increases crippling loss, and (4) skilled hunters lose fewer birds as cripples.

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THE INFLUENCE OF CONTROLLED BURNING ON NESTING PATTERNS OF BOBWHITE IN WEST TENNESSEE

By RALPH W. DIMMICK

Controlled burning has been widely used for managing plant succession in the southeastern United States. This technique has been particularly useful for retarding the encroachment of hardwood species in plantations of southern pines (*Pinus* sp.), and for maintaining herbaceous plant associations in early stages of succession. The results of controlled burning generally have been favorable for bobwhite populations, whether the burning was done for their benefit or for managing pine. More specifically, controlled burning in the deep South has increased the production of wild legumes, an important class of quail foods, and has reduced the amount of litter on the soil surface, enhancing the quail's ability to locate its food.

Controlled burning, however, may induce changes in a plant community which are not beneficial to other aspects of the quail's life history. The removal of dead grass leaves and stems, for example, reduces the amount of suitable nesting material available to quail during the first part of the nesting season, and may render areas unsuitable for nesting. Stoddard's data reworked by Rosene (1969:64) indicated that 91 percent of 581 nests were situated on areas not burned the spring immediately preceding the nesting season. Rosene (1969:63) noted also that 80 percent of 650 nests he observed were in areas containing sufficient dead grass for constructing the nest form, and implied that these areas were not burned during the preceding winter or spring. Klimstra and Scott (1957) stated that virtually all of the 352 nests which they studied in southern Illinois were constructed of dead vegetation from

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the previous or current year's growth. They regarded burning as detrimental to nesting cover on their study area. Lehmann (1946) observed that bobwhites in southwestern Texas ". . . preferred to locate nests in clumps of grass containing considerable green material . . ."; nest linings, however, were constructed almost exclusively of dead or dry grass. In east-central Texas, the amount and density of ground cover produced during winter or retained from the preceding year is important in determining early spring nesting success (Parmalee 1955).

The object of my study was to determine the effects which controlled burning exerted upon nesting patterns of bobwhites in west Tennessee. This paper reports on the relationships between controlled burning of nesting cover and the distribution of nests, the chronology of nesting attempts, and proportion of nests which produced quail chicks. I am grateful to Mr. James Bryan, Mr. James Warmbrod, and Mr. D. W. Smith, all of the Ames Plantation, for their help in conducting prescribed burning of the study area. Many students contributed to this study through their efforts to locate quail nests; particularly helpful were David Capen, William Crenshaw, Steven Tobler, Joseph Dabney, and Thomas Patrick. Funds for this study were contributed largely by McIntire-Stennis Project 3, Bobwhite quail management on forest and associated lands in west Tennessee.

THE STUDY AREA

The study was conducted on Ames Plantation, an 18,600-acre Agricultural Experiment Farm in Hardeman and Fayette counties, Tennessee. Major crops grown on the plantation include soybeans (*Glycine max*), corn (*Zea mays*), and cotton (*Gossypium hirsutum*). The production of beef cattle and forestry are other major enterprises. Each year the National Bird Dog Field Trial Championship is held on the plantation. Those grounds on which the field trials are conducted are intensively managed for quail. A 2,100-acre area on the plantation is utilized for studying the life history of quail in west Tennessee. Approximately 800 acres of the study area is suitable for nesting, though this acreage changes between years.

Five units of nesting cover within the study area, totaling approximately 200 acres, were searched for quail nests each year. These units included land used for pasture and land which had been retired from agricultural usage.

The topography of the study area is relatively flat. Soils are mostly silt loams overlying sandy substrates. These silt loams are deep, fertile, and internally well-drained. The dominant herbaceous species on idle land is broomsedge (*Andropogon virginicus*); several species of *Panicum* and *Paspalum* are also common on the nesting areas. Dense stands of partridge pea (*Chaemacrista faciculata*) frequently appear on moderately to poorly drained sites following burning. Important woody species on the nest study area include smooth sumac (*Rhus glabra*), winged sumac (*R. copelina*), sassafras (*Sassafras albidum*), and persimmon (*Diospyros virginianas*).

Numbers of quail present on the study area during spring remained relatively stable throughout the study period. The highest population occurred in 1968 (1073) and the lowest in 1970 (832), representing densities of one bird per two acres to one bird per two and one-half acres. Mean population for the period 1967-1971 was 965 quail.

METHODS

All of the nesting habitat selected for study was searched intensively for quail nests each year of the study; some portions of the area were searched two or three times during the nesting season. Three to five men conducted the nest-searching, walking adjacent to one another and parting the vegetation with staffs. Nest-searching was done during June through August.

Typically, units of nesting cover were burned in alternate years, with no more than about one-third of the nesting cover being burned in any

year. In some years poor drying conditions prevented some planned acres from burning, and wildfires occasionally burned small areas not scheduled for burning. Burning was accomplished in March each year, early enough to prevent significant damage occurring to the current season's herbaceous growth. Some units were excluded permanently from burning. For the purpose of analysis, nests were regarded as occurring in "burned" or "unburned" areas. "Burned" areas were those areas which had been satisfactorily burned during March preceding the season during which the nest had been established. Areas containing at least one full season's growth were regarded as "unburned", though burning may have been accomplished on these areas at some previous time during the study period.

Chi-square analyses were used for statistical interpretation when appropriate. All tests were conducted at the 95 percent level of probability.

RESULTS AND DISCUSSION

A total of 1106 quail nests was located during the five nesting seasons of 1967 through 1971. Of this total 534 (48.3 percent) contained eggs or fragments of eggs. The remaining nests were empty when found, and were classified as "unused". This designation is arbitrary, for some nests which contained eggs when found were "empty" when revisited. All evidence of eggs having been in the nest disappeared from some nests which were known to have hatched as well as from some which were known to have been destroyed. Thus, not all "empty" nests were "unused". Stoddard (1932:24) observed that bobwhites sometimes build nests and abandon them without laying in them, and that snakes may remove all eggs without disturbing the nest structure. He reported finding about one empty nest for every two that contained eggs, a smaller proportion of empty nests than I observed on Ames Plantation. The contribution which "unused" nests made to the nesting effort of the quail population cannot be determined accurately, however, and they were excluded from my analysis of nesting success.

Distribution of Nests

A disproportionately larger number of nests were found in "unburned" areas than in areas which were burned immediately preceding the nesting season ($p<0.05$) (Table 1). Differences were greatest in 1967, the first year that significant portions of the nest study area were burned, and in 1970 and 1971. In 1968 and 1969 the distribution of nests appeared to be correlated with the acreage of nest habitat available in each category, and the effect of burning on nest distribution seemed negligible.

TABLE 1. Relationship of bobwhite quail nests to burned and unburned nest habitats on Ames Plantation, 1967-1971.

	Burned Habitat				Unburned Habitat				Total	
Year	No. Acres	%	No. Nests	%	No. Acres	%	No. Nests	%	Acres	Nests
1967	69	33.5	6	4.9	138	66.5	117	95.1	206	123
1968	72	36.7	44	31.5	124	63.3	96	68.5	196	140
1969	35	22.4	15	19.2	121	77.6	63	80.8	156	78
1970	72	36.0	9	11.0	128	64.0	73	89.0	200	82
1971	94	47.0	33	29.7	106	53.0	78	70.3	200	111
Total	..	...	107	21.1	...	...	427	79.9	...	534

It was apparent that the effcts of burning varied widely, however, dramatically reducing a nesting area's attractiveness to quail in some cases, and scarcely altering it in others. For example, one field, four acres in size, contained 41 nests (12 with eggs) in 1967. It was burned

in March 1968, and that summer only 2 empty nests were found there. Broomsedge was dominant before and after burning, and the decrease in the area's usefulness for nesting probably reflected a lack of dead grass for constructing the nest structure. A 26.5 acre pasture responded quite differently to burning. This area contained 53 nests in 1967; 19 of these were known to contain eggs. In 1968, following controlled burning, 47 nests (40 with eggs) were located. Broomsedge was abundant in this pasture during both years, but less dense than in the previously described unit. Though the entire area was burned, both the amount of fuel and its moisture content appeared sufficiently variable to prevent a completely uniform burn. The field did not lose its attraction for nesting quail.

These examples represent extreme responses of nesting quail to fire-induced habitat alteration. Generally, where grasses remained dominant, and where some dead grass leaves and stems escaped burning, quail utilized an area for nesting the summer immediately following the spring burn. Dramatic changes in the vegetative complex, such as the appearance of dense stands of partridge pea or sericea lespedeza (*Lespedeza sericea*), or complete removal of nesting material, substantially reduced an area's value for nesting. The outcome of fire on Ames Plantation varied with the quantity and moisture content of fuel present, the soil type, and the pattern of rainfall following burning. Its effect on the distribution of nests was likewise variable.

The Chronology of Nesting

The initiation dates for 127 nesting attempts were determined accurately (Fig. 1). One hundred and one of these nests were in unburned areas, and 26 in burned areas. The peak periods for starting nests were similar on both areas, but nesting commenced much earlier on unburned areas. Few nests were constructed on burned areas prior to June 1, while nesting on unburned areas began by mid-April. The differences reflected the availability of suitable nest material for building nest structures.

Dates of hatching were known for 60 nests, 48 of these in unburned areas (Fig. 2). The distribution of hatching dates paralleled that of nest initiation dates, with the earliest hatching date of a nest in burned habitat occurring approximately one month later than the earliest hatch in unburned habitat.

Though nesting started later on burned areas than on unburned areas, nesting ceased on both areas at approximately the same time. Thus, the significant effect of controlled burning on the timing of the quail's nesting cycle is less related to the delay in the start of nesting than to the compression of the nesting effort into the latter portion of the nesting season. The impact which this will have upon the quail population's reproductive effort for a given season will depend upon the proportion of its nesting habitat which is burned and upon environmental events which occur during mid- and late summer. The buffering effect of a lengthy nesting period in preventing catastrophic nest losses will be reduced.

Success of the Nesting Effort

The final outcome was determined for 534 nests having eggs or fragments of eggs when found (Table 2). The proportion of nests successful in hatching was 23.4 percent, ranging from 15.4 percent in 1967 to 37.2 percent in 1969. Throughout its range, the bobwhite has adapted to accommodate substantial failures in its nesting effort. Losses of 50 to 75 percent of nesting attempts have been reported from Illinois (Klimstra and Scott 1957), the Georgia-Florida boundary (Stoddard 1932:184), Texas (Lehman 1946), and Wisconsin (Errington 1933). However, the bobwhite's inclination and ability to renest after a nesting failure probably compensates partially for this observed high attrition of nests. Thus it is likely that the proportion of females producing broods is much higher than the percent of successful nesting attempts.

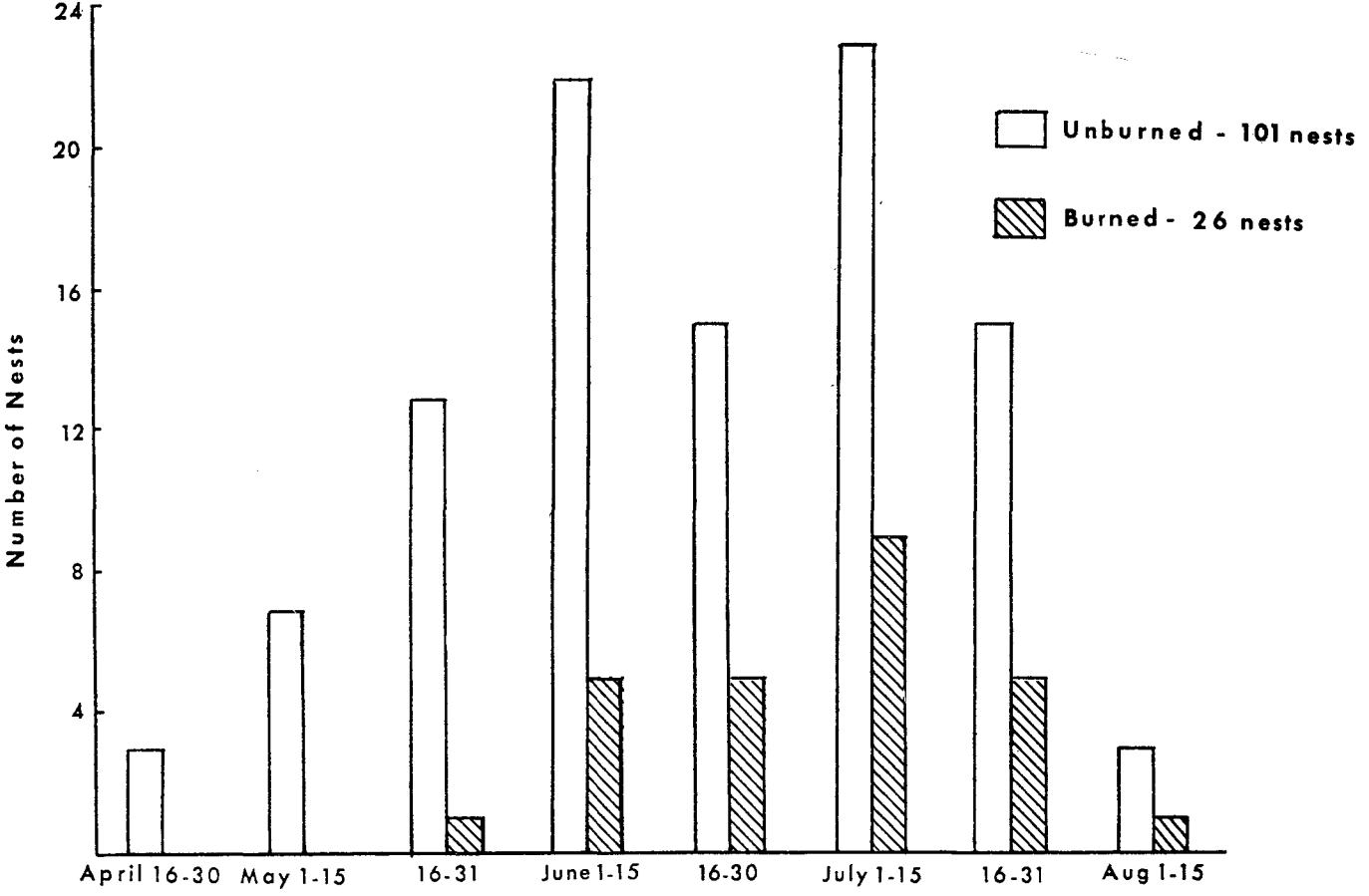

Fig. 1. Nest initiation dates for 127 bobwhite nests in burned and unburned nest habitat, Ames Plantation, 1967-1971

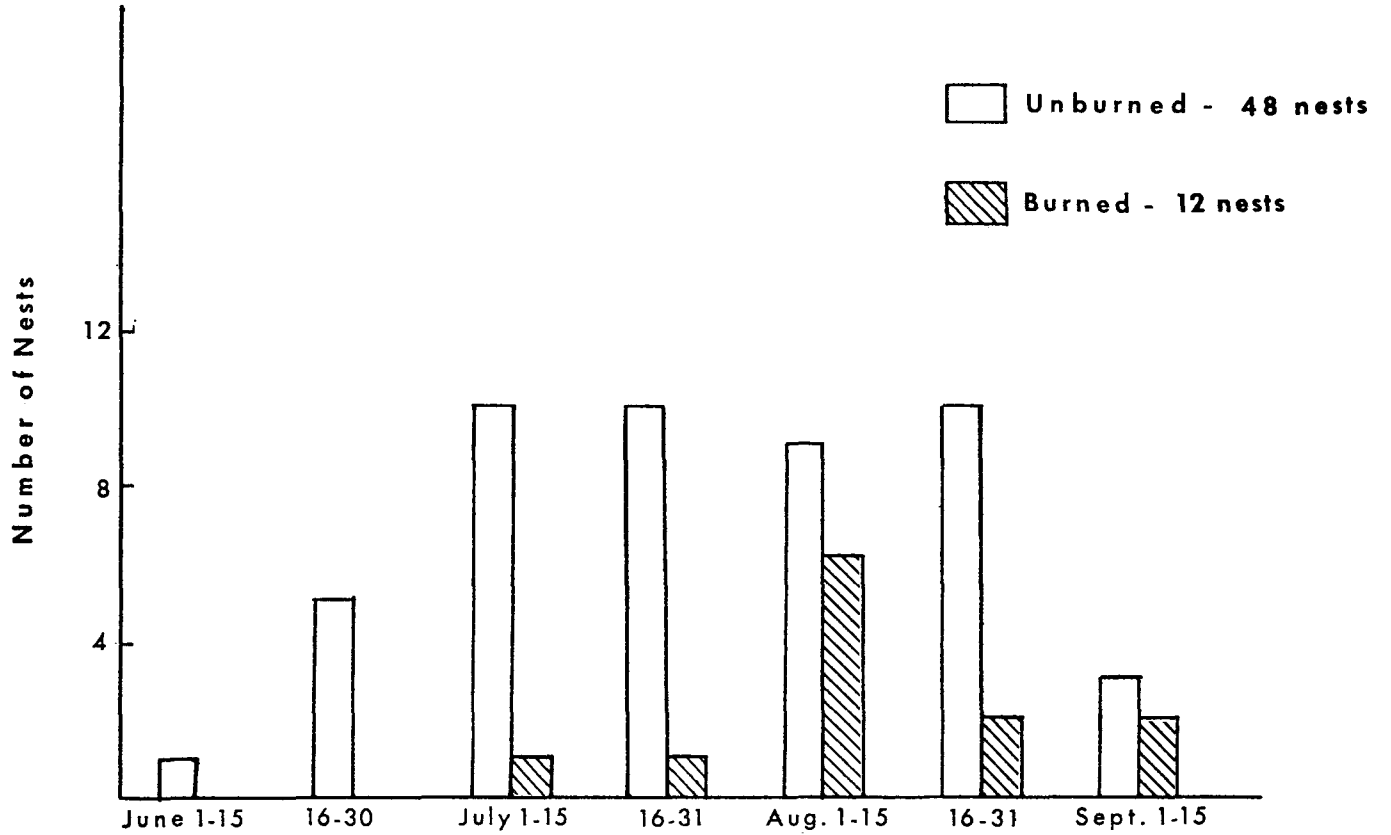

Fig. 2. Hatching dates for 60 bobwhite nests in burned and unburned habitat, Ames Plantation, 1967-1971

TABLE 2. Proportion of successful nests in burned and unburned nest habitat on Ames Plantation, 1967-1971.

Year	Burned (n)*	Burned Hatched No.	Burned Hatched %	Unburned (n)	Unburned Hatched No.	Unburned Hatched %	Total (n)	Total Hatched No.	Total Hatched %
1967	6	0	0.0	117	19	16.2	123	19	15.4
1968	44	10	22.8	96	26	27.1	140	36	25.7
1969	15	7	46.7	63	22	34.9	78	29	37.2
1970	9	4	44.4	73	17	23.3	82	21	25.6
1971	33	5	15.1	78	15	19.2	111	20	18.0
Total	107	26	24.2	427	99	23.1	534	125	23.4

* Number of nests containing eggs or egg fragments when first observed.

Nest success was not significantly greater in either burned or unburned areas on Ames Plantation during the study period (Table 2). Nevertheless, controlled burning of nesting habitat may play an indirect role in influencing nest success during some years through delaying the start of nesting. Clutch size tends to decrease as the nesting season progresses (Errington 1933; Lehman 1946), and the opportunity for renesting would be lessened. On the other hand, nest success in the Southeast may be greater in the latter part of the season, particularly in years when populations of cotton rats (*Sigmodon hispidus*), major nest predators, are high.

In summary, controlled burning of nest habitat on Ames Plantation exerted a measurable impact upon the distribution of quail nests and upon the chronology of nesting. The proportion of nesting attempts which were successful was not significantly greater in either burned or unburned habitats during the study period. Associated environmental conditions, *i.e.*, populations of associated species of animals, and regional agricultural practices, could in some years disproportionately alter nesting success on burned areas if the effect were concentrated in late summer.

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