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North Central Forest Experiment Station  
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Folwell Avenue  
St. Paul, Minnesota 55101

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STUDY PLAN  
for  
PRESCRIBED BURNING STUDY ON A 500-ACRE OPERATIONAL BURN  
(KIRTLAND'S WARBLER HABITAT) AT MIO, MICHIGAN

Line Project No. FS-NC-2101 (rev.)

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NOT FOR PUBLICATION

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## CONTENTS

	<u>Page</u>
Introduction.....	1
<u>Part I -- Fire</u> .....	2
Objectives.....	2
Area Description.....	2
Preburn Survey.....	3
Burning Procedures.....	6
Burning Order and Timing.....	7
Observations During the Burn.....	7
Weather Conditions.....	8
Postburn Survey.....	9
<u>Part II -- Silviculture</u> .....	10
Objectives.....	10
Evaluation of Seed Source.....	10
Preburn sample.....	10
Fire effects.....	12
Postburning Treatments.....	14
Evaluation of Regeneration.....	17
Observation schedule.....	17
Permanent plots.....	18
Temporary plots.....	19
Weather Observations.....	20
Analysis.....	20
Responsibility and Assignment (Fire).....	22
Research Material and Equipment (Fire).....	22

Manpower Requirements and Job Schedule (Field Work Only) (Silviculture).....	23
Material and Equipment.....	24
Cooperation.....	25

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INTRODUCTION

A prescribed burn of approximately 500 acres was made on the Mio Ranger District of the Huron-Manistee National Forests in May 1964. The purpose of this burn was to create suitable nesting habitat for the Kirtland's Warbler. This is a rather rare songbird (estimated population, 1,000) with somewhat exacting nesting requirements in a restricted area of Lower Michigan. Natural regeneration of jack pine on the burned area was the primary objective. After 2 years the area is very spotty, with some portions showing good regeneration and other portions practically devoid of seedlings. A stocking survey is underway to attempt to delineate areas of adequate and inadequate stocking. Until this survey is completed, one cannot say just how successful this first burn was, but there seems little doubt that it failed to fully accomplish its objectives. There are many possible reasons for this: (1) an inadequate seed source, (2) destruction of seed on trees where the fire burned with considerable intensity, and (3) unfavorable weather for seedling survival. While certain observations were carried on, these were not organized in such a way as to provide reliable information on the basic factors contributing to the success or failure of this burn.

Another area of similar size and adjacent to this first burn has now been logged and is scheduled for burning. Seed trees have been left but a casual observation indicates that many of these are small and there is serious question whether the seed source in standing trees is adequate.

Research is interested in assisting Administration obtain the results desired on this burn, and at the same time study the effects of various burning and cultural treatments carried out on a fairly large operational scale. Studies will be carried on jointly by Timber Management Research and Forest Fire Research.

#### PART I -- FIRE

##### OBJECTIVES

To evaluate the effect of six combinations of weather conditions and firing techniques on fire intensity on the basis of fuel reduction, exposure of mineral soil, and destruction of seed. Temperature and heat flux devices will be used as supplemental measures of fire intensity.

##### AREA DESCRIPTION

The area to be burned is located approximately 6 miles southeast of Mio, Mich., in the Kirtland's Warbler Management Area on the M' District of the Huron-Manistee National Forests. This area covers nearly all of Section 2, T25N, R3E. This section has been logged, approximately 15 to 17 seed trees per acre have been left standing.

The area will be systematically divided into eight blocks, to which different burning treatments will be applied (see attached map). The treatment areas are labelled with the letters A through H, and individual areas will be assigned as follows:

- |   |   |
|---|---|
| 1. Strip backfire - Sept. or Oct. 1966                  | A |
| 2. Strip headfire - Sept. or Oct. 1966                  | B |
| 3. Area ignition - Sept. or Oct. 1966                   | C |
| 4. Strip backfire - April or May 1967                   | D |
| 5. Strip headfire - April or May 1967                   | E |
| 6. Area ignition - April or May 1967                    | F |
| 7. Pile with bulldozer or rock rake and burn<br>in fall | G |
| 8. Unburned check                                       | H |

The burning will be done during two general seasons (spring and fall). In the event that fall burning weather does not occur in 1966, the fall burning will be delayed until the fall of 1967.

#### PREBURN SURVEY

An extensive preburn survey will be made on each block to accurately determine conditions existing prior to the prescribed burn. Litter depth, amount of exposed mineral soil, and present reproduction under 6 feet tall will be measured by using milacre plots. Systematic sampling with random starts will be the method used.



Slash will be described in the following manner:

1. Quantity
2. Height
3. Density
4. Composition or size
5. Compactness

Slash quantity in tons/acre will be determined from the age and stocking of severed trees as recorded for each mileacre plot.<sup>1/</sup>

Height of slash will be measured to the nearest 6 inches.

Slash density will be determined in each plot from an ocular estimate by the following classes:

<u>Class</u>	<u>Percent ground covered</u>
1	0 - 25
2	26 - 50
3	51 - 75
4	76 - 100

Slash composition or size of slash components will be determined from ocular estimate of the ratio between fine fuels and coarse fuels. For the purpose of this study, fine fuels are defined as particles having a mean diameter of one-fourth inch or less; coarse fuels include all particles having a mean diameter greater than one-fourth inch. Four composition classes will be noted:

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<sup>1/</sup> Brown, James K. 1965. Estimating crown fuel weights of red pine and jack pine. U.S. Forest Serv. Res. Paper LS-20, 12 pp., illus.



<u>Class</u>	<u>Percent fine</u>	<u>Percent coarse</u>
1	76 - 100	0 - 25
2	51 - 75	26 - 50
3	26 - 50	51 - 75
4	0 - 25	76 - 100

Fuel arrangement or compactness will be recorded from ocular estimation of the ratio between fuel solids and interstices on each three-dimensional milacre plot. Two broad classifications will be made:

1. Compact -- .25 or more
2. Not compact -- less than .25

Litter depth will be measured to the nearest one-eighth inch from the top of the mineral soil to the upper surface of the litter. Thirty random measurements will be made within each block for litter depth.

The amount of exposed mineral soil present on each milacre plot will be estimated and each plot classified according to the following classes:

<u>Class</u>	<u>Percentage exposed</u>
1	0
2	1 - 15
3	16 - 30
4	31 - 50
5	51+

Reproduction under 6 feet tall will be noted and the stocking percent and number of seedlings per acre determined.

An evaluation of the seed source present on each area will also be carried out using random sampling. One-tenth-acre plots will be used and the following observations will be taken on every seed tree within each plot:

1. Total height
2. Height of the bottom of the cone-bearing crown
3. D.b.h.

Each individual seed tree will also be classified according to its cone-bearing qualities as follows:

- Class 1 - heavy (200+ cones)
- Class 2 - medium (100 - 200 cones)
- Class 3 - light (25 - 100 cones)
- Class 4 - very light (9 - 25 cones)

#### BURNING PROCEDURES

Since the objectives of this study are to test different burning techniques and their silvicultural effects, it is recommended that all areas to be burned during the same season be burned on the same day. This will reduce any chances of error due to entirely different burning weather occurring when each area is burned. The burns will probably be conducted during early May and mid-October, although any time between April 15 to May 31 and September 15 to October 31 shall be acceptable if the conditions for burning are right.

The following burning techniques will be used:

1. Strip backfire:

The strips shall be approximately 2 chains wide and the installation of single plow lines to create these strips will be required.

2. Strip headfire:

The strips will be approximately 5 chains wide and will not require additional plow lines.

3. Area ignition:

Electrically fired hydrocarbon fuel boosters will be used to control advection.

#### BURNING ORDER AND TIMING

The strip backfire block will be burned first, beginning about 12:00 noon EST. The strip headfire block will be the next one burned, and the area ignition block will be burned last. All blocks should be burned by 5:00 p.m. EST if possible. Block II will be piled and burned independently of broadcast burning.

#### OBSERVATIONS DURING THE BURN

A portable recording weather station shall be set up on the area to record vital weather data prior to, during, and after the burn. Observations will be made on windspeed and direction, air temperature, fuel moisture, relative humidity, and precipitation. These data will be extremely important for aiding postburning evaluations.

Temperatures at different heights within the crowns of the seed trees, adjacent to the caged cones (Part II page 4 ), will be measured by using a 24-station graphic recording instrument. Iconel Shielded, 24-AWG, chromel-almel thermocouples will be attached in the tree crowns and timed temperatures will be recorded. These data will be used to determine the fire intensity and to also aid in determining the effects of the fire upon the opening of cones on the seed trees.

In addition to the graphic recorder measurements, the black-can "analog" will be used to measure surface fire intensity.<sup>2/</sup> Each area will be sampled, with systematic distribution of at least 50 cans. Temperature differential and water loss from these cans will be measured and caloric calculations made. These data should provide an integrated measure of fire intensity differences that might occur.

#### WEATHER CONDITIONS

The weather conditions prior to and during the burn shall be as follows:

1. BUI of at least 25
2. At least 5 days without rain prior to the burn
3. Relative humidity not greater than 70 percent
4. Windspeeds less than 15 mph
5. Air temperatures greater than 50

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<sup>2/</sup> Beaufait, William R. 1966. An integrating device for evaluating prescribed fires. Forest Science 12: 27-29.

## POSTFIRE SURVEY

After the blocks have been burned, a survey will be made to determine the effects of the fire on each block. Fuel quantity, fuel composition, and litter depth measurements will be made in the same manner as previous to the burn.

Superimposed on each milacre plot will be two 1-square-foot plots that will be used to classify the effects of the fire on the seedbed. One plot will be located 1 foot north of the milacre plot center and the other will be located 1 foot south of the milacre plot center. Each 1-square-foot plot will be classified according to the condition of the seedbed on the majority of the plot. These classes are as follows:

- A. Exposed mineral soil
- B. Fine ash
- C. Charred litter
- D. Undisturbed

One-tenth-acre plots will be used to determine the effects of the fire upon the seed trees. The seed trees will be placed into three classes according to the amount of tree crown destroyed by the fire. These classes are as follows:

- A. Undisturbed crown
- B. Crown partially destroyed
- C. Crown completely destroyed

Also it will be noted if the cones on the trees are opened or closed.

By combining the crown destruction data with the fuel reduction data and seedbed preparation data the overall effectiveness of each burning technique shall be evaluated to determine which has the most desirable result.

## PART II -- SILVICULTURE

### OBJECTIVES

The objective of the silvicultural phase of this study is to evaluate the effect of the burn treatments and postburning seedbed treatments on the regeneration of jack pine and provide a basis for remedial measures if the desired stand is not established.

### EVALUATION OF SEED SOURCE

The sampling of seed trees described in the fire section of this plan will be adequate to determine the distribution of the seed source. In addition, the quantity and quality of seed, as well as the effect of the fire on available seed, will be determined in the following manner.

#### Preburn Sample

The quantity and quality of seed on standing trees will be estimated by collecting cones from sample trees, weighing seed from each tree, and performing cutting and germination tests. A preliminary sample will be taken by selecting trees at 25 points distributed

uniformly within each burning treatment. Since little seed production can be expected from trees under 4 inches d.b.h.<sup>3/</sup> only larger trees will be included in the sample unless it becomes apparent that smaller trees actually have a significant number of cones. At each sampling point, 1 out of every 10 branches on the tree closest to the point will be clipped, and from these branches the cones will be collected and counted. If less than 25 cones are collected, all will be retained for testing. If more than 25 are collected, a sample of 25 will be drawn and retained. Total height, crown length, and d.b.h. will be recorded for each of the sample trees. The 25-sample cones from each tree will be kept separate and placed in storage at 40° F. until seed can be extracted.

Seeds will be extracted by heating the cones to 145° F. for a maximum of 18 hours or a minimum of 10 hours. Seeds will be separated from the cones in a tumbling drum, de-winged and each lot weighed. From each single tree lot of seed, 100 will be counted out for a cutting test, and three lots of 50 will be counted out for germination tests. Germination tests will be carried out in petri dishes, using conditions recommended in the Woody-Plant Seed Manual,<sup>4/</sup> if possible: i.e., night temperature of 68° F., day temperature of

<sup>3/</sup> Roe, Eugene I. 1963. Seed stored in cones of some jack pine stands, northern Minnesota. U.S. Forest Serv., Lake States Forest Exp. Sta., Res. Paper LS-1. 14 pp., illus.

<sup>4/</sup> U.S. Forest Service. 1948. Woody-plant seed manual. U.S. Dep. Agr., Misc. Public. 654, 416 pp., illus.

86° F. for 60 days. Germination will be counted weekly and the germinated seedlings removed from the dishes at each count. Seed not used for cutting and germination tests will be thoroughly mixed to make one composite sample, from which 5 lots of 100 seeds each will be counted out and weighed to the nearest ten thousandths of a gram (4th decimal place). The average weight per 100 seed will be used to convert seed weights to number of seeds available.

#### Fire Effects

Prior to the fire, about 2 bushels of cones will be collected from slash on the area to be burned. Seventy-five lots of 10 cones will be drawn and each lot will be enclosed in a small cage made of wire small enough to retain any seed that falls from the cones. Immediately before the fire, the cages will be suspended in seed trees adjacent to the thermocouples used to record temperatures during the burn. If enough thermocouples are available, three will be placed inside of three cages. If not, a separate test will be made to determine the heat-shielding effect of the cages.

As soon as practicable after the fire, the cages will be recovered. Seed that can be readily extracted will be separated, cleaned, weighed, and subjected to germination tests as described above. The cones will then be heated to 145° F. for 10 to 18 hours and any remaining seed extracted and weighed to determine what proportion of the seed was released immediately.



In addition, 1-square-foot seed traps will be placed in the vicinity of the black can positions used to obtain a rough estimate of fire intensity. If enough traps are available, one will be placed at each black can location, one 5 feet north of it, and one 5 feet south of it, when it is possible to relate snow fall to fire intensity if such a relationship exists. The traps will be placed under any slash that is not lying on the ground.

As the seed traps are placed, cones or slash in the immediate vicinity of each black can will be classified as:

1. Totally consumed
2. Partially consumed
3. Fully even
4. Partially even
5. Closed

Classification will be based on the last prevalent condition. If classes 2, 3, 4, or 5 are assigned, a sample of 10 cones will be collected. The seed extracted, and tested for viability.

Seed will be collected from traps according to the following schedule.

Full burns:

First route following fire.....	once a week
End of first route until seed traps are snow covered.....	every other week
Snow melt until mid-July.....	once a week
Mid-July until snow cover.....	end of series
Snow melt until mid-July.....	beginning and end of period

### Spring burns:

First month following fire.....	once a week
End of first month until mid-July.....	every other week
Mid-July until snow covered.....	end of period
Snowmelt until mid-July.....	beginning and end of period

The number of seed collected each time will be recorded and the composite collection on each date will be subjected to a germination test as described previously. However, there must be a minimum of 25 seeds in each collection in order to make such tests. If there are not enough seed, the collection will be stored at 40° F. until the next one is made and the germination test will be run on the composite from the two dates.

### POSTBURNING TREATMENTS

In Beaufait's studies (1960), jack pine germinated best on mineral soil under light shade, but survived and grew best where there was no shade and some organic material was present in the surface soil. These results suggest that some form of scarification and, possibly, a temporary cover crop would enhance the establishment of jack pine regeneration. Several variations of these treatments will be tested following the fire.

An Athens disc will be used to create uniform soil disturbance and enough surface irregularity so that germinating seedlings will

receive some shade. Two discing directions will be used to vary the amount of shade. A springtooth farm harrow will be used to create less disturbance and surface irregularity. Direction is probably not a factor with this kind of scarification. Also, a cover crop of annual rye will be sown on some of the disturbed and undisturbed area, during the second week after the burn, to provide a different kind and degree of shade than that which might result from scarification.

Altogether, eight combinations of these techniques for altering the seed and seedling environment will be tested. All eight will be tested in the block burned with a strip headfire, because it is anticipated that this will be a better intermediate burn which will create conditions comparable to the less intense portions of the area in either burn and the more intense portions of the strip headfire. Some combinations will also be tested on the other two blocks.

Since it seems very likely that losses to birds and rodents may have a significant influence on the establishment of regeneration, repellent-coated jack pine seed will be broadcast at the rate of 20,000 viable seed per acre on all treatment areas, except for some in the strip headfire block that will be various controls on this variable. These will receive no repellent-coated seed, but if the profl. insect estimate of seed from seed trees is less than 12,000 viable seed per acre, uncoated seed will be broadcast at the rate of 20,000 seed per acre to simulate natural seed fall. This can be sown at the same time as the cover crop.

The treatments in the strip headfire block will be:

1.	Athens disc	east and west	coated seed	annual rye
2.	" "	" " "	" "	no cover crop
3.	" "	" " "	natural seed	annual rye
4.	" "	" " "	" "	no cover crop
5.	" "	north and south	coated seed	annual rye
6.	" "	" " "	" "	no cover crop
7.	" "	" " "	natural seed	annual rye
8.	" "	" " "	" "	no cover crop
9.	Springtooth	any direction	coated seed	annual rye
10.	" "	" " "	" "	no cover crop
11.	" "	" " "	natural seed	annual rye
12.	" "	" " "	" "	no cover crop

Each treatment will consist of one pass at least 10 chains long with the specified type of equipment in the specified direction. A strip approximately as wide as the scarified strip and adjacent to it will be left undisturbed. This undisturbed strip will be seeded with pine and/or a cover crop 2 weeks after the burn, the same as the matching scarified strip.

Treatments 1, 2, will be repeated in the area ignition and strip backfire blocks.

All postburning treatments will be limited to those portions of each block where jack pine was the predominant component of the original stand. Any sizable patches where jack pine was a minor species will

be mapped out and avoided when the treatments are applied, because it is felt that different techniques would probably be required to establish the desired stocking of jack pine regeneration in these areas.

#### EVALUATION OF REGENERATION

Seedling establishment and survival will be evaluated quite intensively on the treated strips and (intermediate untreated strips, using permanent plots so that changes over time can be observed. A more extensive survey using temporary plots will be made on the untreated area in each block.

#### Observation Schedule

If the weather should remain favorable for germination during the first month after the seedbed treatments and seeding are completed on the fall burn, observations on both temporary and permanent plots will be necessary at the end of that month. If not, the first observations will be made the following spring about May 20 and repeated about the end of June. The first observations on the spring burn will be made at the same time unless, for some reason, the burn is delayed until after May 20. In that case, the first observations will be made 1 month after completion of the burn, and repeated 6 weeks later. Observations on both the spring and fall burns will be repeated in the middle of September.

During June 1968, a third observation will be made, and at this time the new seedlings will be tallied separately from those that are 1 year old. It may also be advisable to reclassify shade conditions. A fourth observation will be made in mid-September 1968.

#### Permanent Plots

Immediately after the seedbed treatments and seeding are completed, 10 permanent plot clusters will be established in each treated and intervening untreated strip. The plot clusters will be located at 1-chain intervals along the scarified strips, with a matching cluster in the adjacent undisturbed area. Each cluster will consist of eight plots, 1.65 feet square, oriented in the same direction as the strip. Both ends of the cluster will be marked with a permanent stake.

On each plot, the seedbed will be classified as (A) exposed mineral soil, (B) fine ash, (C) charred litter, or (D) undisturbed based on the condition prevailing on the majority of the area within the plot. If slash or a stump occupies an appreciable portion of the plot, this will be noted. Also, the shade affecting each plot will be classified as:

- A. None - complete exposure with no unconsumed slash more than one-half inch in diameter; no grass, ferns, or weeds; no brush or residual trees that would cast shade on the plot.
- B. Light - occasional pieces of unconsumed slash more than one-half inch in diameter lying on the ground.

herbaceous vegetation, shrubs, brush, or residual trees that cast a shadow on the plot part of the time, or very light shade all the time.

- C. Moderate - stump or snag immediately adjacent to the plot on the south or west sides; herbs, shrubs, brush or residual trees so positioned as to cast spotty shade most of the time (south or west of plot).
- D. Heavy - unburned slash; dense herbaceous cover, shrubs, or brush cover that has not been killed.

#### Temporary Plots

Temporary plots will be taken to determine which burning treatment gives the best overall results and which of the postburning treatments, if any, will be needed to ensure the establishment of an ideal jack pine stand. The ideal stand consists of dense patches of jack pine, interspersed with openings making up about the same area as the stocked patches.

In order to determine what portion of each burn treatment might be considered satisfactory, a systematic sample will be used. North-south transects will be uniformly distributed within each treatment block and 10 1/4-acre plots will be uniformly distributed along each transect. This distribution of quadrats may have to be modified somewhat to avoid treated strips and fit some of the smaller blocks.

At each measurement, each quadrat with one or more jack pine seedlings will be tallied as stocked. During the second year, stocking with 1- and 2-year-old seedlings will be separated.

## WEATHER OBSERVATIONS

As a bare minimum, there should be one standard rain gauge and a hygrothermograph maintained during the 1967 and 1968 growing seasons. If available, a recording rain gauge will be used.

## ANALYSIS

The first step in the analysis of this study will be to determine the adequacy of the seed source. Data on number and distribution of seed trees, together with estimates of seed yield and viability, will be the basis for this determination.

The second step will be to establish the effect of the fire on seed viability and dispersion. The caged cones located in conjunction with the thermocouples will provide enough information about heat required for opening cones and damage to seed resulting from excessive heat so that the applicability of Beaufait's<sup>5/</sup> time-temperature curves can be checked. This information, combined with estimates of fire intensity based on fuel maps, will be used for a preliminary estimate of the amount of viable seed released. Counts of trapped seed and germination tests on trapped seed will be used to check this preliminary estimate.

Regeneration counts in permanent plots will be analyzed in several ways:

1. Comparison of seeded and unseeded areas (or areas seeded with treated and untreated seed) to establish the losses to birds and rodents.

<sup>5/</sup> Beaufait, W. R. 1960. Some effects of high temperatures on cones and seeds of jack pine. Forest Sci. 6: 194-199.



2. Comparison of strips with and without a cover crop.
3. Comparison of scarification methods (direction and equipment).
4. Comparison of nonscarified and scarified plots.

Classification of seedbed and shade conditions on permanent plots will permit an evaluation of the effect of these variables on seedling germination and survival, as well as an evaluation of each treatment in terms of the seedbed and shade conditions created.

The information obtained from this fairly intensive study will be correlated with the results of the postburn survey on other blocks (see fire phase of work plan) to compare the overall effectiveness of each burning treatment and establish the need for further treatment following the fire. This initial comparison will be checked by means of the overall stocked-quadrat survey to be made on each treatment block.

## RESPONSIBILITY AND ASSIGNMENT (FIRE)

1. Preburn survey
  - Rodney Sando
  - Ranger staff
2. Installation of weather station
  - Nonan Noste
3. Installation of supplemental control lines
  - Ranger staff (contract)
4. Organization and supervision of burning and control
  - Ranger
5. Postburn survey and evaluation of data
  - Rodney Sando
6. Written report
  - Wayne Banks
  - Rodney Sando

## RESEARCH MATERIAL AND EQUIPMENT (FIRE)

1. Recording weather station
  - a. Shelter (portable)
  - b. Recording anemometer
  - c. Recording rain gauge
  - d. Max-Min thermometer
  - e. Hygrothermograph
  - f. Aspirated psychrometer

2. Area ignition material
  - a. Ten-cap blasting machine
  - b. 120 14-oz. blivets
  - c. 50 firing squibs
  - d. 1,000 duplex wires
  - e. Pneumatic torch
3. Servo recorder w/thermopile
  - a. 36 chromel-alumel thermocouples, 24-AMC, w/radiation shield
  - b. 24 leads, 100-200 ft.
  - c. 1,500-watt generator
  - d. Phase meter
  - e. Potentiometer
4. 150 black cans w/lids
5. 5-kg. cap. scale--located at Pine River Lab.

MANPOWER REQUIREMENTS AND JOB SCHEDULE  
(FIELD WORK ONLY) (SILVICULTURE)

1. Cone collections from seed trees
 

Fall burns: August 1966 -	5 man-days
Spring burns: October 1966 or March 1967 -	5 man-days
2. Preparation and placement of cone cages
 

At time of instrumenting burn -	6 man-days
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3. Placement of seed traps
 

Immediately after burn -	2 man-days
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4. Seedbed treatments (scarification & seeding)
 

Within 3 days after burn -	8 man-days
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5. Plot layout on intensive study area
  - Start 2 weeks after burn - 20 man-days
6. Regeneration counts
  - Fall burn:
    - 1 month after burn? 15 man-days
    - Mid-June 1967 15 man-days
    - Mid-September 1967 15 man-days
    - Mid-June 1968 15 man-days
    - Mid-September 1968 15 man-days
  - Spring burn:
    - Mid-June to Mid-July 1967 15 man-days
    - Mid-September 1967 15 man-days
    - Mid-June 1968 15 man-days
    - Mid-September 1968 15 man-days
7. Seed collections (as shown on pages 13 and 14) 15 man-days

#### MATERIAL AND EQUIPMENT (SILVICULTURE)

1. 2 lbs. of jack pine seed.
  - 1 lb. treated.
  - 1 lb. not treated in case of inadequate seed source.
  - (Collect 3 bushels of cones from slash on the area)
2. 4 bushels annual rye seed.
3. 75 cone cages.
4. 300 seed traps (from Grand Rapids).
5. Athens disc and crawler tractor.
6. Springtooth harrow and wheel tractor.

## COOPERATION

This study is a cooperative effort involving the Supervisor's staff on the Huron-Manistee National Forests, the Mio Ranger District, the Fire Research Project, the Northern Conifer Research Project, and the Plantation Management Research Project. The research group will be responsible for laying out treatment areas, collecting data, analyzing results, and preparing written reports. The administrative group will be responsible for applying the prescribed treatments and will assist in the collection of data.