EFFECTS OF BURNING AND FALLOWING ON VEGETATION

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ABSTRACT.—During 1954 and 1955 a study of the effects of burning and fallowing on idle land was conducted on property of the United Electric Coal Companies, Inc. near DuQuoin, Illinois. The plant families Rubiaceae, Gramineae, Juncaceae, and Polygonaceae decreased in number as a result of burning. Increases were recorded for the Compositae, Euphorbiaceae, and Leguminosae. Plants showing major increases were lanceleaf ragweed, *Ambrosia bidentata*, threeseeded mercury, *Acalypha virginica*, wild beans, *Strophostyles* spp., annual lespedezas, *Lespedeza* spp., and panic grasses, *Panicum* spp.; decreases were recorded for buttonweed, *Diodia teres*, rush, *Juncus* spp., sheep sorrel, *Rumex acetosella*, perennial rye grass, *Lolium perenne*, goldenrods, *Solidago* spp., and broomsedge, *Andropogon virginicus*. Bare ground was increased about 8 times and soil pH was changed from 6.9 to 7.4. Fallowing resulted in an increase in Gramineae, Rubiaceae, Rosaceae, Solanaceae, and Axonaceae; decreases were noted for the Compositae, Euphorbiaceae, Juncaceae, and Leguminosae. Bare ground was increased 14 times; the soil pH was unchanged. Burning and fallowing resulted in diversified habitats suitable for optimum quail utilization.

From accumulated knowledge of wildlife management there has evolved a relatively basic theory regarding availability of game. Stocking game on land that could normally support only what was already present was not the answer. Improving the habitat, and thereby increasing the carrying capacity of the land has become a fundamental concept in game management. An investigation to evaluate the effects of burning and fallowing on the vegetation, and to determine if these management techniques would be effective in establishing an environment more suitable to the bobwhite quail, *Colinus virginianus*, was prompted by this need for habitat improvement.

THE STUDY AREA

These studies were conducted on non-agricultural lands of the Fidelity Mine, a holding of the United Electric Coal Companies, Inc. located in Perry County just west of DuQuoin, Illinois. The topography of this 1200-acre area is level to gently sloping. The soil type is primarily Wynoose silt loam which is characterized by an impervious subsoil which results in little or no internal drainage (Wascher *et. al.* 1950). The limited topsoil is fine in texture with low water-holding capacity; natural fertility is poor, being deficient in calcium, potash, phosphorus, nitrogen, and organic matter. Many small gullies and outwashes have developed on the slopes.

Open fields and woodlots characterize this non-agricultural acreage. The fields, ranging in size from 3 to 20 acres, represent land that has been out of cultivation for 10 to 15 years. The woodlots of 5 to 140 acres in size were lightly to heavily cutover 15 or more years ago and

show dense to sparse stands of largely third-growth trees. At least four home sites, as evidenced by wells, vegetation and basements, once were located in this area. An old roadway bisects the area from east to west. On the east and north, the area is bordered by inter tilled farmland, on the south, by pastures and on the west, by spoilbanks.

As management practices were restricted to idle fields, general descriptions are limited to these areas. These fields had been farmed previously for the production of corn and small grains; and, it seemed apparent that a suitable plan of crop rotation or soil improvement practices was not followed. The smaller fields, located on slopes, were released from agricultural use before the more level larger fields as evidenced by the stage of plant succession.

All fields, but especially the smaller ones, were being invaded by several trees and shrubs including persimmon, *Diospyros virginiana*, sassafras, *Sassafras albidum*, oaks, *Quercus* spp., wild plum, *Prunus americana*, wild black cherry, *Prunus serotina*, elm, *Ulmus americana*, hawthorn, *Crataegus crusgalli*, dewberry, *Rubus flagellaris*, blackberry, *Rubus frondosus*, and trumpet creeper, *Campsis radicans*. The larger fields showed widely distributed trees and patches of shrubs whereas the small fields exhibited a uniform distribution of these woody species. The several drainage ways showed more mature trees of the above species as well as river birch, *Betula nigra*, sycamore, *Platanus occidentalis*, willow, *Salix nigra*, and red cedar, *Juniperus virginiana*.

The herbaceous vegetation was characteristic of idle fields of southern Illinois which are low in their natural fertility. Extensive stands of broomsedge and many herbs and grasses of which lanceleaf ragweed, goldenrod, aster, *Aster* spp., butterweed, three-seeded mercury, and broomsedge were the most common. Occurring in isolated patches where competition and soil conditions were suitable were partridge pea, *Cassia fasciculata*, rusty foil, *Crotonopsis elliptica*, sheep sorrel, lespedezas, wild beans, desmodiums, *Desmodium* spp., and beggar-ticks, *Bidens* spp. Widely dispersed were such grasses as panic, three-awned, *Aristida* spp., wheat, *Bromus secalinus* and *tectorum*, and foxtails, *Setaria* spp. Except for the severely eroded slopes these herbs and grasses exhibited in autumn dense stands of vegetation 2 to 3 feet in height. They revealed heavy accumulations of dead plant materials of 6 to 8 inches on the surface of the soil. Exceptions to this were the eroded slopes where there was little vegetation other than mosses and lichens. The general appearance, from the standpoint of habitat for upland game was one of unproductiveness because of heavy uniform cover, little natural food, and uniformity of plant species. The low populations of quail and cottontails were a direct reflection of these vegetational characteristics.

Techniques

To improve this environment for the bobwhite quail, various management practices were employed. These included controlled burning, fallowing, food-patch plantings, patch-type farming, release cutting in fence

rows, and release of pen-reared bobwhites. As this paper relates only to burning and fallowing, the techniques presented reflect these two practices.

BURNING.—Techniques of burning were similar to those previously reported (Stoddard 1941; Rosene 1955; Lehmann 1937; and Lay 1954) except for time of year and amount of area burned in any one year. Controlled burning was begun in late March in 1954 and early April in 1955 and continued intermittently until the first of May. Because of extremely dry conditions, especially in 1954, the burn was not as desired, being intense and having to be controlled by fire breaks. Most burning was during early morning hours (7 to 10 AM) as fires required attendance and could be conducted only when wind movement was low. Only the open fields were included as it was too dangerous to burn woodland. To protect desirable clumps of woody vegetation, these were isolated with plowed fire lanes. Approximately one-third of the open field acreage was burned each year.

FALLOWING.—Approximately 30 fallowed strips were prepared in March, April, and May in both years of the study. These strips were 5 to 15 feet wide and 100 to 1500 feet long. The strips were made through various types of herbaceous cover, and included virtually all the prevailing soil conditions. Many of the fallow patches were the plowed strips necessary to control the burning, or the unplanted one-half of food strips prepared for production of annual foods.

SAMPLING. In August, 1954, and July and August, 1955, an ecological study was conducted to determine the effects of burning and fallowing on the natural vegetation. Square meter quadrats (one-quarter milliacre), used in sampling the vegetation, were located at random in unburned, burned and fallowed areas. The samples were established as parts of transects, two or more in a line, or at widely scattered points. A total of 367 quadrats were studied during the 2 years. Plant composition, plant density, the per cent bare ground, average height of vegetation and soil pH were determined in each sample. Plant density was based upon the number of individual plants of each species and not number of stems. Bare ground estimates were established on the presence or absence of vegetation covering the ground when quadrats were viewed from above. The hydronium ion activity was obtained through the use of the La Motte soil testing set.

Adequacy of sample was determined largely by a noted decrease in new species as additional samples were taken. Due to the homogeneity of many sample areas, additional quadrats merely reflected the analysis of previous samples. This marked decrease was also reflected in the "S" curve when species were plotted against samples. Per cent composition of each species of plant was determined for each area and as a total for each type of managed or unmanaged area being analyzed. This was accomplished by dividing the number of individual species by the total number of individuals recorded.

PRESENTATION OF DATA

In an effort to evaluate management techniques, data from 1954 and 1955 samples were combined and analyzed. Thirty-seven families of plants representing 126 species were recorded during the 2 years of the study; included were 66 perennials, 52 annuals, and 8 biennials. Twenty-nine exotic species, mainly of European and Asian origins, were noted. Only 27 species and 11 families yielded one per cent or more of the total plant composition in one or more of the areas investigated (unmanaged, burned, and fallowed).

UNMANAGED AREAS.—Two hundred and thirteen quadrats established in the unmanaged areas yielded 30 plant families representing 91 species. Seven families, Gramineae (33.1%), Rubiaceae (20.1%), Compositae (16.7%), Euphorbiaceae (3.5%), Juncaceae (6.4%), Polygonaceae (5.3%), and Leguminosae (5.2%), comprised over 95 per cent of the plant composition (Table 1).

Gramineae, the most well represented family, consisted mainly of three awned grasses (6.3%): cheat (6.2%), panic grass (5.5%), perennial rye grass (5.1%), and brunnsedge (3.5%) (Table 2).

TABLE 1.—Per cent Composition of Major Plant Families on Unmanaged, Burned, and Fallowed Areas for 1954 and 1955, United Electric Coal Companies, Inc., Du Quoin, Illinois.

Plant Families	Unmanaged Areas			Burned Areas				Fallowed Areas		
	1954-55 Combined	1954	1955	1954-55 Combined	1954	1955	1954 Sampled in '55	1954-55 Combined	1954	1955
Gramineae	33.1	28.6	41.0	22.3	19.2	26.5	46.7	38.9	46.8	35.7
Rubiaceae	20.1	13.4	30.0	17.5	8.1	27.5	12.1	35.9	20.1	42.6
Compositae	16.7	23.9	4.9	21.2	35.6	11.7	10.0	3.1	4.8	2.5
Euphorbiaceae	8.5	10.1	6.2	12.6	15.5	10.8	4.6	.3	1.4	1.2
Juncaceae	6.4	8.3	T*	2.9	2.4	T	T	T	T	T
Polygonaceae	5.3	5.1	5.6	4.5	3.9	4.9	12.9	5.4	2.6	6.5
Leguminosae	5.2	6.2	3.8	12.8	8.6	15.5	0.9	3.1	3.9	2.7
Rosaceae	T	T	T	T	T	T	T	.8	T	T
Solanaceae	T	T	T	T	T	T	T	.9	T	T
Labiatae	T	T	T	1.1	T	T	T	T	T	T
Aizoaceae	T	T	T	T	T	T	T	4.6	10.3	2.2

* Trace—less than one per cent.

TABLE 2.—Per cent Composition of Major Plant Species on Unmanaged, Burned, and Fallowed Areas for 1954 and 1955, United Electric Coal Companies, Du Quoin, Illinois.

Species	Unmanaged	Burned	Fallowed
Buttonweed *Diodia teres*	20.1	17.5	36.0
Lanceleaf ragweed *Ambrosia bidentata*	8.7	13.9	1.4
Three-seeded mercury *Acalypha virginica*	6.6	9.3	0.7
Rushes *Juncus* spp.	6.4	2.9	0.9
Three-awned grasses *Aristida* spp.	6.3	7.7	0.2
Cheat *Bromus secalinus*	6.2	2.5	0.4
Panic grass *Panicum lanuginosum*	5.6	7.4	8.8
Sheep sorrel and dock *Rumex* spp.	5.1	4.5	5.7
Perennial rye grass *Lolium perenne*	5.1	0.6	0.2
Goldenrod *Solidago* spp.	4.2	1.8	0.3
Broomsedge *Andropogon virginicus*	3.5	1.9	2.7
Wild beans *Strophostyles* spp.	2.0	2.3	1.7
Rushfoil *Croton capsicus elliptica*	1.5	2.5	0.2
Partridge pea *Cassia fasciculata*	1.5	1.4	0.2
Tropic-seed *Sporobolus heterolepis*	1.4	—	—
Lespedezas *Lespedeza* spp.	1.4	7.5	1.1
Asters *Aster* spp.	1.3	0.6	0.3
Munro grass *Panicum agrostoides*	1.2	0.3	0.3
Common ragweed *Ambrosia artemisiifolia*	1.0	2.9	0.3
Foxtails *Setaria* spp.	0.9	0.2	1.5
Dewberry *Rubus flagellaris*	0.7	0.8	1.8
Horse nettle *Solanum carolinense*	0.6	0.3	1.9
Bluegrasses *Poa* spp.	0.5	1.1	—
Crab grasses *Digitaria* spp.	0.3	6.2	14.7
Switch grass *Panicum virgatum*	0.1	—	8.2
Carpetweed *Mollugo verticillata*	—	0.1	4.6
Mountain mint *Pycnanthemum tenuifolium*	—	1.1	—

[1] Scientific nomenclature according to Fernwald (1950).

Rubiaceae, ranking second in per cent composition, was represented by buttonweed (20.1%). This plant, the most abundant species recorded, occurred in moderate to thick stands but was only rarely recorded in dense growths of broomsedge.

Lanceleaf ragweed (8.7%), goldenrods (4.2%), asters (1.3%), and common ragweed, *Ambrosia artemisiifolia* (1.0%) were the principal components of the family Compositae. These species were scattered throughout the samples, but were less common in the dense stands of broomsedge. At the edges of woods and along waterways goldenrod and aster often formed thick, high growths.

Three-seeded mercury (6.6%) and rushfoil (1.5%) represented the family Euphorbiaceae. The former, not commonly found growing in direct sunlight was abundant in moderate to thick stands of open fields. Rushfoil was noted growing in dense patches which sometimes measured several meters in diameter.

Rushes (6.4%), belonging to the family Juncaceae, were prominent in both upland and lowland fields. Characteristic of low wet areas, these plants were evidence of the poorly drained soils of upland fields.

Polygonaceae comprised mainly of sheep sorrel, and to a lesser degree by curly dock, *Rumex crispus*, made up 5.1 per cent of the plant composition. Sheep sorrel, an indicator of acid soil, was widely distributed.

Wild beans (2.0%), the major representatives of the family Leguminosae, were recorded in many of the quadrats, but were not numerous. In areas where herbaceous cover was dense, wild bean, partridge pea (1.5%), annual lespedezas (1.4%), and other legumes were scarce.

Further analysis of the flora of the unmanaged areas revealed that, although more perennial species were recorded

than annuals or biennials, the per cent composition was not in this order. Forty-two annuals comprised 41.2 per cent of the plant composition, 45 perennials totaled 34.5 per cent, and 4 biennials yielded 4.3 per cent. The more important annuals were buttonweed, lance-leaf ragweed, three-seeded mercury, three-awned grasses, and cheat. Perennials included a rush, panic grasses, sheep sorrel, perennial rye grass, and broomsedge. The biennials were few and were represented mainly by goldenrods.

The average number of stems recorded per quadrat in the unmanaged areas was 137; the average height of vegetation was 16 inches (Table 3). Estimated per cent bare ground ranged from 0.0 to 70.0 per quadrat and averaged 3.2. Soil samples revealed a median pH of 6.9.

Burned Areas.—A total of 30 plant families totaling 99 species were recorded in 180 quadrats examined in the burned areas. Eight plant families Graminae (22.3%), Compositae (21.2%), Rubiaceae (17.5%), Leguminosae (12.8%), Euphorbiaceae (12.6%), Polygonaceae (4.5%), Juncaceae (2.9%), and Labiatae (1.1%) comprised 95.1 per cent of the plant composition (Table 1).

As in the unmanaged areas, Graminae ranked first in per cent composition. The major species were three-awned grasses (7.7%), panic grass (7.4%), and, to a lesser degree, cheat (2.5%) and broomsedge (1.9%) (Table 2). Three-awned grasses were more abundant on soils supporting a scant herbaceous cover. Broomsedge was observed growing from many of the burned clumps as well as from seeds.

Compositae ranked second in per cent composition. Lanceleaf ragweed (13.9%), a major component of this family (Table 2), occurred in uniform stands. It was the most conspicuous plant wherever burning occurred in open fields. These stands reached a height of 1½ to 2 feet. The typically small, first season's growth of goldenrods (1.6%), the taller asters (0.5%) and common ragweed (2.9%) occurred as either scattered plants or in small patches.

Buttonweed, the only member of the Rubiaceae, comprised 17.5 per cent of the plant composition. This plant was common in the herbaceous substratum and comprised the highest per cent composition of any one species in the burned areas.

Annual lespedezas (7.5%), wild beans (2.3%), and partridge pea (1.4%) were the important plants comprising the Leguminosae. Annual lespedezas were recorded in several areas, one of which was seeded after burning. In the area where seeding occurred, annual lespedeza made up 6.3 per cent of the composition whereas it comprised only 1.2 per cent of the composition in areas not seeded. Wild beans were recorded in practically every sample and were well distributed in the burned areas. Partridge pea occurred in scattered clumps several meters in diameter in many of the burned areas.

The family Euphorbiaceae was comprised mainly of three-seeded mercury (9.8%), and rushfoil (2.5%). These species like buttonweed were most common in areas having medium to light vegetation.

Polygonaceae, made up mainly of sheep sorrel and to a lesser extent curly dock, was well represented in the burned areas. Sheep sorrel was uniformly distributed and made up 4.7 per cent of the composition.

The majority of the flora of the burned areas was composed of annual herbs. Forty-six annual species comprised 71.9 per cent of the composition. The major species were buttonweed, lance-leaf ragweed, three-seeded mercury, three-awned grasses, annual lespedezas, and common ragweed. Forty-nine perennials, comprising 25.7 per cent of the composition and 5 biennials comprising 2.4 per cent, constituted the remaining species. The more prominent perennials were panic grasses, sheep sorrel, rush, and broomsedge. The important biennials were goldenrods and wild carrot *Daucus carota*.

An average of 176 plants per quadrat was recorded for burned areas (Table 3). The average height of vegetation was 15 inches and bare ground estimates ranged from 0.0 to 35.0 per cent with an average of 2.8.0 per cent. The median soil pH was 7.0 in lightly burned areas, and 7.4 in severely burned sites.

Fallowed Areas.—A total of 176 quadrats were established in the fallowed areas with 29 families and 74 plant species being recorded. Nine of the families, Graminae (38.9%), Rubiaceae (35.3%), Polygonaceae (5.4%), Aizoaceae (4.6%), Compositae (3.1%), Leguminosae (3.1%), Solonaceae (1.9%), Rosaceae (1.8%), and Euphorbiaceae (1.3%), comprised 96.7 per cent of the

TABLE 3.—Density, Per cent Bare Ground, Average Height of Vegetation, and Median pH, Recorded on Unmanaged, Burned, and Fallowed Areas for 1954 and 1955, United Electric Coal Companies, Du Quoin, Illinois.

Plant Families	Unmanaged Areas			Burned Areas				Fallowed Areas		
	1954-55 Combined	1954	1955	1954-55 Combined	1954	1955	1954 Sampled in '55	1954-55 Combined	1954	1955
Average Number Plants per Sample	137	89	226	176	125	235	253	84	24	169
Percent Bare Ground	3.2	3.0	4.2	23.0	24.0	20.8	10.0	46.0	50.0	37.5
Average Height in Inches	16	..[1]	16	15	..	15	..	9.6	..	9.6
Median pH	6.9	6.9	..	7.2	7.0[2] 7.4[3]	..	..	7.0	7.0	..

[1] Not recorded.
[2] Light Burn.
[3] Heavy Burn.

vegetation (Table 1). These families yielded 13 species with a composition of more than one per cent. Gramineae, ranking first, was well represented by crab grasses, *Digitaria spp.*, (14.7%), two species of panic grass, *Panicum lanuginosum* (8.8%) and *P. virgatum* (8.2%), broomsedge (2.7%), and foxtail grasses (1.5%) (Table 2). Crab, panic, and foxtail grasses, formed a dense carpet of vegetation with little bare ground. Broomsedge was never found in clumps but as first year seedlings.

Buttonweed (36.0%), belonging to the family Rubiaceae, had the highest per cent composition of any plant recorded on the fallow strips. Unlike its occurrence as an understory plant of the herbaceous vegetation in the unmanaged and burned areas, buttonweed was common in the open areas of the newly disturbed ground.

Sheep sorrel, a small plant common in the fallowed areas and the larger, curly dock comprised the family Polygonaceae. These plants together made up 5.1 per cent of the composition. The former, more numerous than curly dock, grew in concentrations.

Carpetweed, *Mollugo verticillata*, was one of the first plants to become established following disturbance of the soil. Of the total plants, it comprised 4.6 per cent of the composition. This plant was common in open areas or where bare ground was persistent, but soon gave way and disappeared as thicker herbaceous cover developed.

Taller herbs occurring in the flora of the fallowed areas were mainly members of the Compositae. Lanceleaf ragweed (1.4%), although not abundant, was well represented in fallowed strips not overgrown with grasses. The same was true of goldenrods (0.5%) and asters (0.3%) which had their greatest development in the second year after fallowing, often growing 2 to 6 feet high.

Two species of wild bean (1.7%), *Strophostyles leiosperma*, and *S. helvola*, belonging to the family Leguminosae, were common in fallowed strips having a moderate to light herbaceous cover. Wild beans often grew intertwined with partridge pea (0.2%), ragweeds, and other herbaceous plants.

Dewberry (1.5%), a member of the family Rosaceae, occurred most abundantly where fallowed strips dissected already established clumps. The canes of this plant were prostrate on the ground and formed tangled growths.

In the fallowed areas, 37 annuals made up 66.0 per cent of the plant composition. Thirty-two perennials totaling 34.5 per cent and 5 biennials comprising 0.5 per cent constituted the remaining composition. Important annuals such as buttonweed, crab grasses, and carpetweed comprised over one-half of the plant composition (55.2%). Perennial species having a high per cent composition were panic grasses, sheep sorrel, and broomsedge. Goldenrod was the most abundant biennial recorded.

Bare ground ranged from 0.0 to 100.0 per cent and averaged 46.0 per cent (Table 3). An average of 84 stems was recorded per quadrat. The average height of vegetation was 2.6 inches and median soil pH was 7.0.

Analysis of Effects of Burning and Fallowing

In comparing results of the unburned, burned, and fallowed areas, it was evident that about the same major plant species were present in each. Twenty-seven species constituted 90 per cent or more of the plant composition in the three areas. Nineteen major species (those having a composition of 1 per cent or more) made up 89.1 per cent of the composition on unburned sites. Seventeen species totaling 88.7 per cent and 13 species comprising 89.1 per cent made up the majority of the vegetation on the burned and fallowed areas, respectively.

Burning and fallowing resulted in an alteration as to numbers and composition of annual, perennial, and biennial species. Annual species increased from 42 on unburned land to 46 on burned areas. Perennials also increased after burning, showing 45 species in unburned areas and 49 on burned sites. On fallowed land, annual and perennial species showed 37 and 32, respectively. Biennials increased from four on the unburned land to five on burned and fallowed

areas. Annuals comprised 61.2 per cent of the vegetation on unburned areas, 71.9 per cent on burned, and 65.0 per cent on fallowed sections. Perennials represented 34.5 per cent on unburned sites, 25.7 per cent on burned sections and 34.5 per cent in fallowed strips. Biennials yielded 4.3 per cent on unburned, 2.4 on burned, and 0.5 on fallowed areas.

Many plant species increased in abundance as a result of management practices. Species showing major increases in per cent composition due to burning were lanceleaf ragweed, common ragweed, panic grasses, three-seeded mercury, wild beans, three-awned grasses, annual lespedezas, and rushfoil. All of these plants with the exception of the three-awned grasses, are good quail foods. Partridge pea, an important wildlife food, declined in per cent composition in 1954, but an increase and excellent stands were observed in all of the burned areas sampled in 1955. Plants that increased in the fallowed strips were buttonweed, panic grasses, crabgrasses, foxtail grasses, carpet weed, and horse-nettle, *Solanum carolinense*. Dewberry increased from 0.7 per cent in the unburned areas to 1.8 in fallowed strips; subdividing roots and canes probably contributed to this increase.

A few plants decreased after burning and fallowing. Sheep sorrel, rush, asters, goldenrods, cheat, buttonweed, foxtail grasses and panic grass, *Panicum agrostoides*, decreased in composition after burning. Broomsedge, which is of little value to wildlife when it occurs in large, dense stands, decreased from 3.5 per cent on unburned areas to 1.9 per cent on burned sites. Due to fallowing, lanceleaf ragweed, rushes, three-awned grasses, cheat, perennial rye grass, broomsedge, and partridge pea decreased. Broomsedge was virtually eliminated in 1954 but seedlings were recorded on a few fallow strips the following year.

Plant composition 15 to 16 months after burning, as compared to unmanaged and recently burned land, revealed a reduction of buttonweed, sedge, *Carex* sp., rushfoil, broomsedge, and the blue grasses, *Poa* spp. Three-awned grasses and dock showed considerable increases in these areas. Cheat and wild beans also yielded higher compositions in areas unburned for 15 to 16 months.

Because burning on United Electric Land was conducted in early spring, a comparison of data from areas burned in different seasons was not available. Late winter burning according to Stoddard (1941) is most desirable in the Gulf Coast States; however, burning should be conducted after danger of late frost is past. Many wild food plants, particularly partridge pea, are killed by freezing after premature germination in the fire-blackened soil (Lehmann 1937). Burning in spring, after plants have germinated, will also kill many desirable food plants; partridge pea, annual lespedezas, and other annuals will be destroyed. Wild bean, although suppressed by a late spring burn, will usually be stimulated (Lehmann 1937).

As plant composition may vary because of different seasons of burning, plant composition of fallow strips will also be affected by the time of plowing. Because the revegetation of newly disturbed ground is dependent to a large extent on

local weather conditions, it may be advisable to plow strips over a period of several months (Lehmann 1937). Unless the sole purpose of plowed strips is to control burning, strips should not be replowed until completely reverted to the natural vegetation. On our study area plowed strips were necessary in controlling fires but, in order to produce more diversified cover, new strips were plowed adjacent to older ones.

Plant Density.—Marked differences in the unburned, burned, and fallowed areas were evident in the numbers of plants per sample. The density increased from 137 plants in the unburned areas to 176 in areas sampled 3 to 4 months after burning. The greatest number of plants, 253 per quadrat, was recorded in areas sampled 15 to 16 months after burning. This increase in the number of individuals per quadrat was probably a result of the decrease of the dominants as well as more favorable conditions for the growth of dispersed or latent seeds. In the fallowed areas the average number of plants per quadrat was 83. In areas fallowed in 1955, seven times as many plants were recorded than in 1954 (24 plants per quadrat in 1954 and 169 in 1955). This increase was probably due to an increase in precipitation in the spring of 1955.

Bare Ground.—Bare ground was increased approximately 8 times in the burned areas and 14 times in fallowed areas. The ground cover on much of the idle land was composed of dead leaf materials. Broomsedge, when present in concentrated clumps, was responsible for the exclusion of much of the bare ground. On land sampled 3 to 4 months after burning, bare ground averaged 23 per cent. This increase resulted from the destruction of the thick vegetation. After the second growing season, burned areas averaged 10 per cent bare ground, being three times more than that of unmanaged land. Fallowing resulted in the most obvious change in the vegetational cover. In 1954 fallowed strips, bare ground averaged 55.0 per cent while in 1955, bare ground averaged 37.5 per cent. This increase in the vegetational cover in 1955 may have been due to the increase in spring precipitation.

Soil pH.—Although soil conditions were not studied in detail, increases in the median soil pH was noted in the burned areas. The tests for hydronium ion activity indicated a pH of 6.9 for unburned areas, 7.0 for those lightly burned, and 7.4 for those heavily burned. The relatively high readings are not in accordance with the acid conditions of the soil as determined for application of agricultural lime. However, the increase from unburned to light, to severe burn may show a trend in alteration of soil pH due to burning. Partridge pea and other legumes grow best on basic soils and if burning does alter pH, the result would definitely favor the growth of these legumes.

Burning and Fallowing as Management Tools

The unmanaged land on this property was once considered to support some of the best quail populations in southern Illinois. This was approximately 4 to 5 years after the land had been removed from culti-

vation. As the land remained idle, annual food plants and general cover conditions suitable to quail were replaced by thick, non-food producing vegetation. Eventually, with the invasion of woody herbs and trees, climax vegetation could be expected to become established. As pointed out by Lehmann (1937) a climax, whether grass or forest, is not usually favorable to quail. Food plants and cover necessary for good quail populations are those associated with the early successional stages.

To be a useful quail management tool, burning must be done often enough to sustain the most productive habitat. In Michigan, burning every 1 or 2 years produced herbaceous vegetation of bluegrass, aster and goldenrod which would last indefinitely as long as controlled burning was practiced (Beckwith 1954). Infrequent burning only retarded the natural succession and more woody plants became established. From our study, initial observations indicated that more diversified habitat was established when one-third of the land was burned each year. As a result of this plan, three specific habitats were produced, each of which meet certain needs of quail. A few months after burning, a limited amount of plant cover was established to provide some nesting cover; one successful nest was recorded from one such area. More importantly, recent burns made more seeds and insects accessible, offered dusting areas, gave a more desirable roosting habitat, and, in general, made it possible for quail to get their feet on the ground. The latter seemed to be a prime requisite in quail management programs in southeastern United States (Scott and Klimstra 1954). Evidences of the above utilization were repeatedly observed during field studies of the quail populations. In fact, greatest activity in late summer was observed in the annual food patches where cover was even less dense and more bare ground was exposed than on burned areas. In the second year after burning, the land would fulfill somewhat the same requirements. However, plant composition, density of vegetation, and per cent of bare ground would be less desirable. In areas unburned for 2 years, vegetation would be similar to that in the unmanaged fields, although broomsedge would probably not be well established. These conditions are important as sources of nesting and escape cover, and during periods of adverse climatic conditions. Desirable nesting sites for quail offer accumulated vegetation from the previous year's growth. The alternate burning suggested would offer great diversity of plants throughout a given area resulting in an environment more acceptable to wildlife.

More food and cover was provided in the open fields by protecting small trees and thickets from fire. This precaution increased the diversification of the habitat and established nesting, roosting, and escape cover, near a source of annual foods. Unburned strips along the edges of fields were also useful as a protective transitional zone between the open ground cover of the wooded fence rows and the light cover of the burned fields.

As a result of burning, mechanical stimulus or chemical alterations of the soil probably influenced the re-

sulting vegetation. Hard seed coats of partridge pea and rushfoil were possibly scarified by heat during burning resulting in greater germination. Reduction of competition, and generally more favorable growing conditions were believed responsible for the increased production of certain plants. Burning may also have made available plant foods.

Fallowed strips were not particularly important for the amount of food and cover provided; however, because bobwhite quail prefer traveling on the ground, these strips were important in linking parts of their habitat and in making more feeding areas accessible. The fallowed strips served as travel lanes, and feeding, roosting, and resting could be carried on short distances from their edges. According to Stoddard (1941: 21) ". . . the bobwhite in nesting shows a marked partiality for the vicinity of roads, paths, edges of fields, and similar open situations." In his studies, 74 per cent of all nests were within 50 feet or less of such openings. Therefore, well placed strips dividing otherwise featureless vegetation would be beneficial in producing more edge, resulting in greater diversification of vegetation. Quail prefer a light, dry soil for dusting sites, and fallowed areas would be extremely attractive.

The history of uncontrolled burning is indicative of its disastrous effects on wildlife. Controlled burning, during seasons when desirable plants are destroyed, is likewise harmful. Even though vegetational conditions were improved for quail, burning did result in the destruction of cover favorable to the cottontail rabbit. Burning was conducted at a time when rabbits were bearing young, and it is likely that some nests were destroyed. "Fire is rightly comparable to a two-edged sword. While it may be used to good advantage at times to obtain definite desired results, its abuse, or careless uncontrolled use, may be productive of great harm" (Stoddard 1941; 414).

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