Bobwhite habitat use under short duration and deferred-rotation grazing

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Abstract

A study was conducted in the South Texas Plains to contrast the short-term impacts of short duration grazing (SDG) and deferred-rotation grazing (DG) systems on habitats for northern bobwhites (Colinus virginianus). Foliar cover, species richness, and structural attributes of the vegetation were compared at radio-location sites (quail-used) and sites along random transects (available) within and between the 2 grazing systems. Quail-used sites were characterized by increased species richness, forb cover, and bare ground and decreased plant height and litter accumulations. Principal components analysis revealed that available sites on the SDG during the fall and winter were scored higher along a habitat gradient which had greater species richness and forb cover combined with diminished litter accumulations. This habitat gradient explained 41% of the variation in the ground layer variables. In addition, mark-recapture studies suggested positive population responses on the SDG during the first year following its initiation. Short-term improvements in bobwhite habitats may be realized by initiating SDG on some semiarid rangelands.

Key Words: Colinus virginianus, grazing systems, habitat gradients, grazing impacts

By increasing stocking rates, and by using 12 to 20 pastures for short intensive grazing periods, short duration grazing (SDG) may improve forage harvest efficiency and enhance total livestock production (Ralphs et al. 1984, Heitschmidt et al. 1987). In addition, some studies have suggested that northern bobwhite (Colinus virginianus) densities responded positively to the increased grazing pressures of intensive grazing management regimes. Ground layer impacts associated with high-intensity, short-term grazing might improve vegetation structure and composition when compared with continuous grazing (Hammerquist-Wilson and Crawford 1981), only light grazing, or no grazing (Jackson 1969, Guthery et al. 1988). At times resulting in increased bobwhite densities (Schulz and Guthery 1988).

Deferred-rotation grazing (DG) uses fewer pasture units than SDG and normally incorporates lower stocking rates and less frequent livestock movement (Stoddart et al. 1975:293). The simplest DG involves only 2 pasture units, between which the entire herd is transferred at intervals lasting for several months.

Some DG systems have maintained ground layer habitat conditions and levels of bobwhite continuous grazing (Hammerquist-Wilson and Crawford 1981).

We present an interpretation of habitat measurements that further clarifies the dynamics of different grazing systems with respect to habitat change and use by bobwhites. A SDG and a 2-pasture DG (2PDG) system respectively represent high- and low-intensity alternatives to continuous grazing. We sampled recently initiated examples of each system to compare their impacts on habitats for bobwhites in a shrub dominated, semiarid range community. Our objectives were to determine the short-term influence of a SDG and a DG grazing system on bobwhite habitats, habitat use, and population characteristics.

Study Area

The study was conducted on La Copita Research Area, operated by the Texas Agricultural Experiment Station. La Copita is a 1,103-ha tract in west-central Jim Wells County, Tex., where the eastern edge of the South Texas Plains intergrades into the western edge of the Gulf Prairies and Marshes (Gould 1975). Topography was nearly level with gentle slopes down to intermittent streams, drainages, and periodically flooded depressions.

Soils were mainly of alluvial origin interspersed with lacustrine and marine deposits (U.S. Soil Conserv. Serv. 1979). Upland soils were well-drained sandy loams, while moderately well to poorly drained clay loams and clays predominated along drainages and around scattered depressions.

Foliar coverage by shrubs was >45% on both treatment areas. Major shrub species were honey mesquite (Prosopis glandulosa Torr.), bluewood (Condalia Hookeri M.C. Johnst.), huisache (Acacia farnesiana (L.) Willd.), lime pricklyash (Zanthoxylum fagara (L.) Sarg.), spiny hackberry (Celtis pallida Torr.), and Texas persimmon (Diospyros texana Scheele.). A diverse mixture of native grass species was present including three awns (Aristida spp.), gramas (Bouteloua Lag. spp.), fringed signalgrass (Brachiaria ciliarissima (Buckl.) Chase), multiflowered false-rhodesgrass (Trichloris pluriflora Fourn.), and windmillgrasses (Chloris SW. spp.). Important forb species included orange zexmenia (Zexmenia hispida (H.B.K.) Gray.), broomweeds (Xanthocephalum Willd. spp.), western ragweed (Ambrosia psilostachya DC.), golden crownbeard (Verbesina encelioides (Cav.) Gray.), perennial legumes (Fabaceae), plantain (Plantago I. spp.), ruellia (Ruellia I. spp.), creton (Croton L. spp.), and numerous annuals.

Climate is subtropical, but semiarid, with humid southeasterly winds originating over the Gulf of Mexico causing frequent fog and early morning dew. Annual rainfall varies widely (50–91 cm) and averages 72 cm (Scifres and Kuerth 1987), of which 43% falls from August to October.

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Methods

Grazing Systems

The 552-ha SDG (12 pastures) treatment was stocked at an average rate of 6.9 ha/animal unit (AU) and the 353-ha 2PDG treatment at an average rate of 9.5 ha/AU. Each SDG pasture was grazed for 3-8 days and rested for 30-90 days. Each 2PDG pasture was grazed for 3-5 months and rested for a comparable period. Both grazing systems were established in March 1985 and were managed as cow-calf operations.

Radio-location

Twenty quail on the SDG (11 males and 9 females) and 17 on the 2PDG (9 males and 8 females) were fitted with transmitters for radio-location. In each grazing system, at least 5 birds were equipped with radios at any 1 time. The original radioed populations was of all adults. When radioed birds were lost or killed, they were replaced by adults and juveniles having completed their first post-juvenile molt of the wing primaries. Quail were monitored during weekly 4-day tracking sessions during which all quail were located in each of 4 equal segments of daylight hours. Quail were located by taking 3 directional azimuths from known points within 250 m of the bird's location using either a hand-held antenna or a 5-element Yagi antenna mounted through the roof of a vehicle. Efforts were made not to flush or disturb radio-marked birds while tracking. Azimuths were triangulated on a coordinate photooverlay to approximate locations. The central coordinate of an error polygon created by the azimuths was used as the best estimate of location. Locations with error polygons >300-m² were considered unreliable for our purposes and were discarded.

Habitat Sampling

Sample locations were systematically selected from the pool of radio-locations collected. Locations selected for sampling available sites were located at equidistant points (200-m) along random transects running through each treatment. Habitat sampling quantified both quail used and available sites in terms of shrub coverage and structure, herbaceous species richness, foliar coverage and height, and relative amounts of bare ground and plant litter.

All vegetation measurements were taken from a 200-m² circular plot around a point estimate of the available or quail-used site. Percent foliar cover of shrubs, subshrubs, and succulents was recorded within 3 vertical strata (<1, 1-2, and >2 m) at each plot. Cover by grasses, forbs, bare ground, and plant litter was recorded within 10 randomly located 0.5 X 0.5-m quadrats. Mean vegetation height of the ground layer was estimated by averaging heights of herbaceous vegetation at all 4 corners of each quadrat.

Trapping Sessions

We conducted periodic trapping sessions in an attempt to quantify population densities and age and sex ratios. Funnel traps were spaced on an approximate 300 X 300-m grid (60 in SDG and 40 in 2PDG) during fall (1985-86) and spring (1986), and baited with grain sorghum (Sorghum bicolor (L.) Moench). Each captured quail was marked with a numbered leg-band and distinguished as to sex and age. Trapping sessions ended when previously banded birds accounted for >5% of those trapped during an occasion (1 day).

Data Analyses

Ground layer variables were divided by seasons that corresponded to bobwhite biology and behavior: nesting-brooding, July-September 1985; covey, October 1985-February 1986; and pairing-nesting, March-June 1986. Shrub canopies did not present seasonal variability. Thus, these data were not segregated into the seasonal groups.

For available habitats, analysis of variance (ANOVA) was conducted to test for season and grazing treatment effects on ground layer variables. Fisher's protected LSD (SAS Inst. Inc. 1985) was used for mean separation at the P<0.05 level. Two-tailed T-tests were conducted to compare treatment means for ground layer variables at quail-used sites with those at available sites within each season.

Principal components analysis (PCA; SAS Inst. 1985) was used as a data reduction technique to describe and summarize the ground layer. Because variables were of 3 different units (percent, count, and height), the correlation matrix was used for this analysis. All observations were pooled for conducting PCA. We used standard errors and 2-tailed T-tests to compare relative placements of each data class (i.e., treatment mean by season) along the first 2 principal components. Biological meanings of the principal components were interpreted from each variable's factor loading. Absolute values reflected relative importance in determining the principal component score. Sign (+ or –) indicated qualitative direction of influence.

Juvenile:adult ratios of birds trapped during the fall provided an index of productivity for the breeding population. Treatment and year differences in this ratio were tested using a chi-square test for differences in probabilities (Conover 1971:150). We used mark-recapture models and estimators from CAPTURE (Otis et al. 1978) to estimate seasonal population densities.

Our grazing treatments were not replicated, and we were forced to assume that pretreatment conditions were not measurably different. Statistical inference was used only to describe and discuss our data.

Results

Habitat Comparisons

Treatment means for habitat attributes on quail-used and available sites are presented in Table 1. Mean lower-canopy (<1 m) cover on the 2PDG was higher than on the SDG, while differences in the mid- (1-2 m) and upper-canopies (>2 m) were non-significant. Despite this small difference in the lower-canopies, shrub cover estimates considering all strata (49% on SDG and 54% on 2PDG, values not listed in Table 1) were not significantly different (P>0.10). Shrub cover within all strata was less on quail-used habitat than on available habitat.

Grass cover on available sites was higher on the SDG during the nesting-brooding season, but a treatment difference was not apparent during the other seasons. Grass cover decreased with time (seasons) under both treatments. Grass species richness remained stable on the SDG but decreased on the 2PDG from the nesting-brooding season into the covey season and then increased into the pairing-nesting season. Grass richness during the nesting-brooding and covey seasons was higher on the SDG than on the 2PDG. Forb cover declined from the nesting-brooding season into covey season in both treatments, and no treatment difference was apparent. Forb species richness declined on both treatments from the nesting-brooding season into the covey season and then increased again into the pairing-nesting season, being higher on the 2PDG treatment only during the nesting-brooding season. Plant litter accumulation increased on both treatments from the nesting-brooding season into the covey season in both treatments, and no treatment difference was apparent. Differences between quail-used and available habitats were greatest in the covey and pairing-nesting seasons. Ground layer conditions on quail-used sites were most characterized by increased species richness, forb cover, and bare ground but decreased plant height and litter accumulation. Demonstration of significant mean separation was variable. Those ground layer variables for which a treatment difference in available habitat was demonstrated tended to be those for which differences between quail-used and available habitats were apparent.

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Table 1. Means by strata for shrub layer variables, and seasons for ground layer variables, at sites used by radio-located quail (quail-used) and sites along random transects (available) on a short duration grazing (SDG) and a 2-pasture deferred-rotation grazing (2PDG) system, La Copita Research Area, Jim Wells County, Tex. 1985-86.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Seasona</th>
<th>Quail-used</th>
<th>Available</th>
<th>2PDG&lt;sup&gt;b&lt;/sup&gt;</th>
<th>SDG&lt;sup&gt;c&lt;/sup&gt;</th>
<th>2PDG&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrub layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower-canopy (%)</td>
<td>SDG&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.4 ***</td>
<td>22.4 ***</td>
<td>34.8</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Mid-canopy (%)</td>
<td>SDG&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.6 ***</td>
<td>22.4 ***</td>
<td>33.5</td>
<td>40.7</td>
<td></td>
</tr>
<tr>
<td>Upper-canopy (%)</td>
<td>SDG&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.3 ***</td>
<td>20.8 ***</td>
<td>34.5</td>
<td>38.6</td>
<td></td>
</tr>
<tr>
<td>Ground layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass cover (%)</td>
<td>NB</td>
<td>42.3 *</td>
<td>41.4</td>
<td>49.6 A&lt;sup&gt;f&lt;/sup&gt;</td>
<td>39.0 B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>35.0</td>
<td>36.7 *</td>
<td>35.4 BC</td>
<td>30.6 CD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>23.1</td>
<td>20.5</td>
<td>25.9 DE</td>
<td>22.7 E</td>
<td></td>
</tr>
<tr>
<td>Grass richness</td>
<td>NB</td>
<td>9.0</td>
<td>8.5 **</td>
<td>8.2 A</td>
<td>6.6 B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>8.6 **</td>
<td>7.0 ***</td>
<td>6.8 AB</td>
<td>4.9 C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>7.6</td>
<td>7.4</td>
<td>7.1 AB</td>
<td>6.7 AB</td>
<td></td>
</tr>
<tr>
<td>Forb cover (%)</td>
<td>NB</td>
<td>28.2</td>
<td>29.3</td>
<td>26.2 A</td>
<td>31.3 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>16.9</td>
<td>15.3</td>
<td>18.3 B</td>
<td>14.0 BC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>14.6 *</td>
<td>17.0</td>
<td>11.8 C</td>
<td>13.6 C</td>
<td></td>
</tr>
<tr>
<td>Forb richness</td>
<td>NB</td>
<td>10.7</td>
<td>10.5</td>
<td>8.7 B</td>
<td>12.4 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>6.0 **</td>
<td>5.7</td>
<td>5.3 C</td>
<td>4.5 C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>10.2 *</td>
<td>12.3</td>
<td>8.4 B</td>
<td>10.5 AB</td>
<td></td>
</tr>
<tr>
<td>Bare ground (%)</td>
<td>NB</td>
<td>27.5</td>
<td>24.4</td>
<td>23.7 A</td>
<td>23.5 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>26.3 **</td>
<td>25.3</td>
<td>20.0 A</td>
<td>22.9 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>29.7 **</td>
<td>31.8 ***</td>
<td>73.0 A</td>
<td>74.5 A</td>
<td></td>
</tr>
<tr>
<td>Plant litter (%)</td>
<td>NB</td>
<td>15.2</td>
<td>12.7</td>
<td>14.9 B</td>
<td>16.0 C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>19.1</td>
<td>18.9 ***</td>
<td>24.0 A</td>
<td>30.2 AB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>24.7 *</td>
<td>23.6 **</td>
<td>31.6 A</td>
<td>31.6 A</td>
<td></td>
</tr>
<tr>
<td>Plant ht. (cm)</td>
<td>NB</td>
<td>23.7</td>
<td>26.9</td>
<td>26.9 A</td>
<td>27.5 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>13.7</td>
<td>13.6 **</td>
<td>14.5 BC</td>
<td>17.1 B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PN</td>
<td>9.4 ***</td>
<td>10.3</td>
<td>11.3 C</td>
<td>11.1 C</td>
<td></td>
</tr>
</tbody>
</table>

*NB = Nesting-Brooding, C = Covey, PN = Pairing-Nesting.

<sup>a</sup>n = 111 for shrub layer; n = 24, 34, and 28 for ground layer during NB, C, and PN seasons respectively.

<sup>b</sup>n = 85 for shrub layer; n = 28, 34, and 28 for ground layer during NB, C, and PN seasons respectively.

<sup>c</sup>n = 85 for shrub layer; n = 27, 30, and 28 for ground layer during NB, C, and PN seasons respectively.

<sup>d</sup>Within their respective seasons, means for quail-used variables followed by asterisks were significantly separated by t-tests from those at available sites (* = P = 0.10, ** = P<0.05, *** = P<0.01).

<sup>e</sup>For each ground layer variable on available sites, treatment × season means followed by the same letter were not significantly separated (P>0.05) by ANOVA protected LSD.

Habitat Gradients

The first 2 habitat gradients created by PCA (PRIN1 and PRIN2) accounted for 41% and 23.4% of the variation in the ground layer, respectively. The third habitat gradient accounted for <14% and the remaining 4 accounted for <10% each. Only PRIN1 and PRIN2, therefore, were considered important enough for further analyses.

Sites with high values of PRIN1 were characterized by a combination of high species richness, diminished plant litter, and more expansive forb cover (Table 2). Sites with high values of PRIN2 were characterized by a combination of more expansive grass cover, taller mean plant height, and reduced exposure of bare ground. Standard errors around the means of PRIN1 and PRIN2 were plotted against each other to represent the differences, by treatment, in the ground layer components through the seasons on available and quail-used habitats (Fig. 1).

With respect to PRIN1, all habitat categories seemed to be comparable during the nesting-brooding season. During the covey season available habitat on both treatments experienced decreases along the PRIN1 gradient. The decrease was most drastic on the 2PDG where these scores were significantly lower than on the SDG (P = 0.028). During the covey season, quail on both treatment areas made use of sites with greater scores along this gradient (SDG, P = 0.002 and 2PDG, P = 0.005).

Scores along the PRIN1 gradient increased from the covey season into the pairing-nesting season on the 2PDG. These remained unchanged on the SDG. Although differences in the means were not as extreme, quail again used sites scoring higher along the PRIN1 gradient during the pairing-nesting season (SDG, P = 0.066 and 2PDG, P = 0.083).

Seasonal changes caused a decline in PRIN2 on both grazing treatments, but there was a little difference (P = 0.10) between grazing treatments during any season. On quail-used sites, PRIN2 was less than on available sites during the nesting-brooding (P = 0.025), covey (P = 0.039), and pairing-nesting (P = 0.009) seasons on the SDG, while there were no differences (P>0.10) on the 2PDG.

Population Characteristics

All trapping sessions had time-specific variation in trapping probabilities (Mt). Fall 1986 capture probabilities were affected by time and behavior responses (Mt), a model for which there is not an optimal estimator. Of the capture probability models for which estimators currently exist, however, the estimator for Mt was...
During the 1985-86 season: 0.35 and 0.34 quail/ha on the SDG and adult ratios between the 2 grazing systems (SDG: 6.9, n = 628; Trap sites estimates were about 45% on the SDG and 67% on the ZPDG). Reduction of density ranked highest by the model selection procedure in CAPTURE. 2PDG, respectively (195 and 120 quail harvested).

In fall 1985, 228 (SDG) and 114 (ZPDG) birds were trapped and marked while testing methods and choosing birds for radio-tracking. These were not used for CAPTURE calculations but were used for calculating juvenile:adult ratios.

CAPTURE estimates indicated that fall 1985 densities on the SDG were lower than on the 2PDG (Table 3). Reduction of density estimates were about 45% on the SDG and 67% on the 2PDG between fall 1985 and spring 1986. Population densities on the SDG showed an approximate 35% increase from fall 1985 to fall 1986, while 2PDG densities decreased 17%.

In fall 1985, 228 (SDG) and 114 (ZPDG) birds were trapped and banded while testing methods and choosing birds for radio-tracking. These were not used for CAPTURE calculations but were used for calculating juvenile:adult ratios.

In fall 1985, we found no difference (F > 0.25) in the juvenile:adult ratios between the 2 grazing systems (SDG: 6.9, n = 628; 2PDG: 7.4, n = 454, F > 0.25). However, in fall 1986, the ratio was highest on the SDG (SDG: 2.3, n = 607; 2PDG: 1.7, n = 407, F < 0.05). Harvest by hunting was the same on both treatment areas during the 1985-86 season: 0.35 and 0.34 quail/ha on the SDG and 2PDG, respectively (195 and 120 quail harvested).

In the covey season, however, young green leaves become the most important food items for bobwhites in southern Texas, accounting for >70% of total food volume (Campbell-Kissock et al. 1985). For this reason we consider the stimulation of cool-season herbs, as potential food items, to have been an associated benefit of reduced litter accumulations.

PRIN1 returned to former levels on the 2PDG following substantial spring rainfall. This recovery was driven by a 133% increase in forb richness. Forb richness on the SDG, by comparison, only increased by 58%. Dissimilarities found during the covey season emerged as the most noticeable difference in the impacts of the 2 grazing systems on bobwhite habitats.

Sites which scored low on the PRIN2 gradient were apparently used more by quail on the SDG but not on the 2PDG. Since SDG reduces standing crop biomass (Schulz and Guthery 1988), increases soil disturbance, and results in more cattle trails (Walker and Heitschmidt 1986), it could be anticipated that available SDG sites might score lower along the PRIN2 gradient. But treatment means might score lower along the PRIN2 gradient. But treatment means

### Table 3. Mark-recapture estimates of bobwhite densities on a short duration grazing system (SDG) and 2-pasture deferred-rotation grazing system (2PDG), La Copita Research Area, Jim Wells County, Tex., 1985–86.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fall 1985</th>
<th></th>
<th>Spring 1986</th>
<th></th>
<th>Fall 1986</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SDG</td>
<td>2PDG</td>
<td>SDG</td>
<td>2PDG</td>
<td>SDG</td>
<td>2PDG</td>
</tr>
<tr>
<td>Occasions</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>16</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Trap sites</td>
<td>60</td>
<td>40</td>
<td>60</td>
<td>40</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>No. Marked</td>
<td>400</td>
<td>340</td>
<td>202</td>
<td>120</td>
<td>607</td>
<td>407</td>
</tr>
<tr>
<td>No. Captures</td>
<td>593</td>
<td>458</td>
<td>291</td>
<td>202</td>
<td>170</td>
<td>458</td>
</tr>
<tr>
<td>Density (quail/ha)</td>
<td>1.15</td>
<td>1.89</td>
<td>0.63</td>
<td>0.61</td>
<td>1.56</td>
<td>1.57</td>
</tr>
<tr>
<td>Above 95% C.I.</td>
<td>1.04</td>
<td>1.62</td>
<td>0.54</td>
<td>0.48</td>
<td>1.45</td>
<td>1.45</td>
</tr>
<tr>
<td>Upper 95% C.I.</td>
<td>1.26</td>
<td>2.15</td>
<td>0.73</td>
<td>0.73</td>
<td>1.68</td>
<td>1.69</td>
</tr>
</tbody>
</table>
did not differ with regard to PRINZ. Distribution of grazing impacts might have contributed to the lack of observed treatment difference in PRINZ. On the 2PDG, livestock were able to continuously use the same watering facilities, mineral supplements, and bedding areas, thereby increasing the noticeable symptoms of livestock impact (lower mean plant height, decreased grass cover, and more bare ground). Sites were similarly impacted on the SDG. However, because of short periods of high livestock concentrations and their frequent movements through the pastures of the SDG, low PRINZ sites probably were more evenly dispersed than on 2PDG. Actual availability of such modified sites might have been greater on the SDG, thus allowing for greater access and use by radio-marked bobwhites.

Population Characteristics
O'Brien et al. (1985) presented some evidence suggesting that their CAPTURE estimates for bobwhites were negatively biased, being uniformly lower than Petersen (1896) estimates obtained from band recoveries in the hunting bag. They were able to harvest birds for Petersen estimates immediately after trapping had ended, thereby enhancing their chances of sampling within a closed population. Our harvest was spread over a 3-month period, hence increasing opportunities for ingress and egress (a violation of the closed population assumption). As a consequence, we could not make reliable Petersen estimates. We acknowledge potential for negative bias associated with our density estimates. However, if estimates were precise, and they seem to be (i.e., narrow confidence intervals), then they are still of value in comparing population response.

During the 1985–86 hunting season, the SDG sustained a harvest rate equal to that on the 2PDG, even though preseason densities were substantially lower. So, spring 1986 density comparisons suggest that survival rates of the SDG population exceeded those on the 2PDG through the covey season. Reproductive rates were greater on the SDG during the first full breeding season (spring 1986) following establishment of the grazing systems; but these rates were apparently the same during the previous year. Spring 1985 rainfall (37.7 cm from March–May) was more than normal (13.9 cm, Scifres and Koerth 1987), allowing for favorable breeding conditions to develop (Kiel 1976), so that reproductive rates were comparatively high on both areas. Spring 1986 rainfall was about average (13.2 cm) and reproductive rates were correspondingly lower, although not as low on the SDG.

Dissimilarities in reproductive rates of the 1986 breeding populations might have resulted from habitat differences attributable to the grazing systems, although density dependent factors cannot be eliminated from consideration. With increased 1986 reproductive rates, quail densities on the SDG should have been greater than on the 2PDG during the fall. Our CAPTURE estimates did not detect such a difference. We did not have sufficient information concerning ingress, egress, and mortality factors to reconcile this discrepancy.

Conclusions
SDG was capable of altering both the structure and composition of the ground layer. Greater herb species richness, diminished plant litter accumulation, and increased forb cover combined to make a habitat gradient favored by quail during the fall and winter. This gradient was apparently enhanced by SDG, when compared to 2PDG. Bobwhites seemed to benefit from those alterations in the habitat associated with the SDG grazing system during the fall and winter. During the first full year of grazing system operation, survival on the SDG through the covey season was greater and reproductive rates were higher.

Grazing systems that reduce plant litter accumulations and subsequently allow for increased germination and growth of overwintering herbs might improve the utility of some semiarid range habitats for bobwhites. These results support the conclusions of Hammerquist-Wilson and Crawford (1981) and Schulz and Guthery (1988) that short-term ground layer modifications resulting from SDG seem to benefit bobwhites. We emphasize that our conclusions result from a short-term investigation and do not describe any successional changes that might result from SDG.

Literature Cited