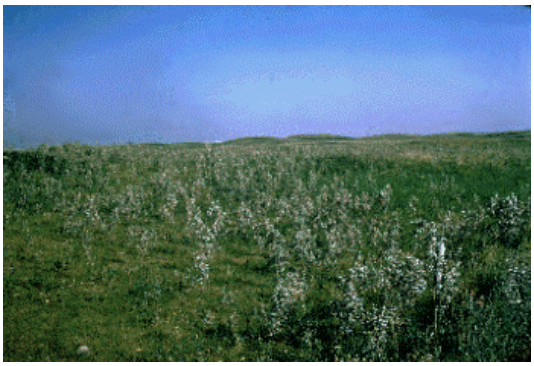
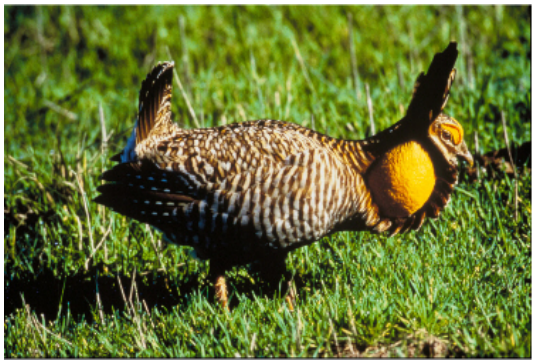
The Effect of Woody Vegetation on Grassland Nesting Birds





An Annotated Bibliography

By Kristel K. Bakker
College of Natural Sciences
Dakota State University
Madison, SD 57042
kristel.bakker@dsu.edu

HAPET
Habitat And Population Evaluation Team

Introduction

Grassland ecosystems have been transformed from vast mosaics of grassland into fragmented agricultural landscapes characterized by large blocks of cropland interspersed with smaller, more isolated grassland patches. Planted woodlands, most of which are linear, further fragment remaining grasslands and create abrupt boundaries that can exacerbate edge effects. Additionally, the suppression of ecological processes such as fire has allowed an increase in woody encroachment into grassland habitats. This bibliography was completed to summarize current knowledge on the effects of woody vegetation on habitat suitability for grassland nesting species.

Methods

Sixty-seven articles with references to species' associations with woody vegetation were obtained. Few of these were designed solely to determine the effect of woody vegetation on avian species, rather woody vegetation was one of several variables analyzed. Bird relationships to woody vegetation were summarized at 4 levels: within the grassland patch (i.e., woody stem density, shrub coverage, presence of mature trees), perimeter comprised of woodland (shrubs, trees, hedgerows), distance of a nest or survey from woodland habitat, and the proportion of woodland habitat within the surrounding landscape (Table 1). Results from studies with rigorous statistical analyses as well as observational studies are annotated in this bibliography.

Results and Conclusions

Game Birds. All seven studies on grouse detected a negative relationship with woody vegetation. Greater Prairie-Chicken nesting success decreased with woody cover near nest sites while active Greater Prairie-Chicken, Lesser Prairie-Chicken, and Sharp-tailed Grouse leks had significantly lower proportions of forest cover within the landscape than inactive leks. Ring-necked Pheasant nests placed within shelterbelts had higher levels of predation than those located in other habitats. While one study found that dense shelterbelts increased survival of pheasants during severe winters, a second one found decreased use of winter food plots associated with increased tree cover. Artificial duck nests had higher predation rates near edges and within American Crow home ranges. Additionally, brood use of stock ponds decreased with increasing perimeter comprised of trees. One study found no difference in woody vegetation between depredated and undisturbed artificial duck nests.

Nongame Birds. Grassland birds are declining more rapidly than any other group of North American birds. Linked to the declines are the loss and degradation of grassland habitats. Many studies indicated that woody vegetation negatively affected presence, abundance, and nesting success of nongame species. While some studies indicated no effect, few detected a positive association of these variables with woody vegetation. Savannah Sparrows had the most consistently negative associations with woody vegetation; fifteen of 22 analyses indicated decreased occurrence, density and/or nesting success associated with woody vegetation inside and adjacent to grasslands as well as with decreasing distance to woodland patches and increasing woodland habitat within the landscape. Grasshopper Sparrows were negatively associated with woody vegetation in 16 of 24 studies. Neither of these species was positively associated with woody vegetation at any level (Table 1). Two species, the Clay-colored Sparrow and Vesper

Sparrow, responded positively to woody vegetation in ≥ 2 studies. The Clay-colored Sparrow was positively associated with shrub coverage within the patch in 3 studies. This species often builds nests in woody stems. However, it was negatively associated with woodland within the landscape in another study. Dickcissels were positively associated with woody cover inside the grassland in two studies but negatively associated in 3 studies. Additionally, Dickcissels exhibited negative associations with woody vegetation at all other levels studied (Table 1). No other grassland nesting passerine was positively associated to woody vegetation at any level. However, this relationship has been studied <3 times in several species and requires additional research.

Overall, these studies indicate woody vegetation has a deleterious effect on occurrence, density and/or nesting success of both game and nongame grassland nesting birds. Few species responded positively to woody vegetation. Only 2 grassland nesting species responded positively to a measure of woody vegetation in ≥ 2 studies. Edge effects associated with woody vegetation have been detected in pheasants, ducks, grouse and nongame birds in studies conducted over a broad geographical range (Montana, South Dakota, Minnesota, Missouri, Oklahoma, Wisconsin, etc.). Managers need to seriously consider the tradeoffs that exist when introducing trees into formerly treeless grassland habitats.

1. **Arnold, T.W. and K.F. Higgins. 1986. Effects of shrub coverages on birds of North Dakota mixed-grass prairies. Canadian Field-Naturalist 100(1):10-14.**

The distribution and density of birds in relation to wolfberry and silverberry coverage in prairie grasslands were studied. Transects with 30-80% shrub coverage contained 19 passerine species while transects with <10% coverage contained 10. Eleven species were detected only in shrubby transects, 9 of which were shrubland nesting species (Willow Flycatcher, Gray Catbird, Brown Thrasher, Yellow Warbler, Song Sparrow, American Goldfinch). Clay-colored Sparrows and Brown-headed Cowbirds were the most abundant species on shrubby transects, comprising 57% of the total bird density. Bobolinks occurred in both transect types. Savannah and Baird's Sparrows occurred only on shrubless transects. Grasshopper Sparrows and Chestnut-collared Longspurs were the most abundant species on shrubless transects.

2. **Bakker, K.K., D.E. Naugle, and K.F. Higgins. 2002. Incorporating landscape attributes into models for migratory grassland bird conservation. Conservation Biology 16:1638-1646.**

Grasslands (n=380) were studied throughout eastern South Dakota to investigate the influence of local and landscape attributes on the occurrence and density of grassland birds. Independent variables included percent perimeter comprised of woody vegetation (>1 row of trees or shrubs) and proportion of trees within 400 m (50 ha/124 ac), 800 m (201 ha/497 ac), and 1600 m (804 ha/1987 ac) of the transect center. Sedge Wren, Savannah Sparrow, Grasshopper Sparrow, and Western Meadowlark exhibited a decreased probability of occurrence as the perimeter comprised of woody vegetation increased. Occurrence of Bobolinks, Dickcissels, and Clay-colored sparrows was not related to the proportion of wooded perimeter. Density was not associated with woody vegetation for any species. The authors recommended high priority be placed on conserving large, continuous blocks of grassland habitat as well as both small and large grassland patches embedded within landscapes with a high proportion of grassland habitat and little or no woodland.

3. **Bakker, K.K. 2000. Avian occurrence in woodlands and grasslands on public areas throughout eastern South Dakota. Ph.D. dissertation, South Dakota State University, Brookings.**

Grasslands (n=380) were studied throughout eastern South Dakota to investigate the influence of local and landscape attributes on the occurrence and density of grassland birds. Independent variables included percent perimeter comprised of woody vegetation and proportion of trees within 400 m (50 ha/124 ac), 800 m (201 ha/497 ac), and 1600 m (804 ha/1987 ac) of the transect center. Savannah Sparrow occurrence was halved when woodland habitat within 400m of a surveyed transect increased from 0 to 2% in grasslands in eastern South Dakota. Grasshopper Sparrows, Bobolinks, and Western Meadowlarks also were negatively associated with increased proportions of woodland habitat in the landscape. Management recommendations included removing woodland habitat within or adjacent to grasslands and acquiring/preserving grassland patches large enough [$\geq$125-250 ha (309-618 ac)] to attract the majority of grassland obligates. Additionally, it was recommended to place priority on purchasing and conserving

grasslands in landscapes with high amounts of grassland habitat (≥ 40% within 1600 m of the patch) and low amounts of woodland habitat (<1.0% within 400 m).

4. Berger, R.P. and R.K. Baydack. 1992. Effects of aspen succession on sharp-tailed grouse, *Typmpanuchus phasianellus*, in the Interlake Region of Manitoba. Canadian Field-Naturalist 106:185-191.

Seven leks of aspen-parkland populations of Sharp-tailed Grouse were abandoned between 1976 and 1986 in the Narcisse Wildlife Management Area in Manitoba. During that time, the closed forest area within 3.14 km^2 of each lek increased from an average of 1.3 km^2 to 2.0 km^2. The authors concluded that the habitat within 1 km of a lek can be comprised of no more than 44% closed aspen forest and must have at least 23% prairie to sustain a population of grouse. Once aspen succeeds to >56% forest and less than 15% prairie remains, the lek will likely be abandoned.

5. Bergin, T.M., L.B. Best, and K.E. Freemark. 1997. An experimental study of nest predation on artificial nests in roadsides adjacent to agricultural habitats in Iowa. Wilson Bulletin 109:437-448.

The relationship between the success of artificial nests and roadside characteristics was examined in south-central Iowa. Transects containing 10 nests were set up along 136 roadsides. Destroyed nests were categorized as follows: 1) disappearance of eggs with no disturbance, 2) disappearance of eggs with disturbance, and 3) broken or crushed egg shells in or near the nest bowl. Roadsides where characterized as wooded, herbaceous vegetation with fences, and herbaceous vegetation without fences. Variables measured included habitat of the roadside and adjacent habitat. Wooded roadsides and roadsides with fences had significantly greater nest predation in the first category than did roadsides without fences. The authors speculated that these wooded roadsides and fences provide cover for mammalian predators and elevated perches for avian predators. In addition, some predators (American crows, raccoons) may have affinities for wooded habitats and use them for travel and foraging.

6. Bergin, T.M., L.B. Best, K.E. Freemark, and K.J. Koehler. 2000. Effects of landscape structure on nest predation in roadsides of a Midwestern agroecosystem: a multiscale analysis. Landscape Ecology 15:131-143.

The relationship between the success of artificial nests and the landscape surrounding roadsides was examined in south-central Iowa. Transects of 10 nests each were set up along 136 roadsides. The proportion of habitat types was quantified within 200, 400, 800, 1200, and 1600 m of the transect line. Woody habitat included woodland block cover (woodlands, farmsteads), wooded roadsides, wooded fencerows, and wooded riparian strips. Woodland block cover, wooded roadsides, and wooded fencerows were positively associated with predation of artificial nests at all spatial scales. The authors speculated that woody vegetation provides cover for mammalian predators and elevated perches for avian predators. In addition, some predators (American crows, raccoons) may have affinities for wooded habitats and use them for travel and foraging. The presence of wooded cover increases the likelihood that predators will come in contact with nests in roadsides.

7. Bollinger, E.K. 1995. Successional changes and habitat selection in hayfield bird communities. Auk 112:720-730.

In a study of the effects of successional changes in vegetation on grassland bird communities in 90 hayfields in New York, the first variable entering regression models for abundance of Savannah Sparrows was a negative association with the percentage of the field bordered by woods. Red-winged Blackbirds, Bobolinks, Eastern Meadowlarks, Upland Sandpipers, and Henslow's and Grasshopper Sparrows did not exhibit a relationship with percent of field edge in woods.

8. Bollinger, E.K. and T.A. Gavin. 1992. Eastern Bobolink populations: ecology and conservation in an agricultural landscape. pp. 497-506 *In* Ecology and conservation of neotropical land birds. J.M. Hagen III and D.W. Johnston, eds. Smithsonian Institute Press, Washington, D.C.

In New York, Bobolink abundance was significantly lower (0.01 males/100 ha or 247 ac) in fields with approximately 25% woody coverage (woody shrubs and saplings) than in old hayfields (2.5 males/100 ha) with <25% woody cover. Habitats with >25% woody coverage were determined to be unsuitable for Bobolinks.

9. Burger, L.D., L.W. Burger, Jr., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. Journal of Wildlife Management 58:249-254.

In a study using artificial nests containing quail eggs in 15 prairie fragments in southwest Missouri, it was determined that nests <60 m from woody cover were less successful than those >60 m from woody cover (predation rates 28.7 vs. 7.9%). Additionally, distance to woody cover explained twice as much variation in predation rates as grassland size. Woody cover was defined as woodlots, riparian areas, hedgerows, and fencerows.

10. Coppedge, B.R., D.M. Engle, R.E. Masters, and M.S. Gregory. 2001. Avian response to landscape change in fragmented southern Great Plains grasslands. Ecological Applications 11:47-59.

Avian response to landscape changes associated with juniper (*Juniper virginianus*) invasion into native grasslands and cropland enrollment in the Conservation Reserve Program in Oklahoma was examined by using 3 Breeding Bird Survey (BBS) routes from 1965-1995. Composition of 11 cover types were delineated within 400 m of each survey point along BBS routes. Most grassland birds (including Ring-necked Pheasant, Eastern Meadowlark, Western Meadowlark, Horned Lark, Cassin's Sparrow, Grasshopper Sparrow, Common Nighthawk, and Dickcissel) exhibited population declines related to the invasion of woody vegetation. From 1981-1995, grassland bird populations declined or exhibited negative associations with woody vegetation gradients. In particular, Western Meadowlark populations declined across a gradient of increasing encroachment, and were extirpated from the area with the most juniper. Woody invasion also affected patch size, and areas with the least amount of woody cover retained core areas suitable for species associated with core patch size (Horned Lark, Cassin's Sparrow, Lark Sparrow, and Eastern and Western Meadowlarks).

11. Cully, J.F., Jr. and H.L. Michaels. 2000. Henslow's sparrow habitat associations on Kansas tallgrass prairie. Wilson Bulletin 112:115-123.

Habitat characteristics of Henslow's Sparrows were examined on the Fort Riley Military Reservation in Kansas, 1995-1996. Survey points were located in tallgrass prairie habitat defined as grassland (n=35), savanna (n=44), or woodland edge (n=40, located within 100 m of extensive riparian habitat). Henslow's Sparrows selected grassland habitat (21/36) significantly more often than either savanna (10/36) or woodland edge (5/36). The presence of some low woody vegetation did not affect use at the microhabitat scale.

12. Davis, S.K., D.C. Duncan, and M. Skeel. 1999. Distribution and habitat associations of three endemic grassland songbirds in southern Saskatchewan. Wilson Bulletin 111:389-396.

Bird surveys were conducted throughout the prairie ecozone of Saskatchewan to determine habitat associations of 3 grassland birds (Sprague's Pipit, Baird's Sparrow, Chestnut-collared Longspur). Baird's Sparrows were associated with pastures having greater coverage of grasses >10 cm tall and sparse shrub coverage.

13. Davis, S.K. and S.G. Sealy. 2000. Cowbird parasitism and nest predation in fragmented grasslands of southwestern Manitoba. pp. 220-228 *In* Ecology and management of cowbirds and their hosts: Studies in the conservation of North American passerine birds. J.N.M. Smith, T.L. Cook, S.I. Rothstein, S.G. Sealy, and S.K. Robinson, eds. Univ. of Texas Press, Austin.

The authors found that female cowbirds were more abundant and nests were more frequently parasitized on the smallest (22 ha/54 ac) of 3 grassland sites where nesting studies were conducted. Also most of this site was bordered by shrubs (wolf willow (*Elaeagnus commutata*), western snowberry (*Symphoricarpos occidentalis*), and *Salix* spp.). The authors attributed increased cowbird activity to the increased availability of perches at this site as compared to the other study areas.

14. Delany, M.F., H.M. Stevenson, and R. McCracken. 1985. Distribution, abundance, and habitat of the Florida grasshopper sparrow. Journal of Wildlife Management 49:626-631.

Grasshopper Sparrows in Florida used treeless habitat on poorly drained soils that averaged 19.2% shrub cover. This is not a prairie population of Grasshopper Sparrows and it was noted that the shrub coverage was much higher than reported in habitats used by other races of Grasshopper Sparrows.

15. Delisle, J.M. and J.A. Savidge. 1996. Reproductive success of grasshopper sparrows in relation to edge. The Prairie Naturalist 28:107-113.

In southeast Nebraska Conservation Reserve Grasslands, none of the 10 Grasshopper Sparrow nests located were within 50 meters of edge habitat (wooded draws, roadsides, and cropland).

16. Esler, D. and J.B. Grand. 1993. Factors influencing depredation of artificial duck nests. Journal of Wildlife Management 57:244-248.

Four 10 ha (25 ac) plots were established within a 187 ha (462 ac) meadow complex to assess depredation rates on artificial duck nests in Alaska. All plots were bordered on one side by forest habitat. Distance to nearest forest edge did not differ between depredated and undisturbed nests.

17. Fuhlendorf, S.D., A.J.W. Woodward, D.M. Leslie, Jr., and J.S. Shackford. *In Press*. Mulitscale effects of habitat loss and fragmentation on lesser prairie-chicken populations. Landscape Ecology.

This study was conducted to determine the effect of landscape structure and change (1959-1996) on population dynamics of the Lesser Prairie-chicken in western Oklahoma and northern Texas. Landscape composition was quantified at 5 spatial scales for 10 leks by using aerial photographs taken between 1959 and 1996. Landscapes were classified as declining or sustained for prairie-chickens based on long-term lek counts. Landscapes with declining Lesser Prairie-chicken populations had significantly greater increases in tree cover types (riparian, windbreaks, juniper encroachment) within 7,238-ha (28-mi^2) than landscapes with sustained populations. Landscapes with declining populations also had more cropland (7,238-ha [28-mi^2] scale), greater changes in landscape composition (3,619- and 7,238-ha [14- and 28-mi^2] scales), and increased edge density (452-, 905- and 1,810-ha [1.75-, 3.5-, and 7-mi^2] scales).

18. Gabbert, A.E., A.P. Leif, J.R. Purvis, and L.D. Flake. 1999. Survival and habitat use by ring-necked pheasants during two disparate winters in South Dakota. Journal of Wildlife Management 63:711-722.

Pheasant survival and habitat use during 2 consecutive winters (a typical winter followed by a severe winter) were compared at 3 sites in eastern South Dakota. The proportion of 10 habitat types within 1,035 ha (2,558 ac) study areas was delineated to determine habitat preference of wintering hens. During the typical winter and the early part of the severe winter, cattail wetland, tall grass (>75cm), and food plot habitats ranked highest in hen use. For the surviving pheasants, woodland/farmstead and food plot habitats were preferred during the late stages of the severe winter. Overall mortality was higher during the severe winter but mortality due to weather was not different between winters. Mortality due to predation was significantly greater than mortality due to weather in both winters. Data from 31 of 41 deaths during the severe winter corresponded with blizzards, indicating an increased vulnerability during severe weather. The authors concluded that cattail wetlands, grassland habitat, and food plots are crucial for winter survival of pheasants. During severe winters (1 every 10-15 years), dense woody habitat may prevent near or total pheasant loss.

19. Gates, J.E. and L.W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. Ecology 59:871-883.

Fledging success for 21 open-nesting passerines was positively correlated with increasing distance from edge. High rates of nest predation <46 m from edges was attributed to high nest densities as well as increased predator activity by ecotones. Brown-headed cowbird parasitism was also higher near edges. The authors hypothesized that open-nesting passerines were not adapted to abrupt, man-made edges, and that such areas functions as

"ecological traps" due to their attractiveness as nesting habitat for birds as well as foraging habitat for nest predators.

20. Gazda, R.J., R.R. Meidinger, I.J. Ball, and J.W. Connelly. 2002. Relationships between Russian olive and duck nest success in southeastern Idaho. Wildlife Society Bulletin 30:337-344.

The relationship between Russian olive abundance, nesting magpies, and duck nest success was investigated on management areas in southeastern Idaho at both the local and landscape scale, 1992-1993 and 1995-1996. Management areas were classified by the proportion dominated by Russian olive (0-5%=low, 10-30%=moderate, >50%=high). Russian olive was considered dominant at $\geq$1 tree per hectare. Incorporating nest search results with unpublished annual estimates of duck nest success (429 nests), a total of 1,134 nests were analyzed. Duck nest success was 6.8% where Russian olive abundance was high, 19.8% in moderate areas and 42.9% in areas with low Russian olive abundance. During the second time period a 654-ha management area was divided into a treatment area (Russian olive removed) and a control area (no removal). A total of 705 duck nests were monitored. Mallard and other upland nesting duck species (grouped) nest success did not change after removal of Russian olive. Median distance to active magpie nest and median distance to nearest Russian olive did not differ between successful and depredated nests. Artificial nests were established along transects with increasing distance to nearest Russian olive (5, 25, 75, and 150 m). Artificial nest survival increased with distance from nearest Russian olive. The authors recommended controlling the invasion of Russian olive early on while it is still effective and economically feasible and urged managers to carefully consider the risks associated with accepting or introducing trees into historically treeless areas.

21. Hanowski, J.M., D.P. Christian, and G.J. Niemi. 2000. Landscape requirements of prairie sharp-tailed grouse *Tympanuchus phasianellus campestris* in Minnesota, USA. Wildlife Biology 6(4):257-263.

Landscape composition was quantified around active and inactive lek sites at 4 spatial scales (200, 500, 1000, and 3000 m buffers around lek points) in brush landscapes in northeast Minnesota. Active prairie sharp-tailed grouse leks had significantly lower proportions of upland forest and brush cover types and higher percentages of native grasses within 500 and 1000 meters of the site than inactive leks. No differences were detected at the 200 m scale. Logistic regression indicated that active lek sites were located in areas with less conifer regeneration and upland forest. The authors determined that grouse were sensitive to even small increases (1-2%) in the amount of woody vegetation in their home range and successful management should include an assessment of planted conifers within the lek vicinity.

22. Hanson, L.E. and D.R. Progulske. 1973. Movements and cover preferences of pheasants in South Dakota. Journal of Wildlife Management 37:454-461.

Movement patterns of ring-necked pheasants were studied from June to October by using radiotelemetry. Nine cover types were used by pheasants (corn, small grains, residual cover, pasture, summer fallow, alfalfa, shelterbelts, ditches, spoil plots). Residual cover and small grains were the most heavily used during June and the first ½ of July. Seventy-

five percent of all locations during the second ½ of summer were in corn fields. Alfalfa was the preferred habitat in both day and night and during all months. Shelterbelts were used intermittently.

23. Helzer, C.J. 1996. The effects of wet meadow fragmentation on grassland birds. M.S. Thesis, University of Nebraska, Lincoln.

Grasshopper Sparrow abundance increased significantly when >75 meters from wooded edges and >50 meters from cornfield edges in Nebraska.

24. Herkert, J.R. 1994a. Breeding bird communities of Midwestern prairie fragments: the effects of prescribed burning and habitat-area. Natural Areas Journal 14:128-135.

Three edge species, Common Yellowthroats, Song Sparrows, and American Goldfinches, were positively associated with woody stem density in 24 grasslands in Illinois. Grassland nesting species were not associated with woody stem density. The author recommended management to remove woody encroachment and scattered trees to eliminate features attractive to nest predators and nest parasites.

25. Herkert, J.R. 1994b. Status and habitat selection of the Henslow's sparrow in Illinois. Wilson Bulletin 106: 35-45.

Native and restored prairies and non-native cool-season grass and fallow fields (n=24) were studied in Illinois to identify habitat features that influence the distribution and abundance patterns of Henslow's Sparrows. There was no significant difference in woody stem density between occupied and unoccupied fields.

26. Hughes, J.P., R.J. Robel, K.E. Kemp, and J.L. Zimmerman. 1999. Effects of habitat on dickcissel abundance and nest success in conservation reserve program fields in Kansas. Journal of Wildlife Management 63:523-529.

Dickcissel abundance was negatively associated with the percentage of woody perimeter and the amount of woodland habitat within 800 meters of CRP fields (n=11) in northeastern Kansas. Daily nest survival rates were associated only with field-level vegetation attributes.

27. Johnson, R.G. and S.A. Temple. 1990. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. In J. Verner, M.L. Morrison and C.J. Ralph, eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Wis. Press, Madison, Wis.

Nest productivity and probability that a species' nest would occur in grassland habitat types defined by size of the grassland fragment, its proximity to forest edge, and the number of growing seasons since last burn were compared in western Minnesota. Nesting success was significantly higher for nests located >45 m from a forest edge. The highest rate of nest productivity for each species (Clay-colored Sparrow, Savannah Sparrow, Grasshopper Sparrow, Bobolink, Western Meadowlark) was detected in habitats far (>45 m) from forest edges. Probability of occurrence of a Clay-colored Sparrow nest was significantly higher in habitats <45 m from a forest edge.

Probability of Grasshopper Sparrow and Western Meadowlark nest occurrence was lower in habitats <45 m from forest edges. It was recommended that management decisions be based on nest productivity rather than occurrence and that prairie fragments managed for grassland birds should be devoid of forest edges.

28. Johnson, R.G. and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54(1):106-111.

Nest predation rates were lower for 5 species (Clay-colored, Savannah and Grasshopper Sparrows, Bobolink, Western Meadowlark) in large prairie fragments (≥130 ha or 321 ac) and for nests ≥45 meters from woody vegetation. Brood parasitism also was lower for nests ≥45 meters from wooded edges for all 5 species. The authors recommended making grasslands as large as possible and removing woody vegetation that creates edges to enhance nesting success.

29. Johnston, D.W. and E.P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37:50-62.

Grasshopper sparrows were found in fields with ≤10% shrub coverage and were absent from fields containing ≥35% shrub cover. Eastern Meadowlarks were found primarily in fields with shrub cover ≤10%.

30. Kahl, R.B., T.S. Baskett, J.A. Ellis, and J.N. Burroughs. 1985. Characteristics of summer habitats of selected nongame birds in Missouri. University of Missouri-Columbia, Agricultural Experiment Station Research Bulletin 1056, Columbia, Missouri.

The authors studied old fields and grasslands in Missouri to determine characteristics of nongame bird habitat associations. They found Eastern Meadowlarks mainly in grasslands which had few (<350/ha or <142/ac)woody stems <2.5 cm dbh and no woody stems ≥2.5 cm dbh. Habitat around Dickcissel song perches contained few or no woody stems <2.5 cm dbh and no woody stems ≥2.5 cm dbh. Typical Grasshopper and Henslow's Sparrow habitat was characterized as having no woody invasion >1m tall.

31. Kantrud, H.A. and K.F. Higgins. 1992. Nest and nest site characterisitics of some ground-nesting, non-passerine birds of northern grasslands. Prairie Naturalist 24:67-84.

Nests of grassland birds other than waterfowl were found in various nesting studies from 1963-1991. Researchers searched a minimum of 5600 ha (13,838 ac) of native grasslands, 1400 ha (3,460 ac) of seeded grassland, and 1000 ha (2,471 ac) of cropland. Northern Harrier nests were usually located in undisturbed grasslands with short brush. Stands of shrubs, particularly western snowberry, contained over ½ of the 129 Northern Harrier nests.

32. Larsen, D.T., P.L. Crookston, and L.D. Flake. 1994. Factors associated with ring-necked pheasant use of winter food plots. Wildlife Society Bulletin 22:620-626.

Thirteen characteristics of food plots (*n*=174) and their surrounding landscapes (300-, 400-, and 600-m radii; 70, 124, and 280 ac) were evaluated to determine associations

with winter food plot use by Ring-necked Pheasants. Food plots were studied during 4 consecutive winters (1988-89 through 1991-92). Woody vegetation variables included percent tree cover, percent tree cover with high visual obstruction in the understory, distance to nearest tree cover, and distance to trees with high visual obstruction in the understory. The presence of wetland and grass winter cover in the surrounding landscape were the most important variables in determining food plot use. Tree cover appeared to be negatively associated with winter food plot use, primarily due to the negative relationship between trees and herbaceous winter cover.

33. Madden, E.M., R.K. Murphy, A.J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in northwestern North Dakota. American Midland Naturalist 144:377-392.

Bird use and vegetative characteristics were surveyed in 160 (1993) and 150(1994) sample points distributed over 9 prescribed burn units exhibiting a wide range of postfire successional stages. Clay-colored sparrows had a 69% probability of occurrence in grasslands with 3% shrub coverage. Probability of occurrence increased to 95% when shrub coverage reached 20%. Baird's Sparrow incidence dropped below 50% with 18% shrub coverage.

34. Mankin, P. C. and R. E. Warner. 1992. Vulnerability of ground nests to predation on an agricultural habitat island in East-central Illinois. American Midland Naturalist 128:281-291.

Artifical ground nests (n=388) in a 61 ha (151 ac) area in Illinois were studied to determine the effects of local habitat characteristics on predation. Pheasant and/or brown chicken eggs were placed in each nest. The authors speculated that crows from an adjacent woodlot may have been responsible for total removal of eggs in artificial nests during one trial of the study.

35. McCarthy, C., T. Pella, G. Link, and M.A. Rumble. 1997. Greater prairie chicken nesting habitat, Sheyenne National Grassland, North Dakota. USDA Forest Service, General Technical Report RM-GTR-298.

A habitat suitability index (HSI) based on vegetation height/density was used to evaluate nesting habitat conditions for Prairie Chickens on the Sheyenne National Grassland (SNG), North Dakota. The HSI predicts that adequate nesting cover is present when 80% of the area supports herbaceous vegetation with a visual obstruction reading of 2-3. The authors determined that the prairie chicken population on the SNG is avoiding extirpation by nesting in small limited areas with adequate nesting cover and that the encroachment of woody vegetation is contributing to a decrease in adequate nesting cover.

36. McKee, G.M., R. Ryan, and L.M. Mechlin. 1998. Predicting greater prairie-chicken nest success from vegetation and landscape characteristics. Journal of Wildlife Management 62:314-321.

The authors measured nest site vegetation characteristics (including percent woody cover) and distance from nest to nearest edge (any transition in vegetation, e.g., fencerows, habitat types, woody draw, creeks, trails) or tree (woody stems $\geq$2 m high) to determine the effects on nest success in 2 public areas [1,670 and 485 ha (4,127 and 1198

ac) in size] in southwestern Missouri. Sixty nests were studied over 3 years, 1990-1992. Nest success declined with increasing woody cover and litter. Only 3 of 17 nests hatched when woody cover was >5%. Conversely, when woody cover was ≤5% 15 of 26 nests hatched. Models using litter and woody cover correctly predicted greater prairie-chicken nest success 81% of the time. Models combining litter cover and distance to tree did produce significant models which correctly predicted nest success 76% of the time but models including only distance to tree were not significant.

37. Merrill, M.D., K.A. Chapman, K.A. Poiani, and B. Winter. 1999. Land-use patterns surrounding greater prairie-chicken leks in northwestern Minnesota. Journal of Wildlife Management 63:189-198.

From 1986-1996, 389 unique Greater Prairie-Chicken leks were observed and classified as either traditional (males displayed in lek ≥6 of 11 years) or temporary (leks used <5 of 11 years). Lek points had significantly less forest (1.6 vs11.0%) and residential land and more Conservation Reserve Program grasslands (20 vs. 15.9%) within 810 ha (2,002 ac) than did non-lek points. Temporary leks had significantly greater percentages of forest (mean = 3.1 vs. 1.6%) and cropland (49.8 vs. 43.9%) within 810 ha than did traditional leks.

38. Michaels, H.L. and J.F. Cully, Jr. 1998. Landscape and fine scale habitat associations of the loggerhead shrike. Wilson Bulletin 110:474-482.

Loggerhead Shrikes were positively associated with savannah habitat (sites that contained >15 shrubs or trees but no continuous woody habitat) within 250 meters of surveyed points (n=119) on Fort Riley Military Reservation, Kansas. However, there were no significant differences in mean tree or shrub density within the patch between used and unused sites. The authors concluded Loggerhead Shrikes were selecting for tallgrass prairie with scattered woody vegetation.

39. Munson, E.S. 1992. Influence of nest cover on habitat selection in clay-colored sparrows. Wilson Bulletin 104:525-529.

Clay-colored Sparrows selected territories containing dense stands of *Salix interior* and *Spiraea alba* (1.8 stems/m^2 *Salix interior*, 7.6 stems/m^2 *Spiraea alba* within territories vs. 0.02 and 4.3 stems/m^2 outside territories) in central Wisconsin. *Spiraea alba* was the second most common plant species within territories. Because Clay-colored Sparrows do not feed within their territories, nesting habitat may differ from feeding habitat.

40. Naddra, R. and D. Nyberg. 2001. Effects of afforestation of pastures on bird abundance. Transactions of the Illinois State Academy of Science 94: 243-250.

Bird abundance in an afforested area (land not previously forested that had trees planted on it), a remnant forest, and a grassland habitat was studied in a 400 ha (988 ac) preserve in Illinois. Seventeen species were observed only in the grassland, 9 only in remnants, and 5 only in afforested areas. Overall species richness between habitats was similar, 32 in both the grassland and afforested area and 39 in the remnant forest. The abundance of birds per station per visit was 11.2 for forest remnants, 8.4 for grassland habitats, and 3.8 for afforested areas. The afforested area was determined to be fairly mature with an

estimated plant date of 1955. The authors determined that the negative impacts of woodland habitats on grassland birds are not offset by a substantial benefit of afforested areas to woodland birds.

41. Newton, J.L. and E.J. Heske. 2001. Predation on artificial nests in small grassland patches in east-central Illinois. American Midland Naturalist 145:29-38.

Predation of artificial nests containing quail (June and July) and zebra finch (July only) eggs was studied in 11 fields (0.8-12.6 ha [2.0-31 ac]) to determine the relationship between distance to woodland edge (<10, 25, and 50m) and nest fate. Depredation rates were 33% in June and 78% in July. Predation rates did not decrease with increasing distance to woody edge or patch area. The authors speculated that the small size of fields studied is below the threshold at which edge effects are detectable (i.e., the entire patch is functioning as edge habitat).

42. Niemuth, N.D. 2000. Land use and vegetation associated with greater prairie-chicken leks in an agricultural landscape. Journal of Wildlife Management 64:278-286.

Landscape was quantified at 5 spatial scales (400, 800, 1200, 1600, 2000, and 2400 m concentric rings) around active leks and random points in central Wisconsin. Active leks had higher percentages of grassland, shrub, and wetland cover and lower percentages of row crop, hay, and forest cover than random points. Forest cover was lower at active sites at the 400 (approx. 6 vs 20%) and 800 (approx. 15 vs 28%) m scales. The positive association with shrub cover was attributed to the degradation of grassland habitat and strong site fidelity to leks, not a preference for shrub cover during the nesting season.

43. O'Leary, C.H. and D.W. Nyberg. 2000. Treelines between fields reduce the density of grassland birds. Natural Areas Journal 20:243-249.

Grassland species set up territories primarily in the interior of fields with woody edges. Numbers of singing males of 5 species (Savannah Sparrow, Grasshopper Sparrow, Henslow's Sparrow, Eastern Meadowlark, and Bobolink) increased in fields of similar size with progressively less woody edge. Savannah Sparrows showed the most dramatic response, with the number of territorial males increasing from 2 in a 16.3 ha (40 ac) field with 8 trees/ha and 20 shrubs/ha to 14 males in a 15.1 ha (37 ac) field with 0.1 trees/ha and 0 shrubs. All fields were located within 150 ha (370 ac) in Cook County, Illinois.

44. Olson, R.A. and L.D. Flake. 1975. Nesting of ring-necked pheasants in eastern South Dakota. Proceedings of the South Dakota Academy of Sciences 54:126-136.

Ring-necked pheasant nests (n=184) were located in nine habitat types during a 2 year study in eastern South Dakota. Fifty-six nests were found in idle farmland, 28 in roadsides, 24 in alfalfa fields, 17 in tame hay, 16 in small grain fields, 15 in fencerows, 15 in pastures, 8 in shelterbelts, and 5 in flax fields. The highest (apparent) nesting success rate was 34.1% in idle farmland, followed by 13.6% in both roadsides and small grain fields. The success rate for shelterbelts was 9.1%. The lowest success rates were detected in fencerows and pastures (2.3%).

45. Overmire, T.G. 1962. Nesting of the dickcissel in Oklahoma. Auk 79:115-116.
In central Oklahoma, 74.5% of 94 Dickcissel nests were located off the ground, usually in woody vegetation. Thirty-four of the elevated nests were located in American elm (*Ulnus Americana*); the remainder of elevated nests were in 12 woody species (32 nests) and 4 forb species (4 nests).

46. Renfrew, R.B. 2002. The influence of patch and landscape characteristics on grassland passerine density, nest success, and predators in southwestern Wisconsin pastures. Ph.D. Dissertation, University of Wisconsin-Madison.
Grassland bird (Savannah Sparrow, Grasshopper Sparrow, Bobolink, Eastern Meadowlark) density and nesting success was studied in 74 pastures in southwestern Wisconsin 1997-1999. Woody vegetation variables measured included the percent woods at 3 spatial scales (200-, 700-, and 1200-m), a woodland connectivity index, nest distance to woody and non-woody edge, and nest distance to nearest type of edge. Savannah Sparrows avoided smaller pastures and concentrated in larger areas as the percentage of woodlands increased within the landscape. Similarly, when the landscape was comprised of many woods, the density of Savannah Sparrows increased with proportion of grassland in the landscape. Eastern Meadowlark density was negatively associated with the proportion of woods in the landscape. Total nest density for 3 analyzed groups: all species, Savannah Sparrow, and species other than Savannah Sparrows(Grasshopper Sparrow, meadowlarks, Bobolink), increased linearly with distance from edge. However, the type of edge, wooded or non-wooded, was not a significant predictor of nest density within 50 m of the edge for any group. Savannah Sparrow daily survival rates (DSR) and daily predation rates (DPR) did not differ between nests near wooded or non-wooded edges. For all other species combined, DSR of nests <100 m from non-wooded edges were significantly higher than nests <100 m from wooded edges. Nests located <50 m from non-wooded edges had significantly higher DSR and lower DPR than nests near wooded edges. Video camera footage indicated at least 11 species depredating bird nests. One-third of the documented predation events were caused by predator species that prefer wooded edges. These species usually depredated nests closer to wooded than any other edge type and traveled up to 190 m into pastures. Management recommendations included prioritizing landscapes with little woods and removal of wooded areas, treelines, and shrubby hedgerows near pastures when feasible.

47. Ribic, C.A. and D.A. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105-121.
Grassland birds (Savannah Sparrow, Bobolink, Eastern Meadowlark, Grasshopper Sparrow) were surveyed along transects in 38 south-central Wisconsin fields. Woody vegetation variables included distance to woodlots (trees, hedgerows, and shrubs) and proportion of the landscape within 200, 400, and 800 meters comprised of shrub swamps, upland shrubs, woodlots, scattered trees and shrubs, hedgerows, and isolated trees. Bobolink abundance was negatively associated with the area of woodlots within 800 meters of the transect edge. Eastern Meadowlark abundance increased with increasing

distance to woodlots, but also increased with the total length of hedgerows within 200 meters. Grasshopper Sparrow abundance decreased with increasing distance to hedgerows. Savannah Sparrow, Bobolink, and Grasshopper Sparrows were negatively associated with landscape habitat diversity; higher habitat diversity was usually associated with more woody patches in the landscape. Total density of grassland bird species of management concern (12 species) was highest on transects further from woodlots and with low habitat diversity. The authors recommended prioritizing landscapes with less woody cover and smaller woodlot patch sizes to manage for grassland species.

48. Roseberry, J.L. and W.D. Klimstra. 1970. The nesting ecology and reproductive performance of the eastern meadowlark. Wilson Bulletin 82:243-267.

Data from 450 nests studied in Illinois indicated that Eastern Meadowlarks nested in pastures, hayfields, soilbank fields, winter wheat fields, and idle and fallow areas. The only prerequisites for utilization appeared to be the absence of woody vegetation or shrubs in the immediate area and the presence of dead grass stems at ground level.

49. Rumble, M.A. and L.D. Flake. 1983. Management considerations to enhance use of stock ponds by waterfowl broods. Journal of Range Management 36:691-694.

Thirty-six stock ponds were surveyed for use by waterfowl broods in western South Dakota. Mallard brood use was negatively associated with the proportion of shoreline with trees. Blue-winged teal and combined total broods (Mallard, Blue-winged teal, Northern Pintail, Gadwall, and Northern Shoveler) were not associated with the occurrence of trees along the pond edge.

50. Sample, D.W. 1989. Grassland birds in southern Wisconsin: habitat preference, population trends, and response to land use changes. M.S. Thesis, Univ. Wisconsin-Madison.

Bobolink density was negatively associated with the percent woody cover 1-3 and 3-6 m above the ground. Western Meadowlarks preferred treeless areas with <0.7% woody cover. Upland Sandpiper density was negatively correlated with percent woody cover. Horned Larks were negatively related to percent woody cover 1-3 m above ground and total percent woody cover. Sedge Wrens occupied areas with an average of 2% total woody cover. Savannah Sparrows used areas with less than 1% woody cover.

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

Horned Larks, Grasshopper Sparrows, and Eastern Meadowlarks were not present in fields invaded by shrubs and smaller trees in a study of breeding bird communities in different stages of ecological succession.

52. Shutler, D., A. Mullie, and R.G. Clark. 2000. Bird communities of prairie uplands and wetlands in relation to farming practices in Saskatchewan. Conservation Biology 14:1441-1451.

In a study comparing upland and wetland habitats within 4 treatment types (conventional farming, minimum tillage farming, organic farming, and wild plots) in Saskatchewan,

Sedge Wrens and Le Conte's, Savannah, and Clay-colored Sparrows were more numerous on wild plots. Horned Larks and Savannah Sparrows were negatively associated with the area of woody habitat within a 100 m buffer of the transect. Five species (Blue-winged Teal, American Coot, Black Tern, Barn Swallow, and Savannah Sparrow) exhibited a significant negative relationship between presence and the percentage of the habitat margin occupied by trees and shrubs.

53. Smith, R.L. 1963. Some ecological notes on the grasshopper sparrow. Wilson Bulletin 75:159-165.

Grasshopper Sparrows were studied by observation for 3 years on a 30-ac farm in Pennsylvania. Territories were absent from fields invaded by shrubs.

54. Snyder, W.D. 1984. Ring-necked pheasant nesting ecology and wheat farming on the high plains. Journal of Wildlife Management 48:878-888.

Ring-necked Pheasant hens were radio marked and monitored throughout the nesting season (1979-81) on a 2,327 ha northeastern Colorado site to determine the relationships of weather, vegetation, and land use to nest site selection and nesting success. Woody cover use ranked second to wheat stubble during pre-laying, dispersal and harem formation. Little nesting occurred in woody cover. Nest predation was greater on or near (<0.6 km) an area with extensive tree plantings than at more distant locations (33 vs 14%). Near this area, both avian and mammalian predators decreased nesting success, whereas mammals were the major source of predation far (> 0.6 km) from the tree plantings.

55. Stauffer, D. F. and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management 44:1-15.

In Iowa, pastures and haylands were preferred by Western Meadowlarks over woody areas. Western Meadowlark density was negatively correlated with sapling/tree richness.

56. Sullivan, B.D. and J.J. Dinsmore. 1990. Factors affecting egg predation by American crows. Journal of Wildlife Management 54:433-437.

The study was conducted on artificial duck nests to determine what variables determine the extent of crow predation on duck nests in southwestern Manitoba. Crows nested in shelterbelts, willows near wetlands, or in small quaking aspen woodlots. Artificial nests were placed overwater and in the upland at varying distances from crow nests both within and outside of the crow's home range. Nests located within a crow's home range had higher depredation rates than those outside of the home range. Depredation rates decreased as distance from the nest increased up to 700 meters from a nest. Upland nests had higher predation rates than overwater nests. The authors recommended that upland nesting habitat be developed at least 700 meters and preferably >1000 meters from areas likely to be inhabited by crows.

57. Trautman, C.G., R.B. Dahlgren, and J.L.Seubert. 1959. Pheasant nesting. South Dakota Conservation Digest 26:18-21.

The heaviest predation rates on pheasant nests were in roadside, fencerow, and shelterbelt habitats.

58. Wedgwood, J.A. 1976. Burrowing owls in south-central Saskatchewan. Blue Jay 34:26-37.

Searches were conducted of previously reported Burrowing Owl nest sites; new areas to search were identified by soil, physiographic, and topographical maps and aerial photos. Burrowing owl habitat was characterized as pasture with short prairie cover, no trees, and devoid of brush.

59. Whitmore, R.C. 1981. Structural characteristics of grasshopper sparrow habitat. Journal of Wildlife Management 45:811-814.

Grasshopper Sparrow territories were mapped on reclaimed surface mines in West Virginia. Successional stages ranged from early grassland to old field. Grasshopper Sparrow territories had lower shrub cover (average 0.7%) than nonterritories (average 31.1%). Burning to remove encroaching shrubs was recommended for preservation of grasshopper habitat.

60. Whitmore, R.C. and G.A. Hall. 1978. The response of passerine species to a new resource: reclaimed surface mines in West Virginia. American Birds 32:6-9.

Although West Virginia was historically a forested area, surface mines are usually reclaimed by planting grasses to establish cover as quickly as possible. At first cover is generally sparse, but gradually shrubs invade and grasses become so thick as to prevent further invasion. Horned Lark, Eastern Meadowlark, Savannah Sparrow, and Grasshopper Sparrow use reclaimed areas throughout the grassy seral stages. Vesper sparrows were commonly observed in open grasslands bordered by trees while Red-winged Blackbirds were reported in grasslands as well as the surrounding forest.

61. Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

The author intensively sampled birds and vegetation in a 37 ha (91 ac) habitat in Dane County, Wisconsin during 1966. Territories of all species studied were located from 100-370 meters from woodland, on average. No Western Meadowlark, Henslow's Sparrow or Vesper Sparrow territories contained trees while 8% of Savannah Sparrow and 10% of Grasshopper Sparrow territories contained trees.

62. Wiens, J.A. 1973. Pattern and process in grassland bird communities. Ecological Monographs 43:237-270.

Birds were censused by territory mapping in core grassland areas throughout the central and northern plains. Lark Buntings and Horned Larks inhabited areas with lower densities of woody stems and decreased percentages of woody cover compared to unoccupied areas in the short grass prairie region of Colorado.

63. Winter, M. 1999. Nesting biology of dickcissels and Henslow's sparrows in southwestern Missouri prairie fragments. Wilson Bulletin 111:515-527.

Dickcissel nests found in 13 prairie fragments were located in forbs (45%), shrubs (29%), grass (16%), and litter (10%). Dickcissels were observed breeding in shrubby edges of the prairie fragment, but nest searches did not include such areas. There were no Henslow's Sparrow nests located within shrubby edge habitat or in close proximity to woody vegetation.

64. Winter, M., D.H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. The Condor 102(2):256-266.

Dickcissel and Henslow's Sparrow nesting success was lower within 50 m of a shrubby edge versus greater distances on 13 prairie remnants in Missouri. Nesting success was not affected by distances to roads, agricultural fields, or forests but few nests were found near forests. Artificial nest survival was lower within 30 m of forest edges. Evidence on artificial eggs indicated that mid-sized carnivores were more frequent predators within 30 m of forest edges than at greater distances and these species visited track stations most frequently within 50 m of forest edges. The authors concluded that edge effects were more pronounced than patch size effects because proximity of woody habitat explained more variation in nest survival and mammal activity than did fragment size. Edge effects appeared to be caused mainly by greater exposure of nests to mid-sized carnivores. Frequency of brood parasitism by Brown-headed Cowbirds on Dickcissels increased significantly within 50 m of shrubby edges.

65. With, K.A. 1994. The hazards of nesting near shrubs for a grassland bird, the McCown's longspur. The Condor 96:1009-1019.

In the shortgrass prairie of northcentral Colorado, over half of 78 McCown's Longspur nests were lost to predation. Nests beside shrubs suffered a 2-3 times higher predation rate than nests in other cover types. No measurable shrub coverage was present within 1 m of successful nests. Increased predation of these nests was apparently due to increased activity of their primary predator, the thirteen-lined ground squirrel *Spermophilus tridecemlineatus*. This species places burrows in areas with high amounts of vertical cover.

66. Wray, T., II, K.A. Strait, and R.C. Whitmore. 1982. Reproductive success of grassland sparrows on a reclaimed surface mine in West Virginia. Auk 99:157-164.

The authors concluded that the woodlots and pastureland surrounding a 41.5 ha (103 ac) reclaimed grassland site, concentrated predators and resulted in low nesting success for Grasshopper, Savannah, Vesper, and Field Sparrows. American Crows were assumed to be one of the major predators based on evidence at the nest and the number of crows in the area.

67. Zimmerman, J.L. 1988. Breeding season habitat selection by the Henslow's sparrow (*Ammodramus henslowii*) in Kansas. Wilson Bulletin 100:17-24.

Survey points within Henslow's Sparrow territories contained significantly less coverage by woody vegetation than points outside territories in the Flint Hills Upland. The author determined that Henslow's Sparrows prefer sites with little woody vegetation.

Table 1. The number of studies in which a species was negatively/positively associated with a measure of woody vegetation. Categories of wood include woody vegetation within the grassland patch, the percentage of the patch encompassed by woody vegetation, distance from a point (survey point, nest, etc.) to woodland habitat, and a measure of the proportion or increase of woodland habitat in the landscape surrounding a grassland patch. The number in parentheses is the total number of studies conducted on a species in each category. Observational studies are not included.

Species	**PIF[a] Status**	**Within Patch** +/-	**% Woody Perimeter** +/-	**Distance to Woody** +/-	**Landscape** +/-
Artificial nests		0/1 (1)	0/1 (1)	1/2 (4)	0/1(1)
Duck spp.		0	0/2 (2)	0/1 (1)	0/2 (2)
Northern Harrier *Circus cyaneus*	21	1/0 (1)	0	0	0
Ring-necked Pheasant *Phasianus colchicus*	11	0	0	0/3 (4)	0
Greater Prairie-Chicken *Tympanuchus cupido*	26	0/2 (2)	0	0/0 (1)	0/3 (3)
Lesser Prairie-Chicken *Tympanuchus pallidicinctus*	NA	0	0	0	0/2 (2)
Sharp-tailed Grouse *Tympanuchus phasianellus*	20	0	0	0	0/2 (2)
Burrowing Owl *Athene cunicularia*	18	0/1 (1)	0	0	0
Upland Sandpiper *Bartramia longicauda*	21	0/1 (3)	0/0 (2)	0	0/0 (1)
Loggerhead Shrike *Lanius excubitor*	16	0/0 (1)	0	0	1/0 (1)
Horned Lark *Eremophila alpestris*	14	0/4 (4)	0/1 (2)	0	0
Sedge Wren *Cistothorus platensis*	21	0/0 (1)	0/1 (3)	0	0/0 (1)
Sprague's Pipit *Anthus spragueii*	26	0/2 (2)	0/1 (1)	0	0
Clay-colored Sparrow *Spizella pallida*	21	3/0 (3)	0/0 (2)	0/2 (2)	0/0 (1)
Grasshopper Sparrow *Ammodramus savannarum*	23	0/8 (11)	0/4 (6)	0/4 (5)	0/1 (3)
Baird's Sparrow *Ammodramus bairdii*	29	0/3 (3)	0/1 (1)	0	0
Henslow's Sparrow *Ammodramus henslowii*	NA	0/4 (7)	0/1 (2)	0/3 (3)	0
LeConte's Sparrow *Ammodramus leconteii*	22	0/0 (1)	0/0 (1)	0	0

Lark Bunting *Calamospiza melanocorys*	21	0/1 (2)	0/1 (1)	0	0
Savannah Sparrow *Passerculus sandwichensis*	15	0/5 (7)	0/6 (7)	0/3 (6)	0/2 (3)
Vesper Sparrow *Pooecetes gramineus*	15	0/2 (3)	1/0 (2)	0/1 (1)	0/0 (1)
Chestnut-collared Longspur *Calcarius ornatus*	27	0/1 (3)	0/1 (1)	0	0
McCown's Longspur *Calcarius mccownii*	25	0/1 (1)	0	0	0
Dickcissel *Spiza Americana*	22	2/1 (6)	0/1 (2)	0/1 (1)	0/1 (2)
Bobolink *Dolichonyx oryzivorus*	21	0/3 (6)	0/2 (5)	0/3 (3)	0/2 (2)
Eastern Meadowlark *Sturnella magna*	14	0/4 (6)	0/1 (4)	0/1 (1)	0/1 (2)
Western Meadowlark *Sturnella neglecta*	18	0/3 (4)	0/2 (3)	0/3 (3)	0/2 (2)
Grassland Bird Group		0	0/1 (1)	0/3 (3)	0/1 (2)

[a]Partners in Flight (PIF) priority scores are from physiographic area 37 (Northern Mixed Grass Prairie) or 38 (West River). Scores are based on 7 criteria (e.g., population trend, threats to breeding) ranked from 1-5 (1=low priority).

Acknowledgments:

I thank K. Higgins, R. Johnson and D. Granfors for reviews of this bibliography. P. Symens and D. Sulzbach provided assistance in obtaining literature. Funding was provided by the US Fish and Wildlife Service, Habitat and Population Evaluation Team.

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