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Effects of Management Practices on Grassland Birds: Northern Harrier

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**EFFECTS OF MANAGEMENT PRACTICES
ON GRASSLAND BIRDS:
NORTHERN HARRIER**



Grasslands Ecosystem Initiative
Northern Prairie Wildlife Research Center
U.S. Geological Survey
Jamestown, North Dakota 58401

This report is one in a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV recently adopted a new goal, to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

American Bittern	Grasshopper Sparrow
Mountain Plover	Baird's Sparrow
Marbled Godwit	Henslow's Sparrow
Long-billed Curlew	Le Conte's Sparrow
Willet	Nelson's Sharp-tailed Sparrow
Wilson's Phalarope	Vesper Sparrow
Upland Sandpiper	Savannah Sparrow
Greater Prairie-Chicken	Lark Sparrow
Lesser Prairie-Chicken	Field Sparrow
Northern Harrier	Clay-colored Sparrow
Swainson's Hawk	Chestnut-collared Longspur
Ferruginous Hawk	McCown's Longspur
Short-eared Owl	Dickcissel
Burrowing Owl	Lark Bunting
Horned Lark	Bobolink
Sedge Wren	Eastern Meadowlark
Loggerhead Shrike	Western Meadowlark
Sprague's Pipit	Brown-headed Cowbird

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NORTHERN HARRIER**

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers. A **range map** is provided to indicate the relative densities of the species in North America, based on Breeding Bird Survey (BBS) data. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief **capsule statement**, which provides the fundamental components or keys to management for the species. A section on **breeding range** outlines the current breeding distribution of the species in North America, including areas that could not be mapped using BBS data. The **suitable habitat** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A **table** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. A special section on **prey habitat** is included for those predatory species that have more specific prey requirements. The **area requirements** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The Brown-headed Cowbird (*Molothrus ater*) is an obligate brood parasite of many grassland birds. The section on **cowbird brood parasitism** summarizes rates of cowbird parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on **breeding-season phenology and site fidelity** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. **Species' response to management** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on **management recommendations** complements the previous section and summarizes specific recommendations for habitat management provided in the literature. If management recommendations differ in different portions of the species' breeding range, recommendations are given separately by region. The **literature cited** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

This report has been downloaded from the Northern Prairie Wildlife Research Center World-Wide Web site, www.npwr.usgs.gov/resource/literatr/grasbird/grasbird.htm. Please direct comments and suggestions to Douglas H. Johnson, Northern Prairie Wildlife Research Center, U.S. Geological Survey, 8711 37th Street SE, Jamestown, North Dakota 58401; telephone: 701-253-5539; fax: 701-253-5553; e-mail: Douglas_H_Johnson@usgs.gov.

NORTHERN HARRIER (*Circus cyaneus*)

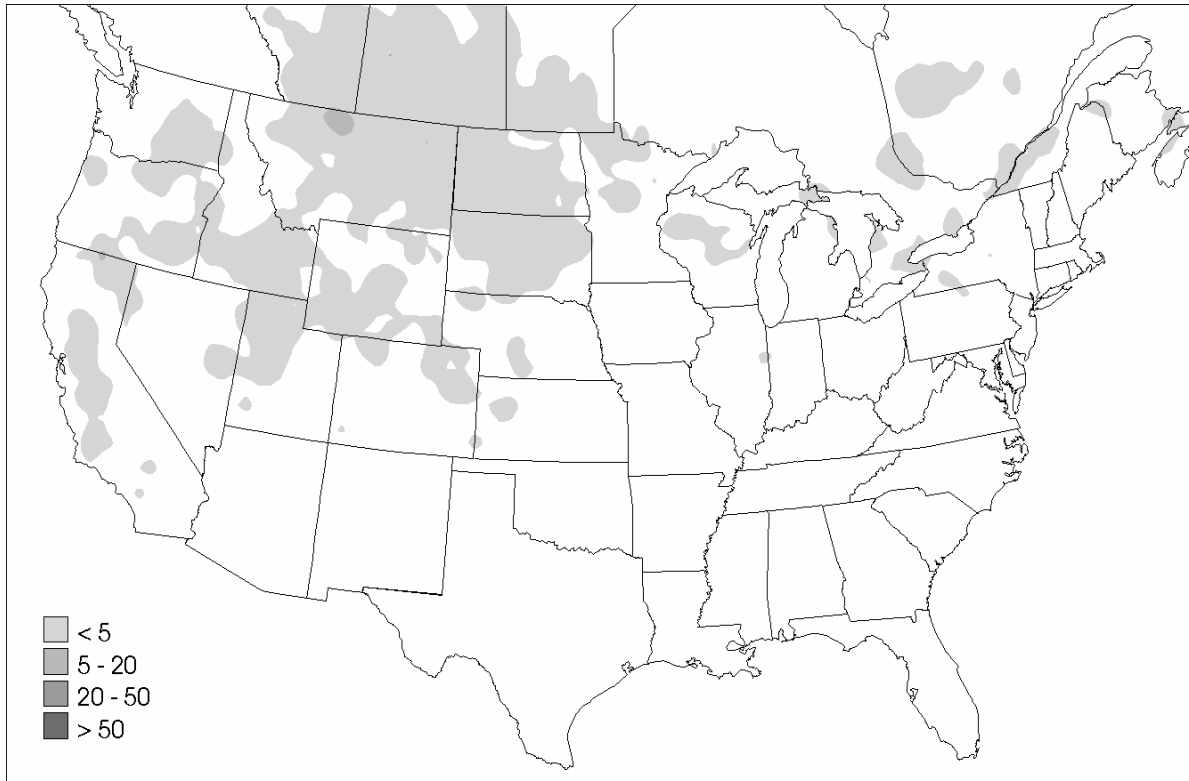


Figure. Breeding distribution of the Northern Harrier in the United States and southern Canada, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. *The summer atlas of North American birds*. Academic Press, London, England. 364 pages.

Key to management is providing extensive wetlands or tall, densely vegetated mesic or xeric grasslands.

Breeding range:

Northern Harriers breed from central Alaska and western Northwest Territories to southern Quebec and Nova Scotia, south to southern California, northern Texas, central Illinois; and east to New Jersey and Maine (National Geographic Society 1987). (See figure for the relative densities of Northern Harriers in the United States and southern Canada, based on Breeding Bird Survey data.)

Suitable habitat:

Northern Harriers prefer relatively open habitats characterized by tall, dense vegetation, and abundant residual vegetation (Duebbert and Lokemoen 1977, Hamerstrom and Kopeny 1981, Apfelbaum and Seelbach 1983, Kantrud and Higgins 1992). They use native or tame vegetation in wet or dry grasslands, fresh to alkali wetlands, lightly grazed pastures, croplands, fallow fields, oldfields, and brushy areas (Stewart and Kantrud 1965, Stewart 1975, Linner 1980, Evans 1982, Apfelbaum and Seelbach 1983, Faanes 1983, Kantrud and Higgins 1992, Dhol et al.

1994, Prescott et al. 1995, MacWhirter and Bildstein 1996, Prescott 1997). Although cropland and fallow fields are used for nesting, most nests are found in undisturbed wetlands or grasslands dominated by thick vegetation (Duebbert and Lokemoen 1977, Apfelbaum and Seelbach 1983, Kantrud and Higgins 1992). Nest success may be lower in cropland and fallow fields than in undisturbed areas (Kibbe 1975).

Northern Harriers nest on the ground or over water on platforms of vegetation in stands of cattail (*Typha*) or other emergent vegetation (Saunders 1913, Bent 1961, Sealy 1967, Clark 1972, Stewart 1975, MacWhirter and Bildstein 1996). Ground nests are well-concealed by tall, dense vegetation, including living and residual grasses and forbs, or low shrubs, and are located in undisturbed areas with much residual cover (Hecht 1951, Duebbert and Lokemoen 1977, Hamerstrom and Kopeny 1981, Kantrud and Higgins 1992, Herkert et al. 1999). In the northern Great Plains, few nests were found in croplands or in areas where litter cover was <12% of total cover; areas with >40% residual cover were commonly used (Kantrud and Higgins 1992). In planted grass/legume fields in North Dakota and South Dakota, most nests (52% of 27) were in cover >60 cm tall and were surrounded by smooth brome (*Bromus inermis*), intermediate wheatgrass (*Agropyron intermedium*), and forbs (Duebbert and Lokemoen 1977). In the northern Great Plains, harrier nests were often associated with western snowberry (*Symphoricarpos occidentalis*) (Messmer 1990, Kantrud and Higgins 1992, Murphy 1993, Sedivec 1994). In northwestern North Dakota, nests were placed in 0.05-0.5 ha stands of western snowberry or snowberry/other shrub with forbs and grass (Murphy 1993). In Saskatchewan, success of nests in shrub patches was highly variable, with fledgling success from 0 to 100% (Sealy 1967). Harrier nests in southwestern Missouri were found almost exclusively in blackberry (*Rubus*) patches with a mean size of 98 m² (Toland 1986). Northern Harriers may have chosen these sites for their protective value (Toland 1986). On an 11-km² island in North Dakota, harriers nested in tame grass/legume and western snowberry areas more commonly than predicted by availability of that habitat type (Sutherland 1987). In Illinois, nest placement by Northern Harriers was influenced less by whether the dominant grass cover in fields was native or introduced than by whether the field was idle or disturbed by burning, mowing, seed-harvesting, or grazing (Herkert et al. 1999).

Nests in wet sites may have an advantage in that fewer predators have access to them (Sealy 1967, Simmons and Smith 1985). Placement of nests in wet versus dry sites may have been dictated by proximity to vole (*Microtus*) populations, such that a compromise was made between nesting in wet areas where depredation was lower and nesting closer to upland areas where vole populations were higher (Simmons and Smith 1985). The relationship between ground moisture and vegetation on fledgling success was examined in New Brunswick (Simmons and Smith 1985). Females preferred wet areas relative to availability, and nests in cattails and wetland grasses (bluejoint [*Calamagrostis canadensis*] and prairie cordgrass [*Spartina pectinata*]) were more successful than those in shrubs (speckled alder [*Alnus incana*] and meadow-sweet [*Spiraea*]) or in upland areas. Contrary to results from upland ground nests, the most successful wet-site nests were less concealed (Simmons and Smith 1985). Similar studies are lacking in the Great Plains. In Alberta, Manitoba, and Montana, nests have been found on platforms of vegetation over standing water in cattail/rush (*Juncus*) wetlands (Saunders 1913, Sealy 1967, Clark 1972). A mean of 83% of young survived to fledgling from nine nests in an Alberta cattail wetland, whereas the young disappeared from two nests in wheatgrasses (*Agropyron*) (Sealy 1967). In Alberta, Northern Harriers were more abundant in large (>8 ha) than in small (<1 ha), fresh wetlands (Prescott et al. 1995). Northern Harriers may nest semi-

colonially, even when large tracts of apparently suitable habitat are available, and also have been found to nest in close association with ducks and Greater Prairie-Chickens (*Tympanuchus cupido*) (Bildstein and Gollop 1988).

Northern Harriers adapt to changes in nesting habitat. In a Wisconsin wetland subjected to chemical shrub control, willows (*Salix*), bulrushes (*Schoenoplectus*) and sedges (*Carex*) were reduced as goldenrod (*Solidago*) and white meadow-sweet (*Spiraea alba*) increased; harriers subsequently switched from nesting in the former to nesting in the latter (Hamerstrom and Kopeny 1981). A table near the end of the account lists the specific habitat characteristics for Northern Harriers by study.

Prey habitat:

Voies and other small rodents are primary prey of Northern Harriers in the northern Great Plains; other mammals, birds, and occasionally reptiles and frogs are also taken (Sutherland 1987, MacWhirter and Bildstein 1996). Insects compose only a small part of the diet, and are most frequently taken by recently fledged young (MacWhirter and Bildstein 1996). In Wisconsin, changes in vole abundance were closely paralleled by corresponding changes in numbers and productivity of nesting harriers (Hamerstrom 1979, Hamerstrom et al. 1985). Northern Harriers forage over open habitats of moderate to heavy cover, such as ungrazed prairies and wetlands (MacWhirter and Bildstein 1996). On an 11-km² island in North Dakota, Northern Harriers foraged in tame grass/legume fields, wetlands, and native prairie (Sutherland 1987). In shrubsteppe habitat in Idaho, Northern Harriers foraged over alfalfa (*Medicago sativa*) fields until the crop reached 46 cm, then shifted to foraging in open shrubsteppe (Martin 1987).

Area requirements:

Studies in Conservation Reserve Program fields in North Dakota indicated that Northern Harriers were uncommon in blocks of contiguous grassland <100 ha (D. H. Johnson, *unpublished data*). In Illinois, grassland size did not influence nest placement (Herkert et al. 1999). Northern Harriers nested in grassland fragments ranging from 8 to 120 ha; five of 29 nests were in grassland tracts <45 ha. However, the authors suggested that Northern Harriers may be responding more to the total amount of grassland available in the surrounding landscape than to the sizes of individual grassland fragments; small fragments may be used if located close to larger blocks of contiguous grassland. One nest per 11-54 ha was typical in cool-season grasses on the southeastern end of the Missouri Coteau of North Dakota (Duebbert and Lokemoen 1977). In the tallgrass prairie of southwestern Missouri, nesting density was 121 ha/pair, and male home ranges averaged 256 ha (Toland 1985). A pair in central Wisconsin used approximately 890 ha (Hamerstrom and DeLaRonde Wilde 1973). In Manitoba, males defended 27.7 ha, centered on the nest (Hecht 1951). Harriers hunted over 259 ha in Minnesota (Breckenridge 1935). In Idaho, home ranges averaged 1,570 ha for males and 113 ha for females (Martin 1987).

Brown-headed Cowbird brood parasitism:

No known records of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) exist.

Breeding-season phenology and site fidelity:

Northern Harriers arrive on the breeding grounds between late March and early April, and nest from April through July (Hammond and Henry 1949, Stewart 1975, Duebbert and Lokemoen 1977, Linner 1980, Murphy and Ensign 1996, Bildstein and Gollop 1988). Harriers produce only one brood per breeding season; however, renesting may occur if the nest is destroyed or deserted during egg laying (Bildstein and Gollop 1988, MacWhirter and Bildstein 1996). Of nine nests that failed during egg laying, 44% of pairs renested elsewhere in their territory (MacWhirter and Bildstein 1996). In Michigan, one pair out of eight renested after nest destruction (Bildstein and Gollop 1988). Harriers leave for the wintering grounds between August and November (Saunders 1913, Bent 1961, Bildstein and Gollop 1988).

Northern Harriers may return to the same general area to breed as the previous year (Hamerstrom 1969, Burke 1979). Polygyny has been reported in this species (Hecht 1951, Hamerstrom et al. 1985).

Species' response to management:

Northern Harriers generally prefer grasslands and associated wetlands with dense cover. During extensive nest-searching in North Dakota, Duebbert and Lokemoen (1977) found few Northern Harrier nests in annually grazed, hayed, burned, or tilled areas. Similarly, in Delta Marsh, Manitoba, no nests were found in burned or mowed areas (Hecht 1951). Although Northern Harriers avoid disturbed areas, periodic disturbance may be necessary to maintain suitable habitat. Berkey et al. (1993) suggested that dense nesting cover (DNC) in uplands could be hayed periodically to stimulate plant growth. Burning or mowing every 3-5 yr is recommended to maintain habitat for Northern Harriers and their principal small rodent prey (Lemen and Clausen 1984, Hands et al. 1989, Kaufman et al. 1990). Disturbances such as burning, haying, and mowing should be avoided during the nesting period (Toland 1986).

Use of prescribed burning in drier, more northern areas may have immediate detrimental effects as it reduces litter accumulation and may destroy nests (Kruse and Piehl 1986, Berkey et al. 1993). Three of four active nests were destroyed by June prescribed burns in North Dakota; one nest hatched (Kruse and Piehl 1986). In Kansas, harriers used both annually burned and unburned areas for foraging, but nested only in unburned areas (Zimmerman 1993). In Missouri, harriers preferred large areas of idle prairie with patches of invading woody plants, and avoided areas that were annually burned (Toland 1986). Reducing cattails through burning or herbicides could eliminate nesting cover (Berkey et al. 1993).

In Illinois and South Dakota, Northern Harriers preferred idle areas to areas mowed for forage or seed production (Luttschwager and Higgins 1992, Herkert et al. 1999). In Illinois, Northern Harriers preferred fields that had been idle <2 yr; only one field had been idle >3 yr (Herkert et al. 1999). Early mowing can destroy nests (Hamerstrom 1986). Delaying haying until 15 July may allow Northern Harriers to nest successfully (Berkey et al. 1993). In Manitoba, Northern Harriers were absent from idle mixed-grass, and were as abundant in native as in tame DNC (Dhol et al. 1994). In Alberta, however, they preferred native over tame DNC (Prescott et al. 1995).

Northern Harriers do not use heavily grazed habitats (Stewart 1975, Berkey et al. 1993, Bock et al. 1993), but may use lightly to moderately grazed grasslands (Kantrud and Kologiski 1982, Bock et al. 1993). In North Dakota, Northern Harriers had significantly higher nesting density on ungrazed areas than areas grazed season-long or under a twice-over rotation (Messmer 1990, Sedivec 1994). In aspen parkland of Alberta, Northern Harriers were most

abundant in deferred grazed (grazed after 15 July) mixed-grass, but were absent from continuously grazed mixed-grass and deferred or continuously grazed tame pasture (Prescott et al. 1995).

Management Recommendations:

Preserve native grassland. Collaborate with ranching and farming interests to maintain native rangeland and pasture land (Johnson 1996).

Protect grasslands through conservation easements, land purchases, and development of farm programs that hold conservation of wildlife habitat in high priority (Hands et al. 1989, Johnson 1996). Continue the Conservation Reserve Program to provide nesting and foraging habitat (Kantrud and Higgins 1992, Bock et al. 1993).

Discourage farmers from tilling wetlands (Hands et al. 1989). Protect wetlands from drainage through conservation easements, land purchases, tax incentives, management agreements, restoration, continuation of Wetland Reserve Program, and enforcement of wetland-protection regulations (Hands et al. 1989, Johnson et al. 1994, Johnson 1996).

Maintain a mosaic of grasslands and wetlands so that while some units are being treated to halt succession, other units are available (Hands et al. 1989, Ryan 1990, Murphy 1993). Treated units should be small (100-200 ha) to minimize the number of displaced nesting harriers. Untreated units should be large enough to meet the requirements of multiple female harriers during the nesting season (Hands et al. 1989). In tallgrass areas, provide native and/or tame grasslands that have been recently (≤ 3 yr) idled. Harriers preferred nesting in idle areas over nesting in mowed areas in Illinois (Herkert et al. 1999), and preferred idle areas over annually burned areas in Missouri (Toland 1986).

In the northcentral United States, periodically mow, burn, or graze to maintain the 2-5 yr old accumulations of residual vegetation preferred by Northern Harriers in this region (Duebbert and Lokemoen 1977, Hands et al. 1989, Berkey et al. 1993, Murphy 1993). Where natural vegetation has been destroyed by drainage, burning, tillage, overgrazing, or conversion to cropland, plant warm-season grasses and legumes. Mowing, burning, or grazing is recommended every 3-5 yr to maintain habitat for small mammal prey (Leman and Clausen 1984, Kaufman et al. 1990).

Provide large areas (≥ 100 ha) of idle prairie with patches of woody plants, such as western snowberry or blackberry (Toland 1986; Messmer 1990; Kantrud and Higgins 1992; Sedivec 1994; D. H. Johnson, *unpublished data*).

Increase the amount of western public rangeland from which livestock are excluded, especially in U.S. Forest Service National Grasslands (Bock et al. 1993). Northern Harriers preferred idle areas to grazed areas in North Dakota (Sedivec 1994).

Avoid disturbing nesting areas during the breeding season, about April through July (Hamerstrom 1986, Toland 1986, Berkey et al. 1993).

Where water levels are artificially maintained, do not allow water levels to rise ≥ 15 cm from April to August. Otherwise, nests in wetland habitat may become submerged (Hands et al. 1989).

On large islands, maintain tame grass/legume and brush cover and reduce mammalian predators (Sutherland 1987).

Minimize human disturbance near nests (Hamerstrom 1969, Toland 1985, Hands et al. 1989).

Do not use chemical pesticides in habitats used by harriers (Hamerstrom 1969, Hands et al. 1989).

Table. Northern Harrier habitat characteristics.

Author(s)	Location(s)	Habitat(s) Studied*	Species-specific Habitat Characteristics
Apfelbaum and Seelbach 1983	Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania, Wisconsin	Cropland, idle, pasture, wetland	Used wet meadows, dry uplands, wetlands, brushy areas, pasture and fallow fields, cultivated hay and wheat; nested in wet or dry sites dominated by thick grass growth, in both open areas and slightly closed forest areas
Bent 1961	Rangewide	Idle mixed-grass	Used grassy, open areas, wet-meadow zones, grassy swales, or other wet areas
Clark 1972	Manitoba	Cropland, mixed-grass hayland, mixed-grass pasture	Nested on dry and wet sites; nests in the latter were on platforms of residual vegetation surrounded by water
Dhol et al. 1994	Manitoba	Dense nesting cover (DNC; idle seeded-native, idle tame), idle mixed-grass	No difference in abundance between native DNC (western wheatgrass [<i>Pascopyrum smithii</i>], thick-spike wheatgrass [<i>Agropyron dasystachyum</i>], slender wheatgrass [<i>Agropyron caninum</i>], streambank wheatgrass [<i>Agropyron riparian</i>], green needlegrass [<i>Stipa viridula</i>], big bluestem [<i>Andropogon gerardii</i>], switchgrass [<i>Panicum virgatum</i>], and purple prairie clover [<i>Dalea purpurea</i>]) and tame DNC (tall wheatgrass [<i>Agropyron elongatum</i>], intermediate wheatgrass [<i>Agropyron intermedium</i>], slender wheatgrass, and alfalfa [<i>Medicago sativa</i>]) was found; were absent from mixed-grass prairie
Duebbert and Lokemoen	North Dakota,	Cropland, idle tame	Preferred tall, dense vegetation in upland areas;

1977	South Dakota		93% of 27 nests were in cover >30 cm tall
Faanes 1983	North Dakota	Idle mixed-grass, mixed-grass pasture, woodland	Used lightly grazed native prairie near wooded draws
Hamerstrom and Kopeny 1981	Wisconsin	Idle	Vegetation around nests shifted to goldenrod (<i>Solidago</i>) and meadow-sweet (<i>Spirea alba</i>) after chemical control reduced former nesting cover of willow (<i>Salix</i>), grasses, quaking aspen (<i>Populus tremuloides</i>), bulrush (<i>Schoenoplectus</i>), and sedges (<i>Carex</i>); vegetation around nests was normally tall and/or dense
Hecht 1951	Manitoba	Wetland: burned, idle, mowed	Used dry nest sites among reed (<i>Phragmites</i>) and sprangletop (<i>Scolochloa</i>); avoided burned or mowed areas
Herkert et al. 1999	Illinois	Burned, idle tallgrass, idle tame, pasture, tallgrass hayland, tame hayland, tame seed-harvested	Preferred undisturbed grasslands (grasslands left undisturbed for at least 12 mo before the beginning of the breeding season) over managed grasslands (grasslands managed through rotary mowing, hay mowing, seed-harvesting, grazing, or burning during the 12 mo prior to the breeding season); nest placement was not influenced by whether grass was native or tame
Kantrud and Kologiski 1982	Colorado, Montana, Nebraska, North Dakota, South Dakota, Wyoming	Mixed-grass pasture, shortgrass pasture, shrubsteppe	Preferred lightly to moderately grazed areas with northern borollic soils; vegetation on these sites averaged 23 to 30 cm in height
	Manitoba,	Burned mixed-grass, burned	Preferred tall, dense vegetation in undisturbed tame

Kantrud and Higgins 1992	Montana, North Dakota, South Dakota	tame, cropland, hayland, idle mixed-grass, idle tame, mixed-grass pasture, tame pasture	grasslands or native prairie dominated by brush, especially western snowberry (<i>Symphoricarpos occidentalis</i>); used vegetation >55 cm and containing >40% residual litter; avoided areas with <12% residual litter
Linner 1980	Utah	Cropland, idle, tame pasture, wetland	Nested in wetlands and oldfields; preferred foraging over wet oldfields, less so over cropland; avoided habitats with short vegetation
Luttschwager and Higgins 1992	South Dakota	Conservation Reserve Program (CRP; idle seeded- native, idle tame, seeded- native hayland, tame hayland)	Nested in idle strips and blocks within mowed fields
Messmer 1990	North Dakota	Idle mixed-grass/tame, mixed-grass/tame hayland, mixed-grass/tame pasture, wet-meadow pasture	Preferred idle areas dominated by western snowberry; density was higher on idle areas than on short-duration or twice-over grazing systems; mowing displaced harriers
Murphy 1993	North Dakota	Burned mixed-grass, burned tame, idle mixed-grass, idle tame, mixed-grass pasture, tame pasture, woodland	Preferred (92% of nests) 0.05-0.5 ha patches of western snowberry and associated low shrubs for nesting; mean height/density index at nest sites was 35 cm
Prescott et al. 1995	Alberta	Cropland, DNC (idle seeded-native, idle tame), idle mixed-grass, idle parkland, idle tame, mixed- grass pasture, parkland pasture, tame hayland, tame pasture, wetland, woodland	Were most abundant in deferred (grazed after 15 July) native mixed-grass and native DNC; were moderately abundant in idle native parkland, large (>8 ha) fresh wetlands, and tame DNC; and were least abundant in small (<1 ha) fresh wetlands; were absent from cropland, idle tame, tame hayland, saline wetlands, continuously grazed

			mixed-grass pasture, idle mixed-grass, medium (1-8 ha) fresh wetlands, shelterbelts, and tame pasture
Sealy 1967	Alberta, Saskatchewan	Cropland, mixed-grass pasture, wetland	Nested in wetlands dominated by cattail (<i>Typha</i>), wheatgrass (<i>Agropyron</i>), and areas containing western snowberry and rose (<i>Rosa</i>)
Sedivec 1994	North Dakota	Idle mixed-grass, mixed-grass pasture	Nested significantly more in idle pasture than grazed; used areas dominated by western snowberry
Stewart 1975	North Dakota	Cropland, idle mixed-grass, idle shortgrass, mixed-grass hayland, shortgrass hayland, tame hayland	Used wetlands, wet-meadow zones, and idle or lightly grazed prairie; occasionally used cropland or fallow areas
Stewart and Kantrud 1965	North Dakota	Wetland	Highest densities were found on semipermanent wetlands with closed stands of emergent cover or with clumps of emergent cover interspersed with open water, except in saline wetlands (i.e., wetlands dominated by alkali bulrush [<i>Scirpus maritimus</i>])
Sutherland 1987	North Dakota	Cropland, idle tame, idle shortgrass	Nested in tall, dense vegetation consisting of smooth brome (<i>Bromus inermis</i>), alfalfa, and western snowberry; height of green vegetation (80 cm) and visual obstruction (48.8 cm) were greater than randomly available
Toland 1986	Missouri	Burned tallgrass, burned tame, idle tallgrass, idle tame	Preferred unburned, idle vegetation; chose areas burned in alternate years over areas burned every year; used large idle prairies with patches (average 98 m ²) of blackberry (<i>Rubus</i>); within 90 cm of nests, mean vegetation height was 79.2 cm and

			ground cover 100%
Zimmerman 1993	Kansas	Burned tallgrass, idle, idle tallgrass, woodland	Used (foraged in) both burned and unburned areas; nests were found only in unburned prairie; were uncommon as summer residents

*In an effort to standardize terminology among studies, various descriptors were used to denote the management or type of habitat. “Idle” used as a modifier (e.g., idle tallgrass) denotes undisturbed or unmanaged (e.g., not burned, mowed, or grazed) areas. “Idle” by itself denotes unmanaged areas in which the plant species were not mentioned. Examples of “idle” habitats include weedy or fallow areas (e.g., oldfields), fencerows, grassed waterways, terraces, ditches, and road rights-of-way. “Tame” denotes introduced plant species (e.g., smooth brome [*Bromus inermis*]) that are not native to North American prairies. “Hayland” refers to any habitat that was mowed, regardless of whether the resulting cut vegetation was removed. “Burned” includes habitats that were burned intentionally or accidentally or those burned by natural forces (e.g., lightning). In situations where there are two or more descriptors (e.g., idle tame hayland), the first descriptor modifies the following descriptors. For example, idle tame hayland is habitat that is usually mowed annually but happened to be undisturbed during the year of the study.

LITERATURE CITED

- Apfelbaum, S. I., and P. Seelbach. 1983. Nest tree, habitat selection and productivity of seven North American raptor species based on the Cornell University nest record card program. *Raptor Research* 17:97-113.
- Bent, A. C. 1961. Life histories of North American birds of prey. Part 1. Dover Publications Inc., New York, New York. 409 pages.
- Berkey, G., R. Crawford, S. Galipeau, D. Johnson, D. Lambeth, and R. Kreil. 1993. A review of wildlife management practices in North Dakota: effects on nongame bird populations and habitats. Report submitted to Region 6. U.S. Fish and Wildlife Service, Denver, Colorado. 51 pages.
- Bildstein K. L., and J. B. Gollop. 1988. Northern Harrier. Pages 251-303 *in* R. S. Palmer, editor. Handbook of North American birds, vol. 4, diurnal raptors. Yale University Press, New Haven, Connecticut.
- Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296-309 *in* D. M. Finch and P. W. Stangel, editors. Status and management of Neotropical migratory birds. U.S. Department of Agriculture, Forest Service General Technical Report RM-229.
- Breckenridge, W. J. 1935. An ecological study of some Minnesota Marsh Hawks. *Condor* 37:268-276.
- Burke, C. J. 1979. Effect of prey and land use on mating systems of harriers. M.S. thesis. University of Wisconsin, Stevens Point, Wisconsin. 46 pages.
- Clark, R. J. 1972. Observations of nesting Marsh Hawks in Manitoba. *Blue Jay* 30:43-48.
- Dhol, S., J. Horton, and R. E. Jones. 1994. 1994 non-waterfowl evaluation on Manitoba's North American Waterfowl Management Plan. Unpublished report. Wildlife Branch, Manitoba Department of Natural Resources, Winnipeg, Manitoba. 12 pages.
- Duebbert, H. F., and J. T. Lokemoen. 1977. Upland nesting of American Bitterns, Marsh Hawks, and Short-eared Owls. *Prairie Naturalist* 9:33-40.
- Evans, D. L. 1982. Status reports on twelve raptors. U.S. Fish and Wildlife Service, Special Scientific Report-Wildlife, No. 238. Washington, D.C. 70 pages.
- Faanes, C. A. 1983. Breeding birds of wooded draws in western North Dakota. *Prairie Naturalist* 15:173-187.
- Hamerstrom, F. 1969. A harrier population study. Pages 367-383 *in* J. J. Hickey, editor. Peregrine Falcon populations, their biology and decline. University of Wisconsin Press, Madison, Wisconsin.
- Hamerstrom, F. 1979. Effect of prey of predator: voles and harriers. *Auk* 96:370-374.

- Hamerstrom, F. 1986. Harrier, hawk of the marshes: the hawk that is ruled by a mouse. Smithsonian Institution Press, Washington, D.C. 171 pages.
- Hamerstrom, F., and DeLaRonde Wilde, D. 1973. Cruising range and roosts of adult harriers. *Inland Bird Banding News* 45:123-127.
- Hamerstrom, F., F. N. Hamerstrom, and C. J. Burke. 1985. Effects of voles on mating systems in a central Wisconsin population of harriers. *Wilson Bulletin* 97:332-346.
- Hamerstrom, F., and M. Kopeny. 1981. Harrier nest-site vegetation. *Raptor Research* 15:86-88.
- Hammond, M. C., and C. J. Henry. 1949. Success of Marsh Hawk nests in North Dakota. *Auk* 66:271-274.
- Hands, H. M., R. D. Drobney, and M. R. Ryan. 1989. Status of the Northern Harrier in the northcentral United States. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 18 pages.
- Hecht, W. R. 1951. Nesting of the Marsh Hawk at Delta, Manitoba. *Wilson Bulletin* 63:167-176.
- Herkert, J. R., S. A. Simpson, R. L. Westemeier, T. L. Esker, and J. W. Walk. 1999. Response of Northern Harriers and Short-eared Owls to grassland management in Illinois. *Journal of Wildlife Management* 63:517-523.
- Johnson, D. H. 1996. Management of northern prairies and wetlands for the conservation of Neotropical migratory birds. Pages 53-67 *in* F. R. Thompson, III, editor. Management of midwestern landscapes for the conservation of Neotropical migratory birds. U.S. Department of Agriculture, Forest Service General Technical Report NC-187.
- Johnson, D. H., S. D. Haseltine, and L. M. Cowardin. 1994. Wildlife habitat management on the northern prairie landscape. *Landscape and Urban Planning* 28:5-21.
- Kantrud, H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. *Prairie Naturalist* 24:67-84.
- Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish and Wildlife Service, Wildlife Research Report 15. 33 pages.
- Kaufman, D. W., E. J. Finck, and G. A. Kaufman. 1990. Small mammals and grassland fires. Pages 46-80 *in* S. L. Collins and L. L. Wallace, editors. Fire in North American tallgrass prairies. University of Oklahoma Press, Norman, Oklahoma. 175 pages.
- Kibbe, D. P. 1975. The nesting season June 1-July 31, 1975: Niagara-Champlain Region. *American Birds* 29:967-970.
- Kruse, A. D., and J. L. Piehl. 1986. The impacts of prescribed burning on ground nesting birds. *Proceedings of the North American Prairie Conference* 9:153-156.

- Leman C. A., and M. K. Clausen. 1984. The effects of mowing on the rodent community of a native tallgrass prairie in eastern Nebraska. *Prairie Naturalist* 16:5-10.
- Linner, S. C. 1980. Resource partitioning in breeding populations of Marsh Hawks and Short-eared Owls. M.S. thesis. Utah State University, Logan, Utah. 66 pages.
- Luttschwager, K. A., and K. F. Higgins. 1992. Nongame bird, game bird, and deer use of Conservation Reserve Program fields in eastern South Dakota. *Proceedings of the South Dakota Academy of Science* 71:31-36.
- MacWhirter, R. B., and K. L. Bildstein. 1996. Northern Harrier (*Circus cyaneus*). In A. Poole and F. Gill, editors. *The birds of North America*, No. 210. The Academy of Natural Sciences, Philadelphia, Pennsylvania.; The American Ornithologists' Union, Washington, D.C.
- Martin, J. W. 1987. Behavior and habitat use of breeding Northern Harriers in southwestern Idaho. *Journal of Raptor Research* 21:57-66.
- Messmer, T. A. 1990. Influence of grazing treatments on nongame birds and vegetation structure in south central North Dakota. Ph.D. dissertation. North Dakota State University, Fargo, North Dakota. 164 pages.
- Murphy, R. K. 1993. History, nesting biology, and predation ecology of raptors in the Missouri Coteau of northwestern North Dakota. Ph.D. dissertation. Montana State University, Bozeman, Montana. 212 pages.
- Murphy, R. K., and J. T. Ensign. 1996. Raptor nesting chronology in northwestern North Dakota. *Prairie Naturalist* 28:51-58.
- National Geographic Society. 1987. *Field guide to the birds of North America*, second edition. National Geographic Society, Washington, D.C. 464 pages.
- Prescott, D. R. C. 1997. Avian communities and NAWMP habitat priorities in the northern Prairie biome of Alberta. NAWMP-029. Land Stewardship Centre of Canada, St. Albert, Alberta. 41 pages.
- Prescott, D. R. C., A. J. Murphy, and E. Ewaschuk. 1995. An avian community approach to determining biodiversity values of NAWMP habitats in the aspen parkland of Alberta. NAWMP-012. Alberta NAWMP Centre, Edmonton, Alberta. 58 pages.
- Ryan, M. R. 1990. A dynamic approach to the conservation of the prairie ecosystem in the Midwest. Pages 91-106 in J. M. Sweeney, editor. *Management of dynamic ecosystems*. North Central Section, The Wildlife Society, West Lafayette, Indiana.
- Saunders, A. A. 1913. A study of the nesting of the Marsh Hawk. *Condor* 15:99-104.
- Sealy, S. G. 1967. Notes on the breeding biology of the Marsh Hawk in Alberta and Saskatchewan. *Blue Jay* 25:63-69.

- Sedivec, K. K. 1994. Grazing treatment effects on and habitat use of upland nesting birds on native rangeland. Ph.D. dissertation. North Dakota State University, Fargo, North Dakota. 124 pages.
- Simmons, R., and P. C. Smith. 1985. Do Northern Harriers (*Circus cyaneus*) choose nest sites adaptively? Canadian Journal of Zoology 63:494-498.
- Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies, Fargo, North Dakota. 295 pages.
- Stewart, R. E., and H. A. Kantrud. 1965. Ecological studies of waterfowl populations in the prairie potholes of North Dakota. U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. 1965 Progress Report. 14 pages.
- Sutherland, J. E. 1987. The predation ecology of the Northern Harrier (*Circus cyaneus hudsonius*) on Mallard Island, North Dakota. M.S. thesis. University of North Dakota, Grand Forks, North Dakota. 152 pages.
- Toland, B. R. 1985. Nest site selection, productivity, and food habits of Northern Harriers in southwest Missouri. Natural Areas Journal 5:22-27.
- Toland, B. R. 1986. Nesting ecology of Northern Harriers in southwest Missouri. Transactions of the Missouri Academy of Science. 20:49-57.
- Zimmerman, J. L. 1993. Birds of Konza: the avian ecology of the tallgrass prairie. University of Kansas Press, Lawrence, Kansas. 186 pages.