

Canada  
Department of Forestry  
FOREST RESEARCH BRANCH  
Alberta District

**THIS FILE COPY MUST BE RETURNED**

**TO: INFORMATION SECTION,  
NORTHERN FOREST RESEARCH CENTRE,  
5320-122 STREET,  
EDMONTON, ALBERTA.  
T6H 3S5**

VIABILITY OF WHITE SPRUCE SEED FROM SQUIREL CUT CONES

by

J.W. Bruce Wagg

(Draft manuscript for publication based on project A-69)

---

If you wish to refer to all or  
any part of this report, you  
are requested to obtain prior  
consent in writing from the  
Director, Forest Research  
Branch.

---

Calgary, Alberta

April, 1962



## ABSTRACT

A study was made of the viability of white spruce, Picea glauca, seed obtained from seven red squirrels' cone caches. This paper describes the habits of the red squirrel, Tamiasciurus hudsonicus, the relation of seed viability to cone-caching activities and the relation of viability of seed obtained from the caches' cones to the cones on the trees.

The viability of seed from cone caches does not vary between the time the squirrels begin to cache cones abundantly and the time the last cones are cached. Most cones were felled prior to being cached. Seed from the caches' cones showed a higher percentage of viability than seed of cones collected from the trees. Some of the heavier mature seed fell from the partial-open cones on the trees, and the percentage of undeveloped seed increased in progressive collections of cones from the trees.



## TABLE OF CONTENTS

	Page
INTRODUCTION . . . . .	1
LIFE HISTORY AND HABITS OF THE RED SQUIRREL . . . . .	1
PURPOSE . . . . .	4
FIELD PROCEDURE . . . . .	5
CONE-CUTTING AND CONE-CACHING ACTIVITY . . . . .	6
RESULTS OF LABORATORY TESTS . . . . .	9
Extraction of seed . . . . .	9
Cutting test . . . . .	10
Germination tests . . . . .	12
CONCLUSIONS . . . . .	18
SUMMARY . . . . .	19
LITERATURE CITED . . . . .	21



# VIABILITY OF WHITE SPRUCE SEED FROM SQUIRREL CUT CONES.

by

J.W. Bruce Wagg<sup>1</sup>

## INTRODUCTION

The red squirrels', Tamiasciurus hudsonicus (Erxleben), caches of cones contain a potential of white spruce, Picea glauca (Moench) Voss, seed for forest regeneration. In Alberta, with forest regeneration assuming an increasingly greater role in the management of the white spruce forests, a need has developed for large quantities of high quality seed. Whilst caches of cones have been used as a source of seed and have been recommended as an economical and satisfactory source of seed (cf. e.g. Toumey and Korstian 1931, Baldwin 1942, Anon. 1948), foresters usually are skeptical of the quality of the seed.

A study was made in 1960 near Solomon, Alberta, of the viability of white spruce seed obtained from seven caches of cones. This paper describes the activities and habits of the red squirrel in the white spruce forests, the relation of viability of seed to cone-cutting and cone-caching activities and the relation of the viability of seed obtained from caches' cones and cones on the trees. Supplementary notes are presented on procedures for germination tests on white spruce.

## LIFE HISTORY AND HABITS OF THE RED SQUIRREL

The red squirrels' life and activity are centered about the midden area: for, near or within the midden, nests are constructed; families are

---

<sup>1</sup>Research Officer, Forest Research Branch, Department of Forestry, Calgary, Alberta.

raised; and food is eaten and stored. Middens delineated by the refuse of cone scales and cores vary in size from a few cone scales to large accumulations of refuse formed through the occupancy of several generations of squirrels.

Bailey (1936) writes that the red squirrel may either nest in burrows in the ground, hollow logs or trees. Litters average from four to six young which are born in June and emerge half grown from their nests about one month later. One litter is reared during the year. The red squirrel is active throughout the year, neither aestivating nor hibernating, although remaining in the shelter of the nest during severe cold and stormy weather.

Squirrels feed on coniferous seeds, staminate buds and flowers, other seeds and fruit, berries, fruiting bodies of fungi, insects and some animal food. When preferred food is scarce or unavailable due to deep snow, the red squirrel will feed on the bark and buds of conifers and other trees and shrubs. At times the feeding causes considerable damage to the leader terminal, lateral and older growth of white spruce, lodgepole pine, Pinus contorta var. latifolia Engelm., and other conifers (cf. e.g. Hosley 1928, Sheldon 1932, Bailey 1936, Balch 1942, Lundberg 1946 and Rowe 1952). Vigorous trees are preferred over unhealthy or slow-growing ones.

During the fall red squirrels are active and conspicuous while cutting and caching cones for winter food. To Yeager (1937) cone cutting and caching appeared to be a community project with the most of the squirrels living near the caches. While Gordon (1936) and Hatt (1943) note that only one squirrel is associated with a midden area. Cones may be either cut singly from the branches or felled in clusters by cutting off the branches.

The locations of caches of cones in white spruce forests vary



Figure 1. Red squirrel cutting a cone which is held in front feet.

with the moisture conditions of the area. In moist areas, with a deep carpet of Hylocomium splendens (Hedw.) BSG. and other feather mosses, the cones are oftentimes cached deeply in the underlying raw humus, inside decayed logs or carried underground into the tunnels of the middens. Within stands on drier area, the cones are cached in the surface of the feather moss, along decayed logs or in the midden remaining from former years. Occasionally cones are cached in the backwaters of small streams.

The cone-caching activity of the red squirrel influences forest regeneration in several ways. When the natural distribution of seed is relied upon to reforest clear-cut areas, the cone-cutting and cone-caching activities in peripheral forest areas reduce seriously the quantity of seed available for regeneration, particularly during years of light seed crops. Occupied middens may lack any stratification of structure because of constant accumulation of cone scales and frequent digging and burrowing activities. However sections of middens with little squirrel activity, which develop structure as the upper layers are overgrown with moss and the cone refuse in the lower layers decomposes, are foci of regeneration in some overmature and partial-cut stands (Bailey 1936).

Yeager (1937) estimates that 2 grams of Norway spruce, Picea abies (L.) Karst., seed are consumed by a red squirrel a day. By interpolation, one bushel of white spruce cones with 13 ounces of seed per bushel and 240,000 seeds per pound (Anon. 1948) could feed a squirrel for the six months from November to April inclusive. The estimated rate of consumption is 1,300 seeds per day.

#### PURPOSE

The purposes, which are similar to those of a study reported on by Lavender and Engstrom (1956) for Douglas fir, are as follows:

1. To indicate whether abundant cutting and caching of white spruce cones by red squirrels occur prior to the maturation of the seed in the cones.

2. To evaluate the quality of the seed, in terms of apparent germination, obtained from cones collected from caches at progressive weekly intervals throughout the cone-cutting and cone-caching period.

3. To compare at progressive intervals, during the cone-cutting and cone-caching period, the viability of seed obtained from the squirrels' caches and from cones on adjacent trees.

4. To collate the red squirrels' cone-cutting and cone-caching habits to the results of apparent germination tests on seed extracted from the felled and cached cones.

#### FIELD PROCEDURE

Seven study plots were located north of the Athabasca River, between the Entrance Ranger Station and Solomon and west of Hinton, Alberta. The forest is 100- to 150-year-old white spruce growing on aeolian sand. Ideally, the plots were to be one mile apart, but because of the sporadic distribution of groups of trees with heavy cone crops, the distance between the plots could not always be maintained. At the predetermined distance the midden areas were sought out and the most potentially productive one in terms of the supply of cones on the trees, nature of the caching area and squirrel activity was selected for the plot.

The four corners of the midden area were marked by stakes, and the enclosed area was denoted as a plot. The size of the plots varied from about 80 to 200 square feet depending upon whether the midden was compact or scattered. The boundaries of each study plot were located on August 14, at a time when the red squirrels were beginning to cut and eat an occasional cone.

At one-week intervals, all the cones that had been felled were removed from the midden area. This included the cones either lying on top of the ground or cached away. Each collection represented the cutting and caching activity in the midden area for the previous seven-day period.

A total of 28 collections was made from the seven plots.

Concurrent with the weekly collections of cones from the caches, ten cones were collected from each of five trees on each study plot. Hence a total of 28 collections was made from trees on the seven plots.

Field collections terminated on September 17 as about 75 per cent of the seed had fallen from the cones on the trees, and subsequent snow prior to the next weekly collection buried the caches.



Figure 2. Midden area of plot III in 130-year-old white spruce stand.

#### CONE-CUTTING AND CONE-CACHING ACTIVITY

Red squirrels cut the first cones about August 14th on the Solomon study areas. The rate of cone-cutting increased rapidly between

the 22nd and 30th of August, and little additional cutting was done after this time. Many of the first-cut cones were eaten without caching. Cone-caching activity, similar to cone-cutting, was vigorous until August 30th and continued at a slower rate until September 15th (Table 1). Over one-half of the total cones to be collected from the caches were in place by August 30th (Figure 3).

Table 1. Rate of Development of White Spruce Cone Caches by Red Squirrels.

Plot	Collection date					Total cones cached
	August			September		
	14	22	30	7	15	
	Number	Number	Number	Number	Number	Number
I	0	19	22	233	189	463
II	0	80	633	243	445	1,401
III	0	23	68	340	97	528
IV	0	97	1,426	730	164	2,417
V	0	60	530	69	112	771
VI	0	112	1,934	221	622	2,889
VII	0	24	241	151	481	897
Average	0	59	693	284	302	1,338
Cumulated average	0	59	753	1,036	1,338	1,338

Although cone caching continued during the two weeks after cone cutting had stopped, on September 15th cones were still abundant on the ground from the earliest cuttings. No effort was made to relate the total cut to the total cache but it appeared that the observations of Yeager

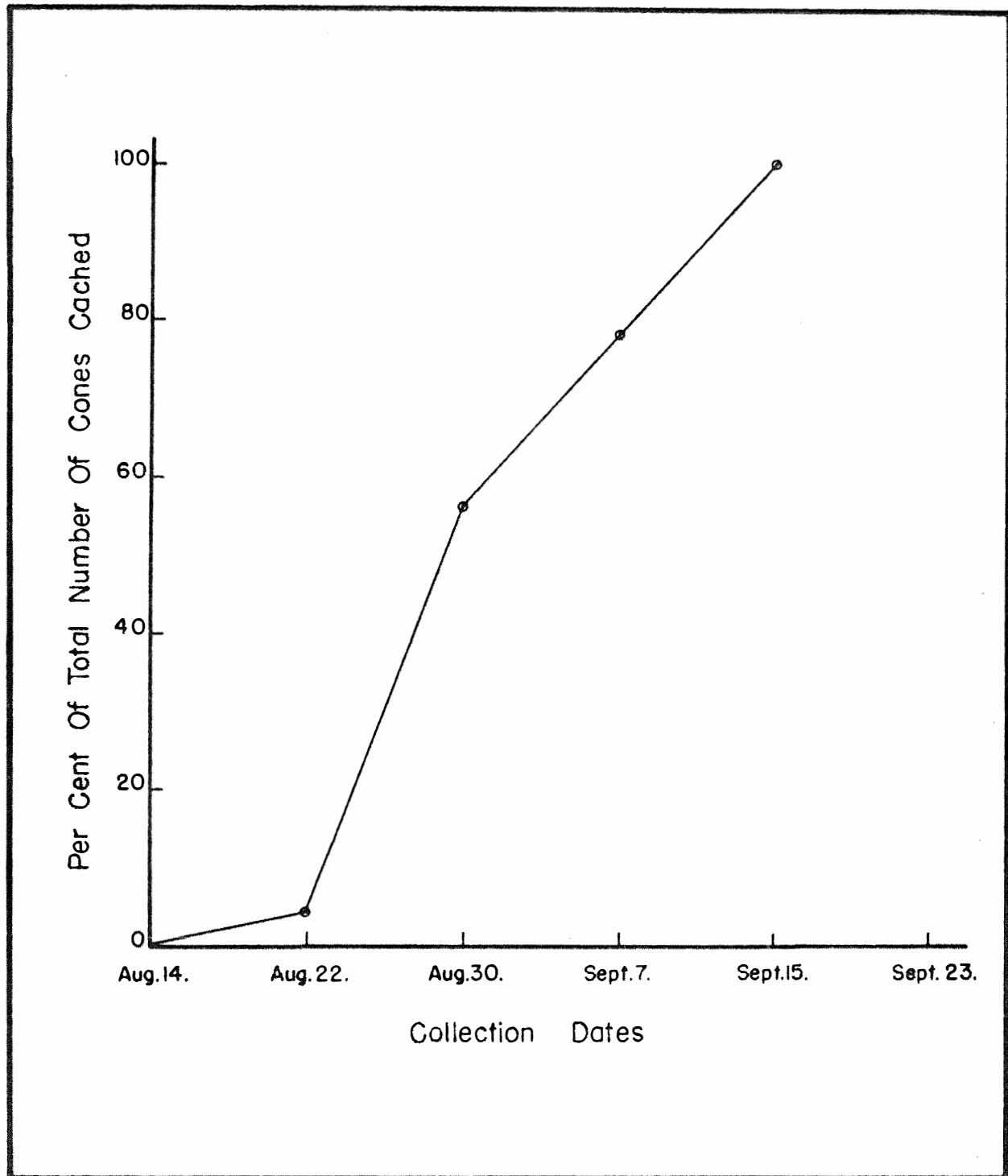


Figure 3. Cumulative per cent of white spruce cones cached at each date of collection.

(1937) are applicable and that at least half of the cones on the area remained unpile and in situ after they were felled. The time of cone cutting could be related to the quality of seed obtained from the felled cones; whereas, the time of cone caching could not influence seed quality.

#### RESULTS OF LABORATORY TESTS

The cones from the tree and cache collections were brought to the laboratory and after being dried and the seed extracted, the seed was subjected to cutting and germination tests.

##### Extraction of Seed

The cones were spread out on the floor of the laboratory and dried at a temperature of about 68°F. When the cones were dry the seed was extracted by vigorously shaking a small quantity of cones in a large jar. The seed was neither dewinged nor cleaned after extraction.

A sample of 20 cones, from all collections was used to determine the percentage of seed that remained in the cones. The individual scales were stripped from each cone and the remaining seeds were counted. From the analysis, 40 per cent of the seed was obtained from the cones during extraction which compares favorably with the 37.4 per cent obtained by Crossley (1953) for partial-extracted cones.

The uncleaned seed from each collection was divided into four equal parts of approximately 300 seeds by pouring through a Boerner Sampler. Of the four seed-samples of each collection, one sample was used for a cutting test and three samples were used for germination tests.

### Cutting Test

One hundred seeds, selected at random from each cone collection, were bisected and the condition of the endosperm noted. Seed was listed as sound when the endosperm was developed, empty when the endosperm was not developed, and undeveloped when the seed size was one millimeter or less.



Figure 4. Graduated white spruce seed from undeveloped on the left to fully developed on the right.

This test was conducted to obtain an index of the amount of undeveloped seed in the cones from the trees and caches for the progressive dates of collection. The results of the cutting tests are presented in Table 2.

Table 2. Number of Sound White Spruce Seeds Determined from Cutting Test .

(Based on 100 uncleaned seeds from each collection).

Plot	Source of seed																							
	Trees												Caches											
	Aug. 22			Aug. 30			Sept. 7			Sept. 17			Aug. 22			Aug. 30			Sept. 7			Sept. 15		
	S*	E**	U***	S	E	U	S	E	U	S	E	U	S	E	U	S	E	U	S	E	U	S	E	U
I	40	56	4	17	82	1	47	35	18	26	42	32	59	37	4	62	37	1	53	44	3	39	57	4
II	22	78	0	60	40	0	14	73	13	50	46	4	56	39	5	47	44	9	49	50	1	36	46	18
III	75	25	0	43	52	5	32	47	21	17	63	20	50	43	7	62	37	1	50	46	4	50	44	6
IV	44	49	7	23	39	38	58	41	1	9	77	14	59	40	1	43	52	5	54	45	1	55	31	14
V	31	64	5	33	60	7	33	65	2	27	42	31	56	29	15	51	44	5	45	49	6	59	36	5
VI	55	38	7	37	60	3	27	60	13	8	84	8	47	48	5	40	56	4	20	71	9	59	39	2
VII	30	63	7	33	62	5	44	54	2	31	62	7	32	63	5	42	56	2	53	43	4	53	43	4
Mean	42.4	53.3	4.3	35.1	56.4	8.4	36.4	53.6	10.0	24.0	59.4	16.6	51.3	42.7	6.0	49.6	46.6	3.8	46.3	49.7	4.0	50.1	42.3	7.6

\*S - Sound      \*\*E - Empty      \*\*\*U - Undeveloped

The number of undeveloped seed increased in the cones on the trees as the date of collection progressed. This was to be expected, particularly in the collections of September 7th and 15th, since the cones on the trees had begun to open and the heavier mature seed to fall.

#### Germination Tests

Apparent germination (Høit and Eliason 1940) was determined for the seed from each cone collection as an index of quality since undeveloped and empty seeds were retained in the sample. This provided a satisfactory comparison of the viability of seed among the collection; whereas, a test of real germination -- based on sound seed only -- would disregard the original seed mass.

A germination test was performed on 100 randomly selected seeds from each of the remaining three seed samples for each cone collection from the trees and caches. One series of tests, comprising one test for each collection of cones, was conducted at a time. The total of 168 germination tests was from three replications of both 28 collections of seed from the trees and 28 collections of seed from the caches.

Seed was treated before germination by cold soaking in tap water for 20 days at 34° to 38°F. (Crossley and Skov 1951). At the end of the cold-soak-period, the seeds were placed on moist blotters in covered petri dishes and germinated at a constant temperature of 70°F. for 30 days. The seed and blotters of petri dishes were dusted with 75 per cent Thiram, and organic sulphide, to inhibit the development of disease during germination. Seed was considered as germinated when the radicle extended

Table 3. Germination of White Spruce Seeds after a 20-day Cold-Soak Pregermination Treatment.

(Based on 300 uncleaned seeds from each collection).

Plot	Source of seed															
	Trees								Caches							
	Aug. 22		Aug. 30		Sept. 7		Sept. 15		Aug. 22		Aug. 30		Sept. 7		Sept. 15	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	97	32.3	45	15.0	117	39.0	77	25.7	121	40.3	157	52.3	122	40.7	122	40.7
II	73	24.3	184	61.3	55	18.3	142	47.3	174	58.0	147	49.0	113	37.7	111	37.0
III	219	73.0	134	44.7	101	33.7	79	26.3	157	52.3	128	42.7	140	46.7	133	44.3
IV	111	37.0	70	23.3	122	40.7	53	17.7	167	55.7	110	36.7	184	61.3	163	54.3
V	88	29.3	115	38.3	78	26.0	108	36.0	126	42.0	120	40.0	104	34.7	128	42.7
VI	169	56.3	125	41.7	73	24.3	48	16.0	125	41.7	105	35.0	65	21.7	140	46.7
VII	84	28.0	98	32.7	156	52.0	85	28.3	97	32.3	117	39.0	140	46.7	146	48.7
Mean	120.1	40.0	110.1	36.7	100.3	33.4	84.6	28.2	138.1	46.0	126.3	42.1	124.0	41.3	134.7	44.9

one-quarter-inch beyond the seed coat and showed a normal growing tip. Seed which produced short, weak and malformed sprouts, was not counted as having germinated.

The results of the germination tests are presented in Table 3. Analysis of variance (Table 4) did not show a significant difference in germination either among the seed samples from the cones collected on different dates, or among the collections on different areas. The interaction was not significant between dates of the collections and sources of seed. The F value of 4.83 indicated a significant difference at 5 per cent between the germination of seed from the cones taken from trees and from cones from caches, the latter having the better apparent germination (Figure 5).

Table 4. ANALYSIS OF VARIANCE

Source of variation	D.F.	Sum of squares	Mean square	F ratio	Snedecor's F values		Significance
					p: .05	p: .01	
Seed source	1	469.3	469.3	4.83	4.35	8.10	Sign.
Dates	6	130.7	21.8	0.22	2.60	3.87	Not sign.
Location	12	499.4	41.6	0.43	2.28	3.23	Not sign.
Interaction: date x seed source	6	98.9	16.5	0.17	2.60	3.87	Not sign.
Error	30	1944.4	97.2				
Total	55	3142.7					

As the combined data does not show a significant difference in the viability of seed taken from the first cone collection and the last cone collection, from the cone caches, then the time of cone caching does not influence seed quality.

Supplementary germination tests on some seed lots from plots IV and VII substantiate the results of the previous tests. A 24-hour warm-soak pretreatment at 70°F. was used instead of the 20-day cold-soak pretreatment. The warm-soak pretreatment has been recommended by Messer (1960) for spruce and if satisfactory for white spruce the pretreatment is advantageous since the total time required for germination tests is shortened appreciably.

Although the trend of the results of the germination tests did not differ from those already reported it is interesting to compare the results of the two pretreatments. From paired samples of seed from the same cone collections, one sample was given a cold-soak pretreatment and the other warm-soak pretreatment. The paired samples were replicated three times, and were germinated concurrently. Table 5 presents the results of this test.

A t-test analysis showed that there was a probability of a significant difference at 5 per cent in the apparent germination between the two pretreatments. Not only was the total apparent germination less for the warm-soak pretreatment than for the cold-soak but the rate of germination was slower for the warm-soak as illustrated in Figure 6.

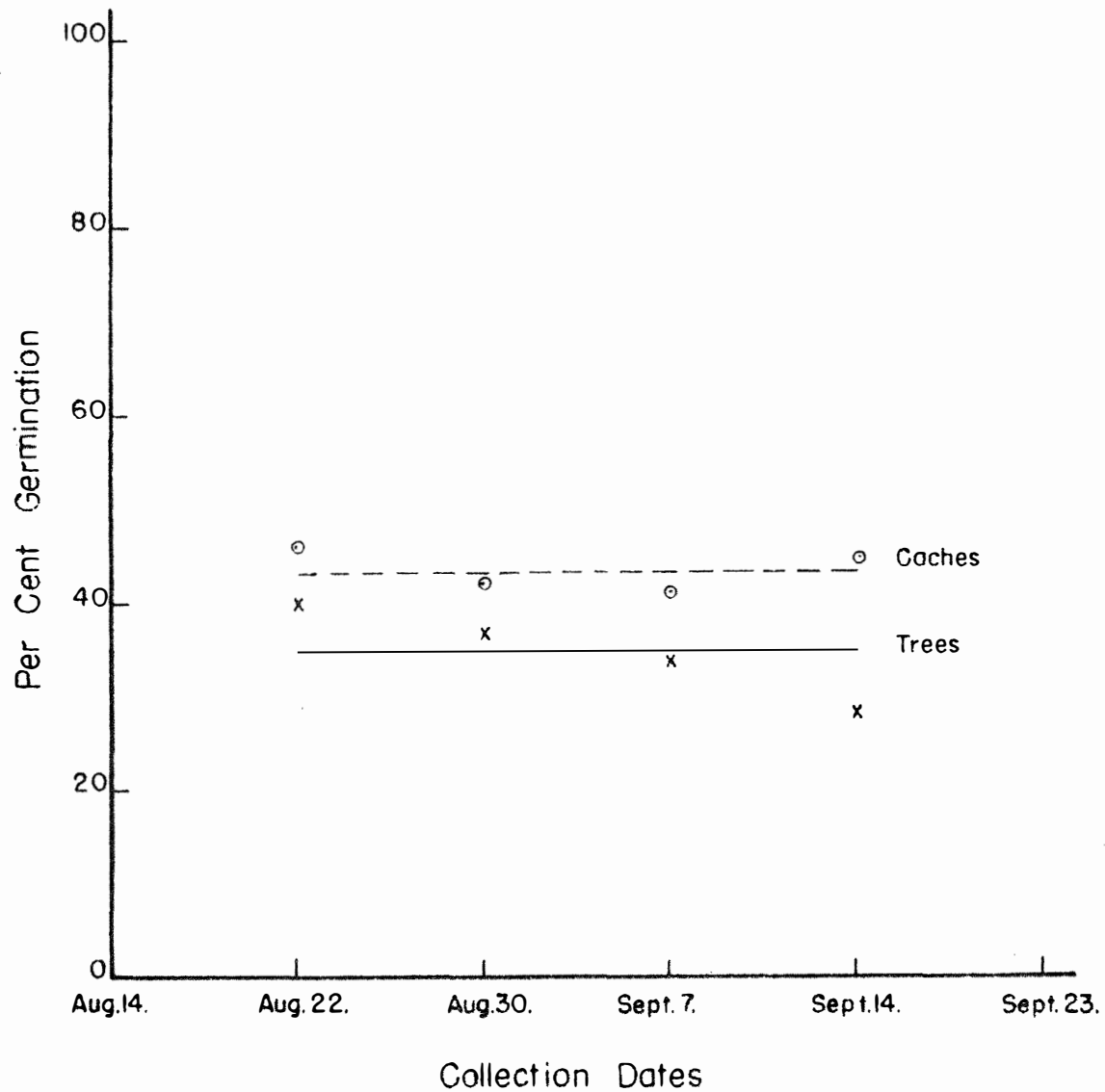


Figure 5. Per cent apparent germination of seeds from each collection from trees and caches for each collection date.

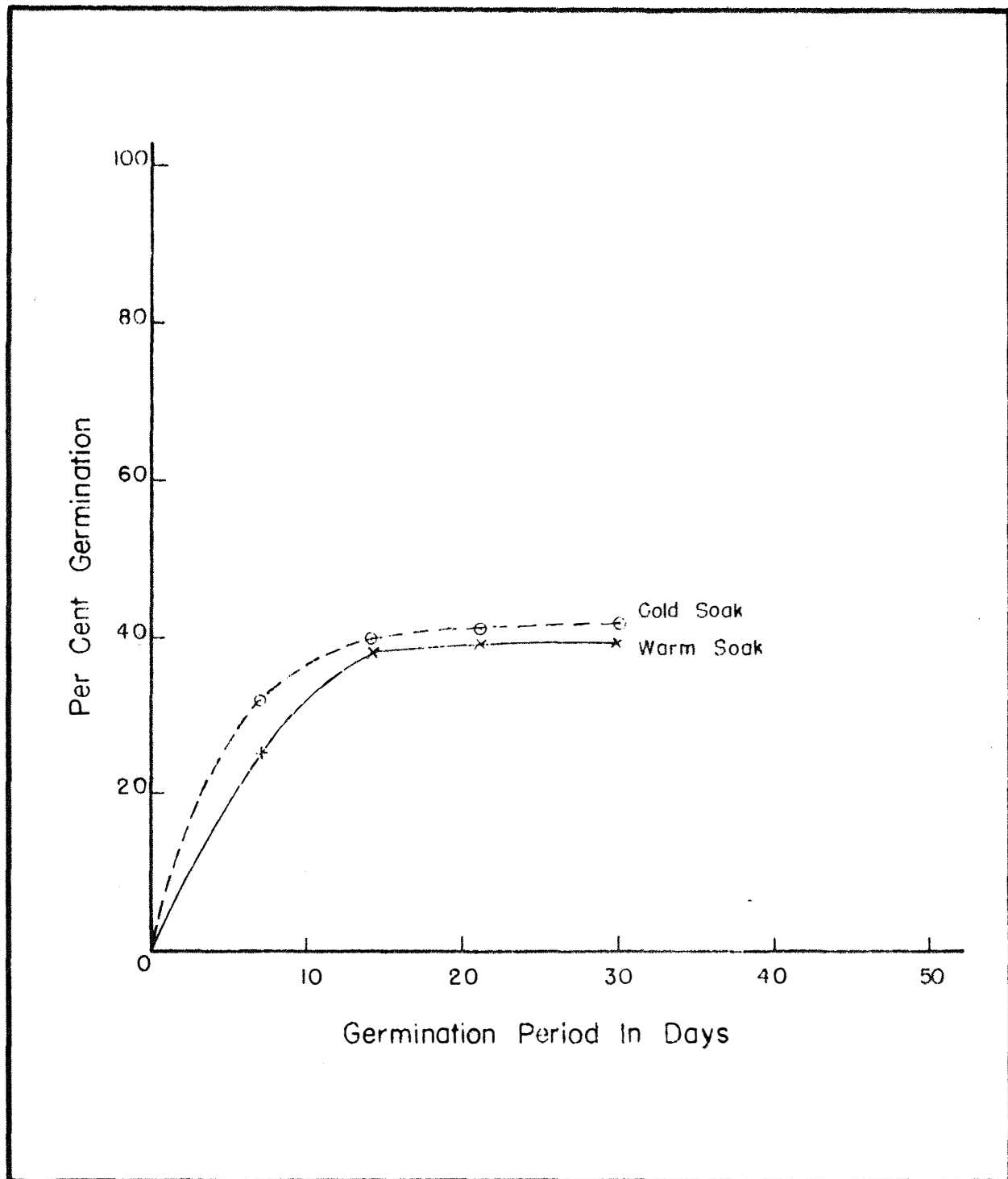


Figure 6. Cumulative per cent apparent germination of paired seed samples given pretreatments of a 20-day-cold-soak and a 24-hour-warm-soak for a 30-day-germination period.

Table 5. Germination of White Spruce Seeds after either a 20-day Cold-soak or a 24-hour Warm-soak Pregermination Treatment. (Based on 300 uncleaned seeds from each collection).

Collection		Pregermination treatment							
Plot	Date	Cold-soak				Warm-soak			
		Trees		Caches		Trees		Caches	
		No.	%	No.	%	No.	%	No.	%
IV	Aug. 22	111	37.0	167	55.7	127	42.3	160	53.3
	Aug. 30	70	23.3	110	36.7	29	9.7	105	35.0
	Sept. 7	122	40.7	184	61.3	116	38.7	168	56.0
	Sept. 15	53	17.7	163	54.3	18	6.0	160	53.3
VII	Aug. 30	98	32.7	117	39.0	84	28.0	97	32.3
	Sept. 7	156	52.0	140	46.7	152	50.7	145	48.3
	Sept. 15	---	---	146	48.7	---	---	157	52.3
Mean		101.7	33.9	146.7	48.9	87.7	29.2	141.7	47.2

#### CONCLUSIONS

The viability of white spruce seed from cones cut and cached by red squirrels does not vary between the time the squirrels begin to cache cones abundantly and the time the last cones are cached. This is in agreement with the conclusions of Lavender and Engstrom (1956) for Douglas fir.

That a significant difference does not exist, in the viability of seed extracted from cones cached during progressive intervals of the cone-caching period, could be anticipated from the red squirrels' cone-cutting activity. Salient cone cutting occurred prior to the first cone collections from the caches. Succeeding collections were composed mainly of previously

felled cones which had been moved from outside the plots to the midden areas within.

Seed from the caches' cones showed a higher percentage of viability than seed of cones collected from the trees. Squirrels are considered to cache cones with the best seed quality (Toumey and Korstian 1931 and Baldwin 1942). In this study the lower percentage of viable seed in the collections from the trees resulted from the falling of some of the heavy mature seed from the partial-open cones on the trees. On all plots there was a steady increase in the percentage of undeveloped seed in the progressive collections which rose from 4 per cent on August 22nd to 16.6 per cent on September 15th.

The collection of white spruce seed from red squirrels' cone caches can be accepted as a desirable practice, considering the results of this study.

#### SUMMARY

A study was made in 1960 near Solomon, Alberta, of the viability of white spruce seed obtained from seven cone caches. The viability of seed from cones cached by red squirrels was determined for progressive periods of cone caching. The viability of seed from cone caches was compared with the viability of seed from the trees for the same periods of collection.

Apparent germination was used as an index of seed quality in collections of cones from the trees and caches. After pretreatment with a 20-day-cold-soak, the seed was germinated in covered petri dishes for 30 days.

The quality, in terms of apparent germination, of white spruce

seed from red squirrels' caches of cones was not significantly different among the progressive periods of cone caching. Seed collected from cones on the trees showed a slight reduction in germination over the seed taken from caches' cones with the progressive collections. This was probably influenced by the falling of mature seed from some of the partial-open cones.

The data substantiate the desirable aspects of the practice of collecting white spruce seed from red squirrel caches of cones.

LITERATURE CITED

- ANON. 1948. Woody-plant seed manual. U.S. Dept. Agriculture, Misc. Pub. 654: VI + 416 pp.
- BAILEY, V. 1936. The mammals and life zones of Oregon. U.S. Dept. Agriculture, Bureau of Biological Survey, North American Fauna 55: 416 pp.
- BALCH, R.E. 1942. A note on squirrel damage to conifers. For. Chron. 18(1): 42.
- BALDWIN, H.I. 1942. Forest tree seed of the north temperate regions. Chronica Botanica Company, Waltham, Mass. 8: XVI + 240 pp.
- CROSSLEY, D.I. 1953. Seed maturity in white spruce. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div. Silv. Res. Note 104.
- CROSSLEY, D.I. and L. SKOV. 1951. Cold soaking as a pre-germination treatment for white spruce seed. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div. Silv. Leaflet 59.
- GORDON, K. 1936. Territorial behavior and social dominance among Sciuridae. J. Mammalogy 17(2): 171-172.
- HATT, R.T. 1943. The pine squirrel in Colorado. J. Mammalogy 24(3): 311-345.
- HEIT, C.E. and E.J. ELIASON. 1940. Coniferous tree seed testing and factors affecting germination and seed quality. New York State Agricultural Experiment Station, Tech. Bull. 255: 45 pp.

- HOSLEY, N.W. 1928. Red squirrel damage to coniferous plantations and its relation to changing food habits. *Ecology* 9(1): 43-48.
- LAVENDER, D.P. and W.H. ENGSTROM. 1956. Viability of seeds from squirrel-cut Douglas fir cones. Oregon State Board Forestry, Research Note 27: 19 pp.
- LUNDBERG, G. 1946. Ekorrskador på granplanteringar. (Squirrel damage to Norway spruce plantations). *Skogen* 33(13): 204-205.
- MESSER, H. 1960. Über das Quellen und das Vorkeimen des Forstsamens. (Swelling and pregermination of forest tree seed). *Forst-u Holzwirt* 15(5): 93-95.
- ROWE, J.S. 1952. Squirrel damage to white spruce. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div. Silv. Leaflet 61.
- SHELDON, W.G. 1932. Mammals collected and observed in the vicinity of Laurier Pass, B.C. *J. Mammalogy* 13(3): 196-203.
- TOUMEY, J.W. and C.F. KORSTIAN. 1931. Seeding and planting in the practice of forestry. John Wiley and Sons, Inc., New York. 2nd edition: XVII + 508 pp.
- YEAGER, L.E. 1937. Cone piling by Michigan red squirrels. *J. Mammalogy* 18(2): 191-194.