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ABSTRACT — The upland vegetation in four stands was analyzed for differences in conditions important for ruffed grouse production. The structure of the control stand suggests that *Acer saccharum* and other shade-tolerant tree species will replace the dominants *Quercus borealis* and *Populus tremuloides*. The *Acer saccharum* would not be useful to grouse. In an adjacent stand in which forest litter had been burned, there was a tremendous amount of reproduction of trembling aspen and much less sugar maple reproduction, compared with the control stand. Differences in the understory beneficial to grouse also were found.

Fire and logging in the Mille Lacs Wildlife Area are known to promote production of ruffed grouse (*Bonsa umbellus*) and other species of wildlife. In numerous studies of the life history of the ruffed grouse, it has been found that *Populus tremuloides* (trembling aspen) is an essential component of grouse habitat (Berner and Gysel, 1969; Gullion and Marshall, 1968; Phillips, 1967; and Schladweiler, 1968). Certain findings from a limited study by Gordon Gullion in the Mille Lacs Wildlife Area in 1969 are presented here that suggest a correlation between fire and aspen production, and consequently an impact on the grouse population.

The Mille Lacs Wildlife Area in east-central Minnesota just south of Mille Lacs Lake is managed by the Minnesota Department of Natural Resources under the direction of Orville Haglund. The management program aims at production of wildlife, including ruffed grouse, deer, woodcock, and waterfowl. The area is well suited for grouse because it is gently rolling country with many transition zones from lowland poorly drained soil to upland well drained soil (Berner and Gysel, 1969). At one time the area supported white pine, but most of it was logged off and has been replaced by red oak. Large numbers of old pine stumps were observed in the sampled sectors, a relatively few old white pine trees remain scattered over the area, and there is a high density of aspen that is characteristic of former pine forests (Curtis, 1959).

Selection and sampling of the area

Study areas were chosen from the treatment sectors used by Orville Haglund and they are identified by the same numbers which he used. The soil of all areas is Milaca very fine sandy loam, which is a well drained soil developed on reddish-brown till. The dominant trees are *Quercus borealis* (Gleason and Cronquist, 1963) and *Populus tremuloides,* with *Tilia americana, Betula papyrifera, Acer saccharum,* and *Quercus macrocarpa.*

Sectors 6, 7, 14, 15, and 20 were chosen for study (Fig. 1). Sector 6 is a reference sector, since it is an untreated control area in the management program. In sector 7, which adjoins sector 6, the litter layer was burned on April 30, 1968. In sector 20 the litter was burned on May 1, 1968. According to Rod Sando at the North Central Forest Experiment Station in St. Paul, the temperature on those two days reached 75 degrees Fahrenheit, the relative humidity was 25 percent, the wind 10 miles per hour, and the fuel moisture content was 8 percent. It had not rained for about two weeks. Due to differences in microclimate and available fuel, sector 7 was more severely burned than sector 20. Finally, the central portions of sectors 14 and 15 were selected for this study and are considered one unit, sector 14/15). The vegetation in these two sectors was affected by a tornado on July 4, 1968. In the central portion of sectors 14 and 15, two to ten trees per acre had been windthrown during the tornado, but many of the trees remained attached to their roots.

Once the study sectors were chosen, a coordinate grid was placed over a map of each sector, and sampling points were selected using a table of random numbers. In order to maintain uniformity, only points on an upland soil were sampled. On each acceptable point a one-meter-by-one-meter plot was laid out in the field with its southwest corner at the sampling point. In each plot the number of herbs, seedlings, saplings, basal shoots, and shrubs were counted and recorded, and an estimate was made of the percent of the plot covered by the aerial parts of each shrub species. Young trees were classified as seedlings if less than one foot in height. Trees more than one foot in height and less than 4 inches in diameter at breast height (d.b.h.) were classified as saplings. This category included tree root sprouts, so that shoots growing from the base of saplings were considered basal sprouts. Four trees were then selected at each sampling point by the quarter method, and the species, the distance from the sampling point, and the d.b.h. were recorded for each one. A total of 35 plots and 140 trees in each of the four study areas were sampled in this way.

Differences in stand structure

Sector 6 is considered first because it was not treated and serves as the control stand in examining the effects of treatment in the other stands. In sector 6 it is striking that *Quercus borealis,* the most important tree in the stand, is producing thousands of seedlings but is not represented by a single sapling (Table 1, Fig. 2). The relative reproductive success of this and the other more im-

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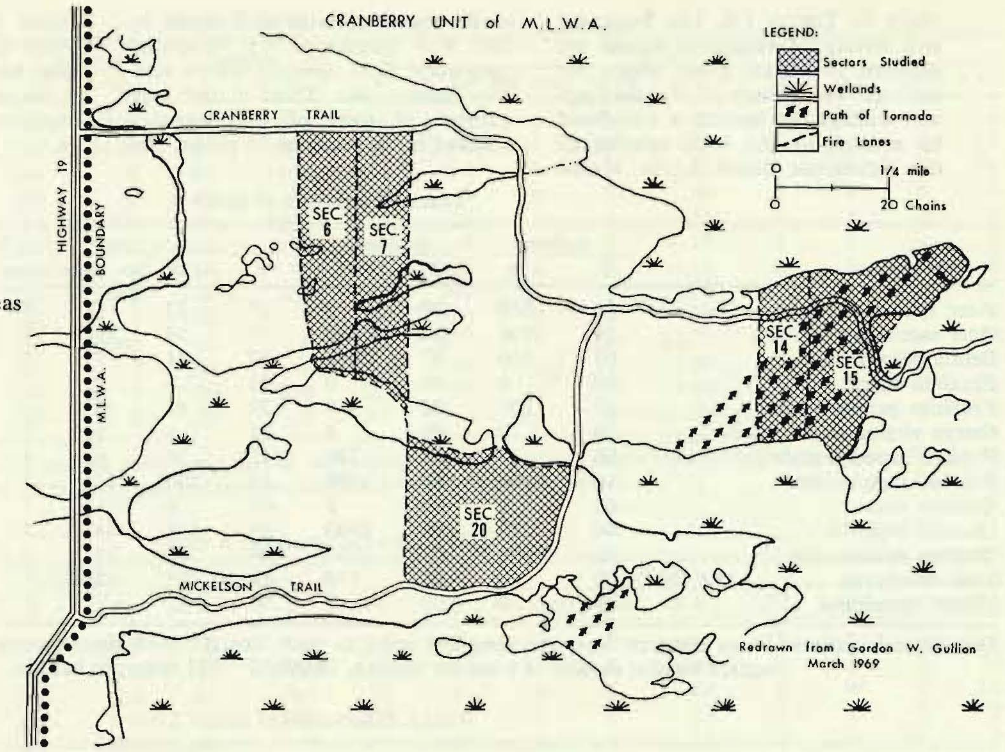

FIGURE 1. Location of the study areas in the Cranberry Unit of the Mille Lacs Wildlife Area.

portant tree species in each stand is easily visualized in the accompanying bar diagrams. *Populus tremuloides,* the second most important tree, is represented by a number of shoots but it is prodigiously exceeded in reproduction by the minor dominants *Acer saccharum, Betula papyrifera,* and *Fraxinus pennsylvanica.* Through consideration of the habits of these trees and the structure of the stand, it is possible to recognize a trend. The last three species mentioned are very shade tolerant (Curtis, 1959). The high density of seedlings and saplings relative to the density of mature trees of these species implies rapidly expanding populations. Red oak, however, is typically a poor reproducer under the closed canopy. Trembling aspen is mainly a gap-phase, shade-intolerant tree and probably reproduces at a low rate because of the closed canopy and absence of fire. Therefore, without a natural or artificial catastrophe in the area, it is possible that the red oak-trembling aspen forest in sector 6 will be replaced by sugar maple and other tree species.

In order to compare the stand in sector 6 with the treated stands, it is desirable to know how alike the sectors are. A chi-square test of homogeneity was performed, using the density of the two dominants. Only the dominants were used because the trees of less importance can be expected to vary greatly from one stand to another in the parameter used for the test (Curtis, 1959). The "P-value" of the chi square test statistic (degrees of freedom = 3, P = .90), suggested that the stands were homogeneous (Beyer, 1966). On this statistical basis, it is possible to proceed with comparison of the four stands (Bailey, 1959).

A number of important differences in stand structure are noticeable between sector 7 and sector 6 (Table 2). The most important difference is the great number of trembling aspen saplings in sector 7. These saplings are mainly root shoots of mature trees and, since most are about a year old, they may be responding to the decrease in shrub and sapling cover, the decrease in the ground cover, and the increase in nutrient levels which are consequences of the fire. Another noticeable change is the

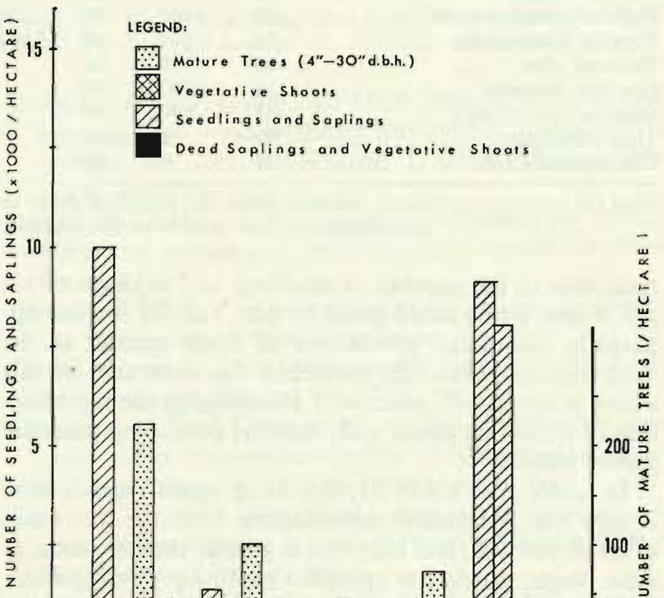

FIGURE 2. The structure of the most important trees in sector 6. Size classes for each species are: seedlings, saplings and vegetative shoots, trees 4-10" d.b.h., trees 10-20" d.b.h., and trees 20-30" d.b.h.; Qb = *Quercus borealis,* Pt = *Populus tremuloides,* Ta = *Tilia americana,* Bp = *Betula papyrifera,* As = *Acer saccharum.*

NOTE TO TABLES 1-4. The frequency and density of vegetative shoots are included in values given above for saplings. The density of the seedlings and saplings per hectare is calculated by multiplying the total number of the individuals found in the 35-one meter square plots in each sector by 286. F = frequency, %F = relative frequency, D = density, %D = relative density, No. Trees = the total number of trees of that species counted in the sector at 35 points, No. Points = the total number of points at which the species occurred, B.A. = the total basal area in square feet, %Do = the relative dominance, I.V. = the importance value for each species (I.V. = (%F + %D + %Do)).

TABLE 1. Structure of sector 6.

Tree Species	Seedlings		Saplings		Mature-trees								
	F	D	F	D	F	D	No. Trees	Points	B.A.	%D	%Do	%F	I.V.
Acer rubrum	.06	860	.00	0	.17	35	6	6	1.33	6	4	3	13
Acer saccharum	.31	5700	.34	17000	.20	59	10	7	4.80	7	7	9	23
Betula papyrifera	.03	860	.03	2000	.17	41	7	6	1.59	6	5	3	14
Fraxinus nigra	.00	0	.00	0	.03	6	1	1	.28	1	1	1	3
Fraxinus pennsylvanica	.03	290	.00	0	.29	65	11	10	1.78	10	8	3	21
Ostrya virginiana	.00	0	.00	0	.03	6	1	1	.10	1	1	0	2
Populus grandidentata	.00	0	.03	290	.11	35	6	4	2.35	4	4	4	12
Populus tremuloides	.14	2300	.06	1100	.34	100	17	12	7.56	12	12	14	38
Quercus alba	.00	0	.00	0	.03	6	1	1	1.79	1	1	3	5
Quercus borealis	.06	570	.09	2500	.66	258	44	23	25.94	23	31	50	104
Quercus macrocarpa	.03	570	.03	1100	.26	65	11	9	2.85	9	8	5	22
Tilia americana	.00	0	.03	570	.51	135	23	18	4.69	18	16	9	44
Ulmus americana	.00	0	.00	0	.06	12	2	2	.86	2	1	2	5

Data for calculations: Mean distance from the sampling point to each tree, $\bar{d} = 3.49$ meters; mean area occupied by a tree, $\bar{d}^2 = 12.18$ square meters; density of trees per hectare, $10{,}000/\bar{d}^2 = 821$ trees per hectare.

TABLE 2. Structure of sector 7.

Tree Species	Seedlings		Saplings		Mature-trees								
	F	D	F	D	F	D	No. Trees	Points	B.A.	%F	%D	%Do	I.V.
Acer rubrum	.11	1100	.06	3700	.26	66	11	9	2.29	9	8	5	22
Acer saccharum	.34	6300	.23	5200	.29	66	11	10	2.84	10	8	6	24
Betula papyrifera	.00	0	.03	290	.43	113	19	15	3.73	15	14	8	37
Fraxinus nigra	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Fraxinus pennsylvanica	.20	2000	.03	570	.11	34	6	4	1.16	4	4	2	10
Ostrya virginiana	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Populus grandidentata	.08	1100	.09	2000	.06	12	2	2	.96	2	1	2	5
Populus tremuloides	.03	290	.40	13000	.43	143	24	15	13.16	15	17	26	58
Quercus alba	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Quercus borealis	.31	3100	.00	0	.60	251	42	21	20.00	21	30	40	91
Quercus macrocarpa	.03	290	.00	0	.34	90	15	12	4.46	12	11	9	32
Tilia americana	.00	0	.00	0	.20	42	7	7	1.53	7	5	3	15
Ulmus americana	.00	0	.00	0	.06	18	3	2	.39	2	2	1	5

Data for calculations: Mean distance from the sampling point to each tree, $\bar{d} = 3.46$ meters; mean area occupied by a tree, $\bar{d}^2 = 11.97$ square meters; density of trees per hectare, $10{,}000/\bar{d}^2 = 835$ trees per hectare.

reduction in the number of seedlings and saplings of sugar maple, a tree killed easily by fire. Yet, the fire has apparently stimulated production of basal sprouts in the same species. Thus, the particular fire treatment of this sector is apparently selectively encouraging the reproduction of trembling aspen and, thereby, producing potential grouse habitat.

In sector 20 (Table 3), trembling aspen reproduction is very low. Vegetative reproduction from the tree bases of birch, red oak, and burr oak is greater than in sector 6. Also, sugar maple has sprouted profusely. Young sugar maples commonly sprout after being cut or browsed, but they sprout infrequently after being burned (Curtis, 1959:108). The data from this stand do not agree with that belief.

In sector 14/15 (Table 4), sugar maple seedlings occupy a dominant position in that size class. Trembling aspen shows little change in sapling production compared with sector 6. This may be due to the fact that the tornado created only a minor distrubance in the area and that the majority of windthrown trees were still attached to their roots. Without fire treatment, this condition would probably be regressive to the development of grouse habitat.

Differences in the understory

If the treatment of two adjacent areas with similar topography, history, and overstory is unalike, major dissimilarities in the understory may be assumed to be the result of treatment differences (Greig-Smith, 1964). Without data from before the treatment, however, it is difficult to determine causal relationships. Nevertheless, comparison of sector 7 with sector 6 shows certain differences in understory that are conducive to good grouse habitat and that may have resulted from the treatment (Tables 5 and 6).

The understory of an upland forest is important in grouse habitat because it provides the grouse with cover

TABLE 3. Structure of sector 20.

Tree Species	Seedlings		Saplings		Mature-trees								
	F	D	F	D	F	D	No. Trees	Points	B.A.	%F	%D	%Do	I.V.
Acer rubrum	.06	860	.03	290	.06	10	2	2	.32	2	1	1	4
Acer saccharum	.40	9100	.31	8000	.29	54	11	10	3.13	11	8	6	25
Betula papyrifera	.00	0	.03	1100	.34	75	15	12	2.47	13	11	5	29
Fraxinus nigra	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Fraxinus pennsylvanica	.14	2300	.09	1700	.14	25	5	5	.75	5	4	2	11
Ostrya virginiana	.03	860	.00	0	.03	5	1	1	.15	1	1	0	2
Populus grandidentata	.00	0	.00	0	.06	20	4	2	1.62	2	3	3	8
Populus tremuloides	.09	1400	.06	860	.49	143	29	17	13.05	19	21	26	66
Quercus alba	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Quercus borealis	.29	10000	.00	0	.83	277	56	29	22.78	32	40	46	118
Quercus macrocarpa	.00	0	.00	0	.14	30	6	5	1.70	5	4	3	12
Tilia americana	.00	0	.00	290	.23	50	10	8	3.86	9	7	8	24
Ulmus americana	.00	0	.00	0	.03	5	1	1	.36	1	1	1	3

Data for calculations: Mean distance from the sampling point to each tree, $\bar{d} = 3.80$ meters; mean area occupied by a tree, $\bar{d}^2 = 14.44$ square meters; density of trees per hectare, $10{,}000/\bar{d}^2 = 693$ trees per hectare.

TABLE 4. Structure of sector 14/15.

Tree Species	Seedlings		Saplings		Mature-trees								
	F	D	F	D	F	D	No. Trees	Points	B.A.	%F	%D	%Do	I.V.
Acer rubrum	.14	1700	.00	0	.06	10	2	2	1.60	3	1	3	7
Acer saccharum	.26	5400	.49	12000	.14	36	7	5	3.45	6	5	6	17
Betula papyrifera	.06	860	.06	860	.14	31	6	5	.84	6	4	2	12
Fraxinus nigra	.03	0	.03	900	.03	5	1	1	.23	1	1	0	2
Fraxinus pennsylvanica	.09	2000	.00	0	.11	21	4	4	.77	5	3	1	9
Ostrya virginiana	.00	0	.00	1700	.00	0	0	0	.00	0	0	0	0
Populus grandidentata	.00	0	.00	0	.26	83	16	9	3.98	11	11	7	29
Populus tremuloides	.03	290	.11	1400	.40	140	27	14	12.75	18	19	24	61
Quercus alba	.00	0	.00	0	.00	0	0	0	.00	0	0	0	0
Quercus borealis	.34	6300	.00	0	.77	306	59	27	24.73	34	42	46	122
Quercus macrocarpa	.00	0	.03	860	.11	21	4	4	1.27	5	3	2	10
Tilia americana	.00	0	.00	0	.20	62	12	7	3.56	9	9	7	25
Ulmus americana	.00	0	.00	0	.06	10	2	2	.84	3	1	2	6

Data for calculations: Mean distance from the sampling point to each tree, $\bar{d} = 3.71$ meters; mean area occupied by a tree, $\bar{d}^2 = 13.76$ square meters; density of trees per hectare, $10{,}000/\bar{d}^2 = 727$ trees per hectare.

and food in the late summer and early fall. This is especially true with respect to grouse broods. Gullion (1967) reports that in that time of the year at Cloquet, the young grouse feed on tough, leafy foods, and particularly on raspberries (*Rubus*), strawberries (*Fragaria*), and other fruits and berries that ripen at this time. Hazel (*Corylus*) is also an important food source. Until covered with snow, these fruits remain important food items for the grouse. When the snow melts in the spring, those herbs which remain green over winter are used extensively for food. Among these are hepatica, strawberry, bunchberry, shinleaf (*Pyrola*), and twinflower (*Trientalis*). With the exception of two of the herbs and shrubs mentioned above, all are equally or more frequently found in sector 7 than in sector 6.

It has been suggested that a high diversity of plant species is important for grouse (Berner and Gysel, 1969). In this study the number of herb species varied from a low of 28 species in sector 6 to a high of 37 species in sector 7. Again, this may be a result of normal interstand variation instead of treatment.

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