Distribution and Habitat of the Least Bittern and Other Marsh Bird Species in Southern Manitoba

by

Stacey Hay

A Thesis Presented to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfillment of the requirements for the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

Abstract

Call-response surveys were conducted to better delineate and estimate the population of the nationally threatened least bittern (*Ixobrychus exilis*) and their habitat requirements in southern Manitoba, Canada. Other marsh bird species whose populations are believed to be declining due to wetland loss throughout, or in parts of, their range were also surveyed including the American bittern (*Botaurus lentiginosus*), pied-billed grebe (*Podilymbus podiceps*), sora (*Porzana carolina*), Virginia rail (*Rallus limicola*) and yellow rail (*Coturnicops noveboracensis*), a species of special concern in Canada.

Four hundred and seventeen surveys were conducted during the 2003 and 2004 breeding seasons at 141 sites within 46 different wetlands in the southern region of the Province. Least bitterns were encountered on 26 occasions at 15 sites within 5 wetlands. The sora was the most abundant and widely distributed target species and was encountered on 330 occasions in 39 of the 46 surveyed wetlands. Yellow rails were not detected during either survey year due to survey methodology.

Use of the call-response survey protocol led to an increase in the numbers of all target species detected. This increase was more significant for the least bittern, sora and Virginia rail. Significantly more American bitterns and soras were detected between May 6 and June 27 than were detected between June 18 and July 22. Significantly more American bitterns and pied-billed grebes were detected in the evening than in the morning survey periods.

Habitat was assessed as percent vegetation cover within a 50-m radius around the calling sites, and forest resource inventory data were used in a Geographic Information System to determine the landscape composition within a 500-m radius around the sites

and within a 5-km radius around the wetlands surveyed. Logistic regression analyses were used to evaluate the relationship between the presence of the target species and the site and landscape characteristics.

Habitat models at the 500-m scale explained the presence of more of the target species than the models at the 50-m and 5-km scales. Marsh bird species responded differently to different site and landscape characteristics. Least bittern and pied-billed grebe selected areas with higher proportions of *Typha* spp. and tall shrubs; American bittern also selected areas with higher proportions of tall shrubs. At the 5-km scale, the American bittern responded positively to the amount of wetland and some positive trends were also detected for the pied-billed grebe. Sora and Virginia rail were not associated with any of the measured landscape characteristics.

One of the most important steps towards the conservation of marsh bird species in Manitoba and elsewhere is the development, adoption, and implementation of a standardized survey protocol. Based on the results of the present study, I recommend that future surveys include both a passive and call-broadcast period for marsh bird species. Future marsh bird surveys should be conducted in both the morning and evening and sites should be visited 3 times each during the breeding season. In southern Manitoba, call-response surveys for marsh bird species should begin as early as the beginning of May to ensure the survey incorporates the period of peak vocalization. I recommend that future surveys for the yellow rail be conducted after dark.

In this study many of the target species selected sites that had a greater area of wetland habitat surrounding them. Future wetland conservation efforts should focus on the protection and/or restoration of wetland complexes to ensure that remaining wetlands

do not become smaller and increasingly isolated from one another. In addition, the Rat River Swamp was found to be the most productive marsh complex for least bittern in southern Manitoba. Measures should be taken to protect this area from future development and alteration.

Key Words: least bittern, Virginia rail, yellow rail, sora, pied-billed grebe, American bittern, call-response survey, resource selection, species at risk, wetland conservation

Acknowledgements

Project funding was provided by the Canadian Wildlife Service of Environment Canada, Manitoba Conservation, the Manitoba Heritage Marsh Program, Parks Canada, the World Wildlife Fund, and Young Canada Works. In-kind project support was provided by Ducks Unlimited Canada, Important Bird Areas of Canada, Manitoba Conservation, and the Natural Resources Institute (University of Manitoba). Ron Bazin, Dr. Jim Duncan, Cory Lindgren, Dr. Micheline Manseau and Laurie Maynard were invaluable for their help in securing funding for this project.

I am grateful to my advisory committee, Dr. Jim Duncan, Cory Lindgren and Dr. Rick Riewe for their assistance throughout this project and comments on my thesis. In particular, I thank my advisor, Dr. Micheline Manseau, for assistance with the statistical analysis, comments that greatly improved all aspects of this thesis and the support she provided throughout this project.

Ron Bazin kindly provided habitat data from the 2004 Canadian Wildlife Service least bittern survey for inclusion in this study and provided insightful comments on an earlier draft of this thesis. Janene Shearer conducted outstanding field assistance in 2004. A number of other people assisted me with various aspects of this project including: Ted Barney, Garth Ball, Cal Cuthbert, Heidi den Haan, Jim Fisher, Paula Grieef, Cam Meuckon, Brady Palsson, Peter Taylor, Marc Schuster, Joanne Tuckwell, Wybo Vanderschuit, and Adam Walleyen. I thank the staff at Oak Hammock Marsh, the Delta Waterfowl Research Station and the Fort Whyte Centre for allowing me to conduct surveys on their property. I thank Karla Guyn and Shane Gabor for allowing me to take time away from work so that I could complete this thesis.

Finally, I thank my family for their encouragement and support. I am most grateful to my husband Graeme - I could not have completed this project without you!

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Context

The least bittern (*Ixobrychus exilis*), the smallest member of the heron family, is considered to be one of the most inconspicuous marsh birds in North America (Gibbs et al. 1992b). In Canada, this migratory species breeds primarily in Ontario and to a lesser extent in southern Quebec, Manitoba and New Brunswick (James 1999). Manitoba represents the northwestern limit of the breeding population, and the species is thought to be a rare and local breeder in the southeastern region of the Province (Koes 2003).

Little is known about the status and population of least bittern in Manitoba and the rest of its range. The absence of a standardized species-specific survey method to detect the bird combined with its secretive nature has resulted in a paucity of available information throughout the species' range in Canada (James 1999). In addition, this study represents the first intense search effort for the least bittern in Manitoba since Dillon's survey of Delta Marsh and the surrounding areas in the 1950s (Dillon 1959).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the least bittern as Threatened in 2001. A national recovery strategy has yet to be drafted for the species. COSEWIC status reports have cited the loss of wetland habitat as the primary threat facing the least bittern (Sandilands and Campbell 1987, James 1999). The least bittern is not currently listed as a species at risk under the Manitoba *Endangered Species Act*, although its status is under review. The Manitoba Conservation Data Centre recently changed the general status rank of the least bittern in the Province from may be at risk to at risk (J. Duncan, pers. comm.).

A number of other marsh bird species with populations that are believed to be declining due to wetland loss throughout, or in parts of, their range also breed in Manitoba. These species include the American bittern (*Botaurus lentiginosus*), pied-billed grebe (*Podilymbus podiceps*), sora (*Porzana carolina*), Virginia rail (*Rallus limicola*), and yellow rail (*Coturnicops noveboracensis*). Like the least bittern, they are under-detected in traditional breeding bird surveys, and concrete population data and information on their status is lacking (Gibbs and Melvin 1993, Conway and Gibbs 2005). With the exception of the yellow rail, which was assessed as a species of Special Concern by COSEWIC, these species are not listed as species at risk in Canada or in Manitoba.

Habitat data exists for the above-mentioned species in various parts of their range, but there is a paucity of habitat data for marsh birds in Manitoba both at a site and landscape level. Along with data on species status and population, information on the habitat requirements of these species is needed in order to conserve them and support recovery actions.

Existing road-side bird surveys are inadequate for surveying secretive marsh bird species (Conway and Gibbs 2005). These surveys are typically not conducted in the densely vegetated wetland habitat where marsh birds are found, and the secretive nature of these species makes it unlikely that they will be detected in passive point count surveys. North America currently lacks a coordinated standardized marsh bird monitoring program.

One method that has been used to survey marsh birds is the call-response survey, in which a species' breeding call is broadcast in order to elicit a vocal response from birds that would otherwise go undetected. Considerable debate exists in the literature regarding the efficacy of call-response surveys. Gibbs and Melvin (1993) and Bogner and Baldassare (2002a) showed that call-response surveys increased the detection of least bittern whereas Lor and Malecki (2002) showed the opposite.

This study tested a modified call-response survey protocol (Conway 2002) in order to better estimate and delineate the population of American bittern, least bittern, pied-billed grebe, sora, Virginia rail and yellow rail (hereafter target species) in Manitoba. In order to determine the types of habitat used by the target species, this study examined the association between the presence of these species and various habitat characteristics at three spatial scales across the landscape.

1.2 Problem Statement

The target species in this study are declining in numbers throughout, or in parts, of their range largely due to the loss of wetland habitat (Gibbs et al. 1992a, Melvin and Gibbs 1996, James 1999, Muller and Storer 1999, Government of Canada 2003, Alvo and Robert 2005). Existing breeding bird surveys are not designed to census marsh birds and there is currently no national marsh bird monitoring protocol, which has resulted in a paucity of information on the distribution and status of the target species and their breeding habitat. In order to effectively conserve these species, additional information is needed on: 1) the most effective and feasible ways to survey for them, 2) their distribution and population status, and 3) their habitat requirements.

1.3 Objectives

The objectives of this study are:

1) Assess the efficacy of the call-response protocol in detecting least bittern and other marsh bird species in southern Manitoba.
2) Assess the habitat requirements of the target species during the breeding season at multiple landscape scales.
3) Form recommendations for the monitoring and conservation of marsh birds in southern Manitoba.

1.4 Organization of Thesis

In Chapter 2, I review the information available on the life history and status of the target species and the causes of their decline. I also review current efforts to monitor marsh bird populations in North America and discuss wetland habitat loss. In Chapter 3, I highlight the results of the call-response survey that was used to detect the target species, and evaluate the efficacy of the method. In Chapter 4, I highlight the findings of the habitat use analysis conducted for each of the target species at multiple landscape scales. I conclude in Chapter 5 by reviewing the key findings of this study, outlining future research needs and discussing the management implications for the conservation of the target species.

2 Background

2.1 Life History and Status of Target Species in North America

2.1.1 American Bittern

The American bittern is a medium sized heron, 60-85 cm in length (Gibbs et al. 1992a). Males are slightly larger than females, but both sexes have similar breeding plumage with brown colouration overall, dark brown crown, white and brown streaked neck and a thin long bill. Juveniles are similar in appearance to the adults, but lack the dark throat patch.

The species' range extends from northern Canada south to the mid-United States (Gibbs et al. 1992a) (Figure 2-1).

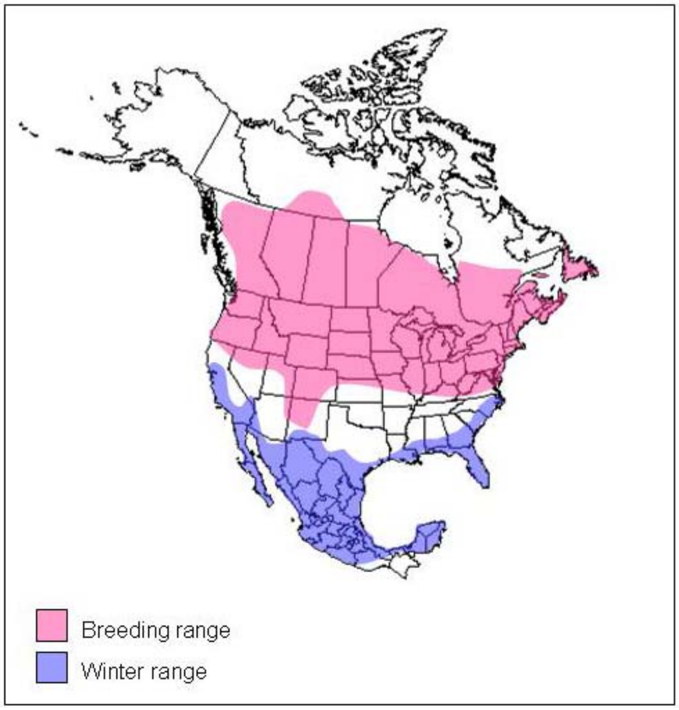

Figure 2-1 Distribution of the American bittern in North America (data source: Cornell Lab of Ornithology 2003).

American bitterns feed on a number of prey items including aquatic and terrestrial insects, fish, crustaceans including crabs, frogs and salamanders, snakes and small mammals (Gibbs et al. 1992a). This cryptically coloured species forages by standing motionless with its bill upright and quickly grabbing prey with its bill (Gibbs et al. 1992a).

Due to the dense vegetation present in their breeding habitat, the American bittern relies heavily on calls to communicate with conspecifics (Gibbs et al. 1992a). During the breeding season, the call most often heard is the *pump-er-lunk* call uttered by the male, which is associated with territoriality and mate advertisement (Gibbs et al. 1992a). Males call most frequently early in the breeding season and can be heard calling day and night (Gibbs et al. 1992a). Little is known about female vocalizations (Gibbs et al. 1992a).

Breeding pairs form soon after females arrive on the breeding grounds. Females construct the nests and incubate the eggs for 24-28 days (Gibbs et al. 1992a). Females also feed and brood the altricial young without assistance from the male for approximately 4 weeks (Gibbs et al. 1992a).

The American bittern is declining over much of its' range in the United States due to habitat loss and degradation (Gibbs et al. 1992a). Breeding Bird Survey (BBS) data show a decrease in populations of 1.6%/yr (P=0.06) over the entire survey range from 1966-2004 (Sauer et al. 2005). Acid rain, pesticides, and contaminants are also believed to threaten the American bittern (Gibbs et al. 1992a). Gibbs et al. (1992a) suggested that the development of standardized methods for surveying the species and monitoring their habitat would aid in their conservation.

2.1.2 Least bittern

The least bittern is the smallest member of the heron family, with both sexes measuring 28-30 cm in length (Gibbs et al. 1992b). The sexes have dimorphic plumage, but both the male and female have necks, sides, and under parts that are brown and white, wings that are chestnut coloured with pale patches, and scapular feathers that are bordered with pale lines. The head is slightly crested in both sexes and the bill is thin and yellow. In the male, the crown and back are black, while these areas are a purple-chestnut colour in the female. The female can also be distinguished from the male by its more darkly streaked neck. Juveniles resemble the adult female, but have darker streaking on the neck and a paler brown crown and back. A rare, dark colour morph, known as Cory's least bittern, also exists, but has not been recorded in Manitoba (Gibbs et al. 1992b).

The range of the least bittern extends from southeastern Canada through the eastern United States to South America (Environment Canada 2004) (Figure 2-2).

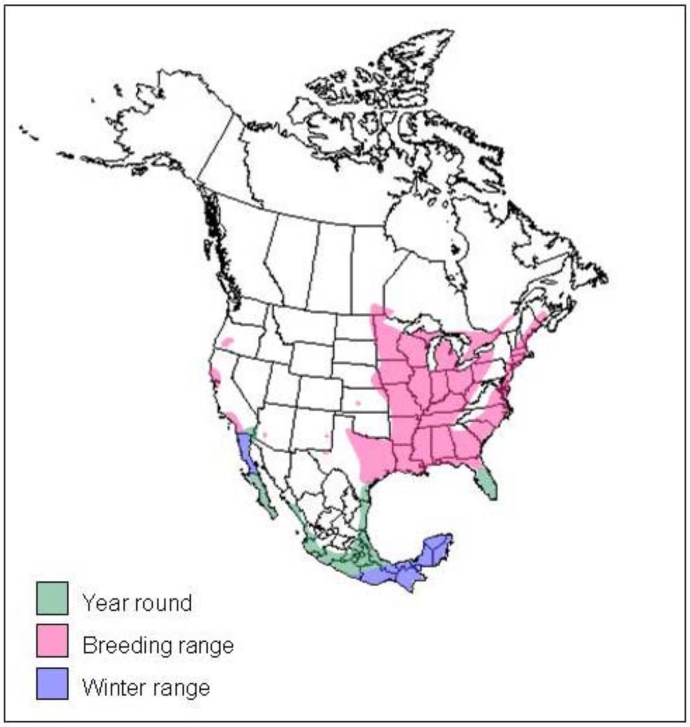

Figure 2-2 Distribution of least bittern in North America (data source: Cornell Lab of Ornithology 2003).

The diet of the least bittern primarily consists of small fish, amphibians such as frogs and salamanders, snakes, small rodents, invertebrates including crayfish and insects, and vegetation (Gibbs et al. 1992b). Least bitterns construct feeding platforms along the open water edge of the emergent vegetation where they forage for their fast moving prey (Gibbs et al. 1992b). The least bittern also forages by using the emergent vegetation as stepping-stones that it grasps with its' feet while hunting on the open water side of emergent vegetation (Weller 1961).

The *coo-coo* call of the advertising male least bittern is the call most often heard during the breeding season. Females have been reported to respond to the male's call with a ticking call, but they do not respond loudly enough to be consistently detected in call-response surveys (Gibbs et al. 1992b, Bogner and Baldassarre 2002a). Bogner (2001) found that females responded to the male advertising call with a soft *angh angh* call that was only audible for 10-20 m. This species is most vocal during the morning and has been found to call most frequently between mid-May and mid-June in New York state (Swift et al. 1988, Bogner and Baldassarre 2002a, Lor and Malecki 2002).

Least bitterns form breeding pairs soon after they have arrived on the breeding grounds (Gibbs et al. 1992b). Nests are constructed by the male (Weller 1961). Both the male and female incubate the eggs, which takes approximately 20 days (Weller 1961). Young are semialtricial and are cared for by both parents until they leave the nest between the 13th and 15th day after hatching (Nero 1950, Gibbs et al. 1992b). Least bittern have been reported to renest and double-brood in New York (Bogner and Baldassare 2002b). A number of studies have shown that least bitterns nest colonially with conspecific nests located as close as 1 m apart (Weller 1961, Kushlan 1973, Post 1998).

Population estimates from the Ontario Breeding Bird Atlas placed the Ontario breeding population at between 392 and 5950 pairs (Sandilands and Campbell 1987). Other data estimate the overall population of least bitterns in Canada to be 1000 pairs, with no more than 100 breeding pairs occurring outside of Ontario (Sandilands and Campbell 1987).

Sandilands and Campbell (1987) report that the least bittern population was not established in Manitoba until the 1920's, and prior to 1949 it was accidental in the Province. Least bittern are now reported annually in southern Manitoba, although there have been no more than 4 occurrences reported annually in the last 20 years (Sandilands and Campbell 1987, Koes and Taylor 2002). Manitoba Conservation estimated that least bittern are found in up to 100 sites in Manitoba (James 1999).

Dillon (1959) compiled all of the known records of least bittern occurrences in southern Manitoba through to the summer of 1958. Occurrences varied in location throughout southern Manitoba, although 12 of the 19 records were from Delta Marsh. Dillon (1959) noted that the number of least bitterns in the Province was increasing annually, especially along the southern shores of Lake Manitoba.

Koes and Taylor (2002) compiled all 78 least bittern records for Manitoba up until the summer of 2002. Occurrences were concentrated in southern Manitoba with the northernmost location being Churchill. Nineteen of the records were from Oak Hammock Marsh. Thirteen occurrences were recorded at Delta Marsh; however 12 of the Delta Marsh records were recorded between 1939 and 1958. P. Grieef (pers. comm.) reported an additional sighting at Delta Marsh in the summer of 1991. Another location of interest is Spruce Siding Road where 6 least bitterns were detected between 1982 and 2000.

Over the entire North American survey range, results from the BBS show a population decrease of 0.6 % per year (P=0.71) for the period of 1966-2004 (Sauer et al. 2005).

The loss and degradation of wetland habitat is the primary threat to the least bittern (James 1999). Because of the large amount of aquatic invertebrates that least bittern consume, agricultural runoff may also negatively affect the North American population (Conway 2002). Human development that degrades wetland quality may also limit the least bittern population. Least bitterns are weak fliers over short distances and collisions with vehicles, power lines and fences are a source of mortality (James 1999).

2.1.3 Pied-Billed Grebe

The pied-billed grebe is a small grebe, measuring 30.5-38.1 cm in length (Muller and Storer 1999). Both sexes have similar breeding plumage with dark brown upperparts and grey sides and neck, black throat patch and grey-blue bill that has a black stripe during the breeding season. Juveniles are similar to non-breeding adults in appearance.

The pied-billed grebe is the most widely distributed grebe in the Americas, and can be found in much of North America, Central America, and parts of South America (Muller and Storer 1999) (Figure 2-3).

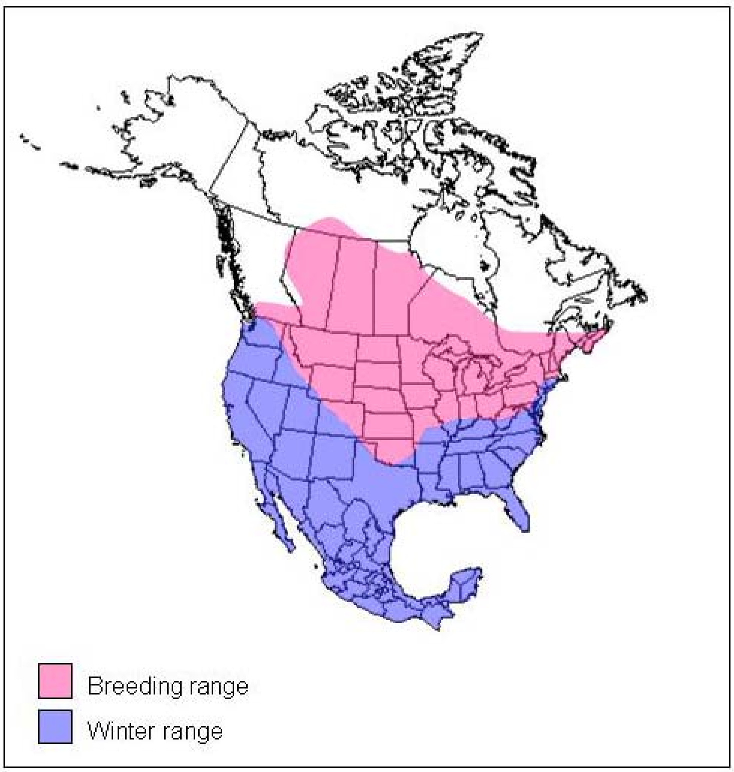

Figure 2-3 Distribution of pied-billed grebes in North America (data source: Cornell Lab of Ornithology 2003).

Pied-billed grebes are opportunistic feeders that catch the majority of their prey during underwater foraging dives (Muller and Storer 1999). Prey items include fish, crustaceans, and aquatic insects (Muller and Storer 1999).

Both sexes of pied-billed grebe give a donkey braying call that is thought to be associated with territoriality and communication between breeding pairs (Muller and Storer 1999). Increased rates of vocalization have been noted during early morning and late afternoon periods (Muller and Storer 1999).

Breeding pairs form during migration north and after they return to the breeding grounds. Some pairs have been reported to winter together (Muller and Storer 1999). Both sexes are involved in building nesting platforms and in incubation. Young are semi-precocial and are brooded by both the male and female for approximately 3 weeks, and are fed by both parents until they are independent at 28-68 days old (Muller and Storer 1999).

Information on the status of pied-billed grebe population varies greatly, with some data showing a decrease in the population and other data showing no significant trend (Muller and Storer 1999). BBS data shows a long-term increase in populations of 1.1%/yr (P=0.23) over the entire survey range between 1966 and 2004 (Sauer et al. 2005). Reasons for the possible population declines include the human-caused disturbance of nests, pesticide contamination of wetlands, collisions with vehicles and stationary objects, and wetland loss (Muller and Storer 1999).

2.1.4 Sora

The sora is a small stocky bird, 20-25 cm in length, with grey-brown colouration overall, long green legs and a short yellow bill (Melvin and Gibbs 1996). Both sexes are similar in appearance, although the female is slightly smaller than the male and has a slightly darker bill. Juveniles are paler in colour on the face, throat and chin than the adults.

The sora is the most widespread and abundant rail in North America (Melvin and Gibbs 1996). It is found throughout southern Canada and much of the United States as well as Mexico, Central America and northern portions of South America (Melvin and Gibbs 1996) (Figure 2-4).

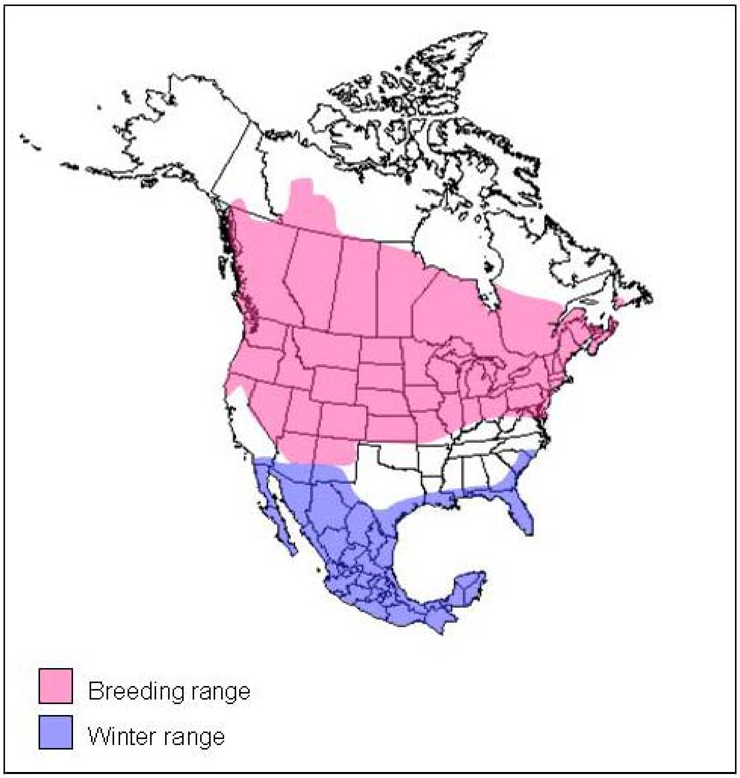

Figure 2-4 Distribution of sora in North America (data source: Cornell Lab of Ornithology 2003).

The sora's diet primarily consists of the seeds of wetland plants and aquatic invertebrates (Kaufmann 1989, Melvin and Gibbs 1996). Soras forage by picking through mats of vegetation with their feet and pulling aside vegetation with their bills (Kaufmann 1989).

In the breeding season, soras are primarily heard making two calls. The descending *whinny* is associated with territoriality and mate contact, and is given by both sexes (Melvin and Gibbs 1996). In central Minnesota, the whinny call was found to increase in frequency between the beginning and middle of May, decreasing in frequency late in the month, and again becoming more frequent from the beginning to middle of June. These periods of increased calling may correspond to the first and second nesting efforts or to the start of egg laying and hatching (Melvin and Gibbs 1996). The *per-weep* call is heard as soon as birds arrive on the breeding grounds and may function in the attraction of mates (Melvin and Gibbs 1996).

Soras form breeding pairs in the spring and both sexes participate in nest building (Melvin and Gibbs 1996). Eggs are incubated by both parents for a period of approximately 20 days (Melvin and Gibbs 1996). Both parents participate in feeding and brooding, which lasts for several weeks and 1 month, respectively (Melvin and Gibbs 1996).

Data from the BBS shows a population decline for the sora of 0.4% /yr (P = 0.45) between 1966-2004 throughout the North American survey range (Sauer et al. 2005). The declines in the sora population have been the greatest in central North America where rates of wetland loss have been the highest (Melvin and Gibbs 1996).

2.1.5 Virginia Rail

The Virginia rail is a small bird, 22-27 cm in length (Conway 1995). In the breeding season, both sexes have a reddish-brown colour overall, long, red bill, red legs, and black and white bars along the flanks. Females are slightly smaller, although this difference in size is not apparent to the casual observer (Conway 1995).

Virginia rails are found throughout much of southern Canada, the northern and western United States, and Mexico (Conway 1995) (Figure 2-5).

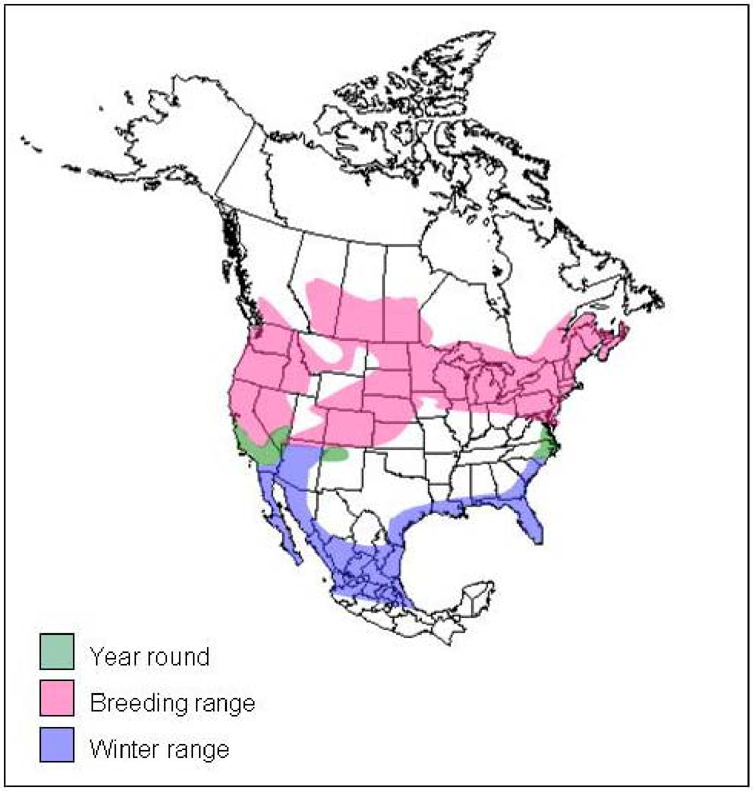

Figure 2-5 Distribution of Virginia rails in North America (data source: Cornell Lab of Ornithology 2003).

During the breeding season, this species primarily feeds on aquatic invertebrates by probing mudflats, areas under floating vegetation, mats of duckweed and shallow water with its bill (Kaufmann 1989, Conway 1995). Feeding effort is most intense at dusk and dawn (Conway 1995).

The pig-like *grunt* call made by both sexes is the call most often heard during the breeding season and is associated with pair contact and aggressive intra-and interspecific encounters (Kaufmann 1989). The *tick-it* call is also associated with breeding, but is heard only in early spring, and is thought to be made by the males only (Conway 1995). In captive pairs, Kaufmann (1989) found that calling occurred most frequently between the period of egg laying until several weeks after chicks hatched.

Breeding pairs form on the breeding grounds and both the male and the female participate in nest building, incubation and brood rearing (Kaufmann 1989, Conway 1995). Nests are constructed of the most abundant vegetation at the nest site and consist of a loosely constructed bowl with a canopy over top. In addition to the nest that is used during incubation, Virginia rails build as many as 5 “dummy” nests that are used for brooding, feeding, resting and as alternates in case of nest destruction or flooding (Conway 1995). Chicks are precocial and are brooded for 3-4 weeks in the breeding territory before the parents expand movements into the surrounding areas (Conway 1995).

Virginia rails are declining in numbers in many areas although there is no conservation program targeted specifically at this species (Conway 1995, Sauer et al. 2005). BBS data shows an increase of 2.7%/yr in numbers of Virginia detected over the entire survey range between 1966 and 2004 (Sauer et al. 2005). Threats to the Virginia rail include hunting, collisions with stationary objects, pesticides and contaminants and degradation of habitat due to altered water levels (Conway 1995)

2.1.6 Yellow Rail

The yellow rail is a small stocky marsh bird, 13-18 cm in length (Bookhout 1995). Both the male and female have buffy yellow colouration on their chests and faces with yellow and black streaking on the back and short bills. Males are slightly larger than females and have bright yellow bills in the breeding season; the bill of the female ranges in colour from olive to black.

The breeding range (Figure 2.6) of the yellow rail is relatively poorly known (Bookhout 1995). It is estimated that there are several thousand breeding pairs of yellow rails along the Hudson/James Bay coast and another 2000 breeding pairs throughout the rest of Canada (Alvo and Robert 2005). The species winters along the southeastern coast of the United States.

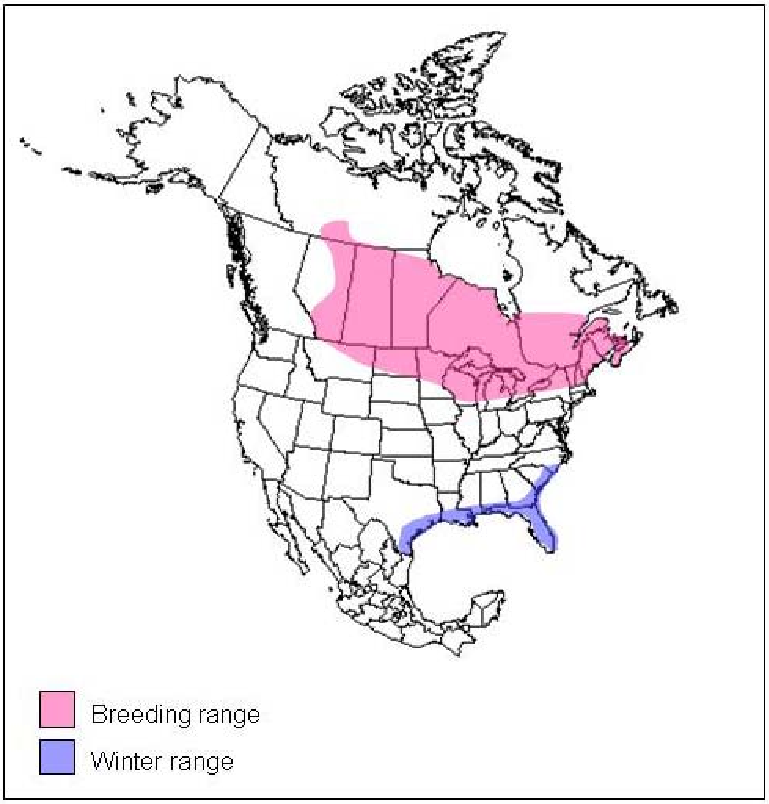

Figure 2-6 Distribution of yellow rails in North America (data source: Cornell Lab of Ornithology 2003).

Yellow rails are very seldom seen and are most likely to be detected by the male's advertising call, which is quite accurately mimicked by banging pebbles together. Males call most frequently and regularly at night, however, Alvo and Robert (2005) reported that the yellow rail is much more active during the day than it is at night, and contrary to popular belief, it is not a nocturnal species.

During the breeding season, the yellow rail forages during the day for food items that include invertebrates and seeds (Bookhout 1995, Alvo and Robert 2005).

Breeding pairs form soon after the birds arrive on the breeding grounds and both the male and female initiate nest building. Females alone complete the nest and then incubate for approximately 18 days (Bookhout 1995). The semi-precocial chicks hatch synchronously and are able to feed themselves after 5 days and fledge at 35 days of age (Alvo and Robert 2005).

Yellow rails were assessed as a species of Special Concern by COSEWIC in 2001. Yellow rail populations are believed to have declined throughout much of their range due to degradation and loss of wetland habitat (Alvo and Robert 2005). In the Hudson/James Bay region, snow geese may be degrading the quality of some local yellow rail breeding habitat (Alvo and Robert 2005).

2.2 Current Efforts to Monitor Marsh Bird Populations in North America

The primary reason for the lack of robust population data on the least bittern and other marsh birds in North America is the lack of a widespread standardized continent-wide survey method. There are a number of regional efforts but they are largely uncoordinated, the survey methods differ across monitoring programs and vary with respect to the species surveyed (Table 2-1). With the exception of the least bittern survey conducted by the Canadian Wildlife Service, there is currently no monitoring program for marsh birds in Manitoba, although several organizations are interested in implementing a survey. This study was the first large-scale marsh bird monitoring effort to be conducted in the Province. The following is a brief summary of the different marsh bird monitoring programs in North America.

Table 2-1 Summary of current marsh bird monitoring efforts in North America

Monitoring Program	*Geographic Area Surveyed*	*Methodology*	*Species Surveyed*	*Organization*
Conway Survey	Wildlife refuges in the United States	Call-response point count surveys	Marsh birds	United States Geological Survey
Marsh Monitoring Program	Great Lakes Region, Quebec and Alberta	Call-response point count surveys	Marsh birds and anurans	Bird Studies Canada and the Canadian Wildlife Service
Least bittern monitoring by Species Recovery Team	New Brunswick, Quebec, Ontario and Manitoba	Call-response point count surveys	Least bittern	Canadian Wildlife Service

The Conway survey, a standardized marsh bird monitoring protocol, was developed for wildlife refuges and other protected areas in North America (Conway 2004). A number of wildlife refuges in the United States began using this survey in 1999. To date, there are over 60 wildlife refuges and management areas participating in the survey. The Conway survey is currently being tested and modified as necessary (Conway 2004).

In the Conway survey, a 5-minute passive listening period is followed by a call-broadcast period for each species of interest that consists of 30-sec of calls followed by 30-sec of silence. Surveys are conducted at each site 3 times during the breeding season during both the morning and the evening. Habitat data is collected as percent cover of all habitat components within a 50-m radius of the call broadcast site.

I selected the Conway protocol for use in this study because it was a multi-species protocol that yielded detailed habitat information. I also selected this study because the passive listening period at the beginning of the survey allowed for an evaluation of the efficacy of the call-response protocol.

The Marsh Monitoring Program (MMP) was initiated by Bird Studies Canada and Environment Canada in the Great Lakes region of Canada and the United States in 1995

(Weeber and Vallianatos 2000, Priestley 2002). Alberta adopted the MMP in 2002 and the program began in Quebec in 2004.

The MMP monitors both anuran and waterbird populations. Calls of marsh bird species are broadcast within 100-m semi-circular sampling stations separated by a minimum distance of 250 m. The survey begins with a 5-minute broadcast period (1 minute for each species of interest) and is followed with a 5-minute passive listening period. Sites are surveyed twice during the breeding season and surveys are conducted in the evening only. The proportions of general habitat types at the sites are noted as is the percent cover of the 4 most dominant emergent plants (Weeber and Vallianatos 2000).

I elected not to use the MMP protocol for a number of reasons. First, the lack of a passive listening period at the beginning of the survey did not allow for an evaluation of the efficacy of the call-response protocol. Also, in the MMP protocol, only the most dominant vegetation types are recorded, which does not provide for a detailed analysis of habitat use. In addition, the MMP surveys are only conducted in the evening providing little flexibility for the surveyor. Finally, only 2 site visits are made during the breeding season using the MMP protocol although Gibbs and Melvin (1993) stated that 3 visits are needed in a breeding season in order to be 90% certain of the presence or absence of all of the species targeted in the present study.

A least bittern survey methodology is under development by the Least Bittern Recovery Team in order to produce a standard protocol to survey for that species (R. Bazin, pers. comm.). The survey is intended to gather population and distribution information to guide recovery planning including the development of a national recovery strategy.

The methodology requires that wetlands are surveyed at least twice and preferentially 3 times between mid-May and late June, with visits separated by 10 days. Surveys are conducted only in the morning and begin with a 4-minute passive listening period followed by the broadcast of least bittern calls for 5 minutes in intervals of 30 seconds calling and 30 seconds silence and conclude with a 4-minute listening period. Survey points are located at least 250 m apart. Habitat is assessed either within a full or semi-circular plot, depending on access to the site. Members of the Least Bittern Recovery Team conducted least bittern surveys in 2004 and 2005 in Ontario, Quebec, Manitoba and New Brunswick to test the efficacy of the protocol and make improvements (R. Bazin, pers. comm.). I did not select this survey methodology as it was not a multi-species survey protocol.

In Manitoba, the Manitoba Naturalists Society, the Canadian Wildlife Service and Manitoba Conservation are interested in implementing a marsh-monitoring program. These organizations are waiting for final results from Conway's standardized protocol work and the recommendations that will stem from a marsh bird monitoring workshop to be held in Patuxent in March 2006 before proceeding with implementation in order to ensure consistency in data collection (R. Bazin, pers. comm.). Interested parties in other regions of Canada are also awaiting the above stated recommendations (R. Bazin, pers. comm.). Bird Studies Canada will likely adopt the final protocol recommendations for their MMP, but will also need to design and implement a comparative pilot study to determine if, and for which species, correction coefficients may need to be calculated and used to standardize the monitoring data derived from different survey protocols (R. Bazin, pers. comm.).

2.3 Habitat Loss and the Need to Monitor Marsh Bird Species

Many species are at risk because of habitat loss (Government of Canada 2003). The loss of wetlands is believed to be the chief cause of the decline of many of the species targeted in this study (Gibbs et al. 1992a, Melvin and Gibbs 1996, James 1999, Muller and Storer 1999, Alvo and Robert 2005). In southern Ontario, approximately 70% of wetlands have been lost, while approximately 71% of wetlands have been lost in the Prairie Provinces (Natural Resources Canada 2004). In Manitoba, Hanuta (2001) compared Dominion Land survey maps from the 1870s with land cover images captured in 1995 in a geographic information system. Wetlands comprised 11.4% of the land mass within 100 townships in southeastern Manitoba in the 1870s. In 1995, wetlands comprised only 0.1% of the same area. Agricultural conversion accounts for 85% of wetland loss in Canada (Natural Resources Canada 2004).

Under Canada's *Species at Risk Act* (SARA), recovery teams are requested to develop recovery strategies for listed species. In order to be effective, recovery strategies must incorporate the best available information on the distribution, population dynamics and habitat requirements of the species of interest. Currently, there is a deficiency of such information for the least bittern in Canada due to the lack of appropriate survey efforts. There are a number of uncoordinated regional efforts to survey marsh birds in North America, but there is currently no standardized or coordinated continental survey.

3 Call-Response Survey for Marsh Bird Species in Southern Manitoba

3.1 Introduction

Marsh birds are under-detected in traditional bird surveys in part due to their secretive nature and use of densely vegetated wetland habitat (Gibbs and Melvin 1993, Conway and Gibbs 2005). One method used to increase the detection of marsh birds is to only sample wetland habitat. Another method is to use a call-response survey protocol. In this survey technique, conspecific calls are broadcast to elicit vocal responses from target species that may otherwise go undetected.

There is much debate in the literature about the effectiveness of call-response surveys in estimating marsh bird populations. Some studies have shown that the use of call-response protocols greatly increases the number of marsh birds detected, while others have shown the opposite.

Swift et al. (1988) found that tape-recorded calls significantly increased the number of least bittern detected; only 16% of the total least bitterns seen or heard, and 9% of the total individuals heard, were detected during the passive listening period. Gibbs and Melvin (1993) found that the use of a call-broadcast protocol increased the detection of least bitterns by 750%. However, Lor and Malecki (2002) found that the use of tape-recorded calls decreased the detection rate of least bitterns by 11%.

In one of the most detailed studies of the effect of call-broadcasts on least bitterns, Bogner and Baldassare (2002a) performed call-response surveys on radiomarked male least bitterns that were engaged in various known stages of the nesting cycle. The survey was conducted in the same area of New York as the study conducted by Lor and Malecki (2002). Researchers located males to within 30-m and conducted a 5-minute passive listening period followed by a 5-minute call-broadcast period that consisted of 15 seconds of calls followed by 15 seconds of silence. Only 9.5% of the males responded during the passive listening period while 25.4% responded during the call-broadcast. Males were found to respond to call-broadcasts most readily during the nest initiation phase and were less responsive to calls broadcast during the period of incubation and hatching. This survey method increased the detection of breeding male least bittern by 80%, and all radiomarked males responded at least once during the surveys. The survey method was not tested on females and non-breeding males.

Differences in the efficacy of call-response protocols are primarily due to the differences in survey methodology. In light of the debate over the efficacy of call-response surveys, and the lack of a standardized survey method for use in North America, Conway (2005) highlighted a number of factors that should be considered when designing call-response surveys:

1. Broadcasting the calls of one species may prevent other species from calling;
2. Individuals may become habituated to broadcast calls;
3. Broadcast calls may interfere with breeding birds;
4. The quality of the broadcast equipment, and therefore the quality of sound, may change over the course of the monitoring program or breeding season;
5. Different surveyors may use different volumes and may vary in their ability to detect calls;
6. Call-response protocols increase the cost of the survey – borne either by the survey participant or the organizing agency;

7. The type, origin and dialect of the broadcast calls may influence the response from target species and may differ amongst observers and over years; and
8. Target species may move towards the source of the broadcast, thereby introducing bias and increasing estimates of density.

Conway (2002) proposed a call-response protocol as one standard for use in marsh bird surveys. In this study I employed a slightly modified version of the protocol proposed by Conway.

3.2 Study Area and Methods

3.2.1 Study Area

Forty six wetlands were surveyed in southern Manitoba in the Lake of the Woods, Interlake Plain, Lake Manitoba Plain and Aspen Parkland ecoregions (Ecosystems Working Group 1989) (Figure 3-1). This area was roughly bound by Hecla Island Marsh in the north (51°3’ N, 96°47’ W), the Rat River Swamp in the south (49°13’ N, 96°43’ W), the wetlands associated with Oak Lake in the west (49°39’ N, 100°43’ W) and Wild Wings Pond in the east (50°16’ N, 95°51’ W). The study area contained the estimated known range of the least bittern in Manitoba and only a subsection of the other species’ Manitoba ranges (Figures 2-1 – 2-6).

Wetlands were selected for the survey in a non-random fashion in order to 1) maximize the likelihood of encountering least bittern and other target species, 2) include a variety of vegetation types and marsh sizes and 3) to ensure that a broad geographic range was surveyed. In total, 141 unique sites within 46 different wetlands were surveyed during the 2003 and 2004 breeding seasons (Figure 3-1). Eleven sites were surveyed in both 2003 and 2004. Appendix I contains a listing of all wetlands surveyed along with coordinates.

Call-broadcast sites were selected based on the presence of densely vegetated habitat and the accessibility of the site by foot. The initial call-broadcast site was selected to facilitate the development of a survey route or transect within the vegetated portion of the wetland only. The number of call-broadcast sites within a given wetland varied according to the size of the wetland, the accessibility of dense emergent vegetation, and the amount of vegetated habitat within the wetland. Call-broadcast sites were separated by at least 400-m to ensure that individuals were not counted twice and to maximize the wetland area surveyed (Conway 2002). Traveled distance between sites was determined using a global positioning system (GPS) unit. Coordinates were recorded at each site in order to easily relocate them.

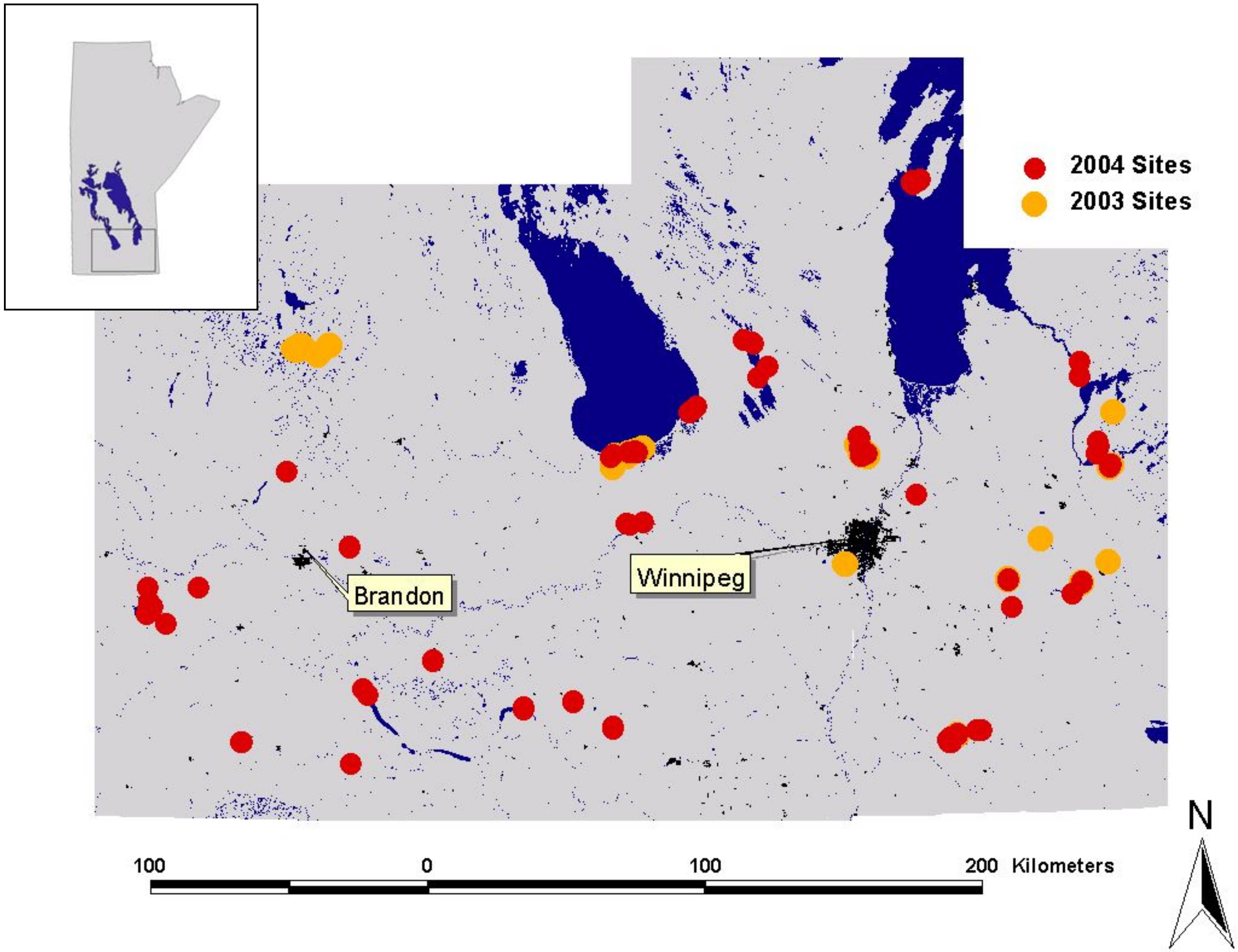

Figure 3-1 Sites surveyed in 2003 and 2004.

3.2.2 Call-Response Protocol

I modified Conway's (2002) standardized call-response protocol by extending the call-broadcast period for each species from 30 seconds to 1 minute based on the advice of experienced local naturalists who indicated that more time was needed to detect the target species (P. Grieef , pers. comm., P. Taylor, pers. comm.).

A 5-minute passive listening period was conducted prior to the call-broadcast. After the passive listening phase, calls were broadcast from a tape player at 90 db chronologically starting with the least intrusive species in the following order: least bittern, yellow rail, sora, Virginia rail, American bittern, and pied-billed grebe (Conway 2002). In 2003, a Sony sports tape player was used and in 2004 both the Sony sports tape player and a Radioshack Venturer tape player were used. Calls were obtained from the *Bird Sounds of Canada* CD (Brigham 1991). The primary advertising call and in some cases, other calls associated with the breeding period were broadcast for each species as suggested by Conway (2002). The calls broadcast for each species were:

- least bittern - *coo-coo* call associated with male advertisement;
- yellow rail – *clicking* call associated with male advertisement;
- sora - *whinny* call associated with territoriality and mate contact and the *per-weep* advertising call;
- Virginia rail - *grunt* call associated with territoriality and pair contact and *tick-it* male advertising call;
- American bittern – *pump-er-lunk* call associated with territoriality and male advertisement; and

- pied-billed grebe – “donkey braying” greeting call.

In 2003, each species’ calls were broadcast for 1 minute followed by 1 minute of silence. In 2004, species’ calls were broadcast for 1 minute followed by 30 seconds of silence in order to decrease the amount of time spent surveying at each station.

In both years, the observer stood approximately 2-m away from the tape player and visually scanned the area while listening for target species. All target and non-target bird species heard calling or observed within the playback phase or silence between calls were recorded, regardless of distance from the observer. The time period during which the target species was detected was recorded (Appendix II). Observers used their judgment to establish whether the detected target individuals had previously been detected. Other environmental variables were recorded including cloud cover, ambient temperature, lunar phase, and wind speed (using the Beaufort scale).

I conducted all call-response surveys in 2003. In 2004 I conducted approximately half of the call-response surveys and a field assistant who I trained conducted the remaining surveys. Ron Bazin of the Canadian Wildlife Service conducted the least bittern surveys at the Brokenhead Swamp using the Least Bittern Recovery team survey protocol.

3.2.3 Sampling Schedule

Call-response surveys were only conducted in the absence of rain or heavy fog, from 30 minutes before dawn until 10h00 and from 16h30 until 30 minutes past dusk. Surveys were only conducted when the wind was below 20 km/h to ensure that the observer could hear the birds (Conway 2002).

Each site was surveyed 3 times in each year to determine the presence or absence of all target species at a site within 90% confidence (Gibbs and Melvin 1993). The number of morning and evening surveys conducted at each site was influenced by environmental conditions such as rain and wind, but each site was visited at least once during the morning and evening survey periods. Subsequent site visits were separated by 10-14 days to ensure that target species were surveyed during their respective nest initiation periods when they are reportedly most responsive to conspecific calls (Bogner and Baldassare 2002a). Sites were surveyed between May 22 and July 22, 2003 and between May 20 and June 28, 2004.

3.2.4 Data Analysis

The efficacy of the call-response survey protocol was evaluated by calculating the percent change in the number of birds that were detected after the conspecific call was broadcast. The percent change was determined using a formula common in the call-response literature (Gibbs and Melvin 1993, Bogner and Baldassare 2002a, Conway and Gibbs 2005):

$$\frac{\text{Individuals detected after call} - \text{Individuals detected during passive survey}}{\text{Individuals detected during passive survey}} \times 100$$

A paired analysis of the efficacy of the call-response protocol was also conducted by comparing the response of target species during all 3 call-response trials at each site where the species was detected at least once. McNemar's test was used for the analysis and was corrected for continuity (Zar 1984).

The number of individuals detected in the morning and evening surveys was also compared for each species as was the number of individuals detected during each round of the survey using Chi-square tests in JMP (SAS Institute Inc. 1996).

Despite the difference in survey protocol between years, call-response data from both years were pooled in all analyses in order to add statistical strength to the analysis. In order to ensure that the data from both years could be pooled, data from each year was compared using the McNeamar's test. For each species, the proportions of individuals in each response category were typically within 10% of each other between years.

In all tests, statistical significance was based on a P value of ≤ 0.05.

3.3 Results

One hundred and twenty-nine call-response surveys were conducted at 43 sites in 2003. A total of 288 call-response surveys were conducted at 96 sites in 2004.

3.3.1 Distribution of Target Species Detections

The distribution of all species detections at the study wetlands is shown in Figure 3-2. The most abundant and widely distributed marsh bird species detected was the sora, which was recorded on 315 occasions during the listening period at 94 sites within 39 of the 46 surveyed wetlands (Table 3-1). Least bitterns were the least abundant species with 21 records captured during the listening period and 5 additional opportunistic detections. Least bittern were detected 15 sites within 4 of the 46 surveyed wetlands. Yellow rails were not encountered during the survey.

Table 3-1 Detection of target species at surveyed sites and study wetlands

Species	*Number of Detections*	*Number of sites (n=138 except least bittern, n=141)*	*Number of wetlands (n=46 except least bittern, n=47)*
American bittern	143	66	19
Least bittern	21	15	5
Pied-billed grebe	119	57	20
Sora	315	94	39
Virginia rail	74	37	17

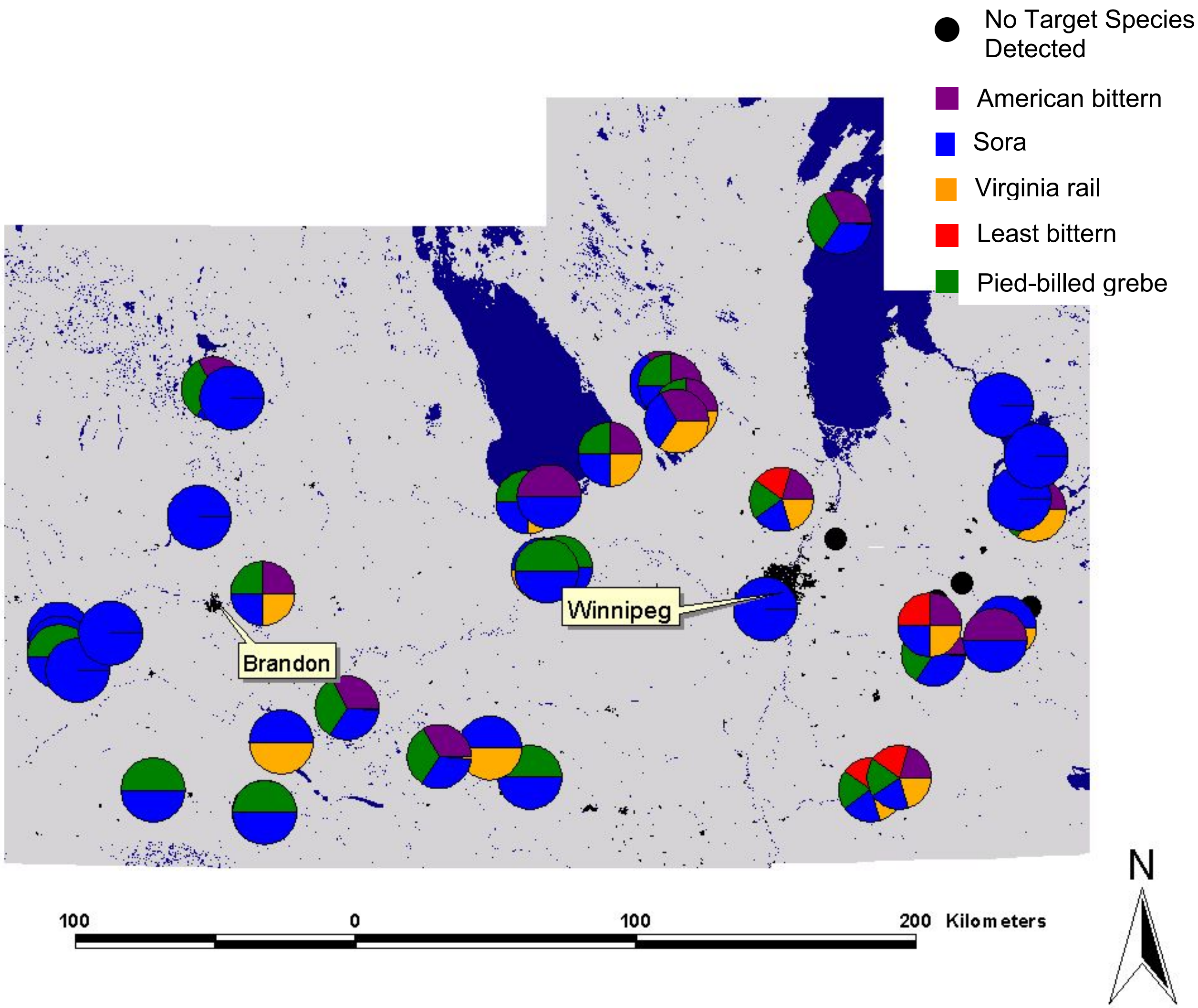

Figure 3-2 Distribution of target species at wetlands surveyed in 2003 and 2004. Species presence and absence was determined by conducting a series of 3 call-response surveys at sites within the wetland.

3.3.2 Efficacy of Protocol in Detecting Target Species

A greater number of least bittern, sora and Virginia rail were detected following the broadcast of the conspecific call than were detected during the passive listening period. More American bittern and pied-billed grebe were detected during the passive listening period than were detected after the conspecific call was broadcast (Table 3-2).

Table 3-2 Percent change in the detection of target species following the call-broadcast. Individuals heard calling both before and after the conspecific call were counted as being detected during both periods.

Species	*Number detected during passive period*	*Number detected after conspecific call*	*Percent change after conspecific call*
American bittern	122	93	-23.8
Least bittern	10	18	80
Pied-billed grebe	104	31	-70.2
Sora	185	267	43.8
Virginia rail	27	67	148.1

The results of McNemar's test showed that the use of conspecific calls increased the number of all target species detected. This increase was more significant for the least bittern, sora and Virginia rail (Table 3-3).

Table 3-3 Results of McNemar's test evaluating the efficacy of the call-broadcast in detecting target species. Numbers represent all trials conducted at sites where the target species were determined to be present.

Species	*Not detected (species was detected at site during other visits)*	*Detected before and after call-broadcast*	*Detected before call-broadcast only*	*Detected after call-broadcast only*	X^2	*P*
American bittern	94	62	25	11	4.69	0.02<P<0.05
Least bittern	19	8	1	8	4.00	0.02<P<0.05
Pied-billed grebe	0	18	62	8	40.1	<0.001
Sora	102	95	26	62	13.9	<0.001
Virginia rail	62	20	5	32	18.3	<0.001

3.3.3 Detection of Target Species by Time of Day and Date

With the exception of the Virginia rail and sora, a greater proportion of each target species was detected in the evening sampling periods than the morning sampling periods (Figure 3-3). This relationship was significant for the American bittern and pied-billed grebe and was almost significant for the least bittern (Table 3-4).

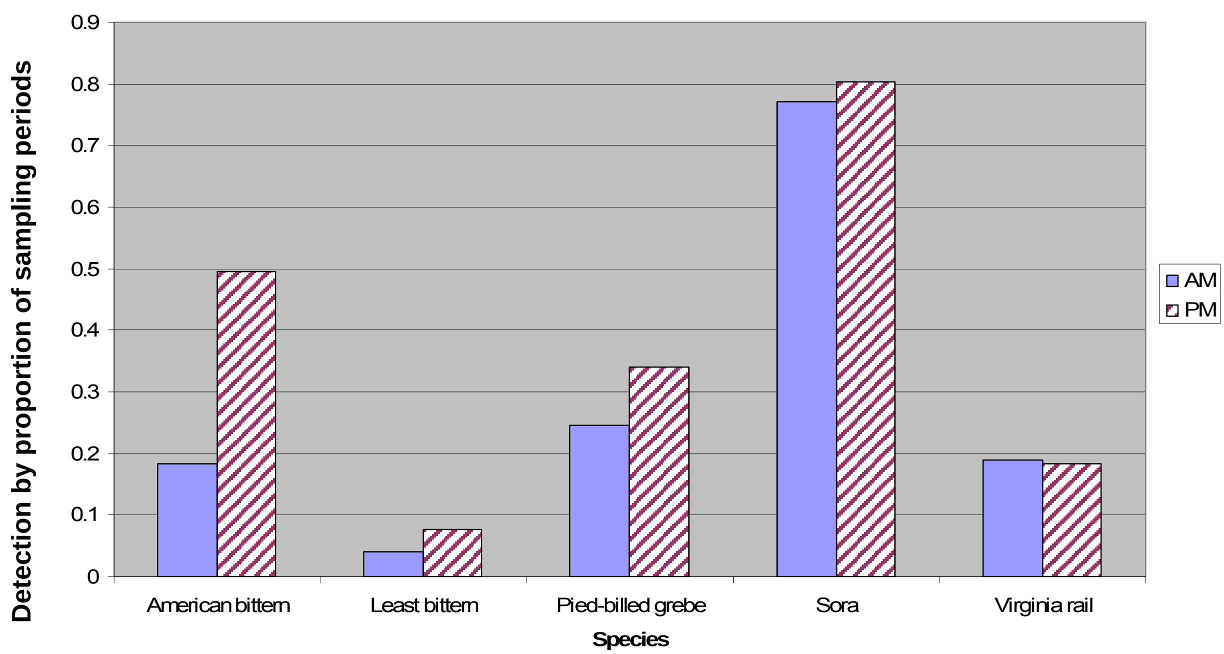

Figure 3-3 Proportion of morning and evening sampling periods target species were detected in. (For AM and PM surveys N =, 175 and 224, respectively)

Table 3-4 Results of t-test comparing the proportion of individuals detected during AM/PM survey periods. For AM and PM surveys, N = 175 and 224, respectively

Target species	*Survey period in which target species were detected (*AM/PM*)* *(P)*
American bittern	< 0.001
Least bittern	0.06
Pied-billed grebe	0.02
Sora	0.22
Virginia rail	0.55

Significantly more American bittern and sora were detected between May 6 and June 27 than were detected between June 18 and July 22 (Figure 3-4, Table 3-5). This finding was almost significant for the pied-billed grebe as well (P = 0.06).

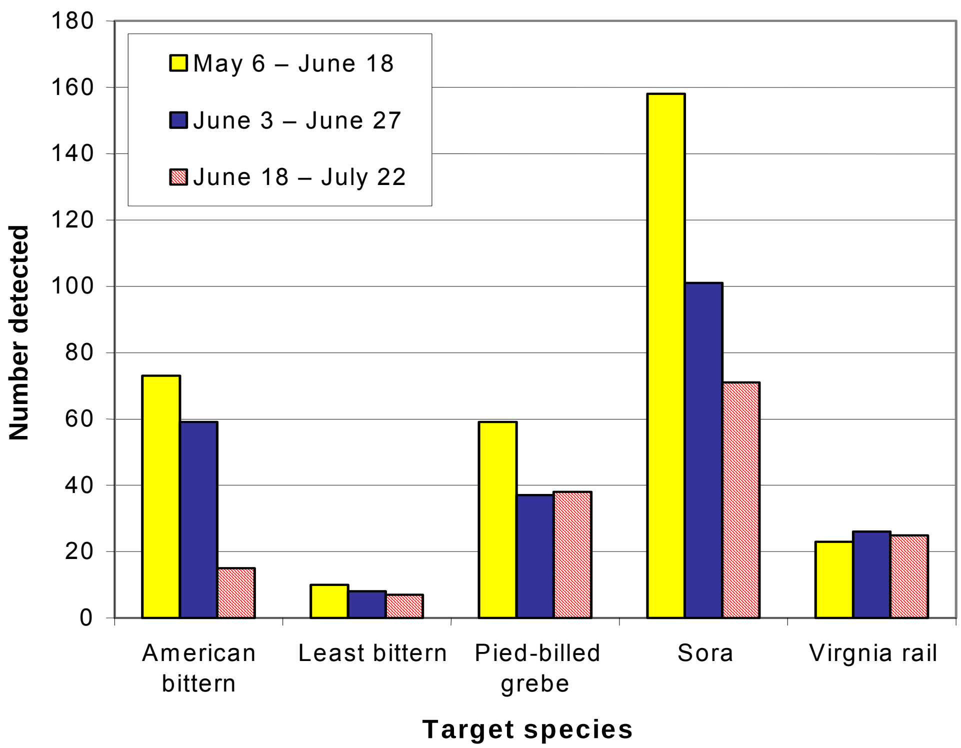

Figure 3-4 Number of target species detected in each round of call-response sampling.

Table 3-5 Results of Chi-square tests comparing the round of call-response survey in which target species were detected.

	Round of call-response survey in which target species were detected (P)
American bittern	< 0.001
Least bittern	0.87
Pied-billed grebe	0.06
Sora	< 0.001
Virginia rail	0.77

3.4 Discussion

3.4.1 Distribution of Target Species Detections

Least bitterns were detected at only 15 of the 141 sites and 5 of the 46 wetlands surveyed, confirming that this is a rare species in the Province. Additionally, least bitterns were not detected at a number of the sites where they had historically been recorded (Koes and Taylor 2002), suggesting that the sites used by the species probably vary between years or are likely no longer being used. Least bittern were only detected in the southeastern portion of the Province within the bounds of their historical range in Manitoba.

The sora was the most widely detected species. This finding is supported by the literature, which indicate that sora are wetland generalists that can be found in a variety of wetland types (Brown and Dinsmore 1986, Johnson and Dinsmore 1986a).

3.4.2 Efficacy of Call-Response Protocol

The call-broadcast survey increased the number of all species detected. This increase was more significant for the least bittern, sora and Virginia rail. The efficacy of the present call-response protocol generally corresponded with the trends in detection presented by Conway and Gibbs (2005) (Table 3-6). However, Conway and Gibbs (2005) reported much higher detection rates for the sora and Virginia rail and lower detection rates for the least bittern. These differences may be due to a number of factors including the origin of the calls that were broadcast, the quality of the broadcast equipment and the species included in the survey. The longer call-broadcast period employed in the present survey may have also resulted in different rates of efficacy.

Gibbs and Melvin (1993) reported much higher percent increases in the number of birds detected than were found in this survey. However, Gibbs and Melvin (1993) conducted passive listening surveys from a small number of sites along the wetland edges and not from the individual call-broadcast sites, thereby decreasing the chances of detecting individuals during the passive listening period.

Bogner and Baldassare (2002a) reported that the broadcast of conspecific calls resulted in an 80% increase in the detection of least bitterns, the same increase as found in the present study.

Table 3-6 Percent change in the detection of target species compared to other studies.

Species	*Present study*	*Conway and Gibbs (2005)*	*Gibbs and Melvin (1993)*
American bittern	-23.8	-44	93
Least bittern	80	13	750
Pied-billed grebe	-70.2	-67	583
Sora	43.8	103	1320
Virginia rail	148.1	657	121

Bogner and Baldassare found that only 22% of radio tagged individuals responded to calls within the first minute of broadcast, while 70% of the responses occurred during the first 3 minutes (2002a). Using the Conway protocol, a 1-minute call-broadcast was sufficient to increase detection of least bittern by 80%. This may be attributed to the fact that the present survey continued for 6 minutes and 30 seconds after the broadcast of the least bittern call, allowing additional time for individuals to be detected. Least bittern may make a delayed response to a conspecific call whether or not the call continues to be broadcast.

The results of the McNemar's test provide additional information about the usefulness of the call response survey. Large proportions of least bittern, Virginia rail and sora were only detected after the conspecific call was broadcast, illustrating the necessity of using call-response surveys when surveying for these species. Some American bittern and pied-billed grebe were detected only after the conspecific call was broadcast, although this proportion was much smaller for these species. The McNemar's test also showed that the likelihood of detecting pied-billed grebe during a survey was very high at sites where they had been detected during other visits. The opposite was true for the American bittern, least bittern, sora and Virginia rail. In order to be 90% certain of the presence or absence of the species targeted in the present study, Gibbs and Melvin (1993) found that 2 site visits were needed during the breeding season for the pied-billed grebe, sora and Virginia rail, and 3 visits were needed for the least bittern and American bittern.

Future multi-species surveys should include both a passive and call-response period in order to detect the largest number of target species. In the present study, it is possible that the detection of American bittern and pied-billed grebes was higher during the passive period simply because the calls of these two species calls are the last to be broadcast.

Yellow rails were not detected in either survey year. The birds were not even detected in the Douglas Marsh, an area that is internationally renowned for its population of yellow rails (Lindgren 2001). This may be due to the timing of the surveys since yellow rails are most likely to call at night (Bookhout 1995, Robert and Laporte 1997, Prescott et al. 2002, Alvo and Robert 2005). Future efforts to survey for yellow rails should include nighttime surveys.

An additional factor that may have hindered the detection of yellow rails is the disparity between the breeding habitats used by this species compared to the habitats used by the other target species. Yellow rail typically use wetlands covered by only 0-15 cm of water whereas other species, such as the least bittern, are typically found in wetlands with deeper water (Weller 1961, Rodgers and Schwikert 1999, Bogner 2001).

3.4.3 Detection of Target Species in Morning and Evening Surveys

In this study, a significantly higher number of American bittern and pied-billed grebe were detected during the evening survey periods, suggesting that evening surveys are the most effective in detecting these target species. In the present study, the majority of least bittern were detected during the evening; this finding was nearly statistically significant ($P = 0.06$). Swift et al. (1988) showed that least bittern were most likely to be detected during morning surveys, although they attributed this finding to the fact that the majority of their evening surveys were conducted too early in the breeding season. Johnson and Dinsmore (1986b) indicated that evening surveys were most effective in surveying for Virginia rails, although these results were not supported by the present study.

Vocalization is largely correlated with the nest initiation period (Bogner and Baldassarre 2002a). American bittern, pied-billed grebe and sora were detected most frequently during the first and second rounds of the call-response survey. Johnson and Dinsmore (1986b) showed that the detection of sora peaked in early to mid-May in Iowa. Johnson and Dinsmore (1986b) also showed that the number of Virginia rail detected was fairly constant throughout the breeding season. In the present study the numbers of least bittern and Virginia rails detected were relatively constant throughout the duration of the survey. In Maine and New York State, detection of least bittern peaks between mid-May and late June, corresponding to the period during which the current survey was conducted (Swift et al. 1988, Bogner and Baldassare 2002a, Lor and Malecki 2002). In Manitoba, future surveys should begin as early as the beginning of May to ensure that the survey captures the period of peak vocalization.

4 A Multi-Scale Analysis of Habitat Selection by Marsh Bird Species in Southern Manitoba

4.1 Introduction

In North America, the primary cause of the decline of marsh bird populations is habitat loss or alteration (Gibbs et al. 1992a, Melvin and Gibbs 1996, James 1999, Muller and Storer 1999, Government of Canada 2003, Alvo and Robert 2005). In Prairie Canada, as much as 71% of wetlands have been lost (Environment Canada 1986, Natural Resources Canada 2004). Wetland loss is even greater in the Fraser River Delta and the areas surrounding urban centres including Winnipeg, Toronto and Edmonton, where 80% of wetlands have been drained (Environment Canada 1986). Similar trends in wetland loss also exist in the United States (James 1999) and in general, the North American wetlands that do remain continue to be degraded by human development, recreational activities and pollution (James 1999). In order to effectively conserve marsh birds in the face of habitat loss and degradation, information about their habitat requirements is needed.

Habitat use by marsh birds has been studied on wintering, staging and breeding grounds and information on site-level habitat characteristics is available for a number of species across the range (see section below and Table 4-1 for detailed information). At the coarser level, the importance of landscape-scale characteristics is not as well understood. Naugle et al. (1999b) found that the area requirements of nesting black terns, a highly mobile species, varied with changes in the composition of the surrounding landscape; these being significantly smaller in heterogeneous landscapes. Naugle et al.

(1999b, 2000) found that the characteristics of the wetland alone explained the presence of pied-billed grebes and yellow-headed blackbirds.

Brown and Dinsmore (1986) examined the effect of wetland size and isolation on the distribution of marsh birds, including all of the species targeted in the present study. They found that 10 of the 25 species studied were not found in wetlands smaller than 5 ha. However, they also showed that smaller wetlands within larger wetland complexes had higher species richness than did larger, more isolated wetlands. Their findings demonstrated that while some species have specific requirements for wetland size, the isolation of the wetland also plays an important role in determining the presence of some species.

It is important to examine the relationships between species and the resources they use at scales that are ecologically appropriate (Wiens 1989). For example, if the scale of the study were too fine, it would appear that an animal's selection of resources was random. This would be due to the fact that the individual had already selected an activity area from a larger area in which resource conditions were ideal (M. Manseau, pers. comm.).

When selecting habitat, an individual's habitat use pattern may involve a number of different spatial scales (Aebischer et al. 1993). Johnson (1980) proposes a hierarchical habitat selection process where *first order* selection refers to the physical range of a species, *second order* selection is the selection of an individuals' home range within the species range, and *third order* selection is the usage of habitat units within the selected home range.

Manly et al. (1993) define resource selection as the use of a resource that is disproportionate to its availability. In the present study, the survey sites were classified as used and unused based on whether a species was detected in the first or second year of the survey. Each site was characterized by the value that it possessed for a range of habitat variables including *Typha* spp., open water and tall shrubs. Measures of food abundance, water quality and depth were not taken.

Habitat characteristics were measured at 50-m, 500-m and 5-km scales using site data and information derived from the Provincial Forest Resources Inventory (FRI). The 50-m scale was selected based on Conway's protocol. The 500-m scale was selected as it produced an area large enough to include the home range of a least bittern (Bogner and Baldassare 2002b) and because it maximized the area that could be studied without creating a large degree of overlap between adjacent sites. The 5-km scale was selected as it allowed for the analysis of a large area of land while retaining enough sampling units to produce statistically significant results.

The resource selection measures are based on the concept of a resource selection probability function, representing that the probability of use for a range of habitat characteristics (Manly et al. 2002). It is important to mention that in this survey, not all potential sites were surveyed and sites were not randomly selected – only sites with large proportions of emergent vegetation were included in the study. This means that the resource selection measures will be based on the higher quality sites and wetlands only and therefore likely present weaker selection results.

4.2 Study Area and Species Breeding Habitat Requirements

4.2.1 Study Area

The 46 study wetlands were located in southern Manitoba in the Lake of the Woods, Interlake Plain, Lake Manitoba Plain and Aspen Parkland ecoregions (Ecosystems Working Group 1989) (Figure 3-1). This area was roughly bound by Hecla Island Marsh in the north (51°3' N, 96°47' W), the Rat River Swamp in the south (49°13' N, 96°43' W), the wetlands associated with Oak Lake in the west (49°39' N, 100°43' W) and Wild Wings Pond in the east (50°16' N, 95°51' W). The study area contained the estimated known range of the least bittern in Manitoba and only a subsection of the other species' Manitoba ranges (Figures 2-1 – 2-6). See Section 3.2.1 for additional information on study site selection.

4.2.2 American Bittern

The American bittern primarily breeds in freshwater marshes with tall emergent vegetation (Gibbs et al. 1992a) (Table 4-1). Sparsely vegetated wetlands are sometimes used during the breeding season, as are coastal marshes and upland areas surrounding wetlands (Gibbs et al. 1992a). Gibbs et al. (1992a) reported that the species is most often associated with wetlands that are 10 cm or less in depth. Compared to the sympatric least bittern, the American bittern is generally found in wetlands with a wider variety of vegetation types and more shallow water (Gibbs et al. 1992a).

American bittern have been found to use wetlands ranging in size from 0.1-1000 ha, but they are more abundant in larger wetlands (Gibbs et al. 1992a). In an Iowa study of 30 seasonal and semi-permanent marshes that were all in hemi-marsh condition, Brown and Dinsmore (1986) found that the species only occurred in wetlands 11-20 ha in size, although this finding was not statistically significant.

Table 4-1 Previous studies examining the breeding habitat characteristics of target species

Species	Habitat Characteristics	Region	Reference
American bittern	Associated with wetlands having water 10 cm or less in depth	North America – compilation of studies	(Gibbs et al. 1992a)
	Primarily breeds in freshwater marshes with tall vegetation; also found in sparsely vegetated wetlands, coastal marshes and uplands	North America – compilation of studies	(Gibbs et al. 1992a)
	Use wetlands ranging in size from 0.1-1000 ha	North America – compilation of studies	(Gibbs et al. 1992a)
	Found only in wetlands 11-20 ha in size	Iowa	(Brown and Dinsmore 1986)
Least bittern	Nests most often located in *Typha* spp. and bulrush over water 107.2 cm deep	Central Florida	(Rodgers and Schwikert 1999)
	Nests in *Typha* spp. over water 32.5 cm deep and 3.5 m away from open water	South Carolina	(Post and Seals 1993)
	Nests constructed in stands of *Typha* spp. that consisted of almost equal amounts of living and dead vegetation 3.8 m away from open water	South Carolina	(Post 1998)
	Two nests located in *Phragmites*	Manitoba	(Dillon 1959)
	Majority of nests located in *Typha* spp., sedge and bulrush over water 3-38 inches deep	Iowa	(Weller 1961)
	Majority of nests located in *Typha* spp., but also nested in bur-reed, grasses, bulrush, swamp loosestrife and purple loosestrife an average of 3.5 m away from open water over water averaging 34.4 cm in depth	Western New York	(Bogner 2001)
	Mean home range of nesting birds, defined as 95% utilization distribution, was 9.7 ha	Western New York	(Bogner and Baldassare 2002a)
	Wetlands exceeding 5 ha in size were more likely to be used than smaller wetlands	North America – compilation of studies	(James 1999)
	Found in wetlands between 5 and 20 ha in size (not a significant relationship)	Iowa	(Brown and Dinsmore

			1986)
	Reach highest numbers in hemi-marshes, possibly due to high production of invertebrates	North America – compilation of studies	(Sandilands and Campbell 1987)
Pied-billed grebe	Breed in fresh to brackish marshes exceeding 0.2 ha in size	North America - compilation of studies	(Muller and Storer 1999)
	Associated with non-moving water habitat containing dense stands of emergent or surface vegetation in close proximity to open water; in rural or agricultural settings	North America – compilation of studies	(Muller and Storer 1999)
	Use of wetlands was related solely to size of wetland and within-patch characteristics; found in wetlands with a minimum size of 5.7 ha	South Dakota	(Naugle et al. 1999b)
Sora	Associated with freshwater marshes; wetland edges and uplands including agriculture also used	North America – compilation of studies	(Melvin and Gibbs 1996)
	Favours areas subject to fluctuations in water level, which result in a mix of fine and robust-leaved emergent vegetation	North America – compilation of studies	(Melvin and Gibbs 1996)
	Majority of nests located in *Typha* spp.	Minnesota	(Kaufmann 1989)
	Vegetative cover used in proportion to availability, no strong vegetative preference exhibited	Iowa and Minnesota	(Johnson and Dinsmore 1986a)
	Wetland size was not found to influence breeding site selection	Iowa	(Brown and Dinsmore 1986)
	Associated with shallow water habitats with an average water depth of 38.4 cm	Iowa and Minnesota	(Johnson and Dinsmore 1986a)
Virginia rail	Breed in both fresh and saltwater marshes	North America – compilation of studies	(Conway 1995)
	Majority of nests located in *Typha* spp.	Iowa and Minnesota	(Kaufmann 1989)
	Was not found to exhibit a strong preference for specific vegetative cover type, used vegetation in proportion to availability	Iowa	(Johnson and Dinsmore 1986a)
	Hemi-marshes appear to be favoured, possibly due to the high production of invertebrates	North America – compilation of studies	(Conway 1995)
	Most common in large wetlands	Maine	(Conway 1995)
	Breeding site selection is not influenced by wetland size	Iowa	(Brown and Dinsmore 1986)

4.2.3 Least bittern

Least bittern breed in fresh water marshes with tall, dense emergent vegetation and clumps of woody plants in deep water (Gibbs et al. 1992b) (Table 4-1). In central Florida, least bittern were found to nest most often in *Typha* spp. and bulrush over water 107.16 cm deep (Rodgers and Schwikert 1999). In a South Carolina study of an impounded wetland, the species was found to nest in *Typha* spp. over water 32.5 cm deep 3.5 m away from open water (Post and Seals 1993). In another study conducted in the same wetland, least bittern were found to nest in stands of *Typha* spp. that consisted of almost equal amounts of new and dead vegetation located 3.8 m away from open water (Post 1998). In Iowa, Weller (1961) found the majority of least bittern nests to be located in *Typha* spp., sedge and bulrush over water 3-38 inches deep. Dillon (1959) reported that two least bittern nests were found in stands of *Phragmites* in the Delta Marsh, located on the southern shore of Lake Manitoba.

In western New York, Bogner (2001) found that the majority of least bittern nests were constructed of only *Typha* spp., but also found that nests were constructed in bur-reed, bur-reed and *Typha* spp., grasses and *Typha* spp., bulrush, swamp loosestrife and purple loosestrife. Bogner also found that nests were constructed over water that averaged 34.4 cm in depth in vegetation that was an average of 3.5 m from open water. In the same study, Bogner and Baldassare (2002b) found the mean home range of the least bittern, defined as the 95% utilization distribution, to be 9.7 ha. Bogner and Baldassare (2002b) also reported that least bitterns reached their highest numbers in hemi-marshes, which may be due in part to the high production of invertebrates throughout the season (Sandilands and Campbell 1987).

Studies have shown that wetland size plays a role in whether or not a wetland is suitable for use by least bittern, with large wetlands (exceeding 5 ha in size) more likely to be used (James 1999). Brown and Dinsmore (1986) found that the majority of least bittern detected in their study were found in wetlands between 5 and 20 ha in size, although this relationship was not significant. Smaller wetlands are used, but are not likely to sustain populations (James 1999).

4.2.4 Pied-Billed Grebe

Pied-billed grebes breed in fresh to brackish water marshes that are generally greater than 0.2 ha in size (Muller and Storer 1999) (Table 4-1). The species is generally associated with wetlands in either rural or agricultural settings that have dense stands of emergent or surface vegetation in close proximity to open water (Muller and Storer 1999). Naugle et al. (1999b) found that the presence of pied-billed grebes was not related to the overall proportion of wetlands on the landscape, but was related solely to wetland area and within patch wetland characteristics. Specifically, Naugle et al. (1999b) found that the presence of pied-billed grebes was positively correlated with wetland size, with the minimum size of wetlands used by pied-billed grebes being 5.7 ha.

4.2.5 Sora

Sora breed in freshwater marshes with fluctuating water depths that result in a mixture of fine and robust-leaved emergent vegetation (Melvin and Gibbs 1996, Johnson and Dinsmore 1986a) (Table 4-1). Johnson and Dinsmore (1986a) found that soras were most likely to be found in shallow water habitats with a mean water depth of 38.4 cm. Wetland edges and upland areas including agricultural land may also be used (Melvin and

Gibbs 1996). Studies have also shown that a high density of floating and submerged vegetation, which creates a substrate for aquatic invertebrates, produces ideal feeding habitat for the short-billed sora (Melvin and Gibbs 1996). In a study of captive soras in Iowa and Minnesota, Kaufmann (1989) found that the majority of nests were located in *Typha* spp., which was the most abundant vegetation available. In Iowa, Johnson and Dinsmore (1986a) did not find that soras selected for any particular vegetative cover type, but used vegetation in proportion to its availability.

Wetland size does not appear to influence breeding site selection in the species (Brown and Dinsmore 1986).

4.2.6 Virginia Rail

Virginia rail breed in both fresh and saltwater marshes in areas that are typically drier than those used by breeding sora (Conway 1995) (Table 4-1). They are also associated with robust vegetation (Conway 1995). In Iowa and Minnesota, Kaufmann (1989) found the majority of nests of captive individuals to be located in *Typha* spp., which was the most abundant vegetation. In Iowa, Johnson and Dinsmore (1986a) did not find that the species exhibited a strong selection for any vegetative cover type, but rather used vegetation in proportion to its availability. Wetlands with 40-70% emergent vegetation appear to be the most favourable habitat for the Virginia rail due to their high production of invertebrates (Conway 1995).

Brown and Dinsmore (1986) did not find that Virginia rail selected wetlands of a particular size.

4.3 Methods of Habitat Data Collection and Analysis

In addition to the 138 sites studied in 2003 and 2004 (Section 3.2.1), Ron Bazin of the Canadian Wildlife Service surveyed 3 sites within the Brokenhead Swamp for the least bittern in 2004 and obtained habitat data at the 50-m scale using the methods outlined in this study. His data is included in the present analysis.

4.3.1 50-m Scale

Site characteristics were assessed after all rounds of the call-response surveys were completed. The percent cover of vegetation and open water within a 50-m radius around the calling sites was visually estimated and recorded (n=138). Emergent vegetation was identified to the species level with the exception of *Typha* spp., while upland vegetation was identified to the genus level.

4.3.2 500-m Scale

Forest resource inventory data were obtained from the Manitoba Land Initiative (Manitoba Land Initiative No date). The vector data was interpreted from 1:15,840 aerial photography using a minimum mapping unit of 2 ha.

Using the animal movement extension (Hooge and Eichenlaub 1997) in ArcView 3.2 (ESRI 1999), buffers of a 500-m radius surrounding each of the survey sites were created. The FRI data, which included linear features, was then clipped by each of the buffers and the proportion of habitat parameters within the buffer was calculated (n=138).

4.3.3 5-km Scale

At the 5-km scale, buffers around call-broadcast sites were created using the methods outlined for the 500-m scale, and habitat attributes were derived from the FRI data. In order to eliminate overlap between the 5-km buffers, buffers were centred on the merged group of surveyed sites for given marsh areas (n=34). A list of all variables examined is presented in Appendix IV.

4.3.4 Wetland Size

Wetland size was determined by drawing polygons around the surveyed wetlands using the FRI layer (n=46).

4.4 Data Analysis – Logistic Regression Models

Logistic regression analyses were performed using landscape variables at the 3 spatial scales as a means of evaluating the relationship between the presence of target species and the site and landscape characteristics. Only habitat variables encountered at > 5% of the sites were used in the analyses. Sets of variables were compared against each other, and the most highly correlated variables ($P \leq 0.05$) were excluded from the analysis. At each scale, sites were defined as "used" by a target species if that species was detected in 2003 or 2004. Data from both years were combined in the analysis as sample sizes were small in each year and provided weak statistical power. If a species was detected at a site in only one of the study years, the 50-m habitat information from the year in which the species was detected was used in the analysis.

Variable residuals were examined for linearity of the logit and adjusted, if necessary (Hosmer and Lemeshow 1989). Models were tested with Akaike information criteria (AIC), and SAS PROC LOGISTIC (SAS Institute Inc. 2003) was used for the analyses.

Due to small sample size, AIC_c was calculated. AIC_c provides an additional correction term in order to account for the bias created by small sample size. Burnham and Anderson (2002) recommend that AIC_c be calculated when the ratio of n/K is less than 40. AIC_c was calculated from the AIC scores generated by SAS using the formula provided by Burnham and Anderson (2002).

In order to evaluate the performance of the models relative to one another, the AIC_c scores from the models were compared to the lowest AIC_c score that was produced by any of the models at that scale. This allowed for a computation of Δ_i, where Δ_i is equal to $AIC_{ci} - AIC_{c\ min}$. Burnham and Anderson (2002) provide a general rule of thumb with which to evaluate the relative significance of various models. They propose that models producing values of $\Delta_i \leq 2$ have substantial support, while models that produce values $4 \leq \Delta_i \leq 7$ have considerably less support and finally, that models producing values of $\Delta_i > 10$ have essentially no statistical support. In cases where the difference between the AIC_c of the null model and the best model was ≤ 4 it was inferred that the species made no selection of habitat variables as the best model did not improve upon the results of the null model.

4.5 Results

At the 50-m scale, tall shrubs and water were highly correlated (Appendix III). Only *Typha* spp. and water were retained in the analysis and included in the “wetland characteristics” model (Table 4-2).

At the 500-m scale, a number of variables were also correlated (Appendix III). In addition to the “null model”, three models were tested at this scale (Table 4-2). The "wetland characteristics" model included the variables wet meadow, marsh, moist prairie, tall shrubs and water; the "other land types" model included the cultivated land variable; and the "global" model included variables from the two previous models.

Table 4-2 Logistic regression models used to analyze habitat use by target species.

Scale	*Model Name*	*Variables**
50-m	1) Null	
	2) Wetland characteristics	*Typha* spp. + water
500-m	1)Null	
	2)Wetland Characteristics	Wet meadow + marsh + moist prairie + tall shrubs + water
	3) Other land types	Cultivated land
	4) Global	Cultivated land + moist prairie + tall shrubs + wet meadow
5-km	1) Null	
	2) Wetland Characteristics	Marsh + Tall shrubs + wet meadow
	3) Other land types	Cultivated land
	4) Global	Cultivated land + marsh + tall shrubs + wet meadow

***See Appendix IV for a description of variables**

A number of variables were also correlated at the 5-km scale (Appendix III). In addition to the "null" model, three models were tested at this scale. The "wetland characteristics" model included the variables marsh, wet meadow and tall shrubs; the "other land types" model included the cultivated land variable; and the "global" model included variables from the two previous models.

Mean values of variables were determined for each target species at sites where the target species were present and absent (Tables 4-3 - 4-5).

Table 4-3. Mean percentage (SD) of habitat components within a 50-m radius around the calling site. Variables that were included in the logistic regression models are indicated with an asterisk.

	American bittern		*Least bittern*		*Pied-billed grebe*		*Sora*		*Virginia rail*	
Absence (0)/Presence (1)	0	1	0	1	0	1	0	1	0	1
No. of 50-m radius buffers	72	66	126	15	81	57	44	94	101	37
Tall shrubs (%)	3.2 (5.6)	6.3 (11.0)	4.0 (7.2)	12.7(17.5)	4.4 (8.7)	5.1 (8.8)	3.6 (9.0)	5.2 (8.7)	3.9 (7.1)	6.8 (12.1)
Typha spp. *(%)	34.7 (17.0)	35.3 (22.8)	34.0 (19.8)	48.0 (20.5)	32.0 (20.7)	39.3 (18.1)	30.8 (22.3)	37.0 (18.5)	34.0 (20.7)	37.8 (17.4)
Open water *(%)	39.7 (19.9)	28.3 (20.0)	33.9 (20.5)	31.7 (24.0)	31.5 (20.7)	38.2 (20.1)	34.9 (24.1)	33.9 (18.9)	34.8 (21.4)	32.7 (18.6)

Table 4-4 Mean percentage (SD) of habitat components within a 500-m radius around calling sites. Variables that were included in the logistic regression models are indicated with an asterisk.

	American bittern		*Least bittern*		*Pied-billed grebe*		*Sora*		*Virginia rail*	
Absence (0)/Presence (1)	0	1	0	1	0	1	0	1	0	1
No. of 500-m radius buffers	72	66	126	15	81	57	44	94	101	37
Linear features (%)	5.0 (3.8)	4.6 (3.0)	4.9 (3.4)	4.2 (2.8)	5.0 (3.3)	4.6 (3.6)	4.2 (3.3)	5.1 (3.5)	4.7 (3.6)	5.3 (3.0)
Cultivated land *(%)	13.8 (19.4)	7.2 (14.3)	10.6 (17.9)	8.6 (11.4)	9.4 (18.1)	12.4 (16.4)	6.7 (13.2)	12.5 (18.9)	10.0 (17.4)	12.4 (17.6)
Moist prairie *(%)	8.8 (11.9)	5.2 (11.6)	7.5 (12.1)	2.7 (6.8)	6.2 (11.3)	8.4 (12.6)	6.0 (10.3)	7.6 (12.5)	7.4 (11.8)	6.4 (11.9)
Water (%)	10.3 (16.2)	14.3 (16.3)	13.3 (16.6)	0.2 (0.5)	15.7 (17.2)	7.2 (13.5)	16.4 (17.3)	10.3 (15.5)	13.7 (16.8)	8.2 (14.2)
Wet meadow *(%)	5.3 (10.6)	13.4 (19.2)	9.2 (16.0)	10.6 (14.9)	10.3 (17.0)	7.6 (13.8)	5.9 (12.1)	10.7 (17.1)	7.4 (13.3)	14.1 (20.8)
Tall shrubs * (%)	8.5 (21.4)	10.3 (19.4)	7.1 (17.2)	28.1 (32.1)	4.5 (9.3)	16.2 (28.4)	4.7 (10.4)	11.5 (23.4)	8.1 (18.3)	12.7 (25.1)
Marsh (%)	29.4 (30.1)	28.6 (29.3)	29.7 (27.3)	17.5 (33.2)	27.0 (25.3)	31.8 (31.7)	36.1 (27.2)	25.7 (28.1)	29.6 (27.7)	27.4 (29.4)

Table 4-5 Mean percentage (SD) of habitat components within a 5-km radius around calling sites. Variables that were included in the logistic regression models are indicated with an asterisk.

	American bittern		*Least bittern*		*Pied-billed grebe*		*Sora*		*Virginia rail*	
Absence (0)/Presence (1)	0	1	0	1	0	1	0	1	0	1
No. of 5-km radius buffers	17	17	30	5	15	19	4	30	17	17
Cultivated land * (%)	39.4 (26.9)	26.8 (25.9)	33.5 (28.1)	25.3 (17.0)	29.7 (26.9)	35.7 (27.1)	19.8 (20.5)	34.9 (27.3)	36.7 (29.2)	29.5 (24.5)
Linear features (%)	3.1 (1.8)	2.4 (1.3)	2.8 (1.7)	2.3 (0.8)	2.7 (1.4)	2.8 (1.7)	2.9 (1.7)	2.7 (1.6)	2.8 (1.2)	2.7 (1.9)
Water (%)	8.5 (13.0)	16.3 (23.7)	14.0 (19.0)	0 (0)	8.2 (16.9)	15.7 (20.7)	3.1 (5.2)	13.6 (20.1)	8.3 (14.4)	16.7 (22.7)
Wet meadow* (%)	1.9 (2.6)	5.1 (5.4)	3.3 (4.4)	6.4 (5.7)	1.9 (2.7)	4.7 (5.2)	0.7 (1.3)	3.8 (4.6)	2.3 (3.2)	4.7 (5.3)
Marsh* (%)	2.9 (5.1)	9.2 (8.2)	5.6 (7.3)	7.5 (8.7)	3.1 (5.9)	8.4 (7.8)	0.4 (0.7)	6.8 (7.6)	3.2 (5.1)	8.9 (8.4)
Moist prairie (%)	3.9 (4.5)	3.9 (5.1)	3.5 (3.7)	5.9 (9.0)	2.3 (1.4)	5.2 (5.8)	0.7 (0.5)	4.3 (4.9)	2.7 (2.6)	5.2 (6.0)
Tall shrubs * (%)	3.7 (5.7)	8.7 (11.0)	4.9 (6.6)	14.6 (16.0)	6.4 (8.0)	6.1 (10.0)	9.3 (9.6)	5.8 (9.0)	5.3 (6.4)	7.2 (11.1)

4.5.1 American Bittern

At the 50-m scale, the best model in terms of predicting site use by American bittern was the "wetland characteristics" model. American bittern were associated with sites that had significantly less water within a 50-m radius (Table 4-6).

At the 500-m scale, the "wetland characteristics" model was the best and showed that American bittern were associated with sites that had more water and wet meadow than unused sites.

At the 5-km scale the "wetland characteristics" model produced the best results and indicated that American bittern selected areas that had higher proportions of marsh and tall shrubs.

Table 4-6 Logistic regression models for evaluating site selection by American bittern at all scales. Δ_i values that indicate substantial support for models are indicated in bold. Models that best explained the presence of a species are indicated in bold.

Scale	*Models*	*-2LL*	*AIC*	*AIC$_c$*	Δ_i	*Significant variables* ß (*P*)
50-m	Null	191.048	193.048	193.077	8.568	
	Wetland characteristics	**180.330**	**184.330**	**184.509**	**0**	**Water -0.0284 (0.002)**
500-m	Null	191.048	193.048	193.077	10.437	
	Wetland characteristics	**175.999**	**181.999**	**182.640**	**0**	**Wet meadow 0.0469 (0.002) + Water 0.0249 (0.03)**
	Other land types	185.763	189.763	189.852	7.212	Cultivated land 0.0244 (0.03)
	Global	181.071	185.071	185.932	**3.292**	Wet meadow 0.0469 (0.002) + Water 0.0249 (0.03)
5-km	Null model	47.134	49.134	49.259	10.435	
	Wetland characteristics	**31.445**	**37.445**	**38.824**	**0**	**Marsh 0.2366 (0.008) + Tall shrubs 0.1842 (0.03)**
	Other land types	45.176	49.176	49.950	11.126	
	Global	31.445	37.445	39.588	**0.764**	Marsh 0.2366 (0.008) + Tall shrubs 0.1842 (0.03)

4.5.2 Least Bittern

At the 50-m scale, the best model was the "wetland characteristics" model. It showed that the species was associated with sites that had higher proportions of *Typha* spp. within a 50-m radius (Table 4-7).

At the 500-m scale, the "wetland characteristics" model produced the best results showing that least bittern were associated with sites that had a higher percentage of tall shrubs. Water was also added and then removed from the model, indicating that this variable may be important to the least bittern.

At the 5-km scale none of the models tested were significant. In the "wetland characteristics" model, tall shrubs were initially added to the model but were then removed; this indicates that tall shrubs may be biologically important to the least bittern at this scale.

Table 4-7 Logistic regression models evaluating site selection by least bittern at all scales. Δ_i values that indicate substantial support for models are indicated in bold. Models that best explained the presence of a species are indicated in bold.

Scale	*Models*	*-2LL*	*AIC*	*AIC$_c$*	*Δ_i*	*Significant variables* ß (*P*)
50-m	Null model	95.566	97.566	97.595	4.124	
	Wetland characteristics	**89.296**	**93.296**	**93.471**	**0**	***Typha* 0.0334 (0.01) #**
500-m	Null model	95.566	97.566	97.595	7.237	
	Wetland characteristics	**85.717**	**89.717**	**90.358**	**0**	**Tall shrubs 0.0318 (0.001)**
	Other land types	95.359	99.359	99.446	9.088	
	Global	72.462	89.717	90.579	**0.221**	Tall shrubs 0.0318 (0.001)
5-km	Null model	28.708	30.708	30.829		
	Wetland characteristics	19.990	27.990	29.323		
	Other land types	28.277	32.277	32.652		
	Global	18.649	28.649	30.718		

Tall shrubs are not included in this model as they were highly correlated with *Typha*. A "wetland characteristics" model including tall shrubs and water was also significant (AIC$_c$ - 91.808, Tall shrubs ß 0.0631, P = 0.005).

4.5.3 Pied-billed Grebe

At the 50-m scale, the "wetland characteristics" model was the best model and showed that increased proportions of *Typha* spp. explained the presence of pied-billed grebe (Table 4-8). However, there was also substantial support for the null model, discounting the credibility of the "wetland characteristics" model.

At the 500-m scale, the "wetland characteristics" model produced significant results. Pied-billed grebes were associated with sites that had higher proportions of tall shrubs and marsh and lower proportions of water. The "global" model also produced significant results and showed that pied-billed grebe were associated with increased amounts of cultivated land, tall shrubs, moist prairie and marsh. There was substantial support for both of these models, however the "wetland characteristics" model produced the lowest Δ_i value.

At the 5-km scale, none of the models produced significant results. However, the marsh variable was added and then removed from the "wetland characteristics" model, indicating that it may be biologically, but not statistically, significant to the pied-billed grebe.

Table 4-8 Logistic regression models evaluating site selection by pied-billed grebes at all scales. Δ_i values that indicate substantial support for models are in bold. Models that best explained the presence of a species are indicated in bold.

Scale	*Models*	*-2LL*	*AIC*	*AIC$_c$*	*Δ_i*	*Significant variables* ß (*P*)
50-m	Null	187.113	189.113	189.142	**2.466**	
	Wetland characteristics	182.497	186.497	186.676	**0**	*Typha* 0.0191 (0.04)
500-m	Null	187.113	189.113	189.142	15.922	
	Wetland characteristics	**164.579**	**172.579**	**173.220**	**0**	**Tall shrubs 0.0377 (0.005) + Marsh 0.0158 (0.03) + Water -0.0276 (0.04)**
	Other land types	186.146	190.146	190.235	17.015	
	Global	169.308	175.308	176.170	**2.95**	Cultivated land 0.0276 (0.02) + Moist Prairie 0.0315 (0.04) + Tall Shrubs 0.0562 (0.0003) + Marsh 0.0248 (0.002)
5-km	Null	46.662	48.662	48.787		
	Wetland characteristics	38.406	46.406	47.785		
	Other land types	46.226	50.226	51.000		
	Global	35.249	45.249	47.392		

4.5.4 Sora

None of the models at any of the scales significantly explained the presence of sora (Table 4-9).

Table 4-9 Logistic regression models evaluating site selection by sora at all scales. Δ_i values indicating substantial support for models are in bold. Models that best explained the presence of a species are indicated in bold.

Scale	*Models*	*-2LL*	*AIC*	*AIC$_c$*	*Δ_i*	*Significant variables* ß (*P*)
50-m	Null	172.774	174.774	174.803		
	Wetland characteristics	169.655	175.655	175.834		
500-m	Null	172.774	174.774	174.803	**3.672**	
	Wetland characteristics	164.749	170.749	171.131	**0**	Marsh -0.0131 (0.05) + Water -0.0222 (0.05)
	Other land types	169.063	173.063	173.152	**2.021**	
	Global	164.749	170.749	171.611	**0.48**	Marsh -0.0131 (0.05) + Water -0.0222 (0.05)
5-km	Null	24.630	26.630	26.755		
	Wetland characteristics	15.499	25.499	26.878		
	Other land types	23.341	27.341	28.115		
	Global	15.499	25.499	27.642		

4.5.5 Virginia Rail

None of the models at any of the scales significantly explained the presence of Virginia rail (Table 4-10).

Table 4-10 Logistic regression models evaluating site selection by Virginia rails at all scales. Δ_i values indicating substantial support for models are in bold. Models that best explained the presence of a species are indicated in bold.

Scale	*Models*	*-2LL*	*AIC*	*AIC_c*	*Δ_i*	*Significant variables* ß (*P*)
50-m	Null	160.460	162.460	162.489		
	Wetland characteristics	159.133	165.133	165.312		
500-m	Null	160.460	162.460	162.489	**2.139**	
	Wetland characteristics	156.049	160.049	160.350	**0**	Wet meadow 0.0241 (0.04)
	Other land types	159.956	163.956	164.045	**3.695**	
	Global	156.049	160.049	160.503	**0.153**	Wet meadow 0.0241 (0.04)
5-km	Null model	47.134	49.134	49.259	**2.308**	
	Wetland characteristics	41.572	45.572	46.951	**0**	Marsh 0.1281 (0.04)
	Other land types	46.487	50.487	51.261	4.31	
	Global	41.572	45.572	47.715	**0.764**	Marsh 0.1281 (0.04)

4.5.6 Wetland Size

American bittern, least bittern, sora and Virginia rails were found to use larger wetlands. Pied-billed grebes did select for wetland size (Figure 4-1).

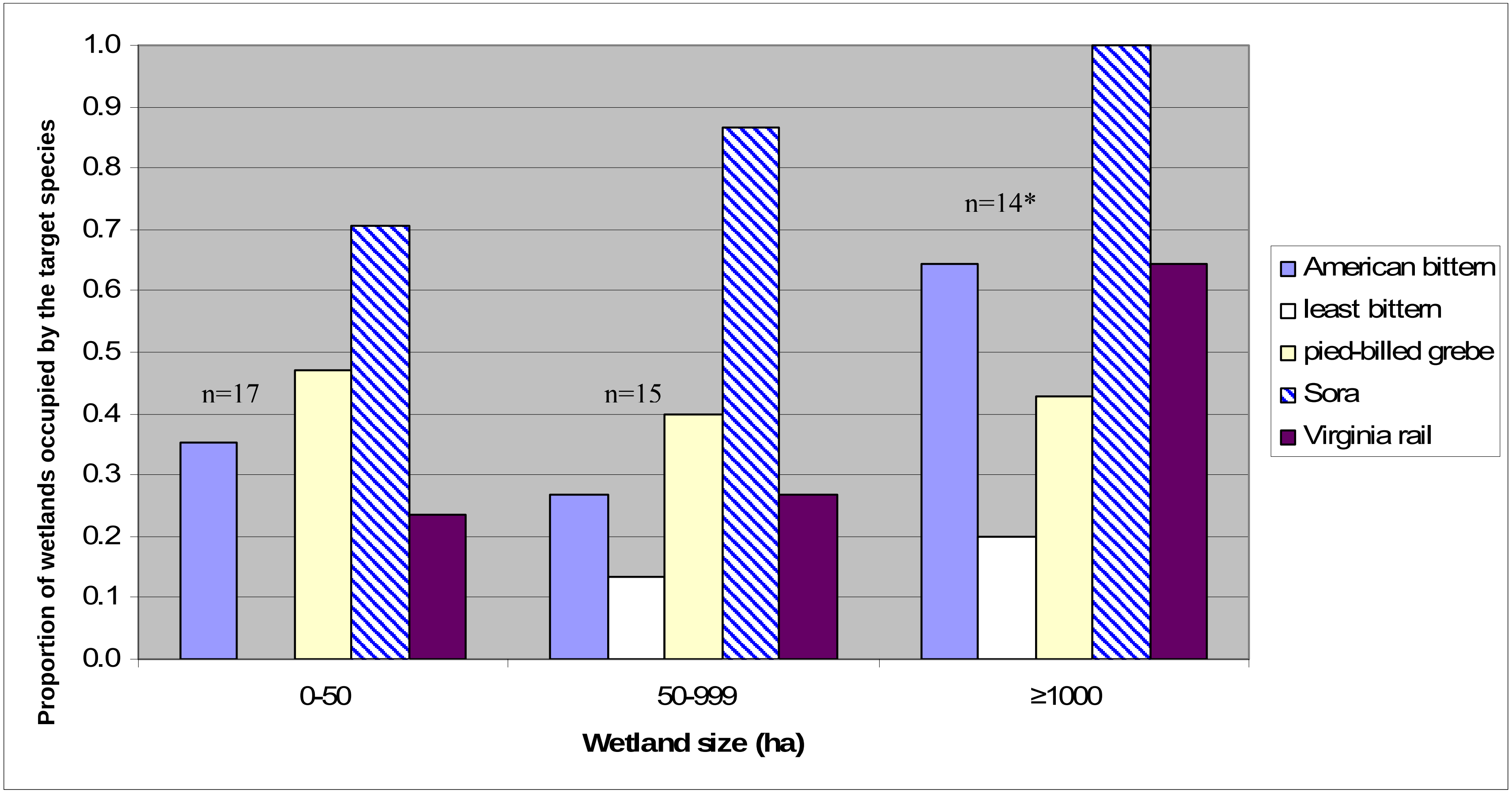

Figure 4-1 Proportion of wetland size classes occupied by target species. (*Sample size for least bittern was 15).

4.6 Discussion

4.6.1 Key Variables in Explaining the Presence of Target Species

Results of the present study show that the target species responded differently to site and landscape characteristics with the American bittern and least bittern being the most selective species and the sora and Virginia rail being the least selective of all target species (Table 4-11).

Table 4-11 - Summary of logistic regression results for each target species by scale. Significant model results that had substantial support are indicated by ++. Significant models that produced AIC_c scores similar to null models and models where variables were added and then removed are indicated with a +.

Target species	*50-m*	*500-m*	*5-km*
American bittern	++	++	++
Least bittern	++	++	+
Pied-billed grebe	+	++	+
Sora			
Virginia rail			

The "wetland characteristics" models best explained the presence of the target species. The "other land types" models did not produce significant results for any of the target species. This indicates that the characteristics of the wetland itself play a key role in determining the suitability of the wetland for the target species rather than the presence of agriculture in the surrounding landscape.

There were some trends in the variables that the target species selected at the different scales. American bittern and pied-billed grebe were associated with increased proportions of marsh at the 5-km scale. Fairbairn and Dinsmore (2001) also found that the percentage of marsh and wet meadow within a 3-km radius of wetland complexes was important in determining overall species richness and the density of 5 species of marsh birds including the pied-billed grebe. In North Dakota, Niemuth and Solberg (2003) found that the numbers of six waterbirds, including the American bittern, pied-billed grebe and sora, were positively correlated with the number of wetlands on the landscape in the spring. American bittern and pied-billed grebe may first select areas within the landscape that have a high percentage of wetlands, and then select sites at the 50/500-m scale that have the variables with which they are positively associated.

Increased proportions of tall shrubs surrounding study sites explained the presence of American bittern, least bittern and pied-billed grebes. Least bittern and pied-billed grebes have been associated with increased proportions of woody vegetation in the literature (Gibbs et al. 1992a, Gibbs et al. 1992b, James 1999). For the least bittern, tall shrubs were an integral part of the sites it used. Sites at which the least bittern was present had much higher proportions of tall shrubs at all scales (Tables 4-4 - 4-6) (Figures 4-2 – 4-7).

Increased amounts of wet meadow better explained the presence of American bittern than the amount of marsh at the 500-m scale. The species is known to select wetlands with shallow water (Gibbs et al. 1992a). Wet meadows typically resemble grasslands and have little or no standing water (Mitsch and Gosselink 1986). At the 50-m scale, American bittern were also associated with sites that had significantly less open water.

Wet meadow and marsh were negatively correlated at the 500-m scale, but not at the 5-km scale. It is possible that these two wetland types are more likely to occur within different landscape settings or landscapes of different composition. However, the 5-km scale may incorporate enough spatial heterogeneity to satisfy the landscape conditions that are necessary to support both wetland types.

None of the models significantly explained the presence of the sora or Virginia rail. These findings are supported by the literature, which indicates that sora and Virginia rail do not select for specific vegetation types (Brown and Dinsmore 1986, Johnson and Dinsmore 1986a). P. Taylor (pers. comm.) also noted that sora are wetland generalists and can be found in a variety of wetlands types. Soras were the most widespread species in this study and were detected at 39 of the 46 wetlands studied.

Figure 4-2 Least bittern habitat within the Rat River Swamp, Manitoba.

Figure 4-3 Least bittern habitat within the Rat River Swamp, Manitoba.

Figure 4-4 Least bittern habitat within the Rat River Swamp, Manitoba.

Figure 4-5 Least bittern habitat within the Rat River Wildlife Management Area, Manitoba.

Figure 4-6 Least bittern habitat within Oak Hammock Marsh, Manitoba.

Figure 4-7 Least bittern habitat at a wetland located east of Ross, Manitoba.

A small number of authors have indicated that wetland size plays a role in determining the suitability of wetlands for the species targeted in this study, with the exception of the sora (Brown and Dinsmore 1986, Gibbs et al. 1992a, Conway 1995, James 1999, Muller and Storer 1999, Naugle et al. 1999b). In the present study, American bittern, least bittern, sora and Virginia rail were most likely to occur in wetlands that were greater than 1,000 ha in size. Pied-billed grebes did not select for wetland size.

These values are much higher than those reported in another study, which showed that American bittern were most common in wetlands 11-20 ha in size, while least bittern and pied-billed grebes were detected most frequently in wetlands between 5 ha and 182 ha in size (Brown and Dinsmore 1986). This discrepancy may in part be due to the large size of the wetlands that were included in the present study (Figure 4-1). Only 17 of the 46 study wetlands were less than 50 ha in size and the largest wetland was 11,231.8 ha in size. Of the 30 wetlands that Brown and Dinsmore studied, the largest was 182 ha in size. It should also be noted that in Brown and Dinsmore's study (1986) only the relationship between pied-billed grebes and wetland size was statistically significant.

Conway (1995) indicated that Virginia rails were associated with larger wetlands, however he did not indicate the average size of the wetlands. Brown and Dinsmore (1986) did not find a statistically significant relationship between the presence of Virginia rails and wetland size. There is no evidence in the literature that sora select for wetlands of a specific size.

4.6.2 Limitations of the Habitat Models

A number of the models for each of the species failed to show any significant difference in habitat composition between sites at which target species were present and absent. At the 50-m and 500-m scales, it is possible that this is due to the similarity of the habitat at the surveyed sites (Tables 4-3 and 4-4). It is likely that stronger selection would have been shown at the 50-m and 500-m scale if the survey sites had been randomly selected and presented larger differences in habitat composition.

At the 50-m scale, an additional factor that may have limited the power of the analysis was the method used to characterize the habitat at each site relative to the detection of species. Habitat data were collected for only a 50-m radius surrounding the observer, while target species were considered present at sites even if they were detected outside of this area. Therefore, it was inferred that the individuals detected outside of the 50-m radius were using the habitat within this radius. Another potential source of bias at the 50-m range was the method in which habitat information was collected. Habitat information was collected by visually estimating percent cover from the ground by 3 different individuals. It is also possible that individuals were present but not detected at the 50-m scale, although (Gibbs and Melvin 1993) report that marsh bird presence and absence can be determined within 90% accuracy after 3 surveys have been conducted during the breeding season.

At the larger 5-km scale, spatial heterogeneity increased as additional landscape elements were incorporated in the buffers, but the sample size was also greatly reduced to eliminate overlap between buffers (Wiens 1989). The reduction in sample size led to decreased statistical powers of these models. In addition, at the 5-km scale, it was assumed that birds were either present or absent from these areas based on the point count sampling that was conducted at select sites within these buffers. The 5-km buffers were not thoroughly sampled for the target species and it is possible that target species may have been present at areas within the buffers that were not sampled.

A number of different GIS data were considered for the habitat analysis. The FRI data was selected for a number of reasons. The data was provided gratis by the Manitoba Lands Initiative and included a number of different wetland classes such as marsh, wet meadow, bog and fen for analysis. Landsat TM data was also considered, but it did not provide as diverse a group of wetland classes for analysis and was not as accurate. It is possible that a different vegetation layer would have produced different results in the habitat analysis.

5 General Conclusions and Recommendations

The primary goal of this study was to examine the distribution and habitat requirements of breeding least bittern and other marsh bird species at multiple spatial scales. It was necessary to employ a call-response survey in order to detect these elusive species. A great deal of debate currently exists in the literature as to the efficacy of call-response surveys in detecting marsh birds. Therefore, a related goal of this study was to evaluate the efficacy of a standardized call-response methodology in detecting the target species. The purpose of this chapter is to summarize the findings of this research in a way that is useful to the audience and to make suggestions for further research and conservation efforts.

In Chapter 3, I examined the distribution of the target species in southern Manitoba. Least bittern were detected at 5 wetlands within their known range in southern Manitoba. Additional research is needed to determine the density and breeding site fidelity of least bittern in the Rat River Swamp and Rat River Wildlife Management areas, as these areas appeared to be particularly important to the species. Additional areas within southeastern Manitoba containing high proportions of shrubby vegetation within large tracts of wetlands should also be surveyed. This habitat type appears to be particularly valuable to the species and remains largely neglected in most general bird surveys.

I also examined the efficacy of the call-response protocol in Chapter 3, and found that the survey protocol increased the numbers of all species detected. This increase was most pronounced for the least bittern, sora and Virginia rail. These findings largely agreed with the literature. I found that American bittern, pied-billed grebe and sora were most likely to be detected during the first and second survey rounds. Least bittern and Virginia rails were detected fairly consistently throughout the duration of the study. The majority of American bittern and pied-billed grebe were detected in the evening sampling periods.

In Chapter 4, I examined the habitat requirements of the target species at 50-m, 500-m and 5-km scales using site level habitat information and information from Provincial forest resource inventory data. The 500-m scale models explained the presence of more target species than did the 50-m or 5-km models. At all 3 scales, the “wetland characteristics” models best explained the presence of the target species. This indicates that the characteristics of the wetlands are more important in determining their suitability for a given species than the characteristics of the surrounding landscapes.

The sites that were included in the study were fairly similar in composition at the 50-m scale. As such, very few variables at this scale significantly explained the presence of the target species. Additional research is needed on a more diverse set of wetland types in order to determine the factors that are important in influencing the suitability of wetlands for these species. It is also possible that alternative site-level scales should be examined.

There were some trends in the variables that the species selected at a given scale. Least bittern and pied-billed grebe selected areas with higher proportions of *Typha* spp. and tall shrubs; American bittern also selected areas with higher proportions of tall shrubs. I found that many of the species selected sites that were located in areas that had higher percentages of wetlands within a 5-km buffer. Fairbairn and Dinsmore (2001) also found that wetland birds were associated with sites that had higher proportions of wetlands within a 3-km radius. Sora and Virginia rail were not associated with any of the measured landscape characteristics.

One of the most important steps towards the conservation of marsh bird species in Manitoba and elsewhere is the development, adoption, and implementation of a standardized survey protocol. Based on the results of the present study, I recommend that future surveys include both a passive and call-broadcast period for marsh bird species. Future marsh bird surveys should be conducted in both the morning and evening and sites should be visited 3 times each during the breeding season. In southern Manitoba, call-response surveys for marsh bird species should begin as early as the beginning of May to ensure the survey incorporates the period of peak vocalization. I recommend that future surveys for the yellow rail be conducted after dark.

Many of the target species selected sites that had increased percentages of wetlands surrounding them. Future wetland conservation efforts should focus not only on protecting remaining wetlands, but also on protecting wetland complexes, ensuring the wetlands do not become increasingly isolated from one another.

In 2004, I detected 13 male least bittern at various locations within the Rat River Swamp. Female least bittern do not give vocal responses that are loud enough to detect in call-response surveys, but it can be assumed that there were at least an equal number of females present in the same area. Only a small percentage (perhaps no more than 5 percent of the total area) of the Rat River Swamp was surveyed and it is likely that a much larger number of least bittern are present in the area. Given that there are only an estimated 100 breeding pairs of least bittern in Canadian provinces excluding Ontario (Sandilands and Campbell 1987), it appears that the Rat River Swamp is quite important to the species. Measures should be taken to further investigate the least bittern population in this area and to protect the area from future development and alteration.

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Appendix I – Wetlands surveyed in 2003 and 2004.

Coordinates are in UTM, Zone 14. Species presence is indicated with a 1 and absence is indicated with a 0.

Wetland Name	*X Coordinate*	*Y Coordinate*	*Number of Call Broadcast sites*	*American Bittern*	*Least Bittern*	*Pied-billed grebe*	*Sora*	*Virginia rail*	*Yellow rail*
Big Creek	723663	5555459	3	1	0	1	0	1	0
Birds Hill	653335	5544711	1	0	0	0	0	0	0
Bob Jones Marsh	554931	5534735	1	0	0	1	1	0	0
Broken Head Swamp *	689458	5522541	3	N/A	N/A	1	N/A	N/A	N/A
Crescent Lake 1	548809	5534096	1	0	0	0	1	1	0
Crescent Lake 2	549989	5533630	1	0	0	1	1	0	0
Delta Marsh - University Property	543227	5558301	13	1	0	1	1	1	0
Delta Marsh - Delta Waterfowl Research Station	550834	5560141	12	1	0	0	1	0	0
Douglas Marsh	448851	5525566	2	1	0	1	1	1	0
Elma	722460	5520680	1	0	0	0	0	0	0
Fort Whyte	627883	5519992	2	0	0	0	1	0	0
Glenboro Marsh	478809	5484676	2	1	0	1	1	0	0
Great Falls 1	711968	5592723	1	0	0	0	1	0	0
Great Falls 2	712005	5587617	1	0	0	0	0	0	0
Hazel	698324	5528932	1	0	0	0	0	0	0
Hecla Island	654334	5657999	6	1	0	1	1	0	0
Killarney 1	449332	5447538	1	0	0	0	1	0	0
Killarney 2	449511	5447397	1	0	0	1	1	0	0
Lizard Lake	543939	5459989	3	0	0	1	1	0	0
Ninette	455416	5472540	2	0	0	0	1	1	0
North Otter Lake	441581	5598613	2	0	0	0	0	0	0
Oak Hammock Marsh	633622	5559160	21	1	1	1	1	1	0
Oak Lake 1	376339	5511061	1	0	0	0	1	0	0

Oak Lake 2	376467	5506138	1	0	0	0	1	1	0
Oak Lake 3	376377	5503106	4	0	0	1	1	0	0
Oak Lake 4	382847	5498145	1	0	0	0	1	0	0
Oak Lake 5	394613	5511369	1	0	0	0	1	0	0
Pinawa Channel	718528	5563689	2	0	0	0	0	0	0
Pinawa Road	718398	5559393	1	0	0	0	1	0	0
Proven Lake	431258	5598633	6	1	0	1	1	0	0
Rapid City	426210	5552808	1	0	0	0	1	0	0
Richer	687716	5503984	1	1	0	1	1	0	0
Ross	686459	5514368	2	1	1	0	1	1	0
Rat River 1	665401	5455468	11	1	1	1	1	1	0
Rat River 2	675507	5459920	4	1	1	1	1	1	0
Shoal Lakes 1	590989	5600674	1	1	0	0	1	1	0
Shoal Lakes 2	593997	5599697	2	1	0	1	1	1	0
Shoal Lakes 3	599541	5590863	1	1	0	1	1	1	0
Shoal Lakes 4	596252	5587118	1	1	0	0	1	1	0
South Otter Lake	437820	5595299	2	0	0	0	1	0	0
Spruce Siding 1	713039	5513309	2	0	0	0	1	1	0
Spruce Siding 2	709718	5508897	1	1	0	0	1	0	0
St Leon	529716	5470401	2	0	0	0	1	1	0
Swan Lake	511642	5467376	4	1	0	1	1	0	0
Twin Beach	572497	5575204	4	1	0	1	1	1	0
Whitewater Lake	409742	5455432	2	0	0	1	1	0	0
Wild Wings Pond	724364	5574639	2	0	0	0	1	0	0

*The Brokenhead Swamp was surveyed for least bittern only.

Appendix II – Sample call-response data sheet (Adapted from Conway 2002)

Marsh			Ambient Temp				bckgrnd. Noise (1-4)			***new line for every individual, enter 1 for heard, s for seen, and 1s for heard/seen												
Date			Wind (Beaufort)				Cloud cover (%)															
Observer			Lunar Phase/vis (if applic.)					Precip.														
			Responded During/seen during																			
Location (stn# & GPS)	**Time (start/fin)**	**Species**	**pass 1st**	**pass 2nd**	**pass 3rd**	**pass 4th**	**pass 5th**	1 min LEBI	30 sec silent	1 min YERA	30 sec silent	1 min SORA	30 sec silent	1 min VIRA	30 sec silent	1 min AMBI	30 sec silent	1 min PBGR	30 sec silent	**Distance**	**Comments**	**calls**

Appendix III – Correlation of habitat variables.

Correlation of variables at the 50-m scale. Significant values are indicated in bold

	Tall shrubs	*Typha*	*Water*
Tall shrubs	1		
Typha	**-0.19759**	1	
Water	**-0.30618**	0.00275	1

Correlation of variables at the 500-m scale. Significant correlation values are indicated in bold.

	Cultivated land	*Linear features*	*Water*	*Moist prairie*	*Wet meadow*	*Marsh*	*Tall shrubs*
Cultivated land	1						
Linear features	**0.219014376**	1					
Water	**-0.21389598**	-0.130221522	1				
Moist prairie	-0.020279705	-0.016410702	-0.14324	1			
Wet meadow	-0.095104494	0.082594899	**-0.2303**	-0.018468317	1		
Marsh	**-0.274051611**	-0.144308008	0.059913	0.00864331	**-0.24357**	1	
Tall shrubs	-0.072120514	**-0.222364367**	**-0.27134**	-0.151093111	-0.09301	**-0.34303**	1

Correlation of habitat variables at the 5-km scale. Significant correlation values are indicated in bold.

	Cultivated land	*Linear features*	*Water*	*Moist prairie*	*Wet meadow*	*Marsh*	*Tall shrubs*
Cultivated land	1						
Linear features	**0.722698**	1					
Water	**-0.42963**	**-0.49339**	1				
Moist prairie	0.184629	-0.08098	0.160385862	1			
Wet meadow	-0.19115	-0.19774	0.023953212	0.024766638	1		
Marsh	-0.15417	-0.34034	**0.735916835**	**0.575126897**	0.04194	1	
Shrub group	-0.33597	-0.17835	-0.2412695	-0.300147766	-0.00419	-0.31125	1

Appendix IV - Description of habitat variables used in logistic regression analysis.

Habitat variables obtained from field data collection and FRI data (descriptions adapted from FRI metadata). Variables that were not included in the analysis were present at fewer than 5% of the sampling sites or were highly correlated.

Scale variable analyzed at	*Variable*	*Description*
50-m	Tall shrubs	Tall woody vegetation under 4 m tall including *Salix* spp.
50-m	*Typha* spp.	Typha vegetation of all species
50-m	Open water	Water free of emergent vegetation
500-m/5-km	Linear features	Anthropogenic features including railway lines, transmission lines, pipelines, fence lines, fire guards,
500-m/5-km	Cultivated land	Areas under agricultural use.
500-m/5-km	Moist prairie	Moist to wet grassland. Grass covers at least 51 percent of the area.
500-m/5-km	Water	Lakes and rivers.
500-m/5-km	Wet meadow	Moist to wet grassland. Grass covers at least 51 percent of the area.
500-m/5-km	Tall shrubs	Low lying areas supporting willow or alder growth. Shrubs cover at least 51% of the area.
500-m/5km	Marsh	Wetland completely or partially covered with tall grass, rushes or sedges.
Not included in analysis	Productive forested land	Areas capable of producing merchantable timber
Not included in analysis	Treed muskeg	Muskeg supporting stagnated trees
Not included in analysis	Treed rock	Bare rock with shallow soil supporting stagnated trees
Not included in analysis	Protection forest	Presently developed or reserved recreational areas and small islands
Not included in analysis	Barren-bare rock	Tundra and rock with less than 25 percent tree cover
Not included in analysis	Meadow	Moist to wet grassland suitable for hay production
Not included in analysis	Other wetlands	Muskeg, string bogs
Not included in analysis	Mud/salt flats	No description available
Not included in analysis	Sand beaches	No description available
Not included in analysis	Unclassified	Gravel pits, beaches, summer resorts, mines, oil fields, etc