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Ring-necked pheasant hens select managed Conservation Reserve Program grasslands for nesting and brood-rearing

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Abstract

The Conservation Reserve Program (CRP) has provided critical wildlife habitat for many species since 1985. However, the quality of this habitat for early successional species, such as ring-necked pheasant (*Phasianus colchicus*), may decrease with field age. Late successional grasslands may lack valuable vegetative and structural diversity needed by pheasants, especially during nesting and brood-rearing stages. Since 2004, the United States Department of Agriculture has required new CRP contracts to include plans for mid-contract management, which could include discing and interseeding. The benefits of such practices have not been assessed, and continuation of current policy could be affected by the lack of information to support such practices. During 2005–2006 we evaluated nesting and brood-rearing habitat used by radio-marked hen pheasants in areas of northeastern Nebraska where portions of CRP fields had been recently disced and interseeded with legumes. Pheasant hens selected managed portions of CRP fields for both nesting and brood-rearing. Hens selected nest sites with greater forb cover and vertical density. Hens with broods also selected sites with greater forb composition. Discing and legume interseeding appeared to be an effective strategy for increasing pheasant use of CRP fields.

Keywords: Conservation Reserve Program, grassland habitat, habitat selection, *Phasianus colchicus,* radio-telemetry, ring-necked pheasant

The Conservation Reserve Program (CRP) has the potential to transform agricultural landscapes by replacing traditional cropland with large blocks of grasslands thereby providing habitat for early successional species, such as grassland birds (King and Savidge 1995). The quality of these habitats, however, depends on many factors, including management and age (Ryan et al. 1998, Ryan 2000). Fields are initially composed of a diverse mixture of grasses, forbs, legumes, and annual weeds, with an abundance of bare ground. In as little as 6 years, with little or no active management, CRP vegetation often becomes dense, monotypic grassland with a thick accumulation of litter and little bare ground (Millenbah et al. 1996, McCoy et al. 2001). This shift in the composition and structure of the plant community reduces the quality of habitat provided by CRP for many bird species (King and Savidge 1995, Ryan et al. 1998, Rodgers 1999). For most states in the Great Plains, ring-necked pheasant (*Phasianus colchicus*) populations peaked in the 1950s and 1960s (Dahlgren 1988). Subsequent shifts in agricultural practices have led to a decline in pheasant numbers because of the lack of suitable cover for nesting and brood rearing (Taylor et al. 1978, Dahlgren 1988, Etter et al. 1988). Although CRP was predicted to boost declining numbers of pheasants, the regional population response was less than anticipated (Church and Taylor 1999, Rodgers 1999). For example, pheasant populations in Nebraska increased during the first 5–6 years after the introduction of CRP, but have declined thereafter (Nebraska Game and Parks Commission [NGPC], unpublished data). The quality of CRP grassland habitat for pheasants appears to be inversely related to the time since disturbance; to maintain CRP fields in the early successional stages required by pheasants, some type of regular disturbance is needed (King and Savidge 1995, Ryan et al. 1998, Rodgers 1999).

Management of land in CRP prior to 1992 was restricted to emergency haying and mowing (Berner 1988). Since 1992, landowners have been allowed to plan and implement management activities for fields dominated by grasses and lacking forbs. Two types of disturbances were allowed: light discing and prescribed burning. The 2002 Farm Bill included guidelines recognizing the benefit disturbance in these grasslands has for wildlife and gave landowners more opportunities for management. Beginning in 2004, mid-contract management was mandatory on new contracts; options included spraying herbicide, discing and interseeding legumes and other forbs, and prescribed burning (U.S. Department of Agriculture 2003). However,

the benefits to pheasants of mid-contract management have not been explicitly assessed, and the continuation of current policy could be affected by the lack of information to support such practices.

Previous research suggests that mid-contract management of CRP fields should improve habitat and food resources for pheasants, especially in monotypic grass stands often found in older CRP fields. But, the conclusion is largely built on circumstantial evidence based on important, yet tangential, studies. For example, Leathers (2003) reported a general increase in the abundance of arthropods, the main food source for pheasant chicks, in disced and interseeded fields compared to those with no management. However, whether hens will target interseeded areas for brood-rearing is still unclear. Similarly, density and diversity of vegetation, as well as bare ground, increased in areas where discing occurred (Greenfield et al. 2002, 2003; Leathers 2003). Greenfield et al. (2002, 2003) related their results to management of northern bobwhite (*Colinus virginianus*), but ring-necked pheasants may not respond in a similar fashion. Last, King and Savidge (1995) reported that nesting hens selected dense vegetation and bare ground. We know that similar conditions may be created by discing, and this structure may also aid chick mobility by creating movement corridors and decreasing encumbrance due to litter. But, managers have not tested how local populations react to management.

The purpose of our study was to directly investigate the response of pheasants to habitat changes in a landscape affected by mid-contract management. We examined how pre-nesting movements of hen pheasants were affected by habitat management. We also assessed habitat selection for nesting and brood-rearing at 2 spatial scales to assess pheasant response to landscape composition (macroscale) and vegetation structure and composition (microscale).

Study Area

We conducted our study in northeast Nebraska during 2005 and 2006. The 83-km^2 study area was located in the tallgrass prairie ecoregion in Stanton County (map: Matthews et al. 2012). The landscape of our study area was dominated by agriculture (35.7%) and CRP fields (37.2%). Other landscape features included pastures and other grasslands (19.9%), wetlands (0.5%), woodlands (4.7%), and farmsteads and roads (2.0%). Agriculture cropland included corn, soybean, and alfalfa. However, approximately 2,200 ha of the study area were composed of cropland that had been enrolled in CRP >10 years prior to the beginning of our study (CP-1: 52%, CP-2: 46%, filter strips: 2%). Fields were initially planted with a mixture of native (CP-2) and nonnative grasses (CP-1) or grass–forb mixtures. Prior to 2002, no management had occurred in the fields since establishment. Preliminary observations revealed fields were generally monocultures of smooth brome (*Bromus inermus*; CP-1) or switchgrass (*Panicum virgatum*; CP-2); legume and other forb components were scarce or nonexistent (S. Taylor, NGPC, unpublished data).

From 2002 to 2005, portions of 36 CRP fields were disced and interseeded. Each managed portion (range: 16–240 ha) was disced 2–3 times with a tractor-pulled tandem disc designed for sod breakup to a depth of 7.6–10.2 cm. All discing depths and seeding rates were performed in accordance with United States Department of Agriculture guidelines (Natural Resource Conservation Service [NRCS] 2002). Discing was followed by interseeding with a seed mixture (Best Legume Mix 1/CRP Upgrade Mix, Nebraska Pheasant and Quail Forever, Elba, NE) containing alfalfa (*Medicago sativa*), red clover (*Trifolium pratens*), and yellow sweet clover (*Melilotus officinalis*) using a no-till drill. Legumes were seeded at a rate of 6.75 kg/ha (3.38 kg of alfalfa, 1.69 kg of red clover, and 1.69 kg of yellow sweet clover). All discing and interseeding dates complied with United States Department of Agriculture guidelines (NRCS 2002).

No more than a third ($\bar{x}$ = 8 ha) of each field was disced and interseeded each year. In rare occasions, a field received a second treatment, but most treated fields only received 1 treatment during the life of our study. Management sites were selected based on topography and landowner preference. Fields that had been mowed in the previous year were disced and interseeded because of the reduction of residual litter and ease of discing. By May 2004, approximately 850 ha of the CRP fields were interseeded in the study area. The interseeded area represented 27.8% of the CRP field area and 10.5% of the study area.

Methods

Radio-Telemetry

We captured hen pheasants using baited funnel-entrance box traps and night-lighting techniques (Labisky 1959) from January until March in 2005 and 2006 at sites with subjectively high winter concentrations of pheasants. We fitted each hen with a necklace-style radio transmitter weighing <20 g (Model #A3960, Advanced Telemetry Systems, Inc., Isanti, MN). Animal capture and handling protocols were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee (Protocol #05-02-007).

We used vehicles mounted with a null-peak antenna-receiver and an electronic compass (C100, KVH Industries, Inc., Middletown, RI) to estimate the location of each hen by triangulation 5 to 10 times per week from March 15 to August 1, 2005–2006. Tracking occurred between 0700 and 2000 hours. We rotated the order of location such that each bird was monitored during different times of day. We took ≥ 3 bearings in a 5- to 15-minute period to minimize movement bias. We took additional bearings until the error polygons were <1,500 m^2 (approx. 22-m radius). We calculated Universal Transverse Mercator coordinates and error polygons in the field using an on-board computer via Location Of A Signal (LOAS) software (version 4.0, Ecological Software Solutions, Urnäsch, Switzerland).

Nest and Brood Monitoring

We monitored the activities of hens via telemetry until we could ascertain the hen had begun incubating. We determined the location of each nest 3–10 days after initiation

of incubation, as determined by sequential hen locations in the same area. While hens were on the nest, we determined the location of the nest within a few meters using a hand held antenna and receiver. We placed flagging 5 m to the north and south of the nest to mark the general location of the nest (Guiliano and Daves 2002). We attempted to avoid flushing hens off nests during our initial visit, because flushing may decrease nest success (Evans and Wolfe 1967). When the hen left the nest, we visually located nests and recorded their exact locations using a hand-held Global Positioning System unit, and recorded the number of eggs. When telemetry observations indicated incubation had ceased, we checked the nest site for success or failure. Nests were considered failed when all eggs were destroyed or the hen abandoned the nest, and a success if ≥ 1 egg hatched. For successful nests, we recorded the number of hatched eggs.

We located hens with broods for 21 days after hatch, as previous studies have suggested that pheasant population growth is sensitive to chick survival during the first 2–4 weeks after hatch (reviewed by Riley et al. 1998). At 10 days post-hatch, we located the roost site of the hen at night and flagged the general area. During the day, after the hen had moved, we looked for signs of pheasant chick presence (e.g., chick droppings, small depressions near roost site). At 21 days post-hatch, we flushed the hen to determine if the brood was still present.

Habitat and Vegetation Sampling

We evaluated macroscale, landscape composition to determine nest and brood-site preference among habitats available in the landscape. We created year-specific, vector-based Geographic Information System (GIS) (ArcGIS 9.0, ESRI, Redlands, CA) landcover layers by visually inspecting aerial photographs to classify landcover, and verifying change in crop type through ground-truthing each year; we modified original polygons established by Hammond (1982). Mid-contract management of CRP fields continued through 2005, and we incorporated these changes into our landcover layers. Our landcover layer included the following landcover classifications: 1) interseeded and 2) non-interseeded warm season CRP fields (switchgrass, big bluestem [*Andropogon gerardii*], little bluestem [*Schizachyrium scoparium*], indiangrass [*Sorghastrum nutans*], sideoats grama [*Bouteloua curtipendula*]), 3) interseeded and 4) non-interseeded cool season CRP fields (predominantly smooth brome), 5) other grasslands (grazed and hayed pastures, roadsides, ditches), and 6) other landcovers (any landcover not included above).

We recorded microhabitat data at nest sites and brood locations to assess vegetation characteristics selected within fields. At each nest site, we estimated percent canopy cover for cool season grasses (cool), warm season grasses (warm), forbs (forb), and bare ground (bare) using a 1-m diameter sampling hoop (modified from Daubenmire 1959). We also assessed the vegetation structure and composition at 1 random point ≥ 50 m away in the same landcover type. We estimated visual obstruction readings (VOR) to the nearest 0.25 dm at both nest and random sites (Robel et al. 1970). We used the location of the hen as the location of the brood, following Riley et al. (1998); they used hen locations to represent chicks that were within a similar-sized error polygon. For every third location estimate, we recorded percent canopy and VOR at a random point inside the 18-m radius and 1 random point at least 50 m from the brood location.

Macrohabitat Selection

Nest habitat. We analyzed nesting habitat selection by using the nest as the sample unit. We used ArcGIS to classify the landcover type for each nest. We defined available habitat as habitat within a circular area centered on the nest, and we evaluated 2 spatial scales. We set the radius of the area equal to the distance a hen can move in either 1 or 2 days: 400-m radius (1-day movement) and 800-m (2-day movement). We grouped the above general landcover classes into 1) interseeded CRP, 2) CRP, 3) other grassland, and 4) other.

We assessed nest habitat selection using 2 methods, discrete choice modeling and compositional analysis. First, we used discrete choice modeling using categorical variables (Cooper and Millspaugh 1999, Alldredge and Griswold 2006). Second, we used compositional analysis, which relies on the log-ratio of the proportion of habitat used to the proportion of habitat available (Aebischer et al. 1993). For discrete choice, we chose 5 random locations within the 400-m and 800-m buffers of each nest to produce a sample of alternative choices. We generated random locations using Hawth's Analysis Tools for ArcGIS (Beyer 2004). We estimated selection parameters using conditional logistic regression (clogit, R Development Core Team 2009).

For compositional analysis, we considered landcover classes to be preferred if the 95% confidence intervals of the log-ratio were positive and did not include 0 (equal use and availability). We could not use a typical multivariate analysis of variance (MANOVA; Aebischer et al. 1993), because our landcover use for each individual consisted of 1 location, the nest site. Thus, we calculated the variance of the log-ratio (LR) using the delta method (Powell 2007):

$$\text{var (LR)} = \text{var}\,(H_U)\left(\frac{1}{(H_U)}\right)^2 + \text{var}(H_A)\left(\frac{1}{(H_A)}\right)^2$$

where H_U is the proportion of nests in a particular landcover class and H_A is the proportion of that landcover class available to the hen (Seber 1982, Williams et al. 2002).

Brood habitat. We conducted brood-habitat analysis in a similar fashion to nest preference analysis. We used 2 methods, discrete choice modeling with categorical variables (Cooper and Millspaugh 1999, Alldredge and Griswold 2006) and compositional analysis (Aebischer et al. 1993) in SAS (Proc GLM, SAS Institute, Inc., Cary, NC) to estimate habitat preference for brooding hens. We used the same landcover categories as in the nest selection analysis. We only used locations from hens with broods still present at 21 days after hatching in this analysis. We used 350-m and 700-m radius buffers around each brood location to estimate available habitat, which are 1 and 2 times the average daily movement we measured for brooding hens. In

our discrete choice modeling, we used 5 random locations inside the available-habitat buffer for each brood location to provide a sample of alternative brood habitats. For compositional analysis, we used the pooled area from all buffers surrounding each daily location as available brood habitat. We incorporated the multiple locations used by hens with broods in a MANOVA analysis (Aebischer et al. 1993), and reported our results as the mean difference of log-ratios for each landcover type and log-ratios for CRP. We did not consider year as a potential predictor variable in our model because habitat use did not vary between years (Table 1).

Microhabitat Selection

We analyzed the microhabitat selection of nesting hens and brood-rearing hens by comparing the microhabitat features of nest sites and brood locations with the features of randomly available vegetation. We built 3 sets of covariates to describe our predictions: 1) forbs, 2) grass (an additive set of warm season grass cover and cool season grass cover), and 3) structure (an additive set of vertical obstruction reading and bare ground cover). We grouped the grass and structure covariates to reduce the number of competing models. We constructed 7 additive, a priori models by combining our covariate sets in biologically reasonable ways, to represent hypotheses; we compared all models against a null model (no effects). We used discrete choice modeling to quantify the influence of variables on nest and brood habitat selection (Cooper and Millspaugh 1999). We used Akaike's Information Criteria corrected for small sample size to calculate Akaike ranks (ΔAIC_c) and weights (ω_i) for the competing models. We set the number of individuals as the sample size, rather than individual vegetation sample, to avoid possible pseudo-replication. We used model averaging of all models to estimate parameter coefficients and standard errors if the best model had $\omega_i < 0.95$ (Burnham and Anderson 2002). However, we followed parsimony rules suggested by Richards (2008); specifically, we were prepared to select a more parsimonious, top-ranked model as the best model in situations when 2 models carried most of the ω_i.

Results

We caught 54 and 56 hens in 2005 and 2006, respectively, prior to the breeding season. Our sample size declined because of mortalities before 15 May, the peak of the nesting period (Matthews 2009, 2005: 16 mortalities, 3 censored; 2006: 22 mortalities, 0 censored). We found 34 nests in 2005 and 39 nests in 2006. Of these nests, 67 (91.0%) were in CRP or interseeded CRP fields (Table 1). In the CRP fields, we found 41 (58.6%) nests in fields dominated by warm season grasses, mainly switchgrass. We found the remaining nests in brome-dominated fields. In 2005, 16 of 34 (47%) nests successfully hatched; 11 broods consisted of ≥1 chick 21 days post-hatch. Two brooding hens died before day 10. Eleven of 39 (28%) nests were successful in 2006; 6 broods were active after 21 days.

Hens spent an average of 43% (SE = 31%), 22% (SE = 27%), 22% (SE = 21%), and 12% (SE = 20%) of the time in CRP, interseeded CRP, cropland, and other grassland, respectively. The average daily movement of hens from 3 weeks prior to nesting until incubation was 172 m (SE = 79), and hens had shorter daily movements during pre-nesting if they spent more time in interseeded landcovers ($F = 9.86$, $P < 0.01$; e.g., approx. 50-m shorter distance between daily positions when hens spent 50% of time, rather than 0% of time, in interseeded CRP; Figure 1). In contrast, hens moved more if they spent more time in cropland ($F = 13.97$, $P < 0.01$; e.g., approx. 90-m longer distances between daily positions when hens spent 50% of time, rather than 0% of time, in cropland; Figure 1).

Discrete choice analyses indicated that hens were not using the landscape in a random fashion for nesting (Table 2). Hens showed a preference of interseeded CRP for nesting, relative to unmanaged CRP, other grasslands, and other landcovers, at both 400-m ($\hat{\beta} = 0.95$, SE = 0.31) and 800-m scales ($\hat{\beta} = 1.09$, SE = 0.35; Table 2). Few nests were located in non-CRP grasslands; when we used the 400-m scale of reference for available habitat, other grasslands were similar in preference to unmanaged CRP fields ($\hat{\beta} = -0.25$, SE = 0.55). However, other grasslands appeared lower in preference than unmanaged CRP when we used the 800-m scale of reference ($\hat{\beta} = -1.21$, SE = 0.56). Hens,

Table 1. Used and available (within 400-m and 800-m radius from nests) nest-site cover types of ring-necked pheasants in landscapes containing managed Conservation Reserve Program (CRP) grasslands in Stanton County, Nebraska during 2005 and 2006.

Cover type	Average available nesting habitat (%)		Nest attempt					
			Initial nest		Renest		Combined	
	400-m	800-m	*n*	%	*n*	%	*n*	%
2005								
CRP	45.96	37.27	11	45.83	4	40.00	15	44.12
Interseeded CRP	24.92	16.06	12	50.00	4	40.00	16	47.06
Other grassland	10.00	13.34	1	4.17	2	20.00	3	8.82
Other	19.12	33.03	0	0.00	0	0.00	0	0.00
2006								
CRP	39.40	31.11	13	46.43	5	45.45	18	46.15
Interseeded CRP	25.24	16.38	12	42.86	6	54.54	18	46.15
Other grassland	10.68	12.52	2	7.14	0	0.00	2	5.13
Other	24.68	40.00	1	3.57	0	0.00	1	2.56

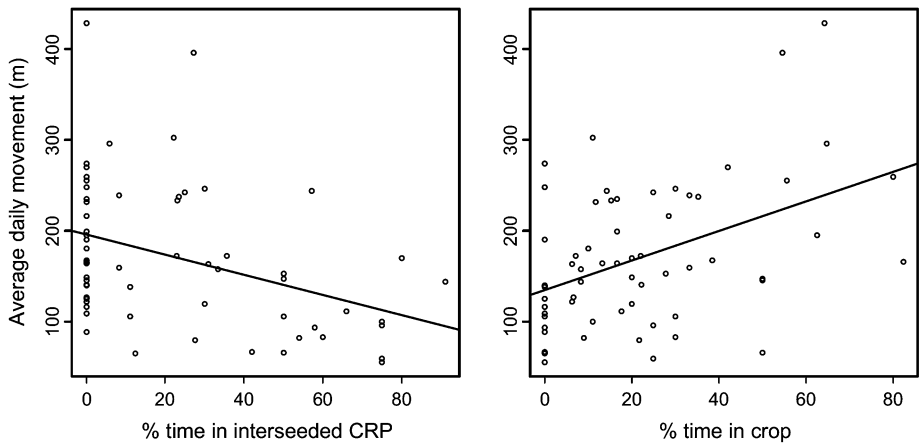

Figure 1. Relationship of percent of time spent in habitats by hen ring-necked pheasants with average daily movement (m) during the 3 weeks prior to incubation in Stanton County, Nebraska during 2005–2006.

in the discrete choice analyses, avoided landcovers classified as other at both scales when compared to CRP fields, but the preference for other was not distinguishable from the preference for non-CRP grasslands. The ranks of preferences from the compositional analyses were the same as the ranks inferred from the discrete choice analyses: interseeded CRP > CRP > other grassland > other, at both scales (Table 2). The compositional analyses described a preference for interseeded CRP at the 800-m scale (log-ratio = 1.02, SE = 0.20) and 400-m scale (log-ratio = 0.62, SE = 0.24). The compositional analyses indicated CRP and other grasslands were neutral (Table 2). However, the method also suggested that nesting hens avoided landcovers classified as other at both scales (400-m: log-ratio = −3.29, SE = 1.01; 800-m: log-ratio = −2.77, SE = 1.02; Table 2). Descriptive statistics of microhabitat variables for used and random locations are provided in Matthews (2009).

Two vegetation models (Model 1: forb + VOR + bare + cool + warm, Model 2: forb + VOR + bare) were better at describing selection of nest sites than any of the other models (Table 3). Nesting hens exhibited a preference for microhabitats with a greater proportion of area covered by interseeded forbs and legumes and sites with greater visual obstruction readings (Table 4).

We sampled landcover at 469 locations used by the 17 broods. Sites used by broods were located in interseeded CRP (36%), CRP fields (28%), other grassland (18%), and other landcovers (17%). Discrete choice analyses suggested that the type of patches used by broods differed from random points at both the 400-m and 800-m scales (Table 5). Hens had a greater relative probability of selecting interseeded CRP for brood-rearing than unmanaged CRP, other grasslands, and other habitats, and the preference was apparent at either scale of reference (400-m: $\hat{\beta}$ = 0.57, SE = 0.15; 800-m: $\hat{\beta}$ = 1.00, SE = 0.142). The relative preference for unmanaged CRP and other grasslands were not distinguishable at either spatial scale (Table 5). Hens with broods showed relative avoidance of landcovers classified as other compared to CRP (400-m: $\hat{\beta}$ = −0.72, SE = 0.17; 800-m: $\hat{\beta}$ = −0.78, SE = 0.16). The ranks of landcover preferences from compositional analyses were the same as those inferred by the discrete choice analyses: interseeded CRP > CRP other grassland > other. The ranks were the same at both 400-m and 800-m scales (Table 5). However, we were unable to distinguish among the relative preference of habitats for brood rearing using compositional analyses, except between the 2 extremes: hens showed a preference for interseeded CRP over landcover classified as other (400-m:

Table 2. Macrohabitat discrete choice coefficient of selection and log-ratio analysis of nesting habitat preference by ring-necked pheasant hens in Stanton County, Nebraska, 2005–2006.

Variables	Discrete choice			Log-ratio	
	Parameter estimate	Standard error	*P*	Log-ratio	Standard error
400-m scale					
CRP[a]				0.06	0.19
Interseeded CRP	0.95	0.31	<0.01	0.62	0.24
Other grassland	−0.25	0.55	0.66	−0.42	0.55
Other	−2.90	1.05	<0.01	−2.77	1.02
800-m scale					
CRP				0.31	0.21
Interseeded CRP	1.09	0.35	<0.01	1.02	0.29
Other grassland	−1.21	0.56	0.03	−0.66	0.53
Other	−3.63	1.04	<0.01	−3.29	1.01

a. Conservation Reserve Program grasslands.

mean difference = 2.94, SE = 0.89; 800-m: mean difference = 3.43, SE = 0.95). No other landcover classifications were found to affect selection of brood sites ($P < 0.05$; Table 5).

The vegetative structure and composition at brood sites differed from random points in the same field (Tables 6 and 7). Although we found a degree of uncertainty with respect to the selection of the best discrete choice model to describe brood microhabitat selection, we used our parsimony rules (Richards 2008) to select the top-ranked model (forb + VOR + bare) as the best model. Brood-rearing hen pheasants selected areas within fields with high levels of interseeded forbs and dense vegetation (Table 7).

Table 3. Comparison of competing discrete choice models for microhabitat selection by nesting ring-necked pheasants in northeast Nebraska 2005–2006. Models are ranked using Akaike's Information Criterion corrected for a small sample size (AIC_c); K is the number of parameters, ΔAIC_c is the difference of each model's AIC_c value from that of the top ranked model (row 1), and ω_i is the Akaike weight (sum of all weights = 1.00).

Model[a]	K	AIC_c	ΔAIC_c	ω_i
Forb + VOR + Bare + Cool + Warm	6	56.64	0.00	0.51
Forb + VOR + Bare	4	56.73	0.09	0.49
Forb + Cool + Warm	4	68.78	12.14	0.00
VOR + Bare	3	70.50	13.86	0.00
VOR + Bare + Cool + Warm	5	71.20	14.56	0.00
Forb	2	79.27	22.63	0.00
Cool + Warm	3	96.71	40.07	0.00
Null model	1	99.81	43.17	0.00

a. Forb, % cover forbs; VOR, visual obstruction reading; Bare, % bare ground; Cool, % cover cool-season grass; Warm, % cover warm-season grass.

Table 4. Model averaged coefficient (β) estimates and 95% confidence intervals describing the relationship of ring-necked pheasant hens' nest site selection with vegetative composition (% forb, % bare ground, % warm season grass, % cool season grass) and visual obstruction reading (VOR) at nests in northeast Nebraska, 2005–2006.

Parameter	β estimate	SE	CI
VOR	1.14	0.37	$0.41 < \beta < 1.87$
Forb	0.11	0.04	$0.02 < \beta < 0.18$
Bare	0.03	0.02	$-0.1 < \beta < 0.08$
Warm	0.02	0.03	$-0.03 < \beta < 0.08$
Cool	0.01	0.01	$-0.02 < \beta < 0.03$

Discussion

Our study supports the notion that CRP can be managed to serve as valuable habitat for nesting pheasants within the context of agricultural landscape. More than 90% of hens' nests were located in CRP fields (Table 1). The greater selection for a grass–legume complex was also noted by Warner et al. (1987) in managed roadsides in Illinois. Our data also support the concept that CRP fields left idle for >10 years generally lose suitability as nesting habitat (Millenbah et al. 1996, Rodgers 1999). Baxter and Wolfe (1973) and Gates and Hale (1975) also showed that monotypic grasslands with little structural variation provided poor nesting cover. Within CRP fields, hens preferred disced and interseeded areas over unmanaged CRP for nesting (Table 2). This trend held true for both extents, although preference for managed CRP was greater when considering the 800-m scale (197% increase in preference) than the 400-m scale (159% increase). This could be explained by size and relative isolation of interseeded habitats. Many of the nests (46.6%) were in interseeded CRP and this landcover constituted a small percentage of the total area (10.5%). As we changed the scale of habitat considered to be available to hens from a 400-m to 800-m radius, the proportion of interseeded habitat often decreased, which had the effect of strengthening the evidence for selection of interseeded CRP.

Nest-site selection was strongly associated with vegetation composition and vegetation density (Table 3). The amount of interseeded legumes and the dense cover provided by this vegetation was the driving factor in determining the selection of nest sites in areas containing managed CRP fields. At the nest-site, hens selected sites with dense vegetation and a greater forb component (Tables 3 and 4). Both of these microhabitat features were found in managed CRP fields (Negus et al. 2010). Similarly, all vegetative covariates in the models for nesting were positive, indicating that hens preferred dense, tall cover. These characteristics were best provided by grass fields interseeded with alfalfa and sweet clover because of their dense vegetative structure and rapid growth rate compared to grasses.

The relative selection of managed CRP by brooding hens supports the idea that pheasants in this life stage select habitats with greater vegetative diversity (Riley et al.

Table 5. Macrohabitat logistic regression and compositional analysis of brood-rearing habitat preference of ring-necked pheasant hens in northeast Nebraska, 2005–2006. Both discrete choice and compositional analysis use Conservation Reserve Program (CRP) class as a baseline; compositional analysis results are provided as mean difference of log-ratio for landcover type and log-ratio for CRP.

Variables	Discrete choice			Compositional analysis		
	Parameter estimate	SE	P	Mean difference of log-ratio	SE	P
400-m scale						
CRP						
Interseeded CRP	0.57	0.15	<0.01	1.12	1.08	0.31
Other grassland	−0.03	0.18	0.89	−0.27	1.17	0.82
Other	−0.72	0.17	<0.01	−1.82	1.13	0.13
800-m scale						
CRP						
Interseeded CRP	1.00	0.14	<0.01	1.20	1.16	0.32
Other grassland	−0.12	0.17	0.48	−0.44	1.23	0.72
Other	−0.78	0.16	<0.01	−2.23	1.24	0.09

Table 6. Comparison of competing discrete choice models for microhabitat selection by ring-necked pheasant brooding hens in northeast Nebraska 2005–2006. Models are ranked using Akaike's Information Criterion corrected for a small sample size (AIC_c); K is the number of parameters, ΔAIC_c is the difference of each model's AIC_c value from that of the top ranked model (row 1), and ω_i is the Akaike weight (sum of all weights = 1.00).

Model[a]	K	AIC_c	ΔAIC_c	ω_i
Forb + VOR + Bare	4	106.57	0.00	0.51
Forb + VOR + Bare + Cool + Warm	6	107.11	0.54	0.39
Forb	2	110.27	3.70	0.08
Forb + Cool + Warm	4	113.26	6.70	0.02
VOR + Bare + Cool + Warm	5	132.31	25.74	0.00
VOR + Bare	3	137.79	31.22	0.00
Cool + Warm	3	170.40	63.83	0.00
Null model	1	180.22	73.65	0.00

a. Forb, % cover forbs; VOR, visual obstruction reading; Bare, % bare ground; Cool, % cover cool-season grass; Warm, % cover warm-season grass.

Table 7. Coefficient (β) estimates and 95% confidence intervals describing the relationship of ring-necked pheasant hens' selection of brood-rearing habitat with vegetative composition (% forb, % bare ground) and vertical obstruction (VOR) surrounding brood locations in northeast Nebraska, 2005–2006; estimates are from the best model.

Parameter	β	SE	CI
Forb	0.10	0.03	$0.04 < \beta < 0.16$
VOR	0.63	0.28	$0.08 < \beta < 1.19$
Bare	0.02	0.02	$-0.01 < \beta < 0.05$

1998), which can be obtained by discing and interseeding monoculture CRP fields. By improving these old CRP fields, brooding-hen use was increased by 77% and 172% compared to unmanaged CRP, as assessed within the 2 scales of 400-m and 800-m buffer areas, respectively. The requirements of forbs for cover and insect production during brood rearing have been well documented (Hammer 1973, Hill 1985). Sites used by brooding hens had greater forb content than randomly selected habitats with no other covariate having much effect (Tables 5 and 6). Most critically, hens appeared to be selecting habitat to maximize productivity: Matthews et al. (2012) reported greater nest success and brood survival in managed CRP. County-level surveys of pheasants provide additional, demographic evidence for the benefits from such management. Biologists saw responses from spring rooster crowing counts (crows/stop doubled), roadside surveys of broods in August (young/mile increased by 400%), and spring and summer rural mail carrier surveys (pheasants/100 km doubled) during the period of time in which land under CRP contract in our study area was disturbed through mid-contract management (S. Taylor, unpublished data).

Recently, biologists have debated the use of compositional analysis for analyzing habitat preference (Thomas and Taylor 2006, Bingham et al. 2007). Our results, using both discrete choice and compositional analysis to compare brood-site preference, did not differ in habitat preference rankings. But, our results did differ in the statistical significance placed on these relationships (Table 3). This may be a result of fewer degrees of freedom in the compositional analysis. In compositional analysis, we pooled all used points for each brood into a percentage of time each separate brooding hen was found in each habitat. We used these percentages with the pooled available habitats for each hen. Discrete choice uses each location, along with its paired random points, as separate entries. This substantially increased the number of data points and thus decreased the variance. For this reason, discrete choice seems to be a more efficient way to analyze similar data. More critical to our study, the discrete choice analysis allowed us to evaluate the effects of continuous and categorical covariates on habitat selection.

Management Implications

By performing mid-contract management, land managers can set back successional progression of CRP grasslands and reintroduce forbs that have been lost through time, which improves CRP as habitat for breeding pheasants. However, the benefits in terms of production may be short-lived without continued management. As fields may become dominated by tall, smooth brome with sparse patches of alfalfa and red clover, local pheasant populations can return to pre-disturbance levels. Thus, the benefits of mid-contract management may only last for 1 or 2 more years on sites dominated by native warm season grasses. Therefore we recommend an annual rotation of management, including discing and interseeding, to continually add newly disturbed habitat to landscapes. Additionally, our research suggests that future Farm Bill programs should support mid-contract management strategies as a tool to increase the benefits of programs for wildlife.

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