NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Distribution, Abundance, and Habitat Associations of the Long-billed Curlew in Southwestern North Dakota

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Terry Steinwand
Director

Submitted by
Michael G. McKenna
Chief, Conservation and Communications Division

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DISTRIBUTION, ABUNDANCE, AND HABITAT ASSOCIATIONS OF THE LONG-BILLED CURLEW IN SOUTHWESTERN NORTH DAKOTA

by

Daniel S. Ackerman
Bachelor of Science, University of North Dakota, 2004

A Thesis

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This thesis, submitted by Daniel S. Ackerman in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

Chairperson

This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School for the University of North Dakota, and is hereby approved.

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ABSTRACT

Gathering information on North American bird populations calls for long-term monitoring programs covering extensive geographic regions to provide basic information on distribution, habitat use and availability, abundance, and changes in abundance. Information regarding population size, distributions and trends is of critical importance to conservation planners, managers, and biologists concerned with widespread degradation of ecosystems, alteration and loss of habitats, and understanding the effective conservation of a species. In accordance with the recommended monitoring of bird populations, especially species of high conservation concern, I undertook a study of the long-billed curlew (*Numenius americanus parvus*; hereafter LBCU or curlew). The LBCU were once abundant over most of the shortgrass and mixed-grass prairie in the United States and Canada. In the mid- to late 19th century, LBCU numbers drastically declined due to the double combination of over-hunting prior to the Migratory Birds Convention Act, and extensive habitat loss from conversion of native prairie to monocrop agriculture.

The current lack of scientific knowledge regarding LBCU population sizes and distributions make it difficult to evaluate the current status of the population. This study looked at estimating abundance by conducting census route surveys throughout the 2005 and 2006 field seasons. Habitat use was analyzed as identified breeding LBCU locations were complied with land cover data. This will provide wildlife managers information as

to what the LBCU prefers for breeding habitat and to where they can help promote the safeguarding of this animal.

A conservative abundance estimate of 518 and 2,074 breeding LBCUs were found in 2005 and 2006, respectively. It was found that LBCUs prefer short-growth grasslands and areas with large amounts of wetland area. They tend to avoid extensively cultivated areas and areas of developed property.

The breeding biology, abundance estimate and relative importance of various habitats to LBCUs in North Dakota is provided here. Wildlife managers must evaluate these results and consider the possibility of labor-intensive efforts.

CHAPTER I

INTRODUCTION

A deliberate framework for monitoring North American bird populations calls for long-term monitoring programs covering extensive geographic regions to provide basic information on distribution, habitat use and availability, abundance, and changes in abundance as fundamental elements of bird conservation programs (NABCI 1998). The Program for Regional and International Shorebird Monitoring (PRISM; Donaldson and Andres 2002) has several stated monitoring goals, including estimating the size of breeding populations of 74 shorebird taxa in North America, with priorities for implementing new surveys of species of high conservation concern (Bart et al. 2005). Knowledge about population size, distributions, and trends is of critical importance to conservation planners, managers, and biologists concerned with widespread degradation of ecosystems, alteration and loss of habitats, and understanding the effective conservation of a species (Grant et al. 2000, Stanley and Skagen, U.S. Geological Survey, unpubl. data). In accordance with the recommended monitoring of bird populations, especially species of high conservation concern, I undertook a study of the long-billed curlew based on recommendations from North Dakota Game and Fish Department (NDGF) personnel.

The long-billed curlew (*Numenius americanus parvus*, hereafter curlew or LBCU), one of only nine species of birds considered endemic to the Great Plains, is

North America's largest shorebird (Allen 1980, Cannings 1999). Despite its size and conspicuous nature, the LBCU has historically received little scientific attention. This is partly due to the unique ecological niche occupied by this bird (mesic upland grasslands). Many shorebird studies focus on species inhabiting wetlands, whereas upland studies focus more on passerines, game birds, or raptors (Morrison et al. 1994, 2001).

The lack of scientific knowledge regarding LBCU population sizes and distributions make it difficult to evaluate the current status of the population. Current estimates place the range-wide population at approximately 20,000 birds, but the accuracy of this estimate is not known (Brown et al. 2001, Dugger and Dugger 2002).

The LBCU has a geographically wide, but patchy, breeding distribution, is relatively secretive during incubation, and is an early nest initiator with most young off the nest and away from the breeding area by mid-June (Dugger and Dugger 2002). These factors contribute to the species' inadequate coverage by the North American Breeding Bird Survey (BBS; J. Bart, U.S. Geological Survey and C. Francis, Canadian Wildlife Service, unpubl. data). The aforementioned information suggests a need for further investigation of breeding LBCUs across their range.

The primary objectives of this study include: 1) participate in a range-wide LBCU survey conducted by the USFWS and the U.S. Geological Survey (USGS; Jones et al. 2003) to produce range-wide population estimates, 2) obtain an estimate of the population size of breeding LBCUs in southwestern North Dakota, 3) investigate habitat use of LBCUs during their stay in North Dakota (i.e., importance of water in nest site selection, vegetative structure [height/density], and species composition), and 4) develop a protocol for monitoring LBCUs within North Dakota that could then be followed in subsequent years with reduced effort. The data collected in this study could form a strong basis for such efforts and provide insight into LBCU population trends in southwestern North Dakota.

Breeding Biology

Curlews are migratory, typically returning to their breeding grounds in North Dakota between late March and mid-April (Stewart 1975, private ranchers, pers. commun.). Initiation usually begins shortly after arrival on breeding grounds (Dugger and Dugger 2002). Egg-laying occurs from late April to the beginning of May in Saskatchewan (Renaud 1980). Egg-laying takes place over a period of four to seven days and incubation begins shortly after the final egg is laid (Allen 1980, Redmond and Jenni 1986, Liebezeit et al. 2006). As with most shorebirds, the standard clutch size is four eggs and rarely five (Maclean 1972). Curlews typically lay only one clutch per season (Sadler and Maher 1976, Redmond and Jenni 1986); however, recent evidence suggests re-nesting may be possible (Clarke 2006). Eggs hatch synchronously within nests (Foster-Willfong 2003), typically from mid-May to mid-June (Dugger and Dugger 2002, Foster-Willfong 2003). Fledging occurs approximately six weeks after hatching (Allen 1980, Baicich and Harrison 1997, Foster-Willfong 2003).

Curlews exhibit site-fidelity and appear to nest in social clusters (Allen 1980, Redmond and Jenni 1982, pers. obs.). The same territories appear to be used in subsequent years (Stewart 1975, private ranchers, pers. commun.). However, it is not known for certain whether sites are re-used by the same individuals.

Habitat Preferences

Prior studies found that LBCUs use expansive, open, level to gently rolling grasslands with short and/or mixed grass prairie (Bicak 1983, Cochran and Anderson 1987, Pampush and Anthony 1993). Curlews have been recorded breeding on native short and mixed-grass prairie and on tame pastures (McCallum et al. 1977, Bicak 1983, Cochran and Anderson 1987). Previous studies reported that LBCUs rarely nest in hayland, cropland, fallow or stubble fields (McCallum et al. 1977, Renaud 1980, Cochran and Anderson 1987). Birds appear to forage in all habitat types (Allen 1980, Pampush and Anthony 1993), except extensively cultivated areas (Renaud 1980), during the breeding season. Curlew habitat preferences are thought to change over the course of the breeding season, from areas of shorter vegetation during nesting, to areas with a different vegetation structure when young broods are present (Redmond and Jenni 1986, Dugger and Dugger 2002).

The amount of suitable, available habitat may also influence habitat selection (Foster-Willfong 2003). European curlews (*Numenius arquata*) have a variable territory size depending on the spatial distribution of grasslands, such that they established larger territories in cropland than in areas of grassland (Berg 1992). In southeastern Washington, where the topography was open and flat with lower plant species diversity, LBCU territories were larger (20 ha), whereas in habitats with diverse topography, territories were smaller (6-8 ha; Allen 1980).

There may be a positive relationship between proximity to water and habitat selection by LBCUs (McCallum et al. 1977, Cochran and Anderson 1987, Dugger and

Dugger 2002). Curlews may also use prior breeding areas regardless of the disappearance of previously existent wetlands (Foster-Willfong 2003).

Range and Population Trends

Curlews were once abundant over most of the shortgrass and mixed-grass prairie in the United States and southern Canada (Sugden 1933, Russell 2006). A state-by-state survey shows a declining pattern of abundance and loss throughout the eastern Great Plains region (Cheri Gratto-Trevor, Canadian Wildlife Service, pers. commun). Once a locally common breeding bird as far east as southeastern Wisconsin and northeastern Illinois, the LBCU rapidly declined in the Midwest in the mid- to late 19th century (Russell 2006). Late 20th century declines may have locally involved loss of grazing economy in sections of the Dakotas, Nebraska, and Kansas, where severe droughts, wetland drainage, and spread of exotic invasive plants occurred. Currently, the species breeds no farther east than the Missouri River in the Dakotas, in west-central Nebraska, and in a few counties in southwestern Kansas (Stewart 1975, Russell 2006). This decline has led to listing the LBCU as a bird of conservation concern by several agencies (Brown et al. 2001; U.S. Fish and Wildlife Service, USFWS, 2002; Dirk 2003; Hagen et al. 2005; NatureServe 2006).

The historical decline of the LBCU throughout its range is thought to have been primarily due to over-hunting coupled with extensive habitat loss. Curlews were shot by both sport and market hunters, for food or for their wings, respectively (Bent 1929, Allen 1980, De Smet 1992). In 1917, the Migratory Birds Convention Act and Regulations afforded protection from hunting LBCUs and other migratory birds. This Act has been credited with saving the LBCU from probable extinction (De Smet 1992).

Arguably, the single greatest factor in the historical decline in LBCU populations has been the loss of habitat as a result of the conversion of native prairie to cropland in the early 1900s, as well as urban expansion (Hill 1998). In Saskatchewan, an estimated 84 % of native grasslands in the Moist-Mixed-Grassland ecoregion and 69 % of native grasslands in the Mixed-Grassland ecoregion have been lost to cultivation (Hammermeister et al. 2001).

Habitat loss continues to be a problem for the North Dakota LBCU population. North Dakota's tallgrass prairie has decreased from 1,200,000 ha to 1,200 ha (99.9 % decline) and mixed-grass prairie has decreased from 13,900,000 ha to 3,900,000 ha (71.9 % decline) (Savage 2004). Currently, no estimate of historic and current amounts of shortgrass prairie is found (Savage 2004). North Dakota's remaining native grasslands are at a medium to high risk of being broken (Savage 2004). Habitat degradation due to fragmentation, invasion of exotic species, industrial development, and overgrazing is potentially problematic for many prairie species, including LBCUs (Foster-Willfong 2003). Decreases in wildfire occurrence and frequency may also have negative impacts over the long term, as fires previously would have reduced shrub coverage and created more open favorable habitat (Allen 1980, Pampush and Anthony 1993). Altogether, the factors contributing to the population decline are exacerbated by the species' low productivity and conservative breeding strategy (Redmond and Jenni 1982, 1986; De Smet 1992, Hill 1998).

Contractions of species' ranges are often tied with an overall population decline. This correlation cannot be made with certainty in the case of the LBCU given that there are few data on population sizes across North America. However, the limited available data provides the impression that LBCU numbers are likely declining. North American BBS data indicate a continental decline of 2.0 % annually between 1980 and 1996 (P = 0.100, n = 186 routes, Sauer et al. 1997), and a decline of 0.6 LBCUs/route between 1966 and 2005 (1.8 to 1.2 LBCUs/route, respectively, Sauer et al. 2006).

In North Dakota, LBCUs are presently considered an uncommon and "local breeder", largely restricted to only a few counties in southwestern North Dakota, and a rare migrant elsewhere in the state (Stewart and Kantrud 1972, Russell 2006). It seems likely that many of the eastern North Dakota breeding LBCUs were subject to the double pressure of prairie sod breaking for agriculture and heavy market hunting along their migration routes from New York south to the Carolinas and possibly in their wintering areas from South Carolina to Texas (Russell 2006). Current population estimates are unclear. Only two attempts to quantify the size of the North Dakota LBCU population have been undertaken (Kreil 1987, U.S. Forest Service, unpubl. data., Table 1). Stewart (1975) described and showed the breeding range of LBCUs in North Dakota based on only a few records (Figure 1).

Table 1. Number of curlews observed in North Dakota in the mid- to late 1980s and early 1990s by opportunistic sightings from wildlife professionals and bird enthusiasts reported by U.S. Forest Service and Kreil's 1986 surveys.

County	1985	1986*	1987	1988	1991	1992
Billings	9	2/26	16**	17	5	3
Bowman	N/A	N/A /7	N/A	N/A	N/A	N/A
Golden Valley	1	0/12	2	2	0	0
Slope	8	15/45	11	2	0	5
Others (5 Counties)	N/A	N/A /18	N/A	N/A	N/A	N/A

* Opportunistic sightings/Kreil (1987)
** One chick included in observations.

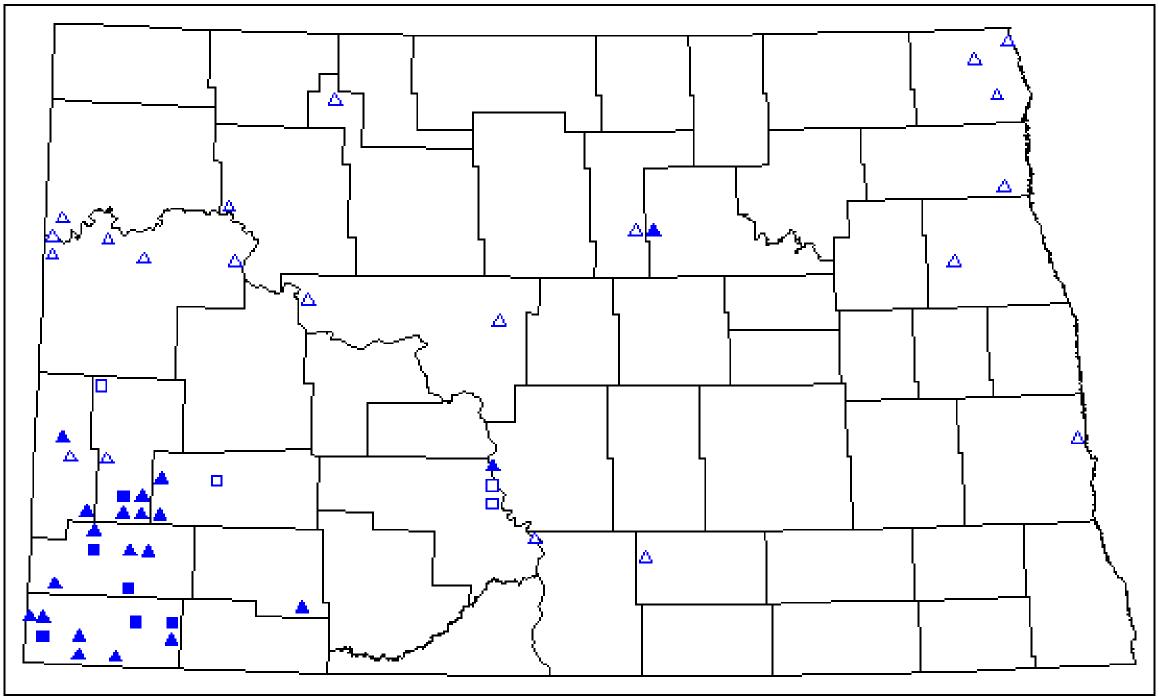


Figure 1. Breeding range of curlews in North Dakota. Filled and unfilled squares indicate nests or dependent young recorded from 1950 through 1972 and prior to 1950, respectively. Filled and unfilled triangles indicate territorial males or pairs recorded from 1950 through 1972 and prior to 1950, respectively (Stewart 1975).

These data were obtained primarily from opportunistic LBCU sightings made by USFS biologists, area bird enthusiasts, and NDGF conservation officers. Additionally, the NDGF gathered information on LBCU locations during the same timeframe using "Wanted" posters published in North Dakota Outdoors magazine (Bry 1986, Kreil 1987) (Appendix A).

The breeding biology, abundance estimate, and relative importance of various habitats to LBCUs in North Dakota have yet to be determined. This study was designed to determine an abundance estimate and relative importance of different habitat types to this species in southwestern North Dakota and provide a basis for management decisions. Wildlife managers must evaluate these results and consider the possibility of labor-intensive restoration efforts.

CHAPTER II

STUDY AREA AND METHODS

The primary study area included the southwestern portion of North Dakota (bordered on the north and east by the Missouri River) with a few study areas north of the Missouri River in Divide and Williams Counties (Figure 2). Curlews were surveyed in various physiographic areas of western North Dakota consisting of the Northwestern Glaciated Plains and Northwestern Great Plains ecoregions (Bryce et al. 1996).

Climate

Of the two field seasons (April – August, 2005 and 2006) only the temperatures in 2005 were considered typical of a normal year. Table 2 reports the mean temperature (°C) and total amount of precipitation (mm) recorded at Bowman (National Climatic Data Center 2007). Bowman, North Dakota was selected for gathering weather data due to its proximity to the largest congregation of curlew locations observed.

Table 2. Mean temperature and total precipitation during the 2005 and 2006 field seasons reported at the Bowman, N.D. weather station. Long-term average reported from 1931 - 2006 (National Climatic Data Center 2007).

	Mean Temperature (°C)			Total Precipitation (mm)		
Month	2005	2006	Long-term Average	2005	2006	Long-term Average
April	7.7	8.4	5.7	13.97	108.46	35.38
May	10.0	12.9	12.0	109.47	63.75	59.49
June	17.5	18.3	17.1	136.40	31.24	86.19
July	21.9	24.3	21.3	31.50	14.73	53.56
August	19.7	21.8	20.3	28.70	26.67	36.84

In 2006, warmer temperatures prevailed with three days in which high temperatures surpassed 38 °C (100 °F). Total precipitation in 2005 was lower than the long-term average during the months of April, July and August, while the months of May and June received high amounts of precipitation (Table 2). Total precipitation in 2006 was lower than the long-term average during the months of June, July, and August, while the months of April and May received high amounts of precipitation (Table 2).

State-wide Census Routes

The state population estimate sampling frame was designed by Tom Stanley and Susan Skagen (USGS) where townships falling on or within the boundaries of the assumed U.S. (range-wide survey, Jones et al. 2003) and North Dakota geographic range of breeding LBCUs were sampled. National Land Cover Data (NLCD; Multi-Resolution Land Characteristics Consortium 2000) and elevation data (Environmental Systems Research Institute 2002) were used to stratify townships, which served as sampling units. First, Stanley and Skagen (USGS, pers. commun.) determined the percentage of each township that could be considered clearly unsuitable for breeding LBCUs, such as areas in the Developed, Forested Upland, or Water NLCD cover classes or those that were too high in elevation (elevation cutoffs for areas above 1524 m, N.D. had no cutoff). Next, townships with less than 70 % unsuitable habitat were placed in one of three strata using the percent grassland criteria of Saunders (2001). Strata 1-3 consisted of townships with 0 % - 5 % grassland (computed as 100 % (grassland ha)/(total ha in township)), >5 % - 50 % grassland, and >50 % - 100 % grassland, respectively, using the NLCD grassland cover class (code 71). Stratum four consisted of townships with 70 % or more unsuitable habitat and was removed from sample units. Stanley and Skagen (unpubl. data) note that in contrast to the grassland definition of Saunders (2001), which distinguished between native prairie and tame pasture, the NLCD grassland cover class combines native prairie and tame pasture.

Stanley and Skagen (unpubl. data) then selected sample units within each stratum using simple random sampling without replacement. In 2005 and 2006, seventeen and an additional two, state-wide census routes covering a total area of 34,180.53 ha and 38,201.77 ha, were produced to assess the current distribution and abundance estimate in North Dakota, respectively (Figure 1). Of the three stratum layers used, three stratum one (0 % – 5 % grassland), ten stratum two (>5 % - 50% grassland), and four stratum three (>50 % - 100 % grassland) state-wide census routes were produced. In 2006, two additional routes (one in each of stratum layers two and three) were added due to remaining time within the survey time periods. Additionally, there were no stratum four (≥70 % unsuitable habitat) units for North Dakota. When a township could not be sampled because of bad weather, bad roads, lack of access, or other issues, a nearby randomly selected alternate township in the same stratum was sampled, if one was available (Jones et al. 2003, Stanley and Skagen, unpubl. data).

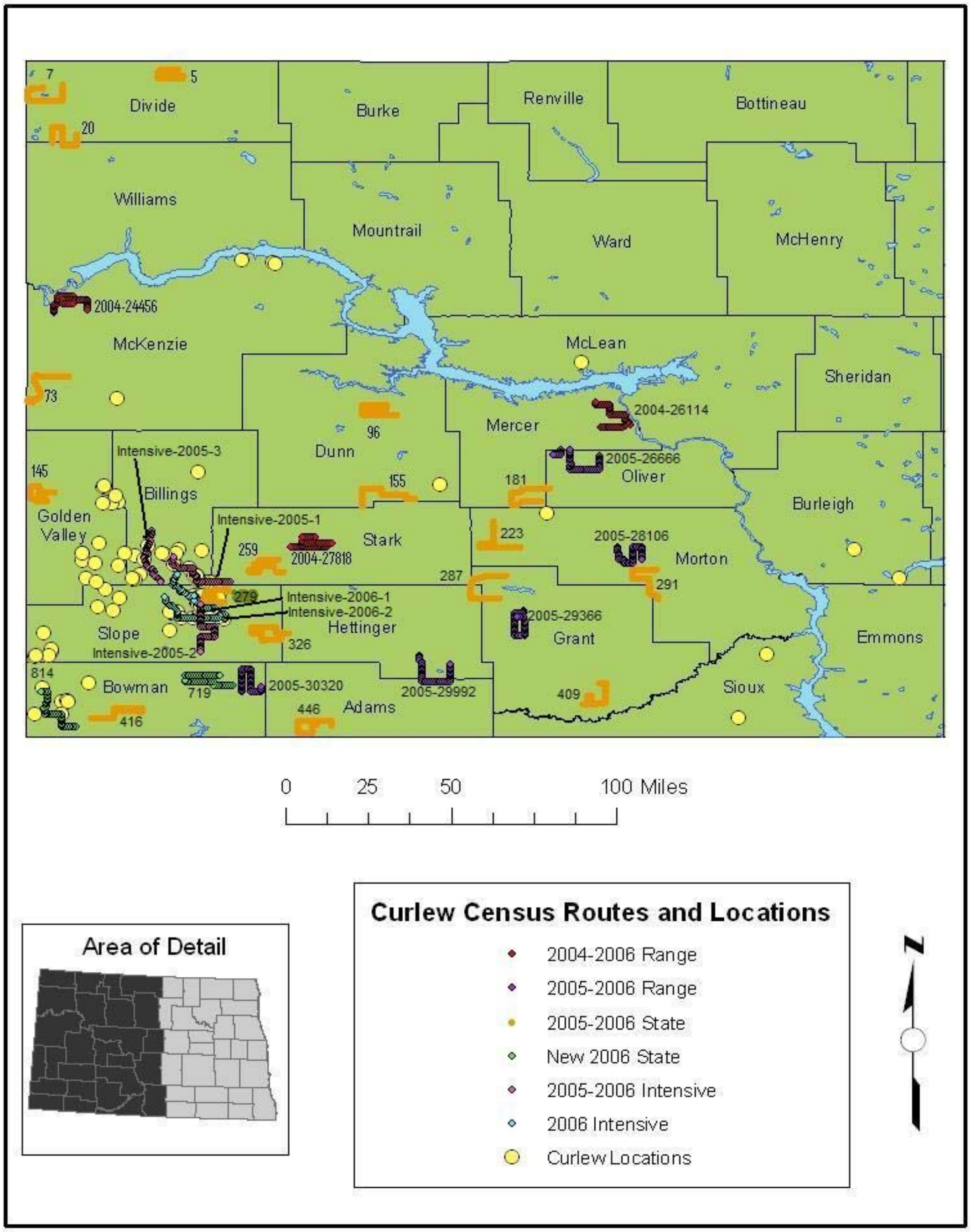


Figure 2. Curlew census routes and current locations in western North Dakota. Years are indicated, followed by the type of census route (Range=range-wide, State=state-wide, Intensive=intensive). Locations of curlews reported during the study are shown.

Surveys were conducted from the period of 8 April to 20 May 2005 and 8 April to 23 May 2006 (Appendix B; survey timing map available at http://mountain-prairie.fws.gov/species/birds/longbilled_curlew/curlew_040505.pdf). Surveys were timed to coincide with local pre-incubation behavior because 1) breeding LBCUs are most conspicuous during this time (Redmond et al. 1981); 2) once hatching is completed, LBCUs tend to wander from their nesting territories and consequently less accurate population counts are obtained (Redmond 1986); and 3) once brood rearing has begun, surveys tend to overestimate male density because of male mobbing behavior (Redmond et al. 1981). Correlating breeding records gleaned from literature and personal communications, then combining this information with expert opinion, was used to partition the survey area into sampling windows. It was estimated that the courtship to hatching period extends from approximately 6 April (Stewart 1975) to 23 June in North Dakota (pers. obs.).

Surveys started no earlier than 0.5 hr after sunrise and continued for four to nine hr (average 6.2 hr for 32 km routes). On several days, more than one route was conducted; later surveys during the day ceased at least 0.5 hr before sunset (Fellows et al., USFWS and USGS, unpubl. data).

Within each of two time periods during the pre-incubation period (Appendix B), crews of two observers surveyed LBCUs by driving the route and stopping at points spaced 0.8-km (0.5 mi) apart to record all individuals seen or heard within 5 min, along 32 km (20 mi) survey routes following a double observer protocol (Nichols et al. 2000, Jones et al. 2003, Fellows 2004). At each survey point, a primary observer detected LBCUs by sight or sound and determined using a laser rangefinder or ocular estimation the radial distance band (0-400 m, 400-800 m, >800 m) in which LBCUs occurred. These data and the 1-min time interval in which each LBCU was detected were recorded by the secondary observer, and the secondary observer recorded all LBCUs (and the radial distance band) they detected that were not detected by the primary observer (Stanley and Skagen, unpubl. data). During the 2005 and 2006 field seasons, the secondary observer also recorded the percentage of the circle created by the 0-400 m radial distance band that was "visible," where visible means no obvious topographic or other factors prevented visual or auditory detection of LBCUs. Observers alternated roles as the primary and secondary observer between stops (Stanley and Skagen, unpubl. data).

When breeding LBCUs were detected at points, observers noted age (i.e., adult, juvenile, downy young) and sex when possible, the behavior of the bird (e.g., feeding, flying overhead, engaging in territorial displays), and other relevant information (e.g., paired birds, see Appendices C and D). Observations of non-breeders (e.g., juvenile or downy young birds, flying overhead), birds that moved to the survey point from a previously surveyed point (as noted by the observer), or birds arriving during the 5-min count were omitted for purposes of analysis. All other birds were considered to be members of the breeding population and included in the analysis (Stanley and Skagen, unpubl. data).

Intensive census routes were designed to test the double-observer methodology (Nichols et al. 2000). Three double-sampling intensive routes, covering a total area of 6,031.86 ha, were conducted in 2005 and two double-sampling intensive routes were conducted in 2006 within the North Dakota survey area, covering a total area of

10,053.10 ha. Intensive routes were placed based on prior observations of LBCUs by wildlife professionals, birders, and survey investigators (S. Fellows, USFWS and G. Knutsen, USFWS, pers. commun.). Intensive routes were surveyed three times over a specified time period (Fellows et al., USFWS and USGS, unpubl. Data, Appendix B).

Incidental Observations

To help gather information on incidental sightings of breeding LBCUs in North Dakota, a "Wanted" poster (Appendix E, Wilson 2006) was printed in the North Dakota Outdoors magazine. Additionally, a request was sent to North Dakota's birding listserve asking birders to report sightings of North Dakota LBCUs. North Dakota Game and Fish Department and USFS personnel also assisted in reporting LBCU observations.

Vegetation Sampling

Habitat variables were collected within the state-wide survey protocols. Intensive plots were used to study the habitat variables collected on the census routes in-depth. Distance to water (McCallum et al. 1977), vegetation height (King 1978, Allen 1980, Jenni et al. 1981, Hooper and Pitt 1996) and heterogeneity (Pampush and Anthony 1993, Hooper and Pitt 1996) have been suggested as important characteristics to determine LBCU nesting habitat.

Habitats where LBCUs were found nesting, thought to be breeding (predicted quarter section the LBCUs were observed/heard to be breeding), and adjacent non-breeding sites (adjacent quarter sections where LBCUs were not observed/heard to be breeding, G. Knutsen, USFWS and S. Fellows, USFWS, pers. commun.) were sampled at five randomly placed radius plots (Appendix F, Grant et al. 2004) per site (Table 3). Sites were classified "breeding" if territorial displays, nesting behaviors, distraction displays, and/or mobbing behaviors were observed. A Global Positioning System (GPS) unit (Garmin e-trex Legend®) was used to place the random radius plots.

Table 3. Habitat variables measured at nesting, breeding, and non-breeding sites of curlews. Habitat association was measured every 0.5 m, and all other variables were recorded every 5-m interval.

Variable	Method
Habitat association (Appendix F and G, modified from Grant et al. 2004)	Belt transect, length of 25 m
Vegetation height (Fellows et al., unpubl. data)	Nearest 0.5 cm
Litter depth (Fellows et al., unpubl. data)	Nearest 0.5 cm
Canopy coverage-class (Daubenmire 1959)	0=0%, 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%, midpoint value used for analysis
Height-density (dm) (Robel et al. 1970, Cochran and Anderson 1987)	Nearest dm
Number of shrubs (Dugger and Dugger 2002)	Visually observed per quadrant
Slope and aspect (Fellows et al., unpubl. Data)	Nearest degree (°)

The vegetative structural data were collected shortly after (one to two days) observing/hearing breeding LBCUs.

Habitat associations were collected from mid-July through early August using the same transects that were used for the vegetative structural measurements (Grant et al. 2004). Though plant group associations (Appendices G and H) were identified and quantified in 2005, changes were made to the associations in 2006 due to the presence of more plant species not identified previously in 2005. Percent frequencies were calculated for each habitat association in both 2005 and 2006 at nest sites (n = 2, 4), predicted breeding sites (n = 30, 125) and non-breeding sites (n = 25, 115), respectively.

Nest Site Measurements and Breeding Chronology

When a nest was located and recorded using a GPS, nest measurements were recorded immediately. Nest measurements included: length (to nearest 0.5 cm), width (to nearest 0.5 cm), depth (to nearest mm) and number of eggs and/or chicks present.

Nest length and width were measured from the outer edge of nest materials while nest depth was measured from upper most nest materials to the bottom of the nest bowl.

If eggs were present in nests, nest sites were visited every other day (after first observation) to determine nest initiation through back-dating once the chicks hatched. Incubation for LBCUs is consistent with many bird species, averaging 28 days (Forsythe 1972, Pampush and Anthony 1993, R. Crawford, UND, pers. commun.). Predation or destruction of the eggs or nest bowl was recorded if necessary.

Land Cover

North Dakota GAP Analysis land cover data (Strong et al. 2005, Table 4), slope (°), aspect (°), and elevation (MSL) (Environmental Systems Research Institute 2005) were compiled (Northern Great Plains Joint Venture) to allow prediction of areas in North Dakota that LBCUs may prefer. Number of observations of LBCUs at identified breeding locations and census route stop points was also included as a potential covariate because this may influence the probability of detecting LBCUs. These data were collected at LBCU breeding locations and census route stop points at a distance of 0.41 km and 1.12 km. These distances were based on 95 % and 50 % fixed-kernal home-range size estimates (Seaman et al. 1999) of LBCUs in South Dakota (Clarke 2006). Area (ha) was summed for each cover type. Edge (m) was calculated for each land cover type, and exterior edge (edge due to sampling around locations and census route stop points) was subtracted from the total edge.

Table 4. North Dakota Gap Analysis Project (Strong et al. 2005) land cover codes and categories.

Strong et al. (2005) Code	Major Category	Land Cover Category
1	Cropland	cropland
2	Planted	planted herbaceous perennials
10	Prairie	prairie - wet-mesic tallgrass
11		prairie - mesic tallgrass
12		prairie - mesic tall and mixed
13		prairie - bluestem-needlegrass-wheatgrass
14		prairie - wheatgrass prairie
15		prairie - needlegrass prairie
16		prairie - little bluestem
17		prairie - fescue
18		prairie - sand
19		prairie - saline
20	Shrubland	shrubland - upland deciduous
21		shrubland - lowland deciduous
22		shrubland - sagebrush
30	Woodland	woodland - ponderosa pine
31		woodland - limber pine
32		woodland - rocky mountain juniper
33		woodland - mixed conifer and deciduous woodland
34		woodland - floodplain
35		woodland - deciduous
36		woodland - greenash
37		woodland - aspen
38		woodland - bur oak
39		woodland - aspen and bur oak
40	Wetland	wetland - lacustrine
41		wetland - riverine
42		wetland - palustrine temporary
43		wetland - palustrine seasonal
44		wetland - palustrine semipermanent
45		wetland - water
50	Bare	barren land
51		sparse vegetation - badlands
52		sparse vegetation - riverine
60	Developed	developed - high intensity residential
61		developed - low intensity residential
62		developed - commercial/industrial/transportation
63		developed - urban grasslands
64		developed - recently developed or omissions in 1992 ND National Land Cover Data

Statistical Analysis

Population Estimation

Population estimation schemes followed Stanley and Skagen (unpubl. data). Detection probability, $\hat{p}^*$, using the double observer method (Nichols et al. 2000) and the removal method of Farnsworth et al. (2002) was incorporated. As originally developed, the double observer method allows detection probabilities to be separately estimated for each of the two observers. In this survey, LBCU detections for the observers were too sparse to estimate detection probabilities (*p*) separately for each observer, so data were pooled data for the primary and secondary observer and imposed the constraint $p_1 = p_2 = p$ (Stanley and Skagen, USGS, pers. commun). Thus, for this survey data, $\hat{p}^* = 1 - (1 - \hat{p})^2$, and the conditional log-likelihood from Nichols et al. (2000) becomes:

$$(1) \qquad c_p \ln\left[\frac{p}{p+(1-p)p}\right] + c_s \ln\left[\frac{(1-p)p}{p+(1-p)p}\right],$$

where c_p = the number of LBCUs counted by the primary observer and c_s = the number of LBCUs counted by the secondary observer that were not counted by the primary observer. Using standard maximum likelihood methods, $\hat{p} = 1 - c_s / c_p$ and the estimated variance of $\hat{p}$, which is denoted as $\hat{V}(\hat{p})$, is $\hat{V}(\hat{p}) = c_s(c_p + c_s)/c_p{}^3$ (Stanley and Skagen, unpubl. data). Using the delta method (Seber 1982), it is found that $\hat{V}(\hat{p}^*) = 4(1-\hat{p})^2 \hat{V}(\hat{p})$ (Stanley and Skagen, unpubl. data). When analyzing the detection data under the removal model of Farnsworth et al. (2002), data from time intervals 1-5 were kept separate. Thus, the conditional likelihood for this model (omitting the multinomial constant) becomes:

$$\left[\frac{1-cq}{1-cq^5}\right]^{x_1}\prod_{t=2}^{5}\left[\frac{cq^{t-1}(1-q)}{1-cq^5}\right]^{x_t}$$ (Stanley and Skagen, unpubl. data),

where c = the probability a bird belongs to the portion of the population that is "difficult-to-detect" (group 2 birds as defined by Farnsworth et al. 2002), q = the probability of failing to detect a group 2 bird, and x_t = the number of LBCUs counted by the primary observer in time interval t (t = 1, 2,…5). Note, a model with $0 < c < 1$ allows for heterogeneity in detection probabilities by assuming there are two groups of birds: easy-to-detect (group 1) and difficult-to-detect (group 2). Under the constraint $c = 1$, it is assumed all birds belong to group 2 and that detection probabilities are homogeneous. Under the Farnsworth et al. (2002) model, the value of p^* is estimated as $\hat{p}^* = 1-\hat{c}\hat{q}^5$ and $\hat{V}(\hat{p}^*) = \hat{q}^{10}\hat{V}(\hat{c}) + 25\hat{c}^2\hat{q}^8\hat{V}(\hat{q})$ (Stanley and Skagen, unpubl. data).

Population estimates for North Dakota followed equations used by Stanley and Skagen (unpubl. data) for the range-wide survey. If N denotes the number of LBCUs in North Dakota, then the estimate of N is $\hat{N} = \sum_{h=1}^{3} A_h \overline{d}_h$, where A_h is the area in hectares of stratum h (h = 1,2,3), and $\overline{d}_h$ is the average density of breeding LBCUs in stratum h. Average density is estimated as $\overline{d}_h = \frac{1}{n_h}\sum_i \hat{d}_{hi}$, where n_h = the number of routes sampled in stratum h, and $\hat{d}_{hi}$ = the estimated density of LBCUs along the ith route of stratum h. The latter quantity is estimated as $\hat{d}_{hi} = \frac{1}{A_{hi}}\frac{c_{hi}}{\hat{p}_{hi}}$, where A_{hi} = the area in hectares sampled along the i^{th} route of stratum h, c_{hi} = the total number of breeding LBCUs counted along the i^{th} route of stratum h, and $\hat{p}_{hi}$ = the estimated detection probability of LBCUs along the i^{th} route of stratum h. Because LBCU detections in this study were sparse, the $\{\hat{p}_{hi}\}$ could not be determined and parameters were constrained to be equal across both routes and strata (i.e., $\hat{p}_{hi} = \hat{p}^*$) (Stanley, USGS, pers. commun.). The estimated variance of $\hat{N}$, denoted $\hat{V}(\hat{N})$, is $\hat{V}(\hat{N}) = \sum_{h=1}^{3} A_h^2 \hat{V}(\bar{d}_h)$ (Stanley and Skagen, unpubl. data) (note, because $\sum_i A_{hi} << A_h$ for all h, the finite population correction factor was omitted from calculations) and the estimated standard error of $\hat{N}$ is $\sqrt{\hat{V}(\hat{N})}$. The quantity $\hat{V}(\bar{d}_h)$ can be derived by rewriting $\hat{d}_{hi}$ as $\hat{d}_{hi} = \frac{b_{hi}}{\hat{p}^*}$, where $b_{hi} = \frac{c_{hi}}{A_{hi}}$ and the constraint $\hat{p}_{hi} = \hat{p}^*$ is imposed, then expressing $\bar{d}_h$ as $\bar{d}_h = \frac{1}{n_h}\sum_i \frac{b_{hi}}{\hat{p}^*} = \frac{\bar{b}_h}{\hat{p}^*}$ and applying the delta method (Seber 1982). Doing this yields the expression $\hat{V}(\bar{d}_h) = \left(\frac{-\bar{b}_h}{(\hat{p}^*)^2}\right)^2 \hat{V}(\hat{p}^*) + \left(\frac{1}{\hat{p}^*}\right)^2 \hat{V}(\bar{b}_h)$, where $\hat{V}(\hat{p}^*)$ is obtained from the relevant likelihood function and $\hat{V}(\bar{b}_h) = \frac{\sum_i (b_{hi} - \bar{b}_h)^2}{n_h(n_h - 1)}$.

As Stanley and Skagen (unpubl. data) had done for estimates of population size and detection probabilities, only observations (audio and visual) of breeding LBCUs in the 0-400 m distance band counted during the 5-min sampling interval were used in analysis. The visibility-corrected area calculations for the 2005 and 2006 data used the following formula $(\%VIS/100)(400\ m)^2\ \pi/(10{,}000\ m^2\ ha^{-1})$, where %VIS was the percentage of the circle created by the 0-400 m radial distance band that was visible (as defined above).

Census route protocol assumptions include: (1) all LBCUs in North Dakota are within the study area, (2) the routes may be viewed as a simple random sample from all possible routes within each stratum, and (3) the survey detects all LBCUs within the count circle. If these assumptions are correct, then the survey yields an unbiased estimate of the population size and of the variance of the estimate (Saunders 2001, Stanley and S. Skagen, unpubl. data).

Effort was allocated among strata, in North Dakota, by making sample size proportional to the estimated amount of suitable habitat in the stratum. Thus, if n is the total number of routes in North Dakota then $n_h = n(A_h P_h / \sum A_h P_h)$ where P_h is the proportion of stratum h that is estimated to be suitable habitat.

Vegetation Sampling

Statistical analysis was performed between breeding and non-breeding sites only, because sample size was low for nest sites ($n = 4$). Vegetation structure elements (vegetation height, height-density, canopy-coverage class, and litter depth) as well as number of shrubs, number of dung piles, and degree slope at breeding and non-breeding sites were pooled across years, if possible, by observing 2-way ANOVAs (Zar 1999) and compared by parametric or non-parametric t-tests (Mann-Whitney) depending on normality of the data and homogeneity of variances (Zar 1999). Interaction terms of site (breeding and non-breeding) and year (2005 and 2006) were observed. All vegetation structure elements were analyzed using medians (non-parametric Mann-Whitney Test) for each plot sampled, except for litter depth, where means were utilized (parametric t-test). All statistical tests were performed using R (R Development Core Team 2006). A significance level of $\alpha = 0.05$ was used for all analyses.

Land Cover

All land cover area (ha), amount of edge (m), number of times census routes were conducted and LBCU breeding locations were visited, slope (°), aspect (°), and elevation (MSL) were analyzed using multiple logistic regressions (backward selection approach) (Quinn and Keough 2002) with R (R Development Core Team 2006). The variables, number of times census routes and breeding locations were visited, and elevation, were removed from analysis to determine land cover characteristics preferred by the LBCU. The backward selection model was developed by reducing the full model (including interactions), by removing factors with the highest Akaike's Information Criterion (AIC; Akaike 1973), until all remaining terms were statistically significant (Quinn and Keough 2002). All assumptions of the logistic regression models were checked (Quinn and Keough 2002).

CHAPTER III

RESULTS

Census Routes

During the 2005 and 2006 field seasons, at least one LBCU was detected on two of the census routes (Figure 2). In both years LBCUs were detected in all radial distance bands, with the majority of birds detected in the 0-400 m distance band. In 2005 and 2006 totals of one and six birds were detected in the 0-400 m distance band, respectively, thus included in analysis.

In 2005, a single adult LBCU was observed flying over a stop point on a state-wide census route (Figure 2). Though sex could not be determined, it was likely a breeding bird. Numerous marbled godwits (*Limosa fedoa*), several upland sandpipers and several burrowing owls (*Athene cunicularia*) were reported on the state-wide census routes. In 2006, all six LBCUs were observed on a single route (Figure 2). All LBCUs detected were determined to be breeding birds.

Double Observer Method

In 2005 $c_p = 1$ and $c_s = 0$, thus, $\hat{p}^* = 1.00$ (SE = 0.00). In 2006 $c_p = 6$ and $c_s = 0$, thus, $\hat{p}^* = 1.00$ (SE = 0.00). This produced the abundance estimates observed in Table 5.

Removal Method

In 2005 and 2006, one and six LBCUs with detection time-interval data were recorded by the primary observer in the first of five time intervals (first minute, second minute, etc.), respectively. In 2005 and 2006, $\hat{p}^* = 1.00$ (SE = 0.00). This produced the abundance estimates observed in Table 5. With $\hat{p}^* = 1.00$ for both methods, the abundance estimates are equal (Table 5).

Table 5. Curlew abundance estimates (SE) with and without the visibility correction included in 2005 and 2006 in North Dakota.

	Abundance estimate (SE)	
Visibility correction factor	2005	2006
No visibility correction	275 (270.8)	1,320 (1,319.9)
Visibility correction	518 (518.2)	2,074 (2,074.0)

Incidental Observations

Fifty-nine LBCUs were observed in six southwestern North Dakota counties during the 2005 breeding season (Table 6). Credible observers positively identified 59 of the 62 observations, whereas the remaining observations were deemed unconfirmed after three follow-up visits provided no confirmed sighting.

Table 6. Number of curlews positively identified (incidental observations and observed on census routes) in southwestern North Dakota in 2005.

County	Adults		Chicks
	Pairs	Individuals	
Billings	8	6	0
Bowman	0	2	0
Dunn	0	1	0
Golden Valley	1	2	0
Morton	0	2	0
Slope	8	5	7
Total	17	18	7

A total of 298 adult and 34 young LBCUs were observed (incidental and census route observations) during the 2 field seasons (Table 7).

Table 7. Number of curlews positively identified (incidental observations and observed on census routes) in western North Dakota during the 2005 and 2006 field seasons.

County	Adults	Chicks
Billings	73	11
Bowman	18	0
Burleigh	8	0
Dunn	1	0
Golden Valley	36	4
McKenzie	9	0
McLean	2	0
Morton	1	0
Sioux	8	0
Slope	142	19
Totals	298	34

Curlews were not observed or heard on any of the five range-wide census routes in North Dakota. However, four upland sandpipers (*Bartramia longicauda*), a reported incidental species commonly found where LBCUs are predicted to be found, were observed on native shortgrass prairie.

Nest Attributes

Four nests (two in 2005, two in 2006) were found (refer to Appendix I). One nest (Nest 1, Appendix I) was found with four newly hatched chicks (presumed to be same day based on wet down, Allen 1980, Jenni et al. 1981) where the female had left the nest bowl. Nest attributes are presented in Table 8.

The second nest (Nest 2, Appendix I) was found 22 June 2005. Three similar-sized eggs and one extremely small egg were observed in the nest bowl. The small egg leads us to believe that this egg was the last one laid (Parsons 1972, Nisbet and Cohen 1975) due to increasing prolactin blood levels with the onset of incubation (Leblanc 1987) or because energy reserves have been depleted throughout the egg laying process (Ryden 1978). Two days after the initial observation observers returned to the nest site and found all eggs to be hatched by evidence of pipping chips. Nest attributes are presented in Table 8.

Table 8. Curlew nest attributes observed in 2005.

Nest Attribute	Nest 1	Nest 2
Date found	25 May 2005	22 June 2005
Habitat around nest	Grazed native shortgrass prairie	Grazed native shortgrass prairie
Slope	8°	4°
Composition	Grass litter, small twigs, and scattered down	Grass litter, small twigs, small pebbles, and down
Eggs or chicks present	4 chicks	3 sim. sized eggs, 1 sm. egg
Predicted initiation	21 April 2005	20 May 2005
Hatch date	25 May 2005	21 June 2005
Nest length	21 cm	19 cm
Nest width	19 cm	19 cm
Nest depth	38 mm	30 mm
Nearest man-made structure	294 m from fenced hay yard	25 m from utility pole
Nearest wetland	352 m	232 m
Elevation	874 m above MSL	854 m above MSL

In 2006, two LBCU nests were found. The first (Nest 3, Appendix I) was found 11 May after a landowner discovered the nest while harrowing his wheat (*Triticum* sp.) field. He marked the nest with a water bottle placed approximately 1 m from the nest bowl so he could avoid destroying the nest. A second nest (Nest 4, Table 9) was observed 18 May 2006 with a female incubating. The nest was located in a field that had been fallowed for one year (Kevin Bock, landowner, pers. commun.). The next day, he harrowed the fallow field to prepare the soil for seeding. The nest was destroyed. No nest measurements were recorded due to the land owner not granting access to his property for research. Nest attributes for the nests found in 2006 are presented in Table 9.

Table 9. Curlew nest attributes observed in 2006.

Nest Attribute	Nest 3	Nest 4
Date found	11 May 2006	18 May 2006
Habitat around nest	Wheat (sp.) stubble	Fallow field
Slope	6°	N/A
Composition	Wheat straw	N/A
Eggs or chicks present	4 eggs	Incubating female present
Predicted initiation	30 April 2006	N/A
Hatch date	3 June 2006	N/A
Nest length	30 cm	N/A
Nest width	26 cm	N/A
Nest depth	35 mm	N/A
Nearest man-made structure	205 m from abandoned farmstead	N/A
Nearest wetland	422 m	N/A
Elevation	873 m above MSL	N/A

Vegetation Sampling

Habitat Associations

The habitat associated with the lone sighting on the state-wide census route was found to be grazed, native, shortgrass prairie (4-10 cm in height). Numerous marbled godwits (*Limosa fedoa*), several upland sandpipers and several burrowing owls (*Athene cunicularia*), reported on the state-wide census routes, use the same type of habitat as the LBCU.

In 2005, nesting curlews used native grass/forbs, while curlews at predicted breeding sites mainly used native grass/forbs and agricultural land, and non-breeding sites not used by curlews had more native grass/forbs and exotic species with similar amounts of agricultural land and low shrubs (Figure 3).

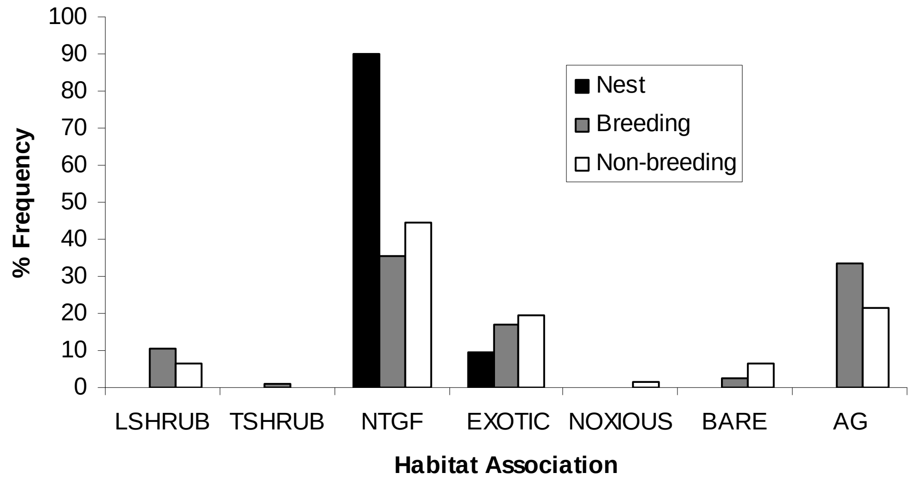


Figure 3. Percent (%) frequency of habitat associated with curlews at nest, breeding, and non-breeding sites located in 2005 in North Dakota. LSHRUB=low shrubs, TSHRUB=tall shrubs, NTGF=native grass/forbs, EXOTIC=exotic species, NOXIOUS=noxious weeds, BARE=bare ground, and AG=agricultural lands (modified from Grant et al. 2004, Appendix G).

In 2006, nesting curlews used primarily bare ground with smaller amounts of agricultural land and exotic species. Curlews at predicted breeding sites used primarily agricultural land and native grass/forbs, and non-breeding sites not used by curlews had similar amounts of agricultural land, native grass/forbs and exotic species, with more low shrubs present (Figure 4).

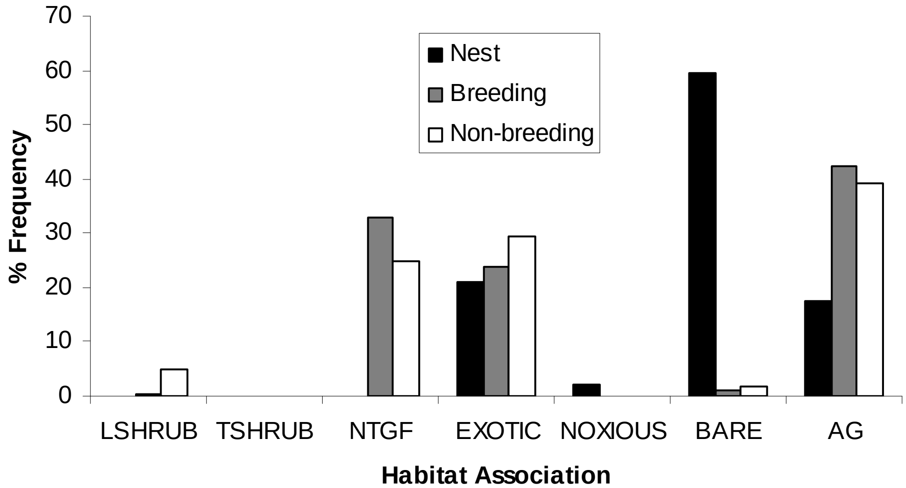


Figure 4. Percent (%) frequency of habitat associated with curlews at nest, breeding, and non-breeding sites located in 2006 in North Dakota. LSHRUB=low shrubs, TSHRUB=tall shrubs, NTGF=native grass/forbs, EXOTIC=exotic species, NOXIOUS=noxious weeds, BARE=bare ground, and AG=agricultural lands (modified from Grant et al. 2004, Appendix H).

Vegetative Structure

Nest Sites

Due to the fact that only two nests were found in each of the two field seasons, nest site measurements were not included in statistical analysis. However, for purposes here, they are reported to show comparisons between nest, breeding, and non-breeding sites (Table 10).

Table 10. Vegetation structure measured at curlew nest sites in 2005 and 2006.

	Value	
Vegetation Structure Variable	2005	2006
Mean vegetation height (SD) (cm)	13.11 (7.15)	2.79 (3.75)
Mean litter depth (SD) (cm)	0.54 (0.41)	0.11 (0.21)
Mean canopy-coverage (SD) (%) in 2006 canopy-coverage for grass, forbs, shrubs, bare ground, and crops	38.64 (15.84)	10.39 (14.70), 8.61 (12.17), 0 (0), 79.31 (14.31), 2.71 (3.84), respectively
Mean height-density (SD) (dm)	0.74 (0.38)	1.0 (0.0)
Mean number of dung piles (SD)	35.3 (16.7)	0.1 (0.4)
Mean number of shrubs (SD)	13.6 (18.7)	0.0 (0.0)

Breeding Sites vs. Non-breeding Sites

Vegetation Height

Vegetation height was significantly different (P = 0.010), based on 2-way ANOVAs, between the two field seasons so the data from the two years were not pooled. It appeared that there was a significant interaction between sight and year (P = < 0.001), based on 2-way ANOVAs.

In 2005, vegetation height did not differ between breeding and non-breeding sites (Figure 5, Mann-Whitney Test U = 363, P = 0.847). In 2006 vegetation height at breeding sites was significantly different from non-breeding sites (Figure 5, Mann-Whitney Test U = 3210, P = < 0.001).

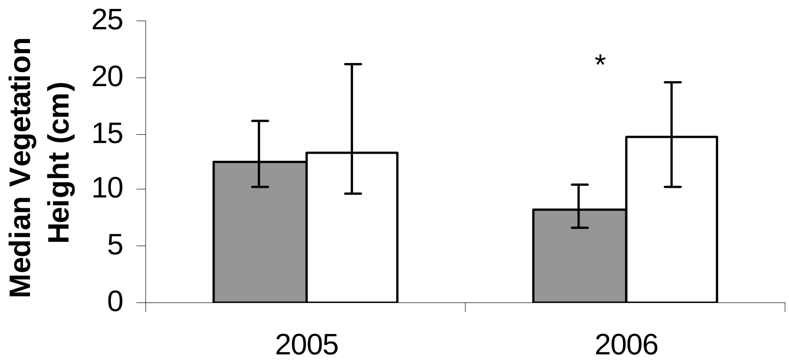


Figure 5. Vegetation height observed at breeding (gray) and non-breeding (white) sites of curlews in 2005 and 2006. Y-error bars indicate 1st and 3rd quartiles. * Significant difference (Mann-Whitney Test $U = 3210$, $P = < 0.001$).

Litter Depth

Mean litter depth measurements differed between breeding and non-breeding sites ($t = -5.520$, df = 241.583, $P = < 0.001$, Figure 6).

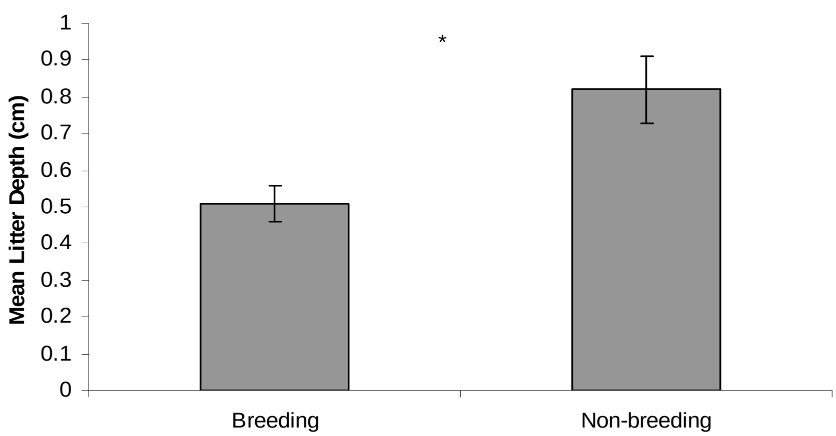


Figure 6. Mean litter depth (cm) observed at breeding and non-breeding sites of curlews ($t = -5.520$, df = 241.583, $P = < 0.001$). * Indicates significant difference.

Canopy-coverage

Due to new methods, canopy-coverage (Daubenmire 1959) was measured for all vegetation in 2005, while in 2006, canopy-coverage was measured for grass, forbs, shrubs, bare ground and crop land. Median percent (%) frequency of canopy-coverage (Daubenmire 1959) of vegetation did not differ between breeding and non-breeding sites in 2005 (Figure 7, Mann-Whitney Test U = 407, P = 0.594).

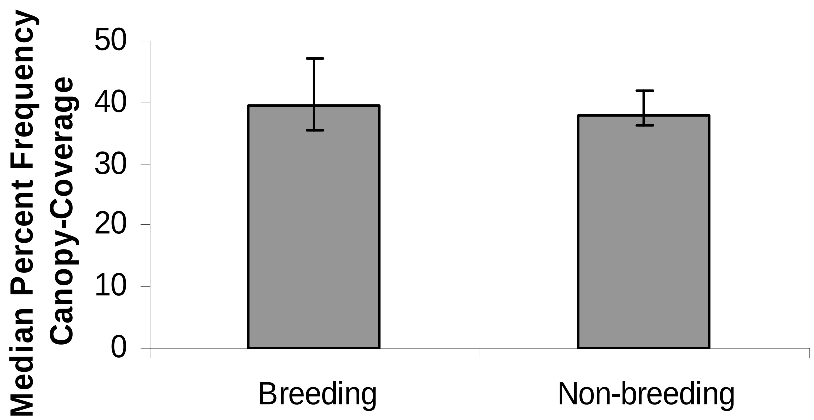


Figure 7. Percent (%) frequency of canopy-coverage observed at breeding and non-breeding sites of curlews in 2005 (Mann-Whitney Test U = 407, P = 0.594). Y-error bars indicate 1st and 3rd quartiles.

In 2006, percent canopy-coverage results are listed for grass (Grass- Mann-Whitney Test U = 8162.5, P = 0.070), forbs (Forb- Mann-Whitney Test U = 7175, P = 0.982), shrubs (Shrub- Mann-Whitney Test U = 3725, P = < 0.001), bare ground (Bare- Mann-Whitney Test U = 8850, P = 0.002) and crop land (Crop- Mann-Whitney Test U = 6962.5, P = 0.593) (Figure 8).

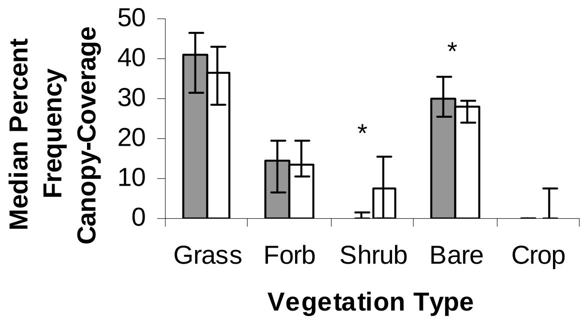


Figure 8. Percent frequency of canopy-coverage observed at breeding (gray) and non-breeding (white) sites of curlews in 2006. Y-error bars indicate 1st and 3rd quartiles. * Indicates significance based on Mann-Whitney Test.

Height-density

Height-density (Robel et al. 1970) was significantly different (P = < 0.001), based on 2-way ANOVAs, between the two field seasons so that data from the two years were not pooled. It appeared that there was a significant interaction between sight and year (P = < 0.001), based on 2-way ANOVAs. The mean natural log of height-density showed that in the year 2005, height-density was similar between breeding and non-breeding sites, and was significantly different in 2006.

When height-density (dm) was compared between breeding and non-breeding sites using a Mann-Whitney non-parametric t-test on the 2005 data, it was found to be similar (Figure 9, Mann-Whitney Test U = 464.5, P = 0.059). In 2006, non-breeding sites had significantly greater height-density (dm) (Figure 9, Mann-Whitney Test U = 3536.5, P = < 0.001).

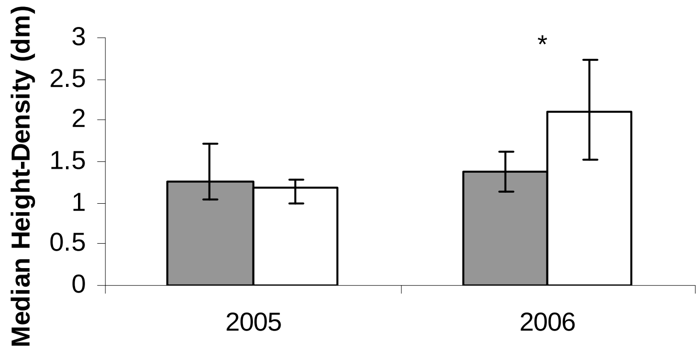


Figure 9. Median height-density (dm) observed at breeding (gray) and non-breeding (white) sites of curlews in 2005 and 2006 (Mann-Whitney Test U = 464, P = 0.059, Mann-Whitney Test U = 3536.5, P = < 0.001, respectively). Y-error bars indicate 1st and 3rd quartiles. * Indicates significance.

Dung Piles

Number of dung piles was significantly different (P = < 0.001), based on 2-way ANOVAs, between the two field seasons so that data from the two years were not pooled. There was not a significant interaction between sight and year (P = 0.912), based on 2-way ANOVAs.

When number of dung piles was compared between breeding and non-breeding sites using a Mann-Whitney non-parametric t-test on the 2005 and 2006 data, the sites were found to be similar (Figure 10, Mann-Whitney Test U = 438, P = 0.290, Mann-Whitney Test U = 8115, P = 0.079, respectively).

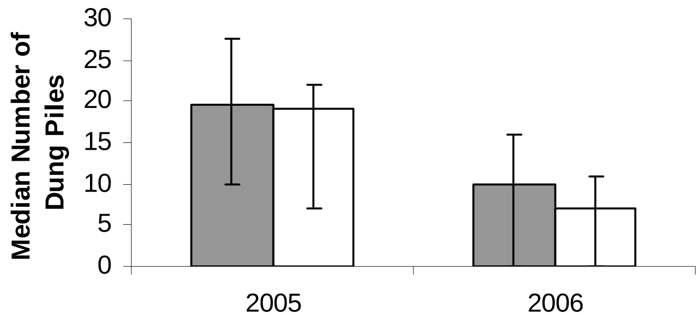


Figure 10. Number of dung piles observed at breeding (gray) and non-breeding (white) sites of curlews in 2005 and 2006 (Mann-Whitney Test $U = 438$, $P = 0.290$, Mann-Whitney Test $U = 8115$, $P = 0.079$, respectively). Y-error bars indicate 1st and 3rd quartiles.

Shrubs

Number of shrubs was significantly different ($P = 0.003$), based on 2-way ANOVAs, between the two field seasons so that data from the two years were not pooled. There was not a significant interaction between sight and year ($P = 0.741$), based on 2-way ANOVAs.

When number of shrubs was compared between breeding and non-breeding sites using a Mann-Whitney non-parametric t-test on the 2005 and 2006 data, the sites differed (Figure 11, Mann-Whitney Test $U = 245$, $P = 0.027$, Mann-Whitney Test $U = 4571$, $P = < 0.001$, respectively).

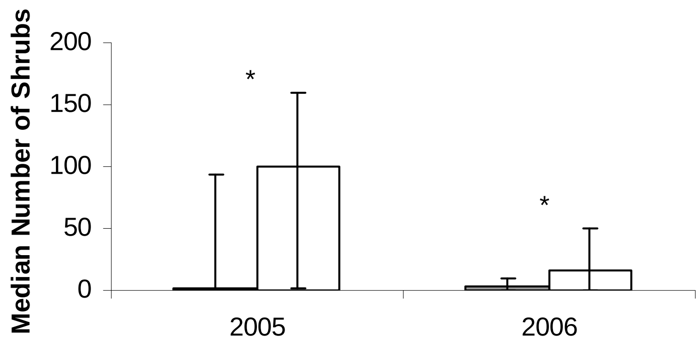


Figure 11. Number of shrubs observed at breeding (gray) and non-breeding (white) sites of curlews in 2005 and 2006 (Mann-Whitney Test $U = 245$, $P = 0.027$, Mann-Whitney Test $U = 4571$, $P = < 0.001$, respectively). Y-error bars indicate 1st and 3rd quartiles. * Indicate significant difference.

Slope

Based on a Mann-Whitney test, slope (°) differed significantly between breeding and non-breeding sites (Mann-Whitney Test $U = 10189.5$, $P = < 0.001$, Figure 12).

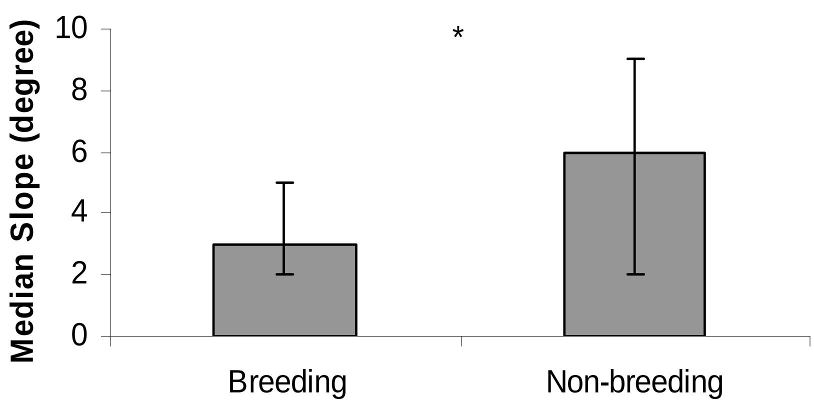


Figure 12. Slope (°) observed at breeding and non-breeding sites of curlews (Mann-Whitney Test $U = 10189.5$, $P = < 0.001$). Y-error bars indicate 1st and 3rd quartiles. * Indicate significant difference.

Land Cover

When observing land cover habitat (Table 11) at a distance of 0.41 km from LBCU observation locations and census route stop points, there appears to be a low probability of observing LBCUs on areas of increasing amount of prairie area, planted herbaceous perennials area, and woodland area.

Table 11. Land cover codes and attributes, and definitions used in multiple logistic regression analysis to determine probability of occurrence of LBCUs.

Land Cover Code	Code Definition
Shrubedge	Shrubland edge (m)
Shrubarea	Shrubland area (ha)
Cropedge	Cropland edge (m)
Croparea	Cropland area (ha)
Prairieedge	Prairie edge (m)
Prairiearea	Prairie area (ha)
Plantedge	Planted herbaceous perennials edge (m)
Plantarea	Planted herbaceous perennials area (ha)
Woodedge	Woodland edge (m)
Woodarea	Woodland area (ha)
Developededge	Developed lands edge (m)
Developedarea	Developed lands area (ha)
Bareedge	Bare ground edge (m)
Barearea	Bare ground area (ha)
Wetlandedge	Wetland edge (m)
Wetlandarea	Wetland area (ha)
Slope	Degree of slope (°)
Aspect	Aspect of slope (°)
Elev	Elevation (MSL)
Multyrsobs	Number of census route and breeding location visits

Significantly lower probabilities of LBCU occurrence were found in areas of increasing developed area, cropland area, bare ground edge, and areas that had been observed multiple times (Table 12). There is a high probability of observing LBCUs in areas of increasing elevation and developed edge (Table 12). The reduced and full models are not significantly different (Deviance = 5.52, df = 1, $P(\chi^2) = 0.48$) and all coefficients are not significant though analysis found the reduced model (AIC = 480.24) to be the best model when compared to the full model (AIC = 486.72).

Table 12. Multiple logistic regression results for predicting LBCU presence in regards to land cover habitats (Table 11) at a distance of 0.41 km from LBCU locations and census route stop points. Significance codes: ***0.001, **0.01, *0.05.

Variable	Coefficient	G^2	$P(\chi^2)$
Intercept	15.230		
Cropedge	< 0.001	1.618	0.106
Wetlandedge	< -0.001	-1.691	0.08
Wetlandarea	-0.230	-1.732	0.08
Slope	-0.090	-1.741	0.07
Shrubarea	-0.204	-1.819	0.06
Prairiearea	-0.270	-2.243	0.02*
Plantarea	-0.294	-2.431	0.01*
Elevation	0.004	2.580	0.01*
Woodarea	-0.512	-2.579	0.01*
Developededge	0.030	2.833	0.004**
Developedarea	-26.980	-2.593	0.003**
Croparea	-0.345	-2.856	0.002**
Bareedge	< -0.001	-3.254	< 0.001***
Multyrsobs	-2.397	-8.988	< 0.001***

When observing land cover habitat (Table 11) at a distance of 0.41 km from LBCU observation locations and census route stop points, with Multyrsobs and Elevation removed, there appears to be a low probability of observing LBCUs on areas of increasing amounts of developed area, prairie area, woodland area, and greater slope. Significantly lower probabilities of LBCU occurrence were found in areas of increasing bare ground edge and cropland area (Table 13). There is a high probability of observing LBCUs in areas of increasing shrubland area and prairie edge (Table 13). The reduced and full models are not significantly different (Deviance = 2.13, df = 1, $P(\chi^2) = 0.91$) and all coefficients are not significant though analysis found the reduced model (AIC = 618.41) to be the best model when compared to the full model (AIC = 628.29).

Table 13. Multiple logistic regression results for predicting LBCU presence in regards to land cover habitats (Table 11) at a distance of 0.41 km from LBCU locations and census route stop points with covariates Multyrsobs and Elevation removed. Significance codes: ***0.001, **0.01, *0.05.

Variable	Coefficient	G^2	$P(\chi^2)$
Intercept	-0.071		
Cropedge	< 0.001	1.587	0.11
Barearea	0.182	1.814	0.07
Developededge	0.015	1.872	0.06
Plantedge	< -0.001	-1.875	0.06
Developedarea	-14.080	-1.840	0.04*
Prairiearea	-0.098	-2.378	0.01*
Woodarea	-0.274	-2.284	0.01*
Shrubarea	0.104	2.737	0.01*
Slope	-0.130	-2.536	0.01*
Bareedge	< -0.001	-2.816	0.003**
Prairieedge	< 0.001	2.821	0.003**
Croparea	-0.068	-4.625	< 0.001***

When observing land cover habitat (Table 11) at a distance of 1.12 km from LBCU observation locations and census route stop points, there appears to be a low probability of observing LBCUs on areas of increasing amounts of bare ground edge and greater slope (Table 14). Significantly lower probabilities of LBCU occurrence were found in areas of increasing wetland edge and areas that were visited more frequently (Table 14). There is a high probability of observing LBCUs in areas of increasing bare ground area, shrubland edge, wetland area, prairie area, and areas of increasing elevation (Table 14). The reduced and full models are not significantly different (Deviance = 1.96, df = 1, $P(\chi^2) = 0.98$) and all coefficients are not significant though analysis found the reduced model (AIC = 364.46) to be the best model when compared to the full model (AIC = 378.49).

Table 14. Multiple logistic regression results for predicting LBCU presence in regards to land cover habitats (Table 11) at a distance of 1.12 km from LBCU locations and census route stop points. Significance codes: ***0.001, **0.01, *0.05.

Variable	Coefficient	G^2	$P(\chi^2)$
Intercept	-3.516		
Woodarea	0.032	1.658	0.10
Developedarea	-2.603	-1.192	0.06
Developededge	0.003	1.358	0.06
Barearea	0.060	2.117	0.03*
Slope	-0.154	-2.496	0.01*
Bareedge	< -0.001	-2.345	0.01*
Shrubedge	< 0.001	2.878	0.003**
Wetlandedge	< -0.001	-2.933	0.002**
Elevation	0.006	3.370	< 0.001***
Wetlandarea	0.032	3.219	< 0.001***
Prairiearea	0.012	5.771	< 0.001***
Multyrsobs	-2.087	-6.879	< 0.001***

When observing land cover habitat (Table 11) at a distance of 1.12 km from LBCU observation locations and census route stop points, with covariates Multyrsobs and Elevation removed, there appears to be a low probability of observing LBCUs on areas of increasing developed area, planted herbaceous perennial edge, bare ground edge and wetland edge (Table 15). Significantly lower probabilities of LBCU occurrence were found in areas of increasing slope (Table 15). There is a high probability of observing LBCUs in areas of increasing planted herbaceous perennial area, wetland area, shrubland edge, and prairie edge (Table 15). The reduced and full models are not significantly different (Deviance = 3.70, df = 1, $P(\chi^2) = 0.81$) and all coefficients are not significant though analysis found the reduced model (AIC = 456.40) to be the best model when compared to the full model (AIC = 466.70).

Table 15. Multiple logistic regression results for predicting LBCU presence in regards to land cover habitats (Table 11) at a distance of 1.12 km from LBCU locations and census route stop points with covariates Multyrsobs and Elevation removed. Significance codes: ***0.001, **0.01, *0.05.

Variable	Coefficient	G^2	$P(\chi^2)$
Intercept	-2.925		
Developededge	0.004	1.255	0.09
Barearea	0.046	1.734	0.07
Developedarea	-3.638	-1.212	0.05*
Plantedge	< -0.001	-2.077	0.04*
Bareedge	< -0.001	-2.004	0.03*
Wetlandedge	< -0.001	-2.438	0.01*
Plantarea	0.010	3.082	0.003**
Slope	-0.177	-3.105	0.001**
Wetlandarea	0.027	3.091	< 0.001***
Shrubedge	< 0.001	5.193	< 0.001***
Prairieedge	< 0.001	6.645	< 0.001***

Curlews will less likely be found on areas with large amounts of prairie area, woodland area, developed area, cropland area, and bare ground edge at areas in close proximity to breeding areas. If number of visits to locations and census route stop points and elevation data are included, LBCUs tend to be found near areas of increasing elevation and areas where developed land may be broken up so as to not be a continuous block, at smaller scales. At the smaller scales, with elevation and number of observations of locations and census route stop points removed, LBCUs might be found in areas of increasing shrubland area and prairie edge, suggesting that native prairie in smaller clusters is preferred with shrubland in the vicinity of breeding grounds.

At larger scales, LBCUs will less likely be found on areas of increasing slope, bare ground edge, and wetland edge. This suggests that LBCUs may prefer a gently rolling topography in areas of continual vegetation coverage and wetlands with less shoreline. In a large home range, developed land area may also be a deterrent for breeding LBCUs, thus preferring areas of less human activity. Smaller clumps of shrublands are preferred for breeding LBCUs at larger areas, suggesting they may use these shrublands as some sort of cover within their larger home range. Curlews tend to be found in areas where more wetland area is present, suggesting the need for water within larger home ranges.

CHAPTER IV

DISCUSSION

Census Routes

Saunders (2001) and the range-wide survey (Stanley and Skagen, unpubl. data) similarly found that LBCUs were present and apparently breeding in areas with little native grassland. Saunders (2001), however, found significantly more LBCUs in stratum three (>50 % - 100 % grassland) than in strata one (0 % - 5 % grassland) and two (>5 % - 50 % grassland), whereas the study by Stanley and Skagen (unpubl. data) did not. This study found curlews in stratum two. This contrast in findings could be either due to the large variances in the range-wide survey strata estimates, or it could be due to differences in the land use databases used to classify the landscape into strata. For example, Saunders (2001) was able to distinguish tame pasture from native prairie using Alberta's Native Prairie Inventory (Alberta Environmental Protection 1999), whereas this survey was not able to do so using National Land Cover Data (NLCD). The "grassland" in the this study was therefore analogous to (native prairie + tame pasture) found in Saunders (2001), so each Canadian stratum most likely averaged more "grassland" than did the comparable North Dakota stratum because of the added tame pasture component in North Dakota.

Stanley (pers. commun.) recommends using simple random sampling in future applications of this survey design because the rationale for using stratification is to minimize the variance in the sample and increase precision of the estimate, and this survey did not do so. Alternatively, stratification schemes based on other criteria could be formally investigated. Grassland type, vegetation structure, and grazing history (as it affects vegetation structure) appear to play a role in habitat selection and may be useful for stratification. Likewise, LBCUs appear to be associated with open grasslands for nesting but also use taller, more dense grass during brood rearing (Dugger and Dugger 2002), thus the juxtaposition of these two grassland structures may be considered for stratification.

It is suggested that simple single-observer counts of LBCUs uncorrected for detectability would be negatively biased, because without knowing if an observer is missing birds, bird estimates would not be accurate. Thus, in future surveys some means of estimating detectability is crucial. Stanley and Skagen (unpubl. data) favor the use of the removal method for estimating detectability over the double observer method on the basis of both precision and cost-effectiveness. Furthermore, there is a need to minimize the instability of the removal estimator (time interval when birds are observed), thus it is recommended in future surveys that survey coordinators: 1) emphasize to observers during training the importance of quickly scanning a full 360° at a point before searching the area more intensively, 2) streamline the data recording process so that more time can be spent searching earlier in the sampling interval (this is especially important when many LBCUs are present), and 3) clearly distinguish on the datasheet which birds were seen arriving during the sampling interval. The net result of these recommendations should be to provide reliable estimates under the removal method.

Potential sources of bias come from the fact that surveys conducted from roads sample only part of the habitat in a township and the habitat along roads may not be representative of habitat in the township as a whole. A second potential bias occurs when the effective area sampled (visible area within 400-m radius) is larger than the nominal area sampled (total area within 400-m radius), which would tend to positively bias abundance estimates. This concerns violation of the assumption of closure, net movement of birds into the 400-m band during the 5-min count, and if observers made errors in estimating the location of the 400-m distance band. In this survey, birds were omitted from analysis if they arrived during the 5-min count, though birds were observed arriving during the count period. Thus, I believe there was bias due to failure of the closure assumption. A third potential source of bias would occur if a route is sampled before the arrival of breeding birds to an area or after the courtship period when birds are less conspicuous (i.e., detectability falls to near zero). In either case, counts would be negatively biased and estimates of the breeding population size would be conservative. Although Saunders (2001), following recommendations of Redmond et al. (1981), targeted the courtship to hatching period for surveys, this survey attempted to further narrow the survey window to exclude the incubation period. The implementation of a narrow time window for surveys is a difficulty, especially over a broad geographic area, because when the number of surveyors is limited, it is often not physically possible to sample every route during the optimal time. During this study, all of the routes were sampled during the allotted time period.

Several bird-survey methods have been proposed that provide an estimated detection probability so that bird-count statistics can be used to estimate bird abundance.

However, some of these estimators adjust counts of birds observed by the probability that a bird is detected and assume that all birds are available to be detected at the time of the survey. Diefenbach et al. (2007) show how estimates of availability can be incorporated in the abundance and variance estimators for distance sampling and modify the abundance and variance estimators for the double-observer method. Methods that directly estimate availability from bird counts but also incorporate detection probabilities need further development and will be important for obtaining unbiased estimates of abundance for various species (Diefenbach et al. 2007).

A simple change to the state-wide census protocol involves reporting incidental sightings. In this study, census investigators were required to report other incidental sightings of several species thought to be commonly associated with LBCUs. It may be necessary to report only sightings of prairie dogs, burrowing and short-eared owls and marbled godwits, due to observations of these species occurring near sightings of LBCUs.

State-wide Population Estimate

Prior to this study, North Dakota state-wide population estimates of LBCUs were not known. This study provided a current estimate for the state of North Dakota. With this study design, it is suspected that estimates of the breeding population size are conservative. The estimated LBCU abundance from this study was 275 ± 271 with no visibility correction and 518 ± 518 with visibility correction included, in 2005, and 1,320 ± 1,320 with no visibility correction and 2,074 ± 2,074 with visibility correction included, in 2006. The visibility correction should be included in the population estimate because topography and other visual obstructions do not allow the surveyor to accurately census a 400-m radius census area. The current estimates from this study follow those described by Partners in Flight (913 individuals; PIF 2007), though the 2006 estimate is markedly higher. The current estimates seem probable based on numerous sightings of LBCUs across the western portion of North Dakota.

Nest Attributes

Due to small sample size (four nests), caution should be used when interpreting these data. It appears that curlews prefer to nest in areas of grazed native shortgrass prairie on the southwest aspect of nearby hills. Curlews appeared to nest in areas of flat terrain (the greatest slope reported within a 25-m radius plot was 8°). Nearby man-made structures did not appear to be negatively associated with nesting curlews (one nest was located within 25 m of a utility pole). As others have indicated (Dugger and Dugger 2002) LBCUs tend to place nests near an adjacent water source (<400 m). Curlews were found to nest in fallow agricultural fields that had been dormant since the previous fall (Shackford 1994, pers. obs.). Also, LBCUs placed nest bowls immediately adjacent to cattle dung piles. These observations follow those of others (Allen 1980, Cochran and Anderson 1987, Berg 1992, Dugger and Dugger 2002, and Dechant et al. 2003). Based on four nests found in this study, nest initiation appears to begin approximately 21 April (pers. obs. 28 April) and extend through 20 May.

Vegetation Sampling

Habitat Associations

In 2005, LBCUs placed nests in areas of primarily native grass/forbs. In 2006, curlews placed nests in areas of primarily bare ground. It should not be surprising that in 2005, nest sites did not include areas of low shrubs, tall shrubs, or noxious weeds.

Dugger and Dugger (2002) found that nesting LBCUs' habitat had <5 % shrubs and noxious weeds. It is interesting to note that bare ground and agricultural land was not selected for nest sites. However, it should be noted that the data are only based on two nests in 2005. Surprisingly, in 2006, the amount of exotic species (Kentucky bluegrass, smooth brome, crested wheatgrass) was large. Similar to 2005, nest sites in 2006 did not include areas of low shrubs and tall shrubs. However, native grass/forb areas were also not found within nesting sites.

In 2005 and 2006, predicted breeding sites had similar plant group associations as those found at nest sites, with native grass/forb areas primarily observed. Non-breeding sites had higher amounts of exotics, noxious weeds, and low shrubs. Also, the amount of native grass/forbs was similarly comparable to predicted breeding sites. However, both site types were located immediately adjacent to one another.

More nest sites are needed to quantify further habitat associations of nesting curlews. In future studies, curlew nests could be located by nest dragging with 5/8 in. hemp rope between two All Terrain Vehicles (ATVs) on predicted breeding sites, as recommended by Clarke et al. (2005).

Vegetative Structure

Only four nests were found during this study. This is a problem for analysis because of low sample size though data gleaned from these nests can provide useful information to wildlife managers. As previously predicted, vegetation height at nest sites was similar to breeding sites, and was shorter than non-breeding sites, perhaps better enabling them to observe approaching predators (Dugger and Dugger 2002). Curlew habitat preferences are thought to change over the course of the breeding season, from areas of shorter vegetation during nesting, to areas with a different vegetation structure when young broods are present (Redmond and Jenni 1986, Dugger and Dugger 2002, pers. obs.). Vegetation height was taller in 2005 than in 2006. This could be due to greater precipitation in 2005 as compared to 2006. It is noted in this study that predicted breeding sites had significantly lower litter depths than non-breeding sites as greater litter depth could hamper LBCU ability to locate forage (Dugger and Dugger 2002). Grass canopy-coverage was significantly lower in nest sites than at predicted breeding and non-breeding sites. This could result from LBCUs wanting less vegetation for ease of detecting predators. Forbs were similarly found across all site types (nest, breeding, non-breeding). Shrub canopy-coverage at nest sites was similar to that of breeding sites and was significantly less than non-breeding sites. Again, this could be preferred due to ease of detecting predators. With bare ground coverage significantly high at breeding sites, LBCUs would have easier access to potential prey (Redmond and Jenni 1986, Dugger and Dugger 2002). The amount of crop canopy-coverage observed at nest sites was similar to that of both breeding and non-breeding sites. Renaud (1980) found that LBCUs do not prefer extensively cultivated areas. This study found similar results to Redmond and Jenni (1986), where height-density observed at nest sites was less than that of breeding and non-breeding sites. Number of dung piles was noticeably more prevalent at nest sites than observed at breeding and non-breeding sites. Dugger and Dugger (2002) predict that LBCUs would breed in areas of higher amounts of grazed land and would use dung piles for camouflage from predators. It is believed that livestock will leave dung piles in areas of active grazing and will lower the height of vegetation preferred by breeding LBCUs (Powell 2006). Trampled nests could be the only disadvantage with grazing livestock. The low number of shrubs observed at breeding sites in this study could allow LBCUs to view approaching predators as well have easier access to locate forage.

Though slope (°) is not considered vegetative structure, it was included for the purpose of describing preferred habitats of breeding LBCUs. In this study, slope was found to be noticeably flat (3°) at breeding sites. This is easily conceivable due to LBCUs often being observed near the crest of a hill rise or in flat agricultural and prairie landscapes. Data presented here is similar to that of others (Dugger and Dugger 2002).

The timing of measuring vegetation structure elements in this study could potentially be conducted earlier. During this study, vegetation structure elements were measured within a few days of observing breeding LBCUs. Some breeding LBCUs may not have been observed until incubation was well underway. It would be advised to perform these measurements earlier in the season when curlews first arrive on breeding grounds to get a more accurate assessment of what these birds prefer for choosing nest sites.

Land Cover

As previously indicated in literature (Pampush 1980, Dugger and Dugger 2002), LBCUs tend to refrain from areas with large amounts of woodland and developed areas, and areas with great amounts of bare ground edge, thus preferring areas with continual vegetation ground coverage. It is of interest that LBCUs show a preference for areas with greater amounts of shrub edge at larger scales and show no preference at smaller scales. Curlews may use areas of shrublands for protection from predators while brood rearing.

Though LBCUs show no preference regarding croplands, numerous LBCUs were spotted feeding in agricultural fields. Observations of LBCUs in croplands could potentially be high due to the short stature of croplands during early portions of the breeding season. Two of four nests found during the past two field seasons were located in fallow croplands, suggesting presence of these fallow fields may be beneficial to nesting curlews. Abundance of preferred prey (grasshoppers, Hamer et al. 2006) was observed in the fallow fields. This may indicate further that LBCUs prefer to nest in areas with easy access to prey.

This study was one of the first to determine importance of wetlands on breeding grounds. Curlews in southwestern North Dakota preferred more wetland coverage on a larger scale (1.12 km). This might suggest that they may not need water in the immediate vicinity of breeding grounds and will fly to areas immediately adjacent to breeding grounds. Surprisingly, at larger scales, LBCU presence in areas with large amounts of wetland edge is negligible. This is interesting because it is assumed LBCUs would prefer more wetland edge (shoreline) for foraging (Forsythe 1972, Cochran and Anderson 1987, Dugger and Dugger 2002).

Interestingly, slope was not of significance to breeding LBCUs at areas near the breeding grounds, though it is of importance at a larger scale. At this larger scale, LBCUs prefer to breed near areas of gently sloping terrain and will then select their nest site after arriving on their breeding grounds. Dugger and Dugger (2002) found data suggesting that in other portions of their range, LBCUs will prefer areas of gradual slope near nesting sites.

CHAPTER V

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

To maintain a database of current up-to-date LBCU sightings, biologists and conservation officers from various wildlife agencies (e.g., NDGF, USFWS, USFS, Bureau of Land Management, National Park Service, North Dakota State Parks), across the state of North Dakota should report sightings to a central state database administered by an agency or organization. Many biologists and conservation officers are currently participating in various wildlife surveys as part of their regular duties, making incidental reporting of LBCU sightings a realistic request. The ND-BIRDS listserve (log of current avian sightings) should be notified annually each spring to remind bird enthusiasts to report LBCU sightings. Conducting North American Breeding Bird Survey routes should also report LBCUs. Many of my 2005 and 2006 sightings came from bird watchers and biologists, as well as several conservation officers. Dates, along with numbers of LBCUs observed, behavior, and location (i.e., legal description, UTM, lat./long.) should be noted. These data should be used to observe trends in population abundance and used to show areas where LBCUs could be retracting or expanding.

Curlews are an infrequent sight on pristine native shortgrass prairies of southwestern North Dakota. Some of the many factors affecting LBCU use include geographic location; wetland area and edge; presence and absence of shrubland, cropland, prairie edge and area; bare ground area and edge; planted herbaceous perennial area and edge; slope; elevation; various vegetative structural attributes; vegetative composition; number of dung piles and shrubs; land use and management; local climate and global climate change; and annual precipitation. This information can be used to predict areas of preferred habitat where LBCUs could one day be reintroduced or used to focus on more intensive studies.

In 2005 and 2006, LBCUs were observed farther east (east of the Missouri River) than expected by local birding groups and wildlife personnel. These LBCUs may be locally expanding into once common breeding grounds of historic significance. Most LBCUs were observed in Slope, Billings, and Golden Valley counties in North Dakota, as expected, with several noted in Bowman and McKenzie counties, and few observed in Burleigh, Dunn, McLean, Morton, and Sioux counties. Curlews were observed performing territorial displays, performing distraction displays, actively pursuing food, and actively mobbing observers and other avifauna.

Range-wide curlew population estimates were published during the duration of this study and found to be larger than expected at 164,515 and 109,533 individuals in 2004 and 2005, respectively (Stanley and Skagen, unpubl. data).

North Dakota state-wide estimates were estimated to be 518 and 2,074 individuals in 2005 and 2006, respectively. These estimates fit predicted numbers estimated by Partners in Flight (PIF 2007). Very few LBCUs were observed on state-wide census routes. This suggests that numbers are markedly lower than historic times, due to pressures of land conversion, and possible global climate change. Curlews may be locally centralized in specific areas in which larger numbers may be observed. This may be another indication of low numbers being observed on state-wide census routes.

Based on few nest observations during this study, LBCUs initiated breeding approximately the third week of April with later initiations beginning a full month later. Nests were located on areas of gradual slope and in close proximity to water. The presence of native grass/forbs is one factor that helped explain where LBCUs were more abundant. Low amounts of shrubs, noxious and exotic weeds, and higher amounts of bare ground are expected in areas of LBCU nesting activity.

Breeding LBCUs were commonly associated with areas of shorter vegetation and less litter depth. Grass, forbs, and bare ground were most often dominant on breeding areas, with few shrubs and crops nearby. Height-density of vegetation is markedly lower in areas LBCUs prefer. Curlews did not significantly prefer a certain amount of dung piles (index of grazing intensity) in breeding areas, though larger numbers of dung piles were observed compared to non-breeding areas. Numbers of shrubs were significantly lower in breeding areas. This is understood because it is believed that LBCUs tend to nest in areas were they can easily see approaching predators. Curlews also tend to prefer areas of a more gradual slope at breeding sites than surrounding landscapes.

There are no LBCU specific conservation activities currently ongoing in North Dakota. However, many state and federal agencies, as well as the Northern Great Plains Joint Venture, are working on grassland conservation in southwest North Dakota. Data from this study is used there. The NDGF has also published several articles on LBCUs in the North Dakota Outdoors magazine (Bry 1986, Kreil 1987, Wilson 2006). In May 2006, this project was featured on the North Dakota Outdoors Television News Program. This suggests that wildlife managers are interested and need information on this species of conservation concern. This study shall fulfill their inquiries.

The LBCU is a potential candidate for reintroduction following the regional success of other charismatic species, including the trumpeter swan (*Cygnus buccinator*), peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaetus leucocephalus*), and an increase in the establishment of large blocks of mid- to tallgrass prairie preserves within the historic range of this species. Several potentially suitable sites exist such as the Sisseton Hills in South Dakota, Minnesota's Glacial Ridge National Wildlife Refuge, and the Sheyenne National Grasslands in southeastern North Dakota (Russell 2006). Oakville and Fairfield townships in Grand Forks County might also support a LBCU re-introduction (R. Crawford, UND, pers. commun.).

Field methodology for future breeding LBCU surveys in North Dakota should remain mostly unchanged from this study. However, new census routes could be developed in potentially new areas of breeding LBCU habitat, since we observed that these birds are greatly clustered in various parts of southwestern North Dakota and appear to be locally expanding. Also, it would be interesting to look at availability of this species to conclude if current census techniques accurately sample LBCUs when they are located in predicted habitat. Additionally, there is no need to conduct range-wide census routes in the future unless one wishes to use the same census routes from this survey to conduct trend analysis. All state-wide census routes should be conducted regularly in the same time periods to produce a population trend.

Further, information on nesting LBCUs can be gathered by considering the use of ATVs for nest searching efforts, as recommended by Clarke (2006). The use of ATVs will increase nest searching efficiency, but it also may potentially damage preferred habitat.

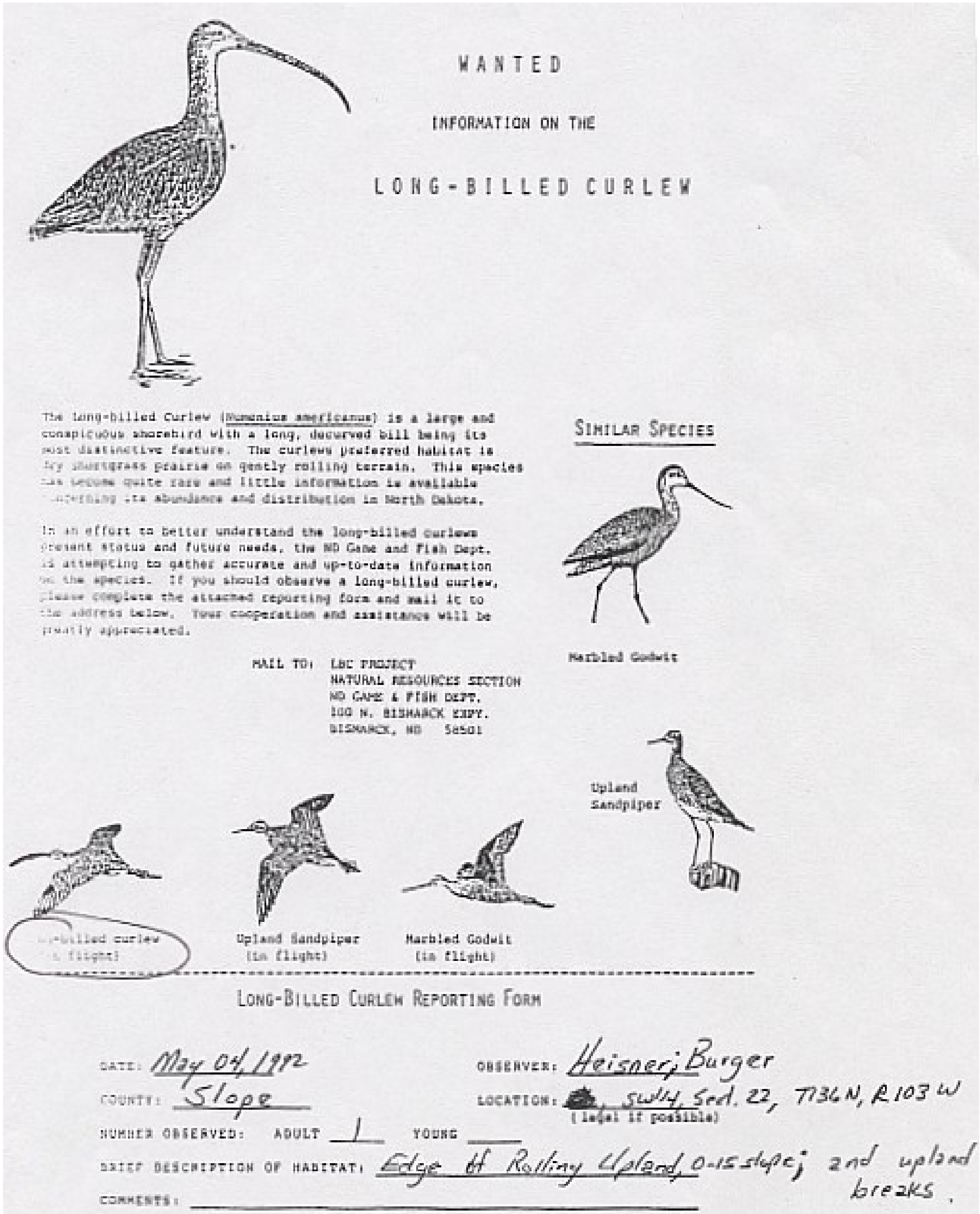
In the near future, a sample of North Dakota LBCUs should be fitted with radio/GPS transmitters to determine approximate home-range sizes, as well as look at the importance of water and how much time they spend in close proximity to this habitat, and determine amount of time spent on predicted breeding areas. Radio/GPS transmitters could also provide information on migratory routes and determine crucial stopover sites (Shane 2005).

Habitat preferences reported here should be overlaid on a GIS of ND GAP Analysis (Strong et al. 2005) land cover to identify areas of probable LBCU occurrence.

The apparent negative trend of breeding LBCUs, suggest that this species is in need of special management considerations. Based on vegetative analysis reported here, habitat restorations of native prairie grasses and forbs are presumed necessary. With continuing habitat conversion and an even greater threat of removing areas set aside for wildlife due to more demand for biofuels in the immediate future, LBCUs may struggle to survive and may soon be federally endangered. Wildlife managers should evaluate these results and consider the possibility of labor-intensive restoration efforts. Diminishing, pristine native prairie should be salvaged to the greatest extent possible.

APPENDICES

Appendix A
Example "Wanted" Poster



WANTED

INFORMATION ON THE

LONG-BILLED CURLEW

The long-billed Curlew (Numenius americanus) is a large and conspicuous shorebird with a long, decurved bill being its most distinctive feature. The curlews preferred habitat is dry shortgrass prairie on gently rolling terrain. This species has become quite rare and little information is available concerning its abundance and distribution in North Dakota.

In an effort to better understand the long-billed curlews present status and future needs, the ND Game and Fish Dept. is attempting to gather accurate and up-to-date information on the species. If you should observe a long-billed curlew, please complete the attached reporting form and mail it to the address below. Your cooperation and assistance will be greatly appreciated.

MAIL TO: LBC PROJECT
NATURAL RESOURCES SECTION
ND GAME & FISH DEPT.
100 N. BISMARCK EXPY.
BISMARCK, ND 58501

SIMILAR SPECIES

Marbled Godwit

Upland Sandpiper

-billed curlew
(in flight)

Upland Sandpiper
(in flight)

Marbled Godwit
(in flight)

LONG-BILLED CURLEW REPORTING FORM

DATE: May 04, 1982

OBSERVER: Heisner; Burger

COUNTY: Slope

LOCATION: SW1/4, Sed. 22, T134N, R103W
(legal if possible)

NUMBER OBSERVED: ADULT 1 YOUNG ____

BRIEF DESCRIPTION OF HABITAT: Edge of Rolling Upland, 0-15 slope; and upland breaks.

COMMENTS: ____

Figure 13. Example of a “Wanted” poster published in North Dakota Outdoors magazine (Bry 1986) to gather information on curlew locations, numbers, and behaviors.

Appendix B
Dates of Conducting Census Routes

Table 16. Census route dates. Survey routes were conducted during height of breeding activity. Time period is the recommended period when census routes were to be run (Jones et al. 2003).

Type	N.D. Route ID	Run	Date Run 2005	Date Run 2006	Time Period
Range-wide	2005-29366	1	8-Apr	8-Apr	3
Range-wide	2005-29992	1	9-Apr	8-Apr	3
Range-wide	2005-30320	1	13-Apr	10-Apr	3
State-wide	145	1	2-May	27-Apr	3
State-wide	326	1	20-Apr	20-Apr	3
State-wide	279	1	4-May	28-Apr	3
State-wide	73	1	3-May	27-Apr	3
State-wide	416	1	12-Apr	10-Apr	3
State-wide	409	1	10-Apr	9-Apr	3
State-wide	446	1	18-Apr	9-Apr	3
Intensive	Intensive-2005-1	1	4-May	25-Apr	3
Intensive	Intensive-2005-2	1	10-May	20-Apr	3
Intensive	Intensive-2005-3	1	9-May	25-Apr	3
Range-wide	2005-26666	1	11-May	7-May	4
Range-wide	2005-28106	1	19-May	9-May	4
Range-wide	2004-24456	1	28-Apr	24-Apr	4
Range-wide	2004-26114	1	25-Apr	22-Apr	4
Range-wide	2004-27818	1	26-Apr	21-Apr	4
State-wide	287	1	14-May	8-May	4
State-wide	155	1	16-May	10-May	4
State-wide	5	1	23-May	11-May	4
State-wide	291	1	15-May	9-May	4
State-wide	20	1	20-May	11-May	4
State-wide	223	1	14-May	8-May	4
State-wide	7	1	20-May	11-May	4
State-wide	181	1	13-May	7-May	4
State-wide	96	1	16-May	10-May	4
State-wide	259	1	21-Apr	20-Apr	4
State-wide	814	1	N/A	11-Apr	3
State-wide	719	1	N/A	13-Apr	3
Intensive	Intensive-2006-1	1	N/A	17-May	4
Intensive	Intensive-2006-1	2	N/A	19-May	4
Intensive	Intensive-2006-1	3	N/A	21-May	4
Intensive	Intensive-2006-2	1	N/A	17-May	4
Intensive	Intensive-2006-2	2	N/A	19-May	4
Intensive	Intensive-2006-2	3	N/A	21-May	4

Run= Run number for each route. Only Intensive routes were run more than once.
Time Period= Corresponds to time period in which census routes were to be run. 3= 8 Apr - 3 May, 4= 21 Apr - 15 May (23 May due to inclement weather)

Appendix C
Curlew Survey Codes

Sky Codes

0	Clear or few clouds
1	Partly cloudy
2	Cloudy (broken, overcast)
3	Rain
4	Fog or smoke
5	Drizzle
6	Snow
7	Showers (intermittent rain)

Topography

F	Flat
R	Rolling
P	Pocketed

Beaufort Wind Scale

0	Smoke rises vertically (<1 mph)
1	Wind direction shown by smoke drift (1-3 mph)
2	Wind felt on face, leaves rustle (4-7 mph)
3	Leaves, twigs in motion; light flag extended (8-12 mph)
4	Dust, loose paper blow; small branches in motion (13-18 mph)
5	Small trees sway, wavelets on water (19-24 mph)

Vegetation Height

Category	Height	In relation to LBCU
1	bare ground-4 cm (1 1/2 in)	can see foot
2	4-10 cm (4 in)	covers foot to "knee"
3	10-15 cm (6 in)	up to base of belly
4	15-45 cm (17 1/2)	up to back
5	45-65 cm (25 in)	up to eye level
6	≥ 65 cm (25 in)	above head

Species Codes

LBCU	Long-billed Curlew
NONE	Nothing seen

Incidental Species Codes

MOUP	Mountain Plover
WILL	Willet
UPSA	Upland Sandpiper
MAGO	Marbled Godwit
SEOW	Short-eared Owl
BUOW	Burrowing Owl
LPCH	Lesser Prairie-Chicken
GPCH	Greater Prairie-Chicken
STGR	Sharp-tailed Grouse
GSGR	Greater Sage-Grouse
CANLA	Coyote
VULVU	Red Fox
VULVE	Swift/Kit Fox
UROCI	Gray Fox
TAXTA	American Badger
MEPME	Striped Skunk
PROLO	Raccoon

LBCU Age & Sex Codes

AHY	after hatch year (adults)
HY	young of the year
DY	downy young
M	male
F	female
U	unknown sex

LBCU Flock Codes

1	Single
2	Pair
3	Flock: more than 1 bird and/or more than one obvious pair

LBCU Activity Codes

FE	Feeding: Actively pursuing food
R	Roosting: Actively roosting (eyes closed, one leg up, head under wing, etc.)
FO	Flying overhead: passing over area, not involved in territorial displays or other behaviors
T	Territorial displays: encounters between 2 or more LBCU, mate advertisement
N	Nesting: Includes copulating, scrape/nest building, egg laying, incubation, brooding young
D	Distraction displays: aerial or ground displays associated with nesting or young defense
M	Mobbing: specify observer, raptor, etc.

Appendix D

Habitat Codes for Curlew Census Routes

Habitat Codes for Curlew Census Routes

Habitat Codes

On Habitat Data Sheet: estimate the % (in increments of 25% or greater) in broad habitat classification categories by quarters (NE, NW, SE, SW) within the 400 m radius of the stop point. Record up to four (4) primary habitat codes in each quadrant and include all appropriate secondary codes and habitat conditions where they are easily determined. On the Survey Data Sheet: use the code which best describes the habitat being occupied by the LBCU, at first detection, within a 5-m radius of where the bird is located.

Primary Codes

GRAS	grasslands
RCWS	rural cultivated woodlands, scattered farm buildings, associated grounds, shelterbelts, orchard tree farms
CROP	cropland, planted growing crops, post-harvest stubble
BARE	barren ground, plowed not yet replanted, planted not yet growing
WEED	weedy fields; former grasslands, forb dominated fields
SHRB	shrubs clumped
STEP	steppe, widely dispersed shrubs with ≥50% grass
WOOD	woodlands
EMWL	wetlands/wet meadows
OWWL	open water wetlands, rivers, lakes, reservoirs, irrigation canals
STOK	stockpond, windmill
OTHR	urban residential and industrial miscellaneous
UNKN	cannot see due to topography or other visual obstructions

Secondary Codes

Grasslands

NTPA	native prairie
PAST	non-native, tame pasture/rangelands
CRPC	Conservation Reserve/ Permanent Cover Program
SHTG	shortgrass prairie: blue gramma-buffalo grass, includes cactus and small shrubs
MIXG	mixed grass prairie: wheatgrass-needlegrass
TALG	tallgrass prairie: wheatgrass-bluestem, needlegrass
TUND	alpine tundra and montane grasslands

Shrublands

SAGE	sagebrush *Artemisia-Agropyron*
SALT	saltbrush-shadescale-greasewood *Atriplex-Sacrobatus* alkaligrass
OAKS	oak shrub *Quercus gambelli*
MTSG	mountain shrublands mixed species *Cercocarpes*
WILC	highland willow carr *Salix*

Woodlands

CONF	conifer forest
RIPA	lowland riparian and hardwood bottomland *Populus-Salix-Acer*
ASPE	aspen *Populus tremuloides*
DECW	deciduous woodlands
MXFO	mixed deciduous-conifer woodland

Wetlands

EPHW	ephemeral/temporary ponds, wetlands, low wet prairie
SPLW	semipermanent lakes and ponds, shallow marshes
PLPW	permanent lakes and ponds, deep marsh
AKLW	alkali ponds & lakes, intermittent alkali
FENW	fen (alkaline) bog, wet meadow

Other

URCP	urban residential and parks
UIND	urban industrial, downtown, commercial districts
ROCK	rocks
OILP	mining pits, oil wells/pipes
HPLT	high power tension lines/poles
FLOT	feedlot
MISC	miscellaneous: specify

Tertiary Grassland Codes

Grassland foliage structure: don't include seedheads

SHRT	short grass, < 5" / < 12cm
MEDM	mid grass, 5-15" / 12-38cm
TALL	tall grass, >15" / > 38cm

Habitat Conditions

Management tool

GRAZ	grazed (cattle currently on, fresh pies)
BURN	burned (presence of ash or soot, black ground)
MCUT	mechanically cut: mowed, hayed
IR	irrigated grasslands, croplands, etc.
DY	dryland cropland, tame pastures

Invasive species

INVA	invasive species, particularly grasses, e.g. cheat grass (*Bromus tectorum*), Kentucky blue-grass (*Poa pratensis*), other bromes (*Bromus* spp.), etc. Indicate species and estimate %

Burrowing mammals

PDOG	prairie dog town
RGSQ	Richardson's ground squirrel
	AC active town (# mounds total)
	IA inactive town (# mounds total)

Appendix E
"Wanted" Poster

Figure 14. "Wanted" Poster published to request information and current sightings of curlews in North Dakota (Wilson 2006).

Appendix F
Radius Plot Schematic

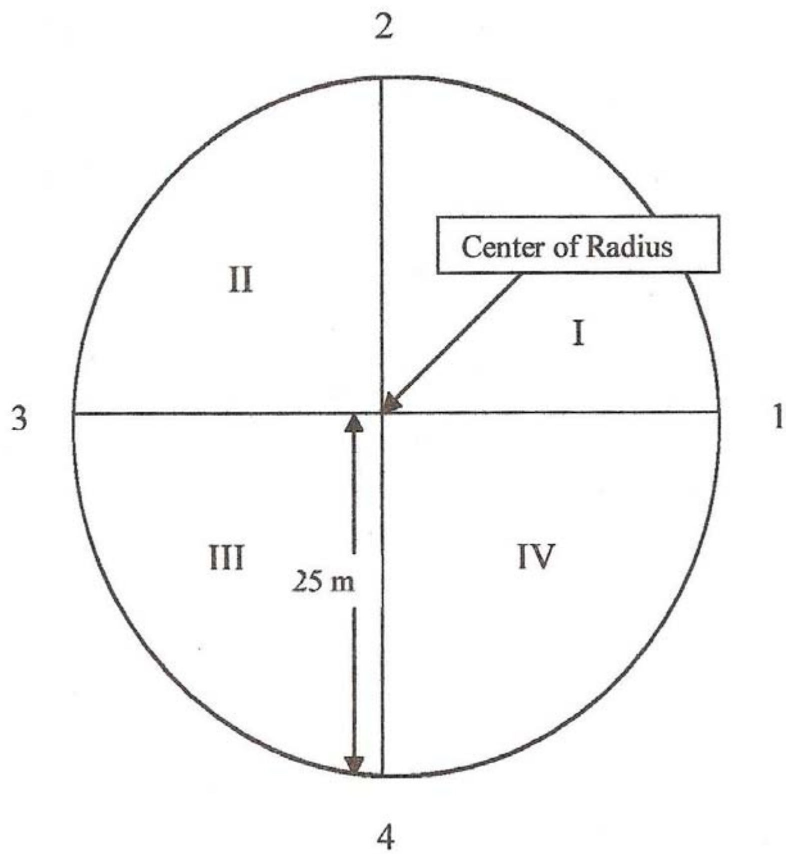


Figure 15. Radius plot schematic. Numbers 1-4 indicate transect number. Roman numerals indicate radius quadrant.

Appendix G
2005 Habitat Associations

Table 17. Hierarchical listing of belt transect habitat associations representative of southwestern North Dakota (modified from Grant et al. 2004). One of the below habitat associations is recorded for each 0.1 m x 0.5 m (0.3 ft x 1.5 ft) segment along an outstretched measuring tape, based on >50% dominance by canopy cover unless otherwise indicated.

SHRUB and TREE TYPES	
Low shrub (generally ≤5 ft (1.5 m) tall	
9	creeping juniper dense (>50% coverage); other plants few or none
10	creeping juniper; remainder mostly native grass-forb types
11	snowberry dense; other plants few or none
12	snowberry; remainder mostly native grass-forb types
13	snowberry; remainder mostly Kentucky bluegrass
14	snowberry; remainder mostly smooth brome (or quackgrass) or crested wheatgrass
15	silverberry prominent; remainder mostly native or invaded native-grass forbs
16	silverberry prominent; remainder mostly Kentucky bluegrass
17	silverberry prominent; remainder mostly smooth brome (or quackgrass)
18	sage (primarily fringed sagewort); remainder mostly native grass-forb types
Tall shrub (generally 5 ft to 16 ft tall) or **Tree** (>16 ft tall)	
21	chokecherry, juneberry, hawthorn, willow, dogwood
22	shrub-stage aspen
23	exotic shrub: caragana, honeysuckle, Russian olive, etc.
24	Rocky Mountain juniper
32	dead or dying (snag)
33	shade-tolerant woodland tree: green ash, box elder, elm
NATIVE GRASS-FORB and FORB TYPES (>95% dominance by native-herbaceous plants)	
41	dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass spp., prairie junegrass, forbs; often blue grama and some other C_4 species)
42	dry warm season (little bluestem, prairie sandreed, plains muhly, fescue spp., blue grama, forbs)
43	mesic warm-cool mix (big bluestem, switchgrass, little bluestem, porcupine grass, mat muhly, prairie dropseed, forbs)
46	subirrigated wet meadow microsite within upland (fowl bluegrass, foxtail barley, northern reedgrass, coarse sedge spp., Baltic rush, dock, prairie cordgrass)
47	cactus
48	yucca
97	wild sunflower (Asteraceae sp.)
EXOTIC and INVADED NATIVE GRASS-FORB TYPES	
51	Kentucky bluegrass >95%
52	Kentucky bluegrass and native grass-forbs, bluegrass 50-95%
53	native grass-forbs and Kentucky bluegrass, bluegrass 5-50%
61	smooth brome (or quackgrass) >95%
62	smooth brome (or quackgrass) and native grass-forbs, brome 50-95%
63	native grass-forbs and smooth brome (or quackgrass), brome 5-50%
71	crested wheatgrass >95%
72	crested wheatgrass and native grass-forbs, crested wheatgrass 50-95%
73	native grass-forbs and crested wheatgrass, crested wheatgrass 5-50%
78	tall, intermediate or pubescent wheatgrass
95	green foxtail and native grass-forbs, green foxtail 50-95%
96	wild oats
98	tall exotic legume: sweet clover or alfalfa

Table 17 cont.

NOXIOUS WEED TYPES	
81	leafy spurge
85	Canada thistle
88	other noxious weeds (user defined)
BARE	
91	barren, unvegetated (rock, anthill, bare soil, etc.)
AGRICULTURE	
92	harvested monocrop agriculture (hard red spring, winter, durum wheat, oats, or barley)
93	mechanical cut hayfield (sweet clover or alfalfa)
94	growing monocrop agriculture (hard red spring, winter, durum wheat, buckwheat, oats, or barley)
99	grazed unknown vegetation
WETLANDS	
00	wetland basin: temporary, seasonal, or semipermanent wetland (Stewart and Kantrud 1971)

Appendix H
2006 Habitat Associations

Table 18. Hierarchical listing of belt transect habitat associations representative of southwestern North Dakota (modified from Grant et al. 2004). One of the below habitat associations is recorded for each 0.1 m x 0.5 m (0.3 ft x 1.5 ft) segment along an outstretched measuring tape, based on >50% dominance by canopy cover unless otherwise indicated.

SHRUB and TREE TYPES	
Low shrub (generally ≤5 ft (1.5 m) tall	
8	shrubby cinquefoil
9	creeping juniper dense (>50% coverage); other plants few or none
10	creeping juniper; remainder mostly native grass-forb types
11	snowberry dense; other plants few or none
12	snowberry; remainder mostly native grass-forb types
13	snowberry; remainder mostly Kentucky bluegrass
14	snowberry; remainder mostly smooth brome (or quackgrass) or crested wheatgrass
15	silverberry prominent; remainder mostly native or invaded native-grass forbs
16	silverberry prominent; remainder mostly Kentucky bluegrass
17	silverberry prominent; remainder mostly smooth brome (or quackgrass)
18	sage (primarily fringed sagewort); remainder mostly native grass-forb types
19	buffalo currant
20	silver buffaloberry
Tall shrub (generally 5 ft to 16 ft tall) or **Tree** (>16 ft tall)	
21	chokecherry, juneberry, hawthorn, willow, dogwood
22	shrub-stage aspen
23	exotic shrub: caragana, honeysuckle, Russian olive, etc.
24	Rocky Mountain juniper
32	dead or dying (snag)
33	shade-tolerant woodland tree: green ash, box elder, elm
NATIVE GRASS-FORB and FORB TYPES (>95% dominance by native-herbaceous plants)	
41	dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass spp., prairie junegrass, forbs; often blue grama and some other C_4 species)
42	dry warm season (little bluestem, prairie sandreed, plains muhly, fescue spp., blue grama, forbs)
43	mesic warm-cool mix (big bluestem, switchgrass, little bluestem, porcupine grass, mat muhly, prairie dropseed, forbs)
46	subirrigated wet meadow microsite within upland (fowl bluegrass, foxtail barley, northern reedgrass, coarse sedge spp., Baltic rush, dock, prairie cordgrass)
47	cactus
48	yucca
97	wild sunflower (Asteraceae sp.)
EXOTIC and INVADED NATIVE GRASS-FORB TYPES	
51	Kentucky bluegrass >95%
52	Kentucky bluegrass and native grass-forbs, bluegrass 50-95%
53	native grass-forbs and Kentucky bluegrass, bluegrass 5-50%
61	smooth brome (or quackgrass) >95%
62	smooth brome (or quackgrass) and native grass-forbs, brome 50-95%
63	native grass-forbs and smooth brome (or quackgrass), brome 5-50%
71	crested wheatgrass >95%
72	crested wheatgrass and native grass-forbs, crested wheatgrass 50-95%
73	native grass-forbs and crested wheatgrass, crested wheatgrass 5-50%
78	tall, intermediate or pubescent wheatgrass
95	green foxtail and native grass-forbs, green foxtail 50-95%
96	wild oats
98	tall exotic legume: sweet clover or alfalfa

Table 18 cont.

NOXIOUS WEED TYPES	
81	leafy spurge
85	Canada thistle
88	other noxious weeds (user defined)
BARE	
91	barren, unvegetated (rock, anthill, bare soil, etc.)
AGRICULTURE	
92	harvested monocrop agriculture (hard red spring, winter, durum wheat, oats, or barley)
93	mechanical cut hayfield (sweet clover or alfalfa)
94	growing monocrop agriculture (hard red spring, winter, durum wheat, buckwheat, oats, or barley)
99	grazed unknown vegetation
WETLANDS	
00	wetland basin: temporary, seasonal, or semipermanent wetland (Stewart and Kantrud 1971)

Appendix I
Long-billed Curlew Nest Locations

Figure 16. Curlew nest locations during the 2005 and 2006 field seasons. Nests 1 and 2 were found in 2005, and nest 3 was found in 2006. Thin black lines indicate section boundaries (T135N, R101W, Secs. 18/17). Aerial photo was taken in 2003 and acquired from the ND GIS HUB Explorer (<http://gf.nd.gov/info/sources.html>).

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