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The Effects of Management Practices on Grassland Birds—Upland Sandpiper (*Bartramia longicauda*)

Chapter F of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–F

U.S. Department of the Interior
U.S. Geological Survey

Cover. Upland Sandpiper. Photograph by David O. Lambeth, used with permission.
Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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By Jill A. Shaffer,[1] Lawrence D. Igl,[1] Douglas H. Johnson,[1] Meghan F. Dinkins,[1,2] Christopher M. Goldade,[1,3] Barry D. Parkin,[1] and Betty R. Euliss[1]

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The Effects of Management Practices on Grassland Birds

Edited by Douglas H. Johnson,[1] Lawrence D. Igl,[1] Jill A. Shaffer,[1] and John P. DeLong[1,4]

[1]U.S. Geological Survey.

[2]U.S. Forest Service (current).

[3]South Dakota Game, Fish and Parks (current).

[4]University of Nebraska-Lincoln (current).

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square meter (m^2)	10.76	square foot (ft^2)
hectare (ha)	0.003861	square mile (mi^2)
	Mass	
kilogram (kg)	2.205	pound (lb)
	Luminance	
candle per square meter (cd/m^2)	0.8361	candles per square yard (cd/yd^2)

Abbreviations

AUM	animal unit month
BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
DNC	dense nesting cover
spp.	species (applies to two or more species within the genus)

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Capsule Statement

The key to Upland Sandpiper (*Bartramia longicauda*) management is providing grasslands of various heights with few shrubs. In general, Upland Sandpipers forage within short vegetation and nest and rear broods within taller vegetation. Upland Sandpipers have been reported to use habitats with less than (<) 93 centimeters (cm) vegetation height, 5–75 cm visual obstruction reading, greater than or equal to (≥) 33 percent grass cover, less than or equal to (≤) 50 percent forb cover, ≤13 percent shrub cover, 3–12 percent bare ground, 11–30 percent litter cover, and <13 cm litter depth. The descriptions of key vegetation characteristics are provided in table F1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).

Breeding Range

Upland Sandpipers breed from northeastern British Columbia to southwestern Ontario; south to northeastern Oregon, Idaho, Wyoming, Colorado, and Oklahoma; east to Virginia; and north to New Brunswick (National Geographic Society, 2011). The relative densities of Upland Sandpipers in the United States and southern Canada, based on North American Breeding Bird Survey data (Sauer and others, 2014), are shown in figure F1 (not all geographic places mentioned in report are shown on figure). The species also breeds in southeastern Alaska, northern British Columbia, and southwestern Yukon Territory.

Upland Sandpiper. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Suitable Habitat

In general, Upland Sandpipers use areas with moderate grass cover, low-to-moderate forb cover, moderate-to-high litter cover, and sparse woody cover and bare ground (Buss and Hawkins, 1939; Rotenberry and Wiens, 1980; Renken, 1983; Skinner and others, 1984; Buhnerkempe and Westemeier, 1988; Sample, 1989; Kantrud and Higgins, 1992; Hull and others, 1996). Display perches, such as fence posts, may be important components of suitable habitat (Bent, 1962; Salt and

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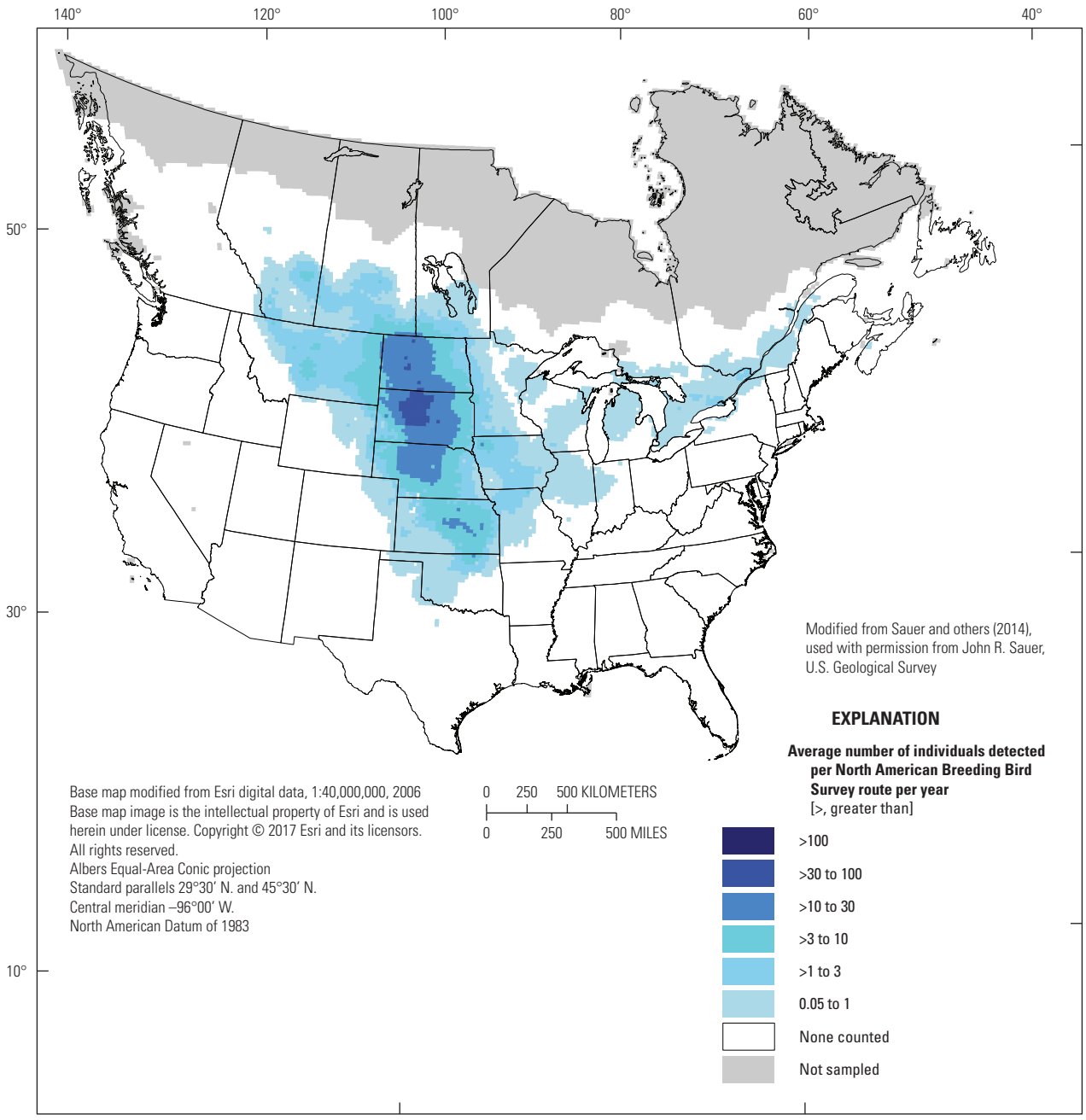

Figure F1. Breeding distribution of the Upland Sandpiper (*Bartramia longicauda*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

Salt, 1976; White, 1983; Snyder and others, 1987). Upland Sandpipers breed in a variety of habitats, including shortgrass, mixed-grass, and tallgrass prairies that are idle, burned, hayed, or grazed (Bent, 1962; Goering, 1964; Stewart, 1975; Salt and Salt, 1976; Johnsgard, 1980; White, 1980; Skinner and others, 1984; Kantrud and Higgins, 1992; King and Savidge, 1995; Houston and others, 2011; Garvey and others, 2013), as well as wet meadows and jack pine barrens (Dorio and Grewe, 1979; Sample, 1989; Faanes and Lingle, 1995; Kim and others, 2008; Korte, 2013; Corace and others, 2016). The species also uses tame grasslands and grassed waterways (Buss and Hawkins, 1939; Goering, 1964; Oetting and Cassel, 1971; Ailes and Toepfer, 1977; Sample, 1989; Bolster, 1990; Bryan and Best, 1991; Kantrud and Higgins, 1992). Planted cover, such as Conservation Reserve Program (CRP) fields, dense nesting cover (DNC), and Waterfowl Production Areas may provide suitable habitat (Renken and Dinsmore, 1987; Luttschwager and Higgins, 1992; Johnson and Schwartz, 1993a, 1993b; Faanes and Lingle, 1995; Johnson and Igl, 1995; King and Savidge, 1995; Hull and others, 1996; Roth and others,

2005). Upland Sandpipers inhabit cropland, such as wheat (*Triticum* species [spp.]) stubble, fallow fields, grains, and rowcrops (Bates, 1907; Bent, 1962; Oetting and Cassel, 1971; Higgins, 1975; Kirsch and Higgins, 1976; Ailes and Toepfer, 1977; Dorio and Grewe, 1979; Ducey and Miller, 1980; Buhnerkempe and Westemeier, 1988; Bolster, 1990; Hultquist and Best, 2001). The species uses open fields at airports (White, 1980; Snyder and others, 1987).

In North Dakota, South Dakota, Montana, Wyoming, Colorado, and Nebraska, densities of Upland Sandpipers were highest in areas with moderately grazed typic ustoll soils (Kantrud and Kologiski, 1982). In North Dakota mixed-grass prairies, Upland Sandpipers were associated with silty range and thin upland range sites; these sites were characterized by thin topsoil, loamy soil, 1–25-percent slope, grassy cover, low shrub coverage, and moderate-to-high litter coverage (Messmer, 1990). In the same area, Sedivec (1994) found Upland Sandpipers more frequently on overflow range sites (areas receiving more than normal soil moisture because of runoff from higher land or from flooding) than silty range sites. In Kansas, Upland Sandpipers appeared to prefer clay upland range sites and to avoid loamy upland range sites and limestone breaks (Bowen, 1976). The species used claypan and shallow range sites in proportion to their abundance; relative abundance of clay upland was a good predictor of use by Upland Sandpipers. In Wisconsin, Upland Sandpipers were found on areas of Clyde silt loam and peat but not on areas of Miami silt loam, possibly because these areas supported trees (Buss and Hawkins, 1939). In Michigan, soil types of areas where Upland Sandpipers had reliably bred for at least the previous 25 years were glacial outwash, coarse glacial till, and lacustrine sand and gravel (Korte, 2013; Corace and others, 2016).

Upland Sandpipers use native and tame grasslands but show no clear preference for either grassland type. In a study encompassing grasslands throughout the Great Plains, areas considered to be the best habitat for Upland Sandpipers were dominated by wheatgrass (formerly *Agropyron* spp.) and Kentucky bluegrass (*Poa pratensis*), followed by green needlegrass (*Nassella viridula*), buffalograss (*Bouteloua dactyloides*), western snowberry (*Symphoricarpos occidentalis*), and slimspike three-awn (*Aristida longespica*) (Kantrud and Kologiski, 1982). Dominant vegetation at nest sites in Manitoba, North Dakota, Montana, and South Dakota were Kentucky bluegrass, smooth brome (*Bromus inermis*), needle and thread (*Hesperostipa comata*), and quackgrass (*Elymus repens*), although most nests were located within native mixed-grass prairies. Within those same States and Province, Upland Sandpipers readily nested in stands of tame grasses; forbs and shrubs were dominant at very few nests (Kantrud and Higgins, 1992). In Saskatchewan, Upland Sandpipers were present in low abundance in native mixed-grass prairies and in tame grasslands dominated by crested wheatgrass (*Agropyron cristatum*) (Sutter and Brigham, 1998). In Manitoba, numbers of Upland Sandpipers were positively correlated with presence of native vegetation and negatively correlated with presence of tame vegetation (Wilson and Belcher, 1989). In northern North Dakota mixed-grass prairies, Upland Sandpiper occurrence was not related to coverage of Kentucky bluegrass, smooth brome and quackgrass, native grasses and forbs, or tame legumes (Grant and others, 2004). Within ungrazed grasslands in North Dakota and South Dakota, 93 percent of 41 nests were in either native or tame grasses located in idle fields or in rights-of-way (Higgins and others, 1969). Nests were primarily placed in little bluestem (*Schizachyrium scoparium*), needle and thread, porcupinegrass (*Hesperostipa spartea*), green needlegrass, junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*), smooth brome, Kentucky bluegrass, quackgrass, and crested wheatgrass; one nest was in alfalfa (*Medicago sativa*) and brome (*Bromus* spp.). The three nests not found in idle fields or in rights-of-way were in pastures. Within grazed grasslands in North Dakota, vegetation within 1 meter (m) of nests consisted of native grasses (needle and thread, green needlegrass, western wheatgrass [*Pascopyrum smithii*]) and small amounts of tame grasses such as Kentucky bluegrass and smooth brome (Bowen and Kruse, 1993). In South Dakota, Upland Sandpipers nested only in native prairie; 97 percent of the 33 nests were in prairies classified as in good or excellent range condition (Kaiser, 1979). The species preferred to nest in mixed-grass or tallgrass prairies, although nests also were found in Kentucky bluegrass. Nest success did not differ between nests in matted and upright residual vegetation or among nests in tallgrass prairies, in the transition zone between mixed-grass and tallgrass, or in mixed-grass prairies. In northwestern Minnesota, 91 percent of 22 nests were in native grasses (little bluestem, junegrass, and muhly [*Muhlenbergia* spp.]); the other two nests were in alfalfa (Lindmeier, 1960). Likewise, in southeastern Wisconsin, nests were placed in tame and native vegetation (junegrass, reed canary grass [*Phalaris arundinacea*], quackgrass, and timothy [*Phleum pratense*]), and two nests were found in legumes (alfalfa and sweetclover [*Melilotus* spp.]) (Buss and Hawkins, 1939). Nests initiated earlier in the nesting season were in pastures, whereas nests initiated later in the nesting season were in idle native grasslands. In central Minnesota and central Wisconsin, Upland Sandpipers nested in tame vegetation; study areas, however, may have contained little or no native vegetation (Ailes, 1976; Dorio, 1977). Dorio (1977) noted that the species nested in smooth brome, quackgrass, yarrow (*Achillea millefolium*), goldenrod (*Solidago* spp.), and in wet meadows (annually mowed sedge [*Carex* spp.], timothy, and Canada bluegrass [*Poa compressa*]). In Illinois, Upland Sandpipers preferred stands of Kentucky bluegrass and other tame grass species as opposed to tallgrass prairie and preferred older (greater than [>] 5 years old) plantings of tame grasses and forbs (Birkenholz, 1973; Buhnerkempe and Westemeier, 1988). Musselman (1935) noted that Upland Sandpipers in Missouri and Illinois nested within an idle clover (*Trifolium* spp.) field and an idle grassland. In Kansas, Upland Sandpipers nested in tallgrass prairies as well as in tame grasses (Goering, 1964). Nests were within dense stands of ungrazed big bluestem (*Andropogon gerardii*) and little bluestem, in spring-burned three-awn, in

heavily grazed smooth brome, and in clumps of yellow sweetclover (*Melilotus officinalis*) within weedy, ungrazed brome. In Nebraska, King and Savidge (1995) observed Upland Sandpipers in CRP fields seeded with warm-season grasses and native tallgrass prairies.

Upland Sandpipers prefer grasslands with minimal coverage of woody vegetation. In North Dakota mixed-grass prairies, Upland Sandpipers were present in grasslands with a lower percentage cover of shrubs >1 m tall than in unoccupied grasslands (Grant and others, 2004). Occurrence was not related to the percentage cover of shrubs <1 m tall. In mixed-grass prairies in South Dakota, Upland Sandpipers generally were more abundant in early seral stage areas than in late seral stage areas; seral stage was defined by percentage cover of three grass species and their frequency of occurrence (Fritcher and others, 2004). In Wisconsin, Upland Sandpipers avoided sites with woody vegetation (Sample, 1989). Sandpiper density was highest in areas with a medium density of prostrate residual vegetation; medium density was defined as <3 cm deep with >50 percent coverage. Density of Upland Sandpipers was negatively correlated with total percentage of woody cover, total number of dead stems, maximum vegetation height, and vegetation height-density. In another Wisconsin study, Upland Sandpipers were more numerous in nonforested areas with level terrain and with large agricultural fields, preferably hay, oats (*Avena* spp.), or pasture, but not corn (*Zea mays*) (White 1980, 1983).

In a multi-State study, the abundance of Upland Sandpipers was positively correlated with the total number of vertical vegetation hits and negatively correlated with the percentage of bare ground (Rotenberry and Wiens, 1980). Within DNC fields in North Dakota, the species used plots with less grass, less forb coverage, shorter and less dense vegetation, and a thinner litter layer than unused plots (Renken, 1983; Renken and Dinsmore, 1987). In North Dakota mixed-grass prairies, Upland Sandpipers were present in grasslands with lower maximum vegetation height and lower percentage cover of live vegetation than in unoccupied grasslands (Grant and others, 2004). Occurrence was not related to litter depth or year. In Colorado, the species used lightly to moderately grazed pastures and bare ground in proportion to the availability of these habitat features (Bolster, 1990). Upland Sandpipers preferred medium-height vegetation in shortgrass prairies and preferred grass-like vegetation more than tangled vegetation. Before incubation, the species used heavily grazed fields more often and weedy fields less often than expected. In North Dakota tallgrass prairies, Upland Sandpiper abundance was affected by the interaction between vegetation height-density (visual obstruction reading) and litter depth; abundance generally increased with variability in litter depth but decreased with high levels of litter depth and vegetation height-density (Ahlering and Merkord, 2016).

Vegetation structure, time of day, daily activities, and phase of nesting cycle influence habitat use (Dorio, 1977; Dorio and Grewe, 1979; Bolster, 1990). For example, in Colorado, Upland Sandpipers were encountered most frequently on heavily grazed (average vegetation <10 cm tall) pastures and on cut and baled alfalfa fields during the morning; during the evening, the species preferred bare ground and small-grain fields in which vegetation was <27 cm tall (Bolster, 1990). In Wisconsin, territories included loafing, nesting, and feeding sites; suitable loafing areas were pastures with low-growing clumps, sparsely vegetated grassland, and open hayland (Buss and Hawkins, 1939). Loafing and feeding sites were near nesting sites and were shared by several sandpiper pairs. In Kansas, Upland Sandpipers used brood rearing sites characterized by short vegetation, low grass density, high bare ground coverage, and a mix of forbs, woody vegetation, and grass coverage (Mong, 2005).

Upland Sandpipers prefer to forage in short vegetation. Upland Sandpipers exhibited seasonal use of foraging habitats in Minnesota (Dorio, 1977; Dorio and Grewe, 1979). Upon first arriving on the breeding grounds in spring, Upland Sandpipers used plowed and seeded fields; in May, sedge-grass meadows were used until vegetation was 30 cm tall; in May and June, overgrazed pastures were used; and in late summer, mowed fields of red clover (*Trifolium pratense*) were used when vegetation was 2.5–15 cm tall. In Wisconsin, a few Upland Sandpipers were observed foraging in plowed and fallow (previously pasture, but plowed and left idle) fields and recently seeded corn fields, in which corn was 5–10 cm tall (Ailes, 1976; Ailes and Toepfer, 1977). Corn fields were no longer used by the species when the corn was >15 cm tall. Overall, however, idle fields, plowed fields, and cropland were used infrequently for foraging, and feeding occurred mostly in grazed pastures, followed by ungrazed pastures and hayfields (Ailes, 1976). In Nebraska, Upland Sandpipers foraged in pastures and corn fields before corn emerged or while corn was still short (Ducey and Miller, 1980). In another Nebraska study, Upland Sandpipers foraged in wheat stubble that contained grain (Bates, 1907). Graber and Graber (1963) suggested that open and idle fields and cropland were used for foraging in Illinois. In Minnesota, both young and adult birds preferred to feed in vegetation <10 cm tall (Dorio, 1977; Dorio and Grewe, 1979). Zimmerman (1993) surmised that the Upland Sandpiper was most abundant in annually burned grasslands in Kansas because the species used these areas as foraging habitat. In another Kansas study, Goering (1964) reported that Upland Sandpipers foraged in areas with short grass, especially burned pastures, upon their arrival in spring. In Indiana, the species foraged in mowed areas and in idle tallgrass prairies (Snyder and others, 1987).

Upland Sandpipers nest in a variety of habitats, ranging from idle prairies with dense, homogeneous vegetation to wet meadows, oldfields (idle or neglected arable lands that have naturally reverted back to perennial cover), pastures, hayland, cropland, tame vegetation, burned areas, and sandy areas with sparse vegetation (Musselman, 1935; Buss and Hawkins, 1939; Bent, 1962; Graber and Graber, 1963; Goering, 1964; Higgins, 1975; Ailes, 1976; Dorio, 1977; Dorio and Grewe, 1979; White, 1980; Snyder and others, 1987; Buhnerkempe and Westemeier, 1988; Colwell and Oring, 1990; Kantrud and

Higgins, 1992; Faanes and Lingle, 1995). Nests may be placed in depressions covered by grass arching over the top, in grass clumps, in dense vegetation, or at the base of forbs or shrubs (Buss and Hawkins, 1939; Lindmeier, 1960; Bent, 1962; Ailes, 1976; Kirsch and Higgins, 1976; Salt and Salt, 1976; Skinner and others, 1984). In Alberta, Saskatchewan, and Manitoba, Upland Sandpipers preferred nesting in native grasslands, either grazed or idled, more than in cropland, hayland, planted cover, wetland, or woodland habitats; however, daily nest-survival rates were not higher in the preferred habitat (Garvey and others, 2013). Of 41 nests located in the Missouri Coteau of North Dakota, 38 were in idle grasslands characterized by moderately tall grasses and abundant ground litter (Higgins and others, 1969). In another North Dakota study, Upland Sandpipers chose nest sites with less grass coverage than random locations (Wiens, 2007). In Wisconsin, choice of nesting sites changed as the season progressed; nests initiated early in the breeding season were located in pastures, whereas nests initiated later in the breeding season were in ungrazed prairies (Buss and Hawkins, 1939). In another Wisconsin study, 38 percent of 553 nests were in pastures, one-fifth of which were in burned pastures White (1983). An additional 28 percent of nests were in tallgrass prairies, 7 percent in hayfields, and the remainder in woody areas, cropland, wetlands, and idle fields adjacent to airport runways. In Colorado, nesting Upland Sandpipers appeared to prefer lightly grazed pastures (average vegetation 17–23 cm tall) and small-grain fields (vegetation <27 cm tall), and to use tall (>27 cm) alfalfa and small-grain fields (vegetation ≥27 cm tall) less than expected (Bolster, 1990).

Vegetation height around Upland Sandpiper nests generally ranges from 10.2 to 63.5 cm (Lindmeier, 1960; Goering, 1964; Higgins and others, 1969; Ailes, 1976; Kaiser, 1979; Buhnerkempe and Westemeier, 1988; Eldridge, 1992). In Saskatchewan, Upland Sandpipers nested in tall, dense, homogeneous vegetation >15 cm tall (Colwell and Oring, 1990). In North Dakota, Upland Sandpipers most commonly nested in areas where grass accounted for ≥50 percent canopy cover and forbs accounted for <50 percent canopy cover (Bowen and Kruse, 1993). Two other habitats used for nesting were those in which forbs accounted for ≥50 percent canopy cover and grass for <50 percent canopy cover, or in which western snowberry with a grass understory accounted for <50 percent canopy cover. Habitats were avoided in which western snowberry with a grass understory accounted for ≥50 percent canopy cover. In South Dakota, nest concealment in grazed prairie was measured from various angles: all nests had ≥50 percent vertical concealment by residual and living vegetation, 33 percent of nests were concealed on all sides, 55 percent were concealed on two sides, and 12 percent had no side concealment (Kaiser, 1979). In northwestern Minnesota, vegetation height at nests measured within 10 days after the first egg was laid averaged 25.4 cm and consisted largely of residual vegetation (Lindmeier, 1960). Standing vegetation over Upland Sandpiper nests was fairly sparse, with an average light intensity of 222 candles per square meter (m^2) for 12 nests. In another study in northwestern Minnesota, mean vegetation measurements from 40 sampling points within four Upland Sandpiper territories were 79 cm vegetation height, 35 percent ground cover (coverage of live vegetation with a total height of ≤10 cm), and 24 cm phanerophyte height (Niemi and Hanowski, 1983). Phanerophytes were defined as shrubs, forbs, or graminoids >40 cm tall and present each year. In Wisconsin, Upland Sandpipers did not initiate nests in vegetation >40 cm tall, although by the time the eggs hatched, vegetation was as tall as 70 cm (Ailes, 1976, 1980).

Sparse-to-moderate forb coverage may be an important component of suitable nesting habitat (Skinner, 1975; Renken, 1983; Buhnerkempe and Westemeier, 1988; Klute, 1994; Hull and others, 1996; Klute and others, 1997). In Minnesota, the predominant forbs within territories were bedstraw (*Galium* spp.), goldenrod, and clover (Niemi and Hanowski, 1983). In Greater Prairie-Chicken (*Tympanuchus cupido*) sanctuaries in Illinois, Upland Sandpipers preferred to nest in fields of seeded grasses that were being invaded by forbs (Buhnerkempe and Westemeier, 1988). In Missouri, Skinner (1974) found fewer Upland Sandpipers in fields that were predominantly forbs than in fields with scattered forbs or with no forbs. In Kansas tallgrass prairies, Upland Sandpipers were significantly more abundant in pastures than in CRP grasslands; grazed pastures had significantly greater coverage of total vegetation, live vegetation, grasses, and forbs than did CRP grasslands (Klute and others, 1997). In Kansas CRP fields, Upland Sandpipers were present in fields described as having a medium frequency of occurrence of forbs (Hull and others, 1996). In Oklahoma, Upland Sandpiper abundance increased with the percentage of forb cover in tallgrass pastures as well as with distance to rock outcrops (that is, any large [>2 m], upright, naturally occurring rocky structure) (Coppedge and others, 2008).

Brood rearing typically occurs in recently disturbed habitats and in areas with shorter, sparser vegetation. In Minnesota, broods used weedy fields, open areas within oldfields, and overgrazed pastures (Dorio, 1977; Dorio and Grewe, 1979). Marshy areas of sedge and cattails (*Typha* spp.) that had dried during drought were used as escape cover by broods. In Wisconsin, brood rearing occurred mostly in heavily grazed (vegetation <10 cm tall) pastures, followed by ungrazed pastures and hayfields (Ailes, 1976). Some broods were observed in idle fields, plowed fields, and cropland. Late-summer feeding occurred mainly in heavily and moderately grazed pastures; lightly grazed pastures were used infrequently (Ailes, 1980). In Illinois, broods were observed in wheat stubble, recently hayed legumes, redtop (*Agrostis gigantea*) intermixed with weeds, and moderately grazed pastures (Buhnerkempe and Westemeier, 1988). In Colorado, brood rearing occurred within short (≤27 cm tall) and cut alfalfa and small-grain fields (vegetation <27 cm tall) more often than expected, whereas small-grain fields (vegetation ≥27 cm tall) were used less often than expected (Bolster, 1990). Bolster (1990) observed a noticeable movement of broods from pastures to alfalfa fields. Prior to migration, heavily grazed fields and cut and baled

alfalfa fields were used more often, and lightly grazed fields, weedy fields, tall alfalfa, and small-grain fields (vegetation ≥27 cm) were used less often than expected.

Moisture levels may affect the abundance of Upland Sandpipers, but as Niemuth and others (2017) stated, the biological meaning of climate variables in models characterizing bird-environment relationships is unclear; they are likely correlates of other factors (for example, plant community composition, primary and secondary productivity) that more directly influence species occurrence, likely in concert with other factors such as soils and landform. Using North American BBS data for four States within the Badlands and Prairies Bird Conservation Regions, Gorzo and others (2016) reported that Upland Sandpiper abundance was positively related to a within-year standardized temperature index, but not to the previous year's temperature index or to a standardized precipitation index. Using BBS data for seven States within the U.S. portion of the northern Great Plains, some of the same BBS routes used by Gorzo and others (2016), Niemuth and others (2017) reported that the occurrence of Upland Sandpiper exhibited a quadratic relationship with the means of long-term (30-year) precipitation and January temperatures, indicating that intermediate values of these climatic variables best explained the species' distribution.

Area Requirements and Landscape Associations

Territory sizes in Wisconsin ranged from 8 to 12 hectares (ha) (Wiens, 1969). In Kansas, home-range size during the breeding season averaged 199 ha for 21 males and 247.7 ha for 23 females (Mong, 2005). Males provided most of the care posthatching, and the average brood rearing home-range size of 200.8 ha based on nine males was three times as large as the nesting home-range size of 67.02 ha based on 14 males.

Upland Sandpipers are sensitive to habitat fragmentation (Herkert, 1991a; Herkert and others, 1993; Vickery, 1993; Winter, 1998; Ribic and others, 2009), and abundance may be positively correlated with patch size (Herkert, 1994; Vickery and others, 1994; Bollinger, 1995; Helzer, 1996; Thogmartin and others, 2006; Vos and Ribic, 2011). In Illinois, Upland Sandpipers were present in grasslands >30 ha (Herkert, 1991b, 1991c). In southwestern Missouri, Upland Sandpipers occurred only on tallgrass prairie fragments >75 ha (Winter, 1998). In Nebraska, Upland Sandpipers required a minimum area of 50–61 ha, with a perimeter-area ratio of 0.008, to reach 50 percent incidence (Helzer, 1996; Helzer and Jelinski, 1999). Occurrence of Upland Sandpipers was positively correlated with patch area and inversely correlated with perimeter-area ratio (Helzer and Jelinski, 1999). In Wisconsin, Upland Sandpipers were found only on large grassland patches (>45 ha) and were absent from smaller patches (<10.5 ha) (Vos and Ribic, 2011). In a second Wisconsin study with patches ranging in size from 4 to 267 ha, Vos and Ribic (2013) reported that Upland Sandpipers occurred only on the largest prairie patch. However, in Canada, Garvey and others (2013) found no relationship between daily nest survival and patch size, proximity to an edge, amount of edge, distance to wetland edge, or to proportion of cropland or natural idled grasslands. In Maine, Upland Sandpipers were rare in areas <50 ha and reached 50 percent incidence in areas that were 200 ha (Vickery, 1993; Vickery and others, 1994).

Upland Sandpipers are generally intolerant of woody vegetation. In North Dakota mixed-grass prairies, Grant and others (2004) classified the Upland Sandpiper as a woodland-sensitive species. The species' maximum probability of occurrence never exceeded 30 percent within the study area, and the probability of occurrence declined to <20 percent at about 20 percent woodland cover. Upland Sandpipers were present in grasslands with a lower percentage of aspen woodland within 100 m and 500 m than in unoccupied grasslands. In North Dakota tallgrass prairies, Upland Sandpiper occurrence was negatively associated with grassland and woodland cover at the 100-m scale and with tree cover at the 400-m scale (Cunningham and Johnson, 2006). In Wisconsin, Upland Sandpiper abundance was highest in an 800-ha landscape with high grassland coverage and low forest coverage (Murray and others, 2008). Using BBS data from Minnesota, Wisconsin, and Michigan, Thogmartin and others (2006) reported Upland Sandpiper abundance was negatively associated with the percentage of forest in the landscape. Niemuth and others (2017) investigated the relationship between Upland Sandpiper occurrence and land use within an 800-m landscape of BBS points throughout the northern Great Plains; occurrence was positively associated with percent coverage of grasslands (native and tame), pasture and hayland (native and tame), shrubland, cropland, and emergent wetlands, but was negatively associated with percent coverage of forest, open water, and developed land.

Brood Parasitism by Cowbirds and Other Species

Brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) is infrequent in Upland Sandpiper nests (Friedmann, 1963; Friedmann and Kiff, 1985; Houston and others, 2011). Upland Sandpipers are unsuitable cowbird hosts because their young are precocial and nidifugous. Rates of parasitism varied from 0 percent (several studies) to 8 percent of 13 nests (Berman, 2007), as summarized in Shaffer and others (2019a).

Breeding-Season Phenology and Site Fidelity

Upland Sandpipers arrive on the breeding grounds from early April to early May (Buss and Hawkins, 1939; Lindmeier, 1960; Bent, 1962; Goering, 1964; Maher, 1973; Higgins and Kirsch, 1975; Ailes, 1976, 1980; Bowen, 1976; Dorio, 1977; Johnsgard, 1980; Buhnerkempe and Westemeier, 1988; Kantrud and Higgins, 1992). They depart from mid-July to late August (Buss and Hawkins, 1939; Bent, 1962; Goering, 1964; Wiens, 1969; Maher, 1973; Higgins and Kirsch, 1975; Ailes, 1976, 1980; Dorio, 1977; Johnsgard, 1980; Bolster, 1990).

Breeding-site fidelity has been observed (Ailes, 1976, 1980; Bowen, 1976; Dorio, 1977). In a Kansas population of radio-marked and color-banded birds, annual return rates varied from 20 to 50 percent; radio-harnessed birds had lower odds of returning than birds without radios (Mong and Sandercock, 2007). Upland Sandpipers sometimes nest semicolonially (Buss and Hawkins, 1939; Bowen, 1976; Bowen and Kruse, 1993). Patterns of nest aggregation may reflect females preferentially settling near relatives, as in cases of joint settlement of female siblings or female-biased natal philopatry (Casey and others, 2011).

Time limitations within a nesting season make double-broodedness unlikely for Upland Sandpipers. However, renesting following failure of initial nests has been reported (Buss and Hawkins, 1939; Lindmeier, 1960; Dorio and Grewe, 1979).

Species' Response to Management

Because Upland Sandpipers use sites with a range of vegetation characteristics throughout the breeding season, management may have different effects on the species depending on the stage of the nesting cycle at the time of the disturbance.

Burning generally benefits Upland Sandpipers, especially by providing habitat for foraging. In Saskatchewan, Upland Sandpipers used a burned plot 2–3 years postburn during 3 years of postburn monitoring, but were not observed on an unburned plot (Pylypec, 1991). Bent (1962) suggested that burning and cultivation of mixed-grass prairie in Saskatchewan forced Upland Sandpipers to nest in cultivated fields. In Minnesota, a 75-percent reduction in nesting cover due to spring fire may have reduced the number of Upland Sandpipers in the year of the burn (Lindmeier, 1960); numbers of breeding pairs returned to preburn levels in the following year. Likewise, in Wisconsin, burning reduced or eliminated nesting attempts in fields where nesting had occurred in the year previous to the burn (Buss and Hawkins, 1939). In mixed-grass prairies in North Dakota, Upland Sandpipers were more abundant immediately following a burn and 1 year after a burn than 2–15 years postburn (Johnson, 1997). In tallgrass prairies of southeastern North Dakota, Upland Sandpipers were most abundant on burned pastures in the wettest year of a 3-year study (Ahlering and Merkord, 2016). In South Dakota, Upland Sandpipers used a burned native pasture significantly more than an unburned pasture (Huber and Steuter, 1984). In another South Dakota study, the species nested at high densities on idle, mowed, and burned prairies (Lokemoen and Duebbert, 1974). In Illinois tallgrass prairies, Upland Sandpipers were most abundant 2 years postburn, but were absent 3 years postburn (Herkert, 1994). In Illinois grasslands that were seeded to both native and tame grasses, Upland Sandpipers preferred nesting in fields 1 year after a burn (Buhnerkempe and Westemeier, 1988). Burned fields were not preferred in the following years, and number of years postburn did not affect nest density.

Many studies have evaluated Upland Sandpiper response to burning in the tallgrass prairies of the Kansas and Oklahoma Flint Hills. Upland Sandpipers appeared to use unburned grasslands for nesting and foraging and annually burned grasslands for foraging, but they nested in watersheds that were not burned in spring (Zimmerman, 1993). Goering (1964) found nests in burned native grasslands as well as in heavily grazed and ungrazed native and tame grasslands. Eddleman (1974) observed Upland Sandpipers on heavily grazed and annually burned pastures, moderately grazed and unburned pastures, and ungrazed and burned areas; Upland Sandpipers did not use unburned and ungrazed areas. Robel and others (1998) found that Upland Sandpipers were present only on spring-burned, seeded-native CRP fields and not on unburned fields. Bowen (1976) observed that Upland Sandpiper abundance did not differ between burned and unburned pastures in Kansas. Radio-marked Upland Sandpipers preferred sites that were recently burned and grazed, followed by burned and ungrazed sites, unburned and ungrazed sites, and unburned and grazed sites (Mong, 2005). The species preferred the most recently burned sites over areas that had not been burned for more than 1 year and showed no preference for grazed or ungrazed areas. Hovick and others (2015) established seven experimental pastures with varying levels of patchiness ranging from annually burned with spring-only fires to a 4-year fire-return interval to examine the interaction of fire and grazing; Upland Sandpiper density was positively influenced by number of patches (that is, increasing heterogeneity), was not related to fire-return interval, and was negatively related to vegetation height.

In the Kansas Flint Hills, Powell (2006) examined the effect of American bison (*Bison bison*) grazing and prescribed burns on grassland bird abundance. Upland Sandpipers were more abundant in pastures in the season of burn and ≥4 years postburn than 1–3 years postburn. Upland Sandpipers also increased with bison grazing. Bison were stocked at low intensity (5 ha per animal with the expected consumption of 25 percent of aboveground plant growth). Powell (2008) also examined the effect of cattle grazing and prescribed burns on grassland bird abundance. Upland Sandpiper abundance was higher during the year of burns than 1–3 years after the last burn and in areas grazed by cattle. Cattle were grazed at low intensity (3 ha per cow-calf pairs with the expected consumption of about 25 percent of aboveground plant growth). Upland

Sandpipers were significantly more abundant in burned idle grasslands than unburned idle or hayed grasslands (Powell and Busby, 2013).

In the Oklahoma Flint Hills, Upland Sandpipers were as abundant in annually burned pastures as in pastures burned in a patch-mosaic pattern (that is, portions of the pasture were burned on a 3-year fire-return interval; Coppedge and others, 2008). However, within the same tallgrass pastures, Upland Sandpiper abundance was five times higher in patches with recent disturbances (that is, patches averaging 100 ha burned once in either spring or autumn every 3 years with cattle stocked at 1.2 ha per 270-kilogram [kg] steer) than pastures not burned within the past 36 months, and 2.5 times greater in pastures with recent focal disturbances than in annually spring-burned pastures stocked from mid-April to mid-July (Fuhlendorf and others, 2006).

Upland Sandpipers readily use hayfields, although haying disturbances may cause nest failure (Ducey and Miller, 1980; Houston and others, 2011). Igl and Johnson (2016) assessed the effects of emergency and managed haying on grassland breeding birds in 483 CRP grasslands in nine counties in four States in the northern Great Plains between 1993 and 2008. Upland Sandpiper densities in CRP grasslands that had been idled for more than 5 years did not differ from sandpiper densities in CRP grasslands that had been hayed 1, 2, 3, or 4 years earlier. In North Dakota, Upland Sandpipers used previously idled areas only after the areas were mowed (Messmer, 1990). In Wisconsin, Upland Sandpipers occurred at higher densities in haylands than in pastures and wet prairies, although differences in densities were not statistically significant (Sample, 1989). Upland Sandpipers were located in annually mowed native prairies (dominated by porcupinegrass) in Iowa (Kendeigh, 1941). In Iowa and Wisconsin CRP fields planted to switchgrass (*Panicum virgatum*), Upland Sandpipers were more abundant in harvested plots than in unharvested plots (Murray and Best, 2003; Roth and others, 2005). In Wisconsin, the species nested in hayland the first year after mowing (Ailes, 1976). In Illinois grasslands that were seeded to native and tame grasses, Upland Sandpipers preferred nesting in fields 1 year after the fields were rotary mowed, whereas grass meadows harvested for seed the previous year were used as nesting habitat less frequently than were other grasslands (Buhnerkempe and Westemeier, 1988). In Missouri, hayfields were preferred over seed-combined fields and were used for foraging and loafing (Skinner, 1974). Skinner (1974, 1975) also compared Upland Sandpiper density between idle fields and fields subjected to haying, seed combining, or grazing at four intensities. Density of Upland Sandpipers was highest under moderate grazing (vegetation 10.2–30.4 cm tall, 20–40 percent grass and forb coverage at 25 cm tall) and heavy grazing (vegetation 0–10.2 cm tall, <20 percent grass and forb coverage at 25 cm tall) (Skinner, 1975, 1982). Upland Sandpipers were present in hayed, combined, and lightly grazed fields (vegetation >30.4 cm tall) but not in idle fields.

Upland Sandpipers use grazed areas for nesting, foraging, and brood rearing (Ailes, 1976; Dorio, 1977), although the effects of grazing vary among studies. Nest loss occasionally occurs as a result of trampling by cattle (Buss and Hawkins, 1939; Ailes, 1976, 1980; Dorio, 1977; Bowen and Kruse, 1993). In Alberta, Upland Sandpipers were found only on deferred-grazed native areas (Prescott and Wagner, 1996). Treatments included tame pastures of crested wheatgrass grazed in spring from late April to mid-June, native grasslands grazed in early summer, and native grasslands grazed after July 15 (deferred); the control was a continuously grazed native pasture. In Saskatchewan, Upland Sandpipers were observed on grazed pastures but not on ungrazed areas (Dale, 1984). In Ontario, Upland Sandpipers preferred lightly grazed pastures over hayland, oldfields, and cropland (Speirs and Orenstein, 1967). In North Dakota, Upland Sandpipers were more attracted to heavily grazed, native grasslands than to lightly grazed, moderately grazed, or mowed grasslands, although densities were relatively high in all habitats compared to other bird species (Kantrud 1981). In south-central North Dakota, Upland Sandpipers only occurred in extremely grazed pastures (20 percent of forage produced in an average year remained, equating to an average grazing rate of 6.8 animal unit months [AUMs] per ha) and not in lightly, moderately, or heavily grazed pastures (35–65 percent forage removed, or 1.1–4.2 AUMs per ha) (Salo and others, 2004). In tallgrass prairies of southeastern North Dakota, grazing intensity of 0–4.57 AUMs per ha (1 cow-calf pair on range for 1 month, regardless of weight) did not negatively affect Upland Sandpiper abundance (Ahlering and Merkord, 2016). Over a broader geographic range (North Dakota, South Dakota, Montana, Wyoming, Colorado, Nebraska), however, Kantrud and Kologiski (1982) did not find any relationship between density of Upland Sandpipers and grazing intensity. Upland Sandpiper densities were significantly higher in idle and grazed mixed-grass prairies than in tame DNC fields; the species also occurred in areas the first year after grazing (Renken, 1983; Renken and Dinsmore, 1987). In Nebraska, Upland Sandpipers were present on areas grazed by cattle and areas that were grazed by American bison and that also were burned (Griebel and others, 1998). In another Nebraska study, Upland Sandpiper densities were similar on grazed and ungrazed plots, but densities in ungrazed plots were highest under moderate moisture levels (Kim and others, 2008). The species also preferred pastures that were grazed year-round by cows and calves than pastures that were grazed by steers. In a third Nebraska study, avian diversity and density were higher on grazed than ungrazed areas because of the presence of species, including the Upland Sandpiper, that were not present on ungrazed areas (Cole and Sharpe, 1976). In the Nebraska Sandhills, Kempema (2007) examined the effect of grazing system duration on Upland Sandpiper density. Average values during the growing season (May 1 to September 30) for short duration was a rotation of 3 days of grazing at 1.4 AUMs per ha (11 animals per ha); medium duration was 23 days at 1.3 AUMs per ha (2.5 animals per ha), and long duration was 78 days at 1.4 AUMs per ha (0.6 animals per ha). Upland Sandpiper densities were similar among grazing systems, with

the highest density occurring on the long-duration system. Shrub coverage provided the best explanation for variation in densities in that as shrub cover increased, densities decreased. In Kansas, Upland Sandpipers preferred grazed pastures more than ungrazed pastures (Bowen, 1976).

Several studies have evaluated the effects of grazing on nest productivity in mixed-grass prairies in south-central North Dakota. Messmer (1990) and Sedivec (1994) compared rotational grazing systems, specifically short-duration grazing and twice-over rotation grazing, to season-long grazing and idle grasslands. Short-duration grazing involves a system of pastures rotated through a grazing schedule of about 1 week grazed and 1 month ungrazed, repeated throughout the season (usually late May or early June to October). Twice-over rotation involves grazing a number of pastures twice per season, with about a 2-month rest in between grazing. Season-long grazing involves leaving cattle on the same pasture throughout the growing season. Research by Messmer (1985, 1990) revealed that nest density and nest success were higher on twice-over deferred and season-long grazing systems than on idle pastures, but that average density of breeding Upland Sandpipers was highest on the short-duration grazing system. As range conditions on the short-duration pastures improved and cover increased, sandpiper density decreased. In a continuation of Messmer's study, Sedivec (1994) reported that nest density was significantly higher on grazed than on idle grasslands. Both authors concluded that grazing is compatible with the breeding needs of Upland Sandpipers. Bowen and Kruse (1993) and Kirsch and Higgins (1976) examined seasonality and intensity of grazing, respectively. Bowen and Kruse (1993) compared nest density among five grazing treatments: autumn grazing, autumn-and-spring grazing, season-long grazing, spring grazing, and ungrazed. Nest densities were lower in pastures subjected to grazing during the nesting season (autumn-and-spring grazing, season-long grazing, and spring grazing) than in control fields or fields with autumn grazing. Nest densities did not differ between spring grazing with high stocking density (3.7 head of cattle per ha and grazing rate of 3.1 AUMs per ha) to that of season-long grazing with low stocking density (1.0 head of cattle per ha and grazing rate of 2.45 AUMs per ha). Nest densities were significantly lower in years after pastures had been subjected to season-long and autumn-and-spring grazing than in the year before grazing treatments occurred. Allowing mixed-grass prairies to remain idle for 2–3 years between grazing treatments was not detrimental to breeding Upland Sandpipers (Bowen and Kruse, 1993).

Within mixed-grass and tallgrass prairies in South Dakota, nest densities did not differ between idle sites and sites that were grazed in May at a grazing rate of 1–2.5 AUMs per ha and in which 20–80 percent of the current year's growth was removed (Kaiser, 1979). Fourteen nests were found within a 256-ha fragment of moderately grazed prairie in South Dakota (Lokemoen and Duebbert, 1974). In North Dakota, Kirsch and Higgins (1976) reported that mean nest productivity was lowest on tilled areas (where no nests were observed), higher on grazed and idle areas, and highest on burned areas. The highest nest density of 6.8 nests per 40.5 ha was on a grassland area burned 2 years previously. In North Dakota, South Dakota, Montana, and Manitoba, nest success was higher in idle grasslands than in grazed pastures (Kantrud and Higgins, 1992). In eastern Kansas, Upland Sandpipers preferred native pastures to CRP grasslands seeded to native grasses, both of which were annually burned; nests were found only in pastures (Klute, 1994; Klute and others, 1997). In Missouri, nests were found on grazed tallgrass prairie (Skinner and others, 1984).

Upland Sandpipers have been reported as relatively uncommon in CRP and DNC grasslands and rowcrops compared to other habitats (Kantrud and Higgins, 1992; Klute, 1994; Best and others, 1997). The species may prefer cropland to CRP fields or idle fields (Skinner, 1975; Johnson and Igl, 1995; Best and others, 1997; Herkert, 2009), although Patterson (1994) and Patterson and Best (1996) reported that the species nested in Iowa CRP fields but not in rowcrops. In a multi-State study, abundance of Upland Sandpipers decreased after the establishment of CRP fields (Herkert, 2009). In North Dakota, densities of Upland Sandpipers were higher in idle and grazed native prairies than in DNC fields (Renken and Dinsmore, 1987). At a landscape scale, Uden and others (2015) evaluated four scenarios of land use change in Nebraska, and the influence of rowcrop, CRP, and switchgrass area on Upland Sandpiper abundance. The first scenario was a baseline condition in which some rowcrops were converted to switchgrass under current conditions of climate, irrigation limitations, commodity prices, ethanol demand, and continuation of the CRP. The second scenario converted more rowcrops to switchgrass. The third scenario converted all CRP to switchgrass, and the final scenario converted all CRP to rowcrops. Upland Sandpiper abundance increased 0.7–2 percent under the first two scenarios, increased little under scenario 3, and did not change under scenario 4, indicating that replacing rowcrops with switchgrass was more beneficial to Upland Sandpipers than replacing CRP with switchgrass or rowcrops. Conversely, Veech (2006) used BBS data to characterize the landscape within a 30-kilometer (km) radius of populations of Upland Sandpipers throughout the Great Plains that were increasing or decreasing; CRP comprised a greater proportion of the landscape for increasing populations than for decreasing populations, and urban land comprised a greater proportion for decreasing populations. The proportion of rangeland did not differ between increasing and decreasing populations.

Cultivation may negatively affect Upland Sandpipers (Bent, 1962; Ailes, 1976; Faanes and Lingle, 1995) by eliminating brood rearing areas and forcing broods to use edge habitats (Dorio, 1977). In Michigan, Upland Sandpipers preferred hayfields, pastures, and grasslands over rowcrop agricultural fields (Korte, 2013). In Nebraska, Upland Sandpipers preferred untilled areas, such as alfalfa fields and pastures, more than tilled areas; however, the species foraged in corn fields before and just after emergence of the corn plants (Ducey and Miller, 1980). In south-central North Dakota,

hatching success was lowest on annually tilled cropland (none of six nests hatched) and highest on burned and idle grasslands (Kirsch and Higgins, 1976). Also in south-central North Dakota, Upland Sandpipers seemed to prefer minimum-tillage (seeding into untilled or moderately tilled land) and organic farming (cultivation and crop rotation, but no chemicals, were used to control weeds) over conventional tillage (spring and fall tillage and use of herbicides); most nests were placed in wheat stands that were physically similar to grasslands (Lokemoen and Beiser, 1997). In another North Dakota study, Upland Sandpipers preferred nesting in untilled uplands (road rights-of-way, bands of vegetation around wetlands, heavily grazed grasslands, and idled grasslands) over fallow (bare ground), mulched or standing stubble fields, or growing small grain (Higgins 1975). In Illinois, the species preferred seeded grasses mixed with forbs, such as young, rotary-mowed seedings and older meadows harvested for grass seed, as nesting habitat (Buhnerkempe and Westemeier, 1988). Upland Sandpipers preferred nesting in fields that were >5 years postseeding, especially in those fields that were >8 years old. Fields that had homogeneous vegetation or that were planted to smooth brome were rarely selected. Grass meadows that were harvested for seed the previous year, brome, and wheat stubble-legume fields were not used for nesting. In Nebraska, woody encroachment into wet prairie and conversion of upland prairie to cropland negatively affected Upland Sandpipers (Faanes and Lingle, 1995). In Indiana, the species used oat fields in spring until the fields were harvested (Snyder and others, 1987).

Some pastures were used more frequently during years when they had been fertilized with nitrogen (Bowen, 1976). In Wisconsin, fertilizing with manure reduced or completely excluded nesting by Upland Sandpipers; however, Upland Sandpipers were found nesting in grass clumps formed around manure droppings (Buss and Hawkins, 1939).

Upland Sandpipers may avoid wind facilities. At two of three wind facilities in mixed-grass prairies in North Dakota and South Dakota, Upland Sandpipers exhibited displacement from areas within and surrounding wind-turbine facilities, with both immediate (1-year postconstruction) and delayed (2–5 years postconstruction) displacement occurring at one facility, and delayed displacement at a second facility (Shaffer and Buhl, 2016). Avoidance distances varied from within 100 m of turbines to overall displacement from the study area.

Management Recommendations from the Literature

Maintaining unbroken native prairie or converting agricultural fields to grasslands will be beneficial to Upland Sandpipers (Veech, 2006; Uden and others, 2015). Large (> 100 ha), contiguous tracts of prairie should be maintained to reduce edge habitats, to provide habitat heterogeneity, and to decrease nest depredation (Herkert and others, 1993; Herkert, 1994; Klute, 1994; Helzer, 1996; Mong, 2005). Herkert and others (1993) recommended maintaining grassland blocks that are within 1.6 km of each other and that are contiguous with adjacent grassy habitats (for example, pastures, hayfields). Helzer and Jelinski (1999) highlighted the importance of considering shape and area of management units; perimeter-area ratio strongly influenced occurrence of Upland Sandpipers in Nebraska (Helzer and Jelinski, 1999).

Several studies have emphasized the importance of managing native prairies every 2–3 years by burning, grazing, haying, or idling (Kaiser, 1979; Kantrud, 1981; Bowen and Kruse, 1993; Ahlering and Merkord, 2016). Grazing provided habitat conditions for nesting to a lesser extent but was more compatible than cropland or tame-grass seedings. In Oklahoma tallgrass prairies, replacing annual burning and grazing with patch burning and grazing increased vegetative heterogeneity and Upland Sandpiper abundance (Fuhlendorf and others, 2006). In Wisconsin CRP fields of switchgrass, Upland Sandpipers used mowed fields but not unmowed fields; mowed fields had lower vegetation height-density and litter cover than unmowed fields (Roth and others, 2005).

Encroachment of woody vegetation into grasslands may be detrimental to Upland Sandpipers and other grassland birds (Herkert and others, 1993). Grant and Murphy (2005) recommended the reintroduction of fire and grazing on lands managed for grassland birds to stem the encroachment of woody vegetation in northern Great Plains grasslands. Grant and others (2004) suggested that managers focus initial restoration efforts on grasslands with <20 percent woodland encroachment because these grasslands would have the most immediate and lasting conservation benefit for grassland birds. Programs that encourage the planting of trees and tall shrubs within grasslands are discouraged (Grant and others, 2004). Cunningham and Johnson (2006) recommended removal of trees for improving habitats for grassland birds; however, perches, such as fence posts, rock piles, or tree stumps, may be important for displaying Upland Sandpipers (White, 1983).

Several authors have recommended that management disturbances (for example, burning, mowing, or plowing) should be avoided or delayed during the nesting season (Buss and Hawkins, 1939; Lokemoen and Beiser, 1997). For example, Bolster (1990) and Patterson (1994) recommended that mowing and spraying of pesticides in CRP grasslands should be delayed until after July to avoid disturbances during the peak nesting season. Buhnerkempe and Westemeier (1988) recommended delaying mowing of habitat for nesting and brood rearing until July 1 or later. Oetting and Cassel (1971) recommended delaying mowing on road rights-of-way until late July.

Upland Sandpipers require a mosaic of habitat types throughout the breeding season, including grasslands of various heights and densities as well as cropland (Bolster, 1990). Grazed, burned, and hayed fields provide suitable habitat for feeding, loafing, and brood rearing, but undisturbed fields are needed for nesting (Lindmeier, 1960; Bowen and Kruse, 1993).

Rotational burning of patches in pastures may benefit Upland Sandpipers by providing vegetation heterogeneity (Fuhlendorf and others, 2006). Herkert (1994) recommended that 20 to 30 percent of grassland fragments <80 ha in size should be burned annually. Small fragments should have <50 percent of their area burned at a time, and, if next to other fragments, should be burned on a rotating schedule that allows unburned fragments to be adjacent to burned fragments (Herkert, 1994). Herkert and others (1993) recommended that burns should occur from March to early April or from October to November to avoid disturbances during the nesting season.

Grazing can be used to improve habitat for Upland Sandpipers. For example, Skinner (1974) recommended moderate grazing levels to provide diverse grass heights and densities. Skinner (1974) also suggested that a rotational grazing system of two or more grazing units also can provide a diversity of grass heights and densities within and among units. Bowen and Kruse (1993) and Sedivec (1994) indicated that season-long grazing should be avoided, and where grazing is necessary, grazing should be delayed until mid- to late June to maintain nest densities. To provide more undisturbed cover, Sedivec (1994) recommended rotational grazing over season-long grazing during the nesting season. To benefit nesting sandpipers as well as to optimize weight gain of calves in rotational grazing systems, Sedivec (1994) recommended that grazing should be delayed until late May to early June. Sedivec (1994) suggested following the stocking-rate recommendations as outlined by the Soil Conservation Service (1984); rates may be slightly higher for rotational grazing (Sedivec, 1994).

Kantrud and Higgins (1992) and Lokemoen and Beiser (1997) highlighted the importance of maintaining areas of undisturbed habitat during the nesting season by encouraging no-till or minimum-tillage practices instead of conventional annual tillage practices. Nest productivity may be low on annually tilled cropland and former cropland planted to grass and legumes (Kirsch and Higgins, 1976). On farms that adopt organic farming practices, Lokemoen and Beiser (1997) recommended delaying the first tilling operations on organic fallow fields until late June or early July to reduce the destruction of nests.

Buhnerkempe and Westemeier (1988) emphasized the importance of maintaining heterogeneous fields of cool-season, tame grasses that are >5 years old; to obtain a mixture of forbs and grasses, fields should not be reseeded until they are 10–12 years old. Management of seeded grasses should include allowing them to idle, rotary mowing to a height of 15–30 cm on a 3-year rotation, or burning (Buhnerkempe and Westemeier, 1988). Moderate grazing may provide suitable habitat in native and tame grasses, but more research is needed (Buhnerkempe and Westemeier, 1988).

In some cases, management might involve the avoidance or reduction of impacts to habitat and avian populations from external stressors. Shaffer and others (2019b) developed the avian-impact offset method to help guide compensatory mitigation of habitat loss associated with energy development. The avian-impact offset method calculates the biological value (measured in terms of avian numbers) lost when Upland Sandpipers avoid otherwise suitable breeding habitat because of energy development. The method's output (ha of grassland necessary to offset development) converts biological value to the traditional unit of measure in which land is purchased or sold, so that compensatory mitigation can be undertaken in the form of conservation easements or grassland reconstruction. The areal unit of measure also lends itself readily to mapping applications in which conservation delivery of offsetting measures can be viewed at local, regional, or landscape scales. To this end, Shaffer and others (2019b) used models developed from Niemuth and others (2017) to develop a decision-support tool that identifies locations for placement of compensatory offset sites with equivalent biological value as impact sites. Alternatively, the tool can be used prior to development of energy facilities to identify locations that would require little compensatory mitigation if developed, relative to other potential locations.

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Table F1. Measured values of vegetation structure and composition in Upland Sandpiper (*Bartramia longicauda*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.

[cm, centimeter; %, percent; <, less than; --, no data; WPA, Waterfowl Production Area; ≥, greater than or equal to; >, greater than; CRP, Conservation Reserve Program; DNC; dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Ailes, 1976 (nests)	Wisconsin	Tame grassland	Multiple	<40	--	--	--	--	--	--	--
Ailes, 1976 (brood-rearing)	Wisconsin	Tame grassland	Multiple	<10	--	--	--	--	--	--	--
Bowen and Kruse, 1993 (nests)	North Dakota	Mixed-grass prairie (WPA)	Multiple	--	5–20[a]	≥50	<50	--	--	--	--
Buhnerkempe and Westemeier, 1988 (nests)	Illinois	Tame grassland	Multiple	17–33	--	--	--	--	--	--	--
Colwell and Oring, 1990 (nests)	Saskatchewan	Mixed-grass prairie	Grazed, idle	>15	--	--	--	--	--	--	--
Dorio, 1977 (nests)	Minnesota	Multiple	Multiple	22.5–35	--	--	--	--	12	25.2	--
Dorio, 1977 (foraging)	Minnesota	Multiple	Multiple	2.5–30	--	--	--	--	--	--	--
Fritcher and others, 2004[b,c]	South Dakota	Mixed-grass prairie	--	26.6–51.8	5.8–17[a]	85.7–91.6	18–26.1	--	1.8–12.9	80.7–94.6	0.9–3.1
Fuhlendorf and others, 2006[d]	Oklahoma	Tallgrass prairie	Annual complete burn and grazed	14.7	--	63	18	--	20.3	8	--
Fuhlendorf and others, 2006[d]	Oklahoma	Tallgrass prairie	Patch burn and grazed	21.7	--	55.7	19	--	14.7	50.3	--
Garvey and others, 2013 (nests)	Alberta, Manitoba, Saskatchewan	Multiple	Multiple	--	7[a]	--	--	--	--	--	--
Grant and others, 2004	North Dakota	Mixed-grass prairie	--	47	--	--	--	13.2	--	--	3.3
Higgins and others, 1969 (nests)	North Dakota, South Dakota	Mixed-grass prairie	Multiple	15–61	--	--	--	--	--	--	--
Hull and others, 1996	Kansas	Tame grassland (CRP)	Burned	--	--	--	50.1	--	--	--	--
Kaiser, 1979 (nests)	South Dakota	Mixed-grass prairie, tallgrass prairie	Grazed	12.7–63.5	--	--	--	--	--	--	--

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Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Kantrud and Higgins, 1992 (nests)	North Dakota, South Dakota, Montana, Manitoba	Multiple	Multiple	--	12[a],26[e]	--	--	--	--	36[f]	--
Kirsch and Higgins, 1976 (nests)	North Dakota	Multiple	Multiple	15.4–30.8	--	--	--	--	--	--	--
Lindmeier, 1960 (nests)	Minnesota	Tallgrass prairie, tame grassland	Idle, burned	25.4	--	--	--	--	--	--	--
Messmer, 1990	North Dakota	Mixed-grass prairie	Multiple	50–70	--	--	--	--	--	--	3.8–9.1
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Total-harvested switchgrass	80.9	71[a]	51.6	19.6	0.4	5	23.2	1.9
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Strip-harvested switchgrass	81.7	75[a]	53.3	17.5	0.1	2.8	29.6	3.5
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Unharvested switchgrass	78.1	71[a]	32.9	25.4	2.1	2.9	22.9	5.5
Niemi and Hanowski, 1983 (territories)	Minnesota	Tallgrass prairie	--	79	--	--	--	--	--	--	--
Powell and Busby, 2013	Kansas	Tallgrass prairie	Unburned idle	93[f]	--	--	--	--	--	--	12.5
Powell and Busby, 2013	Kansas	Tallgrass prairie	Burned idle	52.1[g]	--	--	--	--	--	--	0.3
Powell and Busby, 2013	Kansas	Tallgrass prairie	Hayed	50.1[g]	--	--	--	--	--	--	6.5
Powell and Busby, 2013	Kansas	Tallgrass prairie	Grazed	74[f]	--	--	--	--	--	--	9.4
Renken, 1983[h]	North Dakota	Tame grassland (DNC)	Idle, grazed	--	11[a]	57.4	23.5	5.7	0.5	98.8	2.3
Roth and others, 2005	Wisconsin	Tame grassland (CRP)	Harvested warm-season	--	12.4[a]	--	33.2	--	--	--	1.4
Salo and others, 2004	North Dakota	Mixed-grass prairie	Extreme grazing intensity	17.5[i]	7.9[a]	--	--	--	--	--	0.9
Sample, 1989	Wisconsin	Multiple	--	45.1	13.8[a]	--	81.2[j]	0.5	4.2	10.9	--

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Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Sedivec, 1994 (nests)	North Dakota	Mixed-grass prairie	Multiple	--	12.7[a]	--	--	--	--	--	--
Skinner, 1974	Missouri	Tallgrass prairie	Moderately grazed	10–30.4	--	--	--	--	--	--	--
Skinner, 1974	Missouri	Tallgrass prairie	Heavily grazed	0–10.2	--	--	--	--	--	--	--
Wiens, 2007 (nests)	North Dakota	Tame grassland	Multiple	22	21[a]	43	40	--	--	--	1.4
Wiens, 2007 (plots)	North Dakota	Tame grassland	Multiple	--	22[a]	53	30	--	--	--	1.7

[a]Visual obstruction reading (Robel and others, 1970).

[b]Range of averages across seral stages within study area.

[c]The sum of the percentages is >100%, based on methods described by the authors.

[d]The sum of the percentages is >100%, based on the modified point-quadrat technique as described by the authors.

[e]Effective vegetation height.

[f]Standing dead vegetation.

[g]Live vegetation height.

[h]The sum of the percentages is >100%, based on the modified point-quadrat technique of Wiens (1969).

[i]Mean grass height.

[j]Herbaceous vegetation cover.

For more information about this publication, contact:
Director, USGS Northern Prairie Wildlife Research Center
8711 37th Street Southeast
Jamestown, ND 58401
701–253–5500

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