COMPARATIVE BIRD AND INSECT USE OF TWO OLD FIELD HABITATS

JOHN DOUGLAS McINTOSH

TECHNICAL REPORT SERIES No. 12
Pacific and Yukon Region 1986
Canadian Wildlife Service

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This series may be cited as:

McIntosh, John Douglas. Comparative bird and insect use of two old field habitats. Technical Report Series No. 12. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Ministry of Supply and Services Canada 1986
Catalogue No. CW69-5/12E
ISBN 0-662-15094-5
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service,
Pacific and Yukon Region
P.O. Box 340,
Delta, British Columbia,
Canada V4K 3Y3

COMPARATIVE BIRD AND INSECT USE

OF TWO OLD FIELD HABITATS

by

JOHN DOUGLAS MCINTOSH

B.A., University of British Columbia, 1973

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE IN FORESTRY

in

THE FACULTY OF FORESTRY

We accept this thesis as conforming

to the required standard

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THE UNIVERSITY OF BRITISH COLUMBIA

April, 1985

ABSTRACT

The responses of migratory bird and insect populations to manipulations of two old field habitats were studied in the Qualicum National Wildlife Area in 1983. In two fields wherein annual plant species predominated, beetles (Pterostichus spp.), a weevil (Sitophilus granarius), crickets (family Gryllidae), and centipedes (Scolopocryptops spp.) showed up in higher numbers than would have been expected by chance, as did the American Goldfinch (Spinus tristis), Lincoln's Sparrow (Melospiza lincolnii), the Savannah Sparrow (Passerculus sandwichensis), the Dark-eyed Junco (Junco hyemalis), and the Song Sparrow (Melospiza melodia). In the one field wherein perennial plant species predominated, an earwig (Forfecula auricularia), ants (family Formicidae) and grasshoppers (family Acrididae) showed up in higher numbers than would have been expected by chance, as did the American Robin (Turdus migratorius), the Barn Swallow (Hirundo rustica), the Violet-green Swallow (Tachycineta thalassina) and the House Finch (Carpodacus mexicanus). Results of this study suggest that the manager of old fields for migratory bird habitat can favour different bird and insect species by manipulating old fields so as to maintain annual vegetation or so as to favour perennial vegetation.

Keywords: Annual vegetation, bird habitat, habitat management, insect habitat, migratory birds, old field habitat, perennial vegetation, Qualicum National Wildlife Area.

RESUME

On a etudie, an 1983, la reaction des populations d'oiseaux migrateurs et d'insectes aux manipulations que l'on a fait subir a deux habitats dans des champs en friche a la reserve nationale de faune Qualicum. Dans deux champs en friche ou les plantes annuelles predominaient, l'augmentation du nombre des coleopteras (especes Pterostichus), des calandres des grains (Sitophilus granarius), des grillons (famille Gryllidae) et des mille-pattes (especes Scolopocryptopa) a ete si grande qu'elle ne peut etre attribuee au hasard, et il en a ete de meme des chardonnerets jaunes (Spinus tristis), des pinsons de Lincoln (Melospiza Lincolnii), des pinsons des pres (Passerculus sandwichensis), des juncos ardoises (Junco hyemalis) et des pinsons chanteurs (Melospiza melodia). Dans le champ ou les especes vivaces predominaient, une espece de perce-oreille (Forficula auricularia), les fourmis (famille des Formicidae), et les sauterelles (famille des Acididae) etaient si abondants, tout comme le marle americain (Turdus migratorius), l'hirondelle des granges (Hirundo rustica), l'hirondelle a face blanche (Tachycineta thalassina) et le roselin familier (Carpodacus mexicanus), que cela ne peut etre le seul fait du hasard. On peut donc en deduir que le gestionnaire de champs en friche qui servent d'habitat aux oiseaux migrateurs est en mesure de favoriser des especes d'insecte et d'oiseau differentes par la manipulation des champs en friche, selon qu'il privilegie la vegetation annuelle ou la vegetation vivace.

Mots-cles - Amenagement de l'habitat; habitat dans des champs en friche; habitat des insectes; habitat des oiseaux; oiseaux migrateurs; reserve nationale de faune Qualicum; vegetation annuelle; vegetation vivace.

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ACKNOWLEDGEMENTS

I am grateful to the C.O.S.E.P. Programme of Employment and Immigration Canada which provided me with the opportunity to work at the Marshall-Stevenson Unit of the Qualicum National Wildlife Area in Qualicum Beach, B.C. during the summer of 1983. It was there that I carried out the data collection for this thesis under the direction of Neil K. Dawe, Habitat Manager for the Qualicum National Wildlife Area, whose generous advice and assistance made this thesis possible.

I also wish to thank three members of the Faculty of Forestry at the University of British Columbia, Dr. Dale Seip, Dr. Jon Sweeney and Dr. Tony Kozak, for their direction during the writing of this thesis.

J.D.M.

INTRODUCTION

OBJECTIVES

Within the constraints of geophysical events, the powers of dispersal of a species and the competitive interactions of species, animals typically demonstrate a habitat preference (Partridge 1978). There is an adaptive significance to habitat selection in that animals which succeed in obtaining access to preferred habitats have a better chance of survival and reproductive success. Thus, a rationale for measuring animal habitat exists. Writing of bird habitat in particular, Rotenberry (1981) concluded that the best reason for measuring bird habitat is that it seems to work; that is, there appear to be regular, repeatable patterns of associations or correlations between birds and habitat variables. MacArthur and MacArthur (1961) found no relationship between bird species diversity and plant diversity in a tropical forest ecosystem, but neither were they able to explain the diversity which could be expected between two habitats in any other way. Schoener (1974) explains that three dimensions of habitat (horizontal habitat separation, vertical habitat separation and food type separation) commonly serve to separate species and that the number of important dimensions increases with species number. That combinations of most dimensions are complementary (i.e., that species may overlap in one habitat dimension while being more distinct in another) adds to the complexity of the relationship between animal and habitat. Complex though these relationships may be, the knowledge of habitat is essential (Rotenberry 1981):

> This is because habitat forms the background on which all adaptive patterns are expressed. Virtually all attributes of a species, from its internal physiology on up through its interaction with other members of its community, have evolved for certain environmental conditions. Without knowledge of those conditions, which is expressed through our quantitative and qualitative description of habitat, the adaptive nature of these attributes is unknown. It seems apparent, therefore, that the necessity of defining these environmental conditions will result in the continued intertwining of bird populations and habitat measurements throughout all phases of avian ecology.

Having acknowledged the importance of habitat and that animals are selective of habitat, it follows as a logical precept of wildlife management that habitat is manipulated in order to accommodate different species. Changing vegetation is only one of many techniques of habitat improvement (Yoakum 1979, Yoakum et al. 1980). Vegetation manipulation is used in this study in order to determine its effect on bird use and insect use of a habitat.

The objectives of the study were three-fold: (1) To discover whether there was a difference in bird use of old agricultural fields vegetated primarily by perennials as compared to ones vegetated primarily by annuals; (2) To discover whether there was a difference in insect use of old agricultural fields vegetated primarily by perennials as compared to ones vegetated primarily by annuals, and; (3) To evaluate the implications of any such differences for the manager of field habitat for migratory birds.

DESCRIPTION OF THE STUDY AREA

The 54-ha Marshall-Stevenson Unit of the Qualicum National Wildlife Area ($44^{o}22'N$; $124^{o}29'W$) is located on the east coast of Vancouver Island, approximately 34 km northwest of Nanaimo, B.C. (Fig. 1). It encompasses the Little Qualicum River Estuary, a mixed forest adjacent to Highway No. 19 and several upland fields (c. 5m above chart datum - Dawe and White 1982) which were part of the Kincade homestead established more than 100 years ago. The fields studied cover about 2.3 ha.(Fig. 1)

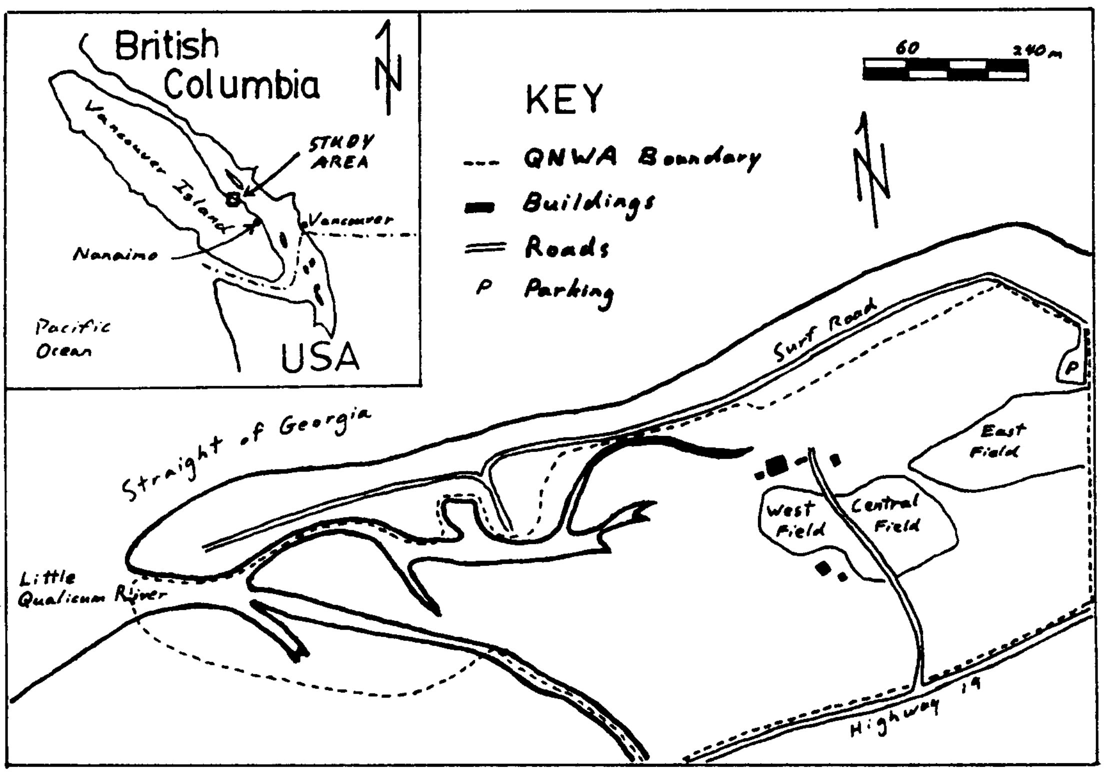

Figure 1. Marshall-Stevenson Unit of the Qualicum National Wildlife Area showing the study fields and property boundary. The inset shows the location of the study area on Vancouver Island.

METHODS

FIELD MANIPULATION

The fields studied on the Marshall-Stevenson Unit of the Qualicum National Wildlife Area had been used for both agricultural crops and pasture land prior to the establishment of the National Wildlife Area. Under the Canadian Wildlife Service, all of the fields were managed as hay fields from 1975 to 1980, when they were plowed, disced and seeded with Buckerfield's Light-to-Medium, High-Forage Pasture Mix. The Pasture Mix has the following composition (by weight): *Dactylis* spp. 50%, *Colium* spp. 20%, *Trifolium pratense* 15%, *Trifolium repens* 5%, *Pileum* spp. 5%. In March of 1983, the East and West Fields were plowed and disced, but neither were resown with anything: The natural seed bank was used in an attempt to encourage annual vegetation with their large seed production. The West Field was also harrowed. The Central Field was left as a perennial hayfield. A 5m-wide fire break was plowed and harrowed around the Eastern and Central Fields adjacent to the hedgerows and forest.

COLLECTION OF FIELD DATA

Data collection was carried out between 19 May and 30 September of 1983 with all vegetation sampling occurring on July 26 and 27. Three transects were established, one in each of the fields, to run along a diagonal from the southeast to the northwest corner of an invertebrate study grid laid out in the central portion of each field (Fig.2). Because of the relative homogeneity of the vegetation, the relevé method of vegetation sampling was used (Mueller-Dombois and Ellenberg 1974). The sample plots (or relevés) were 1 m^2, and were established every 5m along the transects. Data were obtained from a total of 36 relevés. Within each relevé, all vascular plant species were identified and recorded along with their percent cover and total plant cover. The Braun-Blanquet cover-abundance scale was used (Poore 1955). Plants which could not be identified in the field were collected for later identification. Vascular plant nomenclature follows that of Hitchcock and Cronquist (1973).

Sampling of bird species use of the three fields was carried out randomly over the entire summer, approximately every other day. Each field was observed from a distance, using field glasses for a period of 10 minutes, and bird

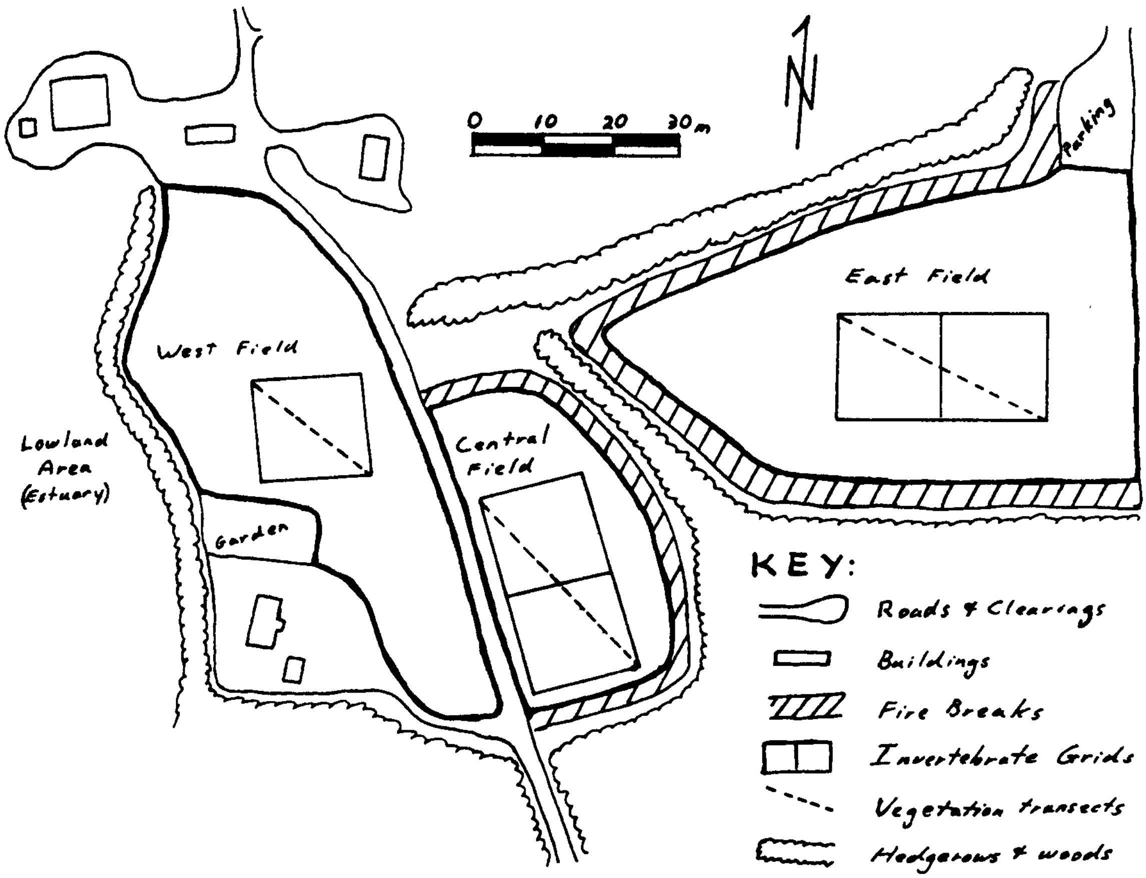

Figure 2. Location of invertebrate grids and vegetation transects within the study fields. Position of the fire breaks is also shown.

presence was recorded in or over the vegetation. Over-flight was not counted as bird use of the field unless the birds were observed to feed in flight above the field. A bird was considered to use the field whether it was observed near a hedgerow (edge) or in the more central, open portion of a field. Because the interest was in relative usage of the different field habitats and not in absolute population estimates, all observations of a species for the course of the summer were totalled and treated as having been made in a single sampling period.

Sampling of insect use of the three fields was carried out every other day, throughout the summer, beginning May. Five grids, each 32m by 32m, were laid out in the three fields, one grid in the West Field, two grids in the Central Field and two grids in the East Field (Fig 2.). The grids were placed in as central a position as possible in order to avoid edge influence. Within each grid, eight 8m by 16m plots were laid out. At the centres of each plot, a 60cm by 60cm plywood board was placed (Fig. 3). Sampling consisted of counting and identifying the insects under each board. Again, observations for the course of the summer were totalled and treated as having been made in a single sampling period.

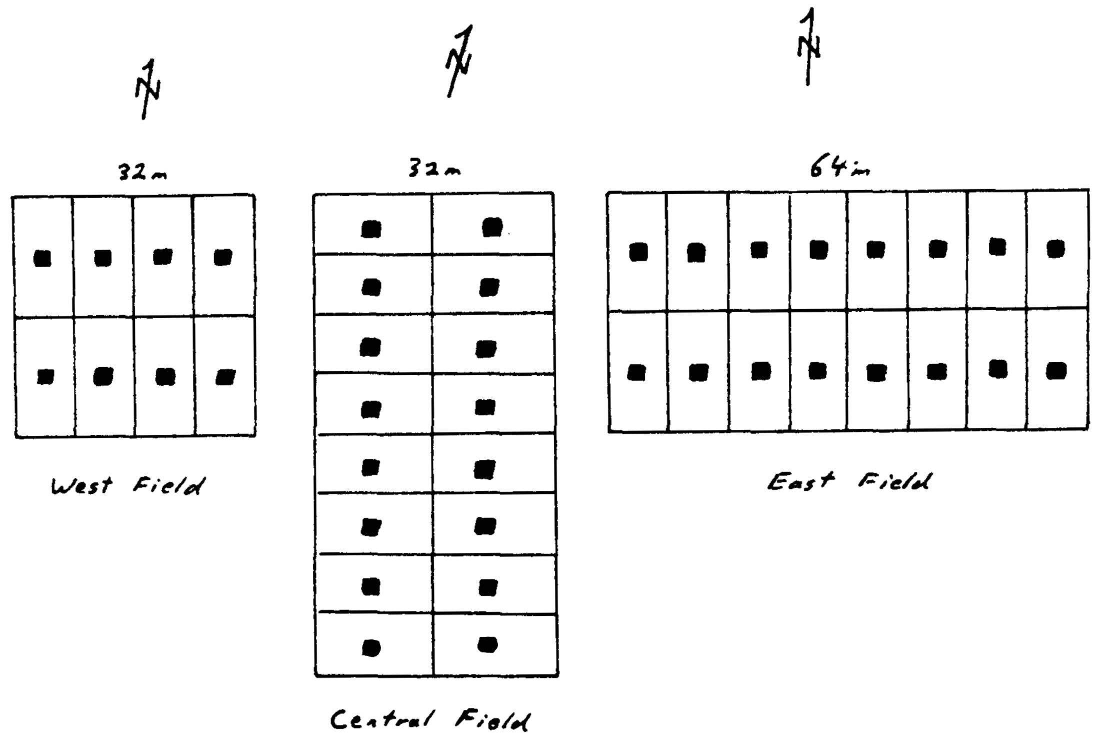

Figure 3. Configuration of the insect sampling grids. The forty plywood boards, 60cm by 60cm, are represented by the small, black squares.

DATA ANALYSIS

For the invertebrate data, logarithmic transformation was first applied to the data before carrying out a principal component analysis. Pimentel (1979) describes several advantages to the use of logarithms: Linearity and multivariate normality are more often characteristic of a set of logarithmic transformations than of the original variables. Moreover, logarithms reduce differences between standard deviations so that the resulting components are independent from the scale and magnitude of original variables (similar to components derived from a correlation matrix). Because the original variables are considered as a product, the logarithmic transformations can be used to study possible proportional relationships between variables. As well, because logarithms of variables approximate multivariate normality, the distribution of logarithms of proportions also approximates normality. Principal component analysis was utilized in order to reduce the dimensionality of the data with as little loss of information as possible from the data set. The method describes the variation of a set of individuals in multi-dimensional space in terms of a set of uncorrelated variables which are linear combinations of the original variables (Everitt and Dunn 1983). The order in which the new variables are derived is such that the first principal component accounts for the greatest amount of variation in the original data. Because the first few components usually account for most of the variation, they can be used to simplify the description of the data. The only difficulty with this type of description lies in the fact that the human mind has difficulty in comprehending more than three orthogonal vectors simultaneously. Principal component analysis is most useful, therefore, when the first two or three principal component vectors account for most of the variation in the data.

Bird data was organized in the form of a contingency table in order to test the hypothesis of independence between bird species and field location. Analysis of the contingency table was carried out using the chi-square statistic, as described by Zar (1974). The fact that there is a bias in chi-square contingency analyses such that no more than 20% of expected frequencies should be less than five and the fact that the fields sampled are not all of the same size necessitated the application of a pro-rating factor to the raw data (Kozak, pers. comm.). Field areas were computed on an Apple II+ graphics tablet: West Field, 5728 m^2; Central Field, 5265 m^2; East Field, 12380 m^2. A pro-rating factor of 2.16 was applied to the

West Field data, and a pro-rating factor of 2.35 was applied to the Central Field data in order that the data would reflect no difference in field size. The pro-rating also solved the problem of there being more than 20% of the expected values below 5.

Vegetation data were analyzed using the RTQ program devised by Orloci (1978) for computing the eigenvalue and vector algorithm of reciprocal ordering. Reciprocal ordering (also known as reciprocal averaging) accomplishes two things at once: The ordination of both samples (relevés) and species in terms of best fit of one to the other. Species with similar site distribution and sites with similar species composition are related independent of species abundance or site richness (Pimentel 1979). The production of simultaneous species and sample ordination on axes that can be treated as having the same scales is an advantage of reciprocal ordering over principal component analysis, a related eigenvector technique of ordination (Whittaker and Gauch 1978). Frequency of occurrence was calculated by summing the number of occurrences of a species within a dataset and dividing that by the total number of possible occurrences within the dataset. Best estimates of mean cover/abundance were calculated by summing the midpoint of each Braun-Blanquet scale range (i.e., by setting r=.01, +=.05, 1=3.0, 2=15.0, 3=37.5, 4=67.5, 5=87.5) and dividing by the number of occurrences of the species within the dataset.

RESULTS

VEGETATION DIFFERENCES

Vegetation data are presented in Table 1. Mean cover-abundance and frequency values by species for the West Field (relevés 1-8), the Central Field (relevés 9-22) and the East Field (relevés 23-36) are presented in Table 2, Table 3, and Table 4, respectively. Mean cover-abundance values and frequencies by species are presented for all study plots, combined, in Table 5.

Considering species scores and relevé scores as two data sets, eigenvalues of canonical correlation of the two data sets can be calculated. These correlations, presented in Table 6, are high for at least the first two sets of species and relevé scores, suggesting that the reliability of those scores is high. Relevé scores are presented with respect to canonical variates I, II and III as a scatter diagram in Figure 4. The scale of the diagram is unimportant as the intention is merely to show the relationship between relevés. Figure 4 suggests that, while the West Field and the East Field are different from the Centre Field (the older field, in terms of succession), they do show certain similarities. Figure

5 is a scatter diagram depicting species scores with respect to canonical variates I, II and III. Figures 6 and 7 show the species relationships with one another and form the basis for separating the relevés. Only the first 12 species are included in the analysis as they were the only species with a frequency of greater than 20% (see Table 5). In comparing Figure 4 with Figure 5, it is apparent that the Central Field was pulled away from the two younger fields, the West Field and the East Field, by species 9,4,1 and 7, while the East and West Fields were separated from the old field by species 3,5,6,8, and 2 (these being the extremes of canonical variate I). In a similar way, the West Field is pulled away from the East Field primarily by species 8, while the East Field is pulled away from the West Field principally by species 3,5, and 2. The separation between the fields makes sense when viewed as an annual-perennial separation: Of the first twelve species, numbers 3,5,6, and 8 are annuals and the remainder are perennials. That species number 2, Plantago lanceolata, should associate with the annuals when in fact it is a perennial may be explained by the fact it is a ubiquitous weed species with very good seed production, so the lower cover and frequency for Plantago lanceolata in the Central Field (the older field) may be a misleading coincidence.

Table I. Braun-Blanquet values for vegetation sampling by species and relevé. Coverage is as follows: 5 = 75 to 100%, 4 = 50 to 75%, 3 = 25 to 50%, 2 = 5 to 25%, 1 = 1 to 5%, + = less than 1%, R= one plant only.

Species	Relevé Number																	
	West Field								Central Field									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Poa pratensis	1	2	1	2	1	3	1	2	2	3	3	1	3	4	2	4	2	2
Plantago lanceolata	+	1	+	1	1	1	+			+	+	+	1			+		
Polygonum convolvulus	1	1	+	+	+	1	2	2		+								
Agrostis alba		R		+				+	4	2	2	4	1		2		5	4
Rumex acetosella	+	+	+		+	+	1	1		+				1			+	
Spergula arvensis	2	2	2	2	3	3	4	4										
Hypochaeris radicata				+	+	+				+		1	1	1	+	+	+	+
Chenopodium album	3	3	2	3	3	2	3	3										
Holcus lanatus							+	+	2	3	2	1	3	2	2	+	+	+
Taraxicum officinale									1	1	+	1					+	
Trifolium repens								+	1	1								
Vicia sativa										+	+							+
Geranium molle							+				+	+	+	+				+
Lotus corniculatus											+	+						
Trifolium pratense								+			+							
Polygonum persicaria															2	2		
Agropyron repens																		
Raphanus raphanistrum																		
Bromus racemosus																		
Dactylis glomerata																		
Medicago sativa																		
Achillia millefolium								+										
Sonchus asper																		
Stokesiella praelonga																		+
Capsella bursa-pastoris	R																	

Table 1. Continued. Braun-Blanquet coverage values: 5 = 75 to 100%, 4 = 50 to 75%, 3 = 25 to 50%, 2 = 5 to 25%, 1 = 1 to 5%, + = less than 1%, R = one plant only.

Species	Relevé Number																	
	Central Field				East Field													
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Poa pratensis	2	3	5	4	+	2	2	1					1	+	1			
Plantago lanceolata	+	+				1	1	+	1	1	2	2	2		2		2	3
Polygonum convolvulus					3	2	3	4	5	5	2	4	4	3	3	3	5	4
Agrostis alba	3	4	1		2	+			1	+	2			2	2		1	
Rumex acetosella						2	3	4	+	1	3	3		2	2	2	1	2
Spergula arvensis					3	3	3	3	1			2	1	1	+	3	2	4
Hypochaeris radicata	+	+		1	+	+			+	+			+					
Chenopodium album					+	+	+		+		+	+	+	2	1			
Holcus lanatus	2		2															
Taraxicum officinale					+								1	+	+		1	+
Trifolium repens				+					+		+	+	+	+		+		
Vicia sativa									+	+		+		1	+	+	+	
Geranium molle			+															
Lotus corniculatus		+		1							+	+						
Trifolium pratense				1										+	1			
Polygonum persicaria														+	1	+	+	
Agropyron repens																3		
Raphanus raphanistrum										1	+							
Bromus racemosus		1	+															
Dactylis glomerata			2															
Medicago sativa			1															
Achillia millefolium																		
Sonchus asper												+						
Stokesiella praelonga																		
Capsella bursa-pastoris																		

Table 2. Braun-Blanquet cover-abundance (mean values) and frequency values by species for relevés 1-8 (the West Field).

Species		Mean Cover/Abundance %	% Frequency
1 *Poa pratensis*		11.81	100
2 *Plantago lanceolata*		1.93	87
3 *Polygonum convolvulus*	*	5.06	100
4 *Agrostis alba*		.34	37
5 *Rumex acetosella*	*	1.21	87
6 *Spergula arvensis*	*	32.5	100
7 *Hypochaeris radicata*		.5	37
8 *Chenopodium album*	*	31.88	100
9 *Holcus lanatus*		.5	25
10 *Taraxicum officinale*		0	0
11 *Trifolium repens*		.5	12
12 *Vicia sativa*		0	0
13 *Geranium molle*	*	.5	12
14 *Lotus corniculatus*		0	0
15 *Trifolium pratense*		.5	12
16 *Polygonum persicaria*	*	0	0
17 *Agropyron repens*		0	0
18 *Raphanus raphanistrum*	*	0	0
19 *Bromus racemosus*	*	0	0
20 *Dactylis glomerata*		0	0
21 *Medicago sativa*		0	0
22 *Achillia millefolium*		.5	12
23 *Sonchus asper*	*	0	0
24 *Stokesiella praelonga*		0	0
25 *Capsella bursa-pastoris*	*	.01	12

* = annual

Table 3. Braun-Blanquet cover-abundance (mean values) and frequency values by species for relevés 9-22 (the Central Field).

Species		Mean Cover/Abundance %	% Frequency
1 *Poa pratensis*	+	35.93	100
2 *Plantago lanceolata*	+	.86	50
3 *Polygonum convolvulus*		.5	7
4 *Agrostis alba*	+	38.73	78
5 *Rumex acetosella*		1.33	21
6 *Spergula arvensis*		0	0
7 *Hypochaeris radicata*	+	1.41	78
8 *Chenopodium album*		0	0
9 *Holcus lanatus*	+	14.13	85
10 *Taraxicum officinale*	+	2	35
11 *Trifolium repens*	+	2.17	21
12 *Vicia sativa*	+	.5	21
13 *Geranium molle*		.5	42
14 *Lotus corniculatus*	+	1.13	28
15 *Trifolium pratense*	+	1.75	14
16 *Polygonum persicaria*		0	0
17 *Agropyron repens*	+	15	14
18 *Raphanus raphanistrum*		0	0
19 *Bromus racemosus*		1.75	14
20 *Dactylis glomerata*	+	15	7
21 *Medicago sativa*	+	3	7
22 *Achillia millefolium*	+	0	0
23 *Sonchus asper*		0	0
24 *Stokesiella praelonga*	+	.5	7
25 *Capsella bursa-pastoris*		0	0

+ = perennial

Table 4. Braun-Blanquet cover-abundance (mean values) and frequency values by species for relevés 23-36 (the East Field).

	Species		Mean Cover/Abundance %	% Frequency
1	Poa pratensis		5.71	50
2	Plantago lanceolata		11.36	78
3	Polygonum convolvulus	*	52.14	100
4	Agrostis alba		8.38	57
5	Rumex acetosella	*	21.38	85
6	Spergula arvensis	*	24.38	85
7	Hypochaeris radicata		.5	35
8	Chenopodium album	*	2.67	64
9	Holcus lanatus		0	0
10	Taraxicum officinale		1.33	42
11	Trifolium repens		.5	42
12	Vicia sativa		.86	50
13	Geranium molle	*	0	0
14	Lotus corniculatus		.5	14
15	Trifolium pratense		1.75	14
16	Polygonum persicaria	*	1.13	28
17	Agropyron repens		37.5	7
18	Raphanus raphanistrum	*	1.75	14
19	Bromus racemosus	*	0	0
20	Dactylis glomerata		0	0
21	Medicago sativa		0	0
22	Achillia millefolium		0	0
23	Sonchus asper	*	.5	7
24	Stokesiella praelonga		0	0
25	Capsella bursa-pastoris	*	0	0

* = annual

Table 5. Braun-Blanquet cover-abundance (mean values) and frequency values by species for relevés 1-36 (all fields).

	Species	Mean Cover/Abundance %	% Frequency
1	*Poa pratensis*	21.98	80
2	*Plantago lanceolata*	5.78	69
3	*Polygonum convolvulus*	33.52	63
4	*Agrostis alba*	22.46	61
5	*Rumex acetosella*	12.23	61
6	*Spergula arvensis*	27.48	55
7	*Hypochaeris radicata*	1.03	52
8	*Chenopodium album*	16.41	47
9	*Holcus lanatus*	12.18	38
10	*Taraxicum officinale*	1.64	30
11	*Trifolium repens*	1	27
12	*Vicia sativa*	.75	27
13	*Geranium molle*	.5	19
14	*Lotus corniculatus*	.92	16
15	*Trifolium pratense*	1.5	13
16	*Polygonum persicaria*	1.13	11
17	*Agropyron repens*	22.5	8
18	*Raphanus Raphanistrum*	1.75	5
19	*Bromus racemosus*	1.75	5
20	*Dactylis glomerata*	15	2
21	*Medicago sativa*	3	2
22	*Achillia millefolium*	.5	2
23	*Sonchus asper*	.5	2
24	*Stokesiella praelonga*	.5	2
25	*Capsella bursa-pastoris*	.01	2

Table 6. Canonical correlations (eigenvalues) of the two data dets (species scores and quadrat scores).

SET	CORRELATION
1 R(X,Y) =	.745255171
2 R(X,Y) =	.502660264
3 R(X,Y) =	.387844966
4 R(X,Y) =	.284590288
5 R(X,Y) =	.271316924
6 R(X,Y) =	.238417105
7 R(X,Y) =	.222616176
8 R(X,Y) =	.207860094
9 R(X,Y) =	.166611216
10 R(X,Y) =	.130703997
11 R(X,Y) =	.117431955

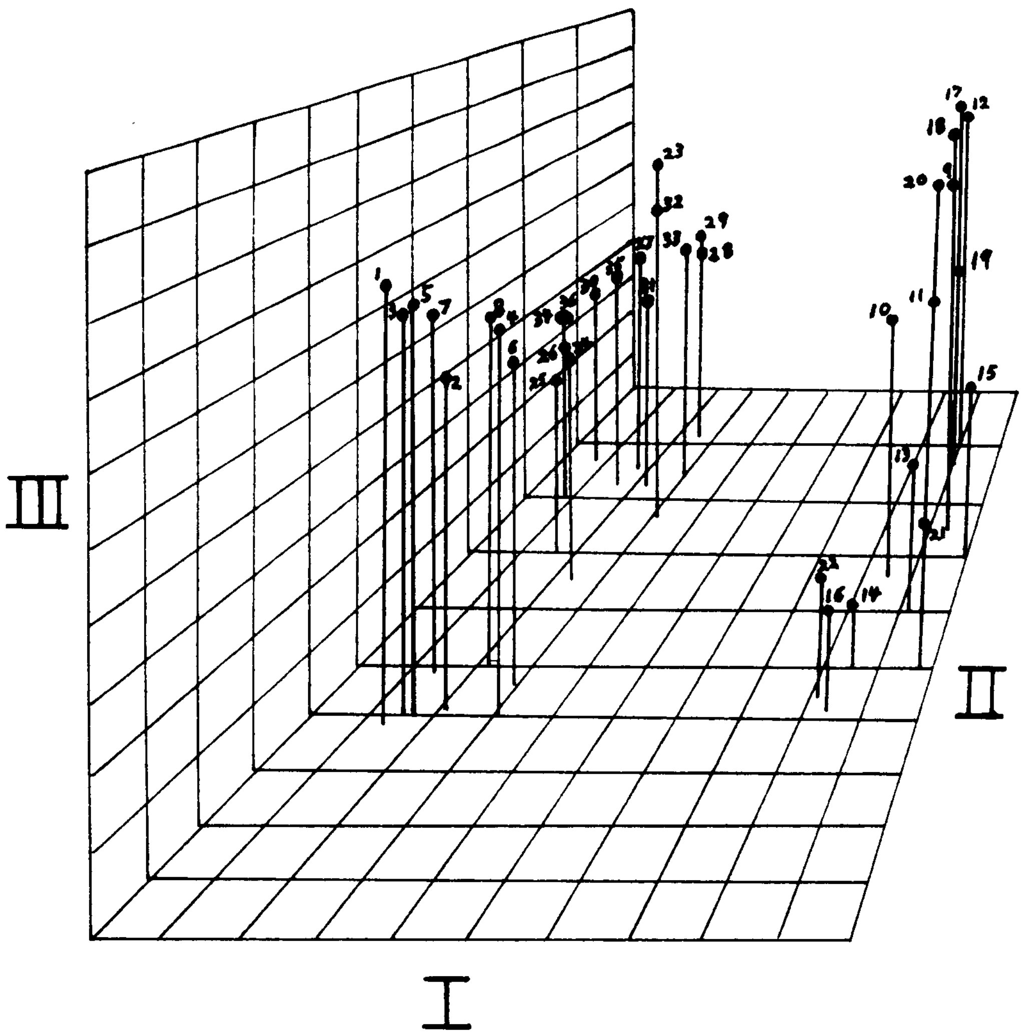

Figure 4. Three-dimensional scatter diagram of quadrat scores with respect to canonical variates I, II and III. Note the separation of the three fields: West Field = quadrats 1-8, Central Field = quadrats 9-22, East Field = quadrats 23-36.

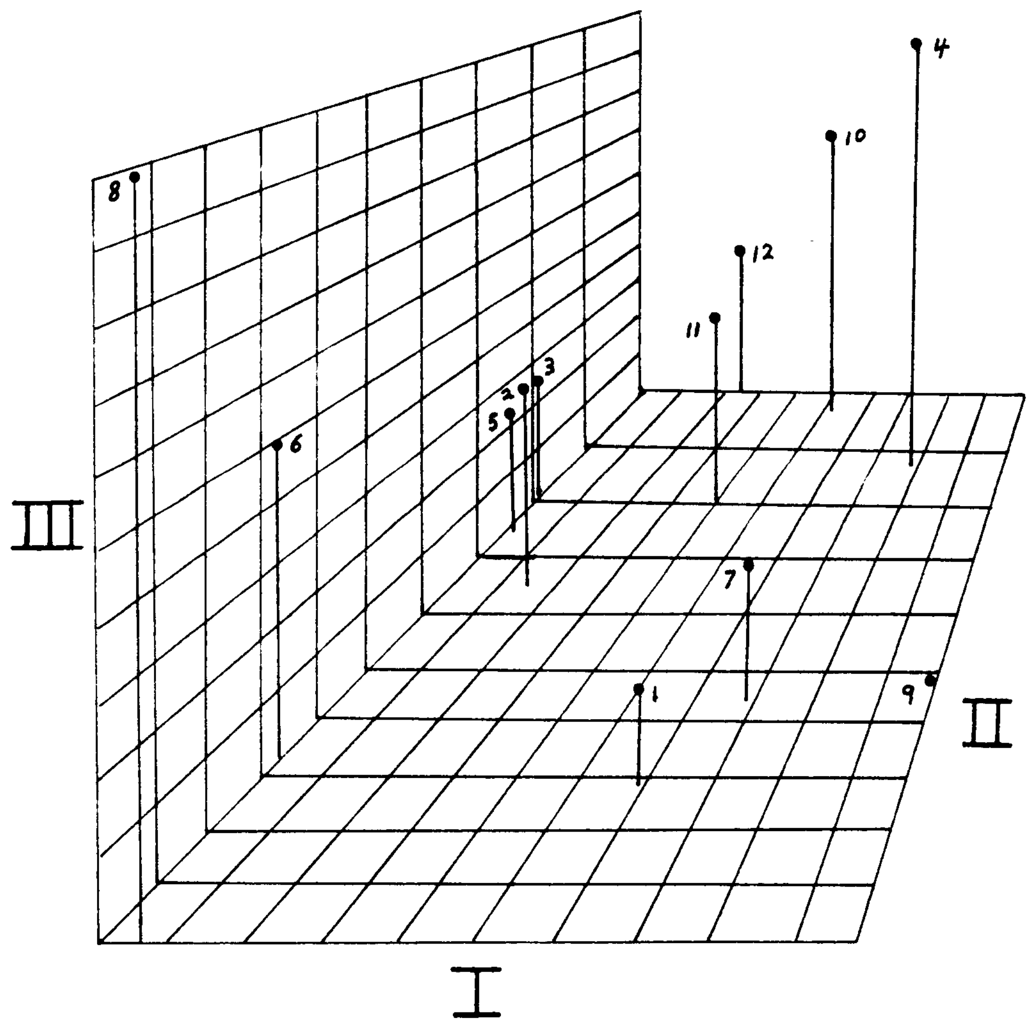

Figure 5. Three-dimensional scatter diagram of species scores with respect to canonical variates I, II and III. Note that the annuals, species numbers 3, 5, 6 and 8, tend to lie on or close to the origin of vector I.

INVERTEBRATE USE

Invertebrate counts by family for each of the 40 boards laid out in the three fields are presented in Table 7. These counts represent actual numbers observed. The portion of the total variation and cumulative variation explained by the ten vectors (i.e., the new vectors derived by the principal component analysis) are displayed in Table 8. Because of the difficulty of envisioning more than three orthogonal vectors simultaneously (they would be impossible to represent graphically), the first three vectors (variables) are considered. This amounts to an acceptance of an explanation for only 55.259% of the total variation. The coordinates of the first three vectors as points along orthogonal axes are displayed in Table 9. It is important to realize that the coordinate values, themselves, are unimportant: It is the separation or grouping of the points that is important. Movement towards or away from the origin of each vector represents a tendency towards one or another species presence as being explanatory of the variation between plots, so that the positive and negative ends of axes can be replaced with species as in Figures 6 and 7. Root scores for the vectors (Table 10) determine how the axes should be labelled.

Plotting the component scores of the first vectors for all 40 of the plots (Figures 6 and 7) enables the viewer to see how the plots cluster. The expectation is that there may be some separation in terms of the fields. The two younger fields are the West Field (plots 1-8) and the East Field (plots 25-40). The older field is the Central Field (plots 9-24). But for plot number 26, the three fields divide out with only a little bit of overlap in Figure 6 when component I is plotted along one axis and component II is plotted along a second axis. Component III is plotted along the third axis (if it were plotted in Figure 7, it would have to be depicted coming out of the page, perpendicular to the plane in which the first two axes lie). Figure 7 shows component III plotted against component I. Here the division between the younger and older fields becomes apparent (but for plot number 26, again, which appears anomalous).

Table 7. Total counts of field invertebrates by plot.

Family	Study Plot																			
	West Field								Central Field											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Beetle	28	10	49	41	72	71	79	71	5	13	1	21	2	1	1	2	3	1	0	4
Isopod	19	7	33	25	130	37	41	88	39	93	48	125	66	68	24	78	35	62	54	34
Earwig	5	13	40	13	1	25	24	15	55	127	215	157	0	91	126	113	138	233	216	69
Spider	7	6	4	4	2	0	5	1	6	17	2	3	3	2	3	1	5	1	2	6
Weevil	5	0	8	7	5	11	5	1	1	0	1	0	4	0	1	0	0	0	0	0
Ant	1	0	0	0	0	2	0	0	0	25	30	0	36	2	0	0	0	0	0	5
Centipede	0	0	2	0	0	0	0	0	1	0	0	0	1	0	8	1	0	0	2	1
Cricket	225	247	466	294	189	276	322	334	0	8	18	61	5	2	4	2	15	2	0	10
Grasshopper	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Harvestman	8	3	4	6	0	0	1	1	2	1	5	2	1	0	0	1	2	2	6	1

Table 7. Continued.

Family	Study Plot																			
	Central Field				East Field															
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Beetle	2	3	1	0	23	72	35	43	78	40	13	65	87	33	52	68	76	78	24	48
Isopod	64	64	122	59	26	18	45	36	43	48	19	56	18	126	112	26	84	100	62	104
Earwig	18	44	88	136	6	2	12	5	5	29	33	2	9	30	7	1	10	0	10	1
Spider	7	2	4	0	4	0	6	3	3	8	11	4	3	8	7	4	5	7	8	5
Weevil	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0
Ant	4	5	0	1	0	0	0	33	2	34	0	5	0	4	0	2	1	0	0	0
Centipede	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	2
Cricket	2	0	0	0	15	62	3	0	9	0	8	2	6	1	1	2	2	2	0	1
Grasshopper	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0
Harvestman	2	0	0	0	0	4	8	6	7	1	9	20	8	7	14	0	10	7	13	4

Table 8. Ten vectors derived by principal component analysis of the transformed invertebrate field data showing the variation explained by each and the cumulative variation explained.

Vector No.	% of Total Variation Explained	Cumulative % of Variation Explained
I	23.496	23.496
II	18.309	41.805
III	13.454	55.259
IV	10.214	65.473
V	9.796	75.269
VI	8.579	83.848
VII	6.809	90.657
VIII	4.928	95.585
IX	2.779	98.364
X	1.636	100

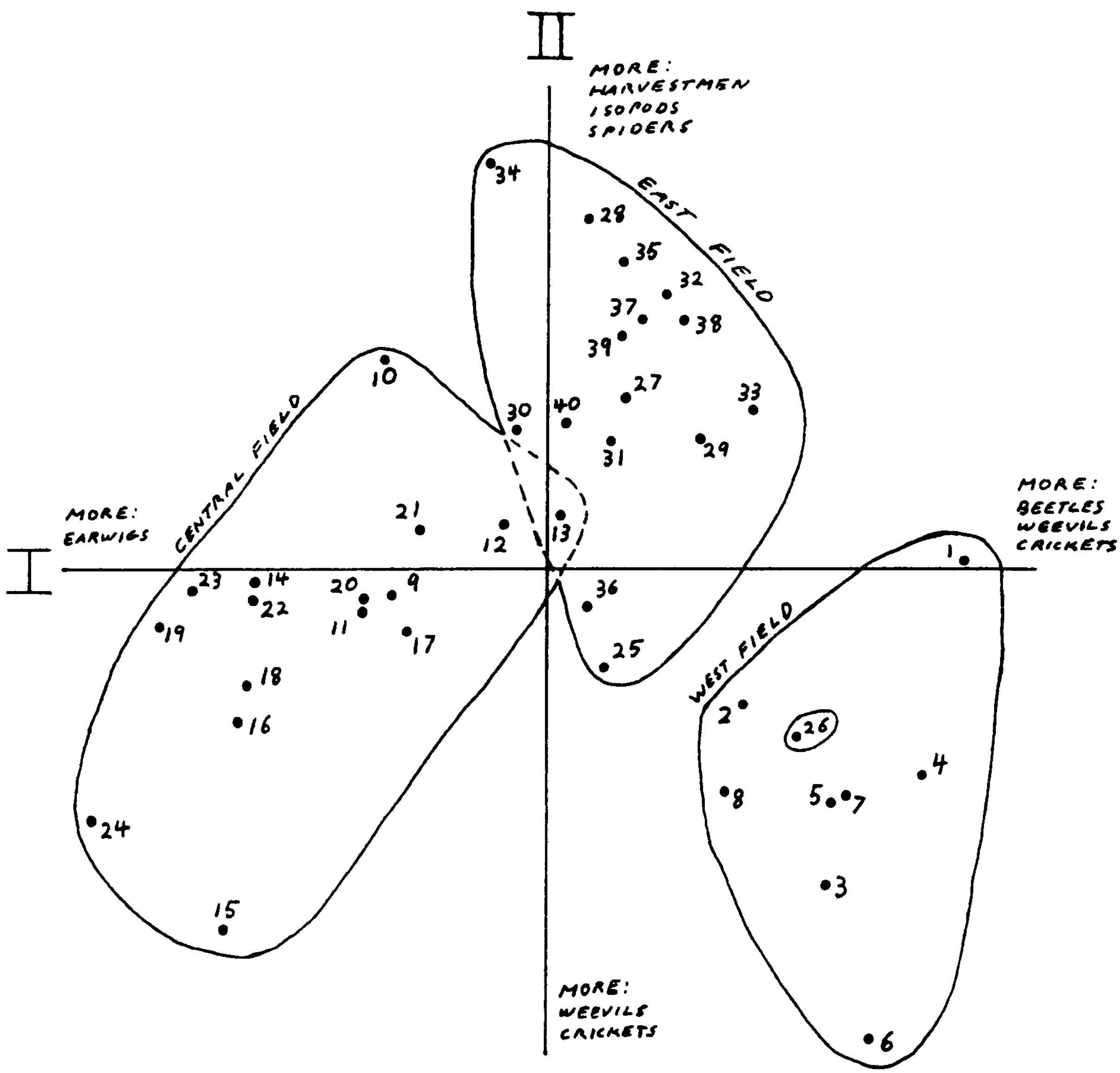

Figure 6. Component scores for vectors I and II, derived by principal component analysis of invertebrate counts for 40 different plots in three different fields.

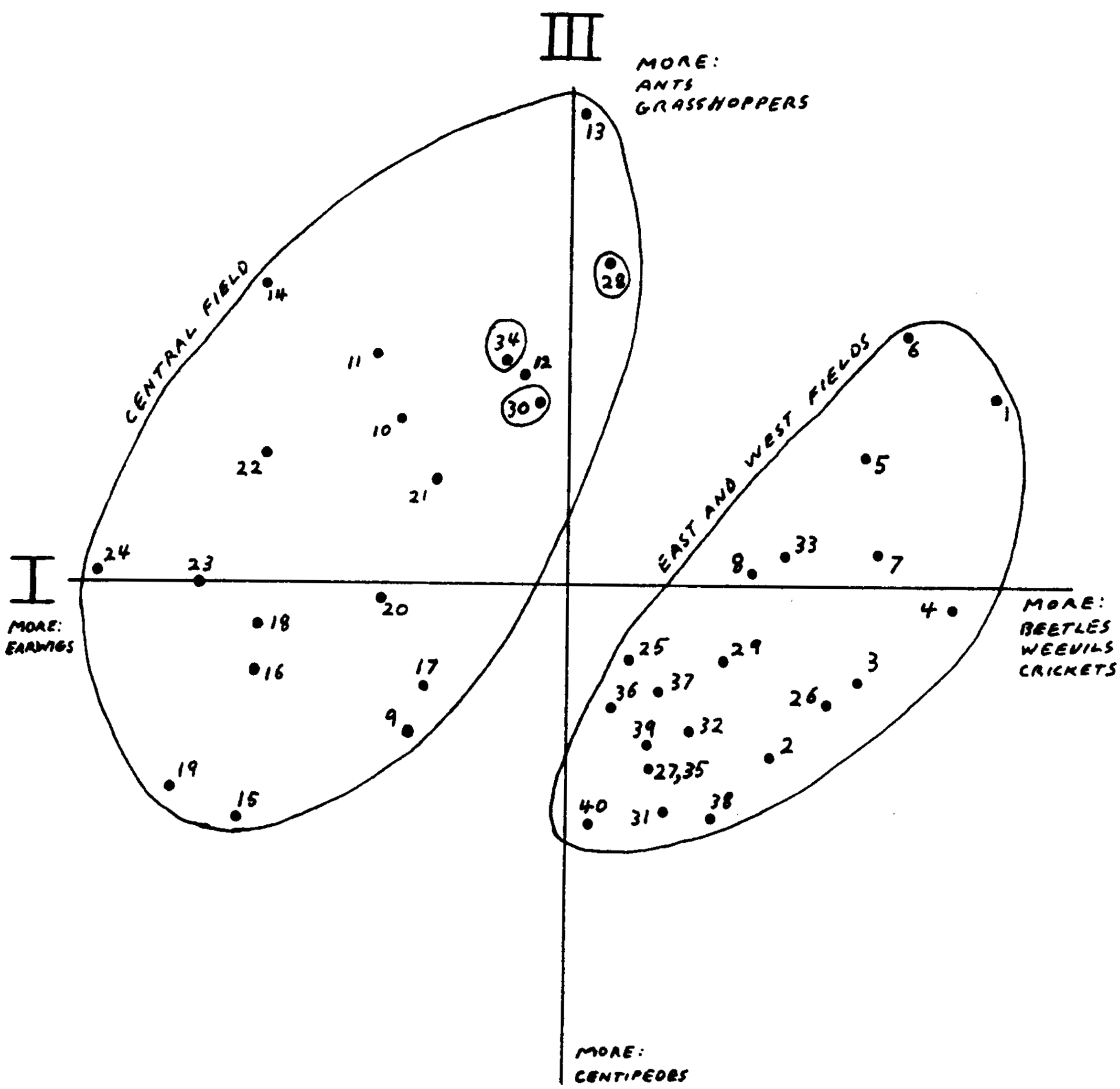

Figure 7. Component scores for vectors I and III, derived by principal component analysis of invertebrate counts for 40 different plots in three different fields.

Table 9. Component scores of the 40 invertebrate plots for the first three vectors dervied by principal component analysis.

Plot No.	Axis I	Axis II	Axis III
1	.439	-.005	.201
2	.211	-.141	-.175
3	.291	-.331	-.097
4	.404	-.212	-.023
5	.309	-.250	.128
6	.349	-.494	.250
7	.332	-.243	.031
8	.196	-.231	.031
9	-.173	-.027	-.155
10	-.177	.226	.173
11	-.198	-.044	.236
12	-.051	.041	.188
13	.017	.049	.493
14	-.312	-.015	.315
15	-.350	-.384	-.232
16	-.337	-.167	-.090
17	-.145	-.069	-.097
18	-.320	-.127	-.042
19	-.415	-.065	-.219
20	-.195	-.040	-.018
21	-.145	.047	.097
22	-.308	-.030	.126
23	-.379	-.022	.000
24	-.489	-.282	.015
25	.062	-.103	-.075
26	.271	-.180	-.119
27	.084	.183	-.186
28	.047	.363	.331
29	.169	.144	-.077
30	-.028	.154	.229
31	.071	.141	-.227
32	.126	.289	-.147
33	.228	.172	.014
34	-.035	.413	.207
35	.082	.328	-.189
36	.038	-.035	-.127
37	.090	.266	-.119
38	.149	.262	-.240
38	.079	.250	-.167
40	.021	.161	-.244

Table 10. Root scores for the first three vectors (orthogonal axes) derived by principal component analysis from invertebrate counts.

Family	Axis I	Axis II	Axis III
Beetle	.55	.18	-.09
Isopod	-.21	.22	.17
Earwig	-.45	-.18	.02
Spider	.08	.45	-.13
Weevil	.34	-.37	.30
Ant	-.10	.24	.60
Centipede	-.19	-.19	.32
Cricket	.45	-.42	.10
Grasshopper	.05	.25	.54
Harvestman	.25	.46	-.28

BIRD USE

Bird counts by species for each of the three study fields are presented in Table 11. These counts represent actual numbers observed. The three fields are different in size, however. The relative field sizes and the pro-rating factors applied to the field data in order to eliminate bias because of size differences are presented in Table 12. The resultant data is presented in the form of a contingency table (Table 13). Since the calculated X^2 (2231.0) is greater than the critical X^2 ($X^2_{0.005}$ for v=20 is 39.991), it is possible to reject the null hypothesis of independence between field and bird species with 99.5% confidence. It is apparent that some species of birds are represented in much greater proportion than others in given fields. Barn Swallows, for instance represent 49% of the bird observations in the Central Field (Table 13). Savannah Sparrows represent 55% of the bird observations in the West Field and 63% of the bird observations in the East Field. Dark-eyed Juncos represent 31% of the bird observations in the West Field. To determine whether the significant X^2 is due to Barn Swallow, Savannah Sparrow and Dark-eyed Junco observations alone, it is possible to momentarily ignore the observations of

Table 11. Summary of bird counts observed on the fields of the Marshall-Stevenson Unit of the Qualicum National Wildlife Area during the summer of 1983.

Species	West Field	Central Field	East Field	Totals
American Robin	4	17	13	34
American Goldfinch	7	4	8	19
California Quail	16	5	7	28
Barn Swallow	116	107	76	299
Violet-green Swallow	61	32	24	117
House Finch	1	15	25	41
Ring-necked Pheasant	1	2	64	67
Lincoln's Sparrow	8	0	18	26
Savannah Sparrow	924	35	1261	2220
Dark-eyed Junco	525	0	379	904
Song Sparrow	7	0	69	76
Totals	1670	217	1944	3831

Table 12. Field Sizes, proportions and pro-rating factors applied to the raw data in Table 11.

Field	Size (m^2)	Proportion	Pro-Rating Factor
West Field	5728	0.46	2.16
Central Field	5265	0.43	2.35
East Field	12380	1.00	1.00

Table 13. Pro-rated bird observations in a contingency table format. Numbers in parentheses are expected observations.

Species	West Field		Central Field		East Field		
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Totals
American Robin	8.64	(36.65)	39.95	(5.18)	13	(19.75)	61.59
American Goldfinch	15.12	(19.35)	9.4	(2.74)	8	(10.43)	32.52
California Quail	34.56	(31.73)	11.75	(4.49)	7	(17.10)	53.31
Barn Swallow	250.56	(343.99)	251.45	(48.63)	76	(185.39)	578.01
Violet-green Swallow	131.76	(134.75)	75.20	(19.43)	24	(74.08)	230.96
House Finch	2.61	(37.14)	35.25	(5.25)	25	(70.02)	62.41
Ring-necked Pheasant	2.61	(42.17)	4.70	(5.96)	64	(22.73)	70.86
Lincoln's Sparrow	17.28	(20.10)	0	(2.97)	18	(11.32)	35.28
Savannah Sparrow	1995.84	(1987.21)	82.25	(280.93)	1261	(1070.95)	3339.09
Dark-eyed Junco	1134.00	(900.44)	0	(127.30)	379	(485.27)	1513.00
Song Sparrow	15.12	(50.06)	0	(7.08)	69	(26.98)	84.12
Totals	3607.20		509.95		1944		6061.15

these three species and consider a contingency table formed of the remaining observations (Table 14). The method is suggested by Zar (1974). Again, the calculated X^2 (359.0) is greater than the critical X^2 ($X^2_{0.005}$ for v=14 is 31.319), so it is still possible to reject the null hypothesis of independence between field and bird species with 99.5% confidence.

Table 14. Reduced contingency table analysis of bird observations. Numbers in parentheses are expected observations.

Species	West Field		Central Field		East Field		
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Totals
American Robin	8.64	(22.14)	39.95	(17.20)	13	(22.25)	61.59
American Goldfinch	15.12	(11.69)	9.40	(9.36)	8	(11.75)	32.52
California Quail	34.56	(19.16)	11.75	(14.89)	7	(19.26)	53.31
Violet-green Swallow	131.76	(83.01)	75.20	(64.51)	24	(83.44)	230.96
House Finch	2.16	(22.43)	35.25	(17.43)	25	(22.55)	62.41
Ring-necked Pheasant	2.16	(25.47)	4.70	(19.75)	64	(25.60)	70.86
Lincoln's Sparrow	17.28	(12.68)	0	(9.90)	18	(12.75)	35.28
Song Sparrow	15.12	(30.23)	0	(23.49)	69	(30.39)	84.12
Totals	226.80		176.25		228		631.05

DISCUSSION

VEGETATION DIFFERENCES

From the vegetation analysis it is apparent that the three fields studied differ in terms of vegetative cover. The differences can be explained primarily in terms of the annual versus perennial vegetation on newly-plowed fields (the East and West Fields) versus a three-year-old field (the Central Field). Re-plowing fields resulted in a distinctive predominance of annual plants, particularly *Polygonum convolvulus*, *Rumex acetosella*, *Spergula arvensis* and *Chenopodium album*, all plants which are dispersed primarily by seed (see Table 15), whereas the Central Field, in the fourth season after plowing, was distinctively high in perennial species, notably *Poa pratensis*, *Agrostis alba*, *Hypochaeris radicata*, and *Holcus lanatus*. Three of those perennials are grass species spreading by creeping rhizomes (*Poa*, *Agrostis* and *Holcus*), while the fourth, *Hypochaeris radicata*, is a tall (15-60 cm), durable forb with a particularly lengthly flowering time (May to October, longer by a month than the flowering time for any of the other 11 species analyzed). The anomalous perennial, *Plantago lanceolata*, which appears more

Table 15. Characteristics of the twelve most prevalent (frequency greater than 20%) plant species analyzed. (From Mulligan 1978, Hubbard 1969, Gilkey and Dennis 1980).

Species	Annual/ Perennial	Grass/ Forb	In Bloom	Vegetative Spreading
1. <u>Poa pratensis</u>	P	G		RZ
2. <u>Plantago lanceolata</u>	P	F	JU-OC	
3. <u>Polygonum convolvulus</u>	A	F	JU-JL	
4. <u>Agrostis alba</u>	P	G		RZ
5. <u>Rumex acetosella</u>	A	F	JU-OC	RT
6. <u>Spergula arvensis</u>	A	F	JU-OC	
7. <u>Hypochaeris radicata</u>	P	F	MY-OC	
8. <u>Chenopodium album</u>	A	F	JU-SE	
9. <u>Holcus lanatus</u>	P	G		
10. <u>Taraxacum officinale</u>	P	F	AP-AU	
11. <u>Trifolium repens</u>	P	F	AP-SE	ST
12. <u>Vicia sativa</u>	P	F	JU-OC	

P = perennial G = grass RZ = spreading by rhizomes
A = annual F = forb RT = spreading by shallow roots
ST = spreading by stolons

important in the younger fields (the East and West Fields) than in the older field (the Central Field), is particularly rugged and has a relatively long flowering time (June to October). It may have been out-competed by the tall grasses.

That soil disturbance creates lower successional communities dominated by forbs is supported by Webb and Guthery (1983) in their study of discing on rangeland as well as by others (Jackson 1969, Turrentine 1971, Derdeyn 1975, Buckner and Landers 1979). The difference in the plantain (Plantago lanceolata) being important in the younger East and West Fields may be explained by the fact that the harrowing carried out in the West Field acted as an inhibitor to plantain regeneration. Webb and Guthery (1983) found that discing discouraged plantain on rangeland.

A key factor in early domination of plants is the capability of their seeds to germinate at a time when habitat is available (Keever 1983, Bakelaar and Odum 1978, Busing and Clebsch 1983). It may be that differences in management practice comes into play in the developmental stage of a given plant, determining the fate of the seedling by providing "safe" (or unsafe) sites (Bakker et al. 1980). Both differential growth and chance of survival may thus be seen as contributing to survival phenomena. The success of *Holcus lanatus* in the older field duplicates findings by Bakker, Dekker and De Vires (1980) that abandonment of grasslands led to greater cover-abundance of *Holcus lanatus*. While some authors (Busing and Clebsch 1983, Keever 1983) point to seed bank composition as being an important factor in determining species success, the past agricultural treatment of the Qualicum National Wildlife Area fields has been similar, so seed bank composition was probably similar.

INVERTEBRATE USE

The statistical analysis of the invertebrate field data makes possible four apparent distinctions: (1) The older, Central Field, is significantly different in terms of having more earwigs, ants and grasshoppers, whereas (2) the younger East and West Fields are significantly different in terms of having more beetles, weevils, crickets and centipedes. (3) The East Field is distinctively high in harvestmen, isopods and spiders, versus (4) the West Field, which is distinctively high in weevils and crickets.

That there should be a field-to-field difference in arthropod fauna comes as no surprise, having discovered differences in the vegetative communities. From a study of Homoptera in three old fields, Murdoch, Evans and Peterson (1972) concluded that there is a high correlation between plant and animal diversity (already established for birds by MacArthur and MacArthur 1961), though they were not able to determine whether plant structure or species diversity was more important. Although their correlations of insect diversity patch-to-patch were weak, the correlations were strong in explaining variations among different old fields. Hodkinson and Hughes (1982) noted that spatial distribution and diversity of plant populations may play an important role in determining insect herbivory. This, in turn, can act to modify both the fitness and the reproductive potential of the plant population. Pathak (1975) expanded on the interaction between insect and vegetation complexes, explaining that the interactions may include various methods of host selection, oviposition and shelter; the effect of insect infestation of a plant; and the effects of the infested plant on insect survival, growth and population build-up. Suitable hosts support growing populations while less suitable hosts constrain the insect population. This suitability can vary within species as well as between species. The notion of an interaction is supported by Clark, Geier, Hughes and Morris (1967) in their life-system explanation of the ecology of insect populations, whereby the inherited properties of individuals of subject species (genotypes) are seen as a co-determinant with the "effective environment" (in terms of numbers and persistence).

A ready explanation of much of the distinction in the insect population of the Qualicum National Wildlife Area Fields might be expected in terms of general food habits and habitat requirements (Table 16). But many of the insects considered in the study were attracted by the habitat created by the 60cm by 60cm sample boards. The

Table 16. Important food habits and habitat requirements for the ten invertebrates identified in the Qualicum National Wildlife Area Fields (for scientific names, see the Appendix). Compiled from Milne and Milne (1980), Kozloff (1976) and Sweeney (pers. comm.).

Invertebrate	Food Preferences	Habitat Preferences
Earwig	Small insects, mites, etc.	Light-proof cover for eggs, in burrows in the ground.
Ant	Live and dead animal matter, nectar, aphid honeydew.	
Grasshopper	Grasses, forbs.	
Beetles	Caterpillars and other soft insects.	Includes beneath boards and in fields planted with forage or grain.
Centipede	Insects.	Under cover, in soil and leaf litter.
Weevil	Dry seeds, seedlings of grasses, grains on farms	Grain fields and grassland.
Cricket	Seeds and seedlings of wild and crop plants, small fruits and dead and dying insects (when available)	Undergrowth with moderate humidity and protection from night winds and cold.
Harvestman	Small insects and decaying organic matter.	Fields on tree trunks and open ground.
Isopod	Decaying vegetation	Under anything that fits tightly against the soil and gives a moist environment.
Spider	Insects	

earwigs, which so distinguished the older field (the Central Field), are one of the species favouring a light-proof cover such as that provided by the boards. They also grow faster with more warmth, and the boards would be expected to reduce both convective and radiative heat loss. But while the boards might provide habitat, they cannot have been a determining factor in the selection of one field over another or earwig numbers would be expected to be in proportion to the numbers of boards, which was not the case.

Ants and grasshoppers, also important in the old field, are two of seven species of arthropods which Hewitt and Burleson (1976) recognize as important in terms of abundance or biomass on rangeland sites. Joern (1979) found that some short-lived grasshoppers could survive on one plant species if it occurred simultaneously, but they are more likely to be polyphagous, adjusting their diet selectively to the probability of finding suitable food plants. Joern (1982) also noted that the use of structural habitat by grasshoppers is proportional to the occurrence of that habitat and that faunal interactions between species may partly account for the occupation of different microhabitats from one site to the next. Similarly, writing with regard to ground-living crickets, Howard and Harrison (1984) suggested that food plant preferences are not an obvious explanation for habitat segregation as the crickets probably utilize a wide variety of food resources. In a study of an isopod, however (a distinctive arthropod of the East Field versus the West Field), Al-Dabbagh and Block (1981) suggest that the difference in habitat structure of two different grasslands is responsible for significant changes in the population structure and dynamics of *Armadillidium vulgare*. Higher populations of *A. vulgare* coincided with a grass heath disturbed by grazing versus an undisturbed area. Regarding spiders (also an important invertebrate in differentiating the East Field from the West Field), Cady, Tietjen and Uetz (1980) concluded that microhabitat, in terms of soil moisture and cover, and social attraction, in terms of there being sites for the collection of pheromones released by the females, are determining factors for local patterns of distribution, although these would not be unique to an ecotone.

Beetles were notably more important in the younger East and West Fields than in the older Central Field. Density, diversity and equitability of Carabidae have been found to be unaffected by meadow disturbance in the form of mowing (Schaefer and Haas 1979). However, carabids have been found to respond positively to increases in water and water plus nitrogen (Lavigne and Campion 1978). In a study of organic farming practices (that is, tillering more often, with lighter equipment, and using no fertilizer or pesticide) versus conventional farming practices (whereby tillering is done less often, with heavier equipment, and fertilizer and pesticide are used), Dritschilo and Erwin (1982) found that species abundance and species richness of carabid communities were higher in the organically cultivated fields, though diversity indices were found to be poor indicators of change. The carabid is one of the insects studied by Stinner, Regniere and Wilson (1982) in their research into the effect of agro-ecosystem structure on arthropod herbivores. They concluded that, while a knowledge of extrinsic characteristics such as spatial and temporal resource availability, the physical variables such as temperature and moisture, and the action of enemies is important, the interaction of extrinsic and intrinsic variables often have a critical effect on species composition. This is precisely what others (Hodkinson and Hughes 1982, Pathak 1975, Clark et al. 1967) have generalized about arthropod-plant relations.

BIRD USE

The analysis of the bird use data from the fields on the Qualicum National Wildlife Area reveals that usage patterns are other than would be expected if the birds were distributed over the fields without discrimination. Several usage rates are greater than would be expected. For the older, Central Field, the American Robin, the Barn Swallow, the Violet-green Swallow and the House Finch all make greater use of the field than population size and total bird usage would dictate. In the East and West fields, usage by the American Goldfinch, Lincoln's Sparrow, the Savannah Sparrow, the Dark-eyed Junco and the Song Sparrow are all greater than would be expected. For the West Field alone, usage by the California Quail is greater than would be expected. In the East Field, only usage by the Ring-necked Pheasant is greater than would be expected. By examining the food preferences and the habitat preferences of each species of bird in turn, it may be possible to explain the apparent discrimination between field habitats. Food and habitat preferences for each species are summarized in Table 17.

Observations of American Robin were nearly four times what they would have been expected to be in the older,

Table 17. Food and habitat preferences for each of eleven bird species studied in the Qualicum National Wildlife Area fields (species names in Appendix). Compiled from Salt and Wick (1966), Godfrey (1966), Bent (1932,1942,1949,1968), Freethy (1982), and Guiguet (1955,1964,1978,1983)

Species	Food preferences	Habitat preferences
American Robin	Worms, fruits, insects on the ground and some aerially, close to the ground.	Farms, woodlots and thickets for cover and nesting. Open fields for foraging.
American Goldfinch	Seeds (esp. thistle and dandelion) and some insects.	Open, deciduous woods or shrubs for nesting. Weedy fields, cultivated lands and similar, open, weedy places not too far from wood edges or wood patches or shrubs.
California Quail	Fruit, weed seeds, grasses, grains and a few insects (including beetles and grasshoppers) and worms.	Nest on the ground. Tall shrubs interspersed with open areas preferred.
Barn Swallow	Aerial insects, esp. ants when swarming. Non-flying insects and some seed are rare.	Near suitable nesting (buildings, caves or cliffs) and water. Forage especially over grassy fields.
Violet-green Swallow	Aerial insects, esp. ants when swarming. Will feed on ground when an abundant hatch of insects is underway.	Near suitable cavity nesting sites.
House Finch	Almost anything, including seeds, fruit and insects.	Sunny, drier areas, such as farmland with thin shrubbery, with at least some water available.

Table 17. Continued.

Species	Food preferences	Habitat preferences
Ring-necked Pheasant	Almost anything. Grain is a staple, but green sprouts are relished. Also insects (incl. grasshoppers, crickets, beetles and larvae), weed seeds, wild fruit, berries, rodents.	Nest in fields, usually on the ground. Forage in farmland with fields of grain, grasses and weeds where there is nearby cover such as hedges, shrubs or woodland.
Lincoln's Sparrow	Esp. insect larvae and spiders in the summer and esp. seeds later in the season when insects are scarce.	Ground nester. Forages in weedy or grassy open places near bushes or wood edges.
Savannah Sparrow	Weed seeds and insects (esp. grasshoppers, beetles and spiders) on the ground.	Ground nester, foraging in open areas, esp. moist grasslands.
Dark-eyed Junco	Mostly a ground feeding seed eater, it will take some insects (rarely in the air).	Nest on or near the ground. In weedy places and fields during migration, also roadside ditches and edges of fields bordered by woods.
Song Sparrow	Insectivorous, turning to seeds as the summer advances, esp. weed seeds.	Nests on the ground in farmland thickets and hedgerows. Forages at the forest edge and other semi-open areas.

Central Field. The American Robin commonly forages in open fields and feeds on worms, fruits, insects on the ground, as well as a few insects in the air (Table 17). Foraging behaviour of the American Robin is influenced by mobility, distribution and abundance of food items as well as environmental structure (Paszowski 1982). When several species of Turdus occupy the same habitat, they may achieve niche separation by differential use of related techniques of ground feeding and by prey size difference (Tye 1981). The greater abundance of plant species, particularly forbs, in the older field probably provides greater shading and moisture retention, which may make it a more favourable habitat for worms. Since the American Robin breeds on the National Wildlife Area, it would likely find more suitable nesting materials for construction and lining of nests in the Central Field.

The Barn Swallow is principally an aerial insectivore, though some feeding on ground insects and on seeds has been recorded. It prefers feeding over fields, near water and suitable nesting sites, such as buildings, caves or cliffs (Table 17). When food is plentiful and nearby the Barn Swallow will increase its load size (Bryant and Turner 1982) and include small insects of low profitability energy-wise, though generally it selects prey by size, seeking economy of effort (Turner 1982). There is the potential for both interspecific and intraspecific competition for food in a swallow feeding guild during the breeding season (Holroyd 1983). Violet-green Swallows also tend to show up more often than they would be expected to do in the Central Field, though for sheer numbers, the West Field rates higher for Violet-green Swallows. Like the Barn Swallow, they are aerial insectivores (Table 17), but competition between the two swallows is not an obvious factor in their choosing of foraging habitat. The West Field was nearest to the known nesting sites of both the Barn Swallow and the Violet-green Swallow. The fact that both species show a particular fondness for ants may have a bearing on their distribution for the greatest numbers of ants were observed in the Central Field (though ant flight is restricted to mating and dispersal).

The House Finch was another species which was far more prevalent in the Central Field than would be expected. Favouring sunny, drier areas with thin shrubbery (such as farmland), the House Finch will eat seeds, fruit and insects (Table 17). The House Finch tends to be an edge feeder (Lewke 1982), so the fact that the Central field tends to have a greater amount of forest and shrub around the field for its size than the other two fields may be strongly influential.

The American Goldfinch is partial to seeds (especially those of thistle and dandelion) as well as some insects of weedy fields and cultivated lands (Table 17). That the bird should occur more often than expected in the younger East and West Fields can be attributed to its generalist feeding habits: May (1982) found that generalist feeders tend to predominate in earlier successional stages, while occurrence of specialists increases with succession. Likewise, Wiens (1973) found short grass sites were populated by omnivores.

Lincoln's Sparrow favours weedy or grassy open places where it forages particularly for insect larvae and spiders as well as for seed when insects are scarce (Table 17). Certainly the relatively large spider population in the East Field might account for the Lincoln's Sparrow favouring it over the Central Field, but the same comparison does not hold true for the West Field and the Central Field. The greater openness of the younger fields may account for their preference.

The Savannah Sparrow takes weed seeds and insects such as grasshoppers, beetles and spiders on the ground (Table 17). They are one of the few songbirds (along with Dark-eyed Juncos) that will feed in an open field.

Savannah Sparrows were observed out in the middle of the East and West fields, feeding on _Chenopodium album_. Six Savannah Sparrows killed accidentally in mist nets on the Qualicum National Wildlife Area were found to have 98-100% _Chenopodium album_ seed in their crops (Dawe, pers. comm.). _Chenopodium album_ showed up in great frequency in the East and West Fields but not at all in the Central Field during the vegetation sampling. Grasshoppers, beetles and spiders also served to distinguish the East and West Fields from the Central Field. Kendeigh (1948) noted that Savannah Sparrows were more abundant where grass was more luxuriant, as it is in the younger fields. Savannah Sparrows also avoid habitats with vegetation of greater than 1m in height unless they are disturbed repeatedly (Grzybowski 1983). That result is in keeping with their selection of younger successional stages.

The California Quail showed particular favouritism for the West Field. Eating fruit, weed seeds, grasses, grains and a small number of insects, it is cursorial by nature and favours tall shrubs or low trees interspersed by open areas (Table 17).

Another cursorial species, the Dark-eyed Junco is primarily a seed eater, but will also take some insects (Table 17). Using both of the more open, younger fields, it showed a slight preference for the West Field which bears no apparent explanation.

The Ring-necked Pheasant, a ground-nester which will eat a wide variety of vegetable and animal matter, including some rodents (Table 17), showed a marked preference for the East Field. As a generalist, if May (1982) is correct, it should favour the younger successional stage. Why it did not so favour the West Field may be due to the smaller size and proximity to the roadway. Mean brood size of Ring-necked Pheasants has been correlated with hectares of row crops (Warner et al. 1983).

The Song Sparrow also preferred the East Field. Largely an insectiverous bird, it is known to take seeds as the summer advances (Table 17). Mitchell (1961) found the most important determinant of Song Sparrow populations to be edge. Certainly the East Field has the greatest edge. It shares both the East and West Fields with a similar insectivore-granivore, but as insects become scarce in the winter and both species turn to seeds, there is interspecific partitioning of the food resource by seed size, with the Lincoln's Sparrow eating a slightly larger seed than the Song Sparrow (Pulliam 1983). The winter of 1983-1984 was the first time that Lincoln's Sparrow was recorded on the Wildlife Area (Dawe, pers. comm.)

Welty (1979) explains that the habitat of a bird can be considered from three different standpoints: (1) Spatial (where it is), (2) structural (what it is), and (3) functional (why it is). It is the third viewpoint which is the most complex. If the foregoing explanations of habitat seem to be many and various, that is not unusual. Some researchers (Lanyon 1981, Shugart and James 1973) point to ecological age of a site as a correlate of species diverstiy. Others (Cody 1968, Wiens 1969, Rice et al. 1983) say that preference of different vegetative species determines habitat. Habitat heterogeneity has been linked to bird community composition (Weins, 1974a, 1974b; Rotenberry 1983), and vegetative structure has been demonstrated to be correlated with avian diversity (Karr 1967, Karr and Roth 1971, Rotenberry and Weins 1980). Still others (Grzybowski 1982, Weins and Johnston 1977) have called bird selection of feeding habitat mere opportunistic feeding. Obviously, not all of those explanations can serve for one species of bird in all habitats any more than they can serve for all species within a given habitat: The final selection is the result of a complex interaction between the bird and its environment, floral, faunal, geographical and climatic. The explanation of functional habitat must necessarily be as complex as the biological system itself.

CONCLUSION

The implications of the study for the manager of a field habitat for migratory birds are as follows: Annual plowing of old field habitat ensures a younger successional stage dominated by annual vegetation which favours the American Goldfinch, the Lincoln's Sparrow, the Savannah Sparrow, the Dark-eyed Junco, the Song Sparrow, the California Quail and the Ring-necked Pheasant over the American Robin, the Barn Swallow, the Violet-green Swallow and the House Finch. The latter group shows a preference for a one-year-old field dominated by perennials when both the younger and older field types are available in close proximity to all eleven species of bird. The differences in vegetation and in insect populations for the two adjacent habitats provide some explanation for the differences in bird preferences by way of ideas, though no causal relationship can be ascribed.

The association of passerine bird species with grassland and their decline with loss of grassland is documented in the literature (Moller 1983, Owens and Myres 1973, Johnston and Odum 1956). An element of agricultural practice not examined by this study is grazing, though the same fields had, many years ago, been used to graze cattle. Skinner (1974, 1982) found that grazed grasslands support more bird species and more individuals than hayed grasslands. Neither was the relationship between farmstead shelterbelts and bird community size and composition explored, though farmstead shelterbelts are recognized as important in association with old field habitat (Yahner 1982, 1983). Likewise, hedgerows have been recognized as being capable of supporting a diverse and abundant avifauna in association with farmlands (Morgan and Gates 1982, Best 1983). Though hedgerows were mentioned in the study, they were not part of the variables analyzed. Nor was the effect of edge measured, though abundance of edge between habitats has been shown to correlate with increased avian diversity (Gates 1981, Arndt and Townsend 1982). No attempt was made to study climatic or geographic variables or to examine species interactions.

No study can hope to include all the variables in a biological relationship. In this study I have endeavoured to focus on a few of the more imporant variables with the hope that they can be used as indicators for adaptive management of old fields for migratory bird habitat.

LITERATURE CITED

Al-Dabbagh, K.Y.; Block, W. Population ecology of a terrestrial isopod in two Breckland grass heaths. J. Anim. Ecol. 50:61-77; 1981.

Arndt, R.S.; Townsend, T.W. Non-game bird populations on areas managed for wildlife and agricultural crops. Ohio J. Sci. 82(3):128-133; 1982.

Bakelaar, R.G.; Odum, E.P. Community and population level responses to fertilization in an old-field ecosystem. Ecology 59(4):660-665; 1978.

Bakker, J.P.; Dekker, M.; De Vires, Y. The effect of different management practices on a grassland community and the resulting fate of seedlings. Acta. Bot. Neerl. 29(5/6):469-482; 1980.

Bent, A.C. Life histories of North American gallinaceous birds. Smithsonian Institutuion, U.S. National Museum Bull. 162; 1932.

__________ Life histories of North American flycatchers, larks, swallows and their allies. Smithsonian Institution, U.S. National Museum Bull. 179; 1942.

__________ Life histories of North American thrushes, kinglets and their allies. Smithsonian Institution, U.S. National Museum Bull. 196; 1949.

__________ and Collaborators. Life histories of North American cardinals, buntings, towhees, finches, sparrows and allies (Part Two). U.S. National Museum Bulletin 237; 1968.

Best, L.B. Bird use of fencerows: implications of contemporary fencerow management practices. Wildl. Soc. Bull. 11(4):343-348; 1983.

Bryant, D.M.; Turner, A.K. Central place foraging by swallows (Hirudinidae): The question of load size. Anim. Behav. 30:845-856; 1982.

Buckner, J.L.; Landers, J.L. Fire and discing effects on herbaceous food plants and seed supplies. J. Wildl. Manage. 43(3):807-811; 1979.

Busing, R.T.; Clebsch, E.E.C. Species composition and species richness in first-year old fields: Responses to season of soil disturbance. Bull. Torrey Botan. Club 110(3):304-310; 1983.

Cady, A.B.; Tietjen, W.J.; Uetz, G.W. The "edge effect" in Schizocosa ocreata (Araneae: Lycosidae): A reassessment. Psyche 87:231-234; 1980.

Capen, D.E., editor. The use of multivariate statistics in studies of wildlife habitat. U.S.D.A. Forest Service General Technical Report RM-87; 1981.

Clark, L.R.; Geier, P.W.; Hughes, R.D.; Morris, R.F. The ecology of insect populations in theory and practice. London: Methuen & Co. Ltd.; 1967.

Cody, M.L. On the methods of resource division in grassland bird communities. Am. Nat. 102(924):107-147; 1968.

Dawe, N.K.; White, E.R. Some aspects of the vegetation ecology of the Little Qualicum River estuary, British Columbia. Can. J. Bot. 60(8):1447-1460; 1982.

Derdeyn, C.H. Manipulating central Oklahoma rangeland vegetation for bobwhite quail. U.S.A.: Oklahoma State University; 1975. Thesis. Cited In: Webb and Guthery, 1983.

Dritschilo, W.; Erwin, T.L. Responses in abundance and diversity of cornfield carabid communities to differences in farm practices. Ecology 63(4): 900-904; 1982.

Everitt, B.S.; Dunn, G. Advanced methods of data exploration and modelling. London: Heinmann Educational Books; 1983.

Freethy, R. Swallows feeding on rising ants. Br. Birds 75(8):379; 1982.

Gates, J.E.; Mosher, J.A. A functional approach to estimating habitat edge width for birds. Am. Midl. Nat. 105(1):189-192; 1981.

Gilkey, H.M.; Dennis, L.J. Handbook of northwestern plants. Corvallis, Ore.: Oregon State University Bookstores, Inc.; 1980.

Godfrey, W.E. The birds of Canada. National Museums of Canada Bull. No. 203, Biological Series No. 73; 1966.

Grzybowski,J.A. Population structure in grassland bird communities during winter. Condor 84(2)137-152; 1982.

_______________ Patterns of space use in grassland bird communities during winter. Wilson Bull. 95(4): 591-602; 1983.

Guiguet, C.J. The birds of British Columbia: (4) Upland game birds. British Columbia Provincial Museum Handb. No. 10; 1955.

_______________ The birds of British Columbia: (8) Chickadees, thrushes, kinglets, pippets, waxwings and shrikes. British Columbia Provincial Museum Handb. No. 22; 1964.

_______________ The birds of British Columbia: (10) Goatsuckers, swifts, hummingbirds and swallows. British Columbia Provincial Museum Handb. No. 37; 1978.

_______________ The birds of British Columbia: (11) Sparrows and finches. British Columbia Provincial Museum Handb. No. 42; 1983.

Hewitt, G.B.; Bureleson, W.H. An inventory of arthropods from three rangeland sites in central Montana. J. Range Manage. 29(3):232-237; 1976.

Hitchcock, C.L.; Cronquist, A. Flora of the Pacific Northwest. Seattle: University of Washington Press; 1973.

Hodkinson, I.D.; Hughes, M.K. Insect herbivory. London: Chapman and Hall; 1982.

Holroyd, G.L. Foraging strategies and food of a swallow-guild. Canada: University of Toronto; 1983. Thesis. In: Diss. Abstr. Int. Eng. B 44(9):2641; 1984. (Abstract only).

Howard, D.J.; Harrison, R.G. Habitat segregation in ground crickets: Experimental studies of adult survival, reproductive success and oviposition preference. Ecology 65(1):61-68; 1984.

Hubbard, W.A. The grasses of British Columbia. British Columbia Provincial Museum Handb. No. 9; 1969.

Jackson, A.S. Quail management handook for West Texas rolling plains. Texas Parks and Wildl. Bull. 48; 1969. Cited In: Webb and Guthery, 1983.

Joern, A. Feeding patterns in grasshoppers (Orthoptera: Acridideae): Factors influencing diet specialization. Oecologia (Berl.) 38:325-347; 1979.

__________ Vegetation structure and microhabitat selection in grasshoppers (Orthoptera, Acrididae). Southwest. Nat. 27(2):197-209; 1982

Johnston, D.W.; Odum, E.P. Breeding bird populations in relation to plant succession on the piedmant of Georgia. Ecology 37(1):50-62;1956.

Karr, J.R. Habitat and avian diversity on strip-mined land in east-central Illinois. Condor 70:348-357; 1967.

__________ Rationale and techniques for sampling avian habitats: Introduction. Capen, 1981 (26-28).

Karr, J.R.; Roth, R.R. Vegetation structure and avian diversity in several new world areas. Am. Nat. 105(945):423-435; 1971.

Keever, C. A retrospective view of old-field succession after 35 years. Am. Midl. Nat. 110(2)397-404; 1983.

Kendeigh, S.C. Bird populations and biotic communities in northern Lower Michigan. Ecology 29(1):101-114; 1948.

Kozloff, E.N. Plants and animals of the Pacific Northwest. Seattle: University of Washington Press; 1976.

Lanyon, W.E. Breeding birds and old field succession on Long Island farmland. Bull. Am. Museum Nat. Hist. 168(1):1-60;1981.

Lavigne, R.J.; Campion, M.K. The effect of ecosystem stress on the abundance and biomass of Carabidae (Coleoptera) on the shortgrass prarie. Environ. Entomol. 7(1):88-92; 1978.

Lewke, R.E. A comparison of foraging behaviour among permanent, summer and winter resident bird groups. Condor 84:84-90; 1982.

MacArthur, R.H.; MacArthur, J.W. On bird species diversity. Ecology 42(3):594-598; 1961.

May, P.G. Secondary succession and breeding bird community structure: Patterns of resource utilization. Oecologia (Berl.) 55(2):208-216; 1982.

Milne, L.; Milne, M. The Audubon Society field guide to North American insects and spiders. New York: Alfred A. Knopf; 1980.

Mitchell, M.J. Breeding bird populations in relation to grassland succession on the Anoka sand plain. Flicker 33:102-108; 1961.

Moller, A.P. Changes in Danish farmland habitats and their populations of breeding birds. Holarctic Ecol. 6:95-100; 1983.

Morgan, K.A.; Gates, J.E. Bird population patterns in forest edge and strip vegetation at Remington Farms, Maryland. J. Wildl. Manage. 46(4):933-944; 1982.

Mueller-Dombois, D.; Ellenberg, H. Aims and methods of vegetation ecology. New York: John Wiley and Sons; 1974.

Mulligan, G.A. Common weeds of Canada. Ottawa: McClelland and Stewart; 1978.

Murdoch, W.W.; Evans, F.C.; Peterson, C.H. Diversity and pattern in plants and insects. Ecology 53(5): 819-829; 1972.

Orloci, L. Multivariate analysis in vegetation research. The Hague: Dr. W. Junk b.v.; 1978.

Owens, R.A.; Myres, M.T. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51: 697-713; 1973.

Partridge, L. Habitat selection. In: Krebs, J.R.; Davies, N.B., eds. Behavioral ecology: An evolutionary approach. Oxford: Blackwell Scientific Publications; 1978:351-376

Paszowski, C.A. Vegetation, ground, and the frugivorous foraging of the American Robin. Auk 99:701-709; 1982.

Pathak, M.D. Utilization of insect-plant interactions in pest control. In: Pimentel, D., ed. Insects, science and society. New York: Academic Press, Inc.; 1975:121-148.

Pimentel, R.A. Morphometrics: The multivariate analysis of biological data. Dubuque, IO: Kendall/Hunt Pulbishing Company; 1979.

Poore, M.E.D. The use of phytosociological methods in ecological investigations: I. The Braun-Blanquet system. J. Ecol. 43:226-245; 1955.

Pulliam, H.R. Ecological community theory and the coexistence of sparrows. Ecology 64(1):45-52; 1983.

Rice, J.; Ohmart, R.D.; Anderson, B.W. Habitat selection attributes of an avian community: A discriminant analysis investigation. Ecol. Monogr. 53(3): 263-290; 1983.

Rotenberry, J.T. Why measure bird habitat? Capen, 1981 (29-32).

________________ Vegetation structure, plant species composition and habitat selection by birds. Ohio J. Sci. 83(2):89; 1983. (Abstract only).

Rotenberry, J.T.; Wiens, J.A. Habitat structure, patchiness, and avian communities in North American steppe vegetation: A multivariate analysis. Ecology 61:1228-1250; 1980.

Salt, W.R.; Wick, A.L. The birds of Alberta. Edmonton: Alberta Dept. of Industry and Development; 1966.

Schaefer, M.; Haas, L. (Studies on the effects of mowing on the arthropod fauna of a meadow.)/Untersuchungen zum Einfluss der Mahd auf die Arthropoden-fauna einer Bergwiese. Drosera 1:17-40; 1979. In: Entomology Abstracts 1980, 1123-E11. (Abstract only).

Schoener, T.W. Resource partitioning in ecological communities. Science 185:27-39; 1974.

Shugart, H.H., Jr.; James, D. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77; 1973.

Skinner, R.M. Grassland use patterns and prarie bird populations in Missouri. In: Wali, M.K., ed. Prarie - A multiple view. Grand Forks, ND: University of North Dakota Press; 1974:171-180.

__________ Vegetation and bird habitat selection on Missouri praries. U.S.A.: University of Missouri; 1982. Thesis. In: Diss. Abstr. Int. Eng. B 44(9):2609; 1984. (Abstract only).

Stinner, R.E.; Regniere, J.; Wilson, K. Differential effects of agroecosystem structure on dynamics of three soybean herbivores. Environ. Entomol. 11(3):538-543; 1982.

Turner, A.K. Optimal foraging by the swallow (Hirundo rustica, L.): Prey size selection. Anim. Behav. 30:862-872; 1982.

Turrentine, J.M. The ecology of bobwhite quail in aerially sprayed sand shinnery oak habitat. U.S.A.: Texas Tech Univ; 1971. Thesis. Cited In: Webb and Guthery; 1983.

Tye, A. Ground-feeding methods and niche separation in thrushes. Wilson Bull. 93(1):112-114; 1981.

Warner, R.E.; Etter, S.L.; Joselyn, G.B.; Ellis, J.A. Declining survival of ring-necked pheasant chicks in Illinois agricultural ecosystems. J. Wildl. Manage. 48(1):82-88; 1983.

Webb, W.M.; Guthery, F.S. Response of Wildlife food plants to spring discing of mesquite rangeland in northwest Texas. J. Range Manage. 36(3):351-353; 1983.

Welty, J.C. The life of birds. 2nd ed. Philadelphia: Saunders College Publishing; 1979.

Whittaker, R.H.; Gauch, H.G., Jr. Evaluation of ordination techniques. In: Whittaker, R.H., ed. Ordination of plant communities. The Hague: Dr. W. Junk bv Publishers; 1978:277-376.

Wiens, J.A. An approach to the study of ecological relationships among grassland birds. Ornthol. Monogr. 8:1-93; 1969.

___________ Pattern and process in grassland bird communities. Ecol. Monogr. 43:237-270; 1973.

___________ Climatic instability and the "ecoloical saturation" of bird communities in North American grasslands. Condor 76:385-400; 1974.

___________ Habitat heterogeneity and avian community structure in North American grasslands. Am. Midl. Nat. 91(1):195-213; 1974.

Wiens, J.A.; Johnston, R.F. Adaptive correlates of granivory in birds. In: Pinowski, J.; Kendeigh, S.C., eds. Granviorous birds in ecosystems. Cambridge University Press; 1977:301-340.

Yahner, R.H. Avian nest densities and nest-site selection in farmstead shelterbelts. Wilson Bull. 94(2): 156-175; 1982.

___________ Seasonal dynamics, habitat relationships, and management of avifauna in farmstead shelterbelts. J. Wildl. Manage. 47(1):85-104; 1983.

Yoakum, J.D. Habitat improvement. In: Teague, R.D.; Decker, E. Wildlife conservation: Principles and practices. Washington: The Wildlife Society; 1979:133-139.

Yoakum, J.D.; Dasmann, W.P.; Sanderson, H.R.; Nixon, C.M.; Crawford, H.S. Habitat improvement techniques. In. Schemnitz, S.D., ed. Wildlife management techniques manual. 4th ed.: Revised. Washington: The Wildlife Society; 1980:329-404.

Zar, J.H. Biostatistical analysis. Englewood Cliffs, NJ: Prentice-Hall, Inc.; 1974.

A P P E N D I X

SPECIES LIST

VEGETATION

Common Name	Scientific Name
Kentucky bluegrass	Poa pratensis
English plantain	Plantago lanceolata
wild buckwheat	Polygonum convolvulus
bentgrass	Agrostis alba
sheep sorrel	Rumex acetosella
sand spurry	Spergula arvensis
hairy cat's ear	Hypochaeris radicata
lamb's quarters	Chenopodium album
velvet-grass	Holcus lanatus
dandelion	Taraxicum officinale
white clover	Trifolium repens
cultivated vetch	Vicia sativa
dove's foot geranium	Geranium molle
bird's foot trefoil	Lotus corniculatus
red clover	Trifolium pratense
smart-weed	Polygonum persicaria
wheatgrass	Agropyron repens
wild raddish	Raphanus raphanistrum
brome grass	Bromus racemosus
cock's-foot grass	Dactylis glomerata
alfalfa	Medicago sativa
yarrow	Achillia millefolium
prickly sow-thistle	Sonchus asper
feather-moss	Stokesiella praelonga
shepherd's purse	Capsella bursa-pastoris

SPECIES LIST

INVERTEBRATES

Common Name	Scientific Name
beetle	*Pterostichus* spp.
isopod	*Porcellio scaber*
earwig	*Forfecula auricularia*
spider	Family Araneidae
weevil	*Sitophilus granarius*
ant	Family Formicidae
centipede	*Scolopocryptops* spp.
circket	Family Gryllidae
grasshopper	Family Acrididae
harvestman	*Phalangium opilio*

SPECIES LIST

BIRDS

Common Name	Scientific Name
American Robin	*Turdus migratorius*
American Goldfinch	*Spinus tristis*
California Quail	*Callipepla californica*
Barn Swallow	*Hirundo rustica*
Violet-green Swallow	*Tachycineta thalassina*
House Finch	*Carpodacus mexicanus*
Ring-necked Pheasant	*Phasianus colchius*
Lincoln's Sparrow	*Melospiza lincolnii*
Savannah Sparrow	*Passerculus sandwichensis*
Dark-eyed Junco	*Junco hyemalis*
Song Sparrow	*Melospiza melodia*