

# EFFECTS OF GROUND FIRE ON SPRING WILDFLOWER POPULATIONS OF OAK-HICKORY FORESTS

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**ABSTRACT.**—Two forested areas, located in East-Central Illinois and West-Central Indiana, sustained ground fire in the spring and fall of 1971, respectively. The spring herbaceous stratum was sampled by 32 square meter plots in the burned and unburned sections of each study site. Significant changes in density were recorded for 8 of 11 wildflower species in the spring-burned tract; 8 of 19 wildflower species had significant density differences due to fall burning. Frequency changes were significant for 7 and 6 species, respectively. Species characteristic of undisturbed forest conditions decreased substantially in density and frequency; whereas, species commonly found on disturbance forest sites increased markedly.

The role of fire as a modifier of forest composition and succession patterns has been documented by numerous workers (Lemon 1949; Buell and Cantlon 1953; Hodgkins 1958; Ahlgren 1960; Cooper 1960). The voluminous forest fire literature was reviewed by Ahlgren and Ahlgren (1960), and Cushwa (1968) summarized more than 800 bibliographic entries concerning fire for a 40-year period. Despite this considerable interest in fire ecology, and although deliberate or inadvertent burning of eastern deciduous forests occurs frequently, few studies have dealt specifically with the effects of ground fires on spring wildflower populations of hardwood forest communities.

Fortuitous burning of two areas in west-central Indiana and adjacent Illinois provided the basis for this study. A portion of one forested tract in Clark County, Illinois, was burned by light ground fire on April 11, 1971. Similar burning occurred in Vigo County, Indiana, in late October of the same year. Neither area had any evidence of previous burning in the recent past. Since both sites were similar, had similar forest cover and were located only 8½ airline miles apart, the major variable was time of burning.

The aims of this study were as follows: 1) To examine the effects of ground fire on the density, frequency and diversity of spring wildflower populations occurring in adjacent burned and unburned areas; 2) To determine if the effects of spring burning after most species had vernalized was more serious than fall burning when herbaceous species were dormant.

## STUDY SITES

The Vigo County, Indiana, site contains about 15 acres of upland oak-hickory dominated hardwood forest that has sustained only minor disturbance during the past 30 to 40 years. Young trees (to 24" diameter) create a nearly-closed canopy. The stand is located adjacent to the Village of St. Mary's of the Woods in the N½, SW¼, Sect. 1, Twp. 12 N, Range 10 W. The study section occupies a northeast-facing slope of 47%.

About ½ acre of the area was burned by light ground fire in late October, 1971. Apparently a roadside debris fire escaped and burned into the woods before it was extinguished naturally. Although moderately moist conditions prevailed, all leaf litter was burned and some shrubs and tree reproduction were

killed. The only variable of consequence between the burned and unburned sections was burning, as vegetative cover, topography, soils and other environmental conditions were similar.

The Clark County, Illinois, site contains about 80 acres of oak-hickory forest that has sustained no cutting or grazing for at least 30 years. Canopy trees (to 32" diameter) provide closed canopy conditions. The stand is located  $1\frac{1}{4}$  miles southwest of the village of Dennison in the  $W\frac{1}{2}$ ,  $SW\frac{1}{4}$ , Sect. 35, Twp. 12 N, Range 11 W. The study site occupies a southwest-facing slope of 7%. There were no apparent environmental differences between the burned and unburned sections.

About 2 acres were burned by ground fire that escaped from a burning fence row on April 11, 1971. All woody stems under 2 inches diameter and all above-ground portions of vernalized spring wildflowers were killed. No fire-caused mortality of mature trees was noted. The Dennison fire, which was fanned by spring winds, burned at higher temperatures than did the St. Mary's burn. Ground fuels were extremely dry due to the absence of spring rains for over 3 weeks. All leaf litter and smaller dead limbs were completely consumed by the fire.

#### METHODS

Thirty-two sample plots were laid out in each of the burned and unburned portions of each study site in early March, 1972. Plots were systematically located 1 meter apart along transects that ran normal to the slope axis. Rectangular plots  $\frac{1}{2}$  m x 2 m were used to facilitate tallying from the plot perimeter.

Full counts of all identifiable spring herbs were taken in each plot. Tallies were taken on April 11 and May 2 at the St. Mary's, Indiana,

site, and on April 14 and May 6 at the Dennison, Illinois, location.

Species attributes of total density, relative density, and frequency were calculated separately for the burned and unburned sections of each study location for each sampling time. Computations were based on the 32 plots considered collectively as separate communities or "stands." Diversity indices were computed for each of the four areas according to Simpson's (1949) formula.

Differences in density and frequency values for each species and for total density in each comparison were tested for significance by Chi-square analysis, using one degree of freedom. Data for the unburned sections were considered to be the expected values; whereas, data for the burned sections were taken as observed values. Computations were Fortran-run on an IBM 360 Series Model 50 computer at Indiana State University.

Species nomenclature follows Fernald (1950).

#### RESULTS

The herbaceous stratum at St. Mary's was dominated by *Claytonia virginica* L. and *Viola* spp. (non-flowering individuals could not be separated) in both the unburned and burned sections, where the two species comprised 50 and 59% of the total density, respectively (Table 1). Fall burning had little effect, on the rate of vernalization at the time of either count. Significant differences in density did occur for 8 of the 10 species in the burned section, however (Table 1). The total density for all species was also significantly lower (627 vs. 569). Three taxa (*Viola* spp., *Ranunculus acris* L. and *Anemonella thalictroides* L.) increased in density in the burned section. Six of the remaining seven species experienced

TABLE 1.—Effects of fall burning on densities of spring wildflower populations at St. Mary's of the Woods, Vigo County, Indiana. (Counts are based on 32 plots each 1 m<sup>2</sup>. Sampled May 2, 1972. Burned in late October 1971.)

Species	Total Density		% Change in Density	Relative Density	
	U	B		U	B
<i>Claytonia virginica</i>	216	179**	— 17	34.	32.
<i>Viola</i> spp.	96	155**	+ 61	15.	27. **
<i>Dentaria laciniata</i>	87	47*	— 46	14.	8.3
<i>Dicentra</i> spp.	72	65	— 10	12.	11.
<i>Galium aparine</i>	57	28**	— 51	9.1	4.9
<i>Polygonatum pubescens</i>	32	2**	— 94	5.1	0.4*
<i>Ranunculus acris</i>	26	44**	+ 69	4.1	7.7*
<i>Galium concinnum</i>	20	16	— 20	3.2	2.8
<i>Podophyllum peltatum</i>	12	3**	— 75	1.9	0.5
<i>Anemone thalictroides</i>	9	30**	+233	1.4	5.3**
Total	627	569*	— 9		
X Density per plot	19.6	17.8			

\* Significant at the .05 level.

\*\* Significant at the .01 level.

significant decreases in the burned area. *Dicentra* spp. (the two species could not be positively separated in vegetative stage) decreased only slightly.

Frequency changes in response to burning were not as pronounced as those for density. Only *Viola* spp. and *A. thalictroides* increased significantly in frequency; *Dentaria laciniata* Muhl., *Polygonatum pubescens* Willd., *Podophyllum peltatum* L. and *Galium concinnum* T. & G. all had significantly lower frequency percentages (Fig. 1).

Five species other than spring wildflowers appeared in the herbaceous stratum at St. Mary's. These species doubled the total density in the unburned section and increased the density by over 50% in the burned portion. When all species were considered, the total density in the unburned area exceeded that in the burned area by 334 (1294 vs. 960). The herbaceous fragile fern (*Cystopteris fragilis* Bernh.) and

blue wood aster (*Aster cordifolius* L.) had highly significant decreases in the burned section; whereas the woody Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.) increased significantly. Common cinquefoil (*Potentilla simplex* Michx.) and round-leaved greenbriar (*Smilax rotundifolia* L.) were present in the burned areas as infrequent species.

The Dennison, Illinois, herbaceous community on the unburned substrate was dominated by cut-leaf toothwort (*Dentaria laciniata*), may-apple (*Podophyllum peltatum*) and trout-lily (*Erythronium americanum* Ker.) which totalled 72% of stand density (Table 2). Major shifts in dominants occurred in the burned section. Toothwort was still the leading species, but *Viola* spp. and Jack-in-the-pulpit (*Arisaema atrorubens* (Ait.) Blume) increased greatly to become the second and third dominants. These three species totalled 65% of the relative density.

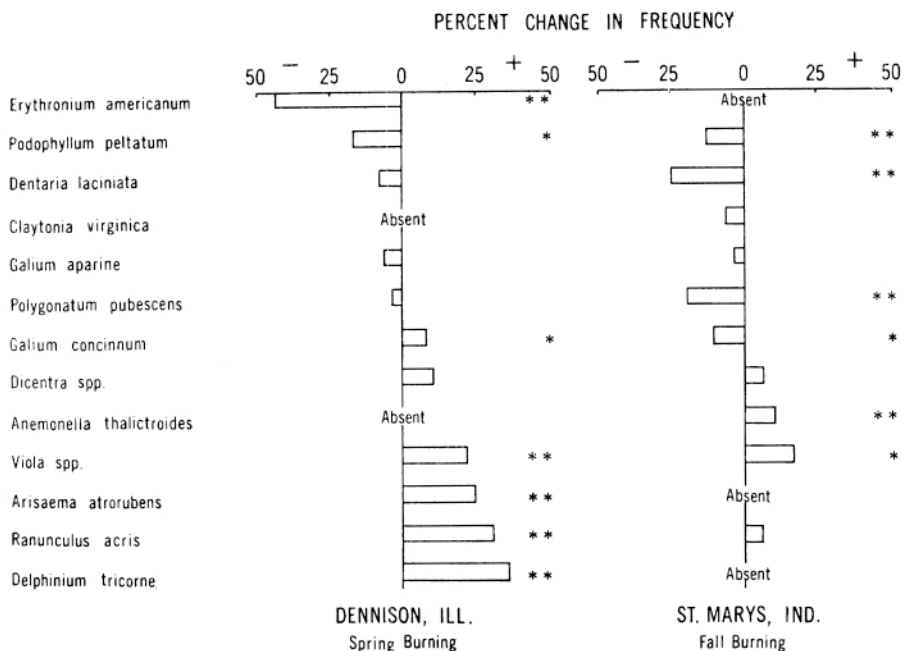


FIGURE 1. Changes in frequency of occurrence of spring herbs due to spring (left) and fall (right) burning. (\*Significant at the .05 level; \*\*Significant at the .01 level)

TABLE 2. Effects of spring burning on densities of spring wildflower populations at Dennison, Clark County, Illinois. (Counts are based on 32 plots each 1 m<sup>2</sup>. Sampled May 6, 1972. Burned April 11, 1971.)

Species	Total Density		% Change in Density	Relative Density	
	U	B		U	B
<i>Dentaria laciniata</i>	463	320**	- 31	44.	32. *
<i>Podophyllum peltatum</i>	187	33**	- 83	18.	3.3**
<i>Erythronium americanum</i>	112	3**	- 97	11.	0.3**
<i>Dicentra spp.</i>	94	73	- 22	8.9	7.4**
<i>Viola spp.</i>	56	221**	+ 295	5.3	22. **
<i>Galium aparine</i>	44	34	- 23	4.2	3.4
<i>Galium concinnum</i>	27	44*	+ 63	2.6	4.4
<i>Arisaema atrorubens</i>	21	114**	+ 443	2.0	12. **
<i>Ranunculus acris</i>	19	72**	+ 279	1.8	7.3**
<i>Polygonatum pubescens</i>	17	15	- 12	1.5	1.5
<i>Delphinium tricorne</i>	14	61**	+ 336	1.3	6.2**
Total	1,054	990	- 6		
X Density per plot	32.9	30.9			

\* Significant at the .05 level.

\*\* Significant at the .01 level.

Spring burning, which destroyed the above-ground portions of most species, substantially retarded the rate of vernalization in the herbaceous stratum during the year following burning. The early Dennison count on April 14 revealed double the total density in the unburned area (1,398 vs. 713); the total species in the herbaceous stratum was reversed, however, with 8 in the unburned and 14 species in the burned portion of the tract. The second count (May 6) showed nearly equal total densities (1,487 vs. 1,470) and 11 versus 15 species.

Data for only the wildflower species are shown in Table 2. At the second count, 8 of the 11 species had significant or highly significant density changes in the burned section. Frequency values were significantly different for 7 species (Fig. 1). Five of the 11 species, *Viola* spp., pretty bedstraw (*G. concinnum*), Jack-in-the-pulpit (*A. atrorubens*), tall buttercup (*R. acris*), and rock larkspur (*Delphinium tricorne* Michx.) increased significantly. Jack-in-the-pulpit experienced major gains in density as a result of germination of many seeds in the burned section. The three dominant species all experienced significant decreases in density (Table 2), and two of the three had significantly lower frequencies (Fig. 1). The two *Dicentra* species, *G. aparine* L. and *P. pubescens*, all experienced minor

density reductions. Three non-wildflower species recorded in the May 6 tally increased the total density by over 40% in each case to 1,487 and 1,470 in the unburned and burned areas, respectively. Virginia creeper was very common in the unburned and nearly absent in the burned area. Clearweed (*Pilea pumila* (L.) Gray) exhibited an opposite pattern. Fragile fern was present in only the burned area at a relatively high frequency and density.

Diversity changes were minor as indicated in Table 3. Fall burning at the St. Mary's area caused a slight decrease in diversity. Spring burning at the Dennison tract resulted in increased diversity at the end of a year following burning. Diversity changes resulted primarily from differences in the equitability component, as the species richness was identical in the burned and unburned sections at St. Mary's. Four additional species were found in the burned section at Dennison (not listed in Table 2), but each was represented by 10 or fewer individuals.

#### DISCUSSION

Although density and frequency differences for some herbaceous species may be due to chance, the changes reported here follow expected trends subsequent to burning. Three interesting patterns of change occurred at both study sites (Tables 1 and 2): 1) Most wildflower species

TABLE 3. Diversity indices for unburned and burned sections at the two study sites. Diversity calculations follow Simpson (1949).

Community	Diversity Index
St. Mary's	
Unburned	.187
Burned	.204
Dennison	
Unburned	.249
Burned	.178

“typical” of relatively undisturbed forest areas had density declines of about 20% in the burned sections. Examples are *Podophyllum peltatum*, *Erythronium americanum*, *Dentaria laciniata*, *Dicentra* spp., *Claytonia virginica*, and *Galium aparine*; 2) Species that commonly occur in forested areas, but frequently occupy less stabilized sites increased in density by 60% or more following fire. Examples include the species of *Viola* considered collectively (some species may have actually declined, while others increased proportionally more), *Ranunculus acris*, *Delphinium tricornis* and *Parthenocissus quinquefolia*; and 3) Species that occur in disturbance forest sites were found only in the burned sections. Examples are *Smilax rotundifolia* and *Potentilla simplex*.

Our results are similar to the few earlier reports involving the effects of fire on understory species in common with our sites. Marked increases in burned forest lands have been reported for *Viola* (Ahlgren 1960), *Parthenocissus* (Oosting 1944) and *Smilax* (Lay 1956). Lemon (1949) reported increased diversity of forest herbs and lesser woody species. We found that spring burning slightly increased diversity but that fall burning did not (Table 3). Buell and Cantlon (1953) and Hodgkins (1958) found that cover of forest forbs increased during the first growing season following fire. Although we did not record cover, the “greenness” of burned sections was noticeably greater than in unburned areas. This resulted largely from substantial density increases in *Viola*, *Ranunculus*, *Arisaema* and *Delphinium*, and increased lushness of most species following fertilizing action of nutrients from the ash. Such changes in species composition and vitality control the nature of herbaceous succession following fire, but dominance by increaser or invader

forbs may be short-lived as woody and grass cover increase (Oosting 1944; Hodgkins 1958).

Burning also influenced the ratio of non-flowering to flowering individuals for some species. The substantial increase in *Arisaema atrorubens* resulted from widespread germination of seeds after fire as few mature flowering individuals occurred in the burned area. Much of the density represented by *Dentaria* and *Claytonia* in the burned areas was also comprised of small, non-flowering individuals which probably represented first-year growth. Otherwise, density reductions in these species due to burning would have been greater. Increased light, mineralization of soil organic matter and the removal of the litter layer from the seedbed enhance germination of many forest species. Scarification of hard seeds by fire may improve germination success of some species. Little is known of the time span of viability of most wildflower seeds in the forest litter or soil. Burning sets back succession in the sub-canopy strata, and the survival strategy of species characteristic of earlier seral stages is rapid invasion into disturbance sites. Stimulated germination of stored seeds and rapid growth following burning would greatly favor such species relative to herbs typical of later stages.

On the other hand, perennial herbaceous species representative of more stabilized communities are largely vegetatively reproduced and would suffer reductions unless their reproductive parts were resistant to fire or well sheltered from fire by sufficient soil. Regeneration would then occur more slowly as seeds were brought in from unburned areas. Species with shallow corms or rhizomes should be most susceptible to fire, with corresponding reductions in chances of recovery by

vegetative reproduction. However, a ground fire that moves rapidly through dry litter probably does not heat the soil substantially to very deep levels for very long periods. Heyward (1938) found that fires in the longleaf pine region heated the upper inch of soil to only 175° F for 2-4 minutes. Moisture in the upper layers of organic forest soils, however, may form steam during ground fires. Such moist heat is more damaging to living tissue than dry heat from fires occurring on drier sites (Ahlgren 1960). This relationship may account for similar density and frequency changes observed in this study following both spring and fall burning. Soils were more moist from fall rains than was the case at the time of the spring fire. Steam produced underground by the fall fires could have killed even the dormant herbs. Most of the species experiencing the greatest density reductions at both sites have rather shallow perennating structures except *Erythronium*. Depletion of carbohydrate reserves due to spring burning may have reduced the recuperative capacity of surviving below-ground structures in that species.

The paucity of data on the effects of burning on forest herbs of this region indicates a need for additional study. Controlled burns of pre-sampled areas, followed by relatively long term post-fire succession studies would answer many questions.

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