U.S. Fish & Wildlife Service

Webless Migratory Game Bird Program

Project Abstracts – 2010-11

Webless Migratory Game Bird Program

Project Abstracts – 2010 and 2011

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The purpose of this report is to provide updated information on projects being funded through the U.S. Fish and Wildlife Service's Webless Migratory Game Bird Program. Any specific questions on projects should be addressed directly to the abstract authors.

Cover photo by Todd Sanders, U.S. Fish and Wildlife Service, band-tailed pigeons visiting a mineral site station.

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HISTORY AND ADMINISTRATION OF THE WEBLESS MIGRATORY GAME BIRD PROGRAM, 1995-2012

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Introduction

The Webless Migratory Game Bird (WMGB) Program is an outgrowth of the WMGB Research Program (1994-present) and the WMGB Management Program (2007-present). The revised WMGB Program was designed to provide cooperative funding for both research and management activities from the U.S. Fish and Wildlife Service (USFWS), state wildlife agencies, and other sources for projects benefitting the 16 species of migratory game birds in North America (Table 1).

Table 1. The 16 species of migratory shore and upland game birds eligible for funding through the Webless Migratory Game Bird Program.

Common Name	**Scientific Name**
King Rail	*Rallus elegans*
Clapper Rail	*Rallus longirostris*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
Purple Gallinule	*Porphyrio martinica*
Common Gallinule[1]	*Gallinula galeata*
American Coot	*Fulica americana*
Sandhill Crane	*Grus canadensis*
Wilson's Snipe	*Gallinago delicata*
American Woodcock	*Scolopax minor*
Band-tailed Pigeon	*Patagioenas fasciata*
Scaly-naped Pigeon	*Patagioenas squamosa*
Zenaida Dove	*Zenaida aurita*
Mourning Dove	*Zenaida macroura*
White-winged Dove	*Zenaida asiatica*
White-tipped Dove	*Leptotila verreauxi*

[1] Formerly Common Moorhen (*Gallinula chloropus)*

History

The WMGB Program is an outgrowth of several funding initiatives, both past and present. The first effort was the Accelerated Research Program (1967-1982). Congressional funding of the ARP was $250,000 annually. Of this total, $175,000 was contracted to states: $50,000 was used directly by the USFWS to support 2 field stations to study woodcock and doves; and, $25,000 was retained by the USFWS to administer the program. The ARP ended when funding for the program was eliminated due to USFWS budget constraints in 1982. In 1984, the International Association of Fish and Wildlife Agencies (now AFWA) formed the Migratory Shore and Upland Game Bird (MSUGB) Subcommittee. One goal of the subcommittee was to reinstate a webless game bird research program. To accomplish this goal, the subcommittee documented the past accomplishments of the ARP and lobbied for reinstatement of a webless research program. The efforts and persistence of the MSUGB Subcommittee came to fruition in the fall of 1994 when funding became available. The new program was titled the WMGB Research Program. Projects were selected for funding beginning in 1995 with funding being obligated for the entire project. Detailed information about the history of the ARP and WMGB Research Programs can be found in Dolton (2009).

The WMGB Research Program was funded at various levels during 1995-2006; however, funding was suspended due to budget limitations in 2003 and 2004. Funding was reinstated in 2005 at a level of $250,000/year, with $30,000 of the total being obligated for webless projects in USFWS Region 5 (Northeast U.S.). In 2007, the USFWS received additional funding for MSUGB work ($487,000/year). The primary purpose of the new funding was to address the management needs of MSUGB. From 2007-2009, funding was directed towards supporting mourning dove banding in several states and other management related projects for woodcock, rails, and sandhill cranes.

Another key contribution made by the MSUGB Committee was the publication of the book entitled *Migratory Shore and Upland Game Bird Management in North America* (Tacha and Braun 1994). This was a revised and updated version of the book edited by Sanderson (1977). Priority research and management activities identified in these books served as a tool for evaluating proposals submitted to the WMGB Research Program for funding.

AFWA's MSUGB Working Group (formerly MSUGB Subcommittee) provided key support in acquiring the additional funding. Due to the addition of funding for management-related projects (as opposed to research only projects), cooperators made the decision to drop "research" from the title of the WMGB Program.

The MSUGB Working Group created the MSUGB Task Force in 2006 in order to update the priority research and management needs identified in Tacha and Braun (1994) and to develop funding strategies for the identified priorities. The task force decided that the best method to identify priorities and estimate costs for completing the priorities was to convene a series of workshops for the webless species identified in Table 1. The workshops were designed to include broad representation from experts (e.g., federal and state agencies, conservation organizations, and university researchers) for each species-specific group. To date, the MSUGB Task Force has completed strategies identifying priority information needs for: (1) mourning and white-winged doves, (2) hunted rails and snipe, (3) sandhill cranes, (4) American woodcock, and (5) American coots, purple gallinules, and common moorhens. The final workshop covering the remaining species (Zenaida doves, white-tipped doves, scaly-naped pigeons, and band-tailed pigeons) was completed in early 2011. The completed priority information-need strategies are available on-line at: www.fws.gov/migratorybirds/NewReportsPublications/Research/WMGBMR/WMGBMR.html.

These webless funding programs have proved to be invaluable in providing much-needed funding for webless species that receive considerably less attention than waterfowl. To date, the Webless Program has supported a total of 118 research and management related projects totaling $5.5 million in WMGB Research and Management Program funds. The WMGB Program funds have generated matching contributions of $10 million from cooperators for a total $15.5 million being expended on webless species (Table 2). Projects completed through the program have resulted in improved knowledge and management of webless migratory game birds. Previous annual abstract reports containing results of projects completed through the program are available on-line at: www.fws.gov/migratorybirds/NewReportsPublications/Research/WMGBMR/WMGBMR.html

Table 2. Summary of projects funded through the Webless Migratory Game Bird Program, 1995-2012[1].

Species Group	**No. of projects**	**WMGBP Funds**	**Matching Funds**	**Total Project Cost**
Doves and Pigeons	41	$2,166,278	$3,953,396	$6,119,674
American Woodcock	16	$1,137,748	$2,161,318	$3,299,066
Sandhill Crane	20	$887,329	$2,035,237	$2,922,566
Marshbirds[2]	25	$1,115,356	$1,845,290	$2,960,646
Webless Workshops/other[3]	16	$168,095	$41,213	$209,308
Total	118	$5,474,806	$10,036,454	$15,511,260

[1] Includes projects funded through FY 2012 Webless funds
[2] Includes sora, Virginia rail, king rail, clapper rail, purple gallinule, common gallinule, American coot, and Wilson's snipe
[3] Includes a series of 6 workshops held during 2008-10 where priority information needs for webless species were identified

Program Administration

The USFWS Project Officer for the WMGB Program distributes an annual request for proposals (RFP) in May to USFWS Flyway Representatives, Regional Migratory Bird Coordinators, USGS-Biological Research Division (BRD) Regional Offices, and the USGS Cooperative Research Units office. In addition, the funding opportunity is posted at: www.grants.gov. Flyway Representatives are responsible for distributing the RFP to biologists in their respective states. State biologists, in turn, are asked to send the information to other state personnel, universities, and any others who may be interested. Migratory Bird Coordinators forward the letter to National Wildlife Refuges and other federal offices. USGS-BRD Regional Offices are asked to forward the RFP to all their respective Science and Technology Centers, while the Cooperative Research Units office distributes the RFP to all Cooperative Fish and Wildlife Research Units. Funding proposals may be submitted for any webless migratory game bird identified in Table 1. Proposals may be orientated toward research or management-related projects. At least 1/3 of the total project cost must come from a funding source other than the WMGB Program. In-kind services, such as salaries of state employees and vehicle expenses, are acceptable as matching funds. Additionally, a letter of support is required for each proposal from the state in which it originates. Proposals for the program are due by November 1 each year.

Four regional review committees (Fig. 1) that follow the boundaries of the North American Flyways (Fig. 2) rank all proposals submitted to the program. The Flyway-based committees are composed of individuals with knowledge of the research and management needs for these species. The chairperson of each Flyway-based review committee serves on a National Review Committee (NRC), which makes final project selections based on input from each Flyway-based committee. The NRC is composed of the Flyway-based Chairs, the U.S. Fish and Wildlife Service Program Manager, and Representatives from the Migratory Shore and Upland Game Bird Support Task Force. The NRC evaluates and ranks proposals based on how well the proposals address the priority information needs that have been identified for the 16 species of Migratory Shore and Upland Game Birds (see Appendix A for specific priorities). After project selection, the NRC is responsible for developing an explanation documenting why successful projects were selected for funding. In addition, the NRC provides unsuccessful applicants with comments on why their project was not funded.

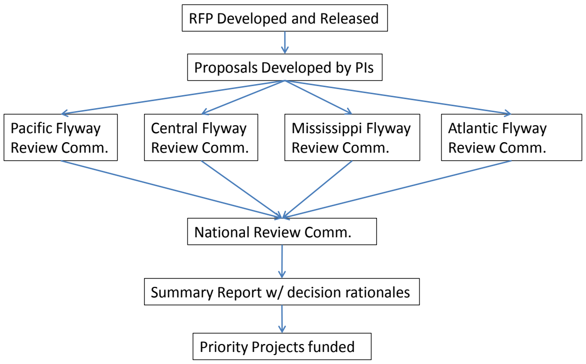

Figure 1. Diagram of review process for proposals submitted to the Webless Migratory Game Bird Program.

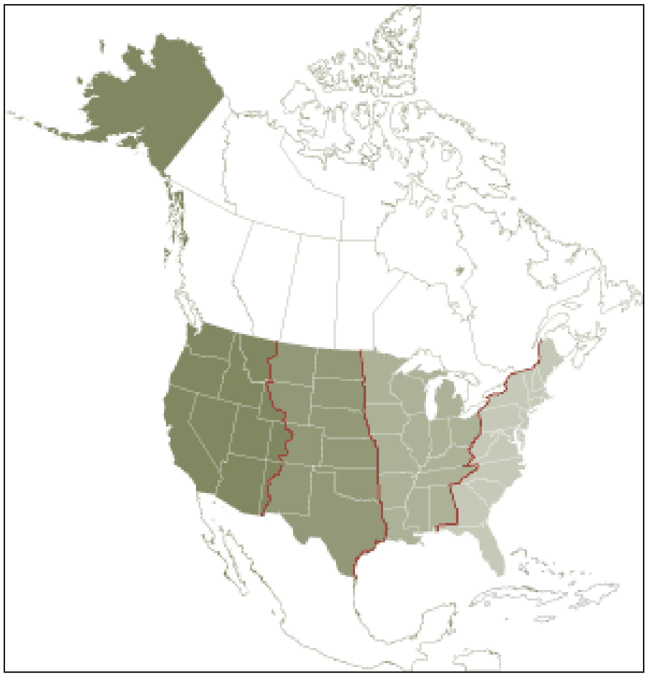

Figure 2. Map of North American Flyway boundaries in the United States. Proposals working with the 16 species identified in Table 1 will be accepted from throughout North America.

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Appendix A – Priority Information Needs for Migratory Shore and Upland Game Birds

Priority information needs have been developed for the following groups: 1) mourning and white-winged doves; 2) hunted rails (sora, clapper, king, and Virginia) and Wilson's snipe; 3) sandhill cranes; 4) American woodcock; 5) American coots, common moorhens, and purple gallinules; and 6) band-tailed pigeon, scaly-naped pigeon, Zenaida dove, and white-tipped dove. Proposals should address the priorities listed below for each species group. A full description and justification are available at www.fws.gov/migratorybirds/NewReportsPublications/Research/WMGBMR/WMGBMR.html.

Mourning and White-winged Dove Priorities:

- Implement a national banding program for doves
- Implement a national dove parts collection survey
- Develop independent measures of abundance and/or trends for doves
- Create a database of predictors of dove vital rates

Hunted Rails and Wilson's snipe Priorities:

- Implement a national monitoring program
- Continue to improve the Harvest Information Program sampling frame
- Improve the rails and snipe parts collection survey
- Estimate vital rates to support population modeling

Sandhill Crane Priorities:

- Improve Sandhill Crane Harvest-Management Decision Structures
- Improve the Eastern Population Sandhill Crane Survey
- Better understand distribution and population trends for sandhill crane populations in the west
- Assess Effects of Habitat Changes on the Rocky Mountain Population of Sandhill Cranes
- Improve Population Abundance Estimates for the Mid-Continent Population of Sandhill Cranes

American Woodcock Priorities:

- Develop a demographic-based model for assessing American woodcock population response to harvest and habitat management
- Develop communication strategies to increase support for policies and practices that benefit American woodcock and other wildlife of young forests
- Improve understanding of migration, breeding, and wintering habitat quality for American woodcock
- Improve the American woodcock Singing-ground Survey

American Coot, Common Moorhen, and Purple Gallinule Priorities:

- Implement a national marshbird monitoring program
- Support National Wetlands Inventory updates and improvements
- Continue to improve the Harvest Information Program sampling frame
- Determine the origin of harvest in select high harvest states in order to help inform monitoring programs

Band-tailed Pigeon, Zenaida Dove, White-tipped Dove, and Scaly-naped Pigeon Priorities:

- Reliable demographics of band-tailed pigeons
- Association of food availability with abundance and distribution of band-tailed pigeons
- Status assessment of white-tipped doves in south Texas to determine distribution, population abundance, and biology
- Population and harvest data collected annually for Zenaida doves and scaly-naped pigeons
- Adaptive harvest strategy for Zenaida doves and scaly-naped pigeons

Webless Migratory Game Bird Research Program Projects
Progress to Date

Mourning Doves

HARVEST AND CRIPPLING RATES OF MOURNING DOVES IN MISSOURI

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Final Report

Mourning dove (*Zenaida macroura*) harvest management requires an assessment of birds shot and not recovered (hereafter crippled doves) to determine harvest mortality. However, estimating crippling rates is challenging. We estimated mourning dove harvest mortality in Missouri, which included crippling rates, by monitoring radio-marked doves. We also compared crippling rates of radio-marked doves to hunter-reported estimates of crippling. During 2005–2008, we estimated annual harvest mortality between 23–30% on one locally managed public hunting area. Crippling rates ranged from 18–50% of harvest mortality in radio-marked doves (Table 1). In comparison, hunter-reported crippling rates during 2005–2011 (14−18%) were, on average, 30% lower but more consistent than estimates from radio-marked doves (Table 1). During 2005–2008, harvest mortality of radio-marked doves was 27%, with one quarter of this mortality coming from crippled doves (Table 1). These results demonstrate crippling was a sizeable component of dove harvest; however, it was within the range of earlier crippling rate estimates for doves. Bias in hunter-reported crippling rates could result in overharvest if not accounted for. Future harvest management decisions should not overlook the potential impacts of crippling on populations, especially on locally managed public hunting areas. Field work on this project concluded during 2008 with analysis and reporting on various other manuscripts; this abstract is one of several documents constituting the final report. Funding and support for this work were provided by the Missouri Department of Conservation–Resource Science Division, the University of Missouri–Department of Fisheries and Wildlife Sciences, and by the U.S. Fish and Wildlife Service Webless Game Bird Research Grant Program.

David Dolton (retired USFWS) watches Tony Mong implant a subcutaneous radio transmitter in a mourning dove captured and released on the James A. Reed Memorial Wildlife Area. *Photo by Missouri DOC*

Table 1. Harvest and crippling of mourning doves on the James A. Reed Memorial Wildlife Area during 2005–2011. Harvest rates (*h*) and crippling rates (*c*) of were derived from numbers of radio-marked recovered and crippled doves available on the area during the first 2-days of the annual managed hunt. Estimated hunter-reported crippling rates (*c*) are based on surveys of all hunters visiting the area during the same 2-day period.

	Radio-marked data						Hunter-reported data		
Year	Available [a]	Recovered[b]	Crippled[c]	Harvest mortality[d]	h^e	c [f]	Recovered	Crippled	c
2005	73	14	3	17	0.23	0.18	6039	1076	0.15
2006	88	20	6	26	0.3	0.23	5000	1006	0.17
2007	21	3	3	6	0.29	0.5	1818	408	0.18
2008	41	8	3	11	0.27	0.27	2406	479	0.17
2009	-- [d]	--	--	--	--	--	2052	415	0.17
2010	--	--	--	--	--	--	1745	363	0.17
2011	--	--	--	--	--	--	2088	330	0.14
Total	223	45	15	60	0.27	0.25	21148	4077	0.16

[a] Sample size of radio-marked doves detected on the area during harvest.

[b] Radio-marked doves that were recovered: number of radio-marked doves shot, recovered by hunters, and checked by hunters.

[c] Radio-marked doves that were crippled: number of radio-marked doves shot but not recovered by hunters.

[d] Harvest mortality of radio-marked doves: recovered radio-marked doves + crippled radio-marked doves.

[e] Harvest rate of radio-marked doves: proportion of radio-marked doves that were available on the site that were either shot and recovered by hunter (recovered radio-marked dove) or shot but not recovered by hunter (crippled radio-marked dove).

[f] Crippling rate of radio-marked doves: proportion of harvest mortality of radio-marked doves that were crippled (shot but not recovered by hunter).

DEVELOPMENT OF A TEMPORALLY AND SPATIALLY EXPLICIT MODEL OF MOURNING DOVE RECRUITMENT FOR HARVEST MANAGEMENT

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Progress Report; Expected Completion: Fall 2013

Introduction

A coordinated effort by state and federal agencies has been undertaken to improve our understanding of the harvest dynamics of mourning doves and to better manage populations. The mourning dove national strategic harvest management plan was developed as part of this effort, calling for the implementation of an informed strategy for harvest derived from predictions based on population models of the species (USFWS 2004). Establishing monitoring programs for population vital rates was a critical component of the plan. This included instituting a large-scale operational program for monitoring reproductive rates and determining how to integrate data from the monitoring program into harvest decision making. In 2005, with the cooperation of 22 state agencies, US Fish and Wildlife Service personnel, and funding from the Webless Migratory Gamebird Research Grant program, a pilot harvest parts collection program began as the first step in developing a national program for monitoring dove recruitment rates (Miller 2009, Miller and Otis 2010). This was followed in 2007 with the implementation of a national mail survey conducted by the US Fish and Wildlife Service and which now serves as the operational program for monitoring dove recruitment. These wings are aged by state and federal biologists at an annual wing bee that has been hosted each year by the Missouri Department of Conservation

This abstract summarizes results of the first year of a new 3-year study funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service). The work focuses on developing an initial model for recruitment, which will serve as a link between the recently implemented recruitment monitoring effort and the development of a population model that can be used in a decision support framework for harvest management. Previous work has suggested potentially useful structure for a recruitment model that can be used in the context of harvest decision making (Runge et al. 2002, USFWS 2004, AFWA 2008,Miller 2009, Otis 2010). Three basic components for such a model are:

1) Mean recruitment estimates: Previous work has demonstrated large geographic variation in dove recruitment rates (Miller and Otis 2010). Differences in recruitment among the 3 dove management units are a necessary minimum that must be estimated when determining harvest effects. Further work to determine within region differences in recruitment will provide further insights about how life-history variation is structured across the range of the mourning dove.
2) Environmental effects on annual variation: Large-scale drivers of annual variation in recruitment are likely to be due to annual variation in weather (Runge et al. 2002, AFWA 2008, Miller 2009). Weather patterns can be correlated across large spatial scales necessary to create synchronized annual variation across regions used for management. The degree to which this will be useful part of a recruitment model will depend on whether or not correlated large-scale variation in recruitment occurs, whether weather predicts this recruitment variation, and whether this variation can be incorporated into predictions on a time-scale useful for harvest decision making (AFWA 2008).
3) Density-dependent effects: Density-dependence can have significant impacts on recruitment rates (Runge et al. 2002) and has important implications for harvest decision making (Runge et al. 2006). Density-dependence is one of the mechanisms that can lead to surplus availability of birds for harvest and therefore should be incorporated into a useful model if it occurs for doves.

Though these factors are not exhaustive, understanding them is an important first step in predicting recruitment dynamics and serve as a bridge between current monitoring efforts and the proposed harvest decision making framework.

Wings are scored annually at the Mourning Dove Wing Bee held outside of Kansas City, Missouri.
Photo by David Miller

Completed Work

The first step in completing the project was to develop a comprehensive analysis framework for estimating recruitment parameters from the mail survey data. The mourning dove parts survey has the advantage of most wings collected during the first weeks of September are local birds. Greater than 93% of band-returns for harvested doves come from less than 100 km from where banding occurred. Thus, the survey provides local replication across their range that can be used to determine patterns. Proper analysis that takes advantage of this replication needs should account for the fact that only a small number of wings are collected at any location and that spatial autocorrelation is likely to occur among collection points.

I have developed a hierarchical modeling framework to analyze the data that addresses these issues. When wings are collected the county where they were harvested is recorded. Wings are assigned a spatial location by the centroid of the county and are aggregated to cells from hexagonal grid that spans their range. The hierarchical model accounts for sampling error related to sample size and local variation within cells by treating the number of hatch-year individuals in the sample as repeated binomial samples. Spatial correlation among cells is accounted for using a conditional autoregressive (CAR) parameter. Accounting for spatial correlation has the advantage of borrowing information among cells when estimating recruitment. In addition, accounting for spatial correlation is important to address the lack of independence among close by collection points for future work that will examine factors related to recruitment variation.

As an initial proof of concept I conducted 2 analyses, the results of which were shared with state cooperators at the Central Management Unit Technical Meeting in March of this year. First I estimated mean recruitment rates for each of the cells using all years of data (Fig.1 – panel 1). The results indicated a high-level of spatial correlation among cells and are consistent with previous analyses of the initial wing collection data (Miller and Otis 2010). In general, recruitment was highest in the eastern states and lower in the western states. In the west, recruitment was higher in the northwest and was lowest in a region that spanned from Arizona to west Texas. The results indicate that very different recruitment patterns occur among the 3 dove management units. This has implications when estimating the impact of harvest on dove population dynamics.

The second analysis I conducted was to estimate annual variation in recruitment. In Fig. 1 (panel 2 – 6), I present annual differences from then mean value in recruitment. Thus, positive values (yellow and orange) indicate an above average year and negative values (green) a below average year. Although much noisier than the pattern for mean recruitment, the results indicate that annual variation in reproductive output may also be synchronized across large areas. For example, in the eastern states recruitment was nearly universally high in 2007 and 2011 and low in 2009 and 2010, with a split between northern and southern states in the east during 2008. Although preliminary, these results suggest that relevant variation (i.e., differences at the management level) occurs in annual recruitment

Next Steps

I am currently working on building more comprehensive models for spatial variation. The goal will be to determine how some simple habitat measures (e.g., mean annual rainfall, forest cover, and human development) relate to geographic variation in recruitment. I anticipate finishing this component of the project by this coming fall.

In addition, I have conducted preliminary analyses to look at the relationship between weather and annual recruitment. These indicate a strong role for summer conditions in predicting reproductive output (Fig. 2). However, these were based on a relatively short sampling period (3 years) and ignored spatial issues. Once wing data and weather covariates are available for 2012, I will begin to integrate this component into the estimated recruitment model.

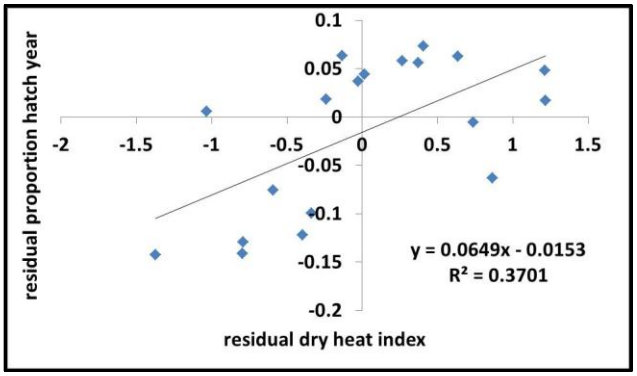

Figure 2. Preliminary results suggest summer conditions can affect mourning dove recruitment at the regional level. This figure shows the relationship between residuals for the annual proportion of hatch year wings in the mail survey sample and the residual for the annual dry heat index for 2007 to 2009. Each point represents values for a single year and region combination (regions were southeast, south-central, southwest, northeast, north-central, and northwest). Future work to explore these patterns will incorporate additional years of data and a more robust methodology to estimate effects

Acknowledgements

Special thanks goes to the efforts of all the state agencies involved in the initial pilot recruitment monitoring effort and the current monitoring effort. Dave Otis, John Schulz, Mark Seamans, Paul Padding, Ken Richkus, Khristi Wilkins, Robert Raftovich, and Philip Dixon have all provided significant technical and logistic support.

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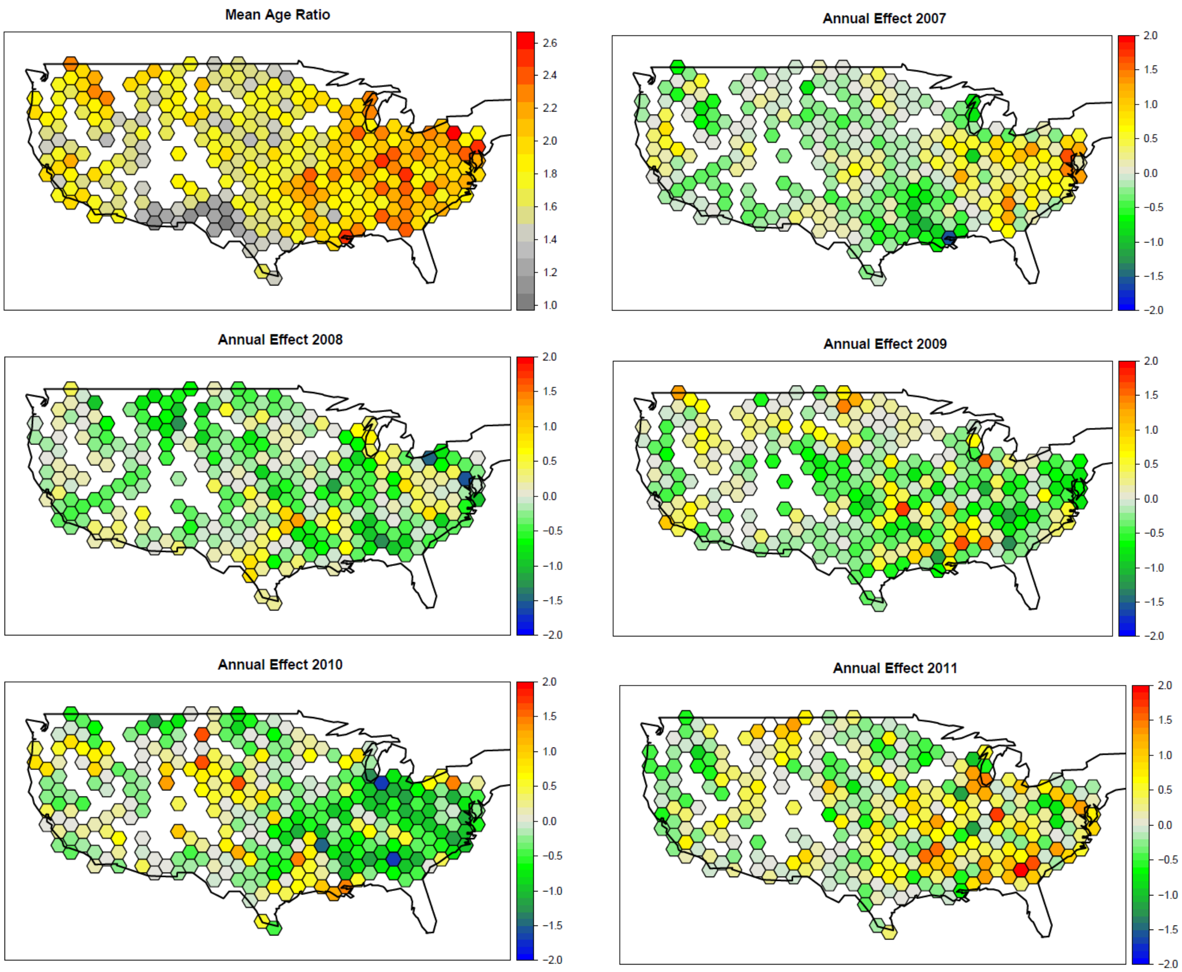

Figure 1. Estimated age ratios of mourning dove wings collected by the U.S. Fish and Wildlife Service mail survey from 2007 to 2011. Values are plotted for all cells where wings were actually collected and are estimated using a hierarchical model that accounts for spatial autocorrelation. Mean age ratios are highest in the eastern part of the range and are lowest in the region from western Texas to Arizona. Annual differences from the mean for each of the 5 years show some evidence of regional correlation consistent with an influence of large-scale processes affecting annual recruitment**.**

IMPROVING THE DESIGN AND COUNT METHODOLOGY OF THE MOURNING DOVE CALL-COUNT SURVEY IN THE EASTERN AND CENTRAL MANAGEMENT UNITS: PILOT STUDY, APRIL–JUNE 2011 AND 2012

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Progress Report; Expected Completion: 2013

The goals of this project are (1) to augment the value of monitoring data for harvest management by improving the design and methodology of the Mourning Dove Call-Count Survey, and (2) to provide an independent measure of abundance that can be used in combination with band-recovery and part-collection survey data to guide regulatory decisions, estimate population trends, and make predictions about population response to management. To achieve these goals, we are surveying on-road and off-road points and analyzing survey data using a combination of count methods (e.g., conventional, multiple-covariate, and hierarchical distance sampling). In addition to point location (1 = on-road, 2 = off-road), we are exploring the effect of multiple covariates that may affect mourning dove detection probability and abundance along and away from roads (e.g., 2-observer team, cluster size, detection time, detection form, time of day, sampling period, vegetation cover, and disturbance level among others).

Table 1. Survey effort ($k = 423$ points) and sample size ($n = 582$ detections before data truncation at distance $w = 180$ m). Points were visited 3 times (April 16–30, May 1–14, May 15–June 5).

State	Route	On-road point	Off-road point	Period 1 count	Period 2 count	Period 3 count
PA	6	62	59	30	52	43
DE	2	23	18	16	18	17
MD	4	46	35	49	53	67
VA	1	10	10	16	13	21
WV	3	31	29	32	42	40
NC	3	33	27	81	87	97
SC	2	20	20	21	28	24
Total	21	225	198	245	293	309

We conducted training workshops at Patuxent Wildlife Research Center (Apr 2011) and Texas A&M, Kingsville (Apr 2012). In this report we provide details of conventional and multiple-covariate distance sampling surveys conducted by 20 2-observer teams at 225 on-road points and 198 off-road points in 21 call-count routes in 7 states of the Eastern Management Unit (Table 1 and Fig. 1).

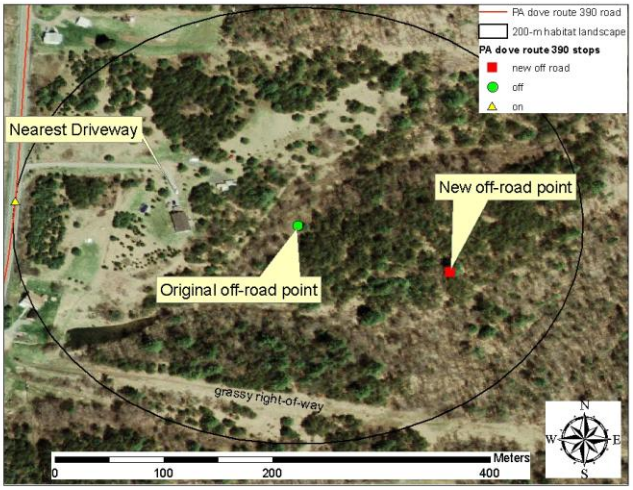

Figure 1. Off-road point and habitats on Route 390 in Pennsylvania, off-road points were located 200–400 m from the nearest paved or unpaved road, including driveways.

On-road and off-road points were sampled 3 times in April 16–30, May 1–14, and May 15–June 5 (i.e., survey effort/point, $v = 3$). Aural and visual detections were recorded during 6 1-min counts/point. Detection form was recorded as heard only (1 = no visual contact) or heard-seen or seen only (2 = visual contact). Two-observer teams surveyed all points, with one observer recording the data and the other measuring detection distances. Both observers remained side by side for 6-min, recording the time of first detection (6 1-min intervals) and measuring radial distances to calling and noncalling doves detected singly or the geometric center of clusters. A cluster was defined as 2 or more doves within 10 m of each other, showing similar behavior (e.g., feeding on the ground). Rangefinders were used to measure exact detection distances. However, when this was not possible (e.g., dove heard only), detections were grouped into distance categories (0–15, 16–30, 31–45, 46–60, 61–90, 91–120, 121–180, 181–240, 241–340, and 341–440 m). The purpose of having two-observer teams was to increase the chance of meeting method assumptions (i.e., detecting all doves at point centers; determining their initial locations before movement; estimating cluster sizes accurately; and measuring distances exactly or at least allocating singles and clusters to correct distance categories).

We truncated the distance data (w = 180 m) to reduce cluster size-bias effect, remove outliers, and improve the fit of detection models. After data truncation, we evaluated the fit of detection models with quantile-quantile plots and goodness-of-fit tests. Model selection was based on minimization of Akaike Information Criterion (AIC). Models with differences in AIC < 2 were considered to be equally supported by the data. We used nonparametric bootstrapping for robust estimation of standard errors and 95% confidence intervals, and accounted for model selection uncertainty through model averaging.

We made 582 mourning dove detections (n) at 423 surveyed points (k). Detection form was the only covariate that caused heterogeneity in the detection function of mourning doves (Table 2, Figs. 2 and 3). Overall, estimated density was 0.114 doves/ha (95% CI = 0.076, 0.174), encounter rate (n/K) was 0.308 (0.306, 0.309), detection probability was 0.371 (0.339, 0.406), and effective radius of detection was 110 m (105, 115; Tables 3 and 4). Factors affecting detection probability were the most important with respect to density variation; and the main source was detection form. Detection probability was 0.643 (0.502, 0.822) for doves heard only and 0.221 (0.165, 0.297) for doves heard/seen or seen only (Table 5). Density was 0.047/ha (0.033, 0.063) for doves heard only and 0.061//ha for doves heard-seen or seen only (Table 6).

We tested a number of hypotheses, including a positive road bias on mourning dove detection and abundance. However, on-road detection was 0.339 (0.261, 0.440), off-road detection was 0.271 (0.142, 0.519), on-road density was 0.057/ha (0.034, 0.083), and off-road density was 0.052/ha (0.032, 0.076; Tables 7 and 8).

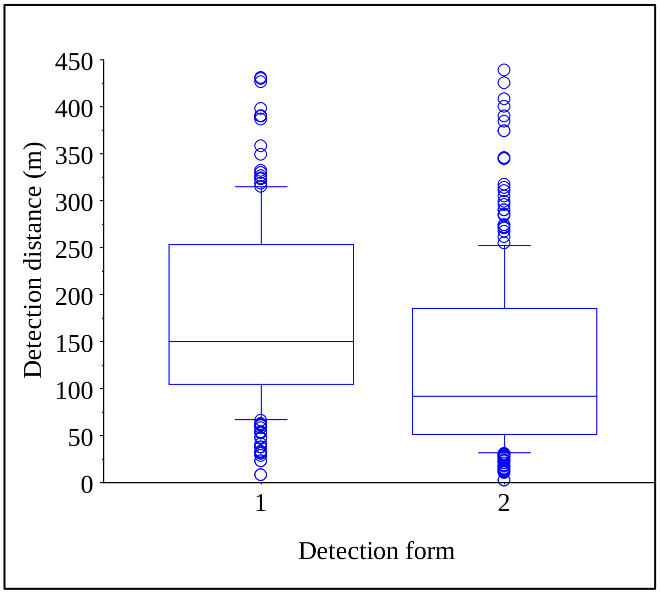

Figure 2. Box plot of mourning dove detection distance and detection form (1 = heard only, 2 = heard and seen or seen only).

From these results, we concluded (1) that the value monitoring data can be augmented by improving survey design and count methods, and (2) that it is possible to provide an independent measure of density (number/unit area) and abundance (number in survey region) for mourning dove harvest management. In April–June 2012, we are planning to repeat surveys in the Eastern Management Unit and initiate surveys in the Central Management Unit (TX, AR, OK, KS, CO, LA, and NM).

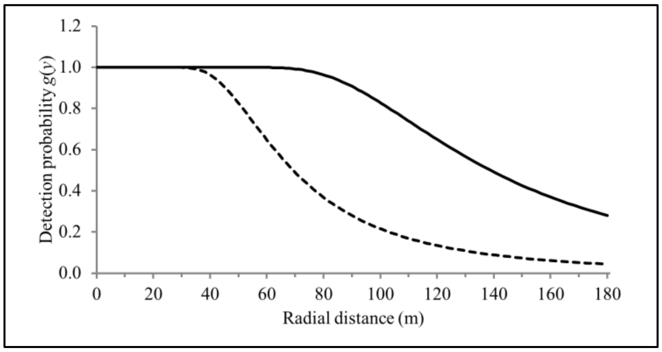

Figure 3. Detection functions of mourning doves heard only (solid line) and heard-seen or seen only (dashed line).

Table 2. Top 10 detection models for mourning doves (k = 423, n = 372, w = 180 m).

Key	Series	Covariate	AIC	ΔAIC
Hazard rate	None	Detection form	3,793.86	0.00
Hazard rate	1 cosine	Detection form	3,794.26	0.40
Half-normal	1 cosine	Detection time	3,799.19	5.33
Half-normal	None	Detection form	3,805.03	11.16
Hazard rate	None	Detection time	3,820.06	26.19
Half-normal	1 cosine	None	3,820.82	26.95
Hazard rate	1 cosine	None	3,822.05	28.18
Hazard	None	None	3,822.83	28.97
Hazard rate	None	Traffic	3,823.72	29.86
Hazard rate	None	Time of day	3,824.00	30.14

Table 3. Mourning dove density and abundance estimates during 3 sampling periods (v = 3 visits/points).

Period	***D***	**SE**	**CV**	***N***	**SE**	**2.5%**	**97.5%**
1	0.098	0.021	0.208	2,512	523	1,654	3,635
2	0.097	0.033	0.339	2,484	845	1,548	4,315
3	0.146	0.048	0.331	3,731	1,233	2,006	6,579
Overall	0.114	0.025	0.215	2,913	626	1,939	4,444

Table 4. Mourning dove encounter rate, detection probability, and effective radius of detection (m) during 3 sampling periods (v = 3 visits/points).

Period	***n*/*K***	**SE**	***Pd*|*a***	**SE**	***p***	**2.5%**	**97.5%**
1	0.270	0.089	0.334	0.027	104	96	113
2	0.267	0.099	0.364	0.031	109	100	118
3	0.344	0.131	0.314	0.027	101	93	110
Overall	0.308	0.080	0.371	0.017	110	105	115

Table 5. Detection probability and effective radius of detection of mourning doves heard only and heard-seen or seen only

Detection form	***Pd|a***	**SE**	***p***	**2.5%**	**97.5%**
Heard only	0.643	0.080	144	128	163
Heard-seen or seen only	0.221	0.033	85	73	98

Table 6. Estimated density of mourning doves heard only and heard-seen or seen only

Detection form	***D***	**SE**	**CV**	**2.5%**	**97.5%**
Heard only	0.047	0.008	0.174	0.033	0.063
Heard-seen or seen only	0.061	0.014	0.224	0.037	0.090

Table 7. Detection probability and effective radius of detection of mourning doves detected along roads and away from roads

Point location	***Pd|a***	**SE**	***p***	**2.5%**	**97.5%**
On road	0.339	0.045	105	92	119
Off road	0.271	0.046	94	67	131

Table 8. Estimated density of mourning doves detected along roads and away from roads

Point location	***D***	**SE**	**CV**	**2.5%**	**97.5%**
On road	0.057	0.013	0.228	0.034	0.083
Off road	0.052	0.012	0.231	0.032	0.076

White-winged Doves

DEVELOPMENT AND EVALUATION OF A PARTS COLLECTION SURVEY FOR WHITE-WINGED DOVES (*ZENADIA ASIATICA*) IN THE SOUTHWESTERN UNITED STATES

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Undergraduate Students: Kyle Hand, Taylor Jacobs, **Progress Report**; **Expected Completion:** Fall 2013

Project Justification

Information on harvest age ratios (ratio of immature birds per adult in the harvest) combined with data on age-specific harvest vulnerability reported from banding studies represents the foundation for estimating population level recruitment of migratory game birds (Munro and Kimball 1982). Estimates of recruitment, when combined with data on population distribution, size, and survival, provide the basis for development of population models focused on adaptive harvest management of dove species within the United States (Runge et al. 2002).

Age ratio data are typically acquired via part collection surveys where parts (typically wings) from harvested individuals (e.g., doves, waterfowl, woodcock) are collected via mail surveys or collection stations and aged based on morphological characteristics (Morrow et al. 1995, Mirarchi 1993, Miller and Otis 2010). As outlined in the "Priority Information Needs for Mourning and White-winged Doves" (Ad Hoc Dove Advisory Committee 2008), development of an operational dove parts collection program for both mourning and white-winged doves was identified as a major priority. This priority is repeated in the 2010 Webless Migratory Game Bird Program RFP: Appendix A, highlighting the importance of accurate PCS methods. One major problem exists with the current status of the United States Fish and Wildlife Services (USFWS) Parts Collection Survey (PCS) for doves within the U.S.; only the mourning dove has a practical parts collection aging key, and even this key is not 100% accurate (Cannell 1984, Miller and Otis 2010). This lack of fundamental information limits management activities, particularly where regulatory restrictions are expected to be based on informed knowledge of species population trajectories. Especially troubling is the fact that although white-winged dove harvest accounts for nearly 1.4 million doves harvested in the Central and Pacific Flyway and ≥500,000 hunter days afield (Raftovich et al. 2010), little or no effort has been focused on determining intermediate metrics necessary for estimating rangewide recruitment rates.

There have been several approaches suggested for aging white-winged doves. Early research indicated that the number of juvenile primaries present on harvested white-winged doves provided a good measure of individual age (Saunders 1944, but also reproduced in Cottam and Treften 1968: pp 324-325). Saunders (1950) key approximates age based on primary replacement (Swank 1955, Bivings IV and Silvy 1980), however aging based on primary replacement is known to exhibit considerable variation in mourning doves (Rous and Tomlinson 1967, Morrow et al. 1992) and we would expect a similar result with white-winged doves. George et al. (2000), working with data from 1950-1978, suggested that white-winged doves can be classified to juvenile or adult using a combination of leg color and primary covert color (thin white borders, pp 11). While these findings are likely based on the experience of the authors of this report, no data or reference information was provided to support this contention (George et al. 2000). Leg color has been indicated as a potential mechanism for accurate aging of white-winged doves by several authors (Cottom and Treften 1968, Uzzell, unpublished data). As detailed by Cottam and Treften (1968, pp 323-324), leg color age identification, with accuracy assessment using Bursa of Fabricius and primary molt, indicated high accuracy, but reliability estimates using these data were never published and are thus unavailable. Recent aviary work by Texas A&M University-Kingsville (Fedynich and Hewitt 2009) suggests primary molt sequence and presence/absence of buffy tipped primary coverts could be used in combination to potentially segregate juveniles from adults, but variability was high for the oft cited buffy-tips on primary coverts (range between 104 and 161 days based on a sample of n ≤ 20 captive individual) leading to considerable variation in the final predictive accuracy. Thus, although referenced in several locations, we have found no definitive, research data which has proven useful for classifying white-winged doves to age classes (HY, AHY) for use in a PCS.

Our inability to accurately quantify age of harvested white-winged doves based on wing morphology compromises the current USFWS PCS for white-winged doves and hinders development of adaptive harvest management strategies that provide for informed regulatory decision making for doves across the United States. Given these conditions, the focus of our study will be to 1) identify morphological characteristics that can be used to assign white-winged doves to age classes and easily incorporated into the U.S. Parts Collection Survey and 2) use those characteristics to develop an accurate approach to aging harvested white-winged doves across the species southwestern U.S. range.

Project Objectives:

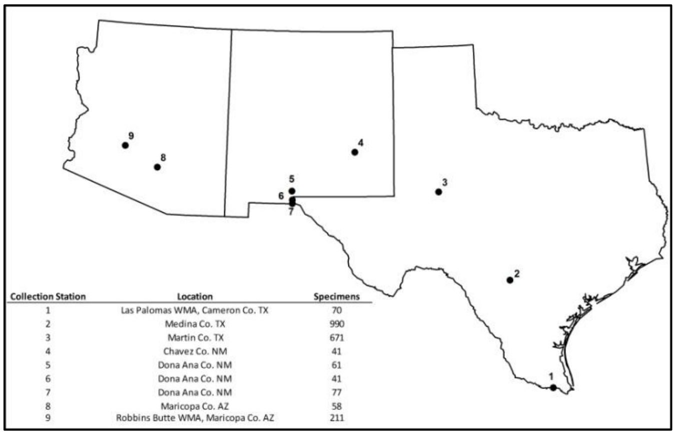
1. Identification of qualitative and quantitative morphological characteristics for use in accurately identifying age of harvested white-winged doves across the southwestern U.S.

2. Explore the relationship between estimated population productivity using harvest age ratios and independent estimates of recruitment from previous field research.

Methods

Study Sites & Data Collection

During the week of 1-6 September 2011, staff with the Institute of Renewable Natural Resources at Texas A&M University, in collaboration with personnel from the United States Fish and Wildlife Service, Texas Parks and Wildlife Department, New Mexico Department of Game and Fish, and Arizona Game and Fish Department collected and processed (see methods below) white-winged doves at 9 locations across Texas, New Mexico, and Arizona (Figure 1).



Collection Station	Location	Specimens
1	Las Palomas WMA, Cameron Co. TX	70
2	Medina Co. TX	990
3	Martin Co. TX	671
4	Chavez Co. NM	41
5	Dona Ana Co. NM	61
6	Dona Ana Co. NM	41
7	Dona Ana Co. NM	77
8	Maricopa Co. AZ	58
9	Robbins Butte WMA, Maricopa Co. AZ	211

Figure 1. White-winged dove collection locations during 2011.

Gross Morphological Evaluation

For each harvested bird (n = 2,220) we collected measurements of the following gross morphological metrics upon initial collection:

- Eye Ring Color (Cottam and Trefethen 1968, George et al. 1994)
- Iris Color (Cottam and Trefethen 1968, George et al. 1994)
- Leg Color (Cottam and Trefethen 1968, Uzell, unpublished data)
- Bill Color (Cottam and Trefethen 1968, George et al. 1994, Collier)
- Primary Covert Molt (Saunders 1950, Cottam and Trefethen 1968, George et al. 1994, Fedynich and Hewitt 2009)
- Primary Molt Pattern (Saunders 1950, Cottam and Trefethen 1968, Fedynich and Hewitt 2009)
- Weight (Proctor and Lynch 1993)
- Wing Chord Length (Proctor and Lynch 1993)
- Bill Length (bill from feathers; Proctor and Lynch 1993, Loncarich and Krementz 2004)
- Bill Depth (measured at the base; Proctor and Lynch 1993, Loncarich and Krementz 2004)
- Tarsus Length (Proctor and Lynch 1993)
- Tail Length (Proctor and Lynch 1993)

Laboratory Evaluation

To ensure accurate aging of birds while in hand, we will perform a laboratory necropsy on whole harvested individuals to determine presence and size of the Bursa of Fabricius (Proctor and Lynch 1993), as reduction in size (and involution) can be used to age from HY to AHY after 8th primary loss (Saunders 1950, Cottam and Trefethen 1968, Kirkpatrick 1994, Mirarchi 1993, Abbate et al. 2007). Bursa of Fabricius absence implies adult (Wight 1956), although remnants (<3mm) may remain (Mirarchi 1993). During necropsy, we will also inspect reproductive organs to determine sex (testis/ovary), obtain tissue samples for genetic evaluation, check frontal bone ossification (Miller 1946, Baird 1963), and collect feather samples for sexing white-winged doves using methods developed by Oyler-McCance and Braun (unpublished data).

After the initial aging and necropsy has been completed, we will collect from each individual 1 wing (left or right alternating between birds) cut at the proximal end of the humerus, tail fans (Oyler-McCance and Braun, unpublished data), and 1 leg (left or right alternating between birds) cut at the proximal end of the fibula. Measurements of tail feathers will be collected to evaluate the method developed by Oyler-McCance and Braun (unpublished data), and to compare methods for sexing white-winged doves.

Results

During the opening week of the 2011 dove season, we collected 2,220 legally harvested white-winged doves across the species range (Figure 2). By state, we collected 1,714 individual from 3 sites in Texas, 227 individuals from 3 sites in New Mexico, and 269 individuals from 2 sites in Arizona. Due to logistical constraints we were unable to sample in California during the 2011 season, but we have reallocated efforts such that we will collect in California during the 2012 season. A vast majority of hunters were interested and willing to participate in our study, and as such we collected over 1,500 whole birds (out of the 2,220 total) for further processing.

Table 1. Distribution of gross morphological characteristics for all samples measured to date (n = 1,058).

Adult Characteristic	Present	Absent
Blue Eye Ring	50.6%	49.4%
Red Iris	37.6%	62.4%
Black Bill	55.0%	45.0%
Red Legs	60.5%	39.5%
Buffy Coverts	63.6%	36.4%
P0	3.7%	
P1	5.8%	
P2	9.3%	
P3	9.3%	
P4	8.6%	
P5	10.1%	
P6	13.2%	
P7	13.9%	
P8	11.9%	
P9	9.5%	
P10	4.7%	

To date, 1058 samples have undergone preliminary screening (quality control inspection confirming accurate field data entry) and entered into the database. Descriptive statistics of measured anatomical variables for these samples are presented (Table 1) for all birds. The distribution of gross morphological characteristics is presented using the field classification categories of “Adult” or “Other” based upon the combined presence blue eye ring, red iris, black bill, and red legs (Table 2). Primary molt (Figure 2) using field classification categories (adult or other) indicated a trend in molt number relative to age. Additionally, based on the field samples collected this year, it seems that a combination of 2-3 morphological metrics (buffy coverts, white-fringed alular quills, scalloped scapular/tertiary coverts) may provide a highly accurate method for wing-based aging (Figure 3).

Currently laboratory measurements of whole birds is ongoing with expected completion of 2011 samples by August 2012.

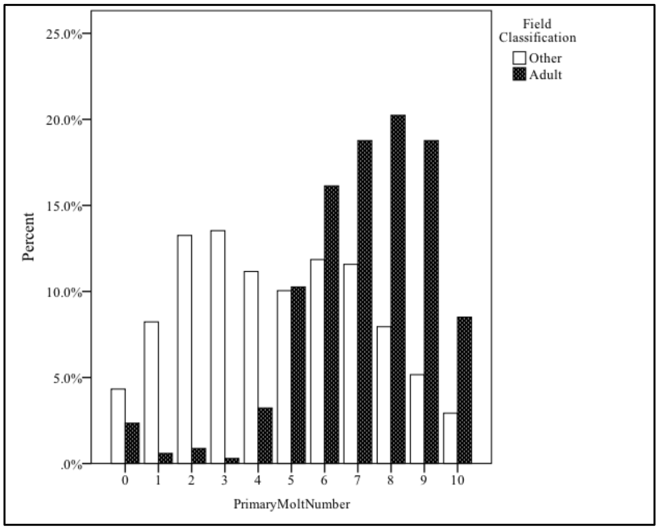


Figure 2. Primary molt pattern for white-winged doves collected across the southwestern United States during 2011.

Finally, we are archiving wing, deck feathers, and multiple tissue samples within the specimen collection at the Texas Cooperative Wildlife Collections http://www.wfsc.tamu.edu/tcwc/tcwc.htm) at Texas A&M University. The specimens archived from our work will represent the largest, and to our knowledge only, white-winged dove specimen collection in the nation providing an host of information for future study of white-winged dove ecology.

Acknowledgements

Our results represent data from the first year of a 3 year study funded by the Webless Migratory Game Bird Management Program (U.S. Fish and Wildlife Service) and the Texas Parks and Wildlife Department, with field support provided by Texas Parks and Wildlife Department, New Mexico Department of Game and Fish, Arizona Game and Fish Department, and California Department of Fish and Game.

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Table 2. Anatomical variables by field classification (adult or other) for all birds to date (n = 1,058).

Field Classification		Weight	Bill Length	Bill Depth	Bill Width	Tarsus Length	Tail Length	Wing Length
Other	N	717	717	717	717	717	717	717
	Mean	138.4	12.7	4.1	3.9	24.9	104.0	154.4
	SD	18.1	1.2	0.4	0.6	2.8	11.2	7.1
Adult	N	341	341	341	341	341	341	341
	Mean	148.0	12.6	4.3	3.7	25.8	107.1	156.4
	SD	14.3	1.0	0.5	0.5	1.5	9.5	5.3
Total	N	1058	1058	1058	1058	1058	1058	1058
	Mean	141.5	12.7	4.2	3.8	25.2	105.0	155.1
	SD	17.5	1.1	0.5	0.6	2.5	10.8	6.7

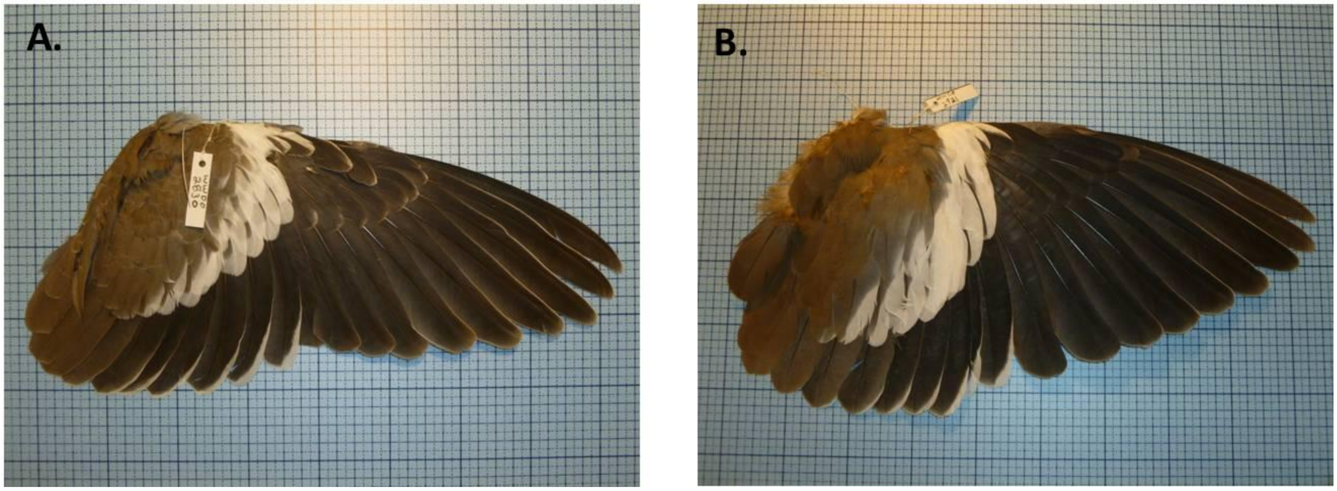

Figure 3: **A**. Hatch year white-winged dove wing showing buffy coverts, white-tipped alular quills, and scalloped scapular/tertiary; **B**. After hatch year white-winged dove wing showing lack of buffy coverts, lack of white-tipped alular quills, and lack of scalloped scapular/tertiary coverts. *Photo by Kyle Hand*.

Band-tailed Pigeons

BAND-TAILED PIGEON USE OF SUPPLEMENTAL SODIUM AND CALCIUM

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Final Report

Introduction

In the Pacific Northwest, band-tailed pigeons have a strong affinity for and use mineral sites (mineralized water or soil) during the nesting season (Sanders and Jarvis 2000). The principal attractant at these sites appears to be sodium ions, but the birds may also seek calcium ions. Pigeons in the U.S. Interior and southern Pacific Coast regions generally do not exhibit this behavior; however, the species should have the same physiology and mineral needs throughout its range. Band-tailed pigeons are thought to have an increased need for sodium, and possibly calcium, during the nesting season for egg and crop milk production. Specific information about the mineral needs and intake of breeding pigeons are unknown. However, the timing and region of mineral site use is associated with reproduction and the availability of red elderberry, cascara, and blue elderberry berries, which are known to be primary food items consumed by band-tailed pigeons when available. The properties of the berries most likely causing pigeons to seek supplemental minerals are high potassium content, low sodium and calcium content, high moisture content, high acidity, and secondary plant compounds such as alkaloids and tannins known to occur in red elderberry and cascara. A plausible explanation for differential mineral site use by band-tailed pigeons throughout their range is a more diverse fruit, acorn, and nut diet consumed by birds in the Interior and southern Pacific Coast regions and greater availability of mineralized grit or alkaline soils in the Interior region compared to the Pacific Northwest. The band-tailed pigeon need for supplemental sodium and calcium during reproduction or in association with a berry diet has not been tested experimentally, and information about the minerals associated with food items and mineral sites is currently limited to elderberry and cascara berries and mineral sites in Oregon. Also, the potential of grit to provide minerals differently across the species range has not been evaluated. Furthermore, band-tailed pigeons are counted annually at select mineral sites by wildlife agencies in British Columbia, Washington, Oregon, and California to monitor the status of the species (relative abundance) without a clear understanding of what factors may cause these counts to vary in time and space (other than population abundance and rainfall during counts) and information about the proportion of the population that these relative counts represent (i.e., density or absolute abundance).

Female band-tailed pigeon. *Photo by Todd A. Sanders*

My goal was to test the hypothesis that band-tailed pigeons need supplemental sodium and calcium during reproduction and in association with a berry diet and to determine supplemental mineral use patterns. Specific objectives were:

(1) Determine mineral content of crop milk, food items, grit, and mineral sites used by these

birds throughout their range in the Interior and Pacific Coast regions,

(2) Determine specific supplemental mineral selection and use patterns of captive and free ranging band-tailed pigeons, and

(3) Determine maintenance and reproductive consequences to captive band-tailed pigeons from restricted access to supplemental minerals when consuming an exclusively berry diet.

Methods

Essential components of the study necessary to accomplish objectives included: (1) collection and evaluation of ionic content of crop milk, food items, grit, and mineral sites known to be used by band-tailed pigeons throughout their range in the Interior and Pacific Coast regions; (2) a feeding trial to experimentally test whether reproduction and food items are associated with supplemental mineral use and to determine the consequences of limited access to minerals; and (3) monitoring of free ranging band-tailed pigeons at a mineral site to determine visitation patterns and use of specific minerals. Methods and results sections are organized under subheadings according to these primary study components.

Ionic content of resources

I collected the gizzard and crop contents from band-tailed pigeons in the Interior and Pacific Coast regions during 2008–2010. Most were voluntarily donated by sportsmen after collection in September, and birds in California, Oregon, and Washington were primarily harvested near mineral sites. Additionally in California, 84 birds were seized as illegal harvest in November and 22 were legally harvested in December near a mineral site. Twelve pigeons were collected via scientific collection permit in Washington during June at a mineral site. For each bird, crop and gizzard contents were examined to identify food items consumed, and where possible (i.e., in cases where crop glands were fully active), crop milk was collected in an individual sterile sample bag. I submitted crop milk samples to the Forage Testing Laboratory at Dairy One, Inc. for analysis of cation composition by induction-coupled plasma (ICP) spectrometer scan. Gizzard contents were washed into a glass beaker with deionized water and grit was carefully separated by floating lighter organic material to the surface. I determined the number, mass (oven dry), volume, size of pieces (via testing sieves or calipers) and angularity class (1 = angular, 2 = sub-angular, 3 = sub-rounded, 4 = rounded, and 5 = well rounded) of grit from each bird. Assessment of the food items consumed was used to verify published accounts (Keppie and Braun 2000, Braun 1994, Jarvis and Passmore 1992, Neff 1947) and provided the basis for subsequent food item sampling for mineral content. Although I collected no birds during mid-June through August, primary food items consumed were apparent from observations of flocks during food item collection and examination of droppings at mineral sites.

Mineralized water and salt deposits on rock outcropping at Jarbo Gap mineral site along the Feather River in northern California. *Photo by Todd Sanders*

The individual collections of grit from 60 randomly selected pigeons, 30 from each of the Interior and Pacific Coast regions, were submitted to the GeoAnalytical Lab at Washington State University for mineral composition determination via ThermoARL Advant'XP+ sequential X-ray fluorescence (XRF) spectrometer analysis. Samples were ground to a fine powder, weighed with di-lithium tetraborate flux (2:1

flux:rock), fused at 1000°C in a muffle oven, and cooled; the bead was then reground, refused, and polished on diamond laps to provide a smooth flat analysis surface. Samples were then assessed for composition of the 10 major and minor elements of most rocks, plus 19 trace elements.

I collected ≥1 sample of the fruit, acorn, and nut species consumed by band-tailed pigeons throughout their range in the Interior and Pacific Coast regions depending on plant species distribution. All samples were collected and analyzed in duplicate subsamples and results were averaged to produce a sample estimate. I submitted food item samples to the Forage Testing Laboratory at Dairy One, Inc. for analysis of cation composition by ICP spectrometer. Mineral results are presented based on percent of dry matter.

I sampled ionic content at all mineral sites known to be currently used by band-tailed pigeons in British Columbia, Washington, Oregon, and California where permission for access could be obtained. This included all of the sites were band-tailed pigeons are counted by government agencies to monitor the status of the species and other sites know to be used by these birds. A 0.5 l water (or soil sample if water was not available) was collected from each site after observing the general location that pigeons used and identifying the area with the greatest conductance measured with a conductivity meter. I submitted water and soil samples to Oregon State University's Central Analytical Laboratory for analysis of cation composition by ICP spectrometer scan.

Feeding trials

I conducted feeding trials in during summer 2009 and 2010 on 24 pairs of wild-caught band-tailed pigeons. Birds were captured in late May–early June prior to feeding trials in 2009 and kept overwinter together in 3 large outdoor aviaries for trials in 2010. During feeding trials, each pair was kept individually in an outdoor flight cage made of 14 gauge 2.5 × 2.5 cm galvanized welded wire mesh measuring 81 cm wide, 152 cm tall, and 122 cm deep with a removable dropping tray below each cage. I randomly assigned pigeons to a cage with the constraint that each cage contained a male and female. The sex of each bird was determined by plumage examination and submitting a blood sample from each pigeon via toenail clipping to Zoogen DNA Services for analysis of the DNA from the sex chromosomes of each bird via Polymerase Chain Reaction. Each cage had a wire mesh loft and plastic nest bowl with pad, 2 perch poles across the width of the cage made of about 5 cm diameter natural wood limbs, and 3 spill proof plastic containers: 1 for feed, 1 for fresh water, and 1 for mineral solution depending on treatment assignment. I randomly assigned each cage (i.e., pair of birds) to 1 of 4 treatment groups (*n* = 6 per treatment), and the mineral solution container was filled accordingly with either water, sodium chloride solution at 3,500 ppm sodium concentration, calcium chloride solution at 1,500 ppm calcium concentration, or sodium chloride and calcium chloride solution at 3,500 ppm sodium and 1,500 ppm calcium concentrations. Sodium and calcium solutions were similar in concentration to the mean of mineral springs used by band-tailed pigeons in Oregon (Sanders and Jarvis 2000). Birds were offered an unlimited amount of feed, water, and mineral solution (during feeding trials) and serviced daily. Cages and droppings trays were cleaned prior to the start of feeding trials each year and only as needed during trials to minimize disturbance, but nest bowls and food and water trays were replaced at least bi-weekly with sterilized replacements.

Feeding trials consisted of 3 to 5 consecutive weeks of feeding a single food item; either grain or elderberry or cascara berries. The grain was Fancier's Choice with 17% protein, a commercially available non-medicated animal feed specifically formulated for pigeons by Land O'Lakes, Inc. (guarantee analysis was 17% adjusted crude protein, 7.5% crude fiber, 6.0% crude fat, 0.06% calcium and 0.004% sodium). I fed birds Fancier's Choice prior to the start of the feeding trials in 2009 when birds adjusted to captivity and overwinter. Berries were wild picked, frozen, and thawed prior to feeding. Berries were kept ≤3 months. Band-tailed pigeon pairs were provided about 500 g of fresh berries daily, and generally consumed about 240–375 g per day. Feeding trials within a year were back to back. For feeding trials in 2009, I fed grains for 3 weeks followed by red elderberry for 5 weeks, cascara for 4 weeks, and red elderberry again for 4 more weeks while in 2010 I fed grains for 1 week, red elderberry for 5 weeks and cascara for 3 weeks. Only 12 pairs of overwintering birds were retained for the berry feeding trials in 2010 due to limited availability of berries, while the other 12 pairs remained on Fancier's Choice. I originally intended to feed birds blue elderberry during the last 4 weeks of feeding trials to simulate the natural progression of primary food item availability, but there was little available for collection due to poor berry production.

Evaporation was measured in 4 spill proof plastic containers placed adjacent to the cages and protected from animal access. I measured evaporation and fluid consumption based on weight once weekly less measured quantities added as needed during the week to maintain containers at full service level. Individual birds were weighed at the beginning and end of each feeding trial to the nearest 100th gram. A fecal sample was collected from each cage dropping pan during the last week of each feeding trial for assessment of mineral excretion. Dropping trays were cleaned 1–7 days prior to collection of fecal samples. I submitted fecal samples to the Forage Testing Laboratory at Dairy One, Inc. for analysis of cation composition by ICP spectrometer scan.

I also conducted a similar feeding trial on 30 pairs of wild-caught rock doves, primarily to evaluate reproductive performance associated with access to supplemental minerals, but rock doves were fed cracked corn during a single feeding trial in 2009 and Fancier's Choice during a single feeding trial in 2010. No fecal samples were collected from rock pigeons and fluid consumption was measured only during 2009. Young were weighed at fledging (25 days post hatch) and removed from breeding cages.

In 2009, there was no evidence that reproductive success, fluid (fresh, mineralized, and total) consumption, mass, or mineral excretion differed between water and calcium treatment groups or between sodium and sodium-calcium treatment groups (all 95% confidence intervals overlapped) for both band-tailed pigeons and rock pigeon feeding trials. Therefore, treatment groups were reduced for trials in 2010 to water or sodium chloride solution at 3,500 ppm sodium concentration, and all pairs were provided unlimited access to commercially available flint grit (insoluble Cherrystone Grit made from crushed 100% quartzite rock, small #1, similar in size to that found in necropsied birds) and oyster shell (calcium) grit. Fresh water consumption was not measured in 2010, but all birds again had access to fresh water regardless of treatment group.

Mineral site use

I tested the possibility of creating a mineral site during 2008–2011 in a forested area in southwestern Washington within the breeding range of band-tailed pigeons. The mineral site was maintained at least March through September each year. The mineral site design evolved over time, but generally consisted of a wood platform about 1.2 m above ground that held 2 or more round plastic trays. Trays were about 6 cm tall and 60 cm in diameter with 11 L capacity each. During pilot study work in 2008 and 2009, trays were filled with tap water, water from a mineral site known to be used by band-tailed pigeons, tap water and sodium chloride mixed to 3,500 ppm sodium concentration, tap water and calcium chloride mixed to 1,500 ppm calcium, or soil from the area finely sifted and mixed with sodium chloride to about 3,500 ppm sodium or calcium carbonate mixed to about 1,500 ppm calcium. Whole corn was placed around the site or in a tray on the platform to encourage pigeon discovery during March–May. Band-tailed pigeons quickly found and used the site beginning in 2008 and band-tailed pigeon use of the site was periodically observed and fluid consumption monitored. Pigeons generally showed no interest in corn after wild berries became available in June; also in June young of the year birds were first observed and birds begin showing interest in supplemental minerals. Pigeon use of the site increased in 2009 compared to 2008.

After pilot study work during 2008 and 2009 (see Sanders 2009 for results), I used passive integrated transponders (PIT, passive radio frequency identification) to better quantify band-tailed pigeon use patterns in 2010 and 2011 with an objective to estimate frequency of supplemental mineral use and specific mineral selection.

Close up of the created mineral site station showing the trays with mineralized water and the perch rail and antenna around the station platform. *Photo by Todd Sanders*

The mineral station design was adjusted slightly and consisted of a 1.2 × 1.8 m wood platform 1.2 m above ground with a 1.2 × 2.4 m plywood roof held 1.8 m above the platform by 4, 5.1 × 7.6 cm board. The roof was necessary for better control of mineral water concentration during spring precipitation events. The station was also fitted with a 2.5 × 5.1 cm wood perch rail around the edge and about 20 cm above the platform. An antenna was housed in a 3.8 cm diameter white PVC pipe around the platform and was attached to the bottom of the wood perch rail (about 16 cm above the platform). The antenna was connected to a stationary ISO transceiver (Destron Fearing FS1001A) that registered system diagnostics and PIT tag detections by time and identification code on a 1-minute unique delay. A laptop computer running software MiniMon was connected to the transceiver and both were housed in a cabinet about 7 m from the mineral station. The computer collected information about system diagnostics and PIT tag detections from the transceiver and wrote an electronic file with the information at midnight daily.

Pigeons were trapped near the mineral station using a box trap baited with whole corn. Pigeons were immediately removed from the trap and marked with a PIT tag and U.S. Geological Survey aluminum leg band. PIT tags were 12 mm, 134.2 kHz Super Tag II (TX1411SST) programmed with a unique 10 hexadecimal (base sixteen) character identification code (15 digit decimal code) from Biomark. PIT tags were implanted subcutaneously in the hind neck using a syringe-style implanter with 3.2 cm 12 gauge hypodermic needle (MK7) from Biomark. Each tag, needle, and the bird hind neck was sterilized with rubbing alcohol and 1% iodine solution was applied to the hind neck post tag insertion. Successful tag implantation was verified with visual inspection and a hand held tag reader prior to release of each bird.

To establish baseline visitation patterns, a single station offered sodium and calcium in 2010. To determine selection for sodium and calcium, I established a second identical mineral station placed 50 m from the initial station in 2011. One station offered sodium and the other calcium, and these offerings were rotated systematically. The original station started with calcium and was switched 1 June, 9 July (after 38 days), and 16 August (after 38 days). I initially offered whole corn along with mineral water at the stations to attract birds for capture, help birds find the mineral, verify willingness to use both stations in 2011, and to identify the tagged population confirmed to be in the area. The stations were monitored 24 hours a day without interruption in 2010 (155 total days) during 5 May–14 June (41 days) with corn and mineral water and 15 June–6 October (114 days) with mineral water only (i.e., no corn in the vicinity), and again in 2011 (184 total days) during 25 March–31 May (68 days) and 1 June–24 September (116 days) similar to the previous year.

In 2010 the mineral station platform held finely-sifted soil from the area surrounding a single tray with mineral water. The soil was mixed with sodium chloride and calcium carbonate while tap water was mixed with sodium chloride and calcium chloride, both to about 3,500 ppm sodium and 1,500 ppm calcium. Mineral soil and water offerings were replaced regularly to maintain concentrations and cleanliness. Birds showed no interest in the soil given the availability of mineral water during 2010. Therefore, in 2011 I eliminated the mineral soil and increased the mineral water offering by fitting each station with 3 trays. All trays at a station had either sodium chloride in tap water mixed to 3,500 ppm sodium or calcium chloride in tap water mixed to 1,500 ppm calcium. Trays were maintained within 2 liters of capacity and cleaned and refilled weekly to maintain mineral concentrations and cleanliness.

In 2010, a replicate mineral station was created in northwestern Oregon, identical to the mineral station in southwestern Washington, but that station was dropped in 2011 based on results from 2010 and the logistical challenge of managing 2 remote sites.

To confirm tag retention and lack of apparent complications associated with tag implantation, I tagged the 60 rock pigeons and 48 band-tailed pigeons held in captivity for feeding trials. These birds were marked in April and evaluated through August 2010.

Results

Ionic content of resources

I necropsied 371 band-tailed pigeons during 2008–2010 to collect grit and determine food items consumed. All Interior pigeons (*n* = 40) had grit while only 70% of Pacific Coast pigeons (*n* = 331) had girt. Most (94%) of the pigeons without grit had consumed Pacific dogwood (*n* = 81), cherry (*n* = 9), or both (*n* = 1). Interior band-tailed pigeons with grit had 163 ± 45.5 ($\bar{x}$ ± SE; range = 7–1,782) stones in their gizzard with a mass of 1.9 ± 0.14 g (range = 0.1–4.1). Pacific Coast band-tailed pigeons had 72 ± 7.6 (range = 1–525) stones in their gizzard with a mass of 1.2 ± 0.08 g (range = <0.1–4.9). Grit generally had smooth round surfaces (86.6% of grit samples where in angularity class 3–5) and were highly polished suggesting that stones are retained for some time.

Grit from the Pacific Coast and Interior regions was primarily silicon; 79.5 ± 2.8% and 89.2 ± 2.4%, respectively. Sodium ion content for the Pacific Coast and Interior regions was 2.1 ± 0.2% and 0.8 ± 0.1% while calcium ion content was 3.3 ± 0.7% and 3.0 ± 2.3%, respectively. There were no soluble sources of mineralized grit identified in any of the birds examined.

I found food items in 339 of the necropsied band-tailed pigeons including cultivated grains and 12 different wild-growing food items; all were fruits, nuts, and seeds with the exception of leafy material before fruits and seeds were available. The food items selected by pigeons collected in the Interior region during September were acorns (Gambel and Emory; frequency = 11), corn (5), blue elderberry (3), and red elderberry (1), but sample size was small (*n* = 20). In pigeons collected in the Pacific region, food items selected varied spatially and temporally. The food items selected in the Pacific Northwest during May to early June were buds and other leafy plant materials 11), grains (corn, millet, wheat, sunflower; 9), unripe red elderberry berries (5), and cherries (2); mid-June to July were red elderberries and cherries; August was cascara berries; and in September were berries of blue elderberry (78), cascara (75), Pacific dogwood (23), and cherry (12), millet and sunflower seeds (5), acorns (Oregon white oak, 3), and madrone berries (1). In pigeons collected in California, the food items selected during September were berries of Pacific dogwood (92) and madrone (10), pine nuts (21), blue elderberries (7), cherries (6), coffeeberries (5), and red elderberries (1); and in October–December were madrone berries (43) and acorns (coastal live oak and canyon live oak, 19). The only other food items found, each in a single pigeon in California during September included snowdrop bush (AKA drug snowdrop) and juniper berries. Many (33%) of the pigeons collected in the Pacific Coast region with food had consumed more than one food item. None of the pigeons collected at a mineral site in central California during winter showed any sign of reproductive activity and had consumed acorns and madrone berries.

I obtained 21 band-tailed pigeons with an adequate amount of crop milk for sampling; only 1 from the Interior region. Crop milk from the Interior pigeon contained 51.7% dry matter, 3.6% inorganic material, 0.15% sodium, 0.64% calcium, and 0.41% potassium. Crop milk from pigeons in the Pacific Coast region contained a 46.9 ± 1.1%) dry matter, 4.5 ± 0.1 inorganic material, 0.14 ± 0.01% sodium, 0.80 ± 0.02% calcium, and 0.53 ± 0.01% potassium. Samples from the Pacific Coast region were combined into 2 subsamples for proximate analysis of macronutrients and revealed that crop milk contained 34.9% adjusted crude protein, 4.2% crude fiber, 57.7% crude fat, and 7,557 calories per gram gross energy. I obtained samples from 8 wild-caught rock pigeons for comparison with band-tailed pigeons. Rock pigeon crop milk did not differ between treatment groups in mineral concentrations (access vs. no access to supplemental sodium, $t_6<1.31$, $P>0.23$) and contained 28.9 ± 3.7% dry matter, 3.0 ± 0.3% inorganic material, 0.26 ± 0.06 sodium, 0.57 ± 0.06% calcium, and 1.02 ± 0.06% potassium.

I collected 55 food item samples representing 31 fruit and nut food species consumed by band-tailed pigeons throughout their range: 9 samples from the Interior region and 46 samples from the Pacific region. There was no apparent difference in moisture or mineral content for each of the food items (acorns, pine nuts, wild cherry, serviceberry, red elderberry, and blue elderberry) sampled in the Interior region compared to the Pacific Coast region. The sodium content of all food species was low (range = 0.00–0.03%), while moisture, calcium, and potassium content was generally moderate to high among pine nuts, acorns, and especially fruits. Pine nuts (pinyon pine, sugar pine) had the least moisture (range = 10.9–18.8%), calcium (0.01–0.02%), and potassium (0.41–0.65%). Acorns (coast live oak, canyon live oak, blue oak, valley oak, Oregon white oak, Emory oak, Gambel oak) had low moisture (25.6–35.9%) and moderate calcium (0.10–0.24%) and potassium (0.46–0.91%). Although fruits were generally high in moisture, calcium, and potassium, there was some apparent variation. The primary fruit food items consumed by band-tailed pigeons in the Pacific Northwest during mid-June through September (red elderberry [ripe and unripe], cascara, and blue elderberry) were especially high in moisture (70.5–79.0%), calcium (0.28–0.49%), and potassium (1.31–1.81%). Other known fruit food items consumed (chokecherry, bitter cherry, coffeeberry, and Pacific madrone), particularly in California, were high in moisture (51.6–65.6%), calcium (0.20–0.42%), and potassium (1.11–1.32%) with the exception of Pacific dogwood, which was low in moisture (48.2%), high in calcium (0.73%), and low in potassium (0.66%). Other fruits (black hawthorn, green-leaf manzanita, Himalayan blackberry, Oregon crab apple, Oregon grape, plum, red huckleberry, redosier dogwood, salal, salmonberry, Saskatoon serviceberry, thimbleberry, and twinberry honeysuckle) that may be consumed by band-tailed pigeons were high in moisture (52.0–89.3%), calcium (0.10–0.49%), and potassium (0.72–1.44%, except twinberry 2.26%). Red elderberry, cascara, and blue elderberry samples from the Pacific Coast region were combined into 2 subsamples for proximate analysis of macronutrients. Elderberry and cascara berries were similar in macronutrients with 11.4 ± 1.0% adjusted crude protein, 18.2 ± 1.7% crude fiber, 19.8 ± 5.1% crude fat, and 5,856 ± 253 calories per gram gross energy.

I located and sampled 66 mineral sites known to be used by band-tailed pigeons including all the sites where these birds are counted annually by government agencies to monitor pigeon population status in the western U.S. Of the mineral sites, 42 were springs, 19 were estuaries, 4 were soil (1 livestock salting area), and 1 was wastewater associated with a paper mill. Mineral sites varied in mineral composition, but were highest in sodium and calcium compared to all other minerals. Spring and wastewater sites had 4,237 ± 677 ppm sodium and 2,774 ± 574 ppm calcium. Soil sites had 1, 860 ± 405 ppm sodium and 1,083 ± 232 ppm calcium. Estuary sites had 6,499 ± 926 ppm sodium and 261 ± 33 ppm calcium, but results depended on tides and site capacity to retain more saline water (i.e., in pools or other reservoirs protected from fresh water inundation). All tidal areas had the potential to provide a mineral resource equivalent to seawater, which I found to have 9,010 ± 590 ppm sodium and 331 ± 6 ppm calcium. Aluminum, arsenic, cadmium, chromium, cobalt, lead, molybdenum, and selenium were all below detectable limits (<1 ppm) while boron, copper, iron, manganese, phosphorus, and zinc were all <100 ppm at all mineral sites. Magnesium and potassium primarily occurred at estuary sites (sea water = 1,008 ppm magnesium and 370 ppm potassium). Magnesium was <160 ppm at 89.4% of non-estuary sites and potassium was <150 ppm at 95.7% of non-estuary sites. Although sodium and calcium were on average the most available minerals among sites, only sodium was consistently high. Sodium was >600 ppm at 63 (95.5%) sites and >300 ppm at all sites. Calcium was >600 ppm at only 32 (48.5%) sites and <340 ppm at 31 (47.0%) sites. I also found 15,818 ppm sodium at the only site earlier reported to be below 678 ppm in Oregon by Sanders and Jarvis (2000).

Feeding trials

My primary interest in feeding trials was supplemental sodium and calcium use and reproductive success associated with different food items, but also individual maintenance. None of the band-tailed pigeon pairs nested successfully during the study, however, 7 eggs were produced by 5 pairs during feeding trials in 2009 and 14 eggs were produced by 8 pairs during feeding trials in 2010. All of the eggs were ultimately displaced from the nest bowl and none of them could be confirmed to be fertile based on visual inspection. About 6 of the pairs were regularly observed participating in reproductive activities.

Little fluids were consumed by band-tailed pigeon pairs during feeding trials. This was especially true for pairs feeding on berry food items (75.3 ± 8.6 ml per week, n = 72) compared to grains (291.8 ± 21.0 ml per week, n = 24). Fluid consumption was apparently inversely associated with the moisture content of these food items. For pairs that had access to sodium, saltwater accounted for most (≥50%) of the total fluids consumed in 2009, particularly when eating berry food items (55.7 ± 12.8 ml per week on a berry diet, n = 36; and 145.0 ± 35.7 ml per week on a grain diet, n = 12). Saltwater consumption by pairs was similar among food items in 2010 (56.1 ± 14.9 ml per week on a berry diet, n = 12 and 110.8 ± 27.1 ml per week on a grain diet, n = 12) compared to that in 2009 although total (fresh and saltwater) fluid consumption was not measured in 2010.

I found no difference in body-mass change between males and females in treatment groups or feeding trials during 2009 and 2010 (all 95% confidence intervals overlapped) and therefore sex differences were not considered further. Band-tailed pigeon body mass increased during berry-diet feeding trials in 2009 (85 days, 51.8 ± 3.4 g, n = 48) and 2010 (64 days, 11.8 ± 4.1 g, n = 24) for both treatment groups and no pigeon perished during trials. Body mass increased more for the treatment group that had access to sodium (60.7 ± 4.6 g) compared to the group that did not (43.3 ± 4.5 g; t_{46} = 2.69, P = 0.01; difference = 17.4 ± 6.5) in 2009, but groups did not differ in 2010 (t_{24} = 0.23, P = 0.82; difference = 2.0 ± 8.5). Within specific food-item feeding trials, body mass did not change differently between treatment groups ($t \leq 0.53$, df = 46 except 22 during red elderberry and cascara trials in 2010, $P \geq 0.60$) except that in 2009 birds without access to sodium lost 15.2 ± 5.4 g (t_{46} = 2.82, $P<0.01$) compared to birds with access to sodium during the cascara feeding trial. Both treatment groups gained body mass (15.2 ± 2.9 g, n = 24) during the cascara feeding trial in 2010. Birds also increased in body mass during red elderberry feeding trials in 2009 (6.3 ± 2.2 g and 54.5 ± 3.3 g, n = 48) and 2010 (54.5 ± 3.3 g, n = 24), but decreased in body mass during the first trial each year on a diet of grains (8.7 ± 1.8 g and 12.5 ± 3.5 g, n = 48). The loss of mass with grains was probably related to movement of birds to breeding cages for trials from overwinter aviaries considering that the diet was the same.

Band-tailed pigeon mineral excrement was inconsistent in mineral concentration among berry food items and years. The pairs that had access to sodium excreted more sodium (0.12 ± 0.02 %) then the pairs that did not have access to sodium (0.03 ± 0.01 ppm) as expected based on treatment, but otherwise all pairs excreted similar concentrations of calcium (0.77 ± 0.04%) and potassium (2.47 ± 0.03%) given a diet of red elderberry and cascara.

Rock pigeons were prolific during feeding trials, especially during 2010 when they had a more adequate diet. In 2009, rock pigeons initiated 25 clutches within 60 days, produced 50 eggs, and fledged 24 young. Each pair had no more than a single clutch, but the group with access to supplemental sodium initiated 14 clutches and fledged 21 young while the no sodium access group had 11 clutches and fledged 3 young. The mean number of eggs per clutch (1.96 ± 0.04), incubation period (18.0 ± 0.3 days), hatch rate (0.94 ± 0.04), and fledgling mass (185.7 ± 8.66 g) did not differ between treatment groups ($t_{22–23}<1.59$, $P>0.12$), but the mean survival rate from hatching to fledgling was greater for the group with access to supplemental sodium (0.75 ± 0.07) compared to the group without access (0.15 ± 0.08, t_{22} = 5.74, $P<0.01$). Results were similar for the feeding trial in 2010 where rock pigeons initiated 73 clutches within 143 days, produced 145 eggs, and fledged 126 young. Four pairs did not nest, 2 in each treatment group, otherwise each pair had 1–4 clutches, but the group with access to supplemental sodium initiated 42 clutches and fledged 72 young while the group without access to sodium had 31 clutches and fledged 54 young. The mean number of eggs per clutch (2.0 ± 0.01), incubation period (18.2 ± 0.2 days), hatch rate (0.94 ± 0.02), and survival rate from hatching to fledgling (0.93 ± 0.03) did not differ between treatment groups ($t_{24}<1.00$, $P>0.33$). However, the mean number of initiated nests and fledgling mass were greater for the group with access to sodium (3.23 ± 0.26 nests, 336.3 ± 5.4 g) compared to the group without access (2.38 ± 0.18 nests, 300.7 ± 5.7 g; $t_{24}>2.69$, $P<0.01$). Nesting cycles were frequently compressed in 2010 by initiating clutches while caring for young prior to fledging. The first nest was initiated 7 days after pairing in breeding cages, but most (17 of 26) pairs initiated 19–24 days post pairing.

Mineral site use

Of the 108 captive pigeons implanted with a PIT tag, all retained the tag during monitoring through September (≥153 days). All birds were examined the day after marking and little sign of the implantation could be found and there were no apparent behavioral changes or other implications. Birds maintained their mass through the week after marking (t_{107} = 1.66, P = 0.44) and no bird perished during monitoring.

I marked 571 free-ranging adult band-tailed pigeons with a PIT tag and aluminum leg band in southwestern Washington; 318 in April–late June and 33 in September–October 2010, and 220 April–mid June 2011. The marked population included 297 males (422.1 ± 1.9 g) and 204 females (393.8 ± 2.1 g) classified based on plumage characteristics.

I detected 472 daily-unique visits by 93 marked band-tailed pigeons using a single mineral station offering only mineralized soil and water during 114 days (15 June–6 October) in 2010. Not all pigeons used the mineral station as the 93 unique birds represented only 29.2% of the 318 birds marked near the station earlier that year and 59.6% of the 156 birds confirmed to be in the area and using the station (174 days, 5 May–6 October). Birds that did use the station with only supplemental minerals first used the station at different times throughout monitoring; 25% of the unique birds were first detected after 13 days, 50% after 24 days, and 75% after 45 days. The number of marked birds at the station each day ranged from 0–14 (4.14 ± 0.30) and use peaked mid-August. Each marked pigeon visiting the station did so up to 12 different days (5.08 ± 0.31), but 83.9% of the birds visited ≤8 days and 10.8% visited only 1 day. The mean span between daily visits for each bird with ≥2 visits (*n* = 83) was 13.08 ± 0.89 days and ranged from 3.8–65.0 days. The number of 1-minute unique detections for each bird within a daily visit ranged from 1–7, but 80.1% (378 of 472) had ≤2. Most all (93.1%) of the 403 time spans between repeat detections in a day were ≤60 minutes and only 5 were >90 minutes (max = 269 minutes). Marked birds visited the station between 0601–2001 hours (daylight), 68.0% by noon and 95.0% by1500 hours. Most (54.6%) of the males first visited the station by 1000 hours and 86.0% of the females after 1000 hours.

In 2011, 2 adjacent stations provided supplemental minerals, 1 with sodium solution and 1 with calcium solution, and both additionally offered whole corn before 1 June. Pigeons used both stations equally before June and were observed flying between stations during use. Overall mineral station use patterns in 2011 were similar to that in 2010. However, pigeons did not use the station with supplemental calcium after 2–3 days following change from supplemental sodium and pigeon use immediately tracked the sodium station. Combining use information from both stations, and when mineral was the only offering, I detected 1,126 daily-unique visits by 174 marked pigeons during 116 days (1 June–24 September) in 2010. The 174 unique birds represented only 32.7% of the 220 birds marked earlier that year (29.1% of the 351 birds banded in the previous year) near the station and 71.0% of the 245 birds confirmed to be in the area and using the station that year (184 days, 25 March–24 September). Birds that did use the station with only supplemental minerals first used the station more quickly than in 2010; 25% of the unique birds were first detected after 2 days, 50% after 12 days, but still only 75% after 44 days. The number of marked birds at the station each day ranged from 0–37 (9.71 ± 0.56) and use peaked mid to late August. Each marked pigeon visiting the station did so up to 20 different days (6.47 ± 0.32), but 82.2% of the birds visited ≤10 days and 13.2% visited only 1 day. The mean span between daily visits for each bird with ≥2 visits (*n* = 151) was 13.74 ± 0.81 days, but ranged from 1.0–85.0 days. The number of 1-minute unique detections for each bird within a daily visit ranged from 1–8; however 80.9% (911 of 1,126) had ≤2. Most all (92.0%) of the 879 time spans between repeat detections in a day were ≤60 minutes and only 5 were >90 minutes (max = 269 minutes). Marked birds visited the station between 0545–1930 hours (daylight), 77.5% by noon and 94.6% by1500 hours. Most (51.3%) of the males first visited the station by 1000 hours and 81.0% of the females after 1000 hours. Periodic observations indicate that about 5% of the population of pigeons using the mineral stations were marked (*n* = 37 flocks, 54 marked of 1,078 birds examined) and in no case was a marked bird observed on an antenna rail or in a station where a detection could not be subsequently verified at the station during the same time.

In May 2010, I also marked 98 adult band-tailed pigeons with a PIT tag and aluminum leg band in northwestern Oregon near a replicate mineral site created that month. The station, mineral offerings, procedures, and monitoring (114 days, 15 June–6 October) were the same as the created mineral site in southwestern Washington. Only 11 birds returned to use the station with mineral only and 14 in total including the earlier days with corn and mineral beginning 12 May when the station was established. Six birds used the mineral station only 1 day while the other 5 birds used the station 2–8 days (2.91 ± 0.88). The span between visits for birds with ≥2 visits was 9.38 ± 4.60 days (range = 2–27), but sample size was small (n = 5). So although use patterns were similar among created mineral sites for birds that used them, I discontinued monitoring at this station because the effective sample size was small for the number of birds marked, which I assume was due to its recent creation and close proximity (<37 km) to other (8) known natural mineral sites. The southwestern Washington created mineral site was 17 km from the nearest known mineral site and 35 km away from the second nearest.

Summary

My data provide evidence that band-tailed pigeons are associated with mineral sites with high sodium concentration and that sodium is the principal ion sought at mineral sites. Sodium and calcium were most available minerals among sites, but only sodium was consistently high. Sodium was >600 ppm at 95.5% of mineral sites and >300 ppm at all sites while calcium was >600 ppm at only 48.5% of mineral sites and 47.0% of the sites had <340 ppm. My results from mineral sites in in California, Oregon, Washington, and British Columbia were consistent with the results from Sanders and Jarvis (2000) restricted to Oregon, but I was able to find a high concentration of sodium at the only site they reported to be low (<678 ppm).

Also, I was able to create a mineral site with sodium and calcium solutions that were used by band-tailed pigeons similarly to natural sites where I visited and observed pigeon use. Pigeons using the created mineral site used only the station offering sodium solution and not the station offering calcium solution when minerals were separated, and station use followed sodium when solutions were exchanged between stations. Use at the created site was estimated to average about 194 birds per day (9.71 mean marked birds per day × 20, the ratio of marked to total birds) and peak use was over 600 birds per day (which could represent more than 3,000 birds in the area considering visitation patterns), more than at many of the natural mineral sites with available count data. Pigeon use of the created mineral site was during daylight hours, primarily sunrise to about 1500 hours (PDT) during summer, and males visited mostly before 1000 hours, whereas females mostly after then, reflecting nest attendance schedules. Use of the created mineral site was consistent with an earlier study at natural mineral sites (Passmore 1977, Jarvis and Passmore 1992) and my observations during studies and monitoring at mineral sites during the last 2 decades.

Use of mineral sites by band-tailed pigeons in the Pacific Northwest is associated with production of crop milk during reproduction and availability of berries when pigeons consume an exclusive berry diet. I confirmed that berry food items throughout the species range (with the exception of Pacific dogwood) provide moderate calcium and especially little sodium compared to band-tailed pigeon crop milk and the nutritional requirements for growing domestic birds, but especially elderberry and cascara fruits, similar to the results of Sanders and Jarvis (2000). The greatest potassium intake is expected to occur during summer in the Pacific Northwest when elderberry and cascara are the primary food items consumed, and to a lesser extent for birds with a diet that includes greater amounts of dogwood, pine nuts, and acorns (i.e., California and the Interior regions). It's possible that band-tailed pigeons in the Pacific Northwest are more challenged in retaining sodium because of the high moisture and potassium content of their almost-exclusive berry diet and the diuretic and laxative properties of these berries. The stools of captive birds were liquid when the birds consumed a diet of red elderberry compared to other fruits, although cascara is known to be a natural laxative. Free ranging band-tailed pigeons are able to find supplemental sodium at certain natural seeps and springs and estuaries in the Pacific Northwest where berry food items primarily occur, or occur in abundance.

I was, however, unable to demonstrate a cause and effect relationship between supplemental mineral use and reproduction and a berry diet during feeding trials as none of the band-tailed pigeon pairs I had in captivity nested successfully during 2 years. This was thought to be related to disruption of natural reproductive processes caused by the reduction of wild birds to captive conditions and forced pairing. Pigeons drank little fluids while consuming a berry diet in captivity, owing to the high moisture content of berries; but birds did consume sodium water when available. There was some evidence that birds with access to saltwater gained or maintained weight during a berry diet compared to those that did not have access to supplemental sodium, but otherwise there were no apparent differences between treatments. Supplemental sodium was apparently non-essential for maintenance over at least 16 weeks, including a 13-week period with an exclusive diet of red elderberry and cascara berries (both known to be especially high in potassium and low in sodium among potential food items). Band-tailed pigeon use patterns at my created mineral site also suggest that supplemental minerals may not be an essential resource. Many (34.7%) of the marked and free ranging birds in the vicinity of my mineral station did not use minerals offered there, and 12% of the birds I detected at the created mineral site during summer visited only 1 day. However, if the results from my nesting rock pigeons apply to nesting band-tailed pigeons, then band-tailed pigeons with access to supplemental sodium may have greater reproductive potential and produce heavier young with greater survival rates. Birds that consume dogwood fruits may not benefit from use of supplemental minerals compared to birds consuming other berry diets.

Grit provides an important function in grinding food but was not an abundant or readily available (insoluble) source of sodium or calcium, and some birds did not use grit when consuming a fruit diet with hard seeds (e.g., Pacific dogwood) or pits (cherry), particularly in northern California during summer. Grit selected by band-tailed pigeons was similar between Pacific Coast and Interior populations, except that Interior birds tended to retain more (in number of stones and mass) grit, likely owing to the more diverse nature of their diet. I remain unable to demonstrate why pigeons in the Interior region do not generally use supplemental minerals, other than the apparent lack of sodium-rich mineral sources (i.e., mineralized springs and soils) in the Interior region and the pigeon's more diverse diet there compared to the Pacific Coast region.

My research on the visitation patterns of band-tailed pigeons at mineral sites provides information that is useful for interpreting counts of pigeons at mineral sites in July, as is done annually by government wildlife agencies to monitor the status of these populations. Counts of pigeons at mineral sites probably represent only a fraction of the birds in that area (considering that some birds don't use mineral sites, some only once, and others visit on average once every 13.4 days, and counts through noon represent only 72.8% of birds likely to use the site in any one day). Also, birds using mineral sites generally do not return more than once in a day after they have successfully obtained supplemental minerals; and if they did, the second visit would likely be after about 3 PM, so the probability of double counting birds before then is very low. However, because the cause and effect relationship resulting in mineral site use remains unknown, there continues to be a lack of assurance that counts at mineral sites represent an unbiased proportion of the population across space and time. The number of birds that pursue nesting activities, the number of initiated nests, and the distribution of birds are known to be highly related to food availability, and food availability (e.g., Pacific dogwood vs. elderberries and cascara) varies annually and geographically and could influence the extent of interest in supplemental minerals accordingly.

This study provides results with application throughout the species' range where little is known about supplemental mineral use and contributes to the priority research needs for this species where the population status is largely either unknown or thought to be less abundant than in the past. Specifically, this research provides information toward developing reliable population monitoring techniques for use throughout the range of the species, describing seasonal habitats essential for maintaining pigeon populations, and understanding the effects of land management practices on food (and associated supplemental mineral) availability and abundance needed to maintain breeding populations.

This work could not have been completed without the financial support provided by the Webless Migratory Game Bird Program. This work also would not have been possible without the substantial contributions of cooperators including: Ryan Koch, U.S. Fish and Wildlife Service; Peter Cheeke, Oregon State University; Don Kraege, Washington Department of Fish and Wildlife; Brad Bales, Oregon Department of Fish and Wildlife; Jesse Garcia, California Department of Fish and Game; Scott Hayes, Arbor House Tree Farm; Frank Tepley, Oregon State University; Jay Bogiatto, Chico State University; Steve Cordes, California Department of Fish and Game; Terry Strange, Strange Resource Management; Bob Trost, U.S. Fish and Wildlife Service; Laurence Schafer, U.S. APHIS Wildlife Services; Gary Renfro; David Schmedding; Scot Williamson, Wildlife Management Institute; Ken Richkus, U.S. Fish and Wildlife Service; and numerous biologists, sportsmen, and private landowners.

Additional Planned Work

The created mineral site in southwestern Washington will be monitored at least during June–September in 2012 and offer only sodium. Use patterns will be compared to the 2 previous years when the site offered both sodium and calcium to verify that mineral station use patterns remain unchanged. Manuscripts will be prepared and submitted for publication in scientific journals.

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Sandhill Cranes

POPULATION GENETIC STRUCTURE IN THE EASTERN POPULATION OF GREATER SANDHILL CRANES (*GRUS CANADENSIS TABIDA*)

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Sandhill Cranes (*Grus canadensis*) are the most populous crane species and found breeding and wintering throughout North America. The Eastern Population (EP) of Greater Sandhill Cranes is expanding from a bottleneck in the 1930's which reduced this population to around 300 birds scattered between fragmented local areas in Wisconsin, Michigan, and Minnesota (Henika 1936). This population currently numbers around 60,000 birds (U.S. Fish and Wildlife Service, unpub. data) and has rapidly expanded and began nesting throughout much of its former range in Illinois, Iowa, Ohio, Indiana, and Ontario (Meine and Archibald 1996) and into the northeast U.S. in Pennsylvania, New York, Maine, Massachusetts, and Vermont (Melvin 2002). The birds breeding in the northeastern U.S. are of special interest because it is assumed that they were established by Sandhill Cranes from the Great Lakes region dispersing to the east.

A population's ability to recover on its own from a demographic bottleneck is remarkable and understanding the process that allowed the EP to do so can further our understanding of species recovery. A first step to accomplishing this is to quantify movements made by Sandhill Cranes in the EP.
Measuring dispersal in large, highly-mobile avian species such as Sandhill Cranes is a difficult task, especially in a migratory population. Therefore, indirect measurement of dispersal through genetic analysis of molecular markers is often used. Understanding gene flow patterns between sample locations allow us to understand historic patterns of movement and successful integration into breeding populations.

The goal of this project was to determine whether population genetic structure was present in the EP of Greater Sandhill Cranes. If there is genetic structure present, can we use this information to estimate historic movements made between sampling locations? The objectives of this project were to 1) capture, color band, and collect DNA from Sandhill Cranes at discrete locations throughout the EP and 2) apply genetic analysis to detect any genetic structure present in this population.

Progress

Flightless Sandhill Crane chicks were captured by foot pursuit until they hid and could be handled (Figure 1; Hoffman 1985). Each chick was banded with a U.S. Geological Survey band along with an engraved 3" band and a unique combination of 1" color bands (Figure 2) to allow identification in the field from a wide audience of observers with varied training. Additionally, a small DNA sample was collected from jugular or tarsal veins for genetic analysis.

Figure 1. Andrew Gossens with the International Crane Foundation releasing a newly banded Sandhill Crane chick in northwestern Pennsylvania. *Photo by Hoa Nguyen*

Field Sampling Progress

Sample locations throughout the EP are listed in Table 1. This includes Briggsville, WI, where the International Crane Foundation has been banding and monitoring Sandhill Cranes since 1991. We focused on sampling areas that served as refugia for this population during the bottleneck (sites 2, 3, 4, 5, and 7) as well as nearby areas that have been recolonized following the bottleneck. The samples in table 1 were compared to other samples collected by various entities to assist in this project. These samples included a Sandhill Crane that was found as an injured hatch year chick in Maine in 2007 and now resides at the Brandywine Zoo in Wilmington, Delaware, 25 samples from flightless Sandhill Crane chicks in Illinois northeast of Chicago collected by Jeff Fox at the Illinois Natural History Survey, and five samples collected from adult Sandhill Cranes in Ohio by Dave Sherman with Ohio DNR. These collectively represent a well-distributed sample of the EP.

Figure 2. A color-banded Sandhill Crane chick following release in northwestern Pennsylvania. *Photo by Hoa Nguyen*

Color band re-sightings from throughout the migratory flyway suggest extensive mixing of breeding populations on migratory stopover and wintering areas (Figure 3). For ICF's long-term study area near Briggsville, WI, band re-sightings suggest strong natal philopatry for chicks hatched in this area. The farthest an individual has been observed was a one-year old bird found dead 200 km north of the study area. Most individuals are observed or tracked within 50 km of their natal area and all individuals found on breeding territories are within 15 km of their natal area. For those cranes banded outside of Briggsville, we have received few re-sightings on breeding areas, but the few we have received suggest natal philopatry is also strong. We hope to continue to receive band re-sightings from these areas into the future.

In 2011, we successfully sampled seven flightless Sandhill crane chicks in New York and Pennsylvania from 16 June – 27 June 2011. Two chicks were captured in New York and five chicks were captured in Pennsylvania (Table 1). Four of these chicks were 1-2 weeks old when captured and were not large enough to be color-banded, so only a small blood sample was collected before release. Three chicks were at least five weeks old and were color-banded. At least one of these chicks was re-observed prior to migration near the breeding area in northwestern Pennsylvania. Additional attempts were made to capture a breeding pair of adults in New York on State Game Lands using whole kernel corn as bait and leg snares designed for catching cranes (Hereford et al. 2001). This pair was known to be local as they had been observed with chicks up to three-four days before we arrived, but subsequently lost them to predation before we could capture the chicks. We were unsuccessful in attracting the pair to our bait as the pair regularly used a germinating corn field and had plentiful food available for them.

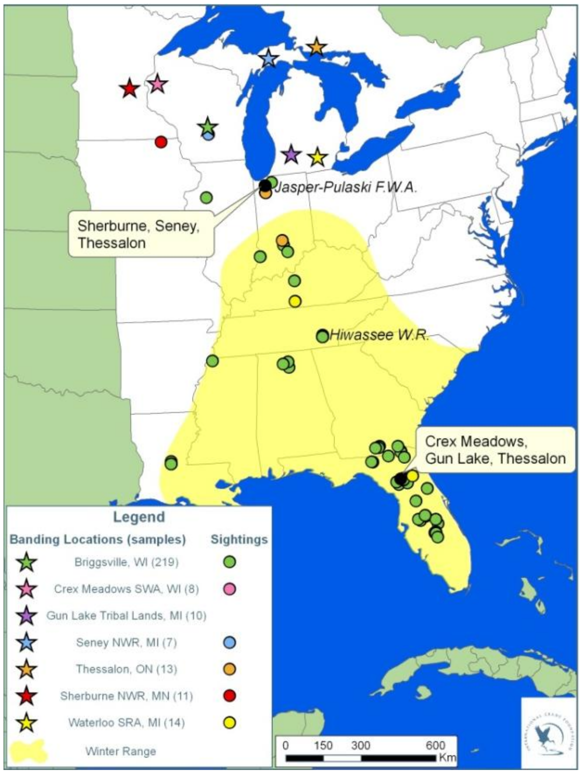

Figure 3. Re-sightings of banded Sandhill Cranes during migration and on wintering areas

Genetic Analysis Progress

Amplified Fragment Length Polymorphisms (AFLP; Vos et al. 1995) were used to estimate gene flow between sampled areas. AFLP samples neutral loci throughout the genome and is capable of distinguishing between nearly identical strains of bacteria and plants. Empirical studies and our own experience indicate that scoring and reproducibility of the AFLP technique approaches 100 percent. We generated 210 loci with one AFLP primer pair, of which 158 showed appropriate baseline resolution and were capable of being consistently scored as present or absent.

Pairwise Fst, scaled between 0 and 1 and a measure of genetic relatedness between sampling locations, was calculated using AFLP-SURV-1.0 (Vekemans 2002). The figures in Table 2 suggest strong differentiation between most sampling locations suggesting strong genetic structure. This further supports the banded bird observations of strong natal philopatry. Chicks are choosing to not only return to near their natal area, but breed near that area as well. Interestingly, some re-colonized areas do show a lack of significant differentiation (i.e. high amounts of gene flow) with specific refugia (e.g. Briggsville and northeastern Illinois) which could suggest that individuals from these sample sites likely served as founders for these populations. Crex Meadows in northwestern Wisconsin, is an interesting outlier where four out of 14 sampling locations show high amounts of gene flow. This includes several sites that served as refugia during the bottleneck including Waterloo in southeastern Michigan and Seney NWR in the Upper Peninsula of Michigan. This suggests that historically, the birds at Crex Meadows may have dispersed widely and may have integrated into many populations. Conversely, many populations may have also immigrated into Crex during this population nadir. Gene flow estimates prior to the bottleneck are unknown.

In the northeast U.S., there is strong differentiation based on pairwise Fst between these locations and other sampling spots, including Ohio. This could suggest gene flow from unsampled areas, including Quebec and the Maritime Provinces of Canada. Caution needs to be taken with these results, however, due to small sample sizes in these locations. Future analyses will focus on clustering of individuals together based on genetic similarity.

Future Work

Pairwise Fst is a crude measure of genetic relatedness and assumes that individuals captured in a population are resident within that population. While most of the birds sampled in this study were flightless chicks and known to have hatched within a few miles of where they were captured, the parents are from unknown areas. Assignment of individuals into genetic clusters has been found to be an unbiased estimator of genetic relatedness between individuals in a population. Moreover, appropriate statistical models which explicitly take into account the spatial distribution of genotype are applicable to dominant AFLP. GENELAND (Guillot et al. 2005, Guillot et al. 2010) is a Bayesian statistical analysis program which can incorporate genetic data with coordinate information to determine how many genetic clusters are present in a sample as well as which individuals best fit into which clusters. While the coordinate data may assist in determining structure if it is weak, it does not override the clustering analysis.

This summary is for the first year of a two-year project funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service), International Crane Foundation, University of Wisconsin – Madison, Wisconsin Society for Ornithology, and Henry Vilas Zoo. This study will go towards fulfillment of a PhD for graduate student Matthew Hayes from the University of Wisconsin – Madison under the advisement of Mark Berres and collaboration with Jeb Barzen (co-advisor) with the International Crane Foundation. Final reports are expected by December 2012.

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This project took a huge effort of collaboration between the International Crane Foundation, University of Wisconsin – Madison, State Wildlife Agencies, U.S. Fish and Wildlife Service, interns, volunteers and private landowners. Field work during summer 2011 in the northeast U.S. was a huge undertaking and would not have been possible without the help of Dan Brauning, Doug Gross, and Jerry Bish from the Pennsylvania State Game Commission, along with Trudy Gerlach in Pennsylvania, as well as Jim Eckler and staff from the New York State Department of Environmental Conservation, and Linda Ziemba and Jackie Bakker with Montezuma National Wildlife Refuge in New York. Their help and on-the-ground information was vital in allowing us to successfully sample these areas.

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Table 1. Sample locations and numbers for the Eastern Population of Greater Sandhill Cranes.

Location Number	Location Name	Sample Dates	Number of chicks sampled	Number of families sampled
1	Sherburne National Wildlife Refuge, central MN	7/9 - 7/12/2007	11	10
2	Crex Meadows, Fish Lake, Amsterdam Slough State Wildlife Areas, northwestern WI	7/13 - 7/16/2007	8	8
3	Briggsville, central WI	1996 – 2011*	121	60
4	Necedah National Wildlife Refuge, central WI	2000**	23	16
5	Waterloo State Recreation Area, southeast MI	6/16 - 6/18/2008	14	10
6	Gun Lake Tribal Lands, southwest MI	6/20 - 6/23/2008	10	7
7	Seney National Wildlife Refuge, Upper Peninsula MI	7/5 – 7/8/2009, 7/12 – 7/15/2010	7	6
8	Thessalon and surrounding areas, southeastern ON	7/5 – 7/8/2009	13	10
9	Central NY (Montezuma NWR and surrounding areas)	6/16 – 6/20/2011	2	2
10	Northwestern PA (Pymatuning Lake and surrounding areas)	6/21 – 6/26/2011	4	2
11	Northeastern PA (Dushore)	6/27/2011	1	1

*Samples from flightless chicks banded as part of a long-term research project on habitat selection of sandhill cranes by the International Crane Foundation.

**Samples from chicks (collected as eggs at Necedah NWR) trained to follow ultralight aircraft to initiate a migratory population of whooping cranes (Urbanek et al. 2005).

Table 2. Pairwise Fst Values between sampling locations in the Great Lakes and Northeastern U.S.

	NY	PA	Ohio	Water	Gun	IL	Briggs	Nec	Crex	Sher	Ont	Seney
Central NY	-											
NW and NE PA	0.1840*	-										
Ohio	0.3075*	0.3176*	-									
Waterloo, MI	0.3019*	0.2908*	0.1053*	-								
Gun Lake, MI	0.3053*	0.2578*	0.0666*	0.0586*	-							
Northeastern IL	0.2100*	0.2484*	0.0820*	0.1136*	0.0976*	-						
Briggsville, WI	0.2186*	0.3034*	0.1721*	0.1974*	0.1594*	0.0466	-					
Necedah NWR, WI	0.2984*	0.3146*	0.2175*	0.1546*	0.1886*	0.1236*	0.1183*	-				
Crex Meadows, WI	0.2387*	0.2486*	0.1039*	0.0237	0.0550	0.0742*	0.1347*	0.0753*	-			
Sherburne NWR, MN	0.2979*	0.2731*	0.2058*	0.0964*	0.1690*	0.1376*	0.2140*	0.1436*	0.0584*	-		
Southeastern ON	0.2611*	0.2966*	0.1666*	0.0947*	0.1234*	0.1020*	0.1366*	0.0894*	0.0353	0.0883*	-	
Seney NWR, MI	0.2776*	0.2993*	0.2034*	0.1005*	0.1820*	0.1334*	0.1785*	0.0682*	0.0419	0.0728*	0.0139	-

Overall pairwise Fst = 0.1962*

*significant pairwise Fst ($p<0.05$) suggesting significant differentiation between sample site

AN INITIAL EVALUATION OF THE ANNUAL MIDCONTINENT SANDHILL CRANE POPULATION SURVEY

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Progress Report; Expected Completion: Fall 2013

Introduction

The midcontinent population of sandhill cranes (*Grus canadensis*) is among the most widely dispersed populations of game birds in the world; breeding in remote regions from western Quebec to northeastern Russia and wintering across a wide area of the south-central and southwestern United States and northern Mexico (Krapu et al. 2011). The U.S. Fish and Wildlife Service (USFWS) has conducted an annual survey of midcontinent sandhill cranes each spring at their major migratory stopover site along the Central and North Platte River Valleys (NPRV and CPRV) in Nebraska for >30 years. Since 1982, estimates of crane abundance have been derived using a probability based sampling design and photo correction of observed crane groups (Benning et al. 1987). The survey is conducted on the fourth Tuesday of March, which generally corresponds to peak abundance of cranes at this staging site (USFWS 1981). Due to annual variation in migration chronology, estimates of crane abundance at the Platte River can be interpreted as indices of midcontinent crane abundance, because an unknown proportion of the population is present in the surveyed area each year. Large annual fluctuations in survey estimates have cast doubt on the survey's ability to reliably track population abundance (Tacha et al. 1994). This variation may be due to numerous factors, including sampling error, observer bias, and variation in detection probabilities. In efforts to improve the survey, experimental techniques designed to greatly reduce variation due to sampling and visibility have been evaluated, including nocturnal surveys of cranes roosting on the river (e.g., Kinzel et al. 2006). Although promising, updated survey methods that provide more accurate estimates of cranes at the Platte River will only be useful for management if these values are a reliable index of the entire midcontinent population. Yearly variation in the proportion of the population at the Platte River during the spring survey (i.e., cranes available to be sampled in the survey zone) degrades the ability of survey estimates to track changes in population abundance; improved survey methods along the Platte River cannot completely ameliorate this variation.

Herein, we assess fundamental assumptions of the midcontinent sandhill crane survey using data from an extensive investigation of spring-staging cranes, which included data from individuals marked with platform transmitting terminals (PTTs), very high frequency (VHF) transmitters, and ground surveys. Specifically, we were interested in estimating variation in the proportion of cranes generally present at the Platte River during the survey period and cranes present within the surveyed area. This information would allow determination of a best time to conduct surveys and how much yearly variation due to these factors could be expected. Determining reliability of survey indices with respect to natural variation in migration chronology will provide insight as to how much improvement in the survey is necessary to consistently meet monitoring objectives given this uncontrolled variation.

Methods

During late February and early April 1998–2006, we captured and tagged sandhill cranes in the CPRV with VHF transmitters to obtain information on arrival to and departure from the CPRV. We also tagged captured cranes with PTTs during this same time period to determine geographic distributions (Krapu et al. 2011). Trapping and tagging efforts were conducted at numerous sites, and generally included pasture or haylands between Chapman and Lexington in the CPRV and near North Platte in the NPRV (Krapu et al. 2011; Fig. 1). To capture cranes, we used rocket-propelled nets and taxidermy-mounted sandhill crane decoys (Wheeler and Lewis 1972). We attached a VHF transmitter (20-25 g, Advanced Telemetry Systems Inc., Isanti, MN) to the left leg of randomly selected captured cranes using a two-piece leg band. We released most captured birds simultaneously within 30 min (range 15–60 min) of capture to maintain potential group and family bonds. The VHF transmitters were programmable, enabling us to get multiple years of data on individual tagged cranes. All

VHF transmitters were synchronized by simultaneous activation in mid-February to allow us to locate any cranes arriving at the Platte River at the onset of the staging period in subsequent years. Cranes carrying potentially functioning transmitters were searched for each evening throughout the staging period. We did not use data from mark-year birds to reduce potential bias. Newly detected arrivals were located nightly through departure to determine patters of roost-site use, movements, and length of stay in the region.

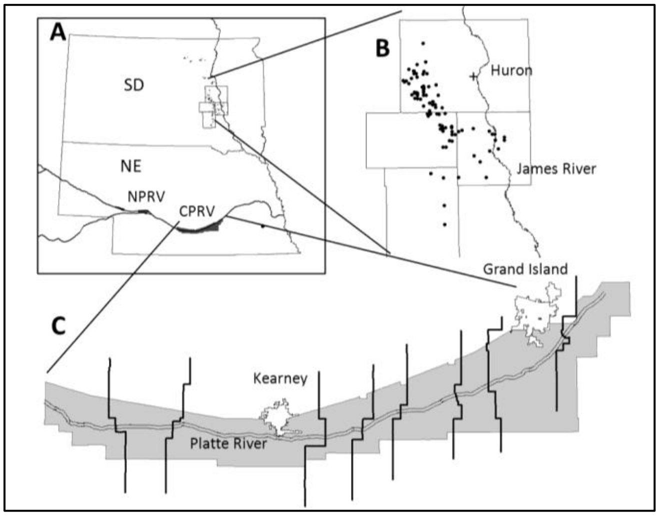

Figure 1. Sandhill crane survey zones in Nebraska and areas within South Dakota where PTT-marked cranes were located during crane surveys, 1999–2004 (A). Locations of cranes during ground surveys in 2009-2011 near the James River in South Dakota (B). Sandhill crane survey zone along the CPRV in Nebraska and 8 north-south transects used during road-based surveys (C).

A random sample of adult sandhill cranes were captured and marked with PTTs during 1998-2003, which allowed monitoring of crane distribution during spring migration. The CPRV and NPRV were chosen for trapping and tagging cranes because available information suggests virtually the entire population stops at these sites during March and April (Krapu et al. 2011). We determined distribution of cranes within a 7-day period surrounding scheduled survey dates each year from 1999–2004. We used this information to direct ground-based surveys conducted during springs 2009–2011, where we visited areas of past use, noted current distributions, and enumerated cranes present (Fig 1). We also included any observations of cranes in the general survey area when traveling between survey points and recorded geographic locations.

We established 8 road-based transects in the CPRV (Fig. 1) to estimate distances cranes foraged from the river and temporal use of the CPRV by cranes. We conducted ground surveys each week on Tuesdays beginning the third week of March and continuing through the first week of April 1998–2002, and 2009–2011. Each transect extended 16.1 km north and south from the main channel of the Platte River and was 440 m on each side of maintained roads (2,834 ha/transect; Fig. 1). Beginning at 0800 hours, a field technician drove the survey route, enumerated cranes in each transect, and recorded their distance from the river channel. We calculated percentage of cranes observed on transects outside of survey bounds used by the USFWS to conduct the aerial crane survey (Fig. 1) for each year.

Results

Over 7 years, we monitored locations of 167 PTT-tagged cranes in the CPRV and NPRV. A total of 74 sandhill cranes carried functioning PTTs while on their wintering grounds and returned to the CPRV and NPRV in spring. During 7-day periods surrounding scheduled survey dates, most cranes were located along the Platte River, and the remainder resided in the James River Valley in east-central South Dakota (Fig 1A). Based on this distribution, we selected 159 sections to visit during springs 2009–2011 concurrent with the Platte River crane survey. During these surveys, we enumerated 17,082 cranes during 24-26 March 2009, 8,671 cranes during 23-24 March 2010, and 15,104 cranes during 21-22 March 2011 (Fig 1B).

We marked 456 cranes with VHF transmitters during springs 1998–2006. Number of cranes reported staging in the CPRV ≥1 year after marking varied from 16 in 2001 to 86 in 2006 (Table 1). Between 2001 and 2007, the scheduled survey date (4th Tuesday of March) varied between 22 and 28 March. The greatest percentage of marked cranes were present on the scheduled survey date during 2001 and 2006 (94%), whereas only 71% of marked cranes were present in 2007 (Table 1). On average, 85% of cranes were present during the scheduled survey date and the standard deviation due to annual variation was 9%. In each year, a portion of cranes had yet to arrive in the CPRV (2-17%); in 5 of 7 years, some cranes departed before the survey date (≤27%; Table 1). By date, the greatest mean percentage of cranes present during 2001–2007 occurred on 26 March, and 22–26 March corresponded with the lowest estimated annual variation (Fig. 2).

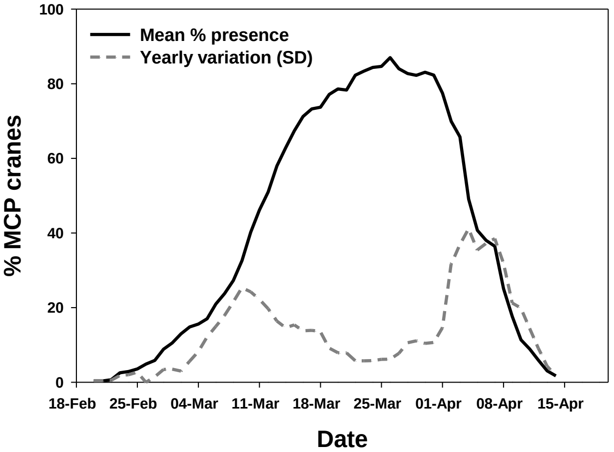

Figure 2. Annual mean percentage of sandhill cranes present at the Platte River during spring migration (solid line) and annual variation (dashed line), 2001–2007.

Table 1. Percentage of midcontinent sandhill cranes staging in CPRV that were present, not yet arrived, or already departed the area during the scheduled survey date on the fourth Tuesday of March each year, 2001–2007.

		During scheduled survey			
Year	Cranes	Date	% present	% not arrived	% departed
2001	16	27 Mar	94	6	0
2002	34	26 Mar	91	9	0
2003	24	25 Mar	75	17	8
2004	59	23 Mar	81	10	9
2005	42	22 Mar	88	10	2
2006	86	28 Mar	94	2	4
2007	44	27 Mar	71	2	27
Mean			85	8	7
SD			9	5	9

We encountered between 12 and 40 thousand cranes during each of 24 ground-based transect surveys conducted over an 8-year period during 1998–2002 and 2009–2011. We estimated 0–11% of cranes were outside of the established survey boundary during the week of the scheduled crane survey (mean = 3%; SD = 4%; Table 2). A smaller percentage of cranes were encountered outside of the survey boundary the week preceding scheduled surveys (mean = 2%) and a greater percentage during week after the scheduled survey (mean = 11%; Table 2).

Table 2. Percentage of midcontinent sandhill cranes observed outside of the survey boundary used in the USFWS coordinated crane survey along the CPRV the week preceding, week of, and week after the scheduled survey, 1998-2002 and 2009-2011.

Year	Pre-survey	During survey	Post survey
1998	<1	0	3
1999	10	6	15
2000	3	11	23
2001	<1	4	25
2002	0	<1	8
2009	<1	5	8
2010	0	0	0
2011	<1	<1	7
Mean	2	3	11
SD	4	4	9

Discussion

We observed substantial annual variation in percentage of marked cranes at the Platte River during the scheduled survey date. Using 650,000 cranes as an estimate of the entire midcontinent population, we found that differences in percentage of cranes present at the Platte could be interpreted as variation of ≤150,000 cranes, using the minimum and maximum values estimated (71 and 94% of population). This margin of error is 5 times greater than yearly estimated harvest (30,000 cranes; Kruse et al. 2008). A survey with this level of potential error may have limited value for yearly monitoring of a species with 5% harvest and 10% annual recruitment. Similarly, natural variation in chronology and some level of population turnover was observed for any conceivable survey date (Fig. 2). The general time period already used to conduct the survey provided the lowest annual variation, yet this level of variation was greater than may be useful to track yearly variation in population abundance.

Sandhill cranes at the Platte River occurred outside of the defined boundaries of the survey area with increasing frequency as spring progressed. As with percentage of birds at the Platte River, percentage of cranes outside of the survey bounds varied annually (0–11%) during the week of the scheduled survey. Conducting the survey a week earlier would not have decreased this variation greatly, and annual variation approximately doubled with a one-week delay (Table 2). Changes to survey bounds would decrease this variation but would likely increase survey costs.

Alternatively, a different survey method, potentially counting roosting birds, would alleviate this source of variation.

Based on natural variation in cranes present at the Platte River, certain changes to the crane survey may be necessary before it can be used to reliably track midcontinent crane population abundance. Initially, variation associated with the Platte River survey itself could be minimized or eliminated, including sampling error and error due to estimation of observation bias. This could be achieved by a fundamental change to how the survey is conducted, potentially shifting from a diurnal sample survey approach to a nocturnal enumeration of roosting cranes. With these sources of variation minimized, efforts would still be needed to reduce variation due to population turnover at the Platte River staging area.

Surveying areas outside of the Platte River area represent one potential solution. Although PTT-marked cranes were observed only in South Dakota during scheduled survey, results from VHF-marked birds indicate that surveys could be useful south and north of the Platte River, likely in South Dakota, Kansas, Oklahoma, and Texas. Compatibility with estimates from the Platte River survey could be achieve through improvements from incidental counts that have been conducted in association with the spring survey in the past. Our ground-survey in South Dakota provided a reasonable survey area, although data from PTT-marked cranes indicated that a larger area may need to be included. An aerial survey would likely be necessary to effectively survey the area if the goal were to generate an estimate of abundance for the region. Developing and conducting these surveys annually might prove cost prohibitive if birds are distributed over a large area. Alternatively, annual estimates or predictions of the percentage of the population present at the Platte River could be used in conjunction with the survey. Our study provided 7 years of data, which could serve as initial estimates for this endeavor. Additional years of data would be necessary to capture the level of variation that might be apparent in this measure. To facilitate these efforts, a manuscript is in preparation that presents these provisional estimates and sets forth a framework for updating estimates as new data become available. This type of approach may be useful because it is reasonable to assume estimates will change with time due to changes in land use and climate.

Acknowledgments

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SANDHILL CRANE NEST AND CHICK SURVIVAL IN NEVADA

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Introduction

Sandhill cranes (*Grus canadensis*) are among the longest lived (annual survival rates = 0.86-0.95; Tacha et al. 1992), and have the lowest recruitment rates of any game bird in North America (Drewien et al. 1995). Population growth of sandhill cranes is therefore most susceptible to changes in recruitment rate of young into the breeding population, in the absence of harvest or additional sources of adult mortality. Because sandhill cranes exhibit low fecundity, with small clutch size (1.94 ± 0.02, Drewien 1973) and low incidence of renesting (1.5-10.5% of total nests [Austin et al. 2007]), nest success may limit recruitment and therefore population growth.

Human modification of the landscape influences nest success for birds, often by influencing predation (Stephens et al. 2003). Roads may attract nest predators by increasing abundance of carrion (Knight and Kawashima 1993). Roads have been associated with increased reproductive success of common ravens (*Corvus corax*) because of anthropogenic food sources associated with roads (Kristan 2001). Ravens are an important egg predator for sandhill cranes in the western U.S. (Walkinshaw 1949, Drewien 1973, Littlefield 1976, Littlefield and Thompson 1987). No studies have yet documented impacts of human development, including roads, on nest survival of sandhill cranes.

Previous studies on nest success of greater sandhill cranes (*Grus canadensis tabida*; hereafter cranes) focused on the importance of water depth (Austin et al. 2007, Ivey and Dugger 2008, McWethy and Austin 2009) and vegetation height surrounding nests (Littlefield and Ryder 1968), and examined effects of land management that reduce nesting cover (Littlefield and Paullin 1990, Austin et al. 2007, Ivey and Dugger 2008). These studies did not, however, examine possible direct impacts of grazing on nest success. Because livestock often use mesic habitats in the arid west (Fleischner 1994), impacts of livestock on nest survival of cranes is possible and should be assessed. Few studies have accounted for variation in crane nest survival within a year (Austin et al. 2007, Ivey and Dugger 2008). No studies have attributed intra-seasonal variation in nest survival associated with a particular environmental factor.

Previous research has focused primarily on productivity of nesting cranes on national wildlife refuges, with limited studies on private agricultural land. Although refuges may provide important habitat, the overall contribution to population dynamics of cranes nesting on state and federal wildlife management areas may be relatively minor, because suitable habitat may largely occur on private land.

Chick (hereafter colt) survival is the least understood component of recruitment in cranes. Previous studies have focused on identifying direct causes of colt mortality, including predators and disease (Littlefield and Lindstedt 1992, Desroberts 1997, Ivey and Scheuering 1997), or habitat use. Although this may be informative for selective management of causes of mortality, the relative contribution of other environmental factors is unknown. No studies have estimated colt survival relative to time-dependent factors such as weather and hatching date.

Mortality of precocial young is often high early in development, and survival probability commonly increases with age (Flint et al. 1995, Stafford and Pearse 2007, Fondell et al. 2008), which has been attributed to increased ability to thermoregulate, forage, and evade predators during the growth period. Weather may have greater effect on survival at young ages, when chicks are more susceptible to cold temperatures. Also, inherent heterogeneity in traits affecting survival of colts allows selective removal of lower-quality individuals. Although previous studies have demonstrated high mortality of young colts

(Bennett and Bennett 1990, Nesbitt 1992), no studies so far have estimated daily survival rates of colts.

Our objectives were to estimate daily nest survival rates, nest success, and prefledging survival of cranes nesting primarily on private lands in northeastern Nevada. We hypothesized nest survival would be negatively related to human development and density of crane pairs. Among land-use practices, we hypothesized survival would be lowest for nests within summer-grazed fields, because of disturbance by livestock.

Study Area

Our study area encompassed Elko, White Pine, and extreme northern Lincoln Counties in northeastern Nevada, USA (Fig. 1). Topography was characterized by north-south oriented mountain ranges and associated basins (Fiero 1986). Average annual precipitation and average annual snowfall in Elko, NV during this study was 24 cm and 73 cm, respectively. Average daily temperatures from April-June in Elko, NV during this study ranged from 21° C to 2° C. Elevation in the study area ranged from approximately 1,300 m at the edge of the Great Salt Lake Desert, to nearly 4,000 m at Wheeler Peak. Lower elevation areas in the study area were used primarily for cattle grazing and native hay production in pastures irrigated by geothermal springs and from intermittent mountain streams via diversion ditches. Although 86% of the land area is in public ownership in Nevada, >85% of lowland meadow habitat is privately owned (McAdoo et al. 1986). Field work was performed at a mean elevation of 1,757 ± 6 m and directed towards known concentrated breeding areas of cranes in northeastern Nevada (Rawlings 1992).

We divided the study area into five subareas each representing a concentrated crane breeding area (Fig. 1): Ruby Valley Area (composed of Ruby, Secret, Steptoe, Spring, and Lake Valleys), Huntington Valley (composed of Huntington Creek Floodplain and Mound and Newark Valleys), Lamoille Valley Area (composed of Humboldt River Floodplain and Lamoille and Starr Valleys), Independence Valley Area (composed of South Fork of the Owyhee River Floodplain and Independence Valley), and North Fork Area (composed of O'Neil Basin, Thousand Springs Valley, and floodplains of the Upper North Fork drainages of the Humboldt River, Bruneau River, Salmon Falls Creek, and Mary's River).

Methods

Field Methods

Nesting data.—We searched for nests in hay meadows and pastures in northeastern Nevada from early April to early July in 2009 and 2010. We searched wet-meadow habitat in pastures and hay fields composed of grasses (*Poa spp.*), rushes (*Juncus spp.*), and sedges (*Carex spp*.). We also searched emergent vegetation along slow-moving streams and in beaver ponds, within natural and artificial ponds, and within marshes containing common cattail (*Typha latifolia*), hardstem bulrush (*Scirpus acutus*), and willow (*Salix spp*.). We began searches on 7 April in 2009 and 11 April in 2010 and searched for nests daily between 1 hr after sunrise and 1 hr before sunset. We focused our nest searching efforts in areas where cranes were present and signs of breeding were observed. We located active crane nests during searches on foot (*n* = 120 nests), helicopter (*n* = 37) and fixed-wing aircraft (*n* = 28) surveys, remote observations using spotting scopes or binoculars (*n* = 18), and canoeing (*n* = 3). We spent ≤2 consecutive days searching for nests at each property and rotated among four subareas (≤5 consecutive days per subarea) to ensure even coverage of the study area and an adequate sample of nests spanning the entire nesting season (Fig. 1).

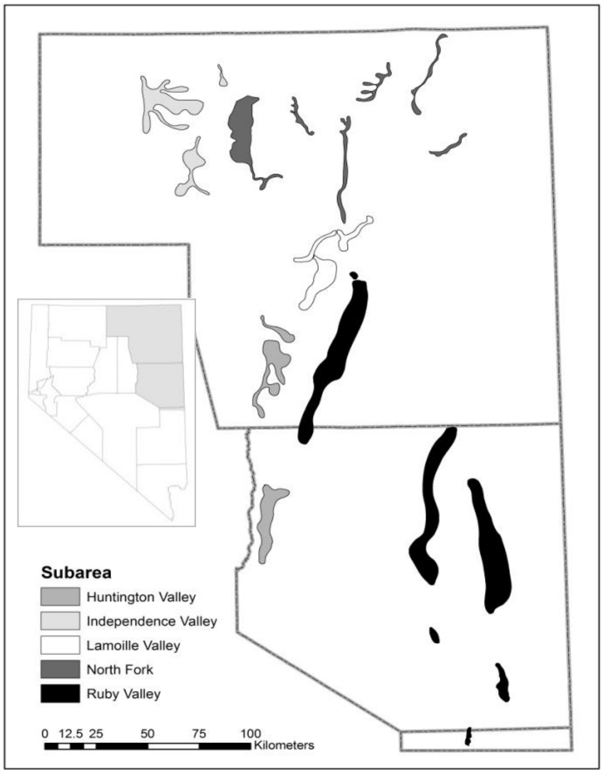

Figure 1. Location of greater sandhill crane study area and five subareas in northeastern Nevada, USA, 2009-2010.

When we found a nest, we floated each egg to estimate incubation stage (6 flotation stages span 3-8 days each, Westerskov 1950) and hatch date (Westerskov 1950, Fisher and Swengel 1991). We assumed eggs were laid at 2-day intervals (Littlefield and Ryder 1968, Drewien 1973). To assess abandonment due to investigator disturbance, we marked an X on one side of each egg and laid the marked side facing down. We considered nests with cold, intact eggs, no rotation of marked eggs from the previous visit, and no crane present on subsequent visits as abandoned. We checked all nests classified as abandoned again after 6 days to verify abandonment. We used a handheld Global Positioning System (GPS) unit to record Universal Transverse Mercator (UTM) coordinates of nests. We revisited nests regularly (mean interval = 8 days) until fate was determined (≥1 egg hatched [success] or the nest was destroyed or abandoned [fail]). We also visited nests near the expected hatch date to capture and radio-tag chicks (August 2011). We used presence of detached egg shell membranes or egg shell fragments, behavior of the territorial pair, or presence of young in, or near, nests to indicate a successful hatch (Nesbitt 1992). Any of these indicators subsequent to pipping eggs was also assumed to indicate a successful nest. Failed nests were represented by broken or missing eggs (Ivey and Dugger 2008). During each nest visit, we floated eggs and measured water depth (±1 cm) 1 m from nest edges, and vegetation height (±1 cm) 4 m from nest centers and at 1 m height in each cardinal direction using a modified Robel pole (Toledo et al. 2008). We recorded vegetation height as the lowest one centimeter band ≥50% obscured by vegetation. We averaged 4 measurements for each visit to obtain date-specific measurements for each nest.

We projected hatch dates using flotation of each egg in the clutch and assuming an average incubation period of 30 days (30.2 ± 0.19 d, Drewien 1973). We floated each egg in the clutch during each nest visit to refine estimates of incubation stage and hatch dates. We captured colts when they were present during a nest visit and after all viable eggs hatched. We assumed eggs hatched at 1-day intervals (Drewien 1973, Walkinshaw 1973). We also captured colts incidental to nest searches when crane pairs displayed parental behavior (i.e., wing display or guard call).

We classified the land-use practice in fields containing nests into 1 of 4 categories: idled, hayed, fall-grazed, or summer-grazed. We classified natural habitats or fields managed for wildlife as idled, which primarily occurred on National Wildlife Refuge land. Fields cut for hay and subsequently fall-grazed during the previous growing season were classified as hayed. We hypothesized direct impacts of livestock (i.e., disturbance) being present during nesting would have a greater impact on nest survival than reduction in vegetation height associated with grazing during the previous or current growing season. Therefore, we classified fields as summer-grazed if livestock were present during nesting.

Pair density.—To assess density-dependent effects, we identified pair locations through the presence of nests, young, or pairs. In conjunction with ground searches of nests, we regularly monitored suitable crane habitat for occupancy and we monitored pairs for nesting activity throughout the nesting period in 2009 and 2010. Cranes have high nest-site fidelity (Drewien 1973), and adult cranes generally nest annually (Tacha et al. 1992). Therefore, a pair location for one year was assumed to represent a pair location during the entire two-year study period. Also, failed breeders generally do not abandon nesting and brood-rearing areas until after the conclusion of the nesting period (Drewien 1973). We performed fixed-wing aircraft surveys on 13 and 20 May 2009, and helicopter surveys during 19-25 May 2010, to identify crane territories and access areas not available for observation from the ground. We augmented aerial sightings through ground surveys and field observations in areas not covered during the aerial surveys. Where possible, we located nests and young, and confirmed pair locations on the ground within a week after aerial surveys.

To avoid double-counting pairs in areas with high nesting densities and consequently overestimating density of pairs, we identified renesting pairs using multiple criteria. We classified nests as renests if distance between nests was ≤350 m (Drewien 1973) and if both 1) the interval between failure and initiation of nests was ≥10 days (Gee 1983), and 2) failure of a potential preceding nest occurred before 15 days of incubation (Drewien 1973). We also assumed females produced similar egg sizes (Walkinshaw 1973), and used this as a final criteria to identify renests. To identify the same pairs between years, we assumed a similar distance (≤350 m) between nests of the same pair, and we assumed similar egg sizes for the same nesting pairs in successive years. Consequently, our estimates of pair density were conservative.

Spatial Data

Landscape-scale data — We analyzed the importance of different habitat types using land cover data derived from the Southwest Regional Gap Analysis Project. We employed the land cover types: open water, North American arid West emergent marsh (hereafter marsh), Great Basin foothill and lower montane riparian woodland and shrubland (hereafter riparian), inter-mountain basins semi-desert grassland (hereafter grassland), and agriculture (USGS National Gap Analysis Program, 2004**)**. Open water was defined as water bodies with <25% vegetation or soil cover. Marsh was frequently or continually inundated by water and contained >80% vegetation cover. Riparian areas had >20% vegetative cover of forest or shrubland and periodically saturated soil or substrate. Grassland was sparse to moderately dense herbaceous layer dominated by medium-tall and short bunch grasses, often in a sod-forming growth, on lowland and upland areas. These areas were often flood-irrigated for hay production or pasture. Agriculture consisted of both center-pivot irrigated crops and hay fields. We observed a large proportion of hay meadows categorized as agriculture that was visually indistinguishable from grassland. Additionally, crop land composed a minor portion of the study area, and was primarily unused by nesting crane pairs. Therefore, we combined the land types agriculture and grassland to create a meadow habitat type. Because of limited vegetation cover, we hypothesized open water habitats would be negatively related to nest survival. Conversely, we hypothesized marsh and meadow habitat would have positive effects on nest survival, because increased vegetation cover should have provided increased nest concealment. Because common ravens prefer riparian areas for nest and roost sites (Engel and Young 1992), we hypothesized increased riparian habitat would result in decreased nest survival.

To assess anthropogenic impacts on nest survival, we identified sources of human development or human disturbance. We identified occupied residences during field observations and recorded locations on aerial photos using ArcMap. We extracted named roads from a Bureau of Land Management road network data layer to identify primary or regularly-traveled roads.

We employed a Geographical Information System (GIS) using ArcMap to help characterize the spatial aspects of our landscape-scale analysis. We calculated distance to nearest roads and distance to the nearest development (roads or settlements) using ArcGIS. We summed the number of 30-m pixels for each habitat type at radii within 100 m (area = 3 ha), 200 m (13 ha), 400 m (50 ha), 800 m (201 ha), and 1000 m (314 ha) of nests. These radii represent varying scales of habitat selection for nesting area, brood-rearing area, foraging area, territory, and home range, respectively (Baker et al. 1995). To identify con-specific effects on nest survival, we calculated density of territories (pair per hectare) around nests within radii of 800 m (201 ha), which approximates the upper limit of territory sizes estimated for cranes (McMillen 1988, Duan et al. 1997).

Weather data.—We gathered weather data from Remote Automated Weather Stations (RAWS) and Natural Resource Conservation Service's SNOTEL sites through MesoWest, and National Weather Service's Cooperative weather stations through the National Climate Data Center. We collected daily minimum temperature, daily maximum temperature, and daily precipitation for each nest from the nearest low-elevation weather station with available data (distances from nests to stations = 0.8 – 42.0 km). We estimated daily weather values for 24-hr periods ending at 0800.

Data Analysis

To assess fluctuations in water levels and vegetation height throughout the incubation period, we applied a general linear regression between date-specific measurements across nest visits. We assumed linear changes in water depth and vegetation height because intervals between nest visits were relatively short (mean = 8 days). For nests with only one day of measurement (n = 6 nests), we calculated average change (i.e., slope) in water depth or vegetation height across all active nests for that date. For nests with missing values during one visit, but with measurements from ≥2 visits, we interpolated using the slope from the regression equation to estimate missing values (n = 7 nests). We also averaged date-specific measurements across all visits for each nest to estimate one season-specific measurement for each nest.

We used the nest-survival module in Program MARK and an information-theoretic approach to evaluate support for competing models (Burnham and Anderson 2002). We evaluated the strength of support for each model by ranking models with Akaike's Information Criterion adjusted for small sample size

(AIC_c) and by calculating AIC_c model weights (w_i; Burnham and Anderson 2002). Prior to model building, we standardized nest-site habitat, landscape, pair density, and weather variables and we standardized nest initiation dates within years (mean = 0 ± 2 SD).

We developed univariate nest survival models to analyze temporal variation in daily nest survival associated with nest initiation date, nest age, and year. Daily nest survival rates often vary with date (Grant et al. 2005), so some models included nest initiation date as a covariate to account for this variation. We fit a linear trend on nest survival because daily survival commonly increases with nest age (Van Der Burg et al. 2010). To allow for nonlinear patterns in daily survival, we also fit a quadratic trend to nest age. To assess the role of weather variables on temporal variation in nest survival, we compared performance of models containing nest initiation date and nest age variables against models including only time-dependent weather variables (daily minimum and maximum temperatures, and daily precipitation). Annual variation in nest survival rates is often due to a variety of factors including weather conditions and fluctuations in predator and prey numbers (Bety et al. 2001, Dinsmore et al. 2002), that we did not measure. Therefore, we did not attempt to explain annual variation in nest survival using covariates. We also considered two-factor models allowing year to be additive or interactive with continuous time-dependent variables.

We developed univariate models containing different habitat types and anthropogenic impacts to detect sources of variation in nest survival beyond the spatial scale of a nest-site. To avoid obtaining competitive models that spuriously resulted by comparing models of different habitat types at different spatial scales, we chose a posteriori to restrict model comparison to a single spatial scale. We compared the relative performance of course-scale (1000 m spatial scale) models with their equivalent fine-scale (100 m and 200 m) models. Overall, we found course-scale models performed better than fine-scale models, so we restricted our comparison of habitat models to the 1000 m spatial scale. We incorporated spatial variables into our main-effects models containing land-use practice and nest habitat variables if 85% confidence intervals did not overlap zero (Arnold 2010).

To reduce bias in daily nest survival estimates attributed to human disturbance during nest visits, we estimated observer-effects (Rotella et al. 2000). We assumed a nest visitation effect on nest survival occurred during a short period (one day) following visits (Rotella et al. 2000). We added the observer-effects variable to the best approximating model lacking observer effects to assess the impact of nest visitation on nest survival.

We calculated nest exposure days as the period from initiation of incubation to hatching of the last egg. We assumed eggs hatched at 1-day intervals (Drewien 1973; Walkinshaw 1973). We calculated nest success by multiplying daily nest survival rates over the first 30 days of incubation (mean incubation period = 30.2 ± 0.19 d, Drewien 1973).

We estimated daily survival rates of colts using the nest-survival module in Program MARK because exact date of mortality was not known for all colts (White and Burnham 1999). We censored encounter histories of colts with undetermined fate at the time when colts were last known alive. We used an information-theoretic approach to evaluate support for competing models (Burnham and Anderson 2002) by ranking models using Akaike's Information Criterion, adjusted for small sample size (AICc), and by calculating AICc model weights (Burnham and Anderson 2002).

Results

We monitored 161 nests in 2009 and 2010. Of 49 nests monitored in 2009, 18 were successful. Of 112 nests monitored in 2010, 38 were successful. We monitored nests located in hayed (63%, n = 102), fall-grazed (21%, n = 34), idled (11%, n = 17), and summer-grazed (5%, n = 8) fields.

We found no support for differences in daily survival rates between years, but we found a significant interaction between year and a quadratic trend on nest age. From field observations, we suspected, a priori, weather conditions were different between years. May of 2009 was cooler (<5th percentile coldest May on record) than May 2010 (<20th percentile warmest May on record; National Climate Data Center). June of 2009 was the second wettest June on record for northeastern Nevada (National Climate Data Center). We compared the year × quadratic nest age trend interaction model with models containing a surrogate time-dependent variable of minimum daily temperature or maximum daily temperature. We found that a model containing quadratic trend in nest age and an interaction between minimum daily temperature and nest age performed better than the year-by-trend model, so we constrained all further models to contain this temporal variation. In addition, we found nest initiation was later in 2009 (mean Julian date = 135 ± 2.00, mode = 138) compared to 2010 (mean Julian date = 128 ± 1.61, mode = 122). Because we standardized initiation dates within years, we needed to account for seasonal variation in nest survival attributed to an environmental factor. Our best temporal model that accounted for seasonal variation in nest survival contained an interaction between daily precipitation and initiation date. Therefore, our final temporal model contained a quadratic trend on nest age, minimum daily temperature, interaction between minimum daily temperature and nest age, initiation date, daily precipitation, and interaction between initiation date and daily precipitation. All terms within the temporal model except initiation date and daily precipitation were important for explaining temporal variation in daily survival rates. Therefore, we constrained all further models to contain these variables accounting for temporal variation, and considered this our base model for comparison of landscape or habitat effects.

We found pair density within 800 m of nests to be an important spatial variable, so we incorporated this variable into our final model set. Within our landscape-scale analysis of univariate models, both distance to roads and distance to development were important. Models <12 ΔAIC_c performed better when distance to roads rather than distance to development was included, and these variables were highly correlated (r = 0.84, $P < 0.001$). Therefore, we included the distance to roads variable in our final model set to test for anthropogenic impacts on nest survival.

Variables within our base model important for nest survival included linear ($\beta = -0.24 \pm 0.11$) and quadratic trends on nest age ($\beta = 0.006 \pm 0.003$), minimum daily temperature ($\beta = 1.28 \pm 0.47$), and minimum daily temperature × nest age interaction ($\beta = -0.07 \pm 0.03$). Among the models considered, we found strong support for an effect of pair density within 800 m [Sum of Akaike weights ($\sum w_i$) = 0.98], nest-site habitat (water depth + vegetation height, $\sum w_i$= 0.91), and distance to roads ($\sum w_i$ = 0.90) on nest survival. Daily survival rates (DSR) were negatively associated with density of crane pairs ($\beta = -0.27 \pm 0.11$) and increased closer to roads ($\beta = -0.23 \pm 0.11$). Addition of nest-site habitat improved performance of models (Table 1). For nest-site habitat, vegetation height ($\beta = 0.23 \pm 0.13$) was important, but water depth was less so ($\beta = 0.16 \pm 0.11$).

Our best approximating nest survival model included the effects of water depth, vegetation height, distance to road, pair density within 800 m, and summer grazing. The second-best model (AIC_c w_i = 0.39; Table 1) was similar to the best supported model, but without a summer grazing effect and had $\Delta AIC_c = 0.11$ with 1 less parameter. Thus, although contained within the best model, we found a general lack of support for a summer grazing effect ($\sum w_i$ = 0.51, $\beta = -0.30 \pm 0.63$; Table 1). Furthermore, an effect of summer grazing alone performed worse than our base model (Table 1). When added to the best model, we failed to find support for an observer effect on daily nest survival ($\beta = -0.75 \pm 0.80$). A model lacking covariates was not competitive, indicating environmental variables had important effects on nest survival.

Lower minimum daily temperatures had a negative effect on nest survival and the effect increased with nest age. Additionally, increasing daily precipitation had a negative effect on daily survival rates of nests initiated early, but a positive effect for nests initiated late. Nest survival did not differ among fields that were idled, hayed, or fall-grazed. Daily survival rates for nests in summer-grazed fields were lower and more variable than in other fields (Fig. 2). Survival was nonlinear across the 30 days of incubation. A negative trend in survival occurred during the first half of incubation, shifting to a positive trend thereafter (Fig. 3).

The best performing model of temporal variation in colt survival constrained colt survival as a quadratic function of age. Weather variables were not competitive with other time-dependent variables. We constrained further models to contain a quadratic trend on colt age. Also, land cover types did not improve our temporal model, and therefore were not incorporated into further modeling.

Within our a priori model set, we found substantial support for an effect of federal versus state or private landownership ($\sum$wi = 0.99) and an interaction between relative body size and age of colt (∑wi = 0.98). We found moderate support for differences in colt survival related to year (∑wi = 0.65). Model-averaged variables important (i.e., 85% confidence intervals did not overlap zero) for colt survival included year (2009 $\beta = 0.66 \pm 0.33$), additive effect of private and state versus federal ownership ($\beta = 1.14 \pm 0.41$), a linear trend on colt age ($\beta AGE = 0.064 \pm 0.037$), an interaction between relative body size ($\beta BODY = 0.92 \pm 0.39$) and colt age ($\beta BODY \times AGE = -0.03 \pm 0.01$).

Discussion

We found nest survival was negatively related to pair density, which was the most important variable describing variation in nest survival. This is the first study we are aware of to detect density-dependent effects on nest survival of cranes. Density-dependent predation may be caused by either a functional or numerical response to prey density (Krebs 2001). Predators with large home ranges may detect heterogeneity in local prey density and alter search image or foraging pattern (Schmidt and Whelan 1999). Effects of density-dependent predation on nest success have been mixed. Density-dependent predation may vary with availability of alternate prey (Bety et al. 2001), or local predator communities (Ackerman et al. *2004).*

Contrary to our initial prediction, we found higher survival for nests closer to roads. Activity patterns of predators may shift in human altered and disturbed landscapes (McClennen et al. 2001). In Illinois, coyotes and red foxes (*Vulpes vulpes*) were less common in developed areas compared to raccoons (*Procyon lotor*; Randa and Yunger 2006). We frequently observed coyotes during field observations, but rarely observed red foxes, striped skunks (*Mephitis mephitis*), or raccoons. Coyotes are known to exclude red foxes (Sargent et al. 1987). Coyotes in areas with more human disturbance decrease diurnal activity and increase nocturnal activity, presumably to avoid human disturbance, shooting or trapping mortality, and competition with domestic canids (McClennen et al. 2001). We believe higher survival of nests closer to roads was primarily related to persecution of coyotes. No crane studies have yet to assess impacts of human development on nest success. The Eastern migratory population of cranes exhibited a long-term increase (Van Horn et al. 2010), which may be explained by positive impacts of human development on nest success.

Similar to other studies, we found nest-site habitat to be important for nesting cranes. Previous studies consistently found water depth (Austin et al. 2007, Ivey and Dugger 2008, McWethy and Austin 2009) to be important, but importance of vegetation was inconsistent. In contrast, we found nest-site vegetation height had a greater impact on nest survival than water depth. Consequently, tall vegetation (e.g. cattails and bulrush) may largely be concentrated in areas inundated by water. We suspect vegetation height provided a simpler, more informative description of both vegetation height and water depth, and may act as a surrogate for both nest concealment and isolation. However, we found no correlation between vegetation height and water depth at nests ($r = 0.07$, $P = 0.39$). We failed to find any importance of habitat beyond the scale of the nest-site, but the resolution (0.09 ha) of available data may have limited our ability to detect fine-scale landscape features important for nest survival.

Similar to previous studies (Austin et al. 2007, Ivey and Dugger 2008), we failed to detect variation in nest survival among idled, hayed, or fall-grazed fields. We found weak to modest support for a summer-grazing effect, but inferences are limited due to small sample size and consequently large variation in survival rates for these fields. We also did not distinguish between types of livestock (e.g. horses, bulls, cow-calf pairs, yearling cattle), which could influence the effect of livestock on cranes. We compared a stocking rate covariate to our categorical covariate of livestock presence and found the categorical covariate performed better.

Nest success estimates for the Lower Colorado River Valley Population of greater cranes nesting in northeastern NV (0.32 ± 0.08 for 30-d incubation period, in fields ungrazed during summer) was lower than estimates from either the Central Valley (0.72 ± 0.04, Ivey and Dugger 2008) or Rocky Mountain (0.41 ± 0.03, Austin et al. 2007; 0.65 ± 0.10, McWethy and Austin 2009) populations. Comparisons are limited because only one study (McWethy and Austin 2009) occurred on private land, and previous studies report apparent nest success or variations of Mayfield estimates, which assume constant daily survival rates that can inflate nest success estimates (Jehle et al. 2004).

We found colt survival was lower on Ruby Lake NWR versus state or private lands, despite high nest success (C. W. August, unpublished data) and abundance of marsh and wet meadow habitat found at Ruby Lake NWR. Therefore, we believe observed differences in survival was primarily related to differences in management of predator populations. In 1984, predator management ceased on Ruby Lake NWR. During 1986-1993, no colts fledged from an average annual population of 15 breeding pairs (J. Mackay, unpublished report). Reduction in the size of a local breeding population of cranes has been observed in areas with persistently low recruitment (Littlefield 1995, J. Mackay, personal communication). Abundant populations of generalist predators, such as coyotes, may exhibit predation that is inverse density-dependent predation, whereby predation exceeds recruitment, which can lead to extinction of prey populations (Sinclair and Pech 1996). In the arid intermountain west, maintenance of wetland or mesic habitats that are attractive to waterbirds may create sink habitats because predators respond numerically to the increased number of nests such habitats create (Hartman and Oring 2009). Future studies that manipulate predator populations are needed to assess the role of predation in population regulation of cranes before implementing predator management programs. Additionally, we suggest caution with species-specific predator control because compensatory predation may occur (Drewien and Bouffard 1990, Littlefield 2003, Ivey and Dugger 2008).

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THE USE OF SATELLITE TELEMETRY TO EVALUATE MIGRATION CHRONOLOGY AND BREEDING, MIGRATORY, AND WINTERING DISTRIBUTION OF EASTERN POPULATION OF SANDHILL CRANES

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Introduction

The Mississippi and Atlantic Flyway Councils recently endorsed a management plan for the EP of sandhill cranes (*Grus canadensis*) due to their increasing population. The plan's stated goal is to manage EP cranes in the Mississippi and Atlantic Flyways at a sustainable population level that is consistent with habitat and societal values (EP Management Plan 2010). The main objectives of the plan include:

1. Maintain the population index between 30,000-60,000 cranes as measured by the U.S. Fish and Wildlife Service (USFWS) Coordinated Fall Survey.
2. Reduce agricultural damage and conflicts due to EP cranes.
3. Provide non-consumptive opportunities
4. Provide consumptive opportunities.

Objective One of the management plan states that the population status will be monitored by the fall sandhill crane survey coordinated by the USFWS. The fall survey is a long-term annual survey, established in 1979. It consists of efforts by volunteers and state and federal agencies from the Atlantic and Mississippi Flyways (Wisconsin, Michigan, Indiana, Tennessee, Georgia, and Florida). The main goal of the survey is to count EP cranes that concentrate in Indiana, Michigan, and Wisconsin. The survey is also timed to count birds migrating from the Manitoulin Island staging area in northern Lake Huron, Ontario (EP Management Plan 2010). The 2011 fall survey resulted in a population index of approximately 72,000 with a five-year average (2007-2011) of 52,300 (Fig. 1).

Early observation records indicate that EP cranes formerly bred across the Great Lakes region (Michigan, Ontario, and Wisconsin) and wintered in Florida and southern Georgia (Walkinshaw 1960). However, the extent of the breeding range in Ontario is unclear. Observation records also indicate that EP cranes migrate southward from their breeding grounds through an east-central corridor that includes Illinois, Indiana, Ohio, Kentucky, Tennessee, and Alabama, enroute to wintering grounds in southern Georgia and central Florida (Walkinshaw 1973, Lewis 1977, Tacha et al. 1992, Meine and Archibald 1996).

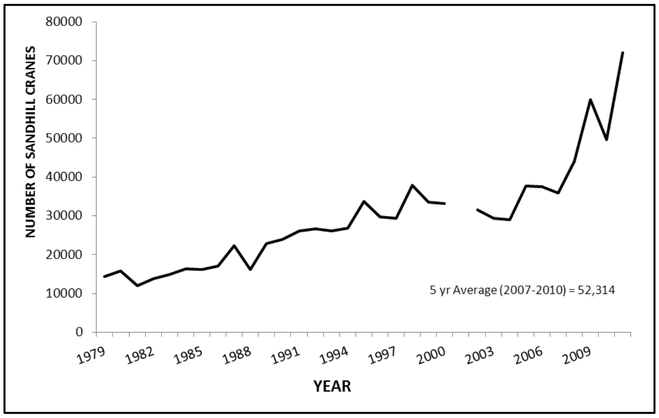

Figure 1. Number of Eastern Population sandhill cranes counted on fall surveys. Survey was not conducted in 2002. U.S. Fish and Wildlife Service data.

EP cranes appear to be expanding their traditional breeding range and migration routes. A 1977-1979 cooperative inventory of sandhill cranes in Minnesota observed breeding pairs, young, and non-breeding sandhill cranes in northwest and east-central counties during the months of May through August. Those cranes observed in east-central Minnesota were considered part of the EP (Henderson 1979). Since the late 1970s, the EP breeding range has expanded to the south and now includes northern Iowa, Illinois, Indiana, and Ohio (Tacha et al. 1992; David Sherman, Ohio Department of Natural Resources, pers. com.).

Recent advancements in technology allow a better examination of sandhill crane movements than was previously possible. For example, in 2007, platform transmitter terminal (PTT) satellite transmitters were placed on 6 sandhill cranes in north-central and southwest Louisiana (Sammy King, U.S. Geological Survey [USGS] Louisiana Cooperative Fish and Wildlife Research Unit 2007). Two of the 6 marked birds migrated east of the Mississippi River into the EP range. The remainder migrated west of the Mississippi River into the Mid-Continent Population (MCP) range, suggesting mixing between the EP and MCP in Louisiana. Of the 2 birds that migrated east of the Mississippi River, 1 migrated through a less traditional route of west Tennessee through Illinois and into Wisconsin. That same year, Long Point Waterfowl – Bird Studies, Canada placed 4 PTT satellite transmitters on EP sandhill cranes on the north shore of Lake Ontario, Canada and described cranes using traditional migration routes and breeding and wintering areas (Long Point Waterfowl - Bird Studies Canada 2009).

In 2009, the Association of Fish and Wildlife Agencies' Migratory Game Bird (MGB) Support Task Force composed of U. S. and Canadian academic, state/provincial, and federal agency experts met to identify priority information needs for the 6 migratory populations of sandhill cranes. These priority needs focused on initiating or enhancing monitoring efforts and estimating vital rates during the annual cycle of sandhill cranes (D. J. Case and Associates 2009). Reviewing the main objectives of the EP management plan and available EP crane studies, the MGB Support Task Force identified 2 primary information needs for EP cranes:

1. Describe the geographic extents of the breeding and wintering range. Document the spatial and temporal aspects of migration and make appropriate suggestions towards improving the design of the USFWS coordinated survey that will reflect current distribution and migration patterns.

2. Conduct a critical review of the current USFWS coordinated survey and evaluate its effectiveness to monitor the population, recommend improvements for the survey, and develop a standard survey protocol.

The objectives of our study are to address the first information priority need for EP cranes identified by the MGB Support Task Force. We will describe the EP breeding and wintering range and migration by trapping sandhill cranes with rocket nets on major staging grounds and placing solar GPS satellite transmitters on 30 EP sandhill cranes. We will trap EP sandhill cranes at the Jasper-Pulaski FWA during the fall months of October and November and then at the Hiawassee Wildlife Refuge, Tennessee during the winter months of December and January, 2010-2011.

Study Area

We trapped and placed 21 solar-powered GPS satellite transmitters on sandhill cranes staging at Jasper-Pulaski Fish and Wildlife Area (FWA), Jasper, Pulaski, and Starke Counties, Indiana and at the Hiawassee Wildlife Refuge, Armstrong and Blythe's Ferry Units, Meigs County, Tennessee (Fig. 2). The Jasper-Pulaski FWA encompasses 3,263 ha and is located in northwest Indiana within the Kankakee Outwash and Lacustrine Plain physiographic region. Small dunes and low marsh lands dominate the area as a result of the retreat of the Saginaw Lobe of the Wisconsin Glacier. The land use surrounding JP is predominately agriculture, particularly corn and soy bean production. Land use on the Jasper-Pulaski FWA is approximately 810 ha of wetland, shallow aquatic impoundments, and upland comprised of 2,023 ha of woodlands (*Quercus* spp. dominate) and 405 ha of upland/cropland. Crops produced for wildlife include corn, soybeans, and winter wheat. Hunting wildlife is allowed in designated zones within the Jasper-Pulaski FWA. However, protection zones are incorporated within the Jasper-Pulaski FWA for crane roosting, feeding, and loafing (Indiana Department of Natural Resources internal report, unpublished).

Hiawassee Wildlife Refuge is located in eastern Tennessee within the Southern Ridge and Valley Physiographic System 13 (Partners In Flight: Physiographic Area Plan 2010) and the tablelands of the Southern Cumberland Plateau. The most abundant land-cover types are oak-hickory or oak-pine mesophytic forest, with scattered agricultural fields comprising a low proportion of the total landscape. The Hiwassee Wildlife Refuge encompasses approximately 2,428 ha (1,112 ha land and 1,416 ha water) located within the Chickamauga Reservoir at the confluence of the Hiwassee and Tennessee Rivers. Included are 162 ha of Hiwassee Island. Land use is approximately 30% agricultural and is cropped and 70% is a wooded mix, primarily of pine and hardwood forest. Crops produced for wildlife consumption include corn, winter wheat, soybeans, milo, varieties of millet, and buckwheat (Tennessee Wildlife Resource Agency, Important Bird Areas 2006). Adjacent sand bars and low water levels on Chickamauga Lake create ideal roosting habitat for waterfowl and sandhill cranes during the fall and winter months. The refuge is managed to provide habitat for wildlife, specifically wintering waterfowl.

We also trapped and placed transmitters (*n* = 5) on EP cranes at Goose Ponds FWA, Greene County, Indiana during the 2010 spring migration, Sherburne NWR, Sherburne County, Minnesota during the 2010 fall migration, Crex Meadows Wildlife Area, Burnett County, Wisconsin during the 2011 fall migration, and Hop-In Wildlife Refuge, Obion County, Tennessee during the 2011 winter (Fig. 2). EP cranes stage and winter at these areas, however cranes do not concentrate at these areas to the extent they do at either Jasper–Pulaski FWA or Hiawassee Wildlife Refuge.

The Goose Pond FWA was established by the Indiana Department of Natural Resources in 2005 and is described as a glacial wetland within the White River Drainage Basin that lies in the Ohio Ecosystem (Indiana Department of Natural Resources 2011). Goose Pond FWA is approximately 3,258 ha and 60% of the land cover consists of herbaceous marsh, wet meadows, and open water. Migrating cranes roost along shallow wetlands on the property and feed in the adjacent agriculture land that includes corn, soybean, and winter wheat production. A peak estimate of 11,000 cranes was observed during an evening feeding flight in March 2010 (Brad Feaster, Indiana Department of Natural Resources, pers. com.).

The Sherburne NWR is located in the Mississippi Headwaters/Tall Grass Prairie Ecosystem in east-central Minnesota and encompasses approximately 12,373 ha (2,959 ha water and 9,378 ha land). Refuge wetlands provide suitable nesting habitat for approximately 30-40 nesting pairs of EP cranes annually and are preferred for roosting habitat for an estimated 2,500-3,500 migrating cranes during the fall. Land use to the north, west, and northeast of Sherburne NWR is predominately agriculture and includes corn, soybeans, and cattle pasture that provide food resources for migrating cranes (USFWS, Sherburne NWR Comprehensive Conservation Plan, 2005).

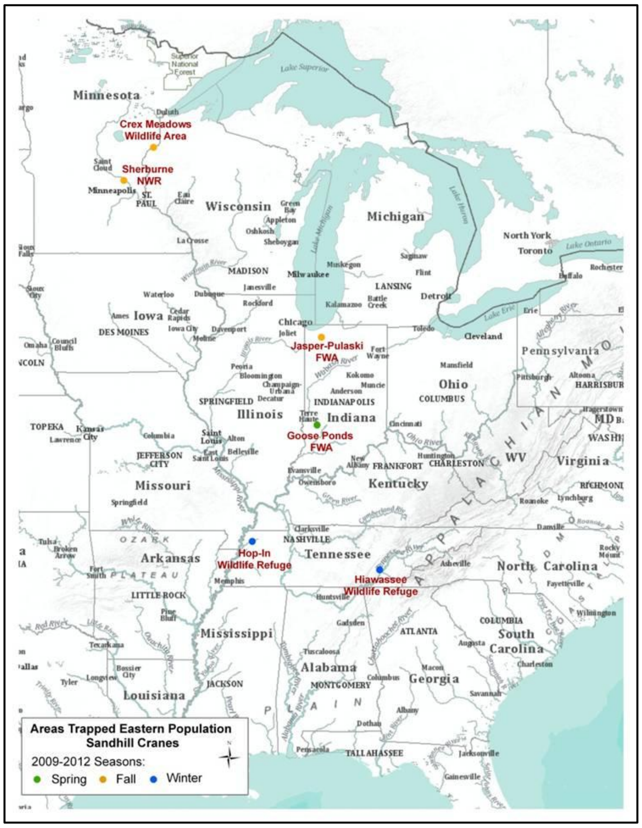

Figure 2. Eastern Population sandhill crane trapping locations in Indiana, Minnesota, Tennessee, and Wisconsin.

The Crex Meadows Wildlife Area is located within the remaining Northwest Wisconsin Pine Barrens and is approximately 12,040 ha in size consisting of interspersions of brush prairie, oak-jack pine (*Pinus banksiana*) forest, and an extensive sedge marsh, which was once the Glacial Lake Grantsburg (Crex Meadows Wildlife Area, Wisconsin Department of Natural Resources 2012). Crex Meadows has an increasing amount of breeding pairs of sandhill cranes within the sedge marsh. However, the largest numbers of sandhill cranes are seen during the staging period prior to fall migration. Recent estimates are that approximately 7,000 EP cranes use Crex Meadows Wildlife Area and the surrounding agricultural fields while staging prior to fall migration (Steve Hoffman, Wisconsin Department of Natural Resources, pers. com.).

The Hop-In Wildlife Refuge is managed by the Tennessee Wildlife Resource Agency and is part of the J. Clark Akers Wildlife Complex within the Mississippi Valley Loess Plains Ecoregion [Tennessee

Wildlife Resource Agency, Obion (South Fork) Watershed 2008]. The Hop-In Wildlife Refuge unit is 251 ha in size and provides roosting habitat within the moist soil units that were created for wintering waterfowl. The surrounding agriculture land (winter wheat, corn, soybeans) offers winter foraging for an average of 1,500-2,000 cranes (Tennessee Wildlife Resource Agency, Important Bird Areas, 2008).

Methods

We used rocket nets as the primary method to trap EP sandhill cranes within the Jasper-Pulaski FWA and Hiawassee Wildlife Refuge during the fall and winter months. We began by identifying daytime loafing sites by observing crane movements, and baiting loafing sites with whole corn. We used the protocol for identifying potential trapping sites developed for rocket netting MCP cranes (David Brandt, USGS Northern Prairie Wildlife Research Center, pers.com.), giving priority to loafing sites with >20 cranes present in pasture or other open land-cover types. When cranes responded to bait for 2 consecutive days, we assembled a rocket net trap as described by Wheeler and Lewis (1972) and David Brandt (USGS Northern Prairie Wildlife Research Center, pers. com.).

Trapping was mainly conducted in the morning because cranes consistently return to these sites after leaving nocturnal roosts. Following capture, we isolated a single crane and placed it in a canvas handling bag as part of the process of affixing a satellite transmitter. If possible, we identified and affixed a transmitter to an adult female sandhill crane that was observed as part of a family group or as a member of a male-female pair. However, if family groups were not identifiable, we isolated a smaller-bodied, adult crane (presumed to be a female—sex will be determined via genetic analysis of blood). We identified adult females based on red skin on the crown of the head, smaller body size, and social behavior among birds (David Brandt, USGS Northern Prairie Wildlife Research Center and Ann Lacy, International Crane Foundation, pers. com.).

For each bird to which we affixed a satellite transmitter, we collected morphological measurements as described by Dzubin and Cooch (1992), and drew blood, which was placed in a Lysis buffer anticoagulant solution and will be used to determine sex of the bird at a later time (Jones 2005). We affixed a North Star Science and Technology solar-powered GPS satellite transmitter to the upper tarsus (Dave Brandt, USGS Northern Prairie Wildlife Research Center, pers. com.) to cranes identified as part of our marked sample. Other cranes captured were affixed with a 7.6-cm coded tarsus auxiliary leg band. All birds captured received a USGS, Bird Banding Laboratory (BBL) size 8, 1-800, aluminum, butt-end band and were released as a group.

In addition to using rocket nets, we used a Coda NetLauncher to capture cranes where using a rocket net was not feasible. We followed the protocol for standard use of the Coda NetLauncher that was developed by the Ohio Department of Natural Resources during their 2010 nesting sandhill crane study in Ohio (Dave Sherman, Ohio Department of Natural Resources, unpublished). We also used modified Victor #3 softcatch leghold traps as described by King and Paulson (1998) to capture 1 crane.

Data: We will describe EP sandhill crane migration staging areas, routes, and chronology by analyzing satellite data from 30 cranes captured during fall migration. Satellite data will consist of 5 GPS locations per day during spring and fall migration (October – May) and 4 GPS locations per day during the summer months (June – September). In addition, PTTs will transmit standard ARGOS satellite system estimated Doppler locations and diagnostic data every 3 days for an 8-hour period. Doppler locations will be filtered to obtain reliable locations using the Douglas ARGOS-Filter Algorithm developed by Dave Douglas (USGS, Anchorage, AK, USA; Krapu et al. 2011).

We will download satellite data every 2 days from the CLS America, Inc. website. Data will be translated by software developed by NorthStar Science and Technology, viewed using ESRI ArcGIS software (2009), and maintained in a database of location and sensor data in SAS v9.1 (2008). We will use ArcGIS (ESRI, Redlands, CA, USA) to analyze satellite data to estimate migration departure dates, distance between stopovers, frequency of stopovers, duration of stay at a stopover, and total distance of spring and fall migration, similar to the analysis described in Krapu et al.'s (2011) satellite study of MCP cranes and described in the mallard (*Anas playtrhynchos*) studies by Yamaguchi et al. (2008) and Krementz (USGS-Arkansas Cooperative Research Unit, unpublished). Breeding and wintering grounds for tagged EP cranes will be defined by the geographic terminus of migration as in Krapu et al. (2011).

Results

To date, we captured and marked 30 EP cranes with satellite transmitters during the spring and fall migration and the winter months of 2009 through 2012. We initiated a pilot project during the months of December 2009 and January 2010 and marked 6 EP sandhill cranes on the Armstrong and Blythe's Ferry Units, Hiawassee Wildlife Refuge. In addition, we affixed a PTT to 1 crane in March 2010 at Goose Pond FWA, Indiana. After the pilot project was completed, we analyzed preliminary satellite movements and evaluated previous trapping events, and used this information to allocate remaining transmitters.

In the fall of 2010, we affixed PTTs to 1 crane at Sherburne NWR, Minnesota prior to assure representation for the northwest extent of the EP range breeding range. We then marked 4 cranes at Jasper-Pulaski FWA in late October 2010 and 3 cranes in late November 2010. We continued trapping and marked 6 cranes at Hiawassee Wildlife Refuge in early December 2010. We concluded marking birds by trapping 1 EP crane during the fall staging period of 2011 at Crex Meadows Wildlife Area, Wisconsin, 2 cranes during winter 2011-2012 at the Hop-In Wildlife Refuge, Tennessee, and 2 cranes during winter 2011-2012 at Hiawassee Wildlife Refuge, Tennessee.

Throughout our trapping effort, we captured approximately 190 sandhill cranes. We captured 178 with rocket nets, 11 with the Coda NetLauncher, and 1 in a softcatch leghold trap. We attached 1-800 aluminum USGS bands and a black-with-white lettering, 3-digit alpha-numeric coded tarsus auxiliary band to 61 cranes; a single black-with-white lettering, 2-digit alpha-numeric tarsus auxiliary band containing a PTT and a 1-800 USGS aluminum band to 30 cranes, and; 1-800 USGS aluminum bands to all other cranes we captured.

Preliminary data analysis of GPS movements indicate that transmitter-equipped cranes returned to their summer territories using the previously described traditional routes and staging areas (Fig. 3). GPS locations also indicate that of 23 active satellite transmitters deployed prior to northward migration in 2011, 3 cranes established breeding territories in Minnesota, 9 cranes settled throughout Wisconsin, 3 cranes settled in Lower Michigan, 2 cranes settled in the Upper Peninsula of Michigan, 3 cranes settled on the north shore of Lake Huron, Ontario, Canada, and 3 cranes in north-central Ontario, Canada (Fig. 4).

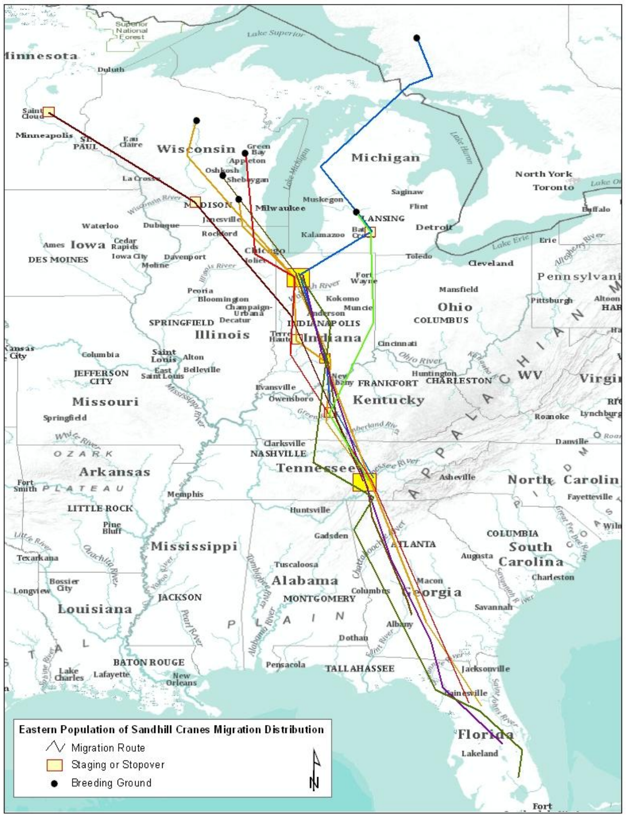

Figure 3. Preliminary breeding and wintering areas, migration routes, and staging areas for Eastern Population of sandhill cranes, 2009-2010. Unpublished data, 2010.

We are currently tracking 27 of the 30 cranes we marked. Three marked birds that were fitted with PTTs subsequently died during the spring migration period and 1 transmitter ceased to register a month after deployment. We did not determine cause of death for any of the transmitter-equipped cranes that died during our study, due to the length of time between when sequential locations indicated that a PTT had become sedentary and the time when we recovered the transmitter. However, we recovered all 3 transmitters, tested them, and then redeployed them on cranes in Tennessee in early2012.

Plans for 2012

We will continue to monitor the progress of marked EP cranes throughout 2012. Satellite data will continue to be collected, processed through a satellite decoding program created by North Star Science and Technologies, and transformed into a workable database for future analysis. We do not anticipate trapping any additional cranes for 2012.

Figure 4. Preliminary breeding territories for Eastern Population of sandhill cranes, 2011. Unpublished data, 2011.

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American Woodcock

HABITAT USE AND ORIGINS OF AMERICAN WOODCOCK WINTERING IN EAST TEXAS

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Introduction

American woodcock (*Scolopax minor*) Singing Ground Surveys indicate long-term declines since monitoring began in the 1960s (Cooper and Parker 2010). Primarily attributed to habitat loss and modification throughout its range, multiple factors have likely contributed to this long term decline (Kelley et al. 2008). Challenges associated with quantifying population dynamics across its range makes it difficult to pinpoint the scale, location, and influence of factors influencing these declines. Only when populations are examined holistically, estimating linkages among wintering, breeding, and stopover habitats, and when available habitat is inventoried, will factors influencing trends be more well understood (Case and Case 2010).

English Setter pointing a woodcock in a pine plantation *Photo by Dan Sullins*

Identification of habitat availability and use on regionally important wintering, breeding, and stopover sites combined with estimates of connectivity among these sites is needed for a more holistic understanding of woodcock population dynamics (Case and Case 2010). Similar to other shorebirds, woodcock select habitat within hydrologically defined ecoclines, where moist soil with accessible prey and adequate cover in the form of dense thickets are readily used. During winter, woodcock are plastic and use a variety of habitat and landcover types as well as forest ages (Kroll and Whiting 1977, Johnson 1980, Berry et al. 2006), all of which are assumed to be largely driven by temporal variability in soil moisture (Glasgow 1958, Cade 1985) and site habitat availability. Prior research has laid the foundation for large scale, regionally relevant habitat evaluations for wintering woodcock.

Harvest data, band recovery (Godfrey 1974, Ingram and Wood 1983), recent telemetry (Myatt and Krementz 2007b) and departure and arrival data (Glasgow 1958, Sepik and Derleth 1993) have provided insight into woodcock migration and movement patterns. However, its elusiveness and use of dynamic early successional mesic habitats, has made it difficult to monitor populations and determine continental scale migratory connectivity. Stable isotope analyses are an excellent means by which to link birds to specific regions, as ratios of stable isotopes vary among landscapes due to precipitation patterns, anthropogenic factors, and photosynthetic pathways used by plants (West et al. 2010). Migratory bird feathers carry isotopic signatures indicative of molt origin to spatiotemporally distinct locations (Hobson and Wassenaar 2008). Stable isotopes of hydrogen are commonly used in bird migration studies (Chamberlain et al. 1997; Hobson and Wassenaar 1997), as deuterium in precipitation follows a gradient across North America, wherein δD (standardized stable hydrogen isotope ratios) values mostly decrease from the Southeast to the Northwest (Sheppard et al. 1969; Taylor 1974).

Beyond estimating migratory connectivity, delineating population connectivity in American woodcock is important as nesting does occur outside the principle breeding region surveyed by Singing Ground Surveys (Roboski and Causey 1981, Boggus and Whiting 1982, Keppie and Whiting 1994, Whiting et al. 2005). The extent of such breeding activity is poorly well understood and presumably variable among years (Olinde and Prickett 1991, Whiting et al. 2005), but such contributions may be significant (Owen et al. 1977, Straw et al. 1994). Identification of key regional population sources, or production areas, that contribute to winter harvest would be valuable for implementing new and updating current monitoring programs throughout the true geographic range of American woodcock.

Objective

This research is multifaceted, in which we are estimating (1) American woodcock habitat use and availability in important wintering region and (2) migratory connectivity throughout the geographic range of the American woodcock. Specifically, the objectives of this research are to:

1. Estimate landscape level occupancy and population densities of American woodcock wintering in east Texas.
2. Quantify American woodcock habitat use and HSI values among available and occupied winter habitats in east Texas.
3. Use stable isotope techniques to estimate population sources and link connectivity among natal, summer, and winter ranges of juvenile hunter harvested American woodcock.

Progress

Objectives 1&2: Woodcock occupancy, density, and habitat suitability.

The study area is within the West Gulf Coastal Plain (WGCP) Bird Conservation Region, comprised mostly of loblolly pine (38%) and other mixed hardwoods (Krementz et al. 2008). The east Texas portion is heavily forested and much of the land has been converted into even aged pine plantations. Two study areas were selected based on land use and representative of available landcover types in east Texas; one on a private timber property and one on the Davy Crockett National Forest.

Within each study area, stratified random sampling was used to select 24 sites for woodcock surveys and habitat estimation (Figure 1). Woodcock survey sites were selected by placing evenly spaced points (1 km apart) on secondary roads throughout each study area. Sites were then randomly selected within different strata of ranked soil suitability classes following Cade (1985). A total of 18 landcover types were classified using maps from the Texas Ecological Classifications Project (Diamond and Elliott 2009).

Woodcock surveys using a pointing dog affixed with a GPS collar (following Guthery and Mecozzi 2008) were conducted from 31 December 2010 – 12 February 2011and 8 November 2011- 3 March 2012. Each survey began at the center point of each survey site (circle) and lasted 1.5 hours. Each site was surveyed at least three times each winter. Upon finding a woodcock, location was recorded using a GPS, while area searched within each survey site was estimated for each survey (Figure 2). A line transect was established from each dog track where estimated effective strip width was calculated using Point to Flush Distance (PFD). Effective strip width was determined from the average PFD for each survey day. Line transects were uploaded into an ArcGIS map to estimate area (ha) searched within the survey site for each survey.

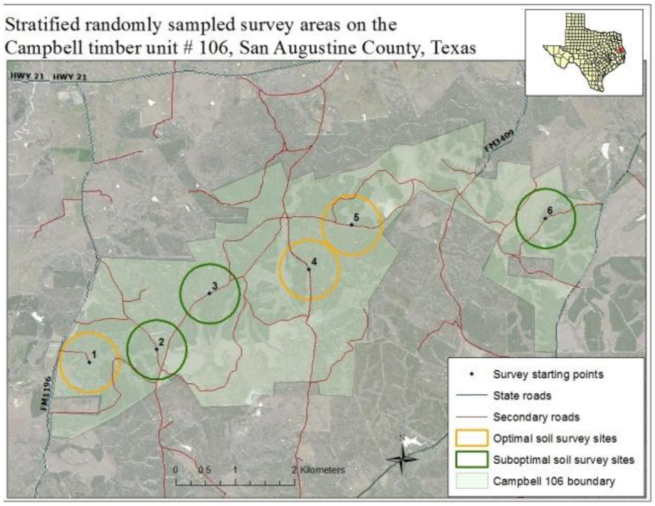

Figure 1. Map of stratified randomly sampled survey areas on the private timber property.

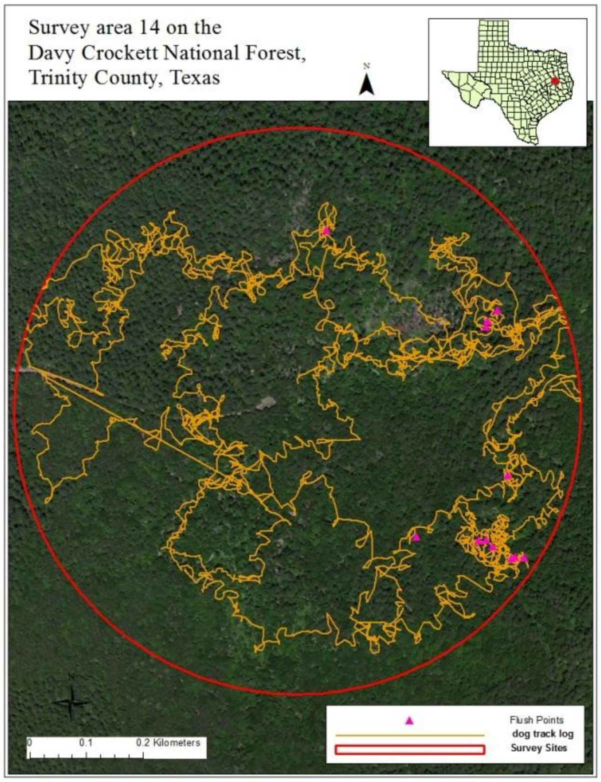

Figure 2: Map of a pointing dog track log used to estimate area searched within a National Forest survey area.

Field habitat data were collected to calculate Habitat Suitability Index (HSI) scores, following Cade (1985). Data were collected at each flush point, previously marked on a GPS, and at random points generated within surveys areas and within landcover types using classifications from Diamond and Elliott (2009). All random points were generated using Hawth's Analysis tools, in ArcGIS 9.2.

At each flush and random point, a soil sample was collected to confirm soil classifications. The following habitat were also measured: canopy cover (%), soil compaction, vegetation cover (%) {in two strata: 0 - 0.5 m and 0.5 - 5 m}, stem density and basal area (m^2/ha) of trees > 5 m, and height when trees were < 5 m.

During the two seasons, 180 woodcock surveys were conducted and 297 flush events were recorded. In 2010-2011 alone > 640 km were traversed during pointing dog surveys. In 2010-2011, all survey sites on the private timber site and 83% (15/18) of National Forest survey sites were occupied by at least one woodcock; 1.7 birds were flushed per survey on both sites combined. In 2011-2012, 17 of 24 plots, including all survey sites on the private timber site and 61% (11/18) of National Forest plots were occupied by at least one woodcock; 1.63 birds were flushed per survey on both sites combined.

From 2010-2011 data, unoccupied sites had a prominent upland mature pine or hardwood component with excessively drained sandy soils. Within survey areas greatest densities occurred in small stream and riparian seasonally flooded hardwood forests closely followed by young (1-3 m tall) pine forests, while upland deciduous forests had the lowest densities. Woodcock were often located under any available cover close to riparian or wetland areas including sapling pine trees (*Pinus spp.*), dewberry vines (*Rubus spp.*), wax myrtle (*Morella cerifera*), switch cane (*Arundinaria spp.*), sapling hardwoods, Chinese privet (*Ligustrum sinense*), yaupon holly (*Ilex vomitoria*), American holly (*Ilex opaca*), and American beautyberry (*Callicarpa americana*).

Severe to extreme drought prevailed throughout winter 2010-2011 (U.S. Drought Monitor), where moist soil was scarce and woodcock were found in the lowest elevation portions of survey areas in close proximity to creek and river channels, next to springs, or on the fringes of drying beaver ponds and swamps. Greatest woodcock densities occurred in riparian switch cane thickets on the National Forest and in sapling/pole pine stands on the edges of streamside management zones on the private timber land. Soils used ranged from loamy fine sands to silty clay loams, but most birds were found on fine sandy loams.

Habitat suitability (HSI) models were used to evaluate 122 flush points and 120 random points. HSI values for the entire study area, National Forest, and Private timberland were 0.69, 0.73, and 0.42 respectively (where value of 1 indicates optimal habitat and 0 indicates unsuitable habitat). In general, HSI estimates were coarsely related to woodcock occupancy.

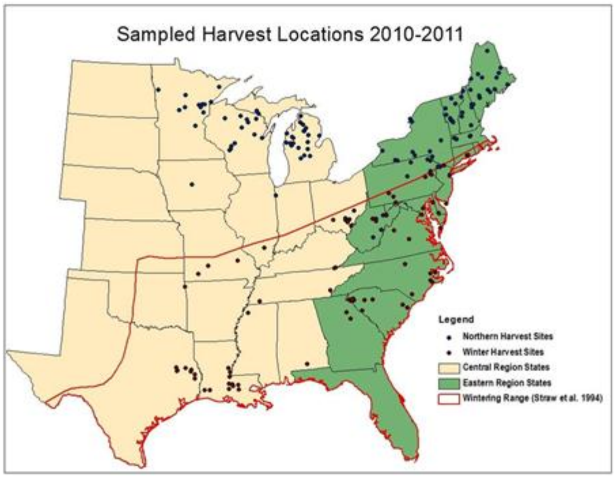

Figure 3: sampled harvest location from 2010-2011 used for hydrogen isotope analysis.

Objective 3: Stable isotopes

Woodcock wings were collected from local Texas and Louisiana hunters, the USFWS Woodcock Wingbee, and the Canadian Wildlife Service (CWS) Wingbee. Each wing was placed in an envelope on which the date, State (province), County (parish), and nearest town of harvest was recorded. All wings were sexed and aged as either hatch year/second year (HY/SY) or after hatch year (AHY), following Pyle (2008).

For each HY/SY woodcock wing, the first primary (representing natal origin) and 13th secondary (from late summer/early fall origin), feathers were removed. From wings collected in 2010-2011, 500 HY/SY feathers were used for stable isotope analysis. Feathers were subsampled to maximize accuracy and robustness of migratory predictions (Wunder and Norris 2008). Subsampling was done to (1) develop a feather based isoscape using feathers collected (harvested) on known molt origins and (2) predict origins of woodcock harvested on wintering grounds using isotope values from the created isoscape.

For the 2010-2011 feathers, a subsample was selected from 13th secondaries collected in northern states prior to 8 October 2010 in the Central Management region and prior to 12 October 2010 in the Eastern Management region. Birds harvested prior to these dates were assumed to be harvested close to 13th secondary molt origins (Myatt and Krementz 2007a). The 13th secondary from 80 individual wings were selected from nearest town harvest locations that had ≥ 4 within site replicates. Among site variance will be estimated using a stratified random sample of 70-13th secondaries. One feather within each 70 latitudinal/management region strata was delineated by dividing the sampled harvest location (nearest town) range in 35 subsets using natural breaks then dividing subsets by Management region (Central and Eastern) in ArcGIS 9.2. From wings used in the subsample 50 - 1st primaries were randomly selected within each Management region to estimate natal origins.

A wintering range subsample was randomly selected within each Management region (Central and Eastern) and randomly selected within Texas and Louisiana. The wintering range of American woodcock was mapped in ArcGIS 9.2 following Straw et al. (1994), then 50-13th secondaries and 1st primaries were randomly selected within each strata and an additional 25-13th secondaries and 1st primaries were randomly selected from Texas and Louisiana using Hawth's analysis tools. A similar sampling scheme will be used for feathers collected during the 2011-2012 hunting season. Feathers were sent to the National Hydrology Research Center of Environment Canada in Saskatoon, Saskatchewan for stable isotope assays. The comparative equilibration method (Wassenaar and Hobson 2003) was used to determine deuterium profiles of each feather. Feathers were homogenized, weighed, pyrolyzed into elemental components, then Hydrogen Isotope ratios were calculated using a continuous flow isotope ratio mass spectrometer (CF-IRMS).

Woodcock in East Texas *Photo by Dan Sullins*

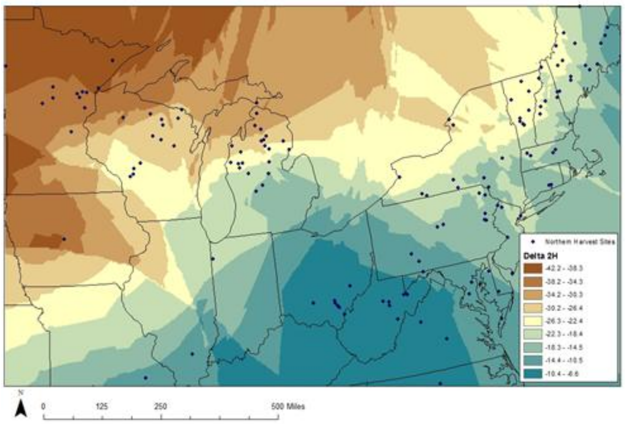

Figure 4: Kriged 13th secondary feather hydrogen isoscape.

Hydrogen isotope ratios ($^{\delta}$D) of 13th secondary feathers selected to create the 2010-2011 isoscape ranged from -54.2‰ in Isabella, Minnesota to 12.5‰ in Davis, West Virginia. High within site variability at the nearest town scale (SD = 9.12) and state scale (SD= 13.4) and a fairly limited sampled latitudinal range (39.2° – 47.6°)have resulted in weak correlations between feather $^{\delta}$D and precipitation based $^{\delta}$D maps from Bowen et al. (2005). Kriging was used to create a hydrogen isoscape from the 13th secondary feather subsample (Figure 4). $^{\delta}$D values in 1st primaries harvested before 12 October 2010 ranged from -81.8‰, harvested in Bloomfield, Vermont to -5.3‰ harvested in Oil City, Michigan.

Feathers collected on the wintering range had 13th secondary $^{\delta}$D values from -68.1‰ harvested in Siloam Springs, Arkansas to 19.1‰ harvested in Lettsworth, Louisiana and 1st primary $^{\delta}$D ranged from -94.9‰ in Askew, Mississippi to –5.7‰ harvested in Weches, Texas. Using all data (breeding and winter sample combined), > 95% of 13th secondaries had greater $^{\delta}$D values than 1st primaries.

Future Work:

Objectives 1&2: Woodcock occupancy, density, and habitat suitability.

Woodcock occupancy will be estimated using PRESCENCE following Mackenzie et al. (2006). Detection probabilities will be estimated using the maximum likelihood technique (Mackenzie et al. 2006). Occupancy models will be created at (1) survey site and (2) study site spatial scales based on detection histories (present =1; absent = 0). Habitat data will be used to estimate if woodcock occupancy and detection probabilities vary with spatially dependent habitat covariates. The best, or most parsimonious, model will be chosen using Aikaike's Information Criterion for small sample sizes (AICc) (Burnham and Anderson 2002). Logistic regression will then be used to identify habitat features that are the best predictors of woodcock presence. Population densities will be modeled and estimated using the program DISTANCE. The model that best fits the woodcock detection function and has the best AICc for small sample sizes (Burnham and Anderson 2002) will be used. Detection functions will be calculated for each year and landcover type. Differences in habitat among study areas, among occupied and unoccupied survey sites, and between years will be examined using multivariate analyses of variance (MANOVA). Differences ($P < 0.05$) occurring within MANOVA will be further examined using analysis of variance (ANOVA) (Mackenzie et al. 2006).

HSI scores will be used to assess woodcock habitat within all 24 survey sites, where each site will be ranked with standardized values from 0 (inadequate) to 1(optimal). Habitat and soil data will be used to assign HSI scores to flush and random points, scores from random points will then be averaged to assign scores within landcover/soil type polygons, within area searched of each survey site, and within each of the 24 survey sites. Habitat suitability scores for different land cover/ soil type groupings will be compared to flush counts within these groupings. New habitat suitability scores corrected by flush count data will be estimated for each land cover/soil type group and used to extrapolate potentially available east Texas woodcock wintering habitat. These HSI values will be used to map habitat suitability in east Texas to determine proportion of regionally suitable and unsuitable habitat. HSI values will be compared to occupancy and population densities within land cover types, soil suitability classes, and estimated land cover type/ soil suitability class. Population densities will be ranked from 0 to 1, 0 = no flushes/ha searched and 1=maximum number of flushes/ha searched then compared with habitat suitability scores. A MANOVA will be used to examine differences in occupancy rate and population density among standardized HSI polygons.

Objective 3: Stable isotopes

A stratified randomly sampling of 600 feathers will be subsampled from the 2011-2012 feather samples, using a subsampling scheme similar to that used for feathers collected in 2010-2011 but with the addition of wings collected from the CWS harvest survey. The addition of feathers from Canadian harvest locations will expand the scope of the study and will improve the strength of migratory predictions a total of 1,100 feathers will be analyzed from both seasons.

Linear regression will be used to determine if feather deuterium profiles correlate with precipitation based deuterium maps following Bowen et al. (2005). This will be accomplished by overlaying harvest locations of birds of known molt origin (e.g., harvested within the first week of hunting season in northerly states) on precipitation based deuterium maps using ArcGIS 9.2. Linear regression will be used to examine relationships between harvest location feather deuterium values and respective pixel values from the precipitation based maps. Multiple precipitation based maps will be tested including mean annual, growing season, and relevant monthly precipitation based deuterium maps (Bowen et al. 2005). If feather deuterium values correlates well with precipitation deuterium values, then a feather based isoscape will be developed by calibrating precipitation based maps using the best fitting linear regression (Wunder and Norris 2008). The spatially continuous woodcock feather deuterium based map will be drawn across the principle breeding range of the American woodcock. Different modeling techniques including, but not limited to, the linear regression approach, likelihood based approach, and probability surfaces described in Wunder and Norris (2008) will be used to predict summer origins of birds harvested on migrational stopovers or on the winter range. This will be estimated using feathers of woodcock harvested after the second week of October. The best, or most parsimonious, model will be chosen based on Aikaike's Information Criterion for small sample sizes (AICc) (Burnham and Anderson 2002).

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ASSESSMENT OF TECHNIQUES FOR EVALUATING AMERICAN WOODCOCK POPULATION RESPONSE TO BEST MANAGEMENT PRACTICES APPLIED AT THE DEMONSTRATION-AREA SCALE

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Introduction

American woodcock (*Scolopax minor)* have experienced significant long-term population declines in the Eastern and Central Management Regions (1.0 % per year) since Singing-ground Surveys (SGS) were first implemented in the mid-1960s (Cooper and Parker 2010). The most recent 10-year trend (2000-2010) also exhibited a significant decline of 1.2 %/year in the Central Management Region (Cooper and Parker 2010). Declines in population trend coupled with declines in woodcock recruitment (indexed through immature:adult female ratios derived from wing-collection surveys; Cooper and Parker 2010) are widely believed to be caused by the loss or alteration of early succession forest and shrubland land-cover types throughout the breeding range (Kelley et al. 2008, D.J. Chase and Associates 2010). However, trends in woodcock abundance (SGS counts) have remained stationary in Minnesota for the period covered by the SGS (1968 – 2008), even though the amount of land-cover types important to American woodcock has increased from historic conditions n the Minnesota portion of Bird Conservation Region 12 (BCR12; Kelley et al. 2008).

In response to declining trends in SGS counts at regional levels, the Migratory Shore and Upland Game Bird Working Group of the Association of Fish and Wildlife Agencies formed the Woodcock Taskforce to develop a conservation plan with a goal to stabilize and ultimately reverse declines in woodcock populations. The taskforce completed the American Woodcock Conservation Plan, which contains both population and habitat goals, in 2008 (Kelley et al. 2008). Under the leadership of the Wildlife Management Institute, partners have formed 5 regional woodcock initiatives to begin implementing the habitat goals of the conservation plan (3 of which are shown in Fig. 1). After considering alternative courses of action, initiative cooperators believed that the best way to influence landscape change and ultimately increase woodcock populations was to develop a system of demonstration areas where specific best management practices (BMPs) are applied throughout the woodcock breeding range.

Banding a woodcock chick at Tamarac NWR. *Photo by USFWS*

Biologists familiar with woodcock habitat requirements developed BMPs for each initiative with the assumption that BMPs applied at the demonstration-area scale (≈200 – 800 ha) will result in positive growth in local woodcock populations. This assumption has not been tested; therefore, the Woodcock Taskforce supports research aimed at evaluating woodcock response to BMPs applied at the demonstration-area scale. In collaboration with cooperators in 2 other study areas (see below), our objective is to evaluated woodcock populations responses to BMPs applied at the demonstration-area scale by focusing on 4 metrics: displaying male use, female use and survival, and recruitment. However, techniques for evaluating these responses have not been fully assessed. To apply these techniques to evaluate woodcock population responses at other areas where BMPs are applied in the future, it is necessary to first assess the efficiency of techniques to describe male and female woodcock use and estimate vital rates.

In collaboration with cooperators in Maine and New York, we will assess techniques to describe male and female woodcock use and estimate vital rates at 3 existing demonstration sites; Tamarac National Wildlife Refuge (NWR) in Minnesota, Moosehorn NWR in Maine, and Lyme Timber Company Land in New York. Tamarac NWR is a demonstration site within the Upper Great Lakes and Young Forest Initiative (UGLW&YFI) coordinated by the Wildlife Management Institute. The UGLW&YFI is modeled after the Northern Forest Woodcock Initiative (NFWI), for which Moosehorn NWR and the Lyme Timber Company Land are demonstration sites (Fig. 1). The UGLW&YFI and NFWI are aimed at increasing abundance of woodcock and other species of concern (i.e.: golden-winged warbler [*Vermivora chrysoptera*], eastern towhee [*Pipilo erythrophthalmus*], black-billed cuckoo [*Coccyzus erythropthalmus*], etc.) that depend on early successional forest land cover. A primary strategy within both these initiatives is the development of a set of BMPs (e.g., Wildlife Management Institute 2009), including application of BMPs at demonstration sites, which will guide habitat management efforts on designated public and private lands.

The objectives of this project are to describe male and female use and estimate baseline demographic parameters for woodcock at demonstration areas and to assess techniques for measuring woodcock response to habitat management at the demonstration-area scale.

Our specific objectives are:

1) Assess response of displaying male American woodcock to BMPs at the demonstration-area scale by comparing abundance of displaying male American woodcock on 3 demonstration areas with abundance in the surrounding landscape, as measured by routes that are part of the American Woodcock SGS.

2) Evaluate radio-telemetry as a tool to measure female woodcock response to application of BMPs at the demonstration-area scale.

3) Estimate adult female survival, nest success, and brood survival and relate these parameters to habitat variables at each demonstration site.

4) Estimate recruitment using night-lighting and mist-net capture techniques on summer roosting fields at demonstration areas, and evaluate these techniques as a means to assess recruitment.

5) Develop and assess techniques for radio-marking American woodcock chicks to estimate juvenile survival and document brood habitat use.

Study Areas

This project is being conducted at 3 study sites, Tamarac NWR located in western Minnesota, Lyme Timber Company land in northeastern New York, and Moosehorn NWR in northern Maine (Fig.1). All 3 of these sites currently participate in regional woodcock initiatives and contain demonstration areas where BMPs have been applied, or are being incorporated into management. In addition, these 3 locations represent different breeding habitats that occur across the woodcock breeding range.

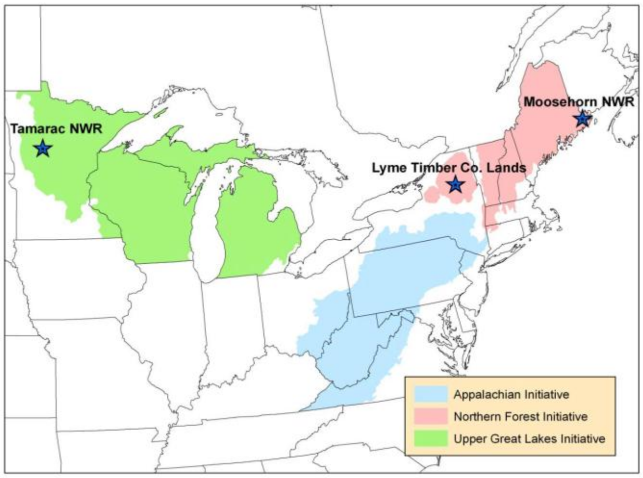

Figure 1. Location of the Regional American woodcock initiatives and study areas (indicated by a blue star).

Tamarac NWR

Tamarac NWR was established in 1938 to protect, conserve, and improve breeding grounds for migratory birds. It lies in the glacial lake country of northwestern Minnesota in Becker County, 97 km east of Fargo, North Dakota and encompasses 17,296 ha (42,738 acres) of rolling forested hills interspersed with lakes, rivers, marshes, and shrub swamps. Vegetation is diverse due to the refuge's location in the transition zone between the coniferous forest, northern hardwood forest, and tall-grass prairie. Sixty percent of the refuge is forested, consisting of aspen (*Populus* spp.), jack pine (*Pinus banksiana*), red pine (*P. resinosa*), balsam fir (*Abies balsamea*), paper birch (*Betula papyrifera*), red oak (*Quercus rubra*), white oak (*Q. alba*), sugar maple (*Acer saccharum*), and basswood (*Tilia americana*) cover types. The refuge lies at the western edge of the American woodcock breeding range in North America. Timber harvest and prescribed fire programs on the refuge have sustained early successional forest cover, which is primary breeding, nesting, and brood-rearing habitat for American woodcock.

Prior to settlement by people of European decent, much of the landscape at Tamarac NWR was dominated by red, jack, and white pine (*Pinus strobus*) cover types. Extensive logging of red and white pine occurred on the refuge from 1890-1910, converting much of the coniferous forest to an aspen cover type. Prior to 1987, limited harvest of aspen occurred on Tamarac NWR due to poor aspen markets in Minnesota (approximately 60 ha were harvested per year for all forest cover types combined); therefore many of the aspen-dominated stands were slowly succeeding to other cover types. Markets for aspen improved in the late 1980s and from 1987 to 1990, approximately 350 ha of aspen were harvested annually. Since 1990, the average annual harvest of aspen has been approximately 50 ha. Although the accelerated timber harvest program in the late 1980s quickly tapered off in the early 1990s, much of the refuge was still managed for early successional habitats, such as young, regenerating aspen. A hydroaxe, or large brush mower, was used to maintain some of these cut-over aspen sites through the 1990s.

Moosehorn NWR

Moosehorn NWR in eastern Maine was established in 1937 as a refuge for migratory birds, with particular emphasis on American woodcock. The refuge consists of 2 divisions, which are approximately 32 km apart; the Baring Division and the Edmunds Division. The Baring Division is 8,136 ha (20,096 acres) and is located southwest of the city of Calais, on the international border with New Brunswick, Canada. The Edmunds Division is 3,562 ha (8,799 acres) and is located to the south of the Baring Division, between the towns of Dennysville and Whiting. Farming, logging, and wildfire affected the uplands of Moosehorn prior to the 1900s; however, as the timber supplied by these lands declined, many farms that were tied to the logging industry were abandoned and came under ownership of the federal Re-Settlement Administration (Weik 2010). These abandoned farmlands eventually succeeded into young, second-growth forests, which provided high-quality woodcock habitat.

Moosehorn NWR has been the site of intensive woodcock research starting in the 1930s, much of which dealt with population responses to management of habitat for woodcock. Woodcock populations peaked on the refuge in the 1950s; however, forest maturation subsequently led to declines in woodcock densities throughout the refuge. Forest management practices ensued in the 1980s through 2009 to improve woodcock habitat, add diversity to the age-structure of the forests, and achieve economic benefit from timber harvest (Weik 2010). American woodcock research and monitoring continue on the refuge.

Forests cover 90% of present day Moosehorn NWR. Species composition varies from nearly pure spruce-fir (*Picea* spp.-*Abies* spp.) stands to hardwood mixtures of aspen, paper birch, red maple (*Acer rubrum*), red oak, and beech (*Fagus grandifolia*) with interspersed white pine. Alder (*Alnus* spp.) stands are also common along streams and abandoned fields. The landscape of Moosehorn NWR also contains natural and human-made water bodies, meadows, and managed blueberry (*Vaccinium* spp.) fields (Weik 2010).

Lyme Timber Company

Lyme Timber Company is a private timberland investment management organization dedicated to the acquisition and sustainable management of land with unique conservation value. Since the company was founded in 1976, Lyme has acquired and managed forestland and rural real estate across the eastern U.S. (Lyme Timber Company 2010). Currently, Lyme manages 180,490 ha (446,000 acres) of forestland located in New York, Pennsylvania, Maine, Massachusetts, Tennessee, Virginia, Delaware, and Louisiana.

The Lyme Timber Company owns and manages the Lyme Adirondack Forest Company (LAFCo) in upstate New York. The LAFCo consists of the largest block of private forestland in New York, including 20 blocks of forests, totaling approximately 112,503 ha (278,000 acres). All lands owned and managed by the LAFCo are contained within Adirondack Park, which is located in northern New York within Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, Oneida, Saint Lawrence, Saratoga, Warren, and Washington counties.

LAFCo lands are heavily forested with northern hardwoods, spruce, and fir and contain numerous lakes, streams, rivers, and wetlands. Nearly the entirety of Adirondack Park is kept in a "forever wild" state where very little or no logging is allowed, so young forest cover types utilized by woodcock are scarce. Since obtaining the property in 2006, LAFCo has incorporated a management plan to put 5% of each of the 20 blocks within the property into young forest cover types over the next 10 years, increasing the amount of area in young forest cover types from 31 ha (76 acres) to > 4,046 ha (10,000 acres). To date, approximately 898 ha have been converted to young forest cover types (Timberdoodle.org 2010).

Methods

1) Assess response of displaying male American woodcock to BMPs at the demonstration-area scale by comparing abundance of displaying male American woodcock on 3 demonstration areas with abundance in the surrounding landscape, as measured by routes that are part of the American Woodcock SGS.

We accessed data from previously established SGS routes surrounding all 3 study areas and establish additional survey routes at Tamarac NWR following the American Woodcock SGS protocol (Cooper and Parker 2010). We conducted surveys on all routes established at Tamarac NWR. We accomplished this by stratifying the refuge and placing new routes with stops within areas where management has occurred or is occurring and areas where no management has occurred proportional to the areas of these lands within the refuge landscape. We surveyed routes in Tamarac NWR following the American Woodcock SGS protocol (Cooper and Parker 2010). We compared abundance indices calculated for routes established on Tamarac NWR to indices calculated for SGS routes at varying spatial scales. These included the 6 closest routes to Tamarac NWR, routes in the state of Minnesota, and routes in the Central Management Region. We used this assessment to compare woodcock population abundance at demonstration areas to abundance in the surrounding landscape, and to evaluate population-level response of displaying male woodcock to management.

2) Evaluate radio-telemetry as a tool to measure female woodcock response to application of BMPs at the demonstration-area scale.

We placed transmitters on breeding female woodcock at Tamarac NWR. We primarily used mist nets to capture females; however, we also used pointing dogs and hand nets to capture females beginning as soon as they arrived on the study area in the spring. We fit all captured females with a radio transmitter weighing < 3% of the bird's mass (McAuley et al. 1993a). This method of attaching radio transmitters has been documented to have no discernable effects on female woodcock behavior (McAuley et al. 1993b). After radio marking, we located females regularly (5-7 times per week), but not more than once every 24 hours. We recorded date, time, and UTM coordinates (derived using hand-held GPS units) at each location.

3) Estimate hen survival, nest success, and brood survival and relate these parameters to habitat variables at each demonstration site.

We monitored radio-marked female woodcock at Tamarac NWR regularly (5-7 days per week) throughout the nesting and brood-rearing season to estimate survival and the ratio of immature woodcock reaching fledging per adult female. The ratio of immature woodcock per adult female provided an estimate of productivity, and is the measure of productivity derived from parts collection surveys by the U.S. Fish and Wildlife Service (Cooper and Parker 2010). To determine nest success and the number of young hatched per successful nest, we monitored nests initiated by radio-marked woodcock at 2-3-day intervals. We also monitored nests found using other methods, primarily the use of pointing dogs, at 2-3 day intervals.

To estimate brood survival, we monitored broods of radio-marked females 5-7 times per week. We also used pointing dogs to locate woodcock broods for radio-marking (Ammann 1974). Once located, we captured chicks using a long-handled dip net. We targeted 2-to-3-day-old chicks to achieve a sample to estimate survival for the entire period from hatch to fledging, but also captured older chicks. At capture, we custom fit a collar-type micro-transmitter with a whip antenna to 1-2 chicks per brood. We monitored radio-marked broods 5-7 days per week. We periodically inspected broods for any radio-marking effects by determining whether transmitters were correctly located around the bird's neck and whether the transmitter's antenna was pointing down the bird's back.

We classified birds as either alive or dead each time we located them via radio telemetry. If the bird was found dead, we attempted to determine cause of death. Cause of death was classified as depredated or "other" (e.g., starvation, exposure, capture-related). Birds classified as depredated were examined to determine cause of predation, either mammalian or avian (McAuley et al. 2005). Mammalian predators usually remove wings and legs, eat most of the bird (including feathers), and remove the transmitter from the carcass, leaving bite marks on the antenna and harness. Some mammals bury carcasses or carry them to den sites. Raptors typically pluck feathers and remove flesh from bones. Occasionally, raptors leave bill marks on the antenna and harness (McAuley et al. 2005). If we were unable to determine whether a bird was depredated by a mammal or a raptor, we classified the cause of that mortality as unknown predation. A few females and fledged juveniles we monitored were classified as "lost," which occurred when either the bird emigrated from the search area or the radio transmitter slipped from the bird. If birds were classified as lost, we censored them from data analyses. For the purposes of this study, if a radio-marked chick was not relocated during the pre-fledged period, we classified it as lost and censored it from data analysis. If we did not relocate a radio-marked chick during the pre-fledged period, but detected the rest of the brood, we classified the chick as dead.

We recorded each female, brood, and fledged juvenile location with a hand-held GPS unit (GPSmap 76CSx set to coordinate system: UTM, datum: NAD83). We also recorded nest site locations with the same equipment and settings. We used an average of 100 points to achieve a minimum estimated error at each point.

4) Estimate recruitment using night-lighting and mist-net capture techniques on summer roosting fields at demonstration areas, and evaluate these techniques as a means to assess recruitment.

We used night-lighting and mist nets to capture woodcock on summer roost fields (Dwyer et al. 1988). Upon capture, we assigned an age (hatch year or after hatch year) and gender using body measurements and feather characteristics (Martin 1964, Sepik 1994) to all birds. We also calculated immature:adult female capture ratios and compared these estimates of recruitment to one another, and also to an estimate of recruitment derived from wing-collection surveys (Cooper et al. 2010) and an estimate of recruitment derived from radio-telemetry survival data.

5) Assess techniques for radio-marking American woodcock chicks to estimate juvenile survival.

We custom fit a collar-type micro-transmitter (BD-2NC or BD-2C, Holohil Systems Ltd.) with a whip antenna (Brininger 2009, Daly and Brininger 2010) to captured woodcock chicks. These micro-transmitters are significantly smaller and lighter than transmitters used to mark American woodcock chicks in previous studies (Horton and Causey 1981, Wiley and Causey 1987). During 2009 and 2010, Brininger (2009) and Daly and Brininger (2010) successfully attached transmitters to 2-day-old and older woodcock chicks at Tamarac NWR, and observed no negative effects of transmitters on behavior or survival. Transmitters were ≤3% of the bird's mass (BD-2NC transmitters weighed approximately 0.6 g and the BD-2C transmitters weighed approximately 1.6 g) and included an elastic collar that stretches as the chick grows. One end of the elastic is attached by the manufacturer, with the other end is loose so the transmitter can be custom fit in the field. Based upon the neck circumference of each chick, the loose end is glued to the base of the transmitter to form an "expanding" collar, which is subsequently slipped over the chick's head and positioned at the base of the neck with the transmitter antenna protruding down the chick's back.

We radio-marked 1-2 chicks per brood and monitored the entire brood based on locating radio-marked chicks and recorded any negative impacts due to the transmitters. Monitoring chicks for negative impacts due to radio transmitter attachment included observing chicks from a distance using binoculars and looking for problems or impediments caused by the transmitter (e.g., entrapment by elastic collar). We documented overall mortality of chicks and broods based on monitoring radio-marked chicks.

Results

Due to inclement weather in the eastern United States during the spring of 2011, results for Moosehorn NWR and Lyme Timber Co. lands were very limited for the 2011 field season. In this report, we only present results of our research project at Tamarac NWR.

1) Assess response of displaying male American woodcock to BMPs at the demonstration-area scale by comparing abundance of displaying male American woodcock on 3 demonstration areas with abundance in the surrounding landscape, as measured by routes that are part of the American Woodcock SGS.

We established 6 singing-ground survey routes at Tamarac NWR following the SGS protocol (Cooper and Parker 2010). We detected a mean of 6.3 male woodcock per route, which is similar to abundance on the 6 official SGS routes in closest proximity to Tamarac NWR ($\bar{x}$ = 6.3) and to all routes in the state of Minnesota ($\bar{x}$ = 6.8) that were surveyed in 2011. The mean count for SGS routes does not include routes that are in constant zero status or routes that were not surveyed in 2011. The mean males detected per route for the Central Management Region in 2011 was 2.8.

2) Evaluate radio-telemetry as a tool to measure female woodcock response to application of BMPs at the demonstration-area scale.

During the 2011 field season we captured 241 woodcock, including 23 adult female woodcock that we radio-marked. We banded all birds captured with U.S. Geological Survey aluminum leg bands (size 3). We radio-tracked 23 females over varying periods beginning 7 April 2011 and ending 27 July 2011. Most females (*n* = 21) remained on Tamarac NWR after capture, and nested and raised broods.

3) Estimate adult female survival, nest success, and brood survival and relate these parameters to habitat variables at each demonstration site.

We estimated daily survival for adult females (*n* = 24), nests (*n* = 27), broods (*n* = 30), and post-fledged juveniles (*n* = 52) using Mayfield's method (Mayfield 1961) for estimating daily survival. We used these estimates to construct a model to estimate recruitment at Tamarac NWR.

Daily survival estimate for hens extended over the entire study period was ~0.997. We divided the period from arrival on the breeding grounds through the end of brooding in late summer into biologically relevant intervals as follows: survival to first nest (*n* = 9), survival during nesting (*n* = 20), and survival during brooding throughout the summer (*n* = 18). Daily survival estimates (based on radio telemetry) for these periods were: 1.00, 0.995, and 0.998 respectively.

Our estimate of daily nest survival for woodcock at Tamarac NWR in 2011 was 0.936 (*n* = 27). This estimate is based on both females that were radio-marked and females located based on other methods, primarily using pointing dogs, and an incubation time of 21 days (Burns 1915,
Worth 1940). Overall apparent nest success was 39.3% (number of successful nests/total number of nests). A successful nest was defined as a nest where at least one egg successfully hatched.

Our estimate of daily brood survival to fledging (15 days since hatch) at Tamarac NWR in 2011 was 0.995 (*n* = 30). After a fledging, chicks become independent from the brood, and we therefore treated each radio-marked chick independently in survival analyses following fledging. This estimate is based on radio-marked and non-radio-marked broods and chicks. Our estimate of post-fledging daily survival was 0.996 (*n* = 52) at Tamarac NWR in 2011. This estimate is based on radio-marked chicks only.

4) Estimate recruitment using night-lighting and mist net capture techniques on summer roosting fields at demonstration areas, and evaluate these techniques as a means to assess recruitment.

Our estimates of recruitment indices through early August varied considerably as a function of capture technique. We captured 3.57 juveniles per adult female (*n* = 87) via mist netting, and 1.54 juveniles per adult female (*n* = 42) via night-lighting. We captured more woodcock using mist netting than night lighting, in part because night lighting is only effective under very specific conditions. We spent a total of 16 hours and 20 minutes mist netting and a total of 23 hours and 30 minutes night lighting between 7 July and 24 July 2011. Trapping effort for mist netting totaled 114 trap nights, which is the number of mist nets per night ($\bar{x}$ = 9.5) multiplied by the number of nights mist nets were set. Capture rate for mist netting on summer roosting fields was 5.3 woodcock captured per hour, whereas the capture rate for night lighting on roosting fields was 1.8 woodcock captured per hour. Our estimate of recruitment based on survival and reproduction of females and survival of chicks was 0.62 juveniles per adult female, considerably lower than the index derived from either capture technique.

5) Develop and assess techniques for radio-marking American woodcock chicks to estimate juvenile survival and document brood habitat use.

During the 2011 field season we radio-marked 32 woodcock chicks and we observed no discernable effect from radio-marking on survival. In addition to observing behavior of radio-marked chicks to assess potential impacts of radio transmitters, we also captured 3 juveniles that had been radio-marked in May, prior to fledging, and observed no obvious signs of transmitter effects on these 3 birds.

Plans for 2012

We intend to repeat our field study in 2012, following the protocol described above. We anticipate more favorable conditions in Maine and New York in 2012, and will incorporate data from those sites if possible.

Acknowledgments

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FACTORS AFFECTING DETECTION OF AMERICAN WOODCOCK ON SINGING-GROUND SURVEYS

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Introduction and Objectives

The American woodcock (*Scolopax minor*; hereafter, woodcock) is a migratory game bird that occurs in forested landscapes in eastern and central North America. Woodcock are migratory and are managed under the Migratory Bird Treaty Act in the U.S. and Canada and are pursued as game birds in southern Canadian provinces from Ontario eastward, and throughout the central and eastern U.S. During the spring, male woodcock engage in a distinctive courtship performance in a variety of forest openings (natural openings, clearcuts, agricultural fields, etc.) called singing grounds. The American Woodcock Singing-ground Survey (SGS), coordinated by the U.S. Fish and Wildlife Service (FWS) and the Canadian Wildlife Service, exploits the male's woodcock display to detect woodcock and monitor woodcock populations. This survey has been conducted throughout the primary woodcock breeding range since 1968 and is used as an index of abundance and to estimate population trends. The survey consists of approximately 1,500 routes that are 3.6 miles (5.8 km) in length with 10 equally spaced listening points (Cooper and Parker 2010). Observers begin surveys shortly after sunset and record the number of woodcock heard peenting (the vocalization made during courtship displays by male woodcock) at each listening point during a 2-min period.

From 1968 to 2010, the numbers of singing male woodcock counted on the SGS declined 1.0% per year in both the Eastern (southern Quebec, the maritime Canadian provinces, and the northeast and mid-Atlantic U.S., east of the Appalachian Divide) and Central Management Regions (southern Ontario and the Midwestern U.S. south to the Ohio River Valley; Cooper and Parker 2010). Concerns about declines in the number of woodcock detected on the SGS have led to harvest restrictions (Cooper and Parker 2010), development of a woodcock conservation plan (Kelley et al. 2008), and a need to better understand how counts of woodcock on the SGS are related to woodcock abundance and population trends.

Releasing a male woodcock at its singing ground. *Photo by Stefanie Bergh*

However, without knowledge about the relationship between counts and population size, and whether this relationship is constant among years, interpreting results of the SGS is complicated. Spatial and temporal variation in detection probability introduces potentially significant noise into counts of woodcock, and there are many factors that can influence detection probability of displaying male woodcock in the SGS including weather conditions, observer error, woodcock behavior, woodcock density, change in singing-ground sites, and the distance from and orientation of a peenting woodcock relative to the listening point. Also, the effective area surveyed (EAS, which can be used to estimate density of displaying woodcock) at a listening stop is not known, and may vary as a function of landscape type (e.g., forest, agriculture, urban, etc.), environmental conditions under which surveys are conducted, abilities of observers, and other factors. To better understand what factors influence detection of woodcock and over what spatial scale woodcock are detected on the SGS, we estimated detection probability of woodcock on the SGS, evaluated factors related to detection, and estimated the effective distance surveyed from SGS points.

Study Area and Methods

We conducted our study in Pine County, Minnesota in the springs of 2009 and 2010. Pine County is located in east-central Minnesota in the Mille Lacs Uplands subsection (Ecological Classification System hierarchy, Minnesota DNR 2006), which is characterized by drumlin ridges with depressions between the ridges containing peatlands with shallow organic material, and extensive wetlands. Total annual precipitation is approximately 75 cm. Large areas in eastern Pine County are heavily forested, dominated by aspen-birch (*Populus* spp.-*Betula* spp.) forest with small areas of pine (*Pinus* spp.) forests. Current land use in Pine County is 40% forest, 24% row crop, 17% wetland-open, 13% pasture, and 6% water (Minnesota DNR 2006).

Spring weather in east-central Minnesota is variable with snowstorms possible into May. Mean maximum temperatures by month during our study ranged from 11.6° C to 19.6° C and mean minimum temperatures ranged from -1.4° C to 5.3° C (Minnesota Climatology Working Group 2010). Minnesota Ornithologists' Union (2008) records from 1985 through 2008 indicate that the median spring arrival date for woodcock in Minnesota was between 13 March and 26 March, with earlier arrival being associated with warmer temperatures on their wintering grounds (Keppie and Whiting 1994).

In April and May of both 2009 and 2010 we surveyed the 4 established SGS routes in Pine County (routes 77, 80, 86, and 91) and 4 randomly selected reference routes following the official SGS protocol for conducting surveys, except that we initiated surveys earlier than the period prescribed by the SGS protocol (see below). Locations of established SGS routes were determined by the FWS (see Cooper and Parker 2010). We visited the starting point of each route and digitized route locations using a Geographic Information System (GIS: ArcMap 9.3^{TM}). We located reference routes randomly by selecting a Universal Transverse Mercator coordinate within Pine County using Hawth's Analysis Tools (Beyer 2004) then locating, using a randomly selected cardinal direction (Microsoft Office Excel^{TM} 2003), the nearest secondary road.

Five (2 in 2009, 2 in 2010, and 1 in both 2009 and 2010) different observers conducted surveys on both SGS and reference routes. Observers had their hearing evaluated prior to conducting surveys and were trained to listen for woodcock by conducting surveys along SGS routes before the start of the sampling period. We surveyed each of the 8 routes once on each of 4 days during 3 of the 6 weeks during the breeding-season study period, resulting in 80 points surveyed 12 times over the course of the breeding season. This design allowed us to meet the assumption of a closed population (i.e., no changes in occupancy) and to assess trends in detection throughout the spring. It took 2 weeks to complete surveys of all 8 routes, starting with the southernmost routes and working north. The 6-week seasons were 12 April - 21 May 2009 and 10 April - 19 May 2010. Surveys started earlier than the SGS-protocol-recommended 25 April because we needed a longer period to survey each route 12 times than the period prescribed by the SGS protocol and we also wanted to allow for the possibility that woodcock may return earlier than in the past to account for potential effects of climate change on the timing of spring behavior of birds (e.g., Murphy-Klassen et al. 2005, Jonzén et al. 2006).

We recorded temperature, wind speed, sky condition, precipitation, and disturbance level (see below) for each survey in the same manner as the official SGS protocol. Disturbance level described the ambient noise at each listening point and was rated in 1 of 4 categories: none, low, moderate, and high. Because these categories are subjective we grouped them into quiet (none or low) and noisy (moderate or high) (e.g., Kissling et al. 2010). The official SGS protocol includes 5 categories of precipitation: none, mist, snow or heavy rain, fog, and light rain. Because fog never occurred during surveys over the course of our 2-year study period and mist only occurred 4 times we grouped fog and mist with light rain to indicate presence of light precipitation.

We classified land-cover types at each listening point on all 8 routes using 2008 U.S. Farm Service Agency (FSA) aerial photos and ground observations. We classified the area within a 330-m radius of the survey point, which was the presumed maximum detection distance for woodcock (Duke 1966), as forest (> 66% forest), non-forest (> 66% non-forest), or mixed (< 66% forest or non-forest). Forest included wet or dry coniferous, deciduous, or mixed forested areas. Non-forest included row crops, pastures, prairie, shrubland, and marsh areas.

Based on the detection history at each listening point along survey routes, we estimated occupancy (ψ) and detection probability (p) using the approach of MacKenzie et al. (2006). This approach models the expected count of an area at a certain time [$E(C_{it})$] as the product of the true number of animals in that area and time (N_{it}) and the associated detection probability (p_{it}).

$$E(C_{it}) = N_{it}p_{it}$$

We used program PRESENCE (Hines 2006) to estimate occupancy and detection probability and to evaluate the relationship between occupancy and land-cover covariates. To evaluate the relationship(s) between detection probability and factors that might influence detection probability (e.g., wind speed, observer, date) we used logistic regression models in program R (R Development Core Team 2010). To examine these relationships we developed a candidate set of 8 *a priori* models; 7 models contained a single detection probability covariate (neighbor, wind, temperature, precipitation, observer, date, quiet): $\psi(.),p(\text{covariate})$ and 1 model was the global model: $\psi(.),p(\text{global})$. We included Julian date as a covariate as a quadratic variable to account for a peak in males' singing activity during the breeding season (Goudy 1960, Sheldon 1967). We ranked single-covariate models using Akaike's Information Criterion (AIC) and combined covariates from single-covariate models with low AIC-values into multi-variable models to assess their likelihood (i.e., lower AIC values) compared with single-covariate models and the global model (e.g., Yates and Muzika 2006, Popescu and Gibbs 2009, Kissling et al. 2010). When the addition of a covariate did not result in a model that received substantially higher support (a lower AIC-value by ≤ 2) we stopped adding covariates, similar in concept to forward selection stepwise methodology (Cook and Weisberg 1999, sensu Yates and Muzika 2006). We used AIC to identify the models best supported by our data and to calculate AIC model weights (w_i) (Burnham and Anderson 2002). The best-supported model, which we identified based on having the lowest AIC score, and models within 2 AIC units ($\Delta\text{AIC} \leq 2$) of that model that also improve model fit (as measured by a decrease in model deviance if they include additional covariates, Arnold 2010), made up our set of competing models. We also evaluated 10,000 bootstrap samples of global models to test for overdispersion of the data, which is indicated by a variance inflation factor ($\hat{c}$) > 1.0 (Burnham and Anderson 2002). We used the variance inflation factor as appropriate to modify AIC as described in Burnham and Anderson (2002).

Finally, to estimate EAS, we conducted call-broadcast trials at 9 sites; 4 that we categorized as forest and 5 that we categorized as field. We broadcasted a recording of a woodcock peent through speakers at a sound level between 70 and 80 decibels (field trials and e.g., Brackenbury 1979, Simons et al. 2007). While 1 observer stood blindfolded on a road, another individual held a game caller (FOXPRO FX3) at a distance unknown to the observer and either played or did not play the recording. Broadcast distances were set at 50-m increments between 100 and 450 m (field) or 100 m and 300 m (forest) based on preliminary assessments of maximum detection distance. The observer listened for 2 min and recorded whether they heard peenting. We recorded wind speed, precipitation, and level of ambient noise during the trial following the official SGS protocol (e.g., trials were not conducted in heavy wind or precipitation). We conducted broadcast trials primarily in the hours during and after sunrise (06:00-09:00) to mimic the conditions during which the official SGS is conducted (following sunset). We conducted trials in April and May of 2009 and 2010 over multiple days and sites in the 2 land-cover types (forest and open field) to estimate detection distance and to compare detection distance between land-cover types.

We calculated the proportion of peent broadcasts detected at each distance and in each land-cover type. Based on the proportion of broadcasts detected and with the assumption that all broadcasts at 0 m from the observer were detected, we used program R to analyze 4 different curves (half normal, inverse normal, negative exponential, and logistic) to identify the detection curve with the best fit (R Development Core Team 2010). We ranked these 4 *a priori* candidate models using Akaike's Information Criterion adjusted for small sample size (AIC_c) for the field and forest land-cover types to identify the model best supported by the data (Burnham and Anderson 2002). We then used the best-supported detection curve (half-normal) to estimate the EAS, following the procedure outlined in Roberson et al. (2005) where probability of detection is a function of distance. In that procedure, the ideal probability of detection (P_i) is equal to 1 out to a given distance (x, y) from the source of the broadcast (0, 0) and zero beyond that distance. The next step is to set the double integral of P_i equal to that of P_t,, the probability of detection as a function of distance based on the data. We then solved for r*, the radius of the EAS (and the x-coordinate on the detection curve), which is the distance at which the area above the probability of detection curve at distances < r* equals the area under the curve at distances > r*. We used this radius to determine the effective area surveyed:

$$EAS = \pi(r^*)^2$$

We calculated a 95% bootstrap confidence interval for r* with 1,000 bootstrap samples to assess uncertainty in the EAS using program R. We repeated this procedure for forest, field, and forest and field combined land-cover types.

Results

Based on the intercept-only model with constant detection and occupancy probabilities and no covariates [$\psi(.),p(.)$], we estimated woodcock occupancy of 0.74 (SE = 0.049) in 2009 and 0.81 (SE = 0.044) in 2010. When we included land cover into models of occupancy with constant detection probability across listening points and surveys [ψ(habitat), $p(.)$], 2009 listening points classified as mixed had significantly higher estimated occupancy than those classified as non-forest. In 2010, listening points classified as forest had significantly higher occupancy than those classified as non-forest. In 2009, listening points classified as mixed had the highest estimated occupancy among land-cover categories and in 2010 listening points classified as forest had the highest estimated occupancy, although in both years the 95% confidence intervals for the 2 highest occupied land-covers (mixed and forest) overlapped (Fig. 1).

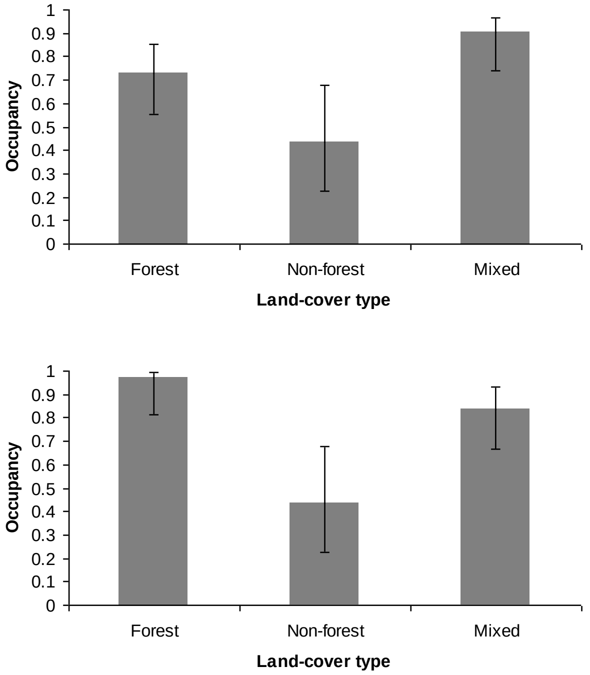

Figure 1. Occupancy estimates for American woodcock during surveys along 4 routes in east-central Minnesota in 2009 and 2010

The best-supported single-covariate model of detection probability for 2009 was $\psi(.),p$(neighbor), which ranked just below the global model (ΔAIC = 6.3). The best-supported multi-covariate model of detection probability for 2009 included the variables neighbor, observer, quiet, and wind. Akaike model weights (AIC w_i) indicated that this model was 7 times more likely than the second-ranked model to be the best model in the set of candidate models. The second-ranked model included date but was not a competing model despite having ΔAIC < 4 because its fit compared with the reduced model, as measured by the model deviance, did not improve enough (no change in the log-likelihood) to warrant inclusion. Wind was negatively related to detection probability; 1 observer had higher detection probability than the other 2 (although confidence intervals overlapped), and neighbor and quiet were positively related to detection probability. The cumulative model weights for individual covariates were neighbor = 1.0, observer = 1.0, quiet = 0.997, wind = 0.929, date = 0.137, temperature = 0.024, and precipitation = 0.024.

The best-supported single-covariate model of detection probability for 2010 was $\psi(.),p(\text{neighbor})$, which ranked just below the global model (ΔAIC = 7.7). The best-supported multi-covariate model of detection probability for 2010 included the variables neighbor, date, quiet, and observer. The Akaike model weights indicated that this model was 2 times more likely than the second-ranked model to be the actual best model in the set of candidate models. The second-ranked model included precipitation but was not a competing model. Again, 1 observer had a higher detection probability than the other 2 observers (although confidence intervals overlapped), date had a quadratic effect, and neighbor and quiet were positively related to detection probability. The cumulative model weights for individual covariates were neighbor = 1.0, date = 0.999, quiet = 0.929, observer = 0.738, precipitation = 0.290, wind = 0.045, and temperature = 0.045.

The best-supported single-covariate model of detection probability when combining 2009 and 2010 was $\psi(.),p(\text{neighbor})$, which ranked well below the global model (ΔAIC = 23.6). The best-supported multi-covariate model of detection probability when combining 2009 and 2010 was the global model, which had a lower deviance and a higher number of parameters than the rest of the candidate models. Wind was negatively related to detection probability, Observer 1 had a higher detection probability than the other 4 observers (although confidence intervals overlapped), date had a quadratic effect, and neighbor and quiet were positively related to detection probability. The 95% confidence interval around the parameter estimates (β_i's) included zero for year, precipitation, and temperature, suggesting they did not have a statistically significant effect on detection probability, even though they appeared in the best-supported model. The cumulative model weights for individual covariates were neighbor = 1.0, quiet = 1.0, observer = 1.0, wind = 0.977, date = 0.855, precipitation = 0.583, and temperature = 0.339. Bootstrap simulations for 2009 and the 2 years combined provided no evidence of overdispersion in the data ($\hat{c}$ = 0.33, 0.43, respectively) whereas 2010 showed slight overdispersion ($\hat{c}$ = 1.2).

We conducted a total of 1,160 woodcock broadcast trials at 5 distances in the forest land-cover type and 8 distances in the field land-cover type for an average of approximately 90 trials per distance in each land-cover type. Trials took place over 19 days in 2009 and 25 days in 2010. The percentage of broadcasts detected ranged from 96.3% and 92.5% at 100 m in the field and forest land-cover types, respectively, to 12.1% at 450 m in the field land-cover type and 6.4% at 300 m in the forest land-cover type. Detection probability decreased less rapidly as a function of distance in the field land-cover type than in the forest land-cover type (Fig. 2).

The best-fit detection curve for all 3 datasets (forest, field, both land-cover types combined) was the half-normal. No other models received substantial support; therefore we used the parameter estimates from the half normal curve defined by our data to calculate the EAS. The EAS radius (r*) was 198 m (95% bootstrap CI = 174-231 m) for the forest land-cover type, 384 m (95% bootstrap CI = 321-440 m) for the field land-cover type, and 309 m (95% bootstrap CI = 273-372 m) for both land-cover types combined. The EAS for SGS listening points in Pine County was 12.3 ha (95% bootstrap CI = 9.46-16.8) for the forest land-cover type, 46.3 ha (95% bootstrap CI = 32.4-60.8) for the field land-cover type, and 30.0 ha (95% bootstrap CI = 23.4-43.4) for both land-cover types combined.

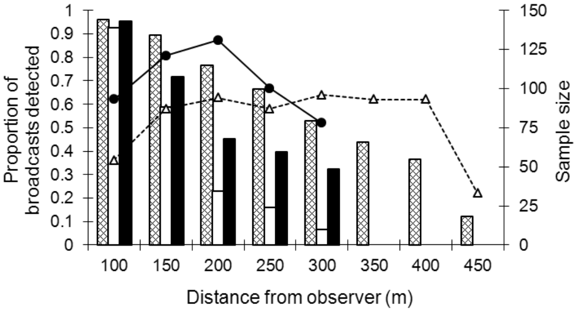

Figure 2. Proportion of broadcast American woodcock calls detected by observers as a function of distance during trials in 2009 and 2010 in east-central Minnesota. Solid bars represent trials in forested land cover and hatched bars represent trials in field land cover.

Discussion

We estimated occupancy and detection probability of woodcock on SGS routes in east-central Minnesota, and documented high occupancy in both 2009 and 2010. Thogmartin et al. (2007) similarly identified east-central Minnesota as an area of high woodcock abundance, based on their landscape-scale models. In our study, occupancy in 2009 (0.74) was similar to that in 2010 (0.81) (based on overlapping confidence intervals), with 6 more sites occupied on SGS routes in 2010 than in 2009.

Listening points classified as forest or mixed land cover had higher occupancy than listening points with non-forest land cover in both years, consistent with documented woodcock-habitat relations (e.g., Dwyer et al. 1983, Sekeete et al. 2000). In 2009, listening points classified as mixed land cover had significantly higher occupancy than listening points classified as non-forest, whereas in 2010 listening points classified as forest had significantly higher occupancy than non-forest listening points. No significant changes in habitat along the routes occurred between years to directly explain the changes in occupancy among land-cover types. The very southern part of Pine County is dominated by row-crop agriculture, which is included in the non-forest category, whereas the majority of the county is mixed agriculture and forest. Woodcock did not occupy areas that were strictly agricultural, but occupied areas that were a mix of agriculture and forest or predominantly forest. Occupancy and abundance of woodcock during the spring have been reported to be influenced by factors other than land-cover type such as interspersion of openings, aggregation or clumping of vegetation types, soil moisture, age and stem density of forests, and urban land use (e.g., Dwyer et al. 1983, Keppie and Whiting 1994, Thogmartin et al. 2007). We did not design our study to assess the factors that influenced occupancy of woodcock, but note that occupancy was not static between years. Godfrey (1974) recognized that singing grounds on the landscape fluctuate with year in that some are perennial whereas others transitory, which could explain the slight changes in occupancy we observed.

The detection probabilities we estimated were considerably lower (0.59 in 2009 and 0.66 in 2010) than perfect detection (p = 1.0), suggesting that accounting for factors influencing detection could improve estimation of occupancy and description of trends in woodcock abundance. We identified 4 factors that were related to detection probability of woodcock using the SGS protocol; neighbor, observer, date, and quiet. Neighbor, which indicated the presence of > 1 woodcock singing at an SGS listening point during a survey, had a strong positive relationship with detection, perhaps due to social facilitation (i.e., motivation to call in the presence of a conspecific) and the competitive nature of male woodcock during the breeding season (Sheldon 1967). Our study area in east-central Minnesota had a higher estimated abundance of woodcock than many other areas (e.g., Thogmartin et al. 2007), so whether this covariate would be related to detection at lower woodcock density is unknown. If calling by 1 woodcock elicits peenting from neighboring woodcock, call broadcasts could increase detection probability, potentially most effectively at low woodcock abundance.

Our models also indicated an observer effect, although approximately half the time the 95% confidence interval for these coefficients overlapped zero. Even though observers in our study were tested for hearing and possessed the ability to hear woodcock peenting (unlike the SGS, where observers are not screened for auditory acuity), we still documented observer effects. It is probably not feasible to assess the ability of SGS observers in detecting peenting woodcock, but differential ability of observers to detect woodcock likely adds considerable random variation, and approaches to control this variation may be warranted.

Our results also confirmed the presence of a peak in detection probability during the middle of the breeding season, as evidenced by the inclusion of a quadratic date covariate in the best-supported models of detection probability. Although to some degree, temperature is confounded with date, the quadratic form of date, with its mid-spring peak is not coincident with trends in spring temperatures that increase essentially linearly. A mid-spring peak in detection was also evident when we plotted detection probability through time, and likely can be explained by a peak in displaying by male woodcock (Goudy 1960, Sheldon 1967). If surveys were timed to be close to this peak, detection probability would likely be higher than if surveys were conducted earlier or later in the season. However, this peak was included within the official survey window for Pine County and it may not be logistically feasible to conduct surveys in a shorter window of time than identified in the current SGS protocol.

Quiet, which indicated that the ambient noise level was "none" or "low" at an SGS listening point during a survey, also had a positive association with detection probability, although not as strong as did "neighbor." This covariate may have been confounded with precipitation because light rain, especially when leafout has occurred, can temporarily increase ambient noise during part or all of a survey. Also, on busier secondary roads where ambient noise level can be quite variable, accounting for this relationship would likely improve the accuracy of estimating short-term population trends as traffic noise during surveys likely varies among years.

We note that detection probability in both 2009 and 2010 was similar even though we employed different observers and conducted surveys under variable spring weather conditions, which suggested that detection probability may be relatively constant, at least over the conditions we encountered. If this is the case, then at least at smaller spatial scales (e.g., the scale of our study), it may be warranted to assume that detection probability is relatively constant through time. Whether this assumption is appropriate at larger spatial scales (e.g., the scale of states or Management Regions) is not known.

Finally, we estimated the EAS for American woodcock in field and forest land-cover types in east-central Minnesota based on call broadcast trials conducted under a variety of conditions within the limitations of the SGS protocol, in relatively flat terrain, and during the hours around sunrise. We conducted trials over many days in a variety of environmental conditions, wind speeds and directions, ambient noise levels, and precipitation. Therefore, our estimates of the EAS should be considered averages over the conditions under which SGSs are conducted. Although these trials were conducted in the hours around sunrise instead of around sunset (as during the SGS), environmental conditions around sunrise are similar to those around sunset, and male woodcock display at both dusk and dawn (Sheldon 1967). Therefore, we conducted our trials around sunrise in conditions nearly identical to those around sunset, in terms of factors that influence detection of peenting woodcock.

The EAS in the field land-cover types was greater than that in the forest land-cover type, likely because of sound attenuation in forest vegetation (Wiley and Richards 1982). Our estimate of EAS radius across land-cover types (field and forest combined) was 309 m, which is similar to previous estimates of 201 m, 235 m, 250 m, and 330 m (Gregg 1984, Duke 1966, Kelley et al. 2008, Cooper and Parker 2010, respectively). However, only Duke's (1966) estimate was determined based on empirical data--the farthest distance he and others could hear 3 known singing males in 28 trials. Our detection distances were considerably farther than the 235 m reported by Duke (1966), especially in the field land-cover type. We do not know why our distances were farther than those reported by Duke (1966), but suspect detection distance is likely related to differences in land-cover type, observer's hearing abilities, and our more extensive and controlled testing protocol. These results also suggest that spatial or temporal comparisons of counts that do not account for detection probability may need to be made with caution. When combining data from both land-cover types, our estimate of the EAS was 30.0 ha, which extrapolates to a total of 300 ha effectively surveyed on a single SGS route (10 listening points).

Based on our estimates of EAS in forested and field land-cover types in east-central Minnesota, the 330-m radius currently used for SGS points appears adequate to ensure that woodcock are not counted on >1 survey point, unless consecutive survey points are completely surrounded by flat, open field. In that case the same bird has the potential to be counted at consecutive survey points, which violates the assumption of independent survey points. Recording the cardinal direction and approximate distance to a peenting woodcock in this situation might prevent an observer from counting the same bird twice. Not counting uncertain detections (i.e., birds heard faintly) will increase confidence in (1) reducing double counting of the same bird from consecutive points and (2) counting birds only within the EAS. In contrast, in forested land-cover types observers likely would not detect woodcock beyond 198 m, suggesting that one must consider land-cover type when comparing counts between locations.

Management Implications

Adjustments for detection probability can be incorporated into estimates of abundance and density of wildlife (MacKenzie et al. 2006) when detection probability is imperfect. Currently, ours is the only study we know of that evaluated detection probability on SGS routes, and we observed less than perfect detection related to several quantifiable variables. To better document and understand the influence of these factors at a larger spatial scale, a subset of SGS routes at various locations throughout the woodcock breeding range could be surveyed repeatedly to estimate detection probability, and measuring these variables as part of the SGS protocol would allow for including detection probability in future monitoring.

In addition to adjusting for variation in detection probability it is possible to assess detection probability covariates and recommend when and when not to survey for woodcock. Based on our assessment of factors related to detection probability of woodcock on SGS and reference routes in Minnesota, there are several factors that could be addressed to potentially improve interpretation of survey data. First, for each latitudinal region, the survey window could be evaluated and possibly condensed to ensure that surveys are being completed during the peak display period. Second, even when observers are trained and have hearing abilities within the normal range, we observed differences in detection probability among observers. Observer variation in the official SGS is likely at least as large as in our study and training and testing observers would likely reduce this variation. Third, ambient noise can be the result of many factors, some of which are more constant than others. For example, SGS listening points near wetlands tend to have frog-call noise throughout the spring, which is constant throughout and perhaps also among springs. Road noise tends to be less constant, but can have a large impact on a survey that takes place on a busier road. Routes could be evaluated to determine if the road(s) being used have experienced increases in traffic levels since the routes were established in the late 1960s. SGS routes with unsafe road conditions can be replaced through official protocol, and an assessment of continued inclusion of routes with high vehicle traffic seems warranted. Finally, detection probability of woodcock on SGS routes decreases in precipitation stronger than a mist, likely due to a decrease in the observer's ability to hear woodcock over the noise of the precipitation. Data resulting from surveys of routes on the SGS during such conditions likely under-represent woodcock abundance and should be discarded.

Finally, based on our estimates of EAS in forested and field land-cover types in east-central Minnesota, the 330-m radius currently used for SGS points appears adequate to ensure that woodcock are not counted on >1 survey point, unless consecutive survey points are completely surrounded by flat, open field. In that case the same bird has the potential to be counted at consecutive survey points, which violates the assumption of independent survey points. Recording the cardinal direction and approximate distance to a peenting woodcock in this situation might prevent an observer from counting the same bird twice. Not counting uncertain detections (i.e., birds heard faintly) will increase confidence in (1) reducing double counting of the same bird from consecutive points and (2) counting birds only within the EAS. In contrast, in forested land-cover types observers likely would not detect woodcock beyond 198 m, suggesting that one must consider land-cover type when comparing counts between locations.

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Marshbirds

THE EFFECT OF WATERFOWL IMPOUNDMENTS ON SORA AND VIRGINIA RAIL POPULATIONS

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Project Description & Objectives

A common management technique to offset wetland habitat loss and provide habitat for migratory birds is the impoundment of aquatic areas. The hydrologic characteristics of impoundments, however, may be dramatically different from the seasonally flooded wetlands that many impoundments replace. This technique has proven effective for many waterfowl and shorebird species, but its effects remain untested for rails which breed in these altered landscapes. The more stable water levels of impoundments could benefit rails by increasing foraging success and decreasing nest predation, but impoundments may harm rail populations by increasing nest flooding and methyl-mercury exposure, or by decreasing the diversity of prey and vegetation. Assessing the effects of impoundments on breeding rails is difficult, however, due to the current limitations of broadcast survey methods. Further research into the influences of rail reproductive stage on vocalization probability is needed. The impacts of wetland impoundment may be multiple and complex, and a controlled study is required to assess this management practice. The objectives of this project are to: 1) establish the probability of rail nest predation or flooding, 2) measure the risk of adult and juvenile rails to methyl-mercury exposure, 3) compare the above measures between different types of impounded wetlands, and 4) develop an individual-based model of vocal detection probability relative to reproductive stage to predict rail population trends more accurately using established broadcast survey methods.

Rail Nest Productivity by Hydrology and Impoundment

The past summer (2011) was the first second and last full field season conducted by E. Robertson and three field technicians. Our nest-scale sites included ten freshwater wetlands: five in the Penobscot region of Maine and five wetlands within Moosehorn National Wildlife Refuge (200 miles east). Five sites had impoundments and five did not. Impoundments in this study (both at Moosehorn National Wildlife Refuge and at Maine state wildlife refuges) are composed of a levee equipped with a water control structure (a floodgate that can be opened or closed to regulate water levels manually). Water levels at our sites have been passively managed with little to no manipulation of floodgates since construction. Impoundments at Moosehorn were created during 1950-1974 in historical beaver dam locations and have remained flooded other than occasional drawdowns (Hierl et al. 2006). Our wetland sites varied in size from 40 to 272 ha ($\bar{x}$ = 98, SD = 155).

Over the course of the study we monitored 97 rail nests (75 Virginia rail, 22 sora) with an effective sample size for logistic exposure models of nest success of 986. Nests were visited every 3-5 days and monitored for predation, abandonment, and flooding. Hydrologic and vegetative data were also obtained and the rails at all nests were surveyed for responses to broadcast at each nesting stage using broadcast methods tested during the pilot season. One HOBO water level logger was placed near the outflow of four impounded and three unimpounded wetland sites to monitor water level fluctuations. Hand measurements were taken at each nest visit to monitor water level fluctuations at individual nests.

We calculated cause-specific (predation, flooding, abandonment) daily probabilities of nest failure for both wetland types (following Etterson et al. 2007) and tested for covariates of daily nest survival rate among all sites (including year, site, and impoundment type) using a logistic-exposure model (Shaffer 2004).

We also modeled average nest success at each wetland with a combination of vegetation, hydrology, and watershed characteristics. We placed Onset HOBO water-level data loggers (U-20 freshwater 13-foot-depth) in perforated PVC pipes (5' length and 1.5" diameter) in each monitored wetland downstream from all nests to obtain a detailed graph of water level changes over the nesting season. We processed water logger data using Indicators of Hydrologic Alteration (IHA) Version 7.1 (The Nature Conservancy, 2009). Wetland sites were digitized on the National Agriculture Imagery Program (2009, 1-m digital orthoimagery layer) using the National Wetlands Inventory layer as a guideline to determine wetland size and 14-digit HUC subdrainage size. We then used Principle Components Analysis (PCA) to identify the major axes of variation in our vegetation, hydrology, and GIS wetland-scale data. We used model-averaged Daily Survival Rates (DSR) from the 97 rail nests in our Nest-Scale model to obtain DSR per site. Logit-transformed, site DSR *(n* = 7) were used as the response variable and all seven principle components and highly loaded variables (>|0.2|) from PCA were tested individually (to avoid overfitting) as potential predictor variables.

Nest Success Results

Our final model set included eight models with a cumulative Akaike weight of 0.9. The top two models had Δ AIC_c =1.6 and both included age, water depth change, the interaction between change in water depth and nest height change, and nest height change. Water depth change, the interaction between change in water depth and nest height change, and age were all positively and significantly related to nest success in both the top models (Table 1). The effect of nest height change was not significantly related to nest success, although the parameter was included in both the top-ranked models (Table 1). The second-best fitting model (Δ AIC_c = 1.6) additionally included the effect of impoundment, but the effect was not statistically significant (Table 1). Akaike weights for the top two models were 40% and 18% of all weights for the 16-candidate-model set.

We used model averaging on the top eight models in an effort to include model selection uncertainty into parameter estimates and their standard errors (Table 1). Water depth change and age had the greatest effects on nest survival. Both were found in six of the top eight models and the model-averaged estimates were statistically significant (Table 1). Water depth change was slightly more important than age when looking at the summed Akaike weights (0.83 vs. 0.82) (Table 2). The interaction of water depth change and nest height change also had a strong and significant effect on nest survival and was found in four of the top eight models (Table 1). The Akaike weights for the interaction of water depth change and nest height change summed to 0.71 (Table 2). Four of the top eight models also included impoundment and nest height change but the 95% CI of the odds ratios included 1.0, making it difficult to assess their strengths (Table 1). Summed Akaike weights were 0.76 for nest height change and 0.31 for impoundment (Table 1).

The overall daily survival rate from our logistic exposure model was 97.60 % (CI, 93.70, 99.02) and overall nesting-period survival rate was 50.52 % (CI, 16.18 to 75.86 %) Apparent nesting success was 31/85 nests or 63.5%. There were no significant differences for water depth change (t= -0.16, P= 0.87), nest height change (*t*= 0.03, P= 0.98), Virginia rail clutch size (*T* = 581.5*, P* =0.41), sora clutch size (*T* = 1627.5, P = 0.08), or daily survival rate (T= 6531, P= 0.1357) between nests in wetlands with impoundments versus those without (Fig. 1). There was a non-significant trend (*t*= -1.8, P= 0.07) with impounded wetlands having deeper mean water depths ($\bar{x}$ = 24.69 cm, SD = 19.99, *n* = 191) than non-impounded wetlands ($\bar{x}$ = 21.72, SD = 10.34, *n*=77).

Table 1. Model-averaged parameter estimates with unconditional standard errors (SE) and odds ratios with unconditional 95% confidence intervals for variables in the top eight models for nest survival of Virginia rails and soras in Maine, 2010 & 2011.

Parameter	**Estimate ± SE**	**Odds ratio (95% CI)**
intercept	2.53 ± 0.61	
age	0.06 ± 0.03	1.07 (1.01, 1.13)
water depth change	0.15 ± 0.05	1.17 (1.05, 1.30)
nest height change	-0.04 ± 0.13	0.96 (0.75, 1.23)
impounded	0.30 ± 0.44	1.34 (0.57, 3.19)
water depth change * nest height change	0.06 ± 0.03	1.06 (1.01, 1.12)

Table 2. Relative Importance of model variables for predicting nest daily survival rates of rails in Maine (2010 & 2011) using summed Akaike weights (w_i)

Parameter	Summed (w_i)
water depth change	0.83
age	0.81
nest height change	0.76
nest height change*water depth change	0.71
impoundment	0.31

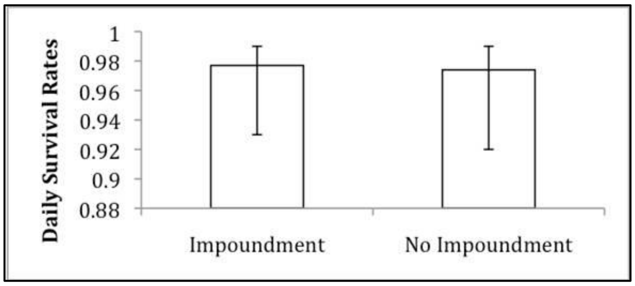

Figure 1. Daily survival probabilities (± 95% CI) for wetlands with and without waterfowl-management impoundments in Maine 2010 & 2011.

Principle Component 3 (PC3) was the best predictor variable we tested to model daily survival rates at the Wetland-Scale (Fig. 2) ($F_{1,5}$ = 31.83, P = 0.002)(Adj. R^2 = 0.84). PC3 is a water-variation axis and the highest positive loading was for the number of reversals (water levels changing from falling to rising or vice versa). Other high loadings (>0.2) included positive relationships with low pulse count, high pulse count, fall rate, width of the vegetation clump the nest was in, the percentage of nest concealment from above, percentage of water cover in a 2-m radius, vegetation stem density, and negative relationships with percentage of nest concealment from the sides, percentage of ground cover by forbs within a 2-m radius, and rise rate. PC3 thus characterizes wetlands with water levels that often rise and fall (with faster rates of falling than rising) that possess more shrub coverage with dense, leafed branches above and open, water-covered ground below.

Between wetlands with and without impoundments, there were no significant differences in the number of reversals (t = -1.15, P = 0.324), high pulse counts (t = -1.46, P = 0.20), low pulse counts (t = -0.45, P = 0.67), fall rates (t = -0.98, P = 0.40), rise rates (t = -0.415, P = 0.70), high-pulse durations (t =0.87, P = 0.47), or rail densities (T = 3, P = 0.40).

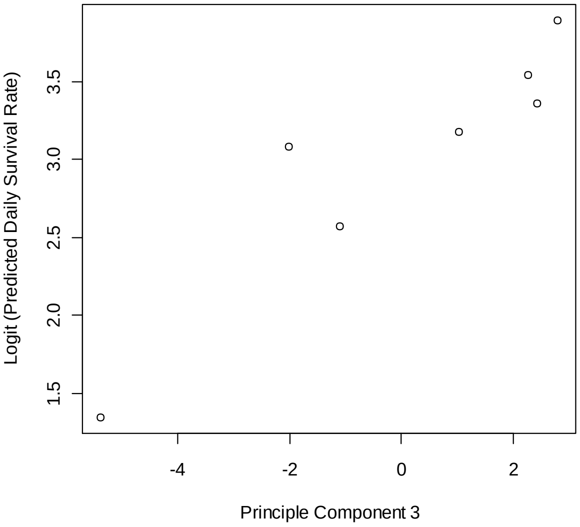

Figure 2. Logit-transformed Daily Survival probability versus Principle Component 3 (which was tightly linked to water-level variability) for rail nests in Maine (2010 & 2011).

Conclusions on Nest Success and Hydrology

Nest survival was higher with increased water-level variation (both at the wetland-scale and the nest-scale). There were also higher densities of rails at wetlands with higher water-level variation. Wetlands with higher water variability are associated with increased emergent vegetation (Weller et al. 1991), increased macroinvertebrate diversity, and higher ecosystem productivity (Galat et al. 1998, Euliss and Mushet 2004) and these areas seem to provide optimal rail nesting habitat in our study. Rail nests were found in shallow areas between dry marsh and deep water. They are likely constrained by a lack of ephemeral plants for nest construction further down the elevational gradient and increased predation risk further up the elevational gradient (Weller 1961). Alternatively, rails may need areas of changing water depths for foraging (emergent plant seeds and invertebrates) and have adapted nesting strategies for areas of consistent water-level change. We witnessed rails building their nests up 18 cm higher in a few days when pressured with rising water levels. They experienced relatively low levels of nest flooding despite water levels that fluctuated at the nest by as much as 30.54 cm over a three day period.

The main cause of nest failure in our study was predation, and nests that were in deepening water had higher survival than those that were in unchanging water or water that was becoming shallower possibly due to changes in predator accessibility (Weller 1961). The linear relationship between nest survival and water depth change could be due to the relatively dry nesting seasons during our study, and we assume that some degree of water level increase, beyond the range we observed, would lead to increases in nest loss.

The Impoundment single-variable model was better than the null model, and the Impoundment variable was also found in our second best model. Impoundment contributes important data to our models but it did not have a significant effect on nest survival (Fig. 1). Furthermore, we found no significant hydrologic differences with wetland impoundment. It is possible that there would be different hydrologic effects if impoundments were actively managed. Active management might involve spring flooding, for example, that could flood rail nests, or could promote increased emergent plant and invertebrate diversity and higher productivity (Weller 1981, Frederickson and Reid 1984), which might increase nest success. Aside from spring and fall manipulations, impoundment management usually involves keeping water at steady, high levels during the summer (similar to hydrologic patterns in our study) and likely would have similar effects on nesting success. Water management regimes that actively attempt to limit water level variation during the breeding season, however, have the potential to limit the wetland area that experiences periodic flooding and thereby limit the wetland area that is suitable for rail nesting and foraging.

Broadcast Survey Detectability by Breeding Stage

From 2010 to 2011, we searched for Virginia rail and sora nests from mid-April to early August (highest nest activity was during early May to mid-July). We played broadcasts of rail calls and randomly searched areas where we heard paired birds responding (the duetting "descending call", sensu Kaufman 1983, of the Virginia rail or the paired "whinny", sensu Kaufman 1983, of the sora). We visited nests every 3-5 days to determine nesting, hatching, or failure stages.

We conducted surveys at each nest during five, potential breeding stages (egg laying, incubation, hatching, post-hatching, post-predation), for each territorial pair that exhibited those stages during observation. Surveys were conducted at least 5 days apart to reduce vocal habituation and to maximize independence between trials (Legare et al. 1999). We placed our broadcast survey location 10m from each nest to compromise between observer detectability issues (Conway et al. 2004) and our probability of recording the nesting pair's responses rather than birds from neighboring territories. We used an Altec Lansing Orbit-MP3 portable speaker with a Sansa SanDisk mp3 player for broadcast surveys at 80-90 dB (measured 1m away) with 5 minutes of silence, 1 minute sora calls, 1 minute of silence, 1 minute Virginia rail calls, and 1 minute silence. We played the sora first and then the Virginia rail calls.

We followed guidelines in the North American Marsh Bird Monitoring Program (Conway 2009) for time of day, weather, and wind speed. Surveys were conducted 30 minutes before to 3 hours after sunrise or 3 hours before sunset (Conway et al. 2004, Gibbs and Melvin 1993). We only surveyed when wind speed was < 20 km/hr (or < 3 on the Beaufort scale) and not during periods of sustained drizzle, rain, or heavy fog. Observers recorded whether birds responded to each survey and, if so, whether it was during the passive or post-broadcast period. For birds that responded, we recorded time until first response, call type, distance from the nest, distance from broadcast speaker, nest stage/age, and date. All observers were trained in estimating distances (0-200 m) using laser finders at the beginning of the season.

We examined response probabilities of each species during the passive period, post-broadcast period, and during the entire survey (passive and broadcast combined). Of birds that were estimated as calling from the nest (nest distance = 0), we determined the percent of birds responding to broadcast and breeding stage. We constructed two logistic regression models for Virginia rail and sora response to broadcast (yes or no) fit by the Laplace approximation with random intercepts for individual nests to account for repeated measurements during the different breeding stages. Virginia rail explanatory variables included breeding stage, Julian date, wetland density, and year. Sora explanatory variables included nest age, Julian date, density, and year. We tested 16 candidate models for each species that included the 4 single component models, all 6, 2-component models, all 4, 3-component models, the full 4-component model, and the constant-intercept model. We used Akaike's Information Criterion corrected for small sample sizes (AIC_c) for model selection, and we evaluated the importance of each variable by summing the Akaike weights across all models (Burnham and Anderson 2002). We examined global-model goodness-of-fit with a Hosmer and Lemeshow (2000) goodness of fit test.

Virginia Rails – We conducted 194 broadcast surveys to 63 unique Virginia rail nests (average of 3.08 surveys per nest). Virginia rails responded on 72.68 % of surveys (141 responses for 194 surveys). Our final model set included six models with a cumulative Akaike $\mathbf{w}_i$ >0.9. The top four models had Δ AIC_c >2 and included combinations of all four explanatory variables. Akaike weights for the top four models were 30%, 20%, 20%, and 10% of all weights for the 16-candidate-model set. All nest stages (incubation, hatching, post-hatching, and post-predation) were negatively related to response probability in comparison to the egg-laying stage reference level (Fig. 3). The model-averaged estimates for the predation stage were significant but the other stages were not (Table 3).

We used model averaging on the top six models in an effort to include model selection uncertainty into parameter estimates and their standard errors (Table 3). Stage and density had the greatest effects on Virginia rail response probability. Density was found in all six top models and the model-averaged estimates were statistically significant (Table 3). Stage was found in three of the top six models and the model-averaged estimate for the predation stage was statistically significant (Table 3). Density was also more important than breeding stage when looking at the summed Akaike weights (0.99 vs. 0.52). Two of the top six models included year and Julian date but the 95% CI of the odds ratios included 1.0, making it difficult to assess their strengths (Table 3). Summed Akaike weights were 0.34 for Julian date and 0.24 for year. Overall Virginia rail response probability from broadcast surveys from the model-averaged estimates was 0.73 (SE=0.08%, n = 194).

Table 3. Summed Akaike weights (w_i) from original 16 models and model averaged parameter estimates with unconditional standard errors (SE) and odds ratios with unconditional 95% confidence intervals for variables in the top six models for Virginia rail response probability to broadcast surveys in Maine, 2010 & 2011. The parameter estimates and odd ratios of the separate breeding stages (failed, hatched, incubation, and hatching) are relative to the reference egg-laying stage.

Variable	Summed (w_i)	Estimate ± SE	Odds Ratio (95% CI)
density	0.99	0.45 ± 0.18	1.57 (1.11 , 2.20)
breeding stage	0.52		
failed stage		-4.94 ± 1.82	0.01 (0.00 , 0.25)
hatched stage		-1.99 ± 1.35	0.14 (0.01 , 1.92)
incubation stage		-1.04 ± 1.12	0.35 (0.04 , 3.16)
hatching stage		-1.18 ± 1.25	0.31 (0.01 , 1.90)
year	0.24	0.46 ± 1.16	1.58 (0.31 , 15.49)
Julian date	0.34	-0.03 ± 0.06	0.97 (0.88 , 1.08)

Sora – We conducted 54 broadcast surveys to 18 unique sora nests (average of 3.00 surveys per nest). Soras responded on 51.85% of surveys (28 responses for 54 surveys). Our final model set included five models with a cumulative Akaike $\mathbf{w}_i$ >0.9. The top three models had Δ AIC_c >2 and included combinations of all four explanatory variables. Akaike weights for the top four models were 46%, 32%, 5% of all weights for the 16-candidate-model set. Breeding stage (Post-predation) and nest age both had significant, negative effects on sora response probability. Sora density significantly positively related to response probability (Table 4). There was no effect of Julian date controlling for the other parameters in these models (Table 4).

We used model averaging on the top five models to include model selection uncertainty into parameter estimates and their standard errors (Table 4). Predation, rail density, and nest age had the greatest effects on sora response probability. Breeding stage was found in all five, top models and the model-averaged estimate was statistically significant (Table 4). Density was found in four of the top five models and the model-averaged estimate was statistically significant (Tables 4). Age was found in three of the top five models and the model-averaged estimate was statistically significant (Tables 4). Predation had the highest summed Akaike weights (0.95) followed by density (0.90) and age (0.88) (Table 4). Two of the top five models included Julian date but the 95% CI of the odds ratio included 1.0, making it difficult to assess its strength (Table 4). Summed Akaike weights were 0.41 for Julian date (Table 4). Overall sora response probability from broadcast surveys from the model-averaged estimates was 0.51 (SE = 0.15, n = 54).

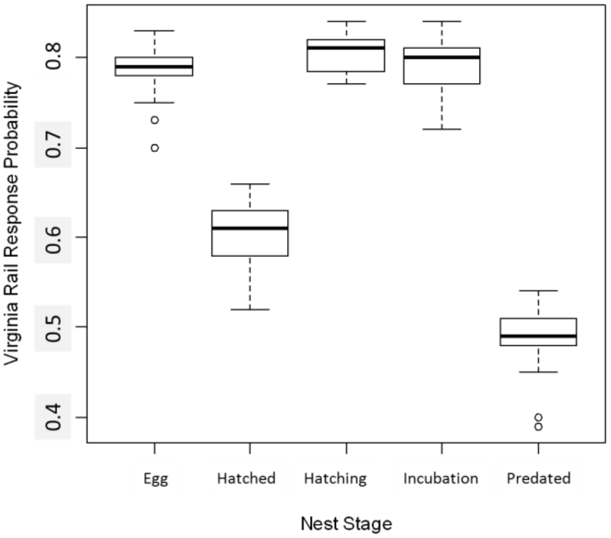

Figure 3. Virginia rail response probability to broadcast surveys was significantly smaller for post-predation nests and had a smaller trend for post-hatched nests in Maine (2010 & 2011).

Conclusions on Factors Affecting Detectability

During broadcast surveys at nests the stage of Virginia rail nests (specifically post-predation) and the density of rails at the site both strongly impacted response probability. Rails whose nests had recently been depredated were significantly less likely to vocalize than those who had not. Virginia rails responded similarly to broadcast during their egg-laying, incubation, and hatching stages. Response rate after hatching (successful nest) was lower, but not significantly, from these other stages. Qualitatively we notice that both Virginia rails and soras were more responsive in the pre-nesting stage, which confirms trends in other marsh bird species (Bogner and Baldassarre 2002, Conway et al. 1993, Legare 1999).

Table 4. Summed Akaike weights (w_i) from original 16 models and model-averaged parameter estimates with unconditional standard errors (SE) and odds ratios with unconditional 95% confidence intervals for variables in the top five models for sora response probability to broadcast surveys in Maine, 2010 & 2011.

Variable	**Summed (w_i)**	**Estimate ± SE**	**Odds Ratio (95% CI)**
predation	0.95	-3.57 ± 1.52	0.03 (0.56 , 0.00)
density	0.90	0.39 ± 0.17	1.48 (1.07 , 2.05)
age	0.88	-0.13 ± 0.06	0.88 (0.77 , 0.99)
Julian date	0.41	0.05 ± 0.08	1.05 (0.91 , 1.22)

Mercury analysis has not yet been completed for the 2011 season. We captured 102 birds in 2010 (73 chicks and 29 adults) and took blood samples that were analyzed by Biodiversity Research Institute for blood mercury levels. Impounded wetlands had an average mercury level of 0.371 ppm (sd 0.239, n=59) compared with unimpounded wetlands with an average mercury level of 0.403 ppm (sd=0.238, n=32)(Figure3). The Penobscot region had an average mercury level of 0.341 ppm (sd=0.22, n=45) compared with the Moosehorn Region with an average of 0.449 ppm (sd=0.26,n=45)(Figure 4). Adult rails had an average mercury level of 0.365 ppm (sd=0.16,n=19) compared with chick rails with an average mercury level of 0.404 ppm (sd=0.26, n=72)(Figure5). Soras had an average mercury level of 0.358 (sd=0.257,n=21) and Virginia rails had an average mercury level of 0.391 (sd=0.234, n=80)(Figure 6). We collected feathers from each adult bird for isotope analysis (pending) and also multiple soil samples from each wetland site for soil methylated mercury analysis (currently at Caltest Laboratory being processed).

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NESTING, BROOD REARING, AND WINTER HABITAT SELECTION OF KING RAILS AND CLAPPER RAILS WITHIN THE ACE BASIN, SC

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Introduction and Objectives

Population numbers of two marsh game bird species, the king rail (*Rallus elegans*) and clapper rail (*Rallus longirostris*), have suffered declines due to loss of wetland and tidal marsh habitats. Three clapper rail subspecies in the western U.S. are both state and federally endangered and populations of the 5 subspecies west of the Mississippi River may be stable or declining. In Canada, the king rail is federally endangered and the U.S. Fish & Wildlife Service has named it a “Bird of Management Concern,” a “Game Bird Below Desired Condition,” and a focal species within its “Focal Species Strategy for Migratory Birds.” South Carolina, along with 29 other states, considers the king rail a “Species of Greatest Conservation Need” (Cooper 2007).

Wetland loss is often mitigated by creating man-made wetlands, including marshes, yet it is unclear if these habitats are capable of sustaining marsh obligate species (Boyer and Zedler 1998, Melvin and Webb 1998, Desrochers et al. 2008). Managed coastal impoundments may supplement rail habitat, if they meet rails’ habitat needs. Because of habitat loss, actual and perceived declining numbers, and hunting pressure, we need data on king and clapper rail population sizes, demographic parameters, and habitat requirements to make informed management decisions to conserve the species. The natural histories of these species are well documented for the Carolinas and Georgia (e.g., Meanley 1969, Meanley 1985), but there are few estimates of either population numbers or basic demographic parameters, e.g., survival, using modern quantitative methods because historical data are lacking (Cooper 2007).

In this study our first objective was to evaluate the effectiveness of capture techniques for king rails and clapper rails for the purpose of attaching radio transmitters. These birds are secretive, reluctant to fly, and inhabit emergent marshes with thick vegetation, thus they are more often heard than seen. Their behavior, combined with the challenges in accessing their habitat, makes capturing these birds in sufficient sample sizes for scientific study difficult. Our study attempted to gather information on a sample of king and clapper rails to address knowledge gaps.

Our second objective was to use radio telemetry to examine seasonal habitat selection, home range, nest site selection, and survival of king rails and clapper rails using impoundments and tidal marshes in the Ashepoo-Combahee-Edisto (ACE) River Basin region of South Carolina. Habitat selection studies are enhanced by investigating demographic outcomes for individuals within their selected habitat. High quality habitats enable individuals not only to survive, but also to reproduce and enable local populations to persist. To conserve or create high quality habitat is an important goal of researchers and land managers concerned with resident species of coastal marsh ecosystems. We developed a more complete understanding of habitat selection (second-order or home range selection) and use by rails and the consequent impact on adult survival. Specific objectives within this topic included: 1) estimate home range size from telemetry data collected from radio-marked birds; 2) determine what variables drive home range selection through a comparison of observed (used) home ranges versus what is available on the landscape (i.e., within simulated home ranges); and 3) estimate adult survival with respect to home range selection.

Resident tidal marsh birds must minimize risks both from predation and regular tidal flooding to reproduce successfully. Nest site selection represents a trade-off between conflicting strategies to avoid these two main risk factors. Along the Atlantic coast, the often dominant marsh grass, *Spartina alterniflora*, serves as a common nest substrate. Tall forms grow at water's edge while short forms grow further inland. While the tall forms provide more cover from predation for nesting species, these nests are more vulnerable to flooding. We evaluated environmental characteristics of nest sites at two spatial scales compared to alternative sites (i.e., sites selected at random for comparison) to quantify selection factors. We modeled the effect of those environmental characteristics on nest survival probabilities.

Methods

During spring and summer of 2008 we used cloverleaf traps with drift fences and periodic call broadcasts of rail vocalizations (Kearns et al. 1998) to attempt to catch rails. We also scanned the marsh with spotlights from a john boat at night on high tides to try to locate rails which we could then capture with dip nets. Our final capture method was to use a thermal imaging camera from an airboat at a night time high tide (Mills et al. 2011). The thermal imaging camera enabled us to locate rails in vegetation that were undetectable with spotlights alone. The airboat provided access to portions of the marsh that were inaccessible using other methods. Once a rail was located with the thermal imaging camera, the driver would maneuver the airboat alongside and the rail could be captured with a dip net.

We evaluated the effectiveness of both necklace and backpack style transmitters on a sample of 24 clapper rails. In a previous study we had found the backpack transmitter attached using the leg loop harness (Haramis and Kearns 2000) to be difficult to attach properly. We elected to try necklace style attachment which would be easier to attach and potentially reduce stress on the birds. However, after increased experience with the leg loop harness and the lower retention rate for the necklaces, we used the backpack transmitters exclusively as we proceeded with the study.

Between January and August 2009 and 2010, we captured and radio-tracked rails throughout an approximately 2300 ha brackish marsh study area within the ACE River Basin in southern South Carolina and at the Combahee Fields Unit of the ACE Basin National Wildlife Refuge. We employed genetic testing to determine each bird's sex. We estimated a home range using the adaptive local convex hull (a-LoCoH) method for each bird with a minimum of 14 recorded locations. We collected habitat variables at landscape and local scales (e.g., landscape: distance to foraging area, amount of foraging area; local: vegetation height, percent bare ground per 0.5 m^2) within used (observed) home ranges and within available (simulated) home ranges across the study area to model clapper rail selection factors using logistic regression analysis. We developed a priori candidate models and ranked their plausibility given our data using AIC_c. We modeled weekly clapper rail survival using Pollock's staggered entry design for each year for all rails captured/tracked and for a subset of rails for which we had collected habitat data. We ranked candidate survival models with AIC_c.

From mid-March through July of 2009 and 2010, we searched for rail nests, focusing on portions of the study area where we had marked birds with radio-transmitters. We monitored each nest to determine its fate and, if it failed, the likely cause of failure. At the landscape scale, we estimated seasonal maximum tides at nest sites and at alternative sites across the entire study area. We also calculated the effective distance from each nest site and from each alternative site to non-marsh habitats (e.g., pine woods) which serve as sources of terrestrial predators. We measured environmental characteristics (e.g., vegetation height and density, percent cover, distance to water's edge) at the nest site and at a local scale alternative site paired with each nest. We used t-tests to evaluate selection at the landscape scale; conditional logistic regression models ranked with AIC_c to evaluate selection at the local scale; and logistic exposure models ranked with AIC_c to evaluate models of nest survival.

Results & Discussion

In 2008, over a 3-month period that included approximately 310 trap nights, we caught 15 clapper rails and 2 Virginia rails with the cloverleaf traps. We were unsuccessful on 4 attempts at using a john boat on night time high tide events to catch rails with spotlights and dip nets. No rails were located or captured using this technique. This was due mainly to the inability to move through the marsh vegetation with a prop driven boat even at high tide. Our most successful capture technique developed involved the use of a thermal imaging camera from an airboat at high tide. This method produced a rate of 19 clapper rail captures per hour, far exceeding the other methods we used (Mills et al 2011). This became our primary technique in future capture efforts.

The airboat method was not successful capturing king rails in our area. A combination of low water levels (even on spring tide nights in the river) and tall, dense vegetation prevented detection and capture of king rails. King rail populations also appeared to be lower than clapper rail populations in this area. During this study only 4 king rails were caught using drop-door traps and in one case, a dip net. This project was originally envisioned as a comparative study between king and clapper rails for the results of each objective, but we did not capture enough king rails to allow this type of analysis between species. Thus, the following results are presented for clapper rails only.

Clapper rail results

We captured and radio-tracked clapper rails (2009: n = 44; 2010: n = 39) between January and August 2009 and 2010. We estimated 54 clapper rail home ranges (mean number of locations per home range = 42; range of locations per home range = 14 to 78). Males and females occupied home ranges of similar sizes and habitat characteristics and so were combined in selection analyses. Food availability at both scales may drive home range choice; observed home ranges contained more foraging area than simulated sites and observed home ranges contained higher percent bare ground, which may approximate home-range wide food availability, than simulated sites. Survival modeling for each year suggested a higher probability of survival for males. Survival probability for 2009 males was 0.74 (n = 29); for females, 0.69 (n = 13). In 2010, survival probability was high for both males 0.94 (n = 25) and females 0.93 (n = 15). For 2009 only, survival models including habitat covariates suggested increased survival with increased foraging area and decreased survival with increasing bare ground.

Rails in this system appeared to select home ranges based on food availability which may have increased their survival probability. An explicit examination of prey items would clarify the results of this study. Both male and female rails survived with a fairly high probability during the study period. However, this study focused mainly on the breeding season with some data from late winter/early spring. Survival may differ during fall and winter months and a year-round telemetry effort would reveal seasonal differences.

We found and monitored 132 active clapper rail nests (2009, n = 55; 2010, n = 77). We used 98 nests (2009, n = 35; 2010, n = 63), for which we collected data on all environmental characteristics, in the analyses. At the landscape scale, rails selected nest sites that experienced significantly lower seasonal maximum tides compared to alternative sites. There was no difference within or across years between the nest sites and alternative sites in effective distance to non-marsh habitats. At the local scale, the 3 most important parameters in explaining differences between nest sites and paired alternative sites were: % bare ground; distance to vegetation edge; and grass height. Rails nested at sites with significantly taller and denser vegetation compared to paired alternative sites. Rails selected nest sites closer to water's edge than paired alternative sites, potentially increasing vulnerability to flooding. However, based on the rails' selection at the landscape scale, we suggest the risk of nest flooding was minimized.

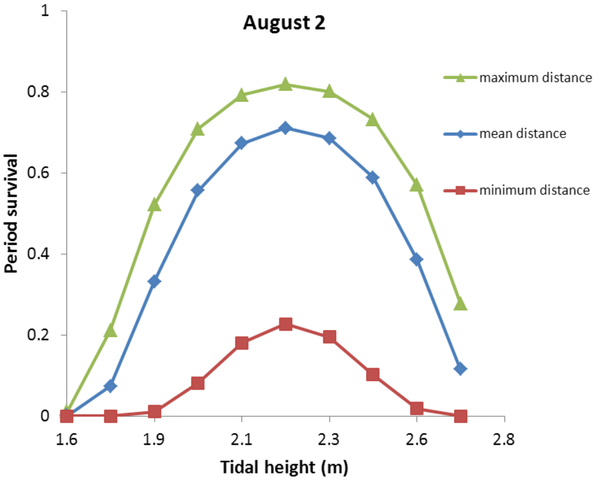

Figure 1. Nest survival probabilities across a range of tidal heights for a particular day of the breeding season at three different distances to non-marsh habitat: the mean, maximum and minimum values calculated. Nest survival probability is most affected by landscape position—survival is less likely the closer to non-marsh habitat, regardless of tide height.

Nest survival probability was best predicted by 4 parameters: Julian date, daily maximum tide and its quadratic term, and the effective distance to non-marsh habitat. Tide had a dual effect on nest survival. Lower maximum tides corresponded to decreased nest survival likely because this facilitated movement of nest predators across the marsh landscape. Extremely high maximum tides also corresponded to decreased nest survival because at these heights nests were flooded. Nest survival probabilities decreased as distance to non-marsh habitat decreased, regardless of tide height experienced by the nest (Figure 1). Thus, despite rails' apparent ability to select sites minimizing flooding risk, they appeared not to select for proximity to non-marsh habitats (i.e., a nest predator source); moreover, any increase in proximity reduced overall nest survival probabilities. Clapper rail productivity is likely diminished in tidal marshes which are smaller or have a proportionally high amount of edge habitat.

Summary & Conclusions

The overall goal of this project was to understand how rails select habitat, what comprises their selected habitats, and how these choices affect survival and reproductive success. Initially, we planned a comparative approach between the mainly freshwater to brackish wetland dwelling king rail and the brackish to saline tidal marsh dwelling clapper rail. Unfortunately, our inability to catch an adequate sample of king rails prevented this analysis. Nevertheless, from this research we were able to explore how clapper rails address the inherent tradeoffs facing residents of coastal tidal marshes.

There are few studies available with which to directly compare our results for clapper rail survival and reproductive success, and none for Atlantic Coast rails. This fact makes a determination of habitat quality somewhat arbitrary, especially because this study does not capture long-term data. Adult survival was variable across years but similar between sexes in each year; breeding season survival was high. Our estimate of rail daily nest survival was < 0.02 lower than a Mississippi study (Rush et al. 2010). A mean of 6.2 chicks were produced from successful nests across years. Unless recruitment and adult survival in the non-breeding season are low, this study area represents high quality clapper rail habitat and could be used as a model system for land managers.

King rails in this study area are known to use impoundments of the ACE Basin National Wildlife Refuge, but we were unable to capture enough king rails to determine what specific features of the impoundments contributed to the rails' habitat choices. In North Carolina and Virginia, king rails used impoundments but occupancy was lower than in non-impounded wetlands and prescribed fire regimes encouraged a positive response in king rail occupancy in both areas (Rogers 2011). Clapper rails were never detected in the managed impoundments at Nemours Plantation, but were observed on levies and the fringe marsh between the impoundments and the Combahee River.

From a management perspective, we continued an effort to assess the capacity for the thousands of hectares of coastal wetland impoundments in South Carolina to function as supplemental rail habitat. Additionally, we contributed to the information needed on rails as described by the Association of Fish and Wildlife Agencies' Migratory Shore and Upland Game Bird Support Task Force (MSUGBSTF 2009). We provided the first estimates of demographic parameters for Atlantic Coast clapper rails which will facilitate the estimation of population trends. We also described the connection between these demographic parameters and specific habitat characteristics. No previous study of Atlantic Coast clapper rails has investigated these relationships. This information can assist in harvest and land management decision-making for these gamebirds.

Now that we have baseline information on specific habitat requirements, experimental manipulation of the vegetation and water levels within an impoundment could be implemented to determine if clapper rails would use this managed habitat. A major part of the manipulation to water levels would consist of mimicking the tidal fluctuations of natural marsh areas such that fiddler crabs could populate the impoundment.

A manuscript on the airboat/thermal imaging rail capture technique has been published in the Journal of Wildlife Management (Mills et al 2011). Three additional manuscripts are in preparation for publication: one on the use of genetic and morphometric techniques to sex rail species; one on home range selection and adult survival of clapper rails; and one on nest site selection and nest survival of clapper rails.

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EVALUATION OF AN EXPERT-BASED LANDSCAPE SUITABILITY MODEL FOR KING RAILS IN THE UPPER MISSISSIPPI RIVER AND GREAT LAKES JOINT VENTURE REGION

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Graduate Student: Jason Bolenbaugh (M.S.); Final **Report**

We conducted a large scale study to assess the status, distribution, and habitat requirements of breeding King Rails (*Rallus elegans*) in the Upper Mississippi River/Great Lakes Joint Venture Region (JV) during the 2008 and 2009 breeding seasons. We also designed the study to validate the predictive ability of a King Rail Landscape Suitability Index (LSI) model developed by the JV. We randomly selected survey sites among predicted high, moderate, and low suitability sites throughout the JV. High, moderate, and low suitability sites were based on wetland cover type (emergent or woody), wetland size (>20 ha or <20 ha), and distance from major river systems and the southern shores of Lake Erie and Lake Michigan. We attempted to estimate detection probabilities and occupancy rates for the King Rail, and determine which habitat covariates influenced those parameter estimates on a local and landscape scale throughout the JV. We surveyed 264 sites on three separate occasions in both 2008 and 2009 using the National Marsh Bird Monitoring Protocol.

Jason Bolenbaugh surveying king rails in the Upper Mississippi River/Great Lakes Joint Venture Region in 2009. Photo by Arkansas Coop Unit

We detected 13 King Rails at 9 sites in 3 state managed areas. We detected 8 King Rails (2008 = 5, 2009 = 3) at Goose Pond FWA in Green County, Indiana, 3 King Rails (2008 = 1, 2009 = 2) at B.K. Leach CA (Bittern Basin Unit) in Pike County, Missouri, and 2 King Rails (2008) at Whiteriver WMA in Winona County, Minnesota. Due to the lack of detections during both seasons we could not estimate site occupancy or determine which habitat covariates influenced occupancy for the King Rail. Qualitatively, in 2008 we detected King Rails in habitats that consisted of a mix of open water, tall emergent vegetation, and upland grasses and forbs. At Goose Pond FWA King Rails were detected at sites with open water and upland grasses. At B.K. Leach CA a King Rail was detected in a mix of open water, Common Spikerush (*Eleocharis palustris*), and upland grasses. At Whitewater WMA a pair of King Rails was detected in a monotypic stand of Reed Canary Grass (*Phalaris arundinacea*). In 2009, King Rails were detected in habitats typical of an undisturbed landscape in which there was topographic variability that provided dry, upland areas intermixed with areas of varying vegetative cover and water depths (0 – 1.5 m). At Goose Pond FWA we detected King Rails at sites that contained a mix of tall emergent vegetation (e.g. *Typha* spp.) and short emergent vegetation (e.g. *Carex* spp.), with varying water depths (0 – 1.5 m). At B.K. Leach CA, King Rails were detected at sites with shallower water (2.54 cm – 10.16 cm), Swamp Smartweed (*Polygonum hydropiperoides*), and Common Spikerush. The variation in the structure of the habitat within Goose Pond FWA and B.K. Leach CA was due to the extensive flooding that occurred within the JV in 2008. Both of these management units were in a region of the JV that received up to 203 – 406 mm above average rainfall during the 2008 breeding season.

Currently, we are collaborating with other researchers whom were working on similar King Rail projects to develop a more comprehensive overview of the distribution of King Rails in the JV during 2008-2009. Based on those results, southeastern Wisconsin and northeastern Illinois are areas with relatively high concentration of King Rails. Three areas in particular that may be considered “hot spots” for breeding King Rails include Rat River SWA in Winnebago County, Wisconsin, and Goose Pond FWA and B.K. Leach CA.

Extensive flooding caused many problems in surveying king rails in 2008. *Photo by Jason Bolenbaugh*

Although we could not determine which habitat covariates best explained King Rail occupancy, we found the proportion of emergent herbaceous wetlands within 5 km of our survey sites had a positive relationship to occupancy of other secretive marshbirds including Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), Least Bittern (*lxobrychus exilis*), Virginia Rail (*R. limicola*), Sora (*Porzana carolina*), and Common Moorhen (*Gallinula chloropus*). Thus, the presence of the emergent herbaceous wetland covariate during model selection suggests secretive marsh birds, and possibly the King Rail, may first select areas within the landscape that have a large proportion of emergent herbaceous wetlands, and then select more suitable wetland habitat at the local scale.

Finally, we do not believe the lack of King Rail detections was due to inadequacies of the LSI model itself. Rather the lack of detections is representative of low King Rail population abundance in the JV. Although we could not evaluate the predictive ability of the LSI, we believe that when we altered the scale from a site-specific scoring method to an area-specific scoring method, we improved the LSI between 2008 and 2009. By altering the scale we were able to improve on the distribution of moderate suitability sites throughout the JV, and we reduced the “clumping” of high and moderate suitability sites within the same wetland complex thus, leaving us less vulnerable for site loss during flooding seasons.

These results are from the second year of a 2-year study funded by the U.S. Geological Survey Science Support Partnership Program, the U.S. Geological Survey Arkansas Cooperative Fish & Wildlife Research Unit, and the University of Arkansas.

IMPLEMENTATION OF THE NATIONAL MARSHBIRD MONITORING PROGRAM IN OHIO

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Introduction

The Ohio Division of Wildlife (Division) has conducted its own wetland breeding bird survey since 1991. Due to the nonrandom spatial design of current survey routes; however, the ability to make inferences about statewide population trends for wetland birds is limited. While trends exist for each of the wetlands that are surveyed, there is no information on population levels of rails, coots, and moorhens for the state. Thus, the Division restructured its current wetland bird surveys so that survey effort yields more reliable and useful monitoring data for a host of species, including several webless marsh bird species of conservation concern within Ohio's State Wildlife Action Plan (Ohio Department of Natural Resources 2001).

In addition, Ohio has identified 3 wetland focus areas within its State Wildlife Action Plan; each focus area consists of relatively large tracts of the best remaining wetland habitat in the state. An initial need associated with the focus area concept is to determine avian use and population trends with an emphasis on state-listed species (Ohio Department of Natural Resources 2001). An improved wetland bird survey will enable the Division to gain baseline data on various species that are state endangered (American bittern [*Botaurus lentiginosus*] and king rail [*Rallus elegans*]), state threatened (least bittern [*Ixobrychus exilis*]), and of special concern (common moorhen [*Gallinula chloropus*], sora [*Porzana carolina*], and Virginia rail [*Rallus limicola*]) with data applicable to monitoring trends at both the focus area and statewide scale.

The needs listed above dovetail nicely with the emergence of National Marshbird Monitoring Program and its implementation within the Mississippi Flyway. Development of a national program to monitor population trends of rails and soras (Case and McCool 2009) and American coots (Fulica americana) and common moorhens (Case and Sanders 2010) is listed as the top priority for the Atlantic and Mississippi Flyways within the next 5 years. Both documents also state that the strata for the program will be hierarchical in nature which fits well with Ohio's intentions to monitor wetland birds at both the focus area and statewide scale (Case and McCool 2009, Case and Sanders 2010). Ohio's integration of a standardized survey protocol will further enhance the development of a flyway-wide monitoring program by contributing data for regional monitoring of marsh birds.

The Upper Mississippi River and Great Lakes Joint Venture has also placed a high priority on determining population status and trends of secretive marsh birds (UMRGLR JV 2007). The king rail is listed both as a priority species and as focal species while American bittern, least bittern, and sora are listed as priority species. All of these species will be monitored with Ohio's improved wetland bird monitoring program.

Study Area

The entire state of Ohio was used as a base from which to draw primary sampling units. Wetland inventory data were recently updated in Ohio (Ducks Unlimited 2009) and served as the database from which sampling units that contained wetlands were selected. Karen Willard (pers. comm..), a graduate student at the Ohio State University, recorded very few marshbirds in the unglaciated southeastern part of Ohio, so no wetlands were selected from that region.

Methods

Survey Point Selection

Ohio's marsh bird monitoring program followed the 2-stage cluster sampling frame design outlined in Johnson et al. (2009). Willard (pers. comm.) reported that in her marshbird surveys she found the majority of the marshbirds in state wildlife areas and large, private holdings such as state wildlife areas and Lake Erie marsh duck hunting clubs. Therefore, the PSUs were divided into 3 strata: High Quality; General Private; and General Public. The High Quality stratum consisted of the Ottawa NWR complex, three wetland focus areas, the Killdeer/Big Island Wildlife area wetland complex, and Lake Erie marsh private duck hunting clubs. Public lands were identified from the Ohio Division of Real Estate and Land Management database.

Survey sites were selected using two-stage cluster sampling using a Generalized Random Tesselation Stratified (GRTS) procedure. The Primary Sampling Units (PSUs) were 40km^2 hexagons that may be thought of as "routes." The individual survey points or Seconday Sampling Units (SSUs) were selected by using GRTS inside the PSUs. This procedure provided point locations that were spatially-balanced yet randomly selected and clustered to improve logistical efficiency.

PSUs and SSUs were provided to the Division by the U.S. Fish and Wildlife Service as GIS shapefiles. PSUs were randomly selected from the shapefiles and the SSUs were selected using aerial photographs from the Ohio State Imagery Program (OSIP). SSUs were excluded if they were not in the appropriate habitat, were too difficult to access, or too far from the other SSUs. SSUs could be moved up to 150m to obtain a suitable habitat, but not to be in "better" habitat. Each SSU had to be alt least 400 m from another SSU, and a PSU had to have at least 7 SSUs that fit the criteria to be surveyed. SSUs were not groundtruthed due to time constraints and the recent date of the wetland inventory and the aerial images.

Surveys

The surveys will be conducted according to Conway (2009). This protocol states that a survey is conducted at each point and consists of a five minute passive listening period followed by five one minute calls of least bittern, sora, Virginia rail, king rail, and American bittern. The calls were broadcast using an mp3 player and portable speakers set on maximum volume. Focal species were Virginia rail, sora, king rail, least bittern, American bittern, common moorhen, American coot, pied-billed grebe (*Podilymbus podiceps*), and black tern (*Chilidonias niger*). Non-focal species that will also be recorded on the survey are willow flycatcher (*Empidonax traillii*), swamp sparrow (*Melospiza georgiana*), marsh wren (*Cistothorus palustris*), and wood duck (*Aix sponsa*). Each SSU was surveyd 3 times between May 1 and June 15. Surveys were conducted in the morning starting 30 minutes before dawn to 3 hours after sunrise or in the evening three hours before dusk and continuing for 30 minutes after sunset. Three surveys are conducted in each PSU approximately every 14 days starting on May 1 and ending on June 15. Survey data were entered into the Marshbird Population Assessment and Monitoring Project Database maintained by the Patuxent Wildlife Research Center. Habitat data was recorded at each survey point, if possible.

Results

Survey Point Selection

There were 2,877 PSUs in Ohio; 44 PSUs were in the High Quality stratum and 1,142 PSUs in the public land stratum. All High Quality PSUs had wetlands, and 826 of the public land PSUs had wetlands according to NWI. Two PSUs were randomly selected from each focus area and the Big Island/Killdeer Plains complex. In addition one PSU containing public land and one PSU containing private land were selected. However, due to difficulty in locating a private PSU from the standard strata with the correct attributes for the SSUs, we only had a total of 9 survey PSUs (Table 1). Each PSU initially had 25 points, and we selected as many of the points as possible as long as each point was 400 m from an adjacent point, located in sufficient habitat, and not to difficult to access.

Surveys

Eight PSUs were surveyed with six PSUs surveyed during all three time periods (Table 1). A total of 14 species were detected during the surveys (Table 2). The ten most numerous birds on the survey ranged from 0.38 birds per survey for the wood duck to 0.025 birds per survey for the least bittern (Fig. 1).

Discussion

The initial year of the marshbird survey was successful although there were a few problems that will need to be corrected before the next field season. The use of aerial images worked extremely well for selecting points. Due to time constraints, very few of the survey points could be groundtruthed before the actual survey. However, there were only 7 points on all of the surveys combined which were located in unsuitable habitat. These few points will be eliminated and new ones will be assigned to correct this error.

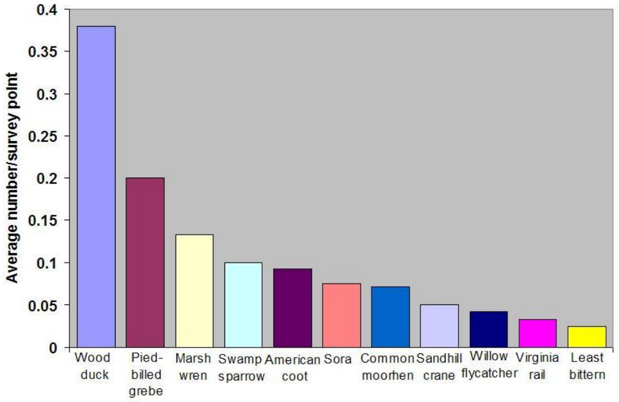

Figure 1. Detection rates of the 10 most numerous priority birds encountered during the marshbird monitoring surveys, May – June, 2011.

Most of the routes took the full 3.5 hours to be conducted, and 2 routes could not be completed in that time frame. The Division of Wildlife will purchase some kayaks to be used on the 2 routes so that the survey points can be accessed more quickly. We will also look at whether switching the order of survey points will allow more points to be surveyed.

The number of detections of various marshbirds declined from the Ohio wetland breeding bird surveys primarily because the old survey points were not randomly distributed, and the routes were located in the best habitat. The new marshbird surveys should give a more accurate index of marshbird abundance and allow inferences to be made regarding numbers of birds within the state. In addition, Ohio has 3 wetland focus areas as part of its strategy to impact the conservation of wetland-dependent species through its State Wildlife Action Plan; an initial priority need is to determine avian abundance within these focus areas. Once baseline information is obtained, management decisions can be made on how habitat management actions can improve conservation success for targeted wetland species. Bird abundance and diversity within focus areas can be compared to statewide data to determine whether any landscape habitat changes need to occur to improve conservation of selected species. The habitat component of the marsh bird monitoring program will also provide direction in terms of exactly what habitat types are most valuable to what species, thus enabling future management efforts to be directed to provide habitat types and associations which benefit the most species.

Future work

This is the first year of an ongoing project within the Ohio Division of Wildlife. The equipment necessary for the project initialization was funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service). Refinements to the survey and additional kayaks should improve the efficiency of the program in 2012.

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Table 1. Marshbird survey locations, number of points on the survey, and number of surveys conducted in 2011.

Strata	Survey Location	Number of points	Number of surveys
Intensive	Magee Marsh WA*	15	2
	Winous Point Conservancy	15	3
	Killbuck Marsh WA North	8	3
	Killbuck Marsh WA South	10	3
	Grand River WA	9	3
	Mosquito Creek WA	11	3
	Killdeer Plains WA	9	2
	Big Island WA	10	0
Standard	East Sandusky Bay	11	3

Table 2. Numbers of individuals of target species detected during the Ohio Marshbird Survey, 2011.

Species	Survey 1	Survey 2	Survey 3	Total
Pied-billed grebe	8	18	22	48
American Bittern			1	1
Least Bittern		3	3	6
King Rail			2	2
Virginia Rail	2	2	4	8
Sora	5	8	5	18
Common Moorhen	7	3	7	17
American Coot	7	6	9	22
Black Tern	1			1
Marsh Wren	8	12	12	32
Swamp Sparrow	5	7	12	24
Wood Duck	10	30	51	91
Sandhill Crane	1	2	9	12
Willow Flycatcher		1	9	10

IMPLEMENTATION OF A NATIONAL MARSHBIRD MONITORING PROGRAM: USING WISCONSIN AS A TEST OF PROGRAM STUDY DESIGN

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Final Report

Background and Objectives

Largely because of their secretive behavior and difficult-to-access habitats, marshbirds such as rails, bitterns, coots, and grebes are among the most poorly monitored bird groups in North America. Yet many species are of high conservation concern (e.g. American Bittern, King Rail, Yellow Rail), some are harvested (e.g. Sora, Virginia Rail, Wilson's Snipe), and all are thought to be excellent indicators of wetland ecosystem quality (Conway 2009). Hence more information on their population status, trends, and habitat associations is needed.

Marshbird monitoring has received greater attention in the past decade but most work has focused on standardization of survey protocols, often in the context of national wildlife refuges or other localized management units (Conway 2009). However, the U.S. Fish & Wildlife Service's Division of Migratory Bird Management recently initiated a surge toward a national marshbird monitoring program, with hopes of establishing a study design and sampling framework that can be used on state, regional, and national scales. The primary objectives of the national program are to: (1) estimate population trends for conservation planning; (2) provide status data, especially for harvested species; and (3) collect ancillary habitat data to inform habitat management decisions at multiple scales.

In 2008, Wisconsin became the first state to pilot the national marshbird monitoring program through coordination efforts of the Wisconsin Bird Conservation Initiative (http://www.wisconsinbirds.org/) and Wisconsin Department of Natural Resources. The goals of the pilot study were to: (1) shape study design of the national program (e.g. provide estimates of detection probability and occupancy, determine number of survey sites required for desired power, and assess utility of WWI/NWI maps for site selection); (2) inform coordination/implementation efforts (e.g. state and regional coordination needs, how surveyors and volunteers are recruited, operating costs, and utility of volunteer bird surveyors); (3) provide baseline data on detectability, occupancy, abundance, and habitats of Wisconsin's marshbirds; and (4) assess feasibility of design for monitoring rare species, such as King and Yellow Rails.

Methods

Study design. Details of the general sampling design framework can be found in Johnson et al. (2009). In Wisconsin, the sampling frame was defined as all wetlands in the state that could potentially have marshbirds. These were selected from the digital layers of the Wisconsin Wetland Inventory (WWI; http://dnr.wi.gov/wetlands/inventory.html) using the following classes: (1) aquatic bed, (2) emergent/wet meadow, and (3) shrub/scrub ONLY when interspersed with emergent/wet meadow. Survey sites were selected statewide within defined wetlands using two-stage cluster sampling via a Generalized Random Tessellation Stratified procedure (GRTS), which clustered survey points (Secondary Sampling Units, or SSUs) within larger Primary Sample Units (PSUs) for logistical efficiency.

PSUs and SSUs were then analyzed (in the order selected) remotely using aerial photographs and ground-truthed in the field to assess their suitability for the survey. Selected SSUs were excluded if they had inappropriate habitat (i.e. no longer a wetland, succeeded to shrub/scrub, too dry, etc.) or were too difficult to access (i.e. bordered by impenetrable habitat and/or greater than ~400 meters from any road/trail access). Selected PSUs were excluded if they had less than five suitable SSUs to be surveyed. This process resulted in a "route" of five to ten suitable SSUs occurring randomly within each 40-km^2 PSU.

Target species. Primary target species in this survey were Yellow, Sora, Virginia, and King Rails, Least and American Bitterns, American Coot, Common Moorhen, Pied-billed Grebe, and Wilson's Snipe (2009 only). Secondary target species were Red-necked Grebe, Black and Forster's Terns, Marsh and Sedge Wrens (the latter in and after 2009 only), Swamp and Le Conte's Sparrows, Yellow-headed Blackbird, and Sandhill Crane (in and after 2009 only). These secondary species were selected because they also occupy the wetland habitats to be surveyed, may be poorly monitored by existing surveys, and/or are of conservation interest on state or regional levels. Surveyors did not record data on non-target species.

Survey protocol. Surveys were conducted at each SSU using the standardized protocol outlined by Conway (2009). The broadcast sequence in this study included six species: Least Bittern, Yellow Rail, Sora, Virginia Rail, King Rail (southern WI only), and American Bittern. Two or three replicate surveys were conducted between May 1 and June 15 in southern Wisconsin and between May 15 and June 30 in northern Wisconsin. Observers included a combination of hired field technicians, biologists, and volunteers who were trained via workshops and online resources. See Brady (2009) for more details.

Preliminary Results and Discussion

Year One – 2008

In 2008, three field techs and 25 volunteers surveyed 326 SSUs (points) at 53 PSUs (routes) statewide. See Table 1 for total detections by survey period. Some patterns included:

- Detections and occupancy rates were lower than expected, probably because we were conservative in groundtruthing and included too much "marginal" marshbird habitat (i.e. wetlands that were too dry, too shrubby, a monoculture of reed canary grass, etc.).
- Detections for "hemi-marsh" species – such as Pied-billed Grebe, Least Bittern, gallinules, and Yellow-headed Blackbird – were especially low. The sampling design, either through WWI or the groundtruthing process, may not be picking up this habitat.
- King Rails were expectedly scarce and mainly in southeast Wisconsin. Yellow Rails were also rarely detected – a nocturnal survey may be needed to adequately monitor this species.
- This survey may be able to monitor population trends of Wilson's Snipe – a harvested species – at the state level.
- Occupancy by Sora, American Bittern, and Virginia Rail was positively related to wetland size and percentage of wetland surrounding the survey point and significantly higher in permanently inundated wetlands. Hence water level is likely a strong predictor of marshbird occupancy and should be measured as a covariate (though this is challenging on a state-level scale).

Detection probability decreased through the survey period for most species. The survey ultimately may require only two replicate surveys to meet monitoring objectives.

Year Two – 2009

In 2009, two field techs and 25 volunteers surveyed 311 SSUs at 42 PSUs statewide. We applied more stringent groundtruthing criteria and thus eliminated some points that were in "marginal" habitat. These were replaced by new, randomly-selected points in more appropriate habitat. This efficiency, coupled with timelier implementation of surveys (early May in 2009 vs. mid-May in 2008), at least in part led to substantially higher detection rates for most species (Tables 2, 4). In addition:

- Sora, American Bittern, and Virginia Rail were again most common (Table 2).
- Detections of hemi-marsh species were higher than 2008 but still low (Tables 2, 4).
- Eleven King Rails were detected but ten of these came over replicate surveys at three survey points within one state wildlife area.
- Detections decreased through each survey period for most primary species, and drastically so for Sora (Table 2).
- Preliminary statewide abundance estimates (*N*) and their coefficients of variation (CV) for the three most common primary target species in 2009 were: Sora N = 104,700 (CV=11%), Virginia Rail N = 36,870 (CV=16%), and American Bittern N = 23,340(CV=25%).

Table 1. Numbers of individuals of target species detected during the 2008 Wisconsin Marshbird Survey. Note that actual dates of time periods differ for “northern” and “southern” Wisconsin (e.g. Period 1 represents May 1-15 in South and May 15-30 in North).

Species	**Period 1**	**Period 2**	**Period 3**	**Total**
American Bittern	48	18	0	66
American Coot	5	2	0	7
Common Moorhen	0	3	1	4
King Rail	2	2	0	4
Least Bittern	2	4	0	6
Pied-billed Grebe	13	6	1	20
Sora	74	55	4	133
Virginia Rail	31	29	9	69
Yellow Rail	2	0	0	2
Black Tern	8	39	0	47
Forster’s Tern	2	6	0	8
Le Conte’s Sparrow	4	4	2	10
Marsh Wren	115	97	8	220
Red-necked Grebe	0	0	0	0
Swamp Sparrow	374	384	97	855
Wilson’s Snipe	23	24	4	51
Yellow-headed Blackbird	0	3	0	3
Points Surveyed	*326*	*307*	*63*	*326*

Table 2. Numbers of individuals of target species detected during the 2009 Wisconsin Marshbird Survey. Note that actual dates of time periods differ for “northern” and “southern” Wisconsin (e.g. Period 1 represents May 1-15 in South and May 15-30 in North).

Species	**Period 1**	**Period 2**	**Period 3**	**Total**
American Bittern	93	62	48	203
American Coot	39	12	4	55
Common Moorhen	14	2	1	17
King Rail	2	5	4	11
Least Bittern	6	5	4	15
Pied-billed Grebe	28	21	11	60
Sora	262	113	22	397
Virginia Rail	56	46	30	132
Wilson’s Snipe	31	17	12	60
Yellow Rail	2	1	1	4
Black Tern	6	5	29	40
Forster’s Tern	27	4	0	31
Le Conte’s Sparrow	8	7	5	20
Marsh Wren	113	155	136	404
Red-necked Grebe	0	0	0	0
Sandhill Crane	262	211	207	680
Sedge Wren	175	240	231	646
Swamp Sparrow	549	634	613	1796
Yellow-headed Blackbird	1	1	1	3
Routes Surveyed	*38*	*37*	*37*	*42*
Points Surveyed	*270*	*266*	*265*	*311*

Ryan Brady conducting a marshbird survey in Wisconsin. *Photo by Tim Oksiuta*

Year Three – 2010

In 2010, two field techs and 25 volunteers surveyed 330 SSUs at 45 PSUs statewide. After surveying mostly on public land in 2008 – 2009, this year we placed additional focus on PSUs predominately in private land ownership. With financial assistance from a USFWS Region 3 Nongame grant, we made landowner contacts by mail and phone and surveyed private lands where permission was granted, which made our sampling effort more comprehensive. Most landowners were very cooperative and highly interested in our survey efforts. Results highlights included:

- Sora, American Bittern, and Virginia Rail were again the most common primary target species in 2010 (Table 3), although Sora detections were much lower than 2009 and Pied-billed Grebe detections increased greatly over previous years (Table 4).
- We detected only 1 Yellow Rail and no King Rails or Common Moorhens.
- Detections for Sora again decreased substantially through each survey period, less so for Virginia Rail, and sharply for American Bitterns around mid-June.
- Preliminary statewide abundance estimates (*N*) and their coefficients of variation (CV) for the three most common primary species in 2010 were: Sora N = 61,820 (CV=15%); Virginia Rail N = 27,860 (CV=13%), and American Bittern N = 15,960 (CV=17%).
- In general, wetlands suitable for marshbirds on private lands were not plentiful and tended to be smaller than those on public lands. However, at the site level we found no clear evidence that private wetlands functioned any differently in terms of marshbird occupancy than similarly-sized wetlands on public lands.

Comments on Study Design and Implementation

- The Wisconsin Wetland Inventory accurately identified wetlands in most cases. Limitations included old data, some counties not yet digitized, and exclusion of restored wetlands. Future surveys would greatly benefit from updated land cover classification maps.
- The two-stage cluster sampling using GRTS was effective in producing "routes" of survey points in appropriate habitat while maintaining randomization and spatial balance.
- Groundtruthing – both remotely and in the field – represented the greatest investment of time and resources but was an essential part of implementing this design, especially with volunteer surveyors. Improved wetland inventory data would substantially reduce this investment. In addition, formalized criteria for making groundtruthing decisions is needed but may prove difficult to standardize.
- Volunteers were reliable and performed well, with retention high across years. Training was critical as the protocol is more complex than other surveys and required use of audio equipment and GPS receivers. We found it essential to explain the study design to volunteers so they understood why they were visiting random wetland locations instead of favored sites of interest. Their understanding, passion, and proficiency suggest this survey could be mostly or entirely citizen-based in the long-term, at least here in Wisconsin.
- Proper coordination and implementation required a statewide survey coordinator. This was facilitated by WBCI's Wisconsin Marshbird Survey website (http://wiatri.net/projects/birdroutes/marshbirds.htm).
- Conway's protocol (2009) appeared to be effective within the context of a statewide, "off-refuge" survey and was readily implemented by trained surveyors.
- Standardized equipment, including mp3 players, portable folding speakers, and GPS receivers, were provided to all surveyors. GPS

was required because it was not reasonable to permanently mark all survey points statewide.

- Measuring habitat variables at survey sites is a significant concern given the large scale of this survey and heavy reliance on volunteers. What variables to measure and how to measure them proved difficult but see an example from this pilot study at http://wiatri.net/projects/birdroutes/Docs/SampleHabitatSheet.pdf. Measuring water levels, a potentially important predictor of marshbird occupancy, could be especially challenging.
- Availability of a centralized database and statistician through the Patuxent Wildlife Research Center fulfilled important state-level needs after surveys were completed. However, the database needs modification to improve web-based data entry and summary/analytical capabilities post-entry. The newly-formed Midwest Avian Data Center may help in this regard.

Future Work

This pilot study has set the stage for an annual, long-term marshbird monitoring program in Wisconsin and beyond.

- In 2011, we partnered with the Chicago Botanic Garden and Northwestern University to examine site- and landscape-level habitat features influencing occupancy by secretive marshbirds, including at some Wetland Reserve Program sites. Results are pending at the time of this report.
- We have no new work planned in 2012 aside from continued surveys at existing sites. We will continue to conduct analyses of occupancy, detectability, power, abundance, etc. to inform survey design and conservation planning for target species.
- By 2013 we hope to add wetland restorations and counties with newly-digitized wetland inventory data to complete the sampling framework.
- We will continue to work closely with national and regional partners, in the context of the Midwest Coordinated Bird Monitoring Partnership, to move from a pilot to fully operational monitoring program by 2013.

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Funding and Completion

This project was completed in January 2011. Results are from a three-year pilot study funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service), USFWS Region 3 Nongame Grant, Wisconsin DNR Citizen-based Monitoring Grant, and Wisconsin DNR volunteer contributions. For more information and future updates see: http://wiatri.net/projects/birdroutes/marshbirds.htm.

Table 3. Numbers of individuals of target species detected during the 2010 Wisconsin Marshbird Survey. Period 1 represents May 1-15 (regardless of north vs. south), Per 2 = May 16-31, 3 = June 1-15, and 4 = June 16-30.

Species	**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Total**
American Bittern	32	85	53	4	174
American Coot	16	4	2	1	23
Common Moorhen	0	0	0	0	0
King Rail	0	0	0	0	0
Least Bittern	1	8	14	1	24
Pied-billed Grebe	30	53	23	10	116
Sora	99	59	24	7	189
Virginia Rail	46	42	41	10	139
Wilson's Snipe	15	24	17	9	65
Yellow Rail	1	0	0	0	1
Black Tern	5	16	15	20	56
Forster's Tern	4	0	0	0	4
Le Conte's Sparrow	8	8	3	0	19
Marsh Wren	69	126	138	39	372
Red-necked Grebe	0	0	0	0	0
Sandhill Crane	288	369	239	30	926
Sedge Wren	117	257	239	31	644
Swamp Sparrow	368	595	716	174	1853
Yellow-headed Blackbird	0	1	1	0	2
Routes Surveyed	*24*	*42*	*38*	*12*	*45*
Points Surveyed	*160*	*246*	*220*	*68*	*330*

Table 4. Cumulative number of marshbird detections for each species by year. Surveyors did not record Sandhill Cranes and Sedge Wrens as target species in 2008.

	2008		**2009**		**2010**	
Species	**Total**	**# / count**	**Total**	**# / count**	**Total**	**# / count**
American Bittern	66	0.09	203	0.25	174	0.25
American Coot	7	0.01	55	0.07	23	0.03
Common Moorhen	4	0.01	17	0.02	0	0.00
King Rail	4	0.01	11	0.01	0	0.00
Least Bittern	6	0.01	15	0.02	24	0.03
Pied-billed Grebe	20	0.03	60	0.07	116	0.17
Sora	133	0.19	397	0.50	189	0.27
Virginia Rail	69	0.10	132	0.16	139	0.20
Wilson's Snipe	51	0.07	60	0.07	65	0.09
Yellow Rail	2	0.00	4	0.00	1	0.00
Black Tern	47	0.07	40	0.05	56	0.08
Forster's Tern	8	0.01	31	0.04	4	0.01
Le Conte's Sparrow	10	0.01	20	0.02	19	0.03
Marsh Wren	220	0.32	404	0.50	372	0.54
Red-necked Grebe	0	0.00	0	0.00	0	0.00
Sandhill Crane	---	---	680	0.85	926	1.33
Sedge Wren	---	---	646	0.81	644	0.93
Swamp Sparrow	855	1.23	1796	2.24	1853	2.67
Yellow-headed Blackbird	3	0.00	3	0.00	2	0.00
Total # of point counts	696	---	801	---	694	---

ESTIMATING POPULATION TRENDS, RELATIVE ABUNDANCE, AND EFFECTS OF MANAGEMENT ACTIONS ON 7 SPECIES OF WEBLESS MIGRATORY GAME BIRDS

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Final Report

We addressed four objectives in this study. First, we summarize the gains in data stemming from marsh bird surveys conducted throughout North America. Second, we present estimates of breeding density and population trends for 14 species of marsh birds based on surveys conducted by over 200 observers at 6,367 points along 720 routes throughout Canada, Mexico, and the U.S. from 1999 to 2009. The 14 species (8 of which are game birds) include: American Bittern, American Coot, Black Rail, Clapper Rail, Common Moorhen, King Rail, Least Bittern, Limpkin, Pied–billed Grebe, Purple Gallinule, Sora, Virginia Rail, Wilson's Snipe, and Yellow Rail. Third, we report on the effectiveness of call–broadcast surveys for monitoring Wilson's Snipe population trends and abundance. Fourth, we evaluate the effect of fire on marsh bird numbers.

Estimates of detection probability derived from distance sampling surveys varied among species and was lowest in American Bittern (0.08; 95% CI: 0.05 – 0.12) and highest in Yellow Rail (0.55; 95% CI: 0.44 – 0.68). Density estimates varied among species and were lowest for Limpkin (0.002 birds/ha; 95% CI: 0.001 – 0.002) and highest for Clapper Rail (0.64 birds/ha; 95% CI: 0.61 – 0.68). Species–specific estimates of population density from point–count analyses also varied among species and varied based on the radius selected for circular plot sampling. Density estimates from 50–m radius circular plots were greater than estimates from 100–m radius circular plots in all species except the 2 for which density was nearly zero. Higher breeding density for 50–m circular plots compared to 100–m circular plots are expected if detection probability decreases with distance. Density estimates based on distance sampling were generally higher than estimates derived from circular plot sampling. Estimates based on distance sampling were significantly higher than estimates derived from circular plots in 6 of the 7 species with non–overlapping 95% confidence intervals. Breeding densities ranged between 0.01 and 0.33 birds/ha and varied widely among USFWS Regions, Canada, and Mexico, and also varied among species within regions. Within all but one region (Region 6), a single species exhibited densities significantly higher than all other marsh bird species detected in that region (i.e., one species was much more abundant than all the others in most regions). We had sufficient data to use distance sampling to estimate habitat–specific density for 11 of 14 species within the United States. American Bittern, Black Rail, Common Moorhen, Least Bittern, Pied–billed Grebe, Purple Gallinule, Sora, and Virginia Rail exhibited higher densities in palustrine marsh than estuarine marsh. In contrast, Clapper Rail exhibited higher densities in estuarine than palustrine marsh.

Data for some species suggest increasing trends but data for a few species suggest decreasing trends. Based on route-regression methods, 5 species (American Bittern, King Rail, Least Bittern, Wilson's Snipe, and yellow Rail) showed a declining trend, while eight species showed an increasing trend (American Coot, black Rail, clapper Rail, Common Moorhen, least Bittern, Pied–billed Grebe, sora, and Virginia Rail). Insufficient data was available to estimate population trend for Purple Gallinule based on route-regression methods. Based on log-linear Poisson regression, population trends were estimable for 9 of 14 species and indicated increasing trends in 8 of the 9 species (American Bittern, black Rail, clapper Rail, Common Moorhen, least Bittern, Pied–billed Grebe, sora, and Virginia Rail) and a decreasing trend for American Coots. Trend estimates (based on log-linear Poisson regression) for three of the remaining species (King Rail, Purple Gallinule, and Yellow Rail) were not significantly different from zero, indicating no increasing or decreasing trends.

Call-broadcast increased the detection probability of Wilson's snipe slightly, but not as much as it does for rails. The proportion of Wilson's Snipe detections recorded varied among the three phases of the call–broadcast sequence: passive, conspecific, and heterospecific. The percent increase in the number of Wilson's Snipe detected as a result of conspecific call–broadcast (compared to the average of the 1–minute passive segments) was 18%. Surveyors detected more individuals during the 1–minute of conspecific call–broadcast than during any of the 1–minute heterospecific call–broadcast segments and they detected fewer individuals during the heterospecific call–broadcast segments compared to passive segments.

Marsh bird detections were associated with variation in salinity for 7 of 10 species. Models including standard deviation of water depth were most parsimonious for Clapper Rail, Common Moorhen, Least Bittern, Limpkin, Pied-billed Grebe, Purple Gallinule, and Sora. The null model was most parsimonious for American Coot, King Rail, and Virginia Rail, but the difference in AIC_c between the null models and the next most parsimonious model, which included variation in water depth, was < 1 in all three cases.

Analyses of data from survey points covering one or more marsh units indicate that marsh bird density was associated with mean salinity in 7 of 10 species. Models including mean salinity were most parsimonious for Black Rail, Least Bittern, Purple Gallinule, Sora, and Virginia Rail and models including the interaction between mean salinity and refuge were most parsimonious for Clapper Rail and Common Moorhen. The null model was most parsimonious for American Coot, King Rail, and Pied–billed Grebe but the difference in AIC_c between the null models and the next most parsimonious model, mean salinity, was < 2 in all three cases. The coefficient for mean salinity was negative in five of six species indicating that density is inversely related to salinity for Common Moorhen, Least Bittern, Limpkin, Pied–billed Grebe, Purple Gallinule, and Sora, but positive for Clapper Rail.

Results indicate that pH is associated with marsh bird occupancy in 2 of 7 species: Common Moorhen and Pied-billed Grebe. Models with and without the pH term fit the data equally well for the remaining 5 species indicating that inclusion of pH in the model does not lead to significantly improved model fit. The raw regression coefficients for pH were negative for Common Moorhen and Pied-billed Grebe, indicating that an increase in pH is associated with a decrease in occurrence for these two species.

The application of prescribed fire led to increases in the numbers of clapper rails and Virginia rails. We detected more Clapper Rails during post–burn years compared to pre–burn years on burn plots but not on control plots. We saw some evidence that the positive effects of fire began to diminish as time since fire increased, even though our sample size declined as years post–burn increased. We also detected more Virginia Rails during post–burn years within burn plots but not on control plots, but we failed to detect an effect of fire on abundance of the other three focal species. We found support for models where both initial detection probability and probability of re–detection varied among the 1–min segments of the survey. However, we found no evidence that detection probability differed between burn and control plots for any of the five species. The species composition of the vegetation did not change noticeably as a result of the burns; most plots were dominated by southern cattail (or cattail and common reed) both before and after fire. The amount of decadent vegetation was reduced as the result of the fires.

Products from this project include:

Conway, C. J. 2011. Standardized North American Marsh Bird Monitoring Protocol. *Waterbirds* 34:319-346.

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This abstract represents a final abstract report. The project is complete and a draft final report has been completed and is currently under internal review. The results presented are from a study funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service) and the U.S. Geological Survey. Estimated completion date for the project is May 2012.

EXPANDING THE MICHIGAN MARSH BIRD SURVEY TO FACILITATE CONSERVATION AT MULTIPLE SCALES

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Progress Report; Expected Completion: July 2014

Introduction and Objectives

Many wetland-dependent bird species appear to have declined and the need to implement conservation actions to reverse this trend has been recognized at continental (Kushlan et al. 2002), regional (Soulliere et al. 2007), and state levels (Eagle et al. 2005). Biologists have also understood that the North American Breeding Bird Survey does not adequately survey marsh bird species (Bart et al. 2004, Rich et al. 2004), which led to the development of standardized survey techniques (Ribic et al. 1999, Conway 2009) and a sample design (Johnson et al. 2009) for a national marsh bird survey. A national secretive marsh bird monitoring program has been piloted in several states in recent years, including Michigan.

Implementation of a national secretive marsh bird monitoring program was the top priority identified for several hunted marsh bird species by the Association of Fish and Wildlife Agencies' Migratory Shore and Upland Game Bird Support Task Force (Case and McCool 2009, D.J. Case and Associates 2010). Soulliere et al. (2007) made implementation of the national secretive marsh bird monitoring program its top monitoring priority, because the survey would provide critical information on marsh bird distribution, abundance, and trends. Data collected from Michigan's marsh bird survey will also provide opportunities for future analyses to better understand habitat needs and ensure sustainability of harvest regulations. A fully functioning survey will also facilitate the use of Strategic Habitat Conservation (SHC), an iterative process of biological planning, conservation design, implementation, and evaluation (National Ecological Assessment Team 2006), to guide marsh bird conservation. Having a robust marsh bird survey is vital to the evaluation portion of SHC to inform regulatory decision-making and conservation planning, implementation, and assessment.

Six states have piloted the national marsh bird monitoring program, of which three are located in the Mississippi Flyway (Wisconsin, Michigan, and Kentucky). Wisconsin has the only fully operational survey in the upper Midwest. In 2010, the Michigan Bird Conservation Initiative (MiBCI) began a pilot marsh bird survey following the national protocol (Conway 2009) and sampling framework (Johnson et al. 2009), with the Michigan Natural Features Inventory (MNFI) coordinating the effort. Volunteers completed surveys on 11 primary sample units (PSUs) in 2010 and 2011 under the pilot program. Using Webless Migratory Game Bird Program funding, MNFI will expand the program by approximately 30 PSUs by 2014. The additional survey effort will vastly improve our ability to track marsh bird populations over time at the State level, as well as provide more meaningful data for regional- (e.g., upper Midwest, Joint Venture, Mississippi Flyway) and national-scale monitoring.

Amerian Bittern, *Photo by Ryan Brady, WI DNR*

By building the Michigan Marsh Bird Survey to a full-scale program, we will be able to gather data on several bird species of management concern at national, regional, and state levels concurrently. An expanded Michigan Marsh Bird Survey will provide improved data on seven species of migratory game birds: King Rail (*Rallus elegans*; MI endangered), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Common Moorhen (*Gallinula chloropus*; MI threatened), American Coot (*Fulica americana*), Sandhill Crane (*Grus canadensis*), and Wilson's Snipe (*Gallinago delicata*). In addition to these game species, we are collecting data on 10 other bird species of management interest. Two of these species, Yellow Rail (*Coturnicops noveboracensis*; MI threatened) and Black Tern (*Chlidonias niger*; MI special concern), are Joint Venture focal species along with King Rail. The eight remaining species are considered species of greatest conservation need under Michigan's Wildlife Action Plan (Eagle et al. 2005): Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*; MI special concern), Least Bittern (*Ixobrychus exilis*; MI threatened), Forster's Tern (*Sterna forsteri*; MI threatened), Sedge Wren (*Cistothorus platensis*), Marsh Wren (*Cistothorus palustris*; MI special concern), Le Conte's Sparrow (*Ammodramus leconteii*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*; MI special concern). Although data are lacking for the above species, information is needed by state and federal agencies making regulatory decisions about game species and agencies and organizations interested in tracking trends in relative abundance and distributions, learning more about habitat requirements, and planning, implementing, and evaluating conservation actions.

Our goal is to implement a three-year plan to expand the Michigan Marsh Bird Survey to a full-scale program able to provide data on marsh bird distributions and abundance and baseline information to begin monitoring population trends. By the end of the three-year project, we will have accomplished the following objectives: (1) expand the Michigan survey from the pilot stage to a fully functional survey; and (2) make data available to partners for conservation and regulatory purposes via the national marsh bird database and other suitable portals (e.g., Midwest Avian Data Center). We will take a phased approach to expanding the program over three years. In year one, we will begin conducting the GIS analysis and field ground truthing required to develop new primary and secondary sample units and continue surveys on pilot survey sites. During year two, we will survey new sites prepared for the expanded program in year one, complete ground truthing on remaining expansion sites, and begin recruiting and training new volunteers. In the final year of the project, we will focus on recruiting and training additional volunteers and conducting surveys on all primary sample units (PSUs).

Progress to Date

Our efforts to date have focused on coordinating with national and regional partners, developing the new sample frame, and preparing for the 2012 field season. During the Midwest Bird Conservation and Monitoring Conference (Zion, IL, August 2011), we participated in a workshop entitled *Secretive Marsh Bird Monitoring throughout the Midwest: Expanding from Pilot Efforts to Coordinated Monitoring Region-Wide*. We discussed the future of marsh bird monitoring in the Midwest and provided an update on Michigan's program and plans for expansion during the workshop. We participated in several conference call meetings of the Secretive Marsh Bird Monitoring Work Group of the Midwest Coordinated Bird Monitoring Partnership. We also met with Michigan Department of Natural Resources (MDNR) staff to discuss plans for expanding the Michigan Marsh Bird Survey.

Initiation of this project coincided with an evaluation of the pilot National Secretive Marsh Bird Monitoring Program, which included a national workshop held in December 2011. Workshop participants focused on identifying ways in which marsh bird monitoring could acquire information within an explicit decision-based framework that focuses on pressing needs of managers and policy-makers. Three issues were identified for detailed consideration and treatment in the near-term: (1) evaluation of management treatments – wetland prescriptions for the benefit of all wetland birds; (2) habitat-specific densities of wintering Yellow Rail and Black Rail; and (3) reversing declines in the Midwest populations of King Rail. Since completion of the national meeting, we have been working with national and regional partners to expand Michigan's program in a way that addresses both national priorities and state needs. We believe the expanded Michigan survey could be designed to evaluate the effects of waterfowl management on marsh birds (i.e., national priority 1 above), while also helping to assess trends in distribution and abundance for species of management concern. In

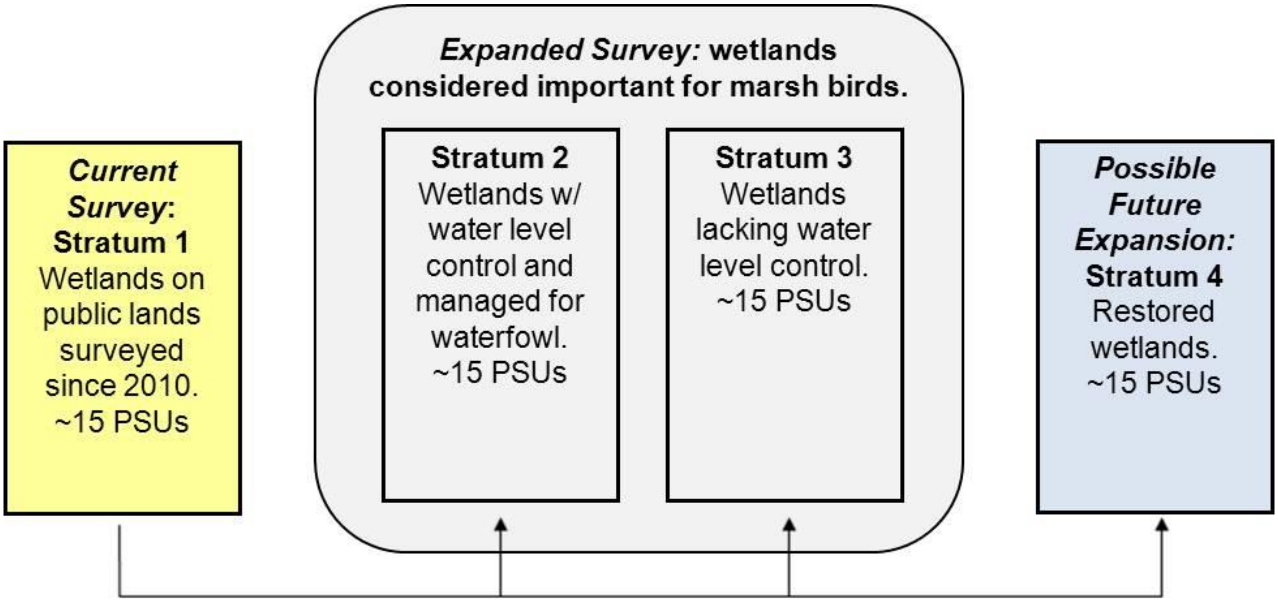

Figure 1. Sample design for an expanded Michigan Marsh Bird Survey consisting of the current survey stratum (yellow box), additional survey strata using current funding (gray boxes), and a possible restored wetland stratum for future expansion (blue box). The approximate number of primary sample units (PSUs) to be surveyed is listed for each stratum.

early 2012, we drafted a proposed framework for expanding Michigan's survey and shared it with national and regional partners (Figure 1). Given the support we have received at national, regional, and state levels, we plan to begin implementing this framework in 2012. Our expanded survey will also provide additional information on King Rail status in the upper Midwest by surveying additional sites at areas managed for waterfowl, which historically supported the greatest numbers of King Rails in Michigan (Rabe 1986).

We have been working with science staff of the Upper Mississippi River and Great Lakes Region Joint Venture (JV) to develop the sample frame for Michigan's expanded survey and select potential primary and secondary sample units. To facilitate sample frame development, we examined recent aerial photography and conservation land boundaries (e.g., Michigan DNR managed lands, Conservation and Recreation Lands database) to identify sites containing emergent wetlands with and without water level control. We developed GIS shapefiles that will be used along with National Wetlands Inventory data to select potential survey sites within each stratum of the expanded survey (Fig. 1).

In preparation for the upcoming field season, we communicated with existing and potential volunteers to continue surveys on current PSUs. We conducted a training workshop for potential volunteers and provided a presentation on the Michigan Marsh Bird Survey at the annual Michigan Bird Conservation Initiative (MiBCI) conservation workshop in March 2012. We recently hired three field technicians that will assist with in-office GIS analysis and ground truthing of potential survey sites, conduct marsh bird surveys, and compile data during the 2012 season.

Future Work

This report summarizes progress during the first 7 months of a three-year project funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service), Upper Midwest Migratory Bird Program, Upper Mississippi River and Great Lakes Region JV (U.S. Fish and Wildlife Service), and MiBCI. During the remainder of 2012, we will focus on finishing the sample frame and selecting potential sites, reviewing potential survey sites via GIS analysis, ground truthing sites to finalize survey routes, and conducting surveys on pilot survey sites and new sites prepared in early 2012. We will begin recruiting and training volunteers to cover new sites in late 2012 and early 2013. In 2013, we will complete in-office and onsite review of remaining new sites identified for the expanded program and conduct surveys at pilot sites and expansion sites prepared in 2012 and early 2013. During 2014, we will focus on recruiting and training additional volunteers and conducting surveys at all survey sites.

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DEVELOPMENT OF A WINTER SURVEY FOR WILSON'S SNIPE (*GALLINAGO DELICATA*) IN THE MISSISSIPPI FLYWAY

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Introduction and Objectives

Despite being widespread and relatively important in the bag of webless game birds, the Wilson's snipe (*Gallinago delicata*) (hereafter snipe) has received little research attention (Arnold 1994). No statistically rigorous population, regional abundance, or higher-level trend estimates exist (Tuck 1972, Arnold 1994, Mueller 1999), however, anecdotal estimates place the North American snipe population at about 2 million (Brown et al. 2001, Delaney and Scott 2006). Nonetheless, snipe are being managed without reliable abundance estimates. The Christmas Bird Count (CBC) provides the only continent wide trend data for snipe, but it was not designed for surveying snipe.

Graduate Student Matt Carroll conducting Wilson's snipe roadside surveys. *Photo by Arkansas Coop Unit*

Tuck (1972) discussed line transects, and focused on winter concentration areas across the U.S. winter grounds. These surveys were to be augmented by CBC data recognizing that the CBC was not designed to survey snipe. As with the breeding ground surveys, Tuck (1972) indicated that there were problems with this approach. The primary issues noted were: 1) numbers of snipe recorded fluctuated annually at individual sites, 2) the number of snipe wintering outside of the United States was uncertain and could change annually, and 3) that weather and water levels affected survey-specific detection. Despite the stated limitations of the winter survey approach, Tuck (1972:380) concluded that, "Winter population censuses have most merit and would be most reliable if carried out in the southern states in early February when the population is relatively stable." Based on the combined consensus that population abundance estimation methods for snipe are needed (Tuck 1972, Fogarty et al. 1980, Arnold 1994, Mueller 1999) and that Tuck (1972) recommended that winter population surveys offered the most promise, we conducted a two year study to evaluate a winter ground survey for snipe in the Mississippi Flyway. This study and the data that we provide serves as a first step towards developing the methods for a United States-wide winter snipe survey.

The objectives of our study were to: 1) develop a feasible roadside survey for wintering snipe, 2) estimate winter snipe population abundance for the Mississippi Flyway, 3) determine whether survey-specific covariates need to be included in the survey design, and 4) examine factors affecting between-year variability in individual site abundance estimates.

Methods

The study area included the snipe wintering grounds in the lower Mississippi Flyway (Figure 1), specifically the Lower Mississippi Alluvial Valley, Red River Valley in Louisiana and the Gulf Coastal

Plain of Louisiana (Figure 1). We selected the study area based on CBC data (Sauer et al. 1996) indicating that the primary wintering states for the Mississippi Flyway include Arkansas, Louisiana, and Mississippi. We included 50 townships of which 20 were based on Christmas Bird Count data (snipe per party hour) (National Audubon Society 2011) and 30 were chosen randomly using ArcGIS 9.2 (Environmental Systems Research Institute Inc. [ESRI] 2006). In 2010, we increased survey coverage by adding 37 more random townships to our sampling strata (Figure 1). We used random townships to estimate snipe densities and abundance for the study area. We compared the CBC township counts against random township counts and we also compared the actual CBC snipe counts against our roadside counts in the same CBC townships (see below).

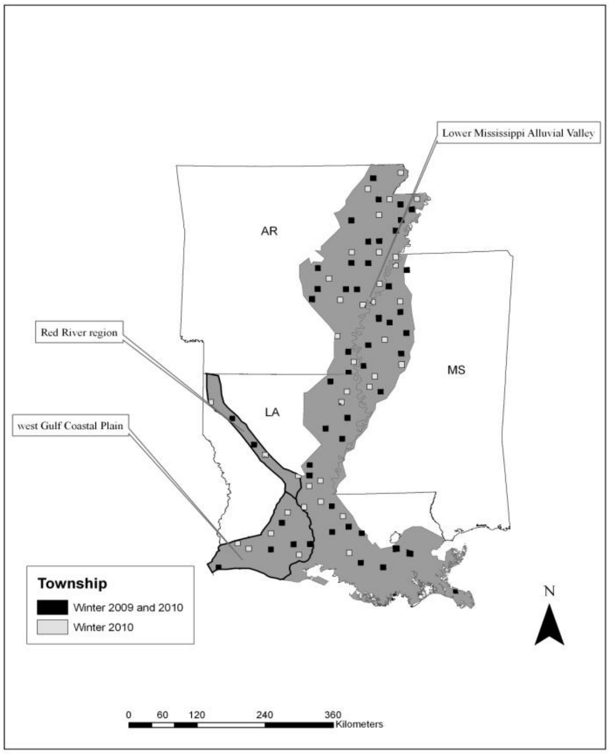

Figure 1. Study area including the lower Mississippi Valley, Red River region of Louisiana and west Gulf Coastal Plain Louisiana. Black symbols represent townships that were surveyed during both years. Gray symbols represent surveys that were newly added for the 2010 field season.

For our sub-sampling unit we attempted to conduct 9 1.8 km (~200m wide) line transects along secondary roads within each township. Along these routes, we recorded the GPS coordinates of start and stop location, distance from the road to each bird (or flock and how many individuals were in the flock), vegetation height, weather conditions, average water depth, percent water and vegetation cover in a segment, and general habitat type. We conducted line transect surveys throughout the daytime from late January to late February during 2009 and 2010. Routes were traveled at <15 Km/h by truck. Both observers scanned for snipe, and periodically stopped to observe for snipe in heavy cover (Rosenstock et al. 2002). We conducted surveys from sunrise to sunset as Hoodless et al. (1998) found that other than crepuscular periods of the day, common snipe (*G. gallinago)* movement was minimal during winter in southwest England. We did not conduct surveys during moderate or heavy precipitation, or during dense fog. We based timing on the recommendation of Tuck (1972) that snipe had not yet begun spring migration then and were relatively stable in distribution.

We applied distance sampling (Buckland et al. 2004) in a road based line transect approach to model detection and derive density and abundance estimates for snipe in the study area. We ran 422 road transects (757 km) in 49 townships during 2009 (21 January - 24 February), and 705 road transects (1271 km) in 84 townships during 2010 (21 January - 27 February). Visual inspection of the 2009 detection histogram from our global plot produced by program DISTANCE (Buckland et al. 2004) did not indicate avoidance of the road by snipe.

Based on our set of a priori covariates we included observer as a factor covariate and percent water cover, percent vegetation cover, and vegetation height score as non-factor covariates. We modeled detection using the Multiple Covariate Distance Sampling (MCDS) engine in program Distance 6.0 (Thomas et al. 2010). This enables the modeling of detection through the inclusion of factors other than only distance (Marques and Buckland 2003). We assessed goodness-of-fit by visually inspecting the relationship between the cumulative distribution (cdf) and the empirical distribution function (edf), and the results of the Kolmogorov-Smirnov test generated by program Distance (Buckland et al. 2004, Marques et al. 2007). We used Akaike's Information Criterion (AIC) (Akaike 1973, Burnham and Anderson 2002) to select among candidate models.

Winter snipe densities can fluctuate locally across years due to changes in weather and habitat availability (Robbins 1952, Tuck 1972). To account for this possible variation in densities, we first analyzed each year separately, and if the 95% confidence intervals for the annual estimates overlapped, we then pooled the years to produce a density estimate with greater precision. We used program Distance 6.0 (Thomas et al. 2010) to estimate detection probabilities and densities (inds/km^2). To calculate abundance we multiplied the size of the study area (~127,507 km^2) by the density estimates (Marques et al. 2007). Finally, used a Wilcoxon matched-pairs signed rank test to compare CBC snipe counts and counts from the same CBC township.

Results

We detected 1,492 snipe (422 transects) in 2009 and 2,487 snipe (705 transects) in 2010. Of the 2,487 snipe detected in 2010, we detected 1,087 in routes repeated from the 2009 season and we detected 1,400 snipe in new routes. In both years combined, we surveyed 1,462 km of roads in random townships and 557 km of roads in CBC townships for a total of 2019 km of survey effort. We detected 58% of snipe as individuals, 34% of snipe in a cluster size of 2-5 birds, and 8% of snipe in cluster sizes of >5 birds.

In both 2009 and 2010 we detected more snipe in row crop than in any other habitat type (Figure 2). In 2009 we detected 74% of snipe in row crop, 14% in rice, 6% in pasture, 5% in aquaculture and 1% in other habitats (Figure 2). In 2010 we detected 80% of snipe in row crop, 14% in rice, 3% in pasture, 2% in aquaculture and <1% in other habitats (Figure 2).

In 2009 we detected more snipe (42%) in habitats with 0% vegetation cover than in any other vegetation cover category (Figure 3). In 2010 we detected more snipe (35%) in habitats with 75-100% vegetation cover (Figure 3). In 2009 we detected more snipe (58%) in habitats with 25-50% water cover than in any other water cover category (Figure 4). In 2010 we detected more snipe (49%) in habitats with <25% water cover than in any other water cover category (Figure 4).

In each year and for the combined years, the most plausible models included observer, water cover and some aspect of vegetation as covariates (Table 1). Density estimates between 2009 and 2010 by either random or CBC townships were not different (Table 1). However, the snipe densities in CBC townships were higher in 2009 compared to 2010 (Table 1). We calculated winter abundance within the study area as 1,167,964 (95%CI: 664,312-2,061,788) in 2009, 511,303 (95%CI: 351,919- 744,641) in 2010, and 529,155 (95%CI: 385,072-726,791) for both years pooled.

In 2009, 16 of 20 comparisons between the CBC snipe counts were greater than road survey counts conducted in the same CBC townships. The mean difference between CBC and road survey counts in CBC townships in 2009 was 87 snipe detected, *p* <0.05). In 2010, 15 of 18 comparisons between the CBC snipe counts were greater than road survey counts conducted in the same CBC townships. The mean difference between CBC and road survey counts in CBC townships in 2010 was 80 snipe detected (*p* <0.005).

Discussion

Using our road survey line transect method for surveying wintering snipe in the lower Mississippi Flyway, we were able to: 1) conduct a large number of surveys over a short period of time, 2) detect a large number of snipe, and 3) survey privately owned lands from public roads. While we recognize that roadside surveys are not without faults, the most plausible alternative method, aerial surveys, have proven ineffective (Robbins 1956). The use of CBC snipe counts as a surrogate for our more statistically rigorous survey approach remains unclear. Our comparisons between the CBC snipe counts and our estimates from the same townships were significantly different each year with the CBC counts being consistently higher than our counts. With only 2 years of data, we cannot say with assurance whether the CBC counts follow the same trends compared to our estimates. Until a longer series of comparisons between the two survey methods are available, we suggest that management agencies be cautious in using CBC snipe counts.

Our abundance estimate of between 0.5 – 1.2 million wintering snipe in the lower Mississippi Flyway appears reasonable given that the current North American estimate is about 2 million (Brown et al. 2001, Delaney and Scott 2006), and taking in to account the importance of the Mississippi Flyway for concentrations of wintering snipe (Robbins 1956, Tuck 1972, Rundle 1981, Twedt et al. 1998). The variation in snipe abundance between years probably reflects habitat availability differences (Tuck 1972).

Our data indicate that based on our number our detections compared to other habitat types, row crop habitats and rice habitats have a comparatively high importance for snipe (Figure 2). More research is needed on how habitat and habitat factors influence snipe densities especially in the face of changing agricultural practices and land development. Because winter habitat has been indicated as being a limiting factor for snipe populations (Neely 1959), our data provides a starting point for future studies addressing the role of habitat and seasonal habitat changes have on wintering snipe.

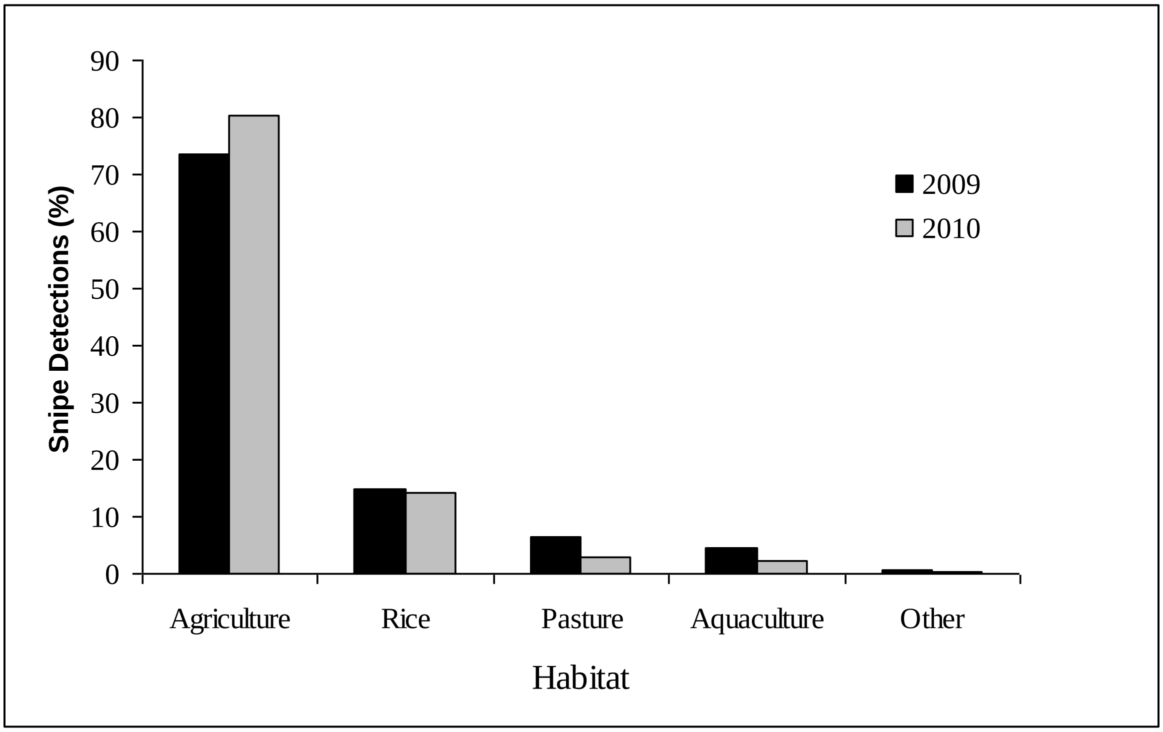

Figure 2. Percent of snipe detected in different habitat types in the lower Mississippi Flyway during winter 2009 and 2010.

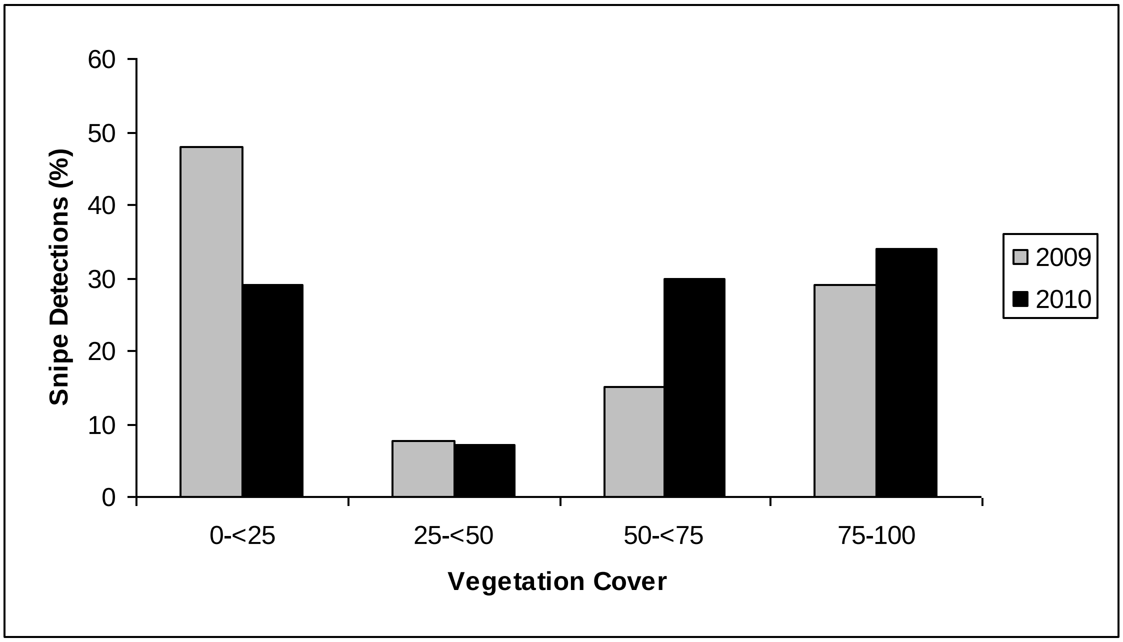

Figure 3. Percent of snipe detected in habitats with varying percent vegetation cover in the lower Mississippi Flyway during winter 2009 and 2010.

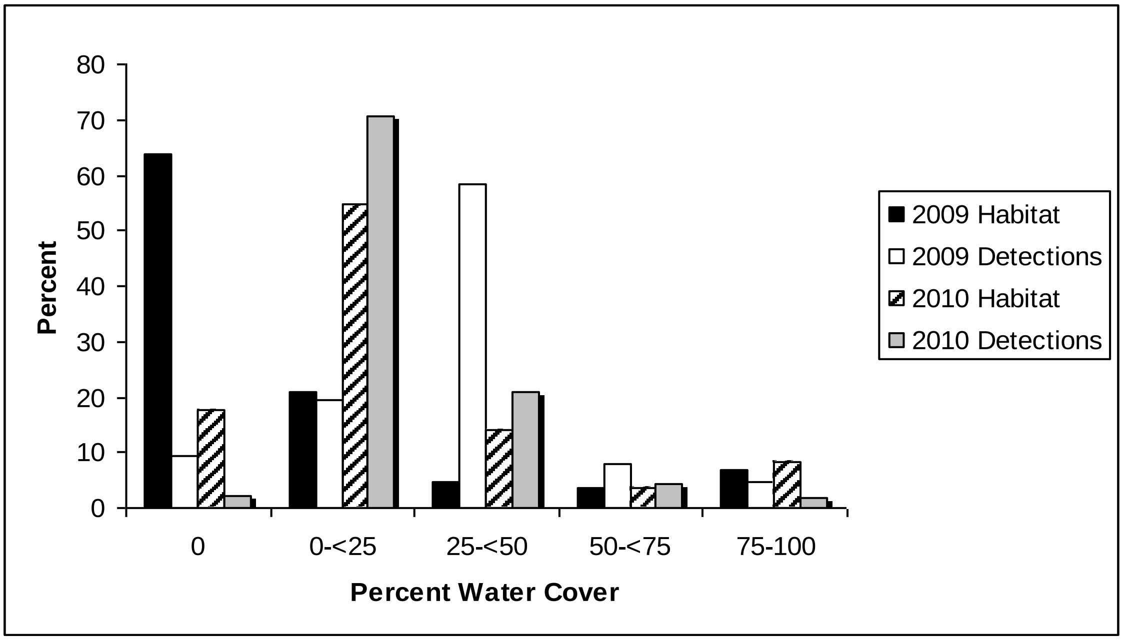

Figure 4. Percent of snipe detected in varying percent water cover in habitats in the lower Mississippi Flyway during 2009 and 2010.

Table 1. Model selection results and corresponding density estimates of the top candidate models for 2009, 2010 and both years pooled, in the lower Mississippi Flyway during winter, 2009 and 2010. Models were ranked within years using AIC score

Year	TS [1]	Effort (km)	N [2]	Candidate Model[3] (key & adjustment + covariates)	No. of Parameters	Density inds/km^2	95% CI	%CV
2009	R	451	364	HNC + obs + veg cover + wat cover	4	9.18	5.21-16.17	29.47
	C	306	376			12.95	6.90-24.31	32.88
2010	R	1010	605	HRC + obs + veg height + wat cover	8	4.01	2.76-5.84	19.29
	C	251	126			2.30	1.15-4.58	36.30
Pooled	R	1462	975	HNHP + obs + veg cover + wat cover	8	4.15	3.02-5.70	16.32
	C	557	375			2.82	1.53-5.19	31.84

[1] Townships. Random (R) or Christmas Bird Count (C)

[2] Number of clusters used in density estimation after truncation.

[3] Half normal cosine (HNC), hazard rate cosine (HRC) or half normal hermite polynomial (HNHP) with observer (obs), vegetation cover (veg cover), vegetation height (veg height), and water cover (wat cover) as covariates.

These are the final results from a 2-year study. Primary funding was provided by the Webless Migratory Gamebird Research Program (U.S. Fish and Wildlife Service). Support was also provided by the USGS Arkansas Cooperative Fish and Wildlife Research Unit.

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DEVELOPING OPTIMAL SURVEY TECHNIQUES FOR MONITORING POPULATION STATUS OF RAILS, COOTS, AND GALLINULES

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Final Report

The acreage of emergent wetlands in North America has declined sharply during the past century. Populations of many species of webless migratory game birds that are dependent on emergent wetlands may be adversely affected. For these reasons, a need for more accurate information on population status and trends has been identified as a top research need for 15 years. Standardized survey protocols are now available, however, numerous methodological questions related to optimal survey methods were raised at a recent marsh bird symposium and in recently published papers, including: (1) the optimal annual timing for conducting surveys in each region of the country, (2) the optimal tide stage for conducting surveys in tidal wetlands, and (3) the effect of broadcasting non-local dialects on detection probability. We worked with the National Estuarine Research Reserve (NERR) program and the National Wildlife Refuge System (NRWS) to address these questions.

We surveyed marsh birds at 113 survey points on 3 NERRs in 2009: Apalachicola in Florida, Weeks Bay in Mississippi, and Grand Bay in Louisiana. We also surveyed marsh birds at 271 survey points on 4 National Wildlife Refuges in Florida in 2009. We surveyed a subset of routes at each location every two weeks from 15 February to 1 August. We also surveyed a subset of survey routes on mornings or evenings when the tide was high, mid, or low to determine how tidal stage affects response rates of each species. Lastly, we surveyed a subset of routes using call-broadcast tracks of least bittern and clapper rail recorded in Florida and California. We surveyed each route on consecutive days using a broadcast track from one location on day 1 and a broadcast track from the other location on day 2. We randomly selected which broadcast track we used on day 1 and we only varied the dialect of one species (either clapper rail or least bittern) during each set of two surveys. We used these data to examine the effect of broadcasting different dialects of the same species on probability of detection.

<u>Survey Timing:</u> We monitored marsh birds between 19 March and 28 July 2009 using the North American Marsh Bird Monitoring Protocol at 3 locations in south Florida (Appendix 1): Fakahatchee Strand Preserve State Park (FSPSP), A.R.M Loxahatchee NWR (ARMLNWR), and Lake Woodruff NWR (LWNWR). We conducted surveys on 12 survey routes during nine 2-week survey periods to document the seasonal variation in marsh bird detections for the following 8 species: American coot (Fulica americana), common moorhen (Gallinula chloropus), green heron (Butorides virescens), king rail (Rallus elegans), least bittern (Ixobrychus exilis), limpkin (Aramus guarauna), pied-billed grebe (Podilymbus podiceps), and purple gallinule (Porphyrio martinica). We observed differences in the peak detection period among survey sites and among species within a survey site. The range of the peak detection period for all species was from 1 June to 31 July for FSPSP, from 1 April to 31 May for ARMLNWR, and from 16 March to 15 June for LWNWR. The recommended survey period for Florida is between 15 March and 30 April or between the 1 April and 15 May, depending on the geographic location. Our data suggests that the 6-week survey periods suggested by the Standardized North American Marsh Bird Monitoring Protocol may be too short to encompass the peak detection

period of each of the focal species in Florida.

Tide Stage: We surveyed clapper rails (Rallus longirostris) and least bitterns (Ixobrychus exilis) during high, mid, and low tides at St. Marks and St. Vincent National Wildlife Refuges on the northern coast of the Gulf of Mexico. The objective was to determine the optimal tidal stage for conducting marsh bird surveys. We tested four different questions to address this objective: (1) does the number of marsh birds detected along survey routes differ among tidal stages? (2) does the optimal tidal stage for conducting surveys differ between boat- and land-based survey points? (3) does the optimal tidal stage for conducting surveys differ depending on the tidal range? and (4) does the optimal tidal stage for conducting surveys differ between the two species? The number of birds detected varied markedly among tidal stages during our surveys for both clapper rails and least bitterns, but the effect size was much greater for least bitterns. Moreover, the variation in the number of birds detected among tidal stages differed between boat- and land-based points for both species. We detected the most birds during high-tide surveys at boat-based points and a similar number of birds among the tidal stages at land-based points for both species. Furthermore, the variation in the number of clapper rails detected among tidal stages was greatest when the tidal range (i.e., the difference in water depth between high and low tide) was smallest. Our results suggest that marsh bird surveys on the northern coast of the Gulf of Mexico should be conducted during high tide at both boat- and land-based survey points to maximize the number of clapper rails and least bitterns detected.

Dialects: The effectiveness of call-broadcast surveys varies regionally for some secretive marsh bird species and this has been attributed to variation in an individual’s responsiveness to regional dialects of the same call. We evaluated differential responses by least bitterns and clapper rails to call-broadcasts of local and foreign call dialects at 2 National Wildlife Refuges in Florida. We detected similar numbers of least bitterns and clapper rails responding to local and foreign call dialects in two of three seasonal survey windows (Fig. 1). During one survey window, clapper rails responded more to foreign dialects and least bitterns responded more to local dialects suggesting that there may be seasonal changes in the effectiveness of different call dialects. Our results indicate that additional research is required to further assess the effects of call dialects on detection probability of marsh birds during call-broadcast surveys. In the meantime, surveyors should use the same call sequences each year at each location to ensure that differences detected are not the result of changes in dialects on the broadcast sequence.

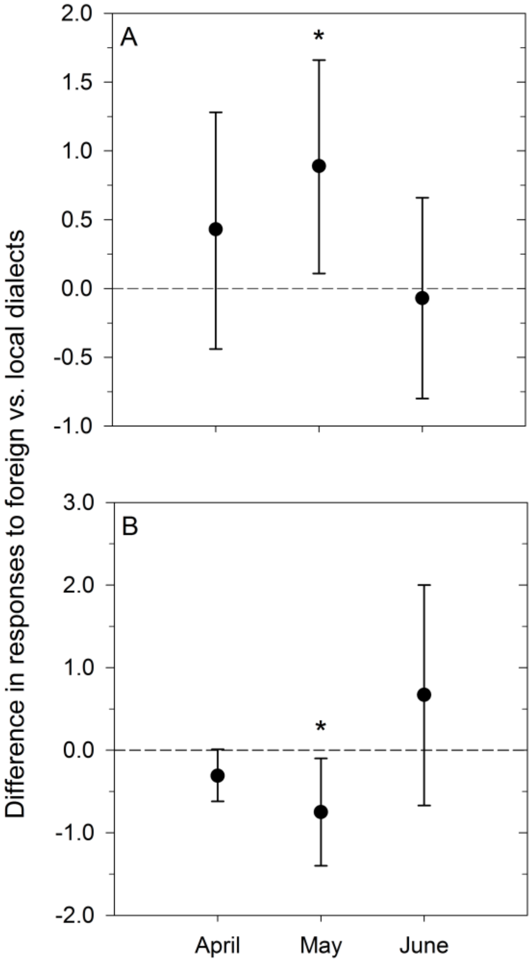

Figure 1. Mean difference with 95% confidence intervals in responses to foreign versus local dialects during monthly trials for (A) clapper rail and (B) least bittern. Negative values indicate more responses to local dialects than foreign dialects and vice versa. Values significantly different than zero ($P < 0.05$) are denoted by an asterisk (*).

Products from this project, thus far, include:

Conway, C. J. 2011. Standardized North American Marsh Bird Monitoring Protocol. *Waterbirds* 34:319-346.

Conway, C. J., and J. P. Gibbs. 2011. Summary of intrinsic and extrinsic factors affecting detection probability of marsh birds. *Wetlands* 31:403-411.

Conway, C. J., and C. P. Nadeau. 2010. The effects of conspecific and heterospecific call-broadcast on detection probability of marsh birds in North America. *Wetlands* 30:358-368.

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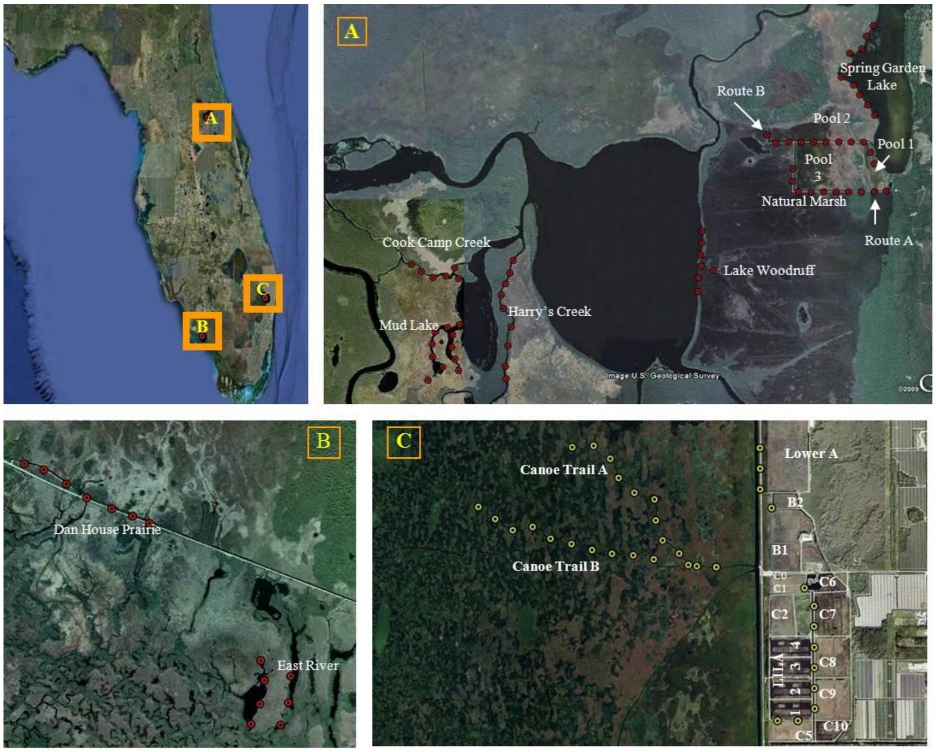
This abstract represents a progress report. The project is complete and a draft final report is being prepared. The results presented are from a study funded by the Webless Migratory Game Bird Research Program (U.S. Fish and Wildlife Service) and the U.S. Geological Survey. Estimated completion date for the project is May 2012.

Appendix 1. Location of marsh bird surveys in Florida.



KING RAIL NESTING AND BROOD REARING ECOLOGY IN MANAGED WETLANDS

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Graduate Student: Karen Willard (PhD); **Progress Report**

Introduction

The King Rail (*Rallus elegans*) is a secretive marsh bird of conservation concern. The species has a large range throughout the eastern half of the United States extending from southern Canada to the Gulf Coast. Qualitative accounts indicate that inland migratory populations were once quite common, but have experienced major population declines in the latter half of the 20th century (Peterjohn 2001, Cooper 2008). North American Breeding Bird Survey data suggests a significant annual King Rail population decline of 3.44% (97.5% CI: -6.72, 1.43) across its range in the United States from 1990 to 2009 (Sauer et al. 2011). King Rails are listed as threatened or endangered in 12 states (Cooper 2008).

Wetland loss and alteration are considered the major factors responsible for declines in King Rail and many other wetland-dependent bird populations (Eddleman et al. 1988). Wetland management approaches, specifically water level management and control of woody encroachment, can also affect habitat use during the breeding season (Naugle et al. 1999, McWilliams 2010). King rails are more likely to select nest sites in standing water but little information is known about how water drawdowns affect nest survival, brood habitat use, movement, and chick survival (Reid 1989). Chick survival was hypothesized to be a limiting factor for population growth and the need for more information regarding brood ecology was highlighted during the 2006 King Rail Workshop (Cooper 2008). Multiple observational studies have found a negative association between marsh bird occupancy or nest density and tree cover (Pierluissi 2006, Budd 2007, Darrah and Krementz 2011), however, an experimental approach is needed to strengthen the inference regarding this relationship.

The goal of our study is to investigate the nesting and brood rearing ecology of the King Rail with respect to water level management (early versus late drawdown) and site preparation (soil disturbance and woody vegetation removal). Objectives of the study are to: 1) determine local scale King Rail habitat use and selection during the nesting and brood rearing period, 2) estimate nest and chick survival rates and document sources of nest and fledgling loss, 3) document movements and estimate home range size during the breeding season, and 4) estimate occupancy rates within units under different management treatments. This information will help wetland managers make better management decisions for King Rails during the breeding season. Parameter estimates produced can be used in viability analyses and simulation models to identify factors limiting population growth.

Methods

Study area

The study area included restored wetlands in southeastern Oklahoma in the Red River floodplain. Two public sites, Red Slough Wildlife Management Area (WMA) and Grassy Slough WMA, and three privately owned wetlands were used in 2011. Red Slough Wildlife Management Area contains multiple impounded wetland units totaling 2,158 ha in size (Figure 1). Dominant emergent vegetation included common rush (*Juncus effusus*), shortbristle horned beaksedge (*Rhynchospora corniculata*), ovate false fiddleleaf (*Hydrolea ovata*), cattail (*Typha* sp.), eastern annual saltmarsh aster (*Symphyotrichum subulatum*), willow (*Salix* sp.), spikerush (*Eleocharis* sp.), smartweed (*Polygonum* sp.), and arrowhead (*Sagittaria* sp.).

Grassy Slough WMA included three impounded wetlands totaling 264 ha. One unit had no standing water and sparse, short vegetation from late April 2011 through early August 2011. The other two units contained shallow water (5-15 cm) with a diverse emergent plant community similar to that at Red Slough WMA. By late June 2011 most units had no standing water aside from a couple channel segments. Similar borrow ditches and ridge/swale features were present at this management area.

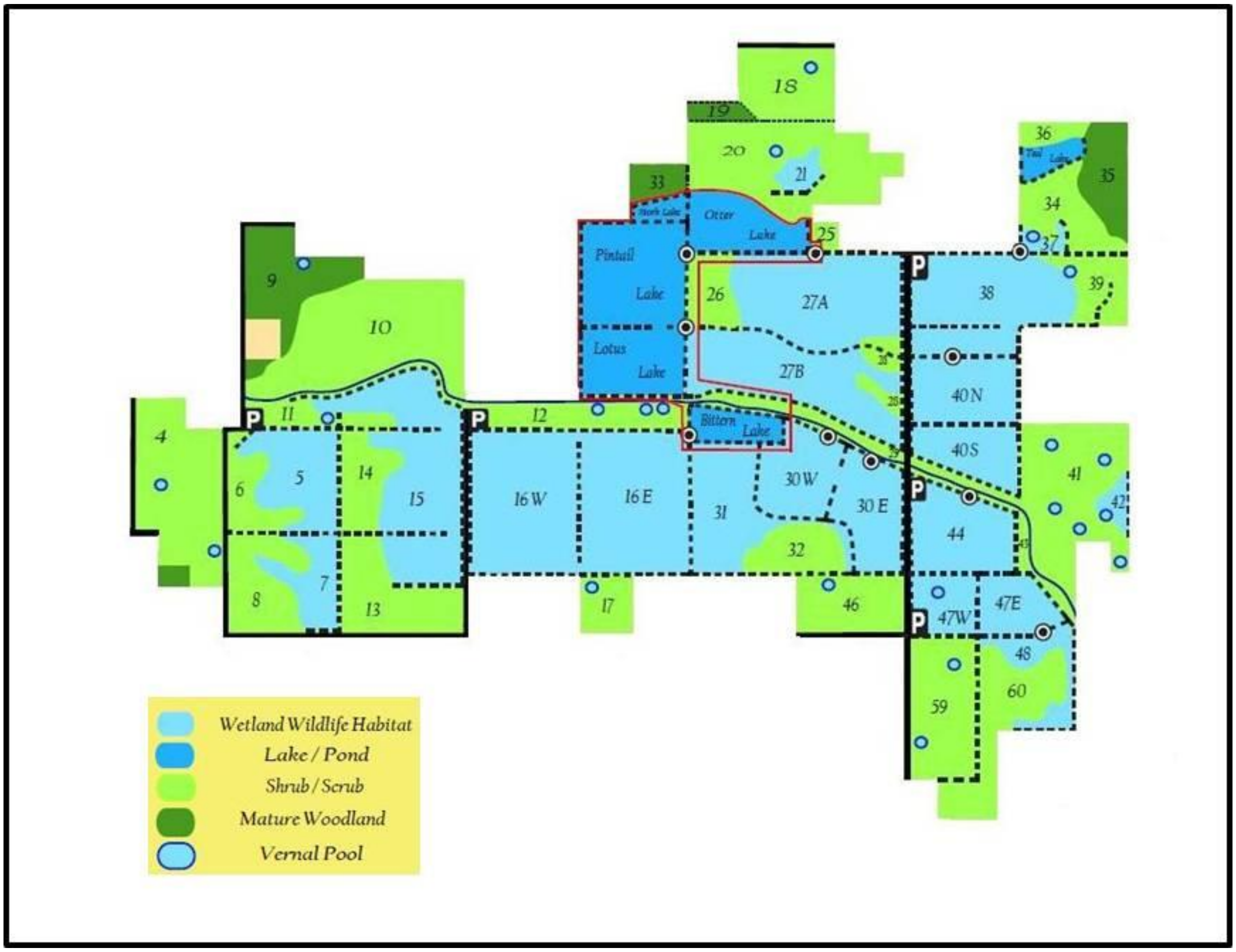

Figure 1. Red Slough Wildlife Management Area wetland units surveyed May-August 2011 to locate breeding King Rail (*Rallus elegans*) territories and document brood rearing habitat use.

Private Restoration area 1 was dominated by cattail with small patches of spikerush. Water depth within the emergent vegetation was approximately 5 cm but was deeper in the channel along the edge of the wetland. Approximately 60% of Private Restoration area 2 was a deep, open water pond. Along the sides the dominant emergent vegetation was soft rush, but woody encroachment had taken over and there were few patches without woody vegetation. Private Restoration area 3 also contained a deep water pond but also had an extensive stand of dense sedges (*Carex* sp.) in shallow or no standing water. Woody encroachment was also evident but not as dominating as in Private Restoration area 2.

Unit Management

Habitat manipulation occurred at Red Slough WMA and private restoration area 1. Boards were removed from stop-log structures at Red Slough WMA during different times of the year and with varying frequency (Table 1). More boards were removed than planned at unit 30E, resulting in a rapid drawdown of water. Beaver activity hindered drawdown management at unit 27. In mid-June unit 16 experienced an unplanned, rapid water loss suggesting structural problems with the levee. Disking occurred in five units during August and September 2011. Private restoration area 1 was drained early in the season and mowed in June.

Table 1. Unit number and management action taken at Red Slough Wildlife Management Area in 2011.

Unit	Management	Area (ha)	Schedule
7	drawdown	24.5	June, six boards pulled
27b	drawdown	78.9	start February, one board every 10-14 days
27a	drawdown	86.6	start May, one board every 7-10 days
30e	disking	38.1	August
30e & 30w	drawdown	80.2	start May, one board every 7-10 days
31	drawdown	47.7	Start June 9, one board every 7-10 days
40n	disking	2.4	September
40s	disking	5.7	September
42	disking	3.6	September
44	disking	42.5	August
47w	disking	12.1	August
48	disking	8.5	August

Wetland units contained a borrow ditch between the levee and the marsh interior which contained water well after the interior of the marsh was dry. Many units also included circular or linear excavations containing open water or deep-water emergent vegetation such as American lotus (*Nelumbo lutea*). The soil from these excavations was placed directly adjacent to the ditch and is typically covered by willows or upland herbaceous vegetation (referred to as ridge/swale in the text).

Experimental Design

A field experimental approach was taken to explore the effect of wetland management on King Rail habitat use and chick survival. The experimental unit was the impounded wetland and the factor was water-level management. Treatment levels consisted of an early drawdown (prior to the start of the breeding season) and a late drawdown (during the breeding season). Starting in 2012, we will include site preparation as an additional treatment factor. Treatment levels will include removal of woody vegetation and disking.

Sampling & Trapping

We broadcasted King Rail calls to elicit a territorial response at all wetland units in order to locate breeding territories. We surveyed sites opportunistically and calls were broadcasted on the levee and inside the wetland. We surveyed all wetland units at least twice and wetlands appearing to have ideal habitat conditions based on review of the scientific literature were surveyed up to 5 times.

We captured King Rails in order to attach VHF transmitters, collect morphological measurements, and collect feather samples for a concurrent study. We attempted to capture King Rails using mist nests, walk-in traps, toe-snares, and airboat and dip-net. We set up two mist nets in a “v” in the emergent vegetation and placed a King Rail decoy in the center and played calls. A walk-in trap containing a decoy and speakers broadcasting King Rail calls was also used to capture birds. We also used toe-snare traps towards the end of the field season. The traps consisted of monofilament tied into a loop with a slipknot and attached to a thin bamboo dowel. We tied a series of ten traps together with monofilament and inserted them into the ground along a used path or at the water/emergent vegetation interface in the hopes that a King Rail would pass over them. An airboat was used in early July to capture birds at night with a dip-net. We also used a large spotlight and walked transects in the marsh at night to find and capture roosting King Rails on two occasions.

Once a bird was captured and marked, we allowed the bird three days to adjust to the harness and transmitter. We used triangulation with a Yagi antenna to estimate the location of birds daily. We tracked individuals at different times during the day and night.

We collected habitat data at King Rail telemetry point locations and at a random location on the same day that the bird’s location was estimated. Random locations were selected from the entire Red Slough WMA complex using the sampling application in ArcGIS. All data were collected within a 50 m radius circular plot centered at the telemetry point or the random point. We visually estimated the percent cover of short emergent (< 1 m), tall emergent (≥ 1 m), open water and counted the number of woody stems in the plot. We counted shrubs composed of multiple stems as one woody stem and counted all trees past the sapling stage (≥ 7cm DBH). We also recorded the dominant tall and short emergent plant species (20% or more of cover type). Water depth was collected at the point and 10 m from the point in the four cardinal directions. We used a cover board to estimate visual obstruction 10 m from the point in the four cardinal directions. Four interspersion cover classes were used to estimate the amount of interspersion within each plot. Interspersion class 1 indicates a plot dominated by emergent vegetation with ≤ 5% open water or exposed soil. Class 2 indicates high interspersion (or water/emergent edge density) with dense emergent cover between 50% and 95%. Class 3 represents a lower degree of interspersion typical of channels or large pools of water surrounded by emergent vegetation. Class 4 represents a site with high interspersion but emergent cover is sparse or less than 50% of the plot area.

We searched known King Rail territories in order to locate broods from 1 June-August 16 2011. Observers sat with spotting scopes on the levee or next to areas within the marsh that contained shallow open water (5-15cm) and adjacent emergent cover. Once a brood rearing site was identified, we observed the brood to collect information on chick survival, habitat use, and foraging behavior.

Results

Weather Conditions

Average monthly precipitation in April 2011 was 20 cm above normal in the region, resulting in relatively deep wetland units in the early breeding season (Figure 2). This was followed by an average monthly precipitation seven and eight cm below normal in June and July and monthly temperatures above normal (Figures 2 & 3). Mid-summer conditions resulted in little to no standing water in the majority of impoundments by the end of July.

Territories

We detected a Sora and Least Bittern but no King Rails at Grassy Slough WMA on 13 May 2011. We detected a Virginia Rail but no King Railss on 13 May 2011 at one privately owned wetland. We identified 17 King Rail territories at Red Slough WMA in early to mid-May (Figure 4). Vocal Detections of King Rails were greatly reduced at these sites after June. We were unsure whether these individuals moved from their territories because of a lack of water or if vocalizations ceased because of changes in the breeding status of the bird. A resurgence of territorial behavior (vocalizations and response to call-broadcasts) occurred in units 27A and 27B on 17 June 2011 in locations where a territory had not been identified previously. We also observed a King Rail pair copulating in unit 27B on 28 June 2011, but a nest was never found. Our observations suggest that territories locations may change throughout the season. Following radio marked birds in future field seasons will help to determine if King Rail movements are related to nest failures or changes in water levels.

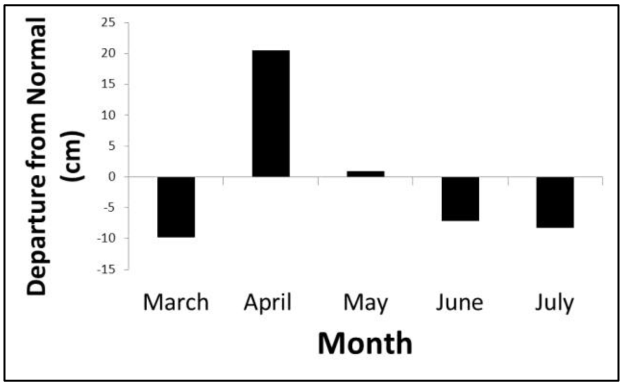

Figure 2. Departure from normal of monthly average precipitation in McCurtain County, Oklahoma from March through July 2011. Standard Normals are defined as the mean of a climatological element computed over three consecutive decades, in this case from 1971-2000 from Idabel, OK weather station data (NCDC 2002).

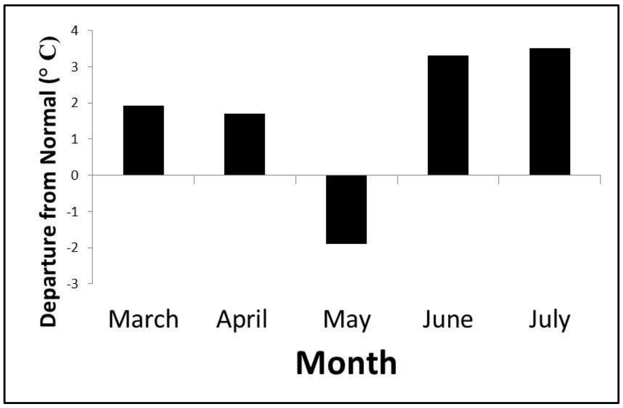

Figure 3. Departure from normal of monthly average temperatures in McCurtain County, Oklahoma from March through July 2011. Standard normals are defined as the mean of a climatological element computed over three consecutive decades, in this case from 1971-2000 from Idabel, OK weather station data (NCDC 2002).

Figure 4. Locations of King Rail breeding territories (yellow stars) identified at Red Slough Wildlife Management Area in May 2011. Classification of breeding territory based on detection of adult King Rail at the site on more than one occasion or detection of an adult pair on at least one occasion.

Capture Data

The use of an airboat and dip nets at night was the most successful means of trapping King Rails (Table 2). The airboat trapping method was used in unit 5, unit 15, and unit 38. Two individuals, one adult and one juvenile, were captured in unit 5 with the airboat and dip net on 6 July 2011. We fitted both birds with a VHF transmitter harness. We found the transmitter and remains of the juvenile King Rail at 9:30 am two days later near the release site. The adult King Rail captured in unit 5 was tracked for 17 days. The individual remained in an area dominated by ovate false fiddleleaf for eleven days (Table 3). The site had high interspersion (class 2 and 4) with patches of both saturated soil and standing water. Mean water depth ranged from 0 to 15 cm at telemetry point locations. Standing water was found only in the borrow ditches surrounding the unit and not in the marsh interior when the adult left unit 5. The King Rail then traveled approximately three kilometers to unit 27B. The bird was then tracked in unit 27A for five days. Dominant vegetation included soft rush and willows and a small patch of standing water with arrowhead. The adult remained near the western end of the levee adjacent to a deep water reservoir. On 29 July 2011, the transmitter was found with the harness intact. Habitat at the telemetry locations tended to have a higher proportion of open water or saturated soil than randomly selected points (Table 4).

Table 2. Catch rate per hour for trapping methods used to capture King Rails at Red Slough Wildlife Management Area, May-August 2011

Method	**Hours**	**individuals captured**	**Catch rate per hour**
Airboat	4.2	2	0.48
Mist net	23.8	1	0.04
Spotlighting	2	0	0
Toe trap	10.8	0	0
Walk-in Trap	51.9	0	0
Total	**92.7**	**3**	**0.52**

At least five individuals or territorial pairs responded aggressively when a decoy and mist nets were used. In most cases, the rails would either lift the net up with their bill and walk under the net or fly away from the net when flushed. A downy chick was captured in a mist net in unit 27a on 2 August 2011. The bird was mostly black but had white auricular tufts and lighter colored feathers on the underside. The chick was most likely between four and five weeks old, based on plumage descriptions from captive chicks (Meanley 1969). The capture site was dominated by cattail in 0-15 cm of water. We observed two chicks and an adult foraging on the edge of open water and cattail a couple minutes after the bird was captured. The chick was fitted with an aluminum USFWS band and a VHF transmitter attached around the neck with a stretchy nylon cord to allow room for growth. On 3 August 2011, the transmitter was found in a patch of soft rush and it was surmised that the neck harness was removed by the bird during grooming. The banded chick was also observed foraging that same day, but the brood was never observed at the site again.

We used walk-in traps frequently throughout the season and on two occasions we set the trap up overnight. Adult rails responded with territorial calls to the play-back call system and would walk around the trap. Unfortunately, no King Rails ever entered the traps. We did not capture any rails with the toe-snare traps, although King Rails were observed walking in the area where the traps were placed. We used a spotlight and dip-net at night to search for and capture roosting King Rails in unit 27A where the airboat could not be launched. Although an adult pair had been observed at the site on several occasions prior, we never observed rails in this location at night.

Table 3. Habitat measurements recorded at King Rail telemetry locations at Red Slough Wildlife Management Area, 6 July-29 July, 2011.

Unit	Date	Distance moved from previous pt. (m)	Mean Water Depth (cm)	Interspersion Class[a]	% Open Water/ exposed soil	% Short Emergent	% Tall Emergent
5	12-Jul	-	1.3	2	17	83	0
5	13-Jul	180	15.4	4	60	40	0
5	14-Jul	84	3.4	4	60	40	0
5	15-Jul	37	7.0	2	50	50	0
5	16-Jul	100	7.4	4	65	35	0
5	17-Jul	110	0.2	2	40	60	0
5	18-Jul	71	6.0	2	35	65	0
5	18-Jul	8	3.0	2	20	80	0
5	19-Jul	12	1.0	2	15	85	0
5	20-Jul	54	0.0	2	45	55	0
5	21-Jul	59	0.0	2	25	75	0
5	22-Jul	16	0.0	2	30	70	0
27b	24-Jul	3,100	0.0	3	15	5	80
27a	25-Jul	196	0.0	1	0	15	90
27a	26-Jul	334	0.0	1	0	5	55
27a	26-Jul	18	0.0	1	5	20	40
27a	27-Jul	41	14.4	2	10	30	25
27a	28-Jul	31	4.2	1	5	20	15
27a	29-Jul	22	0.0	1	2	95	75

[a] Class 1: low interspersion, ≤ 5% open water/exposed soil, Class 2: high/medium interspersion, dense emergent veg. between 50-95%, Class 3: low/medium interspersion typical of channels or large pools surrounded by emergent vegetation, Class 4: high interspersion but with sparse emergent cover or < 50% of plot.

Table 4. Mean and standard deviation (S.D.) of habitat variables collected from random and telemetry locations at Red Slough Wildlife Management Area in July, 2011.

Habitat Feature	**Telemetry Location**		**Random Location**	
	Average	**S.D**	**Average**	**S.D.**
Mean Water Depth (cm)	3.2	4.8	2.1	8.2
% Open Water/Exposed Soil	29.5	21.7	2.4	5.7
% Short Emergent	41.8	28.8	42.7	30.4
% Tall Emergent	20.3	31.1	30.8	28.0

Brood/Juvenile Observations

King Rail broods or solitary juveniles were observed at four different locations at Red Slough WMA in 2011. We observed the first brood on 2 June 2011 on the eastern side of unit 30E. The brood included one adult and one young in full juvenile plumage. In general, the juvenile would forage in the open at the edge of standing water and frequently run back to the emergent vegetation at the adjacent ridge/swale. The juvenile appeared substantially more wary of this feeding site than the adult which would slowly walk around or preen in the open. Mammalian tracks including raccoon and coyote were observed on the edge of the receding pool of water close to the site where the rails were observed. We made observations at this location for a total of seven hours and the brood was visible for approximately 2.5 hours over the course of these observations. We observed the brood at this location again on 3 June 2011 and on 12 June 2011. The brood was not sighted again during two subsequent visits.

We observed two downy chicks with an adult bird next to the borrow ditch in unit 16E on 23 June 2011. The adult was on the levee side of the borrow ditch and flew to the chicks on the opposite side of the ditch when we approached. The brood proceeded to hide in the emergent vegetation dominated by sedges. By this time, there was no standing water within the wetland except for at the ridge/swale pools. We observed the site for a total of eight hours at various times of the day after the first sighting, but the brood was never observed again.

On 2 August 2011, we observed a brood with four chicks in unit 27A. The brood was observed foraging with one adult in a small open area adjacent to the levee. The site was predominately exposed, saturated soil and may have been flooded previously because the adult was observed picking up and feeding a small fish to one of the chicks. On occasion the chicks would venture back into the surrounding cattail. We also observed the brood moving down a ditch through the middle of the marsh surrounded on both sides by willows. We attached a VHF transmitter to one of the chicks, but it fell off the next day. The brood rearing site was observed for a total of five and a half hours over the next week, but we never saw the brood again after 3 August 2011.

We observed solitary King Rail chicks of varying ages foraging at the northwest corner of 27B starting on 2 July 2011. The site contained a channel ending in a pool of water with a shallow grade surrounded by emergent vegetation. The forage site was along the water's edge between 0 and 5 cm deep. The rails would slowly walk along the edge probing their bill into the water. Food items were small and not identified. We made observations at the site for a total of ten hours in July-August 2011. We observed Juvenile rails foraging at different times mostly in the morning from 6:00am to 10:00am although on one occasion a juvenile was observed foraging at 12:40pm.

Future Efforts

We will conduct point count surveys based on the North American Marsh Bird Monitoring Protocols starting in the 2012 field season (Conway 2010). We will use a random sampling design stratified by habitat types to select survey points. Habitat type strata include tall emergent (≥ 1 m), short emergent (< 1 m), and woody vegetation. Surveys will begin in April and run through June. We will survey each point up to five times. We will use program Presence to estimate detection probability, occupancy rate and abundance for the study area. Habitat data will also be collected after each survey to determine habitat associations at different stages in the breeding period.

We have arranged with the Oklahoma Department of Wildlife Conservation to use their airboat again in spring 2012 to help capture King Rails. We hope to use the airboat at least twice between late February and early April before King Rails nesting begins. We still believe that toe-snares can be an effective capture method and will continue to use then in 2012. We will visit with biologists at the Mississippi Sandhill Crane National Wildlife Refuge in November to fine tune our methods.

Acknowledgements

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Appendix I. Projects Funded by the FY2012 Webless Migratory Game Bird Program

22 proposals requesting nearly $2.2 million in funding were submitted to the 2012 Webless Migratory Game Bird Program (WMGBP). The 22 proposals were reviewed and ranked by four Flyway-based Technical Review Committees. The National WMGBP Review Committee further reviewed the proposals and made recommendations for final project selection. The following 11 proposals were selected for funding:

A Novel Approach to Mapping and Quantifying Age Classes of Forest Habitat to Support American Woodcock Management in the Upper Great Lakes. University of Missouri and U.S. Forest Service. Total project cost: $80,800; WMGBP funds: $54,388. **Justification**: Addresses American Woodcock Priority 3 by providing managers with better data about the location and spatial arrangement of young forest habitat.

Analysis and Review of the USFWS Mourning Dove Parts Collection Survey. Dave Otis. Total project cost: $28,500; WMGBP funds: $18,000. **Justification:** Addresses Mourning and White-winged Dove Priority 2 and will likely increase efficiency of the mourning dove parts collection survey.

Effects of Wetland Management Strategies on Habitat Use of Fall Migrating Rails on Intensively-managed Wetland Complexes in Missouri. Arkansas Cooperative Fish and Wildlife Research Unit and Missouri Department of Conservation. Total project cost: $273,238; WMGBP funds: $80,156**.** **Justification:** Addresses Rail and Snipe Priority 4

Estimating Numbers of Breeding Sandhill Cranes in Northwest Minnesota. Minnesota Department of Natural Resources and Agassiz National Wildlife Refuge. Total project cost: $100,650; WMGBP funds: $54,545. **Justification:** Addresses Sandhill Crane Prioritues 1 and 5.

Evaluating Singing-ground Survey Timing and Detectability of American Woodcock using Autonomous Audio Recorders. Bird Studies Canada. Total project cost: $211,406; WMGBP funds: $52,636. **Justification:** Addresses American Woodcock Priority 4.

Exploring New Technologies to Estimate Abundances of Sandhill Cranes. U.S. Fish and Wildlife Service and U.S. Geological Survey. Total project cost: $85,430; WMGBP funds: $4,500. **Justification:** Tests new survey methods for estimating sandhill crane numbers, which may be applied to different populations of cranes thereby providing better population estimates.

National Marshbird Monitoring Program in Ohio. Winous Point Marsh Conservancy and Ohio Department of Natural Resources. Total project cost: $16,655; WMGBP funds: $3,000. **Justification:** Addresses Priority 1 for the Rail and Snipe Priorities and the American Coot, Purple Gallinule, and Common Moorhen Priorities.

Ohio Sandhill Crane Migration Chronology and Population Expansion. Winous Point Marsh Conservancy and Ohio Department of Natural Resources. Total project cost: $93,760; WMGBP funds: $23,400. **Justification:** Addresses Sandhill Crane Priority 2.

Population Dynamics of the King Rail on the Atlantic Coast: Reproductive Ecology, Population Genetics, and Dispersal. East Carolina State University. Total project cost: $138,378; WMGBP funds: $65,316. **Justification:** Addresses Rail and Snipe Priority 4.

Reproductive Success and Survival in the Eastern Population of Sandhill Cranes within Different Landscapes: Will the Population Explosion Continue? Illinois Natural History Survey. Total project cost: $150,188; WMGBP funds: $99,093. **Justification:** Addresses Sandhill Crane Priorities 1 and 2.

Survival and Recovery Rates of Webless Migratory Game Birds. University of Minnesota. Total project cost: $40,166; WMGBP funds: $26,666. **Justification:** Addresses the needs identified in several priority information needs documents to better understand vital rates for webless game bird species.

The WMGBP funding request for these projects totals $481,700, with matching funds totaling $737,481. From 1995 through the present, 118 projects totaling nearly $15.5 million have been supported with nearly $5.5 million in WMGBP funds.

The WMGBP National Review Committee consisted of John Schulz (Missouri – representing the Association of Fish and Wildlife Agency's Migratory Shore and Upland Game Bird Working Group), Mark Seamans (USFWS), Jim Kelley (USFWS), Tom Cooper (USFWS) and the four Flyway-based Technical Committee chairmen: Bill Harvey (Maryland – Atlantic Flyway); John Brunjes (Kentucky – Mississippi Flyway); Jeff Lusk (Nebraska – Central Flyway); and Mike Rabe (Arizona – Pacific Flyway).

Appendix II. Summary of FWS Region 5 Projects Supported by the Webless Migratory Game Bird Program

Each year, $30,000 of Webless Migratory Game Bird Program funding is directed to the U.S. Fish and Wildlife Service Region 5 (Northeast U.S.) Migratory Bird Program to work on webless migratory game bird issues in Region 5. Attached below is summary of expenditures of Webless Migratory Game Bird Program funding during FY 2010 and FY2011.

Maine - The Region 5 Migratory Bird Program continued to support the Northern Forest Woodcock Initiative (NFWI) through efforts to develop communication strategies to enhance habitat management for woodcock and other early-successional species. As part of a cooperative project conducted by Moosehorn National Wildlife Refuge (NWR), the Wildlife Management Institute (WMI) and the U.S. Geologic Survey, Patuxent Wildlife Research Center (USGS PWRC), fieldwork was conducted during FY10 on a project entitled: "Response of American Woodcock (*Scolopax minor*) to Habitat Management on Demonstration Areas at Moosehorn National Wildlife Refuge." This project was designed to: 1) investigate suspected changes in diurnal and nocturnal habitat use and movement patterns by radio-marked woodcock in a managed forest, and 2) incorporate results into interpretive panels along two trails located at Moosehorn NWR to improve visitors' understanding of habitats used by woodcock. Additionally, the data is intended to be used as part of a long term dataset to monitor changes in the population in response to changing management practices and priorities.

In 2009, 166 telemetry locations and corresponding habitat data were obtained from 10 male woodcock (1 hatch year, 6 second year, and 4 after second year). In 2010, an additional 137 telemetry locations were obtained from 11 male American woodcock (6 second year, and 5 after second year). Nocturnal locations were obtained in 2010 to gain insight into woodcock roosting areas, and attempts were made to locate each bird at least once per week from May through late August. Additional telemetry work was conducted in 2011 through continued support by WMI and USGS to obtain data on nesting and brood rearing habitat.

Analysis of the habitat use data is ongoing, and two interpretive panels on woodcock have been developed describing the life cycle, habitat use, management and monitoring techniques. Panels were completed in late 2010 and were installed in spring 2011. Lead Investigators: Dan McAuley, Ray Brown, Andy Weik, and Brian Allen.

New Jersey – To ensure that potential gains in woodcock populations from habitat conservation efforts on the breeding grounds are not offset by losses and/or changes in key migration and staging habitats, a study was initiated to investigate the use of managed areas in southern New Jersey for migrating and staging woodcock. Funding was provided by USFWS Region-5, Moosehorn NWR, USGS, the Webless Migratory Game Bird Program, and WMI through the Northern Forest Woodcock Initiative. Research efforts focused on lands owned and managed by the NJ Division of Fish & Wildlife (NJ DFW) and Cape May NWR (CMNWR) (Figure 1), with logistical support from both agencies.

The goal of the study is to address one component of a priority information need of the MSUGB Program, which is to improve understanding of migration, breeding and wintering habitat quality for woodcock. The specific objectives include: 1) assess diurnal and nocturnal habitat use of migrating and staging woodcock; 2) determine the duration of stay at stopover sites and departure dates; and 3) assess survival rates and potential causes of mortality during migration.

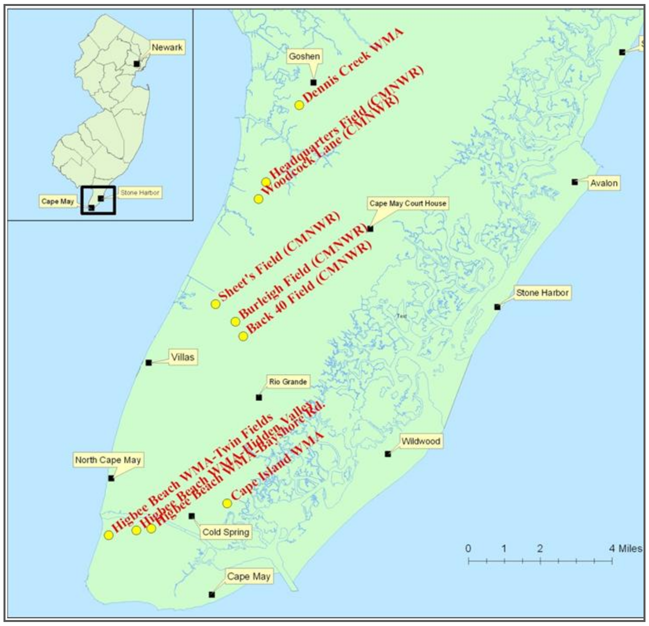

Figure 1. Location of primary study sites for fall migrating and staging woodcock in Cape May County, New Jersey, 2009-2012.

During the pilot study (Nov.-Dec. 2009), technicians used night-lighting to obtain flush counts and capture woodcock roosting in fields, in which 114 woodcock were successfully captured and banded in 17 nights (67 woodcock on Cape May NWR; 47 on State Wildlife Management Areas). Several birds were recaptured 1 or more weeks after their initial capture. On Cape May NWR, 3 fields (HQ's, Woodcock Loop, and Burleigh Rd.) were used extensively by birds with 16 – 31 birds flushed during 2-3 hours of searching. On NJ DFW areas, several fields on Higbee Beach WMA and 1 field on Dennis Creek WMA had flush counts from 9-29 birds over 2-3 hour periods.

During Oct.- Dec. 2010, 72 woodcock were captured and banded in southern NJ, of which 59 were marked with radio transmitters. During Oct.- Dec. 2011, 96 woodcock were captured and banded, of which 53 were marked with radio transmitters. Woodcock captures were distributed over much of Cape May County ranging from Dennis Creek WMA in Goshen, NJ, to Higbee Beach WMA on Cape Island, NJ, while CMNWR and TNC properties covered the central portion of the study area. Of the 96 woodcock captured during 2011, 42 were male and 54 were female. Similar to previous years of research, the majority of woodcock captured (*n* = 77) during 2011 were hatch-year birds; while 17 after-hatch-year and 2 after-second-year woodcock were also captured. Over the course of the study, 423 and 483 diurnal woodcock locations were recorded in 2010 and 2011, respectively.

Habitat Use

The majority of woodcock diurnal locations (92.9%, *n* = 423) during 2010 were in forested habitat, with 7.1% in open areas including fields (17 locations), roadsides (3), lawns (3), paths (2), and salt marsh (1). A majority of woodcock locations occurred in mature timber with various densities of greenbrier and other shrubs and vines. Similarly, 95.2% of diurnal locations in which habitat data could be obtained (*n* = 483) during 2011 occurred within forest covers. The remaining 4.8% occurred in a variety of open areas of mostly grasses and forbes, some with scattered shrubs, or fields that have reverted to shrubs without an overstory. Seventy-five percent of forest locations (*n* = 340) during 2011 occurred in mature forest, 18% (*n* = 82) in pole sized forest, and 3% (*n* = 12) in saplings with the remaining 7% occurring in stands of mixed size classes.

Survival and Migration

Multi-state live encounter models in Program Mark were used to estimate weekly survival and emigration probabilities of woodcock during fall migration during 2010-11 (*n* = 56) and 2011-12 (*n* = 51). Since radio-marked woodcock were not adequately tracked on a consistent basis after they left the study area, survival was fixed to 1.0 once the birds left New Jersey. The probability of emigrating back to the study area after they left was set to 0.0 (i.e., once a bird left in the fall, it was not coming back). Detection probability of radio-marked birds within the study area was assumed to be 1.0.

Based on preliminary analysis, the best supported model for the 2010-11 fall migration indicated that survival was dependent on time period and age, while emigration was time and age dependent. During the first 7 weeks (period 1), adults had a weekly survival rate of 0.97 (95% CI = 0.90 – 0.99) and hatch-year birds had a weekly survival rate of 0.93 (95% CI = 0.89 – 0.97). During the last two weeks (period 2) of tracking, a major winter storm hit the study area and weekly survival dropped. During this period, adults had a weekly survival rate of 0.86 (95% CI = 0.66 – 0.95), while hatch-year birds had a survival rate of 0.77 (95% CI = 0.64 – 0.87). Weekly emigration rates ranged from approximately 0.0 to 0.64 (Figure 2), with peaks occurring during Week 4 (17 - 23 November) and during the last two weeks (29 December – 12 January) of tracking. Around December 23, 2010, 27 of 59 birds marked were still there. By January 10, 2011 after the big snow event 16 were still in NJ and most had died. Mean duration of stay in the area was 24.5 days (SE = 2.0, *n* = 59) post capture. Adults tended to be tracked for fewer days (= 17.1, SE = 4.5, *n* = 11) than juveniles (= 26.1, SE = 2.2, *n* = 48) and females tended to be tracked for fewer days (= 21.8, SE = 3.0, *n* = 28; compared to = 26.8, SE = 2.7, *n* = 31 for males) than males.

During the 2011-12 fall migration, the weather was unseasonably mild with no major storms hitting the study area like the one that occurred in 2010-11. The best model for the 2011-12 fall migration indicated that survival and emigration were both period dependent. Weekly survival during the first period (Oct. 27 – Nov. 16) was near 100%, while emigration from New Jersey was near 0%. For the second period (Nov. 17 – Jan. 12), estimated weekly survival was 0.97 (95% CI = 0.93 – 0.98), while weekly emigration was 0.094 (95% CI = 0.061 – 0.14). In 2011, the majority of radio-marked woodcock (n=27) remained on Cape May peninsula from the time they were radio-marked to the end of the study period and did not leave. The mild weather during the winter of 2011-2012 probably kept the birds in the Cape May area through the winter. Of those 16 birds that migrated during the study season, most were lost/migrated between November 21 and December 11, 2011. The week of December 5th had the most woodcock (n=9) that were lost/migrated.

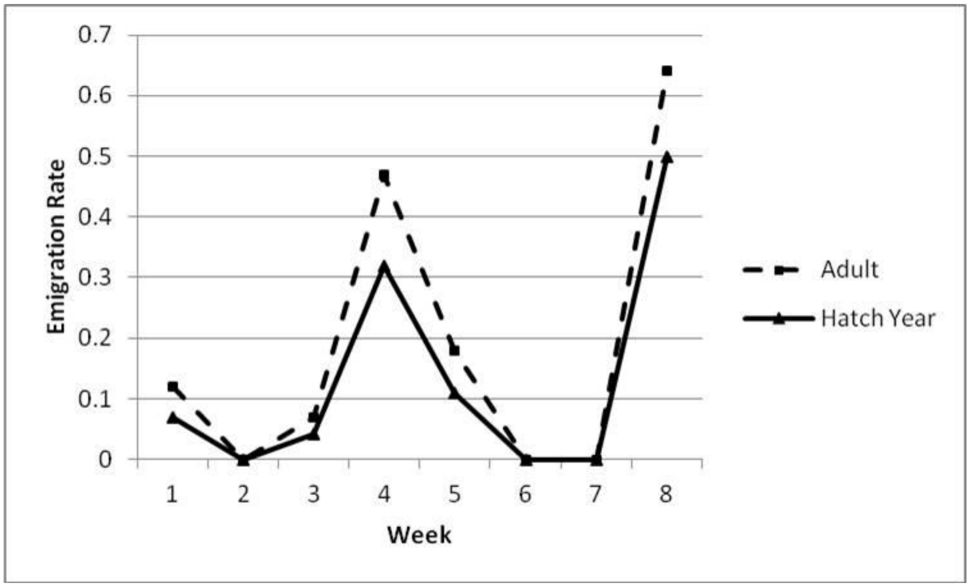

Figure 2. Point estimates of weekly emigration probability of adult and hatch year woodcock from Cape May, New Jersey from late October 2010 to early January 2011.

When interacting with private landowners and interested individuals from the general public, comments were often made about the abundance of woodcock in Cape May County 8-10 years earlier and prior. Local residents spoke of hundreds of woodcock flying around roost fields at dusk where in recent years only a few woodcock have been observed around these same fields. Coincident with this perceived decline of woodcock in Cape May, many individuals who used to hunt woodcock no longer do. Local residents recall harsh winters with snow and frozen ground for extended periods in recent years and approximately 10 years ago, which reportedly resulted in a large mortality of wintering woodcock in Cape May. Some locals attribute the seemingly drastic decline of woodcock in Cape May to these winter mortality events.

Current plans are to continue this research during the fall of 2012, with the potential of adding a component to determine whether habitats used by radio-marked woodcock during staging periods have a measurable effect on body condition. Although migrating and staging woodcock experienced relatively high survival rates and predominately used mature forest habitats in southern New Jersey, key questions remain as to whether habitats used are of sufficient quality to support continued fall migration or survival during harsh weather events that may occur during staging. Lead Investigators: Dan McAuley, Brian Allen, Henry Jones, Ray Brown, Tom Cooper & Chris Dwyer.

Mourning Dove Banding – During FY 2010, Region 5 MB staff hosted a workshop to support State and NWR participation in the National Mourning Dove Banding Program. This 1-day workshop held in western New York was instructed by Dave Otis (USGS) and John Schulz (MO Dept. of Conservation). Workshop participants (n = 27) from the NYS Department of Environmental Conservation, Montezuma NWR and Iroquois NWR received instruction on: the National Strategic Harvest Management Plan, Mourning Dove Banding Needs Assessment, Wing Collection Program, dove trapping, determining age and gender of doves, data management, and a field visit to several banding stations to discuss trap site selection and trapping. Following the workshop, a total of 726 mourning doves were banded during the 2010 pre-season period at 37 locations around the state. An outreach document for the Eastern Management Unit (Figure 3) was also developed to help encourage additional NWR's to participate in mourning dove banding efforts, which can be adapted for the Central and/or Western Management Units.

U.S. Fish & Wildlife Service

National Banding Program for Effective Management of Mourning Doves in the United States

The Importance of Doves
Mourning doves are the most hunted migratory game bird species in the U.S. with nearly 20 million doves being harvested by more than one million hunters annually. According to the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 1.2 million hunters spent 6 million days hunting doves in 2006.

Photo/MO Department of Conservation

The economic impact of dove hunting in the U.S. is considerable. Based on the National Survey, migratory bird hunters spent an average of $588 during the 2006 hunting season, generating more than $1.3 billion in direct expenditures. In addition, mourning doves are valued by the public in rural, suburban, and urban areas because they occur widely, nest readily around homes and farmsteads, and are frequent visitors to bird feeders.

The Challenge
There has been concern among managers for some time about potential declines in populations of mourning doves in portions of their range based on data from the nationwide mourning dove Call Count Survey and the North American Breeding Bird Survey.

In 1998, the U.S. Fish and Wildlife Service (Service) notified the dove technical committees in the Central Management Unit (CMU) and the Eastern Management Unit (EMU) that if downward population trends continued, harvest framework reductions would be implemented. Furthermore, the Service asked that harvest management strategies be developed to include decision criteria that would explicitly state when regulatory changes will be made and what the changes would be, and an estimate of the effect of the regulatory options. In 1999, a workshop was held in the CMU to improve upon the harvest management decision-making process, resulting in a joint Flyway recommendation that was approved in 2000 to support the establishment of a National Mourning Dove Planning Committee composed of representatives from the Service and each of the flyway councils. The charge of the committee was to develop acceptable guidelines for management unit plans, which included harvest management objectives and strategies. Similar recommendations were made by the Central Flyway Council and the Migratory Shore and Upland Game Bird Working Group of the Association of Fish and Wildlife Agencies.

National Strategic Harvest Management Plan
In 2001, a National Mourning Dove Planning Committee was formed and met to begin the process of developing a plan of action that would lead to guidelines which the Dove Management Unit Technical Committees could use to prepare harvest management plans for their respective management units (Fig 1). A Mourning Dove National Strategic Harvest Management Plan was completed in 2005. The purposes of the plan are to:

- Promote the concept of coordinated management of mourning doves to ensure uniformity of regulatory action and equitable conservation across the species range in the three Mourning Dove Management Units;
- Acknowledge the need to recognize demographic differences among management units; and

Figure 1. Mourning Dove Management Units in the United States

Figure 3. Outreach document to encourage NWR participation in the National Mourning Dove Banding Program.

Summary of Expenditures for Webless Migratory Game Bird Projects in USFWS Region 5, FY 10 & FY 11.

Year	Project Description	Funding Source	Amount
FY10	Response of AMWO to Habitat Management on Demonstration Areas at Moosehorn NWR	WMGBP	5,280
	Use of Managed Areas in Southern New Jersey by Migrating and Staging AMWO	WMGBP	24,720
	New York Dove Banding Workshop	Region 5, MB	2,688
	Dove Banding DVD	Region 5, MB	2,000
		Total FY10	**34,688**
FY 11	Use of Managed Areas in Southern New Jersey by Migrating and Staging AMWO	WMGBP	30,000
	Radio transmitters (n = 50) – Southern NJ study	Region 5, MB	7,238
	Aerial telemetry support – Southern NJ study	Region 5, MB	1,800
	Travel support for AF representatives to attend Marshbird Monitoring Summit	Region 5, MB	2,486
		Total FY11	**41,524**