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The Effects of Some Silvicultural and Soil Treatments on Aspen (Populus Tremuloides Michx.) Reproduction in Northern Utah

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THE EFFECTS OF SOME SILVICULTURAL AND SOIL TREATMENTS ON ASPEN (POPULUS TREMULOIDES MICHX.) REPRODUCTION IN NORTHERN UTAH

by

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TABLE OF CONTENTS

INTRODUCTION 1

REVIEW OF LITERATURE 3

DESCRIPTION OF THE STUDY AREA 8

METHODS AND PROCEDURES 10

RESULTS 20

Response of Aspen to Treatments 20

Clear cut treatment 20

Reduced canopy 30

Other treatments 30

Amount of Utilization and Trampling by Cattle, Deer, and Elk 34

DISCUSSION AND CONCLUSIONS 39

SUMMARY 42

LITERATURE CITED 43

APPENDIX 47

VITA 55

LIST OF TABLES

Table		Page
1.	Analysis of variance and Duncan's multiple range test for the aspen sucker response to treatment, 1966	21
2.	Analysis of variance and Duncan's multiple range test for the aspen sucker response to treatment, 1967	22
3.	Number of aspen stems per acre counted in the fall of 1965, 1966, and 1967, and the average height of stems measured in the fall of 1966 and 1967	25
4.	Mean maximum and mean minimum soil temperatures at 2-inch depths for treatments during the period of May 30 through September 10, 1966	29
5.	Mean soil moisture percentages, by weight, for treatments at two soil depths during the period of May 6 through September 10, 1966	33
6.	Utilization and trampling of aspen by animals and cow days use per acre on the treatment plots	36
7.	Stand information on the Twin Creek Study Area prior to initiation of treatments, 1965 . . .	48
8.	Basal areas in square feet per acre of aspen stand on the Twin Creek Study Area, 1965 . . .	49
9.	Canopy cover for the treatment plots before treatment 1965, and after treatment 1965 and 1966	50
10.	Estimated green weight of understory vegetation at the Twin Creek Study Area, 1965	51
11.	Estimated green weight of understory vegetation at the Twin Creek Study Area, 1966	53

LIST OF FIGURES

Figure		Page
1.	Study design at Twin Creek, Cache National Forest	11
2.	Representative clear cut plot, Twin Creek, 1966	12
3.	Representative reduced canopy cut plot, Twin Creek, 1966	12
4.	Representative girdled plot, Twin Creek, 1966 .	13
5.	Representative scarified plot, Twin Creek, 1966	13
6.	Representative control plot, Twin Creek, 1966 .	14
7.	Modified horse-drawn ripper used for scarified treatment at Twin Creek, 1965	17
8.	Representative sucker response to clear cut treatment, Twin Creek, 1966	24
9a.	Mean maximum and mean minimum soil temperatures measured at 2-inch depths for three treatments and air temperature during the period of May 30 through September 10, 1966	27
9b.	Mean maximum and mean minimum soil temperatures measured at 2-inch depths for three treatments and air temperature during the period of May 30 through September 10, 1966	28
10a.	Mean soil moisture percentages for three treatments at 0-6 inches during the period of May 6 through September 10, 1966	31
10b.	Mean soil moisture percentages for three treatments at 0-6 inches during the period of May 6 through September 10, 1966	32

ABSTRACT

The Effects of Some Silvicultural and Soil Treatments on Aspen (*Populus tremuloides* Michx.) Reproduction in Northern Utah

by

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Utah State University, 1969

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Department: Range Science

Research was conducted in northern Utah from 1965 through 1967 to determine the reproductive response of aspen to the following treatments: clear cutting, reduced canopy cutting, girdling, scarifying, and control.

Work was also done to determine what amount of the aspen reproduction was utilized and trampled by cattle, deer, and elk on the various treatments.

The response of the aspen to treatment was determined by estimating the number and height of sucker stems for each treatment plot. In 1967, both the clear cut and reduced canopy cut had a significantly greater number of suckers than did the control; the clear cut supported 23,900 stems per acre, the reduced canopy cut supported 11,600 stems per acre, and the control cupported 3,470 stems per acre. Stems were about 30 inches taller on the clear cut and reduced canopy cut plots than on the control plots.

Cattle used most of the other forage in the study area heavily while using the aspen reproduction lightly.

(60 pages)

INTRODUCTION

Quaking aspen (*Populus tremuloides* Michx.) is an important tree in the Rocky Mountain region. In Utah, the aspen type occupies approximately 2 million acres and is highly valued for wood products and as a source of forage for game animals and domestic livestock. Moreover, it is important for watershed values.

Forest, range, and wildlife personnel are concerned over the failure of aspen to reproduce in some areas. Aspen depends almost entirely upon suckers for reproduction, but some stands do not regenerate well after logging or burning (Graham, Harrison, and Westell, 1963). Grazing by domestic livestock and game animals is often so severe that the establishment of adequate reproduction is prevented. Sprouting of suckers is induced when the overstory is removed, but little is known about the factors which provide the stimulus for sprouting and methods which could increase the amount of sprouting.

In order to gain a greater knowledge of the regenerative responses of aspen, this study was begun on September 1, 1965. The primary purpose was to explore methods of increasing sucker density and to investigate some of the factors which may provide the stimulus for aspen regeneration. The specific objectives of this study were: (1) to determine the reproductive response of aspen to: clear cutting, reduced canopy cutting, girdling, scarifying, and control; and (2) to determine what amount of the aspen reproduction was utilized and trampled by cattle, deer, and elk.

REVIEW OF LITERATURE

Quaking aspen was considered a weed species for many years. It had little commercial value and although it interested a few casual observers and researchers, there was no economic incentive to stimulate an intensive study of it. Consequently, while the more valuable timber species were studied, quaking aspen one of the most widespread tree species in North America, received little attention.

New technology during the 1940's, made possible greater use of aspen wood. As the commercial value of aspen increased, researchers devoted more time to studying the tree and its behavior. Recent studies supported many older findings and opened up many new and interesting areas of research.

One of the earlier findings supported by current authors is that quaking aspen seldom reproduces itself by seed because of its low seed viability and exacting seedbed requirements (Baker, 1918; Graham, Harrison, and Westell, 1963).

The primary means of reproduction of quaking aspen is by suckering. The suckers arise adventitiously in the pericycle of shallow lateral roots (Sandberg, 1951). While Gifford (1966) observed that most suckers originate from lateral roots 2 to 12 inches deep, Sandberg (1951) found the maximum depth of suckering was 4.3 inches, and Horton and Maini (1964) found that most sucker-producing roots occur within 1.5 inches of the ground surface. The lateral root systems are extensive. Upon excavation, one 35-year-old tree was found to have more than 360 feet of lateral roots 0.3 inch or larger in diameter (Sandberg, 1951).

Early researchers believed the suckers developed from dormant buds (Brown, 1935; Barth, 1942; Zehngraff, 1949). Later investigations have shown that most suckers come from buds formed during the year of sprouting (Sandberg, 1951; Farmer, 1961; Horton and Maini, 1964; Fowells, 1965; Maini and Horton, 1966b).

Generally, few suckers originate under undisturbed stands (Maini, 1960; Fowells, 1965; Maini and Horton, 1966a). Although a few weak suckers occasionally occur (Baker, 1918; Slabaugh, 1958; Fowells, 1965), few survive unless they are freed of shade (Weigle and Frothingham, 1911).

After burning or clear cutting, sucker production may be prolific. Commonly reported figures vary from 10,000 to 30,000, but as many as 85,000 suckers per acre have been reported the first season after cutting (Baker, 1918).

Weigle and Frothingham (1911) were the first to try to explain what causes the great increase in suckers following a clear cut or a burn. They attributed the response to increased soil aeration.

According to Shirley (1931, 1932) fire may cause increased suckering by blackening the soil and thus increasing the rate of heat absorption by the soil.

Zehngraff (1949) and Stoeckeler and Macon (1956) indicated that increased light was important to sucker initiation. Even though suckers originate from lateral roots several inches below the ground surface (Day, 1944; Westell, 1954; Farmer, 1961), a few researchers believe that light may have a direct effect on sucker initiation. Barth (1942) suggested that light may awaken dormant buds on the lateral roots of European aspen (Populus tremula L.). Zehngraff (1947a) and Stoeckeler (1960) believed the same held true for quaking aspen.

Experiments conducted by Farmer (1962b) and Maini and Dance (1965) have shown that the visible segment of insolation is not required for sucker initiation, although light is essential for good growth (Zehngraff, 1947b; Farmer, 1963).

Farmer (1962a, 1962b) postulated that suckering was caused by removing the effect of apical dominance. He found that severing the lateral roots from the parent stem resulted in the initiation of suckers on the detached root. No suckers were formed on the root portion attached to the parent stem. From this Farmer speculated that growth-inhibiting auxins flowing basipetally from the tree crown prevented suckering on the attached root.

Experimenting further, Farmer found that suckering on small root segments could be suppressed by applying concentrated IAA (indole-3-acetic acid). However, since the experiment involved changing other factors such as nutrition and moisture, the exact nature of the controlling mechanism could not be stated.

Once the aspen suckers begin to grow, they face a battle for survival. Hundreds of organisms can damage the young sprouts. Many animals use the sprouts for food.

Baker (1925) found that sheep were one of the greatest enemies to aspen reforestation because they graze the reproduction heavily. Sampson (1919) reported sheep were responsible for severe damage to the aspen reproduction, both as it occurred in standing timber and on clear cuttings, regardless of the variety and supply of choice forage.

Much utilization of the aspen sprouts is also made by white-tailed deer (Odocoileus virginianus) in some areas, the amount of damage increasing as deer numbers increase (Westell, 1954). In Michigan, 7 percent of the logged-over areas studied were damaged so excessively by deer that it was doubtful if stands would establish on the sites (Westell, 1955). Julander (1937) stated that aspen reproduction was browsed to the ground each year during years of serious overpopulation on the Kaibab game reserve.

He further observed that when browsing by mule deer (Odocoileus hemionus) was reduced to 65 percent, the aspen showed signs of improvement from an overbrowsed condition. Westell (1954) suggests that one-half to three-fourths of the available browse can be taken by white-tailed deer without impairing reforestation.

According to Julander (1937), cattle are much less damaging to aspen reproduction. He rated the palatability of aspen for sheep and deer at 70 percent, but only 5 to 10 percent for cattle. Frykman (1958) believed that cattle were less damaging since they did not seem to feed on the branches or terminal buds as much as sheep and deer. Sampson (1919) found that cattle caused little injury to aspen reproduction on lands that were not overgrazed.

Grazing of aspen reproduction has indirect effects as well. One study in Rocky Mountain National Park revealed that wounds produced by barking of aspen by elk and browsing by deer created ideal places for fungi to attack (Anonymous, 1942).

From another viewpoint, browsing may be beneficial, especially where aspen reproduction is dense. It was pointed out by de Vos (1958) that browsing may actually help to insure a well developed stand by aiding natural thinning.

DESCRIPTION OF THE STUDY AREA

The study area is on the Twin Creek drainage of the Cache National Forest approximately 20 miles northeast of Logan, Utah, in Logan Canyon (T13N, R3E, Salt Lake Meridian).

Topographically, the study site is located on a hillside exposed to the southeast at an elevation of 7,850 feet. It lies between two small draws. There is a draw on the north side which produces a small stream of water until June or July depending on the weather, and a very small draw to the south that has running water only for a short time during snow melt. Adjacent to and approximately 50 yards from the northeast corner of the study area a small spring produces a stream of about 15 cubic feet per minute. There is usually snow on the area from November until April and occassional thunderstorms occur during the summer.

The overstory was a healthy, vigorous stand of aspen. Leaf, bark, and other tree characteristics indicated the stand was part of a single male clone. The stand averages for 75 randomly selected trees were: age 55 years, height 58 feet, and DBH (diameter at breast height) 8.0 inches. Tree density and canopy cover were similiar throughout the stand.

The understory vegetation contained a mixture of forbs and grasses consisting primarily of blue wildrye (*Elymus glaucus*, Buckl.), big brome (*Bromus marginatus*, Nees.), niggerhead (*Rudbeckia occidentalis*, Nutt), sawtooth butterweed (*Senecio serra*, Hook.), and peavine (*Lathyrus* spp., L.).

The soil profile is characterized by a dark sandy loam *A* horizon that grades into a mottled silty clay *B* horizon below the upper 7 to 14 inches. The *B* horizon continues for another 10 to 15 inches before contacting the substratum, a light yellow-brown mixture of clay and sand.

METHODS AND PROCEDURES

The study site was divided into 15 plots, 175 feet on a side (Figure 1). Five treatments were randomly assigned to the 15 plots which allowed three replications per treatment. The treatments were: (1) clear cut (100 percent canopy removed); (2) reduced canopy cut (larger stems cut until a 30 percent canopy remained); (3) stems girdled, no trees cut (100 percent canopy retained); (4) soil surface scarified, no trees cut (100 percent canopy retained); and (5) control; (Figures 2-6).

Data were gathered on the aspen stand before any treatments were initiated. Age, height, and diameter of selected trees, basal area per acre, and canopy cover were taken in order to obtain a record of present growth.

Five trees were randomly selected on each treatment plot for height, age, and DBH measurements. Tree heights were taken with an Abney level and diameters were measured at breast height with a diameter tape. An increment borer was used to determine tree age.

Basal area of aspen trees per acre was found using the Purdue Sampling Block with twin prisms and the point sampling method. Beers and Miller (1964) discussed this procedure. The two prisms were aligned so that approximately six trees were tallied at each sampling location. The average number of trees per sample

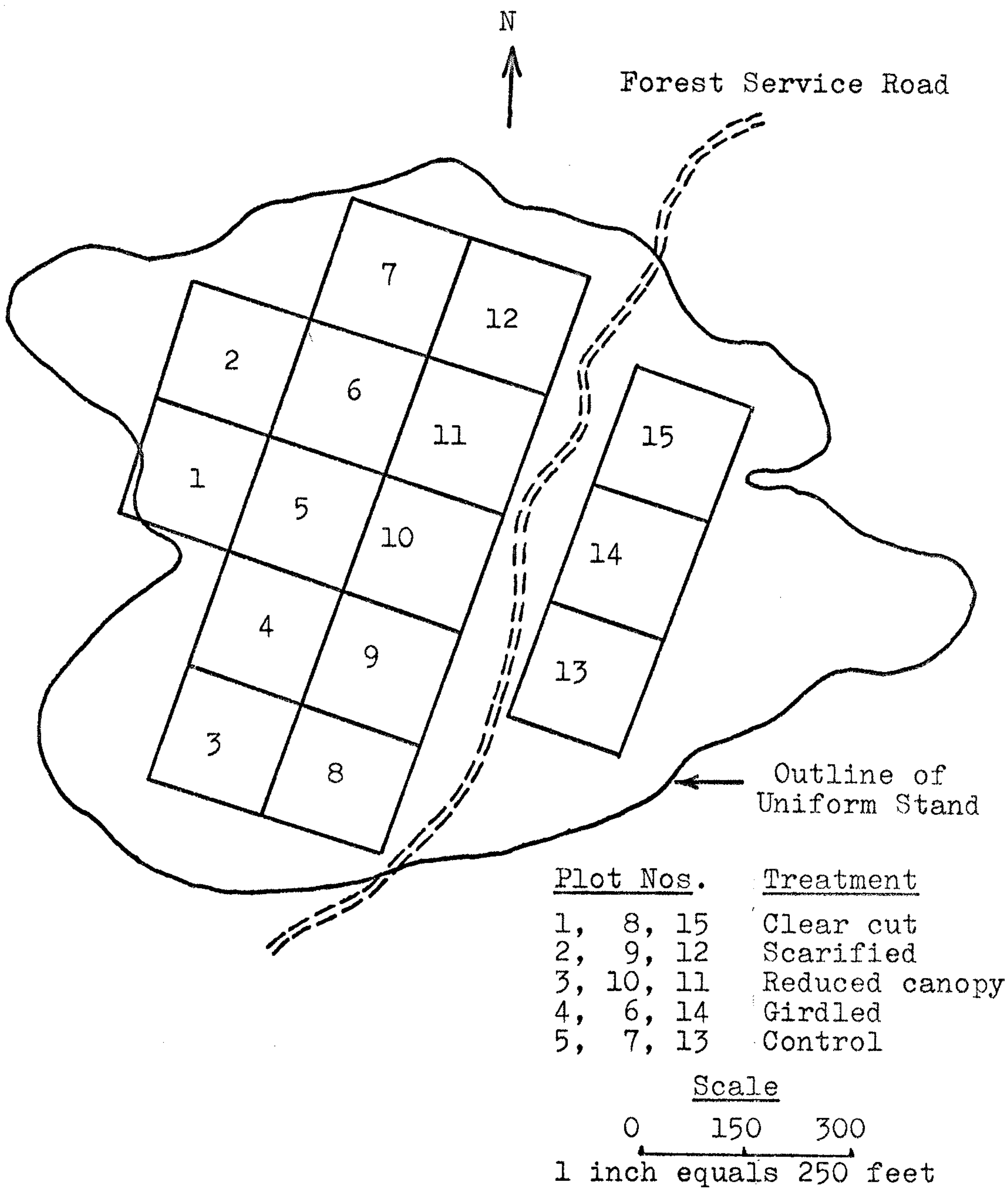

Figure 1. Study design at Twin Creek, Cache National Forest.

Figure 2. Representative clear cut plot, Twin Creek, 1966.

Figure 3. Representative reduced canopy cut plot, Twin Creek, 1966.

Figure 4. Representative girdled plot, Twin Creek, 1966.

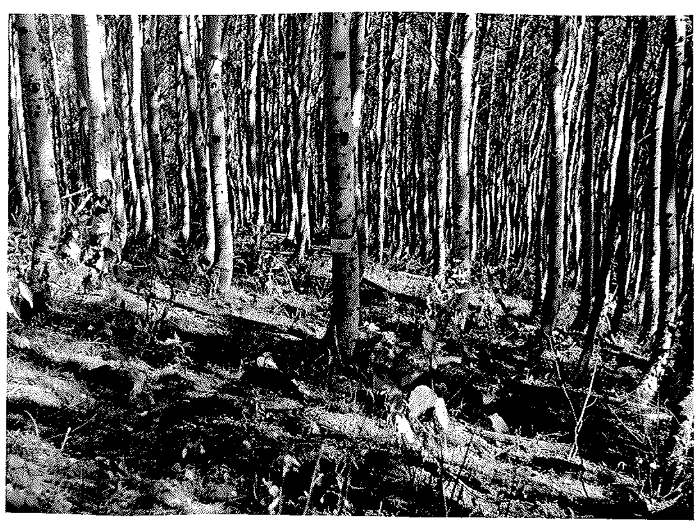

Figure 5. Representative scarified plot, Twin Creek, 1966.

Figure 6. Representative control plot, Twin Creek, 1966.

multiplied by the calibration factor for the particular prism alignment yielded the basal area per acre.

Canopy cover was measured at 15 or more random locations within each treatment plot by a spherical densiometer before treatments were begun in 1965. Canopy cover was measured again on the reduced canopy plots to determine what percent of cover remained after treatment. Percent canopy cover was remeasured in the summer of 1966. The spherical densiometer developed by Lemmon was found to be highly reliable (Lemmon, 1956, 1957).

In 1965, understory vegetation was inventoried by green weight estimates within 50, 9.6-square-foot samples on 11 of the treatment plots. Partial samples were taken on two other plots. Frequently, portions of the samples were weighed to increase the accuracy of estimation. In July of 1966, the vegetation was inventoried on all treatment plots.

Soil temperature and moisture measurements were taken in three random locations near the center of each treatment plot on May 30, June 18, July 16, and September 10, 1966. Maximum and minimum soil temperatures were measured with three standard soil thermometers at a depth of about 2 inches. The maximum soil temperatures were recorded between 1:30 and 3:12 p.m. The time prior to and during sunrise was used to record minimum soil temperatures. Soil moisture measurements were made at depths of 0 to 6 and 6 to 12 inches using the gravimetric method.

Maximum and minimum air temperatures were recorded by U. S. Forest Service personnel at the Card Ranger Station in Logan Canyon, 15 miles down the canyon from the study area.

Application of the treatments started on June 26, 1965 and was completed on August 12, 1965. Chain saws were used to fell trees on the clear cut and reduced canopy cut areas. Felled trees on the clear cut areas were trimmed and either towed to the boundary by a horse or carried there by hand. Since the trees were scattered on the reduced canopy cut areas, the logs were trimmed and left in their felled position.

Girdling of the stems was done with a hand axe, and scarification of the soil surface was accomplished with a horse-drawn ripper fashioned from a hand plow (Figure 7).

The scarified treatment was difficult to accomplish because of the dead logs lying on the areas to be treated. Despite numerous difficulties, the blade was drawn over the plots at 6 to 10-foot intervals and at depths varying from 3 to 8 inches. Subsequent inspection of the trenches revealed that numerous lateral roots up to one-half inch in diameter were cut. Surface vegetation in the direct path of the ripper was destroyed.

After the treatments were completed, sprouts appeared

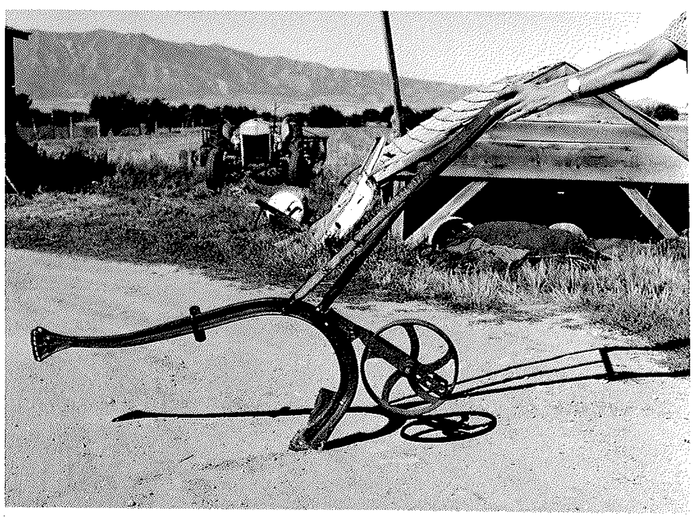

Figure 7. Modified horse-drawn ripper used for scarified treatment at Twin Creek, 1965.

on the clear cut areas. In order to document their appearance and utilization, 50 random, 9.6-square-foot sub-plots were taken on each of the 15 treatment plots.

Each plot was 0.7 of an acre, but data were taken only from the interior 0.36 acre to avoid boundary effects. A boundary margin of about 25 feet was left around each plot. The boundary acted as a buffer zone to reduce the effects of shading and reduce penetration of root systems from adjoining areas.

In September of 1966, 50 permanent 9.6-square-foot sub-plots were established on each of the treatment plots. The sub-plots were made permanent by driving two, 18-inch stakes into adjacent corners of each plot. After each sub-plot was established, the number of aspen suckers two years old or younger and the number of browsed terminal buds were tallied. A height measurement was taken of a representative sucker in each sample. The total number of aspen suckers tallied for each treatment was used to calculate an analysis of variance. A multiple range test was used to determine the difference between treatments (Li, 1959). Since the results of the test were disappointing, the sampling design was improved. Based on the information obtained in 1966, the buffer zone was increased from 25 to 40 feet and the 50, 9.6-square-foot sub-plots were replaced with 50 milacre sub-plots. Sucker counts along with utilization and trampling data were collected in September of 1967 using the improved sampling design.

Percent utilization of the aspen suckers by animals was estimated. In 1966, cow days use per acre were estimated from a cow chip count made on 30 random 99.6-square-foot samples on each treatment plot. In 1967 cow days use per acre were calculated from the cow chip count on the 50 permanent milacre samples.

RESULTS

Response of Aspen to Treatments

The parent aspen stand produced an abundance of sprouts on the clear cut and reduced canopy treatments, but it failed to respond to the scarified and girdled treatments.

The stem population estimates for the five treatments were subjected to an analysis of variance. The resulting F values of 5.024 and 24.46 for 1966 and 1967 respectively, were both larger than the tabulated F value of 3.48 (Tables 1, 2). Therefore the hypothesis that the treatment effects were equal was rejected for both years ($p = < 0.05$). Duncan's multiple range test was used to test which treatments were significantly different from the control and from each other. Only the clear cut treatment was significantly different from the control and other treatments in 1966 (Table 1).

The 1967 data showed the clear cut to be different from the control and from the other treatments as in 1966, but data from the improved sampling technique also showed that the reduced canopy treatment was significantly different from the control and other treatments (Table 2).

Clear cut treatment

A few aspen suckers appeared on the clear cut areas

Table 1. Analysis of variance and Duncan's multiple range test for the aspen sucker response to treatment, 1966

Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean square
Treatment	4,771,589,500	4	1,192,897,300
Experimental Error	2,374,363,050	10	237,436,300
Total	7,145,952,550	14	

$$F = \frac{\text{Treatment MS}}{\text{Error MS}} = \frac{1,192,897,300}{237,436,300} = 5.024 \qquad F_{.05} = 3.48$$

Five Percent Level
New Multiple Range Test

g	Treatments	Difference	SSR	Conclusion
5	E - A	48,883	30,515	Significant
4	E - B	47,310	29,981	Significant
3	E - C	39,113	29,358	Significant
2	E - D	30,279	28,024	Significant
4	D - A	18,604	29,981	Not significant
3	D - B	Do not test	29,358	Not significant
2	D - C	Do not test	28,024	Not significant
3	C - A	Do not test		Not significant
2	C - B	Do not test		Not significant
2	B - A	Do not test		Not significant

Treatments:	Control A	Scarified B	Girdled C	Reduced Canopy D	Clear Cut E
Means:	3,449	5,022	13,219	22,053	52,332

Table 2. Analysis of variance and Duncan's multiple range test for the aspen sucker response to treatment, 1967

Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean square
Treatment	1,007,120,000	4	251,800,000
Experimental Error	102,940,000	10	10,294,000
Total	1,110,060,000	14	

$F = \frac{\text{Treatment MS}}{\text{Error MS}} = \frac{251,800,000}{10,294,000} = 24.46$ $\quad F_{.05} = 3.48$

Five Percent Level
New Multiple Range Test

g	Treatments	Difference	SSR	Conclusion
5	E - A	22,020	6,350	Significant
4	E - B	20,430	6,230	Significant
3	E - C	19,850	6,110	Significant
2	E - D	12,300	5,830	Significant
4	D - A	9,720	6,230	Significant
3	D - B	8,130	6,110	Significant
2	D - C	7,550	5,830	Significant
3	C - A	2,170	6,110	Not significant
2	C - B	Do not test		Not significant
2	B - A	Do not test		Not significant

Treatments:	Control A	Scarified B	Girdled C	Reduced Canopy D	Clear Cut E
Means:	1,880	3,470	4,050	11,600	23,900

after treatments were completed in the fall of 1965, but the main response came in the spring of 1966 (Figure 8). By May 30, 1966, hundreds of reddish green sprouts started pushing up through the soil and litter. A few came up as singles, some in large clumps of 70 to 80 stems, but most came up in small clumps containing 2 to 10 stems. Competing surface vegetation was small and sparse at this time and the aspen leaves on neighboring trees had attained about three-fourths of their full size.

The surface vegetation grew rapidly and soon was taller than the suckers. In July most of the suckers were between 0.5 and 1.5 feet tall, whereas the competing understory plants had attained a height of over 3 feet.

Sucker counts taken in September revealed that the three clear cut areas produced more suckers than all the other treatments combined. The average number of live suckers was estimated at 52,332 per acre in 1966 and 23,900 per acre in 1967 (Table 3). Although the 9.6-square-foot sub-plot used in 1966 produced a less accurate estimate than was obtained with the milacre sub-plot used in 1967, nonetheless, it was obvious that the first year's response was a marked one. When the sucker count was made in 1966, a large number of the weaker suckers counted in the bigger clumps were turning black and beginning to die. The loss of these suckers along with those trampled by cattle would account for the reduced estimate obtained

Figure 8. Representative sucker response to clear cut treatment, Twin Creek, 1966.

Table 3. Number of aspen stems per acre counted in the fall of 1965, 1966, and 1967, and the average height of stems measured in the fall of 1966 and 1967

Plot No.	Number of stems/acre			Avg. height of stems in inches	
	1965[a]	1966[b]	1967[c]	1966	1967
		Clear Cut			
1	1,815	33,396	21,600	23.7	53.7
8	2,360	91,385	31,300	20.4	47.2
15	1,634	32,216	18,900	19.4	41.0
Mean	1,936	52,332	23,900	21.2	47.3
		Scarified			
2	182	2,178	2,000	10.2	16.8
9	91	11,253	1,900	9.1	16.6
12	91	1,634	1,740	9.8	20.9
Mean	121	5,022	1,880	9.7	18.2
		Reduced Canopy			
3	0	20,419	13,100	15.8	46.0
10	91	23,777	12,200	19.4	42.9
11	91	21,962	9,640	15.4	40.3
Mean	61	22,053	11,600	16.9	43.1
		Girdled			
4	91	15,972	6,120	7.7	8.4
6	272	14,066	2,320	13.8	22.9
14	182	9,620	3,700	4.8	11.6
Mean	182	13,219	4,050	8.8	14.3
		Control			
5	272	4,084	5,060	9.6	15.5
7	0	3,358	2,360	6.6	13.2
13	0	2,904	2,980	9.2	11.4
Mean	91	3,449	3,470	8.5	13.4

[a]Basis, 50, 9.6-square-foot plots/area.
[b]Basis, 50, permanent 9.6-square-foot plots/area.
[c]Basis, 50, permanent milacre plots/area.

in 1967.

The dominant suckers in the clear cut plots were bigger and appeared more vigorous than those on the other treatments. In both 1966 and 1967, stem heights on the clear cut areas averaged 4 inches taller than those on the reduced canopy areas (Table 3).

Many of the dominant suckers grew 6 feet or more during the two growing seasons following clear cutting.

Soil temperatures were measured in the center of the plots at a depth of 2 inches. Maximum temperatures were measured in the afternoon from 2:00 to 3:00 p.m. Minimum temperatures were measured in the morning from 5:00 to 6:00 a.m. The average of the measurements recorded for plots of similiar treatment have been referred to as mean maximum and mean minimum soil temperatures.

The mean maximum soil temperatures measured on the clear cut areas increased from 79 F on May 30, 1966, to 90 F on September 10, 1966. These temperatures were 7 F to 10 F higher than those measured on the control plots (Figures 9a, 9b; Table 4).

The mean minimum soil temperatures were essentially the same for all the treatment plots.

As the season progressed, soil moisture decreased rapidly on all the treatment areas at both the 0 to 6-inch and 6 to 12-inch depths. The clear cut areas were lowest in moisture. On May 6, 1966, they had an average of 36.8

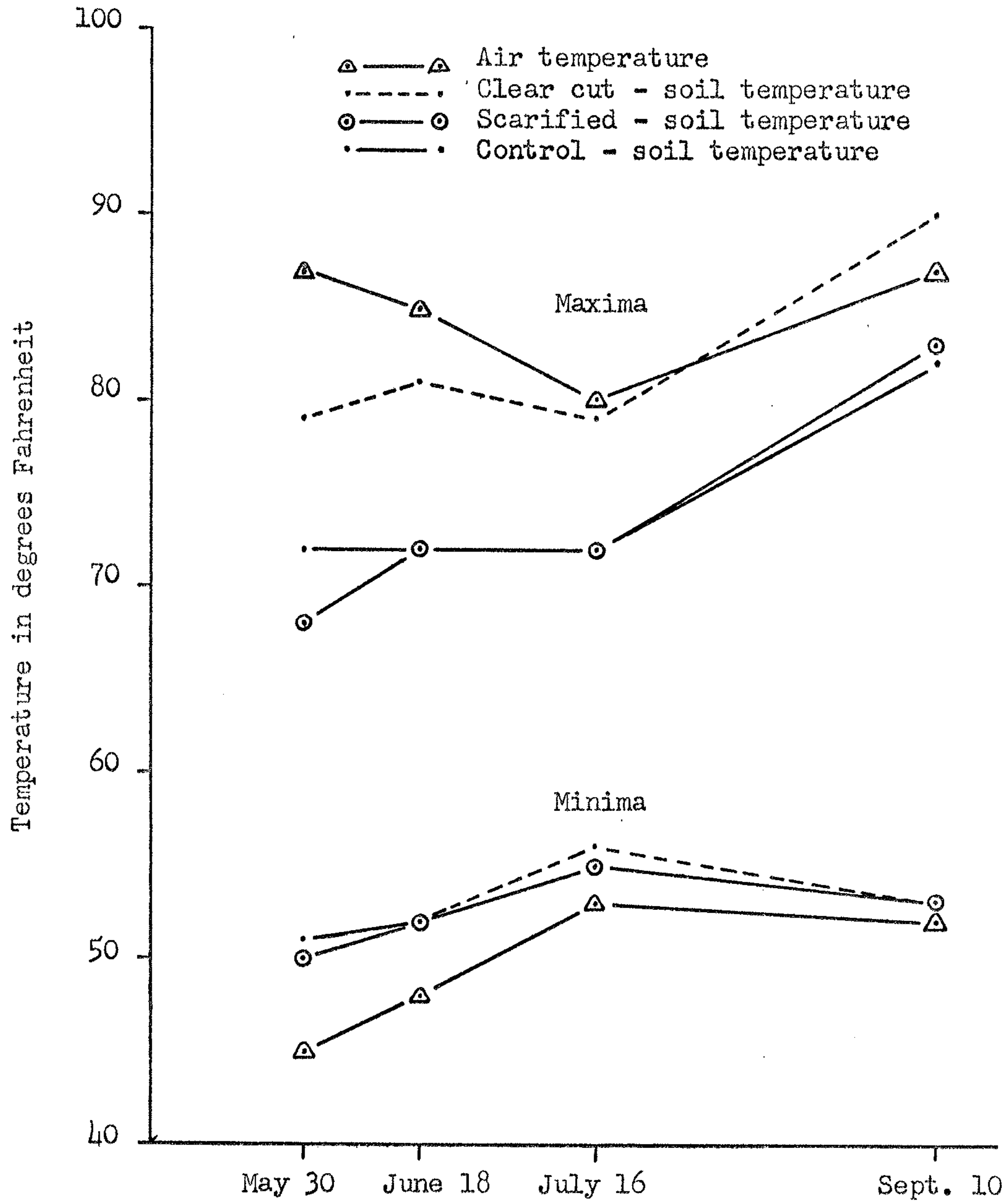

Figure 9a. Mean maximum and mean minimum soil temperatures measured at 2-inch depths for three treatments and air temperature during the period of May 30 through September 10, 1966.

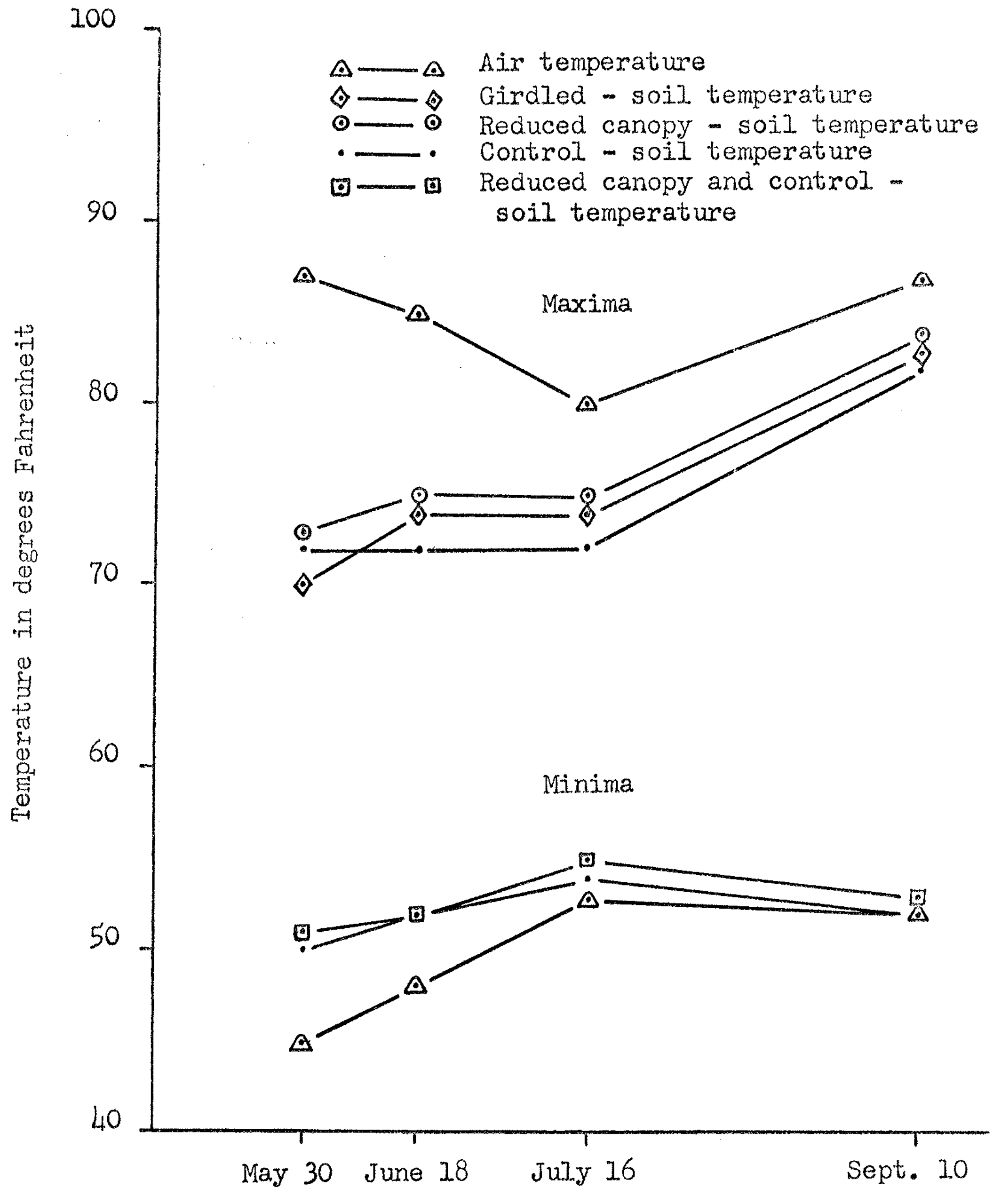

Figure 9b. Mean maximum and mean minimum soil temperatures measured at 2-inch depths for three treatments and air temperature during the period of May 30 through September 10, 1966.

Table 4. Mean maximum and mean minimum soil temperatures at 2-inch depths for treatments during the period of May 30 through September 10, 1966

	May 30		June 18		July 16		Sept. 10	
p.m.	Max. 2:00 to 3:12		Max. 1:40 to 2:40		Max. 2:00 to 3:00		Max. 1:30 to 2:15	
a.m.	Min. 5:15 to 6:03		Min. 5:05 to 6:03		Min. 5:15 to 6:10		Min. 5:45 to 6:30	
Plot No.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
				Clear Cut				
1	78	51	81	51	79	55	90	52
8	78	53	83	54	81	57	92	54
15	81	49	78	52	78	55	89	52
Mean	79	51	81	52	79	56	90	53
				Scarified				
2	68	51	74	53	73	55	82	53
9	69	49	72	52	72	55	82	52
12	67	51	71	52	72	54	84	53
Mean	68	50	72	52	72	55	83	53
				Reduced Canopy				
3	74	52	76	52	77	55	86	54
10	73	50	74	52	75	55	83	52
11	72	50	74	52	73	55	84	54
Mean	73	51	75	52	75	55	84	53
				Girdled				
4	71	51	74	51	73	55	82	53
6	68	50	72	52	73	54	82	52
14	70	50	77	52	75	54	85	52
Mean	70	50	74	52	74	54	83	52
				Control				
5	72	51	74	51	74	55	82	52
7	66	51	69	52	71	55	80	53
13	66	51	74	52	72	55	83	53
Mean	68	51	72	52	72	55	82	53

percent soil moisture (0 to 6 inches) which dropped to 5.4 percent soil moisture by September 10, 1966 (Figures 10a, 10b; Table 5).

Reduced canopy

The reduced canopy treatment produced less than half as many stems as the clear cut. An estimated 22,053 stems per acre were observed in 1966 and 11,600 stems per acre in 1967 (Table 3). Average height of the stems the second year after treatment was 43 inches.

The mean maximum soil temperatures for the reduced canopy plots were lower than might be expected. The mean soil temperature increased from 73 F on May 30 to 84 F on September 10. These temperatures were more similar to the temperatures on the treatment plots that retained full canopies than they were to temperatures on the clear cut treatment, even though the canopy on the reduced canopy treatment had been reduced to 23 percent (Figures 9a, 9b; Table 4).

Other treatments

The girdled, scarified, and control treatments were not significantly different from each other in 1966 or 1967 (Tables 1, 2). Estimated stems per acre on these treatments in 1967 were as follows: scarified, 1,880; control, 3,470; and girdled, 4,050. Stems on these treatments were less vigorous and had yellowish leaves.

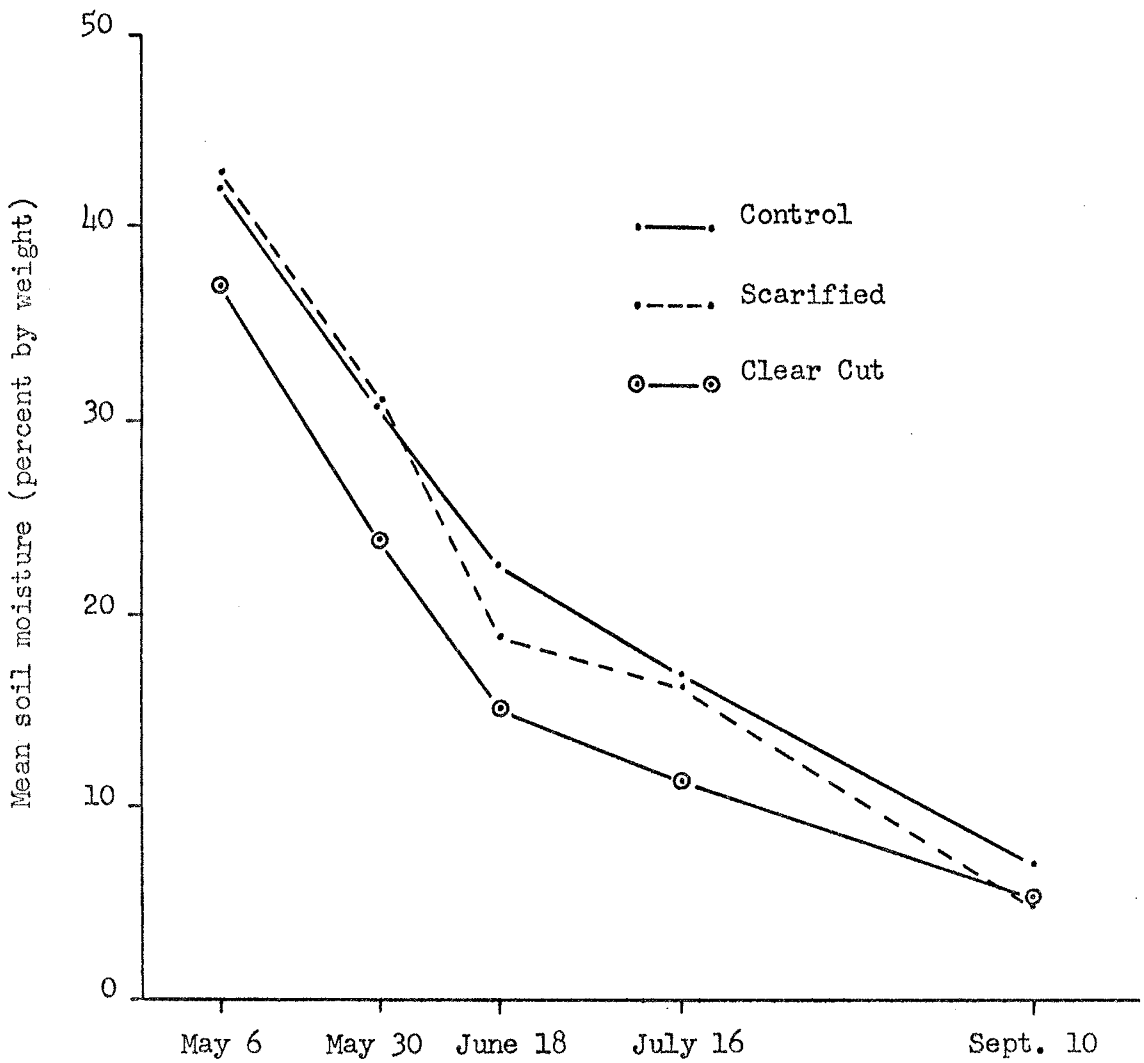

Figure 10a. Mean soil moisture percentages for three treatments at 0-6 inches during the period of May 6 through September 10, 1966.

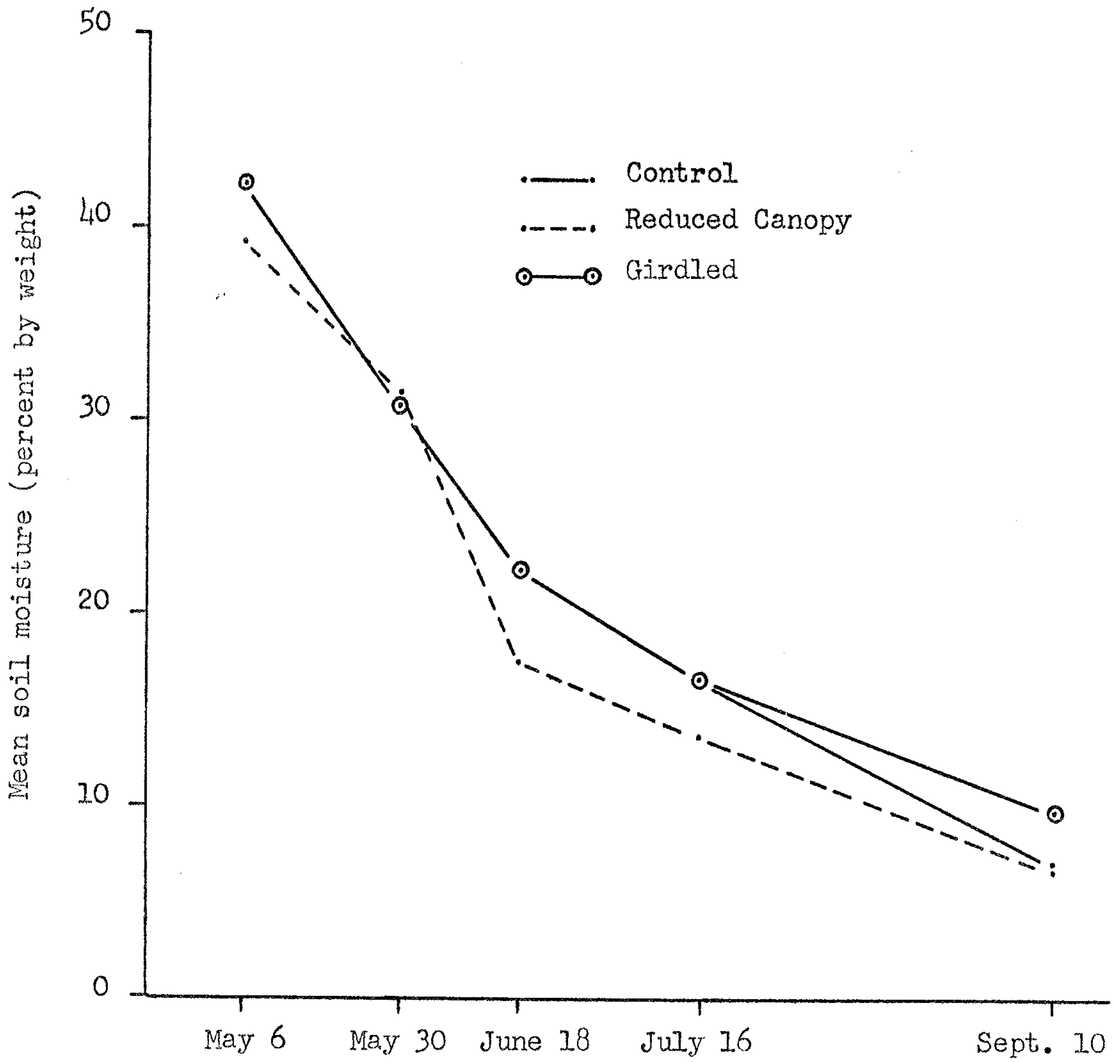

Figure 10b. Mean soil moisture **percentages for** three treatments at 0-6 inches during the period of May 6 through September 10, 1966.

Table 5. Mean soil moisture percentages, by weight, for treatments at two soil depths during the period of May 6 through September 10, 1966

Plot No.	May 6 0-6"	May 6 6-12"	May 30 0-6"	May 30 6-12"	June 18 0-6"	June 18 6-12"	July 16 0-6"	July 16 6-12"	Sept. 10 0-6"	Sept. 10 6-12"
					Clear Cut					
1	37.4	37.5	26.7	27.5	19.9	23.9	10.5	12.9	4.0	10.4
8	33.0	30.2	21.7	26.5	12.4	16.1	7.7	9.5	7.1	8.9
15	40.0	33.9	23.1	26.2	12.9	18.7	8.4	11.9	5.0	9.0
Mean	36.8	33.9	23.8	26.7	15.1	19.6	8.9	11.4	5.4	9.4
					Scarified					
2	43.5	39.4	32.1	30.0	19.5	21.2	16.1	10.6	4.1	9.3
9	47.6	39.4	32.5	31.5	18.5	20.7	16.2	11.2	7.1	9.8
12	36.7	38.7	28.7	32.9	18.1	23.1	16.4	11.8	4.8	10.3
Mean	42.6	39.2	31.1	31.5	18.7	21.7	16.2	11.2	5.3	9.8
					Reduced Canopy					
3	37.2	35.2	34.4	32.8	17.3	19.7	14.2	10.0	7.7	10.6
10	38.6	37.4	32.1	32.5	18.3	17.9	14.2	10.9	7.3	10.3
11	41.9	36.7	28.1	28.1	17.2	15.9	12.6	9.6	5.1	10.5
Mean	39.2	36.4	31.5	31.1	17.5	17.8	13.7	10.2	6.7	10.5
					Girdled					
4	38.8	34.6	36.0	31.0	25.4	20.6	18.2	11.5	11.4	11.9
6	43.6	38.4	25.9	26.6	19.8	19.7	15.8	13.6	9.6	11.2
14	44.2	39.6	30.2	30.7	21.8	22.3	15.7	11.9	8.5	9.1
Mean	42.2	37.5	30.7	29.4	22.3	20.9	16.6	12.3	9.8	10.7
					Control					
5	44.2	37.7	30.6	29.9	22.7	23.0	16.0	12.5	6.3	9.6
7	35.9	34.1	28.9	28.7	21.4	20.6	17.9	12.6	8.3	11.2
13	46.0	41.1	32.6	30.5	23.3	24.1	16.6	11.6	6.4	10.8
Mean	42.0	37.6	30.7	29.7	22.5	22.6	16.8	12.2	7.0	10.5

They averaged about 30 inches shorter than the stems on the reduced canopy and clear cut treatments (Table 3). The parent trees on the girdled treatment area maintained a full canopy in 1966 and appeared to have three-fourths of a full canopy in 1967.

The mean maximum soil temperatures in the girdled and scarified areas were much like those in the control areas.

Amount of Utilization and Trampling by Cattle, Deer, and Elk

Mule deer and elk (*Cervus canadensis*) were not observed on or near the study area during the field seasons of 1965 and 1966. Some signs of elk were seen in July, 1966. It appeared that a small group had passed through the area, causing limited damage along a trail that cut through the middle of plot 15. In terms of total utilization, the amount of aspen use was insignificant. Deer and elk signs were again scarce in 1967. No deer and only three elk pellet groups were found on the study area.

Cattle moved into the vicinity of the study area toward the end of July and did not leave until mid-September. Cattle were frequently observed eating new aspen growth, particularly in the fall when most of the other forage was gone. In the fall of 1965, the cattle were extremely short of forage and completely destroyed many of the new shoots that appeared following completion of the treatments. Several times cattle were seen eating the dried aspen trimmings that had been left in the area.

By the time the cattle re-entered the area in late July of 1966, some of the aspen suckers were two feet tall. Overall utilization of the suckers was light, even though the surface vegetation was heavily used by cattle. Cow chip counts indicated 28 cow days use per acre on the clear cut treatments, but only 16 percent of the aspen green weight was utilized. By 1967, the aspen stems were taller and woodier and the aspen utilization dropped to 4 percent on the clear cut treatments even though there were 21 cow days use per acre (Table 6).

In 1966, the aspen on the other treatments received less use than the aspen on the clear cut plots, but in 1967 the suckers on several of the other treatments received more use. The most utilization was recorded on the girdled plots where 9.6 percent of the aspen growth was taken (Table 6).

Although percentage utilization of the new aspen growth was light, damage to the terminal buds was severe. On one of the clear cut plots 63 percent of the terminal buds had been removed by animals in 1966. The average number of terminal buds removed for the clear cut plots was 43 percent in 1966 and 21 percent in 1967 as more of the aspen suckers grew out of reach. On the girdled plots,

Table 6. Utilization and trampling of aspen by animals and cow days use per acre on the treatment plots

Plot No.	Percent of terminal buds used			Estimated mean utilization of aspen by animals in % of green weight		Cow days use/acre		Percent of aspen stems trampled	
	1965[a]	1966[a]	1967[b]	1966[a]	1967[b]	1966[c]	1967[d]	1966	1967
				Clear Cut					
1	70	27	14	13.6	1.9	18	14	3.3	6.7
8	38	39	12	16.6	2.2	42	26	3.3	4.5
15	50	63	37	17.4	7.9	25	23	0.6	4.8
Mean	53	43	21	15.9	4.0	28	21	2.8	5.3
				Scarified					
2	0	4	21	0.8	5.7	6	7	0.0	1.0
9	100	27	31	5.0	11.5	25	0	4.0	0.0
12	100	17	20	1.4	2.1	14	10	0.0	2.1
Mean	67	16	24	2.4	6.4	15	6	1.3	1.0
				Reduced Canopy					
3	e	22	27	8.7	2.6	15	5	4.5	11.4
10	0	32	25	9.1	3.2	23	4	3.0	7.2
11	100	41	19	14.8	1.7	16	7	3.7	10.2
Mean		32	24	10.9	2.5	18	5	3.7	9.6

Table 6. Continued

Plot No.	Percent of terminal buds used			Estimated mean utilization of aspen by animals in % of green weight		Cow days use/acre		Percent of aspen stems trampled	
	1965[a]	1966[a]	1967[b]	1966[a]	1967[b]	1966[c]	1967[d]	1966	1967
				Girdled					
4	0	31	46	10.6	8.4	29	0	4.6	0.0
6	67	35	47	12.2	5.5	13	24	1.3	6.9
14	100	40	61	11.2	15.0	6	0	1.9	0.0
Mean	56	35	51	11.3	9.6	15	8	2.6	2.3
				Control					
5	67	13	21	3.0	3.0	6	19	2.2	9.1
7	e	14	24	1.7	5.7	18	12	5.4	4.2
13	e	34	21	3.9	8.9	15	0	0.0	0.0
Mean		20	22	2.9	5.9	10	10	2.5	4.4

[a]Basis, 50 random 9.6-square-foot plots per treatment plot.
[b]Basis, 50 permanent milacre plots per treatment plot.
[c]Basis, 30 random 99.6-square-foot plots per treatment plot.
[d]Basis, 50 milacre plots per treatment plot.
[e]No stems observed on these plots in 1965.

35 percent of the terminal buds were taken in 1966 and 51 percent in 1967. The reduced canopy treatment received moderate use with an average of 32 percent of the terminal buds nipped off in 1966 and 24 percent in 1967 (Table 6).

Most of the damage from trampling was caused by cattle wandering through the study area. In all but one case, the damage was 5 percent or less for both 1966 and 1967. The exception was the reduced canopy treatment, which had 9 percent of its suckers damaged by trampling in 1967.

DISCUSSION AND CONCLUSIONS

Over twice as many aspen suckers were found on the clear cut treatments as on the reduced canopy treatments. This emphasizes the need for clear cutting to obtain maximum sucker production. Not only were the suckers on the clear cut treatment twice as numerous, but they also grew faster. After two growing seasons, they averaged 4 inches taller than the suckers on the reduced canopy area.

Reinke (1955) and Garrett and Zahner (1964) found the difference between a reduced canopy cut and a clear cut became more striking in time as the suckers on the reduced canopy cut continued to lose vigor and became less numerous.

It is difficult to state why the clear cut was so much more prolific than the reduced canopy cut; however the study did provide some clues. The girdled areas failed to produce many more suckers than did the controls. Assuming that auxin does flow basipetally from the crown to the lateral root system and that it inhibits sucker development, complete girdling of the phloem should have restricted this flow and allowed the lateral root system to produce suckers just as profusely as if the trees had all been cut. Since the major difference between the two treatments was the presence of an overhead canopy on the girdled areas following treatment, it may be possible to assume that it was the environmental conditions created by the canopy and not the auxin that suppressed suckering. Thus the environmental conditions created by the remaining canopy on the reduced canopy treatment may have been responsible for the significantly lesser reproductive response on that treatment than occurred on the clear cut treatment.

The maximum soil temperature and the percent soil moisture under the girdled and reduced canopy treatments were much like those found on the control where a full canopy was retained and suckering was at a minimum. The maximum soil temperature was higher and the amount of soil moisture was lower on the clear cut than on the other treatments.

Although scarification has been reported to increase suckering (Zehngraff, 1947a; and Zillgitt, 1951), no increase in suckering was noted for the scarified treatment during this study. The canopy maintained on the scarified treatment areas may have been responsible.

The aspen reproduction on the study area suffered only light to moderate damage from browsing by cattle. Cattle were allowed on the study area from the end of July until mid-September. Cattle grazed the area heavily as indicated by cow chip counts, but the damage to terminal buds was moderate and the use of the aspen reproduction was light. The size of each treatment area was relatively small and the cattle wandered through them rather than using only the edges.

Other studies have shown that aspen is lightly used by cattle. This could explain the light use of aspen reproduction by cattle in an area where most of the other vegetation received heavy use.

Deer and elk have a large summer range in proportion to their numbers in northern Utah, and they were not abundant in the vicinity of the study area. The road which passes through the study site is frequently traveled by people during the summer and the travelers may cause deer and elk to avoid the area. Since deer and elk sign were meager, it is believed these animals little utilized the aspen suckers.

SUMMARY

Research was conducted in northern Utah from 1965 through 1967 to determine the reproductive response of aspen to the following treatments: clear cutting, reduced canopy cutting, girdling, scarifying, and control.

Work was also done to determine what amount of the aspen reproduction was utilized and trampled by cattle, deer, and elk on the various treatments.

The response of the aspen to treatment was determined by estimating the number and height of sucker stems for each treatment plot. In 1967, both the clear cut and reduced canopy cut had a significantly greater number of suckers than did the control; the clear cut supported 23,900 stems per acre, the reduced canopy cut supported 11,600 stems per acre, and the control supported 3,470 stems per acre. Stems were about 30 inches taller on the clear cut and reduced canopy cut plots than on the control plots.

Soil temperature and moisture measurements indicated the clear cut treatment plots were hottest and driest.

Cattle used most of the other forage in the study area heavily while using the aspen reproduction lightly. Small tender suckers and terminal buds on larger suckers accounted for much of the utilization. Trampling damage by cattle contributed little to overall sucker mortality. Deer and elk utilization of the suckers was negligible.

LITERATURE CITED

Anonymous. 1942. Wildlife and aspen in Rocky Mountain National Park, Colorado. Ecology 23:478-482.

Baker, F. S. 1918. Aspen reproduction in relation to management. J. Forestry 16:389-398.

Baker, F. S. 1925. Aspen in the central rocky mountain region. U. S. Dept. Agric. Bull. 1921. 47 p.

Barth, A. 1942. Aspen: its culture and treatment for quality production. Frolich Fund for the Advancement of Aspen Management: 87 p. (transl. from Norwegian by P. Zehngraff, Lake States Forest Expt. Sta.) (Original not seen; cited by Horton and Maini, 1964.)

Beers, T. W. and C. I. Miller. 1964. Point sampling: Research results theory and applications. Purdue University Agric. Expt. Sta., Research Bull. No. 786. 55 p.

Brown, A. B. 1935. Cambial activity in two species of poplàr. New Phytol. 34:163-179. (Original not seen; cited by Horton and Maini, 1964.)

Day, M. W. 1944. The root system of aspen. Am. Midland Naturalist 32:502-509.

de Vos, A. 1958. The influence of browsing animals on forest regeneration. Forestry Chron. 34(1):21-24.

Farmer, R. E., Jr. 1961. Some physiological aspects of root sucker initiation and early growth in Populus tremuloides and P. grandidentata. Ph.D. Thesis, Univ. of Mich. 181 p. (Original not seen; cited by Maini and Horton, 1966b.)

Farmer, R. E., Jr. 1962a. Aspen root sucker formation and apical dominance. Forest Sci. 8(4):403-410.

Farmer, R. E., Jr. 1962b. Some physiological aspects of root sucker initiation and early growth in Populus tremuloides and Populus grandidentata. Diss. Abs. 23(1):10.

Farmer, R. E., Jr. 1963. Effect of light intensity on growth of Populus tremuloides cuttings under two temperature regimes. Ecology 44(2):409-411.

Fowells, H. A. 1965. Silvics of forest trees of the United States. U. S. Dept. Agric., Agric. Handbook No. 271. 762 p.

Frykman, J. L. 1958. Aspen management in Utah. Proc. Soc. Amer. Foresters 1958:71-74.

Garrett, P. W. and R. Zahner. 1964. Clonal variation in suckering of aspen obscures effect of various clearcutting treatments. J. Forestry 62(10):749-750.

Gifford, G. F. 1966. Aspen root studies on three sites in northern Utah. Am. Midland Naturalist 75(1):132-141.

Graham, S. A., R. P. Harrison, Jr., and C. E. Westell, Jr. 1963. Aspens, Phoenix trees of the Great Lakes Region. Univ. Michigan Press, Ann Arbor, Michigan. 272 p.

Horton, K. W. and J. S. Maini. 1964. Aspen reproduction: Characteristics and control. Canada, Dept. For., For. Res. Br. Rept. 64-0-12. 90 p.

Julander, O. 1937. Utilization of browse by wildlife. Trans. N. Am. Wildl. Conf. 2:276-287.

Lemmon, P. E. 1956. A spherical densiometer for estimating forest overstory density. Forest Sci. 2: 314-320.

Lemmon, P. E. 1957. A new instrument for measuring forest overstory density. J. Forestry 55:667-669.

Li, Jerome C. R. 1959. Introduction to statistical inference. Jerome C. R. Li, Ann Arbor, Michigan. 553 p.

Maini, J. S. 1960. Invasion of grassland by _Populus tremuloides_ in the Northern Great Plains. Ph.D. Thesis, Univ. of Sask. 231 p. (Original not seen; cited by Maini and Horton, 1966b.)

Maini, J. S. and B. W. Dance. 1965. Temperature relationships of a blight attributed to _Fusarium solani_ (Mart.) Sacc. on trembling aspen suckers. Can. Dept. For., Bi-monthly Progr. Rept. 21(2):2-3. (Original not seen; cited by Maini and Horton, 1966b.)

Maini, J. S. and K. W. Horton. 1966a. Reproductive response of _Populus_ and associated _Pteridium_ to cutting, burning and scarification. Canada, Dept. For., (Mimeographed). For. Br. Dept. Publication No. 1155. 20 p.

Maini, J. S. and K. W. Horton. 1966b. Vegetative propagation of Populus spp. I. Influence of temperature on formation and initial growth of aspen suckers. Can. J. Bot. 44(9):1183-1189.

Reinke, M. E. 1955. Management of aspen. Wisconsin Conserv. Bull. 20(11):25-28.

Sampson, A. 1919. Effect of grazing upon aspen reproduction. U. S. Dept. Agric. Bull. 741. 29 p.

Sandberg, D. 1951. The regeneration of quaking aspen by root suckers. Masters Thesis. Univ. of Minn. 172 p. (Original not seen; cited by Maini and Horton, 1966b.)

Shirley, H. L. 1931. Does light burning stimulate aspen suckers? J. Forestry 29:524-525.

Shirley, H. L. 1932. Does light burning stimulate aspen suckers? II. J. Forestry 30:419-420.

Slabaugh, P. E. 1958. Silvical characteristics of bigtooth aspen (Populus grandidentata) U. S. Dept. Agric. For. Serv., Lake States Forest Expt. Sta., Sta. Paper No. 63: 16 p. (Original not seen; cited by Horton and Maini, 1964.)

Stoeckeler, J. H. 1960. Soil factors affecting the growth of quaking aspen forests in the Lake States. Univ. of Minn. Agric. Expt. Sta. Tech. Bull. 233. 48 p. (Original not seen; cited by Maini and Horton, 1966b.)

Stoeckeler, J. H. and J. W. Macon. 1956. Regeneration of aspen cutover areas in Northern Wisconsin. J. Forestry 54(1):13-16.

Weigle, W. G., and E. H. Frothingham. 1911. The aspens: Their growth and management. U. S. Dept. Agric. For. Serv. Bull. 93. 35 p.

Westell, C. E., Jr. 1954. Available browse following aspen logging in lower Michigan. J. Wild. Mgmt. 18:266-271.

Westell, C. E., Jr. 1955. Ecological relationships between deer and forests in Lower Michigan. Proc. Soc. Amer. Foresters 1955:130-132.

Zehngraff, P. J. 1947a. Possibilities of managing aspen. U. S. Dept. Agric. For. Serv., Lake States Aspen Rept. 21. 23 p.

Zehngraff, P. J. 1947b. Response of young aspen to overhead shade. Lake States Forest Expt. Sta. Tech. Note 278. 1 p.

Zehngraff, P. J. 1949. Aspen as a forest crop in the Lake States. J. Forestry 47(7):555-565.

Zillgitt, W. M. 1951. Disking to increase stocking in aspen stands. Lake States Forest Expt. Sta. Tech. Note 357. 1 p.

APPENDIX

Table 7. Stand information on the Twin Creek Study Area prior to initiation of treatments, 1965

Plot Number	Tree age (years)	Tree height (feet)	Diameter breast height (inches)
		Clear Cut	
1	55	54	7.3
8	54	57	7.8
15	55	59	8.4
Mean	55	57	7.8
		Scarified	
2	53	57	7.4
9	54	56	8.5
12	55	56	7.6
Mean	54	56	7.8
		Reduced Canopy	
3	56	56	8.9
10	54	57	8.0
11	53	57	7.8
Mean	54	57	8.3
		Girdled	
4	53	56	7.7
6	59	62	8.7
14	54	58	7.6
Mean	55	59	8.0
		Control	
5	60	63	8.9
7	56	59	8.1
13	54	59	7.6
Mean	57	60	8.3
Stand Mean	55	58	8.0

Table 8. Basal areas in square feet per acre of aspen stand on the Twin Creek Study Area, 1965

Plot No.	Before treatment	After treatment
	Clear Cut	
1	131.1	0
8	132.5	0
15	122.0	0
Mean	128.5	0
	Scarified	
2	144.3	Unchanged
9	115.6	
12	139.5	
Mean	133.1	
	Reduced Canopy	
3	126.2	44.1
10	136.0	42.7
11	114.3	36.7
Mean	125.5	41.2
	Girdled	
4	122.0	Unchanged
6	130.0	
14	123.3	
Mean	125.1	
	Control	
5	123.3	Unchanged
7	130.0	
13	146.5	
Mean	136.6	

Table 9. Canopy cover for the treatment plots before treatment 1965, and after treatment 1965 and 1966

Plot No.	Before treatment summer 1965 %	After treatment summer 1965 %	Summer 1966 %
		Clear Cut	
1	72.0		
8	79.5		
15	80.8		
Mean	77.8		
		Scarified	
2	83.7		
9	74.9		70.5
12	79.8		71.6
Mean	79.5		70.0
		Reduced Canopy	
3	70.8	26.6	22.3
10	75.1	28.9	24.9
11	77.0	25.5	21.3
Mean	74.3	27.0	22.8
		Girdled	
4	77.9		70.9
6	77.0		70.8
14	83.1		68.8
Mean	79.3		70.2
		Control	
5	81.9		71.7
7	81.7		72.7
13	84.4		72.9
Mean	82.7		72.4

Table 10. Estimated green weight of understory vegetation at the Twin Creek Study Area, 1965

	Clear Cut[a]	Scarified[b]	Reduced Canopy[c]	Girdled[a]	Control[a]
	Mean production in pounds/acre				
Grasses					
Agropyron trachycaulum	13.5	24.3	---	10.0	---
Bromus marginatus	194.3	257.1	222.5	271.7	177.0
Dactylis glomerata	10.7	59.7	---	30.5	13.4
Elymus glaucus	94.3	264.3	205.8	138.0	210.7
Melica spectabilis	---	---	0.8	1.0	1.3
Poa reflexa	1.7	0.7	---	---	---
Carex spp.	18.7	35.0	33.3	12.3	18.7
Forbs					
Achillea lanulosa	7.7	20.7	10.8	10.0	6.0
Agastache urticifolia	89.0	107.1	90.8	32.7	65.3
Aster engelmanni	---	26.4	---	---	---
Delphinium occidentale	27.7	82.9	180.0	55.7	53.3
Descuriana pinnata	---	3.6	---	---	---
Floerkea occidentalis	---	12.2	29.5	60.0	17.0
Hackelia jessicae	10.7	29.6	15.8	9.0	13.3
Hydrophyllum capitatum	31.7	---	9.2	---	---
Lathyrus spp.	229.5	282.9	285.0	208.0	200.7
Latuca spp.	---	---	---	0.3	---
Nemophila breviflora	342.0	5.7	36.7	---	---

Table 10. Continued

	Clear Cut[a]	Scarified[b]	Reduced Canopy[c]	Girdled[a]	Control[a]
	Mean production in pounds/acre				
Forbs					
Osmorhiza occidentalis	132.5	184.3	144.2	148.7	112.7
Polemonium foliosissimum	4.0	2.9	8.3	2.3	---
Pteridium aquilinium	68.3	---	---	151.7	2.7
Rudbeckia occidentalis	628.0	942.9	941.7	1,016.0	817.7
Senecio serra	230.0	455.0	287.5	105.0	112.3
Smilacina spp.	---	3.6	---	3.0	0.7
Taraxacum officinale	5.7	2.9	---	---	3.3
Thalictrum fendleri	40.0	77.1	92.5	51.3	25.7
Urtica spp.	---	---	---	24.7	---
Valeriana occidentalis	159.0	176.4	90.8	133.0	94.5
Browse					
Populus tremuloides	22.2	5.4	41.7	33.4	28.0
Rosa spp.	---	---	---	3.3	---
Sambucus spp.	---	---	---	20.0	2.9
Symphoricarpos spp.	27.3	25.0	11.7	11.3	21.7
Total pounds/acre green weight	2,389	3,088	2,739	2,543	1,999

[a]Basis, 150 sample plots. [b]Basis, 70 sample plots. [c]Basis, 60 sample plots.

Table 11. Estimated green weight of understory vegetation at the Twin Creek Study Area, 1966

	Clear Cut	Scarified	Reduced Canopy	Girdled	Control
	Mean production in pounds/acre				
Grasses					
Agropyron trachycaulum	8.3	3.3	---	1.3	3.3
Bromus marginatus	421.4	228.0	355.0	291.0	208.7
Dactylis glomerata	0.7	11.3	5.7	11.0	16.7
Elymus glaucus	119.9	199.3	215.3	196.3	173.7
Melica spectabilis	---	9.3	1.0	---	0.7
Poa pratensis	0.7	---	---	---	---
Poa reflexa	29.0	47.0	10.0	24.0	30.3
Trisetum spicatum	---	2.3	0.7	13.4	28.0
Carex spp.	10.8	24.3	9.7	9.3	16.3
Forbs					
Achillea lanulosa	11.8	18.3	2.0	8.0	15.0
Agastache urticifolia	73.3	31.0	55.3	37.3	31.0
Aster engelmanni	11.9	14.0	11.0	6.3	15.3
Collinsia parviflora	8.0	3.0	4.7	---	---
Delphinium occidentale	4.3	41.0	33.6	56.3	28.6
Descuriana pinnata	221.9	108.0	170.0	168.3	66.7
Disporium spp.	1.0	1.6	---	---	0.3
Floerka occidentalis	1.6	---	---	---	---
Hackelia jessicae	19.7	72.7	51.3	29.0	24.0
Lathyrus spp.	98.3	210.3	267.7	165.7	223.0
Nemophila breviflora	37.1	---	---	---	---

Table 11. Continued

	Clear Cut	Scarified	Reduced Canopy	Girdled	Control
			Mean production in pounds/acre		
Forbs					
Osmorhiza occidentalis	25.2	64.7	107.0	145.0	102.7
Phacelia luecophylla	29.0	3.7	---	3.7	8.3
Polemonium foliosissimum	16.0	9.0	22.7	12.0	12.7
Potentilla glandulosa	1.7	---	3.0	1.0	0.3
Pteridium aquilinium	48.3	---	92.3	60.7	---
Rudbeckia occidentalis	486.2	645.7	577.7	1,034.0	742.7
Senecio serra	136.2	201.0	145.3	46.3	112.3
Stellaria spp.	8.9	---	---	---	---
Thalictrum fendleri	21.7	53.7	46.3	45.0	20.0
Urtica spp.	---	---	---	35.0	---
Valeriana occidentalis	60.0	117.3	111.0	133.7	71.3
Vicia americana	75.6	55.3	26.3	42.3	23.0
Browse					
Populus tremuloides	1,268.5	42.7	363.0	109.7	43.8
Rosa spp.	---	---	---	0.3	---
Sambucus spp.	5.3	19.0	7.3	---	16.7
Symphoricarpos spp.	34.9	19.3	6.0	1.3	13.3
Total pounds/acre green weight	3,297	2,256	2,701	2,687	2,049

VITA

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Master of Science

Thesis: The Effects of Some Silvicultural and Soil Treatments on Aspen (*Populus tremuloides* Michx.) Reproduction in Northern Utah

Major Field: Range Science

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