REPRODUCTIVE SUCCESS OF WESTERN AND MOUNTAIN BLUEBIRDS IN GRASSHOPPER CONTROL AREAS, AND POTENTIAL FOR REDUCING GRASSHOPPER DENSITIES BY INCREASING BLUEBIRD NUMBERS 1988 TO 1990 REPORT

Charlotte C. Corkran
Northwest Ecological Research Institute
Portland, Oregon
NERI Report # 91-01

ABSTRACT
A study was started to examine possible effects of chemical grasshopper control on Western Bluebird (*Sialia mexicana*) and Mountain Bluebird (*Sialia currucoides*) reproduction, and to assess the potential for reducing local grasshopper densities by increasing bluebird numbers. The first 3 years are reported. Nest boxes were placed at 10 study sites in grassland / juniper areas of central Oregon, and were monitored during breeding seasons. Observational samples of nestling diets were taken at some nests. Bluebirds were censused and grasshoppers counted at study sites and similar sites with no boxes. No grasshopper control has occurred yet. Nest success rate, number of fledglings from successful nests, and other reproductive parameters varied between years and between the 2 species, but were comparable between study sites. Grasshoppers comprised the majority of the diet samples, with higher percentages for Western Bluebirds. Bluebirds used 24% of the boxes in 1988 and 60% by 1990. Censuses also showed increased bluebird numbers at study sites but not at no-box sites. Grasshopper densities were very low in 1988, low in 1989, and irregular but high in spots in 1990. Placing nest boxes in suitable habitat increased local numbers of Western and Mountain Bluebirds. Grasshoppers were an important food resource for nestlings. Additional data are needed to meet the objectives of the study.

Reproductive success of Western and Mountain Bluebirds in grasshopper control areas, and potential for reducing grasshopper densities by increasing bluebird numbers: 1988 to 1990 report.

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INTRODUCTION

Chemical insecticides have been widely used on rangelands of the western United States for the control of grasshopper infestations. However, there has been limited research either on the impacts of these insecticide uses to wild bird populations or on the role of grassland birds in regulating grasshopper populations. This study has 2 objectives: to investigate the effects of chemical grasshopper control on the reproductive success of Western Bluebirds (*Sialia mexicana*) and Mountain Bluebirds (*Sialia currucoides*), and to examine the potential for reducing grasshopper densities by increasing bluebird numbers. Data from the first 3 years of the study are included in this report. Insecticide spraying for grasshopper control has not occurred during the study, but baseline bluebird reproductive and nestling diet data have been obtained, as well as preliminary information on the relationship between bluebird and grasshopper populations.

STUDY AREA AND METHODS

Ten study sites in north central Oregon are being used in the project (Figure 1). All are in areas of grassland with scattered junipers. Eight of the sites are in Wheeler County and were established just prior to the breeding season in 1988; the 2 in Grant County were established after the breeding season in 1989. At each study site, about 35 wooden nest boxes were placed 4 - 5 feet above ground on fence posts or on junipers from which most of the branches on one side had been removed. Inside dimensions of the boxes are 4 X 5 X 11 inches, with an entrance hole 1 9/16 inches in diameter. Boxes are 100 - 150 meters apart. Boxes that have proved to be in positions vulnerable to cattle damage or to usurpation by House Wrens (*Troglodytes aedon*) have been repaired and moved where possible, occasionally to other sites. Because of these changes and losses due to splitting wood and cattle rubbing, the number of boxes per site has ranged from 28 to 43. An additional 6 sites with similar habitat but no nest boxes have also been established.

Each year, the boxes were checked approximately every 2 weeks during the breeding season. In 1989 and 1990, no visits were made until several weeks after nesting began. On each visit, nest data collected included the species, number of eggs or number and development stage of nestlings, whether the nest fledged, and, for failed nests, any signs of predation, and whether eggs had any development of embryos. A nest was assumed to have fledged at least 1 nestling if all of the following were true: nest flattened; droppings on nest and/or whitewash on walls; abundant feather sheath dandruff; fewer than 3 dead, feathered nestlings; no signs

of disturbance; at least 13 days after egg hatch date. Predation was assumed if eggs were punctured, cracked, or on the ground outside the box, or if feathers or damaged, dead nestlings or adults were found in the box. Predation was also assumed if all of the eggs or nestlings were missing, except that eggs found cold and untended on a previous visit were assumed to have been abandoned first, and were so classified. Eggs and nestlings were assumed to have been abandoned if they were found dead in the nest with no sign of disturbance. Frequently it was possible to tentatively identify the predator, both by the type of damage to eggs, nestlings, or the box, and often by the subsequent usurpation of the box by the suspected predator. Rodent nests were removed from the boxes, and in 1989 and 1990 wren nests or some of the wren eggs were removed and destroyed from areas of regular bluebird use. Fledged or failed nests were cleaned out unless a new bluebird nest had been built on top. All boxes were cleaned out at the end of each breeding season.

At some of the nests with nestlings, visual diet samples were obtained by watching with 10X binoculars from 5 to 15 meters away from the nest box. Diet data collected included the time of delivery of each food item, identity of the provider (male, female, or fledgling), and identity, whenever possible, of the food item.

Nestlings were banded with U. S. Fish and Wildlife Service numbered aluminum leg bands at some of the nests each year, and a few adult females that were incubating eggs were also banded. In 1990 a colored plastic leg band was also put on each nestling.

On visits early in the breeding season, in 1988 and 1990, a census was taken of the number of adult bluebirds or pairs seen on the study sites while checking boxes. A bluebird census was also taken at the no-box sites early in the season, by walking around each site, stopping frequently to search for bluebirds and for potential natural nest cavities. Grasshopper counts were taken in 1990 at the study sites and some of the no-box sites, several counts being taken at intervals during a bluebird census and box checking visit. For each grasshopper count, the observer visually located a 1 square foot plot of ground roughly 10 feet ahead, and counted the grasshoppers leaving that plot as the observer approached. After 18 repetitions, the total number of grasshoppers counted was divided by 2 to obtain an estimate of the number of grasshoppers per square meter (U.S. Department of Agriculture count procedure).

In the absense of any grasshopper control programs, several parameters of bluebird reproduction were compared between study sites, in order to quantify variability, and to determine whether the sites are comparable, so that if control occurs in a future year, data from several sites could be pooled. Since only one year of data is available from the Grant County sites, analysis of their comparability with the Wheeler County sites is preliminary. One of the Wheeler County sites (Butte Creek) has not received enough bluebird nests to permit analysis of many parameters. The number of Mountain Bluebird nests was too small on some sites to permit full analysis of comparability, therefore in some cases only data from Western Bluebirds is analyzed; in other cases data from all bluebirds including unknown bluebird species is used. Second nests

by the same pair of bluebirds could be considered related to the first nests, in which case the nest box should be the data point. However, because the use occasionally shifted to the other bluebird species, or was unknown on the earliest nests, each nest that received at least one egg was considered an independent data point.

Chi-square distribution tests were used to determine if several of the statistics from individual sites or years fitted the frequencies expected from the total data. The Kruskal-Wallis test was used to determine whether the number of fledglings per successful nest on the different sites were samples from identical populations. Other data were examined descriptively.

RESULTS AND DISCUSSION

Objective 1 - To examine the impacts of chemical grasshopper control on Western and Mountain Bluebird reproduction and nestling food supply.

The parameters chosen for comparing study sites were those that will be considered most important if a spray program is carried out, that is, the success rate for all nests in a given year, the number of fledglings per successful nest, and the composition of the nestling diet. Other data were used to corroborate whether or not bluebird reproduction on the sites appeared to be comparable.

Successful nests were defined as those that fledged at least one nestling. The percent of nests that were successful varied between sites and between years, but most sites were consistent in having a higher success rate in 1989 than in the other 2 years (Table 1). The ratio of successful to failed Western Bluebird nests from all Wheeler County sites together was significantly different ($p = 0.012$) in 1989 than in 1988 or 1990 (Table 2). The ratio of successful to failed Western Bluebird nests in each year was not significantly different ($p = 0.689$, 0.391, and 0.651) between Wheeler County sites (Table 3). Western Bluebirds had a higher success rate than Mountain Bluebirds, and the relationship was consistent in all years and on most Wheeler County sites (Table 1). Western Bluebirds had a higher success rate in Grant County than Wheeler County, but there were not enough nests at the Grant County sites to analyze.

For the nests that fledged at least 1 nestling, the number of fledglings per nest was comparable at all sites in both counties, although it ranged from 1 to 7 for individual nests (Table 4). For Western Bluebirds, there was not a significant difference ($p = 0.90$-0.95, 0.75-0.90, and 0.95-0.98) between the Wheeler County sites in each of the 3 years (Table 5). Western Bluebirds averaged slightly higher (4.37) than Mountain Bluebirds (3.85) for the 3 years, in each of the 3 years, and on most of the sites each year (Table 4). Both species had a slighlty higher mean number of fledglings in 1989 (4.39 for Western Bluebirds, 4.27 for Mountain Bluebirds) than in 1988 (4.33 and 4.00). In 1990, Western Bluebirds dropped only slightly to 4.37, while Mountain Bluebirds dropped to 3.43.

Nest failures were due to either predation or abandonment and starvation. For Western Bluebirds on all the sites considered

together, the ratio of predation to abandonment was significantly different ($p = 0.012$) between each of the 3 years (Table 6).

The sites were somewhat comparable in the level of predation that occurred in each year, and many sites suffered an increase in predation in 1990 (Table 7). Over the 3 years there was no site that consistently suffered a higher rate of predation than the others. Mountain Bluebirds had a higher rate of predation than Western Bluebirds on many sites in 1990, when Mountain Bluebirds lost 18 nests to predators (32% of all nests), a considerably higher rate than Western Bluebirds which lost 13 nests (12% of all nests). House Wrens, chipmunks, and mice were the most common predators where identity could be determined. House Wrens were responsible for at least 20% of the predation that occurred in 1990. House Wren occupancy of the boxes did not increase, and in 1990 there were several cases of bluebirds successfully maintaining ownership of a box after attempted takeover by wrens. Chipmunks and mice may have learned over the 3 years to raid the nests. They certainly increased the number of boxes that they built nests in, although most of the rodent nests were not used for reproduction or winter shelter.

Abandonment of eggs or nestlings occurred at a fairly comparable rate on the study sites, with all but 2 sites having a moderate rate in 1988, a low rate in 1989, and a high rate in 1990 (Table 7). One site (Campbell) had a higher abandonment rate in all 3 years than the average for all sites, if all bluebirds are considered. In 1988, Mountain Bluebirds abandoned nests at a higher rate (7 or 27% of all nests) than did Western Bluebirds (6 or 14% of all nests). In 1989 there was little difference between the 2 species. In 1990, Mountain Bluebirds abandoned nests at a lower rate (9 or 14% of all nests) than did Western Bluebirds (30 or 27% of all nests). Nest abandonment appeared to be associated with periods of cloudy, cold, and often wet weather, however correlation between abandonment and weather has not been analyzed.

The number of eggs laid per full clutch was comparable on all of the study sites in both counties (Table 8). The number of eggs in individual nests ranged from 3 to 9, however the few 8 and 9 egg nests could have been laid by more than 1 female. An 11 egg nest with 2 females in attendance was not included in the calculations. The mean for all bluebirds, including unknown bluebird species, was 5.36 for each of the 3 years. Western Bluebirds averaged slightly higher than Mountain Bluebirds, and the difference was consistent through the 3 years, and on all of the sites with more than 4 nests per species.

Determination of hatch and fledge rates was made difficult by the common phenomenon of the disappearance within a few days before or after the hatching date of 1 or 2 eggs or hatchlings. The possibility exists that these were infertile eggs that the adult bluebirds removed from the nest when the fertile eggs hatched. On the other hand, it is also possible that the adults removed nestlings that died within the first few days after hatching. There were frequently 1 or several unhatched eggs that remained in the nest, gradually being pushed down into the nest material as the nestlings grew. Because unhatched eggs remained in at least a few nests that also lost 1 or 2 eggs or hatchlings, in this report

these lost eggs or hatchlings were counted as having hatched and died, rather than as having been infertile eggs that did not hatch.

The egg hatch rate, nestling fledge rate, and egg fledge rate varied considerably between sites and between years, but many sites were consistent with the data from all the sites together in having higher hatch and fledge rates in 1989 than in either 1988 or 1990 (Table 9). Western Bluebirds were more successful than Mountain Bluebirds in both hatch and fledge rates at many sites in 1988 and 1990, but had similar success in 1989. Comparing the egg hatch and nestling fledge rates gives an indication that nestlings were more vulnerable than eggs to predation and abandonment, especially in 1990.

Nestling diet samples were taken at 5 of the study sites in Wheeler County in 1989 and 1990, and at 1 of the Grant County sites in 1990. Most samples were from Western Bluebirds. Grasshoppers (including crickets) comprised between 30 and 100% of the samples (Table 10). For Western Bluebirds at the Wheeler County sites the mean percent grasshoppers was 78% in 1989 and 79% in 1990, and the means for each site in each year were fairly consistent. For Mountain Bluebirds at the Wheeler County sites, the mean was 71% in 1989 and 63% in 1990. At the Grant County sites, grasshoppers comprised a higher percent of the diet samples. For Western Bluebirds the mean was 100%, and for Mountain Bluebirds the mean was 93%. Other important items in the nestling diets at the Wheeler County sites were spiders, caterpillars, moths and butterflies, ants, and beetle grubs, while at the Grant County sites ants were the only other food items identified (Table 11).

Nestling feeding rates were extremely variable, with periods of rapid feeding (4 to 8 visits in 5 or 10 minutes) often alternating with periods of 20 minutes to an hour when the adults either were absent from the area of the nest, or were not actively foraging. Given the arbitrary time periods of the diet samples, where a sufficient number of observations per site were made, the average feeding rate appeared to be comparable on the Wheeler County sites in 1990, and slower on the Grant County site (Table 12). 1989 feeding rates in Wheeler County appeared to be slower than in 1990. The slower rate may have been associated with larger size of food items being delivered to the nestlings, since larger items might tend to delay the time when nestlings would beg for food again.

Objective 2 - To evaluate the potential for reducing grasshopper densities in unsprayed areas by providing nest boxes to increase numbers of bluebirds.

The measurements of bluebird numbers were the nest box occupancy rate and bluebird census. Grasshopper counts were used to determine their density per site. Diet composition was also used to indicate the relationship between bluebird and grasshopper numbers. Lack of funding has limited the number of bluebird censuses and grasshopper counts made on no-box sites and the number of diet samples taken, so the following analysis is preliminary.

The number of boxes used by bluebirds was not at all comparable between sites, except that every site in Wheeler County had an increased occupancy rate for all bluebirds in each

succeeding year (Table 13). The number of boxes used in 1990 was 260% of the 1988 number, with the percentage on individual sites ranging from 200% to 420%. Western Bluebirds increased to between 200 and 300% on all but 1 site. Mountain Bluebirds increased on most sites (to 700% of the first year on 1 site), but remained the same on 2 sites, and decreased to 67% on 1 site. The low occupancy rate at the Grant County sites in 1990 was comparable to the first year on the Wheeler County sites. It is possible that the increase in occupancy at the Wheeler County sites was largely due to the fledglings from 1 year returning to the same area to breed in subsequent years. The color banding of nestlings, that started in 1990, may make it easier to determine that. On the other hand, it is possible that at least some bluebirds moved onto the study sites after discovering the existence of the boxes during winter or migration. Western Bluebirds used more of the boxes than Mountain Bluebirds on most sites each year, except for 1 site where the reverse was true, and 1 site where similar numbers of boxes were used by each species each year. The consistent pattern of different occupancy rates by the 2 species at each site over the 3 years may also be due to the return of fledglings.

Bluebird censuses on the study sites were taken on 2 of the visits in 1988 and 1990 (Table 14). The number of adult bluebirds (or pairs, counted as 1 adult) was always equal to or less than the number of nests that were known to be active at the time of the census. The ratio of number of adults seen to number of known active nests ranged from 0.3 to 1, with a mean of 0.8 in 1988, and ranged from 0.2 to 1.0, with a mean of 0.6 for the Wheeler County sites in 1990. In Grant County in 1990, the ratio was 0.7. The number of adults seen on the Wheeler County censuses in 1990 increased to 325% of the 1988 censuses, which is consistent with the increase seen in the occupancy of nest boxes (Table 13).

Bluebird censuses on sites without nest boxes were made in 1988 and 1990, although not all sites were visited each year. The first year, at least 1 bluebird was seen on each no-box site census, and 2 natural nest cavities were found. However, in 1990 only 1 no-box census yielded any bluebird observations, and no natural nests were found. Possibly the nest boxes attracted the bluebirds to the study sites from these nearby areas. Certainly the increase in bluebirds at the study sites was not part of a general increase in bluebirds in the region. It appears that the placement of nest boxes has increased the number of bluebirds on the study sites during the breeding season. In subsequent years, several additional no-box sites will be established at greater distances from the study areas.

Grasshopper counts were made in 1990 at the study sites in Wheeler and Grant Counties and at some of the no-box sites. The number of grasshoppers per square meter estimated from the counts ranged from 0 to 25.5 on the Wheeler County study sites, and the mean was 6.4 (Table 15). There was no comparability between individual sites, which had mean grasshopper densities of 1.8 to 12.1. On the no-box sites, all in Wheeler County, the mean was 5.8, which may be somewhat comparable to the study sites. Grasshopper counts were higher on the Grant County sites; the mean was 16.4, and the range was 7 to 24.5. No counts were made in

earlier years, although it was generally observed that grasshoppers were extremely sparse in 1988 and sparse in 1989. Despite considerable cold, wet weather early in 1990, grasshopper numbers were generally observed to be moderate, but very unevenly distributed on the Wheeler County sites, with fairly high concentrations in areas of as little as a few hundred square meters, and none observable for thousands of meters in any direction. There may have been a tendency on some sites to make grasshopper counts in these higher density areas, which would have increased the mean of the counts on those sites. In subsequent years, count transects will be randomized.

Nestling diet sample data, discussed above, indicates that both species of bluebirds have a strong preferance for grasshoppers as a food source to deliver to nestlings. The higher percentage of grasshoppers in the diet samples taken at the Grant County sites may be related to the apparently higher grasshopper densities found in the counts at those sites.

CONCLUSION

Reproductive measurements of bluebirds, and nestling diet composition, are similar at the study sites which receive enough nests to analyze. If chemical grasshopper control occurs in future years, data from treated and untreated sites can be pooled. Bluebird occupancy and census counts increased on the study sites but not at nearby sites with no boxes, indicating that placement of nest boxes in suitable habitat can increase local bluebird numbers. Additional grasshopper counts, bluebird censuses, and diet samples are needed before meaningful analysis of potential correlation between bluebird numbers and grasshopper densities can be made.

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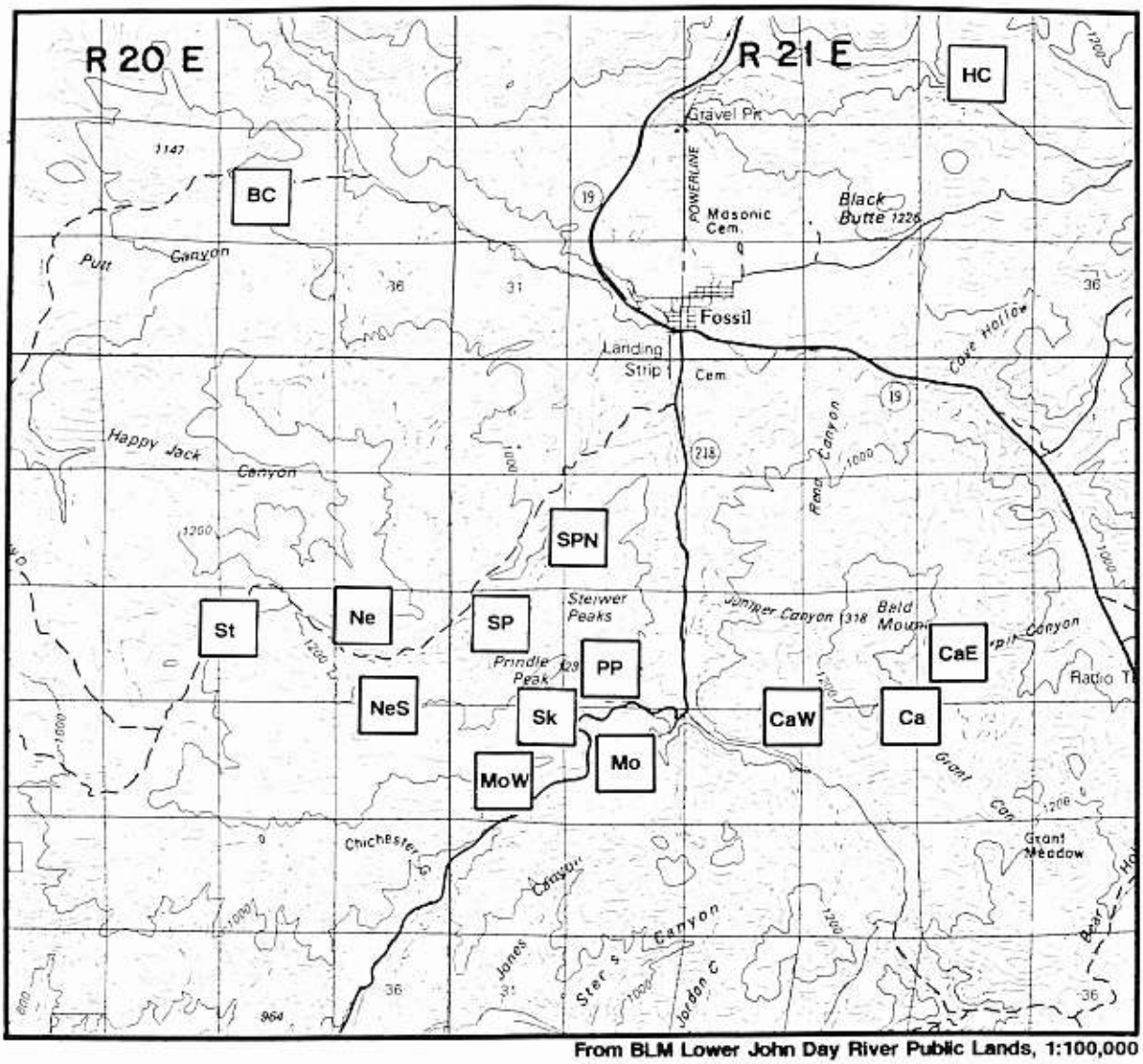
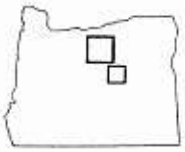


From BLM Lower John Day River Public Lands, 1:100,000

STUDY SITES
Wheeler County:
NE Neri
St Steiwer
Ca Campbell
Mo Morris
Sk Skites
PP Prindle Peak
SP Steiwer Peak
BC Butte Creek

Grant County:
MC Murderers Creek
CG Chickenhouse Gulch

NO-BOX SITES
NeS Neri South
CaW Campbell West
CaE Campbell East
MoW Morris West
SPN Steiwer Peak North
HC Hoover Canyon



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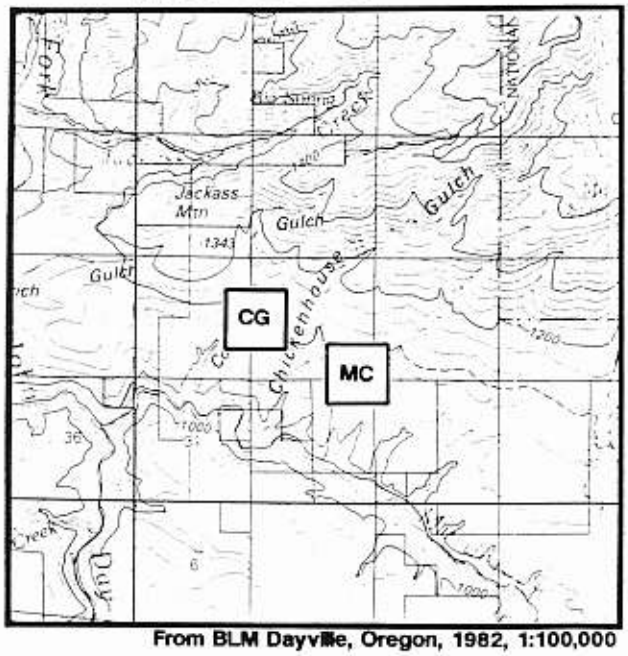

From BLM Dayville, Oregon, 1982, 1:100,000

Figure 1

Table 1. NEST SUCCESS. The number of nests on each site and the percent of those nests that fledged at least one nestling. Data from all nests with at least one egg.

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
					WESTERN BLUEBIRDS					
1988										
# nests	7	4	10	8	4	3	5	2		
Success	43%	100%	60%	63%	75%	67%	60%	100%		
1989										
# nests	11	5	16	8	5	7	8	3		
Success	100%	100%	68%	88%	80%	71%	75%	100%		
1990										
# nests	21	14	27	14	12	8	7	1	5	3
Success	57%	79%	48%	64%	58%	63%	71%	100%	100%	33%
					MOUNTAIN BLUEBIRDS					
1988										
# nests	2	8	6	5	1	3	0	1		
Success	50%	88%	50%	20%	100%	33%	0%	100%		
1989										
# nests	2	13	6	8	3	6	1	2		
Success	100%	85%	33%	88%	100%	83%	100%	100%		
1990										
# nests	3	14	8	18	9	2	1	0	1	0
Success	0%	57%	63%	61%	33%	50%	100%	0%	100%	0%
					ALL BLUEBIRDS					
1988										
# nests	10	12	17	13	5	6	5	3		
Success	40%	92%	53%	46%	80%	50%	60%	100%		
1989										
# nests	15	21	25	17	11	17	10	6		
Success	93%	76%	64%	88%	82%	65%	70%	83%		
1990										
# nests	32	43	48	37	26	17	12	7	9	5
Success	50%	53%	48%	59%	46%	47%	58%	71%	78%	40%

WHEELER COUNTY SITES

	WESTERN BLUEBIRDS	MOUNTAIN BLUEBIRDS	ALL BLUEBIRDS
1988	43 nests, 65%	26 nests, 58%	71 nests, 61%
1989	63 nests, 83%	41 nests, 80%	122 nests, 76%
1990	104 nests, 61%	55 nests, 54%	223 nests, 52%

Table 2. SUCCESS AND FAILURE - COMPARISON OF YEARS. The number and percentage of successful and failed Western Bluebird nests on all study sites in Wheeler County is compared between the 3 years of the study. The chi-square value is given, with the degrees of freedom and probability.

	1988	1989	1990
# succ.	28	52	63
% succ.	65%	83%	61%
# fail.	15	11	41
% fail.	35%	17%	39%

Chi-square = 8.932, 2 df, p = 0.012

Table 3. SUCCESS AND FAILURE - COMPARISON OF SITES. The number and percentage of successful and failed Western Bluebird nests is compared between each study site in Wheeler County that received at least 3 nests in each year. For each year, the chi-square value is given, with the degrees of freedom and probability.

	Ne	St	Ca	Mo	Sk	PP	SP
1988							
# succ.	3	4	6	5	3	2	3
% succ.	43%	100%	60%	63%	75%	67%	60%
# fail.	4	0	4	3	1	1	2
% fail.	57%	0%	40%	38%	25%	33%	40%
Chi-square = 3.906, 6 df, p = 0.689							
1989							
# succ.	11	5	11	7	4	5	6
% succ.	100%	100%	68%	88%	80%	71%	75%
# fail.	0	0	5	1	1	2	2
% fail.	0%	0%	31%	13%	20%	29%	25%
Chi-square = 6.293, 6 df, p = 0.391							
1990							
# succ.	12	11	13	9	7	5	5
% succ.	57%	79%	48%	64%	58%	63%	71%
# fail.	9	3	14	5	5	3	2
% fail.	43%	21%	52%	36%	42%	38%	29%
Chi-square = 4.192, 6 df, p = 0.651							

Table 4. MEAN NUMBER OF FLEDGLINGS PER SUCCESSFUL NEST. The mean number of fledglings from all nests that fledged at least one nestling and where number of fledglings was known. WB = Western Bluebird; MB = Mountain Bluebird; BB = all bluebirds including unknown bluebirds; * = data from ≤ 3 nests; - = no data.

1988

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB F #M	4.7*	5.0*	4.0	4.2	4.0*	5.0*	4.0*	5.0*		
MB F #M	2.0*	4.0	3.3*	-	5.0*	5.0*	-	6.0*		
BB F #M	4.0	4.4	3.8	4.2	4.3*	5.0*	4.0*	5.5*		

Wheeler County: WB 4.33 (n = 24) (s = 1.27)
MB 4.00 (n = 12) (s = 1.65)
BB 4.22 (n = 36) (s = 1.40)

1989

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB F #M	4.8	4.8	4.0	4.2	4.5*	3.8	4.0	5.7*		
MB F #M	4.0*	4.3	-	4.0	4.7*	4.8	2.0*	5.0*		
BB F #M	4.7	4.4	3.9	4.1	4.6	4.2	3.7	5.5		

Wheeler County: WB 4.39 (n = 44) (s = 1.33)
MB 4.27 (n = 26) (s = 1.22)
BB 4.32 (n = 72) (s = 1.30)

1990

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB F #M	4.5	4.4	4.4	4.4	4.4	3.8	4.3	3.0*	4.3	5.0*
MB F #M	-	3.1	4.0	3.6	2.7*	2.0*	3.0*	-	5.0*	-
BB F #M	4.5	3.6	4.4	4.0	3.9	3.5	4.0	3.5*	4.4	5.0*

Wheeler County: WB 4.36 (n = 58) (s = 1.47)
MB 3.38 (n = 29) (s = 1.35)
BB 3.99 (n = 95) (s = 1.49)

Table 5. NUMBER OF FLEDGLINGS PER SUCCESSFUL NEST - COMPARISON OF SITES. Data from all nests that fledged at least 1 nestling and where number of fledglings was known. For the Western Bluebirds, the Kruskal-Wallis test value is given, with the degrees of freedom and probability.

	WESTERN BLUEBIRD	MOUNTAIN BLUEBIRD	UNKNOWN BLUEBIRD
		1988	
Ne	4,5,5	2	
St	5,6,4	2,6,5,5,2	
Ca	4,3,4,5,3,5	3,2,5	
Mo	6,3,7,3,2		
Sk	3,5	5	
PP	5	5	
SP	5,2,5		

Kruskal-Wallis = 2.09, 6 df, p = 0.90 - 0.95

		1989	
Ne	4,5,5,6,6,3,4,4,6,5	2,6	
St	5,4,6,4	2,5,4,4,6,5,5,6,2,4	
Ca	3,6,4,4,6,3,2,4,4		2,5
Mo	3,2,5,6,5	4,5,3,4,4	
Sk	4,5	5,5,4	
PP	5,5,4,4,1	4,5,5,5	
SP	6,5,5,4,1,3	2	

Kruskal-Wallis = 2.76, 6 df, p = 0.75 - 0.90

		1990	
Ne	5,5,1,6,5,6,3,3,6,5,5,4		
St	6,3,3,6,5,6,3,3,5	3,5,3,1,5,3,4,1	4,2,1
Ca	7,5,3,3,5,6,5,3,6,5,4,1	5,3,3,5,4	5,5
Mo	4,4,6,2,6,6,3,4,5	4,5,3,5,4,5,2,4,5,1,2	3
Sk	3,1,6,6,4,5,6	4,2,2	
PP	3,3,5,4	2	4
SP	3,6,5,3	3	

Kruskal-Wallis = 1.41, 6 df, p = 0.95 - 0.98

Table 6. CAUSES OF FAILURE - COMPARISON OF YEARS. The number and percentage of Western Bluebird nests, on all study sites in Wheeler County, that failed because of predation or abandonment are compared between the 3 years of the study. The chi-square value is given, with the degrees of freedom and probability.

	1988	1989	1990
# pred.	9	8	12
% pred.	60%	73%	29%
# aban.	6	3	29
% aban.	40%	27%	71%

Chi-square = 8.87, 2 df, p = 0.012

Table 7. YEARLY NEST SUCCESS AND CAUSES OF FAILURE. The number of nests that were successful, that failed from predation, and that failed from abandonment, and the percentages from the total number of nests. Data from all nests with at least 1 egg.

	Ne	St	Ca	Mo	Sk	PP	SP	BC	Wh.Co	MC	CG
					WESTERN BLUEBIRD - 1988						
Succ. #	3	4	6	5	3	2	3	2	28		
Succ. %	43%	100%	60%	63%	75%	67%	60%	100%	65%		
Pred. #	2	0	3	1	1	1	1	0	9		
Pred. %	29%	0%	30%	13%	25%	33%	20%	0%	21%		
Aban. #	2	0	1	2	0	0	1	0	6		
Aban. %	29%	0%	10%	25%	0%	0%	20%	0%	14%		
					WESTERN BLUEBIRD - 1989						
Succ. #	11	5	11	7	4	5	6	3	52		
Succ. %	100%	100%	68%	88%	80%	71%	75%	100%	83%		
Pred. #	0	0	3	0	1	2	2	0	8		
Pred. %	0%	0%	19%	0%	20%	29%	25%	0%	13%		
Aban. #	0	0	2	1	0	0	0	0	3		
Aban. %	0%	0%	13%	13%	0%	0%	0%	0%	5%		
					WESTERN BLUEBIRD - 1990						
Succ. #	12	11	13	9	7	5	5	1	63	5	1
Succ. %	57%	79%	48%	64%	58%	63%	71%	100%	61%	100%	33%
Pred. #	1	1	5	1	2	1	1	0	12	0	1
Pred. %	5%	7%	19%	7%	17%	13%	14%	0%	12%	0%	33%
Aban. #	8	2	9	4	3	2	1	0	29	0	1
Aban. %	38%	14%	33%	29%	25%	25%	14%	0%	28%	0%	33%

	Ne	St	Ca	Mo	Sk	PP	SP	BC	Wh.Co	MC	CG
					MOUNTAIN BLUEBIRD - 1988						
Succ. #	1	7	3	1	1	1	0	1	15		
Succ. %	50%	88%	50%	20%	100%	33%	0%	100%	58%		
Pred. #	1	0	0	2	0	1	0	0	4		
Pred. %	50%	0%	0%	40%	0%	33%	0%	0%	15%		
Aban. #	0	1	3	2	0	1	0	0	7		
Aban. %	0%	13%	50%	40%	0%	33%	0%	0%	27%		
					MOUNTAIN BLUEBIRD - 1989						
Succ. #	2	11	2	7	3	5	1	2	33		
Succ. %	100%	85%	33%	88%	100%	83%	100%	100%	80%		
Pred. #	0	1	3	1	0	1	0	0	6		
Pred. %	0%	8%	50%	13%	0%	17%	0%	0%	15%		
Aban. #	0	1	1	0	0	0	0	0	2		
Aban. %	0%	8%	17%	0%	0%	0%	0%	0%	5%		
					MOUNTAIN BLUEBIRD - 1990						
Succ. #	0	8	5	11	3	1	1	0	29	1	0
Succ. %	0%	57%	63%	61%	33%	50%	100%	0%	54%	100%	0%
Pred. #	2	6	1	5	4	0	0	0	18	0	0
Pred. %	67%	43%	13%	28%	44%	0%	0%	0%	32%	0%	0%
Aban. #	1	0	2	2	2	1	0	0	8	0	0
Aban. %	33%	0%	25%	11%	22%	50%	0%	0%	14%	0%	0%

Table 8. NUMBER OF EGGS PER FULL CLUTCH. The mean number of eggs in all nests where incubation was initiated and where number of eggs was known. WB = Western Bluebird; MB = Mountain Bluebird; BB = all bluebirds including unknown bluebird species; ! = a nest with 11 eggs and 2 females was not included; + = a nest with 8 or 9 eggs was included; * = data from ≤ 3 nests; - = no data.

1988

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB E #M	5.8	5.0	5.2	5.2!	5.5	6.7*	5.4	6.0*		
MB E #M	5.5*	5.1	5.0	5.6	6.0*	4.7*	-	-		
BB E #M	5.7	5.1	5.2	5.4	5.6	5.7	5.4	6.0*		

Wheeler County: WB 5.45 (n = 38) (s = 0.86)
MB 5.22 (n = 23) (s = 0.85)
BB 5.36 (n = 61) (s = 0.86)

1989

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB E #M	5.0*	5.0*	5.8	6.6	5.5	5.2	4.7*	6.0*		
MB E #M	-	4.0	5.0*	5.3+	6.5+*	5.0*	3.0*	-		
BB E #M	5.0	4.3	5.6	6.0	5.8	5.1	4.3	6.0		

Wheeler County: WB 5.56 (n = 27) (s = 0.89)
MB 5.00 (n = 15) (s = 1.65)
BB 5.36 (n = 42) (s = 1.23)

1990

	Ne	St	Ca	Mo	Sk	PP	SP	BC	MC	CG
WB E #M	5.5	5.3	5.7	5.2	6.0	5.2	5.8	-	5.8	5.5*
MB E #M	5.5*	5.0	5.0	5.3+	4.6	4.0*	5.0*	-	5.0*	-
BB E #M	5.5	5.2	5.5	5.3	5.4	5.0	5.6	-	5.6	5.7*

Wheeler County: WB 5.49 (n = 75) (s = 0.86)
MB 5.00 (n = 35) (s = 1.06)
BB 5.36 (n = 119) (s = 0.93)

Table 9. HATCH AND FLEDGE RATES. Data from all nests with incubation initiated and with numbers of eggs, nestlings, and fledglings all either known or > 80% sure. WB = Western Bluebird; MB = Mountain Bluebird; BB = all bluebirds including unknown bluebird species; E-H = percent of eggs that hatched (mean number of nestlings / mean number of eggs; N-F = percent of nestlings that fledged (mean number of fledglings / mean number of nestlings); E-F = percent of eggs that fledged (mean number of fledglings / mean number of eggs); * = data from 3 nests or fewer; -- = no data; Site WC = all sites in Wheeler County.

1988

SITE	WB E-H	WB N-F	WB E-F	MB E-H	MB N-F	MB E-F	BB E-H	BB N-F	BB E-F
Ne	90%	54%	48%	45%*	40%*	18%*	77%	52%	40%
St	100%*	100%*	100%*	62%	100%	62%	75%	100%	75%
Ca	69%	75%	52%	56%	89%	50%	63%	79%	50%
Mo	83%	81%	67%	66%	0%	0%	76%	51%	39%
Sk	73%	83%	60%	100%*	83%*	83%*	79%	82%	64%
PP	38%*	100%*	38%*	100%*	36%*	36%*	70%	53%	37%
SP	74%	60%	44%	--	--	--	74%	60%	44%
BC	100%*	83%*	83%*	100%*	100%*	100%*	100%*	92%*	92%*
WC	77%	75%	57%	69%	62%	43%	74%	70%	52%

1989

SITE	WB E-H	WB N-F	WB E-F	MB E-H	MB N-F	MB E-F	BB E-H	BB N-F	BB E-F
Ne	100%	94%	94%	100%*	100%*	100%*	100%	96%	96
St	100%*	100%*	100%*	88%	95%	84%	90%	98%	88%
Ca	86%	80%	68%	90%*	56%*	50%*	82%	78%	64%
Mo	88%	69%	61%	89%	80%	71%	86%	74%	63%
Sk	100%*	57%*	57%*	78%*	100%*	78%*	89%	66%	59%
PP	58%	87%	51%	93%	76%	70%	74%	82%	60%
SP	100%	76%	76%	67%*	100%*	67%*	96%	78%	74%
BC	100%*	95%*	95%*	100%*	100%*	100%*	100%	79%	79%
WC	88%	83%	73%	88%	87%	76%	88%	82%	72%

1990

SITE	WB E-H	WB N-F	WB E-F	MB E-H	MB N-F	MB E-F	BB E-H	BB N-F	BB E-F
Ne	82%	60%	49%	55%*	0%*	0%*	81%	50%	41%
St	94%	72%	68%	80%	58%	46%	80%	61%	49%
Ca	79%	64%	50%	88%	91%	80%	80%	70%	56%
Mo	91%	75%	68%	68%	81%	55%	77%	78%	60%
Sk	90%	63%	57%	43%	60%	26%	75%	61%	45%
PP	78%	63%	49%	88%*	29%*	25%*	84%	64%	54%
SP	100%	48%	48%	60%*	100%*	60%*	93%	54%	50%
BC	60%*	100%*	60%*	--	--	--	60%*	100%*	60%*
MC	100%	74%	74%	100%*	100%*	100%*	100%	79%	79%
CG	88%*	34%*	30%*	--	--	--	66%	34%	22%
WC	86%	65%	55%	71%	68%	48%	80%	64%	51

Table 10. PERCENT GRASSHOPPERS IN NESTLING DIET SAMPLES. The mean percent grasshoppers in nestling diet samples from each study site, with the number of diet samples. At the bottom of the page are the percent grasshoppers in each of the diet samples taken at each site.

	WESTERN BLUEBIRDS		MOUNTAIN BLUEBIRDS	
	1989	1990	1989	1990
Ne:	77%, n = 3	88%, n = 11	--	--
St:	--	77%, n = 3	83%, n = 1	44%, n = 1
Ca:	74%, n = 5	75%, n = 9	--	70%, n = 2
Mo:	95%, n = 2	72%, n = 4	71%, n = 1	--
Sk:	70%, n = 1	74%, n = 4	60%, n = 1	--
Wheeler County sites:	78%, n = 11	79%, n = 31	71%, n = 3	63%, n = 3
MC:	--	100%, n = 3	--	93%, n = 4

	WESTERN BLUEBIRDS	MOUNTAIN BLUEBIRDS
	1989	
Ne:	64%, 82%, 86%	--
St:	--	83%
Ca:	80%, 80%, 69%, 70%, 70%	--
Mo:	100%, 90%	71%
Sk:	70%	60%
	1990	
Ne:	80%, 83%, 88%, 88%, 88%, 86%, 100%, 80%, 70%, 100%, 100%	
St:	80%, 83%, 67%	44%
Ca:	91%, 100%, 80%, 75%, 50%, 67%, 71%, 75%, 70%	73%, 67%
Mo:	100%, 91%, 67%, 30%	
Sk:	75%, 69%, 80%, 70%	
MC:	100%, 100%, 100%	90%, 90%, 91%, 100%

Table 11. IDENTIFIED ITEMS IN BLUEBIRD DIET SAMPLES. All samples from 1989 and 1990 are included, and percentages are taken from the total 489 items.

	Wheeler County	Grant County	Study areas
Arachnida	18		18 - 3.7%
Orthoptera	326/422 = 77%	64/67 = 96%	390 - 79.8%
Grasshoppers	280	62	
Crickets (black)	46	2	
Homoptera			3 - 0.6%
Cicada	3		
Coleoptera (mostly grubs)	11		11 - 2.2%
Lepidoptera (caterpillars, moths, butterflies)	18		18 - 3.7%
Diptera	2		2 - 0.4%
Hymenopotera			22 - 4.5%
Ichneumon	3		
Ant	15	3	
Bee	1		
Unclassifiable non-grasshopper			~ 5%

Table 12. NESTLING FEEDING RATES. The number of minutes of each diet sample and the number of feeding visits made by adults (or fledglings from the previous brood), with the rate being the ratio.

	MINUTES	VISITS	RATE	MINUTES	VISITS	RATE
1989						
NERI:	71	12	5.9	100	12	8.3
	52	7	7.4			
	Total: 223/31 - 7.19					
Campbell:	42	7	6.0	15	1	15.0
	80	5	16.0			
	Total: 137/13 - 10.54					
Morris:	78	16	4.9	41	11	3.7
	Total: 119/27 - 4.41					
Skites:	67	13	5.15			
Wheeler County total: 546/84 - 6.50; range - 3.7 to 16.0						
1990						
NERI:	59	20	3.0	45	13	3.5
	23	9	2.6	15	8	1.9
	28	8	3.5	66	7	9.4
	50	17	2.9	65	10	6.5
	64	10	6.4	57	11	5.2
	39	4	9.8			
	Total: 511/117 - 4.37					
Steiwer:	64	11	5.8	16	8	2.0
	16	8	2.0	21	9	2.3
	Total: 117/36 - 3.25					
Campbell:	55	13	4.2	74	6	12.3
	40	14	2.9	44	11	4.0
	67	21	3.2	69	11	6.3
	20	10	2.0	29	13	2.2
	18	11	1.6	38	10	3.8
	Total: 454/120 - 3.78					
Morris:	28	14	2.0	70	12	5.8
	64	18	3.6	47	9	5.2
	Total: 209/53 - 3.94					
Skites:	47	10	4.7	39	17	2.3
	57	11	5.2	40	14	2.9
	Total: 183/52 - 3.52					
Wheeler County total: 1474/378 - 3.90; range - 1.6 to 12.3						
Murd. Cr.	43	11	3.9	38	10	3.8
	79	11	7.2	52	10	5.2
	30	10	3.0	54	10	5.4
Grant County total: 296/62 - 4.77; range - 3.0 to 7.2						

Table 13. NEST BOX OCCUPANCY. Number of boxes on the site, and number and percent of those boxes that received at least one nest with at least one egg. Number of boxes used in 1990 as a percent of number of boxes used in 1988. WB = Western Bluebird, MB = Mountain Bluebird, BB = all bluebirds, including unknown species.

YEAR: 1988

	Ne	St	Ca	Mo	Sk	PP	SP	BC	Wh.Co
# boxes	37	35	33	35	34	33	35	33	275
WB occ.#	7	4	9	6	4	3	5	1	39
WB occ.%	19%	11%	27%	17%	12%	9%	14%	3%	14%
MB occ.#	2	7	6	5	1	3	0	1	25
MB occ.%	5%	20%	18%	14%	3%	9%	0%	3%	9%
BB occ.#	10	11	15	11	5	6	5	2	65
BB occ.%	27%	31%	45%	31%	15%	18%	14%	6%	24%

YEAR: 1989

	Ne	St	Ca	Mo	Sk	PP	SP	BC	Wh.Co
# boxes	32	30	29	31	33	31	35	29	250
WB occ.#	7	4	11	6	5	6	6	3	48
WB occ.%	22%	13%	38%	19%	15%	19%	17%	10%	19%
MB occ.#	2	11	5	8	3	5	1	2	37
MB occ.%	6%	37%	17%	26%	9%	16%	3%	7%	15%
BB occ.#	11	17	18	14	11	14	8	4	97
BB occ.%	34%	57%	62%	45%	33%	45%	23%	14%	39%

YEAR: 1990

	Ne	St	Ca	Mo	Sk	PP	SP	BC*	Wh.Co	MC	CG	Gr.Co
# boxes	33	37	40	43	33	32	34	28	280	30	40	70
WB occ.#	19	11	21	12	12	8	5	1	89	3	2	5
WB occ.%	58%	30%	53%	28%	36%	25%	15%	3%	32%	10%	5%	7%
MB occ.#	2	14	7	13	7	2	1	0	46	1	0	1
MB occ.%	6%	38%	18%	30%	21%	6%	3%	0%	16%	3%	0%	1%
BB occ.#	26	31	32	27	21	16	10	6	169	6	3	9
BB occ.%	79%	84%	80%	63%	64%	50%	29%	21%	60%	20%	8%	13%

* Not all the boxes were checked after June 1

1990 OCCUPANCY AS A PERCENT OF 1988 OCCUPANCY

	Ne	St	Ca	Mo	Sk	PP	SP	Wh.Co
WB	271%	275%	233%	200%	300%	267%	100%	228%
MB	100%	200%	117%	260%	700%	67%	100%	184%
BB	260%	282%	213%	245%	420%	267%	200%	260%

Table 14. BLUEBIRD CENSUSES. The number of adult bluebirds or bluebird pairs observed on 2 counts at study sites, with the number of known bluebird nests active at the times of each count, and the ratio of observed bluebirds or pairs to the number of known active nests. The number of adults or pairs observed on 2 counts at no-box sites, with the number of natural nests observed at the time of each count, and the number of expected nests if the mean ratio from the study sites is applied. BB = number of adult bluebirds or pairs seen; N = number of nests known; E = number of nests expected; - = no census taken during that time period.

	1988					1990				
SITE	CENSUS BB	N	RATIO	CENSUS BB	N	RATIO	CENSUS BB	N	RATIO	CENSUS BB	N	RATIO
STUDY SITES												
Ne	4	4	1.0	1	1	1.0	5	15	0.3	13	16	0.8
St	3	4	0.8	-	-	-	12	25	0.5	16	20	0.8
Ca	4	5	0.8	1	2	0.5	14	21	0.7	10	18	0.6
Mo	2	7	0.3	5	5	1.0	10	21	0.5	15	18	0.8
Sk	3	4	0.8	2	3	0.7	2	12	0.2	6	10	0.6
PP	1	1	1.0	-	-	-	4	10	0.4	4	4	1.0
SP	2	2	1.0	0	0	0	3	5	0.6	1	2	0.5
BC	1	1	1.0	0	0	0	1	2	0.5	-	-	-
Wh.Co.	Mean ratio = 0.8						Mean ratio = 0.6					
MC							4	4	1.0	3	4	0.8
CG							3	4	0.8	1	4	0.3
Gr.Co.							Mean ratio = 0.7					
NO-BOX SITES												
NeS	2	1	E=1.6	2	0	E=1.6	0	0	0	-	-	-
CaW	2	1	E=1.6			E=1.3	3	0	E=4.3	-	-	-
CaE							0	0	0	-	-	-
MoW							0	0	0	-	-	-
SPN							0	0	0	-	-	-
HC	1	0	E=1.3									

MEAN 1990 CENSUS AS A PERCENT OF MEAN 1988 CENSUS

Ne	St	Ca	Mo	Sk	PP	SP	BC	Wh.Co.
360%	467%	480%	357%	160%	400%	100%	100%	325%

Table 15. GRASSHOPPER DENSITIES - 1990. The number of grasshoppers per square meter estimated from each count, in (), and the mean for all the counts made on each date. The mean grasshopper density from all counts on all dates at each site.

SITE	6/6 COUNTS	6/20 COUNTS	7/5 COUNTS	YEARLY MEAN
Ne		(7,1.5,9)	(7,10)	
		5.8	8.5	6.9 (n = 5)
St	(0,0)	(1,0,4)	(6)	
	0	1.7	6.0	1.8 (n = 6)
Ca	(12.5,5.5,6)	(6,22,20.5,12.5)	(3.5,20.5)	
	8.0	15.3	12.0	12.1 (n = 9)
Mo	(0,0)	(0,2,7)		
	0	3.0		1.8 (n = 5)
Sk	(7,2.5,5)	(3,4.5,6.5,4.5)		
	4.8	4.6		4.7 (n = 7)
PP	(25.5,4.5,2,4,4,12)	(6,1,20.5,2.5,2)		
	8.7	6.4		7.6 (n = 11)
SP	(7.5)	(0,4,6.5)		
	7.5	3.5		4.5 (n = 4)
Wheeler County study sites:			Mean - 6.4 (n = 47, s = 6.34)	
CaE		(4.5,10,5,24.5,8.5,3.5,2.5)		
		8.4		8.5 (n = 7)
MoW		(0,2.5,8.5,7,4.5)		
		4.5		4.5 (n = 5)
SPN		0,0		0 (n = 2)
Wheeler County no-box sites:			Mean - 5.8 (n = 14, s = 6.30)	
MC	(7.5,15.5,12.5)	(20,7,23.5,24.5,21.5)	(20.5,13.5,17.5)	
	11.8	19.3	17.2	16.7 (n = 11)
CG	(16,11.5,14)	(11,19,14,18,25)		
	13.8	17.4		16.1 (n = 8)
Grant County study sites:			Mean - 16.4 (n = 19, s = 5.33)	