STATUS OF MARBLED GODWITS IN SOUTH DAKOTA: BASED ON A 2007 LITERATURE SYNTHESIS

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ABSTRACT

The current status of the marbled godwit *(Limosa fedoa)* population in South Dakota is of primary concern to natural resource managers because the two main habitats this species needs, native rangelands and wetlands, are being converted to other land uses at a rapid rate. We synthesized over 250 references to generate a comprehensive review on the occurrence and ecology of the marbled godwit population in South Dakota to determine obvious and significant information voids necessary to form a population management plan. In general, our literature synthesis indicated a nearly uniform lack of baseline data concerning marbled godwit life history, distribution and population trends, and habitat requirements in South Dakota. Spatially and temporally, population and species accounts were sparse and inconsistent, but indicated extensive utilization of the northeast and north-central regions of the state during the breeding and migration periods. Life history data collected incidentally to spatially limited waterfowl nesting studies indicated grazed grasslands provided essential nesting habitat in north-central South Dakota. The most vital wetlands were those of temporary to semipermanent water regimes in uncultivated landscapes with vast expanses of mudflats and low vegetation. To maintain or enhance the populations of marbled godwits in South Dakota, large intact grazed grasslands containing wetland complexes should be preserved, and future research should focus on filling information voids relative to their life history and habitat needs.

INTRODUCTION

Marbled godwits *(Limosa fedoa)* are large sandpipers of the order Charadriiformes and family Scolopacidae that breed primarily in the temperate grasslands of north-central U.S. and south-central Canada, with small isolated populations in southwest James Bay and on the Alaskan Peninsula. During the non-breeding season, marbled godwits inhabit coastal areas from central California to Sinaloa,

Mexico. Monogamous pairs defend multiple-use territories which include nesting, feeding, and brood rearing habitats. Nests are simple scrapes lined with grass that may be fully concealed or wholly exposed. Clutch size is typically four eggs, rarely three or five. One brood is raised per year, but renesting after the failure of the first clutch has been documented. Both sexes participate in incubation, which typically lasts 24-26 days, and brooding of the precocial young until fledging at approximately 30 days. These breeding activities are typically carried out in landscapes containing short, sparsely to moderately vegetated grasslands intermixed with wetland complexes, while tall dense vegetative cover is avoided (Gratto-Trevor 2000, Johnsgard 1979, Melcher et al. 2005).

Marbled godwits were described by early explorers as "very abundant" in the Northern Great Plains (Bent 1927). However, many populations of shorebirds species crashed due to excessive market and sport hunting during the late 1800s and early 1900s (Brown et al. 2001). The Migratory Bird Convention Act of 1916 reduced hunting pressure, but a large portion of breeding habitat had already been destroyed or degraded by farming and ranching practices. These activities further slowed the recovery of these populations whose low reproductive rates make it difficult to reverse past declines (Brown et al. 2001). Today, habitat conversion and degradation still limit, and possibly cause declines in, upland nesting shorebird populations of the U.S. and Canada (Brown et al. 2001). Prairie breeding shorebirds have been substantially affected by the loss of breeding and nesting habitats, largely due to conversions of grasslands and wetlands to agricultural uses (Brown et al. 2001).

Since settlement, approximately 50% of native grasslands and 35% of wetlands in South Dakota have been lost to agricultural conversion (Peterson 1995). The majority of conversions have occurred east of the Missouri River, with the most extensive losses occurring in the southeastern corner and the largest tracts of remaining grasslands occurring in the northern and central portions. West of the Missouri River, the greatest conversions have occurred along the Missouri River (Anderson and Noyes 2005, Peterson 1995, USDA 2005) (See Gardner 2007). Furthermore, the remaining grasslands are fragmented, degraded, and threatened by invasive woody plants or exotic grasses and weeds especially in the absence of historic disturbance regimes, and they are vulnerable to environmental contaminants (Higgins et al. 2002, Peterson 1995, Stukel 2003). If livestock grazing does not remain a profitable economic alternative to cash grain farming, further fragmentation and conversion may occur, especially west of the Missouri River (Higgins et al. 2002, Peterson 1995).

Currently over 90% of the state is in agricultural production, with approximately 50% in pastureland, mainly west of the Missouri River, and approximately 47% in crop production, mainly east of the Missouri River (USDA 2005). Over 50% of the total planted acres are in corn *(Zea mays)* and soybean *(Glycine max)*, 22.5% in hay, and the remainder in wheat (*Triticum* spp.), sunflower (*Helianthus* spp.), and oat (*Avena* spp.) production (Anderson and Noyes 2005). Conservation Reserve Program (CRP) and Wetland Reserve Program lands occupy 3.1%, and woodlands occupy 0.5% of the remaining area (USDA 2005). Surface water covers approximately 12.2% of the state, 2.4% west (Rieger et al. 2006) and 9.8% east of the Missouri River (Johnson and Higgins 1997).

West of the Missouri River there are 172,867 wetland basins of which 35.7% are temporary, 29.2% seasonal, 34.3% semipermanent, and 0.8% permanent basins (Rieger et al. 2006). East of the Missouri River are 932,829 wetland basins of which 55.7% are temporary, 35.9% seasonal, 8.1% semipermanent, and 0.2% permanent basins (Johnson and Higgins 1997).

The most recent accounts indicate the global population of marbled godwits to be between 168,000 (Brown et al. 2001) and 171,500 birds (Melcher et al. 2005). Due to their relatively low and declining population size, their poorly understood ecology, and significant habitat loss and degradation occurring throughout much of their range, the marbled godwit in South Dakota is listed as a Species of High Concern in the U.S. and Northern Plains - Prairie Potholes Regional Shorebird Conservation Plans (Brown et al. 2001, Skagen and Thompson 2006), as a Partners in Flight Criteria I species in the northern mixed grass prairie region, (Fitzgerald et al. 1999) and Criteria III species in the northern tallgrass prairie region (Fitzgerald et al. 1998), as a National Audubon Society "yellow status" species (Melcher et al. 2005), and the U.S. Fish and Wildlife Service lists it as a Bird of Conservation Concern in Bird Conservation Regions 11, 17, and 22 (USFWS 2002).

In South Dakota the current population size is unknown; furthermore, based on accounts from South Dakota bird books from 1920 to 2002, the original distribution of marbled godwits in South Dakota is unclear (See Gardner 2007), making it difficult to determine if range reductions have occurred since European settlement. However, the accounts do indicate a reduction in relative abundance of this species throughout the state from the early 19th century to the present (Over and Thoms 1920, 1946, SDOU 1991, Tallman et al. 2002, Whitney et al. 1978). The South Dakota Breeding Bird Survey (BBS) also indicates that portions of north-central and northwestern South Dakota show prominent population declines, although the overall population appears stable to possibly increasing throughout most regions of the state (Sauer et al. 2005). In 2005, the South Dakota Department of Game, Fish, and Parks listed the marbled godwit as a Species of Greatest Conservation Need. Primary criterion for listing this species was that "South Dakota represents a significant portion of the species' overall breeding range" (SDGFP 2005). The primary causes of concern for marbled godwits in South Dakota are habitat loss and degradation due to the conversion, drainage, and degradation of wetlands for agricultural and other purposes, suppression or interruptions of historical disturbance regimes that have reduced the heterogeneity of habitat, fragmentation of remaining tracts of habitat, and waterfowl management techniques that have promoted tall grass near wetlands (SDGFP 2005).

Generally, the importance of grassland and wetland habitats to marbled godwits in South Dakota is not well known. Furthermore, the current population status and distribution is poorly understood. Every publication has a different distribution map based on different data sets, data collection methods, or possibly on individual perceptions, causing large variations in distribution maps from similar time periods. In order to help develop a comprehensive conservation plan for the marbled godwit in South Dakota, biologists need access to the literature and historical occurrence records pertaining to this species and

a synthesis report that summarizes the pertinent information available. Thus, the purpose of this study was to compile, review, and synthesize all available data relative to the marbled godwit in South Dakota to: (1) determine spatial and temporal distribution based on all available data, (2) identify voids in the knowledge base regarding life history and habitat data essential for population management plans, (3) identify future research needs, and (4) determine the best habitat preservation and management practices for the marbled godwit in South Dakota. This research will partially fulfill the current U.S. Shorebird Conservation Plan call for the synthesis and review of available upland nesting shorebird data throughout their ranges (Brown et al. 2001). More importantly this research will provide resource managers with a current base of information relative to the management of marbled godwit populations throughout the state.

METHODS

Gardner (2007) reviewed and synthesized approximately 1,500 articles of gray and scientific literature from the 1800s to 2007. The primary sources were South Dakota Ornithologists Union species accounts, South Dakota Breeding Bird Atlas (SDBBA) records, BBS records, theses, scientific publications, and internal agency reports. We further summarized the research and accounts from approximately 250 references documenting marbled godwit occurrence or research in South Dakota. To gather the most information possible, yet guard against duplication of information, (e.g., thesis data resulting in journal data), multiple publications resulting from the same study were pooled. The data collected from the review were synthesized into two data sets. The first data set was a collection of occurrence records and provided a means to determine spatial and temporal distribution. The second data set was a collection of research data and was used to determine the current knowledge base relative to habitat usage and life history.

Records were initially summarized by decade and county within four main categories: spring migration, fall migration, general breeding season, and confirmed breeding season, which was further subdivided into three categories: breeding pair and breeding behavior, nest, and brood sighting records. The confirmed breeding category included only records with defendable documentation, while the general breeding season category included all other records from the breeding season, which was determined to be from 15 May to 1 August, based on known valid nest and brood sighting dates. Records dated prior to 15 May were categorized as spring migration records and those after 1 August, as fall migration records. Records documenting migrants or breeders outside of these dates were included in the appropriate category, and records documenting more than 25 birds in a group were placed in the appropriate migration category.

To determine spatial and temporal shifts in record frequency, records were further summarized into seven regions (See Gardner 2007) and four time periods: (TP1) prior to 1950, (TP2) 1950-1969, (TP3) 1970-1989, and (TP4) 1990-2007, due to the low number of records per county per decade. Distribution maps were produced utilizing county and time period data; from this analy-

sis, regions of importance or declining populations were determined based on record frequency and consistency of record reports. Peak dates for migration and breeding periods were determined based on dated records divided into five-day and 10-day intervals, respectively, throughout that period.

RESULTS

Distribution of Records

Spring Migration—From 1896 to 2007, we found 374 records documenting the occurrence of marbled godwits in 58 of the 66 counties in South Dakota (Figure 1). The earliest record was 31 March (SDOU 2008), and the latest was 15 June (Elliott 1959, Harris 1979). The peak occurred between 11 and 30 April (62% of dated records) (Figure 2).

Overall, the number of records per time period and the number of counties with records has increased generally from TP1 to TP4 (Table 1). However, the east-central, northeast, and southeast were the only regions with records for all four time periods (Table 2). Based on counties with records (n=58), 38 counties (66%) had ≤ five records, and only six counties (10%) had ≥ 20 records. Minnehaha was the only county with records for all four time periods, and 16 counties (28%) had records for only one time period (Figure 1).

Temporally, there were spatial shifts in the frequency of records (Table 2). The highest frequency of records during TP1 was in the southeast (n=10), during TP2 in the northeast (n=48), during TP3 in the north-central (n=16) and east-central (n=14), and during TP4 in the east-central and central (n=50) regions of the state. In the northwest and south-central regions frequency of occurrence was low for all four time periods (n=4).

Fall Migration—We found 172 records documenting the occurrence of marbled godwit in 52 counties of South Dakota from 1869 to 2007 (Figure 3). The earliest record was 1 July (Peterson 1960, 1964) and the latest was 11 October (Peterson 1953, SDOU 1991). August 1 to 15 denoted the peak with 32% of the dated records (Figure 4).

The number of counties with records and the number of records per time period was variable over time (Table 1). Furthermore, the northwest and west-central regions only had records for one time period, and the northeast was the only region with records for all four time periods (Table 2). Based on counties with records (n=52), 44 counties (85%) had ≤ five records, only five counties (0.1%) had ≥ 10 records, no county had records for all four time periods, and 28 counties (54%) had records for only one time period (Figure 3).

Spatial shifts in the frequency of records occurred temporally. The southeast (n=10) had the highest frequency of records during TP1, the northeast (n=33, n=6) during TP2 and TP3, and the central (n=17) and east-central (n=15) regions during TP4. For all four time periods the northwest (n=3) and south-central (n=4) regions had the lowest frequency of records (Table 2).

Table 1. Statewide totals in the number of records and number of counties with records, by category, for the marbled godwit in South Dakota, from 1857 to 2007.

		Time Period				
Category	**No. Of**	**1**	**2**	**3**	**4**	**Total**
Spring Migration	Counties	7	48	27	42	58
	Records	14	103	66	191	374
Fall Migration	Counties	8	41	10	22	52
	Records	16	76	13	67	172
General Breeding Season	Counties	12	36	38	50	57
	Records	19	118	166	316	619
Confirmed Breeding	Counties	4	5	8	19	26
	Records	20	12	15	51	98
Nest	Counties	3	2	3	3	8
	Records	3	4	5	22	34
Brood Sightings	Counties	1	1	5	11	14
	Records	1	2	5	14	22
BB/BP	Counties	2	4	2	12	16
	Records	16	6	5	15	42

Table 2. Number of South Dakota marbled godwit spring and fall migration records by region and time period, from 1869 to 2007.

		Time Period				
Region	**Category**	**1**	**2**	**3**	**4**	**Total**
Central	Spring	0	10	4	50	64
	Fall	0	9	1	17	27
East-central	Spring	2	17	14	50	83
	Fall	2	10	0	15	28
North-central	Spring	0	11	16	21	48
	Fall	0	11	2	10	23
Northeast	Spring	1	48	11	16	76
	Fall	2	33	6	3	44
Northwest	Spring	0	0	2	2	4
	Fall	0	0	0	3	3
South-central	Spring	0	3	0	1	4
	Fall	0	3	0	1	4
Southeast	Spring	10	12	8	10	40
	Fall	10	10	1	0	21
Southwest	Spring	0	1	5	9	15
	Fall	1	0	2	7	10
West-central	Spring	0	1	6	30	37
	Fall	0	0	0	9	9

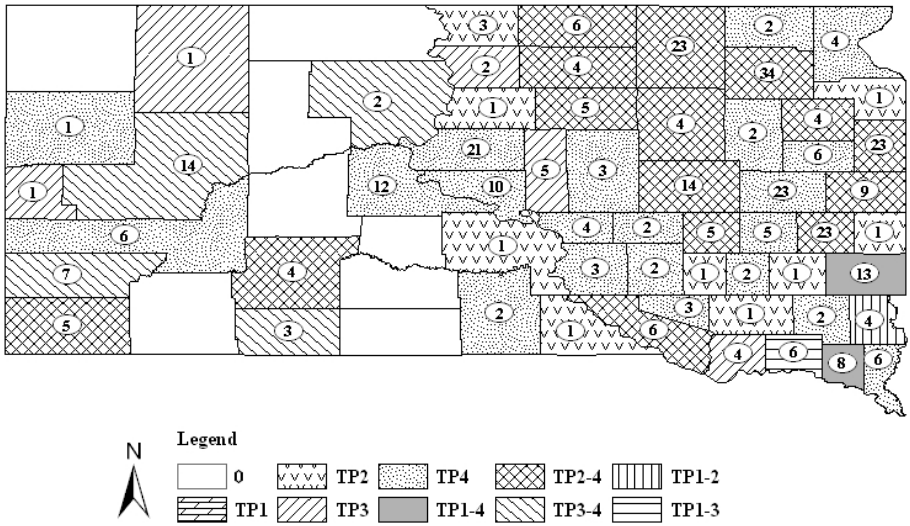

Figure 1. Marbled godwit spring migration records. Numbers within counties indicate the total number of records reported from 1896 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

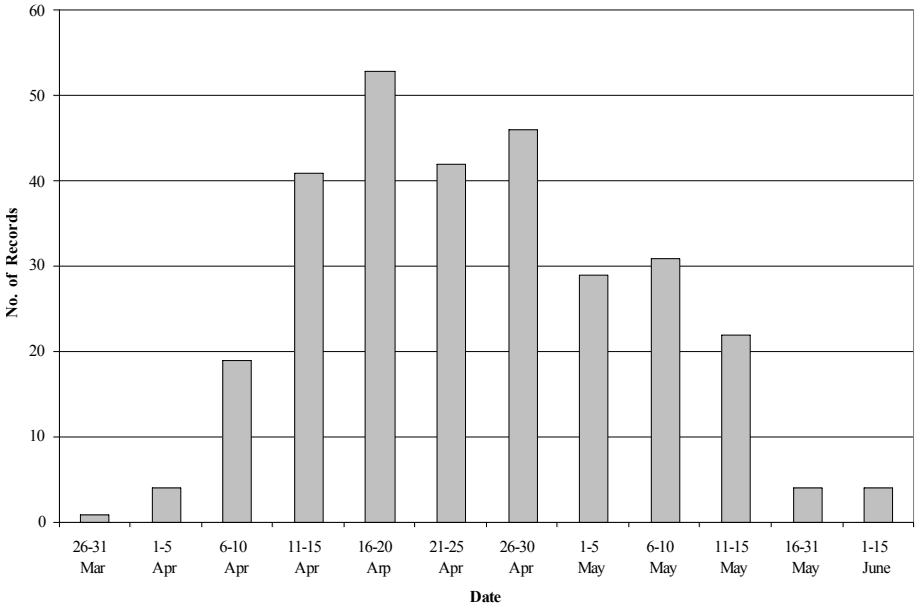

Figure 2. Number of records for each five-day time interval during spring migration for the marbled godwit in South Dakota from 1869 to 2007.

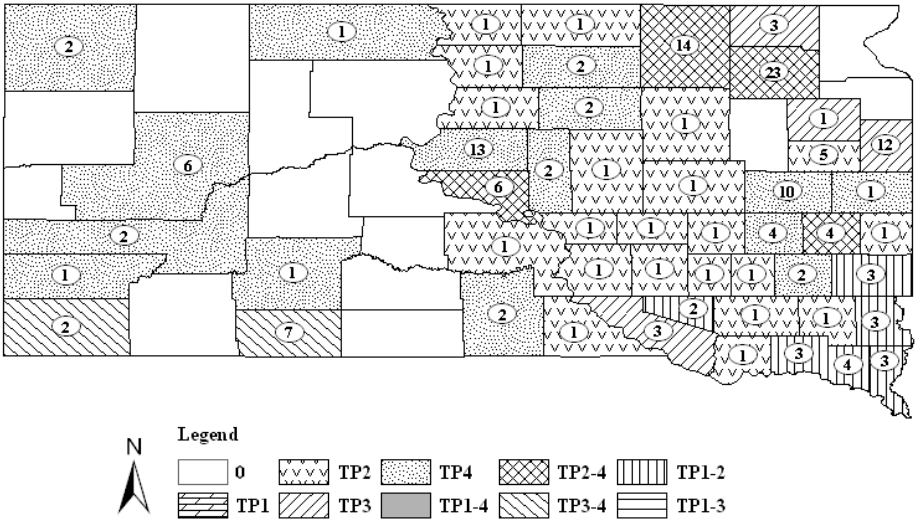

Figure 3. Marbled godwit fall migration records. Numbers within counties indicate the total number of records reported from 1869 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

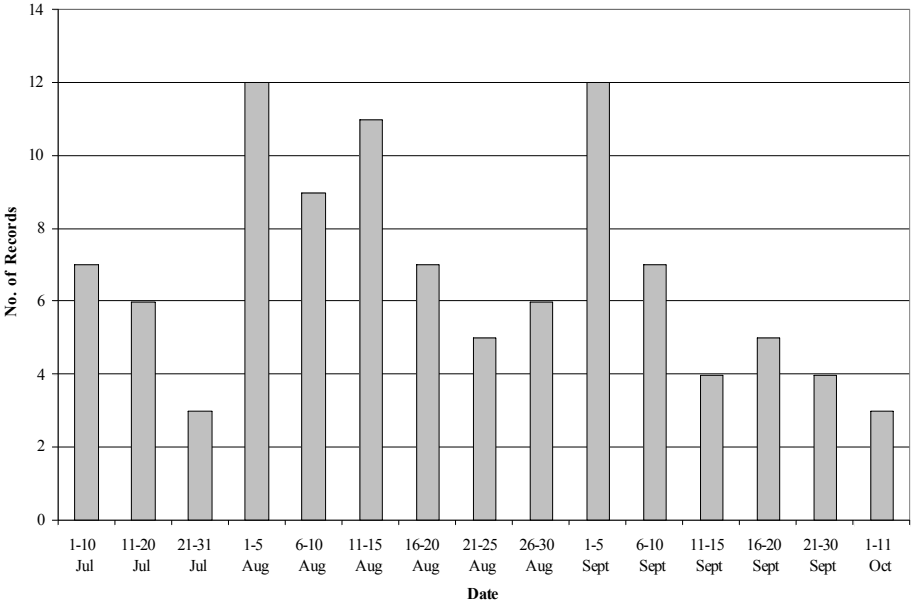

Figure 4. Number of records for each five-day time interval during fall migration for the marbled godwit in South Dakota from 1896 to 2007.

General Breeding Season—From 1857 to 2007, we found 619 general breeding season records documenting the occurrence of the marbled godwit in 57 counties of South Dakota (Figure 5). Statewide there was a general increase in the number of records and the number of counties with records from TP1 to TP4 (Table 1). All regions had records for at least three time periods (Table 3). Based on counties with records (n=57), 23 counties (40%) had ≤ five records, and only seven counties (12%) had ≥ 20 records. Ten counties (18%) had records for only one time period, and only five counties (9%) had records for all four time periods (Figure 5). Temporally, spatial shifts in the frequency of records were minimal. During TP1 (n=6) and TP2 (n=68) the highest frequency of records was in the northeast region, and the north-central region had the highest frequency of records during TP3 (n=46) and TP4 (n=78). However, the frequency of records was also high in the central region during TP4 (n=71) (Table 3).

Confirmed Breeding Season—From 1892 to 2007, there were 98 confirmed breeding records for the marbled godwit in 26 counties (Figure 6). Statewide there has been an increase in the number of counties with records and in the number of records between TP1 and TP4 (Table 1). The southeast and south-central were the only regions without records. The highest frequency of records during TP1 (n=19) and TP2 (n=8) was in the northeast, during TP3 in the north-central (n=5) and central (n=4), and during TP4 in the north-central region (n=27) (Table 4). The counties with the highest frequency of records were Day (n=26) and McPherson (n=22) (Figure 6).

Confirmed Breeding Season: Breeding Pair and Behavior—There were nine records documenting breeding behavior and 33 records documenting breeding pairs of marbled godwits in South Dakota from 1929 to 2007 in 16 counties (Table 1, Figure 7). The earliest date was 26 April (SDOU 2008), and the latest date was 13 July (Serr 1972). The majority (52%) of records were dated between 6 and 15 June (Figure 8). There were no regions with records for all four time periods; furthermore, the south-central and southeast regions had no records. Temporal spatial shifts were minimal. During TP1 (n=16) and TP2 (n=4) the northeast had the highest frequency of records, and during TP3 (n=4) and TP4 (n=5) the central region had the highest record frequency (Table 4). Eighty-one percent of the counties with records had only one or two records; Day (n=19) and Hyde (n=5) counties had the highest number of records (Figure 7).

Confirmed Breeding Records: Nests—We found eight counties with nest records for the marbled godwit in South Dakota from 1892 to 2007 (Table 1, Figure 9). All nests were located between 14 May and 30 June (Figure 8). The north-central and northeast were the only regions with records for more than one time period (Table 4). Twenty-one of the 34 (62%) nests were in McPherson County and were documented incidentally from two waterfowl nesting studies (Lokemoen and Duebbert 1974, Schultze 1995). Only one nest has been documented since the nesting study conducted in the early 1990s (SDOU 2008), and only three nests have been documented west of the Missouri River (Lohoefener and Ely 1978, Peterson 1995, SDOU 2008) (Figure 9).

Confirmed Breeding Records: Brood Sightings—Twenty-two marbled godwit brood sighting records were found for 14 counties from 1941 to 2007 (Table 1,

Figure 10). The earliest date was 31 May (Drilling 2005, SDOU 2008), the latest was 11 July (SDOU 2008), and the peak occurred from 6 to 25 June (55%) (Figure 8). The south-central and southeast regions had no records, while the northeast and north-central regions accounted for 50% of the records. However, no region or county had records for all four time periods (Table 4).

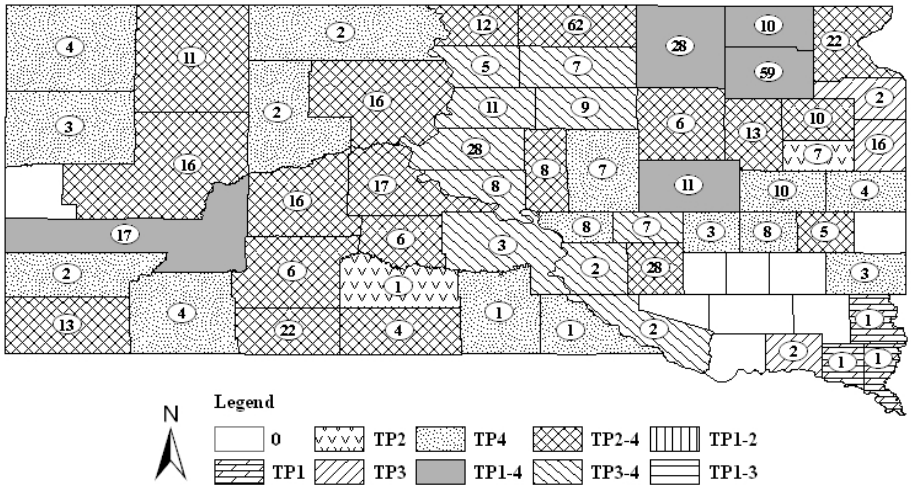

Figure 5. Marbled godwit general breeding season records. Numbers within counties indicate the total number of records reported from 1857 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

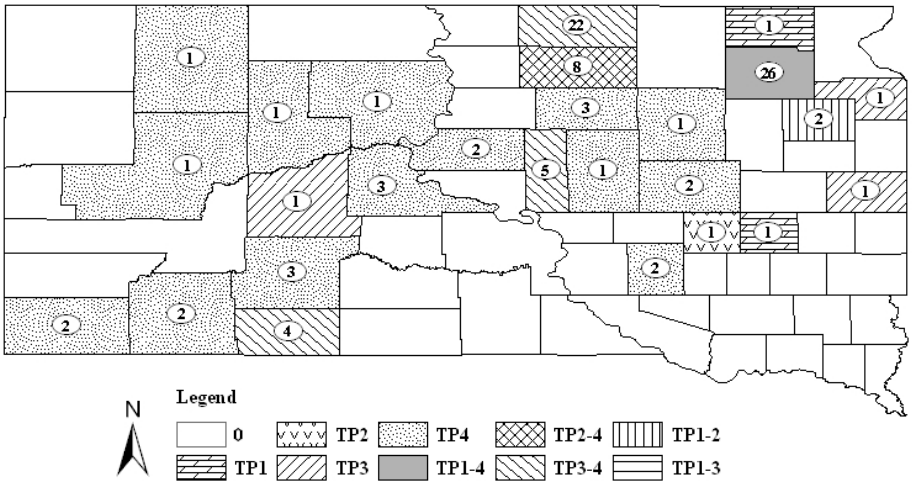

Figure 6. Marbled godwit confirmed breeding records. Numbers within counties indicate the total number of records reported from 1892 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

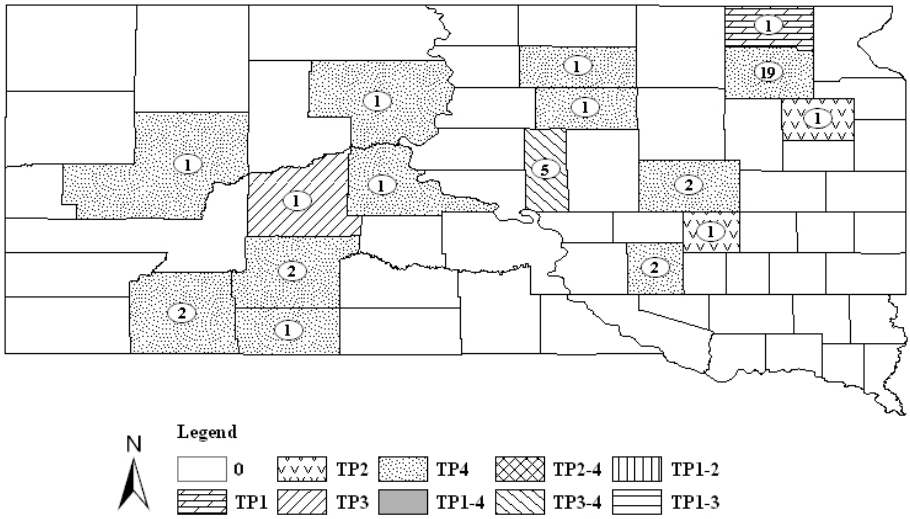

Figure 7. Marbled godwit breeding pair and behavior records. Numbers within counties indicate the total number of records reported from 1829 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

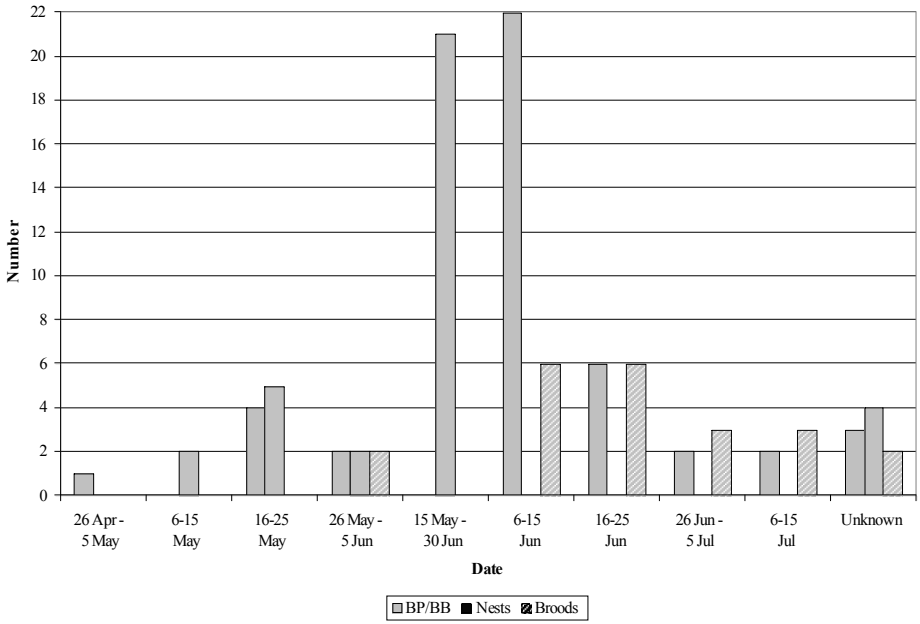

Figure 8. Number of breeding pair/breeding behavior, nest and brood sighting records for each 10-day time interval during the breeding season for the marbled godwit in South Dakota from 1892 to 2007, all nests located during the two waterfowl nesting studies are included in the column dated 15 May – 30 June.

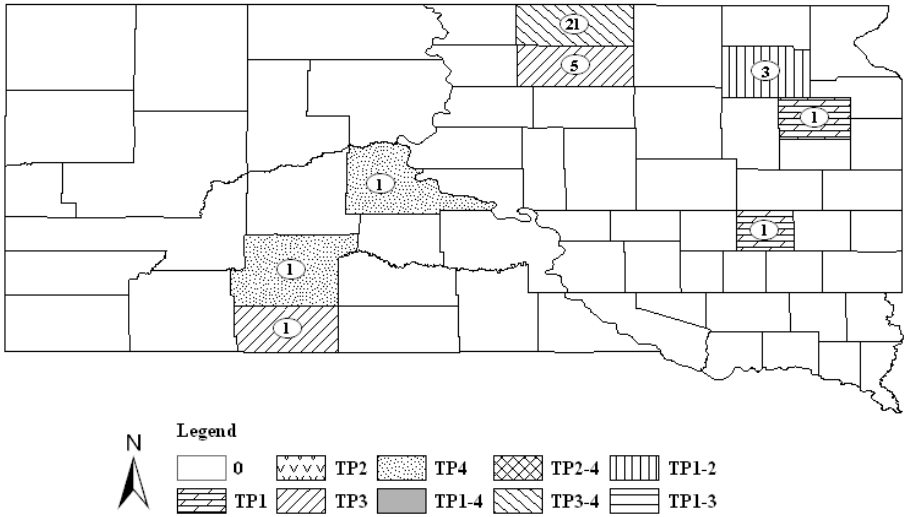

Figure 9. Marbled godwit nest records. Numbers within counties indicate the total number of records reported from 1892 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

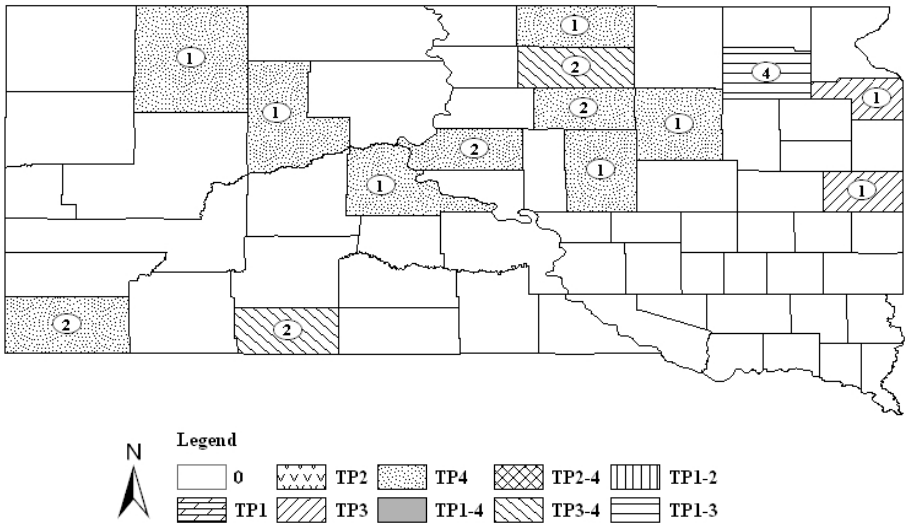

Figure 10. Marbled godwit brood sightings. Numbers within counties indicate the total number of records reported from 1941 to 2007. Coding scheme based on time periods (TP) in which each county had records. When multiple time periods in non-sequential order occurred, the last time period with a record was reported.

Table 3. Number of South Dakota marbled godwit general breeding season records by region and time period, from 1857 to 2007.

	Time Period				
Region	**1**	**2**	**3**	**4**	**Total**
Central	1	5	30	71	107
East-central	3	4	2	24	33
North-central	1	15	46	78	140
Northeast	6	68	34	31	139
Northwest	0	7	9	22	38
South-central	0	3	3	10	16
Southeast	4	0	2	1	7
Southwest	0	4	11	26	41
West-central	1	8	17	46	38

South Dakota Marbled Godwit Research

Monitoring—The only structured, long-term monitoring system for marbled godwits has been minimal and limited mainly to the BBS, initiated in 1967. In 2004, a breeding shorebird survey was initiated by the U.S. Fish and Wildlife Service HAPET Office to begin monitoring of this species in the Prairie Pothole Region, and is currently the only shorebird-oriented monitoring program in the state (Niemuth 2004, 2005, 2007). The SDBBA study, conducted in the late 1980s and early 1990s, has been the only study to document breeding activities throughout the state, and it was scheduled to be repeated in 2007 (Peterson 1995). Furthermore, there has been no initiation of a banding program, only one bird having been banded throughout the state (BBL 2005).

Nesting Habitat and Success—Generally, marbled godwits are thought to nest adjacent to or in dry areas of wetlands within the riparian/wetland matrix of the Great Plains Steppe Ecoregions in the tallgrass and mixed-grass subregions of South Dakota (SDGFP 2005). Of the 34 records found, 11 had no documented habitat type (32%), 21 were located in native prairie (62%), and two in pastures (6%); moreover, 19 nests (56%) were located in grazed grasslands (Table 5). Vegetation metrics of nest sites are limited to the documentation from 21 nests located incidentally during two waterfowl nesting studies (Lokemoen and Duebbert 1974, Schultze 1995) conducted in the north-central region. Grassland patch size ranged from 57-259 ha, with a mean of 67 ha, and each patch contained 3-16 ha of wetlands, with a mean of 8 ha. Visual obstruction readings (VORs) on the grazed patches ranged from 0.2-0.9 dm, and within ungrazed patches the VORs ranged from 0.4-2.5 dm. No nests were located within an ungrazed Waterfowl Production Area (WPA), where VORs ranged from 0.8-2.2 dm; however, point counts did indicate the occurrence of marbled godwits within this area during the breeding season. The absence of marbled godwit nests within the WPA indicated a preference for shorter cover in grazed grassland easements over the heavier cover in ungrazed WPAs (Schultze 1995). In a third study, marbled godwits were documented to nest in crop fields surveyed in North and South Dakota (Higgins and Kantrud 1973).

Table 4. Number of South Dakota marbled godwit confirmed breeding season, nest, brood, and breeding pair/breeding behavior records by region and time period, from 1892 to 2007.

		Time Period				
Region	**Category**	**1**	**2**	**3**	**4**	**Total**
Central	Nest	0	0	0	0	0
	Brood	0	0	0	3	3
	BP/BB	0	0	4	5	9
	Total	0	0	4	8	12
East-central	Nest	1	0	0	0	1
	Brood	0	0	1	0	1
	BP/BB	0	1	0	0	1
	Total	1	1	1	0	3
North-central	Nest	0	2	4	20	26
	Brood	0	0	1	5	6
	BP/BB	0	0	0	2	2
	Total	0	2	5	27	34
Northeast	Nest	2	2	0	0	4
	Brood	1	2	2	0	5
	BP/BB	16	4	0	1	21
	Total	19	8	2	1	30
Northwest	Nest	0	0	0	0	0
	Brood	0	0	0	2	2
	BP/BB	0	0	0	1	1
	Total	0	0	0	3	3
South-central	Nest	0	0	0	0	0
	Brood	0	0	0	0	0
	BP/BB	0	0	0	0	0
	Total	0	0	0	0	0
Southeast	Nest	0	0	0	0	0
	Brood	0	0	0	0	0
	BP/BB	0	0	0	0	0
	Total	0	0	0	0	0
Southwest	Nest	0	0	1	0	1
	Brood	0	0	1	3	4
	BP/BB	0	0	0	3	3
	Total	0	0	2	6	8
West-central	Nest	0	0	0	2	2
	Brood	0	0	0	1	1
	BP/BB	0	1	1	3	5
	Total	0	1	1	6	8

Apparent nest success, from the 6 records with known fate, was 83% (n=5); however, 82% (28 of 34) of the records had unknown fate (Table 5). In comparison, a compilation of nest records from South Dakota, North Dakota, Montana, and Manitoba indicated only 60% nest success (Kantrud and Higgins 1992). Ninety-three percent of the nest failures were attributed to predation, with 50% attributed to mammalian predators (Kantrud and Higgins 1992).

Table 5. Nest fate and habitat type of marbled godwit nest records in South Dakota from 1892 to 2007, by region.

Region	Habitat Type	No. Nests	Nest Fate	Reference(s)
East-central	Unknown	1	Unknown	Cooke 1910
North-central	Unknown	2	Unknown	Duebbert 1968
		3	Successful	Serr 1971, 1972
	Native prairie	1	Unsuccessful	Lokemoen & Duebbert 1974
	Idle native prairie	1	Unknown	Schultze 1995
		2	Successful	Schultze 1995
	Annually grazed native prairie	17	Unknown	Schultze 1995
Northeast	Unknown	3	Unknown	Peterson 1963, Tallman et al. 2002, SDOU 1991, Whitney et al. 1978
	Pasture	1	Unknown	Over & Thoms 1946
Southwest	Pasture	1	Unknown	Lohoefener & Ely 1978
West-central	Unknown	2	Unknown	Peterson 1995, SDOU 2008, Skadsen 1992, Tallman et al. 2002

Grassland Habitat Usage—Generally, optimal habitat conditions for marbled godwits in South Dakota are thought to be relatively large contiguous blocks (> 103 ha) of short, sparsely to moderately vegetated, intact, grazed grasslands intermixed with wetland complexes (SDGFP 2005). However, no studies have been conducted to determine grassland habitat needs for marbled godwits in South Dakota; the seven studies documenting marbled godwit occurrence on grasslands have primarily focused on passerine or game birds, and were conducted on lands managed to increase nesting habitat for waterfowl and other game species. The only study (Peterson 1995) to document marbled godwit occurrence

throughout the state found most marbled godwits were in upland grasslands, followed by lowland grasslands and open water (n=78); furthermore, 74% of the observations occurred in natural habitats and 25% in manmade habitats. Sightings were most frequent in the northern Missouri Coteau and north-central areas of the state (Peterson 1995). Furthermore, Niemuth (2007) indicated that the highest concentration of the most suitable landscapes in the Prairie Pothole Region for marbled godwits were present in the north-central and central regions of the state, with the least suitable habitats located in the southeast region. Based on similar studies, marbled godwit frequency of occurrence was low on WPA and Game Production Areas in eastern South Dakota (0.9%) (Bakker 2000), and was moderately dense on private grasslands (0.4 birds/100 ha) in western South Dakota (DeJong 2001). Comparison between lands managed to increase waterfowl nesting habitat and non-managed lands indicated higher frequency of occurrence rates (0.4%) on non-managed lands than on managed lands (0%) (USDA 1985). On the Fort Pierre National Grassland, marbled godwits were common (Fritcher 1998), while on the Grand River National Grassland, frequency of occurrence was only 1% (Knowles 2001). In western South Dakota, no significant difference could be found between frequency of occurrence rates on grassland patches within non-fragmented landscapes (n=8) and patches within fragmented landscapes (n=7); however, no marbled godwits were located in croplands (DeJong 2001). Surveys of CRP fields in Montana, South and North Dakota, and Minnesota (n=303) found marbled godwit density to be 0-11.5 pairs (Johnson and Schwartz 1993); furthermore, marbled godwits were found only on patches > 50 ha (Johnson and Igl 2001). On grasslands in north-central South Dakota, Shultze (1995) found minimal usage by marbled godwits in managed areas lacking grazing, and greater usage on grasslands that were grazed.

Wetland Habitat Usage—Generally, greater emphasis has been placed on marbled godwit usage of wetland habitats than grassland habitats; however, the studies have been spatially limited and wetland type specific. In western South Dakota, marbled godwits utilized bentonite clay and coal mine impoundments during the breeding season at a density of 0.01 birds/impoundment (n=36) (Uresk and Severson 1988), and on livestock impoundments at a density of 0.4 birds/ha with a frequency of occurrence of 4.6% (n=196) (May 2001, May et al. 2002). In eastern South Dakota, marbled godwits (n=2) had a frequency of occurrence of 3% on borrow-pit or road rights-of-way wetlands throughout the region (Hop et al. 1989).

Only one study (Flake and Vohs 1979, Weber 1978, Weber et al. 1982) has compared marbled godwit use of multiple wetland types throughout the state. Results from this study indicated a frequency of occurrence of 1.7% on all wetland basins, and an average density of 0.07 birds/ha of surface water (Weber 1978), with more observations occurring in eastern than in western South Dakota (Flake and Vohs 1979). Frequency of occurrence (5.3%) and average densities (0.23 birds/ha of surface water) were highest on Missouri Coteau wetlands (Flake and Vohs 1979, Weber 1978), with marbled godwits absent from wetlands in the Northern and Southern Plateau Regions, and the Minnesota-Red River Lowlands (Flake and Vohs 1979, Weber 1978). Frequency of occurrence was highest on permanent ponds or lakes (6.3%) (Flake and Vohs 1979, Weber 1978), and

average density was highest on dugouts (0.26 birds/ha of surface water) (Flake and Vohs 1979, Weber 1978). However, Weber et al. (1982) reported frequency of occurrence was highest on temporary ponds (4.1%), followed by stock ponds (2.4%). Marbled godwits were absent from permanent streams and ephemeral ponds (Weber 1978, Weber et al. 1982).

One study (Knapp 2001) conducted on temporary wetlands in central South Dakota documented activity and microhabitat usage. Most marbled godwits observed were in vegetation (60%), followed by mud (19%), water (15%), and uplands (6%) (n=124). Foraging (63%) was the most prominent activity, followed by preening or resting (30%), and flight (7%) (n=145). Low vegetation height (92%) was preferred over high (5%) and medium (3%) (n=97). No correlation could be found between activity and microhabitat because most foraging and non-foraging birds were observed in the same microhabitat. A second study (Miller 2003) in north-central South Dakota documented the effects of basin size on marbled godwit occurrence. Marbled godwit observations (n=11) were higher on large wetlands (basin area ≥ 0.5 ha) than on small wetlands (n=3) (basin area < 0.5 ha). The mean number of birds/wetland was 0.17 on large wetlands and 0.04 on small wetlands, and the mean number of birds/ha of surface water was 0.78 and 0.21, respectively.

Parameters positively influencing marbled godwit occurrence on all wetland types included increased area of untilled upland habitat (Miller 2003, Naugle 1997) or hectares of alfalfa-hayland surrounding the wetland (Flake and Vohs 1979, Weber 1978), increased wetland area (Naugle 1997), wetlands with cover type I (closed stands of emergent vegetation with open water or bare soil covering < 5% of the wetland) (Flake and Vohs 1979, Weber 1978), expanses of open water devoid of emergent vegetation (Miller 2003, Naugle 1997), and increased percentage of shoreline in mud (Miller 2003, Naugle 1997). The number of hectares of cultivation surrounding wetlands (Flake and Vohs 1979, Weber 1978), the increased coverage of emergent vegetation (Miller 2003, Naugle 1997), and the percentage of the shoreline containing vegetation >15 cm (Miller 2003, Naugle 1997) were negatively associated with marbled godwit occurrence. On bentonite clay and coal mine impoundments positive factors influencing marbled godwit occurrence were impoundment area, amount of nitrogen in the water, and percent slope (+1 m elevation to shoreline) (Uresk and Severson 1988).

DISCUSSION

We found a general absence of published literature relative to marbled godwit occurrence and habitat requirements within the state of South Dakota. In over a century, there was a low number of migration and breeding season records, and even fewer studies had information relative to the primary habitat requirements of this species. The general lack of records, and the spatial and temporal inconsistencies among these records greatly limited the ability to identify key population locations, changes in population size and distribution, and the primary habitat parameters required for successful reproduction.

However, it is evident that wetlands in the north-central, northeast, east-central, and central regions of the state were the most extensively utilized during the migration periods, while wetlands in the northwest and south-central regions received the lowest number of migrants. During the general breeding season, marbled godwits occurred at the highest frequency in the northeast, north-central, and central regions of the state. Perhaps the differences in the distributions of these species could be related to the higher density of wetland basins in the eastern compared to western portions of the state (Rieger et al. 2006), and the large tracts of native grasslands remaining in these regions (Peterson 1995). However, it is plausible that observers themselves may have had an influential impact on the spatial and temporal distribution of the records, due to the distribution of observers (i.e., higher number in more populated areas), favorite birding destinations (i.e., wetlands where shorebirds will positively be seen), non-random nature of the observations, and the variation in the number of observers or the number of observations reported each year. These variables may mask the actual importance of certain regions of the state, such as western and central South Dakota which still have large expanses of native grasslands, or skew the distribution of records to areas such as the northeast and north-central regions of the state which have a high density of wetlands. Furthermore, residential wildlife viewing has increased 55% from 1996 to 2006 (USDI et al. 2003); this could be correlated to the increasing temporal trends in the number of spring and fall migration records. The internet has also changed the way in which bird sightings are reported in South Dakota, and the simplicity of this new method may have increased the number of observations that are reported and the number that can be viewed by the public (e.g., fewer records can be placed in a published journal compared to an online database due to cost and time restraints). Overall, most regions of the state had poor representation, and it is unclear as to the significance of these areas to marbled godwits during migration and breeding periods.

It was very evident that the location of research sites greatly influenced the distribution of nest and other confirmed breeding records. The majority of these data were collected from waterfowl nesting studies located in the north-central and northeast regions of the state. Correspondingly, the spatial and temporal maps indicate these areas as the most extensively utilized breeding areas. However, there is minimal representation from other regions of the state, especially western South Dakota, probably under-emphasizing the importance of this area during the breeding season.

Furthermore, the majority of the marbled godwit life history and habitat data was collected incidental to waterfowl nesting studies, limiting determination of specific habitat requirements. Overall, marbled godwits preferred native grasslands and tended to utilize grazed grasslands more frequently than idle grasslands, with the majority of nests being located in grazed native grasslands. Research within the Northern Great Plains supports this finding and further indicates that marbled godwits prefer native to tame grasslands and grazed to idle grasslands (Dechant et al. 2003); however, tame and idle grasslands have been frequently used (Dechant et al. 2003, Kantrud and Higgins 1992), and preference has been shown for grazed grasslands that were idle during a breeding season over continually grazed grasslands (Kantrud and Higgins 1992).

Furthermore, marbled godwits did not nest where visual obstruction was > 1 dm, effective cover height was > 3.5 dm and dead vegetation was typically < 40% at nest sites. Similar nests in South Dakota were found on grasslands with VORs ranging from 0.2-2.5 dm, and vegetation height and density less than in idle grasslands (Shultze 1995). Across the Northern Great Plains states vegetation at nest sites was dominated by graminoids (Kantrud and Higgins 1992), typically native grasses and grass-like plants such as green needlegrass *(Nassella viridula)* and sedges (*Carex* spp.); however, introduced grasses such as Kentucky bluegrass *(Poa pratensis)* and smooth brome *(Bromus inermis)* were also utilized. Brood rearing habitat was taller (15-60 cm) and denser than nesting cover (Ryan et al. 1984), indicating grazing or burning practices on native grasslands that produced vegetation of short to medium height and density are beneficial to marbled godwits, while practices encouraging tall, dense vegetation should be avoided for marbled godwit management throughout the Northern Great Plains (Dechant et al. 2003).

Though patch size requirements have not been directly determined for South Dakota, the few nests that were located occurred in native grassland patches > 57 ha in size (Shultze 1995), indicating a minimal patch size requirement of 50 ha, but more probably as high as > 100 ha. North Dakota research supports this higher minimal patch size requirement, because marbled godwit territories averaged 90 ha there (Ryan et al. 1984), and most birds required blocks of grassland habitat > 100 ha (Dechant et al. 2003).

Preservation of semipermanent, seasonal, temporary and ephemeral wetlands appears essential to marbled godwit populations, based on their high occurrence rates. Furthermore, management for mudflats, shorter vegetation, increased wetland area and surface area, and reduction of tilled lands surrounding these wetlands would positively benefit this species. Wetlands of greater than 0.5 ha with shallow water also appeared beneficial to marbled godwits.

The BBS provides long-term data sets and a means of monitoring breeding shorebird populations. However, there are multiple factors affecting the efficiency of the BBS in monitoring shorebird populations; e.g., the eastern portion of the state has a more even distribution of routes, routes are often located in unfavorable habitats, not all routes are surveyed every year (e.g., < 50% of routes are surveyed each year), surveys are conducted from the road during the general nesting period (incubation) when birds remain on the nest and are less visible and vocal, and studies have shown fewer birds are observed on transect surveys than on "walk-about" surveys. With the exception of the Prairie Pothole Region during spring, local birders are presently the only means of determining changes and distributional patterns of migrating birds. In recent years, there has been an increase in monitoring systems focused on upland nesting shorebirds; however, these systems are spatially limited. Thus, the lack of any statewide, structured survey data targeted at upland nesting shorebirds limits an extensive temporal and spatial baseline data set on which to compare any future assessment of the trends or distributional changes in the breeding populations of marbled godwits within the state. However, it is evident that the population of this species is reduced from historic levels and in some portions of the state currently may be declining in abundance (Sauer et al. 2005, Skagen and Thompson 2006). Fur-

thermore, there were little data relative to nesting and hatching success or brood and adult survival making it impossible to accurately determine production and recruitment rates within the state, further limiting the ability to assess the breeding population of this species throughout the state.

In general, future research should focus on all aspects of life history and habitat requirements during migration and breeding periods and the development of monitoring systems. Initially, a more accurate set of baseline data relative to the current breeding population within the state should be developed to provide a means of comparison for future management practices and inventory records. To develop this breeding population baseline data set, a statewide survey starting at or near the onset of the nesting season is needed. The establishment of a statewide monitoring system beyond the BBS and local birders is necessary to determine distributional and population changes during the breeding and migration periods. Monitoring units should be distributed throughout the state, be representative of all habitats, and be designed to provide representative spatial and temporal data for marbled godwits. Furthermore, occurrence records should be consolidated into one easily accessible and useable database, and require the documentation of the essential notations (e.g., number of birds seen, the habitat type in which the observation occurred).

Extensive banding and marked-bird studies should be initiated to enhance known population parameters and fill unknown parameters (e.g., migration routes, wintering locations, site fidelity). Coordinated nesting and survival studies should be conducted to fill the multiple voids in the reproductive demographics of this species. Ideally, these studies should be conducted in various landscapes across the state from mid-April through fledging; such studies would fill multiple knowledge voids relative to arrival dates, pre- and post-breeding foraging sites, nesting and brood rearing habitat, nest success and causes for failure, brood and fledgling survival rates and causes for failure, pre- and post-breeding behavior, adult survival and success, and departure dates. Although grazed native grasslands seem to be preferred, further study comparing different grasslands types (e.g., native, non-native, CRP, croplands) is required. Studies documenting the impacts of grassland management activities (e.g., spring burning, fall burning, rotational grazing, annual grazing) and agricultural practices (e.g., pesticide and herbicide applications) throughout the breeding season are needed to determine effects on aspects of marbled godwit breeding ecology (e.g., nest site selection, forage site selection, brood sites, nest success, brood survival). Landscape level factors should also be taken into consideration during these studies (e.g., distance between nest sites and nearest wetland). Additionally, consideration should be given to incorporate additional data collection on marbled godwits in conjunction with other on-going avian studies within the state.

In conclusion, there was a nearly uniform lack of baseline data for all aspects of marbled godwit life history, population status and trends, distribution, habitat needs, and structured survey methodology both temporally and spatially. Beyond this, occurrence records were sparse and most habitat and life history data were collected incidental to waterfowl, upland game bird, and grassland passerine bird research conducted in South Dakota. Despite these facts, it was apparent that marbled godwits utilized larger grazed grassland patches (> 50 ha) with a mosaic

of vegetation heights, < 60 cm, and multiple wetland complexes (e.g., ephemeral, temporary, seasonal, semipermanent) with shorelines containing an increased percentage of mudflat habitat and vegetation of relatively short stature (< 15 cm) and medium density. It is evident that the two most threatened habitats in South Dakota, native grasslands and natural wetlands with non-permanent water regimes (Peterson 1995), provide essential breeding habitat, while lands managed to increase waterfowl and other game bird nesting habitat receive minimal usage due to increased height and density of the vegetation (Schultze 1995). Grassland management practices, such as grazing and burning, which produce vegetation of short to medium heights and densities, appear beneficial to marbled godwit nesting populations and could increase utilization of public lands. Future studies should focus on life history and habitat requirements of marbled godwits throughout the state. Even though the BBS has shortcomings, the decreasing trends in specific locations should not be ignored. Immediate action should be taken to fill the habitat and life history information voids, and conservation or management strategies should be devised to ensure marbled godwits will continue to prosper in South Dakota. Furthermore, preservation of large, intact, grazed native grasslands containing a mosaic of vegetation heights and wetland complexes are needed to ensure the future welfare and productivity of marbled godwits in South Dakota and throughout the Northern Great Plains.

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