

STUDIES OF THE MORPHOLOGY OF JACK PINE CONE
OPENING AND THE PHENOLOGY OF
SEED DISPERSAL AND GERMINATION

Project MS-235

by

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FOREST RESEARCH LABORATORY
WINNIPEG, MANITOBA
INTERNAL REPORT MS-48

DEPARTMENT OF FORESTRY AND RURAL DEVELOPMENT
MARCH 1967

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Internal Report

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N. G. Bruce and N. R. Walker¹

INTRODUCTION

Jack pine logging operations in Manitoba are carried out during winter months and slash is lopped and scattered during the operation by the cutters. In order to obtain reproduction after logging, cones must open and disperse seed over a suitable seedbed and seed must germinate at a time favourable to seedling survival.

As jack pine cones require a temperature of 45°-50°C to dissolve the resin bond of the cone scales, seed from scattered slash may be released at times unfavourable to germination. For example, seed in southeastern Manitoba during late April largely germinates in the first three weeks of June, (Sims 1964) a time believed to be optimum for seedling survival. However, it is believed that many cones on scattered slash have not opened at that time, therefore the remaining seed supply is in danger of being dispersed at times believed to be detrimental to germination and survival.

In the spring of 1964 studies were begun to provide more information on seed dispersal from cone bearing slash, seed germination, and effects of time of germination on seedling survival.

Such information could lead to modifications in slash dispersal treatments to provide dispersal of seed when conditions are optimum for seed germination and survival of seedlings.

The study has been divided into two experiments. Experiment I is designed to assess the total cones and seeds per cone contained in lopped and scattered slash following clear cutting and to determine the phenology of seed dispersal from lopped and scattered slash following clear cutting. Experiment II will assess germination, survival and development of seedlings from seed sown at two-week intervals throughout the growing season.

¹Forest Technicians, Canada, Dept. Forestry and Rural Development, Forest Research Branch. (Experiments I and II were conducted and described in this report by Messrs. Walker and Bruce, respectively. The supplementary study to experiment I was conducted and described by N. G. Bruce).

WORK COMPLETED IN 1966 EXPERIMENT I

Description of Area

The area selected for the study is located on Sec. 29, Twp. 2, Rge. 12 E.P.M. of the Piney Conservation District.

Logging took place during the winter of 1965-66. Hauling of logs from the area was completed during the first two weeks of May. The slash was scattered by the cutters at the time of logging and additional scattering was done by the Department of Forestry to give an even distribution throughout the area.

Table 1 gives a summary of the former stand characteristics for the area.

TABLE 1

SUMMARY OF STAND CHARACTERISTICS - JACK PINE

Area acres	Site index	Age (years)	Jack pine 4 inches d.b.h. and up		
			Trees/ acre	Basal area /acre(sq.ft.)	Merch. Vol./ acre (cords)
9.6	42	55-80	140.5	58.0	14.2

Study Plot Location

An area (7 chains x 7 chains) was marked out and 50 transects were established within the area. Transects were located in three rows at a spacing of 30 links between each transect and 90 links between each row. Transects were numbered consecutively from 1 to 50. Each transect was 1.1 chains long and 10 links wide and was divided into 11 one-milacre quadrats. A numbered wooden corner post, 2 x 2 inches by 2.5 feet was used to mark the northeast corner of each transect. Wooden stakes, 1 x 1 inch by 2.5 feet were used to mark the three remaining corners.

Cone Crop Sampling

A total cone count was made on the first or last quadrat of each transect to determine the total number of cones per acre. Cones were classed as open, (when 75 per cent or more of the cone scales had opened) partially open (when one or more cone scales up to 75 per cent had opened) and closed. Cones were grouped into three height-above-ground classes. The height classes used were: 0 - 7 inches, 7 - 12 inches, and above 12 inches.

On May 9, 1966 a total cone count by height class was made on 25 quadrats located on the 1965 experimental area. The purpose of the count was to determine whether the slash had been compacted by the winter snowfall.

Cone Collections for Seed Dispersal Counts

Every 28 days, as weather and work schedules permitted, cone collections were made from one quadrat, randomly chosen from quadrats 2 to 10, on each transect. The four cones nearest the centre of the quadrat in each height class were sampled. Only open and partially open cones were collected. When there were not four cones in a height class on the plot a sample was taken outside the quadrat to make up the remainder. If no cones were present in a height class no sample was taken.

Two cone collections, on June 8 and on September 7, 1966, were made on the area established in 1965. Cones were placed in polyethylene bags and taken to the laboratory for the seed dispersal counts. Markings on the top of the cone scales indicated whether a seed had been dispersed or was not present before the scale opened. Loose seeds found in the polyethylene bags were subtracted from the seed dispersal count.

Supplementary Study to Experiment I

The supplementary study to experiment I was established immediately adjacent to experiment II in the trough portion of a furrow created by a middle buster plough. Forty-eight seed traps each 1/20,000 acre in size and constructed of Fourdrinier wire were placed in the trough and filled with sieved sand to a depth of approximately one inch. Firm contact between the soil in the trap and that in the furrow was established. The corners of each trap were secured by a one inch by 1 inch wooden stake. Ten closed jack pine cones from the previous season's cone crop were attached to string and suspended over each seed trap. Cones were suspended above slash or mineral soil at ground level, four inches above ground level and nine inches above ground level. The traps were located in eight blocks, each block containing the six treatments. Cones at ground level were placed directly on the slash (Figure 1) and traps with cones at four and nine inches above the soil surface contained slash suspended two inches below the cones (Figure 2). The slash was cut into short lengths and tied to mats made of hardware cloth. Mat size was approximately eight inches by eight inches with $\frac{1}{2}$ -inch mesh.

The cones were examined at monthly intervals from May 30 to October 12 inclusive and classed as open or closed. Released seed was collected by sieving the sand in each trap.

Weekly maximum air temperatures were recorded at four and nine inches above ground by means of two Lambrecht thermometers. Soil surface temperature of a trough portion in a furrow and the surface temperature of soil contained in a seed tray located in the trough portion of a furrow were also recorded.

In order to prevent predation of dispersed seed by rodents, the area was enclosed by a low fence constructed of 30-inch by 96-inch sheets of galvanized metal dug into the ground to a depth of six inches (Figure 3). The fence was supported by two-inch by two-inch wooden stakes driven into the ground at eight foot intervals (Wagg).

WORK COMPLETED IN 1966 EXPERIMENT II

Study Plot Location

The study area for 1966 was located on a fresh site in the extreme south east quarter of section 29, in township 2, range 12E (Figure 4). Ten plots each containing 12, 1/20-acre quadrats were established in the trough portion of a furrow created by a middle buster plough. All slash, cones and debris were removed from the furrow and immediate area as a precaution against natural regeneration interfering with the experiment. Numbered 2-inch by 2-inch wooden stakes were used to mark the north west corner of each plot, each quadrat was marked by a numbered 1-inch by 1-inch wooden stake located in the north west corner. Small barricades (1-inch by 1-inch wooden stakes) were placed between the quadrats to prevent the seeds from washing.

As a precaution against mammal damage the area was located within the enclosure described above.

Plot Seeding

Plot seeding was carried out at two-week intervals beginning May 17 and ending October 18.

One quadrat in each plot was randomly selected and sown with 50 jack pine seeds. The seed was treated with Arasan, Endrin and aluminum flakes. The compound contains fungicidal properties and also acts as an animal repellent. Germination tests conducted in the laboratory from March to September of 1966 showed the seed to have a germination capacity of 90.9 per cent.

Again, as in the 1965 study¹, the seed was lightly covered at time of planting.

¹Throughout the remainder of this report the 1964, 1965, and 1966 study areas will be referred to as areas I, II and III respectively.



Figure 1. Jack pine cones at ground level over slash.

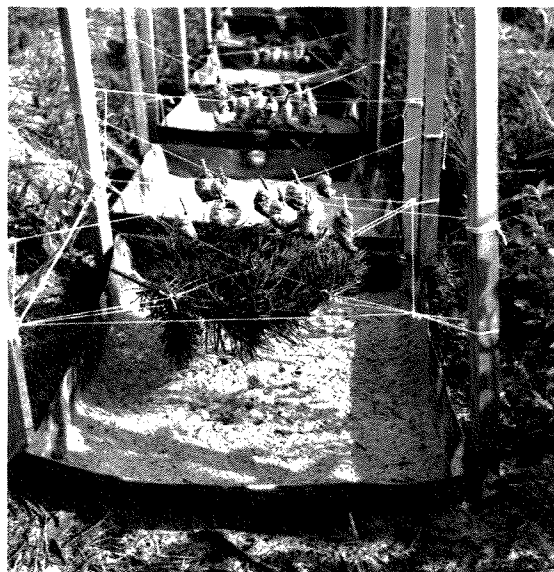
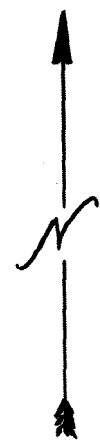


Figure 2. Slash suspended below cones.

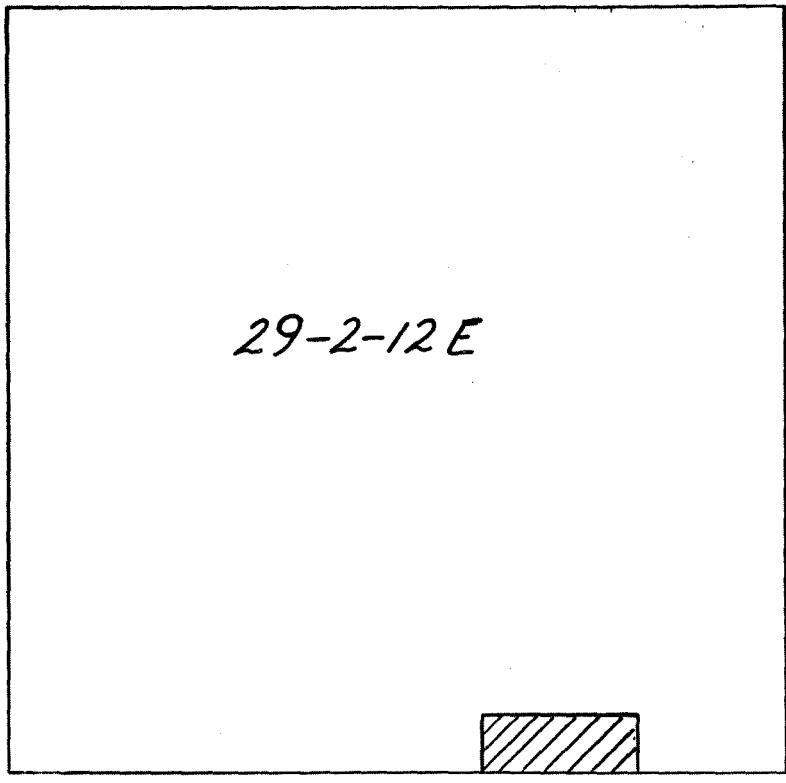


Figure 3. View of study area showing mouse fence in background.

Figure 4
MS 235 - 1966 AREA
Piney District
SCARIFICATION



Scale 1 inch. = 20 chain.



Fire Guard

Germination and Mortality Counts - Area III

Germination and mortality counts were carried out at weekly intervals beginning May 24 and ending October 18. As germination occurred, germinants were marked with coloured plastic skewers and the week of germination recorded. Each week of germination was depicted by a different coloured skewer. Dates of mortality were recorded and dead seedlings were marked with red skewers.

Germination and Mortality Counts - Area II

Germination and mortality counts were carried out at two-week intervals beginning in late May and continuing until late September. New germination was marked with a coloured plastic skewer and period of germination was recorded. Mortality of seedlings that had germinated in 1965 and 1966 was recorded and dead seedlings were marked with red skewers.

Several plots in this area were disturbed during the late summer and a number of skewers were removed.

Seedling Measurement - Areas II and III

Total height and 1966 growth of seedlings in areas II and III were obtained during the late fall of 1966. Branching was also recorded.

Climatic Data

- (i) Temperature and relative humidity: Daily air temperature and relative humidity were recorded on area III from May 17 to October 11 using a Lambrecht hygrothermograph. The instrument was serviced weekly and was housed in a bird cage shelter one meter above the ground.
- (ii) Precipitation: Rainfall was collected weekly on area III using three Beal-type rain gauges. Collections were made for the period May 17 to October 18.

RESULTS - EXPERIMENT I

Cones Per Acre in Slash

Table 2 shows the total cone sample by height class and degree of openness immediately after logging for the 1966 area.

Table 3 shows the number of cones per acre for the 1965 area. Cones in the 0 - 7 inch class increased by 10 per cent from 1965 to 1966. Cones in the 7 - 12 inch class decreased by 10 per cent during this same period while the per cent of cones above 12 inches remained the same.

TABLE 2

NUMBER OF CONES IN SLASH BY HEIGHT-ABOVE-GROUND CLASS -
1966 AREA, PINEY

Cone condition	Height above ground (inches)			All cones
	0 - 7	7 - 12	12 +	
Open	0	0	0	0
Partially open	0	0	0	0
Closed	3,788	485	493	4,766
Total	3,788	485	493	4,766
Cones per acre	75,760	9,700	9,860	95,320

TABLE 3

NUMBER OF CONES IN SLASH BY HEIGHT-ABOVE-GROUND CLASS -
1965 AREA, HADASHVILLE

	Year of sample	Height above ground (inches)			All cones
		0 - 7	7 - 12	12 +	
Cones per acre	1965	78,420	17,960	8,600	104,980
Per cent		75	17	8	
Cones per acre	1966	109,960	9,520	9,880	129,360
Per cent		85	7	8	

Monthly Cone Collections

Table 4 summarizes the monthly cone collections by height-above-ground class and degree of openness for the 1966 area. By July most cones had opened and the number of open or partially open cones remained fairly constant during the remainder of the season. Fifty-eight per cent of the cones in the 0 - 7 inch height class, 88 per cent in the 7 - 12 inch class, and 96 per cent in the above-12-inch class remained closed throughout the entire collection period.

Table 5 shows the collection dates and the number of open, partially open and closed cones in each height class for the 1965 area as sampled in 1966. The per cent of open and partially open cones showed an increase between 1965 and 1966 for all the height classes. The per cent of open and partially open cones as based on all the 1965 collections was 42, 14 and 5 for levels 0 - 7, 7 - 12 and 12 + inches respectively. For the two collections made in 1966 the per cent of open and partially open cones increased to 61, 26 and 13 for the respective levels.

On October 12 the cones suspended over the seedtraps on the supplementary study to experiment I were collected and a total seed dispersal count was made. The number of open cones at this time is shown in Table 10.

Monthly Seed Dispersal per Acre

Table 6 shows the monthly seed dispersal per acre for all open and partially open cones in each height class for the 1966 area. Seed dispersal was highest in the 0 - 7 inch class and lowest for cones above 12 inches. Total seed dispersal to October 12 was 6.78 pounds per acre. The highest period of seedfall occurred from May 27 to July 25 when a total of 4.76 pounds of seed fell per acre.

Seed dispersal in 1966 for the 1965 area is shown in Table 7. No additional seedfall had occurred by June and only .12 pounds were dispersed by September. The actual seedfall may be higher than that shown in the table. Cones two years after cutting have already weathered considerably and accurate counts are more difficult than on cones made the first summer after cutting.

Seed dispersal per acre from the cones suspended over the seed traps on the supplementary study to experiment I is shown in Table 8. Where cones were suspended over slash seedfall was 16.77 pounds per acre; where no slash was used seedfall was 15.72 pounds per acre

TABLE 4

NUMBER OF OPEN, PARTIALLY OPEN AND CLOSED CONES AT
MONTHLY INTERVALS - 1966 AREA, PINEY

Date	Height above ground (inches)											
	0 - 7				7 - 12				12 +			
	Open	Part- ially open	Closed	Total	Open	Part- ially open	Closed	Total	Open	Part- ially open	Closed	Total
May 27	8	5	179	192	0	0	164	164	0	0	132	132
June 27	50	16	126	192	5	2	173	180	0	2	154	156
July 25	72	21	91	184	3	7	126	136	0	4	120	124
Aug. 22	85	16	91	192	11	14	127	152	5	2	113	120
Sept. 16	72	17	91	180	27	15	122	164	7	6	111	124
Oct. 12	99	10	76	185	12	12	100	124	3	4	105	112
Total	386	85	654	1125	58	50	812	920	15	18	735	768
Per cent	34	8	58		6	6	88		2	2	96	

TABLE 5

NUMBER OF OPEN, PARTIALLY OPEN AND CLOSED CONES
1965 AREA, HADASHVILLE

Date	Height above ground (inches)											
	0 - 7				7 - 12				12 +			
	Open	Part- ially open	Closed	Total	Open	Part- ially open	Closed	Total	Open	Part- ially open	Closed	Total
June 8/66	91	20	88	199	16	18	110	144	1	8	63	72
Sept. 7/66	110	21	65	196	22	16	98	136	5	2	49	56
Total	201	41	153	395	38	34	208	280	6	10	112	128
Per cent	51	10	39		14	12	74		5	8	87	

TABLE 6

PERIODIC SEED DISPERSAL PER ACRE FROM SLASH - 1966 AREA, PINEY

Date	Height above ground (inches)				Pounds per acre
	0 - 7 ¹	7 - 12 ²	12 + ³	Total	
May 27	53,640	0	0	53,640	0.40
June 27	297,954	4,022	448	302,424	2.27
July 25	328,863	2,220	26	331,109	2.49
Aug. 22	130,040	14,147	5,410	149,597	1.12
Sept. 16	0	16,918	10,648	27,566	0.21
Oct. 12	38,627	0	0	38,627	0.29
Total	849,124	37,307	16,532	902,963	6.78

¹Based on 75,760 cones per acre²Based on 9,700 cones per acre³Based on 9,860 cones per acre

TABLE 7

SEED DISPERSAL PER ACRE FROM SLASH DURING 1966 -
1965 AREA, HADASHVILLE

Date	Height above ground (inches)				Pounds per acre
	0 - 7 ¹	7 - 12 ²	12 + ³	Total	
June 8/66	0	0	0	0	0
Sept. 7/66	10,737	0	4,839	15,576	0.12

¹Based on 78,420 cones per acre²Based on 17,960 cones per acre³Based on 8,600 cones per acre

TABLE 8

SEED DISPERSAL PER ACRE BASED ON CONE SCALE COUNTS
ON SUPPLEMENTARY STUDY TO EXPERIMENT I ON OCTOBER
12, 1966 AREA, PINEY

	Height above ground (inches)			Total
	0 ¹	4 ¹	9 ²	
Over slash	2,119,179	112,129	0	2,231,308
Pounds per acre	15.93	0.84	0	16.77
No slash	1,971,367	107,804	12,498	2,091,669
Pounds per acre	14.82	0.81	0.09	15.72

¹Based on 75,760 cones per acre

²Based on 9,700 cones per acre

Supplementary Study to Experiment I

Table 9 shows the periodic seed dispersal in pounds per acre for each cone height class and treatment. The majority of seed was dispersed during June and July for both treatments. The most seed was dispersed by cones at ground level and dispersal of seed decreased as the cone height above ground level increased. Cones over slash dispersed slightly more seed than those over sand.

Table 10 shows the percentage of cones open at each examination period. Cones suspended over slash in the ground and 4-inch levels appeared to open sooner than those over sand. In the 9-inch level however, the reverse was evident.

Table 11 shows the maximum weekly temperature from June 7 to October 18 occurring at various levels and locations. Little difference in the average soil surface temperature of soil contained in a seed trap and that in a trough portion of a furrow was evident.

Some predation of seed dispersed from cones at ground level, and in one instance seed from 9-inch level, occurred during May to August inclusive. The predation was attributed to birds as the area was enclosed by a mouse fence. A correction factor was applied to percentages for these levels. The correction factor was derived by weighing the chewed particles of seed, found in each collection, obtaining corresponding seed weights and converting the seed weights in to number of seed.

TABLE 9
PERIODIC SEED DISPERSAL — POUNDS PER ACRE
SUPPLEMENTARY EXPERIMENT AREA III

Collection period	Height above ground				Height above ground			
	Over slash				No slash			
	Ground level	4 inches	9 inches	Total	Ground level	4 inches	9 inches	Total
May 30	0.00	0.00	0.00	0.00	0.67	0.00	0.02	0.69
June 27	6.28	0.01	0.00	6.29	4.18	0.00	0.01	4.19
July 25	5.18	0.12	0.00	5.30	4.65	0.12	0.01	4.78
August 22	1.29	0.19	0.00	1.48	1.60	0.07	0.01	1.68
September 16	0.39	0.14	0.0008	0.53	0.43	0.20	0.005	0.64
October 12	0.28	0.16	0.003	0.44	0.11	0.02	0.01	0.14
Total	13.42	0.62	0.0038	14.04	11.64	0.41	0.06	12.12

TABLE 10
PER CENT OPEN CONES AT SPECIFIED PERIODS
SUPPLEMENTARY EXPERIMENT AREA III

Collection period	Height above ground				Height above ground			
	over slash				no slash			
	Ground level	4 inches	9 inches	All levels	Ground level	4 inches	9 inches	All levels
May 30	15.0	0.0	0.0	5.0	15.0	0.0	3.8	6.3
June 27	72.5	1.2	0.0	24.6	71.2	0.0	3.8	25.0
July 25	98.8	15.0	0.0	37.9	93.8	15.0	5.0	37.9
August 22	98.8	30.0	0.0	42.9	93.8	31.2	6.2	43.7
September 16	98.8	40.0	3.8	47.5	94.9	38.8	6.2	46.6
October 12	98.8	40.0	3.8	47.5	94.9	38.8	6.2	46.6

TABLE IV
MAXIMUM TEMPERATURE °F
SUPPLEMENTARY EXPERIMENT AREA III

Week ending		Level			
		Trap	Ground	4" above ground	9" above ground
June	7	107	108	90	91
	14	95	98	82	82
	21	103	111	95	95
	28	110	113	92	92
July	5	113	110	99	99
	12	110	101	97	97
	19	115	109	99	101
	26	112	107	91	92
August	2	113	118	99	90
	9	111	108	102	99
	16	99	97	88	88
	23	91	87	84	84
	30	104	105	99	99
September	6	101	98	90	90
	13	99	94	91	91
	20	90	91	83	82
	27	88	95	79	79
October	4	77	72	62	63
	11	76	77	80	79
	18	58	65	61	60
Average		98.6	98.2	88.2	87.7

RESULTS - EXPERIMENT II

Germination and Mortality - Area III

- (i) Germination: Seed sown during two week intervals from May 17 to June 28 inclusive accounted for 77.5 per cent of the total germination on the area. The majority of germination from seed sown during these periods occurred during June 15 to July 13, or approximately three to five weeks after sowing. Germination percentages from seed sown after June 28 dropped sharply and gradually decreased with each successive seeding until no germination resulted from seed sown after September 6.

Table 12 shows germination percentages for seed sown at two-week intervals throughout the summer. Table 14 relates germination period numbers to week of seeding and germination.

Total germination was slightly lower, 18.3 per cent as compared to 19.3 per cent, than in 1965.

- (ii) Mortality: Seed sown between May 17 and June 28 produced seedlings which suffered relatively low mortality as compared to mortality suffered by seedlings originating from seed sown later in the growing season.

Seedlings germinating during the weeks of May 25, June 29, August 10 to August 24 inclusive and September 7 suffered the highest mortality loss.

Total mortality was slightly higher, 16.4 per cent as compared to 14.8 per cent, than in the preceding year.

Table 13 gives mortality percentages for seedlings germinating from seed sown at two week intervals during the growing season.

Germination and Mortality - Area II

- (i) Germination: Table 15 shows per cent germination that occurred on area II during 1966 and per cent germination that occurred in 1965. Although germination in 1966 occurred on all quadrats sown in 1965, the majority occurred on quadrats sown from late July to early October. Seed sown after July 13, 1965 showed higher germination percentages in 1966 than in 1965 and seed sown after September 7, 1965 germinated entirely during 1966. Although germination in 1966 occurred throughout the growing season, over 75 per cent occurred between May 11 to June 7.

Total 1966 germination was only 1.7 per cent below the total germination that occurred during the preceding year.

- (ii) Mortality: Mortality of 1966 germination is shown in Table 16 and is expressed as a per cent of the number of 1966 germinants occurring from seed sown at each two-week seeding interval in 1965. Total mortality was 4.0 per cent.

TABLE 12

PER CENT GERMINATION¹ FOR EACH SEEDING DATE AND GERMINATION PERIOD

AREA III

Seeding date	Germination Period Number																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total	
May 17		0.4	5.5	6.8	25.3	1.5	3.7	1.8	0.2	0.4	0.2	0.2												46.2
31					2.6	9.9	19.4	5.5	0.9	-	0.9					0.2	0.4							39.9
June 14						2.0	27.8	17.0	2.4	0.2	0.7		0.7	0.2	0.4		0.7	0.4						52.4
28							2.2	18.1	8.8	0.7	0.2	0.2	0.4		0.2		1.3							32.1
July 12								0.7					2.6	2.6		0.7	1.1		1.3					9.0
26												0.2	12.3	3.5	0.2	0.2	1.1	1.1		0.2		0.2		19.2
Aug. 9														0.9	4.4	0.4	5.5	0.2	0.7	0.2	0.2			12.6
23																	2.6	2.9	1.3	0.9				7.7
Sept. 6																	0.2		0.4	0.4				1.1
20																								
Oct. 4																								
18																								
Seasonal percentage		0.04	0.5	0.6	2.3	1.1	4.4	3.6	1.0	0.1	0.2	0.05	1.3	0.6	0.4	0.1	1.1	0.4	0.3	0.1	0.02	0.02		18.3

¹ Per cent germination for each germination period is expressed as a per cent of 500 seeds sown at 90.9% viability

TABLE 13
PER CENT MORTALITY¹ OF GERMINANTS FROM EACH GERMINATION PERIOD

AREA III

Seeding date	Germination period number																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
May 17		36.0		9.7	0.9		5.9	12.5															3.3
31					16.7	2.4	30.7	28.0		25.0													21.5
June 14							15.1	9.1					66.7				33.3						12.2
28							40.0	11.0	7.5								16.7						11.6
July 12													25.0	50.0			20.0						24.4
26													41.1	25.0	100.0								32.2
Aug. 9														75.0	55.0	50.0	40.0						43.8
23																	50.0	23.1					25.7
Sept. 6																							
20																							
Oct. 4																							
18																							
Seasonal percentage		50.0		9.7	2.4	3.3	21.2	12.3	5.4		11.1		38.4	39.4	50.0	14.3	32.2	14.3					16.4

¹ Per cent mortality based upon number of germinants in each germination period.

TABLE 14

<i>Week of germination</i>	<i>Germination period no.</i>
<i>May 17* May 23</i>	<i>1</i>
<i>24</i>	<i>2</i>
<i>31*</i>	<i>3</i>
<i>June 7</i>	<i>4</i>
<i>14*</i>	<i>5</i>
<i>21</i>	<i>6</i>
<i>28*</i>	<i>7</i>
<i>July 5</i>	<i>8</i>
<i>12*</i>	<i>9</i>
<i>19</i>	<i>10</i>
<i>26*</i>	<i>11</i>
<i>Aug 2</i>	<i>12</i>
<i>9*</i>	<i>13</i>
<i>16</i>	<i>14</i>
<i>23*</i>	<i>15</i>
<i>30</i>	<i>16</i>
<i>Sept. 6*</i>	<i>17</i>
<i>13</i>	<i>18</i>
<i>20*</i>	<i>19</i>
<i>27</i>	<i>20</i>
<i>Oct. 4*</i>	<i>21</i>
<i>11</i>	<i>22</i>

* Seeding date

TABLE 16
PER CENT MORTALITY OF SUBSEQUENT GERMINATION
AREA II

Seeding date 1965		Per cent mortality ¹
May	4	4.0
	18	—
June	1	—
	15	6.1
	29	—
July	13	1.8
	27	4.9
August	10	1.5
	24	—
September	7	3.9
	21	7.5
October	5	6.1
Total for area		4.0

¹ Expressed as a per cent of total germination in 1966 for each seeding date.

Second year mortality of the 1965 stock on area II is given in Table 17. Winter mortality for all germination periods was 9.4 per cent, summer mortality 2.8 per cent and mortality for the year was 12.0 per cent. Seedlings germinating later than germination period number 13 (August 4, 1965) showed considerably higher mortality than those germinating earlier.

Seedling Measurement - Areas II and III

Area II: Per cent branching, total height after two growing seasons, and 1966 growth for seedlings established in 1965 is given in Table 18.

The best second-year growth occurred on seedlings which had germinated early in the growing season in 1965. Per cent branching and first-year growth was also highest on these seedlings.

The average height and per cent branching for 1966 germination occurring on area II is given in Table 19. Height growth appears to be nearly equal for all seedlings. However, first-year height growth of 1966 germination was slightly higher than the first-year growth of seedlings established during the preceding year.

Area III: Little difference in height growth among seedlings germinating during the various periods was evident as the average growth ranged from 0.4 to 0.6 inches. Branching, however, occurred only on seedlings germinating during periods 1 to 9 inclusive. The average height and per cent branching of seedlings germinating during the various periods is shown in Table 20.

Climatic Data

Average weekly rainfall and maximum temperature (°F) occurring on area III are shown in Table 21.

WORK PROPOSED FOR 1967 - EXPERIMENT I

A total cone count by height class will be made on 25 quadrats on the Piney area established in 1966 to check whether the slash has been compacted by the winter's snowfall. During the first week in June and September cone collections will be made on this area to determine 1967 seed dispersal. Total seed dispersal will be based on the number of cones per acre as sampled in 1966.

A new area to be cut during the winter of 1966-1967 will be used to replicate Experiment I. Fifty transects will be established for the total cone-per-acre count and for the monthly cone collections. Procedures will be the same as carried out in 1966. Cones which can be recognized as having been open on the trees or that are already partly decayed will not be included in the cone per acre count or in the monthly collections.

TABLE 10
HEIGHT AND GROWTH MEASUREMENTS - 1965 GERMINATION
AREA II

<i>Germination period number</i>	<i>Number seedlings measured</i>	<i>Average height (inches)</i>		<i>Per cent branched</i>
		<i>Total height</i>	<i>1966 growth</i>	
1	—	—	—	—
2	—	—	—	—
3	—	—	—	—
4	15	3.7	3.2	80.0
5	93	3.6	3.2	60.2
6	50	3.9	3.5	94.0
7	22	3.9	3.2	86.4
8	13	3.5	2.9	69.2
9	90	3.1	2.6	68.9
10	98	3.0	2.6	67.3
11	83	2.5	2.0	43.4
12	265	2.4	1.8	46.4
13	57	2.1	1.5	22.8
14	20	2.6	1.6	20.0
15	7	3.2	2.7	14.3
16	4	2.8	2.4	25.0
17	—	—	—	—
18	—	—	—	—
19	2	0.8	0.2	0.0
20	2	1.5	1.2	30.0
21	—	—	—	—
22	—	—	—	—

TABLE 19
SEEDLING MEASUREMENTS 1966 GERMINATION
AREA II

<i>Seeding date (1965)</i>	<i>No. seedlings measured</i>	<i>Average height inches</i>	<i>Per cent branched</i>
<i>May 4</i>	<i>67</i>	<i>0.9</i>	<i>0.0</i>
<i>18</i>	<i>20</i>	<i>1.0</i>	<i>0.0</i>
<i>June 1</i>	<i>73</i>	<i>1.0</i>	<i>1.4</i>
<i>15</i>	<i>38</i>	<i>0.9</i>	<i>0.0</i>
<i>29</i>	<i>19</i>	<i>0.9</i>	<i>0.0</i>
<i>July 13</i>	<i>55</i>	<i>0.9</i>	<i>0.0</i>
<i>27</i>	<i>77</i>	<i>1.0</i>	<i>1.3</i>
<i>Aug 10</i>	<i>62</i>	<i>1.1</i>	<i>3.2</i>
<i>24</i>	<i>72</i>	<i>1.0</i>	<i>0.0</i>
<i>Sept. 7</i>	<i>148</i>	<i>1.1</i>	<i>2.0</i>
<i>21</i>	<i>155</i>	<i>1.0</i>	<i>0.0</i>
<i>Oct. 5</i>	<i>143</i>	<i>1.2</i>	<i>1.4</i>

TABLE 20
SEEDLING MEASUREMENTS - 1966 GERMINATION
AREA III

Germination period number	No. seedlings measured	Av. height (inches)	Per cent branched
1	—	—	—
2	1	0.5	100.0
3	25	0.6	8.0
4	27	0.6	14.8
5	124	0.5	19.4
6	58	0.5	15.5
7	190	0.5	3.7
8	171	0.5	3.0
9	55	0.6	—
10	5	0.6	—
11	9	0.6	—
12	3	0.6	—
13	45	0.4	—
14	18	0.5	—
15	12	0.4	—
16	6	0.6	—
17	40	0.6	—
18	18	0.5	—
19	17	0.5	—
20	8	0.5	—
21	—	—	—
22	—	—	—

Supplementary Study to Experiment I

A replication of the supplementary study will be established again in 1967 with the following modification. An additional eight seed traps will be added to each cone height class. Slash tied to a hardware cloth mat will be suspended two inches above the cones at the various levels.

WORK PROPOSED FOR 1967 - EXPERIMENT II

Germination and Mortality Counts - Area II and III

New germination and mortality will be tallied at two-week intervals during the 1967 field season. Germination will be marked in a manner which will be distinguishable from seedlings already marked, and will be recorded by plot, quadrat and date. Mortality will be recorded in a like manner.

An examination of all quadrats will be made in spring of the year for over-winter mortality.

Height and Growth Measurements

Total height and 1967 growth will be measured on seedlings established in 1965 and 1966 on area II and III. Total height will be determined on subsequent germination occurring on area II and III and on new germination occurring on the 1967 study area.

Sample Plot Establishment

Sample plots will be established on a new area in 1967 as previously outlined in this report (page 4). The area will be fenced as in 1966 for protection against rodents.

REFERENCES

- Bruce, N.G. and Walker, N.R. 1965. Studies of the morphology of jack pine cone opening and the phenology of seed dispersal and germination. Canada Dept. Forestry, Forest Research Branch, Unpubl. MS-18. 27 p.
- Wagg Bruce, J.W. 1964. Design of small mammal exclosures for forest seeding studies. Forest Research Branch contribution No. 558.