Effects of Six Disking Regimens on Quail Foods in Fallowed Fields

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Abstract: The effect of disking fallowed agricultural fields was studied in the Piedmont and Coastal Plain of South Carolina. Six combinations of disking frequency and time-of-year and a control were tested. Although plant communities responded by returning to an earlier seral stage, well-established perennials prevented a complete return to Stage 1 succession. The effect of disking frequency proved more influential than that of time-of-year. Treatments were evaluated for their ability to produce food plants for northern bobwhite (*Colinus virginianus*). In the Piedmont, food values were found to have increased 1 year after all treatments, while control plots showed no increase. Annual March treatment extended the increase into the second year. In the Coastal Plain, no significant differences in food values were found between sampling periods regardless of treatment. Vegetation density was controlled by annual disking; density in biennially disked and control plots increased. Species diversity was shown to decrease significantly in biennial treatments in the Coastal Plain. Seed samples showed that very few plant species were present in the seed bank that were not present as standing vegetation. Relative food value of standing vegetation and costs of planted food plots should be the primary factors considered in determining whether to disk fallowed fields or plant conventional food plots.

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Leasing of hunting rights to clubs or individuals has become a popular method of generating income for rural landowners (Busch 1987). This project was initiated to study the feasibility of disking strips in fallowed agricultural fields and pastures, and relying on volunteer vegetation as a substitute for planted food plots to benefit northern bobwhite. Food plots are costly and a method which would reduce or eliminate some costs without sacrificing quality management would increase owner profit and perhaps encourage greater participation in management for northern bobwhite. If workable, the advantages of disking strips are numerous: 1) no seed or fertilizer required, 2) no loss of space in currently planted fields, 3) less equipment use, and 4) less time investment. Timing and disking frequency were studied to discover which combination might best produce a volunteer stand with high amounts of available quail foods.

Disking has long been cited as producing a flush of fall and winter quail foods in the Coastal Plain of the Southeast (Stoddard 1931, Rosene 1969, Buckner and Landers 1979). However, no research on this technique has been published regarding the Piedmont. Intensive site preparation in which disking is combined with other treatments has been examined a number of times (Brunswig and Johnson 1972, Moore and Swindel 1981, Sweeney et al. 1981), but because of the combinations the effects of disking are confounded. Also, each of those studies was conducted on land which had been forested prior to treatment; early succession on these areas differs from that on agricultural areas.

The timing of treatment is essential. Stoddard et al. (1961) found that time of year affected the production of 4 important quail foods in southern Georgia. Work at Tall Timbers Research Station in northwestern Florida has shown that fall disking encourages different plants than disking in spring or summer (Landers and Mueller 1986). The effects of prescribed burning have also been shown to differ by season of application (Moore 1957, Lewis et al. 1967), though not always (Whitehead and McConnell 1979). Frequency of treatment is also a concern. Harlow and Bielling (1961) found differences between areas burned only once and those burned annually over the same period. Also, basic ecology tells us to expect plant communities to change markedly during the first few years following disturbance.

This study addresses these questions by 1) examining disking in both the Coastal Plain and the Piedmont, 2) conducting the tests on fallowed agricultural land, 3) testing the effect of timing, and 4) comparing annual with biennial treatment.

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Methods

The Piedmont study site was a 5.4-ha improved pasture located on the Sumter National Forest in Union County, South Carolina. The property was acquired through a land exchange in 1987, prior to which it had been grazed for at least the previous 11 years. The vegetation was dominated by a variety of grasses, primarily fescue (*Festuca elatior*), broomsedge (*Andropogon virginicus*), panic grasses (*Panicum aciculare* and *P. dichotomum*), and orchard grass (*Dactylis glomerata*). Other dominant species included Korean lespedeza (*Lespedeza stipulacea*), horseweed (*Erigeron canadensis*), and horsenettle (*Solanum carolinianum*). The soil is

Cataula sandy clay loam, 6% to 10% slopes, eroded. Mean annual precipitation is 119.9 cm; mean annual temperature is 16.4° C. Growing season averages 200 days from last spring to first fall frost (Camp et al. 1975).

The Coastal Plain site was located in Berkeley County, South Carolina, on land operated by Oakland Club, a private hunting preserve. The site was composed of a 1.15-ha agricultural field which was fallowed in fall 1987. Prior to fallowing, it had been planted in row crops, primarily corn, for the 4 previous years. Vegetation was typified by perennial grasses such as coastal bermuda (*Cynodon dactylon*) and Johnsongrass (*Sorghum halapense*), crabgrass (*Digitaria sanguinalis*), Florida pusley (*Richardia scabra*), morningglory (*lpomoea hederacea*), dewberry (*Rubus trivialis*), and sicklepod (*Cassia obtusifolia*). The soil is Goldsboro loamy sand, 0% to 2% slope; mean annual precipitation and temperature are 120.1 cm and 17.8° C, respectively. Growing season averages 260 frost free days (Long 1980).

Each study site contained 21 plots arranged in either a completely random design (Piedmont) or a randomized complete block (Coastal Plain). Each plot measured 5 x 32 m and was separated from other plots and surrounding vegetation by a 5-m buffer strip maintained by periodic mowing. The plots were divided among 6 treatments and 1 control with 3 replications each. Treatment consisted of harrowing the soil to a depth of 15 cm, using either a disk harrow or rotary tiller, during 1 of 3 times of year and either the first year only (biennial maintenance) or 2 years in a row (annual maintenance) (Table 1). All treatments were applied within the first 14 days of the month to which they were assigned.

Vegetation surveys were conducted at each site during April and late August - early September to document the greatest number of species to be found during the growing season. The initial survey, conducted in August - September 1988, collected baseline data prior to any treatment. Ten 1-m^2 subplots were evenly spaced along the center line of each plot. All plant species within each subplot were identified and percent cover was recorded for each, percent cover of bare ground and dead material was also recorded. All non-living vegetation was recorded as dead

Table 1. Schedule of treatments and sampling periods for study of disking volunteer food plots in fallow fields for northern bobwhite in South Carolina.

Date	Action
Aug–Sep 1988	Vegetation survey (sampling period 1—pre-treatment data)
Nov 1988	Disking of November annual and November biennial plots
Mar 1989	Disking of March annual and March biennial plots
Apr 1989	Vegetation survey (sampling period 2)
Jun 1989	Disking of June annual and June biennial plots
Aug 1989	Vegetation survey (sampling period 3)
Nov 1989	Disking of November—annual plots
Mar 1990	Disking of March—annual plots
Apr 1990	Vegetation survey (sampling period 4)
Jun 1990	Disking of June—annual plots
Aug 1990	Vegetation survey (sampling period 5)

material, including that above ground level. Due to stratification of the vegetation, total cover often exceeded 100%.

Seed samples were collected using a bulb transplanter to extract 2 plugs of soil 2.5 cm deep at the outside corners of each subplot (Ripley and Perkins 1965). Following collection, samples were homogenized and thoroughly mixed by hand. A 100-g sample was taken from each plot and processed through Malone's (1967) flotation technique to extract organic material. The extracted material was then dried under a laboratory hood to prevent seed germination. Once dry, samples were viewed under a dissecting microscope; all seeds were identified to the lowest possible taxon, usually species, and counted.

Analysis

Vegetation data were analyzed on 2 levels. First, a descriptive approach was used to compare responses of plant communities to treatments. Next, data were modified to enable comparisons of mean total food values of each treatment for northern bobwhite so that recommendations for possible implementation could be made.

The descriptive analysis was performed using the program PAUP™ (Phylogenetic Analysis Using Parsimony) (Swofford 1990). This program is used primarily for assessing relatedness between taxa by comparing the levels of expression for a series of selected characteristics. In our case, each plant species found on a study area was considered a characteristic, and its mean percent cover within a treatment, the level of expression. This allowed a comparison of treatments based on both content (presence/absence of a species) and structure (percent cover of species relative to each other). Output was in the form of dendrograms. Once the data matrix was entered, PAUP performed an exhaustive search for the shortest dendrogram which explained the final arrangement of the treatments. Each sampling period was run separately.

To compare treatments based on their capacity for producing food plants for bobwhites, data were modified to reflect the relative food values of individual species. First, importance values (IV's) were determined for each species using the criteria of Landers and Johnson (1976) through a literature review process including all known food habits studies conducted in the Piedmont (Davison 1942, Dickson 1971, Brunswig and Johnson 1972, McRae 1980) and Coastal Plain (Percivial 1966, Harshbarger and Buckner 1971, Weber 1975, Saunders 1977, Robinson and Barkalow 1979, Harrigal 1982) of North Carolina, South Carolina, and Georgia. IV's were averaged across all studies to yield a single value for each species within a region; missing values were not included. Next, mean percent cover was calculated by plot for all species, then multiplied by their IV's, for each sampling period. The products were summed to yield a single value for each replication; replications were then averaged to yield a mean value for each treatment within each sampling period. A general linear model (PROC GLM) (SAS 1989) was used to test the interaction of sampling periods (SP's) and treatments (TMT) at 1- and

2-year intervals to determine whether disking affected a change in mean total food value (FDVAL), using the model FDVAL = TRT * SP, where FDVAL is the dependent variable. PROC GLM was also employed to test the effects of disking frequency (DFREQ) and time-of-year (TOY) within each sampling period, using the model FDVAL = TOY DFREQ TOY * DEFREQ, with FDVAL again the dependent variable. The effect of disking frequency on vegetation density was tested using PROC GLM to compare mean percent cover of bare ground. Tukey's studentized range test was used to separate significantly different groups in these 3 tests. Species diversity was compared between annual and biennial treatment by applying *t*-tests to the treatment mean of the number of species found per subplot. All statistical significance was considered at an experiment-wise error rate of alpha = 0.05.

Seed samples were taken to give an indication of overall presence or absence of individual species in the seed bank at each site. Three plots were randomly sampled from the Piedmont site and 1 from each of the 3 blocks on the Coastal Plain site for sampling periods 1–4.

Results

PAUP Analysis

Initially, we would not expect dendrograms to show a pattern of grouping common to both study areas, since we assigned plots randomly. A comparison between sites of sampling period 1 shows no common pattern (Fig. 1). As treatments were applied over the course of the study, groupings became somewhat predictable.

Sampling period 2 dendrograms show that disking substantially altered the arrangement from pre-treatment. At this point, there were effectively only 3 treatments: March, November, and Control/June. Succession in the first 2 had been set back and, because the sample was taken early in the growing season, the treated plots had substantially more bare ground than the untreated plots. Separation of these groups, then, was as expected. In sampling period 3 there were 4 actual treatments: March, June, November, and Control. Both dendrograms show a predictable arrangement for this situation, although there were minor differences between the sites. In the Piedmont, June was the first treatment to branch away; this was due to the prominence of crabgrass (*Digitaria sanguinalis*), a summer annual. In the other treatments, fescue, a cool season perennial, maintained its dominance and forced the separation of the June treatments.

In the Coastal Plain, June and March, the most recently applied treatments, aligned more closely to each other, whereas November, which had the longest recovery period, moved closer to Control.

In sampling period 4 there were effectively 6 treatments: March-biennial, March-annual, November-biennial, November-annual, June, and Control. Now the effect of disking frequency begins to appear. As expected, the June treatments remained grouped; however, the possibilities for the March and November treatments were not so predictable. Judging from the groupings, it appears that disking frequency has a more powerful effect than time-of-year. As we move on to sampling

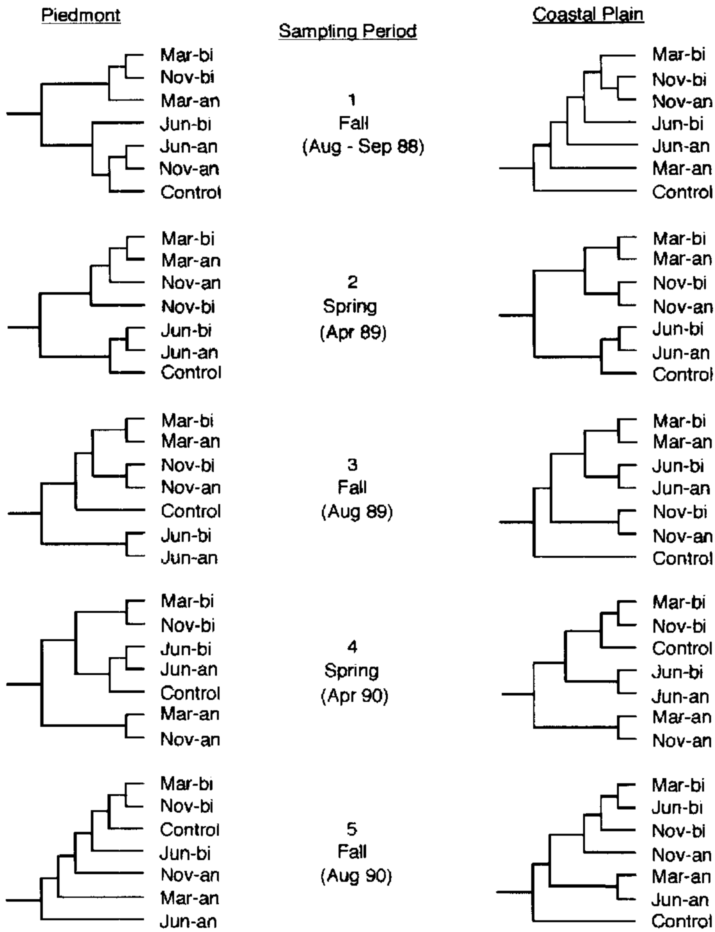

Figure 1. Dendrograms resulting from PAUP analysis of vegetation data from disked strips in fallow fields of the Piedmont and Coastal Plain of South Carolina, 1988–1990. Treatments are abbreviated as month of application - frequency of application (biennial or annual). Closer final proximity and greater numbers of shared nodes indicate greater likeness among treatments.

period 5, where all 7 treatments have been implemented, the groupings make even more apparent the greater role of disking frequency in determining the final grouping pattern. The fact that November-annual remains closer to the once-disked treatments on both sites is of interest. In the Piedmont, it can be explained by the persistence of fescue in the November-annual plots, where it quickly reestablished during the favorable winter months following treatment. In the Coastal Plain, bermuda grass did essentially the same thing, regaining dominance early in the growing season.

The most noteworthy difference in groupings between the study sites was the placement of Control. Logically, Control should have maintained an affinity to treatments where disturbance had either not yet occurred, or else had taken place in the more distant past so that natural succession had time to advance the vegetation. This is the case in the Piedmont without exception. However, in the coastal Plain the fall dendrograms revealed that Control was the first treatment to branch, and that it branched alone. After nearly an entire year of vegetative succession, the older treatments still were very different. The most likely explanation seems to be grounded both in the amount of bare ground and the type of vegetation present. It is clear from the sampling period 1 dendrogram that Control was vegetatively different from the beginning. A perusal of the raw data showed that their structure and composition remained virtually unchanged over the 2 years of the survey. Periods of affinity with the most distantly treated plots were due more to the commonality of having only a small amount of bare ground in comparison to the more recent treatments rather than by any great similarity in vegetation. However, as vegetation rerestablished during the summer, the grouping power of bare ground was eliminated. Vegetative differences then pushed Control away from the rest of the treatments by the time of the fall survey.

Modified Data Analysis

Test of treatments between sampling periods revealed no significant differences in mean total food value in the Coastal Plain (Table 2). Disking had no effect on the amount of quail food present from 1 year to the next. In the Piedmont, a number of differences did occur, showing that disking substantially increased quail food plant production, but only for the season following treatment. All treatments showed a significant increase in mean total food value from period 1 to 3. However, only the March-annual treatment maintained this increase into the second year (period 5).

Comparisons of treatments within sampling periods found differences at both sites. In the Piedmont, both disking frequency (P = 0.0002) and time-of-year (P = 0.0322) showed differences in period 5; Tukey's test revealed these differences to be between annual and biennial disking, and between March and November treatments. The Coastal Plain exhibited differences due to time-of-year (P = 0.0098) in period 2 and the interaction of time-of-year and disking frequency (P = 0.0121) in period 4. Tukey's attested these differences to higher mean total food values in June treatments than March treatments in period 2; in period 4, annual March disking showed lower food values than Control.

Density comparisons between sampling periods 1 and 5 revealed a tendency for vegetation density in Control and biennially disked plots to increase. In the Coastal Plain, Control showed a decrease in mean percent bare ground from 12.33% to 4.33% while biennial treatments decreased from 12.16% to 5.96%. Conversely, bare ground in annual treatments increased from a mean of 8.78% to 23.47%. No significant differences between treatments were discovered in sampling period 1 (P = 0.0761); significance did occur in period 5 (P = 0.0001).

Table 2. Mean total food values (S.E.) calculated using importance values and mean percent cover for each treatment and sampling period in fallow agricultural fields in South Carolina, 1988–1990.

	Fall sampling periods			Spring sampling periods	
Treatment	1	3	5	2	4
Piedmont					
March—biennial	397.55A[a] (124.14)	827.19B (88.66)	336.28A (141.12)	67.33A (8.97)	59.70A (17.72)
March—annual	413.26A (216.42)	813.97B (162.21)	891.31B (131.26)	80.96A (17.04)	79.25A (23.91)
June—biennial	317.40A (86.16)	746.92B (79.13)	271.23A (62.40)	190.44A (73.90)	117.38A (17.89)
June—annual	413.64A (199.40)	760.77B (161.18)	622.08AB (97.81)	155.69A (129.87)	162.72A (43.41)
November—biennial	302.63A (76.02)	649.05B (85.89)	162.89A (50.26)	104.24A (10.88)	54.60A (31.26)
November—annual	461.83A (87.27)	1071.83B (208.16)	468.44A (108.63)	132.16A (27.40)	133.33A (42.34)
Control	570.75A (191.17)	524.33A (140.79)	498.83A (74.42)	234.27A (80.09)	124.04A (67.03)
Coastal Plain					
March—biennial	1074.61A (199.99)	1119.29A (122.13)	829.01A (159.41)	132.74A (28.92)	514.58A (68.54)
March—annual	763.60A (175.88)	848.23A (142.28)	936.91A (305.64)	60.89A (17.01)	73.97A (33.00)
June—biennial	868.73A (266.08)	1118.59A (205.22)	965.22A (76.41)	707.85A (191.67)	408.44A (128.46)
June—annual	819.19A (181.57)	808.05A (243.01)	776.34A (180.59)	489.07A (251.37)	439.50A (100.49)
November—biennial	1230.21A (252.13)	1329.20A (115.03)	1001.76A (54.49)	359.75A (110.90)	445.67A (33.75)
November—annual	1345.36A (130.78)	1372.35A (71.41)	1148.52A (234.75)	130.78A (59.27)	543.73A (107.80)
Control	690.76A (119.89)	628.03A (310.77)	614.99A (116.54)	391.69A (62.49)	702.54A (116.54)

[a] Results of PROC GLM test and subsequent groupings using Tukey's studentized range test. Within treatment-season classes means followed by the same letter are not significantly different.

Tukey's grouped Control and biennial treatments separately from annual treatments. In the Piedmont, Control showed a decrease from 2.47% to 0.60%, biennial treatments increased slightly from 1.81% to 1.99%, and annual treatments increased from 5.81% to 12.38%. Significance in sampling period 1 ($P = 0.0011$), grouping the June annual and November annual treatments separately from the remaining treatments, was repeated in sampling period 5 ($P = 0.0001$).

Diversity measurements showed no significant difference between annual and biennial treatment in either sampling period 1 or 5 in the Piedmont. Diversity was slightly increased from period 1 to 5 in both cases, but was not significant in either. In the Coastal Plain, annual treatment began with a significantly higher diversity than biennial treatment in period 1 (t = 3.17, 4 df) which was maintained into period 5 (t = 4.68, 4 df). Biennial treatments showed a highly significant decrease in diversity from period 1 to 5 (t = 35.57, 4 df), while annual treatments held steady (t = 0.035).

Seed Data Analysis

A total of 1,345 seeds of 33 identifiable taxa were recovered from the Piedmont samples, representing only 36 of the 89 species (40.4%) identified as standing vegetation. The Coastal Plain samples yielded 919 seeds of 16 taxa, representing only 13 of the 53 plant species (24.5%) identified there. Overall, 98.5% of the Coastal Plain and 98.4% of the Piedmont seeds were of plants identified at their respective sites. In general, annual plants which expressed seasonal dominance, such as crabgrass and sheep sorrel (*Rumex hastatulus*), were prominent. Dominant perennials, especially the grasses, were poorly represented.

Discussion

Modified Data Analysis Methods

The value of food habits studies has been questioned by Gullion (1966). Bias may occur due to season, locale, presence/absence of food plots (Robel et al. 1974), field conditions, or condition of the birds. Also, very few studies compare use with ground availability. By using all known studies in a region, bias for any of these reasons should be reduced substantially. Application of the Landers and Johnson (1976) criteria to all studies promotes consistency and helps to moderate extremes.

Management Implications

In the Piedmont, the clear favorite for food plot establishment was annual March disking. As the results of the tests show, and the man total food values illustrate, this treatment increased and maintained levels of quail food plants over both years of the survey. Most other treatments managed an increase the first year, but then showed a significant decline the next. Control plots showed no change in production of food plants.

In the Coastal Plain of South Carolina, disking showed little promise as a tool for establishing food plots in fields with long agricultural histories. The absence of significant differences between treatments shows that no more or less food is produced by disking than by simply doing nothing. As the results of the seed samples and the vegetation surveys show, plants which were not present either in the seed bank or as standing vegetation had very little change of appearing regardless of treatment. However, had the field contained substantial amounts of known quail foods to begin with, we might have expected a response similar to those cited in other Coastal Plain studies (Stoddard 1931, Stoddard et al. 1961, Rosene 1969, Buckner and Landers 1979).

However, simple disking in long-term agricultural fields may have value other than increasing food plants. The maintenance of a stand with substantially more bare ground, and therefore greater accessibility, was realized by annual disking, while undisked and biennially disked plots showed a tendency to thicken over the course of the surveys. On the Coastal Plain site, dewberry (*Rubus trivialis*) commonly occurred at a height of 6–10 cm, and would certainly discourage use by quail of areas where it was present in large quantities. Annual disking controlled the spread of dewberry; biennial and no disking did not. Control plots showed dramatic change in mean cover of dewberry from period 1 to 5, increasing from 6.23% to 57.83%. Biennial plots showed a similar trend (7.61% to 28.40%); annual treatments showed a decrease from 11.68% to 8.79%. Diversity, important when depending on weed seeds as a food source (Bookhout 1958), was also better maintained by annual treatment.

Comparisons With Planted Food Plots

The main purpose of this study was to evaluate the effectiveness of an inexpensive alternative to planted food plots. It is therefore appropriate to make some comparisons between the 2 methods to determine the value of disking relative to planted plots. The primary considerations are food value and cost.

Food Value. The attractiveness of a food plot is the abundance of food that is found in it relative to surrounding habitat. We have already shown that disking can increase food abundance in fallow fields. However, if we are to consider disking as a viable alternative to planting, it should produce something close to a comparable amount of food. For example, using the same method as was used for disked plots, we find that a planted plot with 90% coverage of Korean lespedeza (IV = 14) would have a total food value of 1260. By contrast, the greatest mean food value of our "best" treatment in the Piedmont is 891 (71%).

Aside from sheer volume, plots should also provide a food source that will last as long as possible, preferably through the entire winter. Hard-coated seeds, especially certain lespedezas, are known for remaining in good condition even through winter (Bookhout 1958). Haugen and Fitch (1955) found that bicolor lespedeza patches provided a dependable and abundant food source year-round, even during drought years. Such reliability has a distinct advantage over weed seeds, which overall tend to decline in abundance over the course of the winter (Bookhout 1958).

Predictability is another desired trait of food plots. The high standard error associated with the data shows the unpredictability of volunteer vegetation. Although it can safely be said that there will be nothing new in a disked strip, it is not possible to predict with certainty what will come up, or in what quantities. Much of the vegetation that volunteered, perhaps the majority, had little or no known food value for quail.

Cost. The cost of establishing a food plot can be quite substantial. Using recommended planting and fertilization rates from Yarrow (1992) and prices from local dealers, the cost of establishing 1 ha of food plots using Kobe lespedeza (*Lespedeza striata*) in the Piedmont and partridge pea (*Cassia fasciculata*) in the Coastal Plain was $150.85 and $257.61, respectively. In addition to seed and fertilizer, the planted fields suffer the costs of more man-hours, greater equipment use, possible need for weed control, and substantially greater opportunity cost. Cost-share programs, such as the Stewardship Incentive Program and Agricultural Conservation Practices, can significantly reduce seed and fertilizer expenses, but do not assist with remaining costs. Although these costs would vary somewhat, simple disking is far less expensive than planting food plots.

Literature Cited

Bookhout, T. A. 1958. The availability of plant seeds to bobwhite in southern Illinois. Ecology 39:671–681.

Brunswig, N. L. and A. S. Johnson. 1972. Bobwhite quail foods and populations on pine plantations in the Georgia Piedmont during the first seven years following site preparations. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 26:96–107.

Buckner, J. L. and J. L. Landers. 1979. Fire and disking effects on herbaceous food plants and seed supplies. J. Wildl. Manage. 43:807–811.

Busch, F. A. 1987. Lease hunting in the southern United States. M.S. Thesis, Clemson Univ., Clemson, S.C. 78pp.

Camp, W. J., J. C. Meetze, W. H. Fleming, and L. E. Andrew. 1975. Soil survey of Laurens and Union Counties, South Carolina. U.S. Dep. Agric., Soil Conserv. Serv. 66pp.

Davison, V. E. 1942. Bobwhite foods and conservation farming. J. Wildl. Manage. 6:97–109.

Dickson, J. G. 1971. Food habits of the bobwhite quail in the Georgia Piedmont. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:281–285.

Gullion, G. W. 1966. A viewpoint concerning the significance of game bird food habits. Condor 68:372–376.

Harlow, R. and P. Bielling. 1961. Controlled burning studies in longleaf pine-turkey oak association on the Ocala National Forest. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 15:9–23.

Harrigal, D. E. 1982. Annual food habits of bobwhite quail on the commercially managed forests of the Savannah River Plant, South Carolina. M.S. Thesis, Clemson Univ., Clemson, S.C. 106pp.

Harshbarger, T. J. and J. L. Buckner. 1971. Quail foods in Georgia flatwoods. Ga. For. Res. Paper 68. 5pp.

Haugen, A. O. and T. W. Fitch, Jr. 1955. Seasonal availability of certain bush lespedezas and partridge pea seed as determined from ground samples. J. Wildl. Manage. 19:297–301.

Landers, J. L. and A. S. Johnson. 1976. Bobwhite quail food habits in the southeastern United States with a seed key to important quail foods. Tall Timbers Res. Sta. Misc. Publ. No. 44. 90pp.

——— and B. S. Mueller. 1986. Bobwhite quail management: a habitat approach. Tall Timbers Res. Sta. Misc. Publ. No. 6. 39pp.

Lewis, J. B., D. A. Murphy, and J. Ehrenreich. 1967. Effects of burning dates on vegetative production on Ozark forests. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 18:63–72.

Long, R. M. 1980. Soil survey of Berkeley County, South Carolina. U.S. Dep. Agric., Soil Conserv. Serv. 94pp.

Malone, C. R. 1967. A rapid method for enumeration of viable seeds in soil. Weeds 15:381–382.

McRae, W. A. 1980. Unusual bobwhite foods on abandoned Piedmont farmlands. Ga. J. Sci. 38:49–54.

Moore, W. H. 1957. Effects of certain prescribed fire treatments on the distribution of some herbaceous quail plant foods in loblolly-shortleaf pine communities of the Alabama Upper Coastal Plain. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 11:349–351.

——— and B. F. Swindel. 1981. Effects of site preparation on dry prairie vegetation in south Florida. South J. Appl. For. 5:89–92.

Percival, H. F. 1966. The winter diet of the quail on Belmont Plantation. S.C. Wildl. and Mar. Resour. Dep., Columbia, S.C. 19pp.

Ripley, T. H. and C. J. Perkins. 1965. Estimating ground supplies of seeds available to bobwhite. J. Wildl. Manage. 29:117–121.

Robel, R. J., R. M. Case, A. R. Bisset, and T. M. Clement, Jr. 1974. Energetics of food plots in bobwhite management. J. Wildl. Manage. 38:653–664.

Robinson, I. R., Jr. and F. S. Barkalow, Jr. 1979. Bobwhite quail foods in pocosin habitat converted to pine. J. Wildl. Manage. 43:516–521.

Rosene, W., Jr. 1969. The bobwhite quail: its life and management. Rutgers Univ. Press, New Brunswick, N.J. 418pp.

SAS Institute Inc. 1989. SAS™ user's guide: statistics. Version 6, Fourth Ed., Vol. 2, Cary, N.C. 846pp.

Saunders, M. 1977. Winter bobwhite quail food habitat study. S.C. Wildl. and Mar. Resour. Dep., Columbia, S.C. 15pp.

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

———, H. L. Beadel, and E. V. Komarek. 1961. The cooperative quail study association. Tall Timbers Res. Sta. Misc. Publ. No. 1. 500pp.

Sweeney, J. M., C. R. Wegner, and N. S. Yoho. 1981. Bobwhite quail food in young Arkansas loblolly pine plantations. Ark. Agric. Exp. Sta. Bul. 852:3–18.

Swofford, D. L. 1990. PAUP: Phylogenetic Analysis Using Parsimony, Version 3.0. Computer program distributed by Ill. Nat. Hist. Survey, Champaign. 162pp.

Weber, A. J. 1975. Fall and winter food habits of the bobwhite quail in the sandhills of North Carolina. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 29:687–694.

Whitehead, C. J. and C. A. McConnell. 1979. Controlled burning studies in old fields. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 33:88–95.

Yarrow, G. K. 1992. Wildlife planting guide and native wildlife plants in South Carolina. Clemson Univ. Coop. Ext. Serv. AFW 2. 47pp.