Performance of the Marden Brush Cutter in south central Montana

Lee Forrest Werth
The University of Montana

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THE PERFORMANCE OF THE MARDEN BRUSH CUTTER
IN SOUTH CENTRAL MONTANA

by

Lee F. Werth
B.S., University of Montana, 1966

Presented in partial fulfillment of the requirements for the
degree of
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1972

Approved by:

[Signatures]
Chairman, Board of Examiners
Dean, Graduate School
Date June 2, 1972
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CHAPTER I

INTRODUCTION

Extensive stands of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.,) which occur throughout the Rocky Mountain region are in most cases a result of past wild fires. Fire has played a major role in the distribution of this species by releasing an abundance of seed that is stored in persistent, serotinous cones and creating favorable seedbeds for the survival of lodgepole pine seedlings. These factors are responsible for very dense stands; consequently, overstocking is a serious problem in lodgepole pine management. The term "dog haired" stand is frequently used to describe present stand densities. Stands that are 75 years old containing over 10,000 stems per acre, which have an average diameter of less than 2 inches and a dominant tree height of 30 feet, are not uncommon.

In order to obtain better height and diameter growth, overstocked stands would have to be thinned. Thinning operations are very costly; therefore, forest managers are interested in a site preparation technique that will result in regeneration at favorable stocking levels (approximately 200-300 well distributed seedlings per acre). The most common site preparation method today involves piling the slash in windrows and then burning when weather conditions are suitable. However, this treatment has not solved the problem. More recently, use of the
Marden Brush Cutter, which is a method that does not involve burning, has been introduced in Montana as a new site preparation technique.

The primary objective of this investigation is to evaluate the performance of the Marden Brush Cutter as a suitable site preparation method for the natural regeneration of lodgepole pine. To be more specific, this will involve an analysis of the amount of exposed mineral soil, number of released seeds, competing vegetation, and costs. A secondary objective is to determine if the Marden Brush Cutter can treat the slash well enough to meet fire hazard reduction standards.
CHAPTER II

LITERATURE REVIEW

I. UTILIZATION

Lodgepole pine was once regarded as strictly a weed species by most lumber men. Low average diameter coupled with a volume flood of more desirable species kept lodgepole pine's market value very low during the 1910-1945 era (Wikstrom, 1957; LeBarron, 1952). When the value of lodgepole lumber was near zero some lumber men were forced to sell lodgepole under another species name to deplete their stock. The reduction in supply of higher value species and the increased efficiency of sawmills to handle smaller logs brought the stampage value of lodgepole pine from $3.10 per thousand board feet (MBF) in 1950 to over $8.00 per MBF in 1956 (Wikstrom, 1957). Now the stumpage value of lodgepole is about $18.00 per MBF. The land owner who managed strictly against lodgepole pine in the past was made to step back and reevaluate his management objectives.

The increased awareness of lodgepole is not surprising when one considers its physical properties. In comparison to ponderosa pine (Pinus ponderosa Laws), lodgepole is heavier, has greater static bending strength, is harder, and is in the same painting class as ponderosa pine. However, lodgepole does shrink somewhat more than ponderosa pine. Small trees of lodgepole yield a little more board feet
than ponderosa pine trees of the same size. Lodgepole pine yields greater grade recovery in the 1, 2, and 3 common lumber grades compared to ponderosa pine. The uniform texture, characterized by small tight knots and the relative straightness and lack of taper in trees, have combined to make lodgepole pine an ideal species for ties, boards, and dimension lumber. The only real marketing problem is the narrow width boards that hold down the lumber value of small trees (Wikstrom, 1957). Lodgepole pine is well suited for paneling stock and the manufacture of 2 x 4 studs (Kotok, 1967). Increased efficiency in sawmills to handle small logs and the discovery of new methods to transport chips to pulpmills, such as the pipeline process being studied, will improve the lodgepole pine markets even more (Gardner, 1967).

Just how commercially neglected this species has been can be clearly seen by noting the actual cut in 1955, which was 1/5 of the allowable cut of about 1,000 million board feet per year. Vast amounts of still undeveloped lodgepole pine acreage promise a brighter future for lodgepole pine (Wikstrom, 1957). See Table I for cutting trends in Region I for the past 39 years.
TABLE I

LODGEPOLLE PINE TIMBER HARVEST

(SAWTUMBER)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>M Board Feet</th>
<th>Calendar Year</th>
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<tr>
<td>1931</td>
<td>6,067</td>
<td>1951</td>
<td>12,024</td>
</tr>
<tr>
<td>1932</td>
<td>4,738</td>
<td>1952</td>
<td>10,517</td>
</tr>
<tr>
<td>1933</td>
<td>3,594</td>
<td>1953</td>
<td>9,729</td>
</tr>
<tr>
<td>1934</td>
<td>3,808</td>
<td>1954</td>
<td>6,065</td>
</tr>
<tr>
<td>1935</td>
<td>5,187</td>
<td>1955</td>
<td>14,532</td>
</tr>
<tr>
<td>1936</td>
<td>5,568</td>
<td>1956</td>
<td>11,871</td>
</tr>
<tr>
<td>1937</td>
<td>7,664</td>
<td>1957</td>
<td>16,880</td>
</tr>
<tr>
<td>1938</td>
<td>5,978</td>
<td>1958</td>
<td>24,872</td>
</tr>
<tr>
<td>1939</td>
<td>7,907</td>
<td>1959</td>
<td>40,371</td>
</tr>
<tr>
<td>1940</td>
<td>5,279</td>
<td>1960</td>
<td>34,114</td>
</tr>
<tr>
<td>1941</td>
<td>2,222</td>
<td>1961</td>
<td>40,960</td>
</tr>
<tr>
<td>1942</td>
<td>2,682</td>
<td>1962</td>
<td>63,731</td>
</tr>
<tr>
<td>1943</td>
<td>2,112</td>
<td>1963</td>
<td>90,843</td>
</tr>
<tr>
<td>1944</td>
<td>3,210</td>
<td>1964</td>
<td>105,383</td>
</tr>
<tr>
<td>1945</td>
<td>3,726</td>
<td>1965</td>
<td>95,451</td>
</tr>
<tr>
<td>1946</td>
<td>8,301</td>
<td>1966</td>
<td>118,257</td>
</tr>
<tr>
<td>1947</td>
<td>9,187</td>
<td>1967</td>
<td>102,317</td>
</tr>
<tr>
<td>1948</td>
<td>5,552</td>
<td>1968</td>
<td>127,239</td>
</tr>
<tr>
<td>1949</td>
<td>5,166</td>
<td>1969</td>
<td>131,540</td>
</tr>
<tr>
<td>1950</td>
<td>10,189</td>
<td></td>
<td></td>
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Source: U.S.D.A. Forest Service Region One, 1970
II. DISTRIBUTION

Lodgepole pine is found from southeastern Alaska (64°N. latitude) and the interior Yukon Territory south to northern Baja California (31°N. latitude) and as far east as the Black Hills of South Dakota (U.S.D.A. Handbook 271, 1965).

The two most common varieties of this pine distinguished by some taxonomists are: Pinus contorta var. contorta, a coastal form, and Pinus contorta var. latifolia, an inland or mountain form. The coastal form, which is a low, scrubby tree, grows primarily along the Pacific coast from southeastern Alaska to northern California. This study is concerned with the inland form, that is a taller tree of the mountains from the Yukon southeast to Colorado (U.S.D.A. Handbook 271, 1965).

There are 14.5 million acres of lodgepole pine type in the United States. It ranks third behind the Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Franco) and ponderosa pine types in the West from the standpoint of area covered. Eighty percent of lodgepole pine growth occurs in the four Rocky Mountain States of Montana, Idaho, Wyoming, and Colorado, where it covers 11.6 million acres. Montana ranks first with 4.7 million acres of lodgepole pine.

III. HABITAT

Most sites where lodgepole pine grows are characterized by fairly dry summers and, during the growing season, precipitation is deficient for short periods. Extensive lodgepole pine stands are found where the annual precipitation is only 18 inches, but best development occurs
where the precipitation is 21 inches or more. Average snowfall is from 11 to 120 inches and may be as much as 250 inches or more. The growing season is only from 60-100 days long and frosts may occur every month in the year. The average July temperature ranges from 55° to 63°F. Extreme temperatures may be from 100°F to 55°F below zero for short durations (U.S.D.A. Handbook 271, 1965).

Lodgepole pine has a wide ecological amplitude, and is one of the most widespread western coniferous trees. Lodgepole is found growing either on wet flats and poorly drained soils or the bare gravel on steep slopes and ridges. The better stands are on soils derived from granite, shale or sandstone, while extensive stands grow on soils from coarse-grained lavas. Soils from limestone or fine grained igneous rocks are considered poor for growth. Limestone soils are too dry and igneous soils break down into clays that are too poorly drained. Gentle slopes and basins are best for growth, although many good stands are found on rough and rocky terrain. Elevational range is from 1,500 to 11,500 feet above sea level. Lodgepole pine is more adaptable to northern and eastern aspects, while western aspects are not as good and southern aspects are the least desirable, except in sheltered locations (U.S.D.A. Handbook 271, 1965).

IV. CONE HABIT

Lodgepole pine’s widespread occurrence throughout the Rocky Mountain Region is related to its unique cone habit. Cones on individual trees may be either open, closed (serotinous) or a combination of both upon reaching maturity (Crossley, 1956b). The number of serotinous
cones within a given timber stand may vary by physiographic area, stand age (Crossley, 1956b), and stand life history (Lotan, 1967). The exact reason for the closed cone habit is not known. Lotan (1967) speculates that genetics could be a strong influencing factor. He found, in areas near the study location, more serotinous cones in even age stands than in uneven aged stands (57 percent vs 37 percent; stand fire history maybe the reason (Lotan, 1967). Crossley (1956b) suggested that there may be an age relationship to closed cone habit, with very young stands (17 years old) bearing open cones and 55 to 250 year old stands bearing closed cones.

Before serotinous cones will open the resin bond sealing the cone scales together must be ruptured and, high temperatures from 113°F to 122°F are required (Clements, 1910). Most fires are hot enough to do this. Lodgepole pine is a widely acclaimed fire species because of its ability to survive and take over a site after a wild fire. This adaptability is responsible for lodgepole pine having increased its acreage in the Rocky Mountain Region.

Fires may not be necessary, Crossley (1956c) and Lotan (1964a) found that if the cones are on or near the ground, the heat radiation from the soil surface will be sufficient. Lotan (1964a) observed that, if the cones are not greater than one foot above the ground, radiation, conduction, and convection from solar heat will open cones.

V. SILVICULTURAL METHODS

According to Smith (1962), after a timber stand has been logged in a clearcut block, successful natural regeneration will depend upon
the satisfaction of three conditions. The first prerequisite is an adequate supply of seed. This condition is only met during a bumper seed crop, and for most species, occurs every two or three years. Second, the seed must fall on a favorable seedbed to insure germination. Most species require mineral soil seedbed that is free of duff and competing vegetation. Finally, even after the above two mentioned conditions are satisfied, successful regeneration may be poor if there is an excessively dry period during seedling establishment. While the forest manager has little control over environmental conditions, he can regulate the seed supply and type of seedbed.

Lodgepole pine generally has good seed crops at one to three year intervals, so in stands with serotinous cones seed is not likely to be a limiting factor (Boe, 1954). In the case of a clearcut, most of the seed will come from cone-bearing slash and loose cones in the cutting area (Ackerman, 1962). Studies (Dahms, 1963; Tackle, 1964) have shown that seeds from trees on the edge of a clearcut contribute very little to restocking the area because seed dispersal falls off rapidly at one chain beyond the timber edge and reaches very low levels at distances exceeding three chains.

Once the seeds are released, the chances for germination and survival will in part depend upon the type of bed the seed falls on. Lodgepole pine, which is an intolerant species, requires either a mineral seedbed or disturbed duff that is free of competing vegetation (Ackerman, 1962; Boe, 1951; Crossley, 1956c; Lotan, 1964b; Tackle, 1956). Germination is poor on duff and concentrated slash (Bates, Hilton, and Krueger, 1929; Boe, 1956; Crossley, 1956a; Mason, 1915a; Tackle, 1956; Trappe, 1929; Boe, 1956; Crossley, 1956a; Mason, 1915a; Tackle, 1956; Trappe,
1959). However, this is not always the case because sometimes favorable regeneration occurs in clearcut areas where the slash remains, but it is generally believed that the slash must be less than one foot thick (Bates, Hilton, and Krueger, 1929).

Before the advent of modern fire fighting methods, the occurrence of widespread wild fires throughout the Rocky Mountains provided a mineral seedbed; the majority of the fire created stands produced low volumes because of growth loss due to overstocking (Clements, 1910; Mason, 1915b). At first after lodgepole pine stands were logged, foresters used to hand pile the slash and then burn the piles, primarily to reduce the fire hazard. This treatment provided some site preparation and usually the areas had moderately dense reproduction in the exposed mineral soil areas (Mason, 1915a). When the economic value of lodgepole was high enough to justify deliberate site preparation treatment, the duff layer and slash were removed by broadcast burning (covers at least 75 percent of the total area). The resulting stocking levels from the treatment were either excessive or very low (Boe, 1956; Clements, 1910). After many failures, most foresters abandoned broadcast burning and began using tractors to pile the slash in windrows which are burned when the weather conditions permit. The combined effects of scraping and fire exposes a great deal of mineral soil. This method is the current recommended silviculture treatment for the natural regeneration of a lodgepole pine stand (Le-Barron, 1952). Stocking levels are satisfactory (Crossley, 1956a), but are usually too great following this treatment (Tackle, 1964).
All of the preceding site preparation methods utilize fire. However, the question of whether fire is really needed is disputed. Clements (1910) advocated that fires are essential for natural regeneration of lodgepole pine because they open cones, provide favorable seedbeds, and establish proper conditions of sunlight. Foresters can not refute the fact that when fire is used the resulting stocking levels are at the extremes -- too high or too low. One of the major factors influencing stocking levels in burned areas seem to be related to the amount of cone-bearing slash that is destroyed which in turn depends upon the fire intensity (Boe, 1956). In addition, other factors such as slope, aspect, soil, and age of previous stand have been directly related to causes of stocking variation after fires (Horton, 1953).

Not all site preparation techniques use fire. A new method, which was used in the Rocky Mountain Region for the first time in 1966, cuts and crushes the slash by means of steel blades mounted on a tractor drawn water or diesel filled drum that weighs approximately 20,000 pounds. This device is called the Marden Brush Cutter.

Little is yet known about the performance of the Marden Brush Cutter in the Rocky Mountain Region, but it has been used in Florida, Canada, California, Oregon, and Wyoming. The cutter has been used for some time in an attempt to eliminate scrub oak and wiregrass competition for sand pine regeneration and slash pine plantings in the Florida sand hills. Grelen (1958) found that one pass over an area with a tandem double-drum chopper (11 tons) did not remove enough scrub oak and wiregrass competition, but planted slash pine seedlings achieved
sufficient growth with two chopper passes. Cooper (1959), in a
natural regeneration study of sand pine, observed that the chopper
could cut through heavy slash and tops, but occasionally matted heavy
needle litter and induced hardwood sprouting.

Trials were made by Ritchie and Dodge (1962) with the Marden
(B-7) Duplex Brush Cutter in California to see if it could be used to
convert a brush field of manzanita (Arctostaphlos parrvana var.
pinetorum), chinkapin (Castanopsis sempervirens), and snowbrush
(Ceanothus velutinus) into a timber stand. The brush was not com­
pletely cut or mixed into the soil with one pass. Additional passes
and reversing the direction of travel failed to make any noticeable
improvement. Failure to satisfactorily prepare the site for seed­
lings was probably because the brush was too tall, too dense, and the
woody material was not brittle or soft enough. In addition, large
hidden rocks dulled the chopper blades considerably. Hopkins and
Anderson (1958) in Oregon found the Cutter would chop up light slash
and grind it into the soil, but did not prepare a satisfactory site
in heavy slash or where the slash was from 3 to 6 inches in diameter.
A 1966 survey from another study in Wyoming (Van and Gallagher, 1968)
showed that a Cutter, which had worked the area in 1963, prepared the
site adequately enough to allow the mean establishment of 1,830 lodge­
pole pine seedlings per acre.

Considerations for a suitable slash disposal method involves not
only site preparation but the ability to reduce the fire hazard as
well. After the timber crop is harvested in a clearcut area, a poten­
tial fire hazard exists because of remaining slash. Slash, which is
the debris left after logging, consists of needles, bark, twigs, limbs, top logs too small to market, cull logs, and knocked down trees. How great the fire hazard is depends on the quantity, arrangement, and condition of the slash. The slash must be treated to reduce the fire danger and this is accomplished by burning or placing it in contact with the ground so it can rot. Generally, whenever fire is employed under the proper moisture conditions, the fire hazard is greatly reduced. The method known as lopping and scattering has never reduced the fire hazard very much, even though the slash is nearer to the ground where it deteriorates more rapidly. Slash treatment with a Marden Brush Cutter is similar to lopping and scattering but sometimes it splinters and grinds the slash into the soil. Rothermel (1969) has shown that fire hazard is reduced when slash depth is decreased. Van and Gallagher (1968) observed that the limbs and treetops in a lodgepole pine stand were broken and partially buried in the soil. Larger material up to 7 inches was broken, shattered or sliced. Light lodgepole slash was chopped up and ground well into the soil in the Oregon study, but the chopper did not do a completely satisfactory job of slash disposal in logging debris that was still present because fire would still travel through the slash. The tandem double-drum chopper used in Florida, reportedly easily cuts trees as large as 6 inches in diameter. Albert (1966), in Canada, discovered that under average conditions, the maximum size tree effectively crushed and chopped is one that is between 4 to 5 inches diameter breast height (DBH). In contrast, Johnson (1966) found that light slash or logs up to 6 inches in diameter were well broken and smashed almost even with the ground in preliminary
trials in a lodgepole stand in Montana. Medium slash that had quite a few logs in the 6 to 12 inch group were seldom broken, but were often crushed and splintered. Fine fuels in the medium slash were well broken, but large logs (10-16 inches in diameter) in the heavy slash kept the chopper off the smaller slash and the ground.

Compared to other slash disposal methods the Marden Brush Cutter has many advantages. Treatment can be applied any time after the soil has dried enough to be passable, instead of having to wait for certain weather conditions before burning (Van and Gallagher, 1968). Cost is less than one-third the cost of piling and burning, because treatment is completed in one operation and supervision time is reduced (Johnson, 1966). Costs on a thinning project in Montana averaged $12.55 per acre (Decelle and Wolfe, 1968). Slash on the ground or partially buried decomposes rapidly and returns organic matter to the soil, rather than being consumed when fire is used. Furrows made by the chopper blades provide a good bed for seeds to accumulate, germinate, and survive because they catch and hold moisture. The furrows also help to reduce runoff and erosion. After treatment other equipment can traverse the area. Disposal of slash does not affect air pollution. Mistletoe control work in lodgepole pine is almost eliminated.

Along with its many advantages over other methods the Marden Brush Cutter has its limitations and disadvantages. The Cutter should not be used on slopes greater than 20 percent, in swampy areas, and where there are numerous rock outcrops. They can not be used when foresters want to save advanced reproduction. Van and Gallagher (1968) recommended that cutter treatments should be applied within three years after logging,
should not be used on lodgepole stands containing more than 2½ cords per acre of residual stand, should not be used on areas less than 20 acres, and should not be used on areas where live or dead snags with diameters of 10 inches or more exceed 5 per acre.

Land managers assume that the type of environment created by the cutter will be more conducive to favorable stocking levels. For instance, since lodgepole pine is shade intolerant, best germination takes place under conditions of full sunlight (U.S.D.A. Handbook 271, 1965). Thus shade from the remaining slash may have an oppressive effect on germination. The condition of the slash will also influence stocking levels. Lotan (1964a) found that more seedlings were established when the slash was piled green compared to piling dry slash. Also, Crossley (1956c) found that the final stocking level can be influenced by the amount of exposed mineral soil, which is necessary for lodgepole pine germination. The Marden Brush Cutter, depending upon the size of slash, does not do as thorough a job of scarification as dozer piling and burning; thus, the undisturbed duff areas may tend to control overstocking.
CHAPTER III

I. AREA DESCRIPTION

The study area was located approximately 34 miles south of Ennis, Montana, in the Beaverhead National Forest. Unit #1 was in sections 16, 17, and 21 of Township 11 South Range 1 East, and unit #6 was in sections 4, 5, 8, and 9 of Township 11 South Range 1 East, Montana Principle Meridian.

The two clearcuts lie in the eastern foothills of the Gravelly Mountain Range. From unit #6 looking eastward, the Madison River can be seen meandering northward along the Madison Valley and the majestic peaks of the Madison Mountain Range bordering the east edge of the valley. (See enclosed map for exact study area locations.)

Both units are located on relatively flat benches which are situated above steep ridges overlooking the Madison Valley. Unit #1 was on an eastern aspect varying from 0-6 percent in the western part of 11 percent in the eastern portion. There is a small eastern microsite in the southern part of unit #1 that commences at a 40 foot long slope. Unit #6 is on more uniform terrain sloping gradually from 20 percent in the western portion to 0-5 percent in the eastern section.

Elevation in the area ranges from about 5,840 feet in the Madison Valley to 10,545 feet on top of Black Butte Peak in the Gravelly Range. The mean elevation of both units is approximately 7,000 feet above sea level.
FIGURE 1

MAP SHOWING STUDY AREA LOCATIONS
Existing landform and soils are a result of glaciation, alluvial deposits, and limited volcanic action. The Madison River once flowed at the same level as unit #6 and unit #1. The most common outcrops in unit #1 were identified as a Precambrium metamorphic quartzite. A rhyolitic tertiary tuff of volcanic origin was the most predominant rock in unit #6 and also was found in unit #1.

At first it was suspected that there was a major difference in soils between units. Soil pits dug in the northern part of unit #1 and unit #6 later showed there was no difference except slope. Soil profile description is shown below in Table II.

**TABLE II**

**SOIL PROFILE DESCRIPTION OF STUDY AREA**

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Unit #1</th>
<th>Texture</th>
<th>Horizon</th>
<th>Unit #6</th>
<th>Texture</th>
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<tr>
<td>0</td>
<td>1-0</td>
<td></td>
<td>0</td>
<td>1-0</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>0-18</td>
<td></td>
<td>A2</td>
<td>0-12</td>
<td>Fine sandy loam</td>
</tr>
<tr>
<td>B2t</td>
<td>24+</td>
<td></td>
<td>B2t</td>
<td>24+</td>
<td>Clay loam</td>
</tr>
</tbody>
</table>

Description from personnel communication with Roger Poff, Soil Scientist U.S. Forest Service.

Soil development is considered poor. The soils are in the Alfisols or Gray Wooded Soil Group. Rock is found in all layers. Silt and clay are prominent so there should be abundant soil moisture.
II. WEATHER

The weather in the surrounding area is generally cool and moist. Summer time temperatures may exceed 80°F for July and August, the average summer temperature is 55°F. Temperatures in the winter may get as low as 40°F below zero. Weather information was obtained at the nearest permanent weather station located at Hebgen Lake Dam. The temperatures at the dam, situated in a canyon, are probably lower than the sunny slopes of the study area. The average annual precipitation is 20 inches or more, most of it falling in the form of snow from September to May. Snow depths up to 106 inches have been recorded at Hebgen Lake. The mean summer time precipitation is 7.06 inches.

III. STAND DESCRIPTION BEFORE LOGGING

Unfortunately, both units had been logged before the areas were entered in the summer of 1967. Prelogging vegetation sample plots were to be established to determine exact stand composition and density. At first it was believed that data from sample plots along the cutting unit's margins would suffice, but closer observation of the ground and aerial photographs showed that topographic dictates and stand densities served as guidelines to delineate cutting boundaries. In general species composition and densities differed on the outer edge of the clearcuts.

The dominant species of both units was lodepole pine with small amounts of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), Engelmann spruce (Picea engelmannii Parry), sub-alpine fir (Abies lasiocarpa (Hook) Nutt.), and whitebark pine (Pinus albicaulis Engelm). Douglas-fir occur-
red more frequently and was larger in unit #6 than in unit #1. Understory vegetation consisted primarily of pinegrass (*Calamagrostis rubescens* Buckl.), and grouse whortleberry (*Vaccinium scoparium* Leiberg.).
CHAPTER IV

EXPERIMENTAL DESIGN

The original purpose of the study was to divide each unit in half and in one half treat the slash with the Marden Brush Cutter and in the other half pile the slash in windrows and then burn them. The units selected were approximately 175 and 250 acres respectively. This way a comparison between treatments could be made while keeping the variables of elevation, aspect, and soils constant. The variables of number of cones, percent mineral soil, competing vegetation, fuel volume, and number of seedlings would be tallied for each treatment area and then statistically analyzed. However, both treatments were started too late in the fall of 1968 to permit the sampling of these variables in the pile and burn areas. Therefore only number of cones, percent mineral soil, competing vegetation, and fuel volume were sampled in the Marden Brush Cutter areas.

Logging was completed in unit #1 in December, 1966, and was treated by the Marden Brush Cutter in September, 1968. Unit #6 was logged in June, 1967, and treated by the cutter in September, 1968.

I. PLOT LOCATION AND LAYOUT

Units #1 and #6 were plotted on graph paper and superimposed on a topographic map to determine location of dividing lines and orientation of plot lines. A line bearing N66°15'W divided unit #6 into almost equal
halves and unit #1 was equally divided by a line at N53°E. Because of
topography better sampling could be obtained by having west to east
plot lines. Plot lines were plotted on graph paper before going into
the areas to avoid personal bias. Unit #1 had 3 plot lines in the pile
and burn area and 2 plot lines in the Marden Brush Cutter area. From
now on whenever P&B and MBC are used they will mean pile and burn and
Marden Brush Cutter respectively. Unit #6 had only 2 plot lines in the
P&B area and 2 plot lines in the MBC area because it is larger and more
homogenous than unit #1.

A minimum of 50 plots per treatment area in each clearcut were
chosen to sample the variables. Plots were randomly located along the
plot lines with the limitation that plot centers must be more than 10
feet apart or less than 300 feet. Metal tags tacked on boundary trees
at the end of plot lines served as permanent reference markers. The
plots were numbered consecutively from west to east. Plot centers were
marked by driving 12 inch steel spikes almost flush with the ground. To
facilitate locating the spikes after treatment, they were painted at the
top with orange or red fluorescent paint and red ribbon was tied on every
other plot pin. Plots that landed on roads or landings were not sampled
because of the erroneous amount of scarification compared to other plots
in the treated areas. Instead additional plots were added on the end of
the last plot line, in each treatment. This was done after the original
50 were established.

An uncontrolled fire in the fall of 1968 that started in the pile
burn area of unit #1 swept across the dividing line and destroyed 9 plots
in the Marden Brush Cutter area. The plots were to be relocated on
another sample line but heavy snowfall and lack of assistance prevented it. Therefore only 44 plots were evaluated in unit #1.

II. WEATHER

A hygrothermograph and rain gauge were located in the center of each clearcut in July of 1968 to determine if the summer weather was above or below local averages. Weather data would also aid in comparing this study with other areas of similar climate and help explain differences in study results.

III. SITE PREPARATION AND COMPETING VEGETATION

Percent mineral soil was measured using a square aluminum milacre frame. The frame was composed of 10 vertical and 10 horizontal wires that crossed forming 100 wire intercepts. The total number of strikes on bare mineral soil when a steel probe was vertically dropped from the wire intercepts represented the percent mineral soil per plot. Strikes on duff and mixed in mulch were not tallied. Bare mineral soil under plant cover and logs were recorded in the total mineral soil. The square foot density method, which is a quantitative estimate of plant cover used in range forage inventories to help calculate grazing capacities, was used to measure the amount of competing vegetation. The plot frame was oriented north of the plot line on even numbered plots and south of the plot line on odd numbered plots. The corner of the frame was placed over the plot pin and the long axis oriented in the direction of the plot line. An ocular estimate was made to see what segment subdivision, divided into 50, 30, 10, 8, and 2 percent cover vegetation, was
filled in the frame area. Vegetation was identified by species if possible or categorized in the 4 classes of grass, herb, sedge, and shrub. Sampling was done after treatment in the fall so it was quite difficult identifying most of the vegetation. The area would have been sampled the following summer if time would have permitted.

IV. CONE SEROTINITY

Percent of cone serotiny in a timber stand varies by physiographic area. Lotan's (1963) method of determining percent serotinous cones was used. Three plots were established on the southern, western, and eastern outside edges of unit #1 and one plot on the northern outside edge of unit #6. The plots were 1/50 acre in size and all dominant and codominant lodgepole pine trees in the plot were felled and recorded by diameter, height, and age. All the serotinous cones on one foot outer branch segments from the top down were tallied until 25 samples were taken. A serotinous cone was one in which 50 percent or more of the cone scales were closed. Closed immature cones were recorded as serotinous and noted as to stage of development.

V. AVAILABLE SEEDS

Earlier stages of the study showed that it was impossible to count the number of seeds per plot without 100 percent soil scarification. The number, condition, and species of cones per circular milacre plot were tallied to get an estimate of total number of seed available for germination. Cone condition was classified as either closed, fresh open, or old open. The color of the inner cone scale was the criterion of whether
a cone was judged fresh or old open. Light brown scale was an indication of fresh open and dark brown to gray an indication of old open. It was impossible to classify a cone serotinous or non-serotinous once the cone opened.

Fifty cones in each unit per cone condition were sampled and destroyed to determine the average amount of sound seed available in each cone.

VI. FUEL VOLUME

Van Wagner's (1965) line intersect method was used to sample fuel volumes in the circular milacre plots. The horizontal bar of the milacre frame, that was perpendicular to the plot line, was used to tally fuels. Logs and limbs greater than .5 inches under the sample line were noted by species and diameter. Tallying rules:

1. if the sample line passes through the end of a piece, tally it only if its central axis is crossed.
2. if the sample line passes exactly through the end of the central axis, tally every second such piece.
3. if the sample line coincides exactly with the central axis, tally every second such piece.

Using piece diameter and known length of sample line, fuel volume could be calculated per acre. The formula used was: \[ V = 0.00857d^2/L = \text{ft}^3/\text{acre} \]. In the equation "d" is the diameter in inches and "L" is the length of the sample line in feet. Logs were also tallied by green or dry.
VII. COST DATA

Contracting cost data and total hours spent per treatment for each clearcut were recorded. This included any down time for repairs, administration costs, and equipment and supply expenses.
CHAPTER V

RESULTS

I. WEATHER

Temperature and relative humidity were obtained from a weather station located at Soap-Bogus Divide from April 24 to July 3, 1968. Data from July 4 to October 15, 1968, was collected in the center of unit #1. Refer to table III for monthly weather data. Weather information from the Divide Weather Station could be used because of proximity to the study area. A hygrothermograph in unit #6 would have had the same data as unit #1 if calibrated properly. An investigation by Kovalchik (1971) illustrates this. A total of 7.52 inches of precipitation was measured from July 18 to October 31, 1968. This is 1.52 inches more than the three year average (1968, 1969, and 1970), recorded at the Forest Service Weather Station in Ennis, Montana. Weather pattern similarities between the study area and Ennis have been previously established (Kovalchik, 1971). For example, in 1969 there was 3.94 inches of rain measured at the study area compared to 3.10 inches at Ennis for the same period. The summer of 1968 was rather cool and moist compared to average temperatures and precipitation for this area.
### TABLE III
WEATHER STATION DATA

<table>
<thead>
<tr>
<th></th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Mean Minimum Temp. (°F)</td>
<td>30.6</td>
<td>32.3</td>
<td>44.5</td>
<td>40.2</td>
<td>39.8</td>
<td>34.6</td>
<td>30.0</td>
</tr>
<tr>
<td>*Mean Maximum Temp. (°F)</td>
<td>45.0</td>
<td>47.7</td>
<td>61.6</td>
<td>76.5</td>
<td>64.9</td>
<td>61.2</td>
<td>51.0</td>
</tr>
<tr>
<td>*Mean Minimum Humidity (%)</td>
<td>35.0</td>
<td>47.6</td>
<td>49.9</td>
<td>29.4</td>
<td>40.4</td>
<td>42.0</td>
<td>39.9</td>
</tr>
<tr>
<td>*Mean Maximum Humidity (%)</td>
<td>80.0</td>
<td>92.6</td>
<td>90.1</td>
<td>89.4</td>
<td>88.9</td>
<td>92.7</td>
<td>87.1</td>
</tr>
<tr>
<td>**Total Precipitation (inches)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.15</td>
<td>4.06</td>
<td>2.03</td>
<td>1.28</td>
</tr>
</tbody>
</table>

* Temperature and humidity data is from April 24 to October 15, 1968.

** Precipitation data was only recorded from July 18 to October 31, 1968.
II. SITE PREPARATION AND COMPETING VEGETATION

Site preparation in this investigation means only the amount of bare mineral soil exposed after treatment. Average amount per plot of mineral soil site preparation was not significantly greater in unit #6 than in unit #1, 10.56 percent vs 8.07 percent. The maximum amount was 99 percent in unit #1 while the maximum in unit #6 was only 58 percent. High amounts of mineral soil in plot 59, unit #1 resulted from absence of logs and grass turf.

Numerous factors effect the amount of mineral soil per plot. The blades of the Marden Brush Cutter are most effective if they are not riding on top of medium to large sized logs that keep the blades well off the ground. Refer to plate number 1. Delayed application of treatment after logging reduced the effectiveness of the cutter because of thickly matted grass turf which was allowed to become established. Cutter blades passing over plots with scarce vegetation were allowed to sink deeper into the soil and churn more soil. When treatment was applied during or after precipitation more mineral soil was exposed. In dry soil the blades did not penetrate very deep or churn the soil up much. Wet conditions allowed the weight of the steel drum to send the blades deeper into the soil, enhanced mixing action, and made the grooves wider. See plate number 2. Large amounts of mineral soils were exposed by means other than the brush cutter. Both units had numerous trees still standing after logging. Trees uprooted when pushed over by the dozer blade accounted for most of the mineral soil observed. This was especially true in unit #6 where the treatment was applied during the wet period of October.
PLATE 1

UNDISTURBED AREA BETWEEN TWO LOGS
PLATE 2

WET CONDITIONS AND SCARCE VEGETATION

RESULTED IN MORE MINERAL SOIL
Plots where the tractor turned around to make another swath had understandably more exposed mineral soil. Also plots that were passed over more than once had more exposed mineral soil because of their relative position in terms of the first and succeeding swaths.

The combined effect of the steel drum and the dozer tracks created more mineral soil. This was especially true during or after measurable amounts of precipitation.

Competing vegetation was measured during a period when it was difficult to identify species; and they were not as abundant compared to the middle of summer. The most common recognizable vegetation on both units was pinegrass followed by grouse whortleberry, dwarf juniper (*Juniperus communis* L. var. montana Ait), and oregon grape (*Berberis repens* Lindl.).

The majority of the pinegrass was in a cured matted stage. Vegetation underneath logs and debris will probably not survive because of lack of sunlight.

Table IV shows that slightly more vegetation occurred in unit #6 than in unit #1 using mean percent of the total, 12.12 percent vs 10.48 percent. The difference between means was not statistically significant.

**TABLE IV**

**COMPETING VEGETATION EXPRESSED IN PERCENT COVER**

<table>
<thead>
<tr>
<th></th>
<th>Unit #1</th>
<th>Unit #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum per plot</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean per plot</td>
<td>10.48</td>
<td>12.12</td>
</tr>
<tr>
<td>Maximum per plot</td>
<td>58</td>
<td>40</td>
</tr>
</tbody>
</table>
III. CONE SEROTINY SAMPLING

Three plots of 1/50 acre were established along the perimeter of unit #1 while only one was established along the outer edge of unit #6. Heavy snowfall prohibited the establishment of others.

A total of 13 trees were sampled near unit #1 and only three trees near unit #6. Unit #1 had 6 serotinous trees, 2 intermediate trees, and 5 non-serotinous trees. Trees were serotinous if they bore 90 percent or more serotinous cones. Intermediate trees had more than 10 percent but less than 90 percent serotinous cones, and trees were non-serotinous if bearing 10 percent or less serotinous cones. Unit #6, which is not a different physiographic area, had 2 serotinous and one non-serotinous tree.

Using the equation \( Y = 252.69X - 215.32 \) for estimating the number of serotinous cones per tree, unit #6 had 1,089 serotinous cones per tree and unit #1 had only 573. Refer to table V. In the above equation \( r = .814 \) and the standard error is 84.41 cones. The difference in values may be result of sample size near unit #6 and unknown variations in stand life history.

Table VI shows the average diameter, average height, and average age for the trees sampled in the two units. No conclusions regarding cone serotiny as related to tree age and stand life history can be drawn from the limited data.
TABLE V
ESTIMATE OF CLOSED CONE HABIT FOR STUDY
AREA SOUTH OF ENNIS, MONTANA

<table>
<thead>
<tr>
<th></th>
<th>Unit #1</th>
<th>Unit #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number serotinous cones per branch segment</td>
<td>3.12</td>
<td>5.16</td>
</tr>
<tr>
<td>Number of serotinous cones per tree</td>
<td>573</td>
<td>1,089</td>
</tr>
<tr>
<td>Number trees sampled</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>

TABLE VI
CHARACTERISTICS OF TREES SAMPLED FOR CLOSED CONE HABIT

<table>
<thead>
<tr>
<th></th>
<th>Unit #1</th>
<th>Unit #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average diameter (in.)</td>
<td>8.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Average height (ft.)</td>
<td>58</td>
<td>49</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>108</td>
<td>100</td>
</tr>
</tbody>
</table>

IV. AVAILABLE SEEDS

The only logical method of estimating the total number of sound seeds available for germination was to count the number of cones per plot. In general the three cone conditions recognized were closed, fresh open, and old open. As expected the number of seeds in each
class varied. In unit #1 the closed cones contained on the average 16.02 seeds. Refer to plate number 3 for cone size variation. Fresh open cones with a light brown inner cone scales, had only a mean of .34 sounds seeds per cone, and old open had an average of .24 sound seeds per cone. To estimate the total number of sound seeds per plot as shown by table VII the sum of each cone class was multiplied by the mean seed of that cone class. The mean number of seeds per the 44 plots sampled were 469.60 or approximately 469,600 sound seeds per acre. The lowest was 11.5 seeds and the highest was 10,174.1. Total cones per plot ranged from a high of 918 to a low of 8 in unit #6.

Only 3 Douglas-fir and 3 Engelmann spruce cones were found in unit #1. In comparison 126 Douglas-fir and zero Engelmann spruce cones were found in unit #6.

TABLE VII

ESTIMATE OF TOTAL CONES AND SOUND SEEDS ON THE FOREST FLOOR FOR STUDY AREA PER PLOT

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Mean</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit #1</td>
<td>Cones</td>
<td>1.0</td>
<td>97.90</td>
</tr>
<tr>
<td></td>
<td>Sound Seeds</td>
<td>0.2</td>
<td>469.60</td>
</tr>
<tr>
<td>Unit #6</td>
<td>Cones</td>
<td>8.0</td>
<td>105.80</td>
</tr>
<tr>
<td></td>
<td>Sound Seeds</td>
<td>11.5</td>
<td>617.47</td>
</tr>
</tbody>
</table>
The maximum and minimum number of cones per plot in unit #1 was 381 and 1 respectively. Most of the cones found were old open. Old open cones made up 52 percent of the total, closed cones 29 percent, and fresh open 19 percent. The mean number of seeds per closed cones in unit #6 was slightly higher at 20.8. Fresh and old open cones had .92 and .20 sound seeds respectively. Mean number of seeds per plot was 617.47 or 617,470 sound seeds per acre.
V. FUEL VOLUMES

Both units were clearcut but they were not cleancut. Approximately 1,330.82 MBF of all species were removed from unit #1, and 1,736.01 MBF from unit #6. Large numbers of residual and supposedly unmerchantable trees under 6 inches DBH were left in each unit (Refer to plate number 4 which shows panoramic view of unit #1 after logging). Consequently, fuel volumes in both units were high.

Marden Brush Cutter treatment did not reduce the fuel volume, but did alter the fuel arrangement and condition, thereby hopefully reducing the overall fire hazard.

In unit #1 the mean volume per plot was 76.69 ft$^3$/milacre and in unit #6 it was 103.52 ft$^3$/milacre. This is equivalent to 76,690 ft$^3$ per acre and 103,520 ft$^3$ per acre respectively. Table VIII below illustrates the quantities of fuel found in each clearcut.

<table>
<thead>
<tr>
<th>TABLE VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL VOLUME FT$^3$/MILACRE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit</th>
<th>No. Plots</th>
<th>Total</th>
<th>Minimum</th>
<th>Mean</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>44</td>
<td>3,374.39</td>
<td>0</td>
<td>76.69</td>
<td>290.89</td>
</tr>
<tr>
<td>#6</td>
<td>50</td>
<td>5,175.93</td>
<td>0</td>
<td>103.52</td>
<td>353.86</td>
</tr>
</tbody>
</table>

After treatment most of the slash was laid closer to the ground, reducing fuel depth. (Refer to plate number 5 and 6 which shows slash depth before and after treatment.) The combined weight effect of the
PLATE 4

PANORAMIC VIEW OF UNIT #1 AFTER LOGGING
PLATE 5

SLASH DEPTH BEFORE TREATMENT
dozer and cutter accomplished this. Some exceptions were when the blades rode on top of large logs and stumps skipping over material in between. Dense stands and concentrated fuel were not flattened very well.

Small to medium sized fuels were generally cut into 21 inch pieces and splintered. In some cases small fuels were even ground into the soil.

The ability of the cutter in reducing fuel continuity varied considerably. Logs 6-7 inches in diameter were generally cut into 21 inches sections, but this varied with their condition. Green trees, 6 inches and greater, felled and then passed over with the cutter were only cut into sections near the top of the tree. See plate number 7 showing a treated pole stand in unit #1. Cut marks were on the remaining trees, especially near the base. Refer to plate number 8. Logs from dead snags or material that was already on the ground since logging were easily cut into 21 inches if they did not exceed 8 inches in diameter. Some old dried up logs as much as 11 inches in diameter were crushed and splintered.

All logs that were aligned parallel to the cutter's blades were hardly touched at all. Logs that were perpendicular to the blades had a far better chance of being cut.

Weather played a major role in the brush cutter's effectiveness. During cold fall days the wood was more brittle and easier to cut and break. The soil was also harder and aided the brush cutter. During warmer days the soil was softer and gave a somewhat cushioning effect to the action of the weight and blades.
PLATE 7

TREATED LODGEPOLE PINE STAND
PLATE 8

CUT MARKS IN A GREEN 8 INCH LOG
Usually the dozer was run in 2-3 gear. The brush cutter was most effective at higher speeds. This was attributed to the more bouncy action of the cutter, especially when it was rolling over the top of large logs and tree stumps. The springy action allowed more force to be applied to the slash.

VI. COST DATA

Marden Brush Cutter costs were lower per acre than piling with a dozer and burning. The brush cutter was contracted out at $15 per acre as compared to $26 per acre for the dozer piling. Contract costs do not include administration, equipment, and supplies. The fact that the brush cutter was only a one sequence operation reduced costs.

TABLE IX
TOTAL SLASH DISPOSAL COSTS FOR STUDY AREA

<table>
<thead>
<tr>
<th>Unit</th>
<th>Method</th>
<th>Acres (no.)</th>
<th>Total Cost (Dollars)</th>
<th>Contract Cost/Acre (Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>P&amp;B</td>
<td>101</td>
<td>3,111.70**</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>MBC</td>
<td>76</td>
<td>1,293.52*</td>
<td>15</td>
</tr>
<tr>
<td>#6</td>
<td>P&amp;B</td>
<td>123</td>
<td>3,342.89**</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>MBC</td>
<td>123</td>
<td>2,093.47*</td>
<td>15</td>
</tr>
</tbody>
</table>

* Total includes $.25/acre administration cost and $1.77/acre equipment and supply costs.

** Costs include burning but not administration, equipment, and supplies.
Table X shows the production rates for MBC and P&B treatments. A small TD-15 dozer with brush blade was used to pile the logging slash. Although it was not new, not many mechanical difficulties were encountered during operation time. An average of 10.5 percent of the total time was required for maintenance and repair on both units. The large pulling force needed for the steel drum required at least a D-8 caterpillar with 200 horsepower. The D-8A used was relatively old and many mechanical problems occurred during operation. In contrast, an average of 27.5 percent of the total time was needed for maintenance and repair on unit #1 and unit #6. The torque converter and oil hoses caused the greatest difficulties. Oil consumption was very high, one gallon every two days. Constant jarring action and stress frequently snapped the shear pin between the drawbar and dozer hook up. Loose nuts on the drawbar connection were a constant problem. Overheating of the tractor motor made it necessary to stop operation and allow it to cool 15 minutes for every hour of operation.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Method</th>
<th>Acres (no.)</th>
<th>Productive (hours)</th>
<th>Maintenance &amp; Repair (hours)</th>
<th>Mean Acres/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>P&amp;B</td>
<td>101</td>
<td>130</td>
<td>16</td>
<td>.8</td>
</tr>
<tr>
<td></td>
<td>MBC</td>
<td>76</td>
<td>40</td>
<td>22</td>
<td>1.9</td>
</tr>
<tr>
<td>#6</td>
<td>P&amp;B</td>
<td>123</td>
<td>185</td>
<td>21</td>
<td>.7</td>
</tr>
<tr>
<td></td>
<td>MBC</td>
<td>123</td>
<td>61</td>
<td>15</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Rocks in the area did not pose much of a problem in this investigation. There were few rocks large or hard enough to break the chopper blades. Wet boggy areas presented the greatest problem. In one location in unit #1 the dozer and chopper sank so deep into mud, that it took another dozer and half a working day to free it. Hourly work rate was reduced when the dozer was operating on slopes from 15-20 percent. The dozer had to be cooled more often and it moved slower.
CHAPTER VI

DISCUSSION

I. FIELD TECHNIQUES

The greatest weakness of this study was not being able to make prelogging inventory of stand conditions. Knowledge of minimum and maximum tree size and stand density would have been an invaluable aid in comparing this study with other areas. Especially in terms of sampling the cone serotiny in the clearcuts to predict more accurately the cone habit and number of seeds for germination. Statements on fire hazard reduction would have been more meaningful if original fuels had been previously sampled.

Cone counts should have been delayed until after treatment. Plots sampled before and after treatment generally revealed large discrepancies in total cones. Cones shaken loose when the dozer pushed over standing trees were scattered several hundred feet in all directions and the overall plot disturbance caused by the Marden Brush Cutter increased and some cases decreased the total cones. Insufficient time precluded complete resampling of effected plots.

Present data gives the false impression that very little area was suitably prepared. A better idea of total site preparation would have been obtained if duff and mulch had been tallied in addition to percent mineral soil. Lodgepole pine will germinate and survive on disturbed duff as stated earlier.
II. PERFORMANCE OF THE Marden Brush Cutter

The operator of the Marden Brush Cutter treated both areas without any special regard for plot locations. The general procedure was to make one swath, outlining a selected area, and then finish up the area by overlapping swaths. Most of the time the tractor went in a counter clockwise direction. The 20 percent grade of unit #6 made it necessary for the operator to follow the contour of the slope rather than going straight up and down. Generally, the plots were passed over only once except the plots located on the corner of swaths and turn around points.

Kovalchik (1971) in the summer of 1969 and 1970 found the number of surviving seedlings after treatment were essentially the same as the pile and burn areas. It was believed before that the environment created by the chopper would not be conducive to overstocking. Seedlings growth rate, with other variables remaining constant, on the two treatments will probably differ because of rapid release of some nutrients on burned areas versus the slower release of nutrients on mechanically treated areas.

Some seedlings that became established before and after logging were destroyed by the cutter. Refer to plate number 9 that shows plot 43 unit #6 after treatment. The brush cutter should not be used in areas if the survival of advanced reproduction is desired.

In theory the fire hazard should be sufficiently reduced after cutter treatment by laying the fuel closer to the ground, allowing more rapid deterioration and breaking the fuel continuity. How true this is
remains to be seen. It is interesting to note, however, that the only thing which stopped the rapid spread of a spot fire from a brush pile was a dozer fire line. The burned area had been treated almost a month before. Refer to plate number 10.

In this study best performance occurred where the trees had been knocked down previous to treatment. Dry dead logs were more easily cut into sections or crushed.

The cutter should only be used in timber stands that do not exceed 6 inches in diameter. Trees exceeding this would only have cut marks. Possibly the addition of more weight or ballast to the back of the cutter drum would increase the maximum tree size.

The cutter should not be used in rocky, steep, and marshy terrain. Areas with large amounts of rock dull the blades rapidly and in some cases break them. This adds to the cost per acre and time to complete the job. Slopes exceeding 20 percent cause undue stress to the dozer and decrease the cutter's efficiency by reducing the dozer's speed. Cutters pulled through marshy terrain are often stuck. Considerable time is required, and sometimes another tractor is needed to free a dozer and cutter that have sunk deep in the mud.

The Marden Brush Cutter should not be used in very dense stands. Optimum density cannot be readily set without more study. Stands exceeding 20,000 stems per acre should not be treated with brush cutters. This of course would vary with tree diameter.

Generally, the Brush Cutter treatments are not as costly as other conventional slash disposal methods known to date. How great cost reduction is depends on other variables mentioned previously.
PLATE 9
DESTROYED SEEDLINGS NEAR SEEDFLAT MARKERS
PLATE 10

BURNED AREA IN MBC SECTION IN FRONT OF PLOT STAKE
More research is needed on maximum tree size, stand density, and slope the brush cutter can be effectively used on. Studies on tree size should include modifications of the brush cutter such as more weight and various blade arrangements.

Soil compaction resulting from dozer and cutter weight should be investigated further. The amount of precipitation infiltrating into the soil will probably be decreased and thereby reducing the quantity of available soil moisture for seedlings.

In some areas proper site preparation timing is necessary to insure satisfactory reproduction. On other sites early site preparation is not as critical for reproduction so the slash could be allowed to lie on the ground for more than one season after logging. The brush cutter seemed more effective when the slash was laying on the ground for almost two summer seasons. Delaying slash disposal would of course sacrifice fire hazard reduction and result in a greater eyesore.
CHAPTER VII

CONCLUSION

Many questions must be answered when selecting the right site preparation and slash disposal method. Will the method meet the management goal for stocking and still meet fire hazard standards? Can the method compare favorably with alternate procedures economically? From an ecological viewpoint is it beneficial? Is the treated area aesthetically pleasing afterwards or will it result in vociferous public outcry?

Regeneration levels following treatment with the Marden Brush Cutter are still too high. The resultant high stocking levels may necessitate later thinning to insure optimum diameter growth. Fire hazard, although reduced, may still be a problem for several years afterwards. Major air pollution problems do not exist with the Marden Brush Cutter and it is the least expensive of other conventional treatments to date. Possibly, pollution problems from prescribed fires could result in the Marden Brush Cutter, with limitations, being the only acceptable slash disposal method. Until the time when prescribed fires are forbidden, the continued practice of piling and burning heavy slash volumes is recommended. Light slash could be treated with the Marden Brush Cutter.

Areas treated with the Marden Brush Cutter are not aesthetically pleasing and could generate considerable public discontent. Ecological
considerations must be thoroughly weighed to justify treatment; for example, the nitrogen tie up when slash decomposes slowly.

The Marden Brush Cutter has earned a rightful place in the silvicultural management of lodgepole pine, but is not a cure-all.
LITERATURE CITED


____. 1956c. Effect of crown cover and slash density on the release of seed from slash-borne lodgepole pine cones. Canada, Dept. of Northern Affairs and Natural Resources. Tech. Note No. 41.


Rothermel, R. C. 1969. Tailoring the fire spread rate model to the field. U.S. Forest Serv. Northern Forest Fire Laboratory. Spring Meeting Central States Section of the Combustion Institute at Minneapolis, Minnesota 23 pp.


