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FIRE HAZARD RESULTING FROM JACK PINE SLASH

by

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Forest Research Division
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INTRODUCTION

The accumulation of slash during logging operations introduces a serious problem to those concerned with fire control. Not only are fires more likely to start in slash areas but once ignited they have a greater resistance to control and often do more damage than fires burning in an uncut forest. Slash is treated in a number of ways depending usually on the cutting method. Essentially, there are two main treatments—leaving the slash on the cut-over area, or removing it by burning. Further, the manner in which the slash is left has an effect on the subsequent fire hazard.

The comparative fire hazard of areas of burned and unburned slash was investigated by Munger and Matthews (6) and they concluded that unburned slash in western Washington and Oregon is one-third more hazardous than burned slash ten years after logging. Cheyney (2), on the other hand, writes in the Journal of Forestry: "It would be a conservative statement to say that no slash is a special fire hazard in the Lake States for more than five years after it is cut". There appears to be no doubt, however, that an accumulation of slash in a cut-over forest will increase the fire hazard of the area for a considerable period after cutting operations have been completed. Further, it is evident that in any locality the increase of hazard brought about by the presence of slash will vary somewhat with the method of slash treatment employed, and with the number of years which have elapsed since cutting took place.

The Federal Forestry Branch, in co-operation with the Manitoba Forest Service, conducted a series of large-scale test fires in slash areas in the Sandilands Forest Reserve. The object of the study was to determine experimentally, (a) the comparative fire hazard in jack pine slash in similar cut-over areas where different slash treatments had been employed and, (b) the variations in hazard which occur as slash ages. The term 'slash age' will be used to refer to the number of years since logging.

This study also provided an opportunity for an investigation of the effect of slash disposal methods on jack pine regeneration. The results of this investigation are described by H. J. Johnson in a current publication of the Federal Forestry Branch, (4).

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DESCRIPTION OF AREA

The Sandilands Forest Reserve lies near the southeast corner of Manitoba at the western extremity of Halliday's (3) Great Lakes—St. Lawrence Forest Region. The topography is flat and the soil is sandy. Stands of jack pine (*Pinus banksiana*, Lamb.), the most important commercial species in the area, are typically very open and consequent heavy branching results in moderate to heavy slash accumulation during logging operations. High underbrush is very scattered and other vegetation is moderate with bearberry (*Arctostaphylos uva-ursi*), blueberry (*Vaccinium* spp.) and caribou moss (*Cladonia* spp.) as the main components along with a considerable amount of grass.

The area in which the study was made is adjacent to agricultural land and is subject to fires started by land clearing operations. Owing to the lack of natural water supplies and to the nature of the soil, fire suppression is best effected by hand tools and pumper-tankers.

The cutting methods which had been employed were mainly medium to heavy selection cuts and a few clear cuts.

METHOD OF STUDY

Examples of six different slash treatments were available in the Sandilands area. They were:

(1) Left as cut—
After felling, trees were limbed. Slash and tops were left where they fell.

(2) Piled and left unburned—
Piles were about 6 feet high, roughly circular, and spacing varied according to slash volume.

(3) Piled and burned—
Slash was piled as in (2) and thoroughly burned.

(4) Tops only left—
After felling, tops were lopped off and left. Very little limbing of the trees was done, since little more than the clear lengths of the trees were extracted.

(5) Lopped and scattered—
Slash was lopped from the trees and scattered so as to be not more than one and one-half feet deep at any point.

(6) Piled in windrows—
Slash was piled in long parallel rows, approximately one chain apart.

For each slash treatment studied, an attempt was made to locate areas representing four stages of slash deterioration, referred to here as slash age-classes:

Age-class I	1 – 2 years since cut.
Age-class II	3 – 5 years since cut.
Age-class III	6 – 9 years since cut.
Age-class IV	10 – 12 years since cut.

It was felt that these classes would include all ages of slash that might be of importance from a fire hazard standpoint.

Duplicate test fire plots, A and B, were located within each slash age-class for each type of disposal method, wherever it was possible to do so. Table I shows the distribution of plots which were available and on which the conclusion of this study was based. In addition to the plots listed, two control plots were located in a representative uncut jack pine stand.

TABLE I

Number of Plots Burned

Treatment	Slash Age-Class			
	I	II	III	IV
Left as cut	2	2	2	1
Piled and left	1	2	2	2
Piled and burned	1	2	2	2
Tops only	1	2	2	0
Lopped and scattered	1	2	2	2
Windrows*	0	2	0	0
Uncut 2				

* This treatment was dropped from the study because of insufficient data.

The sample plots were square, 100 feet to the side. Two single furrows were plowed around the perimeter of each plot as a fireguard and, where slash was particularly heavy, an additional fireguard was plowed approximately 20 feet outside the first. A Manitoba Forest Service fire ranger and five or more men were present at all tests and, when the plots had been burned, hand tools and pack tanks were used to extinguish the fires.

Four-foot stakes were set at 20-foot intervals throughout the plot providing a grid which greatly facilitated the plotting of the fire perimeter as burning progressed (*see* Appendix I). Just before burning, each plot was inspected and a complete plot description was recorded on specially prepared forms (*see* Appendix II). Particular attention was paid to the height of slash; ground vegetation; kind, amount, and depth of duff; and the thickness of the humus layer. The number of pieces and sizes of the heavier fuels (three inches or more at the large end) were recorded.

Air temperature and relative humidity were measured with a sling psychrometer, and other weather conditions were noted. The wind velocity at the time of the fire was measured with a portable anemometer and its direction was estimated with the aid of a box compass. The amount of dew which formed the previous night was measured by the method developed by the Federal Forestry Branch (7) and recorded in the field notes.

Various sizes of branches, duff, and other fuels were sampled and their moisture content determined by laboratory methods.

Immediately after igniting each test fire, an observer and an assistant began plotting the position of the fire perimeter at one or two-minute intervals depending on the rapidity of spread. Observers worked independently on the leeward and windward sides of the starting point and were able to keep accurate records of the fire's progress with the aid of stop watches and guide stakes. Notes were made also on the height of flame, vigour, smouldering, and depth of ash.

When the fire was out, further notes on the severity of the burn were made. Estimates were made of the percentage of the area left unburned as well as the percentages of each type of unburned fuel.

The careful plotting of the fire perimeter at regular intervals gave a very comprehensive picture of the fire's progress and a measure of its rate of spread. The grids were planimetered and the proportionate area burned during each five-minute interval of the fire's progress was determined.

A numerical hazard index was computed for each test fire, using much the same method as that employed regularly by the Forestry Branch in rating small-scale test fires (5). In calculating this hazard index the factors used and the relative weights given to each were as follows:

(1) rate of spread—30%
(2) total area burned—20%
(3) vigour—20%
(4) height of flame—10%
(5) smouldering—10%
(6) depth of ash—10%

The above factors, with the exception of vigour and smouldering, can be measured directly with the result that errors owing to personal judgment are kept to a minimum. Notes taken at one test plot are included in Appendix II.

Following the described procedure, all test fire plots shown in Table I were burned during the summer periods of 1949, 1951, and 1952. A fire weather station was set up in the area and the danger index was calculated daily, throughout the periods of the tests, from the Midwest Fire Danger Tables (1). All tests were made when this local danger index was in the range 7 to 12; the average for all tests was found to be 9.

Each test fire was given a hazard rating as determined by the six performance factors listed above. An adjustment of one hazard index unit was made to the rated hazard for those tests made on days when the local danger index differed from the mean by two units or more. For example, Plot No. 2A was burned on a day when the local danger index was 7. To adjust for the lower fire danger conditions on this day, the rated hazard index for that test fire, calculated to be 11, was increased by one unit to 12.

It should be noted here that the local danger index refers to the average fire danger in all fuel types in the area, whereas the rated hazard index is a measure of the fire hazard as indicated by the individual test fires in the fuel concerned.

ANALYSIS OF DATA

The slash studied here may be considered as having two basic divisions: (a) burned slash and, (b) unburned slash. These will be discussed separately.

Burned Slash

Analysis of test fire behaviour in cut-over areas where slash had been piled and burned indicated that the hazard is substantially lower than in areas where the slash had been left unburned. Further, it was found that, when slash is burned after cutting operations, the fire hazard can be expected either to be similar to that existing before the area was cut or slightly higher because of increased insolation. Other investigators have found that, under full insolation, fuel temperatures approaching 150°F. are not uncommon.

The conclusions drawn here will hold true only if the slash burning operations have been thoroughly carried out, in which case all the slash in the piles will have been destroyed. It is to be expected, however, that in some instances the original duff and litter will be left unburned between the piles.

Of the test plots burned in this group, one, number 13-A, was not included in the analysis. The plot description indicates that there was an 85 per cent coverage of jack pine duff and litter on the plot as opposed to an average of less than 10 per cent on the remaining six plots representing this treatment. The depth of litter and humus on plot 13-A was double the average of the other plots. This was, no doubt, a result of the unusually high density of the residual stand. Observations made on this plot, therefore, were excluded from the analysis on the basis that fuel conditions were not typical.

Figure 1 shows graphically the comparative hazard to be expected with each type of slash treatment studied and with slash age. Curve E in Figure 1 describes the hazard of burned slash over the years since it was cut. This curve shows that, if slash burning is done thoroughly, the hazard will be almost non-existent immediately afterward and will increase, within a period influenced by the density of the residual stand and the growth of new vegetation, to a value comparable to that in the uncut stand (Curve F).

Unburned Slash

The analyses of tests on unburned slash showed that fire hazard will remain comparatively high, regardless of treatment, for at least ten years after the cut. Figure 1 shows graphically the per cent of worst possible* hazard to be expected with each disposal method. These methods are listed hereunder in decreasing hazard potential at a slash age of approximately two years.

(1) lopped and scattered,
(2) piled and not burned,
(3) left as cut,
(4) tops only.

Differences in hazard owing to the use of different treatments of unburned slash, however, were found to be small and of little significance. Of somewhat greater significance is the fact that slash which has been lopped and scattered or left as cut deteriorates more rapidly over the years than that which has been piled and left. Thus the hazard existing in cut-over areas where the slash has been scattered or left strewn about, although initially high, falls off with age at a relatively rapid rate.

On areas where tops only have been left after cutting, the hazard is lower than when other treatments have been employed and the reduction in hazard over the years parallels closely that for piled slash. It should be borne in mind however that, in the Sandilands area, stands are typically open, and this type of slash consists mainly of scattered tops. Where this treatment is used in heavy stands the tops are more or less contiguous and the slash resembles that left as cut.

Of the test fires made in slash which had been piled and left, only six of the seven fires were considered to be truly representative of normal conditions. A changing wind direction during the course of the burning of plot 9-A prevented the fire from burning consistently on any one front. Also, there were more bare patches on this plot than were normally encountered on the remaining six plots. In consequence, observations made on plot 9-A were not included in the analysis.

* "worst possible" refers to the highest hazard rating based on the 0 to 16 danger index scale.

Figure 1

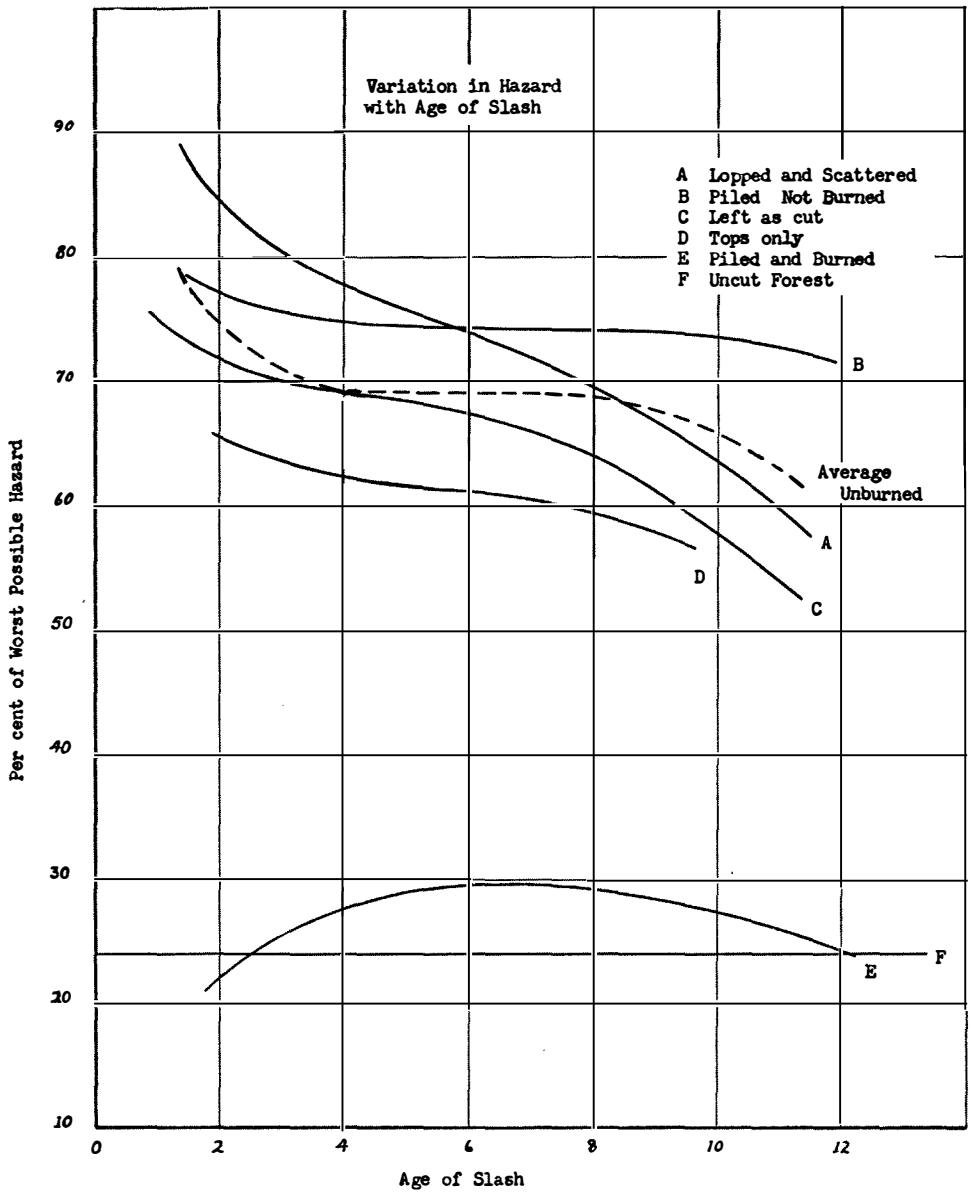
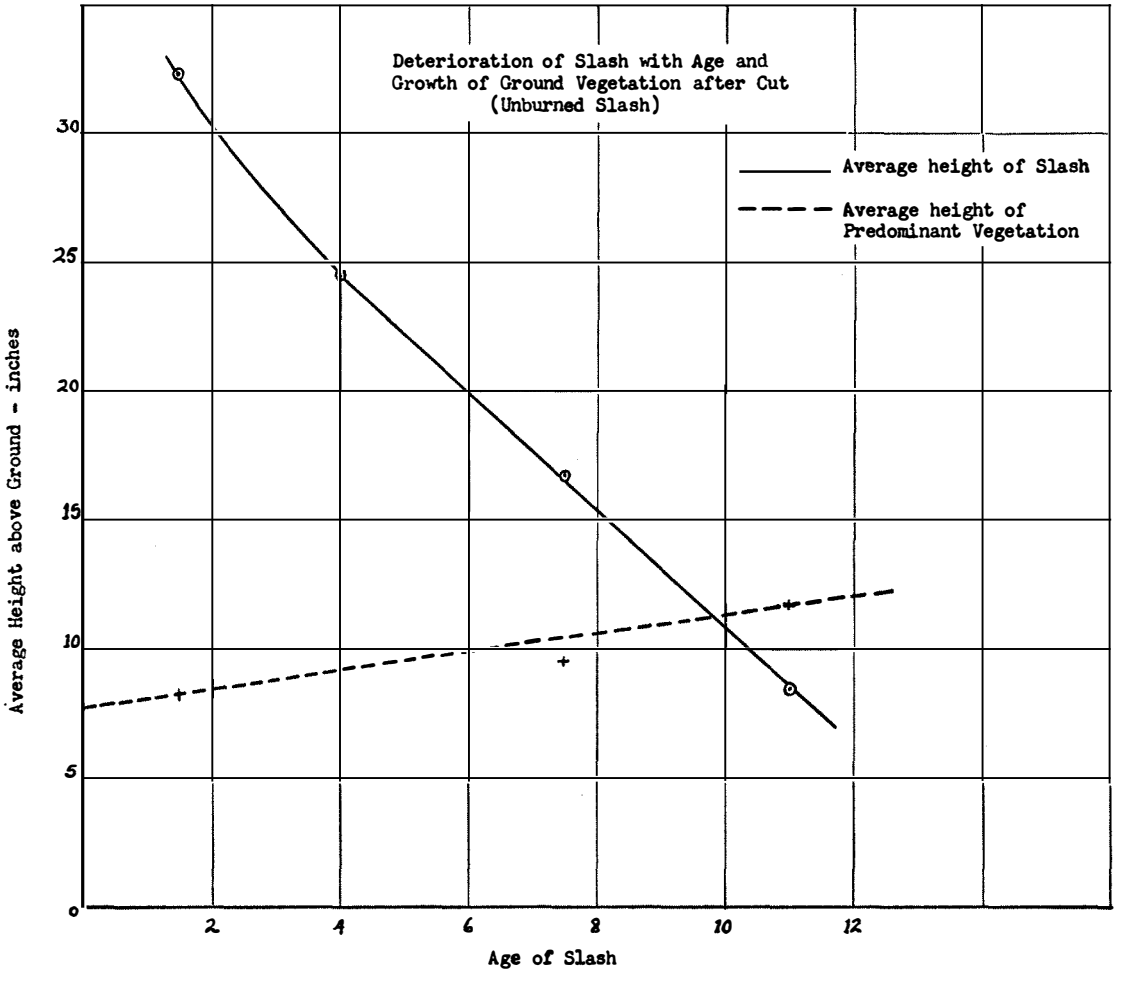

Variation in Hazard
with Age of Slash
A Lopped and Scattered
B Piled Not Burned
C Left as cut
D Tops only
E Piled and Burned
F Uncut Forest
Average
Unburned
A
B
C
D
E
F
Per cent of Worst Possible Hazard
90
80
70
60
50
40
30
20
10
0
2
4
6
8
10
12
Age of Slash

Figure 2


Deterioration of Slash with Age and
Growth of Ground Vegetation after Cut
(Unburned Slash)
Average height of Slash
Average height of
Predominant Vegetation
Average Height above Ground - inches
0
5
10
15
20
25
30
2
4
6
8
10
12
Age of Slash

The average height of the piled slash was three feet and when the test fire was in progress, sufficient heat was produced by the burning piles of slash to promote the rapid spread of the fire between the piles. This was normally a distance of 20 feet. Under the piles, all duff and organic matter was completely burned to mineral soil, whereas between piles the burn was light. There was less falling off of hazard with slash age than occurred when the lopped-and-scattered or left-as-cut methods were employed.

In almost all areas of piled slash and tops only, there were sufficient surface fuels to allow the fire to run from pile to pile or from top to top.

CONCLUSIONS

In the region and season in which these tests were made, the burning of jack pine slash, when thoroughly carried out, will reduce the fire hazard to a level comparable to that of the uncut forest and to about one third of that of unburned slash. Therefore, where hazard reduction is of primary importance, serious consideration should be given to slash burning after cutting operations. This is the only commonly used slash disposal method which is effective in reducing the fire hazard.

The hazard resulting from unburned slash is comparatively high for at least ten years after it has been cut; about three times as great as the hazard of the uncut forest.

Some further effects regarding unburned slash were noted in this study. They are:

(a) The hazard is highest immediately following the cut when the dead foliage is still clinging to the twigs. (b) The hazard diminishes gradually as the needles dry and fall—that is, until approximately four years after the slash has been cut. (c) From this point until the slash is eight or nine years old, the hazard decreases slowly as the debris weathers and compacts. (d) After this time the slash has been reduced by weathering and other action to a point where it is overgrown by an increasing abundance of vegetation. With this increased shade, the slash receives less ventilation and solar radiation and, as a result, the rate of moisture loss is reduced, thus further lessening the hazard.

A graphic illustration of this process is given in Figure 2. The two curves show the relationship between average height of slash and height of ground vegetation during the first 12 years following the cut. From this graph it appears that green vegetation begins to overtop the slash ten years after the cut. Figure 1 shows a general falling-off of fire hazard at approximately this same point. It may be expected that, where environmental conditions differ from those of the area under study, the rate of slash deterioration and vegetative growth may also be different.

The small differences in hazard resulting from the use of the four different treatments of unburned slash are more or less of academic interest only. The choice of one method over another will depend a great deal on the chooser's point of view. For example, it may be felt that the high initial hazard of slash which has been lopped and scattered or left strewn over an area is offset by the relatively rapid rate of hazard decrease which would obtain with increasing slash age. Others may argue that this high initial hazard is too risky to tolerate under any circumstance.

Although Johnson (4) found that the poorest regeneration resulted from piling and burning, no slash treatment studied gave a satisfactory stocking of seedlings. Thus, because it results in the lowest hazard, the piling and burning of jack pine slash should be carried out whenever it is economical to do so.

SUMMARY

A study of the fire hazard resulting from jack pine slash was made in southeastern Manitoba. A number of sample plots were burned in cut-over areas where the method of slash treatment had been: (1) left as cut, (2) piled and left unburned, (3) piled and burned, (4) tops only left, and, (5) lopped and scattered. For comparison, two additional plots were established in typical uncut jack pine.

It was found that, if logging slash is piled and burned, the fire hazard in the area will be approximately one-third of that in slash left unburned and will be comparable to the hazard in the uncut forest. If slash is left unburned, the fire hazard can be expected to remain relatively high, regardless of treatment, for at least ten years after the cut. The rate of slash deterioration, coupled with the rate of vegetative growth after the cut, determines the rate at which the hazard decreases toward a more normal condition.

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6. MUNGER, T. T., and D. N. MATTHEWS. 1941. Slash disposal and forest management after clear cutting in the Douglas fir region. United States Dept. Agriculture, For. Ser. Circular No. 586.

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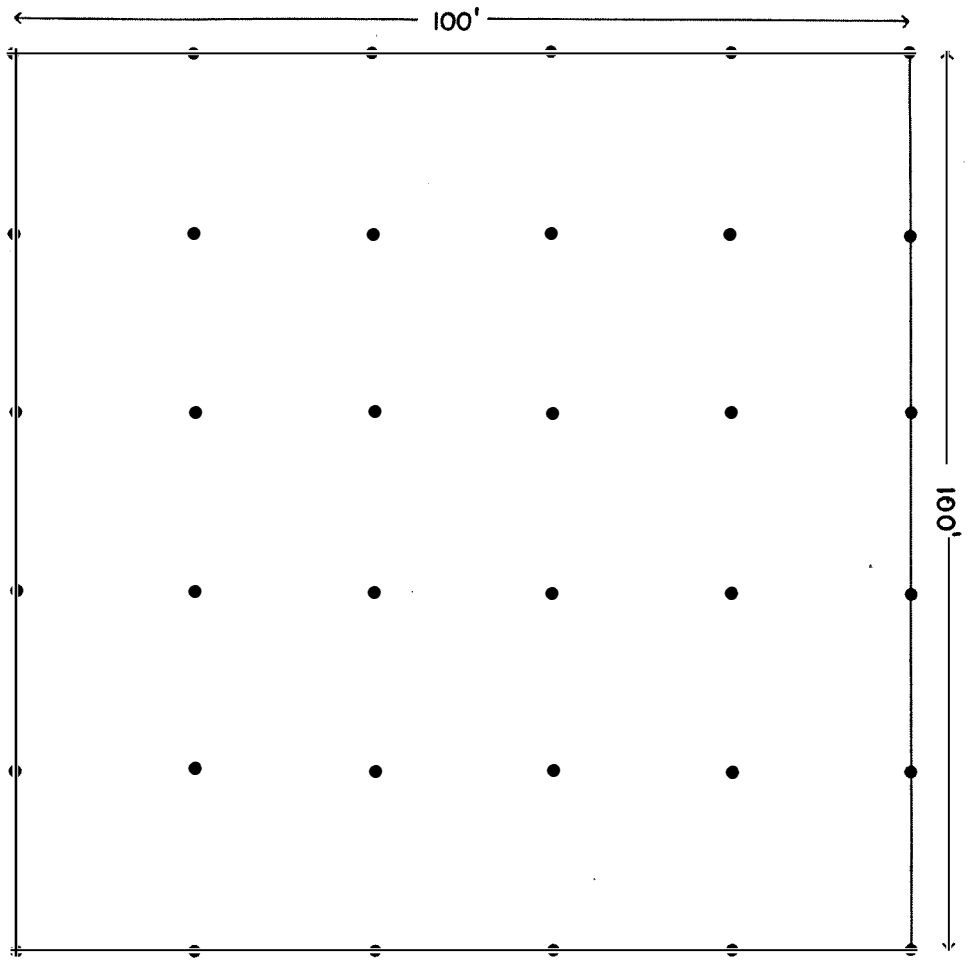
Appendix I

100' x 100' Plot staked out at 20 ft. intervals



The dots in the above square indicate the positions of the stakes used to facilitate the plotting of the fire perimeter at one or two minute intervals. For completed fire plot see appendix II page 2.

Appendix II

LARGE SCALE TEST FIRE

Station Piney, Man. Date Aug. 25/49 Time 1:05 p.m.

Location NE 3-2-12 Type Pj left as cut Plot No. 1-A
logged 1947-48 medium selection

Average height of Slash or Twig Litter

2½ to 3 feet

Species	% Density	% ground covered
Pj	100 mod.	35 to 40

GROUND VEGETATION

Species	Height	Density	%
Grass	10"	mod.	45
Arctos.	4-6"	light	5
Solidago	12"	sparse	2
Cladonia	2-4"	mod.	35
Salix	12"	sparse.	2
Others	8"	light	11

DUFF: Kind Pj % 50 Depth 1/16 - 1/8" Depth of Humus ¼-½"

No. of tops of poles 3" diameter at large end, or more, on plot.
12 tops 3-4" diameter

Number of matches used to start (or other fire brand) (1) match

Time required to ignite Immediately in jack pine duff

Height of flames Av. 4', Max 12-15' Time to reach Max.Ht. 4½ min.

Rate of spread exceptionally rapid after 2 min. with wind.

Size of largest branches or twigs consumed 1¼" larger branches partly burned

Time to reach edge of plot 10½ min. (N side)

Time last flame out 39½ min. in SE corner

Amount of smouldering Heavy, particularly in large branches

Difficulty putting out smouldering easily put out

Depth of burn in ground ¼ to ½" - to mineral soil in places

Crowning and scorching of trees all trees on plot partially crowned

Density of slash or litter in which fire went out light slash - litter

Effectiveness of fire guards in stopping fire A few spots easily put out.

Details of escape of fire and control measures necessary —

UNBURNED % 1 Branches 15 Duff 0 Vegetation 0

No. of days since last rain 9 Amount last rain 1.71 ins.

WEATHER CONDITIONS: clear and warm Temp. 83°F

Time 1:05 pm Wind Dir. & Vel. SW 4-6 R.H.% 34 Clouds Clear Dew or Moisture Prev. night 13cc.

Samples: Slash ..... 9.4 ... %

Twig litter ..... — %

Top layer Duff 6.7 %

Full layer Duff 7.8 %

Green foliage .... —

Cladonia 7.3 %

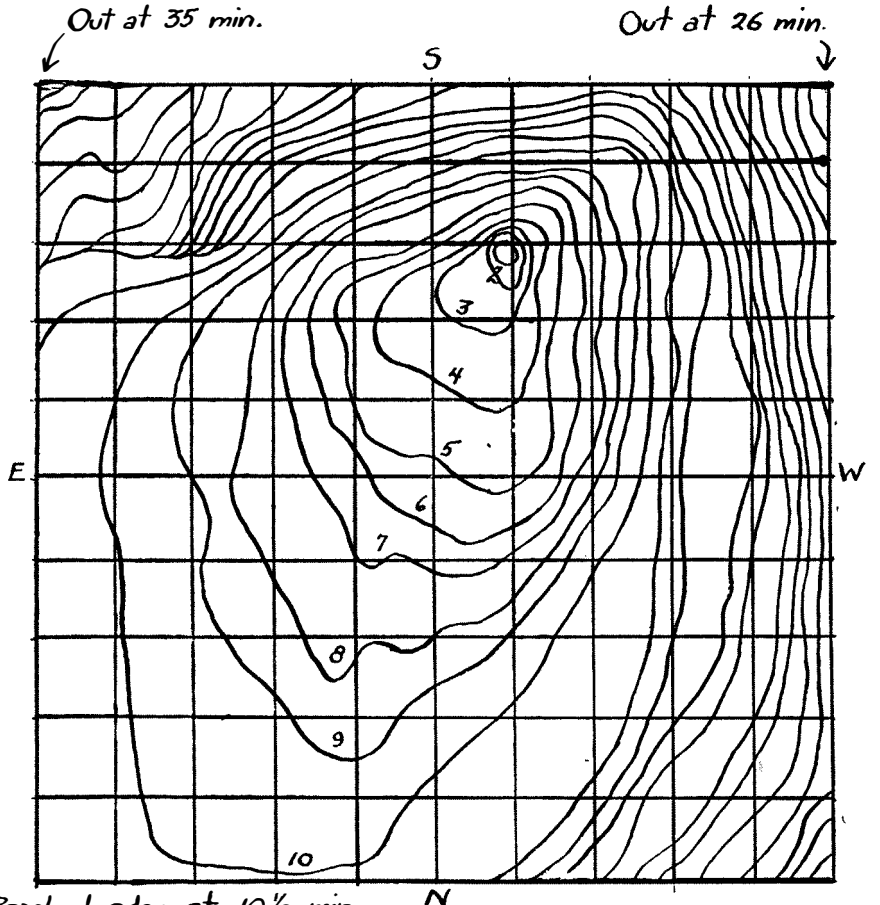
Danger Index .....9.....

.....Hazard ....14.....

Drought Index ....9.....

Other Remarks:

- A few light gusts of wind added impetus to fire
- Extinguished by 5 men with shovels and hand pumps - tractor plough in reserve.



Reached edge at 10½ min.

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