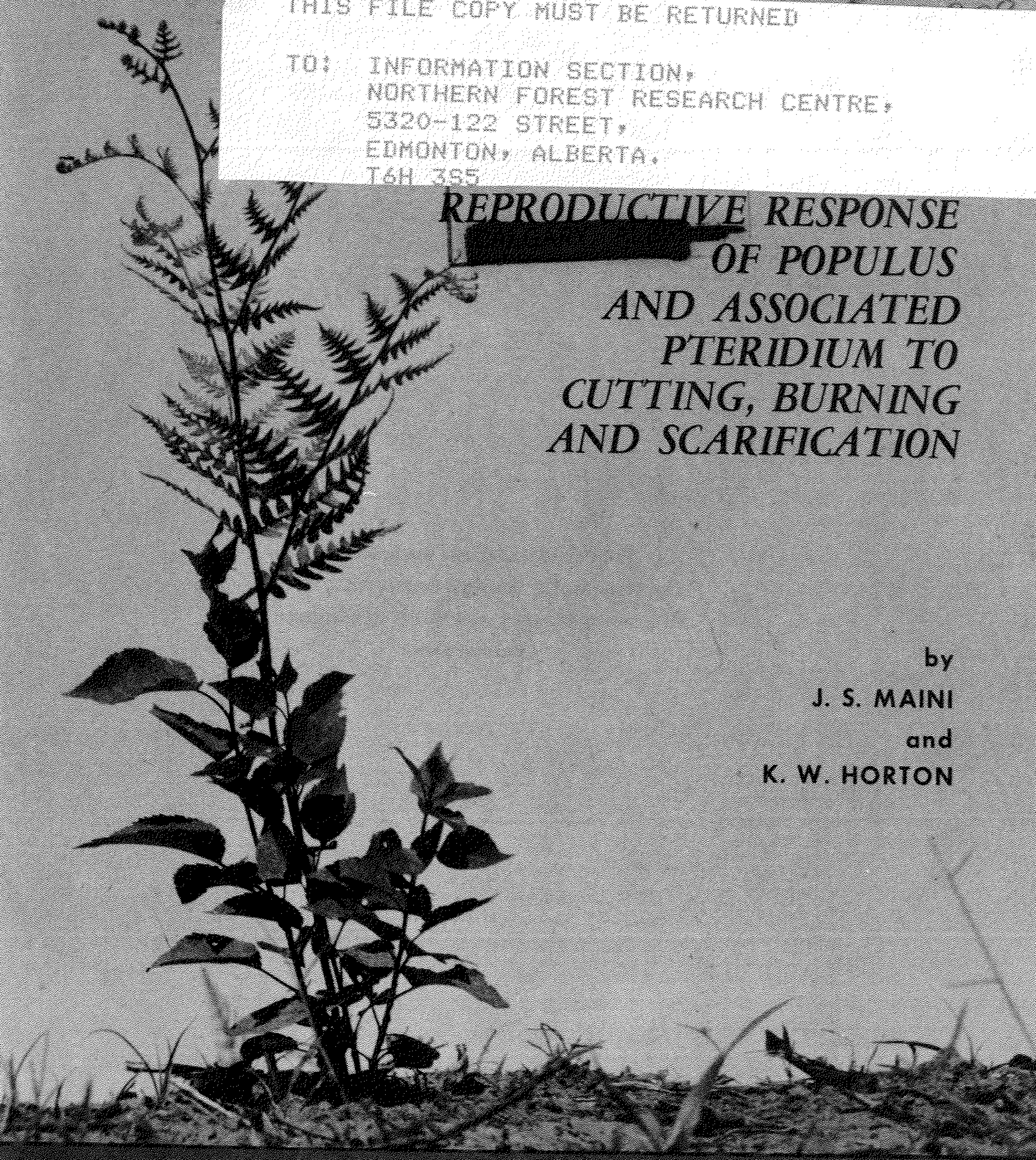

REPRODUCTIVE RESPONSE [redacted] OF POPULUS AND ASSOCIATED PTERIDIUM TO CUTTING, BURNING AND SCARIFICATION

by
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Sommaire en français

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CONTENTS

PAGE

INTRODUCTION 5

THE STUDY AREA 6

METHODS 6
Environmental Modification by Treatments 8
Collection of Data 8
Analysis of Data 8

RESULTS 9
Temperature 10
Vegetation 11
Aspen 11
Bracken 13
Small Herbs 13

DISCUSSION 14

SILVICULTURAL APPLICATIONS 16

SUMMARY 16

SOMMAIRE 17

ACKNOWLEDGEMENT 17

REFERENCES 18

APPENDICES:

1. Comparison of midsummer and fall values of density, dominance, frequency and height of *Populus* suckers by different treatments . . 19
2. Comparison of midsummer and fall values of relative density, relative dominance, relative frequency and reproduction index of *Populus* suckers by different treatments 19
3. Comparison of midsummer and fall values of density, dominance, frequency and height of *Pteridium aquilinum* in various treatments 20
4. Comparison of midsummer and fall values of relative density, relative dominance, relative frequency and reproduction index of *Pteridium aquilinum* in various treatments 20

Reproductive Response of *Populus* and Associated *Pteridium* to Cutting, Burning and Scarification

by

J. S. Maini and K. W. Horton[1]

INTRODUCTION

Populus tremuloides Michx. and *P. grandidentata* Michx. (aspens), taxonomically and silviculturally closely related species, are gaining economic importance in North America. Whereas natural regeneration of these two species is negligible in undisturbed stands, abundant root suckering generally occurs when aspen stands are subjected to cutting, burning and other disturbances. According to Maini (1960) and Maini and Horton (1966) an insolation-induced thermal increase usually plays a critical role in sucker initiation. Management of aspen stands, either for the propagation of aspen or for conversion to some other desirable species requires judicious application of various cultural treatments. The present investigation was conducted during 1962 in southern Ontario to appraise the relative effects of cutting, burning and ground scarification treatments on the regeneration of *P. tremuloides*, *P. grandidentata* and associated ground vegetation, particularly *Pteridium aquilinum* (L.) Kuhn (bracken). The influence of these treatments on the heat economy of the upper soil layers was also evaluated.

The significance in the timing of cutting aspen stands has been discussed by Baker (1918) and Stoeckeler and Macon (1956). Dormant-season cutting produces initially more vigorous root sucker regeneration than summer cutting because in the latter, suckers emerge when the reserve food material in the roots is presumably low and competition by associated ground vegetation is intensive. The later the suckers appear during the growing season, the poorer is their development. However, after a lapse of two years, sucker density was similar in summer-cut and winter-cut stands (Sandberg and Schneider 1953).

Scarification by discing has been found effective for inducing aspen suckering in under-stocked stands (Zillgitt 1951) and in stands where cull trees have been left standing (Zehngraff 1949). Also, following fire in a *Populus* stand, development of a dense sucker crop is usual. An increase in number and vigour of suckers was observed when heavily cut areas were lightly burnt (Shirley 1931, 1932). Repeated burning also stimulated suckering (Shirley 1941).

Suckering response of aspen to the above cultural treatments is effected internally or externally, and it is impossible to separate the two. Among the internal influences, sucker formation may result from injuries inflicted on stems and roots by cutting, scarification or burning, which upset the internal metabolic balance. However, the same disturbances have important external effects—the thermal, hydrological and nutrient conditions may be significantly altered by removing trees, ground vegetation and loose litter, by burning organic matter, as well as by disturbing and loosening superficial soil layers. The present study attempts to separate these causative factors and to determine their relative effects on reproduction of aspen and associated bracken.

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THE STUDY AREA

The study area is located at 44° 19′ N. Lat. and 79° 52′ W. Long. in Essa Township, 60 miles north of Toronto, Ontario, and lies on a level terrace about 650 feet above sea level. In spring the ground is completely covered with the litter of *Populus* and *Pteridium* and the F and H layers are about 0.6 inches thick. The soil is deep, uniform, medium sand and according to Hills' system (1952) the moisture regime is somewhat dry.

Pertinent weather data are available from a weather station located 5 miles from the study area. Based on five years of observations, mean annual precipitation in the area is 34.9 inches out of which 13.9 inches falls during the growing season between May and September (Canada, Department of Transport, unpublished records). Mean maximum and mean minimum temperatures during the growing season (May to September) are 73.1° and 58.4°F, respectively. The length of frost-free period is approximately 140 days.

FIGURE 1. A general view of the study area.

The 15-year-old stand studied was dominated by *P. tremuloides*, with a few individuals of *P. grandidentata* (Figure 1). Height of the arboreal stratum was about 25 feet. Diameter distribution, basal area and density of the arboreal component on the experimental plots is presented in Table 1. Occasional individuals of *Prunus pensylvanica* L. and *P. virginiana* L. ranging from 6 to 10 feet in height were scattered throughout the stand. The most noticeable feature of the ground vegetation was a continuous layer of *Pteridium aquilinum* about 3 feet high with a foliage cover of about 80 per cent (Figure 2). A few species, procumbent or less than 8 inches tall, grew under the *Pteridium* cover.

METHODS

The study was carried out on circular plots, each with a radius of 10 feet around a central aspen tree. Seventy-two plots were located within a 30-acre area and half of them, distributed randomly, were clear cut. Six uncut plots were set aside as a control and the remaining plots were treated as indicated on accompanying chart, with treatments assigned at random and with 6 replicates per combination of ground and tree treatments.

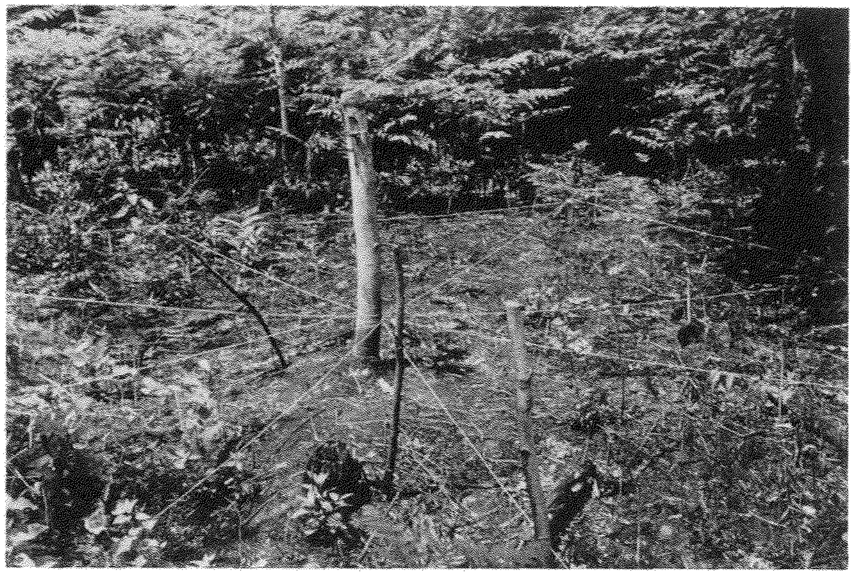

FIGURE 2. A treated plot of 10-ft. radius centered around an aspen stem. Note the dense growth of unclipped bracken outside the plot.

CHART SHOWING TREATMENT OF PLOTS

Treatment No.	Ground Treatments	Vegetation Treatments: Bracken* clipped	Trees: Uncut	Trees: Cut
			No. of plots**	
	SCARIFIED			
1.	Lightly #1—litter raked off *before* aspen leaves flushed; 2 May	yes	6	6
2.	Lightly #2—litter raked off *after* aspen leaves flushed; 20 May	yes	0	6
3.	Moderately—humus and topsoil rototilled; 2 May	yes	6	6
	BURNED			
4.	Lightly—existing litter and some F layer burned off; 2 May	yes	6	6
5.	Moderately—additional litter equal to the existing amount raked on to plots and burned on 2 May, eliminating most of the humus.	yes	6	6
6.	Untreated Ground	yes	6	6
7.	Control	no	6	0

*Bracken (*Pteridium*), the dominant constituent of the ground vegetation was clipped close to the ground on 30 May and 6 July to improve conditions for aspen suckering. Note that treatment No. 6, the untreated ground—uncut combination, differs from No. 7, the control, only in that bracken was unclipped in the latter.

**Each treatment was replicated on 6 plots and each plot sampled by four 1-m^2 quadrats; therefore 24 m^2 quadrats per treatment.

Environmental Modification by Treatments

The treatments employed in this study affected the edaphic conditions in several ways. The light scarification (raking) exposed the F and H layers and left the mineral soil undisturbed. Superficial soil was loosened by the rototiller in the moderate scarification treatment, and the F, H, and upper mineral soil were mixed. In the light and moderate burn treatments, loose organic matter was converted to charcoal and ash, resulting in a blackened compact soil surface and release of nutrients. The removal of litter by scarification or burning essentially resulted in the removal of the insulating layer, exposing the H and upper mineral soil to direct insolation. This would not only alter the thermal economy of the superficial soil but would also increase evaporation of soil moisture. Cutting of trees and clipping of bracken resulted in increased insolation and ventilation of the soil surface. The tree cutting in this study involved clearing patches more than 20 feet in diameter. Since the heights of surrounding trees ranged from 15 to 30 feet, some variable shadowing would occur. The effect was closer to partial cutting than to block clear cutting.

Collection of Data

The vegetation on each plot was sampled by permanent 1-m^2 quadrats, mechanically located along the four cardinal radii, at right angles to each other. Thereby, for each treatment, 24 quadrats provided a sample of density (number of individuals or rooted shoots), average dominant height, and estimated dominance or per cent foliage cover (per cent of area in a quadrat covered by vertical projection of foliage) of each species. Data for *Pteridium* were collected before the early-summer and mid-summer clippings and at the end of the growing season, while those for the *Populus* species were recorded in midsummer and at the end of the growing season. For control, undisturbed ground vegetation was sampled in mid-summer.

Soil temperature in the variously treated plots was measured by metal dial thermometers, each comprising an 8-inch stainless steel stem joined vertically to a dial. The thermometers employ a bimetallic principle of temperature indication in a double helix coil. The sensitive area at the end of the stem is one-inch long and the temperature at 0-1, 1-2, 2-3, 4-5 and 6-7 inch depths were recorded intermittently during the growing season. The first record on 9 May represents pre-leaf-flushing conditions and subsequent records cover part of the growing season up to full development of the vegetation. The temperature measurements, taken mainly in cut plots, were made between 1.30 to 3.30 p.m. mostly on clear days, but occasionally on overcast days.

Temperatures were sampled at the prescribed depth in three plots for each treatment, with four stations in each plot. Each time, the station points were changed at random. Examination of the data showed no more variation between plots of a given treatment, than between stations in a plot. Therefore, for the purpose of analysis, the 12 temperature stations within each treatment were treated as 12 replicates which, according to Franssila (1962), constitute an adequate sample for soil temperature measurements.

Analysis of Data

For the present investigation, no distinction is made between *P. tremuloides* and *P. grandidentata* since the latter species constituted a relatively small component of the original stand (Table 1) and of the sucker population after treatments.

Structurally, on an average height basis, the ground vegetation of the study area may be divided into a lower and an upper stratum. Vegetation attaining a height of 8 inches or more at maturity constitutes the upper, and below 8 inches the lower, stratum. Aspen suckers and bracken have therefore been assigned to

TABLE 1. NUMBER PER ACRE, BASAL AREA PER ACRE AND PER CENT FREQUENCY DISTRIBUTION BY DIAMETER CLASSES OF *POPULUS;* AVERAGES FOR ALL PLOTS PRIOR TO TREATMENTS.

B.H. Diameter Class - Inches	*P. tremuloides*	*P. grandidentata*	Total both species
		Number per acre	
< 3	689	92	781
> 3	98	2	100
All trees	787	94	881
		Basal area per acre (square feet)	
All trees	20.2	1.5	21.7
		Per cent frequency distribution	
< 1	9.2	0.2	9.4
1	39.8	5.8	45.6
2	19.8	3.9	23.7
3	9.4	0.5	9.9
4	7.6	0.0	7.6
5	3.4	0.2	3.6
6	0.2	0.0	0.2
3 and below	78.2	10.4	88.6
> 3	11.2	0.2	11.4
All trees	89.4	10.6	100.0

the upper and the rest of the ground vegetation, forming an insignificant component of the total, to the lower stratum.

The distribution of suckers within plots of any given treatment did not show any consistent pattern of variation along cardinal directions. Density of aspen suckers, bracken and other components of ground vegetation was mathematically converted from no./m^2 to no./milliacre and is expressed as average number per milliacre. Foliage development is presented as per cent cover, and dispersion of individuals in m^2 quadrats is evaluated as per cent frequency (stocking). To appraise the response of aspen and bracken to different treatments, a "Reproduction Index" (R.I.) has been calculated by attributing equal significance to the density (number), dominance (foliage cover) and frequency (stocking) characteristics of the species.

Data for aspen and bracken, collected at midsummer, were analysed separately from those collected in the fall. The Reproduction Index calculations for each taxon at a particular time were made as follows:

$$\text{Relative Density} = \frac{\text{Density for a treatment}}{\text{Total densities for all treatments}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{\% Foliage cover for a treatment}}{\text{Total \% foliage cover for all treatments}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency for a treatment}}{\text{Total frequency for all treatments}} \times 100$$

$$\text{Reproduction Index (R.I.)} = \text{Relative Density} + \text{Relative Dominance} + \text{Relative Frequency}$$

(See Appendices 1 to 4)

RESULTS

Growth activity commenced about 10 days earlier on the scarified and the burned plots than on untreated ground and control plots. An earlier emergence and foliar expansion of bracken fronds on the treated than the untreated plots was conspicuous. Bracken emerged at least two weeks before the aspen suckers.

Temperature

Exploratory probing revealed that most of the aspen suckers originated from roots located near the soil surface, commonly the upper one inch. This observation is in agreement with the general consensus (Maini 1960, Farmer 1962, Horton and Maini, In Press). Therefore, the alteration of thermal conditions in the superficial soil following tree removal was considered to be one of the factors affecting the suckering response of aspen. Data indicated that on the treated-cut plots, temperature on

TABLE 2. INCREASE IN SOIL TEMPERATURE AT 0 TO 1 INCH DEPTHS ON VARIOUS GROUND TREATMENTS OF CUT PLOTS DURING 1962 GROWING SEASON.

Date	Air temp. at 1 ft. above ground	Mean temp. of control stations	Mean temp. increase over control (°F)				S.E.** of treatment means
			Light scar. #1	Mod. burn	Light burn	Mod. scar.	
Clear							
May 9	62	68	12*	16*	11*	17*	0.93
May 17	82	76	9*	12*	13*	16*	1.83
June 4	74	67	7*	9*	9*	12*	0.97
July 18	82	76	8*	12*	15*	14*	1.70
July 19	80	77	8*	15*	19*	14*	1.70
Overcast							
May 24	60	60	4*	3*	5*	6*	0.83
May 30	84	75	5*	7*	9*	9*	1.46
June 21	76	77	3	4	6*	5*	1.49

*Temperature increase over control significant.

**The standard error (S.E.) was calculated by Jeffers (1959) method, using the range of temperatures for each treatment and dividing the mean range by a tabulated range/standard deviation ratio. A difference between two means of more than three times the S.E. is taken as indicating significance.

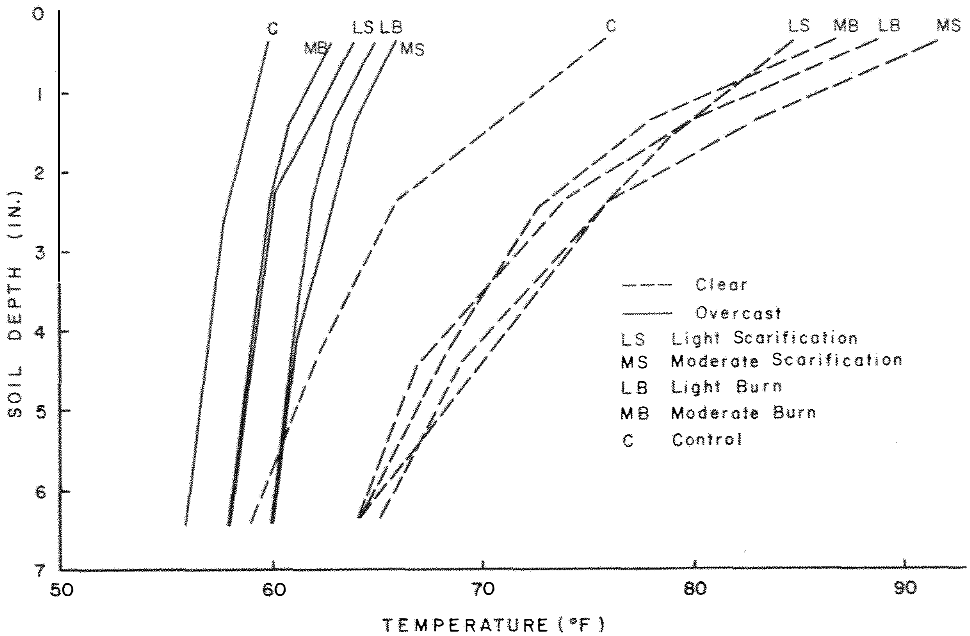

FIGURE 3. Comparison of soil temperature between cut plots of various treatments on one clear day (17 May, 1962) and one overcast day (24 May, 1962).

clear days at the 0 to 1 inch depth was significantly higher than on the control (Table 2) and that temperature differences were generally small at the 6-7 inch depth (Figure 3); the temperature increase above the control was less pronounced in all treatments on overcast days (Table 2, Figure 3). Until early summer (June 4), greatest temperature increases over the control resulted from moderate scarification, and the least increases were produced by light scarification. Temperature differences between the light and moderate burn treatments were small, the former becoming somewhat warmer than the latter as the season progressed.

The temperature differences between various treatments were greater on clear days and were non-significant on overcast days (Table 2 and Figure 3). On clear days, superficial soil temperatures under the cut (open) conditions were significantly higher than under the uncut (shaded) conditions (Figure 4). Diurnal temperature fluctuations were also higher under the treated areas than the control and details are reported elsewhere (Horton, Maini and Hopkins 1962).

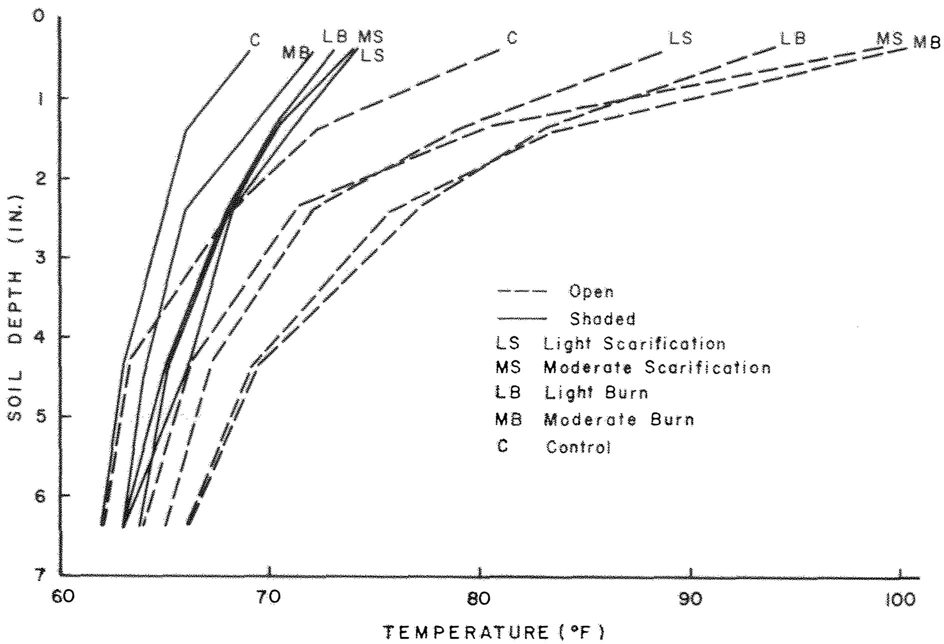

FIGURE 4. Comparison of soil temperature by various treatments under open and shaded conditions on a clear day (26 June, 1962).

Vegetation

Aspen

Tree cutting, scarification and burning treatments stimulated considerable suckering of aspen at midsummer (Appendix 1). However, difference in the response of aspen to various treatments was evident (Figure 5). The response was greater on the cut than uncut plots, and greater for moderate than light ground treatments. The maximum number of suckers at midsummer (35.7 per milliacre) was recorded for the moderate scarification—cut treatment; density was much lower (less than 2) on the untreated ground and was negligible (0.2) on the control. The consistently higher number of aspen suckers recorded on the cut plots in midsummer persisted in the fall (Figure 5). Although midsummer sucker density varied with the various ground treatments, the differences were considerably reduced by fall (Figure 5), when the number of suckers per milliacre ranged from 15.8 to 22.8 in the cut plots and from 6.7 to 7.0 in the uncut plots (excepting the moderate burn where mortality of the trees on the plots possibly simulated cutting). In most cases, sucker density was lower in the fall than in midsummer. Although density in general is directly related to frequency, treatments with a density lower than seven suckers per milliacre had a relatively higher per cent frequency (Appendix 1).

Dominance (per cent foliage cover) of aspen suckers was greater on the cut than uncut plots and generally higher in the summer than in fall (Figure 5 and Appendix 1). However, the size of individual suckers was similar in all treatments.

Height of aspen suckers in the fall generally ranged from 12 to 16 inches on the cut plots and from 8 to 12 inches on the uncut plots, except in the uncut plots with untreated ground where the large average height may possibly be due to low frequency, consequently inadequate sampling (Figure 5). The maximum height of 16 inches was recorded in the light burn—cut plots (Figure 5) where average foliage cover of individual suckers in the fall was also greatest (Appendix 2).

The Reproduction Indices (R.I.) were much higher for cut plots than for uncut plots, both in midsummer and fall; the values were also higher in moderate than in light treatments at midsummer (Appendix 2). Among the cut plots, the highest midsummer values, indicating greatest regeneration response, occurred in the moderately scarified and moderately burned treatments (values of 50 and 46, respectively). In treatments where ground and vegetation were little disturbed or undisturbed, the midsummer R.I. values were considerably lower and ranged from 3 to 7 (Appendix 2). In spite of appreciable midsummer differences, the fall R.I. values among the cut plots of scarification and burn treatments were similar and ranged from 34 to 46. The fall R.I. values were also similar in the uncut plots of scarification and burn treatments and ranged from 13 to 17, except the moderate burn where the value of 35 closely approached those of cut plots.

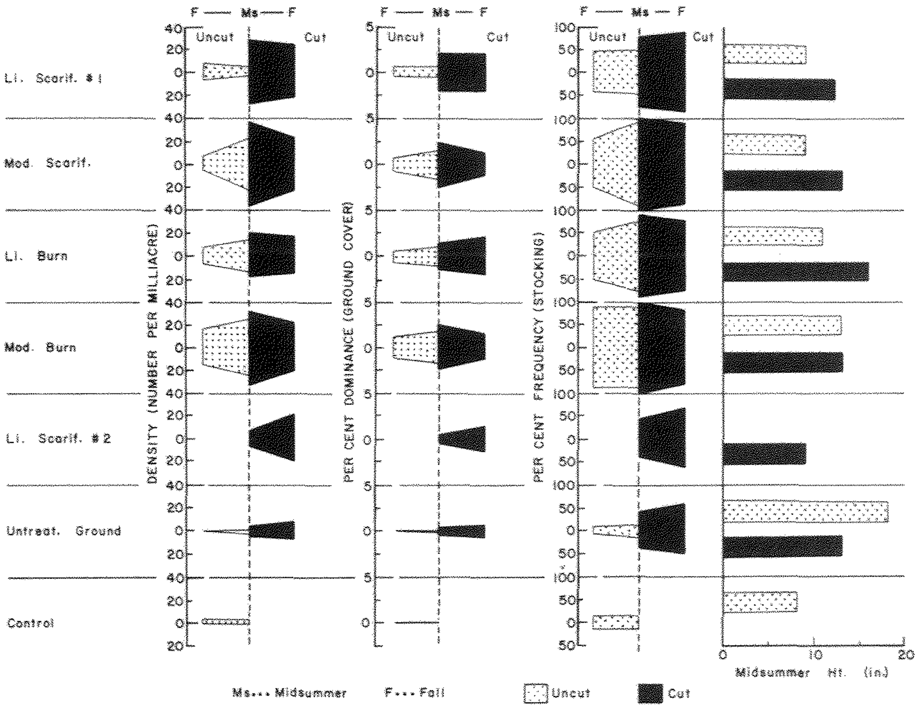

FIGURE 5. Comparison of midsummer and fall density, per cent dominance, per cent frequency and mean dominant height of *Populus* suckers by various treatments.

Bracken

Regeneration of bracken was considerably stimulated by all treatments (Figure 6 and Appendix 3). Before early and midsummer clippings, as well as at the end of the growing season, the number of fronds was greater on the cut plots than the uncut, and the number was considerably higher on the scarified and burned plots than on untreated ground (Appendix 3). Frond density in midsummer reached a maximum number of 81 per milliacre on the lightly burned – cut plots and a minimum of 39 per milliacre on the lightly scarified #2 – cut plots; for the control there were 67 fronds per milliacre (Appendix 3). New sprouts of bracken continued to emerge on all plots except the control which were not clipped. The frond density decreased after early summer clipping except on the moderate burn and the light scarification #2 treatments (Figure 4). After the second clipping, the average density on the treated plots in fall varied from 11.3 to 0.7 fronds per milliacre compared to 67 fronds per milliacre for the control (Figure 4 and Appendix 3).

The predominance of bracken both in early- and mid-summer is evident from its high frequency in all treatment areas and the control. Per cent frequency values were higher in summer than in fall. The highest per cent frequency in the fall, aside from the control (100), was recorded in the moderately burned plots (92) and the lowest was in the uncut plots with untreated ground (25).

Both in midsummer and fall, dominance of bracken was greater on the control than on the treated plots (Appendix 3). At midsummer, the foliage cover on the control was 81 per cent, whereas it ranged from 62 to 76 per cent on the plots with ground treatments and 34 to 45 per cent on the untreated ground. Repeated clipping resulted in a large reduction in density, dominance and frequency of bracken (Figure 6 and Appendix 3).

Generally, no significant differences in midsummer height were observed in relation to ground, cutting and vegetation-clipping treatments. By fall, following clipping, growth was again similar under all treatments with one exception. The exceptional fall height recorded in the uncut plots with untreated ground may be due to the small and insufficient sample (cf. frequency; Appendix 3).

Midsummer data on R.I. indicate that values for the scarification and burn treatments (ranging from 24 to 29) closely approached the control (27) whereas those for untreated ground (ranging from 17 to 20) were less (Appendix 4). The R.I. value in the fall was markedly higher for the control (132) than for all other treatments (range 4 to 24). The fall values were higher for the cut than the uncut plots and they were also higher for the moderate than for the light treatments (Appendix 4).

Small Herbs

Small herbs less than 8 inches tall comprising the lower stratum were only a minor constituent of the ground vegetation (Table 3). In the treated and the

TABLE 3. COMPARATIVE PER CENT COVER OF MAIN VEGETATION COMPONENTS

Vegetation components	Light Scar. #1		Moderate Scar.		Light Burn		Moderate Burn		Untreated Ground		Light Scar #2	Control
	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Cut	Uncut
Upper Stratum												
Populus suckers	0.5	3.8	2.8	4.6	1.9	2.6	3.3	4.3	0.2	0.3	0.4	0.2
P. aquilinum	75.2	65.7	76.5	62.0	62.0	68.0	67.0	69.0	45.6	34.5	63.3	81.0
Total	75.7	69.5	79.3	66.6	63.9	70.6	70.3	73.3	45.8	34.8	63.7	81.2
Lower Stratum												
Small herbs	5.2	8.6	10.3	7.0	8.0	7.9	6.6	5.6	3.9	5.1	3.8	4.8

control plots the combined foliage cover of aspen suckers and bracken fronds (comprising the upper stratum) ranged from 46 to 81 per cent and that of the lower stratum 4 to 10 per cent. Among the lower stratum per cent foliage cover in the treated plots ranged from 3.8 to 10.3, and in the control it was 4.8 cer cent.

DISCUSSION

Earlier initiation of growth activity on the treated than on the control plots was parallel to the recorded temperature increase on the former plots. The Reproduction Indices for aspen shows that the regeneration of aspen in midsummer and fall was higher on the cut than the uncut plots and that it was higher in the moderate than the light treatments (Figure 7). The study also indicated corresponding occurrences of higher superficial soil temperatures under the cut (open) than the uncut (shaded) conditions (Figure 4).

High suckering response at midsummer appeared to be related to relatively more intense disturbance occurring in the moderate burn treatments as well as in the cut plots of the light and moderate scarification treatments (Figure 7). Up to early summer (June 4), the temperatures were also relatively higher in the more intense treatments (Table 2). Poor suckering response on the control and on the untreated ground is apparently related to the presence of insulating L-layer and consequent lower soil temperatures. Although sucker density at midsummer varied considerably among scarification and burn treatments, in fall it was related more to cutting than to the intensity or type of ground treatment. Due to the mortality of a few suckers in most treatments, the sucker density was lower in fall than in midsummer, excepting those relatively less disturbed (i.e., untreated ground – cut, light scarification #1 – uncut and light scarification #2 – cut). The extended period of suckering in the latter treatments is attributed to the low intensity of disturbance and consequently slower soil-warming processes. In the lightly scarified #2 – cut treatment the comparatively lesser foliage development at midsummer was also due to delayed sucker-origin.

In those treatments where sucker density in midsummer and fall was 7 per milliacre or less, the per cent frequency was comparatively high (Appendix 1). This feature is significant and indicates little or no aggregation of individuals when the suckering response is low.

The data show remarkable similarity in the fall R.I. values of aspen among the cut plots of the burn and the scarification treatments (Appendix 2 and Figure 7). However, the temperature increase of superficial soil was highest in the clear-cut plots of moderately scarified and lowest in the lightly scarified treatments. These observations suggest that the temperature increase above the minimum achieved on the lightly scarified – cut plots did not enhance suckering response and therefore was of no consequence. Temperature increases in the loosened, scarified soil was often greater than in the burned plots where compact soil with a blackened surface was covered with ash and charcoal.

At the end of the growing season, R.I. values for suckering of aspen suggest segregation into two response groups. The response was high on the cut plots whether lightly or moderately burned or scarified and was also high on moderately burned – uncut plots, but it was low on the rest of the uncut plots, regardless of ground treatments (Figure 7).

After the first clipping, regeneration and growth attained by bracken on the treated plots was similar to that of the control, except on the untreated ground where relatively lower R.I. values indicate a depression in sprouting and growth due to clipping (Figure 7). Sprouting period of bracken was extended in all treatments as compared with the control.

Although at midsummer, more bracken fronds were recorded on the cut than on uncut plots, their average size on the former was comparatively small (Appendix 4).

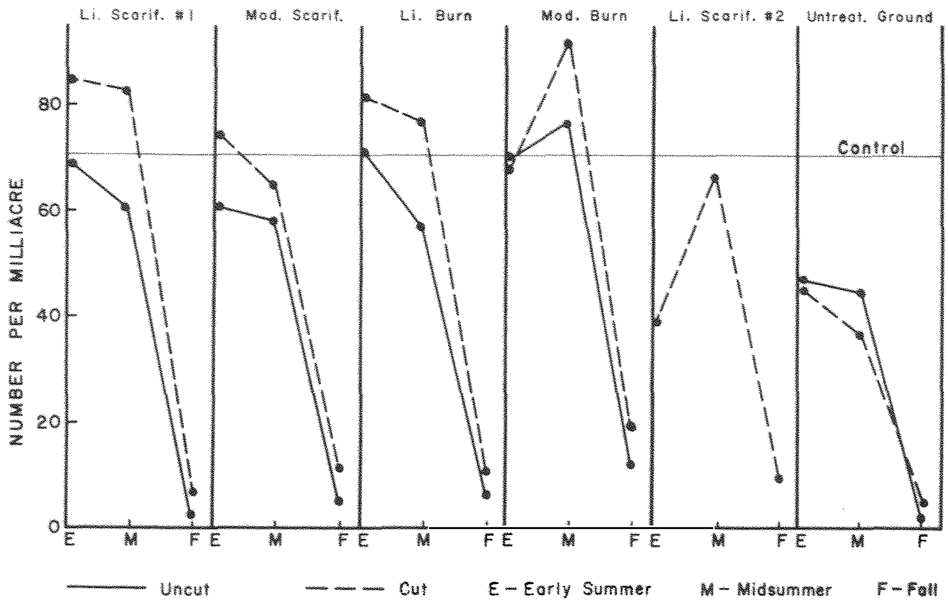

FIGURE 6. Number of *Pteridium* fronds following various treatments but before early summer (E) and midsummer (M) clippings and at fall (F).

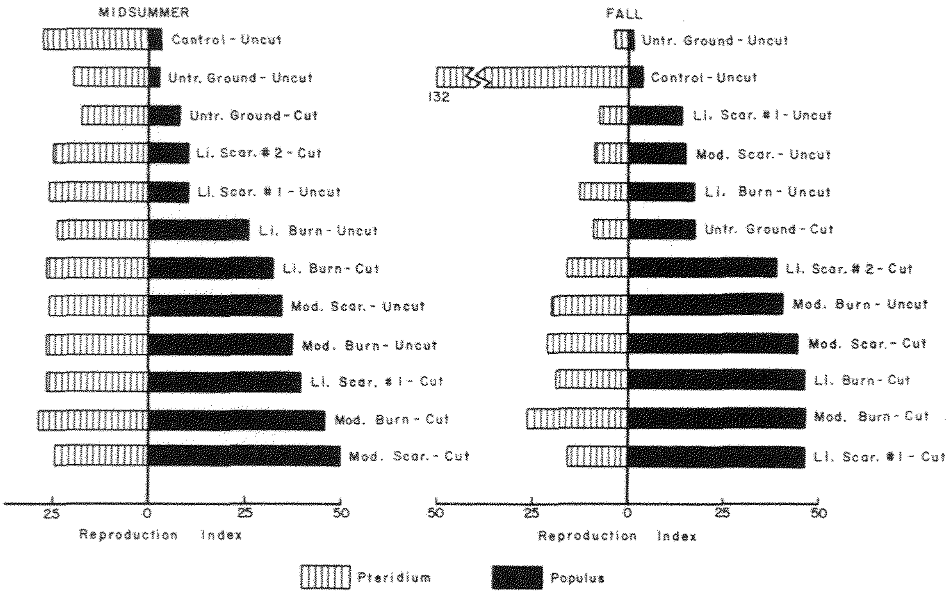

FIGURE 7. Comparison of midsummer and fall Reproduction Index of *Populus* and *Pteridium* by various treatments.

Size and number of bracken fronds originating after the second (mid-summer) clipping was considerably smaller compared to the earlier two crops. This decrease is attributed to a depletion of food reserves in the subterranean parts and to the short growing season remaining after the second clipping.

The variation in the response of bracken in the fall is apparent from the data (Figures 6 and 7; Appendix 3). The two response groups suggested earlier for aspen (based on the intensity of cutting and ground disturbance) are, except for the control, equally applicable to bracken.

The increase in the number and cover of the lower stratum of small herbs due to various treatments was not considered appreciable enough to influence the arboreal regeneration.

SILVICULTURAL APPLICATIONS

The different responses of aspen and bracken to various treatments in this study may be usefully exploited either for regeneration of aspen or for conversion of aspen stands to more desirable species, particularly conifers. In the present study, cultural operations applied to small plots comprised cutting of trees, two degrees of both burning and scarification, and clipping of bracken in early- and mid-summer.

It has been shown elsewhere that high sucker density is a prerequisite to good stand quality (Horton and Maini, In Press). For the regeneration of aspen, a desirable treatment will be one which encourages dense, vigorous aspen suckering and discourages bracken. The treatment best suited to encourage aspen regeneration on this basis involved hand raking in combination with clear cutting of the existing stand in small patches (i.e., light scarification #1 – cut). However, extensive application of this type of treatment would be difficult to mechanize, and the cost might be high. The light burn – cut treatment, which produced similarly abundant suckering and only slightly more bracken seems preferable, since it could be applied readily and inexpensively in cut-over areas. If the cutting of aspen is economically unjustifiable, as is the case in many scrubby understocked or partially cut stands, a moderately intensive burn would kill the canopy and produce only slightly less suckering than a light or moderate burn in cut-over conditions.

Conversion of low grade aspen stands by underplanting more valuable conifers, or by releasing an existing understorey, is frequently desirable. The untreated ground – uncut treatment (where only bracken was removed) appears to be most suitable, since it resulted in minimum production of aspen suckers (Figure 7). Bracken might remain an obstacle to good growth of underplanted conifers. Without further encouraging aspen suckering, competition by bracken may be further reduced by removing it a second time during the growing season. For practical application, clipping should be supplanted by poisoning, or in some cases, mowing.

SUMMARY

Regeneration response of *Populus tremuloides*, *Populus grandidentata* (aspens) and *Pteridium aquilinum* (bracken) to cutting, to two degress of ground scarification and burning and to removal of ground vegetation were studied in a field experiment in southern Ontario. The treatments resulted in significant increases in superficial soil temperature. The increase was generally related to the degree of disturbance, being greater in relatively more disturbed areas. Soil temperature and density of aspen suckers and bracken fronds were higher on the cut than the uncut treatment plots. Suckering response was very low on the untreated ground and the control. However, data indicate non-aggregation of suckers when the density is low. Root suckering response of aspen as measured by a Reproduction Index (R.I.), was considerably greater in cut than in uncut plots and in burned and scarified plots compared with control. Values for the different ground treatments were remarkably similar in cut plots. Sucker density was generally lower in fall than in mid-summer; R.I. values for bracken were similar for all treatments in mid-summer; in the fall, after early and mid-summer clipping, R.I.'s were greatest in the control and greater in the cut than the uncut plots. To promote aspen regeneration under these conditions, removal of the trees, bracken, litter and duff is advocated; to discourage suckering and bracken competition for conversion of stand to more valuable conifers, removal of bracken only is suggested.

SOMMAIRE

Dans des parcelles de terrain expérimentales, en Ontario sud, les auteurs ont brûlé et ratissé l'humus, scarifié le sol de deux façons dans le but de favoriser la régénération de *Populus tremuloides*, *Populus grandidentata* (les peupliers trembles) et de *Pteridium aquilinum* (la fougère aigle ou grande fougère). Il en a résulté une augmentation significative de la température du sol près de la surface; plus celui-ci fut remué ou nettoyé, plus celle-là augmenta. Dans d'autres parcelles, les auteurs ont fait la même chose et en plus, ils ont coupé une partie des peupliers adultes et fougères qui y existaient. Dans ce cas, la température du sol augmenta à nouveau, ce qui favorisa encore plus la naissance de drageons de peuplier et la pousse des fougères.

Le drageonnement fut à peu près nul dans des parcelles voisines, laissées intactes afin de faire des comparaisons. Dans les parcelles travaillées, la densité du drageonnement, mesurée selon un «indice de reproduction» s'avéra plus forte 1) lorsque les drageons croissaient plus par groupes; 2) où on avait coupé les peupliers adultes; 3) où le sol avait été remué, l'humus brûlé; 4) en été qu'à l'automne.

Quant à la fougère aigle, sa régénération fut la meilleure à l'automne dans les parcelles intactes, i.e. où on ne l'avait pas coupée au printemps et à la mi-été précédents; elle reprit un peu mieux dans les parcelles à peupliers coupés que dans celles où on ne l'avait pas fait. Auparavant, à la mi-été l'indice de reproduction avait été égal partout.

Les auteurs recommandent que soient enlevés à la fois les arbres, les fougères aigles, la litière de la forêt et l'humus brut; si, au contraire, on ne désire pas de peupliers, mais plutôt des résineux qui valent plus, ils suggèrent que seules les fougères aigles soient ôtées.

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APPENDICES

APPENDIX 1. COMPARISON OF MIDSUMMER AND FALL VALUES OF DENSITY, DOMINANCE, FREQUENCY AND HEIGHT OF *POPULUS* SUCKERS BY DIFFERENT TREATMENTS.

Vegetation characteristic	Light Scar. #1		Moderate Scar.		Light Burn		Moderate Burn		Untreated Ground		Light Scar #2	Control
	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut*	Cut	Cut	Uncut
Density (No./milliacre)												
Midsummer	4.3	28.3	22.0	35.7	15.2	17.8	23.8	30.2	1.0	1.7	5.8	0.8
Fall	6.7	22.8	6.8	22.0	7.0	15.8	16.0	20.5	0.3	6.8	19.3	0.8
Dominance (% cover)												
Midsummer	0.5	3.8	2.8	4.6	1.9	2.6	3.3	4.3	0.2	0.3	0.4	0.2
Fall	0.5	3.8	0.6	2.2	0.9	3.8	2.3	3.0	0.05	1.1	2.5	0.2
Frequency (% stocking)												
Midsummer	42	75	92	96	75	87	87	96	12	37	42	14
Fall	42	83	54	92	54	79	87	83	8	50	62	14
Av. ht.(in)												
Fall	9	12	9	13	11	16	13	13	18	13	9	8

*Based on 8 samples only.

APPENDIX 2. COMPARISON OF MIDSUMMER AND FALL VALUES OF RELATIVE DENSITY, RELATIVE DOMINANCE, RELATIVE FREQUENCY AND REPRODUCTION INDEX OF *POPULUS* SUCKERS BY DIFFERENT TREATMENTS.

Vegetation characteristic	Light Scar. #1		Moderate Scar.		Light Burn		Moderate Burn		Untreated Ground		Light Scar.#2	Control	All Treat-ments
	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Cut	Uncut	
Midsummer													
Rel. Density	2.3	15.2	11.8	19.1	8.2	9.6	12.7	16.2	0.5	0.9	3.1	0.4	100
Rel. Dom.	2.0	15.3	11.2	18.5	7.6	10.5	13.2	17.3	0.8	1.2	1.6	0.8	100
Rel. Freq.	5.6	9.9	12.3	12.7	9.9	11.5	11.5	12.7	1.6	4.9	5.6	1.8	100
Reprod. Index	10	40	35	50	26	32	38	46	3	7	10	3	300
Fall													
Rel. Den.	4.6	15.8	4.7	15.2	4.8	10.9	11.1	14.2	0.2	4.7	13.3	0.5	100
Rel. Dom.	2.4	18.1	2.9	10.5	4.3	18.1	11.1	14.3	0.2	5.3	11.9	0.9	100
Rel. Freq.	5.9	11.7	7.6	13.0	7.6	11.2	12.3	11.7	1.1	7.1	8.8	2.0	100
Reprod. Index	13	46	15	39	17	40	35	40	1	17	34	3	300

APPENDIX 3. COMPARISON OF MIDSUMMER AND FALL VALUES OF DENSITY, DOMINANCE, FREQUENCY AND HEIGHT OF *PTERIDIUM AQUILINUM* IN VARIOUS TREATMENTS.

Vegetation characteristic	Light Scar. #1		Moderate Scar.		Light Burn		Moderate Burn		Untreated Ground		Light Scar #2	Control
	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut*	Cut	Cut	Uncut
Density (No./milliacre)												
Early Summer	71.5	84.8	60.3	75.0	71.7	80.8	69.2	68.5	47.0	46.3	39.5	—
Midsummer	60.2	83.0	58.8	65.0	56.7	76.2	76.2	92.3	45.0	36.7	67.0	67.0
(sprouts)**	(2.0)	(3.3)	(2.2)	(3.8)	(1.7)	(5.0)	(2.0)	(5.0)	(0.5)	(2.2)	(4.0)	(0)
Fall	2.7	6.5	4.3	10.8	5.8	10.2	11.3	15.7	0.7	3.5	9.5	67.0
Frequency (% stocking)												
Early Summer	100	96	100	100	100	100	100	100	100	100	100	—
Midsummer	100	100	100	100	100	100	100	100	100	100	100	100
Fall	42	79	42	79	67	67	92	79	25	58	71	100
Dominance (% cover)												
Midsummer	75.2	65.7	76.5	62.0	62.0	68.0	67.0	69.0	45.6	34.5	63.3	81.0
Fall	0.7	1.9	0.8	4.7	1.7	4.6	2.5	7.3	0.3	0.9	2.2	81.0
Av. ht. (in)												
Midsummer	33	30	34	29	32	30	28	32	33	30	31	33
Fall	9	10	10	10	9	10	9	11	19	11	10	33

*Based on 8 samples only.

**Included in the total number of fronds.

APPENDIX 4. COMPARISON OF MIDSUMMER AND FALL VALUES OF RELATIVE DENSITY, RELATIVE DOMINANCE, RELATIVE FREQUENCY AND REPRODUCTION INDEX OF *PTERIDIUM AQUILINUM* IN VARIOUS TREATMENTS.

Vegetation characteristic	Light Scar. #1		Moderate Scar.		Light Burn		Moderate Burn		Untreated Ground		Light Scar.#2	Control	All Treat-ments
	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Uncut	Cut	Cut	Uncut	
Midsummer													
Rel. Den.	7.7	10.6	7.6	8.3	7.2	9.7	9.7	11.8	5.7	4.9	8.5	8.5	100
Rel. Dom.	9.8	8.5	9.9	8.1	8.1	8.8	8.7	9.0	5.9	4.5	8.2	10.5	100
Rel. Freq.	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	100
Reproduction Index	26	27	26	25	24	27	27	29	20	17	25	27	300
Fall													
Rel. Den.	1.8	4.4	2.9	7.3	3.9	6.9	7.6	10.6	0.5	2.4	6.4	45.3	100
Rel. Dom.	0.6	1.8	0.8	4.3	1.6	4.2	2.3	6.7	0.3	0.8	2.0	74.6	100
Rel. Freq.	5.2	9.9	5.2	9.9	8.4	8.4	11.5	9.9	3.1	7.2	8.8	12.5	100
Reproduction Index	8	16	9	22	14	20	21	27	4	10	17	132	300

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