CONTROLLED BURNING STUDIES IN OLD FIELDS

CLIFTON J. WHITEHEAD, Tennessee Wildlife Resources Agency, Nashville, TN 37204
CHESTER A. McCONNELL, Wildlife Management Institute, Lawrenceburg, TN 38464

Abstract: A split-plot design was used to determine the effects of controlled burning at various seasons on vegetative communities in old fields on the Laurel Hill Wildlife Management Area. Analysis of variance indicated no differences in the frequencies of grasses, legumes, and forbes resulting from September, December, March and May burns. Split-plot analysis of variance of frequencies of legumes, grasses, and forbes and frequency differences between burned and control plots indicated that benefits to bobwhite quail (*colinus virginianas*) (decreases in grasses and increases in legumes and forbes) can only be achieved through annual burnings, and periodic burnings may be detrimental to bobwhite quail. It was recommended that if benefits to bobwhite quail are expected, controlled burns should be conducted annually.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 33: 88-95

With few exceptions, upland wildlife has a marked affinity for subclimax plant associations. Wildlife management involves maintaining subclimax plant associations in vigorous condition, high density, and proper condition. Burning, plowing, disking, mowing, grazing, and herbicide treatments are common methods used to deter natural plant succession.

Research in other sections of the country indicates that selective use of controlled fires is a very beneficial tool in wildlife management (Frye 1961, Hornsby et al 1962, Sullivan et al 1963, Marshall 1953). This research has also shown that the proper time to burn to get desired results will vary at different locations. Information on the proper timing of control burning in the Central Southeastern United States is needed as a management technique for quail, rabbits, turkey, and deer. Poor soil and rough terrain make many areas in Tennessee undesirable for agricultural production; however, these areas do support small wildlife populations. Economical methods of increasing wildlife potentials on these lands needed investigation. Fire has proven to be an economical and rapid tool to manipulate vegetative composition.

In 1969, a study to investigate the use of fire and burning techniques for upland game management was initiated on the Laurel Hill Wildlife Management Area in Lawrence County, Tennessee. This area is approximately 5666 ha in size of which 4936 ha acres is composed of second growth deciduous hardwoods with a few small scattered stands of pine and the remaining 292 ha is in open land. Approximately 80 ha of the open land is planted to agricultural crops through share-crop agreements with local farmers. Primary crops are soybeans, winter wheat, and bean-millet hay. The remaining 212 ha of open land is in fallow or old fields of weeds, grasses, and forbes. This study was conducted in the old, fallow fields.

The objective of this study was to determine the effects of fire at different seasons of the year on grasses, legumes, and forbes so that exact effects and best fire chronology could be determined.

Appreciation is given to D. Turner of the Southeastern Cooperative Wildlife Statistics Study for his help on statistical analysis of the information gathered.

MATERIALS AND METHODS

A total of eight 0.2 ha study plots was established on old field sites on the Laurel Hill Wildlife Management Area. Plots were selected to minimize variations in soil properties, elevation, and slope. Each study plot was subdivided into 2 equal 0.1 ha subplots to provide a paired control for each treatment plot. Two subplots were randomly selected for control burning during each of the months of February, May, August, and November. A control burn was conducted on randomly selected subplots in each of the plots. The subplot of each plot not selected for burning received no manipulation and served as the control plot for each burning period.

Vegetation surveys were conducted as follows: (1) 1 survey was conducted on each subplot prior to the burns, and (2) surveys were conducted periodically (approximately every 10 weeks during the growing season) after the burns for 4 consecutive years to measure alterations of plant compositions and quantity of each plant species. The line transect method was used in the following manner, four permanent transects, 32.8 m long, were randomly selected and established in each plot, 2 in the subplot to be control burned, and 2 in the subplot that remained unaltered. Steel pipes were driven in the ground to mark both ends of each transect line. A steel measuring tape was used in the survey. Herbaceous vegetation touching the .3 m marks or the plumb line up to 1.3 m above the marks were recorded. One hundred recordings were made on each line. Detailed records of each survey were recorded.

Records were made of the following burning conditons: (1) weather data (temperature, humidity, wind direction, wind velocity); (2) fuel types (dried vegetation) and amount; (3) soil temperature; and (4) soil moisture contents prior to each burn. Monthly temperature (high, low, and mean) and rainfall were recorded during the entire study for possible use in study analysis and evaluation.

The study was designed according to the split or nested plot design described by Snedecor and Cochran (1967). This technique produces precise information on 1 factor (burning) and on the interaction of this factor with another factor (burning seasons) or factors (years).

RESULTS

A total of 118 different species of plants was found at the 6,400 check-points on the transects (Whitehead and McConnell, 1978). Seventeen species of legumes, 20 species of grasses, 61 species of forbes and 20 species of woody plants were tallied in the study plots. For the purposes of this experiment annual and perennial plants were grouped into 3 basic bobwhite quail habitat elements that occur in old fields: grasses, legumes, and forbes; woody vegetation was not used in the analyses.

After the plant species were grouped, it was decided to test for differences encountered between burning seasons first. The first step was to determine the mean frequencies of plant groups in burned and control plots during each burning season and year (Table 1). Then, the mean differences were grouped to produce mean differences between burn and control plots, plant groups and burning seasons (Tables 2 and 3).

The null hypothesis that the mean square differences between burned and control plots of each plant group obtained during each burning season were independent random samples from normal populations with the same variance was formulated. F-values were then computed from $\mathrm{Log}_{10}(X + 1)$ values of means square differences to test the null hypothesis. The F-value for legumes, grasses, and forbes were 0.86, 0.72, and 0.88 respectively. The F-value at the .05 level for 8 plots and 3 degrees of freedom is 4.07 and the null hypothesis that treatment difference did not differ between burning seasons was accepted. It was concluded that no differences in the frequencies of legumes grasses, or forbes could be expected by burning at different seasons of the year. Burning during any season of the year produced the same effect on legumes, grasses, and forbes.

Since no differences were found between burning seasons during which many different fire conditions (fuel moisture, temperatures, humidity, windspeed, etc.) were encountered, there were certainly no differences that could be attributed to fire

TABLE 1. Mean plot vegetation frequencies by burning seasons within years, Laurel Hill Wildlife Management Area, 1971-1973.

Plant Groups	Burning Season	1971 Pre-burn Plots	1971 Control Plots	1972 Burn Plots	1972 Control Plots	1973 Burn Plots	1973 Control Plots
Legumes	February	30.5	48.5	160.5	83.5	96.5	66.0
	May	37.0	49.0	19.0	27.5	104.5	38.5
	September	35.0	32.5	144.0	64.0	107.0	54.5
	December	81.0	67.5	160.5	84.0	171.0	117.5
	MEAN	45.9	49.4	121.0	64.8	119.8	69.1
Grass	February	290.5	351.5	288.5	358.5	409.5	248.0
	May	387.5	368.0	253.0	328.0	407.0	309.0
	September	323.5	348.5	321.0	315.5	471.0	262.5
	December	349.5	350.0	319.5	352.0	416.5	275.5
	MEAN	337.8	354.5	295.5	338.5	426.0	273.8
Forbes	February	556.5	638.0	896.5	679.0	774.5	739.5
	May	469.5	577.0	662.5	621.0	676.0	639.0
	September	481.0	469.0	812.5	477.5	608.0	483.0
	December	583.0	623.0	833.0	687.5	707.5	673.5
	MEAN	522.5	576.9	801.1	616.3	648.8	623.8

TABLE 2. Mean differences between burned and control plots during different burning seasons in controlled burning experiments in old fields on Laurel Hill Wildlife Management Area, 1971-1973.

Plant Groups	Burning Season	Year 1971	1972	1973
Legumes	February	-18.0	77.0	30.5
	May	-12.0	-8.5	66.0
	September	2.5	80.0	52.5
	December	13.5	76.5	53.5
Grass	February	-61.0	-70.0	161.5
	May	19.5	-75.0	98.0
	September	-25.0	5.5	208.5
	December	-0.5	-32.5	141.0
Forbes	February	-81.5	217.5	8.0
	May	107.5	41.5	37.0
	September	12.0	335.0	125.0
	December	-40.0	145.5	34.0

TABLE 3. Mean differences of plant groups occurrences between burned and control plots by burning seasons and F test results testing for differences between Log_{10} burning season differences found in controlled burning experiments in old fields on Laurel Hill Wildlife Management Area, 1971-73.

Burning Season	Plant Groups		
	Legumes	Grasses	Forbes
February	29.83	10.17	48.00
May	15.16	14.17	-9.67
September	45.0	63.00	157.33
December	47.0	36.00	46.23
F Test[a]	0.86 ns	0.12 ns	0.88 ns

[a]F test were conducted on $L_{10}(X + 1)$ values
ns - not significant at .05 level

conditions. Apparently, any burning conditions that will carry a fire will provide the same results regardless of the season.

The final job consisted of assessing the effects of burning on legumes, grasses, and forbes. The split-plot analysis of variance statistical method described by Snedecor and Cochran (1967) was chosen to test for any significant effects. An analysis of variance of the Log_{10} frequencies of each of the 3 plant groups was conducted testing for differences in replications, seasons, years, and burn treatment with interactions of burn seasons, burn seasons with years, burn seasons with burn treatments, year with burn treatment, and season with year burn treatment. The mean squares, F-values, and significance of these tests on each plant group are presented in Table 4. Four significant differences were found. The first was that the frequencies of legumes increased significantly following burning. A review of the mean frequency differences between burned and control plots for legumes, grasses and forbes presented in Table 5 along with a review of mean frequencies by burning season and years presented in Table 1 earlier easily explain the significant increases. The significant difference of frequencies for grasses for interaction of years and burn treatments and the significant differences found in frequencies of forbes between years and for interaction of years and burn treatments could not be explained by simply reviewing mean frequencies and mean frequency differences.

Another analysis of variance of the mean difference between burned and control plots was conducted on each plant group to attempt to explain the differences found in years and year and burn treatment for grasses and forbes. The results of this analysis are presented in Table 6. This analysis explained the significant differences found in interactions between year and burn treatment by pointing out the real differences were between years for grasses and forbes.

Least significant differences (lsd) tests (Snedecor and Cochran, 1967) were then conducted to explain differences in differences between burn and control plots between years for legumes, grasses, and forbes. The results of these tests are presented in Table 7. These tests further explained significant increases found in legumes following burning. These tests explained significant differences in grass by pointing out that grasses were significantly reduced ($P<.01$) following burning and that they significantly increased ($P<.01$) in year 3 of the study to significantly greater frequencies than occurred before

TABLE 4. Split-plot analysis of variance of Log_{10} frequencies of plant group occurrence found in controlled burning experiments, Laurel Hill Wildlife Management Area, 1971-1973.

Plant Group	Source	Degree of Freedom	Mean Square	F Value	Significance
Legumes	Repetition	1	0.74524	1.35	ns
	Burn Season	3	0.35286	0.64	ns
	Error (a)	3	0.55253		
	Year	2	0.21054	1.90	ns
	Burn Season x Year	6	0.10181		
	Error (b)	6	0.11067		
	Burn Treatment	1	0.73000	5.85	*
	Season x Burn Treat	3	0.11570	0.93	ns
	Year x Burn Treat	2	0.26078	2.09	ns
	Season x Year x Burn Treat	6	0.05040	0.40	ns
	Error (c)	12	0.12486		
Grasses	Repetition	1	0.00040	0.02	ns
	Burn Season	3	0.00252	0.13	ns
	Error (a)	3	0.01921		
	Year	2	0.00642	0.27	ns
	Burn Season x Year	6	0.00419	0.03	ns
	Error (b)	8	0.02302		
	Burn Treatment	1	0.16852	1.82	ns
	Season x Burn Treat	3	0.00222	0.24	ns
	Year x Burn Treat	2	0.08858	9.57	**
	Season x Year x Burn Treat	6	0.00314	0.34	ns
	Error (c)	12	0.00925		
Forbes	Repetition	1	0.04497	0.65	ns
	Burn Season	3	0.04291	0.62	ns
	Error (a)	3	0.06855		
	Year	2	0.05506	6.71	*
	Burn Season x Year	6	0.00105	0.12	ns
	Error (b)	8	0.00821		
	Burn Treatment	1	0.02176	4.19	ns
	Season x Burn Treat	3	0.01384	2.66	ns
	Year x Burn Treat	2	0.02367	4.55	*
	Season x Year x Burn Treat	6	0.00129	0.24	ns
	Error (c)	12	0.00519		

ns - not significant
* - significant at .05 level
** - significant at both .05 and .01 levels

burning. The difference found between forbes was also explained in that forbes significantly increased following burning then significantly decreased the following year.

TABLE 5. Mean frequency differences between burned and control plots during different years, Laurel Hill Wildlife Management Area, 1971-73.

Plant Group	Year 1971	1972	1973
Legumes	-3.5	56.2	50.6
Grasses	-16.8	-43.0	152.2
Forbes	-54.4	184.9	51.0

TABLE 6. Split-plot analysis of variance of the differences of Log_{10} values on burned plot versus control plots (Y = Log_{10} (burn plot) - Log_{10} (Control Plot) in controlled burning experiments on Laurel Hill Wildlife Management Area, 1971-73.

Plant Group	Source	Degree of Freedom	Mean Square	F Value	Significance
Legumes	Repetition	1	1.50549	4.35	*
	Burn Seasons	3	0.29767	0.86	ns
	Error (a)	3	0.34598		
	Year	2	0.59777	4.18	*
	Burn Seasons x Year	6	0.12278	0.86	
	Error (b)	8	0.14294		
Grasses	Repetition	1	0.02929	0.78	ns
	Burn Seasons	3	0.00447	0.12	ns
	Error (a)	3	0.03743		
	Year	2	0.17840	17.38	**
	Burn Season x Year	6	0.00634	0.62	ns
	Error (b)	8	0.01026		
Forbes	Repetition	1	0.01066	0.34	ns
	Burn Seasons	3	0.02782	0.88	ns
	Error (a)	3	0.03146		
	Year	2	0.04748	18.76	**
	Burn Seasons x Year	6	0.00260	1.03	ns
	Error (b)	8	0.00253		

ns - not significant at .05 level
* - significant at .05 level
** - significant at both .05 level and .01 levels

It was concluded that natural succession to grasses is set back significantly the first year following burning by significant decreases in frequencies of grasses and significant increases in the frequencies of legumes and forbes. It was also concluded that natural succession is greatly accelerated in the second growing season following burning with a significant explosion of grasses.

TABLE 7. t - Tests for least significant differences of Log_{10} differences between burn plots and control plots between years of controlled burning experiments on Laurel Hill Wildlife Management Area, 1971-73.

Year	Degrees of Freedom	Log_{10} Differences Between Years	Plant Groups		
			Legumes	Grasses	Forbes
1			-0.0451	-0.0280	-0.0329
2			0.3606	-0.0677	0.1211
3			0.4752	0.2085	0.0398
	8	1971 vs 1972	-0.4087 ns	0.0397 ns	-0.1540 *
	8	1972 vs 1973	0.1146 ns	-0.2762 **	0.0813 *
	8	1971 vs 1973	-0.5203 *	-0.2365 **	0.0727 *
$lst_{.05} = {}^{1}.05{,}8^{sc}diff$			0.4358	0.0580	0.0580
$lsd_{.01} = {}^{1}.01{,}8^{sc}diff$			0.6340	0.0844	0.0844

ns - not significant at .05 level;
* - significant difference at .05 level
** - significant difference at both .05 and .01 levels

DISCUSSION

The essential elements of wildlife habitat are food, cover and water. Since bobwhite quail can obtain their water requirements from dew and succulent vegetation, the essential elements of bobwhite quail habitat are food and cover. As far as the bobwhite quail is concerned the habitat elements of food and cover in openings can be broken down into 3 subelements: grasses, legumes, and forbes.

The grasses are the most important subelement from the standpoint of cover, and legumes are the most important subelement from the standpoint of food. Forbes provide a variety of both food and cover requirements. The best habitat in openings would be maximum interspersion of these 3 subelements.

The natural succession in old fields is to progress naturally into a vegetative community composed almost entirely of grasses with few legumes and forbes. It has long been recognized that fire will set back natural succession in old fields resulting in greater interspersion of grasses, legumes and forbes and improved habitat for bobwhite quail.

Almost every bobwhite quail management publication recommends burning old fields during 1 of the 4 annual seasons on a 3 to 5-year cycle to enhance bobwhite quail habitat. While burning in old fields is a commonly recommended and used management tool, there were no publications in the literature when this study was initiated citing examples where the effects of fire on the plant communities was actually measured. All the recommendations had been based on "experiences" of the authors from causal observations and speculation rather than actual measured facts. This produced a considerable amount of contradiction from 1 publication to another on exactly what the effects of fire are and what fire chronology produces the greatest benefits.

This study was designed to measure the effects of fire at differenct seasons of the year on grasses, legumes and forbes so that exact effects and best fire chronology could be determined.

The data in this study suggest that periodic burnings recommended in most quail management publications would not be a beneficial quail management practice in the

Tennessee area studied. Periodic burnings would produce and maintain dense stands of *Andropogon* sp. grasses. Annual burnings, on the other hand, producedresults that were very beneficial to bobwhites. The burning alternative to annual burning would be not to burn at all. However, if these openings did not receive some sort of treatment they would, of course, revert to oak-hickory forest. This study suggests that practices other than controlled burning such as mowing, plowing, disking at periodic intervals might be superior bobwhite management practices for maintaining openings that cannot be treated annually.

In summary, this study indicated that any burn during any season will result in similar effects on legumes, grasses and forbes in old fields. It also strongly suggests that periodic burns on 3 to 5-year cycles might be detrimental to bobwhite quail if expected benefits are reduced frequencies of grasses and increased frequencies of legumes and forbes. This study strongly suggests that these benefits can only be achieved through annual burning. This is based on the finding that natural succession was set back the first year following burning and that natural succession was greatly accelerated the second year following burning.

LITERATURE CITED

Frye, O.E. Jr. 1961. A review of bobwhite quail management in eastern North America. Trans. N. Am. Wildl. Nat. Resour. Conf. 26:273-281.

Hornsby, R.J., J. Bruna, R. Eversole and R. Kessler. 1962. Wildlife in Kentucky agricultural programs. Trans. N. Am. Wildl. Nat. Resour. Conf. 27:202-212.

Marshall, W.H. 1953. A survey of farm-game habitat restoration programs in fifteen states. Trans. N. Am. Wildl. Conf. 18:390-412.

Snedecor, G.W., and W.G. Cochran. 1967. Statistical methods. 6th Ed. Iowa State Univ. Press, Ames. 593 pp.

Sullivan, E.G., L.G. Webb, L.K. Nelson, R.W. Murray, and F.H. Farrar. 1963. Report of the farm game committee Southeastern Section--The Wildlife Society. Proc. Conf. S.E. Assoc. Game and Fish Commissioners. 17:123-126.

Whitehead, C.J., and C.A. McConnell 1978. Final report on controlled burning in old fields, Tenn. PR-W-46-R, TWRA Tech. Rep. No. 79-11, Nashville, 31 pp.