The Effect of Woody Vegetation on Grassland Nesting Birds: An Annotated Bibliography

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

Cite as: Bakker, K.K. 2003. The Effect of Woody Vegetation on Grassland Nesting Birds: An Annotated Bibliography. The Proceedings of the South Dakota Academy of Science 82:119-141.

***Updated January 2008**

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 the effects of woody vegetation on habitat suitability for grassland nesting species.

Methods:

Eighty-one* articles with references to species associations with woody vegetation were obtained. Few studies 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 are summarized at 4 levels: within the grassland patch (i.e., woody stem density, shrub coverage, presence of mature trees), perimeter comprised of woodland (edges: 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. Male Ring-necked Pheasants established territories in association with idled herbaceous and woody cover in eastern South Dakota. Additionally, home range sizes decreased with increasing woody cover in the landscape. 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. Degradation can occur with the loss of natural processes such as fire allowing woody vegetation to encroach into remaining native prairies. Fragmentation can include planting woodlands in areas where they did not historically occur. Several studies have indicated that woody vegetation negatively affects presence, abundance, and nesting success of nongame species. While some studies have indicated no effect, few have detected a positive association of these variables with woody vegetation. The Grasshopper Sparrow, Savannah Sparrow, Bobolink, and Western Meadowlark have $\geq$5 studies examining the effect of woody vegetation completed at multiple levels. All of these species consistently show negative responses to woody vegetation at all levels. Two other species, the Clay-colored Sparrow and Vesper Sparrow, responded positively to woody vegetation. The Clay-colored Sparrow was positively associated with shrub coverage within the patch in four of five studies. This species often builds nests in woody stems. At other levels, it was neutral or positive to woody vegetation, with one exception. Vesper Sparrow responses at all levels were more mixed but there were positive associations at all levels (Table 1). Dickcissel response to woody vegetation within the patch was mixed but they 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.

Overall, these studies indicate woody vegetation has a predominantly deleterious effect on occurrence, density and/or nesting success of both game and nongame grassland nesting birds. Negative associations 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.). However, this relationship has been studied <3 times in some species and requires additional research. Managers need to seriously consider the tradeoffs that exist when introducing or considering removal of trees in formerly treeless grassland habitats.

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.

Studied the distribution and density of birds in relation to wolfberry (*Symphoricarpos occidentalis*) and Silverberry (*Elaeagnus commutate*) shrub coverages in prairie grasslands. Transects with 30-80% shrub coverage contained 19 different passerines species while transects with <10% coverage contained 10. Eleven species were detected only in shrubby transects, 9 of which were shrub 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.

Bakker, K.K. and K.F. Higgins. Avian Use of Natural versus Planted Woodlands in Eastern South Dakota, U.S.A. Natural Areas Journal. *In press*.

Avian use of naturally occurring and planted woodlands in eastern South Dakota was compared to evaluate whether planted woodlands support the same avian communities as natural woodlands. Eighty-five species of birds were detected in eastern South Dakota woodlands, 36 of which occurred in $\geq$ 5 of 524 patches surveyed. The probability of occurrence for 8 of 13 woodland obligate species was significantly greater in natural versus planted woodland habitats. Four of these breed in relatively high numbers in eastern South Dakota. Only one woodland obligate occurred less frequently in natural woodlands. Probability of occurrence for 6 edge and generalist species, including the brown-headed cowbird [*Molothrus ater* (Boddaert)], was significantly higher in planted woodlands. The avian community of planted woodlands was dominated by edge and generalist species. The homogeneous vegetation structure typical of planted woodlands does not appear to provide the habitat characteristics needed by woodland obligate birds. It was concluded that planted woodlands do not support significant numbers of woodland obligates species and may negatively impact grassland nesting birds by attracting edge and generalist bird species and predators into previously treeless habitats. Management may require discriminating between naturally occurring woodland habitat and manmade additions such as tree plantings. Managers need to seriously consider the tradeoffs that exist with introducing trees into formerly treeless grassland habitats. The preservation and maintenance of natural woodlands is critical for woodland obligate species diversity in the northern Great Plains.

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. Variables analyzed 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) radii from the transect center. Four grassland species (Sedge Wren, Savannah Sparrow, Grasshopper Sparrow, and Western Meadowlark) exhibited a significant decline in probability of occurrence on grasslands as perimeters comprised of woody vegetation increased. Bobolinks, Dickcissels, and Clay-colored sparrows did not exhibit a relationship with increased wooded patch edge. Density was not associated with woody vegetation. 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.

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. Variables analyzed 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) radii from 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 were also 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$125-250 ha (309-618 ac)] to attract the majority of grassland obligates. Additionally, it was recommended to place priority on purchasing and conserving grasslands in landscapes with high amounts of grassland habitat ($\geq$ 40% within 1600 m of the patch) and low amounts of woodland habitat (<1.0% within 400 m).

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 this 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 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.

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 characteristics of roadsides and artificial nest success was examined in south-central Iowa. Transects containing 10 nests were set up along 136 transects and 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 nest bowl and roadsides where characterized as wooded, herbaceous vegetation with fencerows and herbaceous vegetation without fencerows. Variables measured included habitat of the roadside and adjacent habitat. Wooded roadsides and roadsides with fencerows had significantly greater nest predation in the first category than did herbaceous fencerows. The authors speculated that these fencerows 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.

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 landscape surrounding roadsides and artificial nest success was examined in south-central Iowa. Transects containing 10 nests were set up along 136 transects and categorized as follows: 1) disappearance of eggs with no shell left behind 2) broken or crushed egg shells in or near nest bowl. Landscape structure was quantified within 200, 400, 800, 1200, and 1600 m of the transect line as proportion of habitat types. Proportions of woody vegetation variables included woodland block cover, wooded strip cover, 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.

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

In a study on 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.

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

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 little (<25%) woody cover. Habitats with >25% woody coverage were determined to be unsuitable for Bobolinks.

***Bollinger, E. K., and T. A. Gavin. 2004. Responses of nesting Bobolinks (*Dolichonyx oryzivorus*) to habitat edges. Auk 121:767-776.**

Bobolinks and their nests were monitored in 3 sites for 3 to 8 years in New York. The majority of breeding Bobolinks were misted netted and marked. Edges habitats consisted of forests (>12 m tall and >10 m wide), wooded hedgerows (>8 m tall and < 5 m wide), old fields with scattered shrubs, and heavily grazed pastures. None of the surrounding habitats contained Bobolink nests. Bobolink nest survival rates were compared between nests located <50 m from and edge to those located >100 m from an edge. Probability of nest success was modeled using distance to variables including distance to forest edge, distance to forest or hedgerow edge and distance to edge. The authors also examined whether females returning for 3 or more breeding seasons altered nest location from one season to the next. Bobolinks consistently avoided nesting near forest edges in all 3 sites. Daily survival rates were lower <50 m from forest and hedgerow edges. Daily survival rates increased with increasing distance from forest edges. Females tended to move further from forest edges for their second nesting attempt, often more than doubling their distance.

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(2):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 (28.7 vs. 7.9% predation rates) than those > 60 m from woody cover. 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.

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.

This study was conducted to examine avian response to landscape changes associated with juniper *Juniper virginianus* invasion into native grasslands and agriculture conversion by CRP in Oklahoma from 1965-1995 using 3 Breeding Bird Survey routes. Composition of 11 cover types were delineated within 400 m of each survey point within BBS routes. Most grassland birds 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.

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.

***Cunningham, M.A. and D.H. Johnson. 2006. Proximate and landscape factors influence grassland bird distributions. Ecological Applications 16:1062-1075.**

Occurrence of 19 bird species was modeled in relation to habitat features (percent grassland, woodland, shrubland and wetland) within each 100-m survey segment and to tree cover within 200-1600 m of the segment. Including only the grassland obligate species from the author's list, the best proximate models included a negative association of occurrence to tree cover for the Blue-winged Teal, Upland Sandpiper, Marbled Godwit, Wilson's Snipe, Wilson's Phalarope, Sedge Wren, Savannah Sparrow (tree and shrub cover), Grasshopper Sparrow, Bobolink, Western Meadowlark. Vesper Sparrow occurrence was positively associated with tree cover at the proximate scale. Clay-colored Sparrow occurrence was positively associated with tree cover. Tree cover at larger scales (800-1600 m buffer) provided better models than smaller scales.

***Davis, S.K. 2004. Area sensitivity in grassland passerines: effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. Auk 121:1130-1145.**

Point-counts were conducted in 89 pastures. Horned Larks, Clay-colored Sparrows, Baird's Sparrow, Grasshopper Sparrow, Chestnut-colored Longspurs and Western Meadowlark models of occurrence and density were negatively associated with distance to nearest shrub during at least 1 year of the 2 year study. Sprague's Pipit was positively associated with shrub distance in 1 year.

Davis, S.K., D.C. Duncan, and M. Skeel. 1999. Distribution and habitat associations of three endemic grassland songbirds in southern Saskatchewan. Wilson Bull. 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.

Davis, S.K. and S.G. Sealy. 2000. Cowbird parasitism and nest predation in fragmented grasslands of southwestern Manitoba. *In* J.N.M. Smith, T.L. Cook, S.I. Rothstein, S.G. Sealy, and S.K. Robinson, eds. Ecology ad

Management of Cowbirds: Studies in the conservation of North American Passerine Birds. 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. This site also had shrubs (wolf willow, western snowberry, and *Salix* spp.) bordering nearly the entire site. The authors attributed increased cowbird activity to the increased availability of perches found at this site as compared to the other study areas.

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.

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 were located within 50 meters of edge habitat (wooded draws, roadsides, and cropland).

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.

***Fletcher, R.]., Jr., AND R. R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorous*) near different types of edges in northern Iowa. Auk 120:799-810.**

Bobolinks were surveyed along 34 agricultural, road or woodland edges in grassland habitats. Bobolink abundance was lowest near woodland edges and increased with distance from all edge types. Territory sizes decreased near woodland edges and results indicated the Bobolinks actively avoided woodland edges.

Fuhlendorf, S.D., A.J.W. Woodward, D.M. Leslie, Jr., and J.S. Shackford. 2002. Mulitscale effects of habitat loss and fragmentation on lesser prairie-chicken populations. Landscape Ecology 17:617-628.

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. Population trends were calculated using long-term data obtained from the Oklahoma Department of Wildlife Conservation and Texas Parks and Wildlife. Landscape composition was quantified surrounding 10 leks using aerial photographs taken between 1959 and 1996. Landscapes with declining Lesser Prairie-chicken population trends also had significantly greater increases in tree cover types (riparian, windbreaks, juniper encroachment) standardized to per decade basis at the 7,238-ha scale than landscapes with sustained populations. Landscapes with declining populations also had significantly more cropland [7,238-ha (17,886 ac) scale], changes in landscape composition between 1959 and 1996 [3,619- and 7,238-ha (8,943 and 17,886 ac) scales], and edge density [452-, 905- and 1,810-ha (1,117-, 2,236-, and 4,473-ac) scales].

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 using a Geographical Information System (GIS) 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 15-10 years), dense woody habitat may prevent near or total pheasant loss.

Gates, J.E. and L.W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. Ecology 59(5):871-883.

Fledging success and increasing distance from edge were positively correlated and highly significant. Higher rates of nest predation <46 m from edges versus habitat interiors was attributed to higher nest densities of open-nesting or edge species as well as increased predator activity by ecotones. Brown-headed cowbird parasitism was also higher near edges.

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 of the area dominated by Russian olive (0-5%=low, 10-30%=moderate, >50%=high). Russian olive was considered dominant at ≥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 differ 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 exhibited an increasing trend 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.

***Grant, T.A., E. Madden, and G.B. Berkey. 2004. Tree and shrub invasion in northern mixed-grass prairie: implications for breeding grassland birds. Wildlife Society Bulletin 32:807-818.**

Grassland bird occurrence to encroaching woody vegetation (aspen (*Populus tremuloides)*,willow (*Salix* spp.) and other) in north-central North Dakota was examined. Only the Vesper Sparrow and Clay-colored Sparrow occurred more commonly as percent woodland within 500 meters increased. Savannah Sparrow, Bobolink, Grasshopper Sparrow, Baird's Sparrow, Chestnut-collared Longspur, Upland Sandpiper, Western Meadowlark, LeConte's Sparrow, and Sedge Wren were all negatively affected by increased woodland cover within 500m. It was determined that grasslands became unsuitable for 9 species as woodland cover exceeded 25%. Landscape woodland was not a significant predictor of occurrence for the Sprague's Pipit but they were negatively affected by trees at the patch level. The Baird's sparrow, bobolink, chestnut-collared longspur, grasshopper sparrow, horned lark, savannah sparrow, sedge wren, Sprague's pipit, upland sandpiper, and western meadowlark exhibited decreased occurrence with increased percentages of shrubs >1 meter in height within 100m bird survey plots. Clay-colored sparrow and vesper sparrow occurrence increased with increased percentages of shrubs >1 meter in height within 100m bird survey plots.

***Grant, T.A., E.M. Madden, T. L. Schaffer, P.J. Pietz, G.B. Berkey, and N.J. Kadrmas. 2006. Nest survival of clay-colored and vesper sparrows in relation**

to woodland edge in mixed-grass prairies. Journal of Wildlife Management 70: 691-701.

The authors examined Clay-colored(n=250) and Vesper (n=246) Sparrow nest survival in relation to nest distance from woodland edge (aspen), percent cover of shrubs >1m in height within 10m of the nest, percent cover of shrubs <1m in height within 10m of the nest and other habitat features in north-central North Dakota (J. Clark Saylor Wildlife Refuge). Mammal trapping and the use of nest cameras were also employed during the study. The 13-lined ground squirrel was indentified as the most common nest predator of eggs and nestlings. Clay-colored and Vesper Sparrow nest survival was highest near woodland edge and decreased with distance from edge. Vesper Sparrow nest survival was higher with increased cover of tall shrubs within 10 m of the nest. The authors speculated the decreased survival further from woodland edge was due in part to the 13-lined ground squirrel being more common further from woodland edge.

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 homerange and successful management should include an assessment of planted conifers within the lek vicinity.

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 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.

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.

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.

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.

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 the CRP field (n=11) in northeastern Kansas. Daily nest survival rates were associated only with field-level vegetation attributes.

Johnson, R.G. and S.A. Temple. 1986. 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.

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 fragments (≥130 ha or 321 ac) and in fragments ≥45 meters from woody vegetation. Brood parasitism also was lower for all 5 species far (≥45) from wooded edges. The authors recommended making grasslands as large as possible and removing woody vegetation that creates edges to enhance nesting success.

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%.

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 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.

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 located in mainly in undisturbed grasslands with short brush. Stands of shrubs, particularly western snowberry, contained over ½ of the 129 Northern Harrier nests.

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 food plot and surrounding landscape characteristics were evaluated to determine associations with winter food plot (n=174) 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 and percent tree understory with high visual obstruction of shelterbelts, distance to nearest tree cover, and distance to trees with high visual obstruction. The presence of wetland and grass cover in the surrounding landscape were the most important variables in determining food plot use. Woody vegetation variables appeared to be negatively associated with winter food plot use.

***Leif, A.P. 2005. Spatial ecology and habitat selection of breeding male pheasants. Wildlife Society Bulletin 33:130-141.**

Ninety-five male pheasants were radiomarked over a five year study conducted in eastern South Dakota to determine spatial dynamics and habitat selection of breeding males. Males were marked in two 2,332 ha study areas. Preferential selection of habitats was examined on 2 levels: habitat composition of home ranges versus habitat available in the study area and daily selection of habitats among habitats available within each male's home range. Idled herbaceous and woody cover were preferred by males when establishing territories. Size of ephemeral home ranges was not associated with habitat composition. Localized home range size decreased with increasing proportion of wood. Within home ranges, males preferred woody cover to other available habitat types. The author suggested that complexes of idled herbaceous and woody cover would maximize the capacity of landscapes to support male ring-necked pheasant territories.

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.

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) study 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.

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 (HIS) based on vegetation height/density was used to evaluate nesting habitat conditions on the Sheyenne National Grassland (SNG). The HIS predicts that adequate nesting cover is present when 80% of the area supports herbaceous vegetation with a VOR 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.

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 $\leq$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.

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 $\geq$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 (3.1 vs. 1.6% means) and cropland (49.8 vs. 43.9%) within 810 ha than did traditional leks.

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.

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 2 species of woody vegetation (1.8 and 7.6 stems per meter within territories versus 0.02 and 4.3 outside territories) in central Wisconsin.

***Murray, L.D., C.A. Ribic, and W.E. Thogmartin. 2008. Relationship of obligate grassland birds to landscape structure in Wisconsin. Journal of Wildlife Management: *in press*.**

The authors examined the variance in abundances derived from roadside counts in relation to landscape composition within the 400 m radii survey points and 6 landscape types based on the amounts of grassland and forest in the 800 ha area (very high grassland, high grassland:low forest, high grassland:medium forest, high grassland:high forest, low grassland:low forest, and low grassland:high forest). Very high grassland category was >0.80, high was 0.60-0.80, and low was 0.30-0.45. Forest cover proportions were low (<0.05), medium (0.05-0.20) and high (>0.20). Nine species of grassland obligate species were analyzed: Bobolink, Dickcissel, Eastern Meadowlark, Grasshopper Sparrow, Henslow's Sparrow, Sedge Wren, Upland Sandpiper, Vesper Sparrow and Western Meadowlark. Dickcissel and Eastern Meadowlark abundances were higher in landscapes with more grassland. Upland Sandpiper and Western Meadowlark abundances were higher in very high grassland and high grassland:low forest landscapes as compared to all other landscape types. At the route level, Dickcissel and Eastern Meadowlark abundance were negatively related to forest composition.

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.

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 to 12.6 ha (2.0 to 31 ac)] to determine the relationship

between distance to woodland edge (<10, 25 and 50m) and nest fate. Quail egg depredation was 33% in June and the quail finch depredation rate was 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).

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.

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 Sparrow numbers increased from 2 in a 16.3 ha (5 to 40 ac) field with 8 trees and 20 shrubs per ha to 14 in a 15.1 ha (37 ac) field with 0.1 trees and no shrubs per ha. All fields were located in the same study area in Cook County, Illinois.

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. A total of 56 nests were found in idle farmland, 28 in roadsides, 24 alfalfa fields, 17 in tame hay, 16 in small grain fields, 15 in fencerows, 15 n pastures, 8 in shelterbelts, and 5 in flax fields. The highest hatch rate was 34.1% in idle farmland, followed by 13.6% in both roadsides and small grain fields. The hatch rate for shelterbelts was 9.1%. The lowest hatch rates were detected in fencerows and pastures (2.3%).

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, mainly in woody vegetation.

Pasitschniak-Arts, M. and F. Messier. 1996. Predation on artificial duck nests in a fragmented prairie landscape. Ecoscience 3:436-441.

Artificial duck nests (n=1110) were analyzed in 3 habitats: native grassland, delayed hay fields, and rights-of-way, in 2 Canadian National Wildlife Area in southcentral Saskatchewan. Except in rights-of-way, nest transects were placed at right angles to habitat edge. In the first area, nests were placed 75, 150, 250, and 400 m into the habitat interior. In the second area, nests were placed 75 and 150 m in. Higher predation rates were detected along the edges versus habitat interiors in the first wildlife area. No significant effect of distance to edge was detected in the second area. The authors inferred that shorter, less dense grassland vegetation may facilitate medium and large-sized predator movement farther into grasslands. Type of edge was not delineated in this study.

Patten, M.A., E. Shochat, D.L. Reinking, D.H. Wolfe, and S.K. Sherrod. 2006. Habitat edge, land management, and rates of brood parasitism in tallgrass prairie. Ecological Applications 16:687-695.

Five years of nest data on Grasshopper Sparrows, Henslow's Sparrows, Dickcissels, Red-winged Blackbird and Eastern Meadowlarks was analyzed to determine how management of tallgrass prairie in northeastern Oklahoma affected brood parasitism rates by the Brown-headed Cowbird. Seven landscape features that may be associated with parasitism were examined: presence of edge, burning, or grazing, and distance of nest from woody vegetation, water, roads or fences. Grasshopper (1 of 274 nests) and Henslow's Sparrows (0 of 24 nests) avoided nesting along roadsides with narrow strips of woody vegetation. Dickcissel (8.2% of 1207) and Eastern Meadowlark (7.5% of 751) also nested less in roadsides. Additionally Dickcissels, Eastern Meadowlarks and Red-winged Blackbirds experienced significantly higher rates of brood parasitism in nests located along woody roadsides as compared to prairie nests. Probability of nest parasitism varied significantly and negatively with distance from woody vegetation for all 5 species. These results led the authors to suggest that Brown-headed Cowbirds respond positively to even low densities of trees and shrubs, even a few woody plants above the grass. They also suggested that even in narrow strips, the breeding bird community changes and attracts various bird species known as nest predators (mockingbirds, thrashers and Common Grackles).

Quamen, F.R. 2007. A landscape approach to grassland bird conservation in the Prairie Pothole Region of the Northern United States. Ph.D. Dissertation, University of Montana, Missoula.

Grassland birds were surveyed in treeless grasslands and in grasslands with trees, both before and after tree removal. Surveys were conducted along each of 5, 100-m long, 40 m fixed width transects paralleling the treebelt. One, 100-m, 20-m fixed width belt was placed in treeless grasslands. Bobolink, Savannah Sparrow and Sedge Wren abundances were lower in grasslands with trees than in treeless grasslands except in transects farthest from treebelts, where abundances were similar to treeless grasslands. Bobolink,

Savannah Sparrow, Sedge Wren and Dickcissel exhibited positive trends in abundance with distance from trees. After tree removal, trends were no longer apparent for the Bobolink, Savannah Sparrow or Dickcissel. Overall abundance of Sedge Wrens increased after tree removal. Abundances of Bobolinks, Savannah Sparrows and Sedge Wrens remained lower in grasslands with trees removed as compared to treeless grasslands. Brown-headed Cowbird and Clay-colored Sparrow abundances were unrelated to distance from tree belts or presence of trees. The author suggested that the effects of woody edges may extend beyond 240-800 m and that the positive effects of tree removal may not be fully realized 1 year after completion.

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: total of 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.

*** Renfrew, R. B., and C.A. Ribic. 2008. Multi-scale models of grassland passerine abundance in a fragmented system in Wisconsin. Landscape Ecology: *in press*.**

The authors evaluated the relative importance of within-patch vegetation structure, patch and three landscape extents (percentage of suitable grassland and woodland area within 0-200 m, 0-700 m. and 0-1200 m buffers from the pasture edge). Savannah Sparrow

(1200 m buffer) and Eastern Meadowlark (200 m buffer) densities were lower in high wood landscapes. Bobolinks and Savannah Sparrows avoided smaller pastures and had higher densities in larger ones when the pastures were located in more wooded landscapes.

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 in 38 south-central Wisconsin fields. Woody vegetation variables included distance to woodlot (the distance from the transect perimeter to the nearest trees, hedgerows or shrubs) and proportion of the landscape within 200, 400, and 800 m from the perimeter of the surveyed transect 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 was higher the farther the woodlots were away from the survey transect. Total density of grassland bird species of management concern (12 species) was highest when woodlots were farther from transects. The authors recommended prioritizing landscapes with low cover and patch size of nonlinear woody habitats such as woodlots to manage for grassland species.

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.

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.

Stock pond (n=36) use by Mallard broods was negatively associated with the occurrence of trees along the pond edge in western South Dakota.

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.

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.

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 LeConte'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.

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

Grasshopper Sparrows were not present in fields invaded by shrubs in Pennsylvania.

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.

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.

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

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, willow 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 homerange. 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 placing upland habitat at least 700 meters and preferably >1000 meters from areas likely to be inhabited by crows.

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.

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

Burrowing owl habitat was characterized as pasture with short prairie cover, no trees, and devoid of brush.

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

Grasshopper Sparrow territories in West Virginia had lower shrub cover than nonterritories with an average of 0.7%. Burning to remove encroaching shrubs was recommended for preservation of grasshopper habitat.

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.

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.

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.

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

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.

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%). There were no Henslow's Sparrow nests located within shrubby edge habitat or in close proximity to woody vegetation.

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.

Dickcissels and Henslow's Sparrows experienced decreased nesting success within 50 m of a shrubby edge versus at greater distances on 13 prairie remnants in Missouri. Artificial nest survival was lower within 30 m of forest edges. Nesting success was not affected by distances to roads, agricultural fields, or forests. Evidence indicated mid-sized carnivores were the major predators within 30 m of forest edges and visited track stations most frequently within 50 m of forest edges. The authors concluded that edge effects were more pronounced than area 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 with proximity to shrubby edge and was highest within 50 m of shrubby edges.

***Winter, M., J.A. Schaffer, D.H. Johnson, T.M. Donovan, W.D. Svedarsky, P.W. Jones, and B.R. Euliss. 2005. Habitat and nesting of Le Conte's sparrows in the northern tallgrass prairie. Journal of Field Ornithology 76:61-71.**

LeConte's Sparrow density and nesting biology was studied over a 5 year period in southeastern North Dakota and northwestern Minnesota. Woody variables included precent ground cover comprised of woody vegetation, distance to trees and percentage of trees or shrubs within a 1 km buffer zone of the patch edge. Woody variables had no effect on density of Le Conte's Sparrows but nesting success did increase slightly with distance from trees.

***Winter, M., D.H. Johnson, J.A. Schaffer, T.M. Donovan, and W.D. Svedarsky. 2006. Patch size and landscape effects on density and nesting success of grassland birds. Journal of Wildlife Management 70:158-172.**

Density and nesting success of Clay-colored Sparrows, Savannah Sparrows and Bobolinks were measured in 3 regions of the tallgrass prairie of southeastern North Dakota and northwestern Minnesota. After controlling for local vegetation structure, climate, and bird density (for nesting success), the effect of trees and shrubs within a 200m buffer zone was determined. While the magnitude of the effect of trees and shrub cover on densities was not consistent among years or regions, the direction for all 3 species was. Savannah Sparrow and Bobolink densities declined with increasing tree and shrub cover within a 200 m buffer while Clay-colored Sparrow densities increased. Distance of a nest to the nearest tree and tree and shrub cover with 200m had no strong or consistent effect on nesting success for any species.

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 placed beside shrubs suffered 2-3 times higher predation rates 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.

Woodward, J.W.M., S.D. Fuhlendorf, D.M. Leslie, Jr., and J. Shackford. 2001. Influence of landscape composition and change on lesser prairie-chicken (*Tympanuchus pallidicinctus*) populations. American Midland Naturalist 145:261-274.

Populations of declining lesser prairie-chickens (1959-1996) in western Oklahoma, northern Texas and eastern New Mexico were associated with landscapes with greater rates of total landscape change than were populations that did not decline. Landscape change after 1959 was primarily attributed to increased tree dominated cover types (juniper encroachment into rangelands, increased riparian areas, intentional tree plantings). Most conversions of rangeland to cropland occurred prior to 1959.

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 surrounding habitat, woodlots, and pastureland, concentrated predators and resulted in low nesting success for Grasshopper, Savannah, Vesper, and Field Sparrows in the 41.5 ha (103 ac) site. American Crows were determined to be one of the major predators.

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. The number in parentheses is the total number of studies conducted on a species in each category (1 study could be in multiple categories). 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 metric of proportion or increase of woodland habitat in the landscape surrounding a grassland patch. Observational studies not included.

		Woody Vegetation		
Species	**Within Patch** +/-	**% Woody Perimeter** +/-	**Distance to Woody** +/-	**Landscape** +/-
Artificial nests	0/1 (1)	0/1 (1)	1/2 (4)	0/1(1)
Duck spp.	0/1 (1)	0/2 (2)	0/1 (1)	0/2 (2)
Northern Harrier *Circus cyaneus*	1/0 (1)	0	0	0
Ring-necked Pheasant *Phasianus colchicus*	0	0	0/3 (4)	1/0 (1)
Greater Prairie-Chicken *Tympanuchus cupido*	0/2 (2)	0	0/0 (1)	0/3 (3)
Lesser Prairie-Chicken *Tympanuchus pallidicinctus*	0	0	0	0/2 (2)
Sharp-tailed Grouse *Tympanuchus phasianellus*	0	0	0	0/2 (2)
Burrowing Owl *Athene cunicularia*	0/1 (1)	0	0	0
Upland Sandpiper *Bartramia longicauda*	0/3 (6)	0/0 (2)	0	0/2 (3)
Marbled Godwit *Limosa fedoa*	0/1 (1)	0	0	0/1 (1)
Wilson's Snipe *Gallinago delicata*	0/1 (1)	0	0	0/1 (1)
Wilson's Phalarope *Phalaropus tricolor*	0/1 (1)	0	0	0/1 (1)
Loggerhead Shrike *Lanius excubitor*	0/0 (1)	0	0	1/0 (1)
Horned Lark *Eremophila alpestris*	0/5 (5)	0/1 (2)	0/1 (1)	0 (1)
Sedge Wren *Cistothorus platensis*	0/2 (4)	0/1 (3)	0/1 (1)	0/1 (3)
Sprague's Pipit *Anthus spragueii*	0/3 (3)	0/1 (1)	1/0 (1)	0/0 (1)
Clay-colored Sparrow *Spizella pallida*	4/0 (5)	0/0 (1)	1/2 (5)	3/0 (5)
Grasshopper Sparrow *Ammodramus savannarum*	0/10 (14)	0/5 (7)	0/6 (6)	0/3 (7)

Species	Woody Vegetation: Within Patch +/-	Woody Vegetation: % Woody Perimeter +/-	Woody Vegetation: Distance to Woody +/-	Woody Vegetation: Landscape +/-
Baird's Sparrow *Ammodramus bairdii*	0/4 (4)	0	0/1 (1)	0/1 (1)
Henslow's Sparrow *Ammodramus henslowii*	0/3 (4)	0/5 (5)	0	0 (1)
LeConte's Sparrow *Ammodramus leconteii*	0/0 (3)	0/0 (1)	0/1 (1)	0/1 (2)
Lark Bunting *Calamospiza melanocorys*	0/1 (2)	0/1 (1)	0	0
Savannah Sparrow *Passerculus sandwichensis*	0/7 (9)	0/6 (7)	0/4 (8)	0/6 (7)
Vesper Sparrow *Pooecetes gramineus*	3/1 (6)	1/1 (2)	1/0 (2)	2/0 (4)
Chestnut-collared Longspur *Calcarius ornatus*	0/2 (4)	0/1 (1)	0/1 (1)	0/1 (1)
McCown's Longspur *Calcarius mccownii*	0/1 (1)	0	0	0
Dickcissel *Spiza Americana*	2/2 (7)	0/2 (3)	0/3 (3)	0/1 (3)
Bobolink *Dolichonyx oryzivorus*	0/5 (9)	0/3 (6)	0/7 (7)	0/6 (7)
Eastern Meadowlark *Sturnella magna*	0/5 (7)	0/1 (4)	0/1 (1)	0/2 (4)
Western Meadowlark *Sturnella neglecta*	0/5 (7)	0/2 (3)	0/4 (4)	0/5 (5)
Grassland Bird Group	0	0/1 (1)	0/3 (3)	0/1 (2)

*Updated 1/2008.

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 Habitat and Population Evaluation Team and Migratory Birds and State Programs, US Fish and Wildlife Service.