored in an old tobacco kiln, which was equipped with a heating system. High moisture contents were achieved by sprinkling the litter with water over a period of several days. Once the needles were saturated, then the temperature of the kiln was raised, whilst the litter was constantly turned and mixed to ensure uniformity. As soon as the litter was dry enough to burn, experimental fires were commenced, and the fuel drying continued until an O.D.M.C. of 5% was achieved. Moisture contents were determined from tin samples collected immediately before each fire.

(c) Control of Fuel Depth

The beds of litter were prepared upon the metal-covered board mentioned above. Litter was spread as evenly as possible, then ten depth readings taken with a gauge. The mean of these readings was accepted as the fuel depth for that bed.

(d) Control of Slope

A range of slopes was obtained by propping the board up at a progressively greater angle. The angle was measured with a clinometer.

(e) Control of Wind

The fires were burnt inside a shed, thus excluding natural wind. Figure 1 shows how a range of controlled wind was obtained. The shed was divided into two compartments with a gap under the partition. A vigorous fire was lit in one compartment, causing a convective updraught, which escaped through a vent in the roof. This led to a horizontal airflow through the gap under the partition, and the speed of this flow could be altered by changing the intensity of the convection fire. The size of the gap was also changed by means of a sliding door, but this was not so effective. Fresh air was admitted through a tunnel to exclude external gusts, and an anemometer in the tunnel recorded air-speed. The experimental fire was placed in the horizontal airstream.

RESULTS

(a) Fuel Depth and Moisture Content

These were studied together under conditions of nil slope and nil wind. Depths of litter burned ranged from 0.5" to 7.0", and moisture contents from 5% to 40%. The results are shown in Figure 2. Rate of spread is influenced by both variables. In general, the greater the fuel depth, and the lower the moisture content, the faster the R.O.S. An interesting relationship was also noted between flame length, fuel depth, and rate of spread, and this is shown in Figure 3.

(b) Slope

A range of slopes from 5° to 40° was studied, the back and headfire R.O.S. being recorded. The backfire, burning down the slope, appears to be the same as the basic rate of spread, determined by fuel depth and moisture content. The headfire R.O.S. however, increased with slope and Figure 4 shows the exponential relationship between slope and the ratio of H.F.R.O.S. to basic R.O.S.

(c) Wind

A range of winds from 0 to 6 m.p.h. at ground level was recorded, and again H.F.R.O.S. and B.F.R.O.S. noted. Figure 5 shows an exponential relationship similar to that for slope, with the interesting difference that the effect of wind seems to be determined by the quantity of fuel present, here represented by fuel depth. Hence the ratio of wind to fuel depth bears an exponential relationship to the ratio of H.F.R.O.S. to basic R.O.S.

DISCUSSION

The experiment yielded some clearly defined functions for the four independent variables studied. The effects of fuel depth, moisture content, and slope are straight-forward. The effect of wind is slightly more complex, and deserves a little discussion. If we consider a fire burning under still conditions, then there will be a vertical convection column, the velocity of which will be a function of the quantity of fuel burning. If now we apply a horizontal wind, then we have a vector situation, in which the resultant will govern flame angle, and so H.F.R.O.S. Hence for a constant vertical convection velocity, increasing horizontal wind will increase the H.F.R.O.S. For a constant horizontal wind, however, an increase in vertical velocity due to an increase in available fuel will decrease the ratio of H.F.R.O.S. to basic R.O.S. It should be remembered here that the increase in available fuel will increase basic rate of spread, and so the actual H.F.R.O.S. may increase or decrease, depending on the particular situation.

It is intended to apply the results here obtained to a study of R.O.S. under natural conditions. Whilst recognizing that the controlled conditions are different from natural ones, it is felt that enough similarities exist to make it probable that the functions will remain similar. It will be necessary to define what fuel depth in nature is equivalent to the fuel depth measured in the experiment, and the flame length, R.O.S., fuel depth relationship will be useful for this purpose.

The sequence visualised is firstly to establish a basic R.O.S. from fuel depth and moisture content. This basic R.O.S. will then be multiplied by a factor representing wind effect, and another representing slope effect, to give an adjusted R.O.S. To this will be added a spotting R.O.S. giving a final predicted H.F.R.O.S.

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Figure 1.

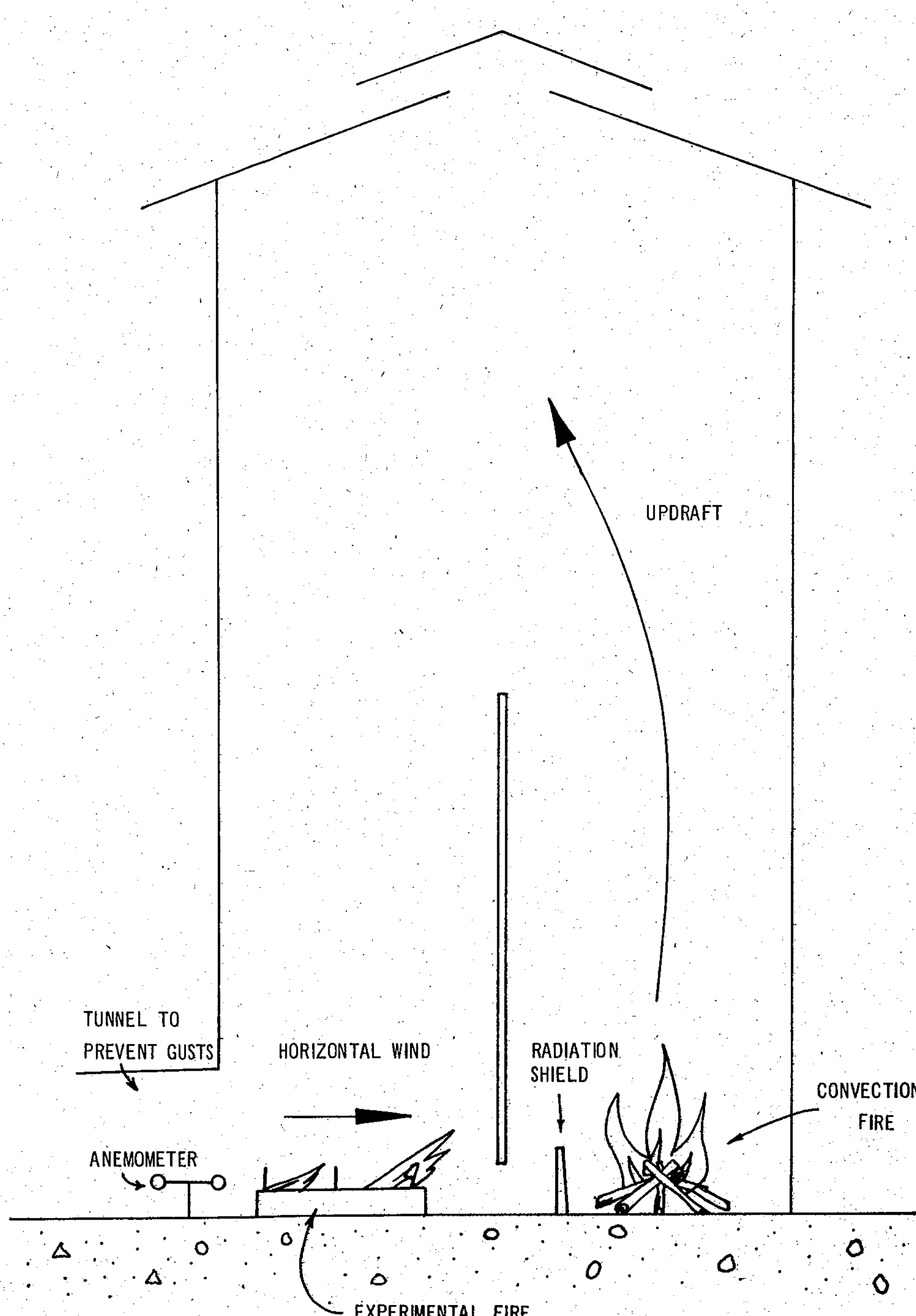
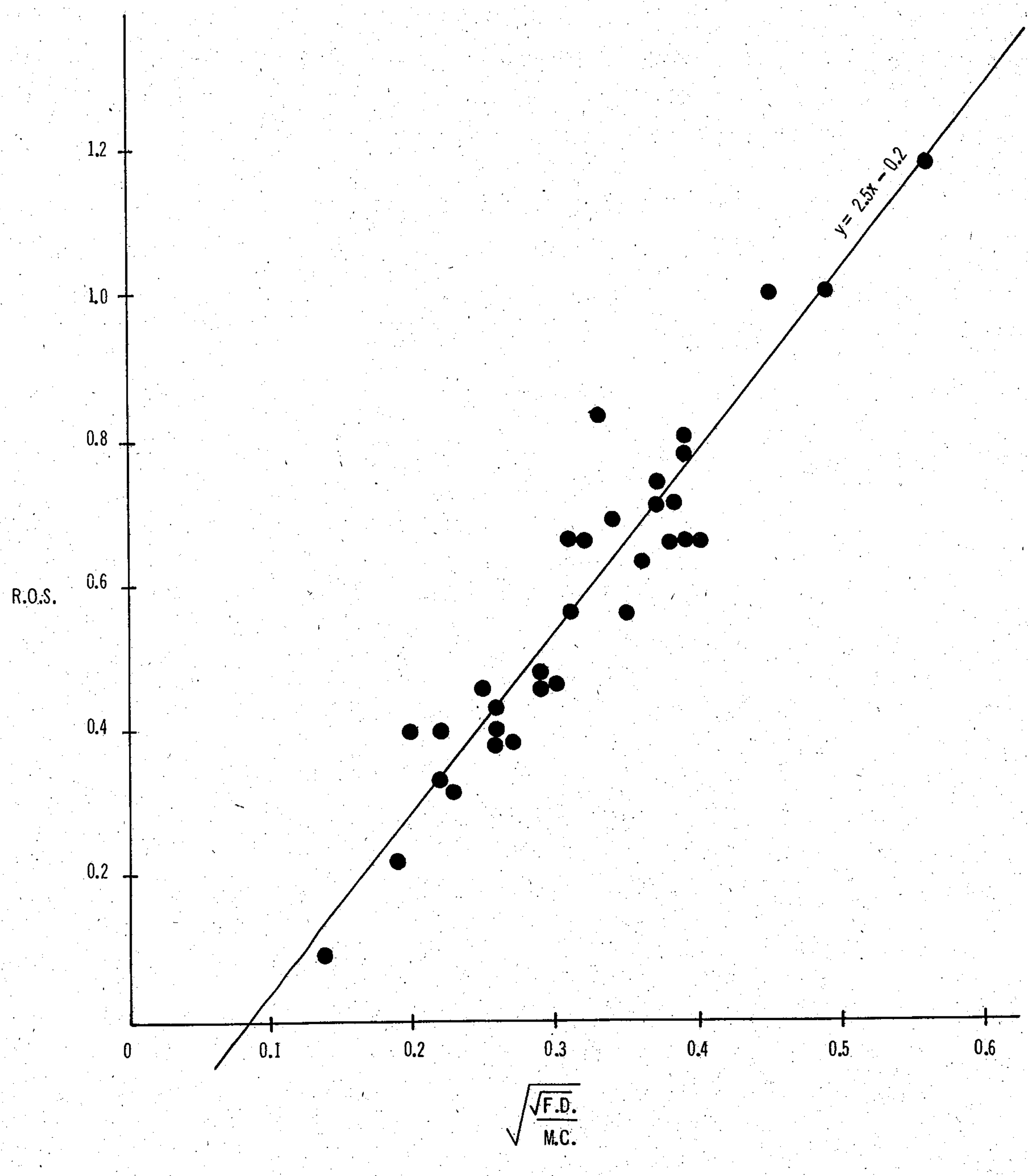
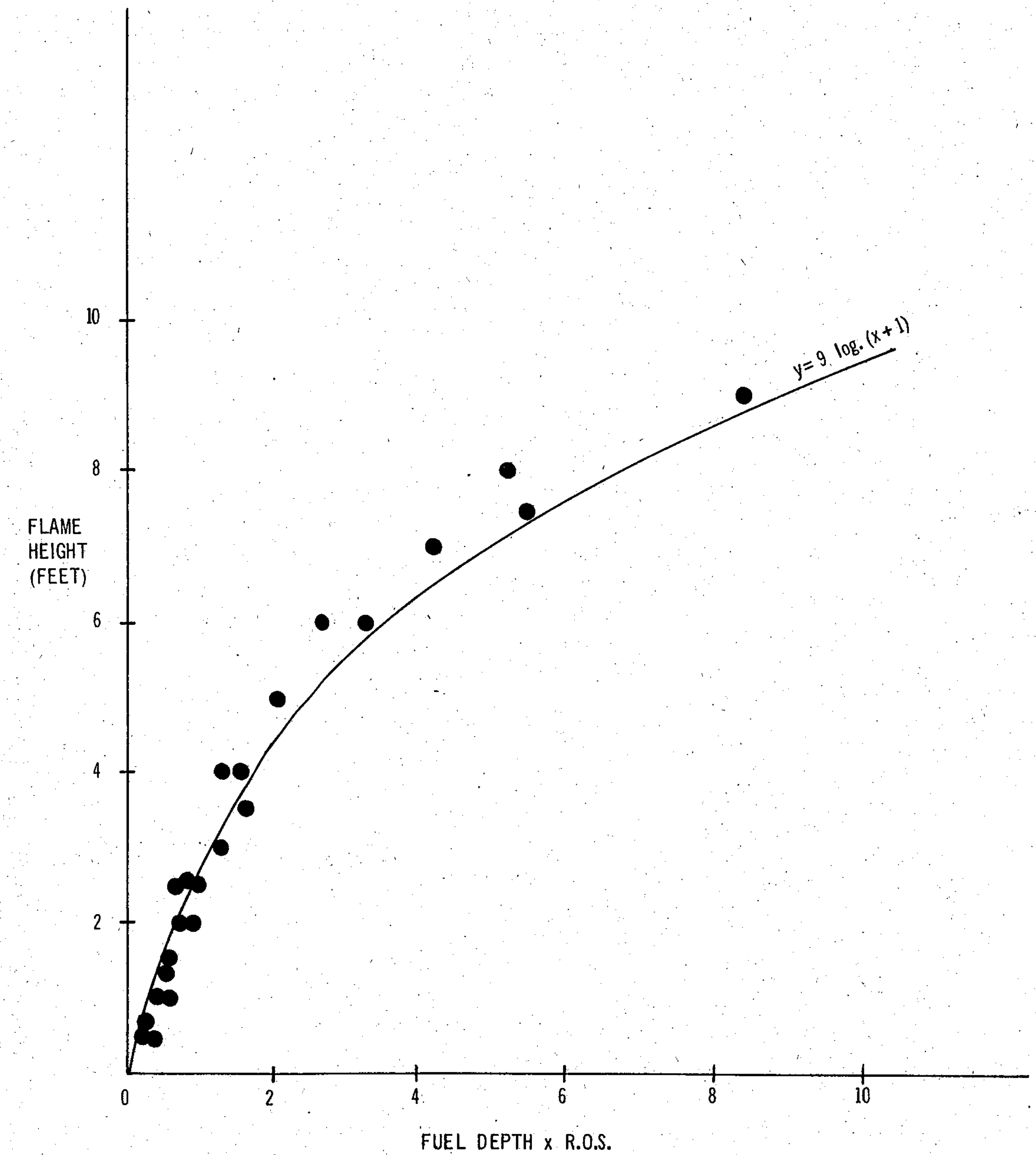

UPDRAFT
TUNNEL TO
PREVENT GUSTS
HORIZONTAL WIND
RADIATION
SHIELD
CONVECTION
FIRE
ANEMOMETER
EXPERIMENTAL FIRE

Figure 2.



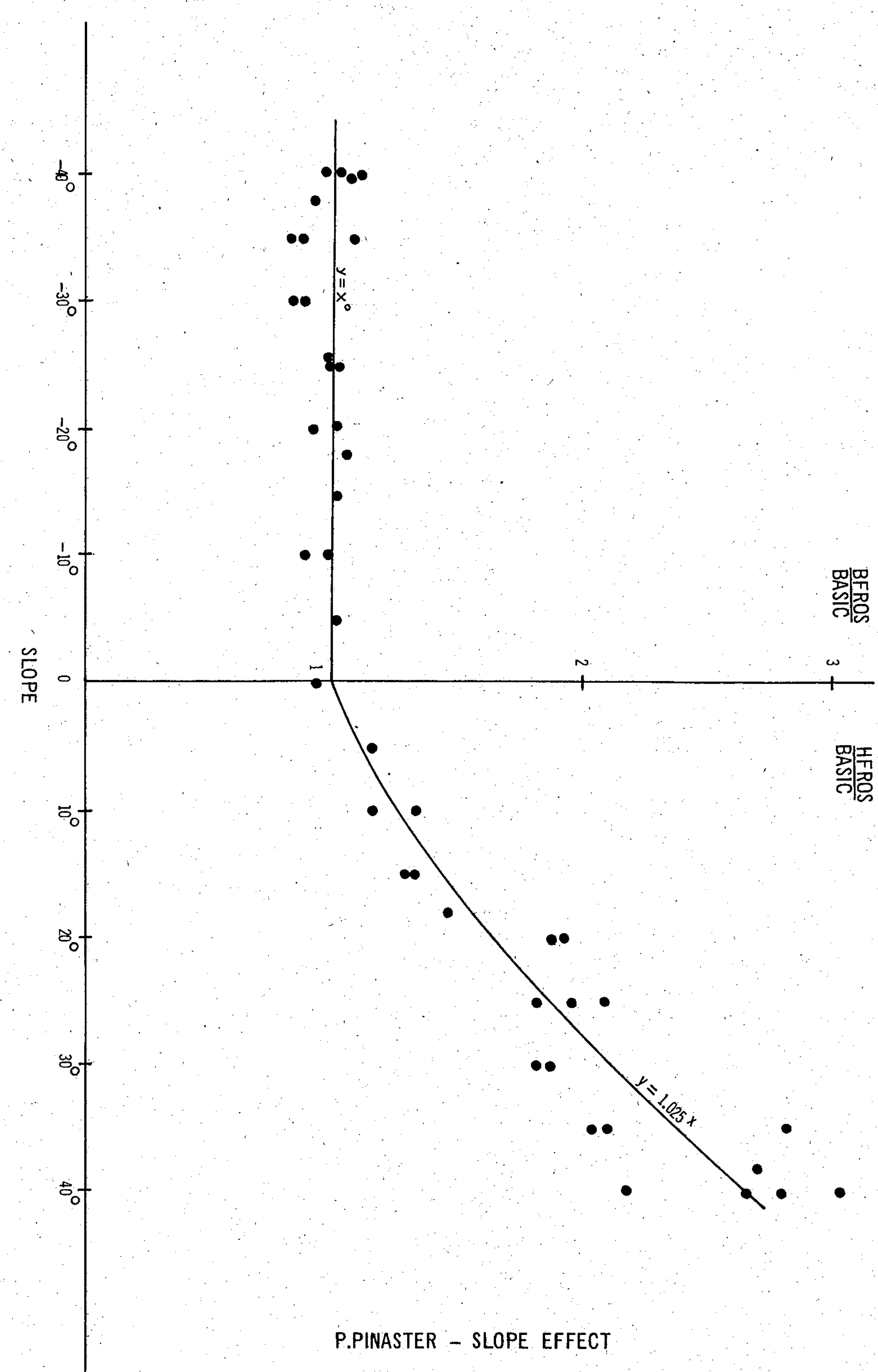
P.PINASTER – NO WIND – NO SLOPE

Figure 3.



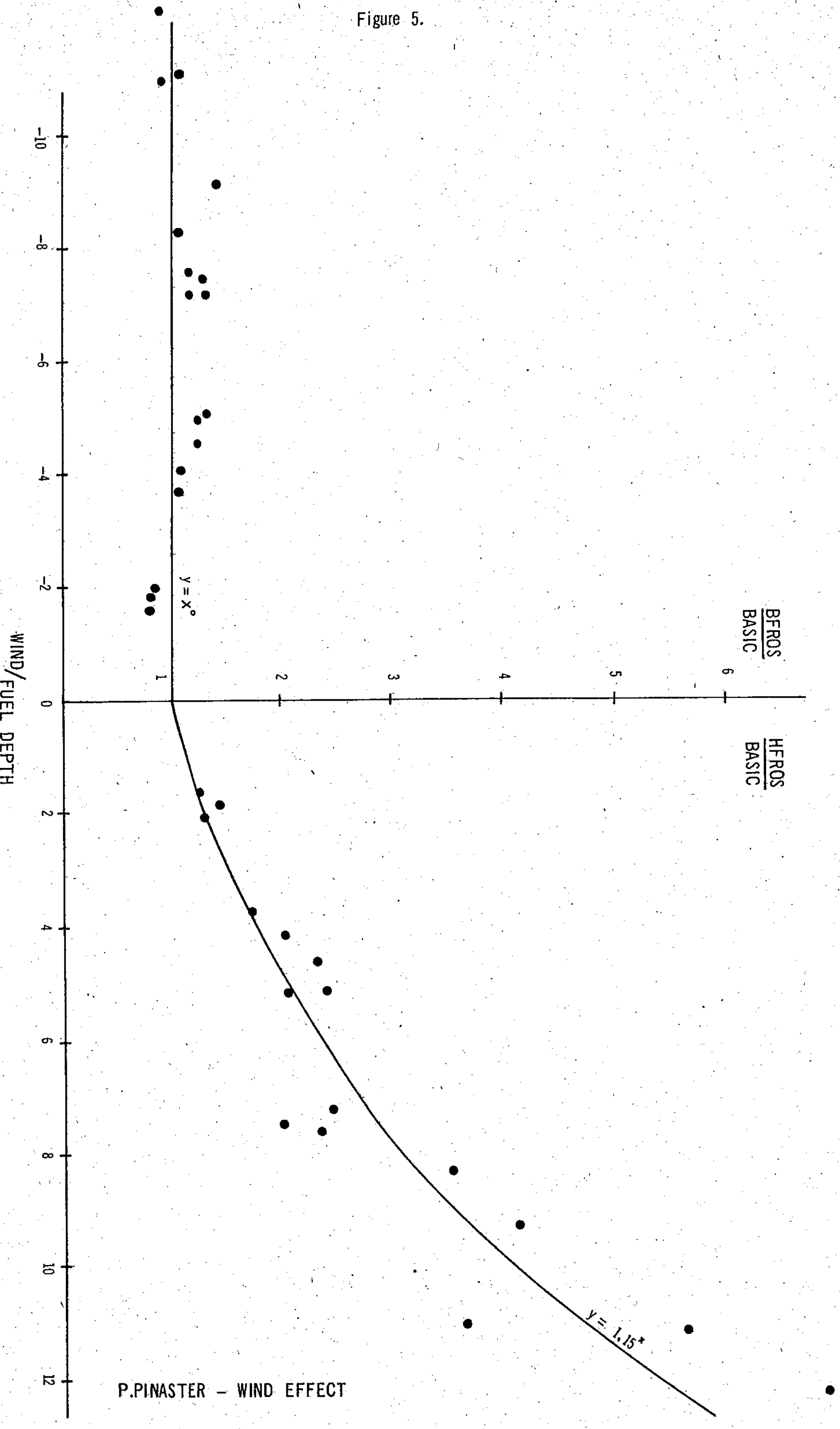
P.PINASTER – NO WIND – NO SLOPE

Figure 4.



P.PINASTER – SLOPE EFFECT

Figure 5.



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