BIRD DIVERSITY, DENSITY, AND HABITAT SELECTION IN THE CARIBOO-CHILCOTIN GRASSLANDS: WITH EMPHASIS ON THE LONG-BILLED CURLEW

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ABSTRACT

Grassland bird diversity, density, and habitat selection in the Cariboo/Chilcotin grasslands were examined. A modified spot-mapping technique was used to census Long-billed Curlews; point counts and spot-mapping plots were used to census other grassland birds. Point count and spot-mapping techniques were analyzed to determine the most effective method for censusing grassland birds. Bird habitat was characterized by vegetation structure and insect availability. Insects were collected by pan, pitfall, and sticky traps to assess the most effective trapping method for grassland insects. The population of Long-billed Curlews throughout the area from Redstone to Soda Creek to 148 Mile House to Gang Ranch was conservatively estimated at 150 individuals. Densities of curlews ranged from one pair/47.9-470 ha. Point counts and spot-mappings revealed five species of birds common in the grasslands - Horned Lark (*Eremophila alpestris*), Long-billed Curlew (*Numenius americanus*), Vesper Sparrow (*Pooecetes gramineus*), Savannah Sparrow (*Passerculus sandwichensis*), and Western Meadowlark (*Sturnella neglecta*). Another nine species were less common. Densities of grassland birds ranged from 0.34-0.92 pairs/ha. Spot-mapping was the most effective method for estimating densities of grassland birds; point counts were best for determining numbers of species present and for sampling large areas. A 12 minute, 100 m radius point count was suitable for censusing all grassland bird species except the Long-billed Curlew. Correlations between bird and vegetation data indicated Vesper Sparrows were positively associated with shrubs, Long-billed Curlews with short, less dense vegetation, Horned Larks with dense vegetation, and Savannah Sparrows and Western Meadowlarks with tall, dense vegetation. Pan traps were the most effective method for collecting grassland insects. More insect sampling over a wider area and longer time period is needed to determine if food availability affects grassland bird distribution. Management guidelines should consider habitat requirements for all grassland bird species, and monitoring of grazing impacts, forest encroachment, and crop cultivation on grassland bird habitat is needed.

RESUME

Nous avons étudié l'abondance et la diversité avienne, de même que l'utilisation de l'habitat dans les prairies de la région du Cariboo Chilcotin en Colombie-Britannique. Le Courlis à long bec (*Numenius americanus*) fut dénombré selon une modification de la technique des plans quadrillés. Les autres espèces furent dénombrées à l'aide de la technique des plans quadrillés et celle des points d'écoute à rayon fixe. Nous avons comparé l'efficacité de ces deux techniques. L'habitat fut caractérisé en quantifiant la structure de la végétation et l'abondance des insectes. Nous avons comparé le rendement de trois types de trappes (piège à eau savonneuse, fosses et plaques gluantes) pour la capture d'insectes. Une population de 150 Courlis à long bec fut estimée pour la région comprise entre Redstone, Soda Creek, 148 Mile House et Gang Ranch. La densité de Courlis à long bec a varie de un couple/47.9ha à un couple/470ha. Cinq espèces d'oiseaux furent identifiées comme abondantes dans les prairies de la zone d'étude: L'Allouette cornue (*Eremophila alpentris*), le Courlis à long bec, le Bruant vespéral (*Poocetes gramineus*), le Bruant des prés (*Passerculus sandwichensis*) et la Sturnelle de l'ouest (*Sturnella neglecta*). Neuf autres espèces étaient présentes en petits nombres. La densité d'oiseaux a varié entre 0.34 et 0.92 couples/ha. La méthode des plans quadrillés s'est avérée meilleure pour estimer la densité d'oiseaux, alors que celle des points d'écoute s'est averée plus efficace pour déterminer le nombre d'espèces présentes. A même effort, cette dernière méthode permet de couvrir un plus grand territoire. Des stations d'écoute d'une durée de 12 min et d'un rayon de 100m se sont avérées adéquates pour dénombrer toutes les espèces d'oiseaux sauf le Courlis à long bec. L'abondance du Bruant vespéral était correlée de façon positive avec l'abondance de buissons, celle du Courlis à long bec avec la végetation courte et éparse, celle de l'Alouette cornue avec la végétation haute et dense. La technique la plus efficace pour la récolte d'insectes fut celle du piège à eau savonneuse. Un échantillonnage plus intense des insectes est nécessaire avant de pouvoir déterminer si leur abondance affecte la distribution des oiseaux dans les prairies. Les recommendations d'aménagement devraient considérer les besoins de toutes les espèces d'oiseaux fréquentant les prairies. Nous avons besoin de quantifier l'impact du broutage, l'envahissement de la forêt et de l'agriculture sur l'habitat des oiseaux associés aux prairies naturelles.

ACKNOWLEDGEMENTS

We wish to thank Harold Armleder and Brian Nyberg for their advice and their technical and logistic support throughout this project. Fred Knezevich also provided much appreciated technical advice. Thanks go to Anna Roberts, Gina Roberts, Wayne Campbell, and the Williams Lake Naturalist club for sharing their wealth of knowledge about the natural history of the study area. Additional information was provided by Ed Houeck of Ducks Unlimited. Todd Mahon, Colleen Bryden, and Barry Forer provided professional and dedicated field assistance. Forestry Canada provided accommodation for the field crew. And finally, special thanks go to Chief Francis Laceese of the Toosey Indian Band, and the local ranchers - Lynn Bonner, the Durrell family, Grant Huffman, Neil and Kerry McDonald, Doug and Marie Mervyn, and Ron and Stephanie Thomson for permission to do our research on their lands.

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1 INTRODUCTION

Birds are a conspicuous element of grassland ecosystems (Wiens 1973). Many grasslands, however, have been severely abused on a scale that exceeds that of other major ecosystems (Graul 1980). In the Great Plains, 85% of the bluestem prairie, 65% of bluestem-grama, and 45% of grama-buffalo grass has already been destroyed. In comparison, for western forest types, only 1% of juniper-pinyon, 5% of Black Hills pine forest, and 3% of western ponderosa pine forests has been lost (Klopatek et al. 1979). In the Canadian prairies, 76% of mixed grassland, 90% of fescue grassland, and more than 99% of the tall-grass prairies has been lost (World Wildlife Fund Canada 1988). Despite this habitat alteration, and that the British Columbia Ministry of Environment and Ministry of Forests have a common goal of preserving biodiversity in this province, no detailed studies of grassland avifauna are available for British Columbia. Although grassland bird species have been identified, few quantitative data are available regarding grassland bird diversity and density, habitat preferences, or habitat requirements.

The Long-billed Curlew (*Numenius americanus*) is a species commonly associated with grassland habitats. This large shorebird winters on the coast of North, Central, and northern South America, but breeds in interior grasslands of North America (Terres 1980). Agricultural and urban expansion into native grasslands threatens curlew breeding grounds throughout North America (DeSmet 1989). In Canada, Long-billed Curlew populations have decreased to levels that have caused concern for the long-term survival of this species (DeSmet 1989). Although some surveys of Long-billed Curlews have been done in the Kootenays and on the Junction near Williams Lake (Ohanjanian 1985, 1986, 1987), no detailed information on habitat preferences or ecological relationships of Long-billed Curlews in British Columbia exists.

Bird diversity and density in any ecosystem is often positively correlated with vegetation complexity (Roth 1977; Cody 1985). Vegetation structure is considered to be the most important

factor affecting grassland bird distribution (Tester and Marshall 1961; Hilden 1965; Wiens 1969; Whittaker and Woodwell 1972; Cody 1985). The most important components of vegetation structure for grassland birds are grass height and/or density (Cody 1966; Creighton 1974; Ohanjanian 1985), litter and vegetation patchiness (Wiens 1969, 1973, 1974a, 1974b; 1976; Wiens and Dyer 1975), and amount of ground and shrub cover (Bock et al. 1984). Bird diversity however, is also affected by food availability (Wiens 1974b). Grassland birds are omnivorous, but during the breeding season, insects form the bulk of the diet (Wiens 1973; Rotenberry and Wiens 1978; Cody 1985). Few studies of grassland birds have examined the effect of both vegetation structure and insect availability on bird diversity and density. Many studies have also failed to consider the effects of climatic patterns, or duration, season, and intensity of livestock grazing on grassland bird communities.

This report provides information on grassland bird diversity and density in the Cariboo/Chilcotin region. Special emphasis is placed on determining the density and distribution of Long-billed Curlews throughout the region. This report also characterizes grassland bird habitat primarily by vegetation structure and insect availability. Only breeding birds are considered since British Columbia's grasslands, in general, offer too little food and shelter to support a winter bird community (Cannings et al. 1987). This report also assesses the effectiveness of two different bird count techniques - point counts and spot-mapping, in measuring grassland bird diversity and density. Three different insect sampling methods - pitfall, pan, and sticky traps, are tested to determine the most effective means of collecting grassland insects. Insect abundance in different grasslands is then analyzed to determine if food availability affects Long-billed Curlew distribution. All field work for this report was done between April 23 and June 27, 1990. Recommendations are made for further research on grassland birds.

2 MATERIALS AND METHODS

2.1 Site Description

The study area was centered around Williams Lake (Lat. 52°13" N, Long. 122°10"W) in the Cariboo/Chilcotin region of British Columbia (Fig. 1) and included grasslands associated with the Fraser River Basin, within an area bounded approximately by Alexis Creek, Soda Creek, 148 Mile House, and Gang Ranch (Fig. 2). All grassland areas studied were accessible by vehicle.

The study area is within the Chilcotin-Cariboo Basin Ecosection and the Interior Douglas Fir/Bunchgrass biogeoclimatc zones (Fig. 3).

2.2 Long-billed Curlew Surveys

To determine the distribution of Long-billed Curlews throughout the study area, records from the William's Lake Naturalist's club and the Royal British Columbia Museum's sight record and nest record files were examined. Areas for which records existed were surveyed by driving along public and private roads and noting the number and location of curlews observed. Areas which had suitable habitat but no previous records of Long-billed Curlews were also surveyed. Surveys were made from April 23 to June 27.

A modification of the spot-mapping technique (Williams 1936, Robbins 1970) was used to assess curlew breeding density in four different grassland areas (Fig. 4). Within each grassland, the number and sex (when discernible) of Long-billed Curlews was recorded (see Allen 1980). Each site was surveyed at least three times. The repeated surveys documented locations of individual breeding territories. Breeding curlew density within a grassland was determined as the number of territories divided by total grassland area. Densities were compared to those found by Ohanjanian in 1987 (see Ohanjanian 1987).

Figure 1. Location of study area within the province.

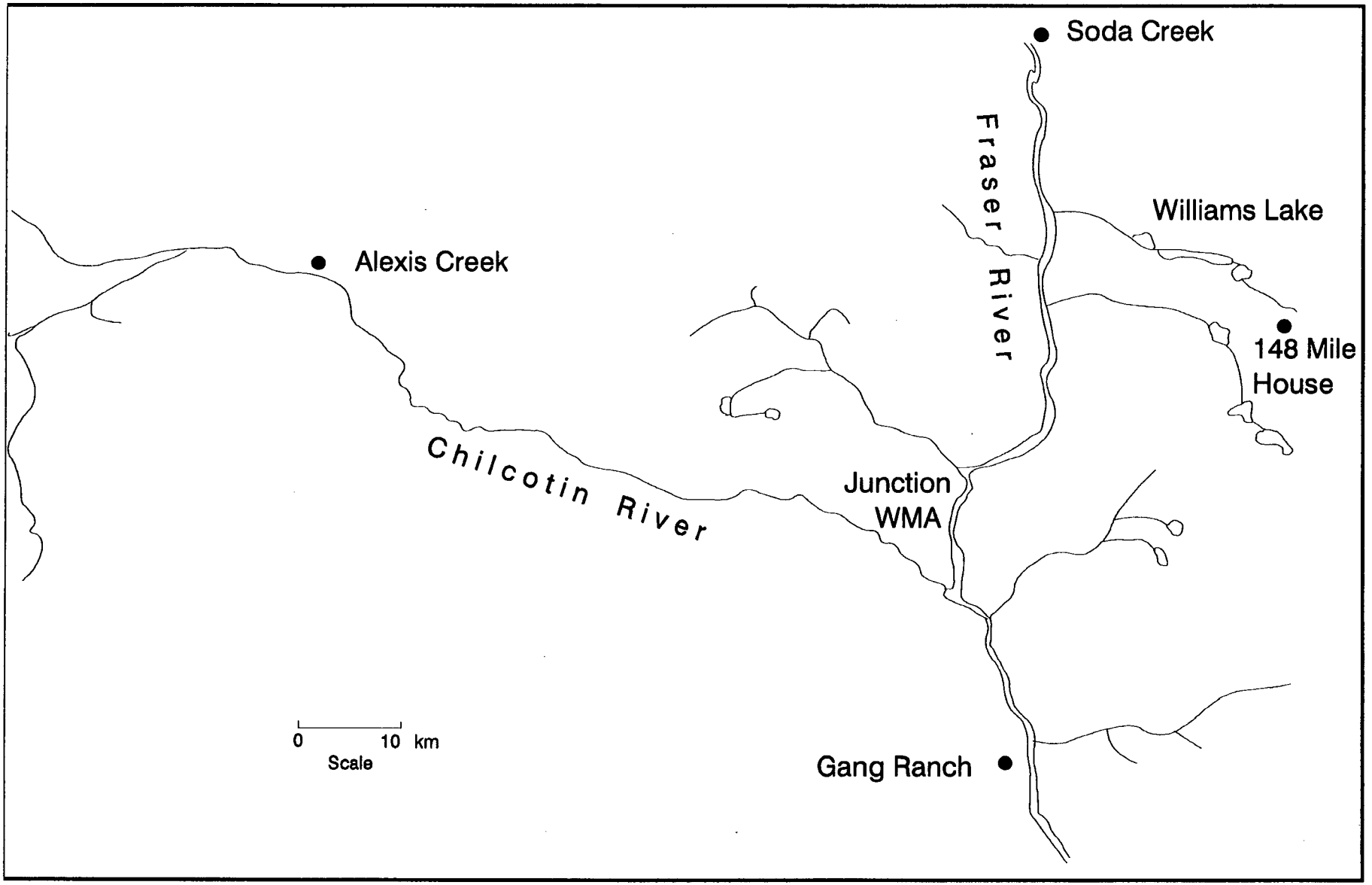


Figure 2. Location of study area.

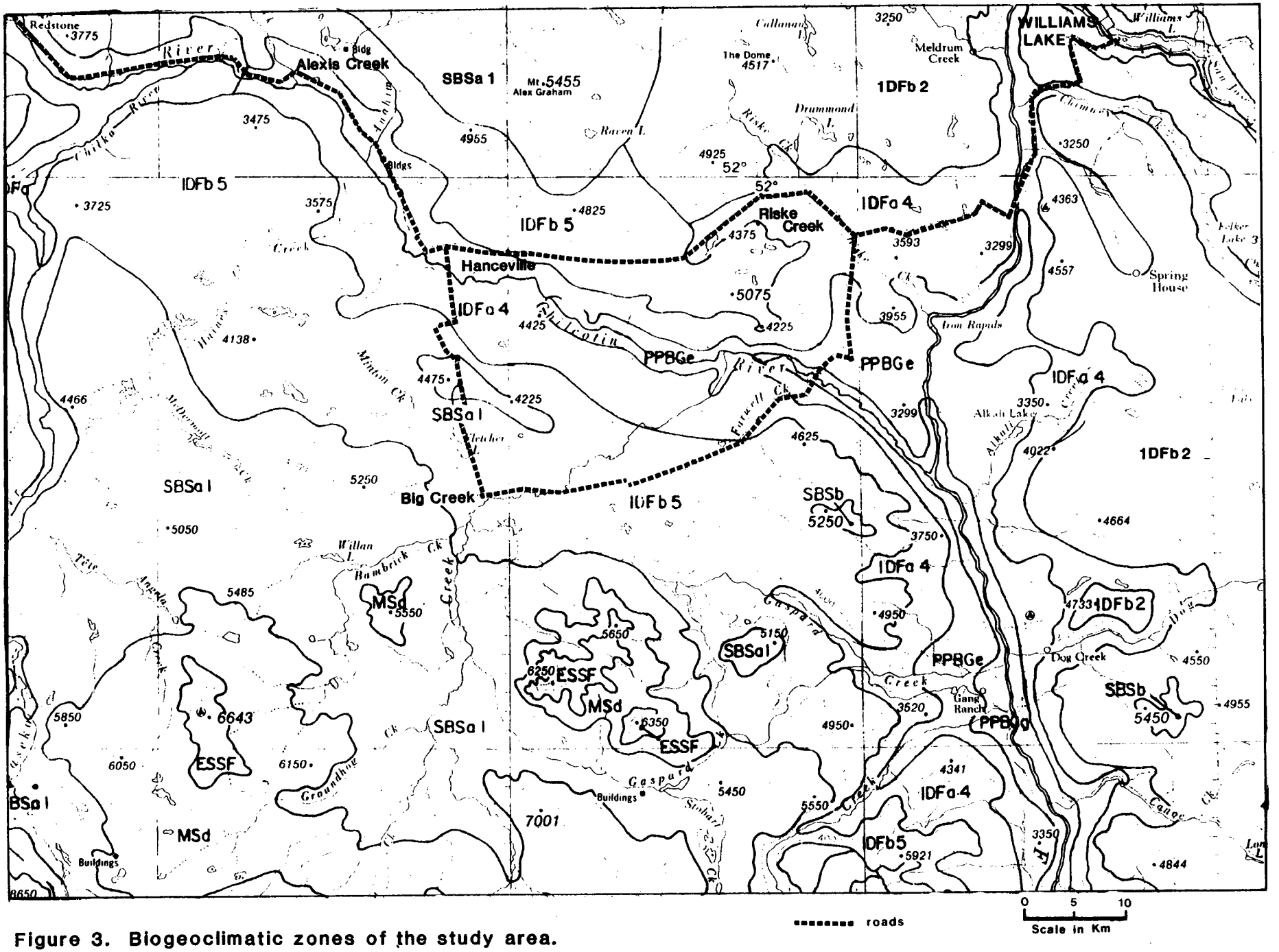


Figure 3. Biogeoclimatic zones of the study area.

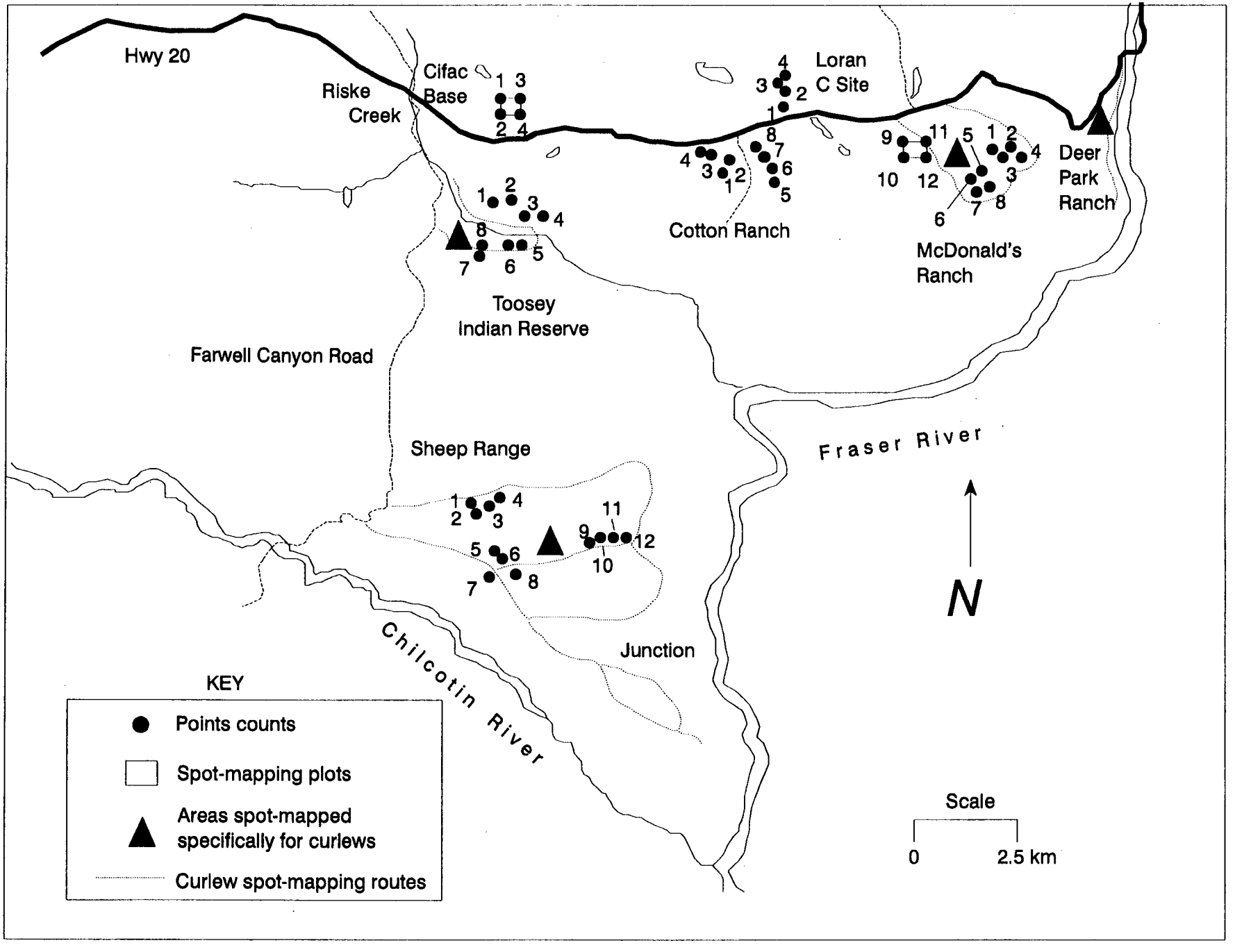


Figure 4. Locations of spot-mapping routes, point counts and spot-mapping plots within study area.

2.3 Grassland Bird Counts

Bird density and diversity was measured by both the point count and spot-mapping methods. Points had a radius of 100 m and were placed at least 300 m apart as measured from the centre of each point. Counts were made for three consecutive four minute periods at each point (12 minutes total per point) and the distance of all bird detections from the centre of the point was recorded. Forty-eight points were established throughout 12 different grassland areas (Fig. 4). Four points (numbered 1-4) were at each of the Cifac Base and Loran C sites, eight points (numbered 1-4, 5-8) were in two different fields at each of the Toosey Indian Reserve and Cotton Ranch, and 12 points (numbered 1-4, 5-8, 9-12) were in three different fields at each of McDonald's Ranch and the Sheep Range. Points were deliberately placed so as to avoid edge effect from fencelines, crop fields, woodlands, forests, dense shrubbery, and wetlands in an attempt to identify those species restricted primarily to grassland habitats. Each point was censused on four different mornings between 05:30 and 10:00 a.m. from May 8 to June 17. The effect of count duration, number of counts, and point radius on the number and species of birds detected was analyzed. Unless indicated otherwise, the total number of detections of birds over the 48 points was compared within and between species to determine if bird communities differed between grasslands.

Spot-mapping was used on one plot at the Cifac Base and on one plot at McDonald's Ranch (Fig. 4). (Four points at each of these sites were located at the corners of the spot-mapping plots). Plots were 25 ha (500x500 m) and each plot was censused eight times between May 10 and June 20. Most censuses were done between 05:30 and 10:00 a.m. One census was done at each plot from 6:00-9:00 p.m. to determine if counts should be done at various times of day. These evening censuses proved too unproductive though, to continue using.

Standards that have been established for breeding bird censuses recommend using 40-100 ha spot-mapping plots in grasslands (Svenson 1970, Cornell Lab. Ornith. 1989). Most grasslands in the

study area, however, are not large enough to accommodate this size plot without also including edge habitat. Twenty-five ha plots, therefore, seemed appropriate for this study area.

Results from the point counts and spot-mappings were examined to determine the most effective means of counting grassland birds.

2.4 Vegetation Sampling

To determine the vegetation structure of areas used by grassland birds, sampling was done from June 14-26 in the 12 grasslands censused by the point count method (see Fig. 4). A 20x 50 cm Daubenmire frame was used to determine % canopy cover of grasses, forbs, shrubs, trees, bryophytes, rocks, bare soil, litter, and feces within each sample (F. Knezevich; H. Armleder pers. comm., June 1990). Maximum height and modal height (height at which vegetation was the densest) of vegetation was also measured. Vertical density of vegetation was measured using a 30x 50 cm vision board. Measurements were made at 5, 10, and 20 m from the board at the approximated height of a curlew's eyes - 30 cm (Bicak et al. 1982). Five vegetation samples were taken in the general area around each of the points censused for birds (240 samples total). A random numbers table was used to locate sampling points around point count locations.

Time constraints prevented the collection of details on cattle grazing history and pressure from local ranchers for the grasslands studied. It may be possible to collect this information during the next field season. If so, associations between grazing pressure and vegetation data collected in this study, could then be determined. Results of cattle grazing/bird community studies however, are outlined in the discussion.

2.5 Insect Sampling

Three different insect trapping methods - sticky traps, pitfall traps, and pan traps were used to determine the most effective means of collecting grassland insects and to determine insect abundance in grasslands with and without breeding Long-billed Curlews.

Pitfall traps were made from 35.5 ml plastic cups buried to the rim and filled 1/2-2/3 full with either non-toxic antifreeze, or water and dishwashing detergent. A 30.5x30.5 cm board held up 2.5 cm over the top of the trap acted as a lid to keep out rainwater and to prevent interference from cattle. Lids were held in place by 15 cm spikes driven into the ground (Fig. 5a). Insects were removed from the traps by filtering the contents through a food strainer lined with a coffee filter. Liquid contents were put back in the traps and replenished, if necessary.

Pan traps were made from 23x23x4 cm cake pans buried to the rim and filled 1/2-2/3 full with water and dishwashing detergent. A 30.5x30.5 cm board was placed at approximately a 45 degree angle over the pan (Fig. 5b). Insects were removed from the traps by filtering the contents through a food strainer lined with a coffee filter. Liquid contents were put back in the traps and replenished, if necessary. Pan traps catch surface crawling insects, and flying insects that are blown onto the water surface.

Sticky traps were made from 30.5x33 cm pieces of plywood coated with tanglefoot. A 2.5x2.5x33 cm piece of wood was used to separate this bottom board from an upper board used to protect the traps from cattle. The traps were held in position on the ground with a 15 cm spike (Fig. 5c). Insects were collected from the traps with a probe and were stored on pieces of paper.

Ten traps of each type (30 traps total) were placed in six different grassland areas (Fig. 6) from June 4-21. Traps were placed in grasslands with and without breeding Long-billed Curlews to determine if availability of food resources influences curlew distribution. Areas with breeding curlews were the Cifac plot and Cotton and McDonald's Ranches around point counts #1-4; non-breeding areas were the Loran plot and Cotton and McDonald's Ranches around point counts #5-8. Two traps of each type were placed at the Cotton and McDonald's sites: one trap of each type

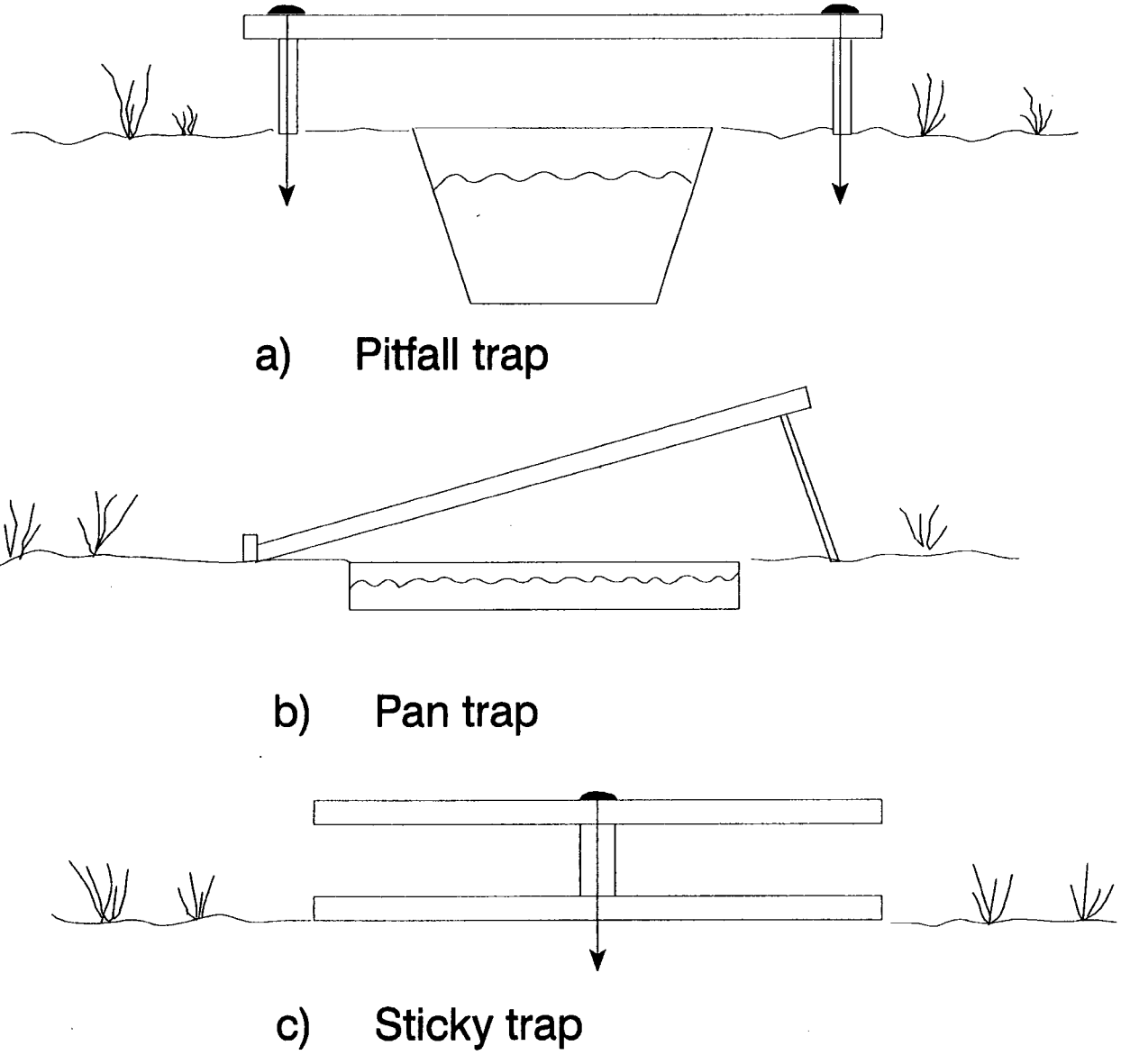


Figure 5. Insect trap types.

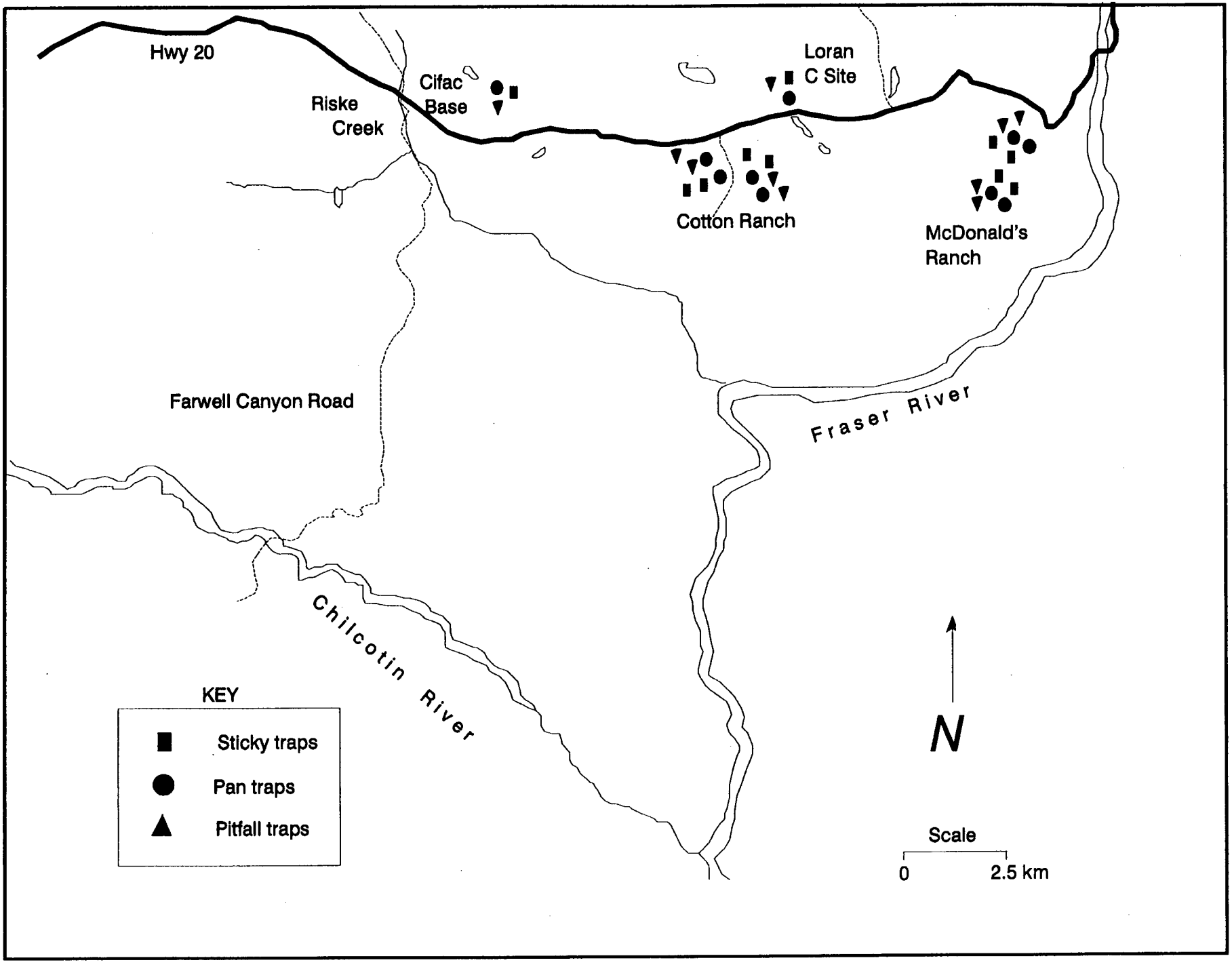


Figure 6. Location of insect traps within study area.

was placed at the Cifac and Loran sites. Insects were collected every three to four days. An error in judgement resulted in the pooling of insects collected by similar trap types in those grasslands with two of each trap type. This created difficulties in calculating statistics, hence, total numbers of insects were used in comparisons between trap types and between areas with and without breeding curlews.

Due to time constraints and inexperience of the researchers with insect taxonomy, insects were identified by the following broad groupings: large or small flies; large or small bees; large or small moths; large or small ants; large, medium, or small beetles; large, medium or small grasshoppers; large, medium, or small spiders; other. These groupings were chosen because grasshoppers, ants, beetles, bugs, butterfly and moth larvae, and spiders are the most common prey items of breeding grassland birds (Rotenberry and Wiens 1978; Cody 1985; Redmond and Jenni 1985). Grasshoppers and beetles are the most common prey items of breeding Long-billed Curlews (King 1978, Redmond and Jenni 1985).

2.6 Data Analysis

Correlations were calculated to determine the relationship between bird occurrence and vegetation structure. Because the data were non-normally distributed, Spearman's rank correlations were used.

3 RESULTS

3.1 Long-billed Curlew Surveys

Records from the William's Lake Naturalists club, the Royal British Columbia Museum, and the 1990 field season located Long-billed Curlews throughout the study area from Redstone to Soda Creek to 148 Mile House to Gang Ranch (Fig. 7). The earliest and latest dates for curlew observations were March 28 and August 11

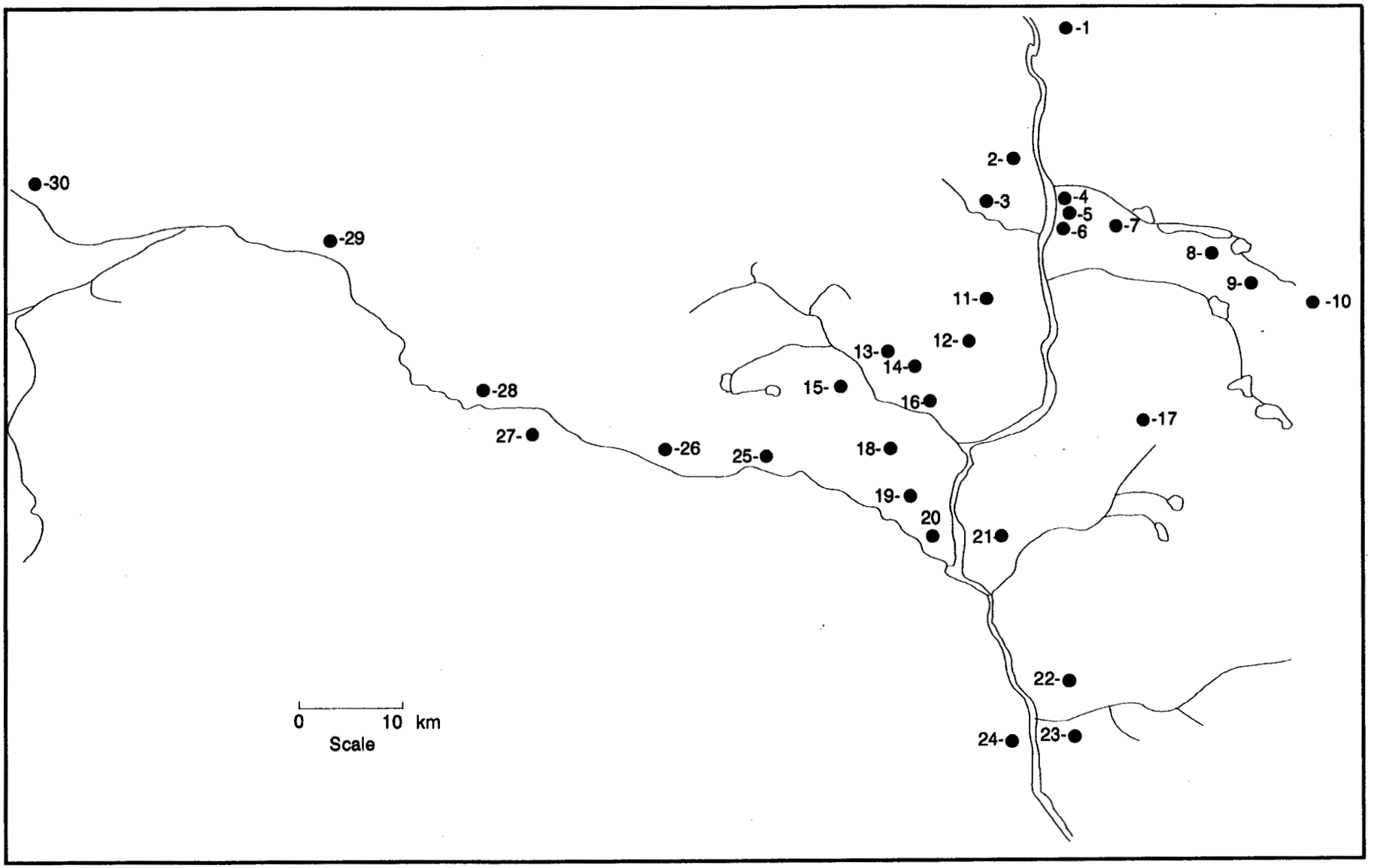


Figure 7. Long-billed Curlew sightings throughout study area.

Figure 7 (continued)

Legend

1. Soda Creek
2. Pablo Creek
3. Meldrum Creek
4. Fraser River Bridge
5. Deer Park Ranch
6. McDonald Ranch
7. Williams Lake
8. Sugar Cane Reserve
9. Cariboo Cattle Co.
10. 148 Mile House
11. Doc English Lake
12. Cotton Ranch
13. Beecher's Prairie
14. Cifac Base
15. Riske Creek
16. Toosey Reserve
17. Springhouse
18. Farwell Canyon Rd.
19. Sheep Range
20. Junction WMA
21. Alkali Lake
22. Circle S Ranch
23. Dog Creek
24. Gang Ranch
25. Wineglas Ranch
26. River Ranch
27. Chilco Ranch
28. Hanceville
29. Alexis Creek
30. Redstone

respectively (Appendix 1). The earliest nest record was May 4 (Appendix 2).

During the 1990 field season, 103 observations of curlews were made. Total number of curlews recorded was 522. Because most areas were surveyed more than once, however, the estimated number of curlews in the area is about 150. This is a conservative estimate though, since many grasslands throughout the study area were not accessible by vehicle.

Spot-mapping surveys revealed three curlew breeding territories at Deer Park Ranch (Fig. 8), nine to twelve territories at McDonald's Ranch (Fig. 9), four territories at the Toosey Indian Reserve (Fig. 10), and seven to thirteen territories at the Sheep Range/Junction area (Fig. 11). Breeding densities were 2.17 pairs/100 ha (46.13 ha/pair) at Deer Park Ranch, 1.26-1.68 pairs/100 ha (59.40-79.20 ha/pair) at McDonald's Ranch, 0.38 pairs/100 ha (272.1 ha/pair) at the Toosey Reserve, and 0.46-0.85 pairs/100 ha (118.12-219.37 ha/pair) at the Sheep Range/Junction. Numbers of territories, and thus, breeding densities were lower in 1990 than in 1987 in areas surveyed by Ohanjanian (Table 1).

3.2 Grassland Bird Counts

3.2.1 Bird Count Results

3.2.1.1 Point count results

Fourteen bird species were found within the grasslands surveyed by point counts (Table 2). Horned Larks were dominant in terms of total numbers recorded and in frequency of observations. Vesper Sparrows were the next most common species, followed by Long-billed Curlews, then Savannah Sparrows. All other species occurred in low numbers in less than five of the 48 point locations. Mountain Bluebirds and Western Meadowlarks seemed to prefer grassland edges. Because these areas were not sampled, relative abundance of these species was probably underestimated. Raw data on maximum, mean, and median counts for most common bird species at all 48 points are presented in Appendices 3, 4, and 5, respectively.

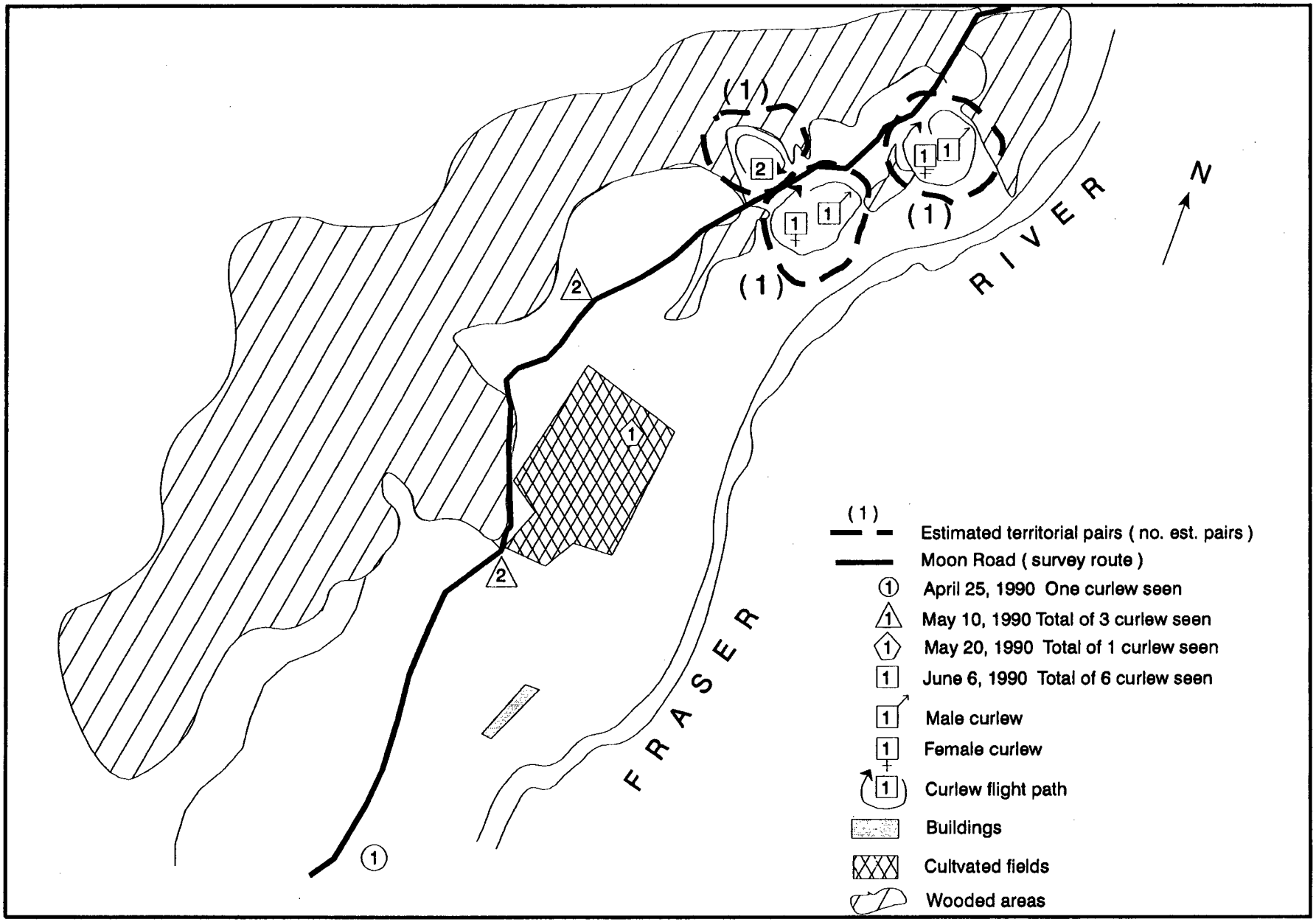


Figure 8. Deer Park Ranch curlew spot-mapping surveys.

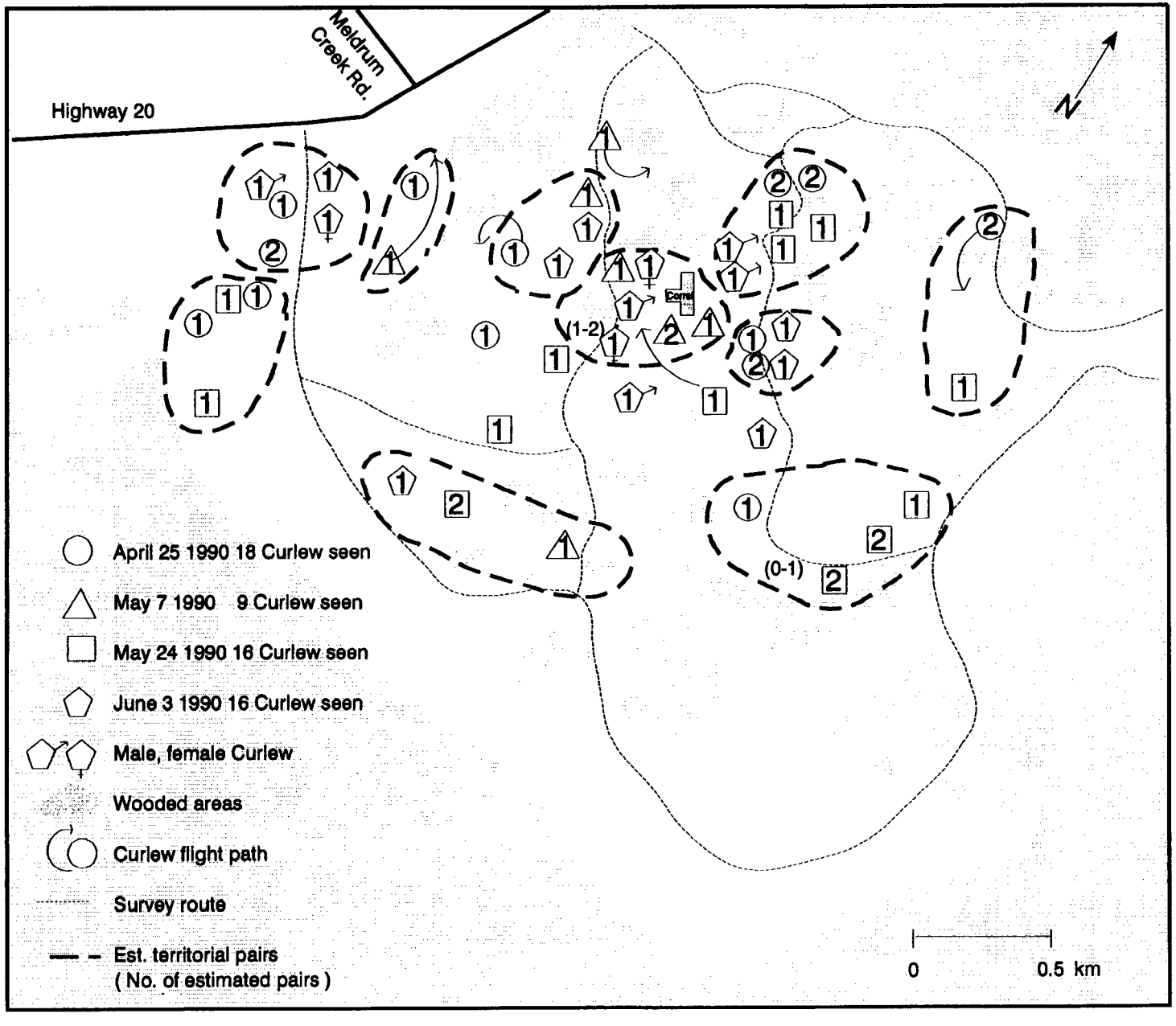


Figure 9. McDonald's Ranch curlew spot-mapping surveys.

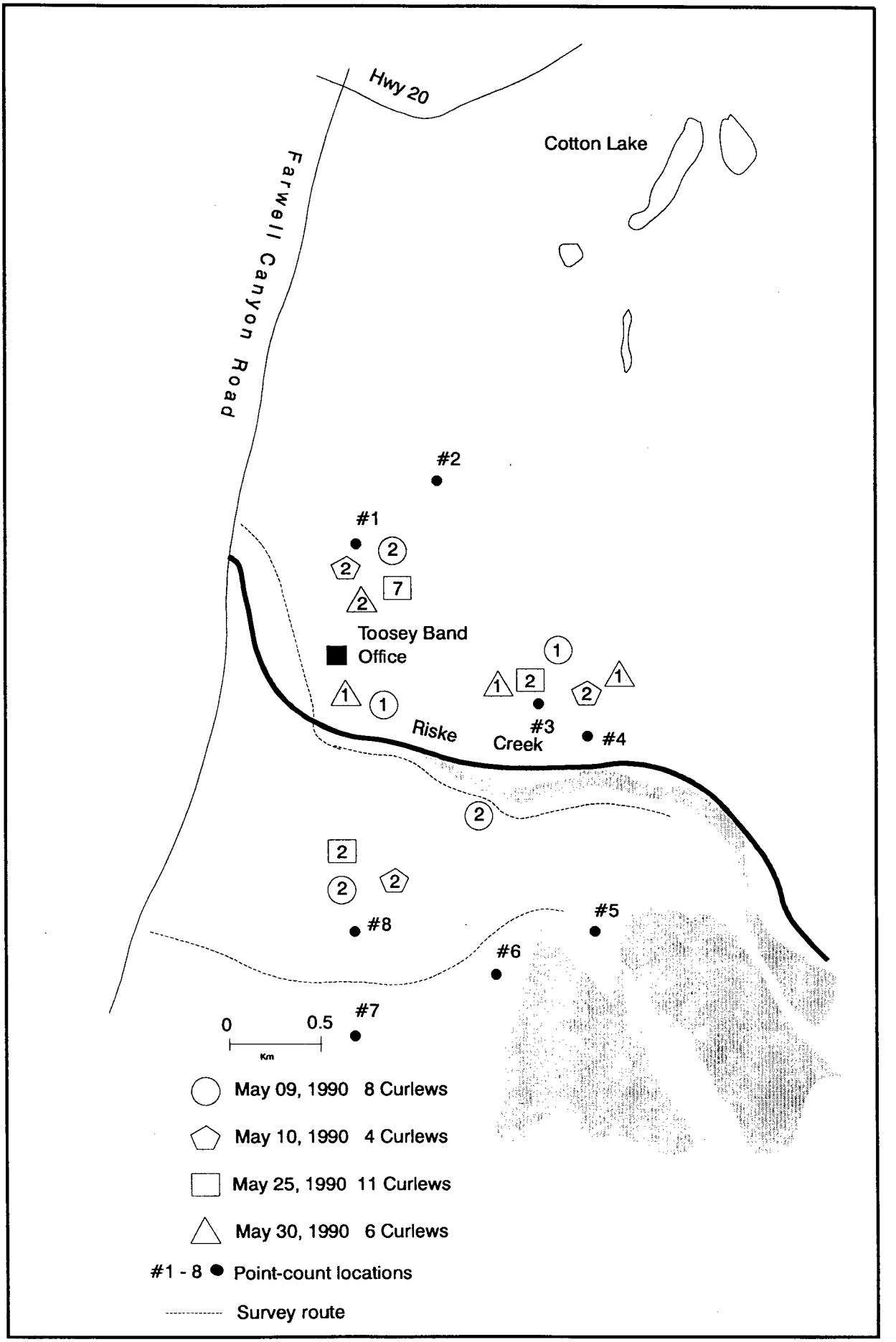


Figure 10. Toosey Indian Reserve curlew spot-mapping surveys.

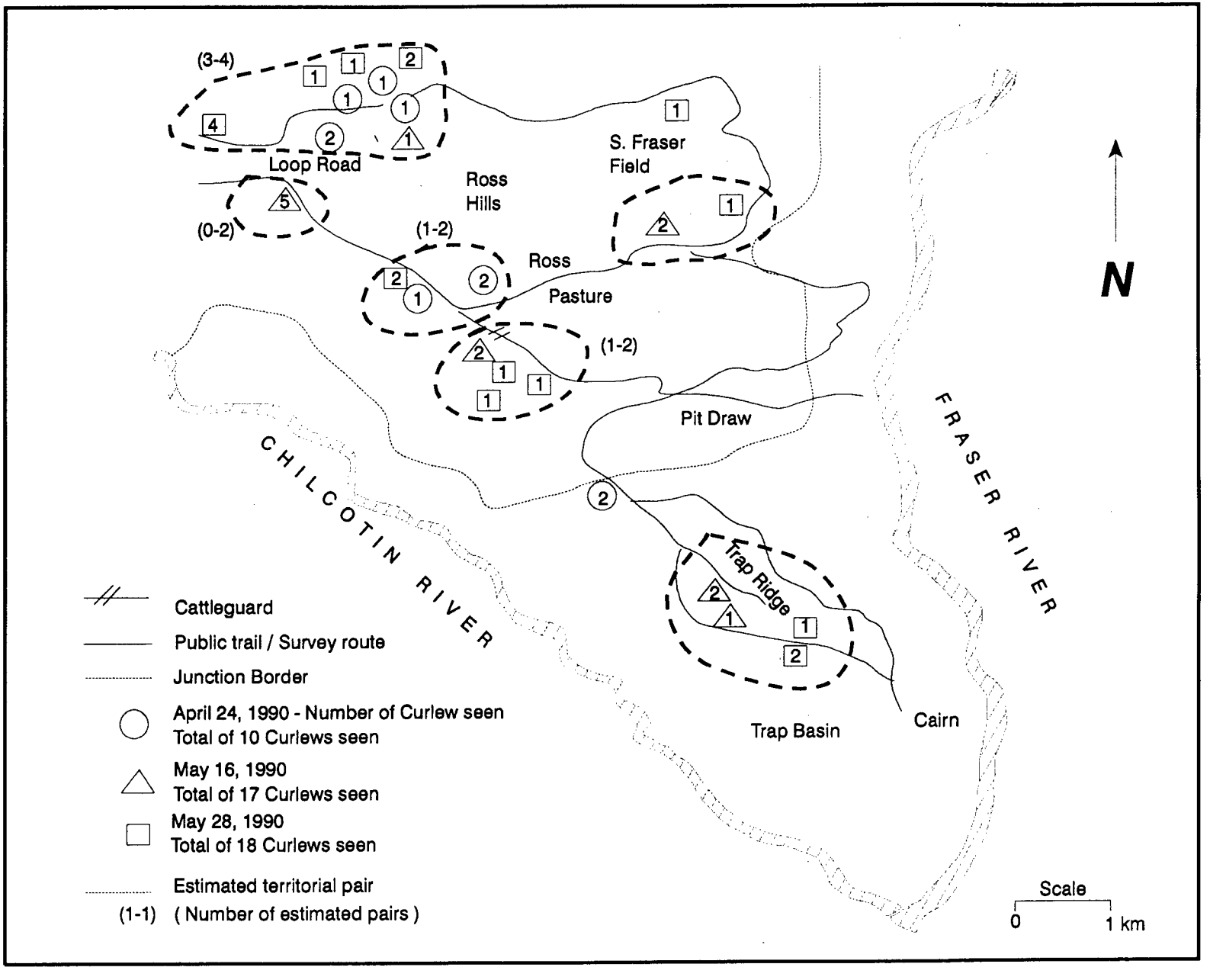


Figure 11. Sheep Range/Junction curlew spot-mapping surveys.

TABLE 1. Comparison of Long-billed Curlew breeding densities in areas surveyed in 1987[a] and 1990.

Site	Area (ha)	Year	No. Breeding Pairs	No. Pairs/ 100 ha	No. ha/ Pair
Junction	410	1990	1-2	0.2-0.5	205-410
		1987	3	0.7	136.7
Pass Pasture	474	1990	2-4	0.4-0.8	118.5-237
		1987	7-8	1.5-1.7	59.3-67.7
South Fraser Field	470	1990	1	0.2	470
		1987	10	2.1	47
McDonald's Ranch	575	1990	9-12	1.6-2.1	47.9-63.9
		1987	20	3.4	29

[a] (Ohanjanian 1987)

TABLE 2. Numbers and species of birds recorded by the point count method.

Species	Total Number Recorded	Frequency of Observation[a]	Number/ Point
Horned Lark	210	47	4.38
Vesper Sparrow	49	26	1.02
Long-billed Curlew	24	16	0.50
Savannah Sparrow	11	8	0.23
Common Raven	11	3	0.23
European Starling	8	4	0.17
Mountain Bluebird	4	3	0.08
Western Meadowlark	4	4	0.08
Brewer's Blackbird	4	1	0.08
American Crow	1	1	0.02
American Robin	1	1	0.02
Brewer's Sparrow	1	1	0.02
Killdeer	1	1	0.02
Northern Harrier	1	1	0.02
Total	330		

[a] Number of points at which species was recorded (N=48)

3.2.1.2 Spot-mapping results

Five species were recorded breeding in the Cifac plot, three were recorded in the McDonald's plot (Table 3). The most common species found were Horned Larks, followed by Vesper Sparrows, Long-billed Curlews, Western Meadowlarks, and Savannah Sparrows. Horned Larks were dominant, but densities were greater on the Cifac plot than the McDonald's plot. Vesper Sparrows and Long-billed Curlews each had similar breeding densities on both plots.

3.2.1.3 Comparison of spot-mapping and point count results

Point counts overestimated bird density when compared with spot-mapping (Table 4). The use of the median value instead of the maximum of the four counts at each point yielded estimates closer to spot mapping. Comparisons of bird density between plots were affected by the count technique used. Vesper Sparrow density was 1.15 times higher at McDonald than at Cifac within the mapping method but was 2.92 of 3.34 times higher according to the point count method (Table 4). All three techniques indicated higher densities of Horned Lark at Cifac than at McDonald but with different estimates of differences: Mapping indicating 3.30 times higher, point median 2.90 times higher and point maximum 2.00 times higher.

3.2.2 Analysis of bird count techniques

3.2.2.1 Effect of point count duration on individual count results

Count duration had a greater effect on the total number of birds than on total number of species detected within the 100 m point count radius (Figs. 12-13). There was a constant increase in total numbers of birds, but not number of species detected from four to 12 minute counts. Four and eight minute counts averaged 68±3% and 85±2% of the twelve minute counts, respectively, for total number of birds, and 84±6% and 91±3% for number of species.

There was also a constant and similar pattern of increase in numbers of birds detected for the two most common species, the Horned Lark and the Vesper Sparrow (Figs 14-15). Four and eight minute counts recorded an average of 68±4% and 84±3% of the total number of Horned Larks, and 73±6% and 87% of the Vesper Sparrows recorded during 12 minute counts, respectively.

TABLE 3. Number of breeding pairs of birds as determined by the spot-mapping method[a].

Species	CIFAC		McDonald	
	Min.	Max.	Min.	Max.
Horned Lark	15.0	16.5	4.5	5.0
Vesper Sparrow	1.5	2.5	1.5	2.0
Long-billed Curlew	0.0	1.5	1.0	1.5
Western Meadowlark	0.5	1.5	0.0	0.0
Savannah Sparrow	0.5	1.0	0.0	0.0
Total	18.5	23.0	7.0	8.5
No. Species	4	5	3	3

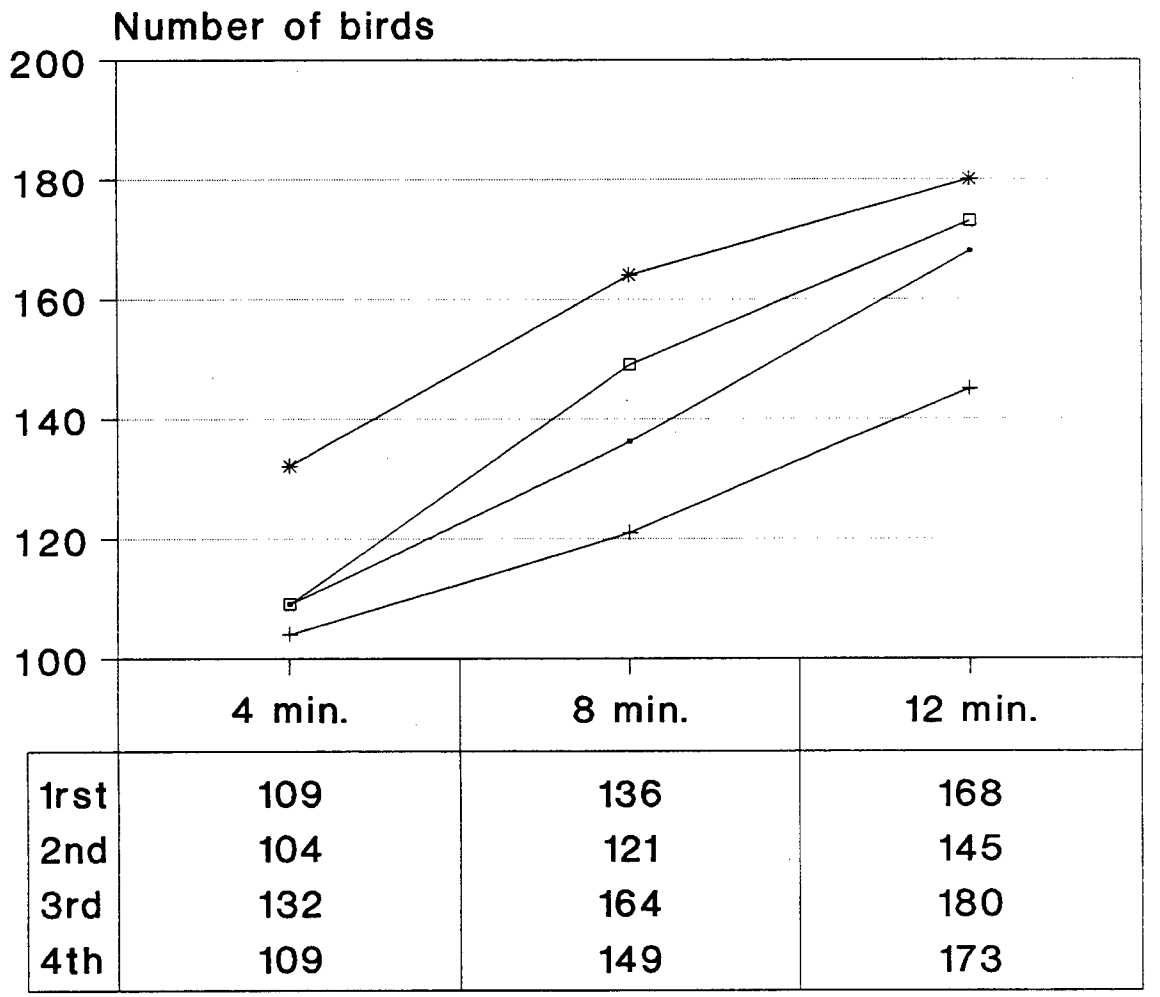
[a] Plots=25 ha

TABLE 4. Comparison of bird densities (birds/40ha) derived from spot-mapping and point count[1] surveys.

	CIFAX			McDonald		
	Mapping	Point max[2]	Point med[3]	Mapping	Point max	Point med
Vesper Sparrow	4.0	12.7±1.3	1.3±1.3	4.6	3.8±3.8	3.8±3.8
Horned Lark	26.4	89.2±19.0	56.0±13.6	8.0	44.6±16.6	19.1±6.9
Savannah Sparrow	1.6	10.2±6.4	3.8±1.8	0	0	0
Long-billed Curlew	0.8	0.0	0	2.4	6.4±6.4	3.8±3.8
Western Meadowlark	2.4	3.8±3.8	0	0	0	0

1 Density calculated using a 100m radius and a 12 min count.
2 Maximum of the four counts at a given point, averaged over the four sampling points located in the mapping plot.
3 Median of the four counts at a given point averaged over the four sampling points located in the mapping plots.

Total birds



	4 min.	8 min.	12 min.
1rst	109	136	168
2nd	104	121	145
3rd	132	164	180
4th	109	149	173

Figure 12. Total number of birds detected during point count census

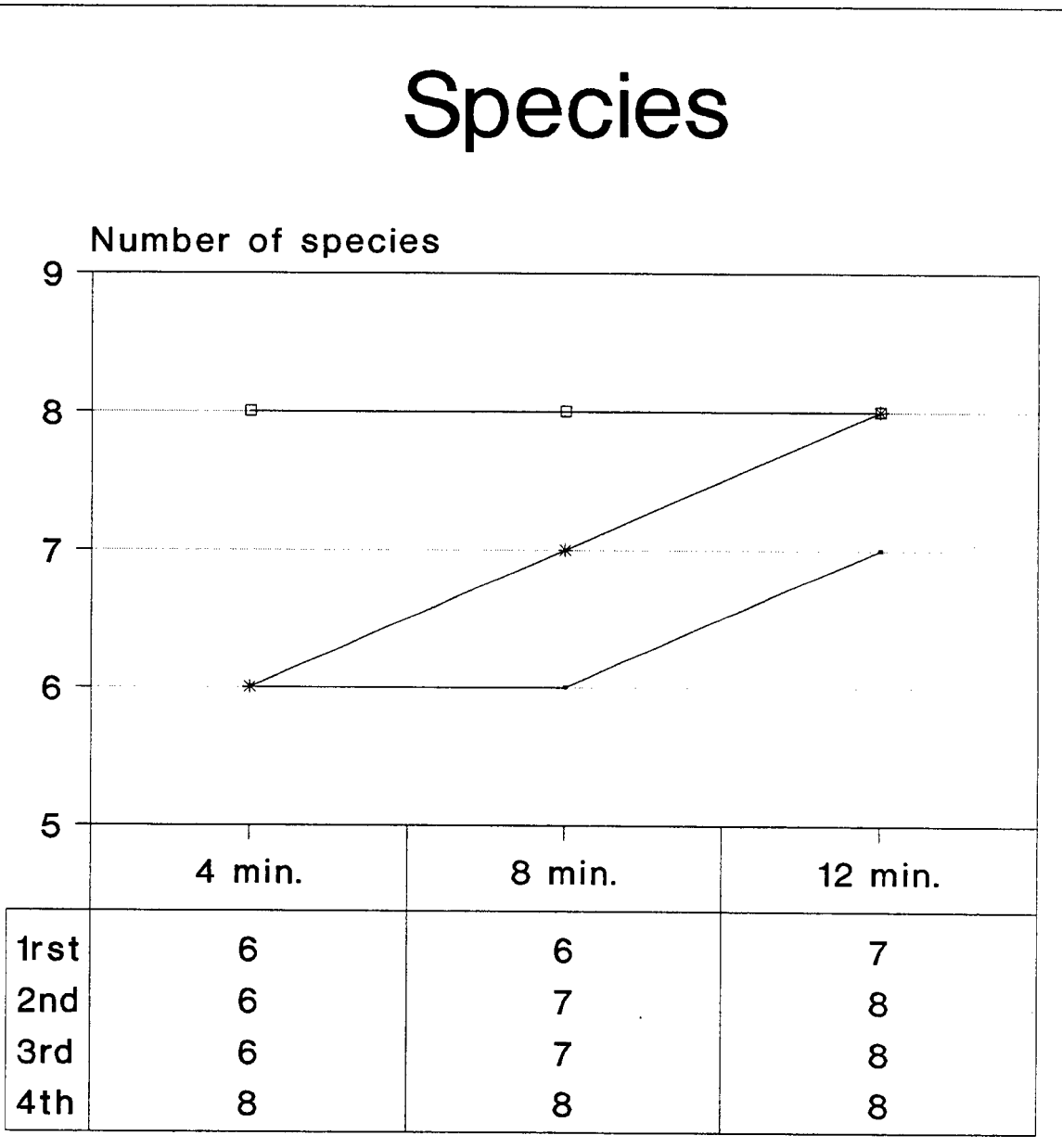
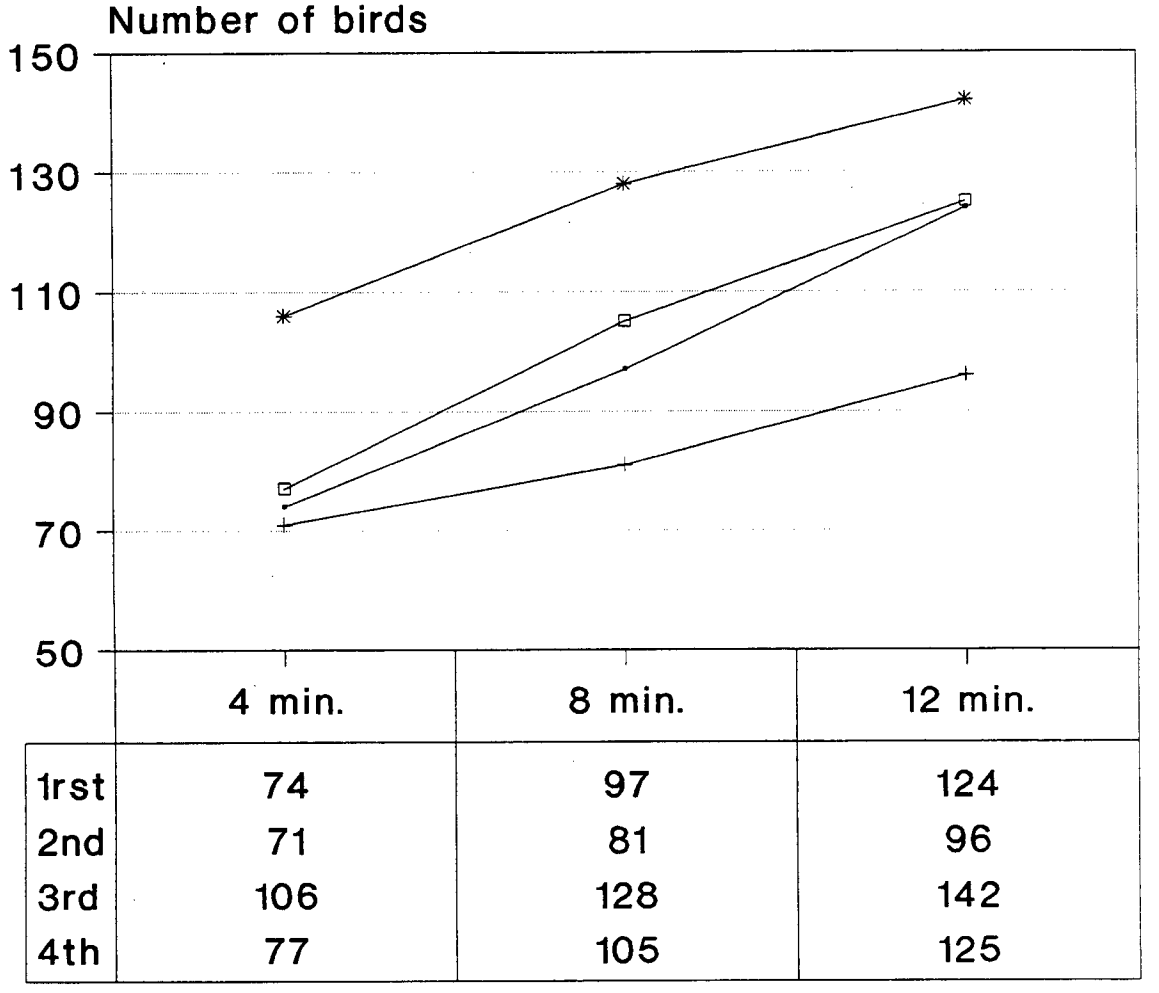


Figure 13. Number of birds detected during point count census

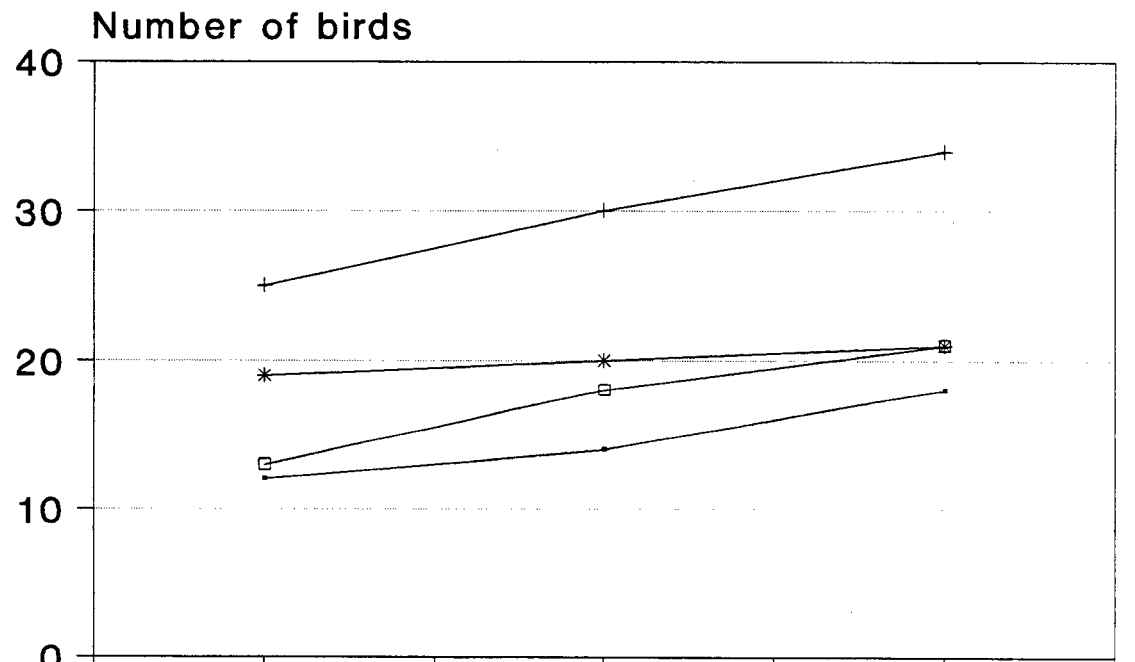
Horned lark



	4 min.	8 min.	12 min.
1rst	74	97	124
2nd	71	81	96
3rd	106	128	142
4th	77	105	125

Figure 14. Number of Horned Larks detected during point count census.

Vesper Sparrow



	4 min.	8 min.	12 min.
1rst	12	14	18
2nd	25	30	34
3rd	19	20	21
4th	13	18	21

Survey length

Survey

1rst 2nd 3rd 4th

Figure 15. Number of Vesper Sparrows detected during point count census.

Detections of Long-billed Curlews did not increase constantly with time (Fig. 16). Four and eight minute counts recorded an average of 58±14% and 100% of the total number recorded during the 12 minute counts, respectively. Patterns for less numerous species like Savannah Sparrows and Western Meadowlarks were inconsistent between counts. Larger sample sizes are needed to draw conclusions for these species.

3.2.2.2 Effect of multiple counts on count results

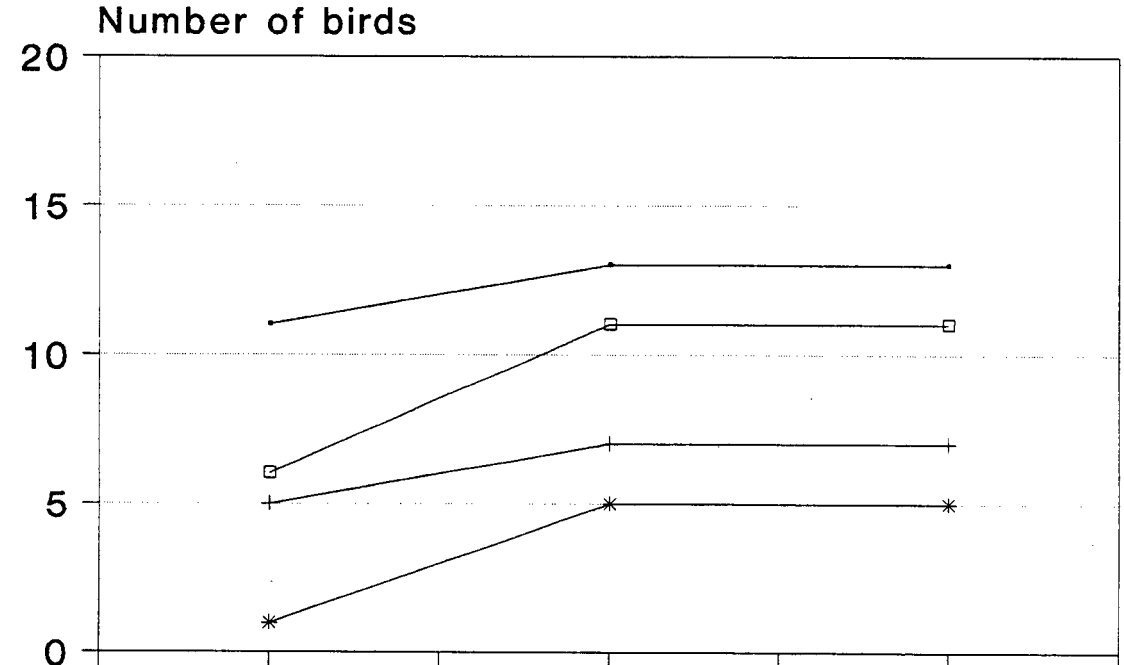
Multiple counts (ie. four) at a given point resulted in reduced differences in number of birds detected between eight and 12 minute counts (Table 5). If the maximum of any of the four counts at a given point is used as an estimate for that point, nearly 80% and 90% of Horned Larks and Vesper Sparrows detected in the 12 minute counts were seen during the four and eight minute counts, respectively. Raw data for each of the four counts at all 48 points are presented in Appendices 6,7,8, and 9.

3.2.2.3 Effect of point count radius on count results

Detections of total numbers of birds and number of species increased as point count radius increased (Fig. 17). There was an obvious disturbance created by the observer's presence though, as no birds were detected within 10 m of the observer (Figs. 17-18). For three of the four most common species - Horned Lark, Savannah Sparrow, and Vesper Sparrow, a radius of 100 m provided almost as many detections as an unlimited radius (Fig. 18). More than three times the numbers of Long-billed Curlews though, were recorded with an unlimited radius as with a 100 m radius. Trends were similar for all three survey durations for any one species. Detections for most species increased more with radius size than with time. Appendix 10 provides actual numbers of birds detected according to point radius size and survey duration.

Density estimates (number of birds per ha) based on different radius sizes and count duration were analyzed for the Horned Lark and Vesper Sparrow (Table 6).

Long-billed Curlew



	4 min.	8 min.	12 min.
1rst	11	13	13
2nd	5	7	7
3rd	1	5	5
4th	6	11	11

Survey length

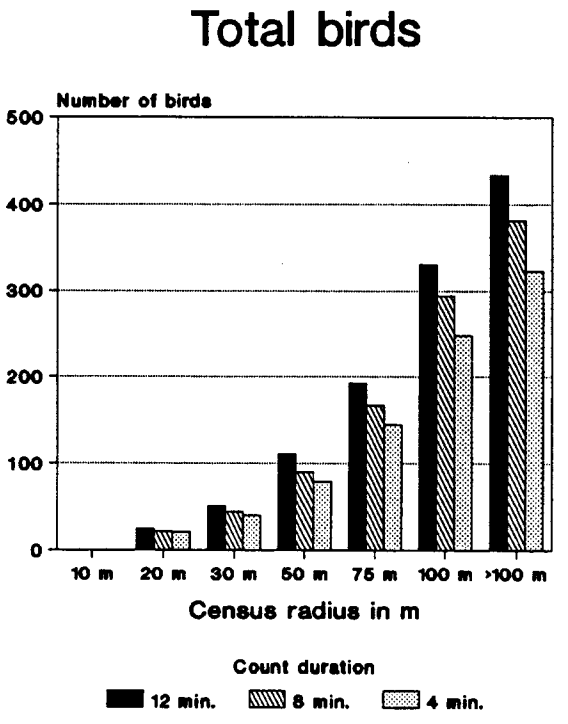
Survey
1rst 2nd 3rd 4th

Figure 16. Number of Long-billed Curlews detected during point count census.

Table 5. Influence of survey length on the number of birds seen and on the number of points at which a species is detected.

	Survey length (Min.)					
	4		8		12	
	Total	Frequency[1]	Total	Frequency	Total	Frequency
Horned Lark	162	47	188	47	210	47
Vesper Sparrow	38	25	44	26	49	26
Long-billed Curlew	16	13	22	15	24	16
Savannah Sparrow	6	6	8	7	11	8
Common Raven	11	3	11	3	11	3
European Starling	4	2	8	4	8	4
Mountain Bluebird	0	0	3	2	4	3
Western Meadowlark	1	1	2	2	4	4
Brewer's Blackbird	4	1	4	1	4	1
American Crow	1	1	1	1	1	1
American Robin	1	1	1	1	1	1
Brewer's Sparrow	1	1	1	1	1	1
Killdeer	0	0	0	0	1	1
Northern Harrier	1	1	1	1	1	1
Total	246		294		330	

[1] Number of points at which the species was seen (n=48).



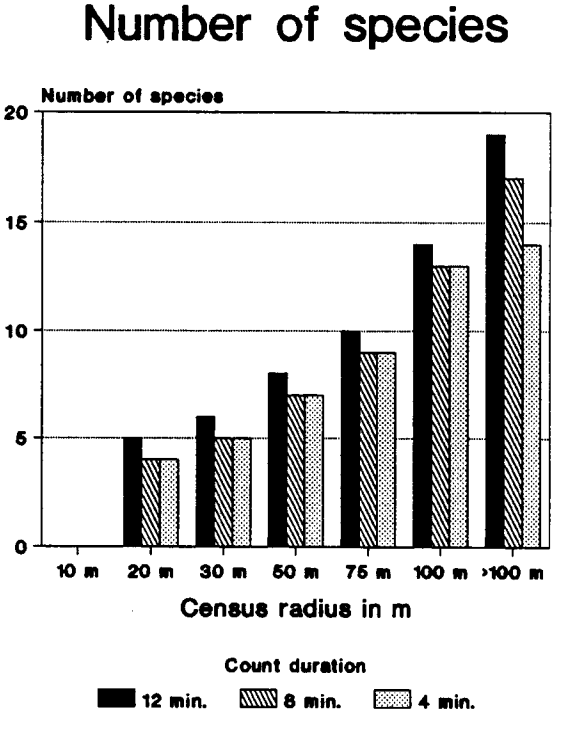


Figure 17. Total number of birds and number of bird species detected by variable point count radii.

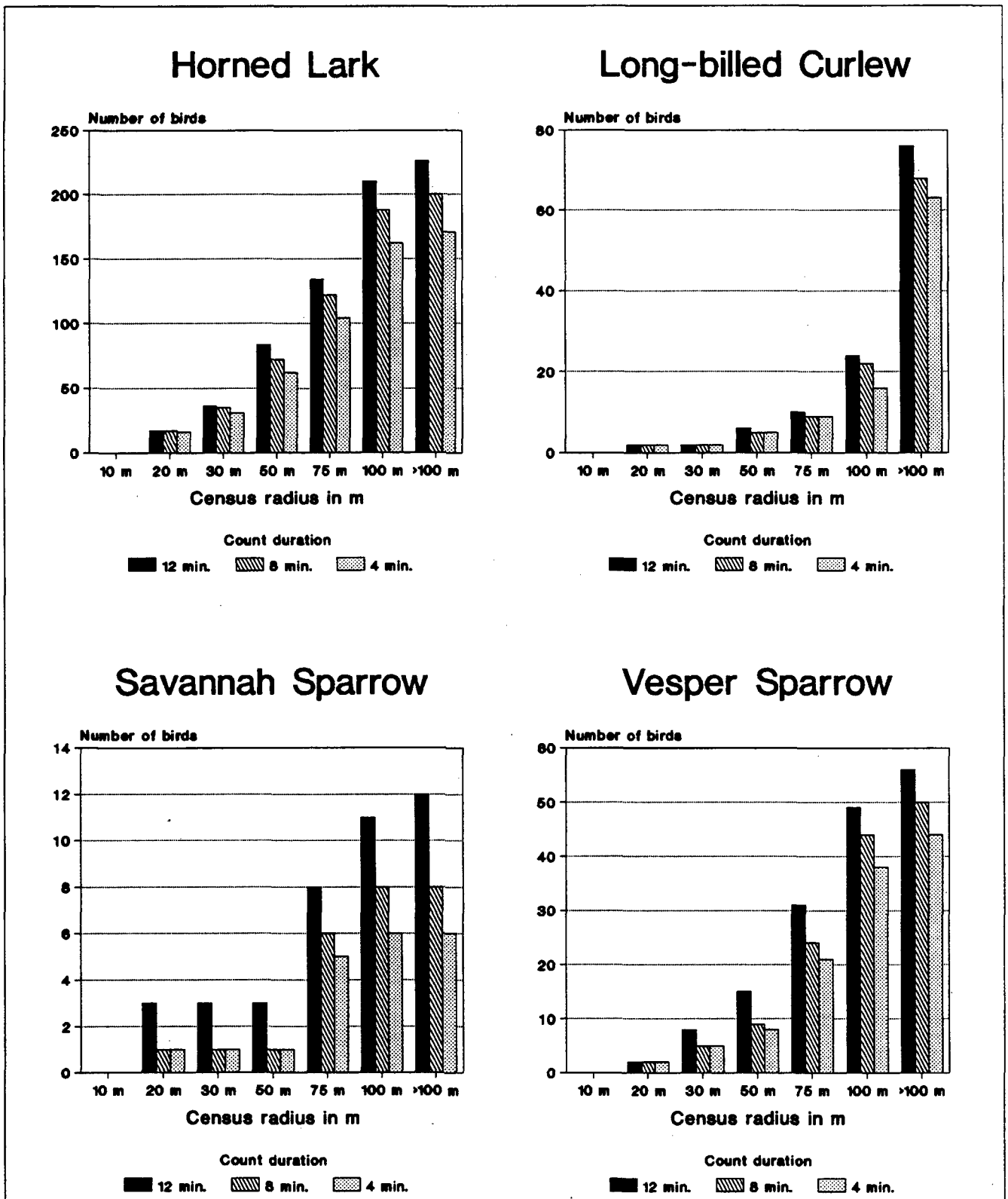


Figure 18. Number of Horned Larks, Long-billed Curlews, Savannah Sparrows and Vesper Sparrows detected by variable point count radii.

TABLE 6. Density estimates of Horned Larks and Vesper Sparrows derived from different point count radii and count length (mean of 48 points).

Species	Radius (m) / Area (ha)	20 / 0.13	30 / 0.28	50 / 0.79	75 / 1.77	100 / 3.14
Horned Lark						
Count length						
4 min.		106.1	91.4	65.8	49.0	43.0
8 min.		112.7	183.2	76.4	57.5	49.9
12 min.		112.7	106.1	88.1	63.2	55.7
Vesper Sparrow						
Count length						
4 min.		13.3	14.7	8.5	9.9	10.1
8 min.		13.3	14.7	9.5	11.3	11.7
12 min.		13.3	23.6	15.9	14.6	13.0

Density estimates of Horned Larks decreased with increasing radius size, especially between 50 and 75 m. Radii of 20 and 30 m provided the highest, and somewhat similar estimates. Density estimates of Vesper Sparrows were highest at 30 m, then decreased with increasing radius size.

3.2.2.4 Effect of point count time period on count results

There was no obvious difference between the total number of birds detected in each of the three four minute count periods (Table 7). Similar trends occurred within most species. Only the Savannah Sparrow showed an increase detection with time. This trend, along with the low number of Savannah Sparrows detected near the observer, suggests the behaviour of this species may be influenced by observer presence. The trend may be spurious though, due to the low numbers of Savannah Sparrow recorded. A larger sample size is needed to confirm this trend.

3.2.3 Comparison of point count results between grasslands

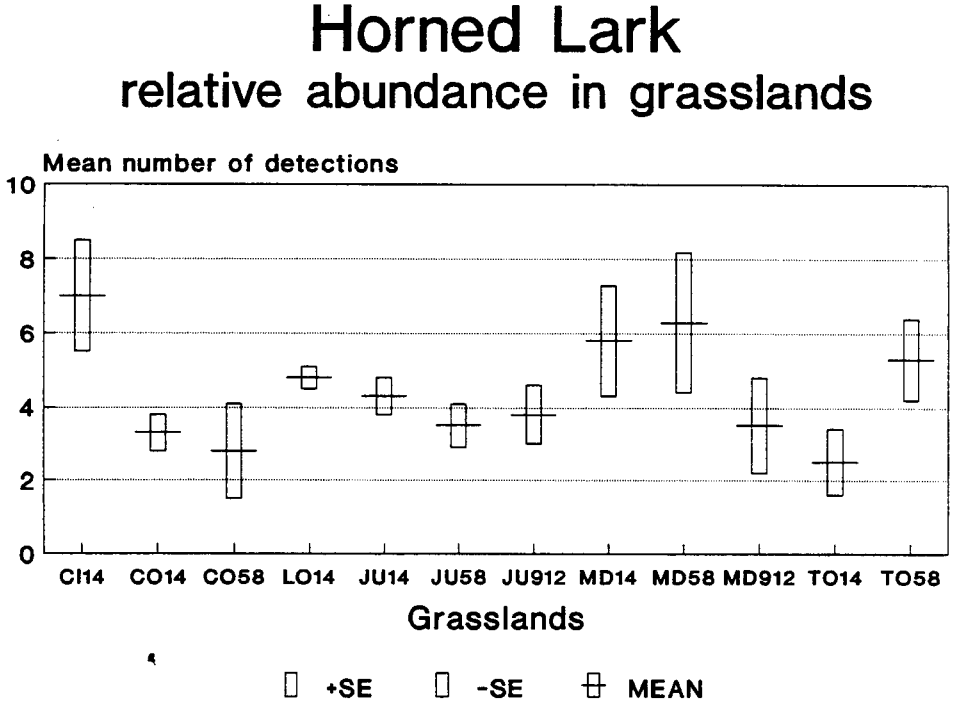
The small sample size used (four points per grassland) precluded any meaningful statistical comparisons between grasslands. Instead, means and standard errors for the major bird species and total numbers of birds in the grasslands sampled were compared qualitatively.

Horned Lark relative abundance varied between grasslands and was highest at the Cifac Base (Ci 14) and lowest at the Toosey Reserve (To 14) (Fig. 19). Vesper Sparrow relative abundance was highest at the Junction (Ju 912) and the Loran C Site (Lo 14) (Fig. 19). Vesper Sparrows were either absent or uncommon in grasslands at McDonald's Ranch and the Toosey Reserve. Savannah Sparrows and Western Meadowlarks were absent from most grasslands (Fig. 20). Long-billed Curlews were most abundant at the Toosey Reserve (To 14), McDonald's Ranch (MD 14), and the Loran C site (Lo 14) (Fig. 21). Curlews were only incidental in other grasslands, but the 100 m radius point count is not adequate for censusing this species. Total bird relative abundance varied

Table 7. Total number of birds seen in the 48 points surveyed in relation to survey length in the 48 points surveys.[1]

Survey	duration	Horned Lark	Vesper Sparrow	Long-billed Curlew	Savannah Sparrow	Western Meadowlark	Total birds
First	4 min.	162	38	16	6	2	246
Second	4 min.	152	35	17	7	1	219
Third	4 min.	167	39	13	9	2	233
	8 min.	188	44	22	8	2	294
	12 min.	210	49	24	11	4	330

[1] Maximum of 4 counts taken for each point.



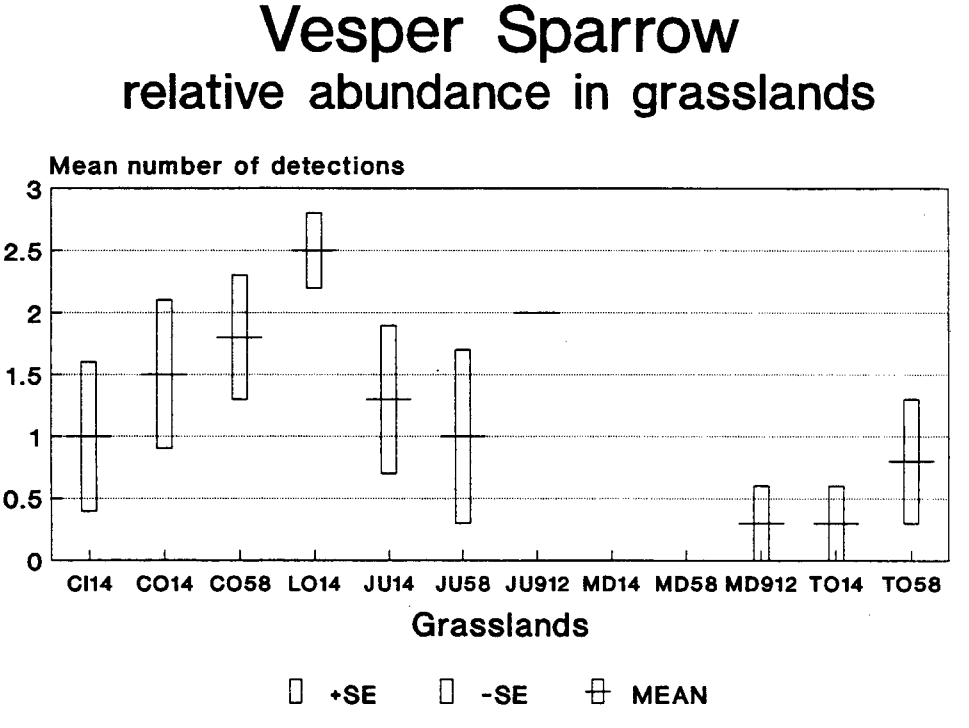


Figure 19. Mean number of detections (± SE) of Horned Larks and Vesper Sparrows in the grasslands sampled.

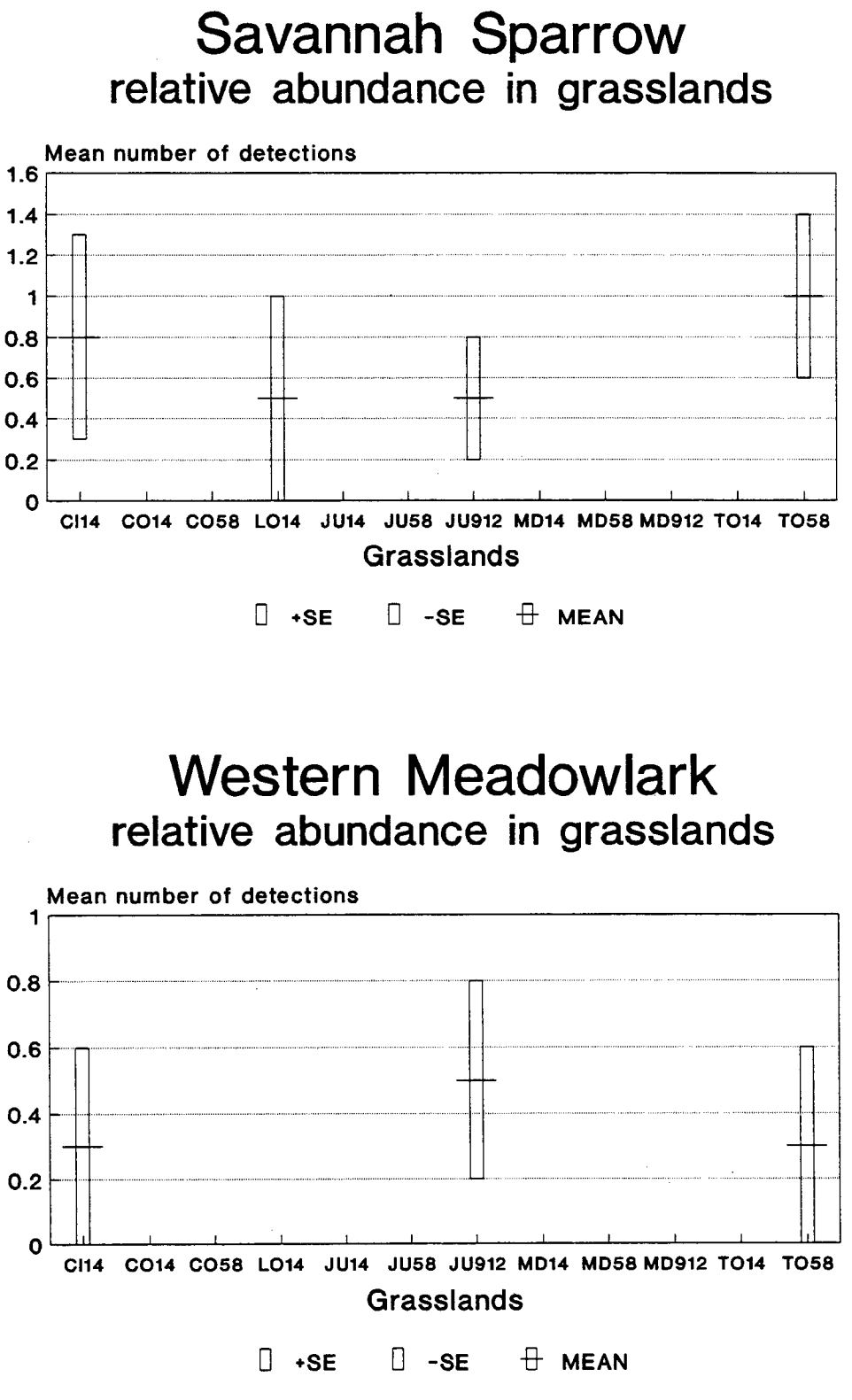


Figure 20. Mean number of detections (± SE) of Savannah Sparrows and Western Meadowlarks in the grasslands sampled.

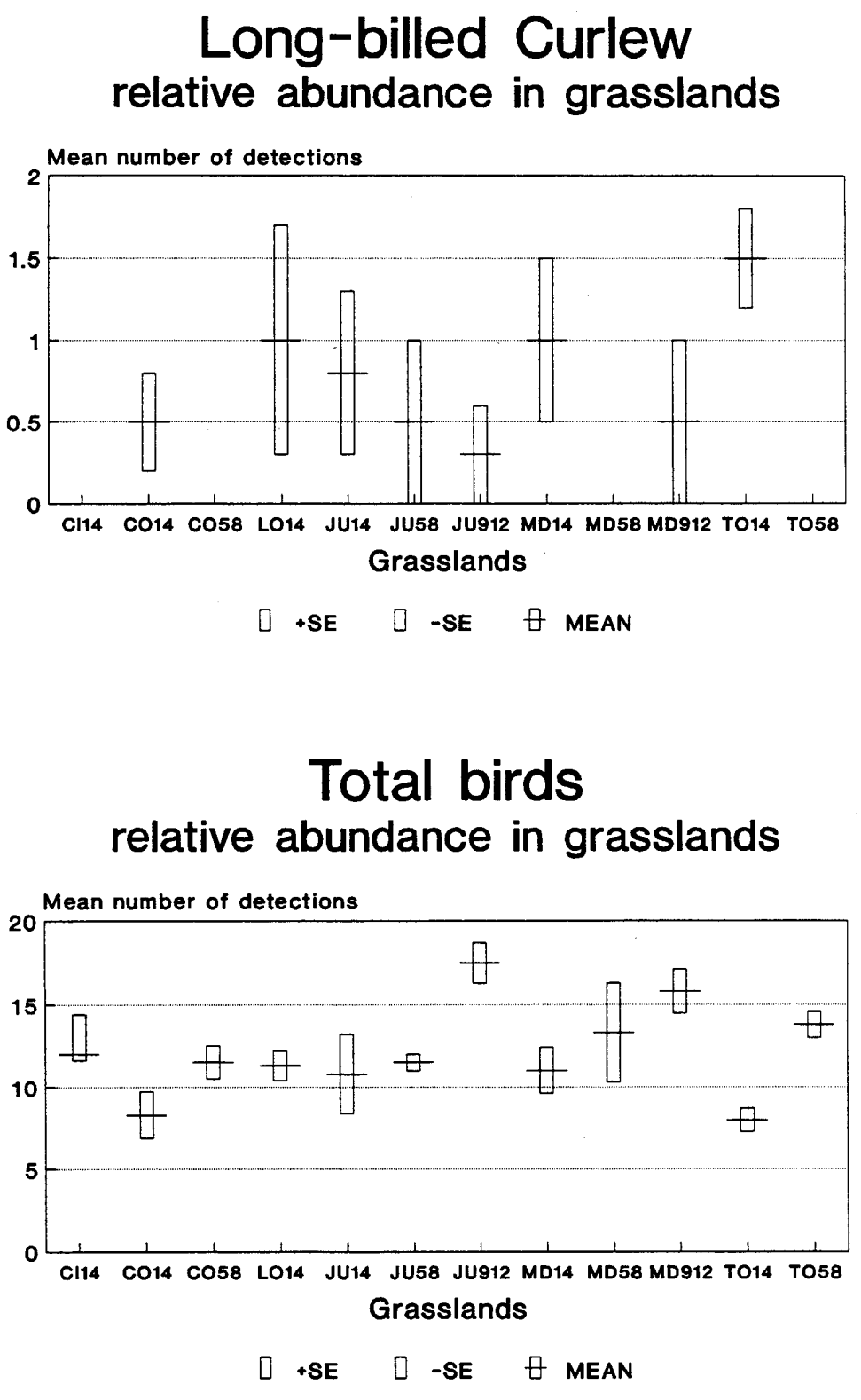


Figure 21. Mean number of detections (± SE) of Long-billed Curlews and of all birds in the grasslands sampled.

between grasslands, being lowest at the Toosey Reserve (To 14) and highest at the Junction (Ju 912) (Fig. 21). Overall, the Toosey Reserve (To 14) had the lowest bird and Horned Lark relative abundances and the highest Long-billed Curlew relative abundance. The Junction (Ju 912) had the highest bird and the lowest Long-billed Curlew relative abundances. Complete point count results by grassland area are listed in Appendix 11. A legend for the grassland codes is provided in Appendix 17.

3.2.4 Estimation of appropriate sample size for point count censuses

To determine the appropriate number of point counts needed for sampling grassland areas, the following formula was used:

$$n = \left(\frac{100 \ CV \ t}{r} \right)^2$$

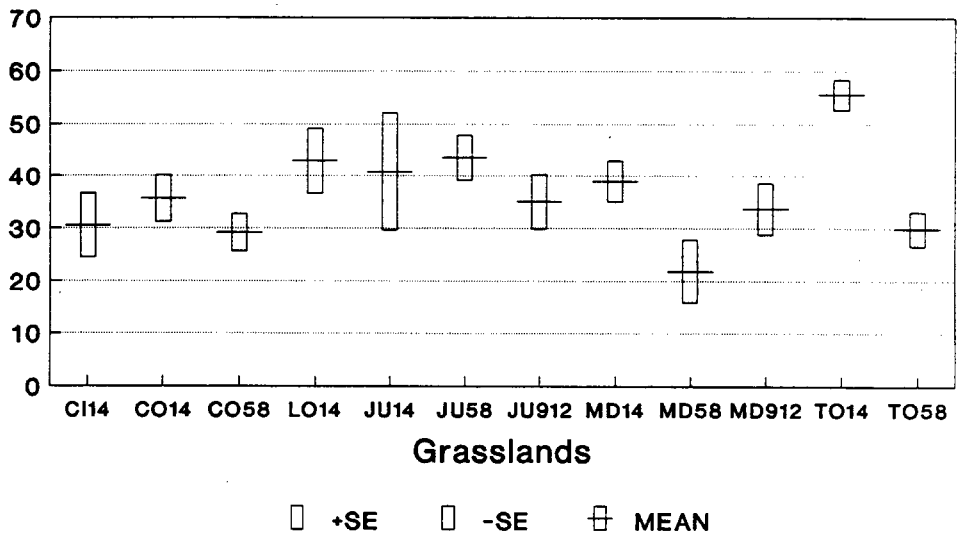
where n is the sample size needed, CV is the coefficient of variation ($CV = s/\bar{x}$, where s is the standard deviation, $\bar{x}$ is the observed mean), t is the t value for a particular confidence limit, and r is the desired relative error (width of confidence limit expressed as percentage) (Krebs 1989).

If CV = 0.23 (calculated from values in Appendix 11), $\alpha = 0.05$ ($t = 2$), and r = 10%, then n = 21. If r = 15%, then n = 9. An optimal number of point counts needed per grassland then is about 15.

3.3 Vegetation Sampling

3.3.1 Comparison of vegetation structure between grasslands

Samples of vegetation structure in the grasslands censused for birds indicated the mean % cover of bare ground varied between grasslands and was highest at the Toosey Reserve (1-4), and lowest at McDonald's Ranch (MD 58) (Fig. 22). Forb coverage was lowest at Cotton Ranch (Co 14) and highest at the Cifac grassland (Ci 14) (Fig. 22). Shrubs were not abundant in any of the grasslands, but point counts were placed deliberately to avoid areas with dense shrubbery (Fig. 23). Grass cover was variable, but was highest at



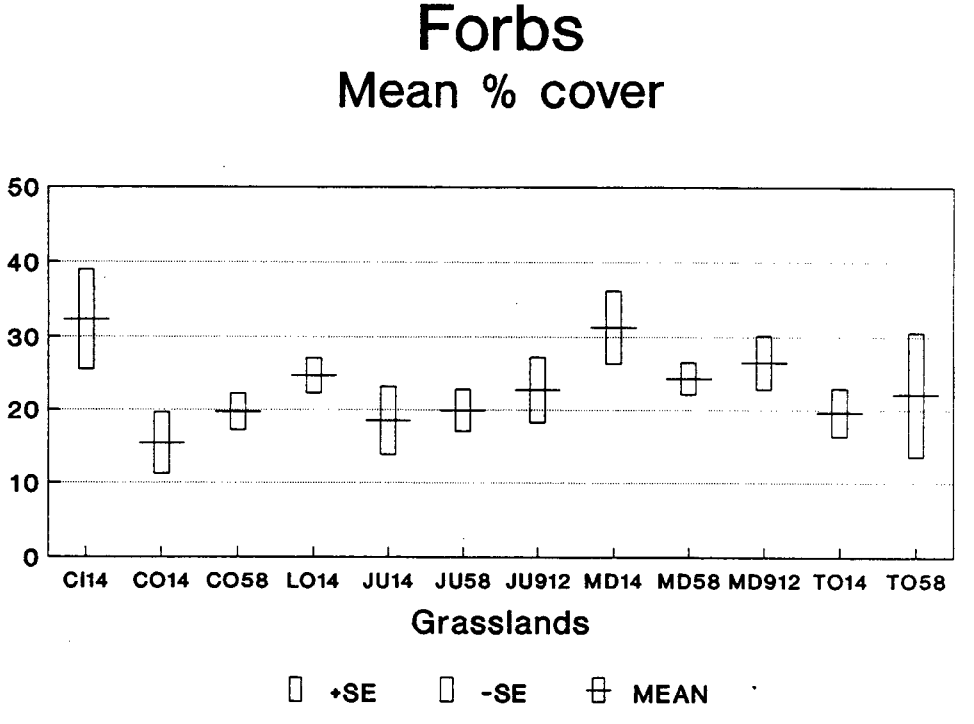
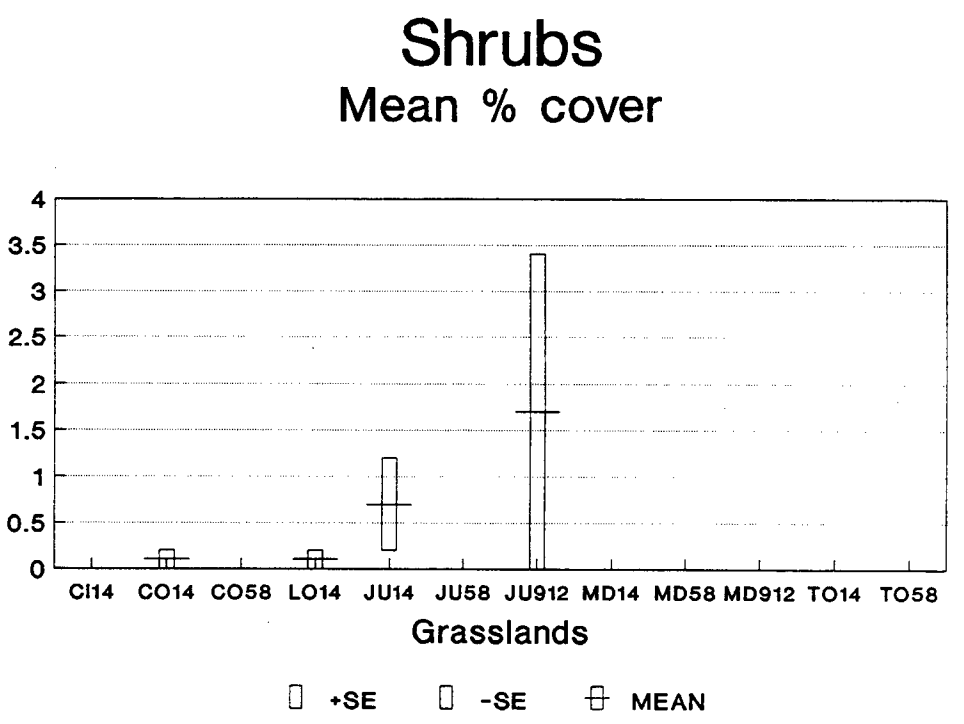


Figure 22. Comparison of the proportion (%) of bare ground and forb cover in the grasslands sampled.



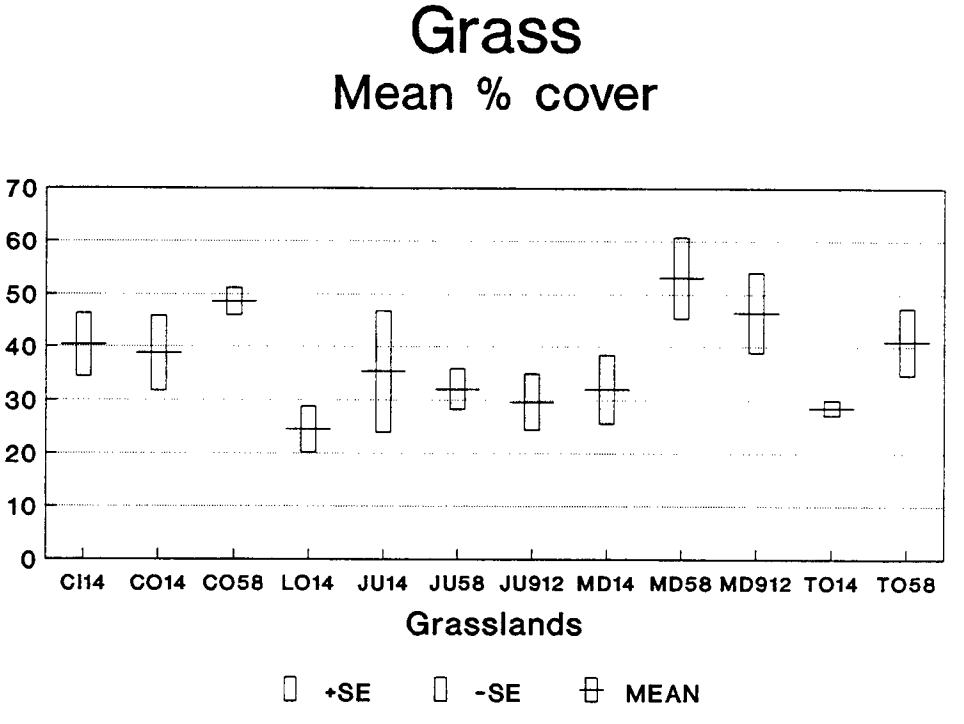


Figure 23. Comparison of the proportion (%) of shrubs and grass cover in the grasslands sampled.

McDonald's Ranch (MD 58) and lowest at the Loran C site (Lo 14) (Fig. 23). Vegetation height was highest at the Junction (Ju 912) and lowest at the Toosey Reserve (To 14) (Fig. 24). Vegetation density was greatest at the Junction (Ju 912) and lowest at Cotton Ranch (Co 14) (Fig. 24). Overall, the Toosey Reserve (To 14) had the most bare ground and shortest vegetation, McDonald's Ranch (MD 58) had the least bare ground and highest grass cover, the Junction (Ju 912) had the tallest, densest vegetation, and the Cotton Ranch (1-4) had the lowest forb cover and least dense vegetation. Actual values for habitat variable measurements are presented in Appendices 12 and 13. Correlations between vegetation structure variables indicated a strong correlation between all three vegetation density measurements, and between both measurements of vegetation height (maximum and modal height) (Appendix 14). Further vegetation sampling, therefore, should involve only one measurement each for vegetation height and density.

3.4 Bird - Vegetation Correlations

Vesper Sparrows were negatively correlated with bryophytes, but positively correlated with shrubs (Table 8). Long-billed Curlews were negatively correlated, Savannah Sparrows and Western Meadowlarks, positively correlated, with tall, dense vegetation. Horned Larks were positively correlated with dense vegetation. Due to small sample sizes, correlations between other species were dubious. All correlations between bird variables, between vegetation variables, and between bird and vegetation variables are given in Appendices 15 and 16 respectively.

3.5 Insect Sampling

3.5.1 Comparison of trap types

Pan traps caught the most ants, beetles, spiders, and total numbers of insects (Table 9). Sticky traps caught the most flies and grasshoppers. Pan and sticky traps were similarly effective in collecting moths. Pitfall traps caught more ants, bees, beetles, and spiders, but fewer insects overall, than sticky traps.

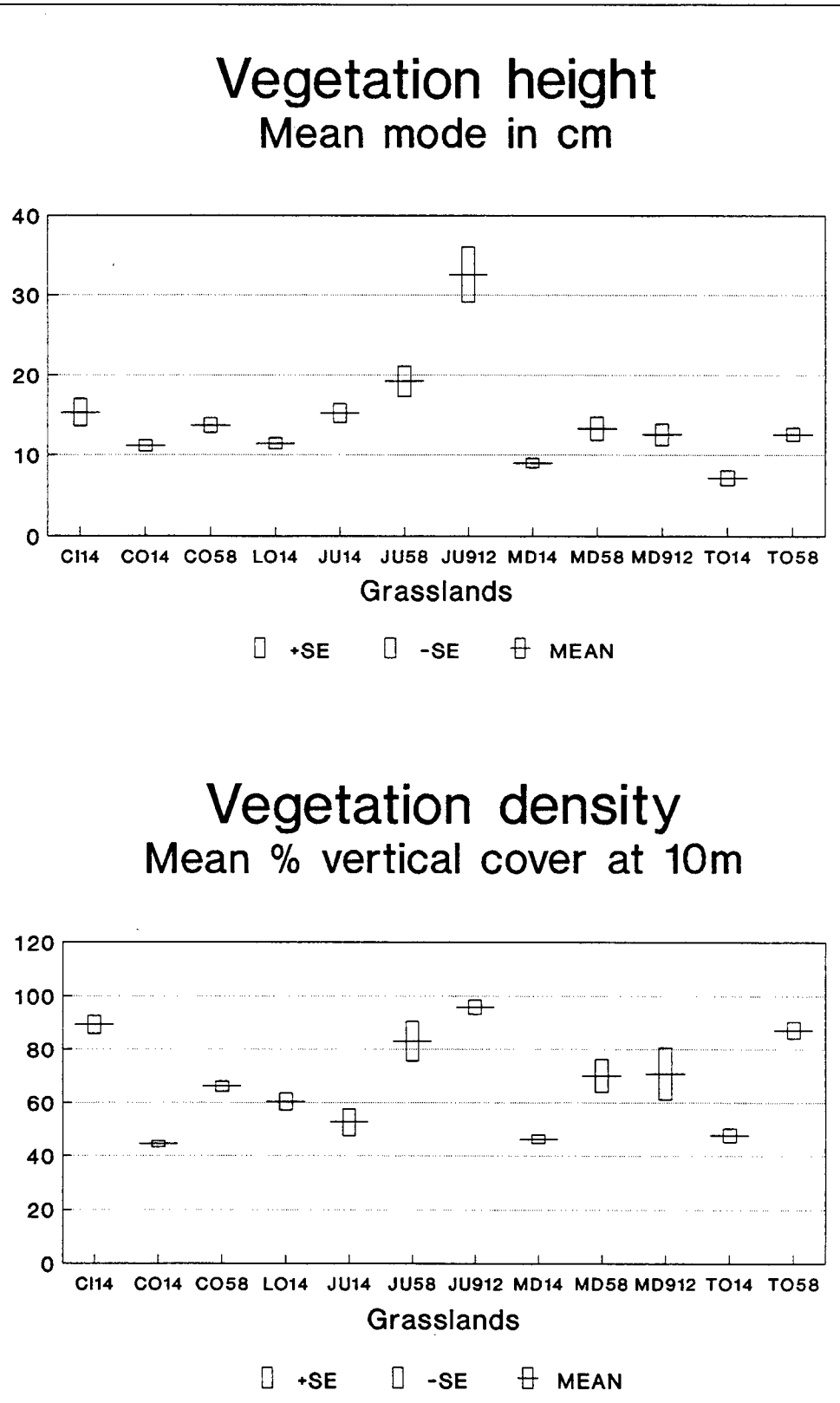


Figure 24. Comparison of vegetation height (mode) and density (% vertical cover at 10 m) in the grasslands sampled.

TABLE 8. Spearman Correlation Coefficients for significant bird and vegetation associations[a].

	Bare ground	Bryophytes	Forbs	Rocks	Shrubs
AMCR	0.242				
CORA				0.272	
MAHA			0.247		
STAR		-0.262			
VESP		-0.321			0.400

	Max. veg. ht.	Mean veg. ht.	Vertical density 5 m
CORA			-0.241
LBCU	-0.337	-0.319	-0.545
SAVS	0.337		0.372
VESP		0.399	
WEME	0.261	0.267	0.392

	Vertical density 10 m	Vertical density 20 m
HOLA		0.268
LBCU	-0.509	-0.476
SAVS	0.378	0.339
WEME	0.354	0.297

[a] 0.240: = 0.10
0.285: = 0.05
0.370: = 0.01
0.465: = 0.001

TABLE 9. Total number of insects collected per trap type.

Trap type N=	Pitfall 10	Pan 10	Sticky 10
Insect type/size			
Ants			
small	323	808	80
large	89	1333	1
Total	412	2141	81
Bees			
small	0	0	0
large	3	3	0
Total	3	3	0
Beetles			
small	31	174	18
medium	4	31	0
large	3	14	0
Total	38	219	18
Flies			
small	138	2315	2844
large	1	79	98
Total	139	2394	2942
Grasshoppers			
small	2	21	77
medium	0	1	10
large	0	4	0
Total	2	26	87
Moths			
small	4	26	31
large	0	9	6
Total	4	35	37
Spiders			
small	12	81	3
medium	20	61	1
large	0	2	0
Total	32	144	4
Unknowns			
not sized	7	137	157
Overall total	637	5099	3326

3.5.2 Food resource availability in Long-billed Curlew habitats

Total number of insects was higher on sites without than with breeding curlews (Table 10). Grasshoppers were more common in two of the three sites with breeding curlews, but beetles were more common on sites without breeding curlews. Numbers of insects in most other groupings were also higher on sites without breeding curlews.

4 DISCUSSION

4.1 Long-billed Curlew Surveys

The decrease in curlew breeding densities between 1987 and 1990 indicates either a population decline or an inconsistency between survey methods. Ohanjanian (1987) does not indicate when or how many surveys were done, of if birds were identified by sex, hence it is difficult to explain the discrepancy between survey results. If the 1987 surveys were done during the pre-laying period in early April, counts of single males may have overestimated numbers of breeding pairs since not all males attract a female (Ohanjanian 1985, 1987). Similarly, if counts of males were made during the brood-rearing period (mid-June through July), breeding pair numbers may also have been overestimated since single males will fly more than half a kilometer to help with cooperative mobbing of predators (Redmond et al. 1981, Ohanjanian 1987). Censusing later in May, however, as was done in this study, may underestimate population size since birds are less conspicuous during incubation (Ohanjanian 1985).

Difficulty was encountered in accurately identifying the number of curlew breeding territories in areas surveyed in this study. This was due mainly to the researcher's uncertainty about sex identification techniques during the first month of the study. Greater accuracy may have also been achieved by spot-mapping each site more than three or four times. Further curlew surveys, therefore, should be made more often within sites, from early April to late May, and should concentrate on sex identification to

TABLE 10. Total numbers of insects collected per trap type for sampling areas with and without breeding Long-billed Curlews.

Trap type	Pitfall		Pan		Sticky		Total	
LBCU Present/ Absent[1]	P	A[2]	P	A	P	A	P	A
Insect type by sample area								
McDonald's Ranch								
Ants	55	54	153	210	5	20	213	284
Bees	0	0	0	1	0	0	0	1
Beetles	2	11	30	67	2	7	34	85
Flies	36	24	403	566	427	694	866	1284
Grasshoppers	1	0	5	8	17	17	23	25
Moths	3	1	12	11	12	9	27	21
Spiders	2	11	13	31	1	3	16	45
Unknown	6	1	25	65	18	47	49	113
Total	105	102	641	959	482	797	1228	1858
N =	2	2	2	2	2	2	6	6
CottonRanch								
Ants	33	110	154	219	4	28	191	357
Bees	0	2	0	1	0	0	0	3
Beetles	13	0	24	63	2	3	39	66
Flies	24	21	696	373	461	709	1181	1103
Grasshoppers	0	0	11	2	16	3	27	5
Moths	0	0	1	7	6	4	7	11
Spiders	3	8	16	46	0	0	19	54
Unknown	0	0	10	21	12	15	22	36
Total	73	141	912	732	501	762	1486	1635
N =	2	2	2	2	2	2	6	6
Cifac/Loran								
Ants	78	82	415	990	12	12	505	1084
Bees	1	0	0	1	0	0	1	1
Beetles	4	8	8	27	4	0	16	35
Flies	27	7	139	217	361	290	527	514
Grasshoppers	1	0	0	0	34	0	35	0
Moths	0	0	1	3	4	2	5	5
Spiders	5	3	30	8	0	0	35	11
Unknown	0	0	11	5	56	9	67	14
Total	116	100	604	1251	471	313	1191	1664
N =	1	1	1	1	1	1	3	3

LBCU- Long-billed Curlew
P - breeding curlews present
A - breeding curlews absent

establish more precise and reliable estimates of population size.

Although curlew breeding densities in the study area apparently were lower in 1990 than 1987, they were still within the range of those found in other North American studies. Densities in this study ranged from one pair/47.9-470 ha; those in other studies ranged from one pair/12-40 ha in Idaho (Jenni et al. 1982), one pair/24 ha at Skookumchuck Prairie, British Columbia (Ohanjanian 1985), one pair/66-136 ha in Washington (Allen 1980), to one pair/600-700 ha in Saskatchewan (Sadler and Maher 1976). It is difficult to determine though, without more and better surveys, if the Long-billed Curlew population in the study area is at maximum density.

4.2 Grassland Bird Counts

4.2.1 Bird Count Results

Results of bird counts in this study were typical for grassland habitats. Since grassland vegetation structure is fairly homogeneous, grassland bird communities are correspondingly relatively simple. In general, grasslands provide habitat for about two to six passerine species, and occasionally, as many nonpasserine species (Cody 1985). In this study, three passerine species were common - the Horned Lark, Vesper Sparrow, and Savannah Sparrow; eight were less common - the Common Raven, European Starling, Mountain Bluebird, Western Meadowlark, Brewer's Blackbird, American Crow, American Robin, and Brewer's Sparrow. One nonpasserine was common - the Long-billed Curlew; two were less common - the Killdeer and Northern Harrier.

Grassland bird densities typically average 0.5-2 pairs/ha (Cody 1985). In this study, densities ranged from 0.34-0.92 pairs/ha.

4.2.2 Bird Count Techniques

4.2.2.1 Comparison of Point Count and Spot-mapping Techniques

More species were detected by point counts than by spot-mapping, but point counts consistently overestimated abundance of the most common bird species. Point counts are presumably more

efficient and provide representative sampling of larger areas than does spot-mapping (Verner 1985), but they also require large open areas to allow for sufficient space between individual points and between points and edge habitats. Some difficulty was encountered in finding sufficient space for the number of point counts used in this study.

Spot-mapping presumably provides better estimates of bird density than do point counts (Verner 1985), but is very time consuming. It took one censuser 2 1/2-3 hours to complete each survey of one 25 ha spot-mapping plot. Six point counts could be completed by one censuser in the same time. Two spot-maps, or 12 point counts could be completed by two censusers in a single morning. Point counts should be censused at least four times each, while spot-mapping plots need to be censused at least eight to ten times each. The advantages and disadvantages of each of these count techniques will have to be weighed in further studies of bird communities in the Cariboo-Chilcotin grasslands.

4.2.2.2 Evaluation of Point Count Techniques

If point counts are chosen as the preferred method of counting grassland birds, consideration should be given to the most effective method of establishing and executing point count censuses. Curlews are much larger, more mobile, more vocal, and thus, more easily detectable than other grassland birds. Hence, eight minute counts are sufficient for detecting all curlews at a given site, but 12 minute counts are necessary to detect the numbers of other species present.

A 100 m radius point count is sufficient for detecting all species but the Long-billed Curlew. Since the relative abundance of curlews in an area may not be properly evaluated using a 100 m radius point count, the modified spot-mapping technique for curlews should be used in conjunction with point counts for other species. Because detections for most species increased more with point count radius size than with time, increasing survey length will probably not compensate for reduced radius size.

Suspicions that birds avoided censusers during point counts were confirmed by the data. Often when observers walked to the point centre, birds flushed and either moved further away or left the area, only to return after the observers had left. A possible

way to avoid this disturbance effect would be to do point counts from grassland roads. Points would be established as a semi-circle on each side of the road. Observers would park their vehicle at the circle perimeter and walk to the point centre. This may create less disturbance since birds often do not use the roadway itself.

4.3 Bird - Vegetation Correlations

Bird density is often positively correlated with vegetation complexity (Roth 1977, Cody 1985). In this study, bird density was highest in grasslands with the tallest densest vegetation and lowest in grasslands with the shortest vegetation and most bare ground.

Although other studies have found positive associations of Vesper Sparrows with litter cover, ground cover, and vegetation density, and negative associations with % bare ground around nest sites (Wray and Whitmore 1979, Reed 1986), this study found only a positive association with shrubs and a negative association with bryophytes. Vesper Sparrows were most common in grasslands with the tallest, densest vegetation, but the associations were not significant. Either Vesper Sparrows have different habitat requirements in the study area, or bird and vegetation sample sizes were insufficient to characterize true habitat associations. Vesper Sparrows may, however, have been positively correlated with shrubs in this study, because of their need for elevated singing perches for territorial defense (Terres 1980). Unlike Horned Larks and Western Meadowlarks that sing from the ground or in flight, Vesper Sparrows sing only from elevated perches (Castrale 1983). In the Okanagan, Vesper Sparrows have also been found using sagebrush bushes for nesting cover (Cannings et al. 1987).

Given the habitat associations for this species, Vesper Sparrows might be expected to be most common in ungrazed or lightly grazed grasslands. Some studies support this idea (Maher 1973, Page et al. 1978), others do not (Owens and Myres 1973, Kantrud 1981, Medin and Clary 1990). In areas like the Okanagan, heavy grazing could benefit Vesper Sparrows by increasing the amount of sagebrush cover (Cannings et al. 1987).

Long-billed Curlews generally nest in short-grass and mid-grass prairies and require large open areas for communal predator detection, effective communication between nesting birds, and ease of movement of chicks when feeding (McCallum et al. 1977, Allen 1980, Renaud 1980, Jenni et al. 1982, Ohanjanian 1986, 1987). Areas of patchy grass are also needed for camouflage and thermal cover for chicks (Allen 1980, Pampush 1980). These habitat requirements were reflected in the negative association with tall, dense vegetation found in this study. Grazing studies, consequently, have consistently found curlews were more abundant in heavier than lighter grazed grasslands (King 1978, Bicak et al. 1982, Kantrud and Kologiski 1982, Ohanjanian 1987, Median and Clary 1990).

The importance of contiguity of open grasslands for breeding curlews has been emphasized in other studies (Jenni et al. 1982, Ohanjanian 1985). Both ranchers and range managers in the Cariboo-Chilcotin expressed concern about forest encroachment on rangelands in the area (F. Knezevich, N. McDonald, pers. comm.). This encroachment could result in loss of breeding habitat for Long-billed Curlews in the region. In the Kootenays, Ohanjanian (1985) recommended a tree removal program to enhance curlew habitat in that area.

Savannah Sparrows prefer dense ground cover where they can build well concealed nests in overhanging vegetation (Linsdale 1938, Tester and Marshall 1961, Lein 1968, Wiens 1969, Potter 1972, Terres 1980). This supports our finding of a positive association of Savannah Sparrows with tall, dense vegetation. General observations from this study suggest that Savannah Sparrows are most often found in wet areas on edges of habitats. These observations are supported by other studies (Burleigh 1972). This would explain the species' association with tall, dense vegetation for nesting. Because of these habitat requirements, Savannah Sparrows have been found more often found in areas with little or no livestock grazing (Lincoln 1925, Rand 1948, Owens and Myres 1973, Karasiuk et al. 1977, Page et al. 1978, Maher 1979, Kantrud 1981, Dale 1984, Medin and Clary 1990).

Western Meadowlarks are considered habitat generalists (Wiens and Rotenberry 1981, Larson and Bock 1986). They will, however, build nests in tall grass. Nests consist of a scraped bowl covered

with a domed canopy of grasses and forbs. Meadowlarks also use elevated singing posts. This use of tall grass for nesting and elevated structures for singing posts may explain the positive association with tall, dense vegetation found in this study (Terres 1980, Harrison 1984, Cannings et al. 1987). More sampling in different habitat types throughout the Chilcotin-Cariboo grasslands, however, may indicate that Western Meadowlarks are also habitat generalists in this area.

Because of their apparent habitat generalization, Western Meadowlarks have generally been equally abundant on grazed or ungrazed grasslands (Johnson 1972, 1973, 1974, Owens and Myres 1973, Karasiuk et al. 1977, Hopkins 1980, Kantrud 1981, Dale 1984, Renken and Dinsmore 1987, Medin and Clary 1990).

Horned Larks typically nest in bare, sandy, or stony ground with sparse grass cover (Harrison 1984). Consequently, most studies on Horned Larks have found a negative association with tall, dense vegetation and with forb and shrub cover, and a positive association with bare ground (Wiens 1973, Bock and Webb 1984, Wiens and Rotenberry 1985, Larson and Bock 1986). This study found only a positive association with dense cover. All Horned Lark nests were found in areas of dense vegetation. Nests were placed at the base of a dense clump of grass, and consequently, were extremely well concealed. Horned Larks are known to build nests in areas protected by vegetation on the windward side (Cannings 1981, Cannings and Threfall 1981). In this study, Horned Larks were occasionally noted using areas of bare, loose soil for dust-bathing. At a site in Newfoundland, Horned Lark territories were linearly distributed along a roadway which males used for dust-bathing, roosting, and singing (Cannings and Threfall 1981).

Either Horned Lark habitat is different in the Cariboo-Chilcotin grasslands, or more bird and vegetation data is needed to elucidate true habitat requirements for this species. Larson and Bock (1986) noted that while Horned Larks typically selected areas with more bare ground, the amount of bare ground between sites was highly variable. This may explain why a positive association with bare ground was not found in the limited number of samples taken in this study. Similarly, an association with low shrub cover would not have been revealed in this study, since point count placements

avoided shrubby areas. This apparent requirement for low, less dense vegetation and bare ground may explain why Horned Larks have typically been found in more heavily than lightly grazed grasslands (Maher 1973, Owens and Myres 1973, Wiens 1973, Karasiuk et al. 1977, Ryder 1980, Kantrud 1981, Bock et al. 1984, Dale 1984, Renken and Dinsmore 1987).

If management guidelines are created for maintaining and enhancing grassland bird populations in the Cariboo/Chilcotin grasslands they must consider the different habitat associations of the bird species involved. Management guidelines for a species of concern like the Long-billed Curlew may not necessarily benefit other grassland birds.

In addition, results of grazing studies should be treated with caution. Few studies have used any kind of statistical tests to determine the relationship between bird communities, vegetation structure, and grazing pressure. The use of statistics in many studies though, was inappropriate since grazing treatments were not adequately replicated. Conclusions made in most studies, therefore, are purely speculative (Hooper unpubl.). Many papers also fail to consider that the effects of livestock grazing on plant communities depends on duration, season, and intensity of grazing, and local climate, vegetation, and soils (Manske 1988, Hooper unpubl.). Most papers also do not consider the effect of grazing on food resource availability (Hooper unpubl.). Bird diversity has been shown to be affected by availability of food resources (Wiens 1974a).

Consequently, management decisions about livestock grazing and bird communities in the Cariboo/Chilcotin grasslands should not be based on current grazing literature, or on studies done elsewhere. Drawing on the weaknesses of these grazing studies, it is suggested that studies done in the Cariboo/Chilcotin use properly replicated treatments and samples so statistical testing can be done. Grazing intensity, season, and duration should be recorded and correlated with vegetation structure, food availability, and bird diversity and density. Climatic data should also be collected to determine if observed results may have been influenced by atypical climatic patterns (eg. droughts, unseasonably high rainfall).

Additional information should be collected on the effects of crop cultivation (for cattle winter feeding programs) on bird

diversity and density. Time constraints did not allow censusing of crop fields, but local ranchers said these fields are generally devoid of birds (L. Bonner, G. Huffman pers. comm.)

4.4 Insect Sampling

Pitfall traps are effective in trapping surface crawling insects like beetles and spiders (Martin 1977), but in this study they were not as effective as pan traps. Overall, pan traps were the most effective, sticky traps, the least effective method of collecting grassland insects. Pan traps are recommended for grassland areas because wind speeds are highest near the ground surface and insect activity is usually confined to the first few centimeters above ground level. (Martin 1977). Further studies involving collections of grassland insects should, therefore, use pan traps.

It is difficult to determine from our results if insect availability influences curlew distribution within the study area. More sampling needs to be done over a longer period (e.g. April-May) and a wider area. Behavioural observations may be required to determine if relationships between food resource abundance and Long-billed Curlew habitat use in the area exist.

5 RECOMMENDATIONS

1. To accurately assess Long-billed Curlew breeding densities throughout the Cariboo/Chilcotin grasslands, the modified spot-mapping technique should be used. Surveys should be done five or six times per grassland from early April to the end of May. Whenever possible, sex of birds should be noted.

2. 25 ha spot-mapping plots should be used if determining densities of grassland birds other than curlews is considered most important. If determining grassland diversity over a wide area is more important, point counts should be used.

3. If censusing is done with point counts, points should have a 100 m radius, and three consecutive four minute counts (12 minutes total) should be done at each point. Each point should be censused on four different mornings, between 05:30 and 10:00 a.m., during the height of the breeding season - May to June. A driving

point count method should be tested to determine if observer disturbance of birds can be reduced.

4. Correlations between vegetation structure variables indicate that only one measure of vegetation density (eg. at 10 m) and one measure of vegetation height (either maximum or modal) need to be taken.

5. Since bird/vegetation correlations in this study were sometimes vague or contradicted those found in other studies, a greater number of bird and vegetation samples should be collected. If possible, 15 point counts should be established, and at least 100 vegetation samples collected (M. Pitt pers. comm.) per grassland area.

6. Details on grazing history and grazing pressure should be gathered from local ranchers and correlated with vegetation structure to assess the effects of grazing on grassland bird communities in the area.

7. Pan traps should be used to collect grassland insects. Trapping should be done from April to July to determine if food availability affects distribution of breeding Long-billed Curlews and other grassland birds.

8. If grazing experiments are to be done in the Cariboo/Chilcotin they should use properly replicated treatments and samples so statistical testing can be done. Grazing intensity, season, and duration should be recorded and correlated with vegetation structure, food availability, and bird diversity and density. Climatic data should also be collected to determine if observed results may have been influenced by atypical climatic patterns (eg. droughts, unseasonably high rainfall).

9. If management guidelines are created for maintaining and enhancing grassland bird populations in the Cariboo/Chilcotin grasslands they must consider the different habitat associations of the bird species involved. Management guidelines for a species of concern like the Long-billed Curlew may not benefit other grassland birds.

10. The rate of forest encroachment and the amount of area being used for crop cultivation in the Cariboo/Chilcotin region should be monitored as this may result in habitat loss for Long-billed Curlews and other grassland birds.

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Appendix 1. Long-billed Curlew sight records throughout study area.

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
122 Mile	5	17	1950	1		1	Lac la Hache
148 Mile House	4	30	1981	1			
148 Mile House	7	8	1983	6			
148 Mile House	6	8	1990	1			Heard calling near Mission Rd.
150 Mile House	6	10	1989	1			Calling around ponds
2 mi e Louis Cr.	5	13	1983	2			Foraging in pasture
6 km s Clearwater	4	16	1984	2			Pasture on e side Yellowhead Hwy
Alexis Creek	6	26	1990	4	1	1	s of Chilcotin R
Alexis Creek	4	24	1991	7	4	3	Fields off Christie Rd
Alexis Creek	5	15	1991	5	2	2	Fields off Christie Rd.
Alexis Creek	4	16	1991	7	4	3	Fields off Christie Rd.
Alkali Lk	5	13	1967	2	1	1	Pair feeding in grasslands above lake.
Alkali Lk	4	4	1968	100			Large flocks fed for a week in meadows beside lake
Alkali Lk	6	24	1971	7			Flying over plateau
Alkali Lk	4	18	1971	1			Feeding in ploughed field
Alkali Lk	4	10	1972	6			Recently arrived
Alkali Lk	4	11	1978	25			Alkali Lk Ranch. Had seen small groups before this date
Alkali Lk	7	18	1978	79			One flock on grasslands above lake. No curlews seen on plateau
Alkali Lk	5	24	1980	5			Beside & east of lake
Alkali Lk	6	21	1990	41			Alkali Lk Ranch
Alkali Lk	3	28	1990	1			Alkali Ranch. First of year
Alkali Lk	5	19	1990	2			Reidemann Lk. In alfalfa fields.
Alkali Lk	4	15	1991	2	2		Resting in alfalfa stubble fields
Alkali Lk (plateau)	6	16	1968	6	3	3	3 pairs defending territories
Alkali Lk (plateau)	6	24	1971	7			Flying overhead
Alkali Lk - Dog Cr	5	28	1978	2			
Big Creek	6	8	1991	6			
Buffalo Lk	4	29	1976	1			ne of 100 Mile House
Chilcotin Rd	6	19	1935	3			
Darfield	5	25	1985	2			Edge of flooded grassy field with cattle
Dog Cr	6	15	1979	10			10 km beyond Dog Creek towards 70 Mile House. Territorial pairs.
Dog Creek	6	15	1934	4			5 mi n Dog Creek. Mus.
Dog Creek	5	16	1950	1			B.C. Prov. Mus. Cat. No.
Dog Creek	5	11	1953	1	1		Nat. Mus. Canada Cat. No.
Dog Creek	6	12	1953	1			Nat. Mus. Canada Cat. No.
Dog Creek	6	12	1953	1			Nat. Mus. Canada Cat. No.
Dog Creek	6	22	1954	1			Nat. Mus. Canada Cat. No.
Dog Creek	5	27	1990	9			On plateau near Circle S Ranch
Dog Creek	5	19	1990	1			On plateau near Circle S Ranch
Dog Creek	5	5	1990	5			near Circle S Ranch
Dog Creek	4	26	1991	2	1	1	On plateau near Circle S Ranch
Dog Creek	4	15	1991	2	2		Circle S plateau
Dog Creek Rd	6	4	1965	4	2	2	2 pairs:alarm calls in grassland
Gang Ranch	6	2	1990	6			
Gang Ranch	5	27	1990	1			Flying over alfalfa fields near buildings
Gang Ranch	5	25	1990	1			
Gang Ranch	5	19	1990	1			
Gang Ranch	4	15	1991	2	1	1	
Hanceville	6	14	1979	13			Chilco Ranch. In pairs, loud calls.
Hanceville	6	20	1979	3			Chilco Ranch. Jones Flat. Behaving as if young nearby
Hanceville	6	18	1980	5			Chilco Ranch, slough #C-3. Circling and calling

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Hanceville	6	5	1980	3			Chilco Ranch. Pair joined by a 3rd bird in alarm over our presence
Hanceville	5	17	1981	15			Chilco Ranch
Hanceville	5	3	1981	2			Chilco Ranch
Hanceville	7		1983	30			Chilco Ranch. Large flocks of up to 30
Hanceville	5	4	1990	24			Chilco Ranch
Hanceville	5	4	1990	1			In alfalfa fields before Fletcher Lk turnoff
Hanceville	4	19	1990	7			Chilco Ranch
Hanceville	5	15	1991	15	6	3	Chilco Ranch
Hanceville	4	24	1991	20			Hay fields on Fletcher Lk Rd
Hanceville	5	1	1991	15			Hay fields on Fletcher Lk Rd
Hanceville	4	16	1991	21			Feeding and making nest scrapes in irrigated field,fletcher lake road
Hanceville	5	15	1991	21			Hayfields on Fletcher Lk Rd.
Hanceville	5	1	1991	14	6	6	Chilco Ranch
Hemp Creek	5	14	1957	1			Wells Gray Park
Hemp Creek	5	3	1971	1			
Hemp Creek	6	4	1971	1			Flying overhead
Lac la Hache	6	29	1892	1			
Lac la Hache	6	29	1892	1			Acad. Nat Sci Philadel. Cat No. 30642
Lac la Hache	5	17	1950	1			Royal Ontario Mus. Cat. No.
Little Fort	4	8	1981	2			In field
Marguerite	5	21	1979	1			North of W.L. on Hwy 97.
McLure	5	25	1985	1			Flying south along Thompson R
Onward Ranch	5	2	1966	1			
Pablo Creek	6	10	1989	2			Off Hwy 20
Pablo Creek	5	8	1990	1			Flying over fields beside Hwy 20
Pete Kitchen Lk	5	12	1981	1			100 Mile House
Pete Kitchen Lk	4	27	1981	1			100 Mile House
Redstone	7	8	1975	1			4 mi nw Redstone bridge along road to Chezacut.Flying,calling
Riske Creek	5	11	1978	1			
Riske Creek	7	4	1948	3			3 mi e Riske Creek
Riske Creek	4	29	1950	2			B.C. Prov. Mus. Cat. No.
Riske Creek	4	23	1951	1			B.C. Prov. Mus. Cat. No.
Riske Creek	7	13	1958	2	1	1	Pair circling in alarm over open prairie
Riske Creek	6	22	1968				Several
Riske Creek	5	10	1968	2			
Riske Creek	5	19	1970	2	1	1	Barnes Lk. Paired
Riske Creek	5	16	1970	12	6	6	Beecher's Prairie
Riske Creek	5	19	1970	1			C. Sackson
Riske Creek	5	27	1970	1			Barkley Lk. Chasing female Harrier.
Riske Creek	5	18	1975	2	1	1	Beecher's Prairie. Pair flying & landing
Riske Creek	5	5	1975	2	1	1	Pair circling & calling on sheep range
Riske Creek	4	19	1976	7			Beecher's Prairie. 2 groups
Riske Creek	6	26	1977	1			w Fraser River Bridge. Perched in tree
Riske Creek	6	18	1977	4	2	2	Junction Sheep Range. 2 pairs
Riske Creek	7	27	1978	5			Junction Sheep Range
Riske Creek	5	21	1978	1			Loran C - on opposite side Hwy 20
Riske Creek	5	3	1978	4			
Riske Creek	5	14	1978	3			Near Box 27 Lk
Riske Creek	6	3	1978	2			MacDonald's farm-near corral
Riske Creek	5	24	1978	2			Junction Sheep Range
Riske Creek	4	16	1978	3			Flying
Riske Creek	6	10	1978	3			Very agitated. Young probably around
Riske Creek	5	5	1978	2			
Riske Creek	6	11	1978	6			Wineglass Ranch Rd

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Riske Creek	6	15	1978	2			Box 27 Lk. Harassing RTHA
Riske Creek	7	10	1978	1			Near CIFAC base. First seen in several weeks.Diving at one of us.
Riske Creek	5	25	1978	9			Flying east in flock at sunset
Riske Creek	7	13	1978	4			Junction Sheep Range. Circling.
Riske Creek	4	9	1978	2			near Meldrum Cr turn-off Hwy 20.
Riske Creek	7	14	1978	7			Junction Sheep Reserve
Riske Creek	6	6	1978	4			Separating Lk. Very agitated; young probably around
Riske Creek	7	14	1978	2			Otter Rd
Riske Creek	8	11	1978	10			Hillcrest Ranch. Flock of 9. One chasing a Red tailed Hawk
Riske Creek	7	18	1978	4			Junction Sheep Range
Riske Creek	5	10	1978	1			Redtail Lk
Riske Creek	4	16	1978	5			Farwell Canyon Rd.
Riske Creek	5	4	1978	1			Riske Creek - Fraser R. Bridge
Riske Creek	5	18	1978	1			L. Lye
Riske Creek	5	17	1978	3			Separating Lk
Riske Creek	5	21	1978	16			CIFAC base. In one flock flying east at sunset
Riske Creek	5	7	1978	1			Barnes Lk
Riske Creek	6	19	1978	7			Hillcrest Ranch. 2 pairs & 1 group of 3 calling and circling
Riske Creek	6	11	1978	7			Junction Sheep Range. Very agitated
Riske Creek	6	28	1978	1			Cotton Ranch. Doc English Gulch
Riske Creek	4	9	1978	6			s Toosey Res
Riske Creek	5	8	1978	2	1	1	Separating Lk. Display flights by male around female made at sunset
Riske Creek	6	8	1978	1			Separating Lk
Riske Creek	6	26	1978	2			Cotton Ranch
Riske Creek	6	6	1978	1			CIFAC base
Riske Creek	6	3	1978	3			Loran C- in field opposite
Riske Creek	6	16	1978	1			Barnes Lk
Riske Creek	4	24	1979	4			Cotton Ranch. Flying over range
Riske Creek	5	23	1979	1			Thompson Ranch near Hwy 20
Riske Creek	6	19	1979	3			w Bald Mtn. Wineglass Ranch.
Riske Creek	5	23	1979	2			Cotton Ranch. Calling
Riske Creek	6	7	1979	6			Cotton Ranch. One group flying over.
Riske Creek	6	8	1979	15			Cotton Ranch. Circling in one spot
Riske Creek	5	21	1980	1			
Riske Creek	4	13	1980	15			Toosey Res
Riske Creek	4	13	1980	9			Thompson Ranch
Riske Creek	4	13	1980	8			Cotton Ranch
Riske Creek	5	23	1980	2			Beecher's Pr. 0.5 km w of McIntyre Lk
Riske Creek	7	26	1981	15			Fairly tight flock flying over gravel roa
Riske Creek	5	9	1982	1			Cotton Ranch in flats above ranch
Riske Creek	5	23	1982	2			MacDonald's Ranch-flying over
Riske Creek	6	13	1982	7			Cotton Ranch. Flying together and calling in agitated manner.
Riske Creek	6	12	1982	8			Farwell Can. 2 mi from jct Chilc./Fras.R.
Riske Creek	5	1	1983	9			In small groups on grassland. No indication of pairing
Riske Creek	5	3	1984	3			Cotton Ranch
Riske Creek	5	8	1984	4			Meldrum Cr Rd - Sword Cr. Feeding.
Riske Creek	4	10	1984	2			Calling & soaring over grassland
Riske Creek	4	9	1984	9			Wineglass Ranch, in alfalfa fields. First time seen was spring 1982
Riske Creek	4	7	1985	1			Cotton Ranch.
Riske Creek	4	30	1985	2			Winegl.Ranch. Seen 8 times Apr.15-30

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Riske Creek	4	30	1985	1			Wineglass Ranch
Riske Creek	5	2	1986	2			Wineglass Ranch. Seen 4 times betw. April 25 & May 2. 4th year here.
Riske Creek	4	5	1987	1			Beecher's Prairie. First one seen
Riske Creek	7	26	1987	15			
Riske Creek	6	2	1989	2			Farwell Canyon Rd.
Riske Creek	5	31	1989	2			Farwell Canyon Rd. Territorial.
Riske Creek	6	4	1989	2			Bald Mtn-Winegl.Ranch.Below mtn.
Riske Creek	5	29	1990	3			Junction Sheep Range. Doing broken wing act
Riske Creek	5	13	1990	2			MacDonald's Ranch
Riske Creek	6	18	1990	2			MacDonald's Ranch
Riske Creek	5	2	1990	2			Cotton Ranch
Riske Creek	5	12	1990	4			MacDonald's Ranch
Riske Creek	5	2	1990	1			Chilcotin Lodge. Heard calling
Riske Creek	6	20	1990	1			Cotton Ranch
Riske Creek	5	1	1990	1			Cotton Ranch, Doc English Lk
Riske Creek	5	16	1990	13			Junction Sheep Range
Riske Creek	5	1	1990	1			Chilcotin Lodge. Heard calling
Riske Creek	6	23	1990	3	1	1	MacDonald's Ranch
Riske Creek	5	7	1990	9	0		MacDonald's Ranch
Riske Creek	6	13	1990	3			MacDonald's Ranch
Riske Creek	4	25	1990	18	5	5	MacDonald's Ranch, s Hwy 20
Riske Creek	6	9	1990	12	2	1	Junction Sheep Range. 3 mobbing.
Riske Creek	4	25	1990	1			Separating Lk, Beechers Prairie
Riske Creek	5	25	1990	23			MacDonald's Ranch. Mobbing
Riske Creek	6	16	1990	14	11	2	Junction Sheep Range, agitated
Riske Creek	6	6	1990	5			MacDonald's Ranch
Riske Creek	4	24	1990	10			Junction Sheep Range
Riske Creek	5	24	1990	6			MacDonald's Ranch
Riske Creek	4	24	1990	1			Behind Chilcotin Lodge.
Riske Creek	6	5	1990	1			Cotton Ranch. At least 1 calling
Riske Creek	5	29	1990	10			Junction Sheep Range
Riske Creek	5	24	1990	16			McDonald's Ranch
Riske Creek	4	23	1990	1			Behind Chilcotin Lodge.
Riske Creek	4	28	1990	2			Bald Mtn-Wineglass Ranch. Flying
Riske Creek	5	28	1990	1			Flying over fields near Hwy 20 and new Farwell Canyon Rd.
Riske Creek	5	11	1990	1			Cotton Ranch
Riske Creek	5	28	1990	2			Cotton Ranch
Riske Creek	6	3	1990	16			McDonald's Ranch
Riske Creek	5	28	1990	18			Junction Sheep Range. 1 pair doing broken wing act
Riske Creek	5	18	1990	7			MacDonald's Ranch
Riske Creek	5	10	1990	4			Toosey Res.
Riske Creek	6	17	1990	1			MacDonald's Ranch
Riske Creek	5	25	1990	11			Toosey Res.
Riske Creek	5	10	1990	3			Deer Park Ranch
Riske Creek	5	25	1990	2			River Ranch
Riske Creek	5	3	1990	1			Chilcotin Lodge. Heard calling
Riske Creek	5	30	1990	6			Toosey Res
Riske Creek	5	10	1990	1			Cotton Ranch
Riske Creek	6	19	1990	1			MacDonald's Ranch
Riske Creek	6	21	1990	6	1	2	MacDonald's Ranch
Riske Creek	6	22	1990	3			Cotton Ranch
Riske Creek	5	19	1990	10			Deer Park Ranch. Feed.in alfalfa fields
Riske Creek	6	9	1990	4	1	2	Cotton Ranch. Were mobbing CORA
Riske Creek	6	8	1990	6			Toosey Res.
Riske Creek	6	7	1990	6	2	1	Loran C. Feeding

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Riske Creek	5	21	1990	2			Wineglass Ranch - below Bald Mtn
Riske Creek	6	18	1990	1			CIFAC Base
Riske Creek	5	17	1990	1			MacDonald's Ranch
Riske Creek	4	28	1990	2			Bald Mtn., Wineglass Ranch
Riske Creek	5	20	1990	2			Sword Creek
Riske Creek	5	9	1990	8			Toosey Res.
Riske Creek	5	8	1990	1			CIFAC Base
Riske Creek	5	8	1990	2			Toosey Res.
Riske Creek	6	13	1990	1		1	CIFAC Base
Riske Creek	5	30	1990	6			MacDonald's Ranch
Riske Creek	6	19	1990	8	2	1	Cotton Ranch
Riske Creek	6	20	1990	3			MacDonald's Ranch
Riske Creek	6	14	1990	8	6	2	Cotton Ranch
Riske Creek	6	8	1990	1			CIFAC Base. At least 1 heard calling
Riske Creek	6	5	1990	3	1	1	CIFAC Base. Acting as if chicks nearby
Riske Creek	6	4	1990	16			MacDonald's Ranch. Mobbing
Riske Creek	5	20	1990	1			Deer Park Ranch
Riske Creek	5	8	1990	2			Behind Chilcotin Lodge.
Riske Creek	6	16	1990	27			MacDonald's Ranch
Riske Creek	6	13	1990	1			Cotton Ranch. At least 1 heard
Riske Creek	6	17	1990	4			Junction Sheep Range
Riske Creek	6	6	1990	6	2	2	Deer Park Ranch Acting as if with chick
Riske Creek	6	11	1990	2	1	1	MacDonald's Ranch
Riske Creek	5	23	1990	2			Cotton Ranch
Riske Creek	5	13	1990	2			Cotton Ranch
Riske Creek	5	10	1990	2			CIFAC Base
Riske Creek	5	22	1990	4			Junction Sheep Range
Riske Creek	5	26	1991	1			Behind Chilcotin Lodge
Riske Creek	5	8	1991	2			Behind Chilcotin Lodge
Riske Creek	4	30	1991	1			Behind Chilcotin Lodge
Riske Creek	5	31	1991	6	3	3	MacDonald's Ranch.
Riske Creek	6	28	1991	1			Behind Chilcotin Lodge
Riske Creek	5	8	1991	1	1		Cotton Ranch pasture
Riske Creek	5	17	1991	1			Behind Chilcotin Lodge
Riske Creek	4	16	1991				Deer Park Ranch. First of the year.
Riske Creek	4	8	1991	1			MacDonald's Ranch
Riske Creek	5	10	1991	2			Behind Chilcotin Lodge
Riske Creek	4	10	1991	2		1	MacDonald's Ranch
Riske Creek	5	31	1991	4	2	2	Sheep Range
Riske Creek	4	12	1991	1			Behind Chilcotin Lodge
Riske Creek	5	10	1991	4	1	1	Deer Park Ranch
Riske Creek	6	18	1991	1			Behind Chilcotin Lodge
Riske Creek	4	14	1991	2			Sheep Range
Riske Creek	4	12	1991	2			Flying over Beecher's Prairie
Riske Creek	5	11	1991	2	1	1	MacDonald's Ranch
Riske Creek	4	13	1991	5	2	1	Sheep Range
Riske Creek	4	22	1991	2	1	1	Flying along Hwy 20 near Chilc.Lodge
Riske Creek	4	14	1991	5	3	2	Toosey Res.
Riske Creek	5	11	1991	1			Racetrack Lk, Beecher's Prairie
Riske Creek	6	17	1991	1			Behind Chilcotin Lodge
Riske Creek	4	6	1991	1			Meldrum Creek Rd. First seen this year
Riske Creek	5	17	1991	2	1	1	MacDonald's Ranch
Riske Creek	5	12	1991	2			MacDonald's Ranch
Riske Creek	6	9	1991	6			Toosey Res.
Riske Creek	4	12	1991	2			Cotton Ranch-across from Loran C
Riske Creek	4	16	1991	1	1		Wineglass Ranch - near corral at base of Bald Mountain
Riske Creek	5	12	1991	1			In gully near Loran C. Acting as if nest nearby

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Riske Creek	4	14	1991	2			Ron Thompson Ranch - Fraser R. First curlews of year
Riske Creek	4	16	1991	1			Behind Chilcotin Lodge
Riske Creek	4	17	1991	5	2	2	Deer Park Ranch. Mating observed.
Riske Creek	5	21	1991	1	1		Near Cifac Base
Riske Creek	4	17	1991	21	9	12	MacDonald's Ranch
Riske Creek	5	13	1991	1			Near Loran C.
Riske Creek	5	30	1991	1			Deer Park Ranch
Riske Creek	4	18	1991	8	4	4	Toosey Res.
Riske Creek	4	18	1991	1			Behind Chilcotin Lodge
Riske Creek	5	14	1991	1			Behind Chilcotin Lodge.
Riske Creek	4	19	1991	1			Behind Chilcotin Lodge
Riske Creek	4	22	1991	19	11	8	MacDonald's Ranch
Riske Creek	4	21	1991	1	1		Behind Chilcotin Lodge
Riske Creek	5	14	1991	7			Junction
Riske Creek	4	22	1991	8	4	2	Toosey Res.
Riske Creek	4	14	1991	1			Behind Chilcotin Lodge
Riske Creek	4	23	1991	2			Behind Chilcotin Lodge
Riske Creek	5	23	1991	1			Behind Chilcotin Lodge
Riske Creek	4	10	1991	2			Behind Chilcotin Lodge
Riske Creek	4	19	1991	22	10	9	Sheep Range and Junction
Riske Creek	4	12	1991	1			In fields east of S. Chilcotin Rd, above Toosey Res.
Riske Creek	4	17	1991	18	6	4	Cotton Ranch. Feeding in hay stubble fields south of ranch buildings
Riske Creek	4	13	1991	1			Behind Chilcotin Lodge
Riske Creek	4	11	1991	1			Behind Chilcotin Lodge
Riske Creek	4	14	1991	2	1		MacDonald's Ranch
Riske Creek	5	22	1991	5	2		Junction
Riske Creek	5	30	1991	1			Behind Chilcotin Lodge
Riske Creek	5	2	1991	6	2	2	Deer Park Ranch
Riske Creek	5	24	1991	1			Behind Chilcotin Lodge
Riske Creek	5	2	1991	21	9	9	MacDonald's Ranch
Riske Creek	4	25	1991	2	1	1	North ridge of Toosey Res.
Riske Creek	5	3	1991	12	4	2	Sheep Range
Riske Creek	4	12	1991	10	4	4	Sheep Range
Riske Creek	5	4	1991	1			Junction
Riske Creek	4	29	1991	2			Behind Chilcotin Lodge
Riske Creek	5	5	1991	8	4	1	Toosey Res.
Riske Creek	4	15	1991	1			Behind Chilcotin Lodge
Riske Creek	5	5	1991	2			Behind Chilcotin Lodge
Riske Creek	5	24	1991	3			MacDonald's Ranch
Riske Creek	5	6	1991	1		1	Rock Lk, Beecher's Prairie
Riske Creek	5	2	1991	2			Behind Chilcotin Lodge
Riske Creek	5	6	1991	3	2		Toosey Res.
Riske Creek	4	25	1991	1			Behind Chilcotin Lodge
Riske Creek	5	7	1991	1			Behind Chilcotin Lodge
Riske Creek	6	16	1991	4			Sheep Range
Riske Creek	5	7	1991	10	2	2	Toosey Res.
Riske Creek	5	1	1991	2	1	1	Behind Chilcotin Lodge
Riske Creek	6	30	1991	2			Heard calling near Loran C.
Riske Creek	4	27	1991	3	1	1	Deer Park Ranch
Riske Creek	5	27	1991	1			Behind Chilcotin Lodge
Riske Creek	5	25	1991	1			Behind Chilcotin Lodge
Riske Creek	5	29	1991	1			Behind Chilcotin Lodge
Riske Creek	5	16	1992	3			Art Grave Ranch south of R.Thompson Ranch on Fraser River
Riske Creek area	4	25	1990	1			Deer Park Ranch
Soda Creek	4	11	1982	2			Near Kaufman's Ranch.

LOCATION	M	D	Y	TOTAL BIRDS	D. M	D. F	REMARKS
Soda Creek	5	27	1991	1			
Springhouse	6	25	1958	25			
Springhouse	4	27	1975	1			Flying over grasslands
Springhouse	5	19	1990	1			Flying across fields near airstrip
Watson Lk	5	9	1959	2			
Westwick Lk	5	17	1948	1	1		Cowan Vert. Mus. (UBC) Cat. No.
Westwick Lk	6	23	1967	4			
Williams Lk	4	29	1977	1			Flying, Scout Island Nature Centre
Williams Lk	4	1	1978	1			Sugar Cane Reserve
Williams Lk	4	20	1980				Sugar Cane Meadows. Several calling
Williams Lk	6	8	1990	1			Cariboo Cattle Co.
Williams Lk	5	8	1990	2			Sugar Cane Reserve. 2 heard calling
Williams Lk	4	22	1990	20			Sugar Cane Meadows
Williams Lk	5	26	1990	3			Sugar Cane Res.
Williams Lk	6	8	1990	1			Sugar Cane Res.
Williams Lk	4	23	1990	1			Cariboo Cattle Co. Heard calling
Williams Lk	4	18	1991	4	1	1	Sugar Cane Res.
Williams Lk	4	24	1991	2	1	1	Cariboo Cattle Co.
Williams Lk	4	24	1991	4	2	1	Sugar Cane Res.
Williams Lk	4	18	1991	2	1	1	Carib.Cattle Co. Feeding in hay field
Williams Lk.	4	19	1978	1			Frost Creek. B.C. Prov. Mus. Cat. No.
Williams Lk.	4	21	1979	1			Sugar Cane River. Calling

GRID	LOCATION	YEAR	MONTH	DAY	EGGS	YOUNG	NEST MATERIAL	NEST POSITION	REMARKS
92O/16	Riske Creek	1978	5	4	2				05/17 eggs cold, punctured, coyote in area
			5	5	3				
			5	9	4				
			5	17	2				
92O/16	1 mi s Riske Creek	1981	5	9	2				Yng w/ adults. Downy, bills 1 1/2" long
			7	3		2			
92O/16	Riske Creek	1983	5	15	4		Small amount of		Cotton Ranch
			5	16	4		dried vegetation		
92O/16	Riske Cr,Cotton Rnch	1979	5	30	3				06/7 eggs smashed by cow stepping on them
			6	3	3				
			6	7	0				
92O/16	Alkali Lk	1968	6	12					Pair w/ nest & egss on plateau above Alkali Lk
92O/16	Riske Creek	1978	6	12		1		(Bighorn Sheep Range)	1+ yng. Downy, 4–5 (?) days old
92O/16	Riske Cr,Cotton Rnch	1987	6	23		2			Downy yng walking across prairie w/ adults
92O/16	Riske Creek	1980	7	5		1		(Bighorn Sheep Range)	7 curlews seen in 1/2 mi length of road
93B/1	Riske Creek	1978	5	29	4		Grass	In open field	20' from bluebird box #388, Thomson corral
			6	5	0	0			
93B/16	25 mi s Quesnel	1979	7	10		2		In very dry cow pasture	Below Moffat's ranch by Fraser R.
93B/3	Alexis Creek	1971	5	28	5			On large open gravel flat with no trees	Crows in vicinity
93B/3	11/2 mi se Alexis Cr	1969	7	21		1		Large open pasture	
92O/16	Riske Cr, McDonald's	1990	5	14		3			Adult flushed from nest
			6	4		3			
			6	14		3			
			6	19		3			
92O/16	Riske Cr, McDonald's	1990	5	22	4				Second nest found this yr, MacDonald's Ranch
92O/16	Riske Crk. Toosey R.	1991	4	23	1		Dirt bowl lined	7 m from edge of dirt	
			5	11	4		with grass	road	
			5	26	1	1			
92O/16	Riske Cr. McDonald's	1991	5	2	1		Grass–lined	Beside 3 dried cow pies	May 25 – nest empty, 2 broken egg shells nearby
			5	25	2		dirt bowl		
92O/16	Riske Cr. McDonald's	1991	5	2	3		Grass–lined bowl	1m from cow trail,betwee	
			5	8	4			rock and cow pie	
			5	25	0	0			
92O/16	Riske Cr. McDonald's	1991	5	20		3			3 chicks seen near lake by old cabin
92O/16	Riske Cr. Toosey Res	1991	6	12		1			Killdeer–sized chick on Toosey north ridge
92O/16	Riske Cr. McDonald's	1991	6	14		1			Chicks were larger than killdeer
			6	16		2			
92O/16	Riske Cr. Sheep Rnge	1991	6	20		1			Chick slightly larger than killdeer,unable to fly
92O/16	Riske Cr., Junction	1991	6	29		1			Fledgeling chick
92O/16	Riske Cr.,Toosey Res	1991	7	2		3			Chicks were flying erratically
			7	3		4			

Appendix 2. Nest records of Long–billed Curlews in the study area.(From nest record cards Royal B.C. Museum)

APPENDIX 3. Maximum counts of most common bird species for all 48 point count locations[a]

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Cifac	1	9.0	0	0	1.0	1.0	11
	2	5.0	0	0	0	0	5
	3	4.0	0	1.0	2.0	0	7
	4	10.0	0	2.0	2.0	0	14
Cotton	1	4.0	0	0	3.0	0	9
	2	2.0	0	0	0	0	2
	3	3.0	1.0	0	2.0	0	6
	4	4.0	1.0	0	1.0	0	6
	5	5.0	0	0	1.0	0	6
	6	5.0	0	0	2.0	0	7
	7	1.0	0	0	1.0	0	2
	8	0	0	0	3.0	0	4
Junction	1	4.0	0	0	3.0	0	7
	2	5.0	0	0	2.0	1.0	8
	3	3.0	2.0	0	2.0	0	7
	4	5.0	1.0	0	2.0	0	8
	5	3.0	2.0	0	1.0	0	6
	6	5.0	0	0	1.0	0	6
	7	2.0	0	0	0	0	2
	8	4.0	0	0	0	0	4
	9	2.0	0	1.0	1.0	0	4
	10	3.0	0	1.0	3.0	0	7
	11	5.0	0	0	0	0	5
	12	5.0	1.0	0	2.0	1.0	9
Loran	1	5.0	0	2.0	3.0	0	10
	2	4.0	0	0	3.0	0	7
	3	5.0	3.0	0	2.0	0	10
	4	5.0	1.0	0	2.0	0	8
McDonald	1	10.0	0	0	0	0	10
	2	4.0	1.0	0	1.0	0	6
	3	6.0	1.0	0	0	0	9
	4	3.0	2.0	0	0	0	5
	5	4.0	0	0	0	0	4
	6	4.0	0	0	0	0	4
	7	5.0	0	0	0	0	5
	8	12.0	0	0	0	0	14
	9	7.0	0	0	0	0	9
	10	3.0	0	0	0	0	3
	11	3.0	2.0	0	0	0	6
	12	1.0	0	0	0	0	1

APPENDIX 3. (Continued)

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Toosey	1	4.0	2.0	0	0	0	6
	2	4.0	1.0	0	1.0	0	6
	3	1.0	2.0	0	0	0	3
	4	1.0	1.0	0	0	0	4
	5	6.0	0	2.0	2.0	0	10
	6	3.0	0	1.0	1.0	1.0	6
	7	8.0	0	0	0	0	8
	8	4.0	0	1.0	0	0	5
Total	12	10	24	11	50	4	311

[a] HOLA - Horned Lark; LBCU - Long-billed Curlew; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark

APPENDIX 4. Mean counts of most common bird species for all 48 point count locations.[a]

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Cifac	1	6.5	0	0	0	0.3	6.8
	2	3.5	0	0	0	0	3.5
	3	2.3	0	0.5	0.8	0	3.6
	4	5.8	0	0.8	0.5	0	7.1
Cotton	1	2.3	0	0	0.8	0	3.6
	2	1.5	0	0	0	0	1.5
	3	1.3	0.3	0	1.5	0	3.1
	4	2.3	0.3	0	0.3	0	2.9
	5	2.6	0	0	0.5	0	3.3
	6	4.0	0	0	1.3	0	5.3
	7	0.8	0	0	1.0	0	1.8
	8	0	0	0	1.0	0	1.3
Junction	1	2.8	0	0	2.0	0	4.8
	2	4.5	0	0	0.3	0	4.8
	3	2.3	0.8	0	0.5	0	3.6
	4	2.8	0.3	0	0	0	3.1
	5	2.5	0.5	0	0	0	3.0
	6	3.5	0	0	0.3	0	3.8
	7	1.5	0	0	0.8	0	2.3
	8	2.3	0	0	0	0	2.3
	9	1.8	0	0	1.5	0.3	3.9
	10	2.3	0	0	1.0	0.3	3.6
	11	3.0	0	0.3	0.8	0	4.1
	12	2.3	0.3	0	0.5	0	3.1
Loran	1	2.8	0	0.5	1.3	0	4.6
	2	2.8	0	0	2.3	0	5.1
	3	2.5	0.8	0	1.0	0	4.3
	4	2.8	0.3	0	1.0	0	4.1
McDonald's	1	6.0	0	0	0	0	6.0
	2	2.3	0.5	0	0	0	2.8
	3	3.3	0.5	0	0	0	4.3
	4	1.5	1.0	0	0	0	2.5
	5	1.8	0	0	0	0	1.8
	6	2.5	0	0	0	0	2.5
	7	2.5	0	0	0	0	2.5
	8	4.5	0	0	0	0	5.0
	9	3.8	0	0	0	0	4.3
	10	1.5	0	0	0.8	0	2.3
	11	1.3	1.0	0	0	0	2.6
	12	0.5	0	0	0	0	0.6

Appendix 4. (Continued)

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Toosey	1	3.3	1.0	0	0	0	4.3
	2	1.5	0.5	0	0.5	0	2.5
	3	0.5	1.0	0	0	0	1.5
	4	0.3	0.3	0	0	0	1.1
	5	1.8	0	1.0	0.8	0	3.6
	6	1.0	0	0.3	0.5	0.3	2.1
	7	4.8	0	0	0	0	4.8
	8	2.8	0	0.3	0	0	3.1
Total		123.1	9.4	4	23.6	1.2	164.1

[a] HOLA - Horned Lark; LBCU - Long-billed Curlew; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark

APPENDIX 5. Median counts of most bird species for all 48 point count locations.[a]

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Cifac	1	7.0	0	0	0	0	7.0
	2	3.5	0	0	0	0	3.5
	3	2.0	0	0.5	0.5	0	3.0
	4	5.0	0	0.5	0	0	5.5
Cotton	1	2.0	0	0	0	0	2.0
	2	1.5	0	0	0	0	1.5
	3	1.0	0	0	1.5	0	2.5
	4	2.5	0	0	0	0	2.5
	5	3.0	0	0	0.5	0	3.5
	6	4.0	0	0	1.0	0	5.0
	7	1.0	0	0	1.0	0	2.0
	8	0	0	0	0.5	0	0.5
Junction	1	2.5	0	0	2.0	0	4.5
	2	5.0	0	0	0	0	5.0
	3	2.0	0.5	0	0.5	0	3.0
	4	2.5	0	0	0	0	2.5
	5	2.5	0	0	0	0	2.5
	6	4.0	0	0	0	0	4.0
	7	1.5	0	0	0	0	1.5
	8	2.5	0	0	0	0	2.5
	9	2.0	0	0	1.5	0	3.5
	10	2.5	0	0	1.0	0	3.5
	11	3.0	0	0	0.5	0	3.5
	12	1.5	0	0	0	0	1.5
Loran	1	3.0	0	0	1.0	0	4.0
	2	2.5	0	0	2.5	0	5.0
	3	2.0	0	0	1.0	0	3.0
	4	2.5	0	0	1.0	0	3.5
McDonald	1	5.5	0	0	0	0	5.5
	2	2.0	0.5	0	0	0	2.5
	3	3.5	0.5	0	0	0	2.5
	4	1.5	1.0	0	0	0	2.5
	5	1.5	0	0	0	0	1.5
	6	2.0	0	0	0	0	2.0
	7	2.0	0	0	0	0	3.0
	8	3.0	0	0	0	0	3.0
	9	3.0	0	0	0	0	3.0
	10	1.5	0	0	0	0	2.5
	11	1.0	1.0	0	0	0	2.0
	12	0.5	0	0	0	0	3.0

APPENDIX 5. (Continued)

Location		HOLA	LBCU	SAVS	VESP	WEME	Total
Toosey	1	3.5	1.0	0	0	0	4.5
	2	1.0	0.5	0	0.5	0	2.0
	3	0.5	1.0	0	0	0	1.5
	4	0	0	0	0	0	0.0
	5	0.5	0	1.0	0.5	0	2.0
	6	0.5	0	0	0.5	0	1.0
	7	5.0	0	0	0	0	5.0
	8	3.0	0	0	0	0	3.0
Total		115	6	2	18.5	0	141.5

[a] HOLA - Horned Lark; LBCU - Long-billed Curlew; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark

APPENDIX 6. Results of the first of four bird counts at the 48 point count locations.

Location		AMCR[a]	CORA	HOLA	KILL	LBCU	SAVS	VESP	Total
Cifac	1	0	0	3	0	0	0	0	3
	2	0	0	2	0	0	0	0	2
	3	0	0	4	0	0	0	0	4
	4	0	0	7	0	0	0	0	7
Cotton	1	0	0	1	0	0	0	0	1
	2	0	0	1	0	0	0	0	1
	3	0	0	1	0	0	0	2	3
	4	0	0	4	0	0	0	1	5
	5	0	0	0	0	0	0	0	0
	6	0	0	3	0	0	0	1	4
	7	0	0	1	0	0	0	1	2
	8	0	0	0	0	0	0	0	0
Junction	1	0	0	3	0	0	0	2	5
	2	0	0	5	0	0	0	0	5
	3	0	0	3	0	1	0	0	4
	4	0	8	5	0	0	0	0	13
	5	0	0	3	0	0	0	0	3
	6	0	0	5	0	0	0	0	5
	7	0	0	1	0	0	0	3	4
	8	0	0	3	0	0	0	0	3
	9	0	0	2	0	0	1	1	4
	10	0	0	1	0	0	0	1	2
	11	0	0	4	0	0	0	0	4
	12	0	0	5	0	1	0	0	6
Loran	1	0	0	0	0	0	0	1	1
	2	0	0	2	0	0	0	1	3
	3	0	0	5	0	3	0	2	10
	4	0	0	5	0	1	0	1	7
McDonald	1	0	0	4	0	0	0	0	4
	2	0	0	2	0	1	0	0	3
	3	0	0	5	1	1	0	0	7
	4	0	0	0	0	2	0	0	2
	5	0	0	0	0	0	0	0	0
	6	0	0	2	0	0	0	0	2
	7	0	0	2	0	0	0	0	2
	8	0	0	4	0	0	0	0	4
	9	0	0	2	0	0	0	0	2
	10	0	0	0	0	0	0	1	1
	11	0	0	0	0	2	0	0	2
	12	0	0	0	0	0	0	0	0

APPENDIX 6. (Continued)

Location		AMCR[a]	CORA	HOLA	KILL	LBCU	SAVS	VESP	Total
Toosey	1	0	0	4	0	1	0	0	5
	2	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	0	0	1
	4	0	2	1	0	0	0	0	3
	5	0	0	6	0	0	0	0	6
	7	0	0	8	0	0	0	0	8
	8	0	0	4	0	0	0	0	4
Total	1	10	124	1	13	1	0	168	

[a] AMCR - American Crow; CORA - Common Raven; HOLA - Horned Lark; KILL - Killdeer; LBCU - Long-billed Curlew; SAVS - Savannah Sparrow; VESP - Vesper Sparrow

APPENDIX 7. Results of the second of four bird counts at the 48 point locations.

Location		BRSP[a]	CORA	HOLA	LBCU	MAHA	SAVS	VESP	WEME	Total
Cifac	1	0	0	8	0	0	0	0	0	8
	2	1	0	2	0	0	0	0	0	3
	3	0	0	1	0	0	0	2	0	3
	4	0	0	3	0	1	0	2	0	6
Cotton	1	0	0	1	0	0	0	3	0	4
	2	0	0	2	0	0	0	0	0	2
	3	0	0	1	1	0	0	1	0	3
	4	0	0	0	1	0	0	0	0	1
	5	0	0	3	0	0	0	1	0	4
	6	0	0	4	0	0	0	2	0	6
	7	0	0	0	0	0	0	1	0	1
	8	0	0	0	0	0	0	3	0	3
Junction	1	0	0	2	0	0	0	1	0	3
	2	0	0	3	0	0	0	0	0	3
	3	0	0	2	2	0	0	0	0	4
	4	0	0	1	1	0	0	0	0	2
	5	0	0	2	0	0	0	0	0	2
	6	0	0	4	0	0	0	1	0	5
	7	0	0	2	0	0	0	0	0	2
	8	0	0	4	0	0	0	0	0	4
	9	0	0	1	0	0	0	2	0	3
	10	0	0	3	0	0	0	0	0	3
	11	0	0	2	0	0	0	0	0	2
	12	0	0	1	0	0	0	2	0	3
Loran	1	0	0	3	0	0	2	3	0	8
	2	0	0	3	0	0	0	3	0	6
	3	0	0	1	0	0	0	1	0	2
	4	0	0	1	0	0	0	2	0	3
McDonald	1	0	0	3	0	0	0	0	0	3
	2	0	0	1	0	0	0	0	0	1
	3	0	0	2	0	0	0	0	0	2
	4	0	0	1	0	0	0	0	0	1
	5	0	0	1	0	0	0	0	0	1
	6	0	0	2	0	0	0	0	0	2
	7	0	0	1	0	0	0	0	0	1
	8	0	0	0	0	0	0	0	0	0
	9	0	0	7	0	0	0	0	0	7
	10	0	0	3	0	0	0	0	0	3
	11	0	1	3	1	0	0	0	0	5
	12	0	0	1	0	0	0	0	0	1

APPENDIX 7. (Continued)

Location		BRSP[a]	CORA	HOLA	LBCU	MAHA	SAVS	VESP	WEME	Total
Toosey	1	0	0	4	0	0	0	0	0	4
	2	0	0	4	0	0	0	1	0	5
	3	0	0	0	1	0	0	0	0	1
	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	2	2	0	4
	6	0	0	0	0	0	0	1	1	2
	7	0	0	1	0	0	0	0	0	1
	8	0	0	2	0	0	0	0	0	2
Total		1	1	96	7	1	4	34	1	145

[a] BRSP - Brewer's Sparrow; CORA - Common Raven: HOLA - Horned Lark; LBCU - Long-billed Curlew; MAHA - Marsh Hawk; SAVS - Savannah Sparrow; VESP - Vesper Sparrow; WEME - Western Meadowlark.

APPENDIX 8. Results of the third of four bird counts at the 48 point locations.

Location		AMRO[a]	HOLA	LBCU	MOBL	SAVS	STAR	VESP	WEME	Total
Cifac	1	0	6	0	0	0	0	0	0	6
	2	0	5	0	0	0	0	0	0	5
	3	0	2	0	0	1	0	1	0	4
	4	0	10	0	0	1	0	0	0	11
Cotton	1	0	4	0	0	0	0	0	0	4
	2	0	1	0	0	0	0	0	0	1
	3	0	0	0	0	0	0	2	0	2
	4	0	3	0	0	0	0	0	0	3
	5	0	5	0	0	0	0	1	0	6
	6	0	5	0	0	0	0	1	0	6
	7	0	1	0	0	0	0	1	0	2
	8	1	0	0	1	0	0	1	0	3
Junction	1	0	2	0	0	0	0	3	0	5
	2	0	5	0	0	0	0	1	0	6
	3	0	2	0	0	0	0	1	0	3
	4	0	1	0	0	0	0	0	0	1
	5	0	2	0	0	0	0	0	0	2
	6	0	4	0	0	0	0	0	0	4
	7	0	2	0	0	0	0	0	0	2
	8	0	0	0	0	0	0	0	0	0
	9	0	2	0	0	0	0	1	1	4
	10	0	3	0	0	0	0	2	0	5
	11	0	1	0	0	0	0	2	0	3
	12	0	1	0	0	0	0	0	0	1
Loran	1	0	3	0	0	0	0	0	0	3
	2	0	2	0	0	0	0	2	0	4
	3	0	3	0	0	0	0	0	0	3
	4	0	3	0	0	0	0	0	0	3
McDonald	1	0	10	0	0	0	0	0	0	10
	2	0	4	0	0	0	0	0	0	4
	3	0	6	0	0	0	0	0	0	6
	4	0	2	0	0	0	0	0	0	2
	5	0	4	0	0	0	0	0	0	4
	6	0	4	0	0	0	0	0	0	4
	7	0	5	0	0	0	0	0	0	5
	8	0	12	0	0	0	0	0	0	12
	9	0	3	0	0	0	2	0	0	5
	10	0	2	0	0	0	0	1	0	3
	11	0	1	0	0	0	0	0	0	1
	12	0	1	0	0	0	0	0	0	1

APPENDIX 8. (Continued)

Location		AMRO[a]	HOLA	LBCU	MOBL	SAVS	STAR	VESP	WEME	Total
Toosey	1	0	3	1	0	0	0	0	0	4
	2	0	2	1	0	0	0	1	0	4
	3	0	1	2	0	0	0	0	0	3
	4	0	0	1	0	0	2	0	0	3
	5	0	0	0	0	1	0	0	0	1
	6	0	0	0	0	1	0	0	0	1
	7	0	3	0	0	0	0	0	0	3
	8	0	1	0	0	1	0	0	0	2
Total	1	142	5	1	5	4	21	1	180	

[a] AMRO - American Robin; HOLA - Horned Lark; LBCU - Long-billed Curlew; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark.

APPENDIX 9. Results of the fourth of four bird counts at the 48 point locations.

Location		BRBL[a]	HOLA	LBCU	MOBL	SAVS	STAR	VESP	WEME	Total
Cifac	1	0	9	0	0	0	0	0	1	10
	2	0	5	0	0	0	0	0	0	5
	3	0	2	0	0	1	0	0	0	4
	4	0	3	0	0	2	0	0	0	5
Cotton	1	0	3	0	0	2	0	0	0	5
	2	0	2	0	0	0	0	0	0	2
	3	0	3	0	0	0	0	1	0	4
	4	0	2	0	0	0	0	0	0	2
	5	0	3	0	0	0	0	0	0	3
	6	0	4	0	0	0	0	1	0	5
	7	0	1	0	0	0	0	1	0	2
	8	0	0	0	0	0	0	0	0	0
Junction	1	0	4	0	0	0	0	2	0	6
	2	0	5	0	0	0	0	0	0	5
	3	0	2	0	0	0	0	1	0	3
	4	0	4	0	0	0	0	0	0	4
	5	0	3	2	0	0	0	0	0	5
	6	0	1	0	0	0	0	0	0	1
	7	0	1	0	0	0	0	0	0	1
	8	0	2	0	0	0	0	0	0	2
	9	0	2	0	0	0	0	2	0	4
	10	0	2	0	0	0	0	1	1	4
	11	0	5	0	0	1	0	1	0	7
	12	0	2	0	0	0	0	0	0	2
Loran	1	0	5	0	0	0	0	1	0	6
	2	0	4	0	0	0	0	3	0	7
	3	0	1	0	0	0	0	1	0	2
	4	0	2	0	0	0	0	1	0	3
McDonald	1	0	7	0	0	0	0	0	0	7
	2	0	2	1	0	0	0	0	0	3
	3	0	0	1	0	0	0	0	0	3
	4	4	3	2	0	0	0	0	0	9
	5	0	2	0	0	0	0	0	0	2
	6	0	2	0	0	0	0	0	0	2
	7	0	2	0	0	0	0	0	0	2
	8	0	2	0	0	0	0	0	0	4
	9	0	3	0	0	0	2	0	0	3
	10	0	1	0	0	0	0	1	0	2
	11	0	1	1	1	1	0	0	0	3
	12	0	0	0	0	0	0	0	0	0

APPENDIX 9. (Continued)

Location		BRBL[a]	HOLA	LBCU	MOBL	SAVS	STAR	VESP	WEME	Total
Toosey	1	0	2	1	0	0	0	0	0	4
	2	0	0	1	0	0	0	1	0	4
	3	0	1	2	0	0	0	0	0	3
	4	0	0	1	0	0	2	0	0	3
	5	0	1	0	0	1	0	0	0	1
	6	0	3	0	0	1	0	0	0	1
	7	0	7	0	0	0	0	0	0	3
	8	0	4	0	0	1	0	0	0	2
Total	4	125	11	3	5	4	19	2	173	

[a] BRBL - Brewer's Blackbird; HOLA - Horned Lark; LBCU - Long-billed Curlew; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark.

Appendix 10. Number of birds observed in various census radii during a 4 minute survey.

Species	Radius (m) 10	20	30	50	75	100	>100
Horned Lark	0	16	31	62	104	162	171
Long-billed Curlew	0	2	2	5	9	16	63
Savannah Sparrow	0	1	1	1	5	6	6
Vesper Sparrow	0	2	5	8	21	38	44
Western Meadowlark	0	0	1	1	1	2	2
Total	0	21	40	79	145	248	323
Number of species	0	4	5	7	9	13	14

Number of birds observed in various census radii during an 8 minute survey.

Species	Radius (m) 10	20	30	50	75	100	>100
Horned Lark	0	17	35	72	122	188	200
Long-billed Curlew	0	2	2	5	9	22	68
Savannah Sparrow	0	1	1	1	6	8	8
Vesper Sparrow	0	2	5	9	24	44	50
Western Meadowlark	0	0	1	1	1	2	2
Total	0	22	44	90	167	294	381
Number of species	0	4	5	7	9	13	17

Number of birds observed in various census radii during a 12 minute survey.

Species	Radius (m) 10	20	30	50	75	100	>100
Horned Lark	0	17	36	83	134	210	226
Long-billed Curlew	0	2	2	6	10	24	76
Savannah Sparrow	0	3	3	3	8	11	12
Vesper Sparrow	0	2	8	15	31	49	56
Western Meadowlark	0	0	1	1	2	4	4
Total	0	25	51	111	192	330	434
Number of species	0	5	6	8	10	14	19

APPENDIX 11. Point count results by grassland area.[a]

Bird Species	Cifac #1-4	Cotton #1-4	Cotton #5-8	Loran #1-4
AMCR[b]	0	0	0	0
AMRO	0	0	0.3±0.3	0
BRBL	0	0	0	0
BRSP	0.03±0.03	0	0	0
CORA	0	0	0	0
HOLA	7.0±1.5	3.3±0.5	2.8±1.3	4.8±0.3
KILL	0	0	0	0
LBCU	0	0.5±0.3	0	1.0±0.7
MAHA	0.3±0.3	0	0	0
MOBL	0	0.5±0.5	0.3±0.3	0
SAVS	0.8±0.5	0	0	0
STAR	0	0	0	0
VESP	1.0±0.6	1.5±0.6	1.8±0.5	2.5±0.3
WEME	0.3±0.3	0	0	0
Total	12.0±2.4	8.3±1.4	11.5±1.0	11.3±0.9

Bird Species	Junction #1-4	Junction #5-8	Junction #9-12	McDonald's #1-4
AMCR	0	0	0	0
AMRO	0	0	0	0
BRBL	0	0	0	1.0±1.0
BRSP	0	0	0	0
CORA	2.0±2.0	0	0	0
HOLA	4.3±0.5	3.5±0.6	3.8±0.8	5.8±1.5
KILL	0	0	0	0.3±0.3
LBCU	0.8±0.5	0.5±0.5	0.3±0.3	1.0±0.5
MAHA	0	0	0	0
MOBL	0	0	0	0
SAVS	0	0	0.5±0.3	0
STAR	0	0	0	0.5±0.5
VESP	1.3±0.6	1.0±0.7	2.0±0	0
WEME	0	0	0.5±0.3	0
Total	10.8±2.4	11.5±0.5	17.5±1.2	11.0±1.4

APPENDIX 11. (Continued)

Bird Species	McDonald's #5-8	McDonald's #9-12	Toosey #1-4	Toosey #5-8
AMCR	0	0	0.3±0.3	0
AMRO	0	0	0	0
BRBL	0	0	0	0
BRSP	0	0	0	0
CORA	0	0.3±0.3	0.5±0.5	0
HOLA	6.3±1.9	3.5±1.3	2.5±0.9	5.3±1.1
KILL	0	0	0	0
LBCU	0	0.5±0.5	1.5±0.3	0
MAHA	0	0	0	0
MOBL	0	0.3±0.3	0	0
SAVS	0	0	0	1.4±0.4
STAR	0.5±0.5	0.5±0.5	0.5±0.5	0
VESP	0	0.3±0.3	0.3±0.3	0.8±0.5
WEME	0	0	0	0.3±0.3
Total	13.3±3.0	15.8±1.3	8.0±0.7	13.8±0.8

[a] Values are means ± SE. N=4.

[b] AMCR - American Crow; AMRO - American Robin; BRBL - Brewer's Blackbird; BRSP - Brewer's Sparrow; CORA - Common Raven; HOLA - Horned Lark; KILL - Killdeer; LBCU - Long-billed Curlew; MAHA - Marsh Hawk; MOBL - Mountain Bluebird; SAVA - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark.

APPENDIX 12. Vegetation measurements by grassland area.

Vegetation Characteristic	Cifac #1-4	Cotton #1-4	Cotton #5-8
Bare ground[a]	30.5±6.1	35.7±4.5	29.2±3.6
Bryophytes	0.4±0.2	0	0.4±0.2
Feces	1.6±0.9	1.8±1.3	3.5±2.0
Forbs	32.3±6.7	15.4±4.2	19.7±2.5
Grass	40.1±5.9	38.8±7.0	48.6±2.6
Litter	3.2±1.7	1.1±0.2	10.7±8.4
Rocks	1.2±0.6	0.3±0.3	0.1±0.1
Shrubs	0	0.1±0.1	0
Max. veg. ht.[b]	54.5±2.5	33.6±2.4	42.8±3.9
Mode veg. ht.	15.3±1.7	11.2±0.7	13.7±0.9
Veg. density 5 m[c]	69.8±3.3	31.5±2.4	50.8±2.1
Veg. density 10 m	89.2±3.3	44.5±1.2	66.1±2.0
Veg. density 20 m	97.9±1.0	54.7±0.6	76.9±3.1

Vegetation Characteristics	Loran #1-4	Junction #1-4	Junction #5-8
Bare ground	42.9±6.2	40.8±11.2	43.5±4.3
Bryophytes	0.2±0.1	0	0.1±0.1
Feces	3.4±2.0	0.4±0.2	0.2±0.1
Forbs	24.7±2.4	18.5±4.7	19.9±2.9
Grass	24.5±4.3	35.4±11.4	32.1±3.8
Litter	1.5±0.3	1.2±0.2	1.5±0.5
Rocks	0.6±0.3	0.8±0.7	0
Shrubs	0.1±0.1	0.7±0.5	0
Max. veg. ht.	37.5±1.9	30.3±1.1	16.9±3.1
Mode veg. ht.	11.5±0.7	15.2±1.2	19.2±1.9
Veg. density 5 m	41.9±2.7	38.3±7.1	58.6±8.9
Veg. density 10 m	60.3±3.1	52.6±5.1	83.1±7.4
Veg. density 20 m	74.4±4.2	66.5±3.3	92.1±5.1

APPENDIX 12. (Continued)

Vegetation Characteristics	Junction #9-12	McDonald's #1-4	McDonald's #5-8
Bare ground	35.1±5.2	39.0±3.9	21.8±6.0
Bryophytes	0	0.6±0.4	0.3±0.2
Feces	0.1±0.1	2.8±0.9	2.5±1.0
Forbs	22.7±4.5	31.3±4.9	24.3±2.2
Grass	29.7±5.3	32.1±6.4	53.1±7.7
Litter	1.3±0.2	1.2±0.1	6.4±2.5
Rocks	1.5±1.4	1.1±0.5	0
Shrubs	1.7±1.7	0	0
Max. veg. ht.	52.2±4.3	33.9±3.2	38.5±3.5
Mode veg. ht.	32.6±3.5	9.0±0.6	13.3±1.4
Veg. density 5 m	83.0±2.1	34.2±1.6	55.6±6.3
Veg. density 10 m	95.9±2.7	46.3±1.6	70.1±6.2
Veg. density 20 m	97.4±2.5	60.8±2.3	88.9±4.1

Vegetation Characteristics	McDonald's #9-12	Toosey #1-4	Toosey #5-8
Bare ground	33.7±4.9	55.5±2.9	29.9±3.3
Bryophytes	0.4±0.2	0.2±0.1	2.4±1.6
Feces	1.5±1.0	0.9±0.6	5.6±2.3
Forbs	26.5±3.7	19.6±3.3	22.1±8.5
Grass	46.5±7.6	28.6±1.4	41.0±6.3
Litter	1.2±0.1	1.0±0	4.7±2.3
Rocks	0.7±0.5	1.7±1.0	0.9±0.6
Shrubs	0	0	0
Max. veg. ht.	44.7±6.8	34.8±2.0	47.2±4.3
Mode veg. ht.	12.6±1.3	7.2±0.9	12.6±0.8
Veg. density 5 m	55.7±1.05	28.9±1.3	70.2±4.3
Veg. density 10 m	70.9±9.7	47.7±2.4	87.2±3.0
Veg. density 20 m	83.6±8.7	68.3±3.8	95.8±1.7

a - Values are means ± SE (% canopy cover). N = 20.
b - Values are means ± SE (cm). N = 20.
c - Values are means ± SE (% vertical cover). N = 20.

APPENDIX 13. Vegetation measurements for individual point count locations.

Point		Bare ground[a]	Bryophytes[a]	Feces[a]	Forbs[a]
Cifac	1	36.8±5.5	0.2±0.2	3.4±1.7	35.6±4.1
	2	42.6±8.4	0.6±0.2	2.6±2.4	29.6±7.1
	3	25.6±2.3	0.6±0.2	0	15.8±7.4
	4	15.2±6.0	0	0.2±0.2	48.2±11.5
Cotton	1	44.6±2.7	0	0.6±0.2	19.4±2.9
	2	39.6±6.3	0	0.2±0.2	13.0±3.1
	3	35.0±10.0	0	5.6±4.0	24.2±6.3
	4	23.6±3.7	0	0.8±0.5	4.8±1.1
	5	25.2±3.2	0.2±0.2	5.8±3.5	18.2±1.2
	6	39.8±4.5	0	0	21.4±7.0
	7	24.2±3.4	0.8±0.2	0	25.4±5.2
	8	27.4±9.8	0.4±0.2	8.0±4.7	13.8±4.1
Loran	1	60.2±8.3	0	8.0±7.3	17.6±3.6
	2	36.8±3.0	0.2±0.2	0.2±0.2	27.6±4.1
	3	42.8±7.7	0.4±0.2	0	27.2±1.9
	4	31.8±4.1	0	5.2±3.0	26.2±3.0
Junction	1	9.0±2.9	0	0.2±0.2	17.8±4.6
	2	61.6±5.9	0	0	9.8±2.3
	3	47.2±9.0	0	1.0±0.9	14.6±4.0
	4	45.2±10.0	0	0.4±0.2	31.8±7.2
	5	32.6±5.7	0.2±0.2	0.2±0.2	13.2±4.5
	6	41.8±6.0	0	0	26.6±8.0
	7	46.4±4.1	0	0.4±0.2	22.2±7.6
	8	53.2±9.3	0	0	17.6±4.4
	9	27.8±12.0	0	0.2±0.2	36.2±6.8
	10	33.0±10.4	0	0	19.0±6.1
	11	50.2±3.8	0	0	18.4±4.5
	12	29.2±5.3	0	0.2±0.2	17.2±4.9
McDonald	1	36.8±3.7	1.6±0.8	4.2±3.6	22.4±2.4
	2	35.4±2.9	0.4±0.2	0.4±0.2	23.2±5.6
	3	50.4±6.0	0	2.4±1.7	39.8±4.0
	4	33.2±3.8	0.2±0.2	4.2±3.1	39.6±6.3
	5	35.2±6.7	0.6±0.2	0.6±0.4	28.2±7.3
	6	16.6±5.1	0	5.0±1.4	24.4±3.3
	7	27.6±6.0	0.4±0.2	3.2±2.7	26.2±4.8
	8	7.8±2.8	0	1.0±0.9	18.2±0.4
	9	33.0±3.7	0	0.2±0.2	21.2±6.6
	10	47.0±5.6	0.2±0.2	0.6±2.3	36.2±6.7
	11	23.2±3.3	0.6±0.2	4.4±3.5	28.2±10.8
	12	31.6±3.6	0.8±0.2	0.8±0.2	23.2±5.6

APPENDIX 13. (Continued)

Point		Bare ground	Bryophytes	Feces	Forbs
Toosey	1	48.2±7.6	0.2±0.2	0.6±0.4	26.6±5.6
	2	57.8±1.9	0.4±0.2	2.6±2.1	22.0±6.1
	3	61.6±4.7	0	0.2±0.2	11.0±5.0
	4	54.2±4.0	0	0.2±0.2	18.8±6.0
	5	32.8±8.5	0	8.0±4.7	0.6±0.2
	6	33.2±3.9	0.2±0.2	3.4±2.2	19.8±5.3
	7	20.0±5.5	2.4±1.7	10.6±5.3	26.4±6.6
	8	33.4±3.6	6.8±5.3	0.4±0.2	41.6±5.8

Point		Grass[a]	Litter[a]	Rocks[a]	Shrubs[a]
Cifac	1	32.8±5.1	2.6±0.9	0.4±0.4	0
	2	28.0±3.1	1.0±0	2.2±1.8	0
	3	52.2±11.1	8.2±3.0	2.2±1.5	0
	4	48.6±13.8	1.0±0.3	0	0
Cotton	1	33.6±7.1	1.0±0	0	0.4±0.4
	2	47.2±5.5	1.2±0.2	0	0
	3	21.6±3.8	0.6±0.2	1.0±0.9	0
	4	52.6±5.8	1.6±0.5	0	0
	5	46.6±3.1	1.6±0.4	0	0
	6	42.2±8.0	36.0±0.2	0.2±0.2	0
	7	53.2±7.9	2.0±0.7	0	0
	8	52.2±11.9	3.2±1.5	0	0
Loran	1	13.2±2.0	1.0±0	0	0
	2	22.0±5.0	1.0±0	1.2±0.9	0.2±0.2
	3	30.8±6.3	1.8±0.8	1.0±0.5	0
	4	31.8±3.5	2.2±0.7	0.2±0.2	0
Junction	1	68.2±10.7	1.0±0	0	0.8±0.7
	2	24.8±8.3	1.0±0	3.0±2.7	2.0±1.8
	3	32.0±10.4	1.8±0.7	0	0
	4	16.4±5.8	1.0±0	0.2±0.2	0
	5	42.8±8.6	1.0±0	0	0
	6	27.2±5.7	1.0±0	0	0
	7	32.0±10.3	1.0±0	0	0
	8	26.2±12.4	2.8±1.6	0	0
	9	25.4±7.0	1.0±0	0	0
	10	32.8±11.0	1.4±0.4	0.2±0.2	6.6±2.8
	11	17.8±3.0	1.0±0	0	0
	12	42.8±7.0	1.8±0.7	0	0

APPENDIX 13. (Continued)

Point		Grass	Litter	Rocks	Shrubs
McDonald	1	39.8±6.5	1.4±0.2	0.2±0.2	0
	2	41.6±9.0	1.0±0	2.6±1.4	0
	3	13.8±2.6	1.2±0.2	0.4±0.2	0
	4	33.2±7.6	1.0±0	1.0±0.9	0
	5	38.8±9.4	1.8±0.7	0	0
	6	55.2±4.5	5.0±1.3	0	0
	7	44.6±11.7	5.2±2.4	0	0
	8	73.8±7.3	13.4±5.5	0	0
	9	55.6±7.9	1.0±0	0.6±0.2	0
	10	23.6±3.5	1.0±0	0.2±0.2	0
	11	52.2±14.1	1.2±0.2	2.0±1.1	0
	12	54.4±4.8	1.4±0.2	0	0
Toosey	1	32.2±5.9	1.0±0	0	0
	2	25.8±5.9	1.0±0	2.0±1.4	0
	3	29.8±7.3	1.0±0	0.6±0.5	0
	4	26.6±11.0	1.0±0	4.2±3.6	0
	5	51.2±1.6	11.0±8.9	0	0
	6	43.8±7.4	1.2±0.2	0	0
	7	46.2±10.6	1.6±0.2	2.6±2.4	0
	8	22.8±1.2	1.6±0.2	1.0±0.9	

Point		Trees[a]	Max.veg. ht.[b]	Mode veg. ht.[b]	Vertical density 5m[c]
Cifac	1	0	50.6±3.3	13.0±1.2	67.6±8.0
	2	0	57.6±4.9	12.4±1.4	65.6±5.3
	3	0	49.8±4.2	16.0±1.0	66.2±5.2
	4	0	60.0±9.4	19.8±2.9	79.6±3.8
Cotton	1	0	29.4±3.0	9.8±0.5	32.6±4.8
	2	0	29.6±1.5	10.0±0.6	37.6±2.6
	3	0	36.0±1.0	12.2±0.3	27.2±3.3
	4	0	39.2±1.3	12.6±0.7	28.4±3.7
	5	0	32.8±2.4	11.8±0.5	54.0±1.7
	6	0	43.8±3.8	16.2±3.8	45.2±5.5
	7	0	43.0±3.3	12.8±0.7	54.2±4.9
	8	0	51.6±5.6	14.0±1.9	49.8±6.8
Loran	1	0	41.0±3.9	9.4±1.5	35.2±4.6
	2	0	37.4±2.5	12.8±1.2	43.8±6.7
	3	0	32.2±3.0	12.0±1.1	40.4±1.0
	4	0	39.4±4.5	11.8±1.0	48.2±6.7

APPENDIX 13. (Continued)

Point		Trees	Max.veg.ht.	Mode veg. ht.	Vertical density 5m
Junction	1	0	33.0±3.3	17.4±0.6	54.2±9.9
	2	0	31.2±1.6	16.2±0.6	45.4±3.0
	3	0	29.2±2.0	15.4±0.7	30.2±3.4
	4	0	27.8±3.1	11.8±1.0	23.2±3.3
	5	0	46.8±6.5	17.2±2.1	47.6±4.9
	6	0	38.2±6.2	16.6±4.5	39.8±3.7
	7	0	51.4±4.7	24.8±3.8	77.2±5.5
	8	0	51.0±4.9	18.0±3.1	69.6±6.4
	9	0	42.4±6.7	26.2±5.0	78.4±12.5
	10	0	50.4±10.2	27.8±5.8	82.4±10.5
	11	0	52.4±1.5	34.8±1.5	82.8±4.8
	12	0	63.4±4.0	41.6±3.4	88.4±3.4
McDonald	1	0	27.6±1.6	8.6±0.5	38.8±2.9
	2	0	37.6±2.7	8.2±0.3	32.0±2.3
	3	0	40.8±4.4	8.4±0.4	32.2±3.3
	4	0	29.6±2.9	10.6±1.0	33.8±2.4
	5	0	31.0±3.9	10.8±1.3	39.2±4.5
	6	0	44.2±3.0	13.4±1.4	52.8±4.9
	7	0	34.0±4.8	11.6±1.2	67.4±9.8
	8	0	44.6±4.1	17.2±1.3	63.2±6.7
	9	0	63.8±1.9	16.0±1.5	85.8±4.6
	10	0	42.8±6.6	10.8±0.7	42.0±3.2
	11	0	40.0±6.5	13.0±2.6	54.8±7.2
	12	0	32.0±3.7	10.6±0.5	40.2±2.4
Toosey	1	0	34.4±3.4	7.0±1.2	25.6±1.0
	2	0	31.6±4.7	6.2±1.1	30.6±2.8
	3	0	32.8±2.4	5.8±0.5	31.2±6.4
	4	0	40.4±5.0	9.8±2.4	28.2±5.8
	5	0	42.0±6.0	14.4±1.5	65.4±7.8
	6	0	52.2±3.5	13.0±1.2	83.6±6.5
	7	0	51.0±3.3	10.8±2.2	69.2±5.4
	8	0	43.4±4.7	12.0±1.8	65.4±11.8

Point		Vertical density 10 m^c	Vertical density 20 m^c
Cifac	1	92.8±2.6	99.0±0.9
	2	84.6±1.5	96.6±1.7
	3	82.6±3.7	96.0±1.7
	4	96.8±0.7	100.0±0

APPENDIX . (Continued)

Point		Vertical density 10 m	Vertical density 20 m
Cotton	1	45.6±5.5	53.2±2.8
	2	47.0±3.0	55.4±1.4
	3	41.2±3.5	54.2±5.8
	4	44.0±2.1	55.8±3.2
	5	70.4±2.1	82.0±5.5
	6	61.2±4.1	69.2±4.6
	7	67.8±4.9	74.2±3.8
	8	64.8±5.8	82.0±5.3
Loran	1	54.8±4.8	69.8±7.4
	2	69.0±6.8	86.2±5.7
	3	58.0±5.0	74.2±4.3
	4	59.2±5.5	67.4±3.6
Junction	1	62.6±7.2	72.2±8.5
	2	59.6±5.1	72.0±7.1
	3	46.6±2.6	60.4±6.7
	4	41.4±4.4	61.2±8.9
	5	75.2±5.9	78.6±5.1
	6	66.4±4.8	89.6±3.9
	7	97.6±1.8	100.0±0
	8	93.2±3.3	100.0±0
	9	88.0±10.9	90.0±9.1
	10	96.6±3.1	99.6±0.4
	11	99.2±0.5	100.0±0
	12	99.6±0.4	100.0±0
McDonald	1	50.2±1.6	61.2±3.0
	2	42.6±2.0	55.2±5.7
	3	45.0±2.8	66.6±5.4
	4	47.4±1.8	60.2±6.8
	5	54.2±3.5	81.0±0.5
	6	66.6±6.9	82.6±7.9
	7	82.0±7.7	96.4±2.1
	8	77.6±6.3	95.4±3.5
	9	96.8±1.8	100.0±0
	10	65.8±3.7	89.8±3.7
	11	70.6±6.6	85.4±6.3
	12	50.2±2.0	59.2±3.1

APPENDIX 13. (Concluded)

Point		Vertical density 10 m	Vertical density 20 m
Toosey	1	41.4±2.0	58.2±4.0
	2	47.0±2.7	69.9±9.0
	3	50.2±6.3	68.6±8.1
	4	52.2±5.6	76.8±8.0
	5	81.8±2.1	91.6±3.5
	6	94.8±4.5	97.0±2.7
	7	89.2±3.7	99.6±0.4
	8	83.0±8.5	95.0±2.0

[a] Values are means ± SE (canopy cover). N=20.
[b] Values are means ± SE (cm). N=20.
[c] Values are means ± SE (% vertical cover). N=20.

APPENDIX 14. Spearman correlation coefficients for vegetation variables[a]

	Bare ground	Bryophytes	Feces	Forbs	Grass
Bare ground	1.000				
Bryophytes	-0.216	1.000			
Feces	-0.224	0.232	1.000		
Forbs	-0.034	0.335	0.106	1.000	
Grass	-0.776	0.176	0.124	-0.302	1.000
Litter	-0.433	0.215	0.170	-0.172	0.483
Rocks	0.190	0.245	-0.064	0.343	-0.364
Shrubs	0.046	-0.212	-0.296	-0.171	-0.060
Max.veg.ht.	-0.274	-0.066	-0.106	0.007	0.169
Mode veg.ht.	-0.343	-0.363	-0.415	-0.191	0.200
Vertical density 5 m	-0.436	0.040	-0.153	0.020	0.301
Vertical density 10 m	-0.330	0.022	-0.198	0.028	0.190
Vertical density 20 m	-0.232	0.020	-0.176	0.099	0.094

	Litter	Rocks	Shrubs	Max.veg. ht.	Mode veg. ht.
Litter	1.000				
Rocks	-0.242	1.000			
Shrubs	-0.232	0.081	1.000		
Max.veg.ht.	0.188	-0.057	-0.195	1.000	
Mode veg.ht.	0.166	-0.226	0.186	0.585	1.000
Vertical density 5 m	0.312	-0.097	0.041	0.759	0.696
Vertical density 10 m	0.242	-0.080	-0.003	0.797	0.704
Vertical density 20 m	0.228	-0.042	-0.060	0.788	0.639

APPENDIX 14. (Continued)

	Vertical density 5 m	Vertical density 10 m	Vertical density 20 m
Vertical density 5 m	1.000		
Vertical density 10 m	0.963	1.000	
Vertical density 20 m	0.888	0.957	1.000

[a] N=48. 0.240: α = 0.10;0.285: α = 0.05;0.370: α = 0.01; 0.465 = α 0.001.

APPENDIX 15. Spearman correlation coefficients for bird variables[a].

	AMCR[b]	AMRO	BRBL	BRSP	CORA	HOLA
AMCR	1.000					
AMRO	-0.021	1.000				
BRBL	-0.021	-0.021	1.000			
BRSP	-0.021	-0.021	-0.021	1.000		
CORA	-0.038	-0.038	-0.038	-0.038	1.000	
HOLA	-0.225	-0.252	-0.129	0.107	-0.140	1.000
KILL	-0.021	-0.021	-0.021	-0.021	-0.038	0.182
LBCU	0.253	0.101	0.253	-0.101	0.333	-0.200
MAHA	-0.021	-0.021	-0.021	-0.021	-0.038	0.236
MOBL	-0.038	0.552	-0.038	-0.038	0.267	-0.233
SAVS	-0.065	-0.065	-0.065	-0.065	-0.115	0.131
STAR	-0.044	-0.044	-0.044	-0.044	0.233	0.211
VESP	-0.146	0.235	-0.146	-0.146	-0.258	-0.068
WEME	-0.044	-0.044	-0.044	-0.044	-0.078	-0.116

	KILL	LBCU	MAHA	MOBL	SAVS	STAR
KILL	1.000					
LBCU	0.158	1.000				
MAHA	-0.021	-0.101	1.000			
MOBL	-0.038	0.025	-0.038	1.000		
SAVS	-0.065	-0.308	0.366	-0.115	1.000	
STAR	0.484	0.059	-0.044	-0.078	-0.134	1.000
VESP	-0.146	-0.215	0.140	0.196	0.325	-0.301
WEME	-0.044	-0.209	-0.044	-0.078	0.243	-0.091

	VESP	WEME
VESP	1.000	
WEME	0.084	1.000

[a] N=48. 0.240: $\alpha = 0.10$; 0.285: $\alpha = 0.05$; 0.370 $\alpha = 0.01$; 0.465 $\alpha = 0.001$.

[b] AMCR - American Crow; AMRO - American Robin; BRBL - Brewer's Blackbird; BRSP - Brewer's Sparrow; CORA - Common Raven; HOLA - Horned Lark; Kill - Killdeer; LBCU - Long-billed Curlew; MAHA - Marsh Hawk; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark.

APPENDIX 16. Spearman correlation coefficients for bird and vegetation variables[a]

	Bare ground	Bryophytes	Feces	Forbs	Grass
AMCR[b]	0.242	-0.127	-0.106	-0.216	-0.090
AMRO	-0.142	0.144	0.228	-0.184	0.163
BRBL	-0.032	0.069	0.149	0.216	-0.005
BRSP	0.090	0.196	0.096	0.163	-0.100
CORA	0.085	-0.042	0.011	0.143	-0.118
HOLA	-0.067	-0.086	0.131	0.174	-0.005
KILL	0.184	-0.127	0.080	0.226	-0.237
LBCU	0.216	-0.044	0.062	0.023	-0.198
MAHA	-0.226	-0.127	-0.106	0.247	0.132
MOBL	-0.127	0.118	0.233	-0.057	0.192
SAVS	-0.082	-0.059	-0.004	-0.009	-0.100
STAR	0.046	-0.262	-0.036	0.008	0.060
VESP	-0.041	-0.321	-0.137	-0.225	-0.100
WEME	-0.087	-0.060	-0.030	0.139	-0.060

	Litter	Rocks	Shrubs	Max. veg.ht.	Mode veg.ht.
AMCR	-0.138	0.101	-0.050	-0.126	-0.248
AMRO	0.182	-0.135	-0.050	0.184	0.068
BRBL	-0.138	0.135	-0.050	-0.200	-0.137
BRSP	-0.138	0.203	-0.050	0.216	-0.016
CORA	-0.166	0.272	-0.088	-0.158	-0.121
HOLA	0.231	0.005	-0.042	0.143	0.087
KILL	-0.000	0.079	-0.050	0.005	-0.205
LBCU	-0.231	0.227	-0.236	-0.337	-0.319
MAHA	-0.138	-0.135	-0.050	0.226	0.195
MOBL	0.020	-0.057	0.193	-0.035	-0.043
SAVS	-0.008	-0.052	-0.152	0.337	0.236
STAR	-0.014	0.154	-0.103	0.180	-0.057
VESP	-0.088	-0.168	0.400	0.140	0.399
WEME	0.031	0.125	0.164	0.261	0.267

APPENDIX 16. (Continued)

	Vertical density 5 m	Vertical density 10 m	Vertical density 20 m
AMCR	-0.174	-0.121	-0.111
AMRO	0.016	-0.016	0.011
BRBL	-0.132	-0.142	-0.174
BRSP	0.111	0.132	0.142
CORA	-0.241	-0.169	-0.085
HOLA	0.226	0.211	0.268
KILL	-0.153	-0.195	-0.132
LBCU	-0.545	-0.509	-0.476
MAHA	0.195	0.211	0.221
MOBL	-0.039	-0.089	-0.125
SAVS	0.372	0.378	0.339
STAR	-0.027	-0.003	0.090
VESP	0.177	0.159	0.090
WEME	0.392	0.354	0.297

[a] N=48. 0.240: $\alpha = 0.10$; 0.285: $\alpha = 0.05$; 0.370: $\alpha = 0.01$; 0.465: $\alpha = 0.001$.

[b] AMCR - American Crow; AMRO - American Robin; BRBL - Brewer's Blackbird; BRSP - Brewer's Sparrow; CORA - Common Raven; HOLA - Horned Lark; KILL - Killdeer; LBCU - Long-billed Curlew; MAHA - Marsh Hawk; MOBL - Mountain Bluebird; SAVS - Savannah Sparrow; STAR - Starling; VESP - Vesper Sparrow; WEME - Western Meadowlark.

Appendix 17. Legend for grassland codes.

CI 14	Cifac Base - points 1-4
CO 14	Cotton Ranch - points 1-4
CO 58	Cotton Ranch - points 5-8
LO 14	Loran - points 1-4
JU 14	Junction - points 1-4
JU 58	Junction - points 5-8
JU 912	Junction - points 9-12
MD 14	McDonald's Ranch - points 1-4
MD 58	McDonald's Ranch - points 5-8
MD 912	McDonald's Ranch - points 9-12
TO 14	Toosey Indian Reserve - points 1-4
TO 58	Toosey Indian Reserve - points 5-8