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The Effect of Fire on a Prairie in Northeastern Illinois

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THE EFFECT OF FIRE ON A PRAIRIE IN NORTHEASTERN ILLINOIS

by

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VITA

The author, Thomas Kevin Shaughnessy, was born on September 3, 1953, in Chicago, Illinois.

His elementary education was obtained in the parochial school of Westchester, Illinois, and secondary education at St. Joseph High School in Westchester, Illinois, where he graduated in 1971.

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INTRODUCTION

The word "prairie" means different things to different people. To those in the western United States, prairie is the grass-covered foothills of the Sierra Nevada range. To the average suburban dweller, prairie is the undeveloped weed field across the street. To the ancient Romans, prairie was the park-like clearings interspersed between forest groves. But to some Midwesterners, as well as to many botanists and ecologists, prairies mean a complex grassland community that at one time covered all of the Midwest farmlands, but is now almost completely destroyed.

There are many factors that can have an effect on prairie maintenance and preservation. Winds, the amount of moisture available for a season, man, and fire have all had an effect on species diversity and importance in the prairie.

Although no one particular factor has been found to control prairie maintenance completely, fire has been found to have a definite effect on the prairie in many studies.

The prairie is composed of a wide variety of perennial forbs, grasses, and shrubs which are affected by fire in various ways. The burr oaks, among other shrub-like trees, are able to survive prairie fires due to the fact that they have a thick, corky bark that is fire resistant. The vast majority of shrubs are not able to resist fires and all or most of the plant is destroyed. However, the native prairie plants are dormant in early spring and late autumn when most fires occur and are practically uneffected. Even if a fire does occur during the growing season, only one year's growth is destroyed, as opposed to several years growth lost by shrubs. In this way it is postulated that the prairie grasses and forbs are maintained in areas with soil and moisture conditions that would normally be forested if not for the effect of fire.

The purpose of this study is to determine the effects of fire on a portion of Wolf Road Prairie-- a disturbed, mesic prairie just outside of Chicago, Illinois. Many of the native plants in the prairie are endangered by development, as well as the wildlife that depends on them.

The study area is located in northeastern Illinois, Cook County, Hinsdale Quadrangle, Township 39 North, Range 12 East. The prairie is known locally as Wolf Road Prairie. It is located at the corner of Wolf Road and 31st Street in

Westchester, eight miles from the City of Chicago. The site is approximately a thirty-two hectare remnant of disturbed mesic prairie.

The vegetation history of the area shows that prairie vegetation advanced into the area immediately behind the conifers due to a xerothermic era between two glacial eras. At the conclusion of this hot, dry era, another glacier advanced, and with it's retreat, deciduous forest claimed the area. In the historical past, fires were set by Indians annually to drive game into the forests. Due to the prevailing westerlies, these fires halted forest growth on the west side of streams and created open, park-like forests, which eventually became praries. The fires also caused the formation of barrens--groves of scrub oak, hazel, and plum--which resisted fire and became part of the prairie. As soon as fires in Illinois ceased to become a factor, due to Indian removal around 1860, the growth of forest once more increased (Gleason, 1923).

In 1820, most settlers were living in the forested region of southern Illinois. The prairies were the last areas to be inhabited, the smaller before the larger. With the establishment of railroads and the invention of the John Deere plow in 1837, the prairies were rapidly settled (Beecher, 1969; Anderson, 1970).

The first known resident of the area now comprising the town of Westchester was Aaron Parsell, who homesteaded in 1832. All land records of the area before 1871 were destroyed in the Chicago Fire. In 1924 Samuel Insull bought 2200 acres of land which he called Westchester. Charles Hough owned the land now comprising Wolf Road Prairie. In 1925 the land was subdivided and sewers, streets, sidewalks, and trees were put in.

After the depression of 1929, most of the properties became delinquent and the prairie, although disturbed, was allow to return to it's natural state. Although development in most of Westchester was resumed by 1940, Wolf Road Prairie remained undeveloped and unused, except for an occasional ball game in the early years, until the present. Recently, a movement has begun to turn the prairie into a housing development. At the time of this writing, the conflict remains unresolved (Nelson, 1943; Hanson, 1975; Vierling, 1976).

REVIEW OF RELATED LITERATURE

Various studies have been performed around the world on the effect of fire on grasslands and prairies.

Keeley and Johnson (1977) found fire to be an integral part of systems in California and Mediterranean areas. Fires were found to occur regularly--two to three times a century in California. These fires are difficult to control, burning large areas and inducing the growth of fire annuals.

Lloyd (1972) found that English grasslands do not burn as completely as prairies do, but fire does cause an increased frequency of annuals and biennials.

In Louisiana, Delcourt (1976) showed that fire and cultivation produced prairies on edaphically favorable sites. The prairie is not the only community that seems to be maintained by fire. The longleaf pine forest is a fire subclimax. Burning will also regenerate black spruce stands if there are sufficient seeds available and sufficient fuel for a deep, hot fire (Chrosciewicz, 1976).

Kilburn (1959) found that the effects of fire on a forest-prairie ecotone were not conclusive.

The four prominent stages in grassland succession as shown by Booth (1941) are pioneer weed (2-3 yr.), annual grass (9-13 yr.), bunch grass (up to 40 yr.), and finally the tall prairie climax.

Various other ideas have been postulated in regards to grassland succession. Mentzer (1950) showed that rapidly degenerating prairie would soon be dominated again by native grasses if left undisturbed except for autumnal mowing. Bluegrass and other weeds, which bloomed after a drought, would be replaced completely by native prairie forbs. The lack of moisture can have a definite effect on prairie invasion. Weaver (1954) found that many of the prairie plants died as a result of an extensive drought in 1940, and that they were replaced by bluegrass. Within a few years, however, with adequate moisture, the prairie plants returned to their natural state. The grasses returned first and the forbs followed. Bluegrass, a strong invader, could also be maintained in check by burning. Curtis and Partch (1948) showed that, as a result of burning a prairie, there was a very great reduction in density of bluegrass. Only one species of prairie plant, Brauneria purpurea, was definitely harmed by the fire. Ehrenreich (1959) found that the time of the year that the prairie is burned affected restriction of bluegrass. Burning by the 1st of March had no adverse effects on prairie plants but inhibited Kentucky bluegrass. Autumn seemed to be the best time of year for prairie fires.

Shelford and Winterringer (1959) felt that drainage, fire, and grazing were important in determining whether an area be forest or prairie. Two main invasions of forest into the prairie were by scattered growth of shrubs in grass and by invasion of grass by edge shrubs. The invasion of the prairie was largely due to lowering of the water table and weakening of the grasses. Animals and birds helped to disperse tree seeds and helped to accelerate the invasion.

Anderson and Valkenburg (1977) found that woodland plants decreased most greatly after burning and annuals and legumes increased. Besides reducing the amount of invading shrubs, burning was found to stimulate dry matter production and flowering, remove the accumulation of surface litter and standing dead vegetation, and result in a 2-3 fold increase in production and a tenfold increase in flowering (old, 1969). Hulbert (1969) also found that with the absence of litter, burning does not result in increased yield. The major effect of short-term fires is because of litter removal, rather than heat or nutrient changes. Early in the season unburned areas were found to reflect much more radiation than burned areas. Soil temperatures were consistently warmer in burned areas, as well as an increase in standing biomass (Peet, et. al., 1975). The study by Hulbert was in contrast to an earlier study by Kucera and Ehrenreich (1962), in which they found that released plant nutrients after a burn acted as a growth stimulus. However, both Kucera and Ehrenreich, as well as Hadley and Kieckhefer (1963) agreed that burning caused an increase of living shoot biomass, a more rapid growth and development, and an increased flowering stalk production. The effects of fire can also be determined by looking at the density, frequency, and coverage of prairie plants and invaders in burned areas and similar controls that are unburned. This may possibly show a different aspect of the effect of burning and is the purpose of this study.

METHODS

The study site is located along the southeastern edge of Wolf Road Prairie with frontage along Wolf Road. This particular area was selected in May of 1977 because a surface fire had occurred on the site in February of the same year (See Figures 1,2,3, and 4). The study site measures approximately 120m. X 180m. with the burned area roughly centered between unburned areas of similar vegetation. The study area is disturbed prairie interspersed with patches of shrubs and trees, specifically along a small creek bed and along the edge of the study site (Figures 5 and 6).

The site was divided into burned and unburned regions and further subdivided into burned with or without shrubs and unburned with or without shrubs. The area was mapped and a grid was superimposed on the map. Study plots were determined by selecting areas on the grid using a table of random numbers (Darnell, 1971). The plots measured 7.05 m. X 1.42 m., giving a total area per plot of $10m^2$. The long axes of the study plots all extended in an east-west direction. Two plots in each of the above subdivided areas

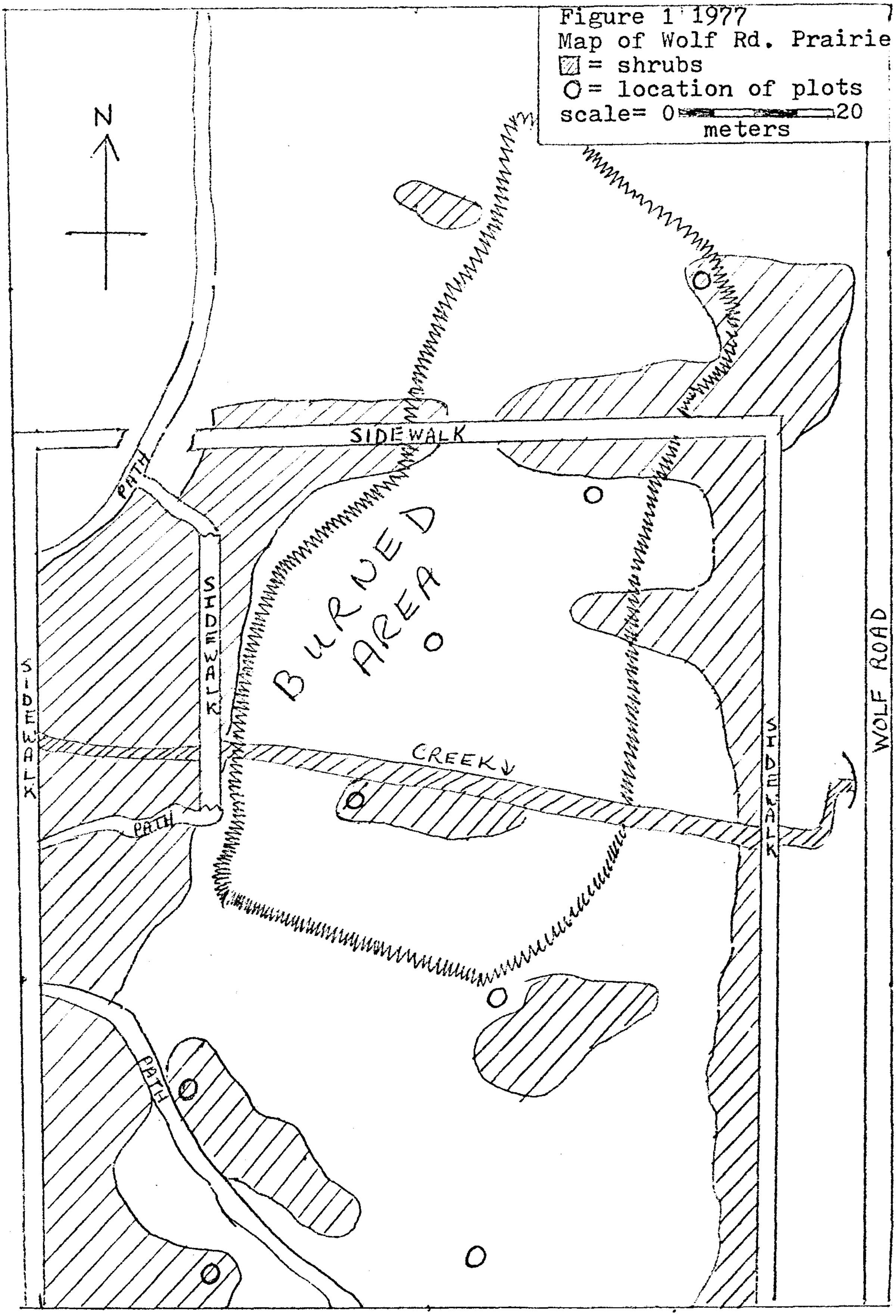


Figure 1 1977
Map of Wolf Rd. Prairie
= shrubs
= location of plots
scale= 0 20
meters
N
SIDEWALK
PATH
SIDEWALK
SIDEWALK
BURNED
AREA
CREEK
PATH
SIDEWALK
WOLF ROAD
PATH

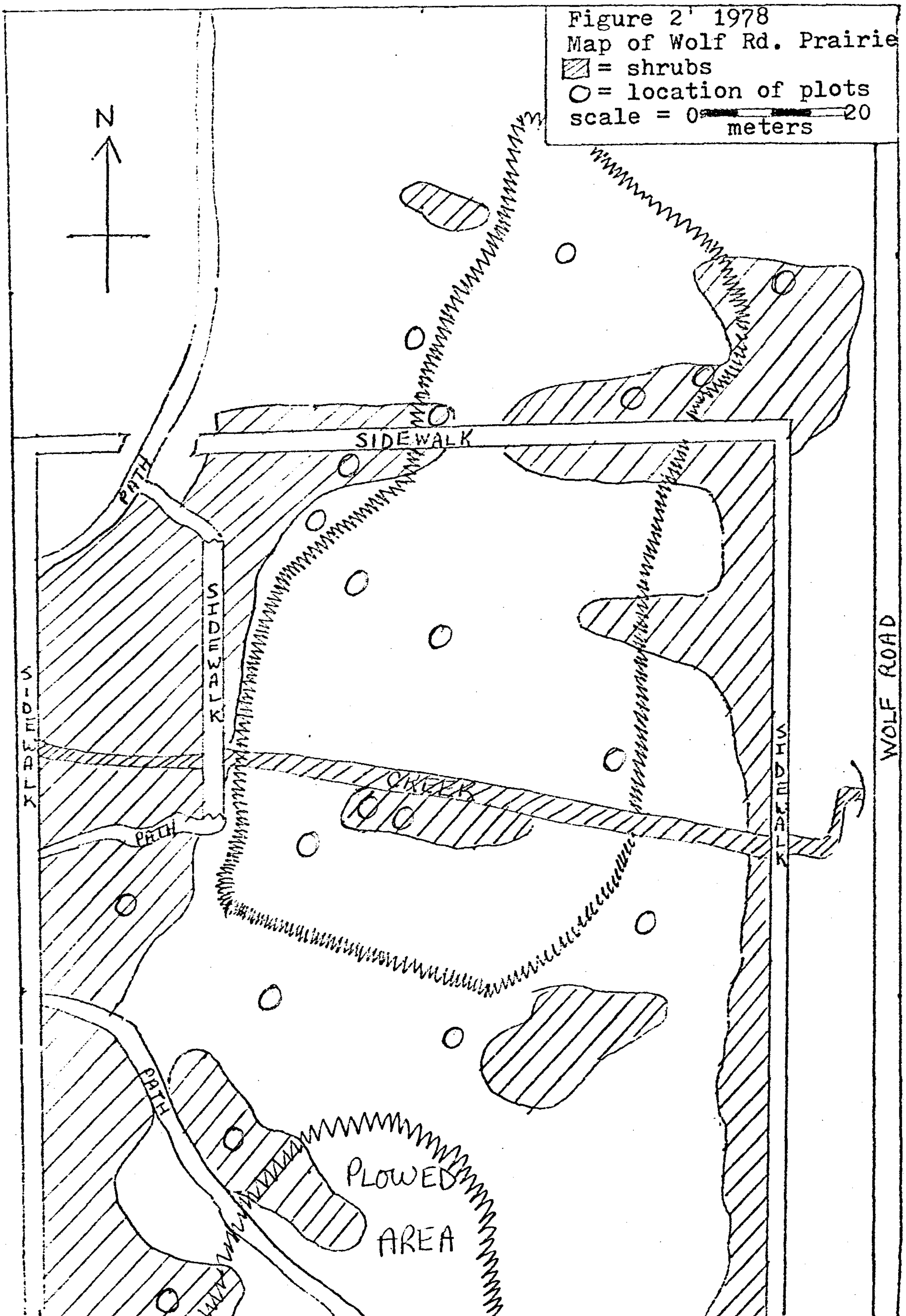


Figure 2' 1978
Map of Wolf Rd. Prairie
= shrubs
= location of plots
scale = 0 20
meters
N
SIDEWALK
PATH
SIDEWALK
SIDEWALK
CREEK
PATH
SIDEWALK
WOLF ROAD
PATH
PLOWED
AREA

(burned with shrubs, burned without shrubs, unburned with shrubs, unburned without shrubs) were determined randomly in September, 1977 for a total of eight plots. In September 1978, 20 plots (five in each subdivision) were sampled to see if differences were still apparent after a year had passed and to also provide data for statistical analyses.

Twelve species composed of a mixture of prairie forbs, grasses, weeds, and shrubs were chosen to be studied because of preliminary sample plots to determine the plants present in the area. In most of the burned areas some of these species were the only plants present (Table 1).

Using the procedure from Darnell (1977) and from Brower and Zar (1977), the density of each species in each plot was calculated by the following formula:

$$D_i = n_i/A \qquad (1)$$

where D_i is the density for species i, n_i is the total number of individuals counted for species i, and A is the total area sampled.

Then the frequency of each species in each plot was determined by the formula:

Figure 3 Photograph: Burned area in background, unburned in foreground, April, 1977.

Figure 4 Photograph: Close-up of burned area showing young S. gigantea and C. canadensis, April, 1977

Figure 5 Photograph: Burned area in background, unburned in foreground, May, 1977.

Figure 6 Photograph: Burned area in background, unburned in foreground, July, 1977.

Aster ericoides
Aster laevis
Aster novae-anglicae
Calamagrostis canadensis
Cirsium discolor
Coreopsis tripteris
Cornus racemosa
Gentiana andrewsii
Pycnanthemum virginiana
Rosa carolina
Silphium terebinthinaceum
Solidago gigantea

Table 1: List of species studied.

$$f_i = j_i/k \tag{2}$$

where f_i is the frequency of species i, j_i is the number of samples in which species i occurs, and k is the total number of samples taken.

The coverage or dominance was determined for each species in each plot by the formula:

$$C_i = a_i/A \tag{3}$$

where C_i is the total coverage for species i, a_i is the total area covered by species i, and A is the total habitat area sampled.

To calculate the area of species that were shrubs or forbs, the floral or foliage area (depending on the species) was used. For the grasses, the clumps were measured by diameter and the basal area was determined (Brower and Zar, 1977).

Once density, frequency, and coverage was determined, the relative density, relative frequency, and relative coverage, respectively, were determined by the following formulae:

$$\text{Relative density} = \frac{\text{density of species i}}{\text{total density of all species}} \times 100 \tag{4}$$

$$\text{Relative Frequency} = \frac{\text{frequency of species i}}{\text{total frequency of all species}} \times 100 \quad (5)$$

$$\text{Relative Coverage} = \frac{\text{coverage of species i}}{\text{total coverage of all species}} \times 100 \quad (6)$$

From these calculations an index of importance, the importance value (IV) was determined for each species by the following formula:

$$IV = \frac{RD + RF + RC}{3} \quad (7)$$

where RD is the relative density, RF is the relative frequency, and RC is the relative coverage (Darnell, 1971).

Statistical Analyses

Statistical analyses were run on the 1978 data with the aid of the Health Sciences Computing Facility, UCLA at the Data Center of Loyola University of Chicago. A univariate analysis of variance, Package BMD08V, was utilized on all species in all four subdivisions except *Cornus racemosa*. *C. racemosa*, being the deciding factor as to whether or not the area contained shrubs, was simply compared in burned and unburned areas with shrubs.

Package BMD12V - Multivariate Analysis of Variance and Covariance of the Health Sciences Computing Facility, UCLA, at the Data Center of Loyola University of Chicago was run on all 1978 density and coverage values.

Chi-square tests were calculated from the frequencies of the four study subdivisions (burned with shrubs, burned without shrubs, unburned with shrubs, unburned without shrubs) for 1978 values to determine significance.

RESULTS

The number of species in burned plots was found to be lower than in unburned plots. In 1977 three species were found to have higher importance values in burned areas without shrubs than in unburned areas without shrubs. Five species showed a decidedly lower importance value in burned areas without shrubs and four species were not present in the plots sampled.

In burned areas with shrubs, four species were found to have higher importance values than in unburned areas with shrubs. Six species had lower importance values in burned areas with shrubs, and two species were not present in the sample plots.

In 1978 four species had higher importance values in burned areas without shrubs than in unburned areas without shrubs, six species had lower importance values in burned areas without shrubs, and two species were not present in the study plots. Three species had higher importance values in burned areas with shrubs than in unburned areas with shrubs, eight species showed a lower importance value for burned areas with shrubs, and one species was not present in any of the plots.

With the variation seen between species, the results from each species will be presented individually.

Aster ericoides (heath aster). A. ericoides was found to have higher densities, coverages, and importance values in burned areas with shrubs and in unburned areas without shrubs for 1977 and 1978.

Specifically, the importance values for 1977 and 1978 for burned areas with shrubs were higher than those in unburned areas with shrubs. For both years the importance values in burned areas without shrubs were lower than in unburned areas without shrubs. From 1977 to 1978 there was no change of importance values in unburned areas with shrubs, and there were lower values in 1978 in burned areas with shrubs, and all areas without shrubs (See Fig. 7A&B).

The changes in coverage were all identical to the above changes in importance values (See Fig. 7C&D).

The density values for 1977 and 1978 for burned areas with shrubs were higher than those in unburned areas with shrubs. For both years the density values in burned areas without shrubs were lower than in unburned areas without shrubs. From 1977 to 1978 unburned areas with shrubs, and burned areas without shrubs had lower values the second year, no change in burned areas with shrubs, and higher values the second year in unburned areas without shrubs (See Fig. 7E&F).

The F-values from the univariate analysis of variance on *A. ericoides* were insignificant for burning or presence of shrubs, but were significant for the interaction factor (Coverage--$.975 < p < .99$; Density--$.95 < p < .975$).of the two.

Aster laevis (smooth aster). *A. laevis* was not present in any burned plots with or without shrubs. With the exception of unburned areas with shrubs in which the densities were higher in 1978 than in 1977, all other unburned areas had higher importance values, coverage, and densities in 1977. The coverage and density values showed no significance when treated statistically.

Aster novae-anglicae (New England aster). *A. novae-anglicae* was not present in most study plots and showed no significance in any statistical tests.

Calamagrostis canadensis (bluejoint grass). C. canadensis was found to have higher importance values and densities in unburned areas with shrubs than in burned areas with shrubs and to have lower values in unburned areas without shrubs than in burned areas without shrubs.

The importance values were lower in burned areas with shrubs than in unburned areas with shrubs in 1977 and 1978. The importance values were lower in unburned areas without shrubs than in burned areas without shrubs for both years. The importance values for unburned areas with shrubs, unburned areas without shrubs, and burned areas with shrubs were lower in 1978 than in 1977. The importance values were approximately the same in burned areas without shrubs for both years (Fig. 8A&B).

The coverage values for C. canadensis were higher in burned areas with shrubs than in unburned areas with shrubs in 1977. The coverage values were approximately the same in burned and unburned areas with shrubs in 1978. The coverage values were higher in burned areas without shrubs than in unburned areas without shrubs in 1977 and 1978. The burned areas and the unburned areas with shrubs had higher coverage values in 1977 than in 1978. There was no change in the coverage values in unburned areas without shrubs (See Fig. 8C&D).

The density values of C. canadensis were lower in burned areas with shrubs than in unburned areas with shrubs for 1977 and 1978. The density values were higher in burned areas without shrubs than in unburned areas without shrubs for 1977 and 1978. The density values were lower in unburned areas with shrubs, burned areas with shrubs, and unburned areas without shrubs in 1978 than in 1977. The density values in burned areas without shrubs were approximately the same in 1978 as in 1977 (Fig. 8E&F).

The F-values from the univariate analysis of variance on the coverage values for 1978 showed significance of $p > .995$ for burning, presence of shrubs, and interaction. The density values were significant for burning, presence of shrubs and the interaction factor for 1978 ($.95 < p < .975$).

Cirsium discolor (field thistle). C. discolor was not present in any areas that were burned. The importance values coverage and density values were all higher in unburned areas with shrubs in 1977 than in 1978. Unburned areas without shrubs had higher coverage and density values in 1977 than in 1978. C. discolor showed no significance in any statistical tests.

Coreopsis tripteris (tall coreopsis). C. tripteris showed higher importance values, coverage, and density values in unburned areas than in burned areas.

The importance values for both years had higher values in unburned areas than in burned areas. The values for burned areas, with or without shrubs, and unburned areas without shrubs were lower in 1977 than in 1978. There were no changes between seasons in unburned areas with shrubs (Fig. 9A&B).

The coverage values for unburned areas with shrubs and burned areas with shrubs were approximately the same for 1977 and 1978. The coverage values of unburned areas without shrubs were higher than the values of burned areas without shrubs in 1977 and 1978. All coverage values were higher in 1978 than in 1977 (Fig. 9C&D).

The density values for unburned areas with shrubs were higher than the values for burned areas with shrubs in 1977. These values were approximately the same in 1978. The density values for unburned areas without shrubs were higher than the burned areas without shrubs in 1977 and 1978. Density values in unburned areas with shrubs were higher in 1977 than 1978. Burned areas with shrubs and unburned areas without shrubs had lower values in 1977 than in 1978. Burned areas without shrubs showed no change between the two seasons (Fig. 9E&F).

The F-values from the univariate analysis of variance showed significance in the presence of shrubs and for the interaction factor ($.90<p<.95$) and due to burning ($.95<p<.975$) for the coverage values of 1978. There were no significant statistical results for density values.

Cornus racemosa (gray dogwood). *C. racemosa*, being a shrub, was only present in areas with shrubs. Data will therefore only refer to areas containing shrubs.

The importance values were lower in burned areas than in unburned areas in 1977 and 1978, and the burned and unburned values were lower in 1977 than in 1978.

The coverage values were lower in the burned than in the unburned for 1977 and 1978, and the values of the burned and unburned areas were lower in 1978 than in 1977.

The density values were lower in the burned than in the unburned for 1977 and 1978, and the density values were lower in both burned and unburned in 1977 than in 1978.

The univariate analysis of variance was run as a one-way analysis on burned and unburned shrubs only for C. racemosa. There was no significant statistical results for the density or the coverage values.

Gentiana andrewsii (closed gentian). G. andrewsii was found to be present in very few sample plots and there was no statistical significance in this study.

Pycnanthemum virginiana (Virginia mountain-mint). P. virginiana was not present in unburned areas in 1977. The importance values were approximately the same in burned and unburned area with shrubs for 1978. The importance values were approximately the same in burned areas with shrubs for 1977 and 1978. In general, P. virginiana showed the same results in data on coverage and density, but was not present in enough plots to make any other comparisons. The statistical analyses of coverage and density showed the data to be insignificant.

Rosa carolina (wild rose). The importance values for unburned areas with shrubs were higher than the values for burned areas with shrubs for 1977. The importance values for unburned areas with shrubs were lower than the values for burned areas with shrubs for 1978. Unburned areas without shrubs had lower importance values than burned areas without shrubs in 1977 and 1978. Burned areas with shrubs had lower importance values in 1977 than in 1978. The importance values were lower in the unburned areas with shrubs and the burned areas without shrubs in 1978 than in 1977. The importance values were approximately the same in burned areas without shrubs for 1977 and 1978 (Fig. 10A&B).

The coverage values for R. carolina in unburned areas with shrubs were higher than in burned areas with shrubs in 1977 and 1978. The coverage values in unburned areas without shrubs were lower than in burned areas without shrubs for 1977 and 1978. There were higher values in unburned areas without shrubs and burned areas with shrubs in 1978 than in 1977. There were lower coverage values in burned areas without shrubs in 1978 than in 1977. The values were approximately the same in unburned areas with shrubs (Fig. 10 C&D).

The density values were lower in unburned areas with shrubs than in burned areas with shrubs in 1977, but higher in 1978. The density values were approximately the same in unburned and burned areas in 1977 and 1978. Unburned areas with shrubs and burned areas without shrubs had higher density values in 1977 than in 1978, burned areas with shrubs had lower values in 1977, and unburned areas without shrubs had values approximately the same (Fig. 10 E&F).

The univariate analysis of variance showed no significant results for coverage or density for R. carolina.

Silphium terebinthinaceum (prairie dock). S. terebinthinaceum was not present in areas with shrubs in 1977, nor was it present in burned areas with shrubs in 1978. The importance values were higher in unburned areas and in 1977 than in burned areas or 1978. These results were, in general, the same for coverage and density. This species was not present in sufficient numbers to make any further comparisons. S. terebinthinaceum showed no statistical significance for density or coverage.

Solidago gigantea (late goldenrod). The importance values, coverage, and densities of all burned areas except areas with shrubs in 1977, were higher than in unburned areas.

The importance values were higher in burned areas with shrubs than in unburned areas with shrubs in 1977. The importance values were lower in burned areas with shrubs than in unburned areas with shrubs in 1978. The importance values were higher in burned areas without shrubs than in unburned areas without shrubs in 1977 and 1978. The values for unburned areas and burned areas without shrubs were higher in 1978 than in 1977. Burned areas with shrubs had higher values in 1977 than in 1978 (Fig. 11 A&B).

The coverage values were higher in burned areas with shrubs than in unburned areas with shrubs in 1977. The coverage values were lower in burned areas with shrubs than in unburned areas with shrubs in 1978. The coverage values were higher in burned areas without shrubs than in unburned areas without shrubs in 1977 and 1978. The values for unburned areas and burned areas without shrubs were higher in 1978 than in 1977. Burned areas with shrubs had higher values in 1977 than in 1978 (Fig. 11 C&D).

The density values were higher in burned areas with shrubs than in unburned areas with shrubs in 1977. The density values for unburned areas with shrubs were approximately the same as burned areas with shrubs in 1978. The densities were higher in burned areas without shrubs than in unburned areas without shrubs in 1977 and 1978. The values for unburned and burned areas without shrubs were higher in 1978 than in 1977. Burned areas with shrubs had higher values in 1977 than in 1978 (Fig. 11 E&F).

The F-values from the univariate analysis of variance of S. gigantea for coverage in 1978 were significant for burning ($.99 < p < .995$), presence of shrubs, and interaction factor ($p > .995$). The F-values for densities in 1978 were significant for presence of shrubs ($.99 < p < .995$) and for the interaction factor ($.975 < p < .99$). Burning was found to be insignificant.

The results of the multivariate analysis of variance are as follows: The effect of burning on the coverage values of all species during 1978 were significant ($.975 < p < .99$), as well as the effect of the presence of shrubs ($.95 < p < .975$) and the interaction factor between the two ($.975 < p < .99$). The effect of burning, presence of shrubs, and interaction factor on the densities of all species during 1978 was statistically insignificant.

The results of the chi-square tests calculated on the frequencies of the 1978 sample plots are as follows: In burned areas without shrubs, chi-square = 29.02, 11 degrees of freedom ($0.01 < p < 0.001$); in unburned, areas without shrubs chi-square = 10.09, 11 degrees of freedom ($p < 0.20$); in burned areas with shrubs, chi-square = 19.00, 11 degrees of freedom ($0.05 < p < 0.01$); in unburned areas with shrubs, chi-square = 10.07, 11 degrees of freedom ($p < 0.20$).

Tables 2,3, and 4 give a summary of relative coverage, relative density, and importance value data for 1977 and 1978.

Species Name	RELATIVE COVERAGE (%)			
	Unburned plots			
	Shrub areas		Non-shrub areas	
	1977	1978	1977	1978
Aster ericoides	0.02	0.76	23.00	8.92
Aster laevis	8.87	0.16	44.10	3.08
Aster novae-anglicae	0.00	0.00	0.00	0.96
Calamagrostis canadensis	5.02	1.52	3.59	3.68
Cirsium discolor	8.91	2.88	0.00	2.04
Coreopsis tripteris	1.27	3.92	8.26	24.76
Cornus racemosa	64.99	61.96	0.00	0.00
Gentiana andrewsii	0.00	0.08	3.81	0.00
Pycnanthemum virginiana	0.00	2.72	0.00	6.78
Rosa carolina	9.88	10.50	1.27	3.10
Silphium terebinthinaceum	0.00	0.06	7.34	0.00
Solidago gigantea	1.00	15.48	8.60	46.64
	Burned plots			
	Shrub areas		Non-shrub areas	
Species Name	1977	1978	1977	1978
Aster ericoides	19.07	7.74	7.09	0.00
Aster laevis	0.00	0.00	0.00	0.00
Aster novae-anglicae	1.50	0.00	0.00	0.00
Calamagrostis canadensis	9.18	2.24	33.66	28.66
Cirsium discolor	0.00	0.25	0.00	0.00
Coreopsis tripteris	0.22	3.12	1.86	4.74
Cornus racemosa	42.72	60.78	0.00	0.00
Gentiana andrewsii	0.00	0.00	0.00	0.00
Pycnanthemum virginiana	3.16	4.14	0.11	00.00
Rosa carolina	5.43	18.50	27.21	14.84
Silphium terebinthinaceum	0.00	0.00	0.04	0.02
Solidago gigantea	18.67	3.20	29.99	51.72

Table 2 Relative Coverage Values for 1977 and 1978

	RELATIVE DENSITY (%)			
	Unburned plots			
	Shrub areas		Non-shrub areas	
Species Name	1977	1978	1977	1978
Aster ericoides	0.81	2.36	11.72	16.42
Aster laevis	19.67	0.14	39.50	9.74
Aster novae-anglicae	0.00	0.00	0.00	4.34
Calamagrostis canadensis	39.34	21.88	32.71	7.40
Cirsium discolor	4.09	0.38	0.00	1.06
Coreopsis tripteris	8.19	2.72	3.70	12.20
Cornus racemosa	13.11	38.10	0.00	0.00
Gentiana andrewsii	0.00	0.26	1.85	0.00
Pycnanthemum virginiana	0.00	1.00	0.00	1.70
Rosa carolina	6.55	4.32	0.61	1.32
Silphium terebinthinaceum	0.00	4.06	1.85	0.58
Solidago gigantea	8.19	24.74	8.02	45.24
	Burned plots			
	Shrub areas		Non-shrub areas	
Species Name	1977	1978	1977	1978
Aster ericoides	21.37	21.38	4.03	0.00
Aster laevis	0.00	0.00	0.00	0.00
Aster novae-anglicae	0.76	0.00	0.00	0.00
Calamagrostis canadensis	20.61	12.76	42.33	41.68
Cirsium discolor	0.00	0.28	0.00	0.00
Coreopsis tripteris	0.38	2.82	1.61	1.12
Cornus racemosa	8.39	22.90	0.00	0.00
Gentiana andrewsii	0.00	0.00	0.00	0.00
Pycnanthemum virginiana	1.14	2.34	0.40	0.00
Rosa carolina	2.29	13.38	14.11	2.46
Silphium terebinthinaceum	0.00	0.00	0.80	0.30
Solidago gigantea	45.03	24.10	36.69	54.40

Table 3 Relative Density Values for 1977 and 1978

	IMPORTANCE VALUES (%)			
	Unburned plots			
	Shrub areas		Non-shrub areas	
Species Name	1977	1978	1977	1978
Aster ericoides	4.72	4.17	16.33	11.88
Aster laevis	13.96	1.13	32.63	8.87
Aster novae-anglicae	0.00	0.00	0.00	2.90
Calamagrostis canadensis	19.23	10.93	16.86	7.13
Cirsium discolor	6.55	3.19	0.00	4.47
Coreopsis tripteris	7.60	7.41	8.74	18.05
Cornus racemosa	30.47	38.55	0.00	0.00
Gentiana andrewsii	0.00	1.15	4.27	0.00
Pycnanthemum virginiana	0.00	4.37	0.00	5.13
Rosa carolina	9.92	7.04	3.01	2.60
Silphium terebinthinaceum	0.00	3.47	7.82	2.49
Solidago gigantea	7.50	18.61	10.30	36.36
	Burned plots			
	Shrub areas		Non-shrub areas	
Species Name	1977	1978	1977	1978
Aster ericoides	16.81	14.04	7.04	0.00
Aster laevis	0.00	0.00	0.00	0.00
Aster novae-anglicae	4.09	0.00	0.00	0.00
Calamagrostis canadensis	13.26	7.90	31.99	32.71
Cirsium discolor	0.00	0.18	0.00	0.00
Coreopsis tripteris	3.53	6.31	4.49	7.52
Cornus racemosa	23.70	35.13	0.00	0.00
Gentiana andrewsii	0.00	0.00	0.00	0.00
Pycnanthemum virginiana	4.77	5.06	3.50	0.00
Rosa carolina	5.91	14.96	20.44	13.17
Silphium terebinthinaceum	0.00	0.00	3.61	1.97
Solidago gigantea	27.90	16.33	28.89	44.64

Table 4 Importance Values for 1977 and 1978

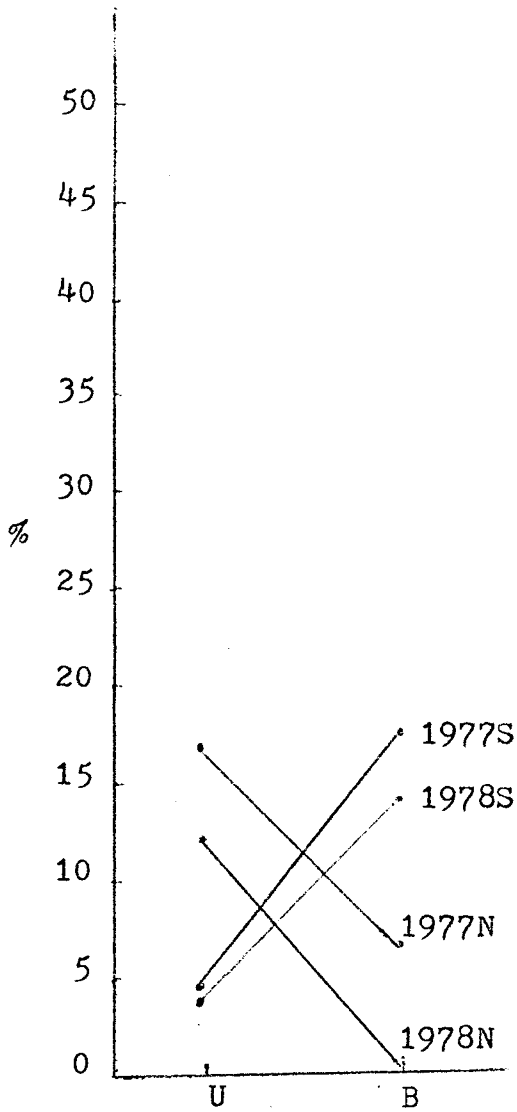


Figure 7-A
Differences between Importance values of A. ericoides for burned and unburned areas.

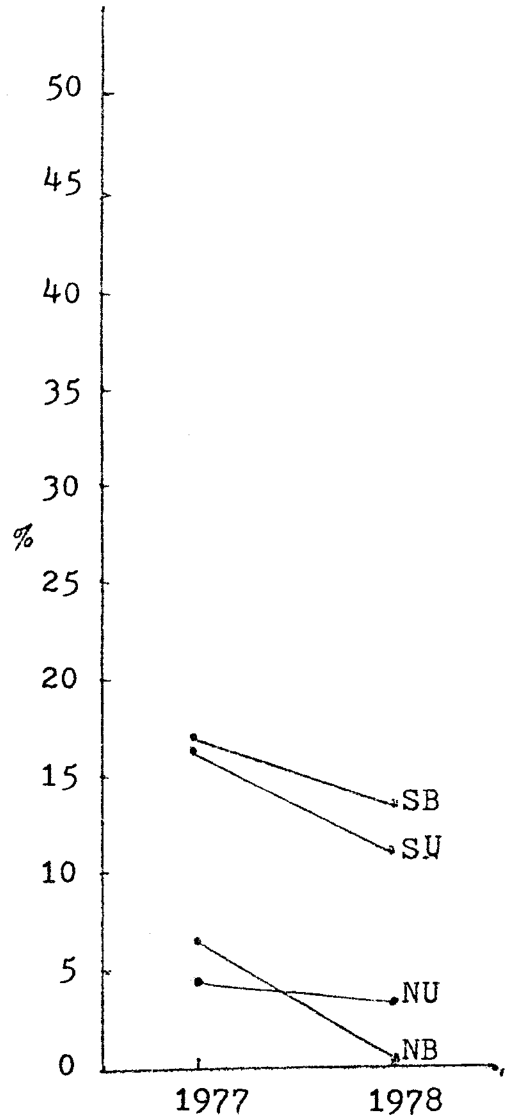


Figure 7-B
Differences between Importance values of A. ericoides in 1977 and 1978.

Key for Figures 7-11.
U= unburned areas, B= burned areas
S= areas with shrubs, N= areas without shrubs.

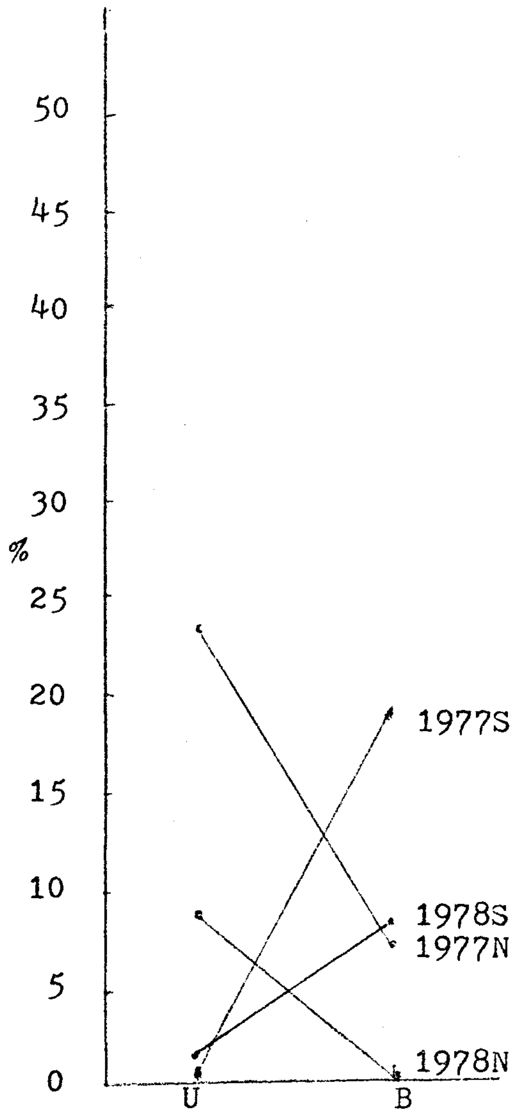


Figure 7-C
Differences between Relative coverage values of A. ericoides for burned and unburned areas.

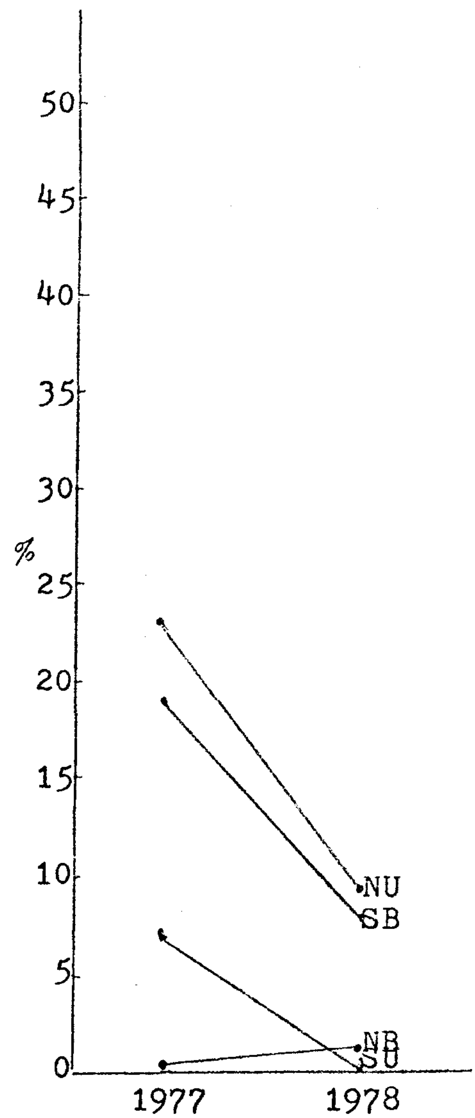


Figure 7-D
Differences between Relative coverage values of A. ericoides for 1977 and 1978.

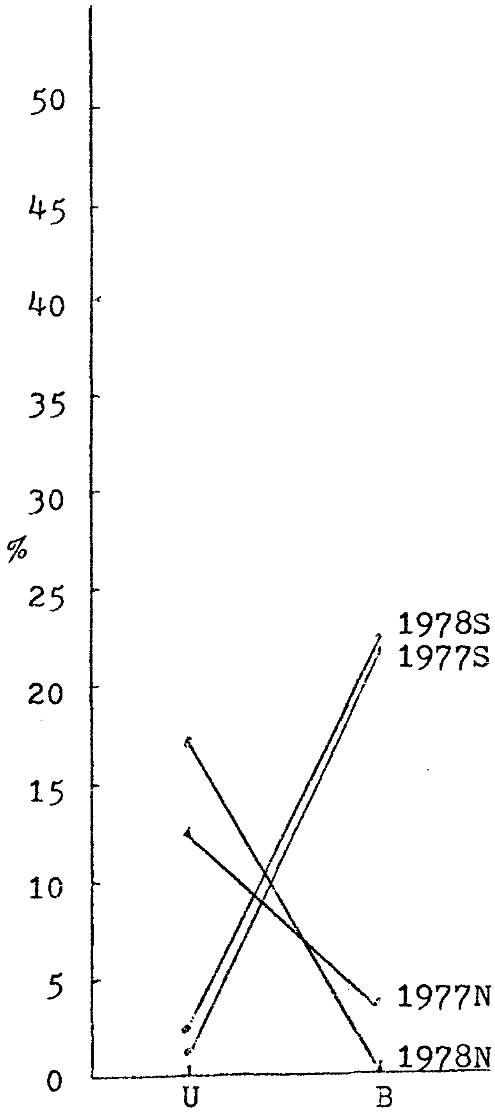


Figure 7-E
Differences between Relative density of <u>A. ericoides</u> for burned and unburned areas.

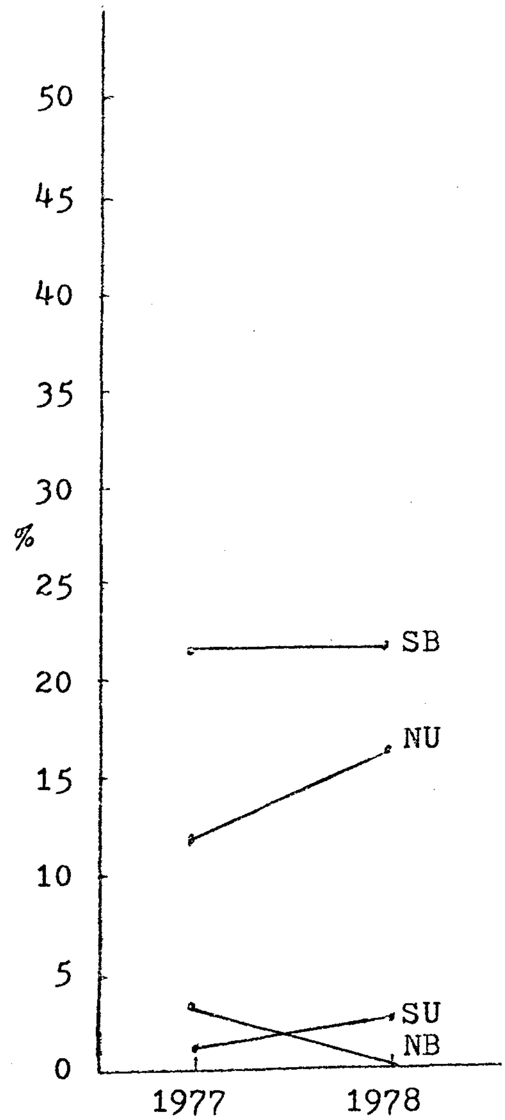


Figure 7-F
Differences between Relative density of <u>A. ericoides</u> in 1977 and 1978.

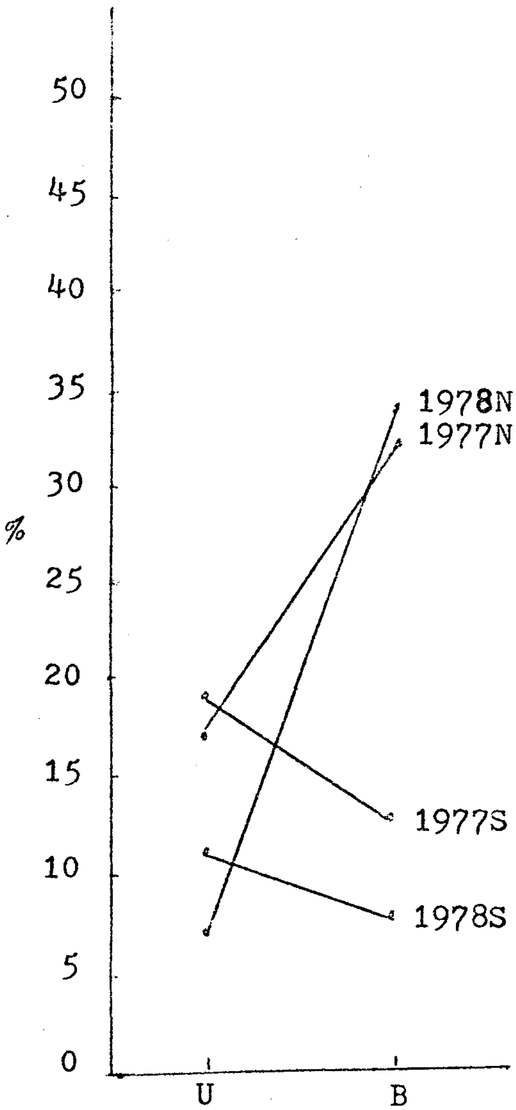


Figure 8-A
Differences between Importance values of C. canadensis for burned and unburned areas.

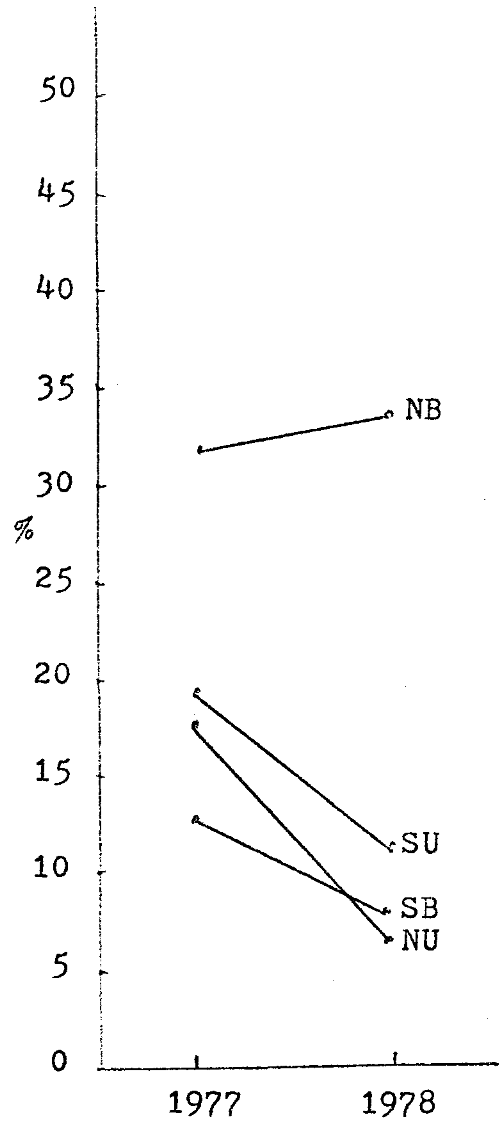


Figure 8-B
Differences between Importance values of C. canadensis in 1977 and 1978.

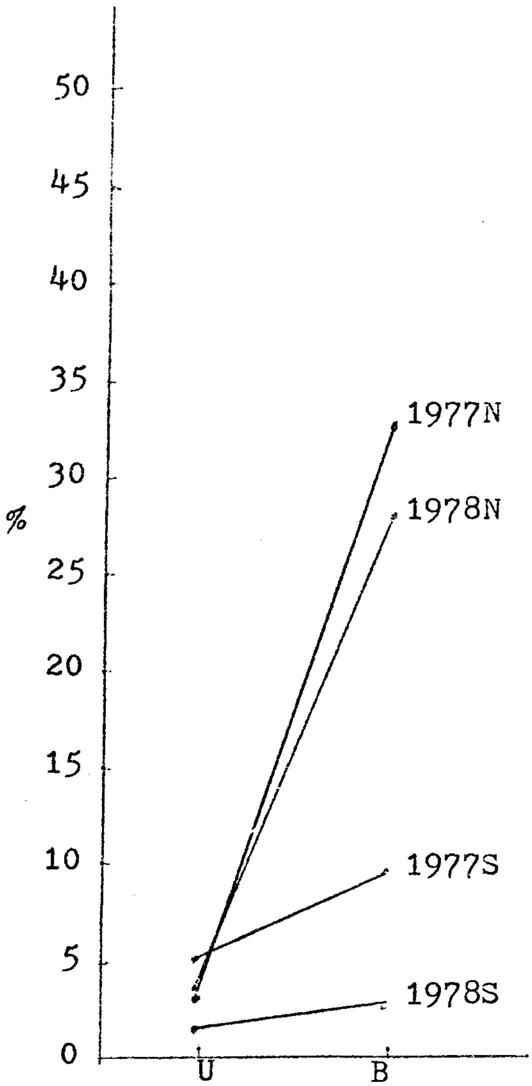


Figure 8-C
Differences between Relative coverage of *C. canadensis* for burned and unburned areas.

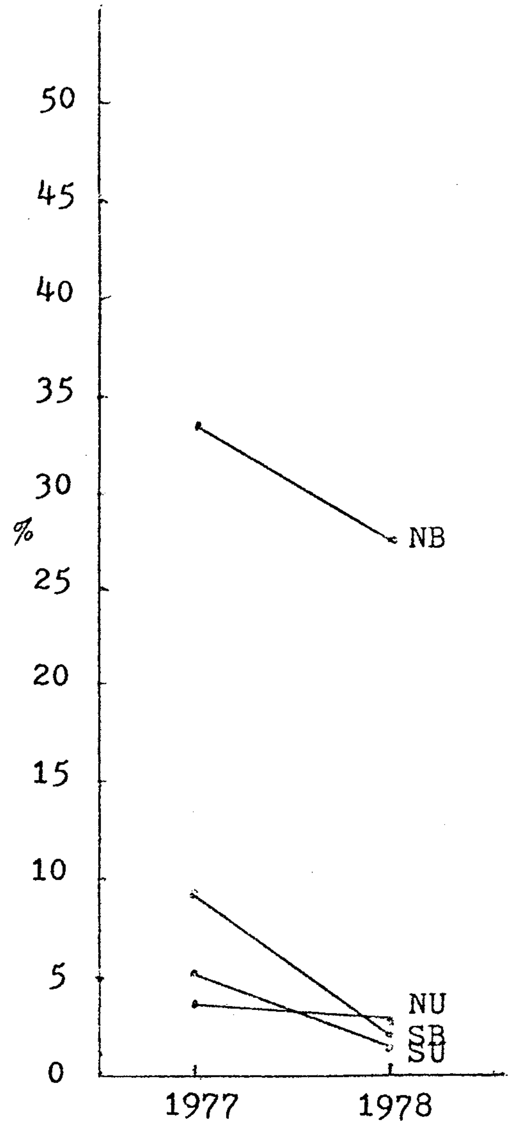


Figure 8-D
Differences between Relative coverage of *C. canadensis* in 1977 and 1978.

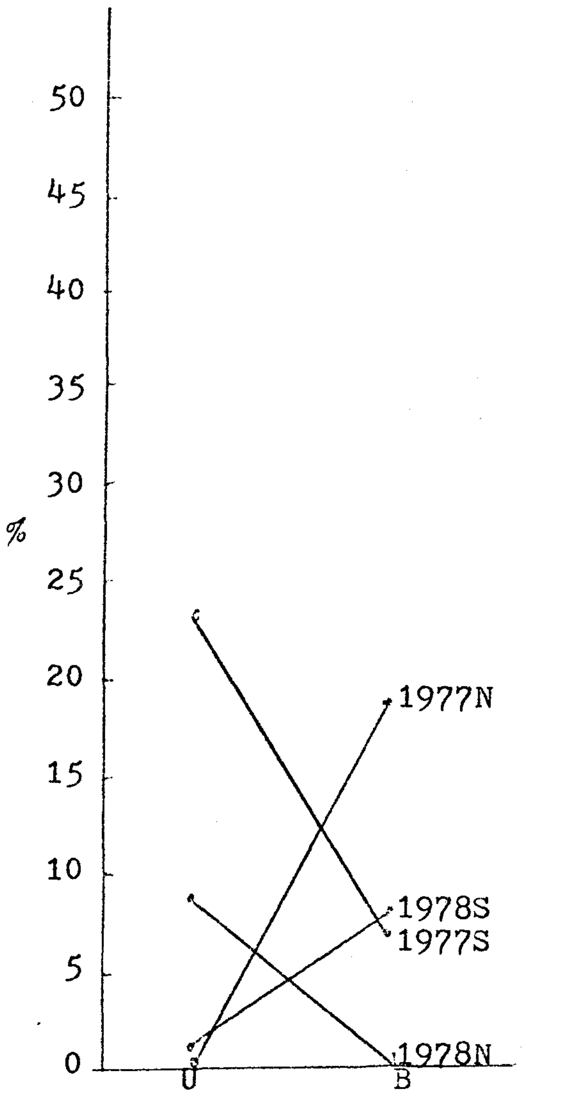


Figure 8-E
Differences between Relative density of C. canadensis for burned and unburned areas.

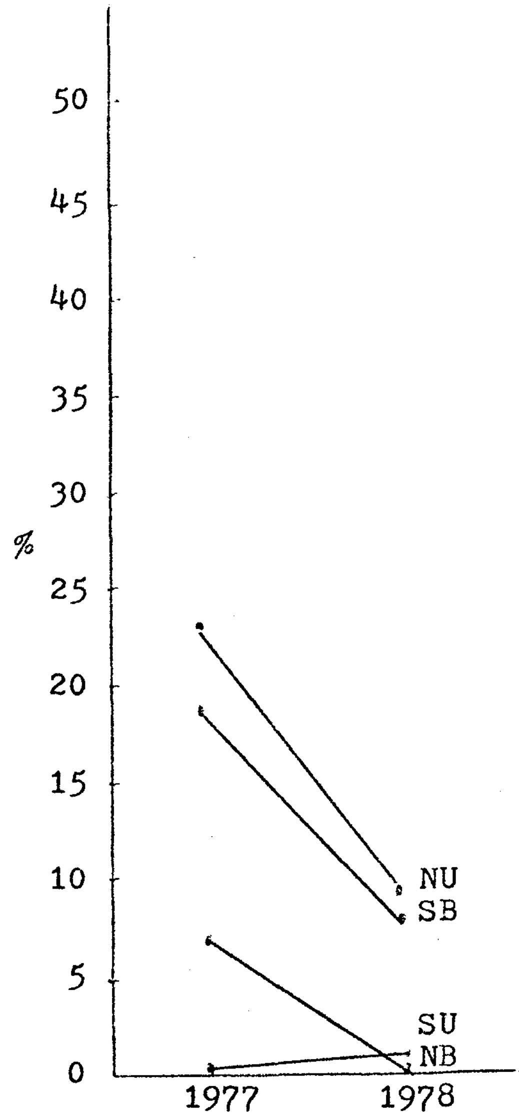
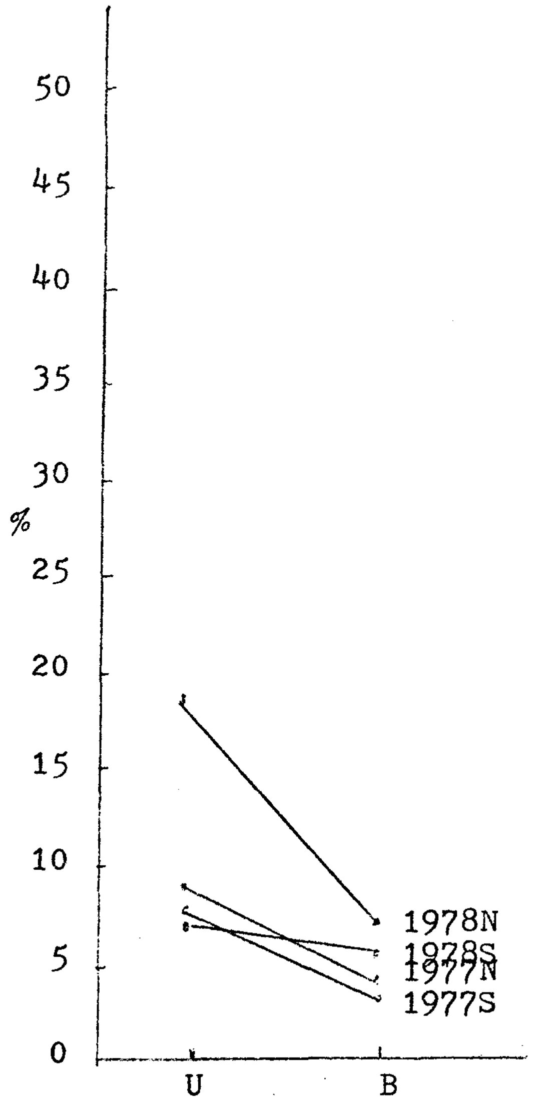
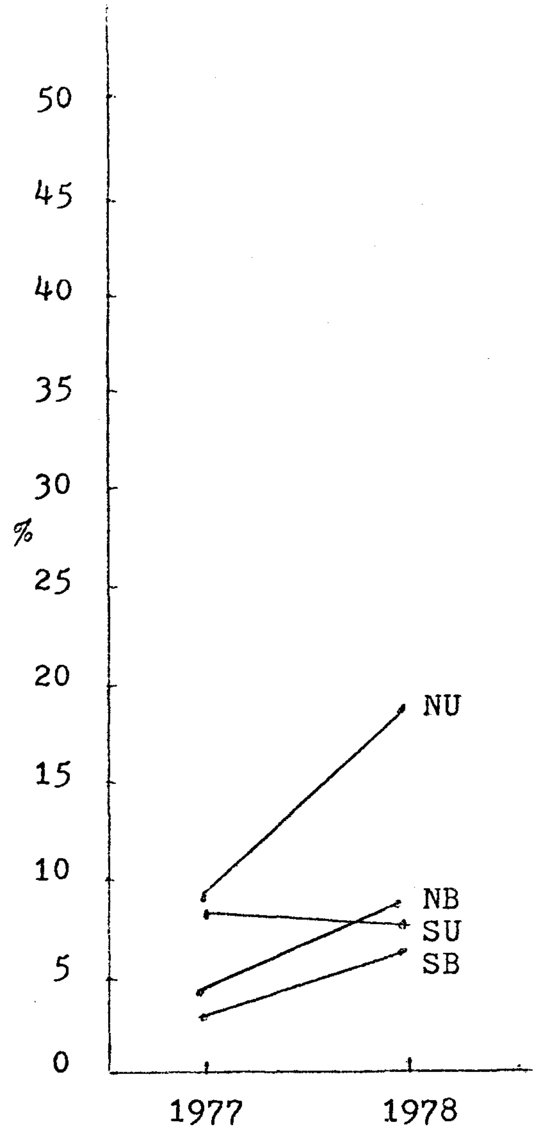


Figure 8-F
Differences between Relative density of C. canadensis in 1977 and 1978.



Differences between Importance values of <u>C. tripteris</u> for burned and unburned areas.
Figure 9-A



Differences between Importance values of <u>C. tripteris</u> in 1977 and 1978.
Figure 9-B

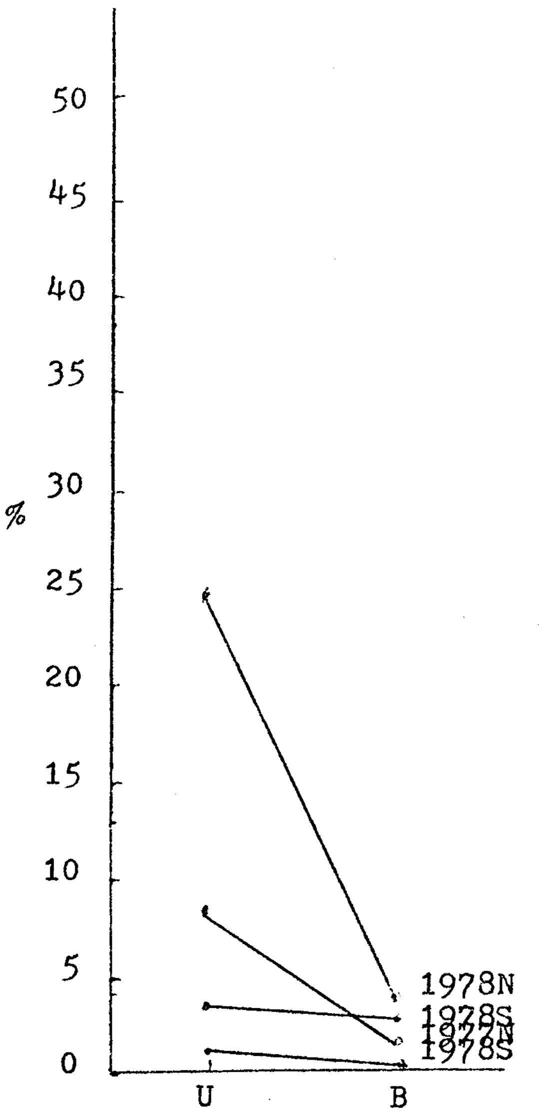


Figure 9-C
Differences between Relative coverage of <u>C. tripteris</u> for burned and unburned areas.

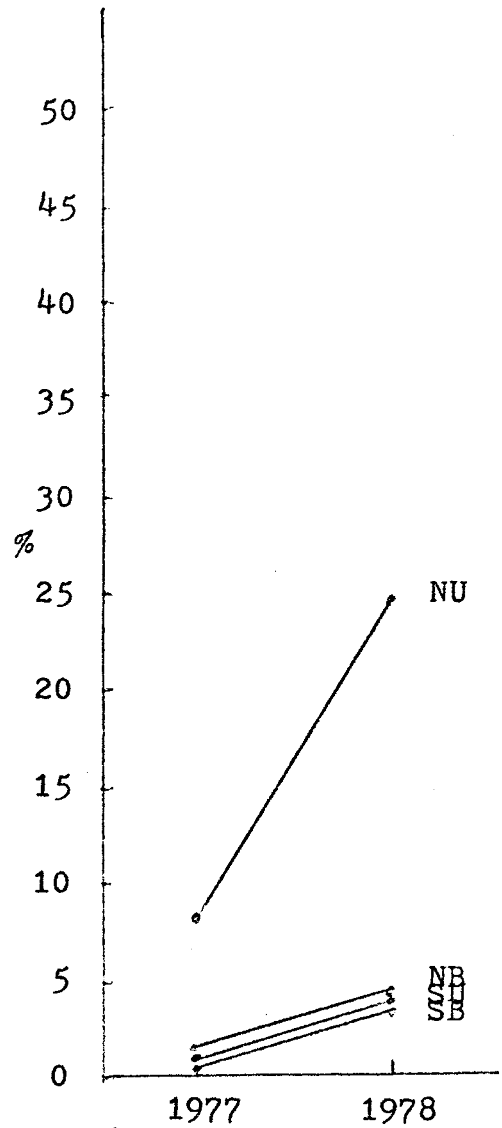


Figure 9-D
Differences between Relative coverage of <u>C. tripteris</u> in 1977 and 1978.

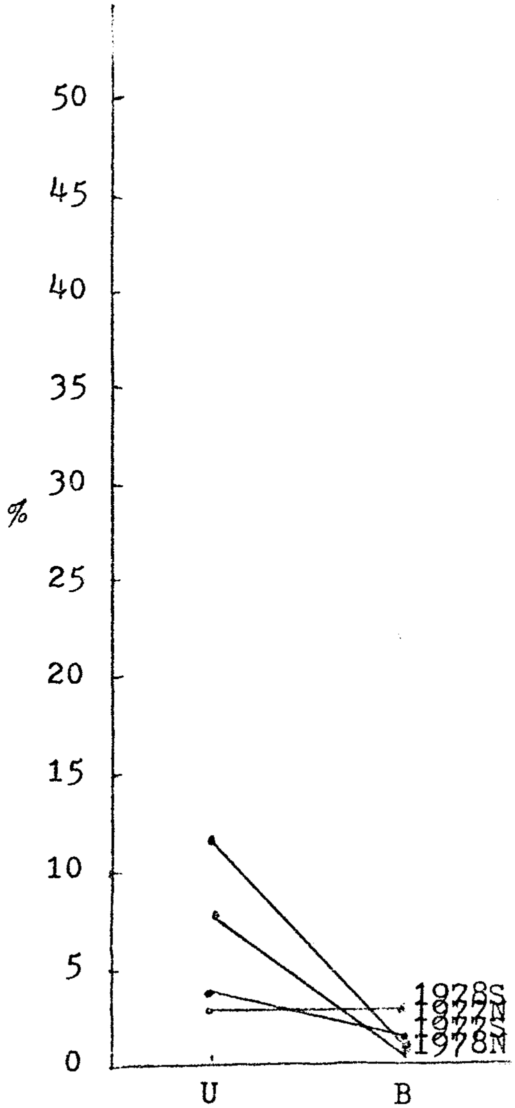


Figure 9-E
Differences between Relative density of C. tripteris for burned and unburned areas.

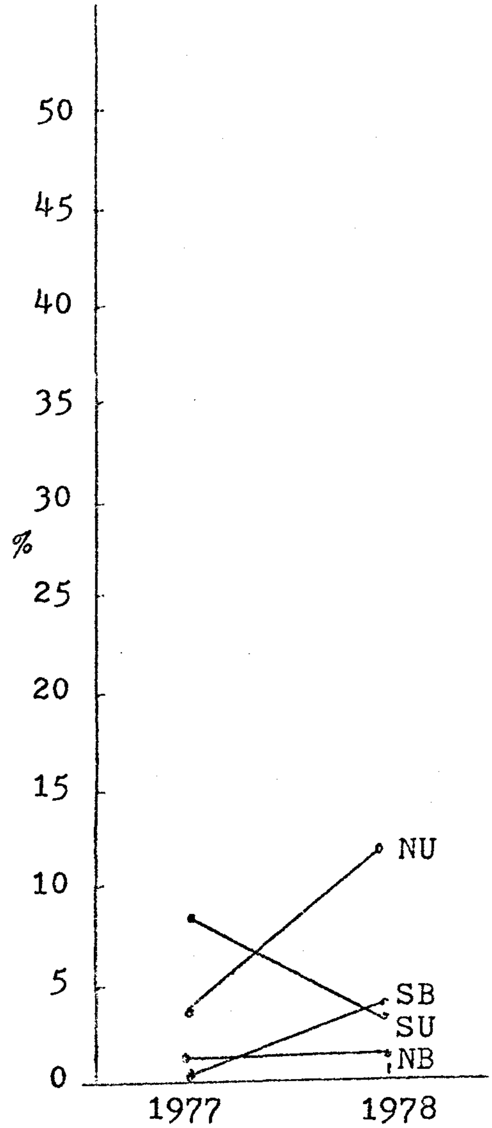


Figure 9-F
Differences between Relative density of C. tripteris in 1977 and 1978.

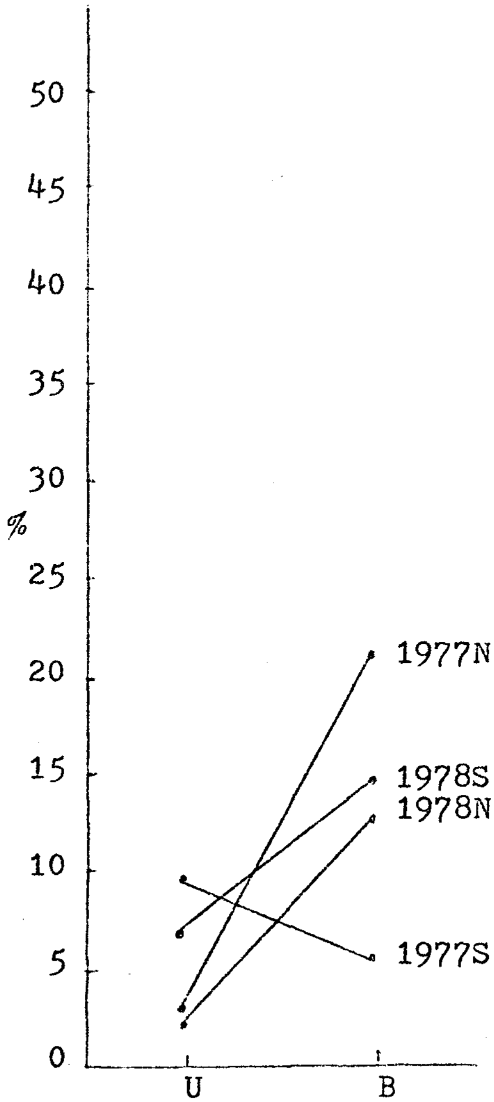


Figure 10-A
Differences between Importance values of R. carolina for burned and unburned areas.

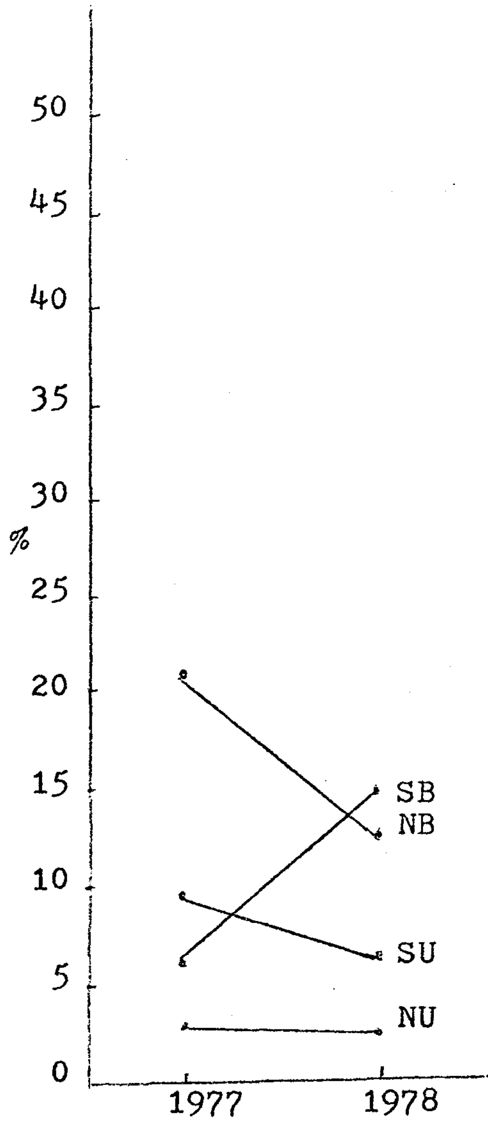


Figure 10-B
Differences between Importance values of R. carolina in 1977 and 1978.

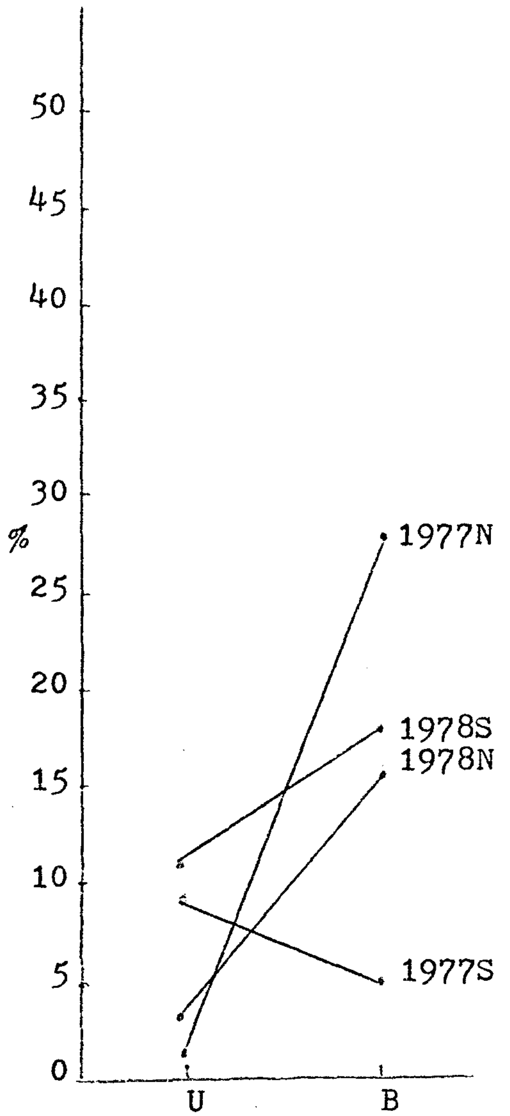


Figure 10-C
Differences between Relative coverage of <u>R. carolina</u> for burned and unburned areas.

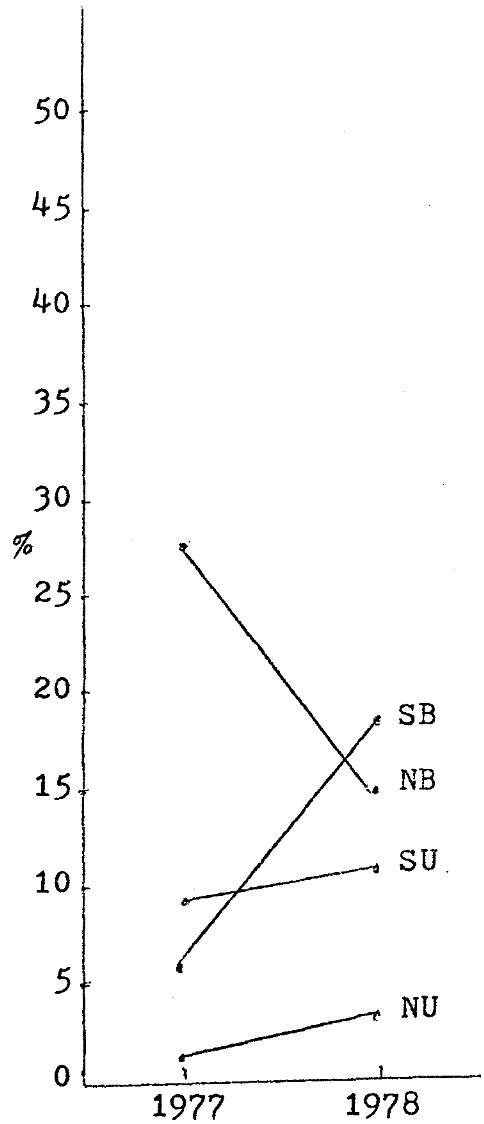


Figure 10-D
Differences between Relative coverage of <u>R. carolina</u> in 1977 and 1978.

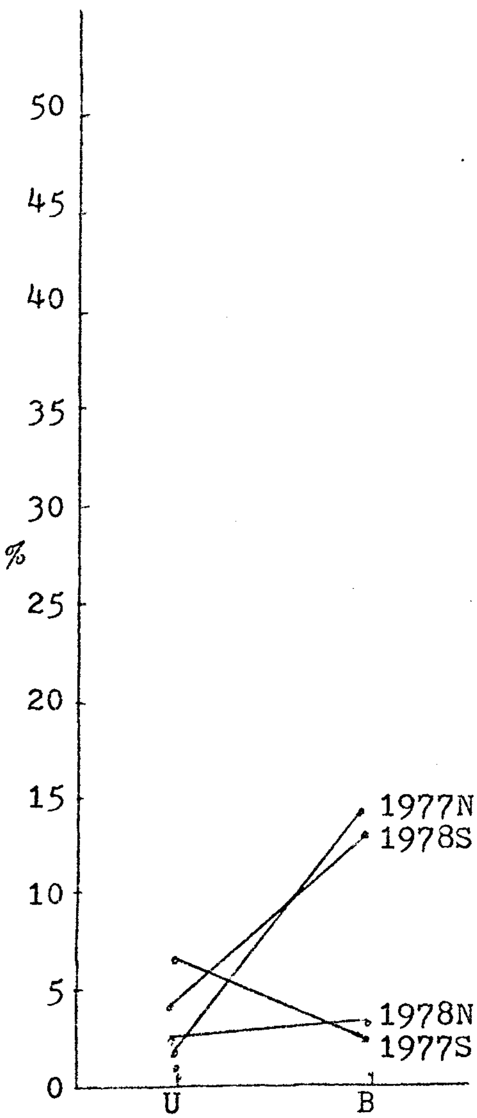


Figure 10-E
Differences between Relative density of *R. carolina* for burned and unburned areas.

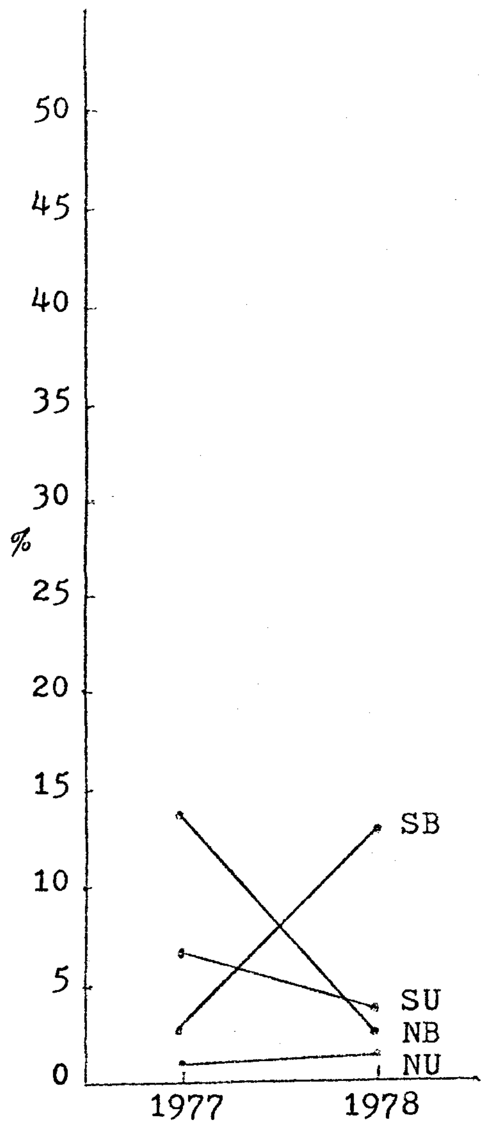


Figure 10-F
Differences between Relative density of *R. carolina* in 1977 and 1978.

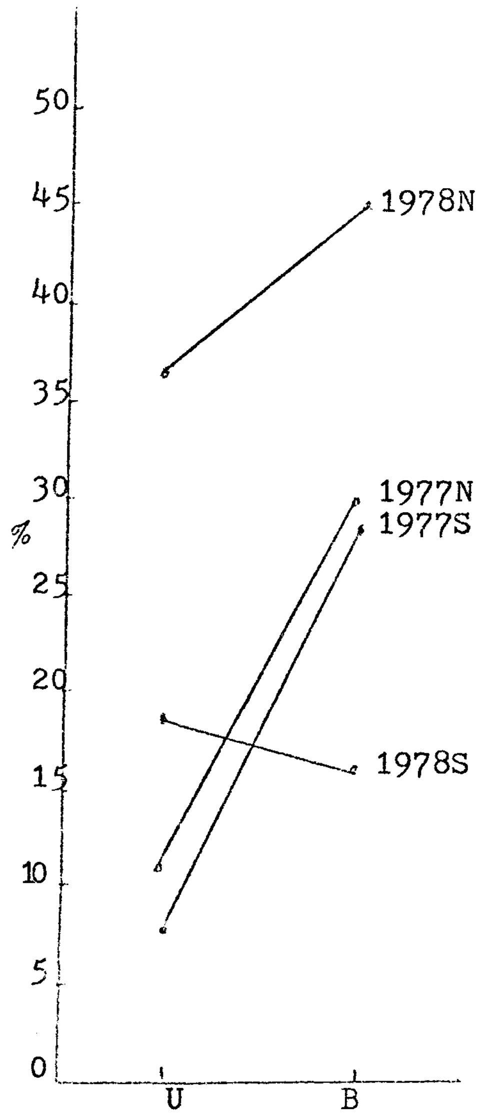


Figure 11-A
Differences between Importance values of *S. gigantea* for burned and unburned areas.

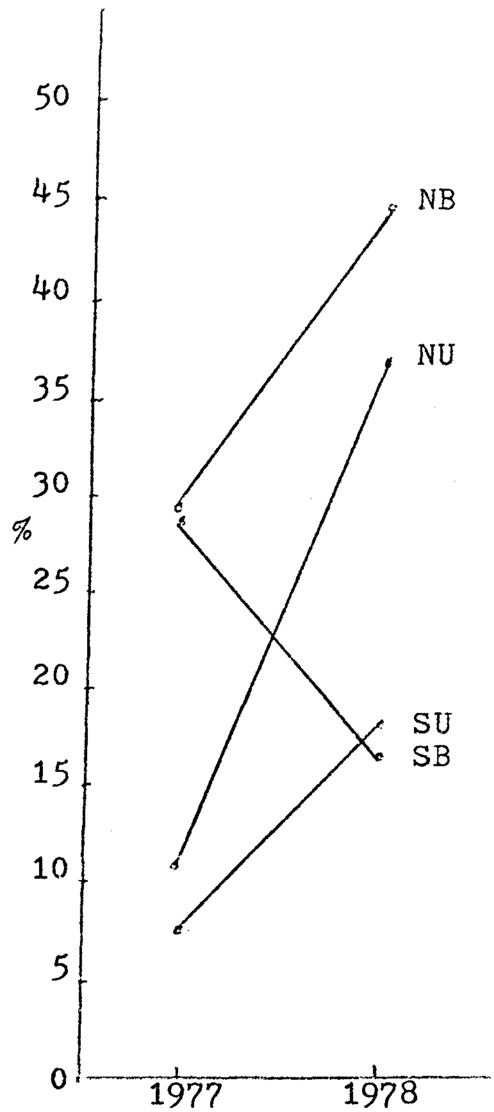


Figure 11-B
Differences between Importance values of *S. gigantea* in 1977 and 1978.

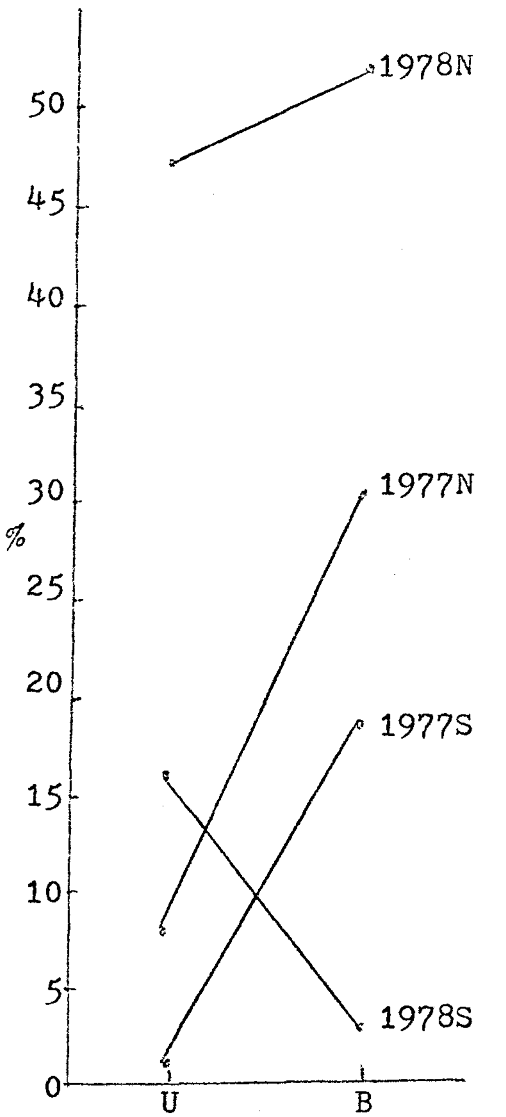


Figure 11-C
Differences between Relative coverage of S. gigantea for burned and unburned areas.

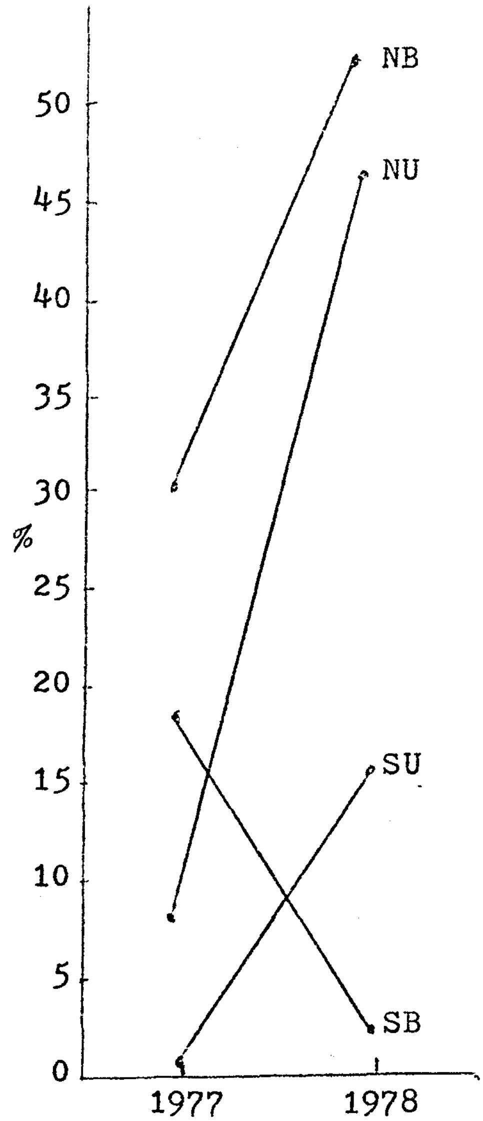


Figure 11-D
Differences between Relative coverage of S. gigantea in 1977 and 1978.

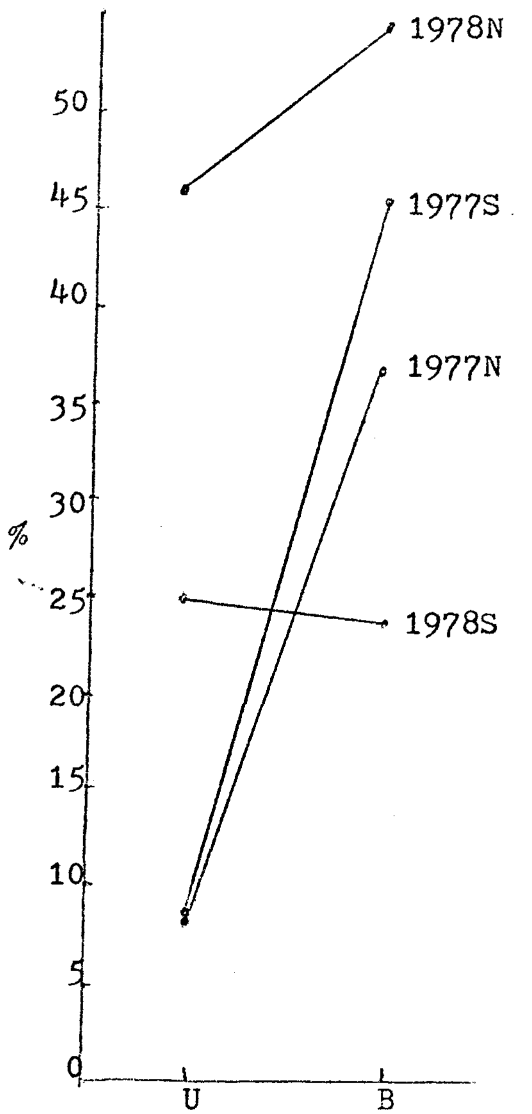


Figure 11-E
Differences between
Relative density of
S. gigantea for burned
and unburned areas.

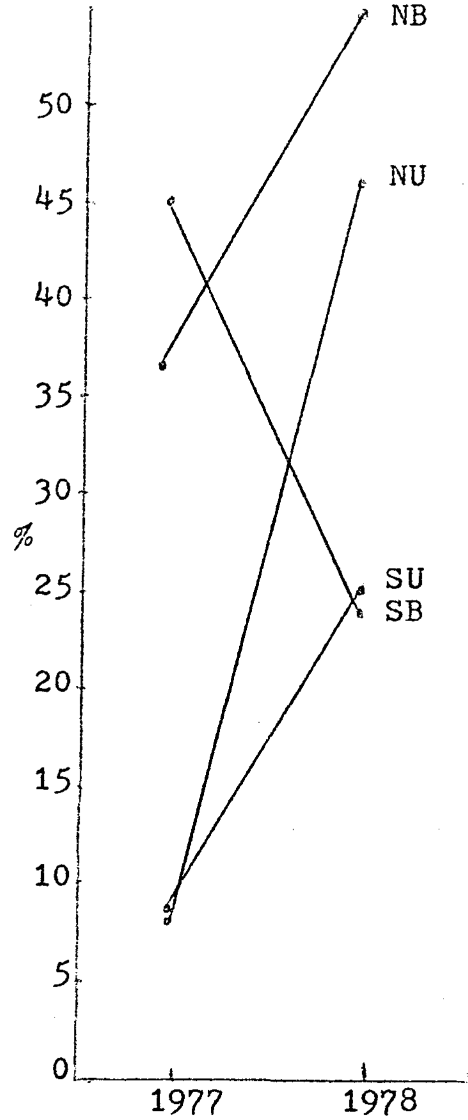


Figure 11-F
Differences between
Relative density of
S. gigantea for 1977
and 1978.

DISCUSSION

The variety of responses to fire by various prairie species in this study indicates that fire is not beneficial to all prairie plants, and therefore the hypothesis that fire promotes prairie vegetation must be accepted only with some alterations. In the long run, prairie vegetation is probably favored by periodic fires, but in the short run, species diversity in the prairie is reduced by fire. The one shrub and one weed included in this study were set back by fire but not killed. Some prairie plants are enhanced by fire, some are hindered by fire, and yet others are apparently unaffected by fire.

Since there is much variation among the species studied, they will be discussed first according to similar fire responses.

Aster ericoides, _Aster laevis_, _and_ _Aster novae-anglicae_ were seen extensively in areas of the prairie that were unburned, especially in areas without shrubs. Although fire reduces the asters present in areas without shrubs, they are not reduced as extensively as _Cornus racemosa_ in areas with shrubs. It seems possible that the asters are intermediate between prairie plants, such as grasses, and shrubs in competitive and fire-resisting abilities.

On the other hand, since asters are found in wetter regions of mesic prairies (Vierling, 1976), and since the study site is in one of the wetter regions of Wolf Road Prairie, moisture and drainage may play a part in conjunction with fire in affecting aster populations.

Calamagrostis canadensis seemed to increase as a result of burning. The largest increase was found in areas without shrubs, and the removal of litter, shrubs, weeds, and some forbs probably enabled it to spread vegetatively. Cooper (1961) feels that grasses are better adapted to withstand fire than are woody plants because the growing point of dormant grasses is below ground and only one year's growth will be removed by burning.

In unburned areas with shrubs, the amount of *C. canadensis* decreased by the second season, probably due to the same reasons it increased in burned areas-- the presence of shrubs, increased amounts of litter, and competition with taller woody plants tending to shade it out.

Since some prairies have been described as being maintained for years without burning (Betz and Cole, 1969), it would seem that in areas without shrubs, C. canadensis did increase without the effects of fire, although the increases were not as great as those in burned areas.

Although some species seemed to level off their increases by the second year, C. canadensis was even more vigorous the second season, producing many flowers and seeds. During the first season no flower production was observed. It might prove interesting to see if, in future seasons, this flower production would have any effect in increasing or maintaining C. canadensis levels in the area.

Cirsium discolor was the one alien species studied and it was only found in areas that were unburned. However, it appeared in amounts too insignificant to say that fire was the sole cause of it's disappearance, although it was probably a factor.

Cornus racemosa, although by no means dominant throughout the prairie, was the only noteworthy shrub in the study area. The amount of coverage was much more reduced after burning than the amount of density due to the fact that most plants were burned back by the fire rather than being completely killed. By the second season many of the shrubs had resprouted, although they were much less extensive than in the unburned areas. Figures 3 and 5 give a good idea of what the burned area looked like two and four months after the fire, respectively. The burned shrubs can be seen in the background. These shrubs resprouted later in the season. Further studies could possibly be done to compare the effects of fire on the burr oak, a prairie tree, and some invading shrubs. These burr oak trees, which were able to resist fires in the historical past, are unique today in Wolf Road Prairie in Illinois, although they were present throughout much of the area and able to support forbs and grasses under their canopy (Kilburn, 1959).

Coreopsis tripteris is a prairie plant that seems to do better on a short term basis in unburned areas, and, to a lesser extent, in areas without shrubs. This species is a prolific blooming plant and seed producer, as well as being able to reproduce by underground runners (Wivagg, personal communication). It would seem to be a strong competitor for sunlight, and able to colonize vegetatively in all the study areas; it's higher importance values in 1978 attested to this. C. tripteris would perhaps benefit in the long term from a burn due to the easier colonization possibilities that would result.

Gentiana andrewsii, Pycnanthemum virginiana, and Silphium terebinthinaceum appeared in such small numbers that it is more difficult to determine any effects due to burning. None of these species were present in the burned areas. It would be interesting to see how other areas in the prairie containing more of Silphium terebinthinaceum are affected by fire.

Rosa carolina seemed to be unaffected by burning. It was present in all the plots that were sampled. This may suggest that factors other than burning, such as the amount of moisture or drainage, may figure into the competition of this species.

The most dramatic effects of burning seen in this study were on Solidago gigantea. This species was much more prominent and had higher importance values in areas that were burned, even more so in areas originally without shrubs. However, by the second season, the importance values in burned areas with shrubs decreased, due to the probable increased competition from resprouting shrubs. All other areas had larger amounts of S. gigantea the second season. In burned areas there were no more than three or four dominant species to be found. S. gigantea was probably the most important species, and Calamagrostis canadensis the second most important.

Since Solidago sp. have been found to increase in large amounts in burned prairies the first year after a fire, and one particular species, S. rigida, showed a need for a fire for maintainence and establishment in other studies, the results above correlate with earlier works (Shelford, 1959; Dix and Butler, 1954; Curtis and Partch, 1948; Zimmerman and Kucera, 1977).

Taking the effects of fire on the prairie as a whole, it can be seen that many plants are doing different things simultaneously and that burning affects no two species in exactly the same way. Connell (1978) suggests that at climax species diversity is lower and that communities such as the tropical rain forest and coral reefs (with high diversity) are kept at non-equilibrium by various disturbances. Assuming the fire to be the disturbance in the prairie, this view tends to contradict what is seen here. These results show a lower species diversity as a result of the fire disturbance. The length of time after the disturbance is probably critical. For the short term effects on the prairie, fire reduces species diversity, but it may be that in the long term, fire enables species diversity to increase by giving more space for other prairie species to colonize. Litter removal by burning enables plants and seeds to get a 2-3 week headstart over plants in unburned areas (Ehrenreich, 1959).

Indeed, the mature prairie has a high species diversity; there are over 130 native plants in the Wolf Road Prairie alone (Save the Prairie Society pamphelet), not to mention many alein plants. It may be that fire acts, in part, as the disturbance that keeps the prairie from turning into a forest.

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APPENDIX A

APPENDIX

Species Name	RELATIVE FREQUENCY (%) Unburned plots: Shrub areas 1977	Shrub areas 1978	Non-shrub areas 1977	Non-shrub areas 1978
Aster ericoides	13.33	9.40	14.28	10.30
Aster laevis	13.33	3.10	14.28	13.80
Aster novae-anglicae	0.00	0.00	0.00	3.40
Calamagrostis canadensis	13.33	9.40	14.28	10.30
Cirsium discolor	6.66	6.30	0.00	10.30
Coreopsis tripteris	13.33	15.60	14.28	17.20
Cornus racemosa	13.33	15.60	0.00	0.00
Gentiana andrewsii	0.00	3.10	7.14	0.00
Pycnanthemum virginiana	0.00	9.40	0.00	6.90
Rosa carolina	13.33	6.30	7.14	3.40
Silphium terebinthinaceum	0.00	6.30	14.28	6.90
Solidago gigantea	13.33	15.60	14.28	17.20
Species Name	**Burned plots: Shrub areas 1977**	**Shrub areas 1978**	**Non-shrub areas 1977**	**Non-shrub areas 1978**
Aster ericoides	10.00	13.00	10.00	0.00
Aster laevis	0.00	0.00	0.00	0.00
Aster novae-anglicae	10.00	0.00	0.00	0.00
Calamagrostis canadensis	10.00	8.70	20.00	27.80
Cirsium discolor	0.00	0.00	0.00	0.00
Coreopsis tripteris	10.00	13.00	10.00	16.70
Cornus racemosa	20.00	21.70	0.00	0.00
Gentiana andrewsii	0.00	0.00	0.00	0.00
Pycnanthemum virginiana	10.00	8.70	10.00	0.00
Rosa carolina	10.00	13.00	20.00	22.20
Silphium terebinthinaceum	0.00	0.00	10.00	5.60
Solidago gigantea	20.00	21.70	20.00	27.80

Relative Frequency Values for 1977 and 1978

APPROVAL SHEET

The thesis submitted by Thomas K. Shaughnessy has been read and approved by the following committee:

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

Daniel E. Wivagg April 23, 1979