A Comparison of Conservation Reserve Program Habitat Plantings with Respect to Arthropod Prey for Grassland Birds

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ABSTRACT.—The Conservation Reserve Program (CRP) was designed to reduce soil erosion and curb agricultural overproduction by converting highly erodible agricultural land to various forms of perennial habitat. It has had an incidental benefit of providing habitat for wildlife and has been beneficial in reversing population declines of several grassland bird species. However, the mechanisms behind these reversals remain unknown. One such mechanism may be differences in food availability on CRP vs. non-CRP land or between different types of CRP. The influence of CRP habitat type on the abundance of arthropod prey used by grassland birds has not been previously explored. We compared the abundance and diversity of arthropods among four CRP habitat types in Texas [replicated plots of exotic lovegrass (Eragrostis curvula), Old World bluestem (Bothriochloa ischaemum), mixed native grasses with buffalo grass (Buchloe dactyloides) and mixed native grasses without buffalo grass] and native shortgrass prairie. Attention was focused on adult and juvenile spiders (Order Araneae), beetles (Coleoptera), orthopterans (Orthoptera: grasshoppers and crickets) and lepidopterans (Lepidoptera: butterflies and moths), as these taxa are the primary prey items of grassland birds during the breeding season. Arthropod diversity and abundance were higher on indigenous prairie compared to CRP, reflecting differences in vegetative diversity and structure, but there were no differences in arthropod richness or abundance among CRP types. These results indicate that, although CRP is not equivalent to native prairie in terms of vegetation or arthropod diversity, CRP lands do support arthropod prey for grassland birds. More direct assays of the survivorship and fitness of birds on CRP compared to native shortgrass prairie are clearly warranted.

INTRODUCTION

The Food Security Act of 1985 authorized the United States Department of Agriculture (USDA) to institute the Conservation Reserve Program (CRP) to combat soil erosion and agricultural overproduction (USDA, 2000). This voluntary program is administered by the Farm Service Agency and uses financial incentives to retire private land from agricultural production. Land is leased for 10–15-y contracts, during which time it is seeded in perennial grasses and/or legumes and not plowed (Young and Osborn, 1990; Ohlenbusch et al., 1995). Grazing and haying are allowed but only temporarily for emergency provisioning of livestock. The legislation authorizing the CRP has been modified several times since 1985, and now the program focuses primarily on replacing marginal agricultural land with native...
habitat and protecting wetlands. Nearly 14 million ha currently are enrolled in the U.S. (USDA, 2000). As an incidental benefit, this program has provided valuable habitat for wildlife, such as grassland birds (Berthelsen and Smith, 1995).

Grassland birds have exhibited the most consistent, widespread and rapid declines of any group of North American birds (Askins, 1993; Knopf, 1994, 1996; Herkert, 1995; Peterjohn and Sauer, 1999; Vickery et al., 1999). One-third of North American endemic grassland bird species have experienced statistically significant declines in abundance in the past 30 y (Knopf, 1996). These declines can be attributed in part to the loss of over 99% of indigenous grassland in most areas of the Great Plains (Noss et al., 1995). Texas, for example, has lost approximately 90% of its original native shortgrass prairie (6,480,000 ha; Samson and Knopf, 1994), but has over 900,000 ha enrolled in the CRP (Berthelsen et al., 1989).

The availability of CRP has been linked to reversing population declines in some species, especially for field sparrow (Spizella pusilla), grasshopper sparrow (Ammodramus savannarum), LeConte’s sparrow (Ammodramus leconteii), lark bunting (Calamospiza melanocorys), chestnut-collared longspur (Calcarius ornatus) and western meadowlark (Sturnella neglecta) (Johnson and Schwartz, 1993; Reynolds et al., 1994; Johnson and Igl, 1995; King and Savidge, 1995; Patterson and Best, 1996; Herkert, 1997; Best et al., 1997, 1998; Robel et al., 1998; Igl and Johnson, 1999; Koford, 1999; McCoy et al., 1999; Coppedge et al., 2001). However, because the mechanisms behind these population changes remain obscure and because most previous studies have been conducted in mixed-grass and tallgrass prairies rather than shortgrass prairie, further research is warranted. One such mechanism pertains to how arthropods of the avian diet respond to differences in CRP habitat plantings.

The original CRP signup allowed landowners to plant less costly, exotic grasses, such as Eragrostis curvula (weeping lovegrass) and Bothriochloa ischaemum (Old World bluestem). Newer leases (those since 1997), however, require landowners to plant at least 90% of the area in a mixture of native grasses, such as Bouteloua curtipendula (sideoats grama), Bouteloua gracilis (blue grama), Panicum virgatum (switchgrass), Buchloe dactyloides (buffalograss) and other species, to simulate native prairie. Similarly, renewal of leases from the original signup require reseeding of at least 51% of exotic CRP lands in native species. Because of the relatively high cost of buffalograss seed, however, many CRP plantings do not include this species despite its abundance and importance in native shortgrass prairie (Berthelsen et al., 1989, Lauenroth and Milchunas, 1991). Only a few studies have evaluated differences in CRP grasslands planted in exotic grasses to those planted in native species or native shortgrass prairie (Delisle and Savidge, 1997; Best et al., 1998; Clawson and Rotella, 1998; Howard et al., 2001; McCoy et al., 2001).

Many grassland bird species are granivorous, but become largely insectivorous during the breeding season and nestlings of these species usually are fed a protein-rich diet of arthropods. Spiders, beetles, orthopterans (grasshoppers and crickets) and lepidopterans (butterflies, moths and their larvae [caterpillars]) make up the bulk of grassland bird diets during the breeding season (Bryant, 1912, 1914 as quoted in Bent, 1960; Baldwin, 1970, 1971; Baldwin et al., 1971; Wiens et al., 1974; Maher, 1979; Wiens and Rotenberry, 1979), and some nestlings receive a diet of 60–100% arthropods (Wiens, 1977; Maher, 1979; Wiens and Rotenberry, 1979; Ehrlich et al., 1988). However, the impact of exotic vs. native seedings on the diversity and abundance of arthropods (particularly taxa that are prey for grassland birds) has not been evaluated. There have been very few studies on arthropods in CRP, and most of those have focused on CRP lands acting as possible refugia for pest species of nearby cropland (Phillips et al., 1991; Carroll et al., 1993; Lefko et al., 1998) or for beneficial insect species (Elliott et al., 2002). Other studies have examined the effects of various CRP management plans such as grazing or prescribed burning on numbers of pests (Davis, 1998).
or biological control agents (French et al., 1998). In addition, there have been no studies comparing arthropod diversity on CRP grasslands with those on shortgrass prairie. Our objective in this study was to compare the diversity and abundance of arthropods (specifically focusing on spiders, beetles, orthopterans and lepidopterans) on replicated CRP plots seeded with exotic or native grasses in Texas and to compare CRP plots with a remnant native shortgrass prairie. Results from our study will provide indirect evidence of how grassland birds may respond to different CRP habitat types compared to native prairie.

**METHODS**

We sampled arthropod diversity on 16 1-km² sites in 2001: 4 CRP plots seeded with weeping lovegrass; 3 CRP plots seeded with Old World bluestem; 4 CRP plots seeded with native species (dominated by sideoats grama, blue grama and switchgrass) minus buffalograss; 4 CRP plots seeded with sideoats grama, switchgrass and buffalograss; and 1 plot of native shortgrass prairie on the Muleshoe National Wildlife Refuge (MNWR). The CRP plots had been enrolled for at least 3 y, with the exotic plots dating from 1987 and 1988 and the native plots dating from 1993, 1997 and 1998 (as per the changes to the original signup criteria; USDA, 2000). The MNWR plot has never been plowed and it had not been grazed by domestic livestock for 3 y prior to our study. The severe shortage of native shortgrass prairie in this part of Texas, especially prairie that currently is not being grazed by domestic livestock, precluded having replicate shortgrass prairie plots. The shortgrass prairie plot is, thus, included solely as a reference and has no variance (standard error) estimates associated with it. The other plots had formerly been planted in cotton, and cotton was still the dominant component of the landscape matrix for all sites. Although cotton is intensively cultivated in this area and is subject to repeated pesticide applications under the USDA Boll Weevil (*Anthonomous grandis*) Eradication Program, cotton fields still support some arthropod species, such as spiders and their prey (Nyffeler et al., 1994). CRP land represents the primary form of undisturbed wildlife habitat in this region (Berthelsen and Smith, 1995). Sites were separated by at least 1 km, with the maximum straight-line distance between two plots being 97 km.

The percent ground cover, height and species richness of vegetation at each site were quantified twice (once each in May and July) during the field season. For each study field, three parallel transects were established, spaced 137 m apart, with five vegetation sampling points established 92 m apart along each transect, giving a total of 15 vegetation sampling points for each study field. Each transect was >50 m from the field borders and ~550 m in length (proportional to the size of the field). At each sampling point, the vertical density of the vegetation was measured with the use of a Robel pole (Robel et al., 1970). Readings were taken of the lowest obstructed point on the Robel pole visible at a distance of 4 m and at a height of 1 m above the ground for each of the four cardinal directions. The highest touching vegetation also was recorded. Percent canopy coverage was visually estimated 1 m in front of the Robel pole and along the direction of the transect using a modified 0.5 m² Daubenmire (1959) frame. Only those plants containing their base inside the Daubenmire frame were recorded. Percent cover of live grasses, live forbs, standing dead vegetation, bare ground and litter were determined on a nonoverlapping basis (i.e., the sum at a sample point could not exceed 100%). The maximum height of living vegetation, dead vegetation, grass and forb was recorded inside the Daubenmire frame at each sampling point. Standing dead vegetation was defined as any dead plant material above the soil surface and still attached in the ground, and litter was defined as any non-attached plant material lying flat on the soil surface (Best et al., 1997).
Determining the abundance and identity of arthropods in the nestling diet directly has been a challenge to researchers for some time (see review in Johnson et al., 1980). The use of video cameras to monitor parental provisioning visits has had mixed success and has been more useful in determining visitation rates than in prey identity per se (e.g., Moreno et al., 1995; but see Franzreb and Hanula, 1995). Other techniques, such as stomach-content analysis, fecal analysis or use of crop ligature, avoid the identification problem but have limitations and biases of their own. Stomach-content analysis cannot be recommended for use on species with declining population trends because birds must be sacrificed for stomach dissection and the results obtained from this method are biased towards food items that are not easily digested (Dillery, 1965). Identification of food items from fecal analysis is likewise biased and fecal samples may be very difficult to obtain (Hartley, 1948). The ligature method has been used with some success (e.g., Wiens et al., 1974; Maher, 1979; Johnson et al., 1980), but also entails risk of strangulating nestlings, changing nestling gaping/begging behaviors or missing items that slip past the ligature (Orians, 1966; Orians and Horn, 1969; Mellott and Woods, 1993). Therefore, the overall availability of arthropods was measured instead, which does not entail such risks or sacrifices.

Arthropod availability was assessed with pitfall traps, consisting of two 500-ml plastic cups nested together and set in the ground with the lips flush with the ground surface (design in McIntyre et al., 2001), with ~95 ml of an aqueous propylene glycol solution (1:1 water:propylene glycol) inside the inner cup. Propylene glycol is an effective killing agent that is largely nontoxic to vertebrates (Weeks and McIntyre, 1997). Pitfall trapping was used because, unlike other arthropod collection techniques such as sweep-netting, it is a passive technique that is relatively insensitive to differences in vegetative structure or physiognomy that could be expected when comparing the tussock-like exotic fields to the native-grass plots (Cooper and Whitmore, 1990). In habitats with a greater vertical stratification of vegetation, unlike grasslands, the use of pitfall trapping as an exclusive sampling technique fails to represent a large portion of the arthropod community because pitfall trapping is most effective in sampling ground-dwelling arthropods. Even so, foliar and aerial species such as lepidopterans are collected in pitfall traps when a killing agent is used, but their abundances from this technique are likely underestimated (Cooper and Whitmore, 1990). However, this bias should be low and consistent across all of our replicate grassland plots.

Pitfall trapping was conducted over 72 consecutive hours once a month between late May through late August 2001 (coinciding with the breeding season for grassland birds, which may nest 1–4 times during the breeding season). All sites were sampled within a 7-d period per month. We used 10 traps per site, with traps spaced 5 m apart along a north-south line transect placed at least 100 m from plot boundaries to avoid potential edge effects. This sampling intensity allowed for adequate spatial coverage without oversampling or being subject to low trap independence (which result from high trap density) while simultaneously allowing for coverage of the core of each field. Traps were covered with tight-fitting plastic lids when not in use.

All specimens were removed from the propylene glycol and preserved in 95% ethyl alcohol. Adult and juvenile spiders, beetles, orthopterans and lepidopterans were identified to Family; all other macroarthropods (~5 mm total body length) were identified to Order. Mean taxonomic richness and abundance among site-types were compared among site types using repeated-measures analysis of variance (ANOVA); significant ANOVA models were followed by Tukey’s HSD post-hoc comparisons of means (Zar, 1999). Taxa that were analyzed individually (i.e., the four focal taxa) had totals combined over the sample year for an overall analysis. Ants (Hymenoptera: Formicidae) were excluded from analysis because
capture of individual ants in pitfall traps is not independent due to pheromone trails and because ants are not an important prey item to most birds.

A stepwise discriminant function analysis (SDFA) with partial F-tests based on vegetation variables and arthropod abundance was used to identify variables that differentiated site types. This was followed by canonical analysis of discrimination (CAD) to quantify differences among site types (McGarigal et al., 2000). CAD was run on a subset of variables identified as significant discriminators in the SDFA based on the partial F-tests and the statistical significance of the canonical function was assessed using a likelihood-ratio approximate F-test (McGarigal et al., 2000). To detect any multicollinearity, all variables underwent Pearson's linear correlation analysis and a significant r ≥ 0.75 was used to eliminate variables with high pairwise correlations (one member of each pair was selected at random for elimination). Five variables were thusly eliminated.

RESULTS

A total of 14,904 individuals belonging to 68 arthropod taxa (55 Families in 17 Orders) was captured. Spiders (18 families) comprised 6.3% of the total number of individuals captured; beetles (24 families), 13.5%; orthopterans (3 families), 2.5%; and lepidopterans (10 families), 1.4%. The most abundant focal families (accounting for at least 5% of individuals captured) were Lycosidae, Gnaphosidae, Salticidae, Thomisidae and Oxyopidae (Araneae); Carabidae, Tenebrionidae and Meloidae (Coleoptera); Gryllidae, Acrididae and Gryllacrididae (Orthoptera); and Pieridae, Nymphalidae, Sphingidae, Noctuidae and Gelechiidae (Lepidoptera). The bulk of individuals captured did not belong to the four focal dietary taxa and was primarily comprised of Hemiptera (41.4%), Hymenoptera (17.2%), Homoptera (14.0%) and Diptera (2.7%).

The diversity and abundance of the focal taxa (as well as for all arthropods collectively) were higher on native shortgrass prairie compared to CRP, but there were no significant differences in richness (F₃ = 0.46, P = 0.71; Fig. 1) or abundance (F₃ = 0.95, P = 0.44; Fig. 2) among CRP types by month. When the focal taxa were analyzed individually, the only significant differences among CRP types were in the number of beetle families and the number of individual spiders (Table 1); there were significantly fewer beetle taxa on native-grass CRP with buffalograss than on other CRP types and significantly fewer spiders on the
bluestem CRP plots. There were significant phenological declines in richness ($F_3 = 12.02, P = 0.0001$) and abundance of focal taxa ($F_3 = 9.84, P = 0.0005$) over time, corresponding to maturation and senescence of the vegetation. This decline was due to differences between May and the other months (July and August did not significantly differ from each other).

The five site types (4 types of CRP + native shortgrass prairie) differed in vegetative diversity and structure and arthropod community composition (Table 2). Beyond the obvious differences in the types of grasses planted, four variables were the most influential in discriminating among sites: grass height (SDFA partial $F$-ratio = 0.9251, $P = 0.0001$), percent ground cover that is grass (SDFA partial $F$-ratio = 0.9033, $P = 0.0001$), forb species richness (SDFA partial $F$-ratio = 0.7988, $P = 0.0069$) and orthopteran abundance (SDFA partial $F$-ratio = 0.7033, $P = 0.0492$). The correlations among the significant discriminatory variables and the four derived canonical functions were significantly different from zero ($P < 0.05$), indicating that the different types of CRP could be characterized based on their vegetative and arthropod compositions, even though the numbers of arthropod taxa and individuals did not differ significantly among site types. There were no clear distinctions in vegetative composition based on native vs. exotic grasses. This also was reflected in the similarity in the arthropods found at the different site types. Of the 68 taxa captured, most occurred at more than one site type; only 13 taxa occurred at only one type. Of these 13, shortgrass prairie had five unique taxa, native CRP with buffalograss had four, native CRP without buffalograss had two and the weeping lovegrass and bluestem CRP plots each had one. The only arthropod taxa that were not detected on at least one type of CRP (i.e., were only found on the seeded prairie of the MNWR) were Pseudoscorpionida, Diplopoda, Thysanura, Araneae: Tetragnathidae and Coleoptera: Melandryidae, each of which was represented by <10 individuals.
TABLE 1.—ANOVA results for comparison of taxonomic richness and number of individuals for the focal groups among CRP site types

<table>
<thead>
<tr>
<th>Group</th>
<th>F&lt;sub&gt;3&lt;/sub&gt;</th>
<th>P-value</th>
<th>F&lt;sub&gt;3&lt;/sub&gt;</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiders</td>
<td>2.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beetles</td>
<td>8.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthopterans</td>
<td>2.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lepidopterans</td>
<td>1.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other taxa</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

Results from our study corroborate findings by Jonas et al. (2002), who compared the diversity of beetle and orthopteran families on exotic grasslands (planted in Bromus inermis), old-fields and native tallgrass and mixed-grass prairies found on a military installation in Kansas. They found that the different site-types could be distinguished based on vegetative structure, that beetle diversity was highest on native prairies and that orthopteran diversity was most closely associated with exotic grasslands. Similarly, in our study, the highest overall arthropod and focal prey diversity values were obtained from the native shortgrass prairie plot, which also possessed the highest vegetative diversity of any site. Although seeded grasslands were not equivalent to native shortgrass prairie in terms of their vegetative or arthropod communities, CRP plots did support an abundance of avian prey and other arthropods and there was considerable similarity among CRP types. The four types of CRP could be characterized based on vegetation and arthropod community composition, although overall arthropod richness and abundance did not differ significantly among CRP habitat types.

The bulk of individuals captured did not belong to the four focal dietary taxa and instead belonged, in decreasing order, to Hemiptera (true bugs), Hymenoptera (bees and wasps, excluding ants), Homoptera (treehoppers and leafhoppers) and Diptera (flies). Maher (1979) found that these orders comprised only a minority (0–45% of abundance) of the nestling diet for several northern prairie bird species. Similarly, Wiens et al. (1974) found that these orders comprised only 0–16.7% of the nestling diet for several species at a location (Pantex) near Amarillo, Texas, approximately 130 km from our northernmost study site. Therefore, exclusion of these taxa from analyses, despite their abundance, is not likely to

TABLE 2.—Vegetative characteristics of the site types. Values for the CRP sites are averages, computed over the replicates within each site type

<table>
<thead>
<tr>
<th>Vegetative characteristic</th>
<th>Unseeded grassland</th>
<th>Lovegrass CRP</th>
<th>Bluestem CRP</th>
<th>Native CRP, no buffalograss</th>
<th>Native CRP with buffalograss</th>
</tr>
</thead>
<tbody>
<tr>
<td>% grass</td>
<td>44.50</td>
<td>71.45</td>
<td>60.62</td>
<td>74.50</td>
<td>24.83</td>
</tr>
<tr>
<td>% forb</td>
<td>29.50</td>
<td>3.89</td>
<td>4.46</td>
<td>8.54</td>
<td>16.87</td>
</tr>
<tr>
<td>% litter</td>
<td>21.00</td>
<td>20.94</td>
<td>15.69</td>
<td>5.00</td>
<td>21.46</td>
</tr>
<tr>
<td>% bare ground</td>
<td>4.83</td>
<td>3.66</td>
<td>19.22</td>
<td>11.93</td>
<td>36.87</td>
</tr>
<tr>
<td>Height (dm)</td>
<td>1.70</td>
<td>4.41</td>
<td>2.67</td>
<td>2.37</td>
<td>2.56</td>
</tr>
<tr>
<td>Number of plant species</td>
<td>27</td>
<td>7.67</td>
<td>11.00</td>
<td>11.50</td>
<td>13.75</td>
</tr>
<tr>
<td>Number of grass species</td>
<td>6</td>
<td>1.67</td>
<td>4.67</td>
<td>4.25</td>
<td>6.25</td>
</tr>
<tr>
<td>Number of forb species</td>
<td>21</td>
<td>6.00</td>
<td>6.33</td>
<td>7.25</td>
<td>7.50</td>
</tr>
</tbody>
</table>
alter our conclusions about the importance of different CRP habitat types on grassland birds.

Very few (12%) of the arthropod taxa collected occurred only on CRP, and those taxa were most often represented by a single individual. There were thus no strong associations between certain taxa and the various CRP habitat types. Given that the availability of arthropods is so similar on different types of CRP, it is likely that the diet of breeding grassland birds and their nestlings is similar on different types of CRP, but possibly different to the diet of birds breeding on native shortgrass prairie. Since our study provides only indirect evidence with respect to birds, research is clearly needed that directly evaluates the abundance and fitness of birds per se on CRP compared to shortgrass prairie.

These results indicate that the 1985 Food Security Act’s original CRP policy of planting exotic grasses, as well as the current policy of planting native grass species, provide valuable habitat for the arthropod prey of grassland birds. However, CRP lands are not equivalent to native shortgrass prairie in terms of vegetation or arthropods and there have been few studies that have compared wildlife survivorship and fitness on CRP lands to shortgrass prairie. Therefore, our knowledge is incomplete about how wildlife in this area has been impacted by the conversion of shortgrass prairie to cropland and thence to CRP grassland. Although there is no support that different types of CRP possess different prey availabilities for grassland birds, more research is needed on how differences in CRP physiognomy, plot size and plot context in the surrounding landscape affect wildlife.

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