BOBWHITE FOODS IN SIX OKLAHOMA HABITATS

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Abstract: This study in 1972-73 in northwestern Oklahoma, using soil-vegetation cores and sweep-net samples, assessed the seasonal biomass of invertebrates and "principal" seeds that are potential foods of bobwhite *(Colinus virginianus)* in 2 natural (stabilized dunes, upland woods) and 4 man-altered habitats (old disked areas, recently disked areas, mature food plots, and thinned bottomland forest). Mature food plots had greater ($P < 0.05$) amounts of seeds during summer and fall than other habitats. Food productivity remains high the second year after a food plot is planted and perhaps longer. Stabilized dunes and old disked areas contained the most foods during winter. Stabilized dunes are preferred winter habitat and require little or no management. When not disturbed annually, disked fire lanes were rich in quail food and did not require the planting costs of food plots. A logical way to save fuel and other expenses would be to convert some food plots to disked areas and to plant the remaining food plots on alternate years or, perhaps, every 3rd year.

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Adult bobwhites are primarily seed eaters; animal matter and green vegetation are utilized to a lesser extent. Martin et al. (1961) indicated use of animal foods by adult bobwhites in spring, summer, fall, and winter amounting to 17, 27, 18, and 3 percent, respectively, of the diet. Insects are the principal food of bobwhite chicks (Hurst 1973) but the importance of animal protein declines until the bird's 1st winter when its diet becomes similar to that of an adult.

Planting food plots, disking, prescribed grazing, shrub and tree planting, mowing and spraying brush, controlled burning, and thinning of woodland are management techniques (Ellis 1973) used to supplement the bobwhites' food supply or to favorably alter habitat. These practices are initiated with the assumption that the natural food supply or some other aspect of habitat is not suitable to support bobwhite populations of a desired density. Agricultural crops such as wheat, sorghum, and soybeans are important in the diet of bobwhite (Korschgen 1948, Baumgartner et al. 1952, Robel 1969, Landers and Johnson 1976) in southern states and Oklahoma and are commonly planted in food plots as a management technique. The important roles of food plots and other previously mentioned management practices may also include improvement of habitat for escape, nesting, feeding, and brood-rearing; provision of areas of light ground cover and medium to sparse stem density that allow easy feeding and movment; and concentration of birds for harvest. However, all of these roles have not been thoroughly evaluated.

A knowledge of the value and effects of these frequently used management techniques is essential for most efficient use of funds. The objectives of this study were to measure the bobwhite foods present in 2 natural and 4 manipulated habitats and the seasonal variation in these foods.

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METHODS

Study Area

The 2.59-km² study area is part of the 6,749-ha Canton Public Hunting Area, managed by the Oklahoma Department of Wildlife Conservation, located in Blaine County of northwestern Oklahoma. The area contains extensive plantings of crops and habitat improvements for wildlife and is characterized by extreme fluctuation of temperature, low irregular rainfall, high winds, a high rate of evaporation, late summer drouth, a growing season slightly over 200 days, hilly relief, and low fertility.

Tivoli soils predominate; these are deep sandy soils subject to severe wind erosion when vegetation is removed by overgrazing or cultivation. Grazing was not permitted on the study area. The upper 25 cm of soil is porous and rapidly permeable (Steers et al. 1963). The study area contained 2 natural (stabilized dunes and upland woods) and 4 man-altered habitats (thinned bottomland hardwood, old disked areas, recently disked areas, and mature food plots).

Stabilized dunes made up 50 percent of the study area; this habitat is common along the large rivers of the southern Great Plains. Herbaceous vegetation, a few shrubs and trees, and litter seldom appeared heavy enough to restrict movement or feeding of bobwhite. Areas void of plant litter or live vegetation occurred frequently on these dry sites, especially on south and west exposures and dune tops. Upland woods (3.8% of the area), the other habitat not altered by man, was limited to upland benches and dry sites. Major species were blackjack oak *(Quercus marilandica)* and American elm *(Ulmus americana)* and the crown closure of the overstory was almost complete. Ground litter was generally heavy; several centimeters of leaf litter covered the soil at most sample plots. Little or no herbaceous vegetation was present. Bobwhite presumably had difficulty finding food items in the litter and upper soil layer.

Bottomland forest, dominated by eastern cottonwood *(Populus deltoides)* and black willow *(Salix nigra)*, occupied 23.4 percent of the area. Bottomland soils were generally moist and rich in humus. Litter was several centimeters thick in some places, and foraging by bobwhite would be difficult in those spots. Most of this bottomland habitat had been altered when 50 percent of the overstory was removed with a bulldozer in 1970, primarily as a browse management measure for white-tailed deer *(Odocoileus virginianus)*. However, the overstory canopy rapidly closed and by 1972, when our studies began, the felled trees had produced litter that made germination and establishment of annuals more difficult.

Disked areas were sites managed as fire breaks, former food plots, or food plots in which the planting had not matured. Old disked areas, cultivated more than 1 year before our sampling, constituted 10.7 percent of the area. Vegetation was highly variable in species composition and plant density and these attributes were influenced by natural fertility of the site and by the time interval since disking. Stem density was usually medium and provided protection from predators and easy movement for bobwhite foraging in the light litter. Recently disked areas, cultivated less than 1 year before our sampling, made up 6.6 percent of the area. Vegetation and ground litter were generally sparse.

Mature food plots, areas planted to sorghum or wheat which had developed to maturity and had been planted no more than 1 year before sampling, occupied 5.5 percent of the

area. Ground litter and herbaceous cover were generally light. Mature food plots were considered ideal feeding habitat for bobwhite; they offered food, easy movement, and provided some protection from predators.

Field Procedure

From June 1972 through March 1973 we sampled seeds, arthropods, gastropods, and other animal life in the top 12 mm of soil; seeds to a height of 20 cm; and arthropods between the soil surface and a height of 38 cm. Some food items in the top 12 mm of soil may not be available to bobwhite, although in sandy soils bobwhite are probably able to scratch down at least that far in habitats lacking heavy leaf litter. Likewise, not all of the arthropods would be accessible at a given moment because bobwhite usually feed only to a height of 20 cm above the ground surface (Rosene 1969:106), however, many of these insects probably spend a part of each day within the feeding range of bobwhite.

We intended to sample monthly from June 1972 through May 1973, but flooding prevented sampling in April and May, 1973. There was no habitat map of the study area available and, because of the complex mixture of habitats, no attempt was made to stratify sampling of habitat types. Sampling locations were randomly selected throughout the study area.

A standard 38-cm diameter sweep net was used to sample arthropods on vegetation. Twenty-five sweeps were made in each sampling unit; 182 units were sampled during the study. The surface area sampled at each site was about 11.6 m^2.

A pipe 21.6 cm long with a 7.6-cm inside diameter was used to collect the soil-litter-vegetation core samples. At each sampling point the pipe was lowered over vegetation and forced 12 mm into the soil. Vegetation protruding above the sampler was cut off and discarded. A shovel was pushed beneath the sampler to aid removal of soil, litter, and vegetation. From each core sample we were able to determine seeds present on vegetation to a height of 20 cm, and quantities of seeds, arthropods, and gastropods within the soil and litter. Eight soil-litter-vegetation cores were taken at each plot location, as recommended by Ripley and Perkins (1965), and the combined contents treated as 1 "sample". Thirty samples per month were all that could be analyzed in the available time, thus we had that number as our monthly goal. The area sampled at each plot was 364.7 cm^2. Further details of the methods used are described by Tobler (1973).

Laboratory Procedure

Soil samples were dried enough to allow them to pass through a series of sieves with openings of 5, 3, 2, 1.5, and 1 mm. Unsound seeds and material that passed through the 1-mm screen were discarded; seeds with diameters less than 1 mm are rarely eaten by bobwhite except in trace amounts. All other seeds were identified and weighed.

Generally, only a few foods make up the bulk of the bobwhites' diet. We considered as "principal" bobwhite plant food those seeds reported consumed frequently by bobwhite in northwestern Oklahoma (Baumgartner 1945, Baumgartner et al. 1952, Hanson 1957). In each of the latter studies, seeds of 5 species made up 61 to 85 percent volume of the food consumed. Our research approach, which measured arthropods and only "principal" seed foods, provided what we believe is a conservative but accurate comparison of bobwhite foods seasonally present in six habitats.

Species termed "principal" seed foods and included in analyses of our samples were redroot amaranth *(Amaranthus retroflexus)*, western ragweed *(Ambrosia psilostachya)*, giant ragweed *(Ambrosia trifida)*, wollybucket bumelia *(Bumelia lanuginosa)*, partridgepea senna *(Cassia fasciculata)*, rough sumpweed *(Iva cilata)*, sunflowers *(Helianthus* spp.), panic grasses *(Panicum* spp.), thin paspalum *(Paspalum setaceum)*, sorghum, wildbean (*Strophostyles* spp.), and wheat. The bulletin by Scott and Wasser (1980) was used as a standard for common and scientific names of plant seeds.

Data Analysis

Samples were pooled because of high variability and analyzed by habitat and season (summer, June-August; fall, September-November; winter, December-February; spring, March-May). Data were analyzed with a simple 1-way analysis of variance and an F test (Snedecor and Cochran 1971) because a 2-way analysis of variance is difficult when data cell sizes are unequal. If the F test indicated significant differences, the means were ranked and Duncan's Multiple Range Test was used to identify means that were different (Steel and Torrie 1960). Tests were considered significant at the 95 percent confidence level.

RESULTS

Principal Seeds Important As Bobwhite Foods

Soil vegetation cores (2,320) were taken at 290 sample sites. Principal seeds eaten by bobwhite accounted for 21 percent of the weight of all seeds found in the samples. Other seeds might furnish additional food, but the bulk of the bobwhites' diet probably consists of the species previously listed that are known to be principal foods in this region. The average seasonal abundance of these seeds ranged from 1.2 kg/ha (1.1 lb/acre) in upland woods in winter to 137.5 kg/ha (122.5 lb/acre) in mature food plots in fall (Table 1).

Significant differences between habitats occurred only during summer and fall when Duncan's Test indicated that the biomass of seeds was greater ($P < 0.05$) in mature food plots than in any other habitat. Sorghum and wheat provided 70.4 percent of the weight of all seeds found in these food plots in summer and fall. In winter, stabilized dunes and old disked areas contained the greatest biomass of principal seed foods.

Among all habitats, seasonal differences in seed biomass were significant only in mature food plots where, between fall and winter, seeds of cultivated species had been depleted by utilization and deterioration. Thus, food plots were a less important source of foods for bobwhites when supplies were low in winter because crops matured too early and their seeds deteriorated rapidly. Seeds from native plants are relatively abundant during fall and the need for seeds of cultured plants then is not as great as in winter. However, if food supplies are limiting bobwhite populations, then use of food plots during fall theoretically means that additional seeds of native plants would be available for winter use. The problem of seed deterioration exemplifies the need to plant in food plots those species having seeds that mature late (when native food supplies are low), persist on the plant, and deteriorate slowly (Preacher 1979).

Exclusive of food plots, stabilized dunes have the greatest amount of principal bobwhite seeds present (Table 1). More samples were taken in stabilized dunes than in any other type of habitat; therefore, their seasonal means should most accurately illustrate seasonal changes in food availability. Seed supply was lowest in summer, but increased by more than 100 percent during fall as seeds matured and dropped to the ground. The supply remained high in winter, but utilization and deterioration caused a 40 percent decrease by spring.

Native foods such as western ragweed, sumpweed, and panic grasses were found in quantity in all seasons, including spring and summer when food supplies were at their lowest. Although mature food plots contained 24 percent of the total weight of all principal seeds, produced on only 5.5 percent of the area, the poor seasonal distribution of these foods may have decreased their importance to bobwhite.

Seeds of panic grasses, ragweeds, thin paspalum, and wildbean are cosmopolitan in distribution; each occurred in all 6 habitats. A small amount of sorghum was the only cultured seed available in food plots in winter (Table 2). Native plants (redroot amaranth, ragweeds, panic grasses, and wildbean) that volunteered in food plots produced a surprising percentage of the total seed weight (42% in fall and 98% in winter). Ragweeds, rough

Table 1. Biomass of principal bobwhite foods found in 6 habitats, Canton Public Hunting Area, Oklahoma, 1972-73.

Habitats	Weight + SE and (sample size)				
	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Annual average
"Principal" seeds (kg/ha)[1]					
Stabilized dunes	8.1± 1.8(31)	17.9± 5.5(53)	18.7±4.6(41)	11.4±4.6(20)	15.1(145)
Bottomland forest	3.7± 0.9(27)	8.0± 4.5(12)	8.5±2.2(24)	9.3±5.7(5)	6.6(68)
Old disked areas	8.5± 3.3(8)	7.8± 2.5(11)	15.5±7.0(8)	3.6±1.9(4)	9.4(31)
Recently disked areas	3.6± 2.1(5)	7.1± 2.6(7)	4.1±1.1(6)	8.6(1)	7.3(19)
Mature food plots	53.6±15.7(7)	137.5±44.3(4)	7.2±3.4(5)	N.D.[2]	60.1(16)
Upland woods	1.5± 1.5(2)	5.4± 3.2(3)	1.2±0.8(6)	N.D.	2.4(11)
Ground-dwelling invertebrates (kg/ha)					
Stabilized dunes	1.9± 0.6(31)	0.9± 0.3(53)	0.7±0.2(41)	2.9±0.8(20)	1.3(145)
Bottomland forest	3.2± 0.9(27)	2.6± 1.1(12)	1.5±0.5(24)	2.7±2.2(5)	2.5(68)
Old disked areas	3.0± 1.1(8)	2.0± 0.6(11)	1.4±0.9(8)	1.0±1.0(4)	2.0(31)
Recently disked areas	0.0(5)	0.2± 0.2(7)	0.7±0.7(6)	0.0(1)	0.3(19)
Mature food plots	< 0.1(7)	< 0.1(4)	0.0(5)	N.D.	0.0(16)
Upland woods	1.3± 1.2(2)	0.0(3)	1.3±0.8(6)	N.D.	1.0(11)

Table 1. Cont.

Habitats	Weight + SE and (sample size)				
	Summer 1972	Fall 1972	Winter 1972-73	Spring 1973	Annual average
Plant-dwelling arthropods (g/ha)					
Stabilized dunes	82.0±13.3(30)	62.4± 6.4(48)	0.3±0.2(14)	N.D.	59.4(92)
Bottomland forest	44.1±20.5(27)	64.6±29.5(10)	0.5±0.2(7)	N.D.	41.7(44)
Old disked areas	83.9±32.3(7)	58.5±14.9(10)	0.6±0.3(3)	N.D.	58.7(20)
Recently disked areas	27.7±16.9(5)	49.9±31.6(3)	0.0(3)	N.D.	26.2(11)
Mature food plots	52.0±45.7(4)	39.8±14.3(3)	0.0(1)	N.D.	40.9(8)
Upland woods	54.9±16.7(2)	35.3± 1.3(3)	0.0(2)	N.D.	30.8(7)

[1]kg/ha is equivalent to 0.89 lb/acre.

[2]N.D. indicates no data. Winter sweep-net samples only from December when temperatures were still high enough so that arthropods were available for sampling. Preliminary sweep-net samples in March indicated arthropod populations were still too low to justify further sampling. Flooding of study area in April and May prevented further sampling in much of the study area.

Table 2. Principal bobwhite plant foods (kg/ha)[1] found in 6 habitats, Canton Public Hunting Area, Oklahoma, 1972-73.

Habitat and species	Summer	Fall	Winter	Spring
Mature food plots				
Amaranthus retroflexus	0.4	2.9	3.0	
Ambrosia spp.	1.1		1.5	
Iva cilata	0.8			
Panicum spp.	1.4	55.1	0.4	
Paspalum setaceum	1.7	0.1		
Sorghum		62.0	0.1	
Strophostyles spp.		0.1	2.0	
Wheat	48.2	16.7		
Upland woods				
Ambrosia spp.		1.1	0.4	
Iva cilata	0.5	4.1	0.1	
Panicum spp.		0.2	0.5	
Strophostyles spp.	1.0			
Stabilized dune				
Amaranthus retroflexus	0.2	0.2	0.8	
Ambrosia spp.	2.9	4.5	5.6	4.0
Bumelia lanuginosa		0.4	1.7	
Cassia fasciculata			1.7	
Iva cilata	0.2	5.5	1.6	1.3
Panicum spp.	2.3	4.3	5.6	6.0
Paspalum setaceum	1.5	2.5	3.3	0.2
Strophostyles spp.	0.9	0.3		
Bottomland forest				
Ambrosia spp.	2.5	3.2	4.1	8.5
Cassia fasciculata		2.5	1.9	
Iva cilata	0.1		0.1	0.7
Helianthus petiolaris		0.1		
Panicum spp.	0.4	0.5	0.6	
Paspalum setaceum	0.1	1.8	0.1	
Strophostyles spp.	0.3		1.1	
Wheat	0.4			

Table 2. Cont.

Habitat and species	Summer	Fall	Winter	Spring
Old disked area				
Amaranthus retroflexus	0.1	0.1		
Ambrosia spp.	4.1	3.0	2.1	0.3
Cassia fasciculata		0.2	1.6	0.4
Panicum spp.	3.9	3.7	12.1	1.3
Paspalum setaceum	0.4	0.7		0.3
Strophostyles spp.				1.4
Recently disked area				
Amaranthus retroflexus	0.2	0.6	0.4	
Ambrosia spp.	0.8	0.2	0.8	0.5
Cassia fasciculata		2.8	0.3	
Iva cilata		0.1	0.1	
Helianthus spp.				0.9
Panicum spp.	0.1	0.1	1.6	7.0
Paspalum setaceum	0.5		0.8	0.1
Strophostyles spp.	2.0	3.4		

[1]Values 0.1 kg/ha not included in table.

sumpweed, panic grasses, and thin paspalum were quantitatively the "principal" seeds in stabilized dune habitat. Ragweeds and partridgepea senna were common in bottomland forest; the same two species plus panic grasses and wildbean were prevalent seeds in recent and old disked areas. Although we can discuss quantitative differences between the habitats, data are lacking to indicate qualitative aspects of seed species, mainly deterioration rates and differences in metabolizable energy as Robel et al. (1979) discussed for some bobwhite foods in Kansas.

Soil Invertebrates

Animal foods commonly eaten by bobwhite made up 45 percent of the total ground-dwelling invertebrates found in soil cores. The average amount of animal life available in habitats at various seasons ranged from 0 to 3.2 kg/ha (Table 1). No differences $P > 0.05$) existed between habitats during any season. As expected, samples from bottomland forest contained the largest population of ground-dwelling invertebrates important as quail food; the habitat's moist soil and high organic matter content appeared to provide the best environment for such animal life. However, some of these foods might be unavailable to quail because of the depth of leaf litter in the habitat.

Seasonal differences ($P < 0.05$) were found in stabilized dunes, but due to high standard error, Duncan's Test could not be used to pick out differences. Invertebrate populations in food plots were highest in spring (2.9 kg/ha) and 2nd-highest in summer.

Mature food plots and recently disked areas contained few ground-dwelling invertebrates important as bobwhite food. The limited ground cover on these types presumably permitted extremes of soil temperature and low soil moisture conditions and, consequently, these habitats provided an inhospitable environment for invertebrate life. Also, we measured standing crops rather than total biomass produced, thus the lower invertebrate populations may be partially a consequence of frequent feeding by bobwhite and other species in habitats where light soils and sparse litter cover permit greater ease of feeding than in other habitats, e.g., bottomland forest.

Plant-dwelling Arthropods

One hundred and eighty-two sweep-net samples were taken. Arthropods important as bobwhite foods accounted for 92 percent of the weight of all arthropods. Seasonal habitat means ranged from 0 in several habitats during winter to 83.9 g/ha during summer in old disked strips (Table 1). Significant differences were not found between habitats in any season.

There were seasonal differences ($P < 0.05$) in 2 habitats; the winter averages in stabilized dunes and in upland woods were significantly different from those of summer and fall. Stabilized dunes and old disked areas supported the largest annual average weight of plant-dwelling arthropods per hectare. Few plant-dwelling arthropods were available as food in any habitat in winter.

During summer, Coleoptera and Orthoptera made up most of the arthropod biomass except in upland woods where Arachnida were more important. Hemiptera were the most important arthropod found in fall in all habitats except upland woods. Only Hymenoptera, Diptera, and Homoptera were found during winter.

DISCUSSION

Few studies have compared bobwhite foods in various habitats, perhaps due to problems associated with extremely high variation among samples, the difficulty of interpreting data, and the tedious, time-consuming work that is involved. We are aware of 7 such studies (Baumgras 1943, Bishop and Spinner 1946, Haugen and Fitch 1955, Bookhout 1958, Korschgen 1958, Ripley and Perkins 1965, Robel and Slade 1965) but none of them sampled invertebrates. They also sampled seeds either of only a few species or only a portion of the total seeds available (e.g., only those still on plants) or did not summarize data as a biomass per unit area. These studies are not similar enough to our research approach or to our habitats to permit meaningful comparisons with our data. Only 2 of the above mentioned studies included statistical testing, without which interpretation of the results is difficult.

Duck (1943) noted that bobwhite in northwestern Oklahoma preferred stabilized dune habitat in winter. Our studies illustrate the year-round and, especially, winter importance of stabilized dunes as a source of bobwhite food (Fig. 1). Irregularity of the terrain encourages within the dune habitat a diversity of species and microhabitats, much edge, and good juxtaposition, all aspects of good bobwhite habitat. Periodic drouth keeps the dune habitat in early successional stages that are ideal for bobwhite but foods are probably scarce in drouth years. The dunes are already excellent bobwhite habitat when moisture is adequate and should not be disked or developed as food plots.

Upland woods can be a rather unproductive habitat in winter. During our study, the acorn crop was poor even though oak mast was 41 and 12 percent during fall and winter, respectively, of the weight of all bobwhite foods in upland woods. Good mast crops are irregular in this habitat. If the manager desires to support a stable bobwhite population where this blackjack oak forest is dense and in large unbroken tracts, the trees should be thinned to improve mast production and interspersed with habitat, e.g., food plots and old disked areas, that contains alternative food supplies.

Resource management agencies, in this time of escalating inflation and fossil fuel shortages, are reevaluating practices that are costly or require considerable use of fuels. The most fuel-expensive management practice depicted in Fig. 1 is the food plot which requires annual planting. Note that the old disked areas, altered more than 1 year before our sampling, contained more food in winter than the food plots and were also a good source of food in summer. Some of the old disked areas were food plots that had not been planted or plowed in the previous 12 months. Based on food present, then, a logical way to save fuel and other expenses would be to plant food plots on alternate years or, perhaps,

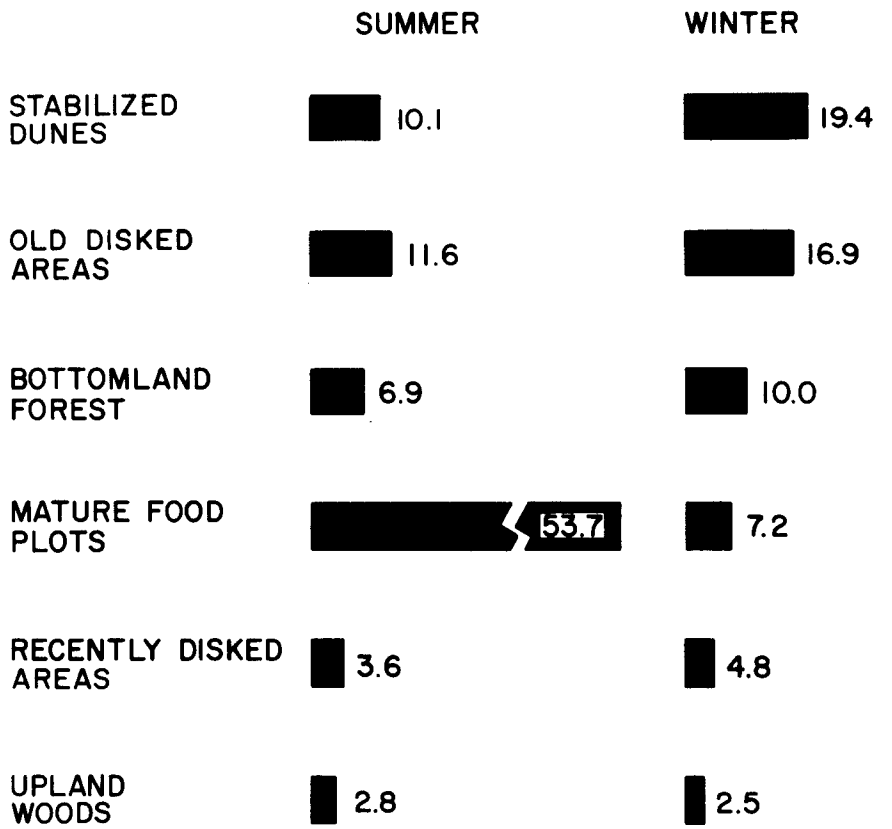

Fig. 1. Average summer and winter biomass (kg/ha) of principal bobwhite food (seeds, ground surface-dwelling invertebrates, and plant-dwelling arthropods) found in 6 habitats of northwestern Oklahoma.

every 3rd year. Food productivity for quail remains high the 2nd year and perhaps longer after a food plot is planted.

Another alternative would be to omit the planting of food plots and simply disk the area every few years, thereby allowing native food plants to reseed in the manner of old disked areas. These old disked areas contain more winter foods than the food plots. However, in dry years wild seed production may be almost nonexistent. The drouth will also affect cultured crops, but not always to the same extent, depending on the time of maturity of the species involved and the distribution of the small amount of rainfall occurring.

Another point is that disked fire lanes, when not disturbed annually, were rich in bobwhite food and did not require the planting costs of food plots. Native plant seeds also tended to be more persistent and to deteriorate slower than seeds of domestic plants; this may partially explain the food biomass difference noted between old disked strips and food plots in winter.

Lastly, litter accumulations interfere with bobwhite feeding in upland woods and, to a lesser degree, in bottomland forest. Controlled burning in late winter, with a fire hot enough to remove litter but not harm the trees, should improve availability of seeds and

insects for bobwhite and probably would stimulate understory growth of seed-producing legumes.

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