Controlled burning in relationship to bobwhite quail populations on the Mount Ayr Game Management Area, Iowa

by

William Kerlin Seitz III

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Major Subject: Wildlife Biology

Iowa State University
Ames, Iowa

1972

TABLE OF CONTENTS

I. INTRODUCTION

In recent years there has been increased interest in use of fire as a tool in wildlife habitat management. Iowa, however, is lacking in data on the use of fire for wildlife habitat improvement. The relationship of fire to bobwhite quail (Colinus virginianus Linnaeus) ecology in the southern states has been well documented. My investigation, conducted on the Mount Ayr Public Hunting Area in Ringgold County, Iowa, was undertaken to secure data on the relationship of fire ecology to quail management practices on state-owned hunting areas in southern Iowa quail range. Objectives of this study were to determine the ecological effects of controlled burning on various game habitat cover types on the Mount Ayr area and to observe quail population responses, if any, to habitat changes resulting from controlled burning.

The bobwhite quail is the most important upland game bird in southern Iowa. Iowa Conservation Commission authorities have estimated that, in 1970, 87,665 hunters spent about 1,820,615 gun hours hunting quail.

Iowa has 240 public hunting areas totaling almost 186,000 acres. Thirty-four of these public hunting areas, in 22 counties and totaling almost 59,000 acres, are located in the southern one-third of the state, an area with high quail populations.

Field work on the Mount Ayr Game Management Area began on June 1, 1967, but was interrupted for 3 years beginning on October 22, 1967 while the investigator served in the United States Navy. Field studies resumed in September 1970 and continued until November 1971.

The use of fire as a tool in game and forest management gained prominence in the southeast in the early 1900's due largely to the efforts of Herbert L. Stoddard. Stoddard (1931, 1933, 1936, 1963), one of the early workers in game management, was first to document the successful use of controlled burning in the open pinelands type of forest characteristic of much of the south Atlantic and Gulf Coastal Plains to improve bobwhite and wild turkey[1] habitat. More recently, Walter Rosene (1954, 1955, 1969) has written much about the use of controlled burning in bobwhite quail hanagement in the southeastern states. Through the efforts of men like Stoddard, Rosene, and their colleagues, controlled burning now plays an important role in habitat management programs of bobwhite quail in the pinelands of the southeastern states (Moore 1957, Speake 1966, Hurst 1970). In more northern areas such as Illinois and Kentucky, fire is used to a lesser degree in quail management (Scott 1958, Triner and Klimstra 1965, Ellis et al. 1969).

---

[1]See Appendix II for scientific names of animal species.

Since Stoddard's pioneering work in controlled burning, there has been wide application of fire to improve the habitat of many species of wildlife. Controlled burning has been used in the management of brush stands on the northern coastal ranges and western Sierra foothills of California to increase available browse for mule deer (Leopold 1950). Studies in Michigan (Smith 1947) and Tennessee (Dills 1970) have shown that controlled burning can be used successfully to increase available browse for white-tailed deer. In northern states, ruffed grouse and sharp-tailed grouse habitat has been improved through the successful use of fire (Grange 1949, Ammann 1963, Sharp 1970). Fire has been recommended to improve the nesting habitat of Attwater's prairie chicken in Texas by opening up the "roughs" that develop under moderate grazing in wet years (Lehmann and Mauermann 1963). In Michigan, fire is an integral part of the habitat management program for the Kirtland's warbler (Berger 1961:353). Grange (1949:215-241) thoroughly discusses the techniques of controlled burning for various types of game habitats.

Iowa has little history of controlled burning in relation to quail. Fire, however, has been used as a management tool to preserve native conditions on several Iowa prairies (Aikman 1955, Ehrenreich and Aikman 1963, Wilson 1970). Iowa quail studies to date have included mainly production and mortality factors (Moorman 1942, Mangold 1950, Elder 1956), management and behavior (Baker 1939, Saunders 1940,

Klimstra 1948 and 1949, Gooden 1952, Boehnke 1954), and habitat requirements and basic ecology (Errington and Hamerstrom 1936, Errington 1941), but none involved the analysis of fire as a management tool in quail habitat management.

II. DESCRIPTION OF STUDY AREA

A. Mount Ayr Game Management Area

Field studies were conducted on the Mount Ayr Game Management Area, a 1,158-acre public hunting area in Ringgold County, Iowa. The hunting area is located about 6 miles southwest of Mount Ayr, the county seat, in Waubonsie and Rice Townships. Portions of the game area are located in Sections 9, 16, 17, 18; T.68N., R.30W., 5th P.M. The game area is only 8 miles from the Missouri state line and is in the region of Iowa's best quail range.

The topography of the upland flats prevalent throughout the county is that of rolling hills cut by drainages and streams. The rolling plains are remnants of an undulating to level till plain which remained after the retreat of the Kansan glaciers (Oschwald et al. 1965).

Four main soil types occur in the area, 1) Grundy silt loam, 2) Wabash silt loam, 3) Lindley silt loam, and 4) Shelby loam (Hall et al. 1918). The Shelby loam is a dark, imperfectly to moderately well-drained soil developed from weathered glacial till. This prairie soil occurs throughout the game area exclusive of the timbered ridge and the Walnut Creek flood plain. The Wabash silt loam, a dark, poorly drained soil derived from alluvium, is located on the Walnut Creek flood plain and associated small drainage gullies. Grundy silt loam, a dark, moderately well to somewhat

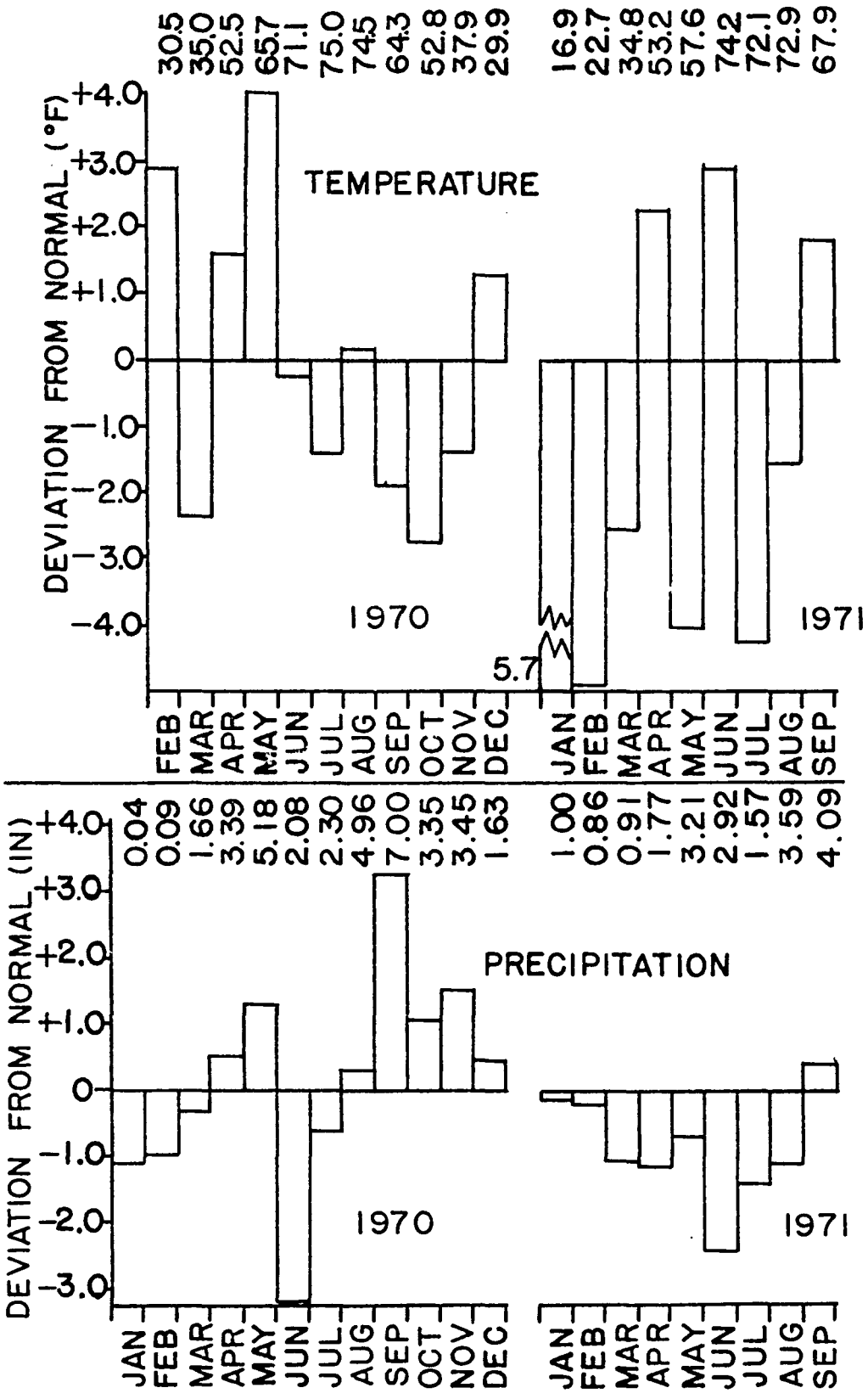
poorly-drained soil, occurs on many of the gentle slopes. Lindley silt loam, a well to moderately well-drained soil, occurs on the strongly sloping north-facing ridge extending along the southern timber-grassland border.

The climate of Ringgold County is temperate with generally warm summers and cold winters. Mean summer temperature is 72.0°F, the mean winter temperature 29.4°F. The annual mean temperature is 51.1°F. Mean annual precipitation is 32.70 inches with the monthly mean summer precipitation 4.14 inches and monthly winter precipitation 1.31 inches. The average monthly temperatures and their deviation from the 30-year average, and the total monthly precipitation and deviation from the 30-year average are summarized for 1970 and 1971 (January through September) in Fig. 1 (U. S. Dept. of Commerce, Environmental Data Service 1970-1971). June, July, and August commonly are the wettest months (Shaw and Waite 1964). Ringgold County's average growing season is 168 days with an average grazing season of 245 days (Hall et al. 1918).

About one-third of the project area is timbered with second growth oak-hickory forest predominating in the uplands and maple-basswood in the Walnut Creek flood plain. The remaining acreage consists of a combination of brushy, timbered draws, crop units, brushy-grassy areas, and planted food patches. Approximately 120 acres are sharecropped each year with corn[1], red clover, oats, and grain sorghum the main

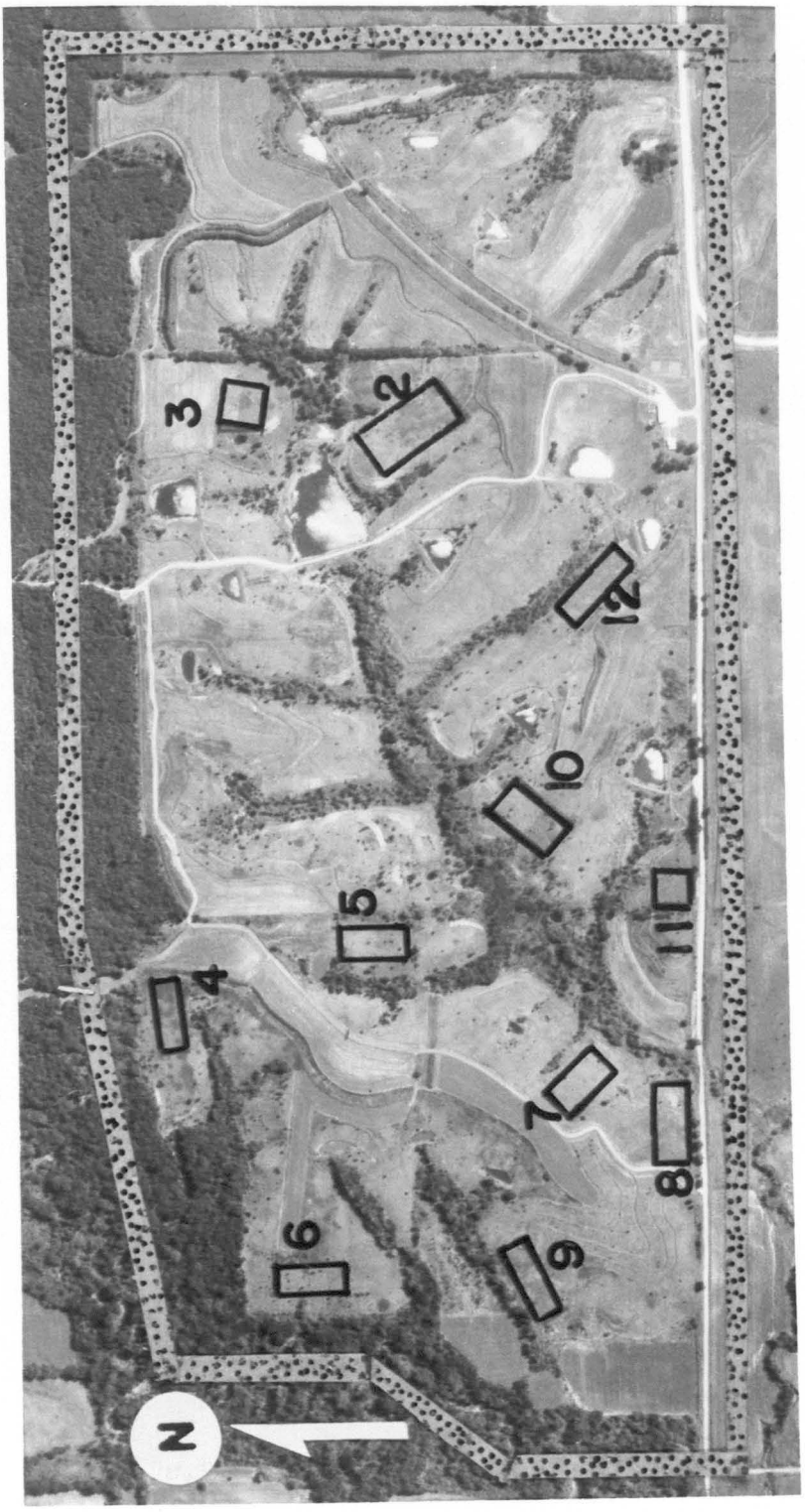
[1]See Appendix I for scientific names of plant species.

Fig. 1. Average monthly temperatures and their deviation from the 30-year average and the total monthly precipitation and the deviation from the 30-year average for 1970 and 1971 (January through September) as recorded at the U. S. Weather Bureau Station, 9 miles north of Mount Ayr, Iowa.


TEMPERATURE
DEVIATION FROM NORMAL (°F)
+4.0
+3.0
+2.0
+1.0
0
-1.0
-2.0
-3.0
-4.0
30.5 35.0 52.5 65.7 71.1 75.0 74.5 64.3 52.8 37.9 29.9
16.9 22.7 34.8 53.2 57.6 74.2 72.1 72.9 67.9
1970
1971
5.7
FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
JAN FEB MAR APR MAY JUN JUL AUG SEP
PRECIPITATION
DEVIATION FROM NORMAL (IN)
+4.0
+3.0
+2.0
+1.0
0
-1.0
-2.0
-3.0
0.04 0.09 1.66 3.39 5.18 2.08 2.30 4.96 7.00 3.35 3.45 1.63
1.00 0.86 0.91 1.77 3.21 2.92 1.57 3.59 4.09
1970
1971
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
JAN FEB MAR APR MAY JUN JUL AUG SEP

agricultural species. American elm, boxelder, cottonwood, and green ash are the main species occurring in the timbered draws. Blackberry, buckbrush, and multiflora rose predominate in the understory. The grassy pastures consist primarily of smooth brome, redtop, and sericea lespedeza. Native prairie grasses such as big bluestem, little bluestem, and Indian grass are present on many of the open upland slopes. Volunteer multiflora rose from many planted hedges, buckbrush, blackberry, wild plum, and red osier dogwood are also present on the grassy slopes. American elm, wild plum, and green ash are invading the open areas. The relationship of the crop units, upland cover, and wooded draws is illustrated by Agricultural Stabilization and Conservation Service aerial photographs of the game area (Fig. 2).

Fig. 2. Agricultural Stabilization and Conservation Service aerial photograph of the 400-acre Study Unit within the 1,158-acre game management area. The numbered plots indicate areas burned in 1971. (Scale 6 in = 1 mi, photograph taken September 4, 1971).


1
2
3
4
5
6
7
8
9
10
11
N

III. METHODS OF STUDY

Field study began in 1967 on June 1 but was interrupted October 22 that same year. After a 3-year absence while the investigator served in the United States Navy, field studies resumed in September 1970, with periodic visits to the study area during the Fall and Winter months. Field work in 1971 began March 8 and terminated September 3. Fall quail census work was conducted in September and October. Hunter surveys were secured in October 1967, 1970, 1971, on the opening weekends of quail hunting seasons, and in November 1970 and 1971, on opening weekends of the pheasant hunting season.

A. Quail Habitat

The preliminary vegetation survey in June 1967 provided the investigator with a knowledge of all major game habitat types present on the entire public hunting area. In the course of the vegetation survey, some "feel" for major areas of quail activity was gained. With this knowledge as a background, 12 rectangular plots, numbers 2 through 13, ranging from 0.6 to 1.9 acres were selected for burning experiments. All plots included varying degrees of the rolling topography prevalent in southern Iowa. The area, dimensions, and location of each plot are listed in Table 1. Approximate locations are shown in Fig. 2. Orange-colored, steel fence posts marked three corners of each plot with a

green fence post with an identification sign marking the fourth corner.

Table 1. Area, dimensions, and location of the 12 burn plots in Section 17, T.68N., R.30W., Mount Ayr Game Management Area, Iowa.

Plot number	Dimensions (feet)	Area (acres)	Location
2	447 x 189	1.9	N½NE¼SE¼SE¼
3	202 x 187	0.9	S½NE¼NE¼SE¼
4	318 x 79	0.6	N½NE¼NE¼SW¼
5	240 x 115	0.6	E½SE¼SE¼NW¼
6	270 x 111	0.7	NE¼SE¼NW¼SW¼
7	252 x 133	0.8	NE¼SW¼SE¼SW¼
8	351 x 211	1.7	S½SW¼SE¼SW¼
9	340 x 151	1.2	NW¼SE¼SW¼SW¼
10	324 x 174	1.3	NE¼SW¼SW¼SE¼
11	197 x 150	0.7	SW¼SW¼SW¼SE¼
12	324 x 196	1.5	W½SW¼SE¼SE¼
13	262 x 173	1.1	SE¼NW¼NE¼NW¼

1. Quail habitat sampling procedures

The vegetation in each of the 12 plots was sampled once during the summers of 1967 and 1971. Randomly located square-meter quadrats were used to sample the herbaceous plant material in both years. In 1971 the major vegetative components on each plot were cover-mapped. From these cover-maps relative percentages of area that each vegetative component occupied on each plot were determined. The number of samples per major vegetation type was directly related to the percentage of area that the vegetation occupied on the burn plot.

For example, if a mixed stand of big bluestem and blackberry occupied 50 percent of the plot, one-half of the samples were chosen at random from this particular vegetation relationship.

A sampling rate of 10 sample sites per acre of plot was used in 1967. In 1971, a sample rate of 14 sample sites per acre was used. Use of species:area curves (Oosting 1956:45) showed the 1967 sampling rate to be sufficient as far as plant species composition was concerned. It was believed, however, that more samples were needed to obtain a better statistical analysis of the quantitative data being collected such as average litter depth, average vegetation height, and estimated stem basal area of live vegetation.

Additional control areas were sampled in 1971 for the purpose of comparing burned and unburned vegetation. The control areas consisted of vegetation immediately surrounding the burned plots. Because the control areas were not cover-mapped in detail, the investigator selected, by visual means, sample sites appearing similar in species composition to a corresponding site on the burned areas. In most instances control area sample sites were selected as close to corresponding burned sites as possible, usually within 20 yards of the plot's boundary; although such factors as previous disturbance by man, topography, and the burn plot's proximity to roads and multiflora rose hedges did necessitate several exceptions. The number of sample sites on the control areas equaled that of the corresponding burned plot.

2. Quail habitat analysis

Species composition, estimated percentage of basal area of live vegetation, estimated percentage of surface area of exposed soil and litter, average height of vegetation, and average litter depth were recorded for each square-meter sample site. Sampling techniques were adapted from Subcommittee on Range Research Methods of the Agricultural Board (1962).

a. Estimated percentage of basal area of live vegetation

Basal area is defined as the total stem area, in a compressed state, of the living vegetation at soil level. A typical square-meter sample plot containing big bluestem is shown in Fig. 3a. In Fig. 3b, the grass is shown after it was cut approximately 1 inch above soil level. The outlined area occupied by the grass tussocks is 0.31m^2 or 31 percent. The stem basal area is 0.01 m^2 or 1.3 percent. One percent of the clipped big bluestem in a compressed state is illustrated in Fig. 4. The wire measuring aid shown in Fig. 4 was constructed to help the investigator estimate basal area. The area in the larger circle is equal to 1.0 percent of a square-meter while the small circle is equal to 0.1 percent of a square-meter.

A training session was held before beginning the vegetation analysis of each of the 12 burned plots and the respective control areas. The training session consisted of 1) recording the main herbaceous species in the previously selected sample sites, and 2) estimating the percentage of

Fig. 3a. A typical square-meter quadrat sample site containing big bluestem.

Fig. 3b. Big bluestem tussocks after they were cut approximately one inch above soil level. The outlined portion occupied by the grass tussocks is 0.31 m^2 (31 percent).

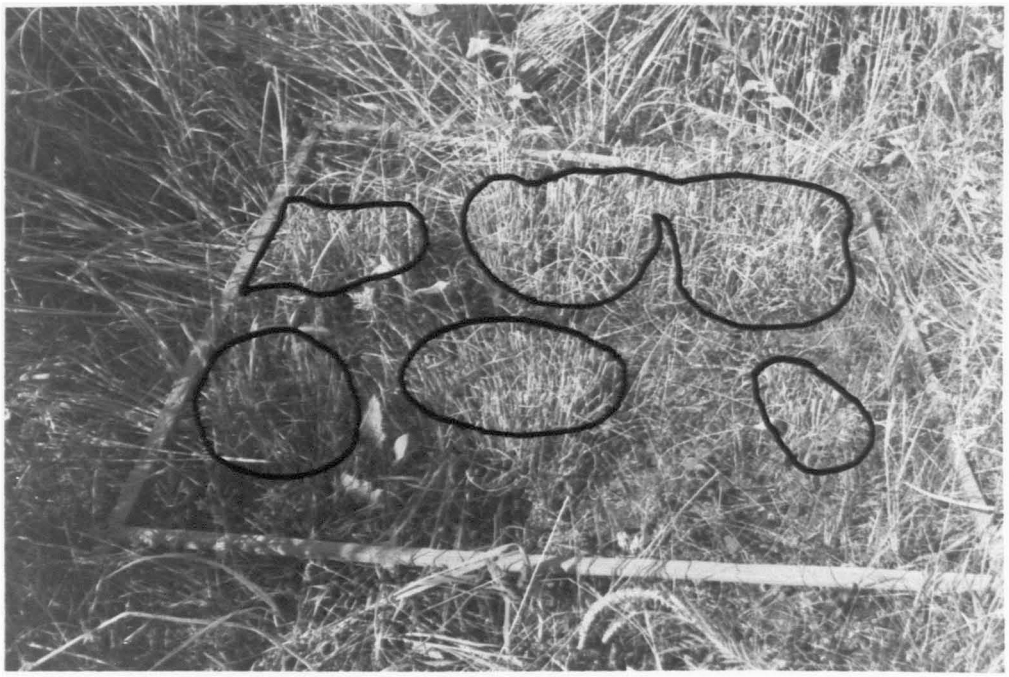
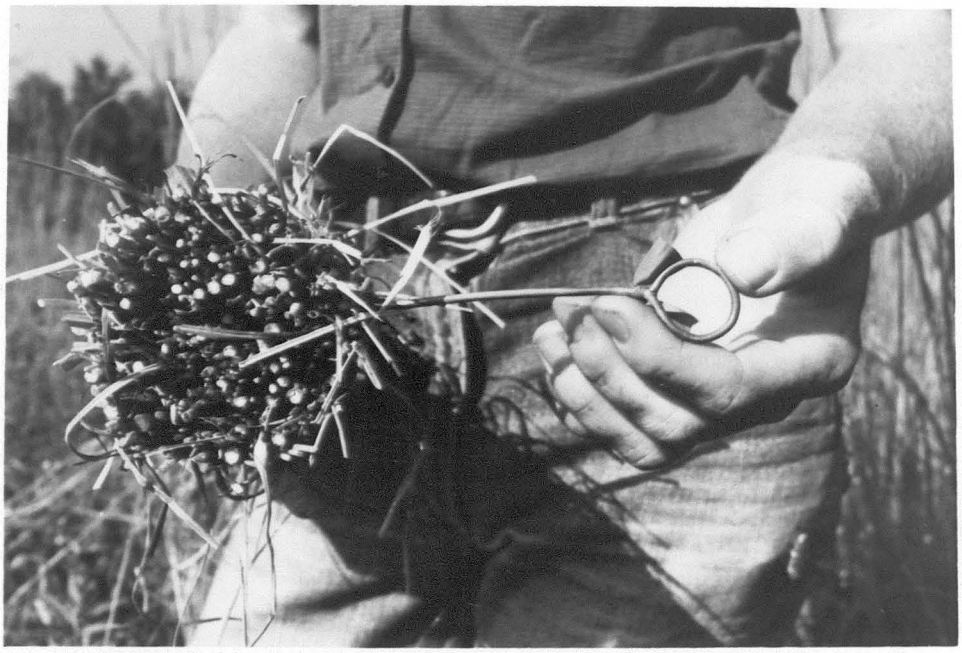
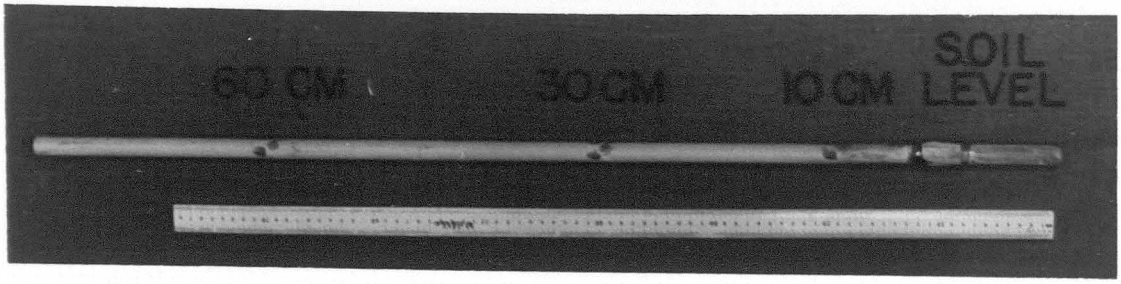


Fig. 4. One percent of the big bluestem in a compressed state. The area in the larger circle of the wire measuring aid is equal to 1.0 percent of a square meter while the small circle is equal to 0.1 percent of a square-meter.

Fig. 5. Dowel rod pyrometer with thermopaper temperature indicators at soil level and thermopaint indicators at various intervals above ground.




60 CM
30 CM
10 CM
SOIL
LEVEL

basal area of a species in a square-meter quadrat and clipping the individual stems as shown in Fig. 4 to test the estimate. Clipping was continued until the investigator could consistently estimate the correct basal area for each species.

Each species present in the square-meter was recorded. The smallest accurate basal area estimate was 0.1 percent of a square-meter. Basal area of a single species was estimated up to a 1.0 percent level using 0.1 percent increments; and if the area totaled more than 1.0 percent, 1.0 percent intervals were used. For example, if the basal area totaled 1.5 percent or more, then 2.0 percent was recorded. If the basal area estimate was less than 1.5 percent, 1.0 percent was recorded. If a species was present but had a basal area less than 0.1 percent it was classed as "trace" quantities. It was possible for the combined stem area of, for example, five species to be 0.1 percent. If this condition existed, the 0.1 percent was tallied in the total vegetation basal area estimate for that sample site.

b. Estimated percentage of surface area of exposed soil and litter Following estimation of the percentage of basal area of live vegetation, the percentage of surface area of exposed soil or litter was estimated using the wire measuring aid. In all instances, the basal area estimate and one surface area estimate were combined and subtracted from 100 percent to obtain the third surface area estimate. For example, if the basal area estimate was 1.2 percent and the surface

area estimate for exposed soil was found to occupy 6.0 percent, then litter occupied 92.8 percent by subtraction. In most instances, percentage of surface area of exposed soil was easiest to estimate accurately.

c. Average height of vegetation The height in centimeters of all species in the sample quadrat that had 0.1 percent basal area or more was recorded and averaged on a weighted basis to give an overall vegetation height for each square-meter plot. For example:

Species	Height measurements (centimeters)	Percent basal area
Species A	82, 79, 69, 85	0.1
Species B	23, 25, 19, 30	0.3
Species C	52, 53, 49, 39	0.5
		Total 0.9

Calculation:

0.1(315/4) + 0.3(97/4) + 0.5(93/4)/0.9 = Average height
7.88 + 7.28 + 24.13/0.9 = 43.6 centimeters

d. Litter depth The litter depth was determined by measuring the distance from exposed soil to the top of deposited organic material. A measurement was taken from each corner of the square-meter quadrat and averaged to give an overall average per plot.

3. Tree and shrub occurrence

Tree and shrub species present on each plot were recorded in 1967 and 1971. Direct counts were used to obtain densities of each tree and shrub species on nine of the 12 burn plots in 1967 and eight of the 12 burn plots in 1971.

On those burn plots where high species densities prohibited direct counts, line transects were used to secure a 11 percent sample of the plot (Oosting 1956:50). All individuals of each species were recorded within an interval of 1 meter on each side of a string stretched from one side of the burn plot to the other. In 1967, the height in centimeters of all individuals less than 1.52 meters (5 feet) was recorded in both the direct count and line transects. Diameter at breast height (dbh) was determined on all individuals 1.52 meters and greater in height. No height measurements were taken in 1971.

In 1971 emphasis was placed on determining the effect of fire on the tree and shrub densities. In May 1971, direct counts of all tree and shrub species were taken and each individual of each species was grouped into one of the three categories: 1) tree or shrub leafing normally, 2) main stem of the tree or shrub dead, individual with leafy shoots at the main stem base, or 3) tree or shrub dead, no leafy shoots present at the base of the stem. Individuals recorded on the line transects taken in August 1971 were similarly categorized.

4. Photographic stations

Photographic stations were established at each burn plot. Black and white photographs were taken on July 20, 1967 and at 2-week intervals after the burning in 1971. Color transparencies were secured on July 27, 1967 and July 19, 1971.

B. Quail Populations

Many aspects of the bobwhite's natural history were investigated. Emphasis was placed on determining seasonal habitat preferences, population densities, i.e. the number of pairs, number of broods, number of coveys, and daily and seasonal activity periods. All quail observations, whistling birds, and field sigh were recorded on field maps. Time of observation, sex, direction of flight, habitat, and abnormal behavior were recorded for each observation. Field procedures consisted of flushing birds, or locating whistling birds and then flushing them. A dog was used to locate birds during fall, winter, and spring months with some success when scenting conditions were good, i.e. moist soil, ground litter and vegetation and wind less than 10 mph. Dirt and gravel roads on the game area were walked regularly and the number of birds heard whistling was recorded. Two Conservation Commission employees working on the area reported their daily observations of quail. Bobwhite movements determined by radio telemetry tracking were observed daily by an Iowa State University student on an NSF undergraduate research grant in the summer of 1971.

Fall pre-hunting season censuses were conducted on September 12, October 3, 4, and 23, 1970 and October 2, 3, and 16, 17, 1971. Winter and pre-nesting censuses were conducted in January and March 1971 respectively. In 1967, a fall hunter survey was conducted on October 21 and 22 (opening

weekend of quail hunting). Surveys in 1970 were conducted on October 24 and 25 (opening weekend of quail hunting), 30, 31, November 1, and 14 and 15 (opening weekend of pheasant hunting). In 1971, hunter surveys were conducted on October 23 and 24 (opening weekend of quail season), and November 13 and 14 (opening weekend of pheasant hunting). The hunter survey questionnaire and the type of information requested from each hunting party is shown in Appendix III. Wings were collected from bagged quail during all hunter surveys. Birds were classified as adults or juveniles on the basis of the moult condition of the two outer primary wing feathers and the color and shape of the 7th greater primary coverts (Haugen 1957). Age of juveniles up to 150 days was determined by measuring the length of the most recently moulted primary wing feather (Petrides and Nester 1943 and Rosene 1969). In some instances it was necessary to use dimorphism in coloration and markings of the middle wing coverts to distinguish the sex of bagged birds (Thomas 1969).

After the burning operations in late March and early April, particular emphasis was made to determine the extent of quail utilization on the burned areas. In order to evaluate the quail population's responses to habitat changes brought about by controlled burning, several qualifying statements had to be made in order to correlate quail sightings with search effort. Only birds actually flushed during times of field work were counted in the total quail sightings on and

off the burned areas. I assumed also that search time for burned areas was proportional on an area basis to that of unburned areas. Although in some instances this was not the case, search effort was largely constant throughout the period of field investigation.

C. Burning

The controlled burning of the 12 plots was conducted on March 30, 31, and April 5, 1971. A total of 13.0 acres was burned. Back fires were used to burn the plots because 1) environmental conditions, e. g. relative humidity, air temperature, and wind, made burning conditions precarious, 2) large quantities of accumulated dead plant material were present, and 3) a slow, hot-burning fire was desired.

Fires were contained on the plots through the use of four-rowed plowed and disked firebreaks approximately 8 feet in width. Two mowed strips were used as firebreaks on some plots where topography presented potential erosion problems. Equipment used during the actual burning consisted of two gasoline-powered sprayers with 400- and 200-gallon capacities, two 5-gallon Indian-type backpack pumpers, two rubber flappers, and a hoe. Personnel involved in the burning varied from three to five.

A knowledge of maximum flame temperatures at various levels was desirable for interpretation of the fire's effect on the vegetation. Birch dowels, three-fourths inch in

diameter, were painted with rings of Tempilaq (Tempil Corporation, New York, New York), a temperature sensitive paint, at 10 cm, 30 cm, and 60 cm levels. The following temperatures were represented at each level: 45°C, 52°C, 66°C, 79°C, 93°C, 121°C, 149°C, 177°C, 204°C, 232°C, 260°C, 288°C, 343°C, 371°C, 399°C, and 427°C. Thermopapers (Paper Thermometer Company, Natick, Massachusetts) were attached at the soil level and the following temperatures were represented: 38°C, 49°C, 93°C, 104°C, 149°C, 204°C, and 260°C. The pyrometer-like device described above is shown in Fig. 5. A device was placed at five different locations on each of the 12 study plots before the burning.

IV. RESULTS

A. Controlled Burning

The 12 experimental study plots were burned on March 30, 31, and April 5, 1971 during daylight hours. All burning was controlled with no major difficulties encountered during the 3-day operation. With the exception of low, moist depressions and drainages present on some of the plots, the organic material was very dry, cracking under foot. Meterological conditions occurring at the time of burning are summarized in Table 2. The data are indicative of the widely varied conditions experienced during burning operations.

Instantaneous flame temperatures at soil level, 10 cm, 30 cm, and 60 cm heights as recorded with the birch dowel rod pyrometers are summarized in Table 3. Due to physical limitations of the pyrometer, no attempt was made to quantitatively relate vegetation composition with instantaneous flame temperatures. As one might expect, flame temperatures at the four levels were directly related to organic composition. For example, high temperatures recorded on Burn Plots 2 and 4 were the result of the burning of thick, highly combustible stands of sericea lespedeza. The same can be said for Burn Plots 6 and 8 which had large quantities of big and little bluestem. On Burn Plot 12 which consisted primarily of bluegrass, the temperatures were hot at the ground and 10 cm levels but relatively lower at the 30 and 60 cm levels.

Table 2. Summary of meterological conditions occurring during the burning of 12 study plots on March 30, 31, and April 5, 1971 on the 1,158-acre game area.

Burn plot number	Date burned	Wind velocity(mph) and direction before/after	Air temp.(°C) before/after	Relative humidity(%) before/after
2	3/30/71	5-SSW/ 4-SSW	22.2 / 20.0	27 / 31
3	3/30/71	9-SSW/ 9-SSW	23.9 / 23.9	21 / 21
4	4/ 5/71	2-NE / 1-NE	5.0 / 6.7	24 / 36
5	4/ 5/71	4-NNE/ 4-NW	8.3 / 7.8	31 / 39
6	4/ 5/71	6-NNE/ 6-NNE	7.2 / 7.8	38 / 32
7	3/31/71	16-SSE/13-S	23.9 / 20.0	31 / 28
8	3/31/71	21-SSE/15-SSE	23.9 / 23.9	27 / 30
9	4/ 5/71	6-N / 6-NE	8.3 / 7.8	31 / 32
10	3/31/71	19-SW /16-SW	21.1 / 22.2	29 / 28
11	3/31/71	19-SW /19-SW	22.2 / 23.9	29 / 30
12	3/31/71	4-SSW/ 5-SW	15.6 / 17.8	39 / 30
13	4/ 5/71	5-NNE/ 5-NNE	7.2 / 7.2	31 / 31

Table 3. Instantaneous flame temperatures recorded during the controlled burning of 12 study plots on March 30, 31 and April 5, 1971 on the 1,158-acre game area.

Burn plot	Instantaneous flame temperatures (°C)			
	Ground level	10 cm	30 cm	60 cm
2	227[a]	302(2)	198(4)	128(4)
3	204	216	116	78
4	227	274(2)	204(3)	156(4)
5	232(4)	241(2)	221	160
6	216	269(3)	221	132
7	249	214(3)	143	78
8	227	278(3)	212(4)	69(4)
9	149	243	128	123
10	249	218	133	63
11	210	149	253(4)	104
12	184	260(3)	118(4)	77
13	260(4)	223(3)	126(3)	116(4)

[a]All temperatures are an average for five different sites except where noted by numbers in parentheses.

B. Quail Habitat Analysis

One primary objective of this study was to determine the effects of controlled burning on the prominent quail habitat types of the open upland areas found on the game area. In June 1967, the game area was cover-mapped and a 400-acre section was selected for intensive study (Table 4, Fig. 6a, b). Twelve experimental burn plots comprising 13 acres were established on various upland cover types prevalent on the game area.

Fig. 6a. West section of an ecological cover-map of the 400-acre Study Unit within the Mount Ayr Game Management Area, Iowa (Table 4 is the key to the cover-map).

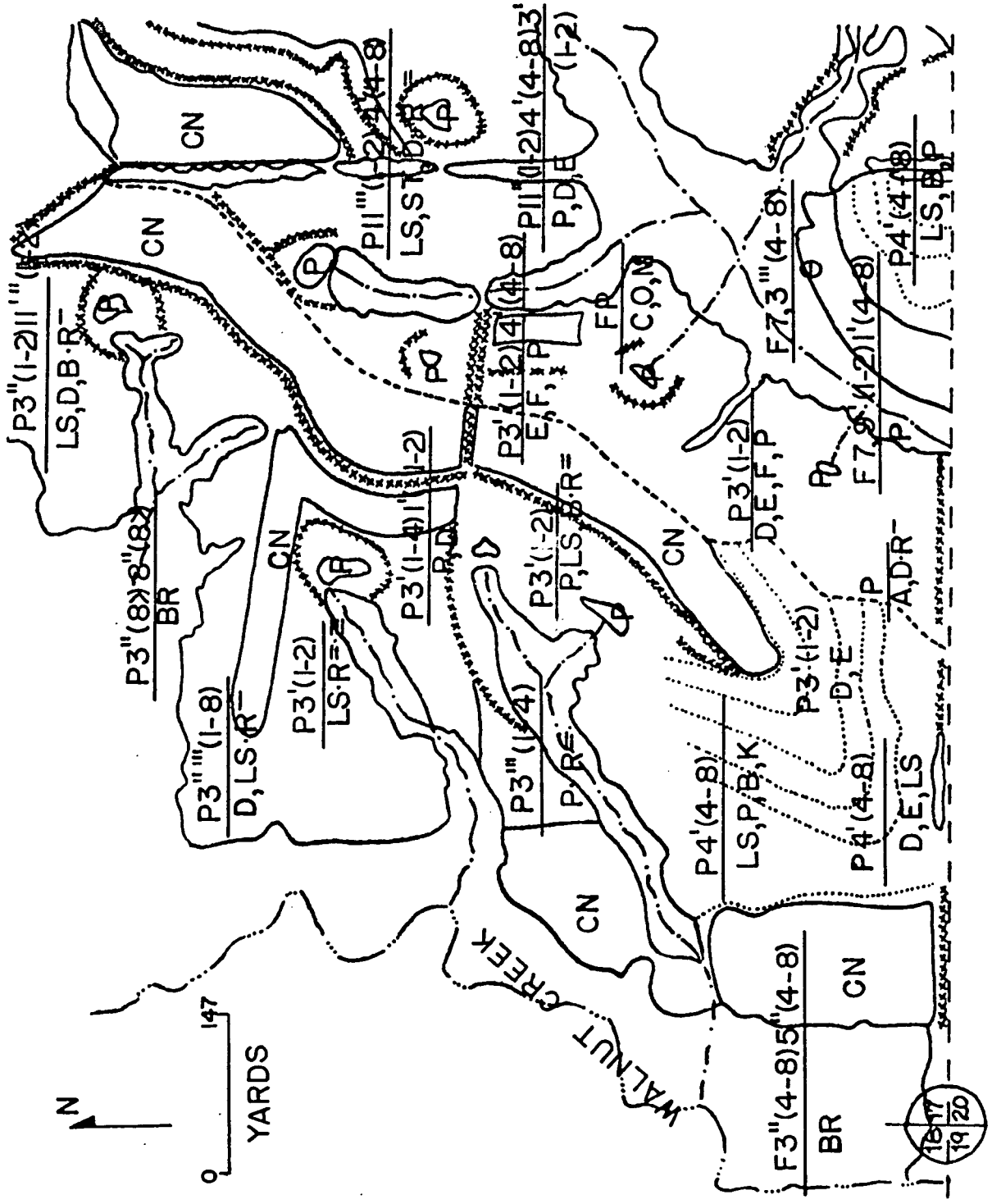

N
0
147
YARDS
WALNUT CREEK
CN
BR
FR
P3"(1-2)11'"
LS,D,B,R
P3"(8)8"(8)
BR
P3"'(1-8)
D,LS,R
P3'(1-2)
LS,R
P3'(1-4)1"(1-2)
P,D,R
P3"(1-4)
P,R
P3'(1-2)
P,LS,B,R
P11'''(1-2)4'(4-8)
LS,ST,B,R
P11"(1-2)4'(4-8)3'
P,D,E
(1-2)
P3'(1-2)4'(4-8)
E,F,P
C,O,M
P3'(1-2)
D,E,F,P
F7,3'''(4-8)
P3'(1-2)
D,E
P
F7,9'(1-2)1'(4-8)
P
P4'(4-8)
LS,P,B,K
P4'(4-8)
D,E,LS
A,D,R
P4'(4-8)
LS,B,P
F3"(4-8)5"(4-8)
BR
CN
16 17
19 20

Fig. 6b. East section of an ecological cover-map of the 400-acre Study Unit within the Mount Ayr Game Management Area, Iowa (Table 4 is the key to the cover-map).

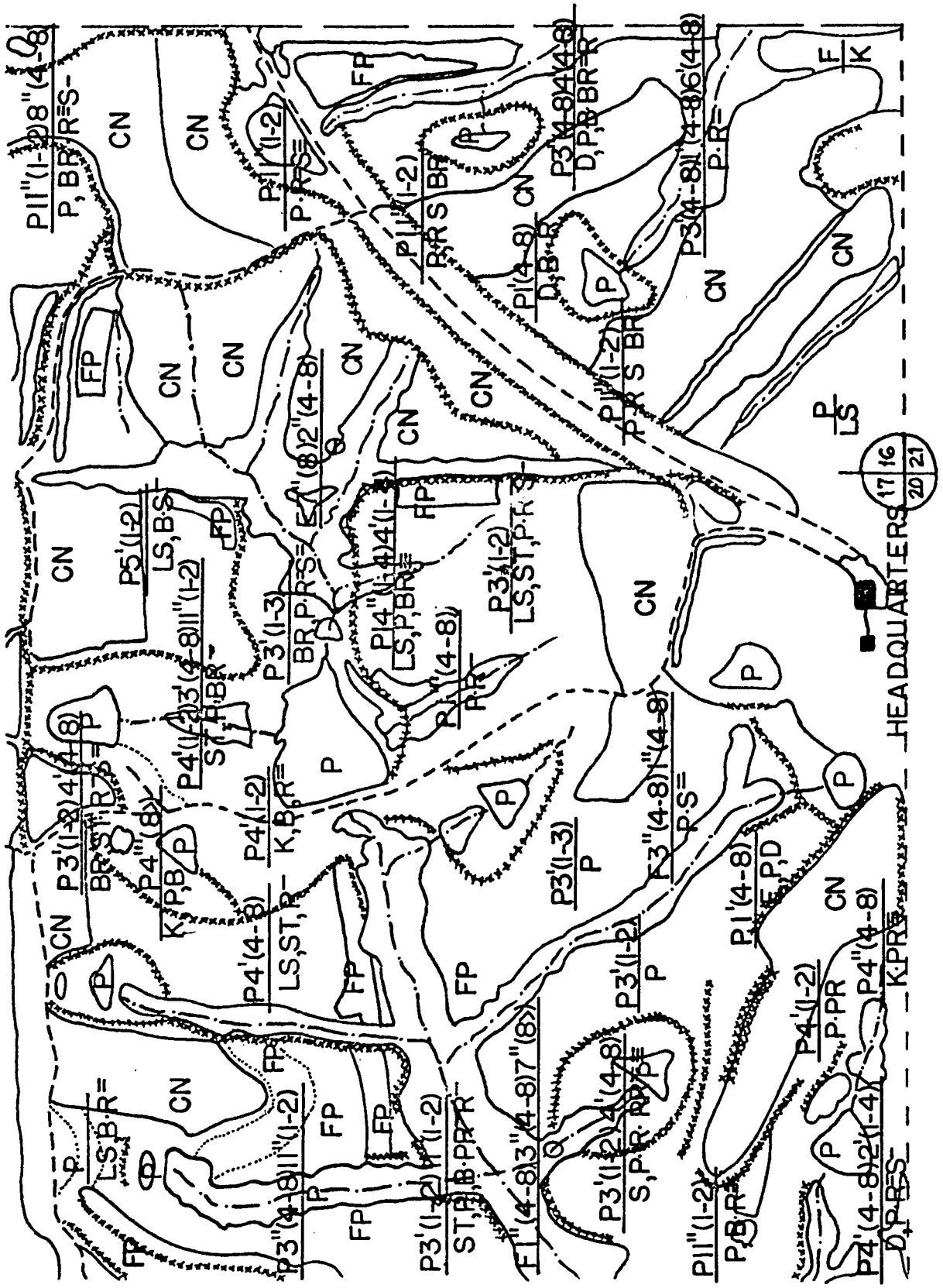

HEADQUARTERS
17 16
20 21
CN
FP
P
LS
K
F

Table 4. Key to the cover-map of the 400-acre Study Unit on the Mount Ayr Game Management Area, Iowa (Fig. 6a, b). This is an ecological classification of existing vegetation (after Graham 1945).

Ecological Classification

I. Soil - Terresterial

Upland	Flood plain
Porus soil - P	Porus soil - F
Non-porus - A	Non-porus soil - E
Plowed Field - CN	Food patch - FP

II. Upperstory species (See Appendix I for scientific names.)

Green ash - 1	Cottonwood - 7
Boxelder - 2	Oak - 8
American elm - 3	Willow - 9
Eastern redcedar - 4	Smooth sumac - 11
Honey-locust - 5	Red maple - 12
Osage-orange - 6	Jack pine - 14

Tree density

' Scattered
'' Medium
''' Dense

dbh (Diameter breast height)
1-2, 2-4, 4-8, greater than 8 inches

III. Understory species (See Appendix I for scientific names.)

Smooth brome - B	Blackberry - R
Bluegrass - P	Wild plum - PR
Little bluestem - A	Buckbrush - BR
Big bluestem - D	Sedge - C
Sericea lespedeza - LS	Pasture rose - S
Bicolor lespedeza - LB	Dogwood - Q
Reed canary grass - K	Redtop - E
Honeysuckle - L	Timothy - F

Shrub Density

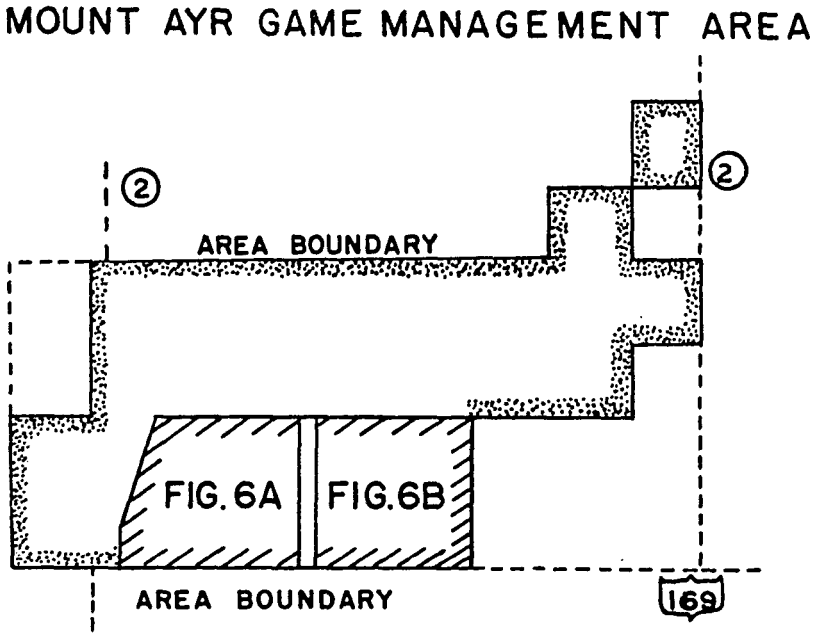
- Scattered
= Medium
≡ Heavy

θ - Ground cover-understory absent
Φ - Upperstory absent

Table 4. (continued).

Legend

Drainage
Creek
Terrace
Pond
Road
Study area boundary
Game area boundary
Multiflora rose hedge
Vegetation boundary



1. Burn plot descriptions

The vegetation components of the 12 rectangular plots were widely varied. Major species components of each plot were subjectively determined by visual means and cover-mapped in June 1971. The relative percentage of area that each component occupied was then obtained by planimeter. Vegetation components described below were those present on the plots during the 1971 growing season.

a. Burn Plot 2 This plot is 1.9 acres in size, the largest of the 12 plots. The most prominent type of 12 major vegetation components on this plot was a mixture of sericea lespedeza, common ragweed, goldenrod, and broom-sedge which accounted for 26 percent of the plot's area. The next most prominent type was a mixture of grass species such as broom-sedge, panic-grass, bluegrass, and redtop and other species such as blackberry, pasture rose, sericea lespedeza, and whorled milkweed. This type accounted for 23 percent of the plot's area. A mixture of sericea lespedeza and goldenrod accounted for 19 percent of the plot's area. The major vegetation components and relative percentage that each occupied is summarized in Appendix IV. An "island" effect was created by the many small concentrations of goldenrod and lespedeza. This characteristic was prevalent in the early stages of vegetation development and created a noticeable increase in the amount of edge.

b. Burn Plot 3 This plot, 0.9 acres in size, had three major vegetation types, the most prominent of which was a mixture of smooth brome grass and sericea lespedeza with localized areas of broom-sedge and big bluestem. This type accounted for 88 percent of the plot's area. The major vegetation components and relative percentage of area that each occupied are summarized in Appendix V. With the exception of the northwest corner of the plot, the vegetation was uniform with gradual changes in the brome grass-lespedeza mixture.

c. Burn Plot 4 This plot is 0.6 acres in size. Four major vegetation components were identified on this plot. Vegetation composition was very similar to that of Burn Plot 3 in that 64 percent of the plot was composed of varying quantities of smooth brome grass and sericea lespedeza. The brome grass-sericea lespedeza mixture with smooth sumac and blackberry accounted for 24 percent of the plot's area. The major vegetation component and the relative percentage of area occupied by each component are summarized in Appendix VI. There was little "edge" effect created throughout much of the 1971 growing season due largely to the homogeneous nature of the brome grass-lespedeza mixture.

d. Burn Plot 5 This plot is 0.6 acres in size, with seven major components arranged in fairly distinct zones. A mixture of big bluestem and Indian grass with lesser amounts of panic-grass and common ragweed occupied the central part of the rectangular plot and accounted for 27 percent of the

plot's area. A mixture of big bluestem, smooth sumac, and blackberry occupied the eastern boundary and accounted for 25 percent of the plot's area. The western one-third consisted of a mixture of varying densities of big bluestem, Indian grass, broom-sedge, pasture rose, and common ragweed. The vegetation components and relative percentage of area that each component occupied are summarized in Appendix VII. A natural "edge" effect was created in July and August when prairie grasses were in late stages of seedhead development.

e. Burn Plot 6 This west-facing plot is 0.7 acres in area. Over 67 percent of the plot was composed of big bluestem with localized concentrations of goldenrod, rosin weed, sericea lespedeza, and various other forbs. American elm occurred in high numbers over most of the plot. The major vegetation components and relative percentages of area occupied by each component are summarized in Appendix VIII. As with Burn Plot 5, vegetation development reached a peak in July and August due largely to large quantities of prairie grasses. Due to the fairly uniform nature of the prairie grasses, little "edge" effect was created.

f. Burn Plot 7 This plot is 0.8 acres in size and was located on an open, east-facing slope with a "poor", rocky topsoil. The vegetation cover was sparse in many spaces due largely to poor soil conditions. Seven vegetation components were identified with a mixture of panic-grass, timothy, broom-sedge, bluegrass, redtop, common ragweed, and sedge the most

prominent. This mixture accounted for 73 percent of the plot's area. A smaller, somewhat localized section of broom-sedge accounted for 13 percent of the plot's area. The major vegetation components and respective percentages of surface area covered by each component are summarized in Appendix IX.

g. Burn Plot 8 This plot, 1.7 acres in area, was characterized by two major areas each comprising about 50 percent of the plot's area: upland and upper flood plain. Vegetation on the upland section consisted of big and little bluestem with localized concentrations of goldenrod, common ragweed, pasture rose, and blackberry. Many small American elm trees occurred throughout the upland area but were not important as quail cover. The lowland section was composed of three main vegetation components: 1) reed canary grass with localized concentrations of goldenrod, 2) goldenrod with a mixture of big and little bluestem, and 3) a mixture of bluegrass, common ragweed, partridge pea, and redtop. Woody species such as willow, dogwood, American elm, and boxelder were conspicious on the lower, moist section. The "island" effect noted on Burn Plot 2 and illustrated graphically in Fig. 7 was very prominent as vegetation developed during the growing season. The major vegetation components and relative percentage of area occupied by each component are summarized in Appendix X.

Fig. 7. Major vegetation components of Burn Plot 8. Table 5 is the key to vegetation components. Diagramic cross-section (A_1-G_1) of burn plot (A-G) illustrating the "edge" effect created by different vegetation components.

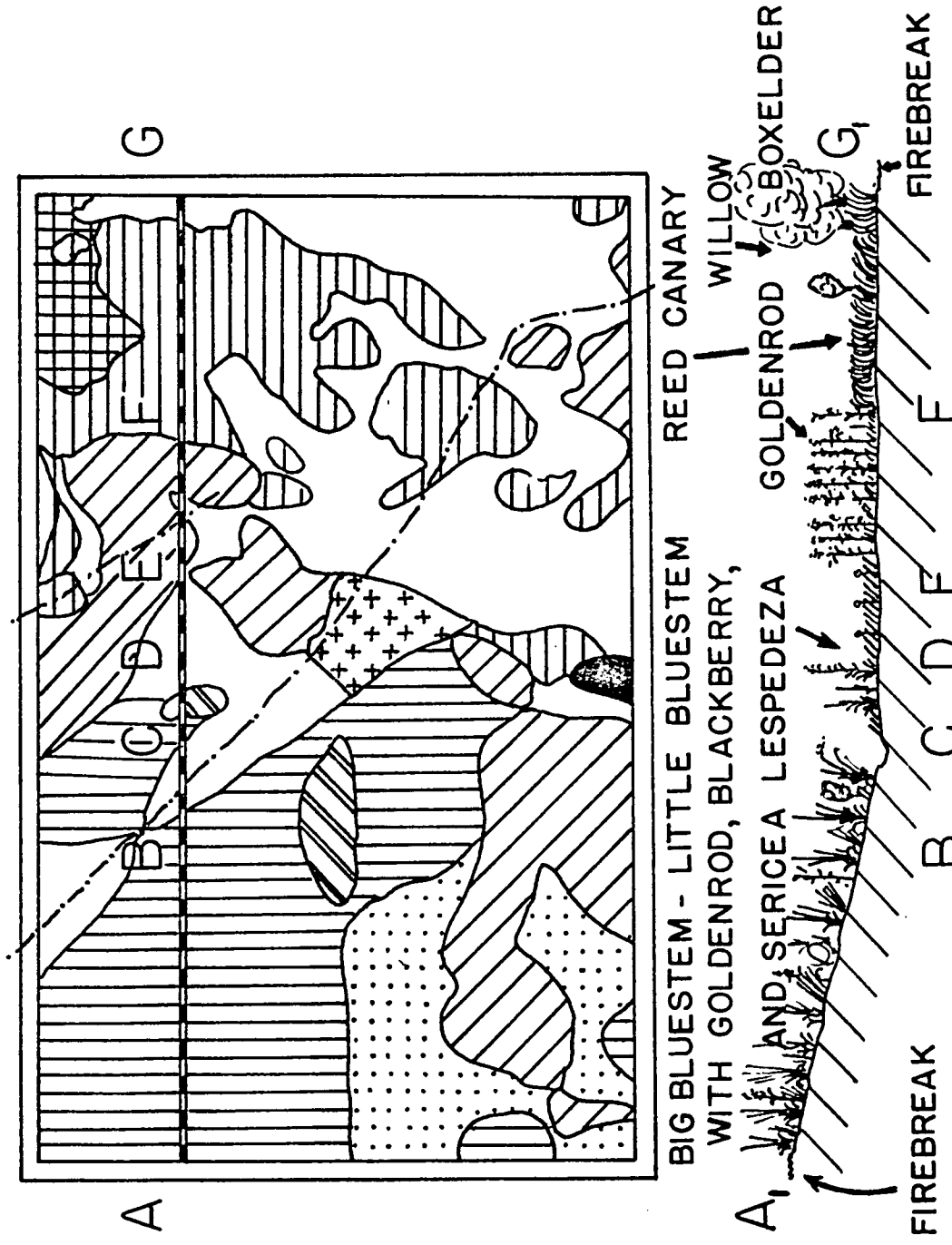

A
B
C
D
E
F
G
BIG BLUESTEM - LITTLE BLUESTEM
WITH GOLDENROD, BLACKBERRY,
AND SERICEA LESPEDEZA
REED CANARY
WILLOW
BOXELDER
GOLDENROD
FIREBREAK
FIREBREAK
A1
B1
C1
D1
E1
F1
G1

Table 5. Key for vegetation components of Burn Plot 8 illustrated in Fig. 7.

	Little bluestem, big bluestem, and blackberry with goldenrod, common ragweed, sericea lespedeza, and pasture rose.
	Little bluestem, big bluestem, and common ragweed.
	Goldenrod with big bluestem and little bluestem.
	Smooth sumac and blackberry with little bluestem, big bluestem, and common ragweed.
	Bluegrass, little bluestem, broom-sedge and common ragweed.
	Reed canary.
	Dogwood.
	Reed canary, goldenrod, and asters.
	Bluegrass and common ragweed with redtop, partridge pea, goldenrod and woody species such as willow, dogwood, and wild plum.

h. Burn Plot 9 This plot was 1.2 acres in size. Vegetation on this plot was widely varied with the same upland-dry and lowland-moist condition that existed on Burn Plot 8 prevailing. The transition from upland to lowland appeared more gradual than the transition of Burn Plot 8. Ten vegetation components were identified. Over one-half of the low, moist area (15 percent of the plot's area) was composed of big bluestem with varying densities of common and giant ragweed, goldenrods, and other forbs. Several large concentrations of

goldenrod and asters occurred throughout the plot. A transition zone composed primarily of goldenrod, common ragweed, bluegrass, and other forbs accounted for 18 percent of the plot's area. The upland area was characterized by such components as reed canary grass, big bluestem, and a mixture of bluegrass, blackberry, and pasture rose. Woody species such as American elm, boxelder, buckbrush, and wild plum were prevalent over the entire plot. The major vegetation components and relative percentage of area occupied by each type are summarized in Appendix XI.

i. Burn Plot 10 Fifteen vegetation components, indicative of the wide variation in habitat types, were identified on the 1.3-acre area. A tertiary drainage divided the north-facing plot into roughly two equal parts. The drainage had high densities of American elm, dogwood, and volunteer multiflora rose with a lush forb and reed canary understory. The eastern one-half of the plot was composed primarily of bluegrass, panic-grass, timothy, redtop and varying densities of wild plum and blackberry. Vegetation density was generally moderately sparse, with the western one-half showing the widest variation. The southern one-half of the section consisted of bluegrass with varying densities of blackberry and smooth sumac. The northern one-half of the section supported a mixture of goldenrod, bluegrass, big bluestem, and ashy sunflower with varying densities of dogwood, American elm, and volunteer multiflora rose. Vegetation densities on the

western one-half of the plot ranged from moderately dense to dense. The major vegetation components and relative percentage of area occupied by each component are summarized in Appendix XII.

j. Burn Plot 11 This plot, 0.7 acres in size, was composed primarily of two prairie grasses, big and little bluestem. Big bluestem with varying quantities of bluegrass, little bluestem, common ragweed, and goldenrod accounted for 46 percent of the plot's area. There were three small areas with dense stands of woody plants: 1) smooth sumac, 2) box-elder, prickly ash, and hazel, and 3) dogwood. The major vegetation components and relative percentage of area occupied by each component are summarized in Appendix XIII. With the exception of the woody species, little "edge" effect was noticeable.

k. Burn Plot 12 This plot, 1.5 acres in size, is located on what was originally a bluegrass pasture. With the exception of an oval-shaped area of big bluestem (15 percent of the plot's area), bluegrass was the prominent species on the plot. Varying quantities of broom-sedge, redtop, sericea lespedeza, timothy, flowering spurge, and common ragweed were found in the bluegrass. Volunteer multiflora rose, green ash, and American elm were conspicuous woody species located over the entire area. The major vegetation components and relative percentage of area occupied by each component are summarized in Appendix XIV.

1. Burn Plot 13 This plot is located along the northern boundary of the game area on a recently disturbed south-facing slope. It is 1.1 acres in area. Due to disturbance, vegetation development was in the early successional stages. Smooth brome and sericea lespedeza along the northern edge of the plot accounted for 20 percent of the plot's area. The remaining vegetation on the plot was a mixture of common ragweed, goldenrod, flowering spurge, ox-eye daisy, black-eyed susan, and other forbs. There were several small areas of big bluestem and a tertiary drainage composed largely of common ragweed. There were no conspicuous woody species present. The seven vegetation components and percentage of area occupied by each component are summarized in Appendix XV.

2. Square-meter quadrat sampling results

Quantitative information regarding species composition, estimated percentage of basal area of live vegetation, estimated percentages of surface area of exposed soil and litter, average height of vegetation, and average litter depth were recorded on 177 sample sites in 1967 and 366 sample sites in 1971. For several reasons only results of the 1971 analysis are reported in depth. For instance, three growing seasons elapsed between the 1967 and 1971 analysis and did not allow valid statistical control versus burn comparisons. Instead, control areas were chosen in close proximity to burned areas. Although sampling techniques remained essentially the same

during both years, the 4-year period separating the two sampling periods undoubtedly introduced some sampling bias.

a. Species composition All plant species found in each square-meter sample site were recorded. A total of 107 different species were recorded on the 12 burned areas and their controls, consisting of 99 species on the 12 control areas and 90 species on the 12 burned areas. Eighty-two species were common to both the burned and control areas. All plant species identified on the burn plots, including those not recorded by the square-meter quadrat analysis, are listed in Appendix I.

The mean number of species per sample site for all plots combined was 9.6 on the burned areas and 9.3 on the control areas (Table 6). Variance between the mean number of species per plot (control versus burn) was tested using analysis of variance. Results of the test indicated that the mean number of species per sample site on the control and burn areas was not significantly different ($F = 0.14$, 1 and 22 df, n.s.).

Frequency of occurrence was recorded for each of the 107 plant species. Forty-five of the recorded species (42 percent) had frequencies greater than 50 percent on burned areas. Five species (5 percent) showed frequencies equal to 50 percent. Overall frequency of occurrence for each species is listed in Appendix XVI. Overall frequencies of occurrence were tested for differences using the Chi-square test for heterogeneity. Results of the test showed there were signif-

Table 6. Means of estimated percentage of surface area of exposed soil and litter per sample site, estimated percentage of stem basal area per sample site, and number of species per sample site on the 12 burn plots and the control areas around the burn plots as determined by square-meter sampling.

Burn plot	Mean number plant species/ sample site Burn/Control	Mean percent surface area of litter/ sample site Burn/Control	Mean percent surface area of exposed soil/ sample site Burn/Control	Mean percent basal area of live vegetation/ sample site Burn/Control	Mean percent basal area of live vegetation adjusted for moss content Burn/Control
2	9.2/10.4	85.1/96.0	14.2/1.9	0.6/2.0	0.6/0.6
3	7.4/ 7.6	51.4/97.7	47.3/0.8	1.2/1.4	1.2/1.4
4	7.5/ 9.4	97.6/99.3	1.1/0.1	1.3/0.6	1.3/0.6
5	11.9/10.2	53.6/98.4	45.4/0.9	1.0/0.7	1.0/0.7
6	9.0/ 9.4	64.6/96.6	34.3/2.6	0.9/0.8	0.9/0.8
7	11.0/10.7	65.6/99.0	33.6/0.4	0.8/0.7	0.8/0.7
8	10.2/ 8.2	77.7/98.6	21.3/0.4	0.9/0.9	0.9/0.9
9	11.0/ 8.7	89.5/99.3	9.8/0.1	0.7/0.6	0.7/0.6
10	10.6/11.2	87.8/98.0	11.6/0.6	0.7/1.4	0.7/0.6
11	7.9/ 6.9	94.2/98.7	4.7/0.4	1.1/0.9	1.1/0.9
12	7.5/ 8.3	62.0/97.6	35.5/0.8	2.4/1.6	1.4/1.3
13	11.0/10.5	72.4/97.9	26.9/1.6	0.6/0.5	0.6/0.5
Average	9.6/ 9.3	76.3/97.9	22.7/1.0	1.0/1.1	0.9/0.8

icant differences in the frequencies on the burned and control areas that could not be attributed to sampling error (χ^2 = 215.5, 100 df, $P<0.05$).

One hundred and seven species were classed into five major groups, four plant families and one group containing the remaining plant species. The plant families were Gramineae (grasses), Leguminosae (legumes), Compositae (composites), and Rosaceae (roses and blackberry). Combined frequencies of occurrence for each major group are summarized in Table 7. Plant species considered in each of the family groups are listed in Appendix XVII. Frequencies were tested using the Chi-square test for heterogeneity. Results of the test again showed there was a significant difference in the frequencies on the burned and control areas that could not be attributed to sampling error (χ^2 = 17.8, 4 df, $P<0.05$). Inspection of the data showed that frequencies of occurrence were greater than 50 percent on the burned areas in two groups, Leguminosae and Compositae. Results of further testing by Chi-square tests indicated that much of the significant difference was attributed to these two groups (χ^2 (Leguminosae and Compositae) = 13.2, 1 df; and χ^2 (Gramineae, Rosaceae, and Group 5) = 4.6, 3 df).

Table 7. Frequencies of occurrence for the combined plant species of the 12 burned plots and their controls as classed in five major groups: 1) Gramineae, 2) Leguminosae, 3) Compositae, 4) Rosaceae, and 5) composed of all other plant species.

Major group	Number plant species	Burn frequency	Control frequency
Gramineae[a]	17	433 (46%)	512 (54%)
Leguminosae	7	200 (52)	181 (48)
Compositae	23	479 (55)	388 (45)
Rosaceae	10	114 (47)	128 (53)
Group 5	50	515 (50)	511 (50)

[a]The plant species in each of the four family groups are listed in Appendix XVII.

b. Estimated percentage of surface area of exposed soil

Percentage of surface area of exposed soil occurring in each square-meter sample site was estimated or obtained by subtraction (see Methods section, page 20). Mean percentage of surface area of exposed soil per sample site on the burned areas ranged from 1.1 on Burn Plot 4 to 47.3 on Burn Plot 3 (Table 6). Mean percentage for all burned plots was 22.7. The mean percentage of surface area of exposed soil per sample site on the control areas ranged from 0.1 on Burn Plot 4 to 2.6 on Burn Plot 6 (Table 6). Mean percentage for all control areas was 1.0.

Variation between the combined mean percentage of exposed soil surface area on the burn plots and their control areas was tested using analysis of variance. Results of the test

indicated there was a significantly greater percentage of surface area of exposed soil on burned areas than on the control areas ($F = 29.02$, 1 and 22 df, $P < 0.05$).

Inspection of the percentage of difference in the means of surface area on the burned areas and their respective controls showed marked increase in amounts of open soil on the burned areas. The increase in surface area of exposed soil ranged from 613 percent on Burn Plot 2 to 9,219 percent on Burn Plot 6 (Table 8). The overall average percentage of increase of exposed soil surface area was 2,240 percent.

c. Estimated percentage of surface area of litter

Estimated percentage of surface area of litter was recorded in each square-meter sample site. Mean percentage of estimated percentage of surface area of litter per sample site ranged from 51.4 on Burn Plot 3 to 97.6 on Burn Plot 4 (Table 6). Mean percentage of surface area of litter for all burned areas combined was 76.3. Mean percentage of estimated surface area of litter per sample site on the control areas ranged from 96.0 on Burn Plot 2 to 99.3 on Burn Plot 4 and 9 (Table 6). Mean percentage of surface area of litter for all control areas was 97.9.

Table 8. Summary of percentage of litter depth reduction, percentage of decrease in litter surface area, and percentage of increase in exposed soil surface area on the 12 burned plots.

Burn plot	Percent reduction in litter depth	Percent decrease in surface area of litter	Percent increase in surface area of exposed soil
2	97[a]	11	613
3	100	47	528
4	87	2	945
5	100	46	4,945
6	100	33	9,219
7	100	33	1,202
8	98	21	4,747
9	90	10	8,033
10	98	10	1,706
11	93	46	1,211
12	90	26	4,127
13	96	26	1,629
Average	97	22	2,240

[a]The differences between the means of average litter depths per sample site (Table 10) and estimated percentage of surface area of litter and exposed soil per sample site (Table 6) were used to calculate the percentages.

The variation between the total mean percentage of litter on all burn plots and all control areas was tested using analysis of variance. Results of the test indicated there was a significantly lower percentage of surface area of litter on burned areas than on control areas ($F = 41.50$, 1 and 22 df, $P < 0.05$).

Some idea of the magnitude of litter reduction on the burned areas can be gotten by inspecting the percentage

difference in the means of the burned and control areas (Table 8). The decrease in the estimated percentage of surface area of litter ranged from 2 percent on Burn Plot 4 to 47 percent on Burn Plot 3. The mean decrease on all burned areas combined was 22 percent.

d. Estimated percentage of basal area of live vegetation

The basal area of all species having an estimated compressed stem area greater than or equal to 0.1 percent of a square-meter was recorded at each sample site. Mean estimated percentages of stem basal area per sample site on burned areas ranged from 0.6 on Burn Plot 13 to 2.4 on Burn Plot 12 (Table 6). The mean percentages of stem basal area for all burned areas combined was 1.0. Variance between the means of basal area of each burned area was tested using analysis of variance. Results of the test indicated there were significant differences between the means of estimated stem basal area on the burned areas ($F = 3.69$, 11 and 170 df, $P < 0.05$).

Mean estimated percentages of stem basal area per sample site on control areas ranged from 0.5 on Burn Plot 13 to 2.0 on Burn Plot 2 (Table 6). The mean percentage of estimated stem basal area for all control areas combined was 1.1. The variation between the means of estimated percentage of stem basal area per sample site of each control area was tested using analysis of variance. Results of the test indicated there were no significant differences between the means of estimated stem basal area per sample site on the control

areas ($F = 1.16$, 11 and 172 df, n.s.).

During the vegetation sampling, large percentages of surface area of moss were encountered on several square-meter quadrats. Surface area of the moss was counted in the basal area totals. The means of the estimated percentage of stem basal area on the burned and unburned areas (Table 6) showed no great differences with the exception of Burn Plots 2, 10, and 12. If the means of Burn Plots 2 (control), 10 (control), and 12 (burn and control) are calculated with moss content separate, the magnitude of difference between the means is greatly reduced. Although the variance between the adjusted means of the control areas was not tested, the data strongly suggested there were significant differences between the means of estimated stem basal area on the control areas.

The variation between means of estimated percentage of stem basal area of all burned areas and all unburned areas was tested using analysis of variance. Results of the test indicated there was no significant difference between the total means of estimated percentage of stem basal area on the burned and unburned areas ($F = 0.20$, 1 and 22 df, n.s.).

In a previous section, frequencies of occurrence for 107 plant species were analysed in five major groups (Table 7). To get some idea of the relationship between frequency of occurrence and estimated percentage of stem basal area, all species having a compressed stem area greater than or equal to 0.1 percent of a square-meter were classed in the five groups

previously discussed. Relative percentages of total basal area each group occupied on each plot are listed in Table 9.

Table 9. Relative percentages of stem basal area that each of five major plant groups occupied on the burned and unburned areas.

Burn plot	Major plant groups				
	Gramineae	Leguminosae	Compositae	Rosaceae	All other species
2 (Burn)	9.8	21.2	23.3	4.1	41.1
(Control)	16.5	13.7	5.1	2.3	3.3[a]
3 (Burn)	51.5	35.6	6.1	0	6.8
(Control)	46.8	22.2	2.9	0	28.1
4 (Burn)	37.6	43.6	1.0	2.0	15.8
(Control)	30.0	32.0	2.0	8.0	28.0
5 (Burn)	55.2	2.1	12.5	1.0	29.2
(Control)	52.5	1.6	1.6	1.6	42.6
6 (Burn)	44.2	11.5	15.4	0	28.8
(Control)	55.1	6.7	19.1	0	19.1
7 (Burn)	65.5	0	19.0	0	15.5
(Control)	68.0	0	5.3	0	26.7
8 (Burn)	81.8	0.5	11.1	0.5	6.1
(Control)	53.2	0.9	27.3	0	18.5
9 (Burn)	57.2	2.4	12.9	1.6	25.8
(Control)	66.7	1.0	13.1	3.0	16.2
10 (Burn)	69.7	0.8	6.7	2.5	20.2
(Control)	31.5	0.4	2.1	1.2	23.0[b]
11 (Burn)	88.4	0	3.3	1.7	6.6
(Control)	93.2	0	0	0	6.8

[a]Moss occupied 59.1 percent of the total.

[b]Moss occupied 41.8 percent of the total.

Table 9. (continued).

Burn plot	Major plant groups				
	Gramineae	Leguminosae	Compositae	Rosaceae	All other species
12 (Burn)	41.1	0.6	6.9	1.0	5.5[c]
(Control)	72.7	0.7	0.7	0	7.9[d]
13 (Burn)	25.3	12.1	33.0	0	29.6
(Control)	26.9	9.0	11.5	0	52.6
Total (Burn)	50.0	8.9	11.4	1.3	16.5
(Control)	47.2	6.8	7.2	1.1	15.0

[c]Moss occupied 44.9 percent of the total.

[d]Moss occupied 48.4 percent of the total.

As a group, grasses occurred 433 times (46 percent) on burned areas and 512 times (54 percent) on control areas. Inspection of the percentages in Table 9 indicated that grasses, as a group, accounted for 50 percent of the total stem basal area on the burned areas and 47 percent on the control areas. Legumes, as a group, occurred 200 times (52 percent) on the burned areas and 181 times (48 percent) on the control areas. Sericea lespedeza accounted for a major portion of the legume group total on and off burned areas with 9 percent and 7 percent respectively. Although composites occurred on burned areas 479 times (55 percent) and 388 times (45 percent) on unburned areas, the total percentage of basal area occupied by the group was 11 on the burned areas and 7 on the control areas. Individual composite species occurred in much

lower densities than the grasses and legumes which accounted for the high number of occurrences and lower percentages of basal area. The same can be said for the relationship of frequency of occurrence and percentages of basal area for Rosaceae and the remaining species not in the other major groups.

e. Average litter depth Four litter measurements were taken on each square-meter sample site and then averaged to get an overall litter depth for the sample site. Average litter depth per sample site on burned areas ranged from zero (<0.25 cm) on Burn Plots 2, 3, 5, 6, 7, 8, 10 and 13 to 0.5 cm on Burn Plot 4 (Table 10). The mean litter depth on all burned areas combined was 0.1 cm. Average litter depth per sample site on control areas ranged from 2.2 cm on Burn Plot 3 to 5.3 cm on Burn Plot 12 (Table 10). The mean litter depth on all control areas combined was 3.9 cm.

Variation between the total average litter depths on the burned plots and the control areas around the burned plots was tested using analysis of variance. Results of the test showed average litter depth per sample site for all burned areas combined was significantly lower than average litter depth per sample site on all control areas combined ($F = 28.26$, 1 and 22 df, $P<0.05$).

Throughout the 1971 growing season, the absence of thick, wiry, or deeply matted litter was one of the most noticeable differences between the burned and unburned areas. There was

nearly 100 percent reduction in litter depths on almost all burned plots (Table 8). Some scattered areas of litter did not burn on those plots having moist, low depressions and drainages. Burn Plots 6, 8, 9, and 10 were in this category. In May a "ridge" effect was noticed on many of the burned areas. This ridge, about 1 inch in height, was caused by deposits of fine, unburned matter that were washed from the sloping topography by moderately heavy rains.

Table 10. Average litter depths and vegetation heights per sample site for the 12 burned plots and their controls.

Burn plot	Average litter depth/ sample site (cm) Burn/Control	Average vegetation height/ sample site (cm) Burn/Control
2	0.1/3.1	75.7/71.6
3	0 /2.2	50.5/55.9
4	0.5/3.8	62.9/65.3
5	0 /4.5	86.1/79.1
6	0 /3.6	95.0/76.9
7	0 /3.6	30.5/41.4
8	0.1/5.0	81.6/65.6
9	0.4/4.1	77.1/62.5
10	0.1/4.0	46.7/50.3
11	0.3/4.4	75.8/66.3
12	0.3/5.3	68.8/52.9
13	0.1/2.7	51.2/37.8
Total	0.1/3.9	67.8/60.5

f. Average vegetation height To complete the habitat analysis heights of each plant species with a stem basal area greater than or equal to 0.1 percent of a square-meter were used to calculate a weighted average height for each square-meter sample site. The weighted average heights were then averaged to get an average plant height for the entire plot. Average heights on the burned plots ranged from 30.5 cm on Burn Plot 7 to 86.1 cm on Burn Plot 5 (Table 10). Average vegetation height for all burned areas was 67.8 cm.

Average vegetation heights on control areas ranged from 37.8 cm on Burn Plot 13 to 79.1 cm on Burn Plot 5 (Table 10). Average vegetation heights for all control areas was 60.5 cm.

It is interesting to note that the average vegetation heights on burned areas were greater than those of control areas on eight of 12 study plots. Although it was assumed that such parameters as surface area of bare soil and litter, stem basal area, and average litter depth did not change appreciably during the time of analysis, this could not be assumed for average vegetation heights. On all plots there was a noticeable increase in vegetation heights on both burned and unburned areas as the analysis progressed during the summer season. Plant composition was also a major factor influencing average heights. Plots such as Burn Plots 5, 6, 8, and 11 which had large quantities of prairie grasses such as big and little bluestem had the greatest height values. Because of the time factor and the wide variation in plant

composition on the plots, the variation between average heights of the burned areas and unburned areas and variation between the average height of all burned areas and all unburned areas was not tested.

3. Tree and shrub occurrence

To further investigate the effects of controlled burning on the various types of upland quail habitat, a survey of the tree and shrub component of each study plot was undertaken. In 1967, direct counts were taken on all of the proposed burn areas except plots 6, 9, and 10. Due to high plant densities, line transect survey techniques were used on these plots.

Direct counts of woody species revealed combined stem densities ranging from 10.0 to 484.5 individuals per acre (Table 11). The approximate combined stem densities for those areas sampled by line transects were obtained by expanding the 11 percent sample to an acreage base. The results are indicative of the extreme densities of woody species that have invaded some of the upland areas (Table 12).

Few species were common to all of the proposed burn plots. American elm, dogwood, volunteer multiflora rose, smooth sumac, and boxelder were the major species found invading the proposed burn plots in high numbers. Densities of individual woody species on those plots surveyed by direct counts are shown in Fig. 8 (for key to Fig. 8 see Table 13).

Table 11. 1967 combined tree and shrub densities as secured by direct count on the proposed burn plots on the 1,158-acre game area.

Plot number	Number individuals	Plot area (acre)	Density (individuals/acre)
2	330	1.93	171.0
3	47	0.87	54.0
4	281	0.58	484.5
5	216	0.63	342.9
7	27	0.77	35.1
8	259	1.70	152.4
11	142	0.68	208.8
12	96	1.46	65.8
13	111	1.11	10.0

Table 12. 1967 combined tree and shrub densities as secured by line transects on the proposed burn plots on the 1,158-acre game area.

Plot number	Number individuals	Plot area (acre)	Density (individuals/acre)
6	261	0.076	3,434
9	402	0.092	4,370
10	242	0.096	2,521

Heights of all tree and shrubs under 1.5 m (5 feet) were recorded in 1967. The heights of all species encountered in plots sampled by direct counts are summarized in Table 14. Heights of the species recorded in the line transects agreed closely with those of the direct counts. Only a very small percentage of individuals had a diameter at breast height (dbh) greater than 12.7 cm (5 inches).

In 1971, major effort was made to record the effects of fire on the growing condition of selected tree and shrub species on the burned areas. Direct counts were taken in May 1971, approximately 30 days after burning operations. By this time representatives of all tree and shrub species showed leaf growth. Line transects surveys were taken in mid-August upon completion of the square-meter quadrat habitat analysis.

Results of the direct counts and line transect surveys showed overwhelming evidence that fire retarded the growth of woody species located on the burned areas. Of 1,674 individuals of all species recorded by the direct count method, 186 (11 percent) were in normal growing condition, 810 (48 percent) had new leafy shoots at the base of a dead stem, and 688 (41 percent) were killed. Of 1,207 individuals of all species recorded by line transects techniques, 41 (3 percent) were in normal growing condition, 1,133 (94 percent) had new leafy shoots at the base of a dead stem, and 33 (3 percent) were killed. Of the 2,881 individuals recorded by both methods, 2,654 (92 percent) were in some way adversely affected by fire. Relative percentages of the total number of individuals of combined species in the three growth conditions are illustrated in Fig. 9a (direct counts) and Fig. 9b (line transects). No counts were taken on Burn Plot 13 due to low plant densities. The total number of individuals of each species in the three growth conditions for each burned area is summarized in Tables 15 (direct counts) and 16 (line transects). Individuals

of buckbrush and smooth sumac were not recorded on those plots sampled by direct counts because of high stem density. American elm, multiflora rose, eastern redcedar, dogwood, green ash, smooth sumac, buckbrush, wild plum, and boxelder were species found most prevalent on burned areas. Relative percentages of the total number of individuals of these woody species as they occurred in the three growth conditions are illustrated in Fig. 10.

Table 13. Key to the tree and shrub abbreviations used in Fig. 8.

Abbreviation	Common Name
ACNE	Boxelder
CORNUS	Red osier dogwood
CORYLUS	Hazelnut
FRPE	Green ash
GLTR	Honey-locust
JUVI	Eastern redcedar
PODE	Cottonwood
PRAM	Wild plum
ROMU	Multiflora rose
RUGL	Smooth sumac
SALIX	Willow
SYOR	Buckbrush
ULAM	American elm
ZACL	Prickly ash

Fig. 8. 1967 pre-burn densities of woody species recorded on the proposed burn plots that were surveyed by direct count. See Table 13 for key to plant species abbreviations.

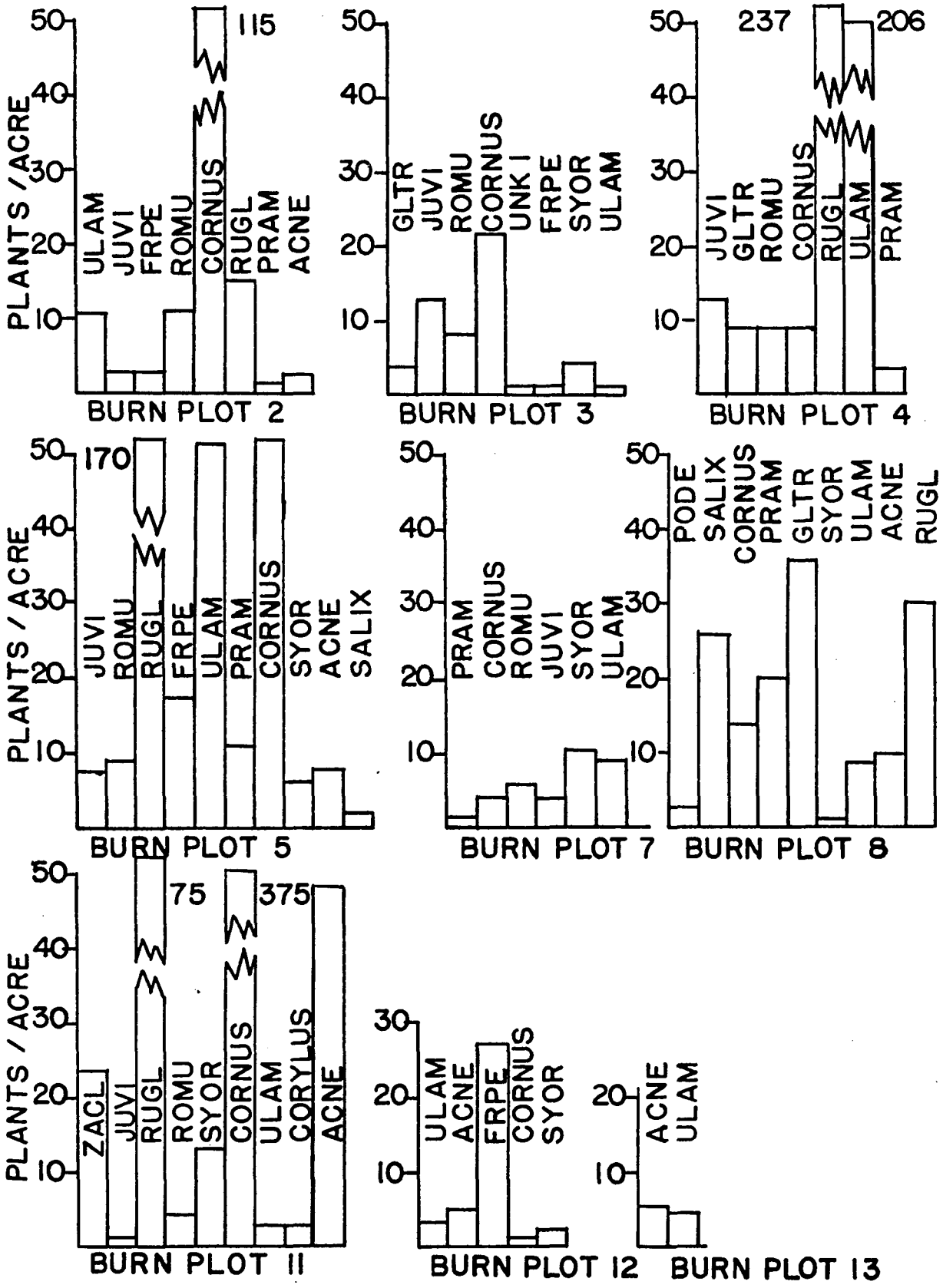

PLANTS / ACRE
50
40
30
20
10
115
ULAM
JUVI
FRPE
ROMU
CORNUS
RUGL
PRAM
ACNE
BURN PLOT 2
GLTR
JUVI
ROMU
CORNUS
UNK I
FRPE
SYOR
ULAM
BURN PLOT 3
237
206
JUVI
GLTR
ROMU
CORNUS
RUGL
ULAM
PRAM
BURN PLOT 4
170
JUVI
ROMU
RUGL
FRPE
ULAM
PRAM
CORNUS
SYOR
ACNE
SALIX
BURN PLOT 5
PRAM
CORNUS
ROMU
JUVI
SYOR
ULAM
BURN PLOT 7
PODE
SALIX
CORNUS
PRAM
GLTR
SYOR
ULAM
ACNE
RUGL
BURN PLOT 8
75
375
ZACL
JUVI
RUGL
ROMU
SYOR
CORNUS
ULAM
CORYLUS
ACNE
BURN PLOT 11
ULAM
ACNE
FRPE
CORNUS
SYOR
BURN PLOT 12
ACNE
ULAM
BURN PLOT 13

Fig. 9a. Relative percentages of individuals of all woody species combined occurring in three growth conditions. Burn plots in Fig. 9a were sampled by direct count method.

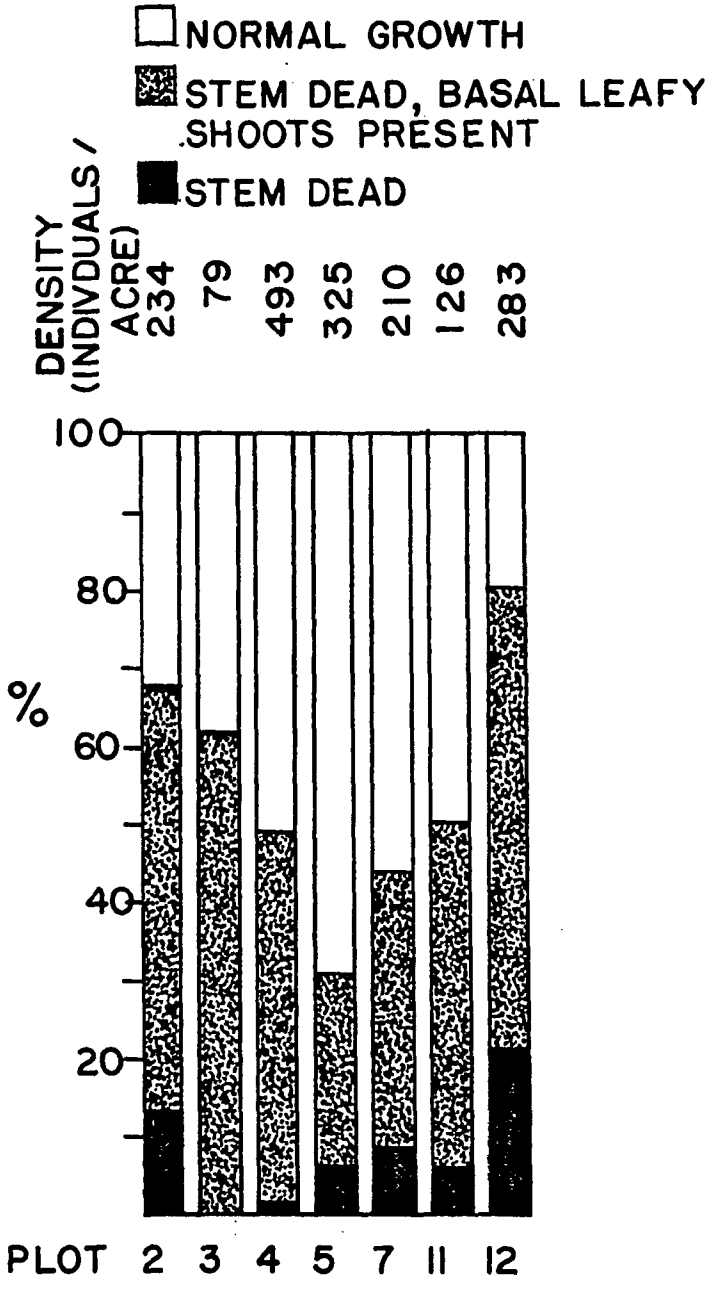

NORMAL GROWTH
STEM DEAD, BASAL LEAFY SHOOTS PRESENT
STEM DEAD
DENSITY (INDIVDUALS / ACRE)
234
79
493
325
210
126
283
100
80
60
40
20
%
PLOT 2 3 4 5 7 11 12

Fig. 9b. Relative percentages of individuals of all woody species combined occurring in three growth conditions. Burn plots in Fig. 9b were sampled by line transect method.

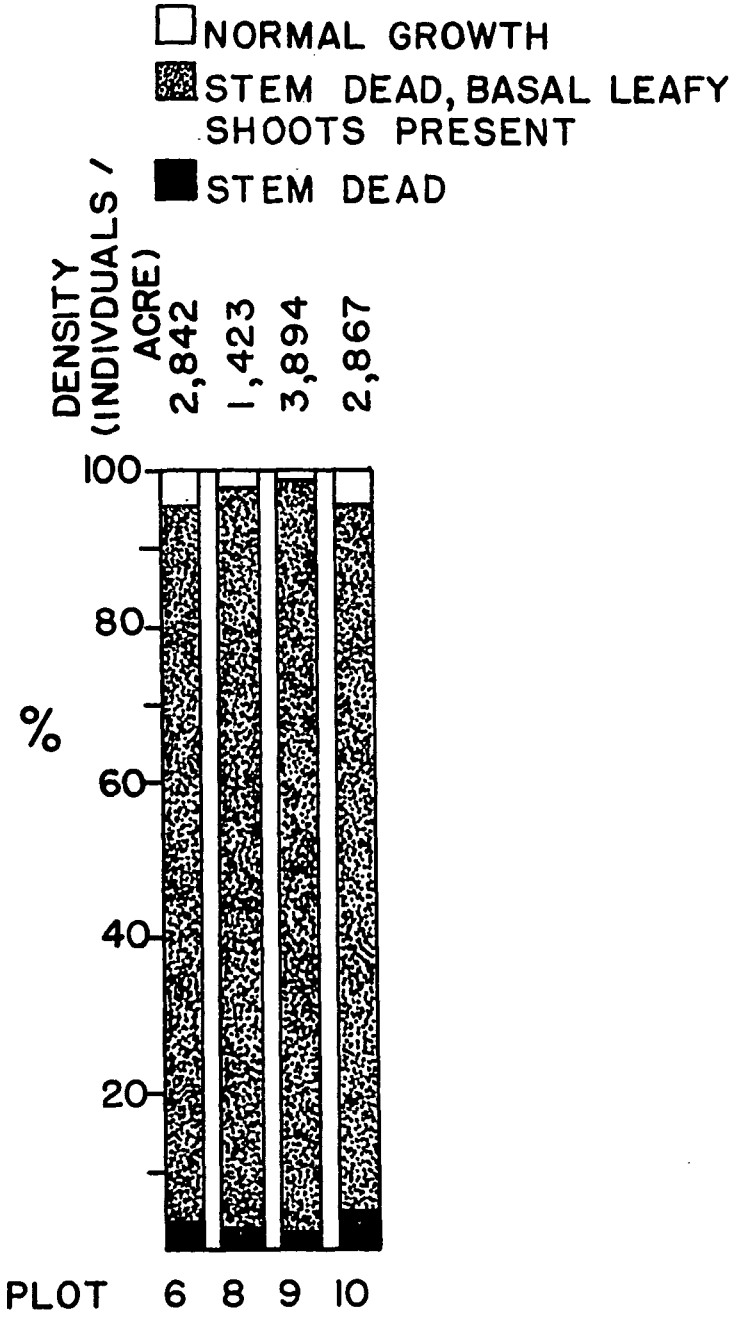

NORMAL GROWTH
STEM DEAD, BASAL LEAFY SHOOTS PRESENT
STEM DEAD
DENSITY (INDIVDUALS / ACRE)
2,842
1,423
3,894
2,867
100
80
60
40
20
%
PLOT 6 8 9 10

Fig. 10. Relative percentages of individuals of major woody species occurring in three growth conditions: 1) normal growing condition, 2) plant with new leafy shoots at the base of a dead stem, or 3) plant dead.

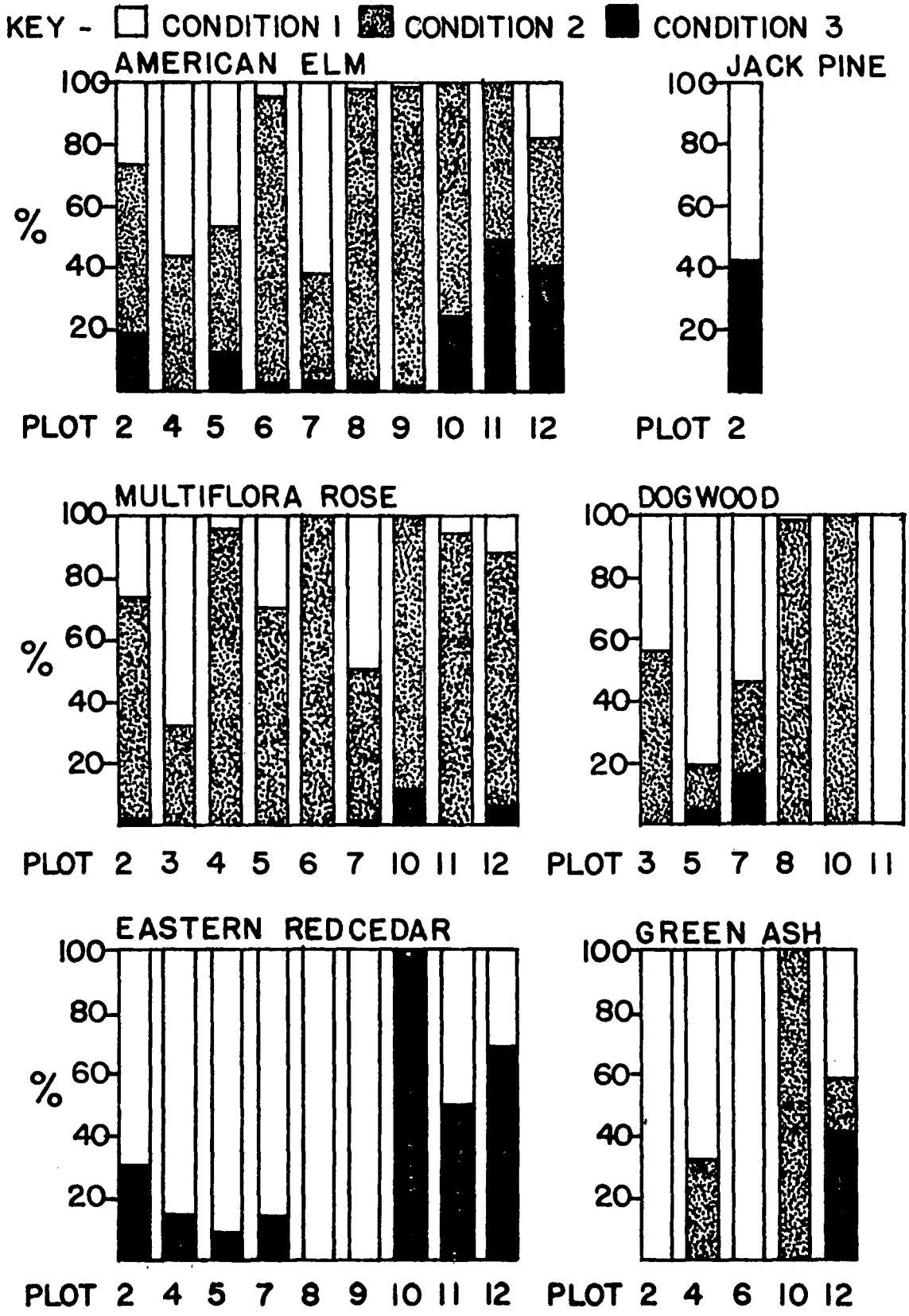

KEY - CONDITION 1 CONDITION 2 CONDITION 3
AMERICAN ELM
100
80
60
40
20
%
PLOT 2 4 5 6 7 8 9 10 11 12
JACK PINE
100
80
60
40
20
PLOT 2
MULTIFLORA ROSE
100
80
60
40
20
%
PLOT 2 3 4 5 6 7 10 11 12
DOGWOOD
100
80
60
40
20
PLOT 3 5 7 8 10 11
EASTERN REDCEDAR
100
80
60
40
20
%
PLOT 2 4 5 7 8 9 10 11 12
GREEN ASH
100
80
60
40
20
PLOT 2 4 6 10 12

Fig. 10. (continued).

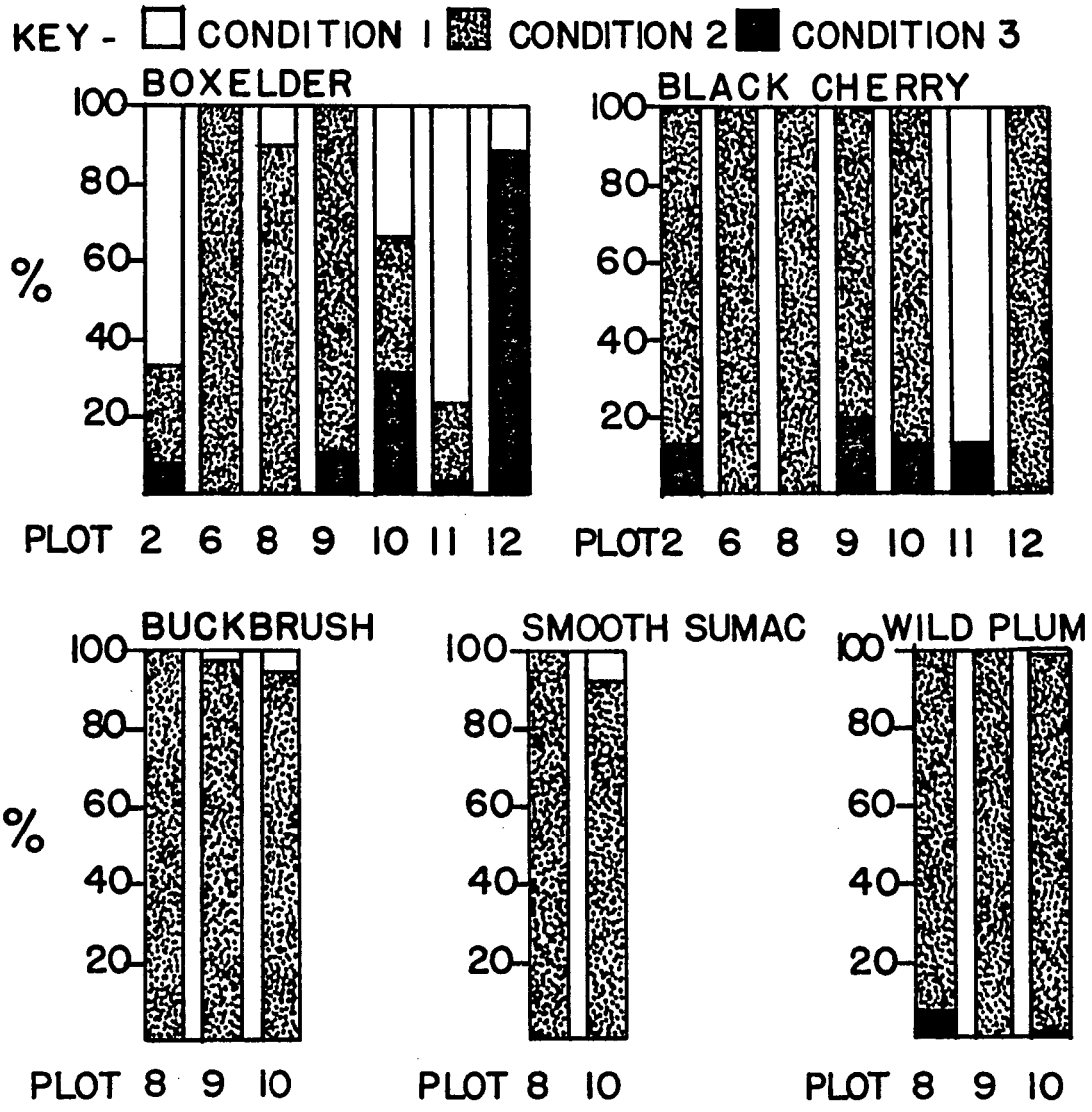

KEY - CONDITION 1 CONDITION 2 CONDITION 3
BOXELDER
BLACK CHERRY
BUCKBRUSH
SMOOTH SUMAC
WILD PLUM
%
100
80
60
40
20
PLOT 2 6 8 9 10 11 12
PLOT2 6 8 9 10 11 12
PLOT 8 9 10
PLOT 8 10
PLOT 8 9 10

Table 14. Average heights (cm) of shrubs less than 1.5 m (5 feet) on those proposed burn plots sampled by direct counts in June through August 1967.

Species	Burn plot 2	3	4	5	7	8	11	12	13
Multiflora rose	96.5	63.8	111.0	108.0	77.7	a	99.8	a	a
American elm	116.8	43.4	44.2 (1)[b]	87.1	63.8	64.8	76.2	141.7	50.8
Dogwood	82.8	62.7	76.2 (1)	75.9	100.8	93.7 (1)	84.8	71.1	a
Eastern redcedar	111.8	74.9	127.0	113.8	76.2 (1)	a	109.2 (1)	a	a
Boxelder	69.8	a	a	57.9	a	57.2	63.5 (5)	117.6	81.3
Green ash	106.4	53.3	a	90.2	a	c	a	86.4	a
Smooth sumac	82.3	a	64.3	101.6	a	56.9	104.1	a	a
Wild plum	73.6	a	36.8	80.5	101.6	84.3	a	a	a
Cottonwood	c	a	a	a	a	146.0 (3)	a	a	a
Buckbrush	a	52.8	a	68.1	70.6	80.8	86.9	66.2	a
Honey-locust	a	79.0	43.7 (2)	a	a	83.8	a	a	a
Willow	a	a	a	50.8	a	110.4 (4)	a	a	a

[a]Species not recorded on the plot.

[b]Numbers in parentheses indicates number of individuals over 1.5 m.

[c]All individuals over 1.5 m.

Table 14. (continued).

Species	Burn plot 2	3	4	5	7	8	11	12	13
Hazel	a	a	a	a	a	a	69.9 (1)	a	a
Prickly ash	a	a	a	a	a	a	127.5 (5)	a	a
Black cherry	a	a	a	a	a	a	c	a	a

Table 15. Total numbers of individuals of woody species occurring on those plots sampled by direct count as recorded in three growth condition categories: 1) normal growing condition, 2) plant with new leafy shoots at the base of a dead stem, and 3) plant killed.

Species	Growth category	Burn plot 2	3	4	5	7	11	12
American elm	1	19	a	0	5	1	1	7
	2	58		87	17	12	1	7
	3	29		110	19	21	0	3
	Total	106		197	41	34	2	17
Multiflora rose	1	4	0	0	0	1	0	19
	2	146	18	45	17	39	32	214
	3	52	9	2	7	16	2	31
	Total	202	27	47	24	56	34	264
Dogwood	1	a	0	a	5	5	0	a
	2		4		16	8	0	
	3		3		87	15	13	
	Total		7		108	28	13	

[a]Species not found on the plot.

Table 15. (continued).

Species	Growth category	Burn plot 2	3	4	5	7	11	12
Eastern redcedar[b]	1	4	a	4	3	a	6	16
	3	9		23	29		35	7
	Total	13		27	32		41	23
Jack pine	1	30	a	a	a	a	a	a
	3	41						
	Total	71						
Green ash	1	0	a	0	a	a	a	40
	2	0		2				17
	3	6		4				40
	Total	6		6				97
Boxelder	1	1	a	a	a	a	1	8
	2	3					5	0
	3	8					20	1
	Total	12					26	9
Black cherry	1	3	a	a	a	a	1	0
	2	19					0	1
	3	0					6	0
	Total	22					7	1
Mulberry	1	0	a	a	a	a	a	a
	2	1						
	3	1						
	Total	2						
Wild grape	1	0	a	a	a	a	a	a
	2	3						
	3	0						
	Total	3						
Cottonwood	1	0	a	a	a	a	a	a
	2	0						
	3	1						
	Total	1						

[b]Species were considered living if some green leaves were present on the stems.

Table 15. (continued).

Species	Growth category	Burn plot 2	3	4	5	7	11	12
Elderberry	1	0	a	a	a	a	a	0
	2	15						2
	3	0						0
	Total	15						2

Table 16. Total numbers of individuals of woody species occurring on those plots sampled by line transect as recorded in three growth condition categories: 1) normal growing condition, 2) plant with new leafy shoots at the base of a dead stem, and 3) plant killed.

Species	Growth category	Burn plot 6	8	9	10
American elm	1	3	4	5	11
	2	162	102	237	33
	3	7	1	1	0
	Total	172	107	243	44
Multiflora rose	1	0	a	a	1
	2	1			7
	3	0			0
	Total	1			8
Dogwood	1	a	0	a	0
	2		55		1
	3		1		0
	Total		56		1

[a]Species not found on the line transect.

Table 16. (continued).

Species	Growth category	Burn plot 6	8	9	10
Eastern redcedar[b]	1	a	0	0	1
	3		1	1	0
	Total		1	1	1
Green ash	1	3	a	a	0
	2	14			1
	3	1			0
	Total	18			1
Boxelder	1	0	0	3	1
	2	1	9	22	1
	3	0	1	2	1
	Total	1	10	27	3
Black cherry	1	0	0	1	1
	2	20	6	4	6
	3	0	0	0	0
	Total	20	6	5	7
Buckbrush	1	a	0	0	0
	2		16	49	38
	3		0	1	2
	Total		16	50	40
Smooth sumac	1	a	0	a	0
	2		8		89
	3		0		7
	Total		8		96
Wild plum	1	a	1	0	1
	2		13	75	134
	3		0	0	1
	Total		14	75	136
Silver maple	1	0	a	a	a
	2	1			
	3	0			
	Total	1			

[b]Species were considered living if some green leaves were present on the stems.

Table 16. (continued).

Species	Growth category	Burn plot 6	8	9	10
Wild grape	1	a	0	a	0
	2		2		1
	3		0		0
	Total		2		1
Willow	1	a	2	a	a
	2		18		
	3		1		
	Total		21		
Cottonwood	1	a	0	a	a
	2		1		
	3		0		
	Total		1		
Elderberry	1	a	a	1	a
	2			2	
	3			0	
	Total			3	
Gooseberry	1	a	a	0	a
	2			1	
	3			0	
	Total			1	
Prickly ash	1	a	a	a	0
	2				1
	3				0
	Total				1
Mulberry	1	a	a	a	1
	2				3
	3				0
	Total				4

C. Mount Ayr Quail Populations

A total of 601 bobwhite sightings were recorded on the 1,158-acre public hunting area during the field investigation. In June, July and August 1967, 104 were seen. Twenty-four sightings were recorded in the 4-month period beginning in September 1970. In 1971, 473 quail were sighted during an 11-month period beginning in January and ending in November. Monthly totals for the two periods of continuous field investigation, June through August 1967, and April through August 1971, are summarized in Table 17 and 18.

Table 17. Weekly totals of bobwhite quail sightings on the 1,158-acre game area from June 1 to August 26, 1967.

Weekly period	Sighting totals					Weekly totals
	Cock	Hen	Pair	Brood	Unknown sex	
June 1-3	3	0	6	0	2	11
4-10	3	2	6	0	1	12
11-17	5	0	4	0	0	9
18-24	9	0	4	0	0	13
25-July 1	7	0	3	0	0	10
2-8	0	1	0	0	0	1
9-15	3	0	3	0	0	6
16-22	2	0	2	0	0	4
23-29	0	0	4	0	0	4
30-August 5	2	1	4	2	0	9
6-12	2	0	5	3	0	10
13-19	0	0	0	2	0	2
20-26	3	3	3	4	0	13
Totals	39	7	44	11	3	104

Table 18. Weekly totals of bobwhite quail sightings on the 1,158-acre game area from April 4 to September 4, 1971.

Weekly period	Sighting totals						Weekly totals
	Cock	Hen	Pair	Covey	Brood	Unknown sex	
April 4-10	6	1	1	1	0	0	9
11-17	4	0	1	4	0	0	9
18-24	5	3	6	1	0	6	21
25-May 1	5	2	1	0	0	2	10
May 2-8	7	0	14	0	0	4	25
9-15	7	3	8	0	0	3	21
16-22	9	0	1	0	0	3	13
23-29	21	0	6	0	0	5	32
30-June 5	46	0	9	0	0	5	60
June 6-12	31	1	12	0	0	1	45
13-19	16	3	4	0	0	1	24
20-26	10	0	0	0	0	0	10
27-July 3	14	1	0	0	0	0	15
July 4-10	6	2	1	0	2	0	11
11-17	5	3	3	0	3	0	14
18-24	7	3	3	0	6	0	16
25-31	5	4	4	0	3	1	17
August 1-7	6	2	3	0	6	0	17
8-14	1	2	0	0	4	0	7
15-21	1	2	0	0	3	0	6
29-September 4	1	0	1	0	4	1	7
Totals	213	32	78	6	28	32	389

1. Brood numbers

a. 1967 Brood numbers The 400-acre Study Unit was searched intensively during the summer months of 1967 and 1971 for quail broods. Of eight broods located on the game area in 1967, six were on the 400-acre Study Unit. The first brood was observed August 8. Brood sizes varied from 4 to 12 juvenile birds with an average of 7.2 birds. Data were inconclusive as to when the main hatching peak occurred. Frequency

of weekly cock and pair sightings (Fig. 11) suggested the peak occurred sometime between late June and mid-July.

b. 1968, 1969, and 1970 Brood numbers Although no brood counts were taken during 1968, 1969, and 1970 by the investigator, Iowa Conservation Commission employees working on the area recorded brood observations during these years (Table 19). During the 1970 hunting season, 147 wings were collected from which ages were determined. A hatching curve was developed from the hatching dates of 116 juvenile bobwhites bagged on the game area (Fig. 12). The peak hatching date as calculated occurred during the week of June 14 to 20 with a later secondary peak in the week of August 9 to 15. Fifty percent of the 116 juvenile birds hatched before July 5, 75 percent hatched before August 2 (Fig. 12). The age in days of juvenile birds older than 150 days when bagged could not be determined by the primary wing feather moult technique used in this study. This aging limitation involved 18 birds which, if they had been included, would have shifted the peak hatching date 7 to 10 days earlier in June.

c. 1971 Brood numbers Fourteen broods were located on the game area in 1971. Brood sizes ranged from 4 to 17 birds. Lack of accurate bird counts, however, did not permit determination of average brood size. The first brood was observed on June 24. Hatching dates of 13 broods as determined from age estimates of birds sighted in the field indicated that 7 of 13 (54 percent) hatched within an 11-day period

Fig. 11. Weekly totals of cocks, pairs, and coveys sighted on the 1,158-acre game area from June 1 to August 26, 1967.

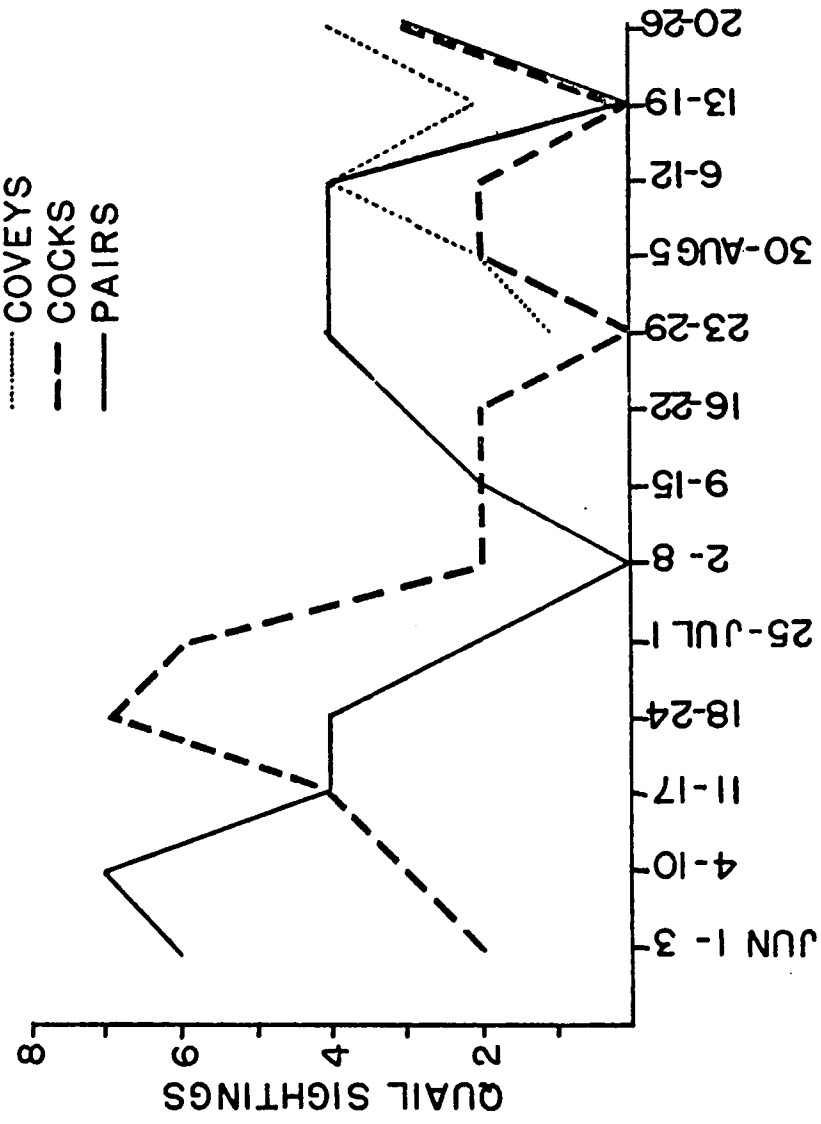
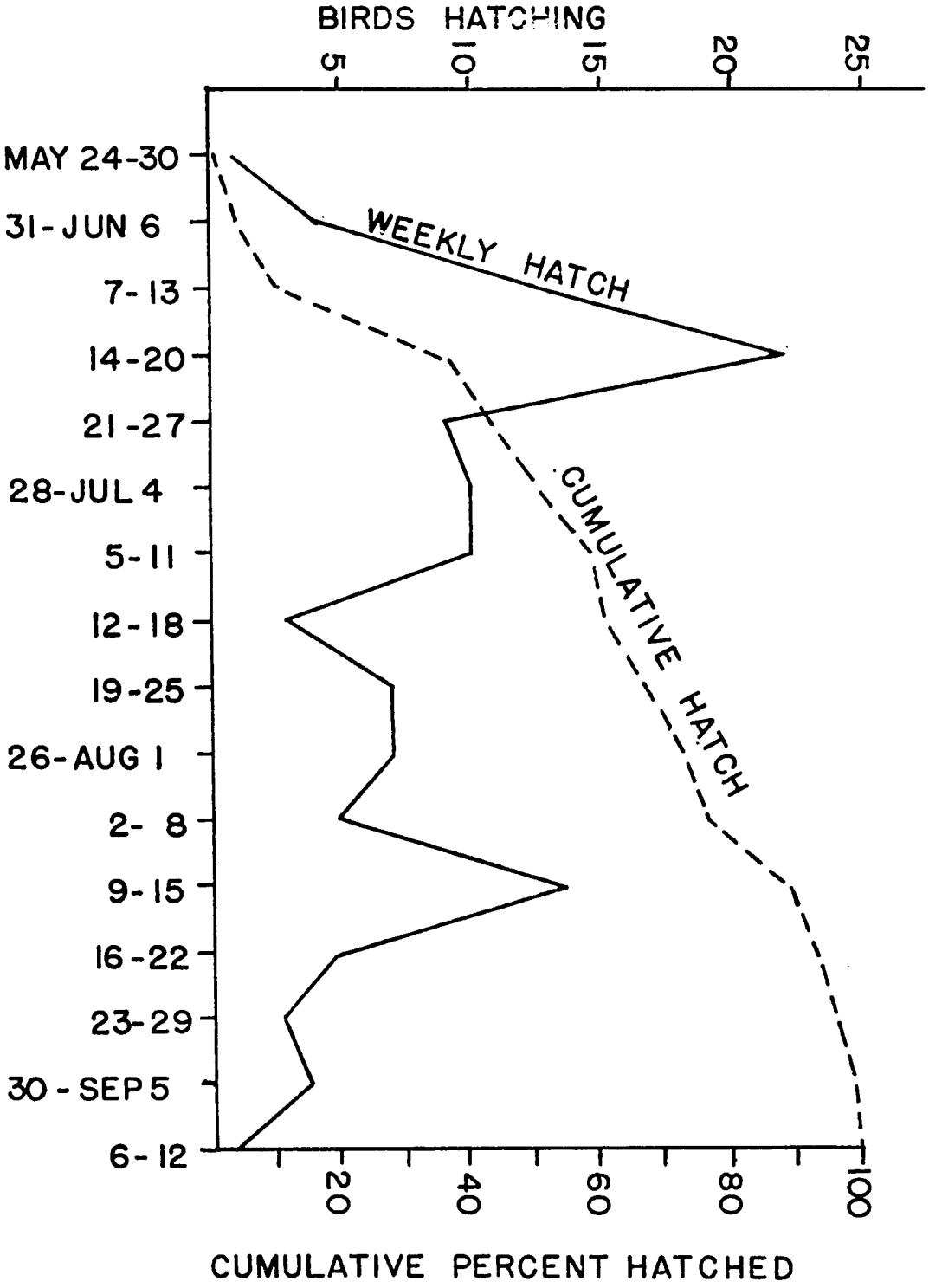

COVEYS
COCKS
PAIRS
QUAIL SIGHTINGS
8
6
4
2
JUN 1- 3
4-10
11-17
18-24
25-JUL 1
2- 8
9-15
16-22
23-29
30-AUG 5
6-12
13-19
20-26

Fig. 12. Seasonal distribution of numbers and percentage of hatch of 116 juvenile bobwhites bagged on the 1,158-acre game area during the 1970 quail hunting season.


BIRDS HATCHING
5
10
15
20
25
MAY 24-30
31-JUN 6
7-13
14-20
21-27
28-JUL 4
5-11
12-18
19-25
26-AUG 1
2-8
9-15
16-22
23-29
30-SEP 5
6-12
WEEKLY HATCH
CUMULATIVE HATCH
20
40
60
80
100
CUMULATIVE PERCENT HATCHED

between June 14 and 24. Ten of the 13 broods (77 percent) hatched before June 24. The nesting and hatching chronology events of the 13 quail broods is summarized in Table 20.

Table 19. Summary of quail brood sightings on the 1,158-acre game area in 1967, 1968, 1969, 1970, and 1971.

Year	Number quail broods on 400-acre Study Unit	Number on game area[a]
1967	6	8
1968[b]	7	9
1969	8	14
1970	7	11
1971	12	14

[a]Total for the 1,158-acre game area includes broods sighted on 400-acre Study Unit.

[b]Iowa Conservation Commission employee counts, 1968 through 1970.

A hatching curve was developed from the hatching dates of 55 juvenile bobwhites bagged on the game area during the 1971 hunting season (Fig. 13). The general peak in hatching activity occurred during June, with the week of June 6 to 12 producing the greatest number of young birds (10 of 55 birds, 18 percent). Over 50 percent of the 55 juvenile birds hatched before July 4, 75 percent hatched before August 15 (Fig. 13). A secondary peak occurred in mid-August. Only four of 55 young of the year birds were older than 150 days when bagged and therefore could not be included in plotting the hatching

Fig. 13. 1971 hatching curve and cumulative percentage of hatching dates of 55 juvenile bobwhites bagged on the 1,158-acre game area during the 1971 quail hunting season.

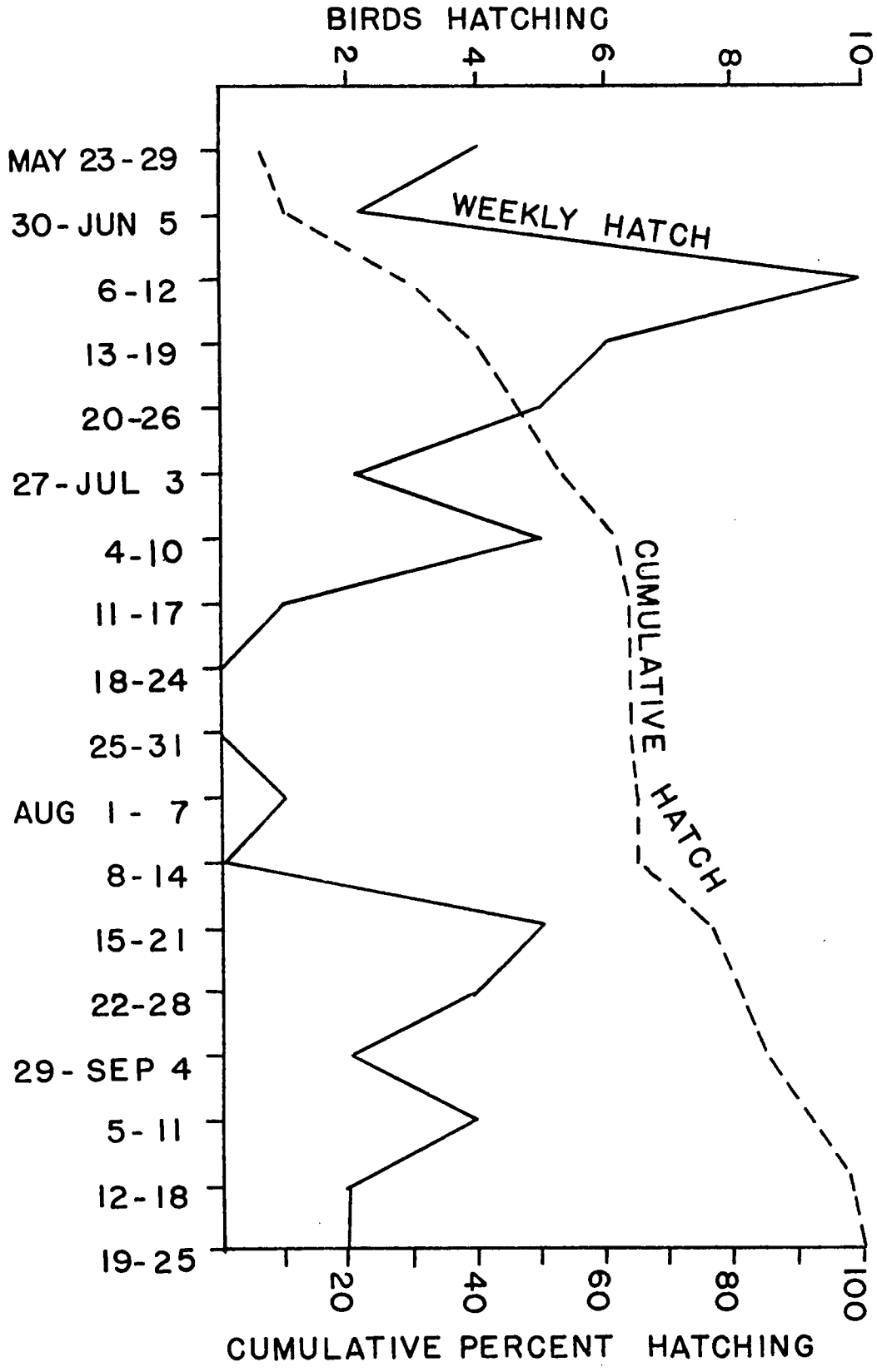

BIRDS HATCHING
2
4
6
8
10
MAY 23-29
30-JUN 5
6-12
13-19
20-26
27-JUL 3
4-10
11-17
18-24
25-31
AUG 1-7
8-14
15-21
22-28
29-SEP 4
5-11
12-18
19-25
WEEKLY HATCH
CUMULATIVE HATCH
20
40
60
80
100
CUMULATIVE PERCENT HATCHING

Table 20. Summary of the nesting and hatching chronology events of 13 quail broods sighted on the 1,158-acre game area in 1971.

Brood	Date brood sighted	Est. age (days)	Hatching date	Calculated date		
				Incubation began[a]	Laying began[b]	Nesting began[c]
A	Jun 24	1-2[d]	Jun 22	May 31	May 15	May 9
B	Jul 7	14-21	Jun 21	May 30	May 14	May 8
C	Jul 7	21-28	Jun 14	May 23	May 7	May 1
D	Jul 12	28-35	Jun 11	May 20	May 4	Apr 29
E	Jul 13	21-28	Jun 19	May 28	May 12	May 7
F	Jul 14	1	Jul 15	Jun 23	Jun 7	Jun 2
G	Jul 19	46	Jun 4	May 13	Apr 27	Apr 21
H	Jul 19	26	Jun 24	Jun 2	May 17	May 11
I	Jul 28	56	Jun 3	May 12	Apr 26	Apr 20
J	Aug 2	31	Jul 3	Jun 11	May 26	May 20
K	Aug 5	46	Jun 19	May 28	May 12	May 6
L	Aug 17	38	Jul 10	Jun 18	Jun 2	May 27
M	Aug 17	73	Jun 6	May 15	Apr 29	Apr 23

[a]Assume incubation period of 23 days.

[b]Assume average laying period of 16 days.

[c]Assume nest building period of 6 days.

[d]Age determined from field observation of plumage development and body size.

curve. Even if these birds had been included, it is doubtful they would have shifted the peak hatching period to an earlier date. Even though hatching dates of all bagged juvenile birds were considered without reference to individual broods, the main peak as determined from the hunters "bag" data agreed closely with the main peak as determined by field age estimates.

2. Covey numbers

A knowledge of the number of coveys and the numbers of birds in each covey was a necessary factor in accessing the management practice of controlled burning. Fall pre-hunting censuses were conducted on the public hunting area in October 1967, 1970, and 1971. The Mount Ayr quail population was checked at least monthly from the fall of 1970 to the 1971 hunting season.

a. 1967 Fall quail populations In 1967 heavy cover conditions and standing corn and grain sorghum prevented accurate pre-hunting season counts. On opening day of quail season, October 21, hunters located eight coveys on the 1,158-acre game area, four of which were on the 400-acre Study Unit (Table 21). Hunters undoubtedly did not find all coveys on the game area. Such factors as superabundance of good cover, standing corn, and vegetation too dry for good scenting conditions for the dogs combined to form less than favorable hunting conditions. Hunting was made even more difficult by the 35-40 mph winds which prevailed on the opening day.

b. 1970 Fall quail populations A pre-hunting season census was conducted on September 14, 15, and October 3 and 4, 1970. The investigator located a total of nine coveys on the 400-acre Study Unit. Sizes ranged from 10 to 20 birds with an average of 13.5 birds per covey (Table 22). As in 1967, dense cover conditions made birds difficult to find.

Table 21. Summary of covey sizes located on the 1,158-acre game area on October 21, 1967 (opening day of quail hunting season) as reported by hunters.

Covey number	Estimated numbers of birds
1	15
2	15
3	8
4	15
5[a]	8-10
6	30-35
7	8-10
8	8-10

[a]Coveys 5 through 8 were found on the 400-acre Study Unit.

Hunters located a total of 28 different coveys on the 1,158-acre public hunting area. This total included the nine pre-season coveys located by the investigator. Covey sizes and hunting mortality suffered by each covey from October 24 to November 14 are listed in Table 22. Covey size information is lacking for nine of the 28 coveys (Table 22). This fact, coupled with the wide range in estimated covey sizes, indicated a misleading average covey size for the entire game management area. Interpretation of hunting data to differentiate separate coveys was difficult in some cases. The investigator was not able to contact all hunting parties before they entered the field and as a result individual birds bagged from different coveys were unknown to the investigator. Some coveys had to be classified solely on the preponderance of juvenile birds

bagged in areas not occupied by known coveys. After opening day, many coveys were separated into smaller groups as a result of hunting. This condition had the effect of increasing the number of coveys reported flushed.

Enough information was gathered to estimate the number of birds available to hunters on opening day of the season on the 400-acre Study Unit. Based on a pre-hunting season covey size of 13.5 birds, a total of 219 birds in 17 coveys was estimated for the area. For comparative purposes, this indicates a density of 0.54 quail per acre, one bird per 2 acres.

A mixing of coveys occurred after the hunting season began. This was determined by comparing the ages of bagged juvenile birds collected from known coveys in adjacent territories. Bag data collected on November 14 suggested that the following coveys combined to form new separate individual coveys: 2 and 3, 4 and 6, and 1, 11, and 13 (Table 22). Inspection of hunting mortality data (Table 22) indicated that many coveys suffered over 50 percent reduction losses, some as high as 80 percent. As an example, Covey 3 suffered over 54 percent mortality while Covey 2 experienced little known mortality.

Table 22. Fall 1970 covey sizes and hunting mortality losses by each covey from October 24 to November 14 on the 1,158-acre game area.

Covey number	Number birds in covey	Hunting mortality
1[a]	13-15	10
2	No estimate	4
3	11(24-36)[b]	15[c]
4	No estimate	6[d]
5	10	3(3 crippled)
6	13-16	7(4 crippled)
7	13	12
8	18-20	1
9	No estimate	7
10	No estimate	4[e]
11	15-18	3(1 crippled)
12	15-20	8
13	12-15	6
14	10	7
15	12-17	4(1 crippled)
16	No estimate	6
17	10-22	6
18	12-15[b]	2

[a]Coveys 1, 2, 3, 6, 7, 11, 12, 14 and 24 were located in the pre-hunting season census.

[b]Hunter estimates.

[c]The pre-season size estimate of Covey 3 was 11 birds. Six birds were killed on Oct. 24, 25, and 30. Kill data and hunter's estimates on Nov. 14 suggest that Coveys 2 and 3 combined in the first part of Nov.

[d]Kill data from Nov. 14 suggest that Coveys 4 and 6 had combined.

[e]Kill data and flush positions indicated single classification for Coveys 10, 11, and 13 in mid-Oct. Kill data in mid-Nov. suggested that remnants of these coveys combined to form one covey.

Table 22. (continued).

Covey number	Number birds in covey	Hunting mortality
19	6-8[b]	8[f]
20	5-7[b]	
21	6-8[b]	1
22[g]	10-15	5
23[h]	No estimate	4
24	No estimate	
25	7-11[i]	
26	13[i]	
27	No estimate	2
28	No estimate	2

[f]Kill data collected from combined bag and included birds from Coveys 19, 20, and 21.

[g]Single covey classification questionable due to wing sample data, basis for single classification based largely on proximity of covey flushes by hunting parties.

[h]Covey numbers 25 through 28 are established on the north half of the game area. Data on covey classifications are fragmentary at best.

[i]Conservation Commission employee estimates.

c. 1970-71 Winter quail populations A total of 64 birds in six coveys was located on the 400-acre Study Unit during the winter census in late December 1970 and January 1971. Covey numbers ranged from 8 to 22 with an average of 11 birds per covey (Table 23). Field data suggest that Coveys 2 and 3 (Table 23) combined for a short time in late December; however, average covey size was calculated using two separate coveys. The winter quail density of the

400-acre Study Unit was 0.16 birds per acre or about one bird per 6 acres.

d. 1971 Spring quail populations In the pre-nesting census conducted in March, the six previously located coveys consisted of 53 birds, indicating a decrease of 11 birds (17 percent). Hunting mortality claimed over half of the 17 percent loss. The number of birds per covey ranged from 7 to 12 birds with an average of 9 birds. There was a pre-nesting quail density of 0.13 birds per acre or about one bird per 7 acres. Pre-nesting season counts for the six coveys are summarized in Table 23.

Table 23. 1971 winter (late December and January) and pre-nesting population (March) counts for six coveys on the 400-acre Study Unit.

Covey number	Winter count	Pre-nesting count	Mortality
1	12	9	3(hunting)
2	13	12	1
3	9	8	1
4	9	9	0
5	12	8	4(2 hunting, 1 predation & 1 trap. mort.)
6	9	7	2
Totals	64	53	11
Average covey size	10.7	8.8	
Density (birds/acre)	0.16	0.13	

Spring break-up began in April with the first whistling heard on April 6. The earliest pairing was observed on April 8 and the latest covey observed, a group of six or more birds, was seen on April 24. Spring covey break-up was largely completed by May 1.

e. 1971 Fall quail populations A pre-hunting season census was conducted on the 400-acre Study Unit on October 1 and 2. No family groups or coveys were located. Even though all corn and grain sorghum had been picked prior to the pre-hunting census, heavy upland cover made birds difficult to locate.

Hunters located a total of 12 different coveys on the 1,158-acre public hunting area (Table 24). Nine of the 12 coveys were located on the 400-acre Study Unit. Since bag checks were made primarily on and near the 400-acre Study Unit, not all coveys on the 1,158-acre area were accounted for in the hunter surveys. The 12 coveys consisted of an average size of 12.3 birds. Because the number of birds bagged (73) during the three 1971 survey periods was considerably lower than the 1970 total (175), the problem of interpretation of hunting data to differentiate separate coveys was greatly reduced.

Based on hunter's estimates of covey sizes, 156 birds in 9 coveys were available to hunters on opening day on the 400-acre Study Unit, indicating a density of 0.39 quail per acre.

Table 24. Fall covey sizes and hunting mortality suffered by each covey from October 23 to November 13, 1971 on the 1,158-acre game area.

Covey number	Number birds in covey	Hunting mortality
1[a]	12[b]	3
2	12-14	6
3	10-12	2
4	15-18	1(6)[c]
5	15-16	4
6	8	4
7	12-15	2
8	8-10	2(1 cripple)[d]
9	7-8	2
10	15	18[e]
11	12-13	
12	15	

[a]Coveys 1 through 8 were located on the 400-acre Study Unit.

[b]All covey numbers are hunter estimates.

[c]Seven singles were collected in the general vicinity where the covey was originally flushed.

[d]Bag data and observations by the investigator suggested Coveys 8 and 9 joined after opening weekend.

[e]All birds were bagged from Coveys 10, 11, and 12. Survey data were inconclusive as to which covey each bird belonged.

3. Hunter surveys

a. 1967 A hunter survey was conducted on October 21, opening day of quail hunting season. Seventeen hunters in eight parties expended 60 gun hours to bag 13 quail and 14 rabbits, indicating a hunting success of 0.21 birds per gun

hour. Hunting conditions were less than optimum.

The total kill of 13 birds was too small for quantitative evaluation. One wing from each of the bagged birds was collected and age of each bird determined. Of the 13 wings collected, 4 were from cocks and 9 from hens, consisting of 2 adults (15 percent) and 11 juveniles (85 percent).

b. 1970 A hunter survey was conducted on the game area on October 24, 25, 30, 31, November 1, 14, and 15 (Table 25). On opening weekend of quail season, October 24 and 25, 30 hunting parties with a total of 98 hunters expended 277 gun hours to bag 127 bobwhites, a hunting success of 0.46 birds per gun hour. On the second weekend of the season, 13 hunting parties containing 27 hunters expended 88 hours to bag 39 bobwhites, a hunting success of 0.45 birds per gun hour. Nine parties consisting of 39 hunters contacted during the opening weekend of pheasant season, November 24 and 25, expended 115 hours to bag 9 quail and 23 pheasants. Hunting success was 0.08 quail and 0.20 pheasants per gun hour. A gusting 15 mph wind, poor scenting conditions, and "skittish" pheasants were largely responsible for the low hunting success on November 14.

During the period from October 24 to November 15, the investigator accounted for the loss of 196 quail: 175 definitely bagged, 12 reported bagged, and 9 cripples. From the 175 bagged, 147 wings were collected from which age of the bird could be determined. Of the 147 wings collected, 76 were

from cocks and 68 from hens, indicating a sex ratio of 1.15 cocks per hen. There were 13 adults (9 percent) and 134 juveniles (91 percent) in the 147-wing sample. The percentage of juveniles bagged is higher than normal. One explanation for the high percentage of juveniles is that 92 percent of the bagged birds were collected during the first nine days of the hunting season. Young birds which have never been hunted may be more vulnerable than adult birds during the first several weeks of the season. In Missouri, Bennitt (1951) found juvenile birds more vulnerable to shooting in the early part of the November-December hunting season.

Table 25. Results of 1970 hunter survey on the 1,158-acre game area.

Date of survey	Number of parties/number of hunters	Number gun hours	Number quail bagged	Hunting success (quail/ gun hour)
Oct. 24 & 25	30/98	276.5	127	0.46
Oct. 30, 31 & Nov. 1	13/27	87.5	39	0.45
Nov. 14 & 15	9/39	115.0	9/23[a]	0.08/0.2[b]
Totals	52/164	479.0	175/23	0.37

[a]Pheasants.

[b]Hunting success for pheasants.

c. 1971 The fall hunter survey was conducted on October 23, 24, November 13, and 14 (Table 26). On opening weekend of quail season, October 23 and 24, 33 hunting parties with a total of 92 hunters expended 189 gun hours to bag 64 bobwhites, a hunting success of 0.34 birds per gun hour. On the weekend of November 6 and 7, hunting pressure was too low to warrant extensive survey effort. On November 13 and 14, ten parties with a total of 38 hunters expended 77 gun hours to bag 4 quail and 7 pheasants. Hunting success was 0.05 quail and 0.09 pheasants per gun hour.

Table 26. Results of 1971 hunter survey on the 1,158-acre game area.

Date of survey	Number of parties/number of hunters	Number gun hours	Number quail bagged	Hunting success (quail/ gun hour)
Oct. 23 & 25	33/92	189.0	64	0.33
Nov. 6 & 7	No survey		1	
Nov. 13 & 14	10/38	77.3	4/7[a]	0.05/0.09[b]
Totals	43/130	266.3	69[c]	0.26

[a]Pheasants.

[b]Hunting success for pheasants.

[c]The quail harvested Nov. 6 was not used in overall hunting success calculation.

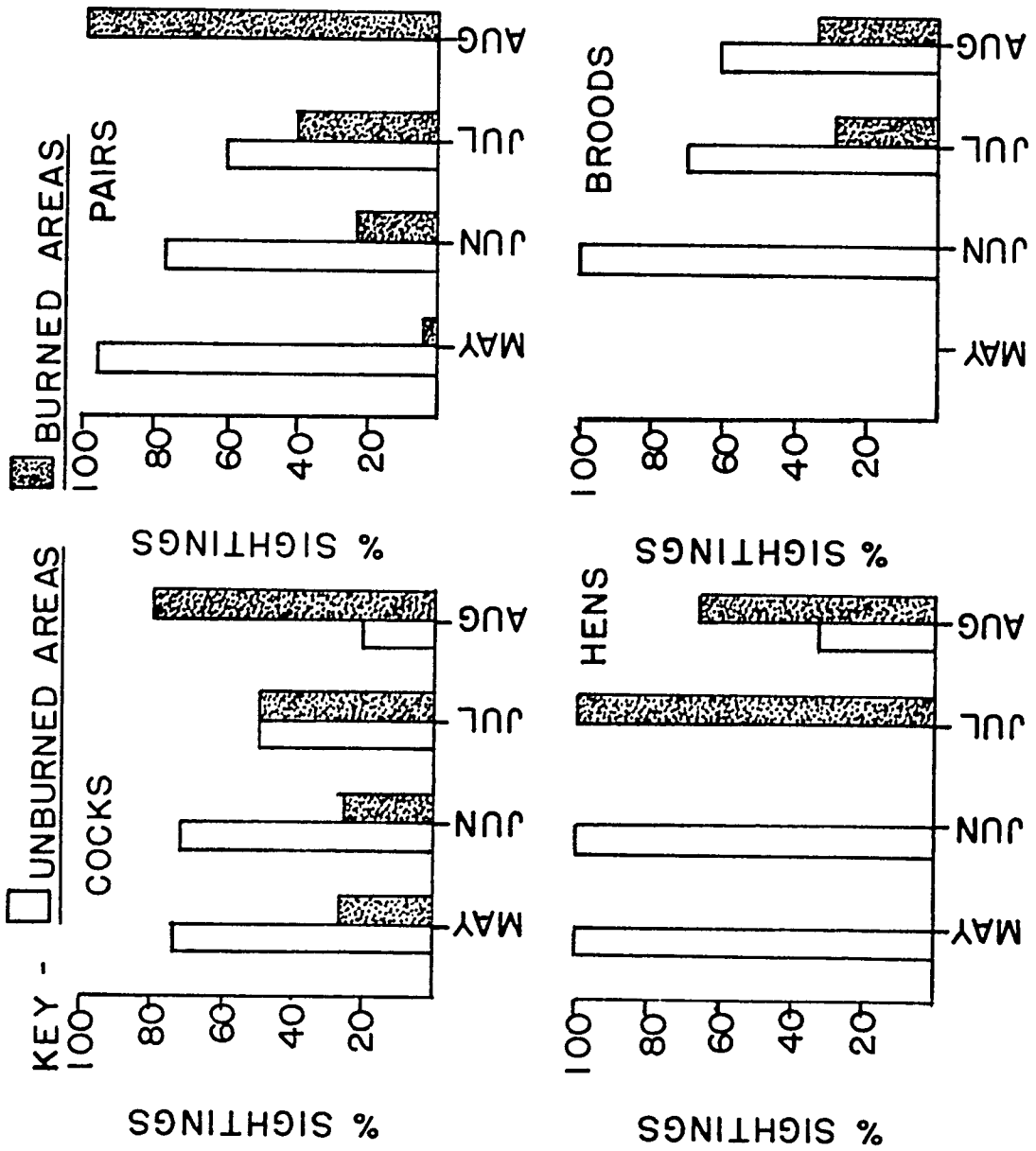
During the period October 23 to November 14, the investigator accounted for a loss of 75 quail: 69 definitely bagged, 4 reported bagged, and 2 cripples. One wing was collected from each of the bagged birds. On the basis of 69 wings collected, 32 were from cocks and 34 from hens, indicating a sex ratio of 0.94 cocks per hen. The sex of the three birds was unobtainable. There were 9 adults (13 percent) and 60 juveniles (86 percent) in the 69-wing sample.

D. Quail Activity on the Burn Plots

To evaluate quail population responses to habitat changes brought about by the controlled burning, major effort was made to record quail activity on the burned areas. The first recorded quail activity on the burned study plots was May 5, 35 days after the burning. In the 123-day period from May 5 to September 4, 39 observations of quail activity were secured on the burned areas. Monthly totals of cock, hen, pair, and brood sightings on and off the burned areas are listed in Table 27.

The proportion of quail sightings on the burned areas was 7 of 61 (11 percent) in May, 14 of 56 (25 percent) in June, 9 of 21 (43 percent) in July, and 10 of 17 (59 percent) in August. The proportion of cock, hen, pair, and brood sightings that occurred on the burned areas during the 4-month period, expressed as percentages of the monthly totals, is shown in Fig. 14. The data were tested by

Fig. 14. Proportions of cock, hen, pair, and brood sightings occurring on and off the experimental burn plots. The proportions are expressed as percentages of monthly totals.


BURNED AREAS
PAIRS
BROODS
UNBURNED AREAS
COCKS
HENS
KEY -
MAY
JUN
JUL
AUG
100
80
60
40
20
% SIGHTINGS

computing the Chi-square for independence of burn area sightings:unburned area sightings ratios for May through August in r x 2 contingency tables. The results are as follows: χ^2 (May through August) = 20.2, 3 df, $P < 0.01$; χ^2 (May and June) = 5.0, 1 df, $P < 0.01$; χ^2 (June and July) = 2.3, 1 df, n.s.; and χ^2 (July and August) = 1.0, 1 df, n.s.

Table 27. Totals of cock, hen, pair, brood, and birds of unknown sex on and off the burned areas for May, June, and August 1971.

Monthly period		Sightings				
		Cocks	Hens	Pairs	Broods	Unknown sex
May	On burn	5	0	1	0	1
	Off burn	14	2	4	0	17
	Totals	19	2	5	0	18
June	On burn	8	0	4	0	2
	Off burn	21	2	14	1	4
	Totals	29	2	18	1	6
July	On burn	3	2	4	0	2
	Off burn	3	0	14	1	4
	Totals	6	2	18	1	6
August	On burn	4	2	1	3	0
	Off burn	1	1	0	5	0
	Totals	5	3	1	8	0

Results of the tests showed the proportion of all observations that occurred on burn plots increased significantly from May through August but particularily between May through June. Although the proportion of observations that occurred

on burn plots increased in July and August, sample sizes were one-half of those in May and June.

The first brood activity on the burned study plots was observed on July 12. The two broods flushed from burn plots in July were estimated at 4 to 5 weeks and 3 to 4 weeks of age (broods D and E, Table 20). Of three broods sighted in August, one was estimated at 8 to 9 weeks of age (brood D, Table 20). The proportion of broods sighted on the burned areas increased from 29 percent (2 of 7 sightings) in July to 38 percent (3 of 8 sightings) in August (Fig. 14). A similar increase in the proportion of cocks and hens on the burned areas was noted in August (Fig. 14). Small sample sizes did not permit testing within sex and age groups for preferences of burned or unburned areas.

E. Quail Habitat Preferences

In order to judge what influence the use of controlled burning had on the bobwhite use, an effort was made to determine seasonal habitat preferences. Due to the varied types of quail habitats on the game area, four broad habitat classes were used: 1) agricultural croplands, 2) upland grassy-shrub areas, 3) wooded draws and major drainages, and 4) edge areas such as roads and "living fences" of multiflora rose and osage-orange.

1. Summer

During the summer months of 1967, edge areas accounted for 47 of the 103 sightings (46 percent) (Table 28). The edge areas were of major importance during all summer months. The frequency of flushings on upland areas was fairly constant throughout the 3-month period and accounted for 25 percent of the sightings. Wooded draws accounted for 8 of the 103 sightings (8 percent). Frequency of flushings in croplands increased in August due largely to the ample supplies of available grain such as clipped oats and grain sorghum.

Habitat preferences in the summer of 1971 were similar to those in 1967 in many respects (Table 29). Ninety-four of 249 sightings (38 percent) were in edge areas. The use of edge areas was of major importance during May through August as it was in 1967. Upland areas accounted for 78 of the 249 sightings (31 percent overall), however monthly usage in May through July followed closely 1967 patterns. Wooded draws accounted for 20 percent of the sightings overall, however flushing frequencies for July and August probably did not represent actual usage. In May and June, many of the birds using the wooded draws were located by flushing whistling birds. As whistling decreased among cocks in July and August, vegetative cover became increasingly heavy making searching attempts difficult. Frequency of flushings in cropland areas (11 percent overall) increased in July and August. This increase agreed closely with the 1967 data.

Table 28. Habitat types occupied at time of flushing during June through August 1967, on the 1,158-acre game area.

Monthly periods	Habitat classes			
	Croplands	Wooded draws	Upland field	Edge
June				
Pairs	2	1	11	9
Cocks	3	3	7	12
Hens	0	0	2	0
Broods	0	0	0	0
Unknown sex	0	2	1	0
Totals	5	6	21	21
Percent of monthly total	9.4	11.3	39.6	39.6
July				
Pairs	0	1	1	8
Cocks	0	0	2	6
Hens	0	0	0	1
Broods	0	0	0	0
Unknown sex	0	0	0	0
Totals	0	1	3	15
Percent of monthly total	0	5.3	15.8	78.9
August				
Pairs	5	0	0	6
Cocks	2	0	2	2
Hens	2	1	0	1
Broods	8	0	0	0
Unknown sex	0	0	0	2
Totals	17	1	2	11
Percent of monthly total	54.8	3.2	6.4	35.5
Summer totals	22	8	26	47
Percent of summer total	21.4	7.8	25.2	45.6

Table 29. Habitat types occupied at time of flushing during May through August 1971 on the 1,158-acre game area.

Monthly periods	Habitat classes			
	Croplands	Wooded draws	Upland field	Edge
May				
Pairs	2	3	7	15
Cocks	2	15	12	13
Hens	0	0	0	2
Broods	3	0	0	0
Unknown sex	0	4	4	4
Totals	7	22	23	34
Percent of monthly totals	8.1	25.6	26.7	39.5
June				
Pairs	1	2	5	14
Cocks	4	22	24	24
Hens	2	0	0	0
Broods	0	0	1	0
Unknown sex	3	1	2	1
Totals	10	25	32	39
Percent of monthly totals	9.4	23.6	30.2	36.8
July				
Pairs	1	0	3	3
Cocks	3	1	1	9
Hens	0	0	0	0
Broods	2	0	4	3
Unknown sex	0	0	0	1
Totals	6	1	8	16
Percent of monthly totals	9.4	3.2	25.8	51.6
August				
Pairs	0	0	1	2
Cocks	0	2	4	0
Hens	0	0	3	0
Broods	4	0	7	3
Unknown sex	0	0	0	0
Totals	4	2	15	5
Percent of monthly total	14.8	7.4	55.6	19.2
Summer total	27	50	78	94
Percent of summer total	10.8	20.0	31.3	37.8

2. Winter

Some idea of winter habitat use can be gained by inspecting the field sightings of January and March 1971 (Table 30). In early January a blizzard deposited 12-14 inches of drifted snow on the study area. This snow cover remained until mid-February. Many of the multiflora rose hedges were used extensively as protective cover during the extreme weather conditions in January. Edge areas (primarily multiflora rose hedges) accounted for 50 percent of the sightings in January and 39 percent of the sightings in the 2-month period. Use of upland areas received widespread use in March (56 percent of the sightings). Agricultural areas accounted for 4 of the 28 sightings (14 percent) in January and March.

Table 30. Habitat types occupied by quail at the time flushed during January and March 1971 on the 1,158-acre game area.

Monthly periods	Habitat classes			
	Croplands	Wooded draws	Upland field	Edge
January	2(20%)[a]	1(10%)	2(20%)	5(50%)
March	2(11)	0(0)	10(56)	6(33)
Total observations	4	1	12	11
Percent of total	14.0	4.0	43.0	39.0

[a]Percent of monthly totals in parentheses.

During the months of January and March, it was interesting to note the importance of grain fields such as picked grain sorghum, corn, or large unpicked food patches of grain sorghum and corn to the quail for their food supply. Although no quail crops were collected, some idea of this importance can be gained by inspecting the distances in yards from covey flushing sites to grain fields. In January and March, 12 were flushed a distance of 0-10 yards from a grain field, 5 from 10-50 yards, 8 from 50-100 yards, and 6 from 100 yards or farther.

F. Quail Nesting Preferences

Five quail nests were located in the field investigation, four in 1967 and one in 1971. All five nests were in grassy areas. Of two nests located in bluegrass areas, one was 2 feet from an oat strip and the other next to a road. Of two nests located in little bluestem tussocks, one was 15 yards from a road and the other 20 yards from a multiflora rose hedge. The fifth nest was located in sparse smooth brome, 10 yards from a multiflora rose hedge. Although the number of nests located in the two summers was relatively small, it was evident quail preferred nesting near edge areas such as field boundaries, multiflora rose hedges or roadsides.

All five nests were either destroyed or abandoned. In 1967, two nests were destroyed by mowing, one abandoned for unknown reasons, and one nest destroyed by predation. In

1970, one nest was destroyed by predation. On two occasions one in 1967 and the other in 1971, destroyed eggs were found.

V. DISCUSSION

One major task of game management is to create and maintain patterns of succession appropriate to species to be managed (Grange 1949:235). In my study, fire was used as a management tool to obtain a plant successional stage favorable to quail. The occurrence of fire on prairies is not new. Fires started by lightning and by Indians were believed to have been the chief factor in perpetuating and extending the prairie in and adjacent to forest climax regions in the United States (Stoddart and Smith 1943). The repeatedly demonstrated habitat preferences of quail have indicated that the bobwhite evolved in successional environments subject to periodic disturbance.

Without periodic disturbances, such as fire, it has been shown that upland grassy areas similar in content to upland quail habitats of Mount Ayr progress rapidly to timber climaxes. Vegetation density rapidly increases, the percent of bare ground decreases, a "rough" or thick litter layer develops, and the incidence of the desirable shade-intolerant quail food plants such as common ragweed and legumes are greatly reduced.

Quail habitat analysis of 1967 and 1971 showed conditions described above prevalent on almost all upland areas of the game area. Many of the upland areas were found to have been invaded by high densities of American elm, volunteer multi-

flora rose, dogwood, buckbrush, and other woody species. Litter depths on many of the 1971 control plots were over 4 cm (Table 10) and were thick and wiry in many places.

Stoddard (1931:406-414) first documented the advantageous effects of fire on bobwhite quail habitat. He found absence of litter on ground recently burned over made the seeds that had fallen fully available for the birds. Mats of tangled grasses prevented bobwhites from utilizing any seeds present. Also increased percentages of bare ground as a result of burning offered all important dusting areas and a chance for the quail to get their feet on the ground. One thing evident after the burning of the Mount Ayr quail habitat was the overwhelming reduction of the deep, thick litter levels to nearly zero (Table 10). Surface area of litter was reduced on all burned areas while percentage of exposed soil was greatly increased. Burning also retarded the growth of over 92 percent of the invading woody species, thus helping to preserve the open, upland areas important to quail.

Because of the lack of previous experience in burning for quail management, burning was done on small plots of reduced acreage rather than large blocks of many acres. For this reason, it was not possible to access the impact of burning on the total Mount Ayr quail population. It is difficult to differentiate increases or decreases caused directly or indirectly by fire from those of a seasonal nature.

Even though only quail sightings for one spring and summer after the burning are available, some general observations of importance have been made. The proportion of all late spring and summer quail sightings that occurred on burned areas increased significantly from May through August. For what reasons the proportion increased on burned areas is only speculative at this time. Burning also resulted in a reduction of litter depths to nearly zero making it easier for the birds to move around in the ground cover. An adult quail leg is about 3.5 to 4.0 cm from the bottom of the foot to the proximal end of the tarsus. Leg length is even shorter on juvenile birds. Since the average litter depths on the 1971 control areas were over 4.0 cm on 8 of 12 plots, the presence of unburned litter obviously hindered movement.

Reduced litter depths and increased amounts of bare soil combined with the lush, green vegetation to provide improved summer brood habitat. The proportion of broods sighted on the burn areas increased from 29 percent (2 of 7 sightings) to 38 percent (3 of 5 sightings) in August. Hurst (1970) showed that burning increased arthropod density and biomass which in turn increased the amounts of preferred summer food available to young and old birds alike. Burning created vegetative conditions that permitted greater chick mobility or manueverability in pursuit of insects.

The proportion of quail sightings on upland areas during spring, summer, and winter months (Tables 27, 28, and 29)

illustrated the importance of upland habitats to quail during these periods. Results of the vegetation analysis showed the grass family present in relatively dense quantities (Table 9). Although native grasses are not important to quail as a source of food (Korschgen 1948), grasses are important to quail for nesting. All five nests located during this investigation were found in grasses. In another southern Iowa study, Klimstra (1948) found 94 percent of all nests constructed of and located in grass. No quail nests were found on burned areas. The absence of nests on the first-year burn agrees with the findings of other controlled burning studies (Stoddard 1931:22 and Rosene 1969:64). Rosene reported finding 80 percent of 650 nests in habitats that had been unburned in the past winter or spring. The absence of large-scale nesting on first-year burns is largely due to lack of suitable amounts of nesting material. For this reason, annual burning of the same areas year after year is not recommended.

By backdating from the estimated hatching dates of broods sighted on the game area in 1971, approximate dates of initiation of nest building were obtained. A major portion of nests were started in late April and May. Vegetative development on the burned areas during these months was not advanced enough to furnish adequate nesting cover. Not until mid-June was vegetative development adequate for good nesting cover.

Controlled burning increases the amount and variety of seeds available and used by quail as food (Moore 1957,

Lewis, Murphy, and Ehrenreich 1964, and Speake 1966). Although this study did not investigate the quantitative aspects of quail food habits, some helpful insight into the effects of burning on native quail foods can be gained by inspection of the habitat analysis results. It was shown that grasses dominated the vegetative content on and off the burned areas in frequency of occurrence (Table 7) and basal area (Table 9). Composites and legumes followed in order of importance in both categories. It was further shown that two groups, Leguminosae and Compositae, occurred more frequently on the burned areas. Many of the native quail foods are members of these two plant families. One of the most noticeable results of burning on Mount Ayr was the tremendous response of common ragweed on the burned areas. Common ragweed occurred 157 times (66 percent) on the burned areas, while occurring only 80 times (34 percent) on the controls. Attempts to determine the importance of common ragweed to Mount Ayr quail through crop collection were unsuccessful. In a late fall and early winter food habitats study in northern Missouri (Korschgen 1948), common ragweed ranked third (10.1 percent, by volume) to corn (38.1 percent) and grain sorghum (26.3 percent) in 388 crops collected from hunters. Other studies have reported similar finds (Barbour 1951 and Larimer 1960).

The response of other native quail foods was not as great. Partridge pea, an important native quail food in the South,

responds readily to fire (Rosene 1969:301). As shown (Appendix XVII), the frequency of occurrence of partridge pea was higher on the unburned areas. One possible explanation for the lack of thick stands was that dormant seed stock was not present in the litter-soil layer. Frequency of occurrence for sericea lespedeza, another native quail food, was similar to that of partridge pea (Appendix XVI). Sericea lespedeza responded in density on the burned areas, having a higher total basal area on the burned areas. Although no information on the importance of sericea lespedeza to Mount Ayr quail is available, the many dense stands of sericea lespedeza were important as winter roosting cover.

The favorable habitat changes brought about by the use of fire and the favorable response shown by the proportional increase in quail activity on the burned areas were encouraging. Based upon results of the first year effects of burning, a continued program of early-spring burning on an experimental and demonstration plot basis is recommended for the Mount Ayr Game Management Area. It is hoped that through continued evaluation of the effects of annual burning on Mount Ayr quail habitat, controlled burning can become a fully understood and useful quail management practice on the Mount Ayr area and on other state-owned public hunting areas in Iowa.

VI. SUMMARY

Objectives of this study were to determine the ecological effects of controlled burning on various game habitat cover types and quail populations on the Mount Ayr Game Management Area. Field work on the 1,158-acre public hunting area extended from June 1 to October 22, 1967 and from September 1970 thru November 1971. Twelve rectangular plots ranging from 0.6 to 1.9 and totaling 13.0 acres were burned on March 30, 31, and April 5, 1971. The operation was carried out during daylight hours using back fires to produce a "hot" ground fire.

A. Plants

Major plant species components of each burn plot were subjectively determined by visual means and cover-mapped in June 1971. Quantitative information regarding species composition, estimated percentages of surface area of exposed soil and litter, average height of vegetation, and average litter depth were recorded on 177 square-meter sample sites in 1967 and 366 sample sites in 1971.

A total of 107 different plant species were recorded on the 12 burn plots and their controls consisting of 99 species on the 12 control areas and 90 species on the 12 burned areas. Eighty-two species were common to both the burned and control areas.

The mean number of plant species per sample site for all plots combined was 9.6 on the burned areas and 9.3 on the

control areas. Results of an analysis of variance test indicated the mean number of species per sample site on the control and burn areas was not significantly different ($F = 0.14$, 1 and 22 df, n.s.).

Forty-five of the recorded species (42 percent) had frequencies of occurrence greater than 50 percent on burned areas. Five species (5 percent) showed frequencies equal to 50 percent. Results of a Chi-square test for heterogeneity showed significant differences in the frequencies on the burned and control areas that could not be attributed to sampling error ($\chi^2 = 215.5$, 100 df, $P < 0.05$).

Frequencies of occurrence for two plant families, Leguminosae and Compositae, were greater than 50 percent on the burned areas. Gramineae and Rosaceae had frequencies greater than 50 percent on the control areas.

Mean percentage of surface area of exposed soil per sample site for all burned plots was 22.7. Mean percentage for all control areas was 1.0. Results of an analysis of variance test indicated there was a significantly greater percentage of surface area of exposed soil on burned areas than on control areas ($F = 29.02$, 1 and 22 df, $P < 0.05$). Overall average percentage of increase of exposed soil surface on burned areas was 2,240 percent.

Mean percentage of surface area of litter per sample site for all burned areas was 76.3. The mean percentage for all control areas was 97.9. Results of an analysis of variance

test indicated there was a significantly lower percentage of surface area of litter on burned areas than on control areas ($F = 41.50$, 1 and 22 df, $P<0.05$). Mean decrease in surface area of litter on all burned areas was 22 percent.

Mean percentage of plant stem basal area per sample site on all burned areas was 1.0. Mean percentage on all the control areas was 1.1. Results of an analysis of variance test indicated there were no significant differences between the total means of estimated stem basal area on the burned and unburned areas ($F = 0.20$, 1 and 22 df, n.s.).

Mean litter depth on all burned areas was 0.1 cm while mean litter depth on all control areas was 3.9 cm. Results of an analysis of variance test showed average litter depth per sample site for all burned areas combined was significantly lower than average litter depth per sample site on all control areas combined ($F = 28.26$, 1 and 22 df, $P<0.05$).

Average vegetation height per sample site for all burned areas was 67.8 cm. Average height on the control areas was 60.5 cm. Average vegetation heights on burned areas were greater than those of control areas on eight of 12 study plots.

Results of direct counts and line transect surveys of woody species on burned plots showed overwhelming evidence that fire retarded plant growth. Of 2,881 individuals recorded by both methods, 2,654 (92 percent) were either killed or had leafy shoots at the base of a dead stem.

B. Quail

A total of 601 bobwhite sightings were recorded on the 1,158-acre public hunting area during the study.

Of eight broods located on the 1,158-acre game area in 1967, six were on a 400-acre Study Unit contained within the larger game area's boundaries. Average brood size was 7.2 juvenile birds.

The peak hatching date for 116 juveniles bagged on the game area in 1970 occurred during the week of June 14 to 20 with a later secondary peak in the week of August 9 to 15. Fifty percent of the 116 juvenile birds hatched before July 5, 75 percent hatched before August 2.

Of fourteen broods located on the game area in 1971, 12 were on the 400-acre Study Unit. The general peak in hatching activity occurred during June with the week of June 6 to 12 producing the greatest number of young (10 of 55 birds, 18 percent). A secondary peak occurred in mid-August. Over 50 percent of 55 juvenile birds bagged during the hunting season hatched before July 4, 75 percent hatched before August 15.

On opening day of the 1967 quail season, eight hunting parties with 17 hunters located eight coveys. Hunters expended 60 gun hours to bag 13 quail, indicating a hunting success of 0.21 birds per gun hour. On opening weekend of the 1970 quail season (October 24 and 25), 30 hunting parties with a total of 98 hunters located a total of 28 different coveys on the game area. The hunters expended 277 gun hours to bag 127 bobwhites,

a hunting success of 0.46 birds per gun hour. Pre-hunting average covey size was 13.5 birds. On opening weekend of the 1971 quail season (October 23 and 24), 33 hunting parties consisting of 92 hunters located a total of 12 different coveys on the game area. The hunters expended 189 gun hours to bag 64 bobwhites, a success of 0.34 birds per gun hour.

A total of 64 birds in six coveys was located on the 400-acre Study Unit during the winter census in late December 1970 and January 1971. Average covey size was 11.0 birds.

In the pre-nesting census conducted in March 1971, 53 birds remained in the six previously located coveys, indicating a decrease of 11 birds (17 percent). Average covey size at that time was 9 birds.

The first recorded quail activity on the burned study plots was May 5, 35 days after the burning. In the 123-day period from May 5 to September 4, 39 observations of quail activity were secured on burned areas. The first brood activity on the burned study plots was observed on July 12.

Results of Chi-square tests for independence showed the proportion of all quail observations that occurred on burn plots increased significantly from May through August but particularily between May through June.

During the summer months of 1967, edge areas such as roads and "living fences" of multiflora rose and osage-orange accounted for 47 of the 103 sightings (46 percent). In 1971, 94 of 249 sightings (38 percent) were in edge areas. Upland

areas accounted for 25 percent of the summer sightings in 1967 and 31 percent in 1971. Sightings in croplands accounted for 21 percent of the summer observations in 1967, 11 percent in 1971.

During January and March 1971, edge areas accounted for 11 of 28 sightings of quail (39 percent), upland areas accounted for 12 of 28 observations (43 percent).

All of five quail nests located in the study were in grassy areas.

Based upon results of the first year effects of burning, a continued program of early-spring burning on an experimental and demonstration plot basis is recommended for the Mount Ayr Game Management Area.

VII. LITERATURE CITED

Aikman, J. M. 1955. Burning in the management of prairie in Iowa. Iowa Acad. Sci., Proc., 62: 53-62.

American Ornithologists' Union. 1957. Check-list of North American birds. The Lord Baltimore Press, Inc., Baltimore, Maryland. 691 p.

Ammann, G. A. 1963. Status and management of sharp-tailed grouse in Michigan. J. Wildl. Mgmt. 27: 802-809.

Baker, M. 1939. Age classes of winter cover used by the eastern bob-white, Colinus virginianus virginianus L., in Davis county, Iowa. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

Barbour, R. W. 1951. Observations on the fall and winter food of bob-white quail in Kentucky. J. Wildl. Mgmt. 15: 108.

Bennitt, R. 1951. Some aspects of Missouri quail and quail hunting 1938-1948. Missouri Conserv. Comm., Tech. Bull. 2. 51 p.

Berger, A. J. 1961. Bird study. John Wiley and Sons, Inc., New York. 389 p.

Boehnke, R. H. 1954. Winter movements and covey composition of the eastern bobwhite, Decatur county, Iowa, 1952-1954. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

Dills, G. G. 1970. Effects of prescribed burning on deer browse. J. Wildl. Mgmt. 34: 540-545.

Ehrenreich, J. H. and J. M. Aikman. 1963. An ecological study of the effect of certain management practices on native prairie in Iowa. Ecol. Monog. 33: 113-130.

Elder, J. B. 1956. Analysis of factors affecting production and whistling behavior of the eastern bob-white, Colinus v. virginianus L., in Decatur county. Unpublished Ph. D. Thesis. Library, Iowa State University, Ames, Iowa.

Ellis, J. A., W. R. Edwards, and K. P. Thomas. 1969. Responses of bobwhite to management in Illinois. J. Wildl. Mgmt. 33: 749-762.

Errington, P. L. 1941. An eight-winter study of central Iowa bobwhites. Wilson Bull. 53: 85-102.

Errington, P. L. and F. N. Hamerstrom, Jr. 1936. The northern bobwhite's winter territory. Iowa Agr. Exp. Sta. Res. Bull. 277: 757-850.

Fernald, M. L. 1950. Gray's manual of botany. 8th edition. American Book Co., New York, N. Y.

Gooden, S. K. 1952. Winter behavior of the eastern bobwhite, Colinus v. virginianus L., on the Decatur county research area, 1951-52. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

Graham, S. A. 1945. Ecological classification of cover types. J. Wildl. Mgmt. 9: 182-190.

Grange, W. G. 1949. The way to game abundance. Charles Scribner's Sons, New York. 365 p.

Hall, E. C., W. E. Tharp, and F. B. Howe. 1918. Soil survey of Ringgold county, Iowa. U. S. Gov. Print. Off., Washington, D. C.

Haugen, A. O. 1957. Distinguishing juvenile from adult bobwhite quail. J. Wildl. Mgmt. 21: 29-32.

Hurst, G. A. 1970. The effects of controlled burning on arthropod density and biomass in relation to bobwhite quail brood habitat on a right-of-way. Tall Timbers Conf. on Ecol. Animal Control by Habitat Mgmt., Proc., No. 2: 173-183.

Klimstra, W. D. 1948. An investigation of the life history and ecology of the interior bobwhite quail (Colinus virginianus mexicanus). Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

_____. 1949. Some factors influencing ecology and management of (Colinus virginianus mexicanus L.) on marginal lands in southeastern Iowa. Unpublished Ph. D. Thesis. Library, Iowa State University, Ames, Iowa.

_____. 1950. Bobwhite quail nesting and production in southeastern Iowa. Iowa State Coll. J. Sci. 24: 385-395.

Korschgen, L. J. 1948. Late-fall and early-winter food habits of bobwhite quail in Missouri. J. Wildl. Mgmt. 12: 46-57.

Larimer, E. J. 1960. Winter foods of the bobwhite in southern Illinois. Ill. Nat. Hist. Sur. Biol. Notes No. 42: 1-35.

Lehmann, V. W. and R. G. Mauermann. 1963. Status of Attwater's prairie chicken. J. Wildl. Mgmt. 27: 713-725.

Leopold, A. S. 1950. Deer in relation to plant succession. N. Am. Wildl. Conf., Trans., 15: 571-578.

Lewis, J. B., D. A. Murphy, and J. Ehrenreich. 1964. Effects of burning dates on vegetative production of Ozark forests. Conf. Southeastern Assoc. Game and Fish Commissioners, Proc., 18: 63-72.

Mangold, R. E. 1950. Fall and winter losses of eastern bobwhite, Colinus v. virginianus L., on Decatur county quail research area, 1949-1950. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

Miller, G. S. and R. Kellogg. 1955. List of North American recent mammals. U. S. Natl. Mus. Bull. 205.

Moore, W. H. 1957. Effects of certain prescribed fire treatments on the distribution of some herbaceous quail food plants in loblolly-short-leaf pine communities of the Alabama Upper Coastal Plain Conf. Southeastern Assoc. Game and Fish Commissioners, Proc., 11: 349-351.

Moorman, R. B. 1942. Comparison of production of eastern bobwhite, Colinus v. virginianus, on an experimental game management area in southern Iowa for 1940-1941. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

Oosting, H. J. 1956. The study of plant communities. W. H. Freeman and Co., San Francisco. 440 p.

Oschwald, W. R., F. F. Riecken, R. I. Dideriksen, W. F. Scholtes, and F. W. Schaller. 1965. Principal soils of Iowa. Iowa State Univ. Coop. Ext. Serv., Special Report No. 42.

Petrides, G. A. and R. B. Nester. 1943. Age determination in juvenile bobwhite quail. Am. Midland Nat. 30: 774-782.

Rosene, W., Jr. 1954. The use of fire in quail management. Conf. Southeastern Assoc. Game and Fish Commissioners, Proc., 8: 9-11.

_____. 1955. Management techniques which encourage bobwhite quail to nest. Conf. Southeastern Assoc. Game and Fish Commissioners, Proc., 9: 126-129.

_____. 1969. The bobwhite quail: its life and management. Rutgers Univ. Press, New Brunswick, N. J. 418 p.

Saunders, E. 1940. History and development of an experimental bobwhite management area in southern Iowa. Unpublished Ph. D. Thesis. Library, Iowa State University, Ames, Iowa.

Scott, D. F. 1958. Fire and quail management at Fort Campbell, Kentucky. Conf. Southeastern Assoc. Game and Fish Commissioners, Proc., 12: 294-300.

Sharp, W. M. 1970. The role of fire in ruffed grouse management. Tall Timbers Fire Ecol. Conf., Proc., No. 10: 47-61.

Shaw, R. H. and P. J. Waite. 1964. The climate of Iowa, III. Monthly, crop season and annual temperature and precipitation normals for Iowa. Agr. and Home Econ. Exp. Stat., Iowa State University, Ames, Iowa.

Smith, N. F. 1947. Controlled burning in Michigan's forest and game management programs. Soc. Am. Foresters, Proc., p. 200-205.

Speake, D. W. 1966. Effects of controlled burning on bobwhite quail populations and habitat of an experimental area in the Alabama Piedmont. Conf. Southeastern Assoc. Game and Fish Commissioners. Proc., 20: 19-32.

Stoddard, H. L. 1931. The bobwhite quail: its habits, preservation, and increase. Charles Scribner's Sons, New York. 559 p.

_____. 1933. Use of controlled fire in southeastern upland game management. J. For. 33: 346-351.

_____. 1936. Relation of burning to timber and wildlife. N. Am. Wildl. Conf., Proc., 1: 399-403.

_____. 1963. Maintenance and increase of wild turkey on private lands of the coastal plain of the deep southeast. Tall Timbers Res. Stat. Bull. No. 3.

Stoddart, L. A. and A. D. Smith. 1943. Range management. McGraw-Hill Book Co., New York. 547 p.

Subcommittee on Range Research Methods of the Agricultural Board. 1962. Range research, basic problems and techniques. National Res. Council, Pub. 890, Washington, D. C.

Thomas, K. P. 1969. Sex determination of bobwhites by wing criteria. J. Wildl. Mgmt. 33: 215-216.

Triner, E. J. and W. D. Klimstra. 1965. Effects of burning and fallowing on vegetation. Illinois State Acad. Sci., Trans., 58: 102-114.

U. S. Dept. of Commerce, Environmental Data Service. 1970-1971. Climatological Data, Iowa. Asheville, N. C.

Wilson, J. H. 1970. Effects of prescribed burning on survival of certain woody plants. Unpublished M. S. Thesis. Library, Iowa State University, Ames, Iowa.

VIII. ACKNOWLEDGEMENTS

The author wishes to take this opportunity to express his appreciation to all who have helped in making this thesis possible. Thanks are due to Dr. A. O. Haugen, Leader of the Iowa Cooperative Wildlife Research Unit, who supplied guidance in the field and useful suggestions and guidance in preparation of the manuscript. The author is also appreciative of the interest shown by Dr. R. Q. Landers, Department of Botany and Plant Pathology and Mr. Gene Hlavka, Iowa Conservation Commission.

The interest and counsel of Dr. D. F. Cox, Department of Statistics, was gratefully received by the author.

Thanks are especially due to Mr. H. J. Ploeger and Mr. Allan Taylor, Iowa Conservation Commission employees, for their interest and cooperation, without which this project could not have been completed.

I am grateful to my wife, Elizabeth, for typing the thesis and supplying helpful ideas and constructive criticism.

IX. APPENDIX I: LIST OF PLANTS ON THE MOUNT AYR GAME MANAGEMENT AREA, IOWA

Nomenclature based on Fernald (1950).

Common name	Scientific name
Alfalfa	*Medicago sativa*
American elm	*Ulmus americana*
American germander	*Teucrium canadense*
Ashy sunflower	*Helianthus mollis*
Aster (2 spp.)	*Aster* spp.
Avens	*Geum laciniatum*
Big bluestem	*Andropogon Gerardi*
Birdsfoot-trefoil	*Lotus corniculatus*
Black cherry	*Prunus serotina*
Black-eyed Susan	*Rudbeckia hirta*
Bluegrass	*Poa pratensis*
Boxelder	*Acer Negundo*
Broom-sedge	*Andropogon virginicus*
Buckbrush	*Symphoricarpos orbiculatus*
Bull-thistle	*Cirsium vulgare*
Butterfly-weed	*Asclepias tuberosa*
Choke-cherry	*Prunus virginiana*
Cinquefoil (2 spp.)	*Potentilla recta* *P. simplex*
Clover	*Trifolium* sp.
Common milkweed	*Asclepias syriaca*
Common mullein	*Verbascum Thapsus*
Common ragweed	*Ambrosia artemisiifolia*
Common St. John's-wort	*Hypericum perforatum*
Common violet	*Viola papilionacea*
Compass plant	*Silphium laciniatum*
Columbine	*Aquilegia canadensis*
Corn	*Zea Mays*
Cottonwood	*Populus deltoides*
Cow-cress	*Lepidium campestre*
Cup-plant	*Silphium perfoliatum*
Daisy fleabane	*Erigeron annuus*
Dandelion	*Taraxacum officinale*
Deptford pink	*Dianthus Armeria*
Downy brome	*Bromus tectorum*
Elderberry	*Sambucus canadensis*
Evening primrose	*Oenothera biennis*
Fall witch-grass	*Leptoloma cognatum*
Field sow-thistle	*Sonchus arvensis*
Flower-of-an-hour	*Hibiscus Trionum*
Flowering spurge	*Euphorbia corollata*

IX. APPENDIX I (continued)

Common name	Scientific name
Foxtail	Setaria sp.
Galium	Galium sp.
Giant ragweed	Ambrosia trifida
Goldenrod (3 spp.)	Solidago spp.
Grain sorghum	Sorgum vulgare
Green ash	Fraxinus pennsylvanica
Ground cherry	Physalis heterophylla
Hairy lettuce	Lactuca hirsuta
Hairy ruellia	Ruellia caroliniensis
Hazelnut	Corylus americana
Hedge bindweed	Convolvulus sepium
Honey-locust	Gleditsia triacanthos
Horse gentian	Triosteum perfoliatum
Horse nettle	Solanum carolinense
Horse tail	Equisetum sp.
Indian grass	Sorghastrum nutans
Indian hemp	Apocynum cannabinum
Ironweed	Vernonia Baldwini
Jack pine	Pinus Banksiana
Lespedeza (2 spp.)	Lespedeza bicolor L. capitata
Little bluestem	Andropogon scoparius
Milkweed	Asclepias hirtella
Milkwort	Polygala sanguinea
Moss	Bryales
Mulberry	Morus sp.
Multiflora rose	Rosa multiflora
Oak	Quercus sp.
Oats	Avena sativa
Osage-orange	Maclura pomifera
Oyster plant	Tragopogon porrifolius
Ox-eye daisy	Chrysanthemum Leucanthemum
Pale dock	Rumex altissimus
Panic-grass (4 spp.)	Panicum spp.
Partridge pea	Cassia fasciculata
Pasture rose	Rosa carolina
Prairie-false indigo	Baptisia leucantha
Prickly ash	Xanthoxylum americanum
Prickly lettuce	Lactuca Scariola
Purple meadow rue	Thalictrum dasycarpum
Pussy's-toes (2 spp.)	Antennaria neglecta A. plantaginifolia
Redcedar	Juniperus virginiana
Red clover	Trifolium pratense
Red osier dogwood	Cornus stolonifera
Redtop	Agrostis alba

IX. APPENDIX I (continued)

Common name	Scientific name
Reed canary	*Phalaris arundinacea*
Rosin weed	*Silphium integrifolium*
Rush	*Juncus* sp.
Sawtooth sunflower	*Helianthus grosseseratus*
Sedge	*Carex* spp.
Sericea lespedeza	*Lespedeza cuneata*
Shagbark hickory	*Carya ovata*
Sheep sorrel	*Rumex Acetosella*
Slender-leaved mountain mint	*Pycananthemum tenuifolium*
Smartweed	*Polygonum* sp.
Smooth brome	*Bromus inermis*
Smooth sumac	*Rhus glabra*
Solomon's-seal	*Polygonatum biflorum*
Spiderwort	*Tradescantia ohiensis*
Spiny-leaved sow-thistle	*Sonchus asper*
Timothy	*Phleum pratense*
Vervain	*Verbena hastata*
Virginia creeper	*Parthenocissus quinquefolia*
White sweet clover	*Melilotus alba*
Whorled milkweed	*Asclepias verticillata*
Wild bergamont	*Monarda fistulosa*
Wild grape	*Vitis* sp.
Wild parsnip	*Pastinaca sativa*
Wild plum	*Prunus americana*
Wild rye	*Elymus canadensis*
Wild strawberry	*Fragaria virginiana*
Willow	*Salix fragilis*
Winter-cress	*Barbarea vulgaris*
Witch-grass	*Agropyron repens*
Wood-sorrel	*Oxalis europaea*
Yarrow	*Achillea Millefolium*
Yellow dock	*Rumex crispus*
Yellow sweet clover	*Melilotus officinalis*

X. APPENDIX II: LIST OF BIRDS AND MAMMALS

Nomenclature based on American Ornithologists' Union (1957) and Miller and Kellogg (1955).

Birds	
Attwater's prairie chicken	*Tympanuchus cupido*
Kirtland's warbler	*Dendropica kirtlandii*
Ring-necked pheasant	*Phasianus colchicus*
Ruffed grouse	*Bonasa umbellus*
Sharp-tailed grouse	*Pedioecetes phasianellus*
Wild turkey	*Meleagris gallopavo*
Mammals	
Cottontail rabbit	*Sylvilagus floridanus*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*

XI. APPENDIX III: MOUNT AYR QUAIL HUNTER QUESTIONNAIRE

Date_____Location of contact_____Time of contact____
Weather_____Investigator_____

No. of hunters in party____Total no. gun hours_____
Was dog used_____: Retriever__Pointer__Combination__Other____
Home town of each hunter:

Bag check:
Quail - Ad. Cock___Hen___/ Juv. Cock___Hen___
Other:

Collection data:

Collection no.	Sex	Age	Crop	Wing	Comments

Covey data:
How many coveys flushed?____Est. no. birds_____
No. of birds crippled:_____

Investigator comments:

XII. APPENDIX IV: MAJOR VEGETATION COMPONENTS OF BURN PLOT 2, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Sericea lespedeza and common ragweed with goldenrod and broom-sedge.	25.6
2.	Broom-sedge, redtop, panic-grass, sedge, with lespedeza and goldenrod.	23.5
3.	Goldenrod and sericea lespedeza.	18.8
4.	Goldenrod, sericea lespedeza, and blackberry.	12.0
5.	Blackberry, pasture rose, common ragweed with redtop and bluegrass.	8.9
6.	Sawtooth sunflower, goldenrod with bluegrass and redtop.	4.6
7.	Reed canary grass.	2.6
8.	Smooth sumac, blackberry, pasture.	1.8
9.	Buckbrush, sericea lespedeza, and bluegrass.	1.3
10.	Dogwood.	0.4
11.	Buckbrush.	0.3
12.	Elderberry.	0.2
	Total	100.0

XIII. APPENDIX V: MAJOR VEGETATION COMPONENTS OF BURN PLOT 3, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Smooth brome and sericea lespedeza with localized areas of broom-sedge and big bluestem.	88.2
2.	Common ragweed, slender mountain mint, and broom-sedge with smooth brome and sericea lespedeza.	11.2
3.	Daisy fleabane.	0.6
	Total	100.0

XIV. APPENDIX VI: MAJOR VEGETATION COMPONENTS OF BURN PLOT 4, 1971 GROWING SEASON

Vegetation Component	Relative percent of cover occupied
1. Smooth brome and sericea lespedeza.	64.5
2. Smooth brome and sericea lespedeza with blackberry and smooth sumac.	24.1
3. Sericea lespedeza and smooth sumac.	4.3
4. Smooth brome and sericea lespedeza with blackberry.	7.1
Total	99.9

XV. APPENDIX VII: MAJOR VEGETATION COMPONENTS OF BURN PLOT 5, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Big bluestem, broom-sedge, common ragweed, and pasture rose.	33.8
2.	Big bluestem, goldenrod, common ragweed with localized areas of Indian grass.	26.6
3.	Smooth sumac, blackberry, and big bluestem.	24.6
4.	Big bluestem, blackberry, and common ragweed.	10.5
5.	Goldenrod.	1.7
6.	Big bluestem and sawtooth sunflower.	1.4
7.	Pussy's-toes.	1.3
	Total	99.9

XVI. APPENDIX VIII: MAJOR VEGETATION COMPONENTS OF BURN PLOT 6, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Big bluestem and little bluestem with sericea lespedeza and goldenrod.	46.5
2.	Big bluestem, wild bergamont, slender mountain mint, sericea lespedeza, goldenrod, common ragweed, and little bluestem.	26.7
3.	Big bluestem, broom-sedge, cup plant, sericea lespedeza, and common ragweed.	10.1
4.	Slender mountain mint, goldenrod, sericea lespedeza, and common ragweed with big bluestem.	5.1
5.	Big bluestem, sericea lespedeza, and goldenrod.	5.0
6.	Sericea lespedeza with goldenrod and common ragweed.	1.9
7.	Sericea lespedeza, broom-sedge, goldenrod, and prairie lespedeza.	4.4
	Total	99.7

XVII. APPENDIX IX: MAJOR VEGETATION COMPONENTS OF BURN PLOT 7, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	A mixture of panic grass, timothy, broom-sedge, common ragweed, redtop, bluegrass with occasion thistle, common milkweed, and sedge.	73.2
2.	Broom-sedge with bluegrass, common ragweed, and goldenrod.	13.4
3.	Bluegrass, timothy, redtop, and common ragweed.	9.8
4.	Goldenrod.	2.1
5.	Timothy, redtop, wild strawberry, and volunteer multiflora rose.	0.5
6.	Volunteer multiflora rose.	0.4
	Total	99.4

XVIII. APPENDIX X: MAJOR VEGETATION COMPONENTS OF BURN PLOT 8, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Bluegrass and common ragweed with redtop, partridge pea, goldenrod and woody species such as willow, dogwood, and wild plum.	30.4
2.	Little bluestem, big bluestem, and blackberry with goldenrod, common ragweed, sericea lespedeza, and pasture rose.	26.3
3.	Goldenrod with big bluestem and little bluestem.	16.9
4.	Reed canary.	12.0
5.	Little bluestem, big bluestem, and common ragweed.	8.2
6.	Smooth sumac and blackberry with little bluestem, big bluestem, and common ragweed.	2.2
7.	Bluegrass, little bluestem, broom-sedge and common ragweed.	2.1
8.	Reed canary, goldenrod, and asters.	1.8
9.	Dogwood.	0.1
	Total	100.0

XIX. APPENDIX XI: MAJOR VEGETATION COMPONENTS OF BURN PLOT 9, 1971 GROWING SEASON

	Vegetation component	Relative percent of cover occupied
1.	Big bluestem, common and giant ragweed with buckbrush, and American elm.	24.6
2.	Goldenrod, common and giant ragweed with bluegrass, big bluestem, slender-leaved mountain mint, wild plum, American elm, and boxelder.	18.0
3.	Goldenrod and common ragweed with partridge pea.	14.2
4.	Reed canary.	11.4
5.	Bluegrass, timothy, panic grass with goldenrod, slender-leaved mountain mint and wild strawberry.	9.3
6.	Blackberry, American elm, common ragweed and pasture rose.	7.7
7.	Asters and goldenrod with common ragweed.	6.4
8.	Aster and common ragweed.	5.1
9.	Blackberry, common ragweed, and bluegrass with wild plum and boxelder.	2.7
10.	Bluegrass and pussy's-toes.	0.6
	Total	100.0

XX. APPENDIX XII: MAJOR VEGETATION COMPONENTS OF BURN PLOT 10, 1971 GROWING SEASON

	Vegetation component	Relative percent of cover occupied
1.	Bluegrass and common ragweed with flowering spurge, panic-grass, wild bergamont, and timothy.	39.5
2.	Big bluestem, buckbrush, ashy sunflower, germander, wild bergamont, bluegrass and common milkweed.	14.2
3.	Blackberry, bluegrass, and ashy sunflower.	8.0
4.	Bluegrass, timothy, and broom-sedge.	7.7
5.	Bluegrass, sedge, germander, wild bergamont, buckbrush, common ragweed, and smooth sumac.	6.5
6.	Blackberry, pasture rose, and bluegrass with common ragweed, redtop, panic grass, and timothy.	6.2
7.	Bluegrass and blackberry	5.0
8.	Smooth sumac, blackberry, and bluegrass with ashy sunflower.	4.7
9.	Smooth sumac and bluegrass.	2.3
10.	Dogwood, volunteer multiflora rose, and American elm.	1.9
11.	Wild plum, bluegrass, redtop, timothy with blackberry, and common ragweed.	1.5
12.	Cinquefoil.	1.0
13.	Goldenrod.	0.6
14.	Reed canary.	0.6
15.	Volunteer multiflora rose.	0.3
	Total	100.0

XXI. APPENDIX XIII: MAJOR VEGETATION COMPONENTS OF BURN PLOT 11, 1971 GROWING SEASON

Vegetation component		Relative percent of cover occupied
1.	Big bluestem, little bluestem, and bluegrass with common ragweed, goldenrod, and pasture rose.	46.6
2.	Little bluestem, bluegrass, and common ragweed.	29.3
3.	Bluegrass with prickly ash, and boxelder.	10.2
4.	Smooth sumac, bluegrass, and blackberry.	4.6
5.	Big bluestem, blackberry, and bluegrass.	2.9
6.	Aster.	2.3
7.	Dogwood.	2.0
8.	Goldenrod and bluegrass.	1.2
9.	Hazel.	0.6
10.	Goldenrod.	0.3
	Total	100.0

XXII. APPENDIX XIV: MAJOR VEGETATION COMPONENTS OF BURN PLOT 12, 1971 GROWING SEASON

Vegetation component	Relative percent of cover occupied
1. Bluegrass, common ragweed, timothy, and broom-sedge.	33.4
2. Bluegrass and volunteer multiflora rose with germander, wild bergamont, partridge pea, and common ragweed.	27.3
3. Big bluestem and bluegrass with common ragweed.	15.4
4. Panic grass, sericea lespedeza, broom-sedge, timothy, and flowering spurge.	15.4
5. Bluegrass, cinquefoil, common ragweed, and germander.	8.1
6. Buckbrush.	0.1
7. Goldenrod.	0.2
Total	99.9

XXIII. APPENDIX XV: MAJOR VEGETATION COMPONENTS OF BURN PLOT 13, 1971 GROWING SEASON

Vegetation component	Relative percent of cover occupied
1. Goldenrod, ox-eye daisy, daisy fleabane, flowering spurge, pasture rose, and common ragweed.	65.6
2. Smooth brome, sericea lespedeza, whorled milkweed, and flowering spurge.	19.7
3. Big bluestem, common ragweed, smooth brome, sericea lespedeza, and flowering spurge.	7.1
4. Common ragweed, germander, and whorled milkweed.	4.8
5. Slender-leaved mountain mint, common ragweed, and sericea lespedeza.	2.0
6. Blackberry and spiderwort.	0.4
7. Rush, sedge and common ragweed.	0.4
Total	100.0

XXIV. APPENDIX XVI: FREQUENCIES OF OCCURRENCE FOR PLANTS IDENTIFIED ON THE 12 BURN PLOTS AND THEIR CONTROL AREAS

Plant species	Burn frequency	Control frequency
Alfalfa	1(50%)	1(50%)
American elm	25(48)	27(52)
American germander	9(56)	7(44)
Ashy sunflower	5(63)	3(38)
Aster (2 spp.)	30(42)	42(58)
Avens	1(25)	3(75)
Big bluestem	45(52)	41(48)
Birdsfoot-trefoil	0(0)	2(100)
Black cherry	1(25)	3(75)
Black-eyed susan	41(55)	33(45)
Blackberry (2 spp.)	49(49)	51(51)
Bluegrass	96(43)	127(57)
Boxelder	4(57)	3(43)
Broom-sedge	49(51)	48(49)
Buckbrush	5(56)	4(44)
Bull-thistle	4(100)	0(0)
Butterfly-weed	1(50)	1(50)
Cinquefoil (2 spp.)	13(57)	10(43)
Clover	58(76)	18(24)
Common milkweed	16(42)	17(58)
Common ragweed	157(66)	80(34)
Common St. John's-wort	1(100)	0(0)
Common violet	3(75)	1(25)
Compass plant	0(0)	1(100)
Cow-cress	0(0)	1(100)
Cup-plant	1(100)	0(0)
Daisy fleabane	7(64)	4(36)
Dandelion	1(100)	0(0)
Deptford pink	0(0)	11(100)
Downy brome	0(0)	5(100)
Evening primrose	4(80)	1(20)
Fall witch-grass	1(33)	2(67)
Flowering spurge	57(46)	66(54)
Foxtail	1(100)	0(0)
Galium	1(33)	2(67)
Giant ragweed	2(25)	6(75)
Goldenrod (3 spp.)	106(55)	85(45)
Green ash	1(17)	5(83)
Ground cherry	19(42)	26(58)
Hairy lettuce	12(63)	7(37)

XXIV. APPENDIX XVI (continued)

Plant species	Burn frequency	Control frequency
Hairy ruellia	6(75%)	2(25%)
Hazelnut	0(0)	3(100)
Hedge bindweed	37(49)	39(51)
Horse gentian	1(50)	1(50)
Horse nettle	40(47)	45(53)
Horsetail	1(100)	0(0)
Indian grass	5(50)	5(50)
Indian hemp	5(56)	4(44)
Ironweed	11(55)	9(45)
Jack pine	0(0)	2(100)
Lespedeza	12(67)	6(33)
Little bluestem	14(48)	15(52)
Milkweed (A. hirtella)	0(0)	1(100)
Milkwort	9(82)	2(18)
Moss	3(15)	17(85)
Multiflora rose	2(29)	5(78)
Oak	0(0)	1(100)
Ox-eye daisy	11(44)	14(56)
Panic-grass (4 spp.)	83(42)	94(58)
Partridge-pea	68(45)	84(55)
Pasture rose	19(54)	16(46)
Prairie blue-eyed grass	3(75)	1(25)
Prickly ash	1(100)	0(0)
Prickly lettuce	39(60)	26(40)
Pussy's-toes (2 spp.)	10(43)	13(57)
Red clover	3(43)	4(57)
Red osier dogwood	2(20)	8(80)
Redtop	87(49)	92(51)
Reed canary	2(48)	8(52)
Rosin weed	3(43)	4(57)
Rush	2(100)	0(0)
Sawtooth sunflower	6(38)	10(63)
Sedge	30(55)	25(45)
Sericea lespedeza	58(47)	66(53)
Shagbark hickory	0(0)	1(100)
Slender-leaved mountain mint	19(56)	26(44)
Smartweed	0(0)	3(100)
Smooth brome	28(51)	27(49)
Smooth sumac	15(54)	13(46)
Spiderwort	1(25)	3(75)
Spiny leaved sow-thistle	4(50)	4(50)
Timothy	21(29)	52(71)
Vervain	3(75)	1(25)
Virginia creeper	6(60)	4(40)

XXIV. APPENDIX XVI (continued)

Plant species	Burn frequency	Control frequency
Whorled milkweed	38(66%)	20(34%)
Wild bergamont	43(48)	47(52)
Wild grape	0(0)	3(100)
Wild parsnip	0(0)	1(100)
Wild plum	5(36)	9(64)
Wild rye	11(61)	7(39)
Wild strawberry	24(44)	31(56)
Willow	1(100)	0(0)
Wing-angled loose strife	0(0)	1(100)
Winter-cress	5(62)	3(38)
Witch-grass	1(17)	5(83)
Wood-sorrel	24(92)	2(8)
Yarrow	45(45)	54(55)
Yellow sweet clover	0(0)	2(100)

XXV. APPENDIX XVII: LIST OF PLANTS CONSIDERED IN THE FOUR FAMILY GROUPS IN TABLE 7

Family Graminae

Big bluestem
Bluegrass
Broom-sedge
Downy brome
Fall witch-grass
Foxtail
Indian grass
Little bluestem
Panic-grass (4 spp.)
Redtop
Reed canary
Smooth brome
Timothy
Wild rye

Family Leguminosae

Alfalfa
Birdsfoot-trefoil
Clover
Lespedeza
Partridge pea
Red clover
Sericea lespedeza

Family Compositae

Ashy sunflower
Aster (2 spp.)
Black-eyed susan
Bull-thistle
Common ragweed
Compass plant
Cup-plant
Daisy fleabane
Dandelion
Giant ragweed
Goldenrod (3 spp.)
Ironweed
Ox-eye daisy
Prickly lettuce
Pussy's-toes
Rosin weed
Sawtooth sunflower
Spiny-leaved sow-thistle

Family Roseace

Avens
Blackberry (2 spp.)
Black cherry
Cinquefoil (2 spp.)
Multiflora rose
Pasture rose
Wild plum
Wild strawberry