1977

Production and Utilization of Sunflower Food Plots at Shelbyville Wildlife Management Area, Illinois

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PRODUCTION AND UTILIZATION OF SUNFLOWER FOOD PLOTS AT SHELBYVILLE WILDLIFE MANAGEMENT AREA, ILLINOIS

(TITLE)

BY

Duane T. Dust

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1977
YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
THIS PART OF THE GRADUATE DEGREE CITED ABOVE

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PRODUCTION AND UTILIZATION OF SUNFLOWER FOOD PLOTS AT SHELBYVILLE WILDLIFE MANAGEMENT AREA, ILLINOIS

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a candidate for the degree of Master of Science and hereby certify that in their opinion it is acceptable.

PRODUCTION AND UTILIZATION OF FOOD PLOTS AT SHELBYVILLE WILDLIFE MANAGEMENT AREA, ILLINOIS

BY

Duane Thomas Dust

B. S., Eastern Illinois University, 1976

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirements for the degree of Master of Science at the Graduate School of Eastern Illinois University

CHARLESTON, ILLINOIS 1977

Abstract: Three sunflower (Helianthus annuus) fields from 3.2 ha to 1.0 ha in size, planted on the Shelbyville Wildlife Management Area, Illinois were analyzed for seed production and utilization by birds. Seed in heads and on the ground were sampled and species and numbers of birds in the fields were censused at two week intervals from September, 1976 to February, 1977. Decline in seed availability was most rapid in the smallest field and least rapid in the largest field. Fields and portions of fields adjacent to wooded cover were also utilized more rapidly. American goldfinch (Spinus tristis) and red-winged blackbird (Agelaius phoeniceus) made up 68.2 percent of the birds counted in the fields, while the three gamebird species present - mourning dove (Zenaida macroura), ring-necked pheasant (Phasianus colchicus) and bobwhite (Colinus virginianus)- comprised 2.2 percent of the sightings.

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Beginning in 1973, sunflower fields have been planted annually on the Shelbyville Wildlife Management Area in Moultrie County, Illinois for the purpose of attracting mourning doves for hunters during the hunting season (from 1 September to 13 November in 1976). Planting of sunflower for the purpose of attracting mourning doves or supplying winter feed to other gamebirds is a recent practice in Illinois and to date, has not been evaluated.

The purpose of this study was to determine not only the extent to which doves were attracted to the fields, but the degree to which

these plantings were utilized by other game and nongame birds and the duration that these fields can be depended on as a winter food source for wildlife.

Various millets (Panicum spp.) are the most popular crops planted as dove attractants (McCartney 1964), and Robinson (1972) demonstrated that of these, proso millet (Panicum miliaceum) is the most heavily utilized by doves. Davison and Sullivan (1963) demonstrated that sunflower as well as the millets are preferred foods of wild doves.

Martin et al. (1951) reported that sunflowers were an important wildlife food source, especilly in the Great Plains states. Sunflowers were found to comprise five to ten percent of the diets of doves and bobwhites and two to five percent of the diet of ring-necked pheasants. Over 30 species of songbirds were listed as feeding on sunflower seeds, the most important being blackbirds and fringillids. Small rodents were also listed as consuming sunflower seeds. Food habits studies carried out in the western states of Oklahoma (Carpenter 1971), Texas (Dillon 1961) and eastern Colorado (Ward 1964) indicate that sunflower is an important component in the diets of doves, especially in fall and early winter. This is also the time of greatest sunflower seed availability in Kansas (Robel and Slade 1965). Sunflower is not as abundant farther east (Martin et al. 1951) as evidenced by the almost total lack of sunflower in the diets of doves from Missouri (Chambers 1963, Korschgen 1958), Iowa (McClure 1943) and Illinois (Hanson and Kossack 1957, 1963).

Sunflower is almost nonexistent in the diets of Illinois bobwhite (Barnes and Klimstra 1964, Bookhout 1958, Larimer 1960), but is important for bobwhite in Kansas, even when they are shown to

simultaneously rely heavily on plantings of other grains (Robel 1969). Robel et al. (1974) suggested that bobwhite habitat be altered to make available high energy foods such as sunflower.

The ring-necked pheasant is known to feed heavily on agricultural grains (Drake 1937, Martin et al. 1951). McClure (1948) found that prairie sunflower (Helianthus petiolaris) was the most important winter food of pheasants in Nebraska, although it was also heavily utilized by red-winged blackbirds and American goldfinches.

Sincere appreciation is extended to my advisor, L. B. Hunt, for technical advice during the study and advice and assistance in the preparation of the manuscript. The support and advice of R. Cottingham, of the Illinois Department of Conservation is also gratefully acknowledged. I would like to thank R. D. Andrews, M. A. Goodrich and J. E. Ebinger for their critical review of the manuscript. Special gratitude is extended to Barbara Stanger for her support, advice and assistance in the field.

STUDY AREA

The study area consisted of three sunflower fields located in the Kaskaskia River Fish and Wildlife Management Area, a part of the Shelbyville Wildlife Management Area in Moultrie County, Illinois, about 16 km (10 miles) northwest of Mattoon, Illinois.

All fields were planted on 15 May 1976 and mowing (with a bushhog) of some portion of each field was completed on 27 August 1976. Arrowhead was the variety of seed used in the plantings by the Illinois Department of Conservation. This is a low oil seed (30%) and is used commercially as a bird seed. Information on seed variety, yield, planting rate and other general information concerning sunflowers as a

cash crop was outlined in a report compiled by Larry Casey, Cooperative Extension Service of the University of Illinois. Row width was 36 inches and seedling survival rate was about 3.4 plants per foot. The total planting, fertilizer and herbicide costs were $143 per hectare ($58 per acre) according to Robert Cottingham (personal communication).

Field A (section 20, T13N, R6E) covered 3.2 ha (7.8 acres) and was the largest field studied. The outside seven rows were cut after seed maturity and a V-shaped swath cut through the center of the field (Fig. 1). The habitat adjacent to the field varied. It was bordered by an unharvested wheat field (Triticum aestivum), a narrow fencerow of multiflora rose (Rosa multiflora), brambles (Rubus spp.), grape (Vitis spp.), milkweed (Asclepias spp.), goldenrod (Solidago spp.) and woody shrubs, and also by an extensive area of old field consisting of goldenrod, multiflora rose, giant ragweed (Ambrosia trifida), common ragweed (A. artemisiifolia), other annual and perennial weeds and grasses and scattered young trees such as osage orange (Maclura pomifera), shingle oak (Quercus imbricaria)and hawthorn (Crataegus spp.).

Field B (section 16, T13N, R6E) at 1.3 ha (3.1 acres) was the second largest field studied. The field was roughly rectangular in shape and the seven outermost rows of the field were cut. The adjacent habitat was not as varied as field A (Fig. 1). The north and west borders were oldfield of annual and perennial weeds, primarily aster (Aster spp.), common ragweed, goldenrod, evening primrose (Oenothera biennis) and various grasses. The south and west sides were bordered by trees, primarily shingle oak, slippery elm (Ulmus rubra), honey locust (Gleditsia triacanthos) and silver maple (Acer saccharinum).

Field C (section 17, T13N, R6E) was the smallest of the three fields studied (1.0 ha, 2.4 acres) and also had the greatest degree

of mowing evident (Fig. 1). The perimeter of seven rows was cut identically to the other two, but in this field, standing strips of three to seven rows were separated from each other by two mowed rows. In effect, little over half of the field was left standing. Field C was enclosed entirely by woody vegetation, primarily shingle oak, honey locust, white oak (Quercus alba) and sassafras (Sassafras albidum).

MATERIALS AND METHODS

Prior to vegetative sampling, average diameter of seed heads was measured from 50 samples from each field. Row width and plant density were also determined.

Vegetative sampling and bird censusing were carried out at 11 to 16 day intervals (Between 15 September 1976 and 4 February 1977 for vegetative sampling and 23 September 1976 and 4 February 1977 for bird censusing). Inclement weather postponed some sampling trips and often after a rain a wait of two to three days was required to allow the fields to dry sufficiently to permit accurate sampling.

Samples of seed on the ground were taken with a 30-inch-square (0.76 meter) wooden quadrat. When removing samples, a predetermined number of steps were paced off along the side of the field and the first quadrat was collected at this point. The outside quadrats were always in the mowed strips. If seed heads had fallen in the quadrat, these were collected and the remaining scattered seeds were scraped off with a thin layer of soil and placed in a plastic bag with a label denoting point and date of collection. If there were few seeds in the quadrat, they were removed individually with a forceps. The remaining sampling quadrats were arranged at regular intervals (10 to 15 rows apart) perpendicular to the field edge. When sampling in the field

with standing heads, the quadrat was placed between the rows and four heads above the quadrat nearest to the investigator were removed and placed in a properly labeled plastic bag. When snow cover was present, quadrats of ground samples were dispensed with and only heads on standing plants were collected.

Seeds from ground samples or seed heads were separated from debris using two screens, one with a 3.2 mm (0.125 in) opening and the other with a 6.4 mm (0.25 in) opening. Chaff was separated from the seeds by the use of an air jet, or more efficiently, blown free with exhaled breath. All seeds were dried at 80°C (176°F) for 48 hours before weighing.

Censusing of bird populations was begun 30 to 45 minutes after sunrise, presumably during the major activity period of most seed-eating birds. The birds were identified to speecies and recorded in one of two ways. Birds flushed out of the fields proper were recorded separately form birds sighted in vegetation within eight meters (25 ft) of the field.

Crops of doves were also collected on 1 September from hunters who shot over the sunflower fields. Crops that were shot open with some contents lost or otherwise damaged were examined only for presence or absence of sunflower seeds. Intact crops were preserved in a solution of five percent formalin. Percent volume of sunflower seeds was determined by flotation in water in a graduated cylinder. Seeds were identified by comparison with seeds in the collection of R. D. Andrews (Zoology Dept., Eastern Illinois University) and seed drawings (Reg. Tech. Proj. NC-10, 1954).

All nomenclature for plant species follows Jones (1963) and for bird species follows American Ornithologists' Union (1957, with supplements).

RESULTS

In all fields, three measurements were taken of the seed resource- seed in heads, seed on the ground in mowed strips and seed on the ground under standing heads. Mean diameter of the seed heads varied with each field. The mean diameter of seed heads from field A was 10.3 cm, from field B- 10.7 cm, and from field C- 7.7 cm.

Seed on the ground under standing heads was passively dropped from heads and constituted an almost negligible fraction of the total standing crop. Seed on the ground in the mowed strips underwent an initial rapid decline in all fields (Figs. 2,3 and 4). In fields A and B the decline slowed during November and December until prolonged snow cover eventually forced termination of this segment of the investigation.

Weight of seed in heads was found to decline through fall and winter in all fields (Figs. 2,3 and 4). Field C, the smallest field, showed the most rapid drop in seed abundance with only 15 kg per ha of seed remaining by 27 November. Field B shows a similar, but slower decline in seed abundance. In field A, the largest field, the seed supply remained almost intact until 27 November. As late as 6 January, field A had as much seed in heads as field B and C had two and three months earlier (Figs. 2,3 and 4).

The presence of woody cover adjacent to a field was found to affect the rate of seed utilization. The decline in seed abundance in field B was found to be more rapid in the east half of the field adjacent to the woods and less rapid in the west half next to the oldfield (Fig. 5). Field C, with the greatest amount of adjacent woody vegetation, showed the most rapid decline in seed abundance, while the seed resource was intact longest in field A which was adjacent to

the least amount of woods (Fig. 2). There seemed to be no noticeable pattern of consumption, other than more rapid utilization of fields or portions of fields nearest to wooded cover. There was no evidence that birds fed on the outside edges of the field before working into the interior portions of the fields.

Density of birds in all fields increased, then declined at approximately the same rate that the seed density declined (Figs. 2,3 and 4), although field A showed heavy utilization by birds in October, due to the presence of migrating flocks of red-winged blackbirds. As in the other fields, the eventual decline in bird density followed the drop in seed abundance (Fig. 2). Utilization of seeds, both on the ground and in the heads, was primarily by two families of songbirds, Fringillidae and Icteridae (Table 1). Two species of songbirds, the American goldfinch and the red-winged blackbird, comprised 68.2 percent of all birds observed in the fields (Table 1). Mourning doves, for which these fields were planted, made up 1.7 percent of the total sightings. Other gamebirds (ring-necked pheasant and bobwhite) were only rarely sighted.

The crop contents of 18 doves shot over the fields were examined and sunflower was found in greater volume than all other food items combined (Table 2).

Actual values for all data are compiled in appendices I through IV.

DISCUSSION

Seed on the ground in mowed strips constituted a large but variable portion of the food supply in the different fields. Cut portions constituted 16.7 percent of field A, 23.2 percent of field B 36.1 percent of field C. These fractions of the total seed crop were

the portions available to the gamebirds of the area (mourning dove, ring-necked pheasant and bobwhite) as none of these species were observed to feed on seed in standing heads. Weight of seed on the ground in field C dropped rapidly, probably as a result of two factors. Due to the smaller mean head diameter, field C had the least food resource of all the fields, which was utilized more rapidly by the birds present. The number of birds utilizing field C in September is believed to be much higher than is shown in Fig. 4. Censusing of field C on 23 September was carried out two hours later in the day than was usual, after the major feeding period. Also, it is possible that rodents may have fed in this field comparatively heavily, since field C, being smallest, had proportionately greater edge than the other two fields. Evidence of small rodents feeding on fallen heads was observed at fields A and B during periods of snow cover. Trends in abundance of seed on the ground were similar in fields A and B. Both fields show a rapid decline seed weight followed by a less rapid decline and leveling off in November and December (Figs. 2 and 3). The leveling off of seed density in the cut-over perimeter of field B is believed to be partially the result of the presence of seed unavailable to birds. The large heads of field B, when cut, often fell "face down" with the seeds intact in the head, hidden by the receptacle of the seed head. These seeds decomposed rapidly and were not utilized to any extent, although they were included in the sampling procedure. This phenomenon was also observed in field A. The last samples of seed in the mowed strips in field A yielded a figure of 393 kg per ha, almost double that for field B on the same date (Figs. 2 and 3). Assuming 190 kg per ha (23 December figure for field B) was unavailable as food,

approximately 200 kg of seed per ha in field A was still available as potential food. Snow cover protected this seed from consumption during January and early February. When fields A and B were visited on 18 March, roughly 250 red-winged blackbirds and American goldfinches were observed feeding field B.

The largest food resource of the sunflower fields was the seed in the heads, although this resource was unavailable to gamebirds. Weight of seed in heads declined similarly in fields B and C. Again, fields A and B initially had a larger standing crop than field C, and consequently the seed resources of these fields were utilized for a longer period of time. The weight of seed in heads for field A stayed almost constant through 23 December, then dropped drastically from 1398 kg per ha to 0.0 kg per ha by 4 February (Fig. 2). The first portion of this rapid decline in seed abundance was accompanied by a sudden increase in the number of bird sightings. As the seed supply continued to decrease to levels approaching zero, a decline in the numbers of birds followed. This pattern of a decrease in seed density followed by a decrease in bird density was repeated in fields B and C.

The explanations of these patterns of availability can be answered by an evaluation of the pattern of utilization by songbirds. Use of these fields was found to be increaed by close proximity to woody vegetation (planting guidelines followed by the Illinois Dept. of Conservation warn that songbird damage to a sunflower crop may result if fields are planted by woody areas). This habitat serves as resting or roosting cover for fringillids, house sparrows (Passer domesticus), and to a lesser extent, red-winged blackbirds. Field C was bordered on all sides by wooded cover (Fig.1) and showed the most rapid decline

in seed abundance (Fig. 4). Field B was bordered by wooded cover on the east and south sides (Fig. 1). Seed utilization was shown to be most rapid in the east one-half (bordered by trees) and less rapid in the west one-half (bordered by early oldfield). This may be due in part to roosting and resting cover present on the east side and also to the presence of a more preferred food supply west of the field. Hespenheide (1966) and Wilson (1971) found that finches prefer to feed on smaller seeds such as millet (and presumably common oldfield seeds such as aster, common ragweed and evening primrose) and rarely eat large sunflower seeds while smaller seeds are still available. Field C had smaller heads which resulted in smaller seeds. These were evidently more preferred by songbirds than the larger seeds of the other fields. Field A was adjacent to little woody cover (Fig. 1) and the seed density of this field remained relatively unchanged from September through December.

The sudden increase in numbers of birds in October (Fig. 2) was due primarily to migrating red-winged blackbird flocks (Table 1). The gradual increase in bird numbers through November and December was likely due to the use of sunflower seeds as an alternative food source. Field A was bordered by few trees (Fig. 1) and consequently the seed supply of surrounding area may have been exhausted before sunflower seeds were eaten in large quantities. Snow in early January also accelerated the increase in the number of birds utilizing the field by covering the remainder of the fringillids' normal food supply.

During the December to February period, it was apparent that a sedentary flock of 10 to 15 doves fed at field A daily although they were not sighted during every censusing trip (Table 1). Henessey and

van Camp (1963) found that wintering mourning dove flocks normally prefer to feed daily at a particular field and could find food through two inches of snow. Common crow (Corvus brachyrhynchos) and rusty blackbirds (Euphagus carolinus) were also found to feed in field A extensively during January and February. The eventual decline in bird numbers in all fields was probably due to dispersal as the seed abundance in the fields approached zero.

Sunflower seed is a high energy food, with a caloric content greater than that of most cultivated grains (Robel and Harper 1965) and common wild seeds (Kendeigh and West 1965). This would make sunflower an ideal winter food planting if it were not favored by small rodents (Michael and Beckwith 1955), flocking nongame birds (Davison 1961), and unreliable as a year-long food supply because of rapid deterioration (Davison 1961, Dillon 1961). Insect damage is common in wild sunflower (Dillon 1961) and also in cultivated varieties (Cooperative Extension Service of University of Illinois report). In this study, insect damage was found only im field C, evidenced by holes in the seed coat and larvae inside the seed. As a mourning dove attractant, sunflowers seem to be outstanding (Robert Cottingham, personal communication), although millets are most commonly planted in "dove fields" (McCartney 1964, Robinson 1972). This study shows that dove activity in the fields drops off during October, probably after most migrating doves have passed to the south of the study area.

MANAGEMENT IMPLICATIONS

The Illinois Department of Conservation planted these three sunflower fields, totaling 5.5 ha (13.3 acres) at a total cost of $670. This yielded approximately 9350 kg (20,620 lb) of seed. It is apparent from the data that at least 95 percent of this total was consumed by songbirds. Gamebirds are insignificant when considering the dynamics of sunflower plot utilization. This study shows that sunflower fields smaller than about 1.5 ha cannot be depended on as a winter food resource. Larger fields such as field A constitute a major winter food supply for songbirds, but are of little value to the upland gamebirds which feed only on fallen seed. Small, extensively mowed fields such as field C would appear to be more suitable for these species, although it is unlikely that the seed resource of these fields could be relied upon to last even to December. Large fields, with six to eight rows cut monthly during fall and winter may be valuable as a winter food supply for mourning dove, ring-necked pheasant and bobwhite, as well as wintering songbirds. It should be pointed out, however, that large fields remove substantial amounts of nesting and escape cover for wildlife.

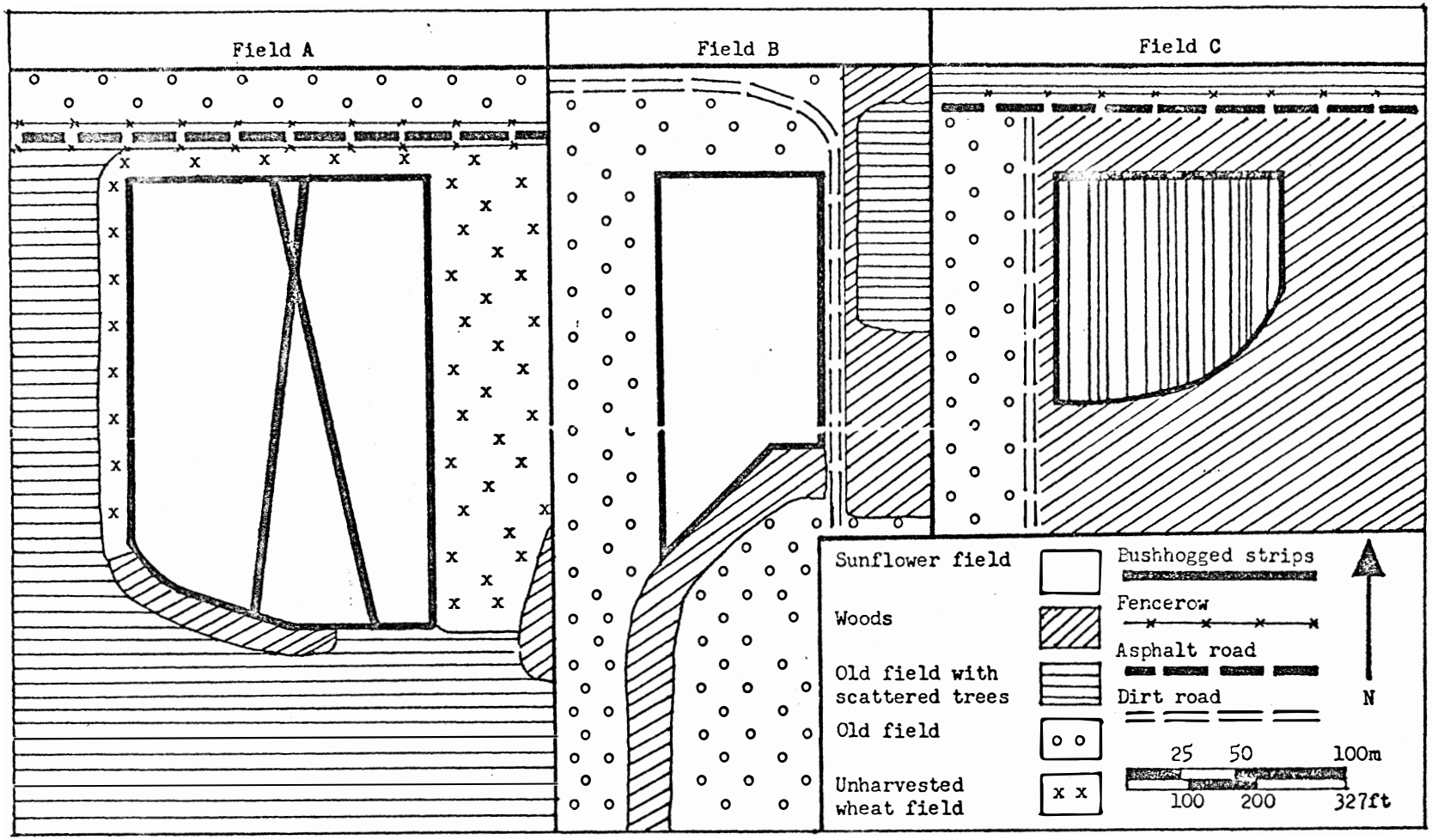

Fig. 1. Three study areas with adjacent habitat at Shelbyville Wildlife Management Area.

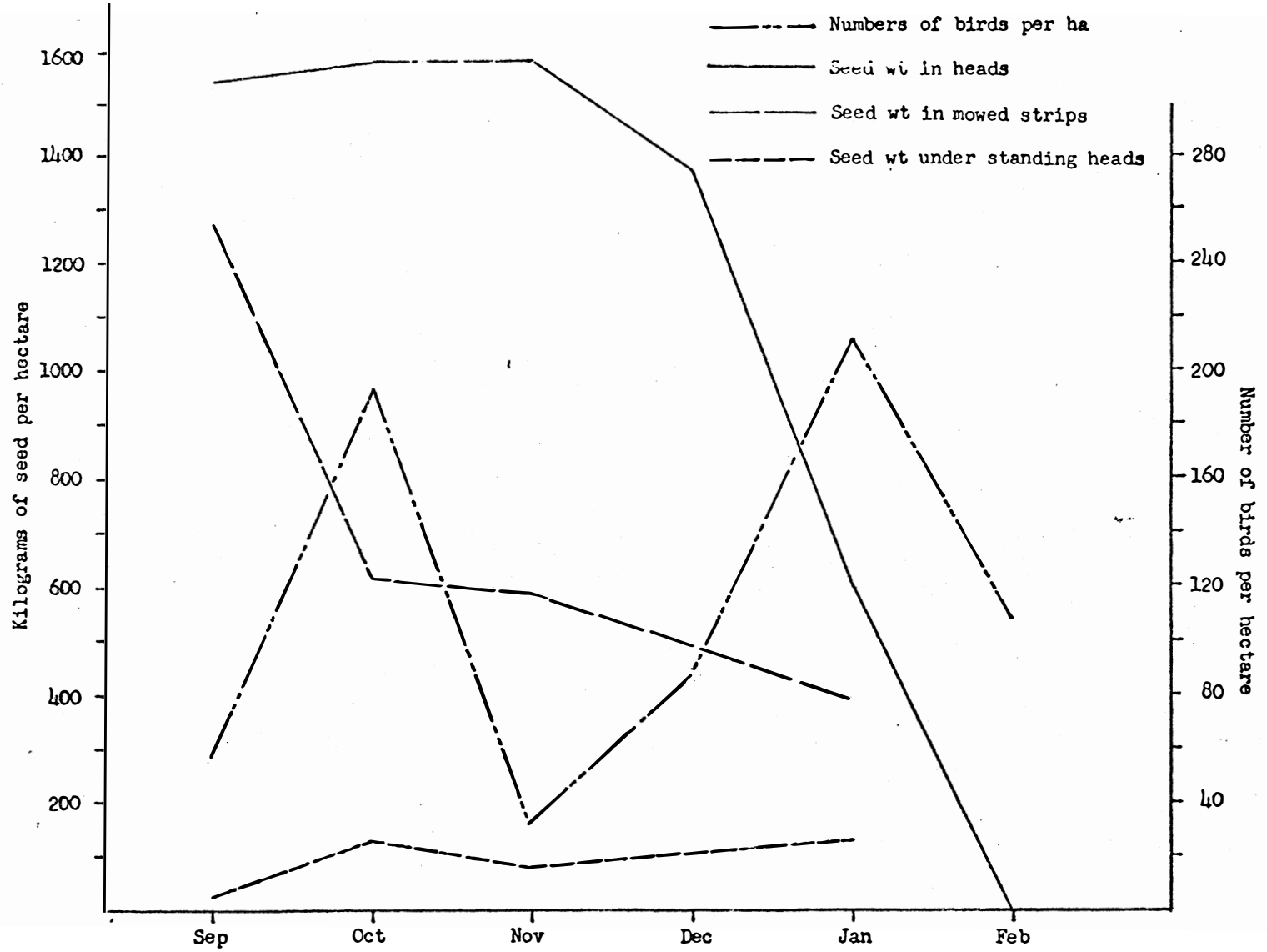

Fig. 2. Monthly changes in seed abundance and bird density for field A.

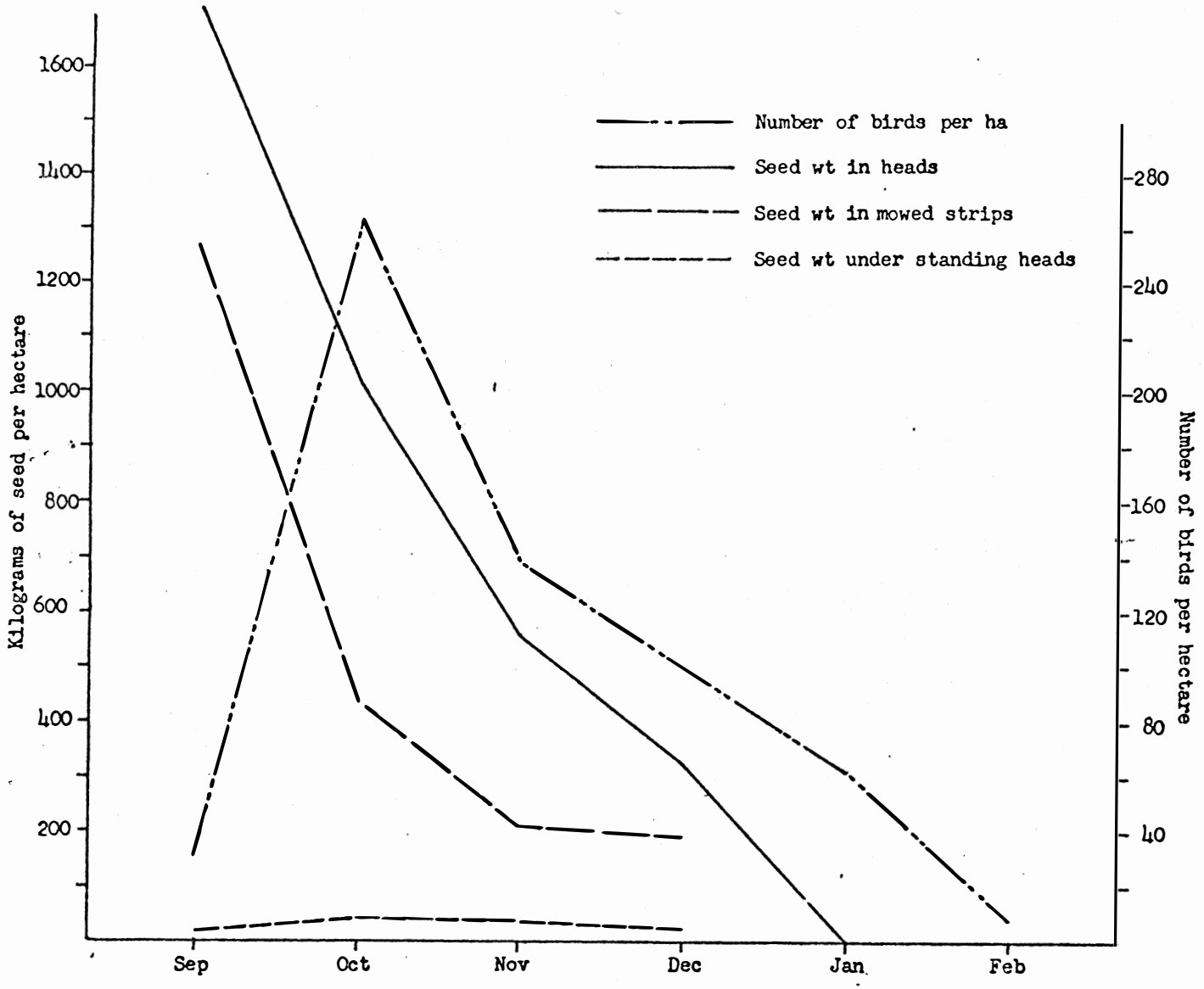

Fig. 3. Monthly changes in seed abundance and bird density for field B.

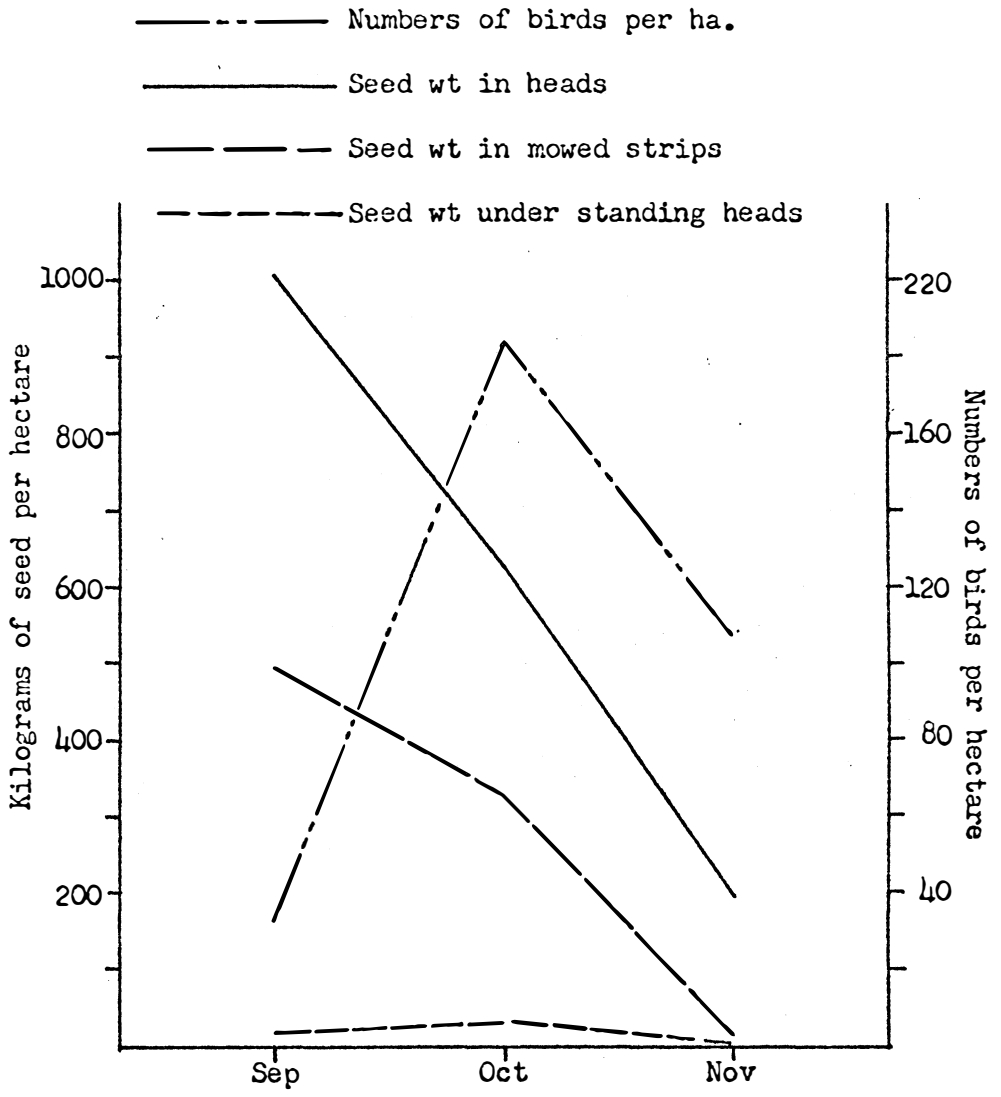

Fig. 4. Monthly changes in seed abundance and bird density for field C.

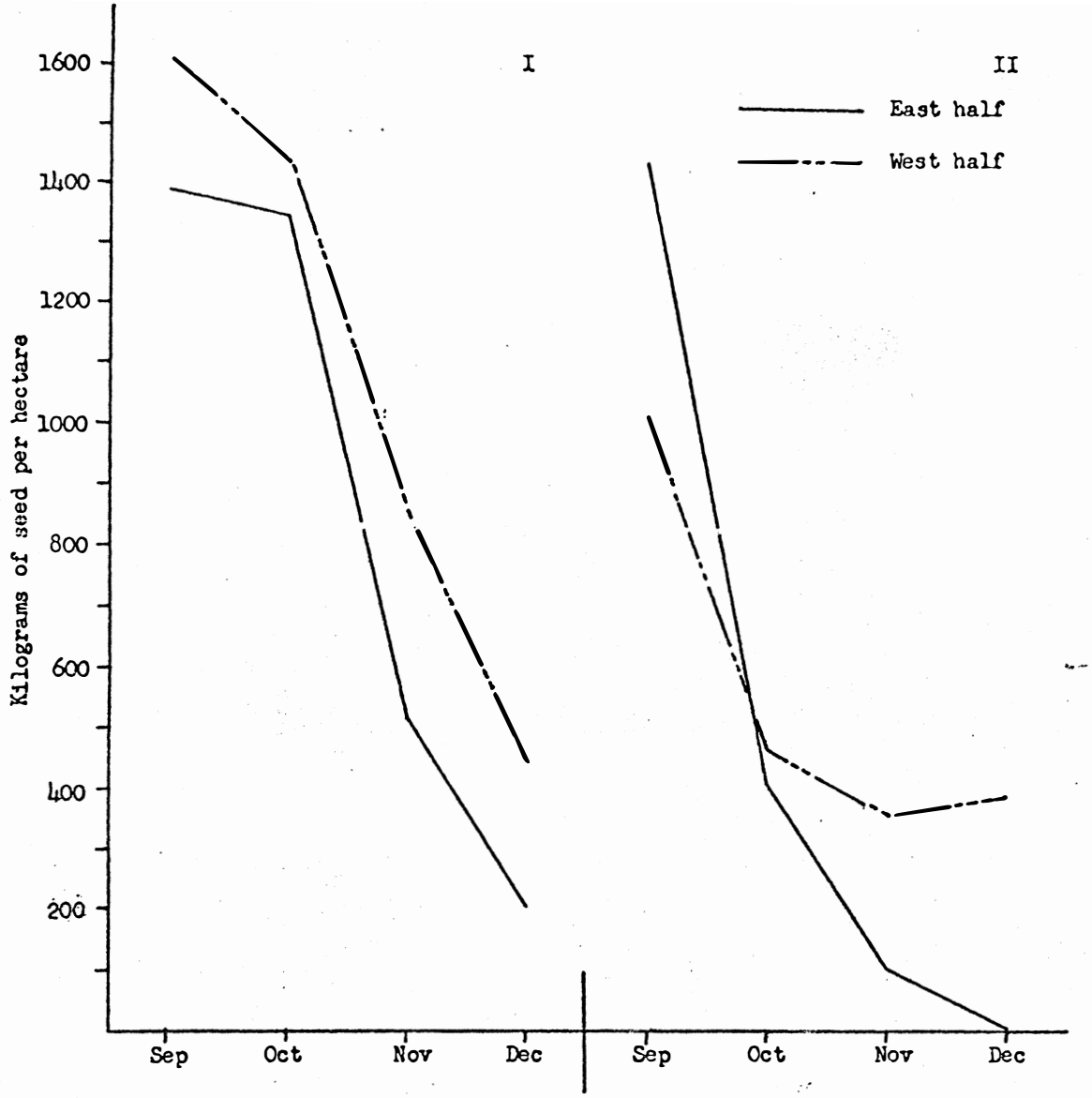

Fig. 5. Monthly changes in weight of seed in heads (I) and seed on the ground in bushhogged strips(II) in east and west halves of field B.

Table 1. Frequency of occurrence of bird species in or within eight meters of fields A-C, between 23 September 1976 and 4 February 1977.

Bird group	Censusing dates: 23 Sep	5 Oct	21 Oct	2 Nov	16 Nov	27 Nov	8 Dec	23 Dec	6 Jan	20 Jan	4 Feb	Total Numbers	% of Total
Fringillidae												2900	44.8
American goldfinch	155	65	312	277	169	160	57	220	270	451	48	2184	33.9
Dark-eyed junco			17	31	18	33	39	21	30	238	77	504	7.8
Tree sparrow			3		1	5	2	4	16	47	59	137	2.1
Other fringillids [a]	12	3	15	13		7	2	16	1	4	2	75	1.2
Icteridae												2429	37.7
Red-winged blackbird		1187	557	215	25		112	17		52	42	2207	34.3
Brewer's blackbird					150							150	2.3
Rusty blackbird					1			11	37	11	12	72	1.1
Ploceidae													
House sparrow	52		25	15	7	6	143	90	247	45		630	9.8
Corvidae												163	2.5
Common crow		6	4		2		3		8	16	115	154	2.4
Blue jay						3		1		4	1	9	0.1
Sturnidae													
Starling			50		25	6	8	45				134	2.1
Columbidae													
Mourning dove	37	8		1			34		17	14		111	1.7
Phasianidae												30	0.5
Bobwhite		9	11						2			22	0.4
Ring-necked pheasant		4		1				1	1		1	8	0.1
All others [b]	3	3		4	7	13			3	5	2	40	0.6
Totals	259	1285	994	557	405	233	400	426	632	887	359	6437	100.0

[a] Includes cardinal, indigo bunting, purple finch, field sparrow, white-crowned sparrow, white-throated sparrow, fox sparrow and song sparrow.

[b] Includes sharp-shinned hawk, marsh hawk, red-bellied woodpecker, downy woodpecker, tufted titmouse, chickadee spp. and Nashville warbler.

Table 2. Crop contents of 18 mourning doves shot over fields A and B on 1 September 1976

Food item	% volume
Sunflower (*Helianthus annuus*)	50.9
Foxtail (*Setaria* spp.)	44.0
Nodding spurge (*Euphorbia maculata*)	3.6
Wheat (*Triticum aestivum*)	1.5
Pokeweed (*Phytolacca americana*)	trace

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Append I. Kilograms of seed in heads per hectare, collected between 15 September 1976 and 4 February 1977 [a]

Sampling Date	Field A				Field B				Field C				Total, A-C			
	trip		monthly		trip		monthly		trip		monthly		trip		monthly	
	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)
15 Sep	1646	18			1782	20			1405	12			1611	50		
23 Sep	1439	16	1543	34	1637	8	1710	28	616	12	1011	24	1231	36	1421	86
5 Oct	1704	20			1134	16			968	12			1269	48		
21 Oct	1461	12	1583	32	903	16	1019	32	267	12	618	24	877	40	1073	88
2 Nov	1542	12			596	16			562	12			900	40		
16 Nov	1659	16			599	16			21	12			760	44		
27 Nov	1543	12	1581	40	489	20	561	52	15	12	199	36	682	44	781	128
8 Dec	1349	20			401	16			0 [b]		0 [b]		583	36		
23 Dec	1398	12	1374	32	228	20	315	36					542	32	563	68
6 Jan	868	20			0	20							289	40		
20 Jan	343	20	606	40	0		0	20					114	20	202	60
4 Feb	0	20	0	20									0	20	0	20

[a] Kilograms of seed in heads per hectare calculated by multiplying the mean weight of seed per plant by the estimated number of plants per hectare, 118,711.

[b] assumed to be 0.0 kg/ha.

Append IIA .Kilograms of seed on ground per hectare, collected between 15 September 1976 and 23 December 1976.[a]

Sampling Date	Field A								Field B							
	Quadrats in bushhogged strips				Quadrats under standing plants				Quadrats in bushhogged strips				Quadrats under standing plants			
	trip		monthly		trip		monthly		trip		monthly		trip		monthly	
	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)
15 Sep	1355	4			24	5			1551	2			19	5		
23 Sep	1193	4	1274	8	40	4	32	9	981	2	1266	4	13	5	17	10
5 Oct	412	3			77	5			308	2			4	2		
21 Oct	824	4	618	7	136	3	132	8	566	2	437	4	82	4	43	6
2 Nov	1129	3			110	3			459	2			52	4		
16 Nov	369	4			61	4			70	2			6	4		
27 Nov	288	2	595	9	75	3	82	10	116	2	215	6	58	4	39	16
8 Dec	snow cover								snow cover							
23 Dec	393	3	393	3	133	3	133	3	193	2	193	2	25	4	25	4
6 Jan	snow cover								snow cover							
20 Jan	snow cover								snow cover							
4 Feb	snow cover								snow cover							

[a] kilograms of seed on ground per hectare was calculated by multiplying the weight of seed in quadrats by the number of quadrats per hectare, 17,215.

Append IIB. Kilograms of seed on ground per hectare, collected between 15 September 1976 and 23 December 1976.

Sampling Date	Field C								Total, A-C							
	Quadrats in bushhogged strips				Quadrats under standing plants				Quadrats in bushhogged strips				Quadrats under standing plants			
	trip		monthly		trip		monthly		trip		monthly		trip		monthly	
	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)
15 Sep	582	3			10	3			1163	9			18	13		
23 Sep	413	3	498	6	18	3	14	6	862	9	1013	18	24	12	21	25
5 Oct	625	3			13	3			448	8			31	10		
21 Oct	41	3	333	6	49	3	31	6	478	9	463	17	106	10	69	10
2 Nov	27	3			9	3			538	8			57	10		
16 Nov	1	3			1	3			147	9			23	11		
27 Nov	17	3	15	9	2	3	6	9	140	7	275	24	45	10	42	31
8 Dec	snow cover								snow cover							
23 Dec	0.0 [a]		0.0 [a]		0.0 [a]		0.0 [a]		177	4	177	4	52	7	52	7
6 Jan									snow cover							
20 Jan									snow cover							
4 Feb									snow cover							

[a] assumed to be 0.0 kg/ha

Append III. Comparison of weight of seed in heads and on ground between the east and west components of field B.

Sampling Dates	Seed in heads (kg/ha)								Seed on ground (kg/ha)							
	East half of field				West half of field				East half of field				West half of field			
	trip		monthly		trip		monthly		trip		monthly		trip		monthly	
	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)	$\bar{X}$	(n)
15 Sep	1619	8			1970	8			1958	1			1145	1		
23 Sep	1147	8	1383	16	1240	8	1605	16	908	1	1433	2	1056	1	1110	2
5 Oct	1412	4			1870	4			220	1			396	1		
21 Oct	1278	8	1345	12	1000	8	1435	12	613	1	417	2	525	1	461	2
2 Nov	676	8			985	8			253	1			770	1		
16 Nov	543	8			656	8			76	1			64	1		
27 Nov	334	8	518	24	897	8	845	24	0	1	110	3	232	1	355	3
8 Dec	snow cover								snow cover							
23 Dec	206	8	206	8	448	8	444	8	5	1	5	1	382	1	382	1
6 Jan	snow cover								snow cover							
20 Jan	snow cover								snow cover							
4 Feb	snow cover								snow cover							

Append IV. Numbers of birds sighted at each field between 23 September 1976 and 4 February 1977.

Census Date	Field A			Field B			Field C			Totals, A-C		
	Number of birds	Birds per ha	Monthly $\bar{X}$ of birds per ha	Number of birds	Birds per ha	Monthly $\bar{X}$ of birds per ha	Number of birds	Birds per ha	Monthly $\bar{X}$ of birds per ha	Number of birds	Birds per ha	Monthly $\bar{X}$ of bird per ha
23 Sep	186	58	58	40	31	31	33 [a]	33	33	259	47	47
5 Oct	1024	320		40	31		221	221		1285	234	
21 Oct	203	63	192	643	495	263	148	148	185	994	181	208
2 Nov	138	43		185	142		233	233		557	101	
16 Nov	92	29		269	207		43	43		405	74	
27 Nov	102	32	33	84	65	138	47	47	108	233	42	72
8 Dec	268	84		132	102					400	89	
23 Dec	299	93	89	127	98	100				426	95	92
6 Jan	482	151		150	115					632	140	
20 Jan	873	273	212	14	11	63				887	197	169
4 Feb	349	109	109	10	8	8				359	80	80

[a] Believed to be unrealistically low as a result of censusing two hours later than usual.