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Angaben zur Bestellung:

Bestelldatum:	2019-01-15 10:54:04
Bestellnummer:	SUBITO:VE19011500398
Name des Bestellers:	Max-Planck-Institut fuer Ornithologie
Benutzerkennung:	SLS08X00031
Lieferdatum:	2019-01-15 11:31:25
Lieferpriorität:	NORMAL
Aktueller Lieferweg:	Email
E-Mail Adresse:	bibliothek@orn.mpg.de

Bemerkungen zur Auslieferung: bulla

Angaben zum Dokument:

Signatur:	SZ 4571
Autor:	
Titel:	The Prairie naturalist
Jahr:	1992
Band / Jahrgang:	24,
Seiten:	67-84
Aufsatzautor:	K. F. Kantrud, H. & Higgins,
Aufsatztitel:	Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grassland
ISSN:	
ISBN:	0091-0376
CODEN:	

Ihre Bemerkung zur Bestellung: bulla

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Nest and Nest Site Characteristics of some Ground-nesting, Non-passerine Birds of Northern Grasslands

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ABSTRACT—We summarized biological and ecological characteristics of 2490 nests of 16 species of upland-nesting, non-passerine birds of northern grasslands found during 1963 through 1991. Nest initiation and hatch dates, clutch sizes, nest fates, causes of failure, success rates of nests among major habitat types and land uses, and vegetation measurements at nest sites are analyzed.

Key words: Nests, grassland birds, non-passerine birds, habitat, clutch size, land use, nest success

Except for waterfowl and gallinaceous game birds, little information is published on the nesting characteristics and habitat affinities of most upland-nesting birds of the grasslands of south central Canada and north central United States. Moreover, only small amounts of grassland in these regions are devoted to the production of non-game birds. Although populations of some grassland birds are declining nationally, we know little about their nest success rates or other basic information for modeling their population dynamics. We think that data presented here on nest initiation dates, nest site characteristics, and nest success of grassland birds are of value to their future management and protection. We also offer the information to land managers who often want to increase species diversity on lands devoted to wildlife production.

METHODS

Biologists and students at the Northern Prairie Wildlife Research Center, several national wildlife refuges and wetland management districts, and a wildlife management area collected the data. They found nests of grassland birds other than waterfowl during various waterfowl nesting studies on public and private lands in the prairie pothole region (Kantrud and Stewart 1977) of North and South Dakota, Montana, and Manitoba during 1963 through 1991.

Chain or cable-and-chain devices towed between motorized vehicles, hand-dragged ropes, dogs, or observers incidentally walking through study fields flushed laying, incubating, or brooding birds from nests. Observers searched for nests from mid-April to late July and marked most nests with wire surveyor's flags or flagged willow saplings.

Depressions or structures with one or more eggs-of-the-year or newly hatched young defined nests; non-parasitized nests in which at least one egg hatched defined successful nests. We defined normal nests as those whose status (normal or abnormal) was recorded when found and for which we had complete histories. Abnormal nests included those whose status was unrecorded when found or were found disturbed (eggs cracked or hen killed or injured during search operations), parasitized, partially destroyed, or terminated. Abnormal nests also included those that had unknown fates because they were not relocated and those judged to be abandoned because of search related activities. The proportion of normal nests in which one or more eggs hatched defined apparent nest success. Observers could identify most interspecific, but no intraspecific, nest parasitism. Numbers of interspecifically parasitized nests were too small to make comparisons with non-parasitized nests, so we eliminated the former from the overall data set. Their inclusion may have biased estimates of clutch size and added potential biases to estimates of nest success caused by species interactions and their possible effects on predation rates.

Observers revisited many nests during laying and incubation stages to determine the number of eggs in full clutches, but the number of revisits varied among observers. Observers candled (Weller 1956) or floated (Westerkov 1950) some eggs to estimate their embryonic development stage. Observers recorded the day of hatching for only a few nests. In all instances, we assumed that one egg was laid per day, a procedure that may have resulted in nest initiation dates a few days earlier than indicated for some shorebirds. We used known incubation periods (Harrison 1978, Ehrlich et al. 1988) and back-dated by clutch size as indicated above to calculate nest initiation dates. We considered the intervals of 90% of nest initiations those dates between the 5% and 95% percentiles. We tested differences in clutch sizes before and after median initiation dates for nests of known age with Chi-square or two-sample t-tests. Because observers did not or could not reliably determine exposure days of most eggs, we calculated the Discrete version (Johnson 1991) of the Green (1989) estimator of nest success. We also reported apparent nest success [(successful normal nests/total normal nests) x 100%] for total nests of known fate. We listed Discrete-Green estimates of nest success by habitat and land use for a few species with large sample sizes ($n \geq 20$) with the caveat that annual variation in nest success can be much larger than variation associated with nesting cover.

General habitat selection of species and the ecological characteristics of their nest sites can be inferred from Tables 5-8, which list distribution of birds among habitats, land uses, current land treatments, and vegetation measurements at nest sites. We differentiated land uses and current land treatments on the basis of time; the former is indicative of general long-term use and the latter of use during the growing season in which a nest was found. For example, a fenced area obviously in long-term use as pasture could be idled during a current growing season. We analyzed differences in nest success among habitat types, land uses, and current land treatments with Chi-square tests on apparent success rates.

Although observers searched a minimum of 5600 ha of native grassland (mostly xeric mixed-grass), 1400 ha of seeded grassland (mostly mixtures of introduced grasses and legumes) and 1000 ha of cropland (mostly small grains or their residues and summer-fallowed land), the number and area of fields searched varied among species. There are many reasons why we did not provide information on nest densities, cover types, or land uses. First, the time spent searching for nests after a bird flushed from a suspected nest varied greatly among investigators. Second, habitat structure varied greatly among fields; thus nests in short grass cover were much easier to find than those in taller, denser cover. Also, we observed that fields with numerous wetlands were more attractive to upland-nesting shorebirds than were similar fields where wetlands were more distant. Third, we seldom knew the number of years each field was searched or the number of searches per season per field. Finally, we could not calculate areas of searched fields that did not contain at least one nest of a particular species and were uncertain if observers recorded all nests of a particular species in each field searched.

Observers considered effective vegetation height the average maximum height of the leaf canopy, i.e,. the uppermost point where leaves provide significant shading effect. For most forbs, effective height was similar to maximum plant height, but for most grasses, effective height was measured from the top of the leaf canopy, not from the tips of culms or seed heads. Exceptions were very dense stands of fine-stemmed grasses in which the stems themselves provided significant shading effect. Measurements of visual obstructions with apparatus described by Robel et al. (1970) provided indices to the amount of vegetation at nest sites. Visual estimates gave the percentage of dead vegetation at nest sites. We used Fisher's F-protected LSD as a multiple comparison technigue to compare vegetation height and percent dead vegetation at nest sites by species. We compared species only if the F-test for equal means was rejected at the 0.05 level.

Scientific names and taxonomic order of birds follow American Ornithologists' Union (1983). Not analyzed were nests of four species for which fewer than 10 nests were found. These included sage grouse (*Centrocercus urophasianus*) greater prairie chicken (*Tympanuchus cupido*) spotted sandpiper (*Actitis macularia*) and burrowing owl (*Athene cunicularia*)

RESULTS

Species Composition, Nesting Chronology, and Clutch Size

We analyzed 2490 nest records of 16 bird species. Most numerous were upland sandpiper (*Bartramia longicauda*) nests (30% of total nests) followed by sharp-tailed grouse (*Tympanuchus phasianellus*, 21%), and mourning doves (*Zenaida* *macroura* 9%). Nests of the remaining species had frequencies of 7% or less.

We estimated nest initiation dates for 969 nests of 16 species (Table 1). The 90% intervals of nest initiations were shortest for shorebirds and longest for American bitterns (*Botaurus lentiginosus*; 60 days), mourning doves (56 days), and short-eared owls (*Asio flammeus*; 54 days).

The earliest hatches among 176 nests with known hatching dates were by short-eared owls, killdeers (*Charadrius vociferus*) and northern harriers (*Circus cyaneus*); latest hatches were by American bitterns, common nighthawks (*Chordelies minor*) and ring-necked pheasants (Phasianus colchicus, Table 1). Median hatching dates and the intervals of 90% of nests hatching for the only two species for which we had 20 or more nests with known hatching dates were: sharp-tailed grouse (n = 37) 15 June (4 June-5 July) and upland sandpipers (n = 39) 27 June (15 June-12 July).

We determined full clutch sizes for 2064 nests (Table 2). Nearly all nests of shorebirds had a four-egg clutch. The only five-egg clutches found among shorebirds were one each of killdeers, willets, and upland sandpipers. We found no clutches larger than two eggs for mourning doves and common nighthawks. We observed a few one-egg clutches for these species. Gallinaceous species had the

Table 1. Nest initiation and hatch dates (month/day) of birds, grasslands of north central United States and south central Canada, 1963-1991.

	Initiation[a]					Hatching[b]		
Species	n	Earliest	Median	Latest	Interval of 90% of initiations	n	Earliest	Latest
American bittern	47	4/21	6/10	7/7	4/30-6/28	14	5/29	8/7
Northern harrier	81	4/30	5/19	6/30	5/3-6/15	19	5/22	7/15
Gray partridge	8	5/19	6/13	6/25		3	6/16	7/4
Ring-necked pheasant	18	4/27	5/19	7/4		4	6/18	7/19
Sharp-tailed grouse	301	4/19	5/10	7/21	4/26-6/10	37	5/29	7/13
Virginia rail	7	6/8	6/15	6/28		1	7/7	7/7
Piping plover	7	5/13	5/20	6/14		1	6/23	6/23
Killdeer	53	4/26	5/27	7/3	5/3-6/16	7	5/20	6/26
Willet	41	5/7	5/20	6/10	5/8-6/8	2	6/10	6/23
Upland sandpiper	179	5/4	5/29	6/30	5/15-6/20	39	6/4	7/18
Marbled godwit	22	5/3	5/16	6/4	5/4-5/26	2	6/15	6/27
Common snipe	4	5/11	5/23	6/22		2	7/15	7/17
Wilson's phalarope	96	5/9	6/8	6/30	5/18-6/19	9	6/11	7/7
Mourning dove	62	4/29	5/23	7/11	5/9-7/3	16	5/23	7/12
Short-eared owl	35	3/31	5/13	6/26	4/22-6/14	16	5/4	7/16
Common nighthawk	8	5/7	6/24	7/6		4	7/4	7/26

[a] Nests used include those known to be in the laying stage, those where number of incubation days since achievement of full clutch was known, or those found with pipping eggs, but with no evidence of young or hatched eggs present. We assumed that one egg was laid per day and used estimated incubation periods from the literature for nests where exact termination dates were known. No 90% interval given for species where n≤ 20 nests.

[b] Nests used include those with pipping eggs or newly hatched young.

Table 2. Overall clutch sizes[a] and clutch sizes before and after median initiation dates for bird nests of known age[b], grasslands of north-central United States and south-central Canada, 1963-1991.

	Overall					Before					After				
Species	n	Mean	Mode	Min.	Max.	n	Mean	Mode	Min.	Max.	n	Mean	Mode	Min.	Max.
American bittern	84	3.83	4	2	6	20	4.10	4	3	6	-	-	-	-	-
Northern harrier	122	5.46	5	3	11	32	7.09	5	3	11	35	5.17	3	3	10
Gray partridge	13	16.23	14	9	22	-	-	-	-	-	-	-	-	-	-
Ring-necked pheasant	41	11.44	14	5	19	-	-	-	-	-	-	-	-	-	-
Sharp-tailed grouse	399	13.55	14	4	23	130	15.09	14	7	22	113	12.20	12	6	23
Virginia rail	7	7.86	10	1	11	-	-	-	-	-	-	-	-	-	-
Piping plover	11	3.82	4	3	4	-	-	-	-	-	-	-	-	-	-
Killdeer	157	3.77	4	1	5	24	3.75	4	2	4	21	3.52	4	2	4
Willet	80	3.87	4	2	5	20	3.90	4	2	4	-	-	-	-	-
Upland sandpiper	654	3.92	4	1	5	84	3.92	4	3	4	76	3.82	4	1	4
Marbled godwit	46	3.85	4	3	4	-	-	-	-	-	-	-	-	-	-
Common snipe	21	3.90	4	3	4	-	-	-	-	-	-	-	-	-	-
Wilson's phalarope	146	3.77	4	2	4	39	3.74	4	3	4	39	3.59	4	2	4
Mourning dove	202	1.94	2	1	2	31	1.84	2	1	2	31	1.90	2	1	2
Short-eared owl	60	6.55	7	2	13	-	-	-	-	-	-	-	-	-	-
Common nighthawk	21	1.86	2	1	2	-	-	-	-	-	-	-	-	-	-

[a] Includes nests under incubation or with pipping eggs and no evidence of young or hatched eggs.
[b] No data given where n ≤ 20 nests; the "after" category includes the median date.

largest clutches. We recorded maxima of 22 for gray partridges (*Perdix perdix*), 23 for sharp-tailed grouse, and 19 for ring-necked pheasants. We found pronounced modes of clutch sizes of four for American bitterns, five for northern harriers, and seven for short-eared owls.

With the exception of mourning doves, all species for which our sample included 20 or more nests of known age before and after median nest initiation dates had smaller mean clutch sizes later in the nesting season (Table 2). The most pronounced, and only significant, reductions were of northern harriers (27%) and sharp-tailed grouse (19%; northern harrier: $t = 3.29$, $df = 65$, $P = 0.0016$; sharp-tailed grouse: $t = 8.04$, $df = 241$, $P \leq 0.0001$).

Nest Fates and Causes of Loss

We considered 2006 (81%) of 2490 nests usable for calculating nest success. The 484 unusable nests included 85 with initial status unrecorded, 104 disturbed, parasitized, partially destroyed, terminated, or abandoned because of search related activities, and 295 that had unknown fates because they were not relocated.

Of the 2006 usable nests, 1261 (63%) were apparently successful, 692 (34%) were destroyed, and 53 (3%) were abandoned (Table 3). Apparent nest success for the 11 species for which we had 40 or more such histories ranged from 52% to 67% (31-48% Discrete-Green success). Apparent nest success did not vary significantly among species ($\chi^2 = 14.11$, $df = 10$, $P = 0.168$). Abandonment rates were quite low and uniform, ranging from 1% to 7% for all species where n >40 nests with complete histories. Among these species, marbled godwits abandoned nests most often and

Table 3. Fate (%) of bird nests of known fate[a], grasslands of north central United States and south central Canada, 1963-1991.

Species	n	Abandoned	Destroyed	Successful	
				Apparent success	Discrete Green estimator[b]
American bittern	96	4	39	57	36
Northern harrier	112	4	35	61	41
Gray partridge	21	38	14	48	27
Ring-necked pheasant	43	7	28	65	46
Sharp-tailed grouse	434	2	38	60	40
Virginia rail	9	11	33	56	35
Piping plover	9	0	33	67	48
Killdeer	135	2	35	64	44
Willet	79	5	43	52	31
Upland sandpiper	617	1	32	67	48
Marbled godwit	43	7	33	60	40
Common snipe	24	0	29	71	54
Wilson's phalarope	136	3	38	59	39
Mourning dove	174	2	32	66	48
Short-eared owl	59	4	39	58	38
Common nighthawk	15	0	13	87	77

[a] Includes nests not terminated, parasitized, abandoned, or partially destroyed when found or where the incubation bird or eggs were not harmed during search procedures. Not included are nests of unknown fate which were not relocated.

[b] Johnson 1991

Table 4. Causes of destruction (%) of bird nests of known fate[a], grasslands of north central United States and south central Canada, 1963-1991.

Species	n	Predation			Livestock	Man	Fire	Unknown
		Mammalian	Unknown	Avian				
American bittern	37	68	16	8	0	5	0	3
Northern harrier	39	38	44	5	0	3	5	5
Gray partridge	3	33	0	0	0	67	0	0
Ring-necked pheasant	12	33	25	17	0	25	0	0
Sharp-tailed grouse	165	58	37	2	1	0	1	1
Virginia rail	3	67	33	0	0	0	0	0
Piping plover	3	0	100	0	0	0	0	0
Killdeer	47	21	43	0	2	19	0	15
Willet	34	44	29	6	0	12	0	9
Upland sandpiper	195	66	18	3	1	5	4	4
Marbled godwit	14	50	43	0	0	7	0	0
Common snipe	7	86	14	0	0	0	0	0
Wilson's phalarope	52	21	56	8	0	2	0	14
Mourning dove	56	48	38	4	0	0	0	11
Short-eared owl	23	4	61	4	0	9	0	22
Common nighthawk	2	50	0	0	0	50	0	0

[a] Includes nests not terminated, parasitized, abandoned, or partially destroyed when found or the incubating bird or eggs were not harmed during search procedures. Not included are nests of unknown fate which were not relocated.

upland sandpipers least often.

Predators destroyed 603 (87%) of 692 nests of known fate (Table 4). Observers determined that 348 (58%) were destroyed by wild mammals, 25 (4%) by birds, and 230 (38%) by unknown predators. Overall, losses caused by the activities of humans, fire, and livestock were small.

Habitat Use

All 16 species we studied used native grassland for nesting, and 14 species nested in seeded grasslands and croplands (Table 5). Seeded grasslands supported all species except piping plovers (*Charadrius melodus*) and common nighthawks. Nests of common snipe and common nighthawks were not found in croplands. Nest success was high for northern harriers and mourning doves in seeded grassland and for upland sandpipers and marbled godwits in native grassland, but success rates did not differ among habitat types for any of the species.

All 16 species nested in pastures (Table 6). Idle lands supported nests of 15 species, hayfields 14 species, and cropfields 13 species. Success of upland sandpipers was uniformly high in idle lands and pastures, but possibly lower in

Table 5. Number and success (%, Discrete Green estimator, Johnson 1991) of bird nests of known fate among major habitat types, grasslands of north central United States and south central Canada, 1963-1991.

	Native grassland		Seeded grassland[a]		Cropland[b]	
Species	n[c]	(%)[d]	n	(%)	n	(%)
American bittern	14	-	37	36	2	-
Northern harrier	44	39	24	53	+	-
Gray partridge	3	-	4	-	+	-
Ring-necked pheasant	2	-	11	-	+	-
Sharp-tailed grouse	287	41	57	41	1	-
Virginia rail	5	-	1	-	+	-
Piping plover	8	-	0	-	+	-
Killdeer	79	39	9	-	27	57
Willet	51	43	1	-	11	-
Upland sandpiper	366	51	58	39	10	-
Marbled godwit	27	52	4	-	1	-
Common snipe	13	-	1	-	0	-
Wilson's phalarope	106	41	2	-	6	-
Mourning dove	79	47	24	54	1	-
Short-eared owl	13	-	12	-	+	-
Common nighthawk	12	-	0	-	0	-

[a] Seeded native grasses, domestic perennial grasses, and perennial or biennial legumes or grass-legume mixtures.
[b] Growing crops, crop residues, and fallow (weedy or barren) cropland under annual tillage regimes; cropland in no-till or minimum tillage regimes not included.
[c] + = at least one nest found, but fate unknown.
[d] Success estimate shown only when n ≥ 20 nests of known fate within a major habitat type.

Table 6. Number and success (%, Discrete Green estimator, Johnson 1991) of bird nests of known fate among major land uses[a], grasslands of north central United States and south central Canada, 1963-1991.

	Idle lands		Pastures		Hayfields		Cropfields	
	n[b]	(%)[c]	n	(%)	n	(%)	n	(%)
American bittern	36	38	7	-	+	-	16	-
Northern harrier	62	42	9	-	1	-	1	-
Gray partridge	3	-	1	-	1	-	1	-
Ring-necked pheasant	10	-	1	-	+	-	3	-
Sharp-tailed grouse	252	40	89	47	+	-	19	-
Virginia rail	3	-	3	-	+	-	0	-
Piping plover	0	-	8	-	0	-	+	-
Killdeer	22	25	60	42	2	-	25	66
Willet	7	-	46	43	+	-	11	-
Upland sandpiper	179	52	219	48	10	-	37	30
Marbled godwit	8	-	19	-	+	-	6	-
Common snipe	2	-	11	-	+	-	0	-
Wilson's phalarope	27	32	83	44	+	-	4	-
Mourning dove	74	42	36	49	1	-	10	-
Short-eared owl	32	35	3	-	+	-	2	-
Common nighthawk	11	-	4	-	0	-	0	

[a] Categories here reflect land use during prior growing seasons that determine the vegetation structure of the habitat. Thus, fields obviously grazed, mowed, or cultivated during the past growing season were considered pastures, hayfields, or cropfields, regardless of whether cattle were present, hay was cut, or the land was cultivated during the growing season when observers found nests. Idle fields were nearly all native or seeded grasslands that contained substantial amounts of litter and standing dead vegetation from prior growing seasons as well as new growth. Cropfields definition same as cropland in Table 5.
[b] + = at least one nest found, but fate unknown.
[c] Percent success shown only when n≥ 20 nests of known fate within major land-use categories.

cropfields (χ^2= 5.04, df = 2, P = 0.081). Killdeers had higher nest success in cropfields than in the other major land use types (χ^2 = 6.02, df = 2, P = 0.049).

Among current (within growing season) field treatments, more species (all 16) used idle lands than recently mowed (13 species), grazed (11 species), burned (10 species), or cultivated (7 species) lands (Table 7). Upland sandpipers had higher nest success in idle than in grazed fields (χ^2 = 6.47, df = 1, P = 0.011) and killdeers had higher nest success in fields cropped during current growing seasons than in idle fields (χ^2 = 5.42; df = 1; P = 0.020).

Measurements of effective vegetation height and measurements of visual obstruction at nest sites (Table 8) differed among species (mean vegetation height: $F_{13,990}$ = 70 .78, P < 0.0001; mean visual obstruction: $F_{13,1496}$ = 154.00, P < 0.0001). American bitterns, northern harriers, short-eared owls, and gallinaceous game birds nested mostly at sites in tall, dense vegetation, whereas most mourning doves, common nighthawks, and shorebirds nested in relatively short and sparse vegetation or bare ground. American bitterns and common snipe mostly nested at sites with large amounts of dead vegetation, whereas most common nighthawks nested where vegetation was mainly green.

Table 7. Number and success (%, Discrete Green estimator, Johnson 1991) of nests of known fate among current field treatments[a], grasslands of north central United States and south central Canada, 1963-1991.

	Idle		Grazed		Mowed		Cultivated		Burned	
	n[b]	(%)[c]	n	(%)	n	(%)	n	(%)	n	(%)
American bittern	55	38	+	-	2	-	0	-	0	-
Northern harrier	66	44	1	-	2	-	0	-	4	-
Gray partridge	5	-	0	-	2	-	+	-	0	-
Ring-necked pheasant	12	-	1	-	1	-	0	-	0	-
Sharp-tailed grouse	309	43	9	-	22	39	0	-	22	21
Virginia rail	+	-	0	-	+	-	0	-	0	-
Piping plover	+	-	0	-	0	-	0	-	0	-
Killdeer	67	36	18	-	4	-	24	83	2	-
Willet	41	43	10	-	2	-	8	-	2	-
Upland sandpiper	374	53	51	32	8	-	8	-	3	-
Marbled godwit	28	44	3	-	0	-	1	-	1	-
Common snipe	7	-	7	-	0	-	0	-	+	-
Wilson's phalarope	104	42	3	-	2	-	4	-	+	-
Mourning dove	76	48	7	-	36	42	+	-	4	-
Short-eared owl	31	38	0	-	+	-	0	-	6	-
Common nighthawk	14	-	0	-	1	-	0	-	0	-

[a] Catagories here reflect land use prior to mid-June during the growing season that nests were found. All lands that were idle, grazed, mowed, or cultivated prior to this date are included, regardless of habitat type or prior land use. Idle land thus contained undisturbed new growth, but may or may not have contained litter and standing dead vegetation from prior growing seasons.

[b] + = at least one nest found, but fate unknown.

[c] Success shown only when n≥ 20 nests of known fate within a treatment.

SPECIES ACCOUNTS

American Bittern

Upland grasslands seeded to domestic grasses and legumes and undisturbed during the growing season provided nesting habitat for American bitterns. Grasses, especially the mid or tall grasses smooth brome (*Bromus inermis*) and wheatgrass (*Agropyron* spp.), dominated about 64% of 98 American bittern nest sites. Forbs, especially the domestic legume alfalfa (*Medicago sativa*) dominated nearly all remaining nest sites. Five nests occurred in stands of the semishrub Arkansas rose (*Rosa arkansana*) but only one nest was in true woody shrub. Most nest sites had 100% visual obstruction greater than 5 dm, effective vegetation height greater than 6 dm, and more than 50% cover of dead vegetation. Bitterns did not nest where visual obstruction or height was less than 3 dm or where dead vegetation was more than 10% of total cover.

Northern Harrier

Undisturbed grasslands, particularly those seeded to domestic grasses and legumes, or undisturbed native grassland dominated by short brush contained most northern harrier nests. Stands of shrubs, especially western snowberry (*Symphoricarpos occidentalis*) contained over half of 129 northern harrier nest

Table 8. Vegetation measurements at bird nest sites arranged according to decreasing effective vegetation height, grasslands of north central United States and south central Canada, 1963-1991.

	Vegetation height (dm)[a]			Visual obstruction (dm)[b]			Dead vegetation (% of total veg.)		
Species	n	Mean[c]	Range	n	Mean	Range	n	Mean	Range
American bittern	41	6.1^{a}	3.0-9.9	53	5.0	3.0-9.0	36	53	10-99
Northern harrier	19	5.7^{a}	0.8-7.8	105	3.8	1.0-8.0	19	42	12-88
Ring-necked pheasant	20	4.6^{b}	1.4-8.0	6	$2.7^{a,b}$	1.0-5.0	15	47	10-88
Gray partridge	8	4.5^{b}	1.7-6.1	9	3.1^{a}	2.0-6.0	7	34	10-88
Short-eared owl	16	4.3^{b}	2.0-8.0	38	$2.1^{b,c}$	0.0-6.0	12	42	12-88
Sharp-tailed grouse	104	4.1^{b}	1.4-8.8	416	$1.9^{c,d}$	0.0-10.0	96	44	5-95
Mourning dove	86	3.0^{c}	0.4-7.5	145	$2.0^{b,d}$	0.0-7.0	82	38	0-95
Common snipe	15	$2.9^{c,d}$	1.5-6.5	22	$1.6^{c,d,e}$	1.0-3.0	16	52	0-99
Upland sandpiper	529	2.6^{d}	0.1-8.5	368	1.2^{e}	0.0-4.0	491	36	0-99
Wilson's phalarope	26	1.7^{e}	0.5-4.6	136	0.8^{f}	0.0-2.0	22	48	0-99
Marbled godwit	16	1.7^{e}	0.1-3.5	28	$0.4^{f,g}$	0.0-1.0	14	36	0-99
Willet	43	$1.1^{e,f}$	0.0-6.0	59	$0.4^{g,h}$	0.0-2.0	43	38	0-99
Common nighthawk	12	$0.6^{f,g}$	0.0-2.0	14	$0.3^{f,h,i}$	0.0-2.0	12	17	0-99
Killdeer	70	0.2^{g}	0.0-1.5	112	$0.1^{g,i}$	0.0-1.0	50	32	0-99

[a] Effective vegetation height was considered the average maximum height of the leaf canopy, i.e. the uppermost point where leaves provide significant shading effect. For most forbs, effective height was similar to maximum plant height, but for most grasses, effective height was measured from the top of the leaf canopy, not from the tips of culms or seed heads. Exceptions were very dense stands of fire-stemmed grasses in which the stems themselves provided significant shading effect.
[b] Robel ploe readings (Robel et al. 1970).
[c] Means with a letter in common are not significantly different from one another.

sites. Graminoids, mostly smooth brome and wheatgrasses, surrounded nearly 30% of the sites, whereas forbs, most commonly alfalfa, dominated remaining sites. Nest sites usually had 100% visual obstruction greater than 3.5 dm, effective vegetation height greater than 5.5 dm, and more than 40% cover of dead vegetation. Harriers did not nest where dead vegetation was less than 12% of total cover.

Gray Partridge

Native and seeded grasslands provide nesting cover for the introduced gray partridge. Grasses, principally introduced species typical of retired cropland or disturbed areas, surrounded over 70% of 17 nest sites. Remaining nests were in forbs, chiefly alfalfa. Most partridge nested where visual obstruction was greater than 3 dm, effective height was greater than 4 dm, and dead vegetation comprised more than 30% of the cover. No birds nested where dead vegetation was less than 10% of total cover.

Ring-necked Pheasant

Undisturbed, seeded grasslands contained most nests of the introduced ring-necked pheasant. Grasses, principally wheatgrasses and smooth brome, dominated 61.9% of 36 ring-necked pheasant nest sites. Alfalfa dominated nearly all remaining sites except for several in stands of western snowberry. Most nest sites had 100%

visual obstruction at more than 2.5 dm, effective vegetation height of at least 4.6 dm, and greater than 45% dead vegetation. Birds did not nest where dead vegetation was less than 10% of total vegetation.

Sharp-tailed Grouse

Nearly all sharp-tailed grouse nested in native and seeded grassland with similar success. Most nests were in idle grassy or brushy cover. Over 86% of 453 sharp-tailed grouse sited nests in shrubs (43.5%) or graminoids (42.9%). Western snowberry was by far the most commonly used shrub. Most grassy nest sites were in Kentucky bluegrass (*Poa pratensis*) (17.4% of nests), smooth brome (9.9%), wheatgrasses (7.5%), and needlegrasses (*Stipa* spp.,4.6%), mostly green needlegrass (*S. viridula*). The only heavily used forb was alfalfa, which was dominant at 8.6% of nests. Most nest sites had 100% visual obstruction greater than 1.5 dm, effective vegetation height greater than 4 dm, and more than 40% dead vegetation, but some nests were completely unconcealed.

Virginia Rail (*Rallus limicola*)

Native or seeded grasslands contained nearly all Virginia rail nests. Graminoids, especially the tall, wet-meadow species prairie cordgrass (*Spartina pectinata*), dominated 8 of 10 nest sites. Forbs surrounded the two remaining nest sites. All nests had 100% visual obstruction greater than 1 dm.

Piping Plover

All piping plover nests were on sand or gravel substrates devoid of vegetation and at the edges of wetlands. Native grassland surrounded all but one of these wetlands; the exception was in cropland. Of the nests in native grassland, all were in pasture.

Killdeer

All major habitat and land-use types contained killdeer nests. Nest success was higher in cropfields than in other land use types (χ^2= 6.02, df = 2, P = 0.049). Even fields cultivated during current growing seasons attracted nesting killdeers, and nest success in those fields was higher than in idle fields. Graminoids dominated about 40% of nest sites, and about 38% of the sites had no vegetation. Wheat (*Triticum aestivum*) dominated 13.0% of nest sites, Kentucky bluegrass 8.4%, and blue grama (*Bouteloua gracilis*) 4.5%. Miscellaneous forbs dominated 23% of nest sites, and 7.1% were in rocks or pebbles. Many forbs were weedy species common in cropland. No nests had 100% visual obstruction greater than 1 dm or effective vegetation height greater than 1.5 dm. Most nest sites had less than 30% dead vegetation.

Willet

Nests of willets were mainly in native grassland. Birds seemed to prefer to locate nests in pastures, particularly those idle during current growing seasons. Birds also nested in cropland, even those fields cultivated during current growing seasons, suggesting a preference for shorter vegetation at nest sites. Graminoids dominated about 76% of 69 willet nest sites. Most nests were in native species, especially green needlegrass and short carices (*Carex* spp.) but some nests were in introduced grasses, especially Kentucky bluegrass. Forbs dominated about 15% of the nest sites, and bare ground, rock, or cow chips dominated an additional 9%. Two nests occurred in growing wheat. Most sites had 100% visual obstruction less than 0.5 dm and effective vegetation height less than 1.5 dm. Most nest sites had more than 40% dead vegetation.

Upland Sandpiper

Native grasslands contained most upland sandpiper nests. Birds readily nested in pastured and idle lands, but nest success in fields idle during current growing seasons was higher than in fields currently grazed. A few upland sandpipers nested in currently mowed, cultivated, or burned fields. Graminoids, especially the midgrasses Kentucky bluegrass, smooth brome, needle-and-thread (*Stipa comata*) and quackgrass (*Agropyron repens*), dominated at about 83% of 588 upland sandpiper nest sites. Forbs, especially alfalfa, dominated at about 13% and shrubs, especially western snowberry, at about 5% of the nest sites. Upland sandpipers readily nested in stands of introduced grasses. Birds selected nest sites intermediate in cover height and density. Most sites had 100% visual obstruction less than 1.5 dm and effective cover height less than 3 dm; no sites were located where obstruction measured more than 4 dm or height was more than 8.5 dm. Most nest sites had 30-99% dead vegetation, but at some sites all vegetation was from current growth.

Marbled Godwit

Native grassland, rather than seeded grassland or cropland, contained most marbled godwit nests. Most nests were in pastures, especially those idle during current growing seasons. Graminoids were dominant at over 94% of 34 marbled godwit nest sites. Birds mostly used sites where native needlegrasses, western wheatgrass (*Agropyron smithii*), saltgrass (*Distichlis spicata*), and carices, as well as introduced Kentucky bluegrass and smooth brome, were dominant. Less than 6% of the nests were in forbs and none was in shrubs. One nest was in growing wheat. Nest sites can be characterized as intermediate to low in cover density and height. Birds did not nest where 100% visual obstruction was greater than 1 dm or where effective cover height was greater than 3.5 dm. Most nests were where dead vegetation was less than 40% of total vegetation.

Common Snipe (*Gallinago gallinago*)

Nearly all common snipe nested in native grassland. More nests were in pastures than in idle fields, but idle conditions during current growing seasons did not seem to deter nesting. Graminoids dominated 85% of 20 common snipe nest sites. Smooth brome, Kentucky bluegrass, and carices were most often used. Only two sites were surrounded by forbs. Common snipe seemed to have narrower nest site requirements than most other species. No nests had 100% visual obstruction less than 1 dm or greater than 3 dm and none occurred where effective vegetation height was less than 1.5 dm or greater than 6.5 dm. However, the percentage of dead vegetation at nests sites varied greatly, probably because the species used both idle and pastured lands.

Wilson's Phalarope

Most Wilson's phalarope nests were in native grassland, rather than seeded grassland or cropland. Nests predominated on lands long used as pasture over lands long unused, but fields idle during current nesting seasons seemed more attractive than those where cattle were present. Graminoids dominated nearly 85% of 151 nest sites of the Wilson's phalarope. Nest sites contained vegetation characteristic of both uplands, especially Kentucky bluegrass, needlegrasses, and wheatgrasses, and wet meadows, especially carices, Baltic rush (*Juncus balticus*), northern reedgrass (*Calamagrostis inexpansa*), and saltgrass. Most graminoids were of low to mid height. Forbs dominated at 19 about 14% of the nests. Birds placed three nests on bare ground, but only one in shrub. Wilson's phalarope nest sites were in relatively sparse low cover. Birds did not nest where 100% visual obstruction was greater than 2 dm or effective plant height was more than 4.6 dm. Birds placed most nests where dead vegetation made up at least half the total vegetation, but some sites had all green vegetation.

Mourning Dove

Nearly all mourning dove nests were in native and seeded grassland. More nests were in fields long idle than in fields long used for livestock grazing. The presence of cattle during the nesting season seemed to deter nesting. A surprisingly large number of nests were in fields mowed during current growing seasons, and success in those fields was not much lower than in idle fields. Graminoids, especially the wheatgrasses, smooth brome, and needlegrasses, dominated over 47% of 200 nest sites. Forbs, especially alfalfa, dominated about 35% of the sites. The native shrub western snowberry surrounded all remaining nests except for one nest at the base of an aspen (*Populus tremuloides*) tree. Although most mourning doves nested in relatively short, sparse cover, birds placed a few nests where 100% visual obstruction was up to 7 dm and effective vegetation height was nearly 8 dm. Percent dead vegetation at sites varied from 0 to 95%.

Short-eared Owl

Nearly all nests of short-eared owls were in native and seeded grasslands. Fields idled during previous growing seasons contained many more nests than fields under long-term grazing regimes. No nests were in fields where livestock were present during the nesting season. Birds placed nearly 58% of 57 nests in forbs, especially alfalfa. Western snowberry and grasses contained about 25 and 17% of nests, respectively. Among the grasses, wheatgrasses dominated nest sites most frequently. Most sites were where 100% visual obstruction was more than 2 dm and effective vegetation height was greater than 4 dm. Dead vegetation at all nests made up 12-88% of total vegetation.

Common Nighthawk

All common nighthawk nests were in native grassland. Birds used fields idled or pastured during previous growing seasons exclusively. All but one nest were in fields idle during current growing seasons, the single exception was a nest in a recently mowed field. Over half of 21 common nighthawk nest sites had no vegetation. Grasses, especially *Stipa* spp., surrounded one-third of the nest sites and forbs the remainder. Nests of common nighthawks had lower values for visual obstruction and effective vegetation height than those of all other species except killdeers and piping plovers. Average percent dead vegetation at nest sites was very low, probably reflecting the late date of nest initiation of this species.

DISCUSSION

Shortest intervals of nest initiations were by determinate laying shorebirds, whereas longest intervals were by non-determinate layers and mourning doves. Only the mourning dove is double-brooded in the northern Great Plains, but many of the other species we studied do renest after nest failure (Johnsgard 1979). Minimum and maximum clutch sizes of some species in our study differ from previously published figures (Harrison 1978, Ehrlich et al. 1988). The small clutches we observed may have been normal or reflected the stealing of eggs by predators, whereas the large clutches may have been natural or reflected intraspecific nest parasitism.

Apparent nest success for the 16 species we studied ranged from 48 to 87%, and Discrete Green success (Johnson 1991, comparable to Mayfield 1961 success) ranged from 27 to 77%. In comparison, a group of upland sandpiper nests in North Dakota had an apparent success of 46-84% and Mayfield (1961) success of 28-82% (Bonnie Bowen, Northern Prairie Wildlife Research Center, pers. commun.). For comparison with other species, Mayfield (1961) nest success rates for the five most common upland-nesting species of ducks in the United States portion of the prairie pothole region seldom exceeded 20% during 1966-1984 (Klett et al. 1988). Why nests of waterfowl nests seemingly are subject to much higher losses than nests of other birds in the region is a challenging question. Nonetheless, nest success of nearly all the species we studied would be much higher were it not for the large numbers of nests destroyed by mammalian predators.

The species we studied nested in a variety of native and planted habitats under a wide variety of land uses. However, except for killdeers, far fewer nests were in annually tilled cropland. This supports the results of studies of shorebirds and upland game birds (Higgins 1975) and waterfowl (Higgins 1977). Populations of many species of grassland birds would benefit from replacement of large areas of annually tilled cropland by no-till or minimum-till cropland where fields are relatively undisturbed during the spring and early summer and are similar in many aspects to the idle grasslands we studied. Many grassland birds nest in no-till or minimum-till cropland where nest losses from farm machinery are low (Basore et al. 1986, Duebbert and Kantrud 1987).

Most nests of raptors and upland game birds were at sites where vegetation height, visual obstruction, and percent of dead vegetation were relatively high. Current management practices on lands devoted to wildlife production, where idle conditions prevail except for occasional treatments to maintain stand vigor, should benefit these birds. Large amounts of land enrolled in the U.S. Department of Agriculture's Conservation Reserve Program (1985 Food Security Act, Public Law 99-198) currently provide similar habitat. However, our results suggest that about one third of the bird species we studied, mostly shorebirds, nested predominantly in the shorter, sparser cover of pastures, rather than in taller idle grasslands and that a few species are attracted to recently burned fields. Greater nest success, nest density, or species richness for ground-nesting birds in grazed rather than idle grasslands in North Dakota are also reported by Sedivec (1989) and Messmer (1990). Grazing and fire benefit many other grassland birds in a variety of other habitats in the northern grassland biome of North America (Kirsch and Kruse 1972; Best 1979; Kantrud 1981, 1986; Ryan et al. 1984; Higgins et al. undated). These findings indicate that, to maintain species diversity and abundance of grassland birds, large, scattered areas of grasslands in the northern Great Plains should not be protected from periodic disturbances that reduce vegetation height, litter, and the invasion of woody plants. In pristine times, these disturbances mostly resulted from fire and grazing by vast herds of wild ungulates (Nelson and England 1971). Thus, the nesting and perhaps feeding habitat for the shorebirds we studied, which usually nest relatively close to wetlands, would probably benefit if some public grasslands in areas of high wetland density were managed with fire, grazing, or combinations thereof. Modern livestock grazing systems can increase habitat quality for many species of non-game birds on mixed-grass prairies in North Dakota (Messmer 1990). However, some species of birds seem attracted to fields where vegetation height and density are reduced by grazing during one or more previous growing seasons even though these fields may be relatively unattractive when cattle are present.

We found perennial plants such as smooth brome, wheatgrasses, and alfalfa dominant in many fields and at many nest sites. These plants are among those most commonly seeded by farmers and wildlife managers in the northern Great Plains. Thus, at nest sites, we attribute the high frequency of these plants more to their availability than to their attractiveness to nesting birds. We have little doubt that it is the structure of the vegetation, especially the height-density and the presence or absence of a litter layer, rather than plant species *per se*, that creates attractive nesting habitat and nest sites for most birds we studied.

In summary, much is yet to be learned about managing northern prairie grasslands and croplands for wildlife. Scientists need detailed information on the life history of many grassland animals. Such studies should provide a background for additional research on the effects of grazing, prescribed burning, and predator management. Wildlife managers need such information to maintain species diversity on public lands devoted to wildlife. The U.S. Department of Agriculture's Conservation Reserve Program (1985 Food Security Act, Public Law 99-198) retired over 11 million acres of highly erodible, privately owned cropland in the northern Great Plains as of 1990 (Luttschwager and Higgins 1991). The future management of this land will greatly affect wildlife populations. Finally, because only a small fraction of the land in the northern Great Plains is in public ownership, scientists must develop land-use systems that prevent population declines of native wildlife species, yet provide adequate economic returns for landowners.

ACKNOWLEDGMENTS

We thank all the biologists, seasonal employees, and students who supplied data on nests of non-waterfowl species to the NPWRC nest files over the past 28 years. A complete list of these contributors would take up several pages. Besides our own contributions, most of the information in these files resulted from the efforts of several NPWRC biologists, including Harold Duebbert, Leo Kirsch, Tom Klett, Arnold Kruse, John Lokemoen, and Harvey Miller. We thank Louis Best, Douglas Johnson, Mike Kjellsen, Rolf Koford, Gary Krapu, and Mark Ryan for manuscript review and Todd Devries and Dan Twedt for statistical analyses.

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Received 18 December 1991. Accepted 25 March 1992.